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AUTOMATED WEATHER STATION (AWS) INSTALLATION
ARIZONA D.O.T. OPEN HOUSE
Phoenix, Arizona
July 20-21, 1994

AGENDA

Afternoon, July 20, 1994 (to be held at Arizona Transportation Research Center[1])

1:00 - 1:15 p.m.	Welcoming Remarks and Introductions Instructors and Participants Objectives of Open House Overview of Agenda	(A. Lopez)
1:15 - 1:45 p.m.	Overview of AWS AWS Sensors AWS Data Acquisition System	(D. Anderson)
1:45 - 2:30 p.m.	AWS Installation Site Preparation AWS Installation	(A. Lopez, D. Anderson)
2:30 - 3:00 p.m.	AWS Data Collection and Maintenance AWS Data Uploading AWS Maintenance Requirements	(D. Anderson)
3:00 - 3:15 p.m.	BREAK	
3:15 - 3:45 p.m.	AWS Roles and Responsibilities Purchase Installation Data Collection Technical Support Maintenance	(G. Rada)
3:45 - 4:30 p.m.	Overview of Arizona SPS Project and AWS Installation Construction AWS Location AWS Installation	(D. Frith)
4:30 - 5:00 p.m.	Open Discussion Period Questions and Answers Feedback	(G. Rada, D. Anderson)
5:00 p.m.	ADJOURN	

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[1]7755 South Research Park Drive, Suite 106, Tempe, Arizona, (602) 831-2620

AGENDA (Continued)

Morning, July 22, 1994

7:00 - 7:30 a.m.	Travel from Hotel to SPS Site	
7:30 - 11:00 a.m.	Demonstration of AWS Installation Site Preparation AWS Installation AWS Data Collection	(D. Anderson, A. Lopez)
11:00 - 11:30 noon	Travel from SPS Site to Arizona Transportation Research Center	
11:30 - 12:00 noon	Open House Closing Activities Questions and Answers Summary and Conclusions Closing Remarks	(A. Lopez, G. Rada)
12:00 noon	ADJOURN	

Draft Report
Not for Publication

EVALUATION OF AUTOMATED WEATHER STATIONS FOR USE AT SPS PROJECT SITES

FHWA Contract No. DTFH61-92-C-00134

Prepared for

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Prepared by

FHWA-LTPP TECHNICAL ASSISTANCE CONTRACTOR TEAM

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January 1994

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INTRODUCTION

As part of the Long Term Pavement Performance (LTPP) program, there is a requirement to collect climatic data at both the General Pavement Studies (GPS) sites and at Specific Pavement Studies (SPS) sites. An extensive climatic database has been developed for all GPS sites. Details of the GPS climatic database development are given in References 1 and 2. This database was developed by using data from up to five nearby weather stations to "estimate" site specific climatic conditions. The GPS climatic database contains data from the date of construction of each GPS site up to 1990. The database will be periodically updated.

A climatic database is also needed for SPS sites. Preliminary guidelines for climatic data collection for SPS sites were presented in a Strategic Highway Research Program (SHRP) report entitled, "Climatic Data Collection Requirements for SPS Test Sites," dated May 1992. The report outlined the essential and desirable climatic data items which are required for the SPS-1, SPS-2, and SPS-8 experiments and identified potential site weather data collection systems that could be installed at the SPS sites. However, the report did not present a detailed climatic data collection plan for the SPS sites and allowed provisions for accepting weather data from nearby weather stations.

Since the May 1992 report was issued, a meeting of the LTPP Expert Task Group (ETG) on Climatic Data was held. The ETG members strongly endorsed the need for collecting climatic data on-site for SPS projects and recommendations were made for installing on-site automated weather stations (AWS). During the fall of 1992, a technical review was conducted of commercially available AWS. Based on this review, one commercially available AWS was selected for pilot evaluation during the summer of 1993. This report presents the details of the requirements for climatic data collection at SPS sites and the results of the pilot AWS evaluation.

CLIMATIC DATA REQUIREMENTS

The collection of site specific climatic data for SPS-1, SPS-2, and SPS-8 sites is considered a mandatory requirement under the LTPP program. The site specific data will be collected using AWS located in close proximity to the project sites. The following climatic data elements are considered essential and must be collected at each SPS test site:

1. Maximum Daily Temperature (TMAX)
2. Minimum Daily Temperature (TMIN)
3. Mean Daily Temperature (MNTP)
4. Daily Precipitation (PRCP)
5. Daily Average Wind Speed (AWND)
6. Peak Gust Wind Speed and Direction (PKGS)
7. Daily Minimum Relative Humidity (MNRH)
8. Daily Maximum Relative Humidify (MXRH)

In addition, it is desired to obtain data on incoming solar radiation. This data element is considered of importance in future studies of pavement response to climatic factors. Thus, the following additional data needs to be obtained:

9. Incoming Solar Radiation

Once the climatic data elements are obtained, the following monthly statistics will be calculated from the daily data:

1. Standard Deviation
2. Skewness
3. Kurtosis

In addition, the following data will be derived:

1. Total Monthly Precipitation
2. Total Monthly Snowfall
3. Number of Air Freeze Cycles - Monthly
4. Mean Daily Temperature Range - Monthly
5. Number of Wet Days (Precipitation > 0.01 in.)
6. High Intensity Precipitation Occurrences (Precipitation > 0.5 in./day)
7. Air Freezing Index

AUTOMATED WEATHER STATION REQUIREMENTS

Automated weather stations (AWS) are designed to accurately measure and record standard meteorological parameters over extended periods, at relatively low cost. Many types of AWS are commercially available. The important features of AWS as described in "Chapter 6 - Automated Weather Stations, *Remote Sensing Reviews, Volume 5(1), 1990*" are:

1. Cost
2. Reliability
3. Minimum maintenance requirements
4. Measurement accuracy
5. Sensor compatibility
6. Processing power
7. Data storage and retrieval options
8. Operating condition requirements (temperature range, etc.)
9. Power requirements and power supply
10. Flexible programmable systems
11. Mast and mounting hardware
12. Protective housing for the electronics

All AWS must have meteorological sensors providing an electronic signal, electronics to convert the sensor signal to a digital value, and either electronic storage media to collect the data on site and/or telecommunications hardware to transmit the digital values. Many AWS use a stand-alone environmental datalogger to perform the measurement, communication, and data storage functions.

AWS EVALUATION OBJECTIVES

Because of the critical nature of the requirements for AWS to be installed at SPS test sites, it was decided to review a selected number of commercially available AWS and to pilot test one system. The pilot testing was deemed necessary to allow hands-on experience with AWS and to ensure that the selected AWS system would provide the expected performance over the designated service life of the AWS. Thus, the overall objective of the evaluation was to select an AWS system that met the requirements for climatic data gathering at SPS test sites in a cost-effective manner. The specific evaluation objectives were to determine operating efficiency of the AWS as a whole, ease of installation, and ease of maintenance. It should be noted that most of the AWS will be located in remote locations with data retrieval activities kept to a minimum (about 3 to 4 times a year). The ruggedness and long-term durability of the system are therefore key concerns.

REVIEW OF COMMERCIALLY AVAILABLE AWS

During the fall of 1992, a review of selected AWS systems was conducted. Several AWS manufacturers were contacted and technical literature on their systems was requested. The following systems were reviewed on the basis of literature provided by the vendors:

1. Campbell Scientific, Inc.
   P.O. Box 551
   Logan, UT 94321
   Telephone: 801-753-2342

2. Climatronics
   140 Wilbur Place
   Bohemia, NY 11716
   Telephone: 516-587-7300

3. Handar, Inc.
   1188 Bordeaux Drive
   Sunnyvale, CA 94089
   Telephone: 408-734-9640

4. Omnidata International
   750 West 200 North
   Logan, UT 84321
   Telephone: 801-753-7760

5. Qualimetrics, Inc.
   Weathermeasure/Weathertronics Division
   P.O. Box 41039
   Sacramento, CA 95841
   Telephone: 916-923-0055

6. Aanderaa Instruments, Inc.
   30F Commerce Way
   Woburn, MA 01801
   Telephone: 617-933-8120

Each of the above listed AWS systems was required to incorporate the following:

1. Sensors
   a. Temperature
   b. Relative Humidity
   c. Wind Speed
   d. Wind Direction
   e. Precipitation
   f. Solar Radiation
2. Datalogger System
3. Data Storage Media
4. System Cabinet (Enclosure)
5. Mounting System and Hardware

The acceptable specifications for the AWS sensors are given in Table 1. The various AWS system features are compared in Tables 2, 3, and 4.

While many of the commercially available systems appeared to be acceptable for meeting the needs of the LTPP program, it was decided to select the Campbell Scientific AWS System for pilot installation at FHWA's Turner Fairbanks Highway Research Center in McLean, Virginia. The selection of the Campbell Scientific system was based on several factors, as follows:

1. *System Reliability* - The Campbell Scientific system was given high marks for long-term performance by the researchers at the U.S. Army's Cold Regions Research and Engineering Laboratories (CRREL).

2. *System Experience* - The LTPP program currently uses several Campbell Scientific supplied electronic systems including the CR-10 datalogger which is the "heart" of Campbell Scientific's AWS. Thus, both FHWA's LTPP Division staff as well as the Contractors working on the LTPP program are very familiar with the CR-10 operation and therefore will not need extensive training for installing and monitoring the AWS. The use of the CR-10 based AWS will minimize confusion in the field as the site personnel have to deal with fewer different data acquisition systems.

Table 1 - Specifications for Meteorological Sensors According to the National Weather Service and Environmental Protection Agency

A. System Accuracies and Resolutions

Organization	**AWOS SYSTEMS*** **National Weather Service**	**Environmental Protection Agency**
Temperature		
Range	-80 to 130°F	±0.5°F
Accuracy	±0.18°F	
Resolution	0.1°F	0.1°F
Relative Humidity		
Range		
Accuracy	Not Taken	Not Taken
Resolution		
Wind Direction		
Range	0 to 360 degrees	
Accuracy	±5 degrees	±5 degrees
Resolution	1 degree	1 degree
Threshold	2 knots (2.3 mph)	
Wind Speed		
Range	0 to 125 knots (0 to 144 mph)	
Accuracy	±2 knots (±2.3 mph)	±0.5 mph + % observed
Resolution	1 knot (1.15 mph)	0.22 mph
Threshold		
Precipitation		
Range	up to 10 in./hr	
Accuracy	1% @ 0 to 3 in./hr 5% @ 3 to 10 in./hr	±10% of observed
Resolution	0.01 in.	0.01 in.
Solar Radiation		
Accuracy	Not Taken	±5% observed
Resolution		10 W/m^2

* Automated Weather Observing System (AWOS) used by the Federal Aviation Administration

Table 1 - Specifications for Meteorological Sensors According to the National Weather Service and Environmental Protection Agency (Continued)

B. Standard Meteorological Sensor Heights

Organization	Air Temperature	Soil Temperature	Humidity	Wind Speed/ Direction	Precipitation	Solar Radiation
NWS/NOAA	150 cm/60 in.	10 cm/4 in.	150 cm/60 in.	900 to 1000 cm/30 to 33 ft	As near to the ground as practical	N/A
AASC	150 cm/60 in.	10 cm/4 in.	150 cm/60 in.	300 cm/10 ft	100 cm/36 in.	Free from any obstruction above the plan

C. Recommended Measurement Intervals

	Interval	Samples/Day
Solar Radiation	10 sec.	8640
Air Temperature	60 sec.	1440
Relative Humidity	60 sec.	1440
Wind Speed	1 to 10 sec.	8640 to 86400
Wind Direction	1 to 10 sec.	8640 to 86400
Precipitation	60 min.	24

Table 2 - AWS System Specifications

Meteorological Variable	Vendor					
	Campbell Scientific	**Climatronics**	**Handar**	**Omnidata**	**Qualimetrics**	**Aanderaa Instruments**
Temperature						
Range	-31 to 122°F	-58 to 122°F	-58 to 140°F	-58 to 176°F	-58 to 122°F	-47.2 to 120.2°F
Accuracy	±0.2°F	±0.18°F	±0.2°F @ 32 to 140°F ±0.6°F @ -58 to 32°F	±0.25°F	±0.20°F	
Relative Humidity						
Range	0 to 100%	0 to 100%	0 to 100%	0 to 100%	0 to 100%	0 to 100%
Accuracy	±2% @ 0 to 80% ±3% @ 80 to 100%	±2%	±2% @ 0 to 80% ±3% @ 80 to 100%	±2% @ 0 to 80% ±3% @ 80 to 100%	±2% @ 0 to 80% ±3% @ 80 to 100%	±3%
Operating Temp.		-40 to 125°F	-58 to 140°F	-58 to 176°F	-40 to 176°F	
Wind Direction						
Range	0 to 360 degrees	0 to 360 degrees	0 to 360 degrees	0 to 360 degrees	0 to 360 degrees	0 to 360 degrees
Accuracy		±3 degrees	±3%		±2 degrees	±5 degrees
Threshold		< 1 mph	3 mph	2 mph	0.75 mph	
Operating Temp.					5 to 131°F	
Wind Speed						
Range	0 to 135 mph	0 to 125 mph	0 to 134 mph	0 to 134 mph	0 to 100 mph	0 to 134 mph
Accuracy		0.25 mph/+1.5 mph	±0.67 @ 0 to 45 mph ±2% @ 46 to 134 mph		±0.15 mph or 1%	±2%
Threshold	2.2 mph	< 1 mph	2.0 mph	1.3 mph	1.0 mph	1.0 mph
Gust Survival	220 mph		227 mph			
Operating Temp.					5 to 131°F	
Precipitation						
Range						1 in/interval
Accuracy	1% @ 2 in./hr	±1% up to 2 in./hr ±5% up to 10 in./hr	< ±0.02 in. @< 1 in./hr ±3% @> 1 in./hr	1% @ 2 in./hr	0.5% @ 0.5 in./hr	
Resolution	0.01 in.	0.01 in.	0.01 in.	0.01 in.	0.01 in.	
Operating Temp.						
Solar Radiation						

Table 3 - Features of Selected AWS Systems (Based on Vendor-Supplied Information)

Organization	Campbell Scientific	Climatronics	Handar	Omnidata	Qualimetrics	Aanderaa Instruments
Power Source	AC Battery Solar	AC Battery Solar	Battery Solar	AC Battery Solar	AC Battery Solar	Battery Solar
Information Transfer	Phone Modem Storage Radio Waves Satellite	Phone Modem Storage Radio Waves	Phone Modem Storage Radio Waves Satellite	Phone Modem Storage Radio Waves	Phone Modem Storage Radio Waves	Radio Waves
Storage Capabilities	192 K 512 K Up to 8 modules in 1 system	32 K 64 K	128 K 1 MB	64 K 128 K 256 K 512 K	32 K 64 K 128 K	128 K
Data Elements						
Air Temp.	Yes	Yes	Yes	Yes	Yes	Yes
Humidity	Yes	Yes	Yes	Yes	Yes	Yes
Rain Fall	Yes	Yes	Yes	Yes	Yes	Yes
Snow Fall	No	Y/N Yes if only AC	No	No	Y/N Yes if only AC	No
Wind Direction	Yes	Yes	Yes	Yes	Yes	Yes
Wind Speed	Yes	Yes	Yes	Yes	Yes	Yes
Solar Radiation	Yes	Yes	Yes	Yes	Yes	Yes
Air Pressure	No	No	No	No	No	Yes
Sunshine Duration	No	No	No	No	No	Yes

Table 4 - Cost of Selected AWS Systems

Cost of Individual Sensors

Organization	Campbell Scientific	Omnidata	Qualimetrics	Climatronics	Handar	Aanderaa Instruments
Meteorological Data						
Air Temperature	470.00 (Both)	500.90 (Both)	785.00 (Both)	125.00	736.00 (Both)	417.00
Relative Humidity				490.00		1075.00
Precipitation Rain Fall Snow Fall	 240.00 N/A	 240.00 N/A	 465.00 830.00	 600.00 900.00	 516.00 N/A	 1147.00 N/A
Wind Speed Direction	 215.00 160.00	 640.00	 320.00 415.00	 700.00	 561.00	 993.00 993.00
Solar Radiation	270.00	240.00	390.00	350.00	516.00	1004.00
Total Costs	1355.00	1620.90 (1100.00)	2740.00 (2375.00)	2265.00 (1965.00)	2329.00	5629.00

Cost of the Total Environmental Weather Station (Including Datalogger)

Organization	Campbell Scientific	Omnidata	Qualimetrics	Climatronics	Handar	Aanderaa Instruments
Total System Cost	6065.00	4708.90	8142.00 (7777.00)	8130.00 (7830.00)	7749.00 (5094.00)	N/A

3. *Compatibility with the LTPP Seasonal Monitoring Program* - Under the LTPP Seasonal Monitoring Program, there will be 60 test sites where the CR-10 datalogger will be used to monitor pavement temperature as well as ambient temperature and rainfall. FHWA had developed a hardware package (mobile data acquisition systems based on the CR-10 datalogger) and customized software to upload and download data being collected. This process is very similar for the evaluated AWS. Thus, there will be compatibility in hardware and software for data collection which will allow more efficiency in the operation of the AWS.

4. *Cost* of the various systems were comparable, with the cost of the Campbell Scientific system somewhat below average.

SYSTEM CONFIGURATION FOR THE PILOT INSTALLATION

As discussed, the system selected for the pilot implementation was obtained from Campbell Scientific, Logan, Utah. The system selected was a system dedicated primarily for use at pavement facilities. The system, Model WS3RG or Model WS3RG-H for locations requiring a heated rain gage, is a complete package consisting of the required sensors, data storage, and retrieval modules based on the CR-10 datalogger, and tower assembly.

The Model WS3RG AWS system consists of the following:

1. *Datalogger/Enclosure/Power Supply*
   CR-10 Measurement & Control Module with CR-10 WP with ..D
   ..OS10-0.1 Prom (Default)
   12 x 14 in. Instrumentation Enclosure Kit (ENC 12/14)
   12 Volt Power Supply with Charge Regulator & SR Battery (PS12LA)
   10 Watt Solar Panel with Mounts (MSX10)

2. *Meteorological Instruments (Sensors)*
   Vaisala Temperature & RH Probe with 5 ft Lead (HMP35C)
   RM Young Wind Monitor with 11 ft Lead (05103)
   LI-Cor Pyranometer with 11 ft Lead (LI200S)
   Met One 12 in. Rain Gage with 25 ft Signal Cable (380-L)
   380 Mounting/Level Base (380MB)

3. *Instrument Mounts*
   Solar Radiation Shield for HMP35C (41002)
   Aluminum Crossarm Sensor Mount (019ALU)
   Pyranometer Base/Leveling Fixture (LI2003S)
   Pyranometer Crossarm Stand (025)
   3-Meter Tower & Grounding Kit (UT3)

4. *Data Storage/Retrieval*
   Storage Module with 192K Memory (SM192)
   Mounting Bracket
   9-Pin Peripheral to RS232 Interface (SC532)
   Datalogger Support Software (PC208)
   Optically Isolated RS232 Interface (SC32A)

For the WS3RG system to be used in northern locations where potential for freezing exists, a heated rain gage (Campbell Scientific Model 385-L) is available and the AWS system is then designated as Model WS3RG-H. The technical documentation for the selected AWS is given in Appendix A.

PILOT SYSTEM INSTALLATION DETAILS

The AWS, designated WS3RG, was procured by FHWA during July 1993. The pilot AWS installation was a cooperative effort by FHWA'S Paving and the LTPP Divisions. The AWS used for the pilot installation and evaluation will ultimately become part of the expanded Accelerated Load Testing Facility now under construction at FHWA's Turner Fairbank Highway Research Center (TFHRC). The system was installed at a temporary site at TFHRC on July 26, 1993. The system was installed by the staff of FHWA's Paving and the LTPP Divisions with support from the staff of FHWA's LTPP Technical Assistance Contractor. In addition, Mr. Dan Anderson of Campbell Scientific, Inc. was present during the installation to provide guidance, as needed, during the installation, to install the software for acquisition of the climatic data and to review operational requirements for the AWS. Mr. Anderson's presence and on-site training also served as the prototype model for future training sessions for LTPP Regional Contractor staff who will supervise future installations of the selected AWS system at SPS project sites.

A schematic of the installed weather station is given in Figure 1. For the pilot installation, the tower assembly and the rain gage assembly were mounted on movable concrete pedestals. The pedestals were used to simulate concrete pads that would normally be used for this purpose.

The AWS installation requires the following basic tools:

1. Level (3 foot recommended)
2. Shovel (for site clearance, if needed)
3. Tape measure
4. Allen wrench set
5. Wire cutters
6. Pipe wrench
7. Screw drivers (regular and phillips)
8. Open end wrenches (7/16 in., 1/2 in., 9/16 in.)
9. (1) 2x4 eight foot long lumber, if constructing concrete pad
10. (4) Wooden stakes one foot long, if constructing concrete pad

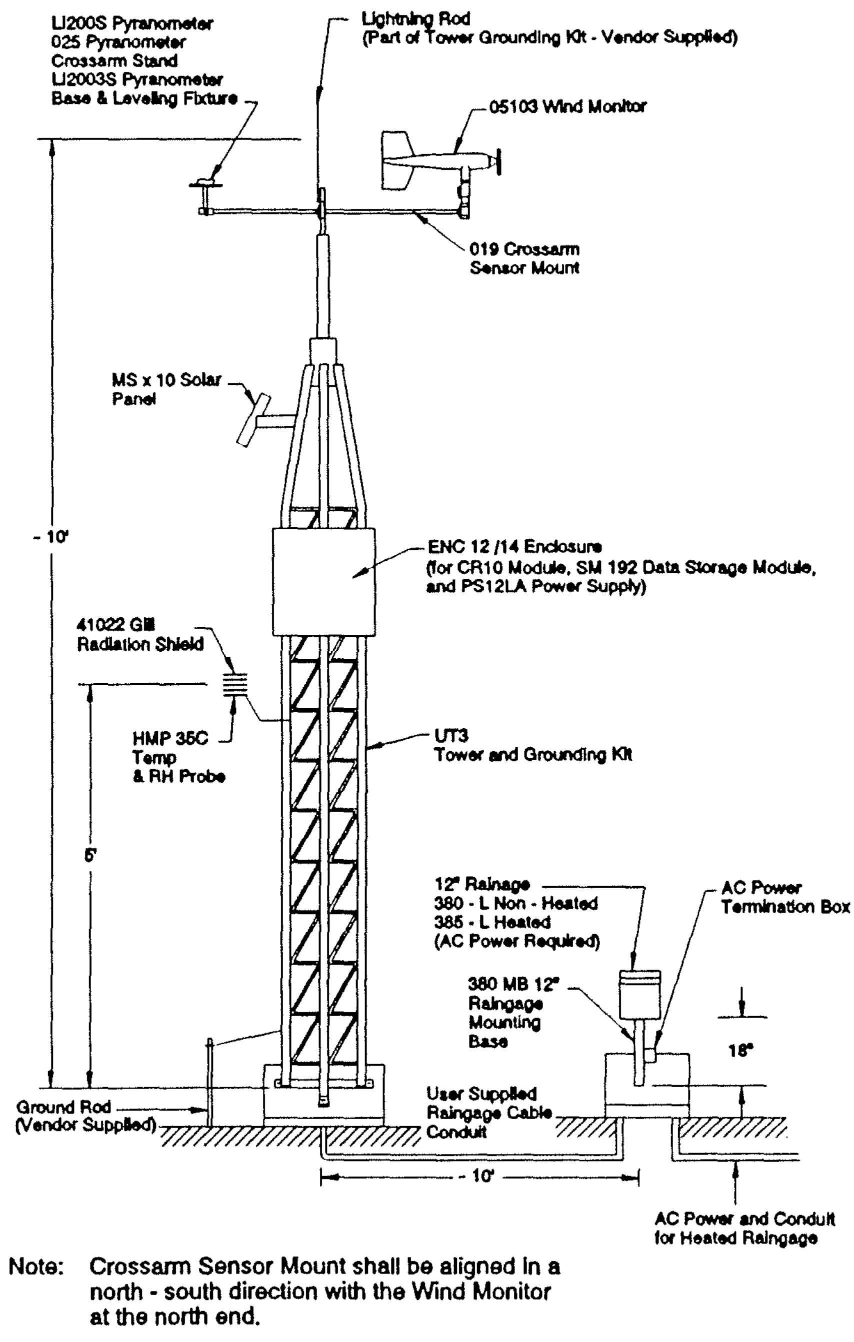


Figure 1 - Schematic of the Pilot AWS (Campbell Scientific Model WS3RG)

11. Hammer
12. Saw, if constructing concrete pad
13. (8) 16p double-head nails, if constructing concrete pad
14. (8) 8p double-head nails, if constructing concrete pad
15. 6 ft ladder
16. Sledge hammer
17. Diagonal side cutters
18. Pliers

The installation was carried out without any problems within a 3-hour period. The following installation sequence was used:

1. Mount the tower assembly with the hinged base on the concrete pedestal. The "J-bolts" required for fastening the tower to the pedestal were pre-positioned using a template supplied with the AWS system.

2. Install the datalogger cabinet (enclosure) housing the CR-10 system and the solid state data module.

3. Install the various sensors
    a. Wind monitor
    b. Pyranometer
    c. Solar panel (for power)
    d. Temperature and relative humidity probes
    e. Lightning rod

4. Install tipping bucket on an adjacent pedestal.

5. Wire all sensors to the CR-10 system and connect the ground cable to one of the grounds of the CR-10 system.

6. Install the PC208 datalogger support software.

    It should be noted that shortly after the pilot AWS became operational, a modem interface was added to the datalogger to allow telephone connection to the AWS. The telephone connection has been regularly used by FHWA's LTPP Division staff to retrieve data from the AWS.

7. Perform initial check of the system sensors using the data acquisition computer software. Campbell Scientific's WeatherPro software was used for this purpose. Once the check is completed, set the datalogger's clock.

The installation followed the step-by-step written installation guidelines provided with the AWS. The written instructions were followed in order to simulate future installations by the staff of FHWA's four LTPP Regional Contractors. The LTPP Regional Contractors will receive training at their first installations by a representative of the AWS vendor.

Based on comments provided by the installers, the installation of the Campbell Scientific AWS system is considered very straight-forward and appropriate for the remote applications throughout North America.

Soon after installation, a telecommunication link was installed at the AWS using a DC112 Hayes compatible modem. This was done to facilitate data downloading by the LTPP Division staff and the Technical Assistance Contractor and to evaluate the telephone communication setup for possible use at few SPS project sites.

PILOT AWS SYSTEM OPERATION DETAILS

Once the AWS was installed, routine operation of the system began. The routine operation, as far as the LTPP program is concerned, includes compiling, storage, and transfer of the climatic data. The core of any AWS system is the datalogger. For the Campbell Scientific AWS, the CR-10 module contains the needed measurement, data processing, data storage, and logical control instructions within the PC208 Datalogger Support Software. The CR-10's standard memory configuration allows storage of 29,900 data points. Use of a SM192 Data Storage Module allows storage of an additional 96,000 data points. A SM192 module was included in the pilot AWS. The CR-10 is accessed using an IBM-PC or compatible computer via the SC32A RS232 interface connection.

The WeatherPro Software

Campbell Scientific's WeatherPro software is a menu-driven software package that contains several independent executable program modules. These modules are briefly described next within the context of their applicability to the needs of the LTPP program.

EDLOG Module

EDLOG is used to develop and document programs for the CR-10 dataloggers. Output files are used to program the dataloggers. EDLOG is written for use on IBM personal computers with at least 256k of RAM memory and an 80 column by 25 line monitor. Instructions and parameters are entered with the same characters that are used to program the datalogger directly. EDLOG automatically describes the instructions and prompts for the parameters. The user may add additional comments as desired.

The LTPP program staff collecting the climatic data will not need to use this software. The program collecting the weather data will already be installed on the datalogger with the appropriate sets of instructions to provide the required data.

GRAPHTERM Module

GRAPHTERM provides, with a RS232 or a modem connection, access to the current weather data that are being recorded (i.e., battery voltage, temperature, RH, etc.). This program will probably not be used with a modem connection but has usefulness in performing quick checks of the system on-site.

SPLIT Module

SPLIT is a general purpose data reduction program. Input files (maximum of 8) are accessed by SPLIT, specific operations are performed on the data, and the results are sent to an OUTPUT file. Input files must be formatted as printable ASCII, comma delineated ASCII, field formatted ASCII, final storage format or RAM A/D data. Typically they should be a comma delineated ASCII files.

Output files generated by SPLIT are formatted as field formatted (default) or comma delineated ASCII. SPLIT applications include: data processing, file reformatting, data quality checking (limit testing), table generation with report and column headings, time synchronizing and merging of up to 8 files, and data selection based on time or conditions.

This module is used to develop climatic data reports.

TELCOM Module

TELCOM allows an IBM-PC or compatible to retrieve and store data from the datalogger by the use of a RS232 connection or a modem. Data is collected in blocks with error checking to assure data integrity. This is another program which will be used for data retrieval only occasionally unless telephone connection with modem is present. It allows all information collected by the AWS to be retrieved and uploaded.

SMCOM Module

This is the primary program to be used at the site to retrieve the data from the AWS. SMCOM is used to collect and store the data from the SM192 data storage module. SMCOM communicates with the data storage module through an asychronous communications adapter at 19,200 baud. Use of SMCOM requires a SC532 storage module interface cable. This equipment must be physically connected to the SC12 cable that runs from the CR-10 module to the SM192 storage module.

SMCOM has 12 options which the user may choose from. They are:

1. Terminal Emulator
2. Collect all data files
3. Collect uncollected data files
4. Collect newest data file
5. Collect one data file starting at display pointer
6. Collect program files
7. Store A DLD program file
8. Store A file
9. Erase and reset storage module

10. Clear Data area
11. Switch settings
12. Quit

For the LTPP program, on-site personnel will only need to use Options 2, 3, or 4. The most practical one to be used will be Option 3 for collecting uncollected data files. This means that only the files that have been stored since the last uploading (site visit) will be retrieved.

Data Acquisition System

The physical process by which the data from the AWS is uploaded is described in this section. The personnel visiting the site must have the following: A personal computer with the AWS system software (e.g., WeatherPro for Campbell Scientific AWS) loaded and a hardware interface that is either the SC532 storage module interface (or the optional PC201 card with the SC209 cable). An older interface, the SM232 or SM232A can also be used.

Once on-site, the interface cable must be connected from the personal computer to the SC12 cable within the enclosure. It must be noted that the SC12 cable should never be disconnected from the CR-10 module or the SM192 data storage module. SMCOM Program is then be used to upload the weather data from the storage module. As discussed earlier the on-site person can either upload all the data files or retrieve uncollected (new) data files.

For the LTPP Program, the climatic data are to be collected about every three months to ensure that data loss, if any due to unforeseen circumstances, are kept to a minimum.

Data Storage and Summaries

The pilot AWS system datalogger was programmed to read sensor data every three seconds to ensure extreme data values (wind gusts) are captured. From this information hourly and daily averages of the weather conditions are calculated and stored. The following information is stored:

1. Julian date
2. Time (military)
3. Average temperature
4. Maximum temperature
5. Minimum temperature
6. Maximum RH%
7. Minimum RH%
8. Average solar radiation
9. Mean wind speed
10. Mean wind direction
11. Maximum wind speed
12. Time of maximum wind speed

13. Direction of maximum wind
14. Total amount of rain

This information is stored in the SM192 storage module which has a capacity of 192k memory. The SM 192 serves as a large buffer with data overwritten from front to back. Therefore, it is important that data be retrieved prior to the storage module becoming full. The CR-10 module stores the data collected every 3 seconds and calculates the needed hourly statistics which are then stored in the SM192 storage module.

The weather data summaries are available in tabular form with column headers. Three different summaries are produced by the SPLIT software - hourly weather report summaries and daily weather report summaries in SI units and a daily weather report summary in conventional units. Typical data summaries obtained from the pilot weather station are presented in Appendix B.

Power Requirements

The Campbell Scientific AWS data acquisition system is powered by a 12 volt battery pack which houses eight alkaline "D" cell batteries. The battery pack is recharged by a 10 watt solar panel which is mounted on the tower assembly. It is necessary that the battery voltage does not drop below 9.6 volts because if it does all information in the CR-10 and data storage module will be lost. No power related problems have been encountered to date at the pilot AWS site.

PILOT AWS MAINTENANCE REQUIREMENTS

Proper maintenance of the automated weather station (AWS) components is essential in order to obtain accurate data over a long period of time. The AWS system and components must remain in good working order over extended periods of time. Routine maintenance and simple maintenance will be performed at the time of data retrieval at about every three months. More difficult maintenance such as sensor calibration, sensor performance testing, and sensor component replacement, will generally require a skilled technician, or will require that the sensor be returned to the factory.

The following sections discuss the maintenance that will be required on the AWS. The maintenance activities were simulated for the pilot AWS installed at TFHRC to determine need and ease of maintenance.

Enclosure and CR-10 Unit Maintenance

The CR-10 and datalogger require a minimum of routine maintenance. Several preventive maintenance steps will optimize the battery life and decrease the chances of datalogger failure.

Battery voltage must be monitored during each site visit (or by modem connection, if available) to make sure the voltage does not drop below 10 volts. The PS12LA or 21XL battery should be connected to the unregulated solar panel at all times. The charge indicating diode should be "ON" when voltage to the charging circuitry is present. If the battery voltage consistently decreases over time, then a failure in the charging circuitry is indicated.

Moisture within the enclosure can be a problem if not addressed. It is recommended that during each visit the desiccant packs in the enclosure be replaced with new ones, using as many as can possibly fit within the enclosure.

Sensor Maintenance

The following is a list of maintenance actions which need to be performed during each site visit:

1. *Temperature and RH Probe* - The solar radiation shield should be inspected and cleaned. Hornets' nests are often a problem found within the shield. It is recommended that an extra clean replacement shield be carried to the site. Otherwise, the existing shield should be cleaned and washed and replaced, if necessary, in a dry condition. The temperature sensor should be calibrated every year along with replacement of the RH chip in the relative humidity probe. Also, the gold plated contacts should be inspected for corrosion.

2. *Wind Speed and Direction* - Maintenance for these sensors is very simple. Check the bearings of the instrument by making sure it rotates freely with no resistance. Gage the wind speed and compare with the actual readings to get a feel if the instrument is working properly. The bearings should be replaced every year.

3. *Rain Gage* - Remove all debris from the top and bottom screens of the tipping bucket. When replacing the screen use a dab of RTV solution in several location on each screen to assure that the screens will not be removed by the wind. Pull the bucket out and check for any insects or spider webs and then clean them out if found. Check that the tipping bucket is working properly by spilling water out of a bucket at a known rate. The rain gage should be calibrated every year.

4. *Pyranometer (Solar Radiation Sensor)* - Check to make sure the base is level and clean the surface of the instrument with distilled water, air brush or camel hair cloth. Bird droppings are typically a major problem causing contamination of the pyranometer. The pyranometer should be calibrated every two years and possibly every year depending on site conditions.

5. *Miscellaneous* - Cables and connections both inside the enclosure and outside should be checked for tightness and damage. Sensor cables should be replaced as needed. The glass of the solar panel should be cleaned to improve its

efficiency. Sensor leads and cables should be checked for cracking, deterioration, proper routing and strain relief. The tower assembly and foundation pads for the tower should be checked for structural damage, proper alignment, and for levelness/plumbness.

Summary

The AWS typically requires only routine maintenance to ensure long-term operation. As discussed, various sensors will need to be calibrated at a frequency of 1 to 2 years. This can be done preferably by replacing the sensors and returning them to the factory for calibration. This will require that an extra set of sensors be available with each LTPP Regional Contractor.

To date the pilot AWS has required only routine maintenance of the type discussed above.

RECOMMENDATIONS

The pilot AWS has been in service now for over 6 months. To date, it has required no specific maintenance activities, other than the routine checks to ensure that sensors have not been damaged and that no dust or debris has collected around the sensors. The hard-wire telephone connection (via modem) has also performed without any problems.

Based on the pilot evaluation, it is our opinion that the AWS installation and operation was a very successful exercise. The pilot installation has provided invaluable hands-on experience to the various parties involved in the LTPP program (FHWA staff, the LTPP technical assistance staff, and the LTPP regional contractor staff). The pilot installation and the subsequent operation of the AWS has proven beyond doubt that use of the AWS at SPS project sites is very feasible and economical and that AWS will reliably provide the designated climatic data over a long-period of time.

In summary, the pilot AWS installation and operation accomplished the following:

1. Established that with proper planning, training, and coordination, the AWS can be installed at a remote site within four hours using routine tools. Only two persons are required to do site installation.

2. Established that with the customized programming, the designated weather data can be collected effortlessly at the required interval. For the LTPP program, sensors will be read every 3 seconds and statistical data will be stored on an hourly basis. The statistical data will include the maximum, minimum, and average hourly readings (as appropriate) for the different sensors.

3. Established that the AWS data can be retrieved without problems from the solid-state data storage module. Although, it is possible to retrieve data at

longer intervals (because of available data storage capacity and solar powered batteries), it is recommended that the data be retrieved at 2 to 3 month intervals. This will safeguard against too much loss of data due to unforeseen system failures.

Data retrieval (upload) procedures using both an on-site connected personal computer and by telephone connection were successful.

4. Established that the type of routine on-site maintenance that the AWS warrants can be performed without requiring extensive technical expertise. The individual sensors can be easily un-installed if replacement is necessary due to damage to the sensor or for factory calibration of the sensor.

Based on our evaluation of the pilot AWS, we found the Campbell Scientific's Model WS3RG to be acceptable as meeting the needs of the LTPP program with respect to climatic data collection at SPS sites. A detailed technical specification for the WS3RG is provided in Appendix C. It is our opinion that the specification meets or exceeds all AWS requirements established for the LTPP program.

APPENDIX A

TECHNICAL DOCUMENTATION FOR THE PILOT AWS

1. Pilot AWS Installation Manual
2. Start-up Procedures for the CR-10
3. CR-10 Measurement and Control System
4. The Model WS3RG System Description/System Integration
5. Rain and Snow Gages - Models 380 and 385
6. HMP35C Vaisala Temperature and Relative Humidity Probe
7. Wind Monitor (Model 05305)
8. LI-S Pyranometer Sensor
9. SM 192 & SM716 Storage Modules
10. SC32A RS232 Interface
11. PC208 Datalogger Support Software
    - Instruction Manual (February, 1993) (Table of Contents Only)
12. Tripod - Based Weather Station Installation Manual (for Campbell Scientific Models CM6, CM6/10K)
    - Used for Installation of Sensors (Table of Contents Only)

PILOT AWS INSTALLATION MANUAL

Tower Installation

1.1 Tools Needed

The following list of tools will be needed to install the UT-3 weather station.

1. Level (3 foot Recommended)
2. Shovel
3. Tape measure
4. Allen wrench set
5. Wire cutters
6. Pipe wrench
7. Screw drivers (Regular and Phillips)
8. Open end wrenches (7/16, 1/2, 9/16)
9. (1) 2x4 eight foot long
10. (4) Wooden Stakes one foot long
11. Hammer
12. Saw
13. (8) 16p double-head nails
14. (8) 8p double-head nails

1.2 Tower Installation

The tower mounts on a concrete foundation as shown in figure 1. Provided with the tower is a tilt base, anchor bolts, and nuts. The tilt base will be used as a template for the anchor bolts.

Step 1

Dig a 24" square hole that is at least 24" deep (below frost level). These estimates are for heavy soil only. Light soil or sand will require additional concrete to stabilize the base.

Step 2

Construct a 2" x 4" frame 24" square to be used as a concrete form. Center the form over the hole previously dug. Drive the stakes along the outside edge of the form. Level the form and drive nails through the stakes into the form while holding the form level.

ep 3

proximately 0.3 cubic yards of concrete will be required fill the hole. Assemble the anchor bolts and tilt base. ere should be two nuts below the base and one above the se as shown in figure 1. Set the anchor bolts so that 2 3 inches of threaded bolt extent above the wooden form ound the concrete pad. Make sure that the base is level d that sufficient bolt is exposed to allow the base to be veled once the concrete has setup.

ce the concrete has hardened and the wooden form has been moved, use the level to adjust the base. Use the second t below the base to lock the nuts into place in the level sition. Once the base is level and secured to the ncrete pad, the tower can be bolted to the base.

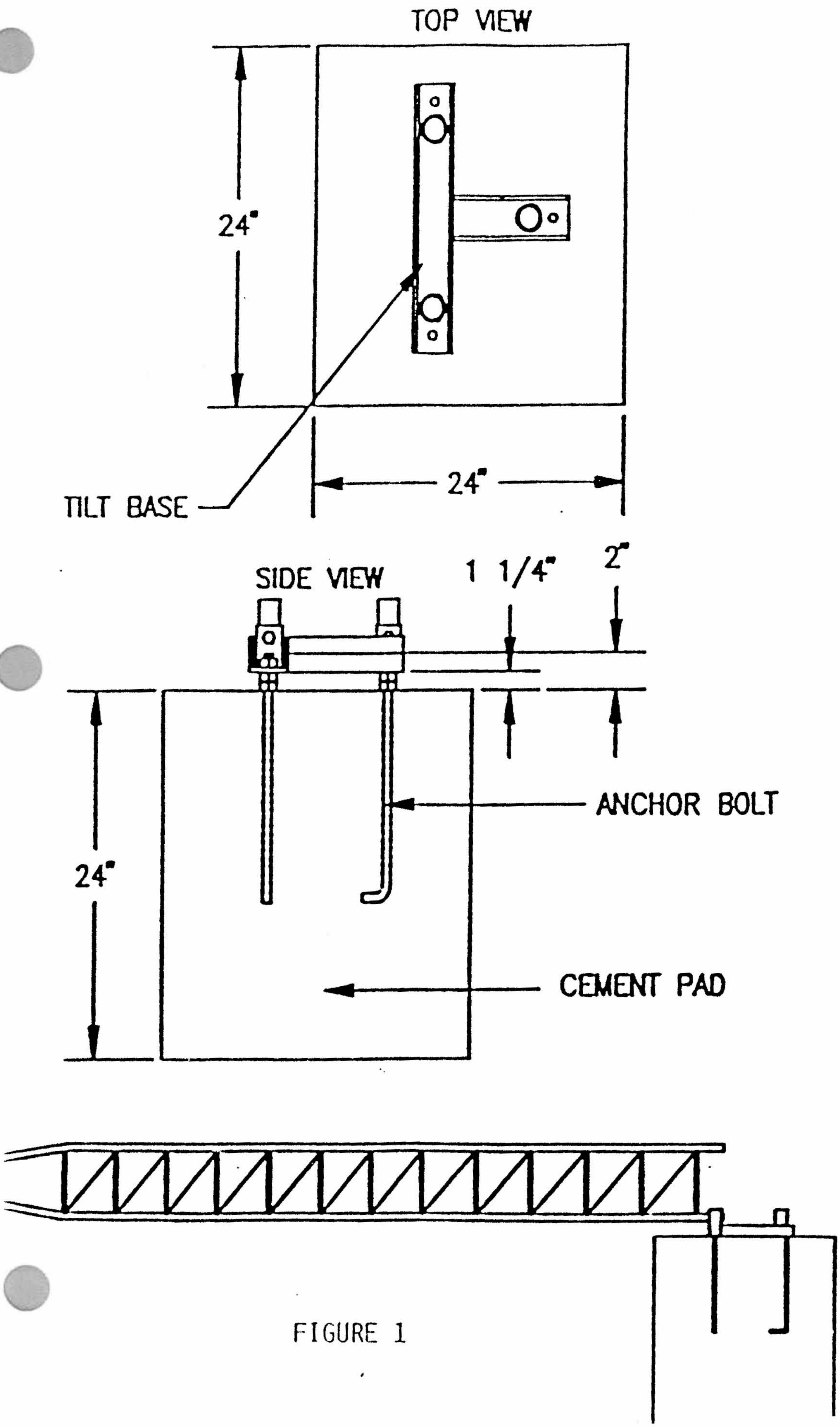

TOP VIEW
24"
24"
TILT BASE
SIDE VIEW
1 1/4"
2"
ANCHOR BOLT
24"
CEMENT PAD

FIGURE 1

Assemble the weather station as shown in figure 2, following the procedures described in steps 1 through 7.

?. Weather Station Assembly

he weather station will be assembled in a similar onfiguration as shown in figure 2.

o assemble the weather station the following steps should e accomplished:

tep 1

lount sensors on the crossarm and connect the crossarm to he tower. Route the sensor cable down the tower and wire ie leads about every 30 inches. It is best to route cables lown the north facing leg to help reduce the deterioration aused by the sun.

tep 2

nstall sensors that are tied to the side of the tower and oute sensor cables down the tower.

tep 3

lount the enclosure with the bottom around 4 1/2 feet off he ground. The enclosure should be mounted so that the loor can be easily opened when the station is tilted down.

tep 4

rive a grounding rod into the ground next to the concrete ad on the side that the station tilts towards. Connect the rounding cable to the ground rod and run a heavy gage wire rom the grounding lug on the enclosure to the grounding od. Secure all the grounding wires to the grounding rod ith the clamp, ensure that enough slack is left to allow he tower to be tilted up and down.

tep 5

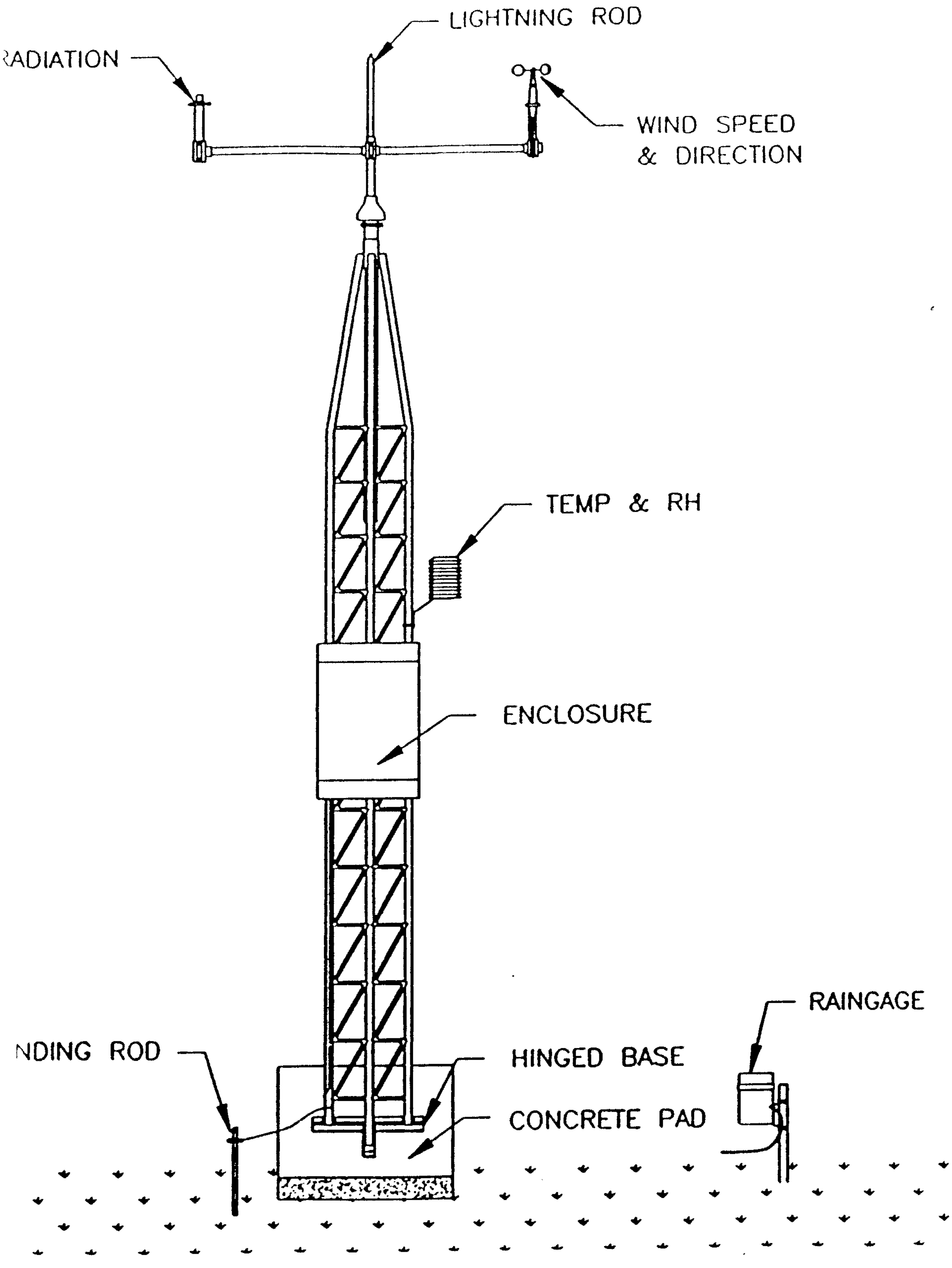
ire all the sensors to the datalogger and connect the round cable to one of the grounds of the datalogger. Check hat each of the sensors are reading correctly and make any hanges to the datalogger program that are needed. Once eadings are correct set datalogger's clock.

s

ent wind direction sensor to true north and secure sensor place. Check the solar sensor (if one is installed) to e sure that the sensor is level.

p 7

ce desiccant into enclosure and seal the cable entry with plumbers putty that is included with the enclosure.



LIGHTNING ROD
RADIATION
WIND SPEED
& DIRECTION
TEMP & RH
ENCLOSURE
RAINGAGE
NDING ROD
HINGED BASE
CONCRETE PAD

FIGURE 2

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Startup Procedures for the CR10 / UT3 Weather Station

1.0 PC208 & WeatherPro Software Installation

Locate the Datalogger Support Software Diskettes **(Model PC208)**. Create a Directory on the hard drive of your computer called **PC208** (C:\MD PC208). Install the PC208 software by inserting *disk 1 of 3* into a disk drive, Type **INSTALL** then press **<ENTER>**.

Select the appropriate display adaptor for your particular PC (option **D=Default** is most often used).

Next enter the appropriate drive letter for your computer that has the PC208 diskette in it.

Next enter the drive and path that you want the PC208 software to be installed on. For example, C:\PC208. The directory must already exist; Install will not create it for you.

Install will prompt you to select what software packages you want installed. Select option **6** to install all of the PC208 Software Package.

After the PC208 software is installed on the PC. Locate the **WeatherPro Program Generator Diskette.** *(WeatherPro is a menu driven, PC-compatible software package that reduces the time required to create simple programs for Campbell Scientific Weather Stations).*

Use the DOS COPY command to copy the file WPRO.EXE to the same directory as the PC208 Software. Example, Copy A:\WPRO.EXE C:\PC208.

2.0 Create Weather Station Data Acquisition Program

To run WeatherPro Type **WPRO** at the DOS prompt. WeatherPro supports the standard meteorological sensors sold by Campbell Scientific. Non-Standard sensors or processing not available in WeatherPro requires direct programming of the datalogger as supported by **EDLOG** in the PC208 Software.

WeatherPro generates 3 files:

WEATHER.DLD	Datalogger Program. This file may be directly downloaded to the datalogger using GraphTerm (GT) or transferred to a Storage Module using SMCOM.
WPRO.FIL	User Documentation. This files lists the measurement input location assignments and labels, detailed output array description, and the wiring diagram for the sensors selected.

WPRO.ANS — WeatherPro Answers. This file is read by WeatherPro. It allows the user the flexibility of returning to WeatherPro to change previous selections.

DOCUMENTING WITH EDLOG

WEATHER.DLD can be documented with the PC208 Program Editor **EDLOG**. The user can then examine, print, or possible modify the program created by WeatherPro.

To document WEATHER.DLD, run EDLOG by typing **EDLOG** at the DOS prompt and press **<ENTER>**. You will be asked for the .DOC file name. Type **WEATHER** for the documented file and press **<ENTER>**. When prompted, enter the Datalogger type as **CR10**. Press **F2** for the file commands and select **D** for "Document .dld file". Enter **WEATHER** for the .dld file to document. EDLOG will import and document WEATHER.DLD.

After the WEATHER.DLD file has loaded (and edited if necessary) press **F2** for file commands and select **S** for "Save". EDLOG will prompt for the filename to save as WEATHER, press <ENTER> to save the documented file to disk.

To print the documented file to an on-line printer, select **F2** for file commands and **P** for "Print". Select **P** again to send the documented file to an on-line printer. A copy of the datalogger program should remain at the weather station site.

To Exit **EDLOG** press **F2** once again for file commands and select **Q** to "Quit".

3.0 Program Transfer (WEATHER.DLD) from PC to SM192 Storage Module.

Connect the **SM192 Storage Module** to the **SC532 Interface** via the blue 9 pin serial cable (Model SC12). Connect the SC532 to the serial port of your PC. Plug the SC532 wall transformer into a 120VAC wall receptacle.

```
          9 pin          25 pin
SM192 ———————— SC532 ———————— IBM PC
                 |
                 |
     120VAC to 7.5VDC Adaptor
```

At the DOS prompt type **SMCOM** and press **<ENTER>**. Select the appropriate serial port for your computer (1,2,3 or 4). SMCOM immediately establishes communication with the storage module and puts a status window at the top of the screen.

The **SMCOM OPTIONS** menu appears as soon as SMCOM establishes communication with the storage module. Select option **D - Store a DLD Program File**. SMCOM prompts for the .DLD filename and program area to store. Type **#8WEATHER.DLD** and press **<ENTER>**. This will allow the .DLD program to be downloaded into the SM192 and put into the 8th program storage area. The 8th program memory area is unique in that when the SM192 is connected to the CR10, on datalogger power-up the program will automatically be uploaded to the CR10 Datalogger. When finished select **Q** to "Quit" and you will exit from SMCOM back to your DOS prompt.

4.0 Instrumentation Wiring

The file WPRO.FIL created from WeatherPro contains the Meteorological Instrumentation wiring diagram in a text format. Print a hardcopy of this file using a DOS print command **(TYPE WPRO.FIL > PRN)** or load the file into a word processor and print it from there. This wiring diagram reflects the analog inputs and excitation outputs required for the instrumentation. A copy of the wiring diagram should remain at the Weather Station site.

5.0 Power up and Auto-Program Upload from SM192 Storage Module.
(with the use of the CR10KD Keyboard Display)

First connect the blue 9-pin serial cable (Model SC12) to the CR10's 9-pin serial I/O port. Next connect the CR10KD and SM192 to the remaining two 9-pin female connectors.

Turn the power toggle switch on the PS12LA to the **ON** position. Once power has been applied look at the CR10KD LCD display. **HELLO** should be in the LCD display for approximately 11 seconds. The LCD will show 7128 when the automatic program transfer is taking place. When the program transfer is completed (about 5 to 8 seconds) the LCD display will show **LOG 1**. The G in LOG looks like a number 6 but interpret it as the letter G.

6.0 Setting Year, Julian Date and Time in the CR10
(with the use of the CR10KD Keyboard Display)

It is very important that the Datalogger's Date and Time are set to allow for an accurate timestamp when data is output.

Key in Star 5 **(*5)** on the CR10KD to enter the Clock Programming Mode. You should see the clock running. This is the time since the logger has been powered up.

Enter **A** once to Advance to the location for Year. The LCD display will show **05:00**. Key in the last two digits of the current year (i.e **93**) and press **A** to enter.

The display will now be showing **05:0000**. Key in the current Julian Day. This can be located on the back of the **Brown CR10 Prompt Sheet** which is located in the CR10 Measurement & Control Module Operator's Manual (i.e. **July 26 = 207**, so key in **207** and **A** to enter.

Next key in the current 24 hour time (i.e. 2:30 = 1430) so key in **1430** and press **A** to enter. The display will now be showing the current time. Key in ***0** to start logging data, the LCD display will return **LOG 1**.

7. Monitoring Weather Measurements Real Time
(with the use of the CR10KD Keyboard Display)

To monitor the Datalogger's input locations which hold the last updated weather measurement use the Star 6 Mode **(*6A)**. The **A** key Advances through each of the sequential measurement locations and the B key Backs up sequentially. To identify each input location weather measurement refer to the printout created by WeatherPro (WPRO.FIL).

8. Using GraphTerm to download program to CR10 and to set the clock.
(with the use of the SC32A Optically Isolated RS232 Interface)

Connect the SC32A Interface to the CR10's 9-pin Serial I/O port via the blue 9-pin serial cable (Model SC12). Connect the 25-pin female connector on the SC32A to the serial port on the PC via a user supplied cable. Toggle the power switch on the **PS12LA** 12VDC Power Supply to the **ON** position.

PC ---25 Pin Ribbon Cable --- SC32A --- SC12 --- CR10

Go to the PC208 Directory on the PC (**C:\ CD\PC208)**. The PC208 program called **GraphTerm** will be used to Download the WEATHER.DLD program to the CR10, set the Datalogger's clock, and monitor the weather sensors real-time. At the prompt type **GT** and press <ENTER>.

At the prompt:

Enter Station Name (add /E to edit Parameters):

Type **WEATHER** and press <ENTER>.

Graphterm will prompt you to setup the **Station File**. The Station File defines the datalogger and the communication path to be used. To edit the Station File use the **<ENTER>** key to move to each of the parameter fields and the **<SPACE BAR>** to scroll through the different options in each parameter field.

The parameters in this station file are:

Telecommunications Parameters For Station:	**WEATHER**
Datalogger Type:	**CR10**
Security Code:	**0 (default)**
Use Asynchronous Communications Adaptor:	**1, 2, 3 or 4**
Communications Baud Rate:	**9600**
Data File Format:	**Comma delineated ASCII**
Final Storage Collection Area:	**Area 1**
Interface Device:	**SC32A**

When finished editing the Station File, press Control P **(<Ctrl><P>)** to save and quit editing.

GraphTerm saves the options you selected in the editing portion to the file **WEATHER.STN** on the Hard Disk.

Once saved the PC screen should now show **GRAPHTERM OPTIONS.**

First select option **K - PC TIME TO DATALOGGER CLOCK.** If the PC clock is correct select Y to dump the current time, Julian date, and year.

Next select option **D - DOWNLOAD PROGRAM TO DATALOGGER.** GraphTerm prompts for name of file to Download. Type **WEATHER** and Press <ENTER>.

The PC screen will show a scenario *similar* to below when the program download is in progress:

220 bytes sent, received, entered.
220 bytes sent, received, entered.
220 bytes sent, received, entered.

When the program download is completed the PC will return to the **GRAPHTERM OPTIONS.**

To monitor the weather measurements real time, select option **M - MONITOR INPUT LOCATIONS.**

When finished monitoring the weather measurements press the Escape Key <Esc> to exit to back to the **GRAPHTERM OPTIONS.** Press **Q** to **Quit** GraphTerm and the user will be returned to the DOS prompt.

9. Retrieving Data From the SM192 Storage Module

In this application Campbell Scientific recommends two SM192 Storage Modules at each site. This allows the modules to be exchanged during site visits; the "fresh" module would remain at the weather station site, and the "filled" module would be carried (or mailed) back to the office for interrogation via the SC532 Interface and SMCOM Software contained within the PC208 Datalogger Support Software Directory.

Go to the PC208 Directory (C:\ CD\PC208) and setup the communications hardware as described in **SECTION 3.0** Above. At the DOS prompt type **SMCOM** and press **<ENTER>**. Select the appropriate serial port for your computer. SMCOM immediately establishes communication with the storage module and puts a status window at the top of the screen.

The **SMCOM OPTIONS** menu appears as soon as SMCOM establishes communications. Select Option **U - COLLECT UNCOLLECTED DATA FILES.**

SMCOM will prompt:

Root collection file name (6 characters max):

Enter a filename that describes the site where the data is being collected from (Example: Turner). Type **TURNER** and press **<ENTER>**. SMCOM will then begin interrogation of the SM192 and retrieve the data since the last time it has been collected. The file created on the Hard Disk will have a **DOS extension of** .DAT (Example: TURNER01.DAT).

When all data has been collected and the SMCOM OPTIONS screen has returned, select option **C - CLEAR DATA STORAGE (SEE WARNING BELOW FIRST).**

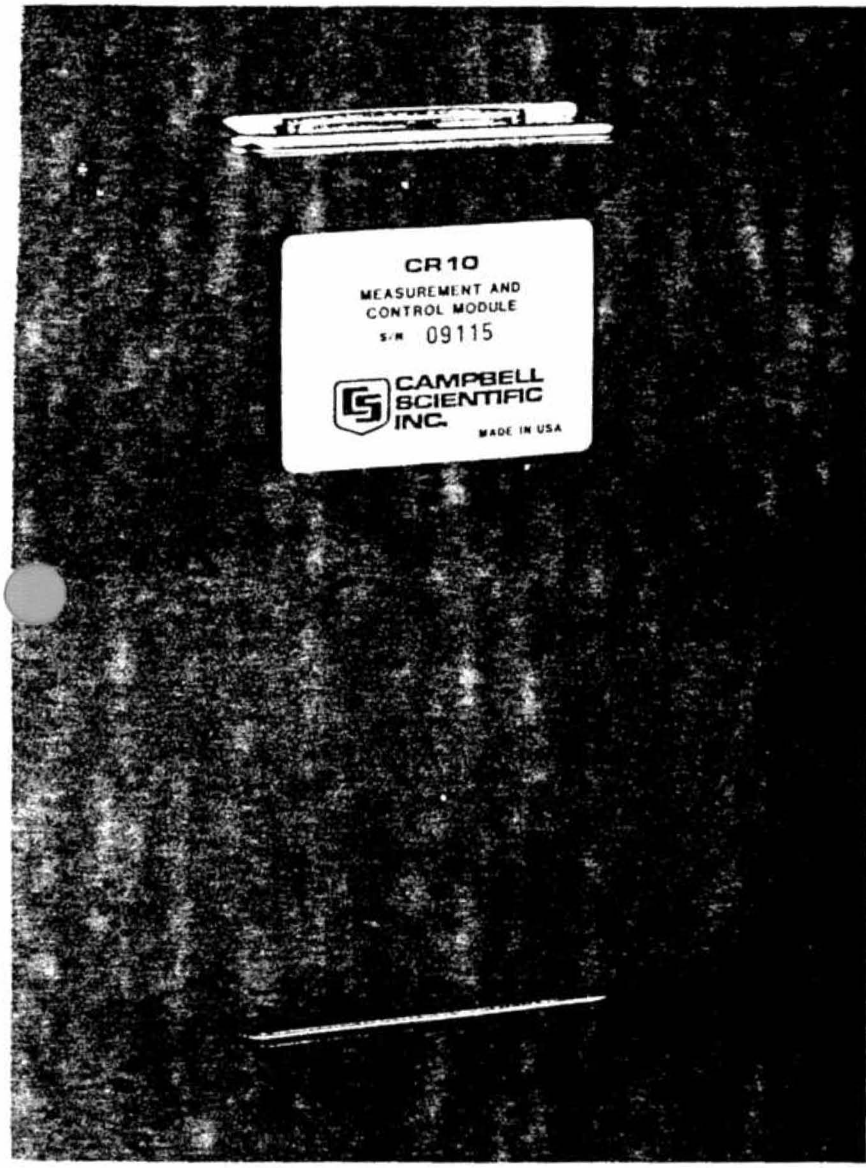
WARNING!: Once Option C is selected ALL Data will be erased from the Storage Module. You may want to select option Q to Quit and verify that the file has been created on the hard disk first before using Option C!

Note: Option C will not ERASE the WEATHER.DLD program

The user may want to consier using Option E - ERASE AND RESET STORAGE MODULE to clear the data area as this option will test the memory. The disadvantage of this option is that the WEATHER.DLD program WILL BE ERASED!

When the memory area is cleared and the SMCOM OPTIONS has returned, select Option **Q** to **Q**uit and the user will be returned to the DOS prompt.

CR10 Measurement & Control System

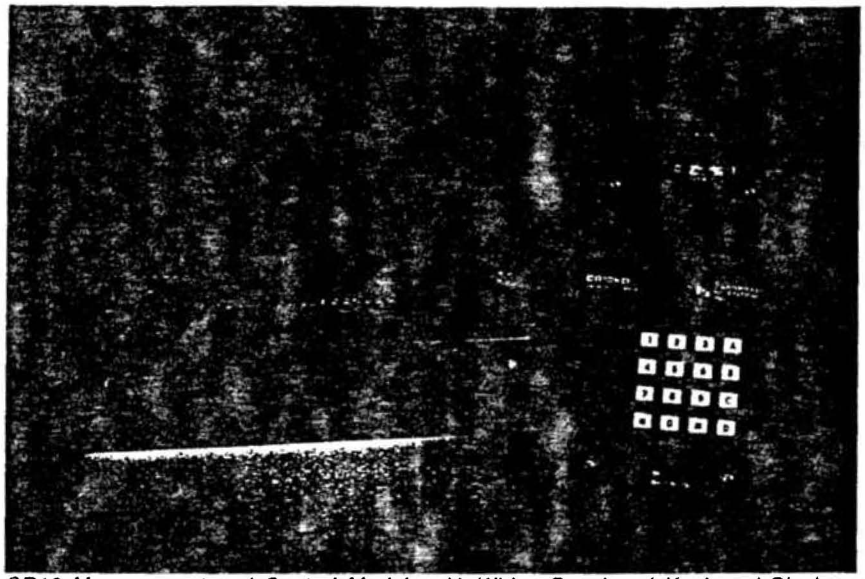


CAMPBELL SCIENTIFIC, INC.™

CR10 Measurement and Control System

A Rugged, Operational Instrument with Research Grade Performance

The CR10 combines a micro-computer, clock, multimeter, calibrator, scanner, timer, frequency counter, and controller in a compact, sealed, stainless steel package.



CR10 Measurement and Control Module with Wiring Panel and Keyboard Display.

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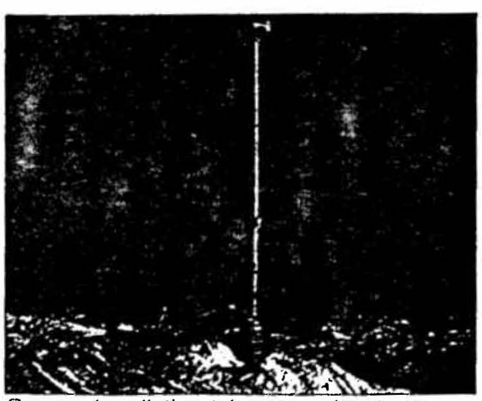
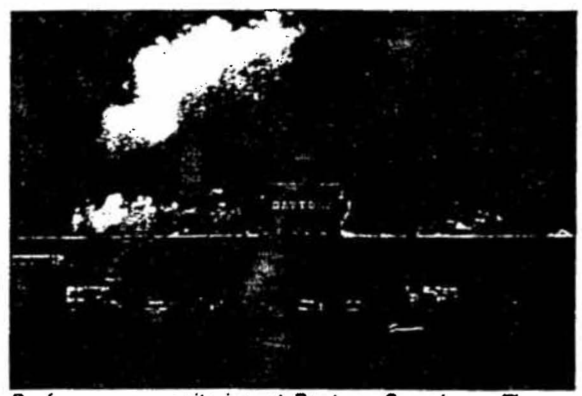
Campbell Scientific data acquisition systems deliver accurate, reliable measurement and control capability, even in extreme environments. Our systems have collected data on every continent and in space.

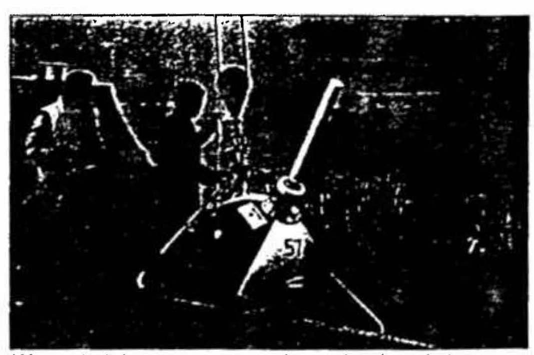
Meteorologic data collection at the Sphinx will determine an appropriate course for preservation and restoration. Photo courtesy The Getty Conservation Institute.



Remote installation telemeters data to an adjacent valley (Bear River Range, Wasatch Mountains, UT).



Performance monitoring at Daytona Speedway, FL.



Wave height spectra are determined and data telemetered via satellite (Bering Sea, AK). Photo courtesy Brown & Caldwell.

Cover Photos: At left: CR10 Measurement and Control Module. From top right (INDUSTRY) Turbine performance and hook load testing, photo courtesy Aerospatiale Helicopters, Inc.; (RESEARCH) NASA CELSS Research Lab, Utah State University, Logan, UT, (AGRICULTURE) Agriculture Research Plots Logan UT; (HYDROLOGY) Weir in Reynolds Creek Drainage, southeast of Boise, ID

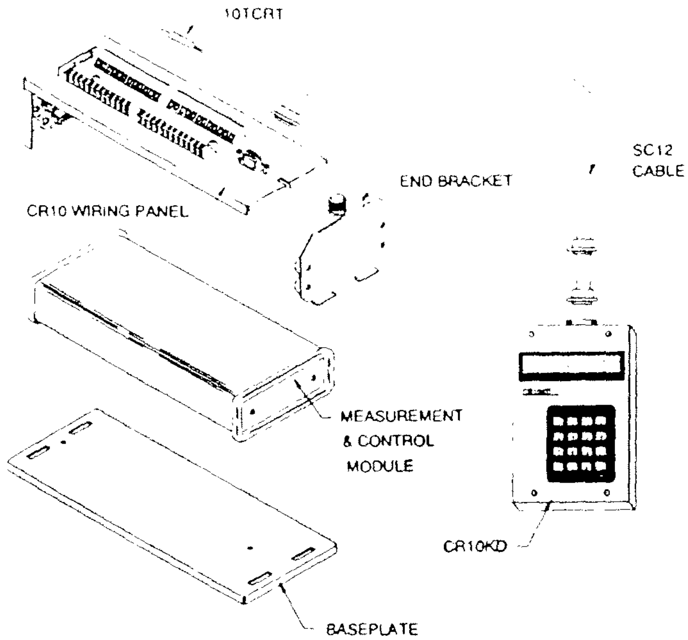
System Description

The primary components of the CR10 are the Measurement and Control Module and the detachable Wiring Panel. The CR10 Keyboard Display is recommended for on-site communication, station setup and trouble shooting, but may be replaced by a computer where environmental conditions allow.

12 Analog Inputs - (single-ended channels, each pair differential*) Five software selectable input voltage ranges. Resolution is 0.33 µV on the 2.5 mV range (0.006°C on type E thermocouple). An AM416 multiplexer provides additional inputs. Vibrating wire sensors may be read with any analog input.

8 Digital Inputs/Outputs for output control, sensing status, or reading SDM peripherals or SDI-12 sensors.

9-Pin Serial I/O Port for connection of data storage, retrieval and telecommunications peripherals.



2 Pulse Counting Channels are software selectable for switch closures, high frequency pulses or low level AC measurement.

3 Switched Excitation Channels for precision excitation of sensors or short-term actuation of external devices. Excitation is programmable over a ±2500 mV range.

Power and Ground Connections for 12 VDC external batteries or peripherals.

CR10 MEASUREMENT AND CONTROL MODULE

Protected in a sealed, rugged, stainless steel canister, the programmable module provides sensor measurement, timekeeping, communication, data reduction, data/program storage and control functions. A multitasking operating system allows simultaneous communication and measurement functions. Operating temperature range is -25° to +50°C, standard; -55° to +85°C, on request.

The standard CR10 instruction set includes 30 measurement instructions, 43 processing/math instructions, and 15 program control instructions. Optional instructions are available for specialized measurement or processing capabilities.

The CR10's standard memory configuration allows storage of 29,900 data points in two Final Storage areas. The SM192 and SM716 Storage Modules provide additional on-site data storage, if required.

The Measurement and Control Module interfaces with the Wiring Panel via two D-style connectors. The CR10's electronics are RF shielded and glitch protected by the sealed, stainless steel packaging. A "watchdog" hardware reset function restores normal microprocessor function if lost due to an input transient or intermittent component failure.

WIRING PANEL

The stainless steel Wiring Panel consists of a top panel and end bracket. The top panel includes screw terminals for sensor connections and a 9 pin serial I/O port; the end bracket attaches the Wiring Panel to the Control Module and to an enclosure-mounted or free-standing baseplate. The Control Module easily disconnects from the Wiring Panel for quick field replacement thus avoiding the need to rewire sensors. All wiring panel connections are protected with spark gaps or transzorbs.

CR10KD KEYBOARD/DISPLAY

The portable CR10KD is used to program the CR10, manually initiate data transfer, and display sensor readings, stored values, or flag/port status. One CR10KD may be carried from station to station in a CR10 network. The CR10KD features an 8-character LCD and a 16-character keyboard. Operating temperature range is -25° to +50°C. The CR10KD is powered by the CR10's power supply.

10TCRT THERMOCOUPLE REFERENCE

The 10TCRT thermistor provides a temperature reference in thermocouple applications. It requires one single-ended analog input. Overall accuracy is typically better than ±0.2°C over the range -33° to +48°C.

PERIPHERALS

The CR10 must be powered by a 9.6 to 16 VDC supply and housed in a weather resistant enclosure (page 8). Measurement, control, and data storage/transfer peripherals are optional depending upon the user's application (pages 4 and 5).

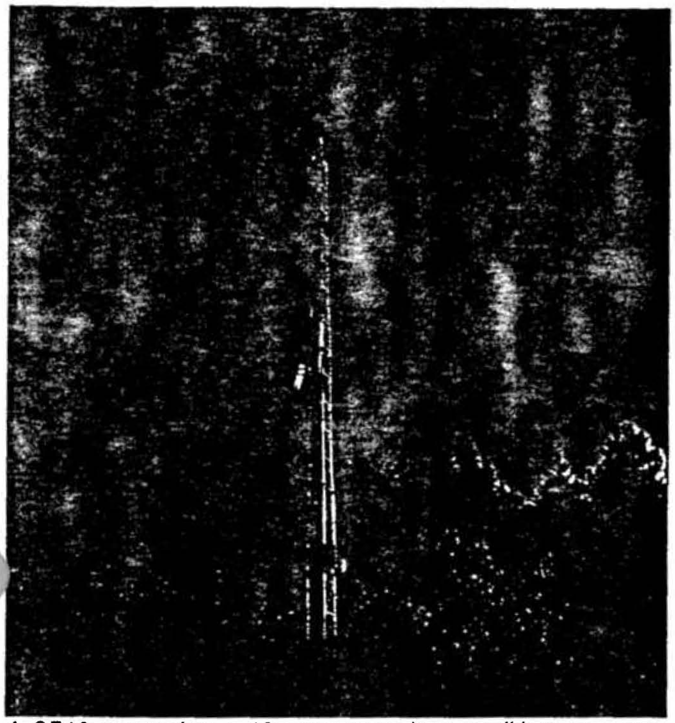
*A differential measurement measures the difference in voltage between two inputs. A single-ended measurement measures the input with respect to ground. All inputs must be within the ±2.5 V common mode range of the CR10.

Applications

The CR10's combination of measurement precision, flexibility, long-term reliability and economical price has resulted in its widespread use in scientific, commercial and industrial applications. Popular applications are discussed below.

METEOROLOGY

The CR10 is designed for long-term climatological monitoring, meteorological research, and routine weather measurement applications. Standard CR10 outputs include wind vector averaging, sigma theta, vapor pressure from wet/dry bulb temperatures, saturation vapor pressure, and histograms.



A CR10 mounted on a 10m tower monitors conditions at a proposed site for the 1998 Winter Olympics (Summit County, UT).

Typical meteorologic measurements:

- WIND SPEED is measured with voltage, photo-chopped, switch closure, or magnetic pulse type anemometers. Expansion peripherals allow wind profile studies.
- WIND DIRECTION is measured by a precision potentiometer wind vane.
- SOLAR RADIATION is measured with a silicon cell or thermopile pyranometer.
- TEMPERATURE sensors include thermistors, thermocouples, RTD's, or silicon types.
- RELATIVE HUMIDITY is measured with wet/dry bulb psychrometers, AC resistive sensors, strain gage or capacitive sensors. Capacitive probes include signal conditioning.
- DEWPOINT is calculated from temperature and relative humidity data or measured by cooled mirror or lithium chloride sensors. Dew point sensors require external power.
- PRECIPITATION data is provided by a tipping bucket switch closure rain gage or a weighing gage.
- EVAPORATION is measured with standard pans or lysimeters fitted with a potentiometer or strain gage.
- BAROMETRIC PRESSURE is sensed by capacitance or strain gage pressure transducers.
- SOIL WATER POTENTIAL is obtained using AC conductivity moisture blocks or analog output tensiometers.
- LEAF WETNESS is detected by a resistance grid.

Specialized applications include:

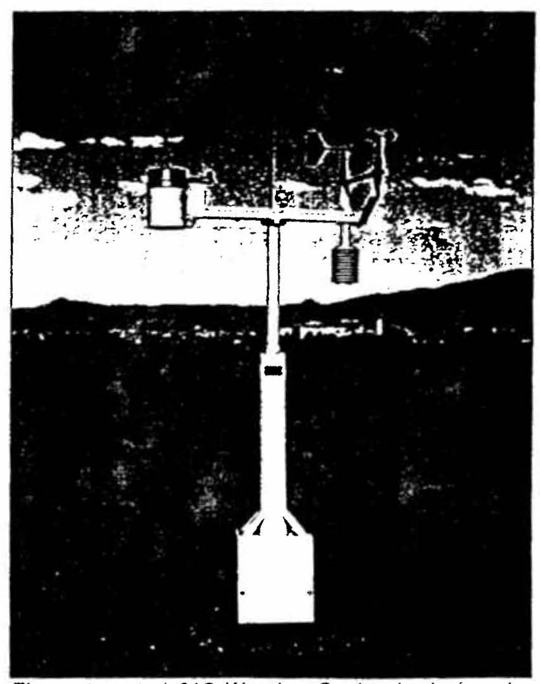
WIND POWER - WECS performance and site evaluation processing includes standard deviations, frequency distributions, wind speed and power histograms. Direct measurements of strain gages and pressure transducers are used to monitor turbines.

AIR QUALITY applications use the CR10's automatic control of calibration sequences and conditional averaging where invalid data taken during power failures, calibration intervals, or other conditions are excluded.

AGRICULTURE

In addition to meteorological monitoring, the CR10's versatility allows measurement of agricultural processes and equipment in applications such as:

- plant water research
- canopy energy balance
- crop management decisions
- irrigation scheduling
- integrated pest management
- erosion studies
- machinery performance
- food processing/storage
- frost prediction
- plant pathology



The automated 012 Weather Station is designed for routine climatological monitoring. Features include a modular design, prewired sensors, and a standard program (Franklin County, ID).

HYDROLOGY

The CR10 is well-suited to remote, unattended monitoring of hydrologic conditions. Many hydrologic sensors interface directly to the CR10, including the new SDI-12 compatibles.

Gaging station equipped with CR10-controlled sampler takes samples based on flow (Little Platte River, WI).

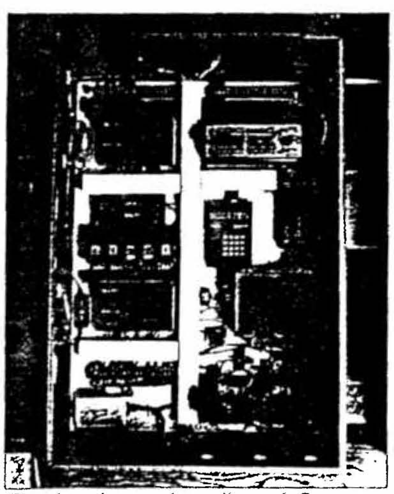
Typical hydrologic measurements:

- WATER LEVEL is read directly with an incremental shaft encoder, strain gage or vibrating wire pressure transducer. Some shaft encoders require a QD-1 Interface. Vibrating wire transducers require an AVW1 or AVW4 Interface.
- WELL DRAW-DOWN TESTS use a pressure transducer measured either logarithmically or at a rate based on incremental changes in water level.
- IONIC CONDUCTIVITY measurements use the AC excitation from one of the CR10's three switched excitation ports.
- WATER QUALITY samplers are controlled by the datalogger as a function of time, water level thresholds, or rate of change.
- ALARM AND PUMP ACTUATION is controlled through any of the eight digital I/O ports which operate external relay drivers.

INDUSTRY

The growing number of applications where the CR10 can inexpensively automate data collection and improve productivity and quality include:

- HVAC systems
- Vehicle/machinery testing
- Transportation
- Process control
- Water and sewage treatment
- Regulatory compliance
- Routine operations and maintenance
- Structural or fatigue analysis
- Energy management/ conservation
- Environmental testing



The heating and cooling of Campbell Scientific's factory is controlled by a CR10 and peripherals (Logan, UT).

More specifically, the CR10 can:

MEASURE input from

• load cells	• speed sensors	• temperature probes
• strain gages	• humidity sensors	• pressure transducers
• flow sensors	• v/mV transducers	• 4-20 mA transducers*

MONITOR conditions of

• valves	• refrigerators	• chillers
• filters	• appliances	• pumps
• boilers	• vehicles	• batteries
• generators	• compressors	• transformers
• engines	• turbines	• weighing scales

CONTROL based on time or measured parameters

• pumps	• motors	• relays
• solenoids	• resistive loads	• alarms

VEHICLE TESTING

The CR10 is ideal for applications requiring compact packaging such as:

- engine test cell monitoring
- durability testing
- fleet monitoring
- solar vehicle "C-studies"
- vehicle performance verification

Datalogger monitors and records pressure on hydraulic rams of haulage trucks (Kennecott Copper Mine, Oquirrh Mtns., UT).

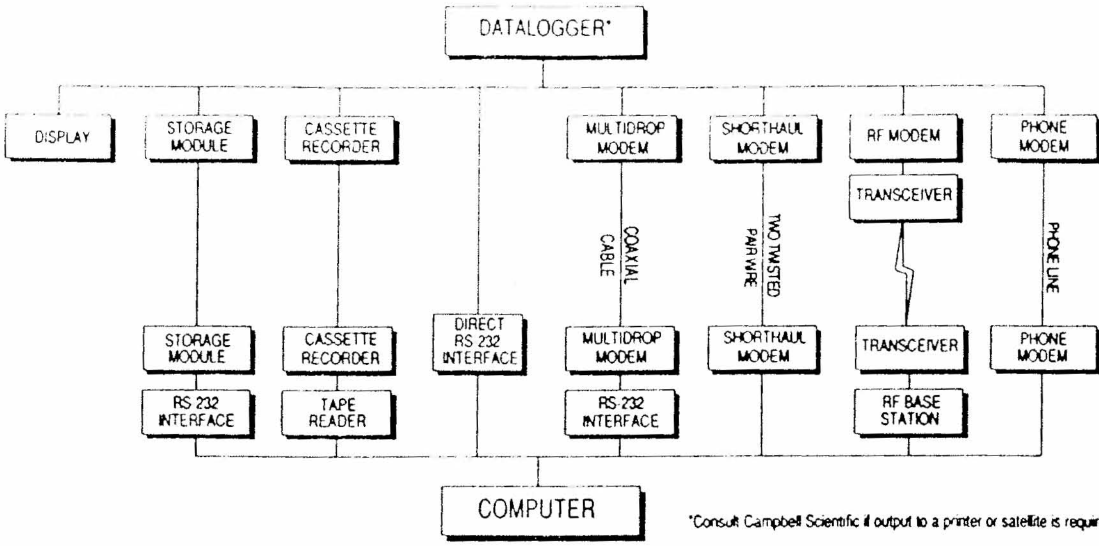
Common parameters for vehicle monitoring and durability testing are listed below:

- TEMPERATURE sensors include thermocouples and infrared (IR) detectors. The linearization for K-type thermocouples extends from -50° to 1370°C, allowing measurements from ambient to extreme exhaust temperatures.
- PRESSURE, FORCE, TORQUE, AND ACCELERATION measurements are accomplished with strain gage transducers.
- FUEL FLOW, ENGINE RPM, AND VEHICLE SPEED usually require magnetic pulse transducers or incremental encoders, either of which connect directly to the CR10 pulse counter inputs.
- THROTTLE POSITION is measured with potentiometers.
- TIMING EVENTS are output to the datalogger in period, pulse width, frequency, counts, or time intervals with the SDM-INT8 Interval Timer.
- FREQUENCY DISTRIBUTION HISTOGRAMS allow data compression over extended performance tests.
- RAINFLOW COUNTING HISTOGRAMS allow fatique analysis tests.

*Contact Campbell Scientific for proper wiring configuration.

Data Storage and Transfer

Up to 29,900 raw or processed data points can be stored in the CR10's memory. Data are transferred to a computer via one or more communications options including multidrop or short-haul modems, radios, phone lines, or satellite. On-site data retrieval options include direct line, storage module, cassette tape, display, or printer.



*Consult Campbell Scientific if output to a printer or satellite is required.

SOFTWARE

PC208 Datalogger Support Software supports telecommunications, programming, and data processing functions. With an appropriate communication link, PC208 provides two-way communication between Campbell dataloggers and IBM-PC or compatible computers. A Monitor mode allows real-time display of datalogger measurements.

DISPLAY

The CR10KD Keyboard/Display provides on-site review of data values and program instructions. On-site connection to a terminal or computer is also possible (Direct Line Options).

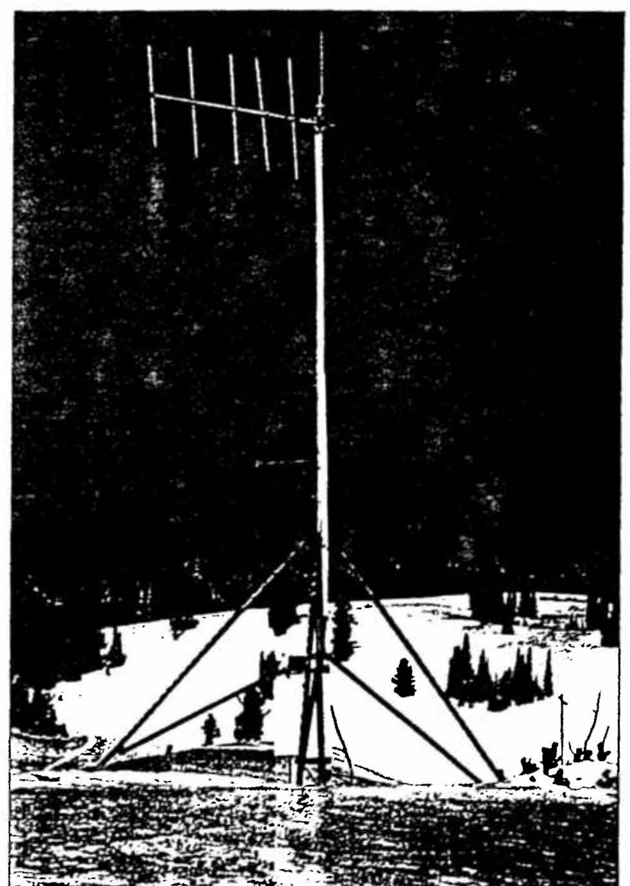
STORAGE MODULES

Rugged, battery-backed RAM storage modules reliably store data over a -35° to +65°C (extended values on request) temperature range. The SM192 or SM716 Storage Module (96K or 358K data values, respectively) can be left connected to the CR10 or carried to the field to retrieve data from the CR10's memory. Up to eight storage modules can be connected to one CR10. The SC532 Interface is used to transfer data or programs between the storage module and an MS-DOS computer. Consult Campbell Scientific if data playback to a non-MS-DOS computer is required.

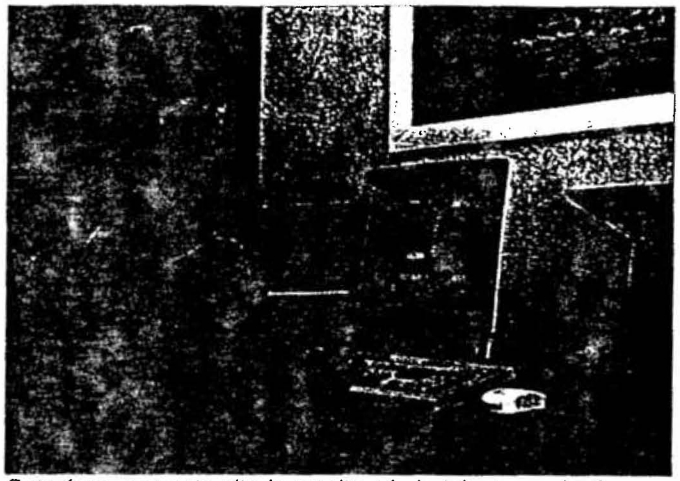
CASSETTE TAPE

The RC35 Recorder stores 180K data values on one side of a C60 cassette over a 0° to +40°C temperature range. Transfer of data from the CR10 to the RC35 requires the SC92A Interface.

Data transfer from tape to a computer is accomplished through either the PC201 Card or the C20 Cassette-Computer Interface. The PC201 requires an IBM PC/XT/AT or compatible computer. The C20 can be used with any computer having an RS-232 serial port.



Record temperature of -69°F was monitored via radio telemetry (Peter Sinks, UT).



Data from a remote site is monitored via telecommunications and PC208 Software.

DIRECT LINE OPTIONS

Direct Datalogger-to-Computer Interface

The SC32A RS-232 Interface supplies an optically isolated connection between the CR10 and a computer over distances up to 100 feet.

Short Haul Modems

Short haul modems provide local communication between the CR10 and a computer with an RS-232 serial port. The modem transmits data up to 6.5 miles over four-wire unconditioned line (two twisted pairs).

Coax Network

The MD9 Multidrop Interface links a central computer to over 200 dataloggers on a single coaxial cable. Total coax cable length can be up to three miles.

RADIO FREQUENCY (RF) COMMUNICATION

Campbell Scientific's RF communication system uses the RF95 modem and a low-powered transceiver at the remote station(s), and a transceiver connected to an RF232 Base Station at the computer site. Up to 255 stations can be interrogated over a single UHF or VHF frequency. Any station can serve as a repeater to extend the line-of-sight transmission of the base station.

TELEPHONE NETWORKS

Telephone communication links require a DC112 modem at the CR10 site and a Hayes-compatible 300 or 1200 baud modem at the calling end. Remote RF or MD9 networks are also accessible by telephone.

Channel Expandability

The following peripherals expand CR10 measurement or control capability. Contact Campbell Scientific regarding the suitability of these peripherals for your application.

SYNCHRONOUS DEVICES FOR MEASUREMENT (SDM's)

SDM's are addressable peripherals that expand digital control ports, analog output ports, and datalogger measurement capabilities. Up to 16 SDM's may be connected to three control ports on one CR10. SDM operation is controlled by datalogger instructions 101-104.

SDM-A04 Four Channel Continuous Analog Output Module provides four independent continuous analog outputs for proportional control or strip chart recording.

SDM-CD16 Control Port Module has 16 digital control ports with drivers to activate external relays, solenoids, or resistive loads. A manual override toggle switch is provided for each port.

SDM-INT8 Eight Channel Interval Timer expands the number of pulse count channels in the system and outputs processed timing data to the datalogger. Timing events are captured with ±1 microsecond resolution over a maximum range of 16.77 seconds. Output options include period, pulse width, frequency, counts, and interval time.

SDM-SW8A Pulse Counter is an 8-channel pulse count expansion for switch closure measurements. Channels can be individually configured for single-pole double-throw (SPDT), single-pole single-throw (SPST), or voltage pulse measurements. Output options include signal state, duty cycle, or counts.

The expansion peripherals are: AM416, SDM-SW8A, SDM-CD16, SDM-A04 and SDM-INT8

MULTIPLEXER

The AM416 Relay Multiplexer increases the number of sensors that can be measured by a CR10. The AM416 sequentially multiplexes sixteen groups of four lines at a time (a total of sixty-four lines). Compatible sensors include thermistors, thermocouples, potentiometers, load cells, strain gages, vibrating wires, and soil moisture blocks. Multiple AM416's can be controlled by a single CR10.

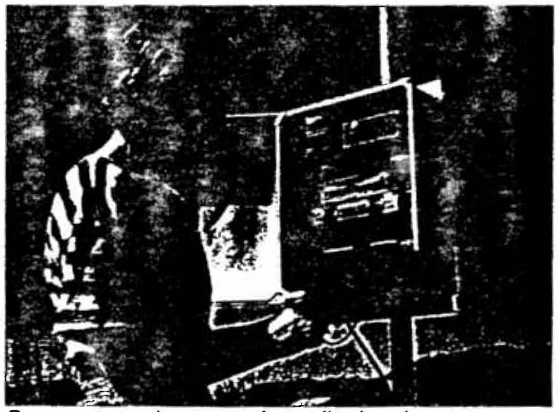
The Datalogger Program

The CR10's ability to make measurements, calculations, logical decisions, and phone calls stems from its internal program. The CR10's program can be extremely powerful, yet is composed of simple instructions. Knowledge of a high level programming language, such as FORTRAN or BASIC, is not required.

PROGRAM DEVELOPMENT

A CR10 program consists of a series of instructions designed to perform measurement, data processing, data storage, and logical control functions. To construct a program, the user selects application-specific instructions from a library of PROM-based instructions. These instructions, developed for data acquisition and control, allow the CR10 to measure most sensor types without the need for external signal conditioning.

Program development can be accomplished with a prompt sheet and a CR10KD keyboard. In addition, a prompt-driven, computer-based datalogger program editor (EDLOG) is available in Campbell Scientific's PC208 Datalogger Support Software.



Programs can be entered or edited and system performance verified on-site with a CR10KD.

INSTRUCTION FORMAT

Each CR10 program instruction is identified by a number. For example, Instruction 1 controls single-ended voltage measurements, Instruction 55 applies a 5th order polynomial to incoming data, Instruction 83 sets up an if/then statement, and Instruction 101 controls operation of an SDM device (SDM-INT8). The variety of instructions allows the user to select measurement, processing, data storage and control sequences that precisely fit his application.

The CR10's instructions can be grouped into four functional categories. A listing of the standard CR10 instruction set follows; more detailed information is available in the CR10 manual and prompt sheet.

INPUT/OUTPUT INSTRUCTIONS are primarily for sensor measurement, but also control and communicate with external devices. Some internal functions, such as control of the CR10's timer, are also classified as I/O instructions. Specific examples include:

- Single-Ended (SE) Volts
- Differential (DIFF) Volts
- Pulse Count
- Excite, Delay, SE Volts
- AC Half Bridge
- Full Bridge
- Three-Wire Half Bridge
- Excite, Delay, DIFF Volts
- Full Bridge with Measured Excitation
- Battery Voltage
- 107 Temperature Probe
- 207 RH Probe
- Thermocouple Temperature (SE)
- Thermocouple Temperature (DIFF)
- Platinum RTD Temperature
- Internal Temperature
- Time
- Signature
- Set Digital Ports
- Read Digital Ports
- Burst
- Excitation With Delay
- Timer
- Period Interval Measurement
- Vibrating Wire Measurement
- Set/Control External Device (e.g. SDM's)

PROCESSING INSTRUCTIONS allow data reduction, entry of simple algorithms, or conversion of raw data into engineering units. In the following instructions, X, Y, and Z are Input Locations where incoming data values or processed results are temporarily stored; F refers to a fixed value (constant).

- Z = F
- Z = X
- Z = Z+1
- Z = X+Y
- Z = X+F
- Z = X-Y
- Z = X*Y
- Z = X*F
- Z = X/Y
- Z = SQRT(X)
- Z = LN(X)
- Z = EXP(X)
- Z = 1/X
- Z = ABS(X)
- Z = FRAC(X)
- Z = INT(X)
- Z = X MOD F
- Z = X↑Y
- Z = SIN(X)
- Z = ARCTAN (X/Y)
- Spatial Maximum
- Spatial Minimum
- Spatial Average
- Scaling Array
- 5th Order Polynomial
- Saturation Vapor Pressure
- Wet/Dry Bulb Temp to Vapor Pressure
- Low Pass Filter
- Resistance from Bridge Output

OUTPUT PROCESSING INSTRUCTIONS process measured values, collected over time.

- Sample
- Average
- Totalize
- Maximize
- Minimize
- Histogram
- Windvector
- Real Time
- High/low Resolution
- Sample on Max or Min
- Redirect Output to Input Storage
- Standard Deviation

PROGRAM CONTROL INSTRUCTIONS allow logic based on time or data. They also control serial data output and CR10-initiated telecommunications.

- Subroutine
- Loop
- If X Compared to Y
- If X Compared to F
- If Flag/Port
- If Time
- If Case/Begin Case
- Else
- End
- Control Serial Data Output
- Initiate Telecommunications
- Send Serial Character

Once an instruction is selected, a set of associated parameters is queued in the datalogger's program memory. Each parameter controls a specific aspect of the instruction's operation. Depending on the versatility of the instruction, from 1 to 12 parameters are required. For example, the parameters associated with Instruction 2 (DIFFerential voltage measurement) are:

1 - REPS - Defines the number of times an instruction executes (allows one instruction to measure several identical sensors).

2 - RANGE - Defines the full scale range of the voltage to be measured. Ranges are ± 2.5, 7.5, 25, 250, and 2500 mV. Fast (272 µs), slow (2.72 ms), 60 Hz rejection, and 50 Hz rejection integration times are also selected with this parameter.

3 - INPUT CHANNEL - Defines the analog input channel that will make the first measurement.

4 - LOCATION - Defines the first Input Storage location.

5 - MULTIPLIER - Allows multiplication of data; for example, 1.8 is entered to convert a temperature measurement from °C to °F.

6 - OFFSET - Allows addition or subtraction of an offset value; for example, 32 is entered to complete the above temperature conversion.

Once the parameters have been entered, the next instruction is selected. This procedure is followed until a specific program has been created. Following program entry, the datalogger checks for errors, then begins executing the program and acquiring data.

SCAN RATE, DATA STORAGE

The maximum rate at which the datalogger can execute its program is 64 times per second. (The maximum rate at which a single input can be measured is 750 samples per second.) After measurement and analog-to-digital conversion, data are directed to Input Storage locations which hold the measurement value for viewing, subsequent processing, or until transfer to Final Storage. Data can be selectively stored based on user-defined events or intervals and need not be tied to scan rate. Data remains in Input Storage until written over by subsequent measurement or processing.

EDLOG

Datalogger program development is supported by PC208 software (EDLOG). Help screens are available to define all instructions and parameter options. Input locations can be annotated with alphanumeric labels so that computer-monitored data is labelled. Once the program has been created, it can be downloaded to the CR10 directly, through telecommunications, or to a storage module for later downloading.

EDLOG simplifies CR10 programming with annotated instructions, parameters and labels.

SAMPLE PROGRAM

Every five minutes, the following program measures air temperature (°C) at six locations within a greenhouse. Critical maximum temperature is 30°C (86°F); if any temperature exceeds that threshold, a control port trips a relay that activates an exhaust fan. The average temperature value measured by each thermistor is recorded hourly.

SENSOR CONNECTIONS
In this example, sensor signal leads are connected to CR10 single-ended input channels 1 through 6, excitation leads are connected to excitation channel 1, and sensor grounds are connected to any analog ground terminal. Port 1 controls the exhaust fan.

			Program	Comments
	*	1	Table 1 Programs	*Executes the following program every 5 minutes.*
	01:	300	Sec. Execution Interval	
Measurement & Processing	01:	P11	Temp 107 Probe	*Measures six Model 107 Thermistors and places the results in Input Locations 1-6.*
	01:	6	Reps	
	02:	1	IN Chan	
	03:	1	Excite all reps w/EXchan 1	
	04:	1	Loc [:TEMP #1]	
	05:	1	Mult	
	06:	0	Offset	
	02:	P49	Spatial Maximum	*Analyzes the incoming data and places the highest temperature in Input Location 7.*
	01:	6	Swath	
	02:	1	First Loc TEMP #1	
	03:	7	Max Value Loc [:MAX TEMP]	
Exhaust Fan Control	03:	P89	If X <=> F	*Compares that temp. against 30°. If the measured temp. is higher, the exhaust fan is activated (or remains active),*
	01:	7	X Loc MAX TEMP	
	02:	3	>=	
	03:	30	F	
	04:	41	Set high Port 1	
	04:	P94	Else	*else, if lower*
	05:	P86	Do	*the exhaust fan is turned off or remains off.*
	01:	51	Set low Port 1	
	06:	P95	End	
Data Output	07:	P92	If time is	*The following data is ouput to Final Storage every hour:*
	01:	0	minutes into a	
	02:	60	minute interval	
	03:	10	Set high Flag 0 (output)	
	08:	P77	Real Time	*date, hour, minute;*
	01:	110	Day,Hour-Minute	
	09:	P71	Average	*average temp. measured by each sensor. (Each average is based on 12 measurements.)*
	01:	6	Reps	
	02:	1	Loc TEMP #1	
	10:	P	End Table 1	

With PC208 software and an appropriate telecommunications link, a researcher can monitor real-time data or control the exhaust fan remotely. Data transfer to a computer can be selected as binary, comma-delineated or printable ASCII.

Enclosures, Power Supplies, and Towers

A CR10 housed in a weather-resistant enclosure is engineered for data collection under extremely harsh conditions. A low power design allows the CR10 to operate one year on 7.0 Ahr, unregulated 12 volt source, depending on scan rate, number of sensors scanned, and external temperature. For field installations, Campbell Scientific can provide towers and mounting accessories.

ENCLOSURES

A protective enclosure for the CR10 is required in indoor or outdoor areas where dust, water, sunlight, or environmental pollutants are present.

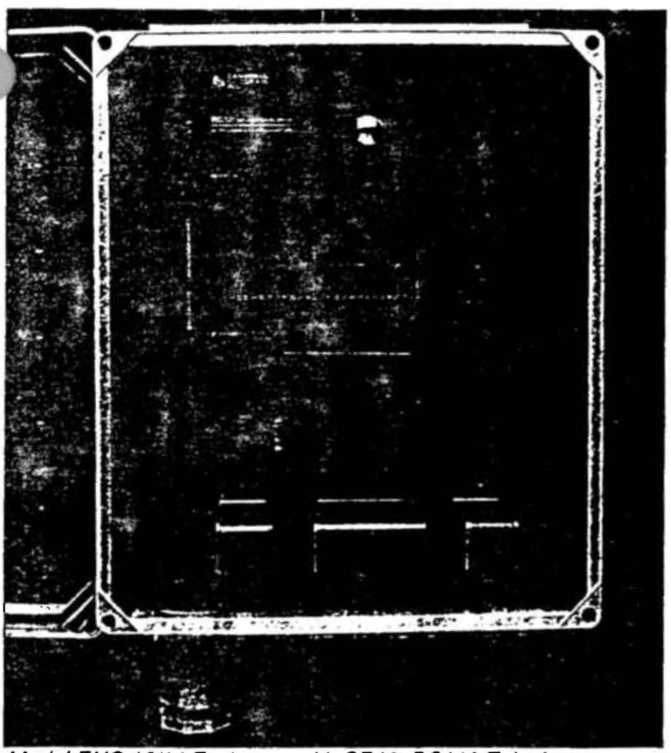
Our NEMA 4X enclosures are modified for cable entry and attach either to a flat surface or a vertical mast (1.00" to 1.25" IPS pipe). The white fiberglass-reinforced polyester enclosures are UV-stabilized and reflect solar radiation, reducing temperature gradients inside the housing. An internal mounting plate is prepunched for easy system configuration and exchange of equipment in the field. A lockable hasp provides additional security.

Two standard enclosures are available for the CR10, its power supply, and peripherals.

MODEL ENC 10/12 houses the CR10, a power supply, and one data retrieval peripheral such as a storage module. Inside dimensions are 12" x 10" x 4.5"; weight is 9 pounds.

MODEL ENC 12/14 houses the CR10, power supply, and one or more peripherals. Inside dimensions are 14" x 12" x 5.5"; weight is 12 pounds.

While these enclosures satisfy most application requirements, larger sizes can be specially ordered.



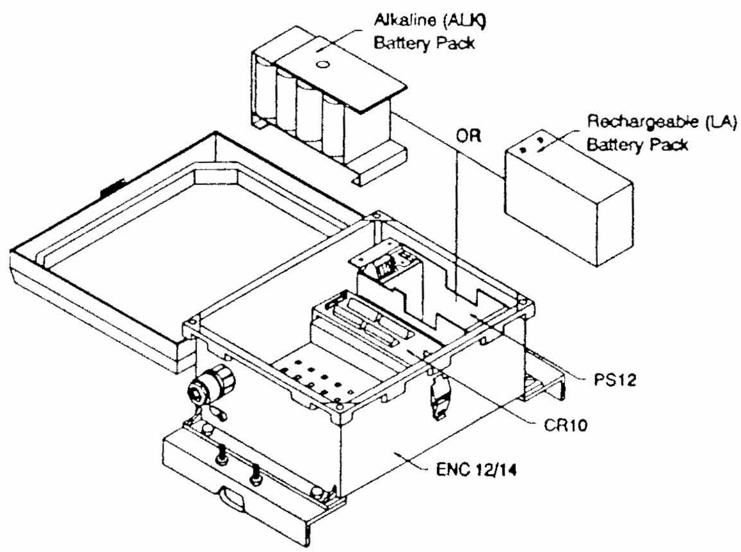
Model ENC 12/14 Enclosure with CR10, DC112 Telephone Modem, SM716 Storage Module, and PS12-ALK Power Supply

POWER SUPPLIES

The **PS12 Power Supply with Charging Regulator** accepts 16 to 26 VDC or AC input and provides a charging voltage to the 12 volt rechargeable battery option or to an external 12 volt battery. The battery options shown below are:

PS12-ALK contains eight non-rechargeable 'D'-cell alkaline batteries with a 7.5 Ahr rating at 20°C.

PS12-LA rechargeable battery option includes one 12 volt, 7 Ahr, rechargeable battery, and an AC transformer. It is float-charged with AC power or a solar panel.



SOLAR PANELS

MODEL MSX5 or MSX10 unregulated solar panel is used to float-charge the PS12-LA rechargeable battery option. Based on an illumination of 1 kW/m² and ambient temperature of 20°C, a peak voltage of 17 volts is supplied. Call Campbell Scientific if regulated solar panels for recharging customer-supplied 12 volt batteries are required.

TOWERS & MOUNTS

For field installations, Campbell Scientific manufactures durable tripods and towers designed for easy installation and adjustable placement of sensor mounts.

CM6 and CM10 TRIPODS are portable, sturdy tripods, six and ten feet, respectively. They can be staked down or mounted to a concrete pad.

10-METER TOWER is an aluminum instrument tower designed for fixed applications. Its triangular sections are bolted together with zigzag bracing. Models are available for cementing into the ground or mounting onto a roof. They can be further stabilized by guy wires.

Specifications

The following electrical specifications are valid for an ambient temperature range of -25° to +50°C unless otherwise specified.

ANALOG INPUTS

NUMBER OF CHANNELS: 6 differential or up to 12 single-ended. Each differential channel can be configured as two single-ended channels.

CHANNEL EXPANSION: The Model AM416 Relay Multiplexer allows an additional 64 single-ended channels to multiplex into four CR10 single-ended channels. Up to three AM416's can be connected to one CR10.

ACCURACY OF VOLTAGE MEASUREMENTS AND ANALOG OUTPUT VOLTAGES:
0.2% of FSR, 0.1% of FSR (0 to 40°C)

RANGE AND RESOLUTION: Ranges are software selectable for any channel. Resolution for a single-ended measurement is twice the value shown.

Full Scale Range	Resolution
± 2500 millivolts	333 microvolts
± 250 millivolts	33.3 microvolts
± 25 millivolts	3.33 microvolts
± 7.5 millivolts	1.00 microvolts
± 2.5 millivolts	0.33 microvolts

INPUT SAMPLE RATES: The fast A/D conversion uses a 0.25 ms signal integration time and the slow conversion uses a 2.72 ms signal integration. Two integrations, separated in time by 1/2 of an AC line cycle, are used with the 60 Hz or 50 Hz noise rejection option. Differential measurements include a second sampling with reversed input polarity to reduce thermal offset and common mode errors. Input sample rates are the time required to measure and convert the result to engineering units.

Fast single-ended voltage:	2.6 ms
Fast differential voltage:	4.2 ms
Slow single-ended voltage:	5.1 ms
Slow differential voltage:	9.2 ms
Differential with 60 Hz rejection:	25.9 ms
Fast differential thermocouple:	8.6 ms

INPUT NOISE VOLTAGE:

Fast differential	— 0.82 microvolts RMS
Slow differential	— 0.25 microvolts RMS
Differential with 60 Hz rejection	— 0.18 microvolts RMS

COMMON MODE RANGE: ± 2.5 volts.

DC COMMON MODE REJECTION: > 140 dB.

NORMAL MODE REJECTION: 70 dB
(60 Hz with slow differential measurement).

INPUT CURRENT: 3 nanoamps maximum.

INPUT RESISTANCE: 200 gigohms.

EXCITATION OUTPUTS

DESCRIPTION: The CR10 has 3 switched excitations, active only during measurement, with only one output active at any time. The off state is high impedance.

RANGE: ± 2.5 volts.

RESOLUTION: 0.67 millivolts.

ACCURACY: Same as voltage input.

OUTPUT CURRENT: 20 mA @ ± 2.5 V; 35 mA @ ± 2.0 V; 50 mA @ ± 1.5 V.

FREQUENCY SWEEP FUNCTION: A swept frequency, square wave output between 0 and 2.5 volts is provided for vibrating wire transducers. Timing and frequency range are specified by the instruction.

RESISTANCE AND CONDUCTIVITY MEASUREMENTS

ACCURACY: 0.015% of full scale bridge output, limited by the matching bridge resistors. The excitation voltage should be programmed so the bridge output matches the full scale input voltage range.

MEASUREMENT TYPES: 6-wire and 4-wire full bridge, 4-wire, 3-wire, and 2-wire half bridge. Bridge measurements are ratiometric and dual polarity to eliminate thermal emfs. AC resistance measurements use a dual polarity 0.75 ms excitation pulse for ionic depolarization, with the signal integration occurring over the last 0.25 ms.

PERIOD AVERAGING MEASUREMENTS

DEFINITION: The time period for a specified number of cycles of an input frequency is measured, then divided by the number of cycles to obtain the average period of a single cycle.

INPUTS: Any single-ended analog channel; signal dividing or AC coupling is normally required.

INPUT FREQUENCY RANGE:

Range Code	Peak to Peak Volts Required @ Max. Freq.*	Maximum Frequency
1	2 mV	8 kHz
2	3 mV	20 kHz
3	12 mV	50 kHz
4	2000 mV	200 kHz

*AC voltage; must be centered around CR10 ground

REFERENCE ACCURACY: ± 40 ppm.

RESOLUTION: ± 100 nanoseconds divided by the number of cycles measured. Resolution is reduced by signal noise and for signals with a slow transition through the zero voltage threshold.

TIME REQUIRED FOR MEASUREMENT: Signal period times the number of cycles measured plus 1.5 cycles.

PULSE COUNTERS

NUMBER OF PULSE COUNTER CHANNELS: 2 eight bit or 1 sixteen bit; software selectable.

MAXIMUM COUNT RATE: 2000 Hz, eight bit counter; 250 kHz, sixteen bit counter. Pulse counter channels are scanned at 8 Hz.

MODES: Switch closure, high frequency pulse, and low level AC.

SWITCH CLOSURE MODE
Minimum Switch Closed Time: 5 milliseconds.
Minimum Switch Open Time: 6 milliseconds.
Maximum Bounce Time: 1 millisecond open without being counted.

HIGH FREQUENCY PULSE MODE
Minimum Pulse Width: 0.002 milliseconds.
Maximum Input Frequency: 250 kHz.
Voltage Thresholds: Count upon transition from below 1.5 V to above 3.5 V.
Maximum Input Voltage: ± 20 V.

LOW LEVEL AC MODE
(Typical of magnetic pulse flow transducers or other low voltage, sine wave outputs).
Minimum AC Input Voltage: 6 mV RMS.
Input Hysteresis: 11 mV.
Maximum AC Input Voltage: 20 V RMS.

Frequency Range

AC Input (RMS)	Range
20 mV	1 Hz to 100 Hz
50 mV	0.5 Hz to 400 Hz
150 mV to 20 V	0.3 Hz to 1000 Hz

(Consult factory if higher frequencies are desired.)

DIGITAL I/O PORTS

8 ports, software selectable as binary inputs or control outputs.

OUTPUT VOLTAGES (no load): high 5.0 V ± 0.1V; low < 0.1 V.

OUTPUT RESISTANCE: 500 Ω.

INPUT STATE: high 3.0 V to 5.5 V; low -0.5 V to 0.8 V.

INPUT RESISTANCE: 100 kΩ.

SDI-12 INTERFACE STANDARD

This communication protocol, developed for microprocessor-based hydrologic and environmental sensors, is available as a software option in the CR10.

SENSOR CONNECTIONS: Digital I/O Port #8 (for asynchronous communication), 12V power, and ground. Up to ten SDI-12 sensors can be connected to a CR10.

TRANSIENT PROTECTION

All input and output connections to the CR10 module are protected using RC filters or transzorbs connected to a heavy copper bar between the circuit card and the case. The CR10WP Wiring Panel includes additional spark gap and transzorb protection.

CPU AND INTERFACE

PROCESSOR: Hitachi 6303.

MEMORY: 32K ROM, 64K RAM.

DISPLAY: 8 digit LCD (0.5" digits).

PERIPHERAL INTERFACE: 9 pin D-type connector for keyboard display, storage module, modem, printer, cassette, and RS-232 adapter. Baud rates selectable at 300, 1200, 9600 and 76,800. ASCII communication protocol is one start bit, one stop bit, eight data bits (no parity).

CLOCK ACCURACY: ± 1 minute per month.

MAXIMUM PROGRAM EXECUTION RATE: System tasks initiated in sync with real-time up to 64 Hz. One measurement with data transfer is possible at this rate without interruption.

SYSTEM POWER REQUIREMENTS

VOLTAGE: 9.6 to 16 volts.

TYPICAL CURRENT DRAIN: 0.5 mA quiescent, 13 mA during processing, and 35 mA during analog measurement.

BATTERIES: Any 12 volt battery can be connected as a primary power source. Enclosures with power supply options are available.

PHYSICAL SPECIFICATIONS

SIZE: 7.8" x 3.5" x 1.5" - Measurement & Control Module; 9" x 3.5" x 2.9" - with CR10WP Wiring Panel. Additional room required for connectors.

WEIGHT: 2 lbs.

WARRANTY

Three years against defects in materials and workmanship.

Additional Information

ASSURANCE OF QUALITY

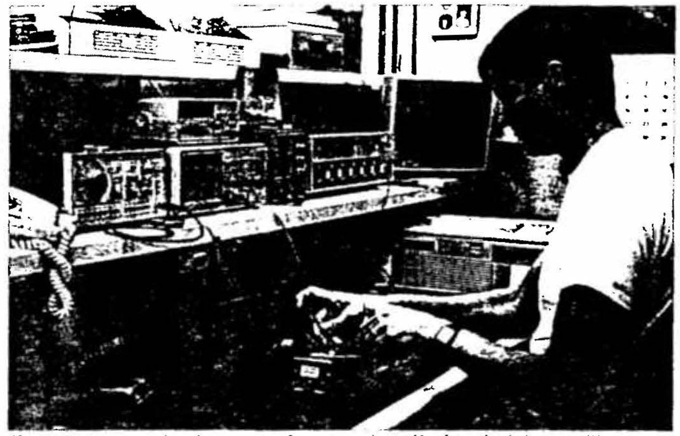
Campbell Scientific has been producing portable research grade dataloggers for over fifteen years. Our commitment to quality is evidenced in the design and workmanship of the CR10 Measurement and Control System. Tailored for demanding field use, the CR10 features durable components, compact size, low power consumption, wide temperature tolerance, and easy field replacement.

After bench testing, all CR10 Modules are cycled between -35° to 60°C in an environmental chamber.

Every CR10 is calibrated and thoroughly tested to ensure consistent, dependable performance. The CPU, system components, and all I/O connections are tested. The datalogger's results are calibrated against NIST traceable standards (National Institute of Standards and Technology, formerly known as NBS). A test report and calibration certificate including NIST traceable numbers are shipped with each CR10.

WARRANTY AND REPAIR

The CR10 is backed with a three year warranty covering parts and labor. Our Mean Time Between Failure (MTBF) is over 50 years.



If repair is required, our professional staff of technicians will repair and recalibrate the CR10 to original specifications.

FOR MORE INFORMATION

For more detailed information on the products mentioned in this brochure, please contact Campbell Scientific sales or application engineers. Their technical and scientific backgrounds cover a wide range of fields including meteorology, agriculture, hydrology, industry, and vehicle testing. Trained in data acquisition, they can help develop your system configuration and give post-sale support if needed.

Pricing and ordering information is available from our price list or from our order entry staff. Contact our marketing department for information on customized training sessions or authorized representatives in your area.

Campbell Scientific's U.S. factory is located in Logan, Utah.

Please call us today, we would like to discuss your application needs with you.

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Campbell Scientific, Inc.
Automated Weather Stations for the

Federal Highway Administration's
Long-Term Pavement Study

System Description/System Integration

Datalogger/Enclosure/Power Supply

The programmable **CR10 Measurement and Control Module** provides sensor measurement, timekeeping, and data processing/reduction capabilities for the weather station. Sensor connections are made directly to the **CR10WP Wiring Panel**; the CR10's inputs can easily accomodate the number of sensors required for this application. The CR10 stores up to 29,900 raw or processed data points in on-board memory; data may also be directed to a connected storage module for back-up and for eventual retrieval. **OS10-0.1 Software** is the standard CR10 PROM for weather station applications; it contains programmable security to ensure integrity of programs and data.

The **ENC12/14 Enclosure** is a white, weatherproof instrumentation enclosure that will house the CR10, PS12LA Power Supply, and storage module. The enclosure is shipped with putty to seal the enclosure conduit, an internal humidity indicator, and replaceable desiccant packs to protect the electronics from condensing humidity. An external hasp allows the enclosure to be locked with commercially-available 1/4" shank padlocks.

The **PS12LA Power Supply** contains a sealed rechargeable, 7.5 Amphr battery that is trickle-charged by the **MSX10 Solar Panel**. System current drain (excluding the heated rain gage) will be minimal; the PS12LA's battery should be sufficient to power the system for several months even without recharge by the solar panel.

Meteorological Instruments & Instrument Mounts

The **HMP35C Temperature and RH Probe** is a precision device that measures temperature to ± 0.25°C and RH to ± 3%. The **41002 Solar Radiation Shield** houses the sensing end of the probe and helps to dissipate the effects of solar radiation on the sensor's measurement.

The **05103 R.M. Young Wind Monitor** is a rugged, yet precise, propeller anemometer and vane. It combines a starting threshold of 1.0 m/s (2.2 mph) with a maximum gust survival of 100 m/s (220 mph). Note: accurate measurements of wind speed are possible only to 134 mph. The Wind Monitor is attached to the tower by the **019ALU Crossarm**.

The **LI200S LI-COR Pyranometer** measures incoming solar radiation between 400 and 1100 nanometer wavelengths. The **LI2003S Pyranometer Base and Leveling Fixture** is used to level the sensor atop the **025 Pyranometer Crossarm Stand** which in turn is inserted in the **019ALU Crossarm.**

The 380-L [redacted] **Raingage** is a non-heated raingage; the 385-L [redacted] is an AC-powered, heated version that allows measurement of frozen precipitation. Both versions feature a 12" diameter orifice for accurate catchment. The 380-MB [redacted] **Base and Leveling Fixture** is used to level the sensor atop a user-supplied concrete pad and pipe.

UT3

The [redacted] Tower provides a solid mounting platform for sensors and datalogger enclosure. Wind and solar radiation measurements will be at approximately 3m (10 ft.); temperature and RH measurements will be at approximately 1.5m (5 ft.). The tower is shipped with UV-resistant cable ties to secure the sensor leads to the tower; adequate lead length is provided to route the leads along the crossarm and tower then allow a "drip loop" underneath the enclosure. A "T"-shaped base fitted with "J"-bolts secures the tower to a user-supplied concrete pad. At the time of installation, the tower is attached to the hinged base and pivoted into an upright position.

Data Storage/Retrieval

The **SM192 Storage Module** stores up to 96,000 data values in battery-backed RAM. The storage module can be left at the site for on-line data transfer or be carried to the site to "milk" the datalogger's data. If left at the site, the module is secured to the backplate of the enclosure with the **6234 Bracket Kit**. In this application, we recommend two modules for each site. This allows the modules to be exchanged during site visits; the "fresh" module would remain at the site, and the "filled" module would be carried (mailed) back to the office for interrogation via the **SC532 Interface, PC208 Software**, and a user-supplied IBM-compatible computer.

An alternative to the SM192 is the **CSM1 Card Storage Module** which consists of two components: a read/write module that communicates with the datalogger and battery-backed "credit-card-sized" RAM cards that are inserted into the CSM1 to accept data. The CSM1 has a few advantages over the SM192 for your application; the data is carried on a small card (for ease of mailing) and the projected cost of the CSM1 system is about 25% less than the SM192 system. Potential limitations of the CSM1 are its operating temperature range (-20 to +60°C) and the fact that we (CSI) have a limited track record in the system's use (although the system has been in use for over a year with Campbell Scientific, Ltd, U.K.).

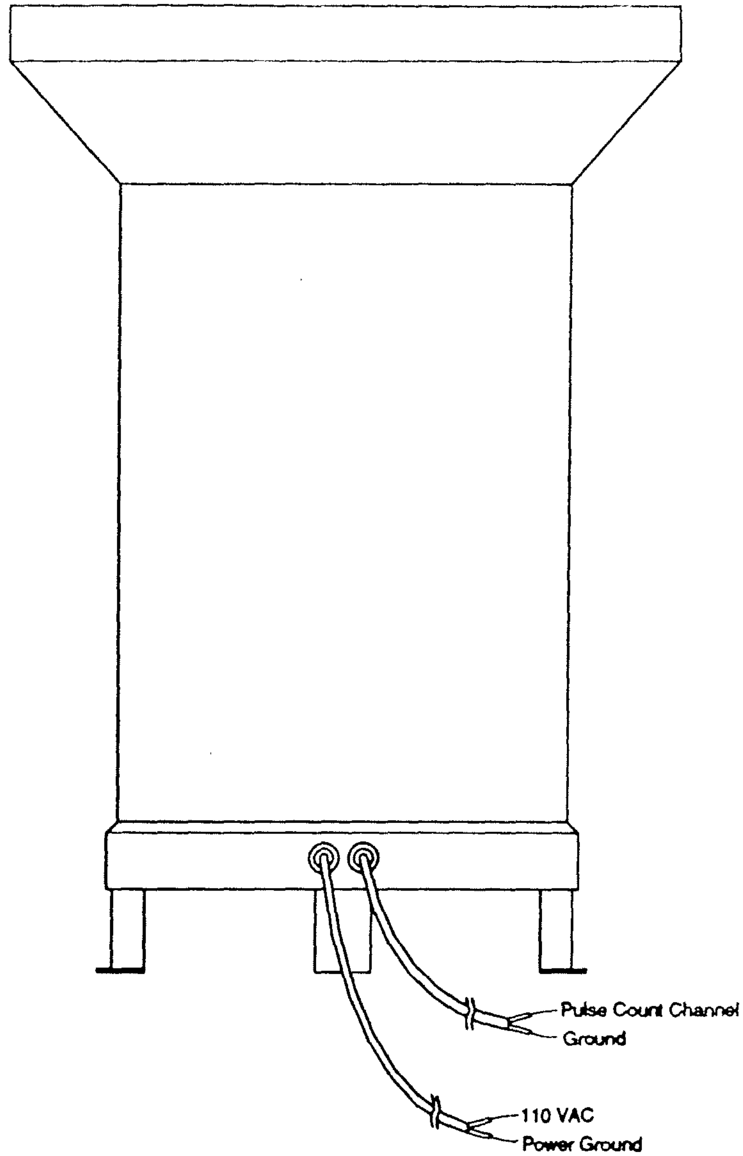
The **SC32A Interface** allows communication between the datalogger and the RS-232 serial port of a battery-operated IBM-compatible laptop computer. The **7026 Adapter Cable** allows connection of the SC32A or SC532 to a 9-pin serial port.

Additional information and product specifications are published in the enclosed product literature.

Rain and Snow Gages

Met One's Models 380 & 385

Met One's tipping bucket rain and snow gages offer an accurate method to continuously measure precipitation. Model 380 measures rain only; Model 385 electrically heated snow gage provides year-round measurement of rain or snow. The 385 gage requires an adequately grounded, reliable source of 110 VAC power.



The gages feature a 12-inch diameter orifice that funnels precipitation into the tipping bucket assembly. When the tipping bucket fills, it tips and activates a mercury switch. The switch closure is recorded by the datalogger, which is typically programmed to output total rainfall over a time interval such as an hour or day. If rainfall intensity data are desired, the datalogger can be programmed to record every tip or total rainfall every one to two minutes during the event. A metric version, available on special order, measures precipitation in increments of 0.1 mm.

Options

As shipped, the base of the gage is supported by three legs. The 380MB Mounting/Leveling Base or a user-supplied baseplate with leveling capability is recommended. The 380MB requires a user-supplied concrete pad and a 1.25" diameter threaded pipe to mount the gage at the recommended 1 m measurement height.

Ordering Information

380-L__	Met One Rain gage (0.01 inch tips). User specifies lead length (in feet) after L.
385-L__(signal)-P__ (power)	Met One Electrically Heated Rain/Snow Gage. User specifies signal cable lead length (in feet) after L and power cable length (in feet) after P.

For example, a 385-L50-P100 orders an electrically heated snow gage with 0.01 inch tips and 50' of signal cable and 100' of power cable.

380MB Mounting/Leveling Base for 380 or 385.

Specifications

Model 380 Rain Gage

- Orifice: 12-inch diamter (30.5 cm)
- Accuracy: ± 0.5% @ < 0.5" (1.25 cm)/hr rate
  ± 2.0% @ < 3.0" (7.50 cm)/hr rate
- Resolution: Model 380 0.01 inch
  Metric Version 0.1 mm
- Weight: 7 pounds (3.2 kg) w/25' cable
- Shipping Weight: 12 pounds (5.4 kg) w/25' cable
- Cable: 2-conductor shielded cable (user-specified length in feet)
- Operational Ranges: 0 to 50°C; 0 to 100% RH

Model 385 Electrically Heated Precipitation Gage

Specifications same as Model 380 unless listed below:

- Heating Element: 115 VAC (50/60 Hz) 300 W element
- Weight: 11.2 pounds (5.1 kg) w/50' power and signal cable
- Shipping Weight: 16.2 pounds (7.4 kg) w/50' power and signal cable
- Power Cable: 115 V power cable (user-specified length in feet)
- Operational Ranges: -20 to 50°C; 0 to 100% RH

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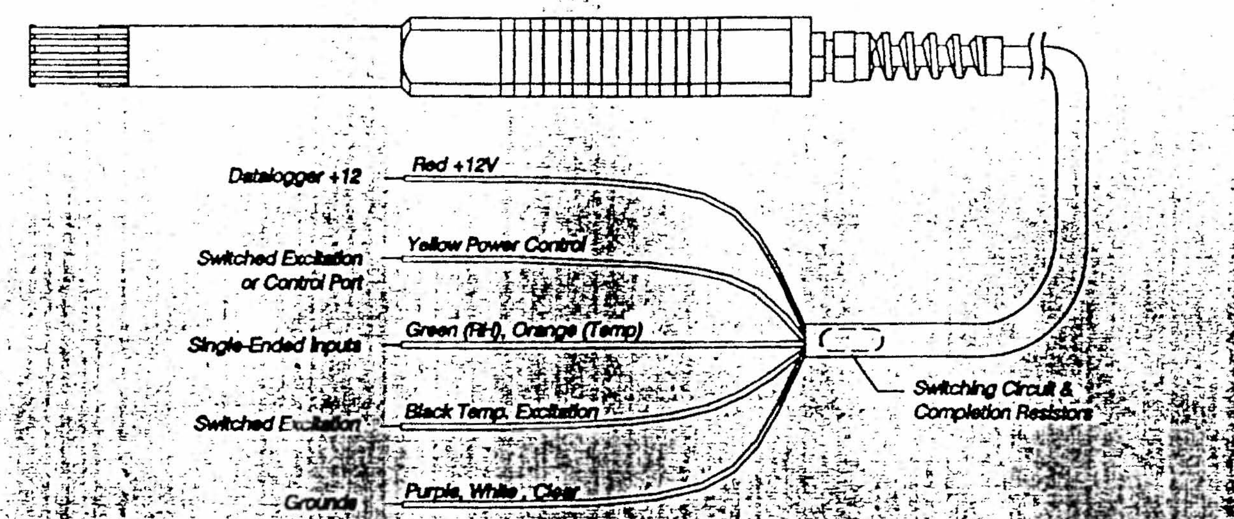
HMP35C Temperature and Relative Humidity Probe

The HMP35C is a rugged, accurate temperature/RH probe designed for long-term, unattended applications. The sensor is compatible with Campbell Scientific CR10, 21X, and CR7 dataloggers. The HMP35C is manufactured by Vaisala, Inc. and uses their capacitive polymer H chip for the RH measurement. Campbell Scientific installs a thermistor for measuring temperature and adds a switching circuit to supply power only during measurement. A radiation shield should be used when the probe is exposed to sunlight.



Ordering Information

HMP35C = 5' lead length for use with Campbell Scientific's CM6 and CM10 tripods.

HMP35C-U = 9' lead length for use with UT930 10m tower.

HMP35C-L___ = For specialized applications where sensor leads must be ordered to length. Maximum lead length is 1000 ft.; enter lead length required (in feet) after L. Note: Each 100' of sensor cable increases the apparent RH reading by approximately 0.6% RH.

Specifications

(RH Specifications from Valsala, Inc., Woburn, MA)

RH Measurement Range:	0 to 100% RH
RH Output Signal Range:	0.002 to 1VDC
RH Accuracy (at 20°C, including nonlinearity and hysteresis):	±2% RH (0 to 90% RH) ±3% RH (90 to 100% RH)
Temperature dependence of RH measurement:	±0.04% RH/°C
Typical long-term stability:	better than 1% RH per year
Response time (at 20°C, 90% response):	15s with 0.2μm membrane filter
Settling time after power applied:	0.15 sec.
Temperature measurement range:	-35 to +50°C
Temperature accuracy:	± 0.4°C worst case (-33 to +48°C) ± 0.2°C typical
Supply voltage:	12 VDC nominal (7-35 V possible)
Current consumption:	4mA max.
Filter:	0.2 μm telfon membrane

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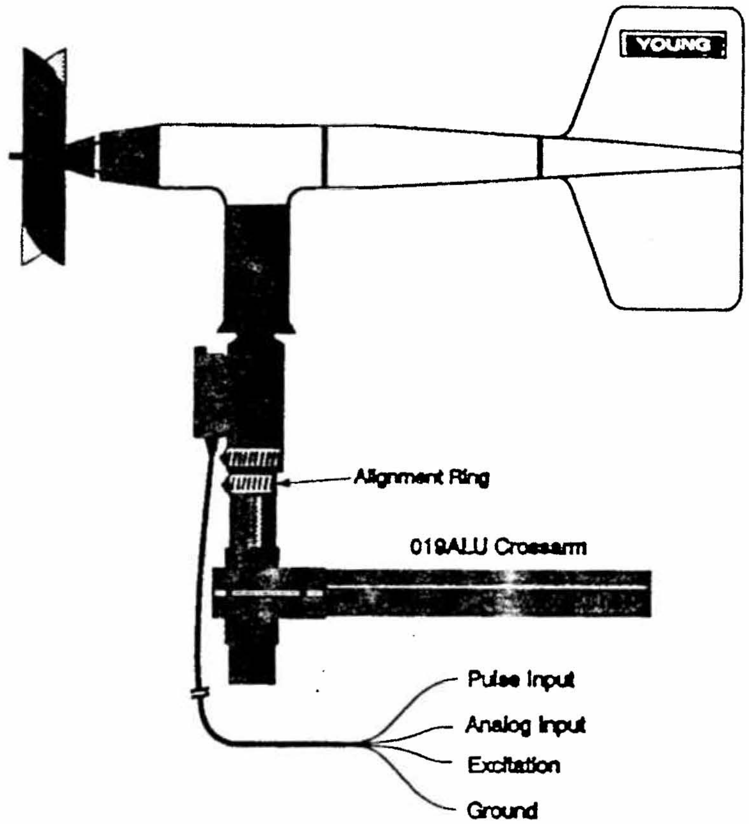
Wind Monitor & Wind Monitor-AQ

RM Young Models 05103 & 05305



Model 05103 Wind Monitor (shown at right) is a sturdy instrument for measuring wind speed and direction in harsh environments. The Wind Monitor's design emphasizes simplicity and lightweight construction. Thermoplastic materials offer improved resistance to corrosion from sea air environments and atmospheric pollutants.

Model 05305 Wind Monitor-AQ is a high performance wind speed and direction sensor designed specifically for air quality measurements, but is less rugged than the 05103. The Wind Monitor-AQ features low starting threshold, fast response, and high accuracy. It meets or exceeds the requirements published by the following regulatory agencies:

- U.S. Environmental Protection Agency - Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD) and On-Site Meteorological Instrumentation Requirements to Characterize Diffusion from Point Sources
- U.S. Nuclear Regulatory Agency - NRC Regulatory Guide 1.23 Meteorological Programs in Support of Nuclear Power Plants
- American Nuclear Society - Standard for Determining Meteorological Information at Nuclear Power Plants

Both models connect directly to Campbell Scientific dataloggers (CR10, 21X, or CR7).

Wind Speed

The wind speed sensor is a helicoid-shaped four-blade propeller. Rotation of the propeller produces an AC sine wave; the frequency is directly proportional to the wind speed. The AC signal is induced in a transducer coil by a six-pole magnet mounted on the propeller shaft. The coil is located on the non-rotating central portion of the main mounting assembly, eliminating the need for slip rings and brushes.

Wind Direction

Wind direction is sensed by a potentiometer. With the precision excitation voltage from the datalogger applied to the potentiometer element, the output signal is an analog voltage directly proportional to the azimuth angle.

Construction and Mounting

Construction is of rigid UV-stabilized thermoplastic with stainless steel and anodized aluminum fittings. Propeller shaft bearings and vertical shaft bearings are stainless steel precision-grade ball bearings.

The 05103 or 05305 mounts directly on a 1.0 inch IPS Schedule 40 (1.32 in O.D.) pipe. Campbell Scientific supplies a 12 inch pipe for mounting the Wind Monitor to the 019ALU Crossarm. An orientation ring maintains wind direction reference during maintenance.

Specifications

	Wind Monitor (Model 05103)	Wind Monitor-AQ (Model 05305)
Wind speed		
Range:	0-134 mph (0-60 m/s)	0-90 mph (0-40 m/s)
Starting threshold:	2.2 mph (1.0 m/s)	0.9 mph (0.4 m/s)
Gust survival:	220 mph (100 m/s)	100 mph (45 m/s)
Distance constant (63% recovery):	8.9 ft (2.7 m)	6.9 ft (2.1 m)
Output:	AC voltage (3 pulses/ revolution) 1800 rpm (90 Hz) - 19.7 mph (8.8 m/s)	Same
Wind direction		
Electrical range:	0-360° mechanical, 355° electrical (5° open)	Same
Starting threshold		
at 10° displacement:	2.0 mph (0.9 m/s)	1.0 mph (0.5 m/s)
at 5° displacement:	2.9 mph (1.3 m/s)	1.6 mph (0.7 m/s)
Delay distance (50% recovery):	4.3 ft (1.3 m)	3.9 ft (1.2 m)
Damping ratio:	0.25	0.45
Damped natural wavelength:	24.3 ft (7.4 m)	16.1 ft (4.9 m)
Undamped natural wavelength:	23.6 ft (7.2 m)	14.4 ft (4.4 m)
Output:	Analog DC voltage from potentiometer - resistance 10K Ω, linearity 0.25%, life expectancy 50 million revolutions.	Same
Power	Switched excitation voltage is supplied by the datalogger.	Same
Sensor cable length	05103 = 11' lead length (CM6/10 tripod 05103-U = 34' lead length for UT930 tower 05103-L = User-specified lead length. Enter lead length (in feet) after L.	05305 = 11' lead length (CM6/10 tripod 05305-U = 34' lead length for UT930 tower 05305-L = User-specified lead length. Enter lead length (in feet) after L.
Dimensions		
Overall:	14.6 in H x 21.7 in L (37 cm x 55 cm)	15.0 in H x 25.6 in L (38 cm x 65 cm)
Main housing (diameter):	2.0 in (5 cm)	Same
Propeller (diameter):	7.1 in (18 cm)	7.9 in (20 cm)
Mounting (diameter):	1.34 in (34 mm) (standard 1.0 in pipe)	Same
Weight (shipping approx.)	3.2 lbs (5.5 lbs)	2.5 lbs (5.5 lbs)

Manufactured by RM Young (Traverse City, MI) and cabled by Campbell Scientific for use with our dataloggers.

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Printed October

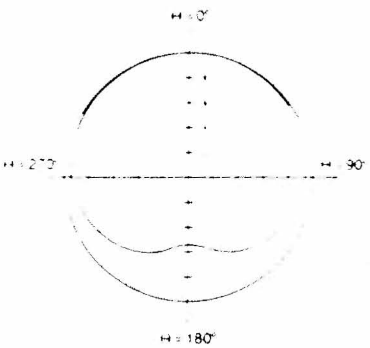
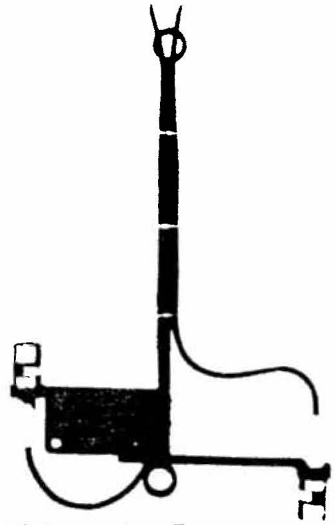


Figure 3. Typical Angular Response of the LI-193SB Spherical Quantum Sensor. The low response on the bottom of the sensor is due to light blockage by the detector housing. The error due to this low response is not significant in most cases because of the small portion of upwelling radiation compared to the total radiation.



2009S Lowering Frame

The 2009S Lowering Frame provides for the placement of two underwater cosine sensors, one each for downwelling or upwelling radiation (shown above), or a single LI-193SB Spherical Quantum Sensor. The 2009S provides stability for proper orientation of the sensor(s), minimizes shading effects, and features a lower mounting ring for stabilizing weight attachment if necessary. Construction: Anodized aluminum. Size: 51.4 L (20.3") x 35.6 cm W (14.0"). Weight: 327 g (0.72 lbs)

2222UWB Underwater Cable

This 2-wire shielded cable is used with underwater sensors and has a waterproof connector on the sensor end. The assembly is fitted for attaching the sensor's Calconnector at the opposite end for connection to the readout instrument. Standard cable lengths are 3, 10, 30, 50, and 75 meters. Custom lengths over 75 meters can also be ordered.

Underwater Sensors require 2222UWB Underwater Cable. The 2009S Lowering Frame is an accessory.

Solar Energy Measurement

LI-200SB Pyranometer Sensor

Sun plus Sky Radiation

The LI-200SB Pyranometer Sensor is designed for field measurements in *solar, agricultural, meteorological and hydrological studies*. The LI-200SB has been used extensively in solar energy studies for site evaluation and monitoring, passive system analysis, irrigation scheduling and other environmental studies.

Patterned after the work of Kerr, Thurtell and Tanner (7), the LI-200SB features a silicon photovoltaic detector mounted in a fully cosine-corrected miniature head. The LI-200SB can be mounted in any plane without affecting its performance.

For clear, unobstructed daylight conditions, the LI-COR pyranometer compares favorably with first class thermopile type pyranometers (5,10), but is priced at a fraction of the cost. The pyranometer's spectral response does not cover the full range of the solar spectrum, but the error induced is < ± 5% under most conditions of natural daylight (7). **The LI-200SB should not be used under vegetation or artificial lights because it has been calibrated for the daylight spectrum.**

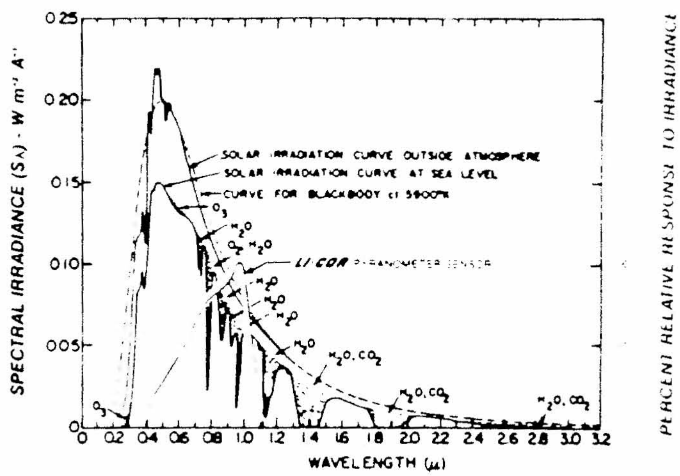


Figure 4. The LI-200SB Pyranometer spectral response is illustrated along with the energy distribution in the solar spectrum (8).

LI-200SB Specifications

Calibration: Calibrated against an Eppley Precision Spectral Pyranometer (PSP) under natural daylight conditions. Absolute error under these conditions is ± 5% maximum, typically ± 3%.
Sensitivity: Typically 80 μA per 1000 W m⁻².
Millivolt Output: 10.0 mV per 1000 W m⁻² using millivolt adapter (included).
Linearity: Maximum deviation of 1% up to 3000 W m⁻².
Cable Length: 5 ft standard. LI-200SB-50: 50 ft.

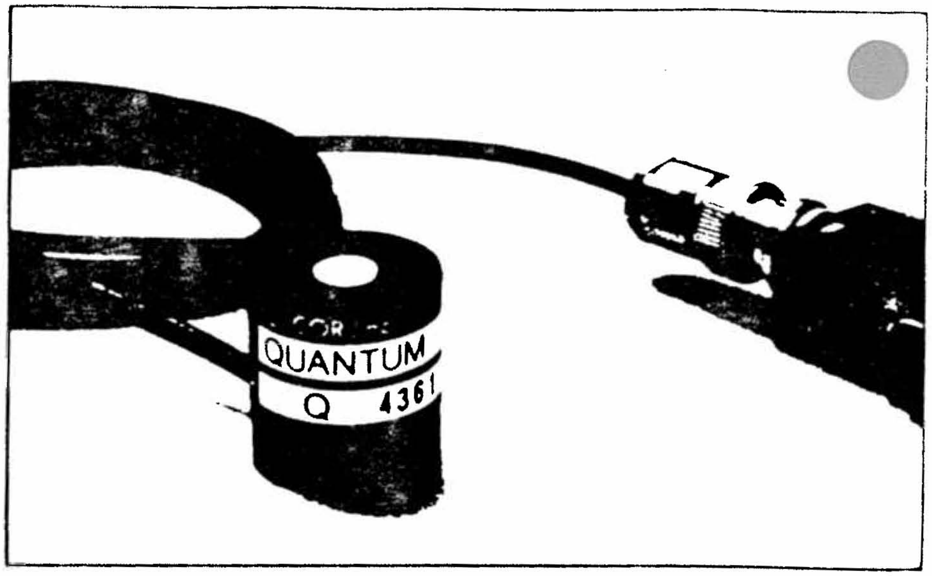
See Common Specifications also.

Sensors

Quantum Sensors

Measure Photosynthetically Active Radiation (PAR) 400 to 700 nm waveband

Plants use the 400 to 700 nm waveband of the light spectrum for photosynthesis (3.9). A simple integral relationship exists between the number of molecules changed photochemically and the number of photons absorbed within the requisite waveband regardless of photon energy (12). The preferred measurement for PAR is *Photosynthetic Photon Flux Density* (PPFD) (9.14). This is the number of photons in the 400 to 700 nm waveband incident per unit time on a unit surface.*



LI-190SB Quantum Sensor

Plant scientists, meteorologists, horticulturists, ecological survey groups and other environmental scientists are using this sensor to measure PPFD in the atmosphere, growth chamber and greenhouse.

Accurate measurements are obtained under ***natural and artificial light conditions*** because of the computer-tailored spectral response of the LI-190SB. This sensor, which has been developed from earlier work (1), was pioneered by LI-COR and has become a standard for PPFD measurement in most photosynthesis related studies.

The LI-190SB is also used in oceanography, limnology, and marine science as a reference sensor for comparison to underwater PPFD measured by the LI-192SB Underwater Quantum Sensor.

*Units currently in use are einsteins, moles, photons and quanta (6, 9, 14): 1 $\mu E\ s^{-1}\ m^{-2}$ = 1 $\mu mol\ s^{-1}\ m^{-2}$ = $6.02 \cdot 10^{17}$ photons $s^{-1}\ m^{-2}$ = $6.02 \cdot 10^{17}$ quanta $s^{-1}\ m^{-2}$

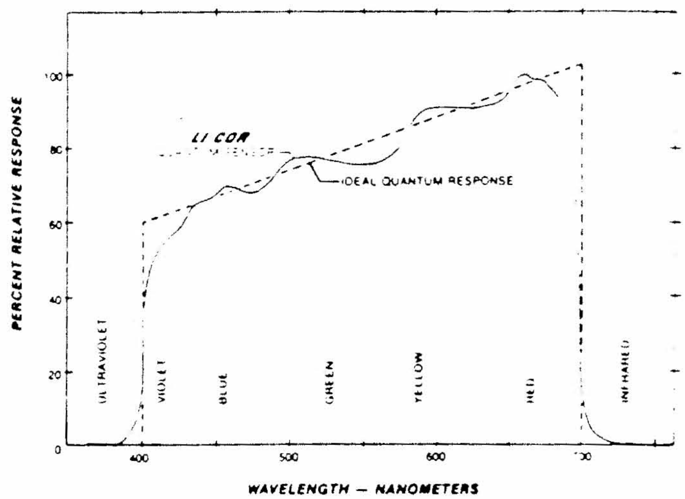


Figure 1. Typical spectral response of LI-COR Quantum Sensors vs. Wavelength and the Ideal Quantum Response (equal response to all photons in the 400-700 nm waveband). An interference filter (for sharp near infrared cutoff at 700 nm), and colored glass filters, tailor the silicon photodiode response to the desired quantum response.

LI-190SB Specifications

Absolute Calibration: ± 5% traceable to the U.S. National Bureau of Standards (NBS). See page 22.
Relative Error (spectral response): < ± 10% relative error for plant canopies; < ± 5% for standard growth chamber lighting (see Figure 1).
Sensitivity: Typically 8 μA per 1000 $\mu E\ s^{-1}\ m^{-2}$.
Millivolt Output: 5.0 mV per 1000 $\mu E\ s^{-1}\ m^{-2}$ using millivolt adapter (included).
Linearity: Maximum deviation of 1% up to 10,000 $\mu E\ s^{-1}\ m^{-2}$

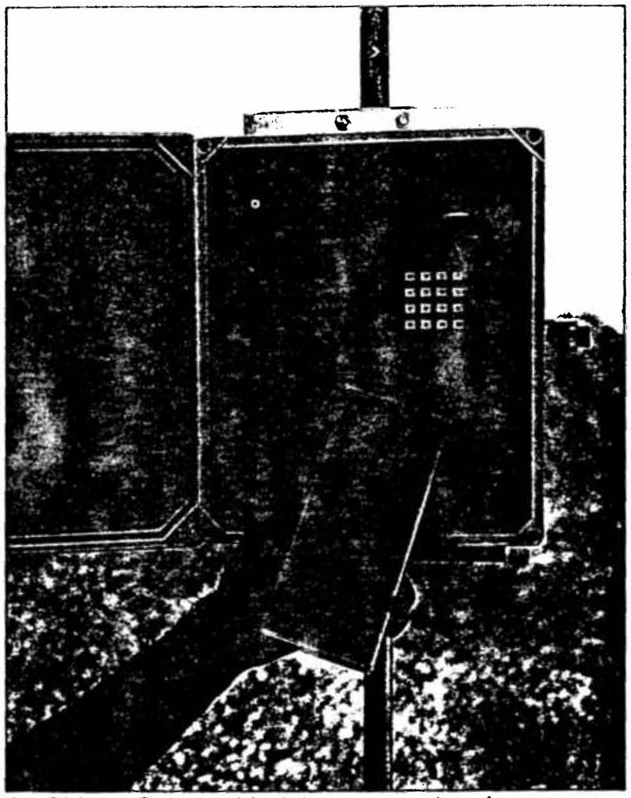
Common Sensor Specifications

(**LI-190SB** Quantum Sensor, **LI-200SB** Pyranometer Sensor, **LI-210SB** Photometric Sensor)

Stability: < ± 2% change over a 1 year period.
Response Time: 10 μs.
Temperature Dependence: ± 0.15% per °C maximum.
Cosine Correction: Cosine corrected up to 80° angle of incidence.
Azimuth: < ± 1% error over 360° at 45° elevation.
Tilt: No error induced from orientation.
Operating Temperature: −20 to 65 C
Relative Humidity: 0 to 100%.
Detector: High stability silicon photovoltaic detector (blue enhanced).
Sensor Housing: Weatherproof anodized aluminum case with acrylic diffuser and stainless steel hardware.
Size: 2.38 Dia. x 2.54 cm H (0.94" x 1.0")
Weight: 28 g (1 oz).
Cable Length: 1.5 m (5 ft)
Accessories: 2003S Mounting and Le[...] Fixture, 2222SB Extension Cable

SM192 & SM716 Storage Modules

The SM192 and SM716 Storage Modules are rugged data storage devices that supplement the internal data storage capacity of Campbell Scientific dataloggers (CR10, 21X, CR7, and BDR320). Storage modules are commonly used to transport data from the field site to the office.



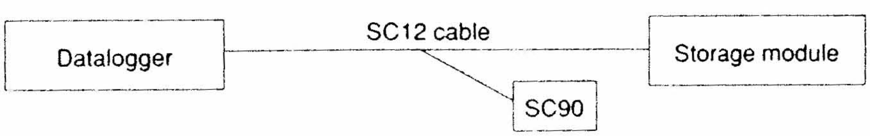
An SM716 Storage Module accepts data from a 21X Micrologger.

Features

- Stores 96,000 (SM192) or 358,000 (SM716) data points
- -35° to $+65^{\circ}$C operating range (-55° to $+85^{\circ}$C available as special order)
- Rugged, sealed, stainless steel packaging
- Battery-backed RAM data storage
- Stores up to eight datalogger programs; can automatically download CR10, 21X, or CR7 program on datalogger power-up
- Small size allows transport in large pocket or backpack

Connection to Datalogger

The storage module connects directly to a datalogger via an SC12 cable (supplied). The SC90 Line Monitor, which lights up during data transfer, may be added.



Field Use

Storage modules are typically mounted adjacent to the datalogger in a weather-resistant enclosure. While in the field, the storage module is powered by the datalogger's power supply. During transport or interruption of system power, an internal battery maintains the storage module's data and programs.

Data Transfer - Datalogger to Storage Module

Data transfer from datalogger to storage module is an attended or unattended operation.

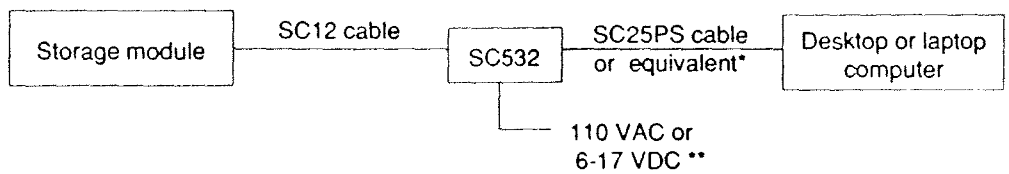
Attended: the user instructs the datalogger to transfer part or all of its data to an attached storage module by entering commands through a keyboard. The keyboard can be on-site (i.e., datalogger keyboard or laptop computer) or remote (i.e., computer using telecommunications).

Unattended: the datalogger is programmed to automatically send data to the storage module.

Data Transfer - Storage Module to Computer

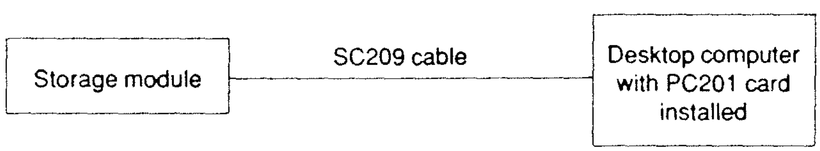
For IBM® Compatible Computers - Recommended Method

The SC532 interface converts the CMOS logic levels of the storage module to the RS-232 levels of the computer and provides power to the storage module. PC208 Datalogger Support Software is recommended for storage module communications, data transfer, data manipulation, report generation, and datalogger program editing.



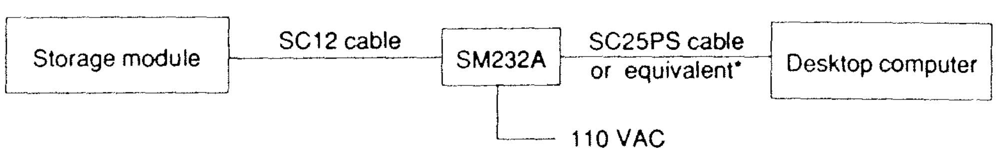
For IBM PC/XT/AT Compatible Computers - Alternate Method

A PC201 card may be used in an IBM compatible computer equipped with a full-size, industry-standard card slot. Due to cost considerations, this method is recommended only for users who presently own a PC201 card or require one for another purpose such as data download from cassette tape or unattended power-up of the computer. An SC209 cable and PC208 Datalogger Support Software are required.



For non-IBM Compatible Computers

The SM232A Storage Module interface and a commercially available terminal emulator program are used with non-IBM compatible computers. This method generally requires substantial understanding of computer and storage module communication protocols. However, some MacIntosh® computers have successfully run PC208 software in conjuction with SoftPC® (a product of Insignia Solutions, Burlington, MA); an application note on this procedure is available from Campbell Scientific.



*Requires 9-pin to 25-pin adapter cable for 9-pin serial ports

**Requires modification for DC operation

Memory Configuration

A storage module's memory is user-selectable as fill-and-stop or as ring (default). Fill-and-stop memory stores data until all available storage is filled. Ring memory continually accepts data from the datalogger; when the storage module is full, its oldest data are overwritten.

Memory Usage Calculations

An SM192 Storage Module stores 96,000 low-resolution data points (4 digits); an SM716 stores 358,000. High-resolution data points (5 digits) require twice as much space.

To estimate how soon your data will fill the storage module, first calculate the number of data points (dp) stored per day. Each Array ID (identifier for each output data string) and time-stamp constitute a data point, i.e., Array ID, date, and hour:minute are three data points. Assuming the datalogger stores 13 data points each hour and an additional eight data points each day, then:
(13 dp/hour x 24 hours/day) + (8 dp/day x 1/day) = 320 dp/day.

Next, divide the available number of storage module locations by the number of data points accumulated per day. In the case of the SM192 Storage Module, 96,000 locations/320 dp/day = 300 days.

Therefore, the data must be retrieved within 300 days to avoid losing data. In practice, the user is advised to retrieve data more frequently.

Use of Multiple Storage Modules

In data intensive applications, two storage modules can be connected to a 21X or CR7; up to eight to a CR10.

In a 21X or CR7 application, one storage module is generally configured as fill-and-stop and one as ring memory. Data are transmitted to both storage modules simultaneously; once full, the fill-and-stop storage module will refuse additional data while the ring memory module continues to store.

The CR10 can accommodate up to eight storage modules. As described above, individual storage modules are configured as either fill-and-stop or ring memory. In addition, each module can be addressed with a number ranging from one to eight. This feature allows the CR10 to direct specific data to a specific storage module.

Program Transfer Capability

A storage module can store up to eight datalogger programs. The programs reside in the storage module's battery-backed RAM; therefore, each stored program reduces available data storage.

Program transfer between the storage module and datalogger is generally accomplished in an attended mode through a keyboard. However, if the datalogger contains the appropriate PROMs, a program stored in the storage module's eighth program area will automatically download into the datalogger upon power-up. The datalogger checks the program for errors and begins executing the program. This allows the datalogger's program to be backed up, reducing the amount of data lost due to a temporary power loss.

Commonly Used Data Retrieval Methods

1) One storage module remains with the datalogger, stores data, then is replaced by a "fresh" storage module during a site visit. The "filled" module is returned to the office and downloaded to a computer.
2) A storage module is periodically taken to the site to "milk" data from the datalogger. Data from several dataloggers can be downloaded to a single storage module.
3) In applications with telecommunications, data are typically transferred directly between datalogger and computer. In these applications, storage modules provide on-site, independent backup of data and datalogger programs.
4) In CR10 applications, the storage module can be interrogated and its data downloaded to a remote computer via telecommunications. (Requires PC208's TELCOM version 6e or later and one of the following communication links: telephone, radio, cellular, multidrop, or shorthaul.)
5) Also in CR10 applications, both the CR10 and the storage module can be interrogated on-site by a battery-operated IBM compatible laptop computer through an SC32A Optically Isolated Interface.

SM192/716 Specifications

- **Storage capacity**
  SM192: 192,896 bytes (~96,000 low resolution Final Storage locations)

  SM716: 716,672 bytes (~358,000 low resolution Final Storage locations)
- **Power requirements**
  5 VDC supplied by the datalogger or SC532 on pin 1 of the 9-pin connector.
  Typical current drain:
  active and processing ..... 18 mA
  active but not processing .... 4 to 4.5 mA
  standby state ("asleep" but connected to datalogger) .... 250 µA
- **Internal battery**
  3.5 VDC lithium thionyl chloride battery. Expected battery life is 10 years for an SM192, 6 years for an SM716.
- **Memory configuration**
  User selectable as either fill-and-stop or ring style
- **File mark**
  A file mark is automatically placed in the data when the storage module is first connected to a datalogger (includes situations where power to the datalogger has been temporarily lost).
- **Baud rates**
  Supports all datalogger baud rates. Data transfer is typically 9600 or 19,200 baud; 76,800 baud in burst mode.
- **Operating temperature range**
  -35°C to +65°C, standard
  -55°C to + 85°C, on special order
- **Packaging**
  Sealed, stainless steel canister
- **Dimensions**
  7.8" x 3.5" x 1.5"
- **Weight**
  SM192: 1.5 lbs
  SM716: 1.9 lbs
- **SM192/716 shipped with:**
  SC12 cable
  User's manual

SC532 Specifications

- **Supply voltage**
  +6 VDC to 17 VDC; factory-installed 110 VAC to 7.5 VDC adapter
- **Output voltage to SM192/716**
  5 VDC ± 0.2 VDC
- **RS-232 output levels**
  High: +10 VDC ± 1 VDC
  Low: -10 VDC ± 1 VDC
- **RS-232 input levels**
  ± 30 V maximum
  Low threshold ≤ 0.8 V
  High threshold > 3.5V
  Input impedance > 3000 Ohms
- **Port Configuration**
  25-pin D-subminiature female configured as DCE. 9-pin D-subminiature female connects to the storage module through the SC12.
- **Operating temperature range**
  -25°C to +50°C
- **Dimensions**
  4.9" x 2.9" x 0.9"
- **Weight**
  0.9 lbs
- **SC532 shipped with:**
  SC12 cable
  User's manual

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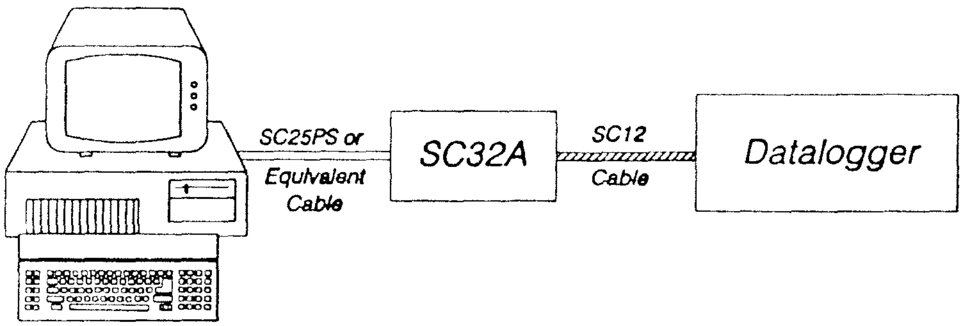
SC32A RS-232 Interface

for direct communication between datalogger and computer

The SC32A Optically Isolated Interface is required for direct communication between a Campbell Scientific datalogger (CR10, 21X, or CR7) and the serial port of a computer or printer. The SC32A isolates the computer's electrical system from the datalogger's, thereby protecting against ground loop, normal static discharge, and noise. The SC32A also converts the computer's RS-232 voltage levels to the CMOS levels of the datalogger. One SC32A can sequentially interface to multiple dataloggers, reducing system cost.



A standard 25-pin ribbon cable (CSI Model SC25PS or equivalent) is required. The SC25PS is approximately 4.5 feet in length; a customer-supplied equivalent cable can be up to 50 feet. If the computer has a 9-pin serial port, a DB9 to DB25 adapter cable is required (CSI Model 7026 or equivalent). For IBM® PC or compatible computers, Campbell Scientific's PC208 Datalogger Support Software supports data retrieval, datalogger program upload/download, and remote monitoring. PC210 "GraphTerm" software supports real-time graphical display of data.

SPECIFICATIONS

- Power
  Drawn from the serial ports of computer and datalogger
- Current (supplied by datalogger)
  ~1 µA quiescent; ~1 mA active
- Connections
  25-pin RS-232 female port configured as DCE
  9-pin port connects to datalogger through the SC12 cable
- Operating temperature range
  -25° to $+50^{\circ}$C
- Size
  2.25" x 1.0" x 3.5"
- Weight (shipping)
  0.25 lb (1 lb)
- SC32A shipped with
  SC12 cable

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Printed July 1992

PC208 DATALOGGER SUPPORT SOFTWARE
INSTRUCTION MANUAL

REVISION: 2/93

PC208 DATALOGGER SUPPORT SOFTWARE

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PRELIMINARY

8/93

TRIPOD-BASED
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1. Hourly Weather Report (SI units)
2. Daily Weather Report (SI units)
3. Daily Weather Report (Conventional units)

Note: Above reports are based on data obtained from the Pilot AWS installed at the TFHRC in McLean, Virginia.

Hourly Weather Report

Weathera
Hourly Weather Report

Julian Date (July 26)	Time	Ave Temp Deg C	Max Temp Deg C	Min Temp Deg C	Max RH%	Min RH%	Ave Solar W/m^2	Mean Wspd m/s	Mean WDIR Deg	Max Wspd m/s	Time Max WSPD	Dir Max WSPD	Total Rain mm
207	1700	28.35	28.99	27.82	55.82	49.78	316.7	2.415	167.4	5.913	1627	158.2	0
207	1800	27.89	28.23	27.55	57.02	52.63	151.9	2.039	158.5	4.573	1747	177.1	0
207	1900	27.27	27.65	27	60.54	55.56	74.5	1.512	138.3	3.299	1807	136.5	0
207	2000	26.44	27.25	26	65.99	58.81	37.42	2.018	141.2	4.737	1958	170.1	0
207	2100	26.16	26.29	26.05	65.13	61.14	3.595	2.492	158	5.063	2032	138.4	0
207	2200	25.68	26.11	25.34	67.4	62.41	0	2.425	155.1	5.39	2130	148.2	0
207	2300	25.25	25.4	25.13	69.73	66.67	0	2.436	151.1	5.031	2250	168.1	0
207	2400	25.01	25.22	24.75	72.5	69.13	0	2.635	162.9	5.88	2310	154.5	0
208	100	24.6	24.79	24.37	75.3	72.2	0	2.307	169.9	4.9	23	183	0
208	200	24.2	24.4	24.05	79.2	75.1	0	2.141	173.9	5.717	112	190.1	0
208	300	24.03	24.12	23.96	81.1	78.9	0	1.694	172.7	4.149	220	153.3	0
208	400	23.94	24.07	23.81	82.6	80.5	0	1.535	170.1	3.561	310	174.3	0
208	500	23.94	24.14	23.78	82.5	80.5	0	1.624	172.5	3.463	444	149.6	0
208	600	24.1	24.21	23.98	82.4	79.9	.034	.966	172.4	3.234	530	175.5	0
208	700	24	24.09	23.94	82.2	80.9	4.531	.599	171.4	2.94	621	161.5	0
208	800	24.11	24.4	23.94	83	81.3	39.02	.485	192.6	2.875	749	168.2	0
208	900	25.18	25.8	24.39	82.4	76.7	200.3	.688	187.9	3.005	825	171	0
208	1000	26.63	27.32	25.75	78.4	70.3	429.8	.872	296.4	3.136	913	316.6	0
208	1100	28.53	29.6	27.32	73.3	55.96	705	.988	293.9	3.332	1023	294.3	0
208	1200	30.09	31.36	29.01	63.73	41.92	808	.803	278.4	2.973	1124	309.7	0
208	1300	31.18	32.17	30.34	52.89	40.66	906	.931	277.3	3.005	1238	301.1	0
208	1400	32.3	33.16	31.43	49.16	32.61	903	.899	289	2.744	1327	285	0
208	1500	33.13	33.95	32.48	45.63	31.94	889	1.112	283.5	3.397	1416	275.3	0
208	1600	33.93	34.89	33.22	41.64	30.88	776	.938	284.1	2.711	1557	293.8	0
208	1700	33.58	34.1	33.04	44.08	32.27	600	.953	291.1	2.319	1602	312.4	0
208	1800	34.04	34.61	33.16	44.75	30.87	451.6	.562	280.1	1.927	1702	294.8	0
208	1900	31.52	33.16	30.42	60.96	41.76	210.5	.331	295.3	1.045	1809	297.6	0
208	2000	29.29	31.1	27.73	69.55	48.88	74.3	.502	293.5	1.731	1919	293.3	0
208	2100	27.38	27.74	27.04	71.9	61.38	5.074	.218	289.9	.882	2003	291.6	0
208	2200	26.41	27.05	25.74	78.4	65.25	0	.288	298.5	1.078	2104	291.9	0
208	2300	25.28	25.77	24.73	83.8	78.4	0	.243	300	.915	2201	302.1	0
208	2400	24.62	25.05	24.13	86.6	82.4	0	.277	301.3	1.209	2324	287.4	0
209	100	24.01	24.35	23.49	88.4	85.2	0	.179	302.2	1.045	37	294.6	0
209	200	23.09	23.5	22.69	88.8	86.1	0	.195	296.6	.817	143	298.8	0
209	300	22.55	22.95	22.04	87	82.7	-.001	.198	299.5	.849	259	287.6	0
209	400	22.17	22.36	21.97	85.4	73.4	0	.313	289.6	1.013	311	283.9	0
209	500	21.68	22.05	21.36	84.9	79.6	0	.024	295.4	.425	457	295.4	0
209	600	21.03	21.37	20.62	88	84.8	.266	.147	295.3	.719	545	295.3	0
209	700	20.99	22.85	20.42	87.7	75.4	30.79	.139	295.5	.751	620	295.4	0
209	800	23.7	25.58	22.86	77.4	62.19	178.4	.226	298.8	1.078	745	305	0
209	900	26.66	27.5	25.57	64.18	58.26	329.8	.515	296.7	1.535	858	283.3	0
209	1000	28.41	29.73	27.35	65.89	50.71	566.9	.739	289.9	2.711	914	285.8	0
209	1100	30.35	31.63	29.63	55.43	41.47	729	.775	295.8	3.593	1004	300.4	0
209	1200	31.41	32.55	30.75	51.5	38.07	854	.829	289.1	2.646	1102	293.7	0
209	1300	32.87	33.53	32.37	50.03	37.6	922	.788	298.5	2.842	1251	284.6	0
209	1400	33.77	34.67	32.93	46.36	33.4	938	.964	290.1	3.463	1331	290.4	0
209	1500	34.93	35.96	34.32	45.15	32.86	890	.991	293.8	3.103	1445	313.3	0
209	1600	35.64	36.19	35.15	42.62	30.94	748	.717	288.8	2.352	1553	294.3	0
209	1700	35.27	36.38	34.04	49.13	32.73	499	.638	276.6	1.862	1602	271	0
209	1800	35.41	36.21	34.64	44.75	35.92	355.9	.358	245.1	2.515	1726	172.4	0

TFHRC Hourly Weather Report

Julian Date	Time	Ave Temp Deg C	Max Temp Deg C	Min Temp Deg C	Max RH%	Min RH%	Ave Solar W/m^2	Mean Wspd m/s	Mean WDIR Deg	Max Wspd m/s	Time Max WSPD	Dir Max WSPD	Total Rain mm
209	1900	34.37	35.02	33.51	50.19	39.44	218.9	.629	193	3.463	1818	163.7	0
209	2000	32.65	33.5	31.86	51.92	43.55	64.21	.404	190	2.548	1903	179.7	0
209	2100	31.33	32.06	30.27	53.08	46.35	4.283	.347	182.8	2.287	2025	174.7	0
209	2200	30.16	30.34	29.86	54.28	49.96	0	.214	180.5	1.993	2115	176.2	0
209	2300	29.47	30.59	28.03	60.61	48.9	0	.406	171.5	2.156	2214	178	0
209	2400	28.73	29.32	28.27	59.54	52.63	0	.642	174.4	2.613	2350	167	0
210	100	28.56	29.23	27.9	61.01	53.5	0	.491	170.7	2.254	6	186.8	0
210	200	26.88	28.13	26.23	69.91	60.21	0	.077	69.7	1.045	101	100	0
210	300	26.12	27.07	25.07	71.2	54.76	0	1.042	310.4	6.076	218	280.7	0
210	400	24.38	25.09	23.84	68.46	60.82	0	.473	315.8	3.136	304	288.5	0
210	500	22.86	23.91	21.79	86.1	66.47	-.003	.785	294.5	3.234	415	310.6	0
210	600	21.56	21.8	21.33	89	84.2	.024	.276	285.4	2.254	508	306.6	0
210	700	21.4	21.66	21.2	90.2	86.7	9.03	.534	273.4	2.646	634	283.6	0
210	800	22	23.02	21.6	88.1	80.2	66.02	.578	242.8	2.711	734	184.5	0
210	900	23.92	24.7	22.98	82.3	72.4	226.9	.938	257.3	3.463	818	184.7	.254
210	1000	23.95	25.61	23.28	83.5	68.42	289.5	1.15	302.2	4.508	946	313.7	0
210	1100	27.15	28.37	25.53	72.7	58.71	722	1.295	297.3	4.247	1015	321.4	0
210	1200	29.84	31.44	28.34	64.28	51.24	877	1.326	299.4	4.018	1131	312.9	0
210	1300	31.36	32.3	30.22	59.81	38.27	776	1.328	293.8	5.031	1242	304.5	0
210	1400	32.64	33.82	32.1	47.37	36.21	966	1.795	299.2	7.61	1337	322.3	0
210	1500	33.25	33.59	32.82	44.03	33.47	912	1.807	296.1	6.795	1441	295.7	0
210	1600	33.98	34.75	33.46	42.44	26.82	816	1.509	291.7	4.998	1504	294	0
210	1700	33.96	34.44	33.52	37.51	26.62	672.8	1.41	289.4	6.043	1611	290.5	0
210	1800	33.15	34.06	32.58	36.91	28.15	493.5	1.65	296.3	5.684	1709	300.8	0
210	1900	31.78	32.58	30.36	39.78	32.66	271.3	1.327	294.6	4.998	1850	300.1	0
210	2000	29.52	30.42	28.57	42.38	35.2	72.4	.852	288.2	3.005	1919	268.7	0
210	2100	27.89	28.76	27.38	43.85	38.73	6.061	.673	289.4	2.875	2057	291.1	0
210	2200	26.19	27.41	24.78	55.29	41.53	0	.309	284.8	1.927	2100	303.1	0
210	2300	23.97	24.8	23.06	64.54	50.57	0	.193	290.7	.686	2258	290.9	0
210	2400	22.39	23.09	21.93	69.35	59.23	0	.188	290.6	.98	2347	294.4	0
211	100	22.23	22.75	21.61	68.77	59.98	-.003	.1	295.1	.817	45	295.6	0
211	200	21.72	22.05	21.4	71.8	64.38	-.004	.044	301.3	.653	119	301.3	0
211	300	21.37	21.92	20.62	74.1	66.31	-.005	.232	300	.882	249	295.3	0
211	400	20.49	20.76	20.16	75.8	71.2	-.006	.204	295.5	.751	324	295.3	0
211	500	19.8	20.25	19.4	80.1	74	-.013	.238	295.4	.947	422	295.5	0
211	600	19.12	19.43	18.86	82.8	78.3	.232	.181	292.8	.784	520	294.4	0
211	700	19.15	20.01	18.79	83.4	76	31.24	.371	291.7	.849	643	292.2	0
211	800	21.49	23.36	20	77.8	66.26	170.9	.372	293	.98	747	295.9	0
211	900	24.85	25.91	23.36	67.59	52.34	332.9	.631	294.4	2.613	850	306.5	0
211	1000	26.56	27.18	25.88	56.53	48.06	568.4	1.233	295.6	3.822	930	285.2	0
211	1100	27.46	27.86	26.69	53.71	34.76	755	1.811	288.8	6.599	1035	304.2	0
211	1200	28.2	28.89	27.71	43.86	31.63	881	1.865	297.9	6.501	1115	313.5	0
211	1300	28.73	29.46	28.17	41.14	30.84	952	1.786	298.6	6.239	1236	297.6	0
211	1400	28.85	29.76	28.06	41.06	30.83	926	2.062	294	6.795	1331	303.6	0
211	1500	28.81	29.67	27.9	42.85	32.62	789	1.651	294	5.521	1415	304.5	0
211	1600	28.68	29.67	27.18	44.64	33.48	727	1.663	295.2	6.599	1506	296.9	0
211	1700	27.81	28.7	26.91	45.31	36.87	625.7	1.619	298.4	5.717	1658	283.3	0
211	1800	26.93	27.72	26.19	45.64	38.93	365.9	1.787	294.9	6.174	1716	309.9	0
211	1900	26	26.78	25.08	47.91	41.53	242.5	1.663	295.1	6.762	1836	305	0
211	2000	24.37	25.32	23.79	52.3	45.46	66.97	1.237	292.6	5.423	1945	294.4	0

TFHRC Hourly Weather Report

Julian Date	Time	Ave Temp Deg C	Max Temp Deg C	Min Temp Deg C	Max RH%	Min RH%	Ave Solar W/m^2	Mean Wspd m/s	Mean WDIR Deg	Max Wspd m/s	Time Max WSPD	Dir Max WSPD	Total Rain mm
211	2100	23.3	23.81	22.77	55.11	50.31	4.575	.929	290	3.659	2004	322.5	0
211	2200	22.04	22.79	21.53	62.04	54.72	-.004	.58	272.1	3.724	2158	311.5	0
211	2300	21.74	21.91	21.52	61.18	57.19	-.012	1.23	289.8	3.985	2205	271.7	0
211	2400	21.34	21.53	21.16	62.19	58.4	-.014	.864	290.8	3.561	2301	286.9	0
212	100	21.16	21.37	20.92	62.39	59.26	-.009	1.148	291.5	3.201	20	311.8	0
212	200	20.63	20.94	20.16	67.78	61.92	-.006	.898	287.5	2.809	121	302.6	0
212	300	19.78	20.17	19.46	69.98	66.85	-.006	.42	277.6	1.699	228	282	0
212	400	19.07	19.48	18.87	73.9	69.18	-.015	.608	286	2.156	300	348.4	0
212	500	19	19.17	18.64	75.4	71.6	-.025	.265	280.3	2.156	400	300.1	0
212	600	18.51	18.73	18.18	79.2	74.5	.013	.152	287.1	1.045	513	288	0
212	700	19.06	19.44	18.72	79.6	75	13.08	.156	291	.882	630	290.9	0
212	800	19.86	20.05	19.43	78.3	74.1	51.92	.269	278	1.241	759	283.5	0
212	900	20.33	21.27	19.92	78.8	69.45	110	.623	289.7	2.417	854	296.4	0
212	1000	22.53	23.49	21.27	73.8	59.86	292	.771	292.6	2.711	954	285.6	0
212	1100	23.31	23.55	23.03	66.18	58.85	279.7	.942	293.6	3.855	1036	291	0
212	1200	23.92	24.72	23.49	65.16	53.92	394.9	.82	288.3	3.299	1127	299.5	0
212	1300	25.74	26.72	24.7	62.9	48.33	722	.893	294.2	3.103	1246	295.2	0
212	1400	25.66	26.14	25.22	61.28	49.78	364.7	.825	271.9	4.083	1351	282.3	0
212	1500	26.51	27.53	25.7	58.42	47.12	599.2	1.424	292.6	4.41	1448	301.5	0
212	1600	27.38	28.2	26.31	54.89	44.39	526.8	1.016	284.2	4.345	1505	316.5	0
212	1700	28.05	28.91	27.1	53.5	41.13	608.7	1.171	291.5	3.92	1617	301.6	0
212	1800	27.13	28.41	26.61	54.89	42.93	231.7	.769	284.9	3.332	1700	277	0
212	1900	25.46	27.21	24.74	64.2	49.18	73.5	.502	284.1	2.319	1800	278.8	0
212	2000	24.98	26.28	23.74	71.5	53.36	65.23	.41	281.8	1.241	1950	287.2	0
212	2100	23	23.84	22.29	76.4	65.99	3.68	.302	283.9	1.045	2045	295	0
212	2200	21.95	22.32	21.69	78.3	73.3	0	.192	293.9	.849	2113	290.5	0
212	2300	21.41	21.83	20.87	79.6	74.9	-.002	.235	297.2	.915	2211	297.2	0
212	2400	20.33	20.89	19.92	84.3	78.9	-.003	.244	297.2	.882	2345	297.2	0
213	100	19.77	19.99	19.3	86.3	83.3	-.012	.33	297.2	.915	100	297.2	0
213	200	19.1	19.31	18.87	89.5	86.1	-.02	.253	297.2	.915	100	297.2	0
213	300	18.71	18.95	18.24	92.3	88.8	-.045	.319	297.1	.784	233	297.2	0
213	400	18.4	18.53	18.15	92.4	90.4	-.055	.174	297.2	.817	301	297.1	0
213	500	18.31	18.44	18.05	92.1	90.5	-.048	.222	297.2	.751	445	297.1	0
213	600	18.17	18.38	17.96	91.9	90	.048	.242	297.2	.849	557	297.2	0
213	700	18.16	18.92	17.93	91.9	87	29.25	.317	296.9	1.078	622	297.1	0
213	800	19.68	21.17	18.91	87.1	78.4	84.8	.16	297.1	.915	700	302.1	0
213	900	23.05	24.26	21.17	80.6	64.46	337.4	.458	336.3	1.339	851	74.6	0
213	1000	25.21	26.83	24.08	69.51	56.66	557.2	.747	282.1	2.287	940	285.1	0
213	1100	27.54	28.12	26.83	62.44	51.05	738	.864	294.3	3.103	1053	302.7	0
213	1200	28.49	29.21	27.89	55.5	46.25	866	1.129	245.9	3.43	1141	296.1	0
213	1300	29.53	30.29	28.65	54.16	40.06	961	1.205	281.2	3.495	1223	297.8	0
213	1400	30.41	31.11	29.74	46.57	37.2	926	1.073	273	3.299	1354	307.8	0
213	1500	31.34	32.13	30.53	45.44	32.88	811	.877	292	3.463	1444	305.1	0
213	1600	30.77	31.4	30.1	49.41	31.61	607.2	.959	281.9	2.319	1546	300.8	0
213	1700	30.74	31.7	29.56	47.95	31.68	429.2	.767	294.6	2.025	1624	301	0
213	1800	30.67	31.87	29.28	57.38	33.74	372.5	.539	285.9	2.581	1735	148.5	0
213	1900	29.88	30.91	28.8	59.05	40.26	254.4	.832	246	3.136	1856	164.7	0
213	2000	28.77	30.68	27.66	56	40.66	36.89	.484	208.7	3.299	1902	155.7	0
213	2100	26.37	27.68	25.55	60.14	50.29	3.358	.257	269.2	1.601	2008	156.2	0
213	2200	25.67	26.15	25.25	61.74	54.16	0	.183	244.7	1.405	2156	201.8	0

Julian Date	Time	Ave Temp Deg C	Max Temp Deg C	Min Temp Deg C	Max RH%	Min RH%	Ave Solar W/m^2	Mean Wspd m/s	Mean WDIR Deg	Max Wspd m/s	Time Max WSPD	Dir Max WSPD	Total Rain mm
213	2300	25.56	26.17	25.1	62.88	56.3	0	.326	167.7	1.895	2257	142.5	0
213	2400	25.55	26.18	23.97	73.1	57.96	0	.654	156.8	2.058	2316	144.7	0
214	100	23.39	23.97	22.74	79.5	72.1	-.002	.265	294	1.111	3	190.9	0
214	200	22.29	22.74	21.99	83	79	-.002	.101	302.5	.653	116	305.6	0
214	300	21.42	22.02	20.85	88.3	82.8	-.009	.293	301.7	.817	217	301.4	0
214	400	20.61	20.89	20.38	90	87.5	-.015	.216	295.6	.882	315	291.2	0
214	500	20.82	21.66	20.64	88	77	-.012	.182	286.7	1.241	456	137.9	0
214	600	20.28	21.48	19.66	88.3	80.6	.101	.26	301.3	.915	534	294.2	0
214	700	19.57	20.24	19.28	88.7	83.8	26.47	.245	297.7	.784	613	298.2	0
214	800	22.33	23.76	20.24	83.8	64.33	170.7	.606	197.9	2.417	738	179.6	0
214	900	25	26.08	23.75	66.39	56.26	333.3	.562	266.6	2.058	804	162.4	0
214	1000	27.17	28.2	26.03	61.58	51.05	563.1	.727	135	2.156	929	147.9	0
214	1100	29.23	30.5	28.1	56.17	42.86	661.1	.773	246.6	2.581	1024	160.7	0
214	1200	30.92	31.59	29.99	49.71	35.35	762	1.234	174.6	4.639	1115	169.6	0
214	1300	32.11	33	31.46	40.52	31.62	797	1.402	174.9	5.194	1240	161.6	0
214	1400	33.09	34.07	32.3	40.12	30.02	905	1.44	176.6	5.913	1339	173.8	0
214	1500	31.79	34.16	24.07	83	30.28	357.5	1.533	222.2	6.697	1451	317.5	6.858
214	1600	23.87	25.61	22.32	93	74.9	373.2	.474	10.25	2.515	1519	92.2	5.08
214	1700	25.01	25.33	24.76	85.9	75.2	223.7	.652	99	2.319	1647	140.2	0
214	1800	25.35	26.93	24.69	86.9	68.72	190.8	.27	134.4	1.797	1706	149.1	0
214	1900	27.19	27.96	26.29	83.2	66.07	227.5	.282	122.7	1.829	1804	170.4	0
214	2000	26.39	27.95	24.69	87.5	65.59	71.1	.231	310.1	.882	1936	307.8	0
214	2100	23.68	24.7	22.99	92.5	85.3	2.76	.418	288.4	.947	2012	285.7	0
214	2200	22.7	23.02	22.27	92.2	85.4	-.002	.31	288.4	.817	2104	288.3	0
214	2300	21.88	22.37	21.42	89.2	83	-.007	.216	288.4	.784	2216	288.3	0
214	2400	21.17	21.46	20.91	90.7	87.8	-.011	.241	288.4	.98	2317	288.4	0
215	100	20.79	21.02	20.62	91.1	89.1	-.01	.256	288.8	.849	15	288.3	0
215	200	20.73	21.02	20.6	92.1	90.5	-.019	.214	294.5	1.143	159	292.1	0
215	300	21.2	21.57	20.9	92.3	88.7	-.027	.214	285.6	1.241	208	310.1	0
215	400	21.03	21.26	20.73	92.3	90.7	-.027	.235	279.6	1.045	312	278.6	0
215	500	20.39	20.74	20.15	93.7	92.1	-.02	.367	283	.849	405	283	0
215	600	20.46	20.82	20.16	93.8	90.7	.052	.311	284.1	.882	528	283.3	0
215	700	20.78	21.31	20.5	92.6	88.3	12.4	.227	284.6	1.013	606	284.3	0
215	800	21.62	22.13	21.28	89.7	85.5	44.24	.322	302.9	1.209	754	289.4	0
215	900	22.8	23.11	22.12	88.4	80.1	106.1	.321	281.2	1.274	849	284.5	0
215	1000	24.99	27.52	22.75	86.5	57.32	422.6	.553	302.2	1.699	918	331.4	0

TFHRC Daily Weather Report

Julian Date	Time	Ave Temp Deg C	Max Temp Deg C	Min Temp Deg C	Max RH%	Min RH%	Ave Solar W/m^2	Mean Wspd m/s	Mean WDIR Deg	Max Wspd m/s	Time Max WSPD	Dir Max WSPD	Total Rain mm	Battery VDC
207	2400	26.48	28.99	24.75	72.5	49.78	70	2.245	154.1	5.913	1627	158.2	0	12.93
208	2400	27.75	34.89	23.78	86.6	30.87	291.7	.915	249.2	5.717	112	190.1	0	12.96
209	2400	28.78	36.38	20.42	88.8	30.94	305.4	.474	275	3.593	1004	300.4	0	12.96
210	2400	27.45	34.75	21.2	90.2	26.62	299	.917	290.8	7.61	1337	322.3	.254	12.98
211	2400	24.21	29.76	18.79	83.4	30.83	310	1.015	293.3	6.795	1331	303.6	0	13.02
212	2400	22.7	28.91	18.18	84.3	41.13	180.7	.627	287.5	4.41	1448	301.5	0	13.03
213	2400	24.99	32.13	17.93	92.4	31.61	292.2	.557	280.3	3.495	1223	297.8	0	13.03
214	2400	24.89	34.16	19.28	93	30.02	236	.539	271.2	6.697	1451	317.5	11.94	13.04

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Daily weather Report

TFHRC Daily Weather Report

Julian Date	Time	Ave Temp Deg F	Max Temp Deg F	Min Temp Deg F	Max RH%	Min RH%	Ave Solar W/m^2	Mean Wspd mph	Mean WDIR Deg	Max Wspd mph	Time Max WSPD	Dir Max WSPD	Total Rain in	Battery VDC
207	2400	79.664	84.182	76.55	72.5	49.78	70	5.0221	154.1	13.227	1627	158.2	0	12.93
208	2400	81.95	94.802	74.804	86.6	30.87	291.7	2.0469	249.2	12.789	112	190.1	0	12.96
209	2400	83.804	97.484	68.756	88.8	30.94	305.4	1.0603	275	8.0375	1004	300.4	0	12.96
210	2400	81.41	94.55	70.16	90.2	26.62	299	2.0513	290.8	17.024	1337	322.3	.00991	12.98
211	2400	75.578	85.568	65.822	83.4	30.83	310	2.2706	293.3	15.2	1331	303.6	0	13.02
212	2400	72.86	84.038	64.724	84.3	41.13	180.7	1.4026	287.5	9.8652	1448	301.5	0	13.03
213	2400	76.982	89.834	64.274	92.4	31.61	292.2	1.246	280.3	7.8183	1223	297.8	0	13.03
214	2400	76.802	93.488	66.704	93	30.02	236	1.2057	271.2	14.981	1451	317.5	.46566	13.04

english Daily weather Report In Engl.

APPENDIX C

AUTOMATED WEATHER STATION SPECIFICATIONS
(As Developed by Campbell Scientific, Inc.)

CAMPBELL SCIENTIFIC, INC.

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Campbell Scientific, Inc.

Automated Weather Station Specifications

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Campbell Scientific, Inc.

Automated Weather Station
Specifications

Overview
Campbell Scientific has been producing research grade dataloggers for over eighteen years. Our commitment to quality is evidenced in the design and workmanship of the CR10 Measurement and Control System. Tailored for demanding field use, the CR10 features durable components, compact size, low power consumption, and wide temperature operating range.

Every CR10 produced is calibrated and thoroughly tested to ensure consistent, dependable performance. Adherence to specifications over the -25 to +50 °C is verified using voltage and frequency references independently calibrated and traceable to the National Institute of Standards and Technology (NIST). A test report and calibration certificate is provided with each unit. Functional testing is performed over a -35 to +60 °C range.

The CR10 is supported by a number of measurement, control and data retrieval peripherals. Its on-board instruction set and user-selectable input ranges allow direct connection of most meteorological sensors without the need for external signal conditioning.

CR10 Measurement & Control Module Specifications

The programmable CR10 Measurement and Control Module provides sensor measurement, timekeeping, and data processing / reduction capabilities for the weather station. Sensor connections are made directly to the CR10WP Wiring Panel; the CR10's inputs can easily accommodate the number of sensors required in a standard weather station configuration. The CR10 stores up to 29,900 raw or processed data points in on-board memory; data may also be directed to a connected storage module for back-up and for eventual retrieval. OS10-0.1 Software is the standard CR10 PROM for weather station applications; it also contains programmable security to ensure the integrity of programs and data.

1.0 Program Execution Rate

System tasks initiated in sync with real-time up to 64 Hz. One measurement with data transfer is possible at this rate without interruption. A single input may be measured over short intervals at rates up to 750 Hz using Burst Measurement.

2.0 Analog Inputs

The CR10's contain 12 single-ended or 6 differential analog input channels. Any pair of single-ended input can be configured as a differential channel. The datalogger has the capability for analog input channel expansion via the Model AM416 Multiplexer. The AM416 Multiplexer allows an additional 32 differential channels to multiplex into 2 CR10 differential channels. Up to three AM416's can be connected to one CR10.

Differential Common Mode Range: ± 2.5 Volts

Software selectable:	Input ranges	Gains
	± 2.5 mV	1000
	± 7.5 mV	333.3
	± 25 mV	100
	± 250 mV	10
	± 2500 mV	1

Accuracy of Voltage Measurements:	0.2 % Full Scale Range (-25 to +50 °C) 0.1 % of Full Scale Range (0 to +40 °C)
Analog to Digital Resolution:	13 bits

3.0 Voltage Excitation Outputs

The CR10 has three precision switched excitation outputs. Excitation voltage is programmable to the nearest millivolt. Excitation Outputs: ± 2.5 Volts

Output Current: 20 mA @ ± 2.5 Volts
35 mA @ ± 2.0 Volts
50 mA @ ± 1.5 Volts

A swept frequency, square wave output between 0 and 2.5 volts is provided for vibration wire pressure transducers. Timing and frequency range are specified by the instruction.

4.0 Resistance and Conductivity Measurements

The accuracy of the CR10's bridge measurements are equal to 0.015% of full scale bridge output, limited by the matching bridge resistors. The excitation voltage should be programmed so the bridge output matches the full scale input voltage range.

The CR10 can measure 6-wire and 4-wire full bridge, 4-wire, 3-wire, and 2-wire half bridges. Bridge measurements are ratiometric and dual polarity to eliminate thermal emf. AC resistance measurements use a dual polarity 0.75ms excitation pulse for ionic depolarization, with the signal integration occurring over the last 0.25 ms.

5.0 Period Averaging Measurements

Period Averaging is the time period for a specified number of cycles of an input frequency is measured, then divided by the number of cycles to obtain the average period of a single cycle.

The input is any single-ended analog channel; single dividing or AC coupling is normally required.

Input Frequency Range:

Range Code	Peak to Peak Volts Required @ Max Freq.*	Maximum Frequency
1	2 mV	8 kHz
2	3 mV	20 kHz
3	12 mV	50 kHz
4	2000 mV	200 kHz

* The AC voltage must be centered around the CR10 ground

Reference Accuracy: (-25 to 0 °C) ± 80 ppm
(0 to +50 °C) ± 30 ppm

Resolution: ± 100 nanoseconds divided by the number of cycles measured. Resolution is reduced by signal noise and for signals with a slow transition though the zero voltage threshold.

Time Required for Measurement: Signal period times the number of cycles measured plus 1.5 cycles.

6.0 Pulse Counters

The CR10 has 2 pulse counter inputs. Each can be configured to accept a switch closure, high frequency pulse, or low level AC signals. Maximum input frequency is 2000 Hz on the high frequency pulse and 1000 Hz on the low level AC mode.

Low Level AC Mode:	Minimum AC Input Voltage:	6 mV RMS
	Maximum AC Input Voltage:	20V RMS

In addition the CR10 can measure a relay closure for the tipping bucket rain gage on Digital I/O Port 7 or 8, and it can time stamp exactly when each tip of the bucket occurred.

7.0 Digital I/O Ports

The CR10 has 8 Digital I/O Ports that are software selectable as binary inputs or control outputs. With optional software, the CR10 can send and receive serial data through the control ports.

Output Voltages (no load):	high 5.0 V ± 0.1V low < 0.1 V.
Output Resistance:	500 Ohms
Input State:	high 3.0 to 5.5V low -0.5V to 0.8V
Input Resistance:	100,000 Ohms

8.0 Transient Protection

All input and output connections to the CR10 module are protected using RC filters or transzorbs connected to a heavy copper bar between the circuit card and the case. The CR10WP Wiring Panel includes additional spark gap and transzorb protection.

9.0 CPU and Interface

The CR10 uses a Hitachi 6303 Microprocessor and has 32K of ROM and 64K RAM Memory. The peripheral interface consists of a 9 pin D-type connector for keyboard display, storage module, modem, printer, card storage module, and RS232 adapter. Baud rates selectable at 300, 1200, 9600 and 76,800. ASCII communication protocol is one start bit, one stop bit, eight data bits (no parity).

The accuracy of the CR10 clock is ± 1 minute per month.

10.0 System Power Requirements

The CR10 can be powered by any 9.6 to 16 VDC source. The typical current drain of the CR10 is as follows:

Quiescent:	0.7 mA
During Processing:	13 mA
During Analog Measurement:	35 mA

11.0 Packaging

The CR10's electronics are RF shielded by a sealed, stainless steel canister and internal RF shield. The physical dimensions are outlined below:

Measurement & Control Module:	7.8" x 3.5" x 1.5"
(with CR10WP Wiring Panel):	9.0" x 3.5" x 2.9"
Weight:	2 lbs.

12.0 Programming

The CR10's ability to make measurements, calculations, and logical decisions originates from its internal programming. Features such as user programmable sampling and reporting intervals, user selectable analog input gains and output processing capability are standard in the CR10's PROM. The standard CR10 contains 30 measurement instructions, 43 processing / math instructions, and 15 program control instructions.

Specific Examples of processing instructions include:

5th Order Polynomial
Spatial Maximum / Minimum
Averaging
Pulse Counting
Maximize / Minimize
Wind Vector
Standard Deviation
Histogram

13.0 Meteorological Applications

The CR10 is designed for long-term climatological monitoring, meteorological research, and routine weather measurement applications. Standard CR10 outputs include wind vector averaging, sigma theta, histograms, saturation vapor pressure, and vapor pressure from wet/dry bulb temperatures.

Typical meteorologic measurements that the CR10 can measure with available sensors:

Wind Speed is measured with voltage, photo-chopped, switch closure, or magnetic pulse type anemometers. Expansion peripherals allow wind profile studies.

Wind Direction is measured by a precision potentiometer wind vane.

Meteorological Measurements continued...

Solar Radiation is measured with a silicon cell or thermopile pyranometer.

Temperature sensors include thermistors, thermocouples, RTD's, or silicon types.

Relative Humidity is measured with wet/dry bulb psychrometers, AC resistive sensors, strain gage or capacitive sensors. Capacitive probes include signal conditioning.

Dewpoint is calculated from temperature and relative humidity data or measured by cooled mirror or lithium chloride sensors. Dew point sensors require external power.

Precipitation data is provided by a tipping bucket switch closure rain gage or a weighing gage.

Snow Depth can is provided by an acoustic sensor which measures the elapsed time between emmission, reflection and return of an ultrasonic pulse. An air temperature sensor is required to correct for variations in the speed of sound.

Evaporation is measured with standard pans or lysimeters fitted with a potentiometer or strain gage.

Barometric Pressure is sensed by capacitance or strain gage pressure transducers.

Soil Water Potential is obtained using AC conductivity moisture blocks or analog output tensiometers.

14.0 Meteorological Instruments Specifications & Instrument Mounts provided by Campbell Scientific

A. Air Temperature & Relative Humidity

The **Model HMP35C** is an integrated Temperature and Relative Humidity (RH) sensor in one probe intended for measurement of Temperature and RH in the atmosphere.

Air Temperature
The temperature sensor is a BetaTherm Corporation interchangeable thermistor in a half bridge configuration. Sensor resistance in linearized in the CR10 and output is in default engineering units of degrees Celsius.

Relative Humidity
The RH sensor is a capacitive sorption sensor with a range of 0 to 100% RH. Sensor output is a voltage proportional to RH.

Specifications

Vaisala Model HMP35C Specifications

<u>Temperature</u>

Thermistor	Betatherm Corp.
Measurement range	-35^{o}C to +50^{o}C
*Accuracy	± 0.25^{o}C

*RMS sum of thermistor interchangeability, linearization, and bridge resistor tolerance.

Model LI200S Specifications

Stability:	< ± 2% change over a 1 year period
Response Time:	10 microseconds
Temperature Dependence:	0.15% per °C maximum
Cosine Correction:	Cosine corrected up to 80° angle of incidence
Operating Temperature:	-40 to +65°C
Relative Humidity:	0 to 100%
Detector:	High stability silicon photovoltaic detector (blue enhanced)
Sensor Housing:	Weatherproof anodized aluminum case with acrylic diffuser and stainless steel hardware.
Size:	0.94 in. dia. x 1.00 in. H (2.38 x 2.54 cm)
Accuracy:	Absolute error in natural daylight is ± 5% maximum, ± 3% minimum
Sensitivity:	Typically 80 microamps per 1000 Wm^{-2}
Linearity:	Maximum deviation of 1% up to 3000 Wm^{-2}
Shunt Resistor:	100 Ohms
Light Spectrum Waveband:	400 to 1100 nm

D. Rainfall

The **Model 380** and **385** tipping bucket rain and snow gages offer an accurate method to continuously measure precipitation. Model 380 measures rain only; Model 385 electrically heated snow gage provides year-round measurement of rain or snow. The 385 gage requires an adequately grounded, reliable source of 110 VAC power.

The gages feature a 12-inch diameter orifice that funnels precipitation into the tipping bucket assembly. When the tipping bucket fills, it tips and activates a mercury switch. The switch closure is recorded by the CR10 Datalogger, which is typically programmed to output total rainfall over a time interval such as an hour or day. If rainfall intensity data are desired, the datalogger can be programmed to record every tip or total rainfall every one or two minutes during the event. A metric version, available on special order, measures precipitation in increments of 0.1 mm.

As shipped, the base of the gage is supported by three legs. The Model 380MB Mounting/Leveling Base or a user-supplied baseplate with leveling capability is recommended. The 380MB requires a user-supplied concrete pad and a 1.25 inch diameter threaded pipe to mount the gage.

Model 380 Rain Gage Specifications

Orifice:	12 inch diameter (30.5 cm)
Accuracy:	± 0.5% @ < 0.5" (1.25 cm)/hr rate ± 2.0% @ < 3.0" (7.50 cm)/hr rate
Resolution:	0.01 inch
Weight:	7 pounds (3.2 kg)
Cable:	2-conductor shielded cable
Operating Ranges:	0 to 50°C; 0 to 100% RH

Model 385 Electrically Heated Precipitation Gage

Specifications are identical to Model 380 unless listed below.

Heating Element:	115VAC (50/60Hz) 300W element
Weight:	11.2 pounds (5.1 kg)
Power cable:	115V power cable
Operational Ranges:	-20 to +50°C; 0 to 100% RH

15.0 Enclosure, Power Supply, Solar Panel and Instrument Tower

A. Environmentally sealed enclosure

The **Model ENC 12/14 Enclosure** is a white, weatherproof instrumentation enclosure that will house the CR10, PS12LA Power Supply, and Storage Module.

Our NEMA 4X enclosures are modified for cable entry and attach to either a flat surface or a vertical mast (1.00" to 1.25" IPS pipe). The white fiberglass-reinforced polyester enclosures are UV-stabilized and reflect solar radiation, reducing temperature gradients inside the housing. An internal mounting plate is pre-punched for easy system configuration and exchange of equipment in the field. A lockable hasp provides additional security.

The enclosure is shipped with putty to seal the enclosure conduit, an internal humidity indicator, and replaceable desiccant packs to protect the electronics from condensing humidity.

Inside dimensions:	14" x 12" x 5.5"
Weight:	12 pounds

B. Power Supply

The **Model PS12LA 12VDC Power Supply** contains a sealed rechargeable, 7.5 Amphr battery that is trickle-charged by the MSX10 Solar Panel. System Current drain (excluding the heated rain gage) will be minimal; the PS12LA's battery should be sufficient to power the system for several months even without recharge by the solar panel.

The PS12 Power supply with Charging Regulator built in accepts 16 to 26 VDC or AC input and provides a charging voltage to the 12 volt rechargeable battery.

The PS12LA has a temperature compensated charging circuit and a charge indicating Light Emitting Diode (LED). An internal diode prevents the battery from discharging through the solar panel.

The PS12 contains a thermal fuse to limit current to 3.0 A. At excess current, the fuse heats, increasing resistance and limiting current. At allowable currents, the fuse cools, decreasing the resistance and passing the current. A transzorb limits the input voltage to 40V to protect the charging circuitry.

The terminal housing is constructed of a corrosion proof thermoplastic. The screw terminals and terminal mechanism are made of copper alloys. Nickel-plating is used to protect the surface of these metal components.

C. Solar Panel

The Solarex Corp. **Model MSX10** is an unregulated 10 Watt solar panel constructed of semicrystalline silicon cells. The panel will float charge a lead acid battery through the Model PS12 Charging Regulator. The solar panel is supplied with a weather-proof junction box. Each panel frame is constructed of a corrosion-resistant, bronze anodized extruded aluminum frame. Solarex specifies their panels to generate 90% of their stated minimum output for five years.

Typical Electrical Characteristics*:

* *This performance data is based on illumination of 1 kW/m² @ 25°C as tested by Solarex Corp.*

	MSX10
Typical Peak Power:	10.3 Watts
Voltage @ Peak Power:	17.5 Volts
Current @ Peak Power:	0.59 Amps

The MSX10 panel has successfully passed the following tests without degradation as claimed by Solarex Corp.:

- o Repetitive temperature cycling between -40 and +90°C
- o Temperature-humidity-freeze cycling from -40 to +85°C at 85% RH
- o Wind loading exceeding 125 mph
- o Surface impact of 1 inch hail at terminal velocity (52 mph) without breakage.

The mounting hardware for the 10 Watt solar panel is constructed of corrosion resistant, bronze anodized extruded aluminum. Stainless steel bolts and nuts are used in the assembly of the mounting hardware to the solar panel. Stainless steel U-bolts and nuts mount the panels to one leg of the tower.

D. Instrument Tower

The **Model UT3 Instrument Tower** is a general purpose, corrosion-resistant instrument tower that provides a sturdy long-term support for Campbell Scientific's sensors, enclosures, and measurement electronics. This tower includes a lightning and grounding rod, grounding cables, grounding cable clamps, a hinged base, and UV-resistant cable ties.

The UT3 can be used as an instrument mount in a variety of applications. For meteorological applications, it can be augmented with mounts (i.e. 019ALU Crossarm) that allows attachment of sensors such as wind sets (Model 05103), pyranometers (Model LI200S), and temperature / relative humidity probes (Model HMP35C). Barometers, soil temperature and moisture probes, and rain gages can also be used with a UT3-based station.

UT3 Instrument Tower Specifications

Required concrete pad dimensions:	24" x 24" x 24" (This assumes heavy soil, light, shifting or sandy soils require a larger concrete pad).
Crossarm measurement height:	3m (10ft.)
Shipping Weight:	40 lbs. (18 kg)
Material:	Aluminum
Vertical Pipes' OD:	1" (2.5cm)
Cross support pipes' OD:	0.375" (0.953 cm)
Leg Spacing:	10.25" (26 cm) between legs (center to center)

Relative Humidity

Measurement range	0 to 100% RH
Operating temperature	-40^{O}C to +60^{O}C
**Accuracy	± 2% RH, 0 to 100% RH
Temperature coefficient	negligible
Typical long term stability	better than 1% RH per year
Response time (at 20^{O}C, 90% response)	15 s with supplied membrane filter
Power-up settling time	1 second
Output signal range	0 to 1 VDC linear, 0 to 100% RH
Supply voltage	12 VDC
Current consumption	≤ 4 mA

**Includes non-repeatability, hysteresis and calibration uncertainty.

Temperature and RH Mounting Hardware

The **Model 41002 Multi-Plate Radiation Shield** houses the sensing end of the probe and helps to dissipate the effects of solar radiation on the sensor's measurement.

Twelve plastic discs permit easy air passage through the shield yet the unique disc profile blocks direct and reflected solar radiation from any angle. The disc material is specially formulated for high reflectivity, low thermal conductivity, and maximum weatherability.

41002 Material:	White thermoplastic UV stabilized for long-term weatherability. Gloss white painted aluminum mounting bracket (with molded V-block and stainless steel U-bolt.
41002 Dimensions:	4.7" dia. x 10.6" height
41002 Weight:	1.5 lbs.

B. Wind Speed and Direction

The **Model 05103 R.M. Young Wind Monitor** is a high resolution rugged wind sensor. Its simplicity and lightweight construction make it well suited for a wide range of wind measuring applications.

The wind speed sensor is a four blade helicoid propeller. Propeller rotation produces an AC sine wave voltage signal with frequency directly proportional to wind speed.

The wind direction sensor is a rugged yet lightweight vane with a sufficiently low aspect ratio to assure good fidelity in fluctuating wind conditions. Vane position is sensed by a precision conductive plastic potentiometer located in a sealed chamber. With a known excitation voltage applied to the potentiometer, the output signal is directly proportional to azimuth angle. An orientation ring is supplied for preserving wind direction reference when the instrument is removed for maintenance.

The instrument is made of UV stabilized plastic with stainless steel and anodized aluminum fittings. All bearings are stainless steel precision grade. Transient protection and transducer terminations are in a convenient junction box on the mounting post. The instrument mounts on a standard 1 inch pipe.

The wind monitor is attached to the tower by the **019ALU Crossarm.**

Model 05103 Specifications

Range:	0-134 mph (0-60 m/s)
Starting Threshold:	2.2 mph (1.0 m/s)
Gust Survival:	220 mph (100 m/s)
Distance Constant:	8.9 ft. (2.7 m)
Output:	AC Voltage (3 pulses/revolution)

Wind Direction

Electrical Range:	0 to 360° mechanical 355° Electrical (5° open)
Starting Threshold	
at 10° displacement:	2.0 mph (0.9m/s)
at 5 ° displacement:	2.9 mph (1.3 m/s)
Delay distance	
(50% recovery):	4.3 ft. (1.3m)
Damping Ratio:	0.25
Damped Natural Wavelength:	24.3 ft. (7.4 m)
Undamped Natural Wavelength:	23.6 ft. (7.2 m)
Output:	Analog DC voltage from potentiometer. Resistance 10,000 Ohms, linearity 0.25%, life expectancy 50 million revolutions.
Power:	Precision switched excitation provided by CR10 Datalogger.
Dimensions	
Overall:	14.6 in. H x 21.7 in. L (37cm x 55cm)
Main Housing:	2.0 in. (5 cm)
Propeller (dia.)	7.1 in (18 cm)

C. Solar Radiation

The **Model LI200S LI-COR Pyranometer** measures solar radiation with a silicon photovoltaic detector mounted in a cosine-corrected head. A shunt resistor in the sensor's cable converts the signal from microamperes to millivolts allowing the LI200S to be measured directly by the Campbell Scientific CR10 Datalogger.

The LI200S Silicon Pyranometer is calibrated against an Eppley Precision Spectral Pyranometer to accurately measure sun plus sky radiation between 400 and 1100 nanometer wavelengths.

The **LI2003S Pyranometer Base and Leveling Fixture** is used to level the sensor atop the **025 Pyranometer Crossarm Stand** which in turn is inserted in the **019ALU Crossarm**.

16.0 Additional On-Line Data Storage for CR10

The **Model SM192** Storage Module stores up to 96,000 data values in battery-backed RAM. The storage module can be left at the site for on-line data transfer or be carried to the site to "milk" the datalogger's data. If left at the site, the module is secured to the backplate of the enclosure with the **6234 Bracket Kit**. The storage module can be interrogated over a telecommunications link if needed (i.e. telephone modem, RF, cellular, etc.), or carried back to the office for interrogation via the **SC532 Interface**, PC208 Software, and a user supplied IBM-compatible computer.

Model SM192 Solid State Storage Module Specifications

Storage Capacity:	192,896 bytes (≈96,000 low resolution data points)
Power Requirements:	5VDC supplied by the datalogger or SC532 on pin 1 of the 9-pin connector.
Typical current drain:	
Active and processing:	18 milliamperes
Standby state ("asleep" but connected to CR10):	250 microamperes
Internal battery:	3.5VDC lithium thionyl chloride battery
expected life:	10 years @ 25°C
Memory Configuration:	User-selectable as either fill & stop of ring style
Baud Rates:	Supports all datalogger baud rates. Data transfer is typically 9600 or 19,200 baud; 76,800 baud in burst mode
Operating Temperature:	-35 to +65°C Standard -55 to +85°C on special order
Packaging:	Sealed, stainless steel canister
Dimensions:	7.8" x 3.5" x 1.5 " (19.8 x 8.9 x 3.8 cm)
Weight:	1.5 lbs (0.7 kg)
SM192 Shipped with:	SC12 Cable & Instruction Manual

Model SC532 (PC to SM192 Interface) Specifications

Supply Voltage:	+6 VDC to +17VDC; factory installed 110VAC to 7.5VDC adaptor
Output voltage:	5VDC ±0.2 VDC
RS-232 output levels:	High: +10VDC ± 1VDC Low: -10VDC ± 1VDC
RS-232 input levels:	± 30 VDC maximum
Low threshold:	≤ 0.8 V
High threshold:	> 3.5 V
Input impedance:	> 3000 Ohms
Port Configuration:	25-pin D-subminiature female configured as DCE. 9-pin D-subminiature female connects to the storage module through the SC12.
Operating temperature range:	-25 to +50°C
Dimensions:	4.9" x 2.9" x 0.9" (12.5 x 7.4 x 2.3 cm)
Weight:	0.9 lbs (0.4 kg)
SC532 shipped with:	SC12 cable & Instruction Manual

17.0 Computer Interface

The SC32A Interface allows communication between the datalogger and the RS-232 serial port of a battery-operated IBM-compatible computer. This interface can be used for initial setup of the station so that the user can download the program, set the datalogger clock and verify sensors measurements while on-site.

18.0 IBM-Compatible Support Software

PC208 Datalogger Support Software contains five IBM-compatible programs (EDLOG, GRAPHTERM, TELCOM, SMCOM, and SPLIT) that provide computer support for functions such as: datalogger program development/editing, telecommunications, data transfer, real-time monitoring, storage module communication, and data reduction/report generation. PC requirements include: IBM PC/XT/AT, 386SX, 386, 486, or 100% compatible, DOS version 2.01 or greater, and 640K bytes of RAM.

It is important to note that TELCOM controls data retrieval from the datalogger, assuring data integrity during transmission with an *error-checking algorithm*. Collected data are directed to a user-specified file and stored as Comma Delineated ASCII, Printable ASCII, or in the datalogger's Final Storage (binary) format. When left in the wait mode, TELCOM will automatically contact the station at predetermined times. SPLIT can be run as a batch file to automatically generate printed reports following data retrieval.

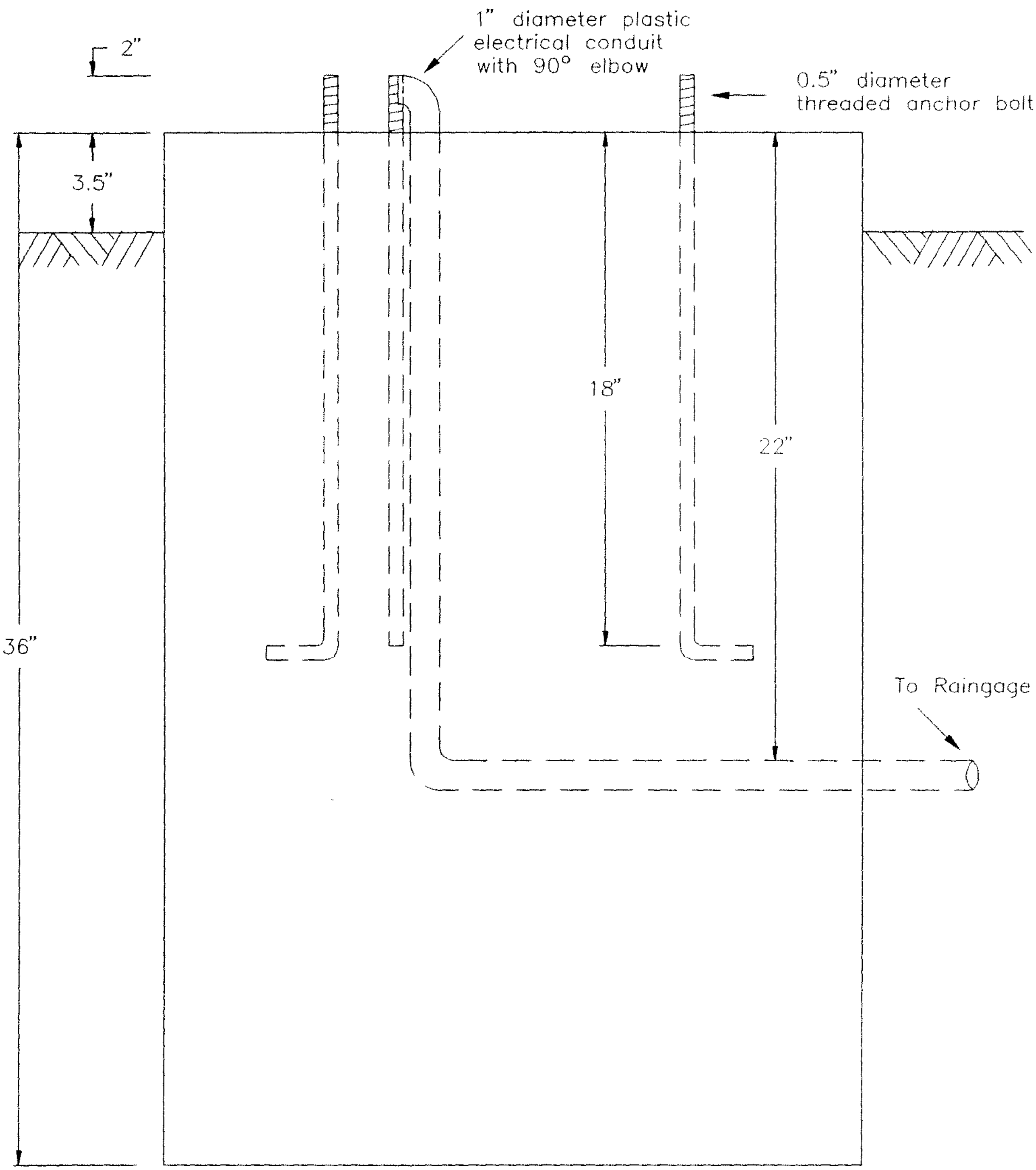
19.0 Warranty

The CR10 is warranted against manufacturer's defects for a period of three years following ship date. The Meteorological Sensors are warranted for 1 year. All other equipment manufactured by Campbell Scientific is also warranted for 1 year (excluding software diskettes which are warranted for 90 days). The cost of parts and labor are covered for warranty repairs. Over the 7 year history of the CR10, the Mean Time Between Failures is in excess of 80 years. This figure assumes product use from the time of shipment and does not include failures due to lightning, abuse, or improper exposure.

20.0 Support Services

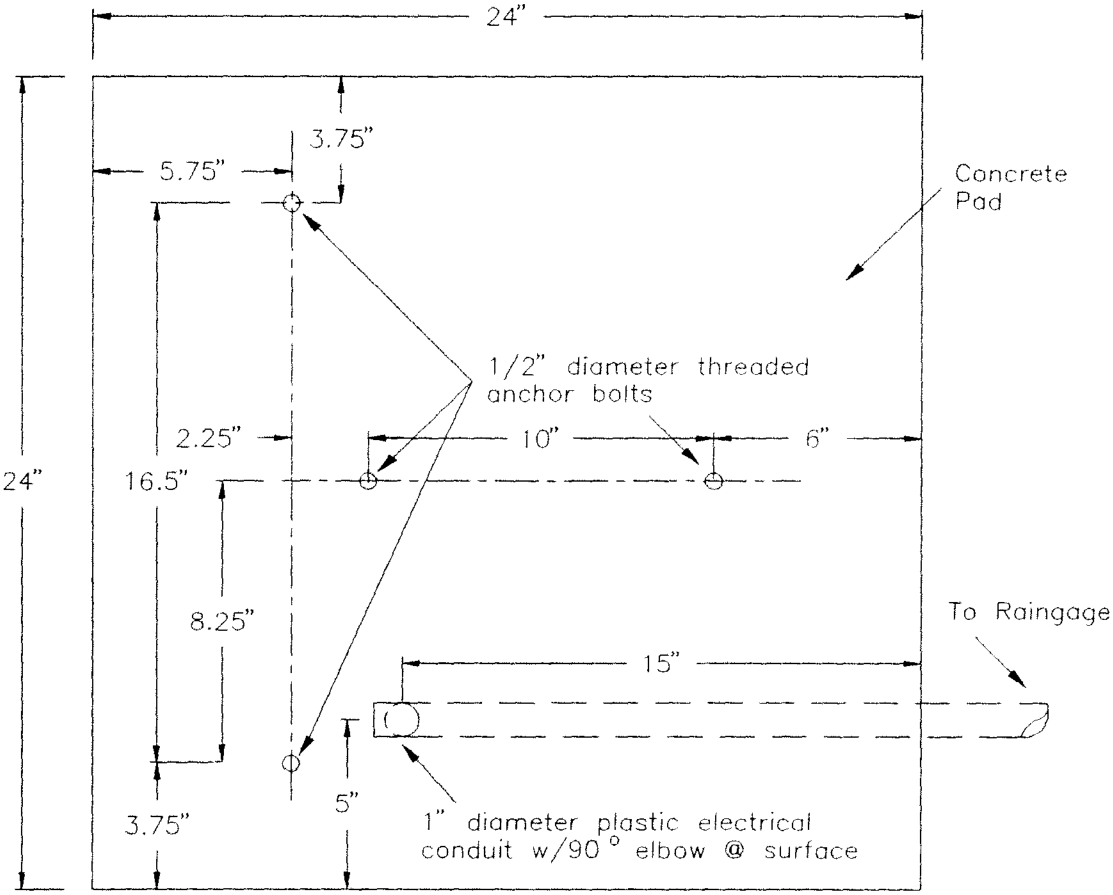
Campbell Scientific has 28 Application Engineers with backgrounds in meteorology, hydrology, chemistry and engineering, that provide daily technical support for Campbell Scientific customers over the telephone. Campbell Scientific also has a a professional staff of technicians who can repair and recalibrate the dataloggers and selected sensors to original specifications.

Campbell Scientific offers a three-day training course covering the CR10 Datalogger and the PC208 Datalogger Support Software. This is a comprehensive, introductory level course with an emphasis on programming. "Hands-on" programming exercises and course handouts are used to reinforce the concepts covered by the instructor. The course is conducted periodically at Campbell Scientific facilities in Logan, Utah. Consult our Training Coordinator for a course schedule and pricing information. Alternatively, on-site training at the user's facility may be economically viable for groups over five or six individuals.



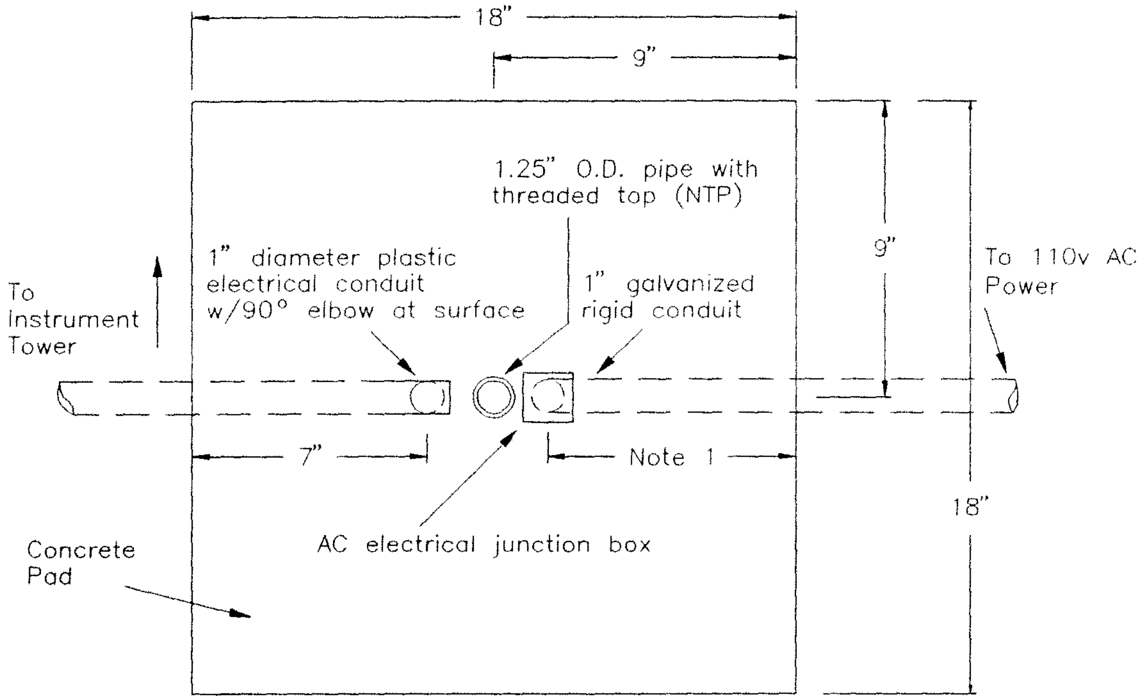
SIDE VIEW

SPS1 and SPS2 Automated Weather Station	Layout of Instrument Tower Foundation



PLAN VIEW

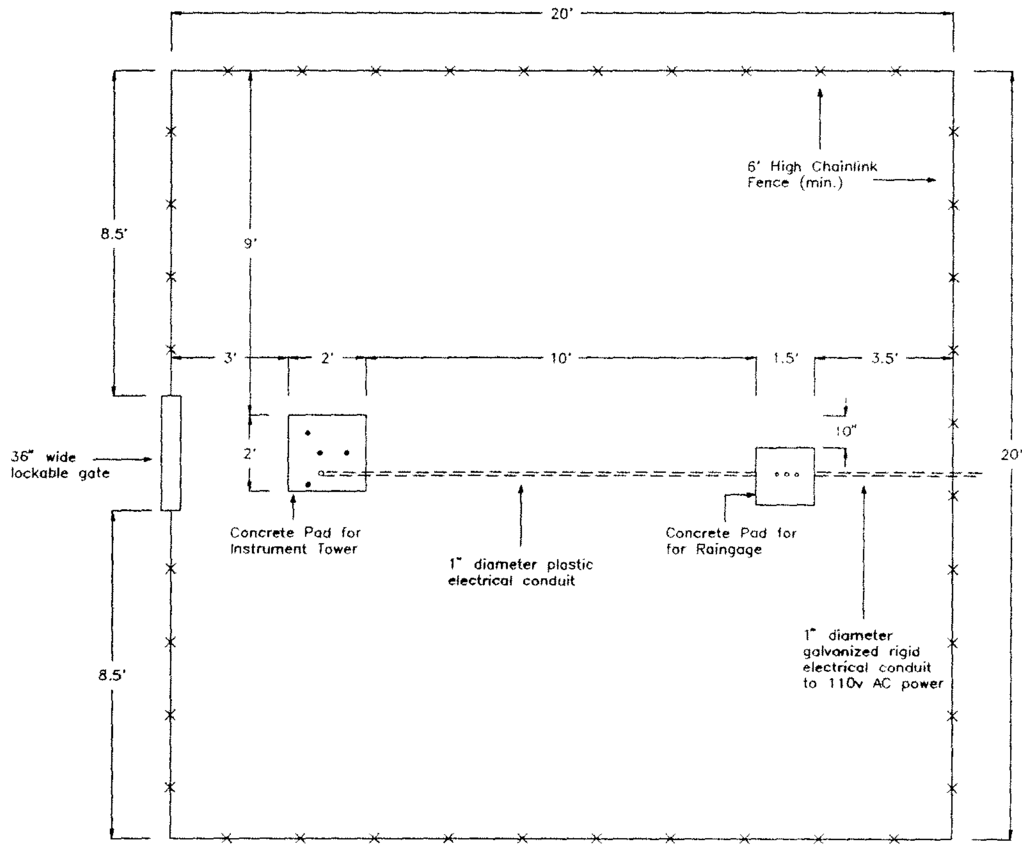
SPS1 and SPS2 Automated Weather Station	Layout of Instrument Tower Foundation



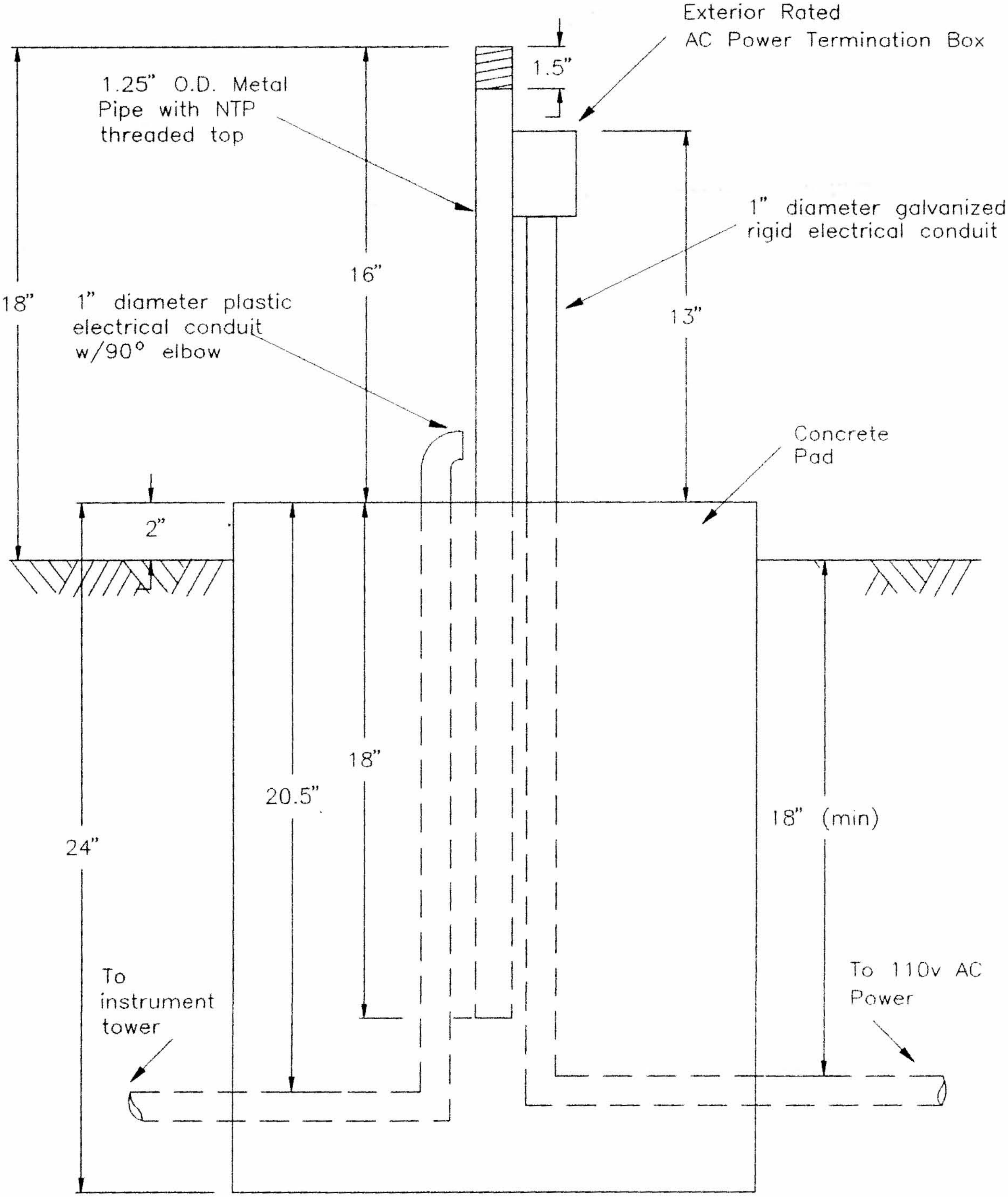
PLAN VIEW

Notes
1. Position conduit so that back of electrical junction box is flush with threaded pipe

SPS1 and SPS2 Automated Weather Station	Layout of Raingage Foundation



SPS1 and SPS2 Automated Weather Station	Weather Station Site Layout



SIDE VIEW

SPS1 and SPS2 Automated Weather Station	Layout of Raingage Foundation

CAMPBELL SCIENTIFIC, INC.

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AUTOMATED WEATHER STATION INSTALLATION
ARIZONA D.O.T OPEN HOUSE
PHOENIX, ARIZONA
JULY 20-21, 1994

TABLE OF CONTENTS

AWS MEASUREMENTS

1. Air Temperature °C 1.5 m
2. Relative Humidity % 3.0 m
3. Wind Speed m/s
4. Wind Direction 0 - 360
5. Solar Radiation watts/m²
6. Precipitation .254 mm = .01"

AWS METEOROLOGICAL SENSORS

1. Vaisala Air Temperature and Relative Humidity Probe
   Model HMP35C
2. R.M Young Wind Speed & Wind Direction Probe *(Wind Monitor)*
   Model 05103
3. Li-Cor Pyranometer *(Solar Radiation)*
   Model LI200X
4. NovaLynx Tipping Bucket Raingage
   Model 260-2500-12

METEOROLOGICAL SENSING ELEMENTS

Air Temperature:	Thermistor in a half bridge resistive configuration
Relative Humidity:	Capacitive Sorption (linear 0 to 1 VDC Output)
Wind Speed:	Magnet & Coil: Low Level AC Output (3 pulses/rev)
Wind Direction:	10 k Potentiometer in a half bridge configuration.
Solar Radiation:	Silicon Cell (microampere converted to millivolt)
Precipitation:	Reed Switch Contact Closure (Pulse Output)

AWS DATA ACQUISITION SYSTEM

1. Model CR10 Datalogger

    a. Provides for Meteorological Sensor Measurement

    b. Timekeeping

    c. Data Processing / Data Reduction

    d. Stores 29,908 data points in on-board memory

    e. Low Power 12VDC Battery Operation

        1. Approximately 50 milliwatts for Weather Station

2. Model SM192 Solid State Storage Module

    a. Provides Supplemental Data Storage to CR10

        1. Data is automatically transferred to the SM192 from the CR10 using one instruction (P96).

```
01:  P96       Serial Output
  01: 71       SM192/SM716/CSM1
```

    b. Stores 96,000 datapoints in battery-back RAM

    c. Stores up to 8 Datalogger Programs (i.e. WEATHER.DLD).

    d. Automatically Loads Program into Datalogger when connected to the CR10 on Power-Up

    e. Data Can be downloaded onto PC in field or transported back to office.

3. Model SC32A Optically Isolated RS232 Interface

    a. Required interface between a Computer and the CR10 Datalogger

        1. The 9-Pin Serial Port of a computer does not have the same pin-out or use the same logic voltage levels as the CR10.

    b. Isolates Computer's electrical system from the Datalogger's.

    c. Converts the computer's RS232 Voltage Levels (-10V to +10V) to the CMOS (0 to +5V) levels of the CR10.

    d. Powered off of both the CR10's 9-Pin I/O and the serial port of the computer

4. Model PS12LA: 12VDC Power Supply & MSX10 Solar Panel

a. The "Main" DC System Power Supply for the Weather Station

b. Uses a Yuasa 7 Amp Hour Re-Chargeable Battery

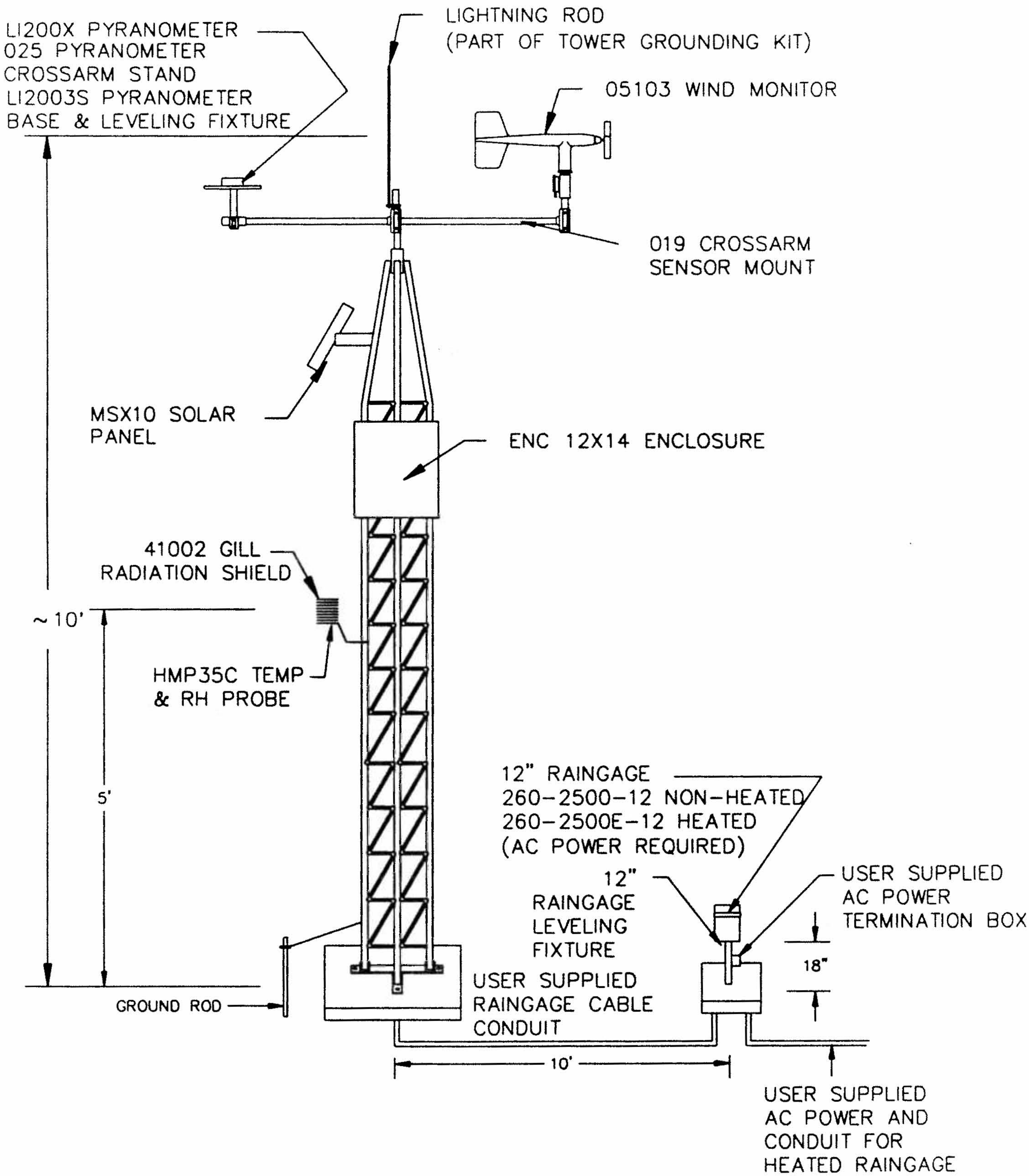
c. PS12LA Battery can be "Float-Charged" with a Solar Panel or AC Power for indefinite operation.

d. Built-in Charging Circuitry (accepts 16 to 26 Volts DC or AC) and "Float-Charges" the Battery at about 14 VDC. Prevents the battery from being over-charged.

e. In this Application a 10 Watt Solar Panel (Model MSX10) is used to Float-Charge the PS12LA system. Solar Panel is connected to the PS12LA terminals labeled CHG and CHG.

f. If the solar panel became damaged (i.e. no output) the PS12LA battery should power the system for approximately 60 days (40-45 days in cold weather). Batteries Overall Capacity is a function of temperature.

PROPOSED LTPP - AUTOMATED WEATHER STATION
FIGURE 1



INSIDE VIEW OF INSTRUMENTATION ENCLOSURE
FIGURE 2

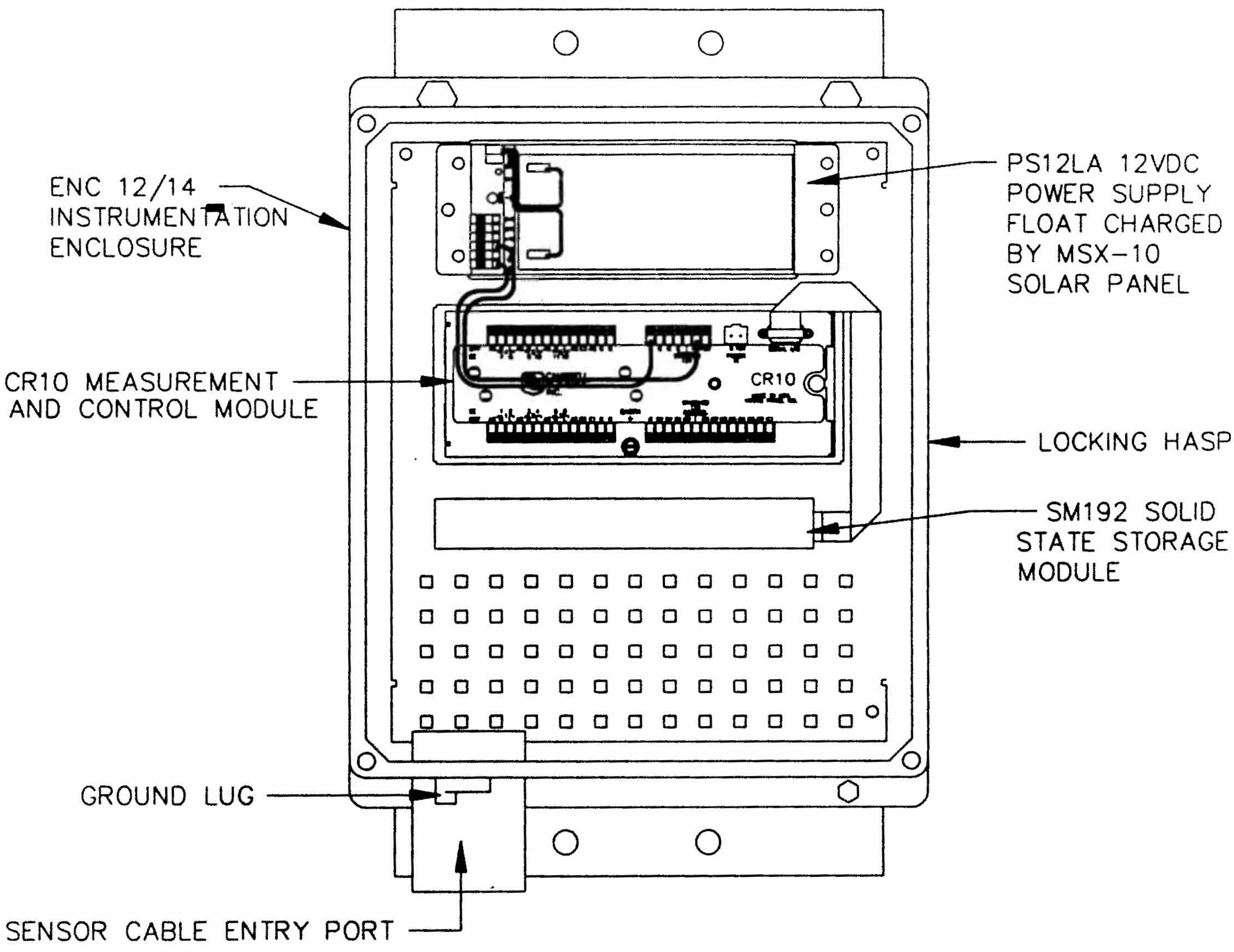
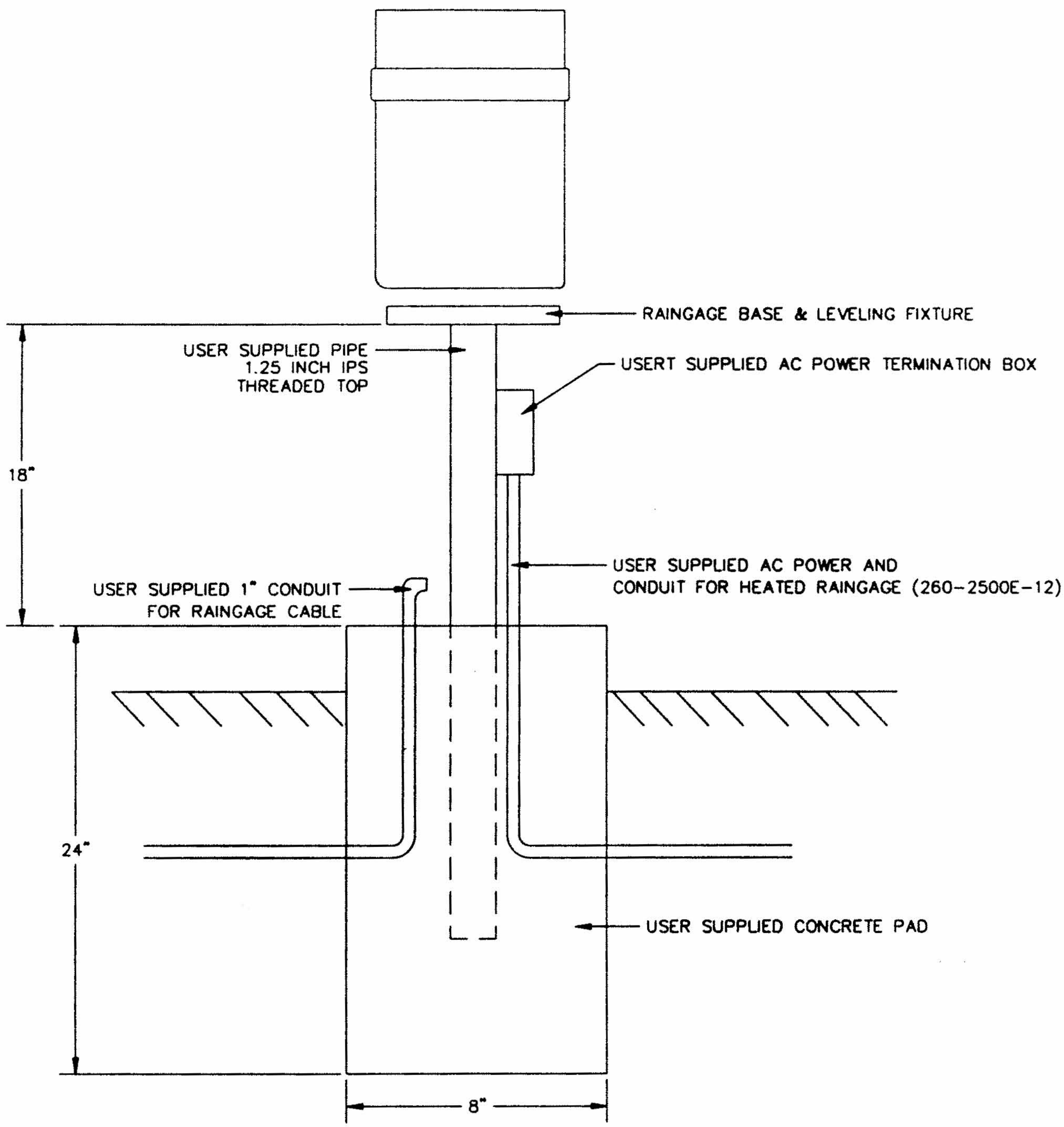


FIGURE 3

1'2" RAINGAGE SIDE VIEW



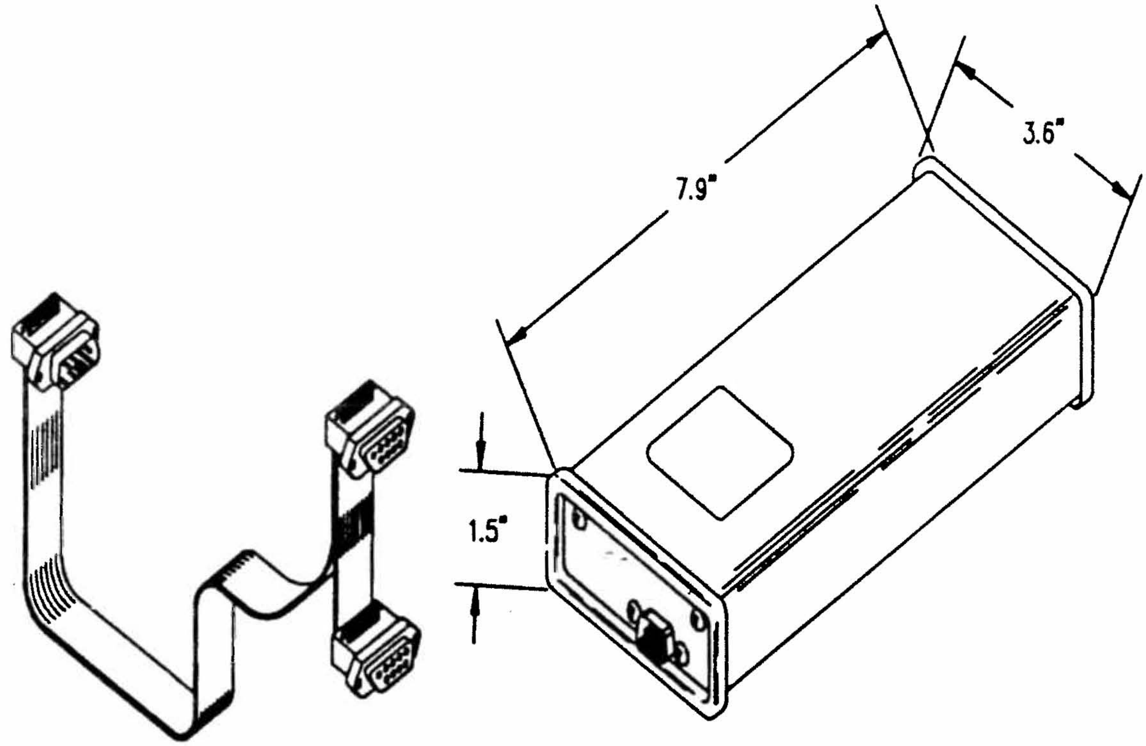


FIGURE 1.2-1. Storage Module and SC12 Cable

1.2 PHYSICAL DESCRIPTION

The Storage Module is housed in a sealed stainless steel canister with a single 9-pin D-connector. The Storage Module is connected to a datalogger via the SC12 9-Pin Peripheral Cable.

The SM192 and SM716 are identical except for the amount of memory they contain. The SM192 has a CPU card with six 32k RAM chips, providing 192,896 bytes of storage. The SM716 contains the CPU card plus a memory extension card with 16 additional 32k RAM chips. Total storage capacity in the SM716 is 716,672 bytes.

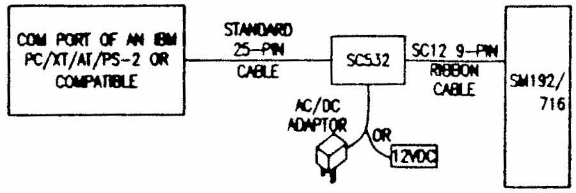
1.3 POWER

1.3.1 PRIMARY POWER

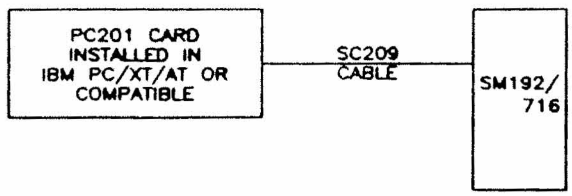
The Storage Module is powered by 5 VDC received from the datalogger or from data retrieval interfaces such as the SC532, 9-pin Peripheral to RS232 Interface, the SM232A Storage Module - RS232 Interface, or the PC201 Clock-SIO Tape Read Card. Pin 1 of the 9-pin D-connector supplies the 5 VDC. Pin 2 is both the power ground and signal ground.

1.3.2 BACKUP POWER

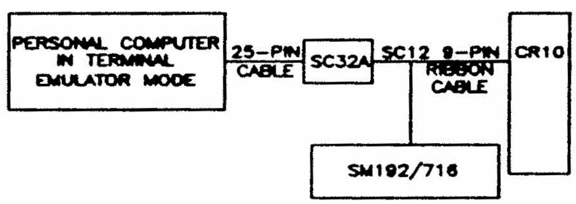
Memory backup power is provided by an internal 3.5 VDC lithium thionyl chloride battery when the Storage Module is disconnected from a primary power source. About 6 years of RAM backup power can be expected from the lithium battery at room temperature. Higher temperatures increase the current drain of the RAM chips and the self-discharge rate of the battery while lower temperatures decrease the battery's capacity, i.e., energy. At 50°C, battery life will be about 2 years; at -25°C, about 4 years can be expected. If possible, keep the Storage Module at or near room temperature when not in use.



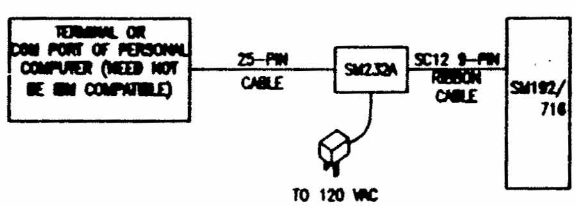
5.1-1 Storage Module Connected With SC532



5.1-2 Storage Module Connected to PC201 Card



5.1-3 Communication Via the CR10



5.1-4 Storage Module Connected With SM232A

AWS INSTALLATION

Refer to the UT-3 Tower-Based Weather Station Installation Manual

RECOMMENDED INSTALLATION SEQUENCE OVERVIEW & CHECKLIST:

[ ] 1. UT-3 Base Installation (page 3-1)

[ ] 2. UT-3 Tower Installation (page 3-2)

[ ] 3. Install 019ALU Horizontal Crossarm Mount (page 4-1)

[ ] 4. Perform Tower Grounding (page 3-3)

[ ] 5. Install 025 Pyranometer Crossarm Stand, LI2003S Pyranometer Base & Leveling Fixture and LI200S Pyranometer (pages 4-2 & 5-3)

[ ] 6. Install the RM Young Wind Monitor on 1" NU-RAIL of 019ALU (page 5-2)

[ ] 7. Check height of Wind Monitor (Measure from Center of Prop. to Ground: Should be approximately 10 feet ± 4"). May require adjustment of the 12" Mast inserted in the 1" Nu-Rail.

[ ] 8. Install 41002 12-Plate Gill Radiation Shield & HMP35C Air Temp & RH Probe (pages 4-1, 4-2 & 5-4).

[ ] 9. Install the ENC 12/14 Instrumentation Enclosure & Attach Wire to Ground Lug. (page 6-1).

[ ] 10. Mount the MSX10 Solar Panel to the UT-3 Tower. (page 7-3).

[ ] 11. Install the PS12LA Battery and Power Connections to the CR10 Leave switch in the OFF position (pages 7-2 & 7-3).

[ ] 12. Connect the MSX10 Solar Panel to the PS12LA (Ports Labeled CHG & CHG, Red LED should light-up). (page 7-2).

[ ] 13. Install Raingage, run sensor wires through conduit to station.

[ ] 14. Perform sensor to Datalogger wiring on the CR10 Wiring Panel & secure with wire ties. (page 8-1 & Attached Wiring Diagram)

[ ] 15. Load Program into SM192. (Attached Software Sheet).

[ ] 16. Install the SM192 Solid State Storage Module (page 9)

[ ] 17. Install Desiccant, Humidity Indicator & Conduit Putty (page 11-1)

[ ] 18. Connect the SM192 to the CR10 via the Blue 9-Pin Serial Cable (Model SC-12).

[ ] 19. Turn the PS12LA Power Switch to the ON Position to Boot CR10 and Auto-Upload the Datalogger Weather Station Program (takes approx. 30 seconds).

[ ] 20. Connect PC to Datalogger via SC32A Interface, Load GraphTerm to set CR10 Clock and verify sensor measurement. (Attached Software Sheet).

[ ] 21. Disconnect Computer Interface then Close & Lock Enclosure Lid.

Model: USCON90 Latitude : 33/30 N

Date : 7/15/94 Longitude: 112 W Elevation: 1800.000 ft

	D deg	D min	I deg	I min	H nT	X nT	Y nT	Z nT	F nT
	12	17.3	59	52.1	24952	24381	5310	42989	49706
Annual change:	0	-2.2	0	-0.1	-29.2	-25.2	-21.6	-54.0	-61.4

AWS DATA UPLOADING

I. Software Packages used for Automated Weather Station Application

1. GraphTerm **(GT.EXE)** - Terminal Communications Program
   a. Used for communicating with the CR10 Datalogger (via the SC32A)
      1. Setting the Datalogger Clock
      2. Monitoring Real-Time Measurements
      3. Optionally downloading Program to the CR10
      4. Optionally retrieving data from the CR10
2. SMCOM **(SMCOM.COM)** - **S**torage **M**odule **COM**munications
   a. Used for communicating with the SM192 Storage Module
      1. Retrieving Data Stored in the SM192
         (via CR10 + SC32A or SC532 only)
      2. Storing Datalogger Program for auto-upload feature into CR10.
3. SPLIT **(SPLIT.*)** - Report Generator
   a. General Purpose data reduction program
      1. Create Reports based off of data collected from Weather Station.

II. Storing a .DLD Program in the Storage Module (using SMCOM)

1. Make the appropriate hardware connections between the PC and Storage Module (either A or B).
   A. PC--SC532--SM192
   B. PC--SC32A--CR10--SM192
2. Type **SMCOM** at DOS prompt and press **<ENTER>** to start SMCOM.
3. Select the Appropriate Communications Port (1,2,3 or 4).
4. Answer **No** to SM232 Question.
5. When you see the **SMCOM Options** listed select Option D to Store a **.DLD** program file.

6. NOTE: **.DLD** is the filename extension for the actual datalogger programming code. This code is what is downloaded into the CR10.

7. To enable the auto-program upload feature store the .DLD program file into the 8th programming slot of the SM192 Storage Module.

Example: **#8WEATHER.DLD** press **<ENTER>**

8. SMCOM will upload the WEATHER.DLD from the computer hard-disk to the SM192 Storage Module's 8th programming slot.

9. When it has finished SMCOM will return to SMCOM Options.

10. Type **Q** to **Q**uit.

III. Retrieving Data from SM192 Storage Module

1. Follow steps 1 to 4 from previous section (II).

2. When you see SMCOM Options select either **Option A** to collect **All** data files OR **Option U** to Collect **Uncollected** data file.

3. SMCOM will prompt:

Root Collection file name (6 characters max):

Enter a descriptive filename (i.e AZDOT), then press **<ENTER>**.

4. When prompted for the Data Collection Format, select Option **C** for **Comma** Delineated ASCII Arrays. This data format is easily importable into many popular spreadsheet programs (i.e. Lotus 123, Quattro Pro, etc.).

5. SMCOM will begin interrogation of the SM192 and retrieve the data as indicated in STEP 2. The **data** collected on the hard disk will have a filename extension of **.DAT**.

6. When SMCOM Options screen appears, Select Option Q to Quit.

IV. Erasing Storage Module After Data Collection (OPTIONAL).

1. At the SMCOM Options screen the next optional step will be to clear the Storage Module's data area by selection of Option **C** to **Clear** Data Area.

WARNING!!: Once Option C is selected ALL Data will be erased from the Storage Module. You may want to select option Q to Quit and verify that the file has been created on the hard disk before using Option C!

Alternatively the user may want to select Option E to Erase and Reset the Storage Module. The main difference between Option C and E is:

1. Option E Clears ALL DATA AND STORED PROGRAMS. Option C clears the DATA area ONLY.

2. Option E performs a write / read cycle to check all memory. Option C does not.

Option E may be preferred if storage module is to be left at site for an extended period. Better to know if there is a problem now than to risk loosing data.

V. Graphterm Setup

Using GraphTerm with the CR10 to set the clock and monitor Weather Measurements.
(with the use of the SC32A Optically Isolated RS232 Interface)

1. Connect the SC32A Interface to the CR10's 9-pin Serial I/O port via the blue 9-pin serial cable (Model SC12). Connect the 25-pin female connector on the SC32A to the serial port on the PC via a user supplied cable.

PC ----25 Pin Ribbon Cable ---- SC32A ---- SC12 ---- CR10

2. The PC208 program called **GraphTerm** will can optionally be used to Download the WEATHER.DLD program to the CR10, set the Datalogger's clock, and monitor the Weather Measurements - Real Time. At the DOS prompt type **GT** and press **<ENTER>** to startup GraphTerm.

At the prompt:

Enter Station Name (add /E to edit Parameters):

Type **Weather** and press **<ENTER>**.

3. Graphterm will prompt you to setup the **Station File**. The Station File defines the datalogger and the communication path to be used. To edit the Station File use the **<ENTER>** key to move to each of the parameter fields and the **<SPACE BAR>** to scroll through the different options in each parameter field.

The parameters in this station file are:

Telecommunications Parameters For Station:	**WEATHER**
Datalogger Type:	**CR10**
Security Code:	**0 (default)**
Use Asynchronous Com. Adaptor:	**1, 2, 3 or 4 (com port)**
Communications Baud Rate:	**9600**
Data File Format:	**Comma delineated ASCII**
Final Storage Collection Area:	**Area 1**
Interface Device:	**SC32A**

4. When finished editing the Station File, press Control P **(<Ctrl><P>)** to save and quit editing.

5. GraphTerm saves the options you selected in the editing portion to the file **WEATHER.STN** on the Hard Disk.

6. Once saved the PC screen should now show **GRAPHTERM OPTIONS.**

7. First select option **K - PC TIME TO DATALOGGER CLOCK**. If the PC clock is correct select Y to dump the current time, Julian date, and year.

8. To monitor the weather measurements real time, select option **M - MONITOR INPUT LOCATIONS**.

9. When prompted with:

File Containing Labels: WEATHER.DLD,

make sure it indicates Weather.dld as this file contains the input location label description. Next selection option **L** (for input locations to display) and type **1..33** to display all input locations and press **<ENTER>**.

10. When finished monitoring the weather data press the Escape Key **<Esc>** to exit to back to the **GRAPHTERM OPTIONS**. Press **Q** to **Q**uit GraphTerm and the user will be returned to the DOS prompt.

VI. Generating Reports Using SPLIT

1. To simplify report generation, a batch file called **REPORT.BAT** has been created. This Batch File contains the parameters necessary to execute and start the SPLIT Report.

2. SPLIT uses a series of files created by the user called **PAR**ameter files. These files have already been created as an example of the reporting capabilities of SPLIT. The parameter files are:

HOURP1.PAR	Hourly Data Report Part 1
HOURP2.PAR	Hourly Data Report Part 2
DAILYP1.PAR	Daily Data Report Part 1
DAILYP2.PAR	Daily Data Report Part 2
DAILYP3.PAR	Daily Data Report Part 3
RAIN.PAR	15 Minute Rainfall Intensity Report

When run through SPLIT each PARameter file will create a new data file (.DAT) called:

HOURP1.DAT
HOURP2.DAT
DAILYP1.DAT
DAILYP2.DAT
DAILYP3.DAT
RAIN.DAT

Another group of files called a **RePorT** file with Column Heading is also created, where each has a an extension of .RPT. The difference between this and the .DAT file is that the .RPT file has column headings.

3. The reason there are several PARamter files for each report is due to the 80 column limit of many printers. More than 9 columns are available if the user sets-up their printer in a landscape mode rather than the vertical mode. However; the SPLIT files will needed to be adjusted to output more than 9 columns.

4. To edit the parameter files listed above simply type SPLIT followed by the paramter file you wish to edit:

SPLIT HOURP1.PAR press <ENTER>

5. The raw data input filename to the SPLIT parameter files is set as default to:

WEATHER.DAT

Therefore all data must be renamed to this or the SPLIT Parameter file must be edited to accommodate a different file name.

```
SPLIT  Version 4.8 (c) 1985,1988,1990 Campbell Scientific, Inc.

F1=Help  F2=Commands                    Insert is On   Param file is HOURP1.PAR
---------------------------------------------------------------------------
    Name(s) of input DATA FILES(s): weather.dat
   Name of OUTPUT FILE to generate: hourp1.dat/r
      START reading in weather.dat:
       STOP reading in weather.dat:
             COPY from weather.dat: 1[111]
 SELECT element #(s) in weather.dat: 2,Date(3;2),4..10
                HEADING for report: PCDATE Hourly Weather Report Part 1
 HEADINGS for weather.dat, col. # 1: Year
                         column # 2: Date
                         column # 3: Time
                         column # 4: Ave\Temp C
                         column # 5: Max\Temp C
                         column # 6: Min\Temp C
                         column # 7: Max\%RH
                         column # 8: Min\%RH
                         column # 9: Ave\Solar\W/m^2
```

```
F1=Help  F2=Commands                    Insert is On   Param file is HOURP2.PAR
---------------------------------------------------------------------------------
      Name(s) of input DATA FILES(s): weather.dat
     Name of OUTPUT FILE to generate: hourp2.dat/r
        START reading in weather.dat:
         STOP reading in weather.dat:
               COPY from weather.dat: 1[111]
  SELECT element #(s) in weather.dat: 2,Date(3;2),4,11..16
                  HEADING for report: PCDATE Hourly Weather Report Part 2
  HEADINGS for weather.dat, col. # 1: Year
                          column # 2: Date
                          column # 3: Time
                          column # 4: Mean\Wspd\m/s
                          column # 5: Mean\Wdir\deg
                          column # 6: Max\Wspd\m/s
                          column # 7: Time\Max\Wspd
                          column # 8: Dir\Max\Wspd
                          column # 9: Total\Rain\mm
```

```
F1=Help  F2=Commands                    Insert is On   Param file is DAILYP1.PAR
------------------------------------------------------------------------------
      Name(s) of input DATA FILES(s): weather.dat
     Name of OUTPUT FILE to generate: dailyp1.dat/r
         START reading in weather.dat:
          STOP reading in weather.dat:
                COPY from weather.dat: 1[222]
  SELECT element #(s) in weather.dat: 2,Date(3;2),4..10
                   HEADING for report: PCDATE Daily Weather Report Part 1
  HEADINGS for weather.dat, col. # 1: Year
                            column # 2: Date
                            column # 3: Time
                            column # 4: Ave\Temp C
                            column # 5: Max\Temp C
                            column # 6: Min\Temp C
                            column # 7: Max\%RH
                            column # 8: Min\%RH
                            column # 9: Ave\Solar\W/m^2
```

```
 .it   Run   Save   Quit   Load new parameter file
 ------------------------------------------------------------------------
      Name(s) of input DATA FILES(s): weather.dat
     Name of OUTPUT FILE to generate: dailyp2.dat/r
           START reading in weather.dat:
            STOP reading in weather.dat:
                  COPY from weather.dat: 1[222]
 SELECT element #(s) in weather.dat: 2,Date(3;2),4,11..16
                     HEADING for report: PCDATE Daily Weather Report Part 2
 HEADINGS for weather.dat, col. # 1: Year
                           column # 2: Date
                           column # 3: Time
                           column # 4: Mean\Wspd\m/s
                           column # 5: Mean\Wdir\deg
                           column # 6: Max\Wspd\m/s
                           column # 7: Time\Max\Wspd
                           column # 8: Dir\Max\Wspd
                           column # 9: Total\Rain\mm
```

```
elp  F2=Commands                    Insert is On   Param file is DAILYP3.PAR
----------------------------------------------------------------------------
     Name(s) of input DATA FILES(s): weather.dat
    Name of OUTPUT FILE to generate: dailyp3.dat/r
       START reading in weather.dat:
        STOP reading in weather.dat:
              COPY from weather.dat: 1[222]
SELECT element #(s) in weather.dat: 2,Date(3;2),4,17,18
                 HEADING for report: PCDATE Daily System Check
HEADINGS for weather.dat, col. # 1: Year
                        column # 2: Date
                        column # 3: Time
                        column # 4: Battery
                        column # 5: Sig.
```

```
Edit   Run   Save   Quit   Load new parameter file
---------------------------------------------------------------------------
     Name(s) of input DATA FILES(s): weather.dat
    Name of OUTPUT FILE to generate: rain.dat/r
        START reading in weather.dat:
         STOP reading in weather.dat:
               COPY from weather.dat: 1[444]
  SELECT element #(s) in weather.dat: 2,Date(3;2),4,5
                  HEADING for report: PCDATE 15 Min. Rainfall Intensity Report

  HEADINGS for weather.dat, col. # 1: Year
                          column # 2: Date
                          column # 3: Time
                          column # 4: Total\Rain\mm
```

AWS MAINTENANCE REQUIREMENTS

CREATE A LOG BOOK!

Indicate the date the station was visited and comments on any problems found or maintenance performed.

I. Site Visits (3 Months Maximum)

1. Visual inspection of station.

    a. Any sensor cables cut or broken?

    b. Any sensors show physical damage?

2. Inspection of Solar Sensor

    a. Are there any bird-droppings on solar sensor?

        1. Clean sensor with water, soft bristle brush or dry air.

        2. BE CAREFUL NOT TO SCRATCH THE SURFACE OF THE SOLAR SENSOR

        3. Check to make sure the drain hole next to the surface of the sensor is clean from debris

3. Rain Gage

    a. Check for and remove any debris inside the rain gage funnel.

    b. Be sure the screen inside the funnel is clean from bird nests or debris.

    c. Remove the RainGage Funnel. The raingage is assembled in 2 pieces. The screws at the base of the rain-gage must be removed first.

    d. Be sure the funnel hole is not clogged with debris.

    e. Observe the tipping mechanism inside to be sure there are no spider webs of bugs that have caused the mechanism to freeze in one position.

    f. Tip the mechanism from side to side to be sure that it moves freely. Clean the tipping buckets if they have any dirt or dust accumulated.

    NOTE: The test tips will be recorded by the weather station as rain.

g. Be sure upon leaving the site that the rain gage is level.

4. Wind Monitor

   a. Check for free horizontal movement of Wind Sensor.

   b. Check for free movement of propeller.

   NOTE: Do not use WD-40 or other lubricants on the bearings. These are special precision ball bearings that use a unique instrumentation oil

   c. Verify that the propeller nut is secured to the shaft.

5. Temperature / Relative Humidity Probe.

   a. Check to make sure the radiation shield and end cap on the sensor are free from debris.

   b. Check the sensor end-cap by removing the sensor from the radiation shield. The sensor is fastened by a plastic compression screw which screws into the shield.

   c. Check the screen for debris and clean by removing dirt or dust with a soft brush.

   d. Replace end-cap if still dirty.

6. Datalogger Enclosure

   a. Open enclosure and inspect for any bugs, spider webs, or moisture.

   b. Swap-Out Desiccant packs with recently dried units.

   c. Verify that the conduit putty is sealed firmly around sensor leads and that there is no daylight showing through the conduit hole. If there is, firmly press the putty around sensor leads and conduit hole.

   d. Remove PS12LA cover and check to see if the RED LED is lit. If it is not it may indicate there is a problem with the solar panel or charging circuitry.

   e. Verify that there are no loose sensor leads going into the CR10 Wiring Panel. If any are, firmly secure their screw terminals.

   f. Connect the SC32A to the CR10 and start GraphTerm. Enter the Monitor Mode and check current sensor readings. Take note of any readings that show -99999. This is characteristic of a faulty sensor or loose connection. Also verify the CR10 Clock.

II. Sensor Calibration

1. Air Temperature — Calibration check every 2 years
2. Relative Humidity — Re-Calibrated every 2 years

$25 recalib./m

3. Wind Speed — Replace Bearings every 2 years (Yearly if near blowing soils, i.e. next to an open field)
4. Wind Direction — Replace Potentiometer every 2 years

recalibrate $1.00

5. Solar Radiation — Re-Calibrate every 2 Years.

$60 recalib

6. Precipitation — Every 1 to 2 years. Can be calibrated in Field.

Leave a copy @
AWS site

CR10 Wiring Diagram

MP35C Probe

```
============
Red    = +12V
Yellow = E2
Purple = AG
Clear  = G
Orange = 1L
Green  = 2H
Black  = E3
White  = AG
```

05103 or 05305 Wind Monitor

```
==========================
Blk of Red & Blk   = G
Blk of Green & Blk = AG
Green              = 2L
Black              = E2
Red                = P1
Clear              = G
```

Rain Gage

```
==========================
Red    = P2
Black  = G
```

I200X Solar Sensor

```
===================
Red   = 3H
Black = 3L
White = AG
Clear = G
```

Input Location Assignments

1	BattVolt
2	Temp C
3	RH %
4	Wspd m/s
5	Wdir deg
6	slr W/m2
7	Rain mm
8	Signature
10	Temp F
11	Wspd mph
12	Rain inch
28	Rainfall Intensity

Output Data Format

60 Minute Output (HOURLY)

1 Array ID 111
2 Year
3 Day
4 Hour Minute
5 Average temperature deg C
6 Max Temperature deg C
7 Min Temperature deg C
8 Max Relative Humidity %RH
9 Min Relative Humidity %RH
10 Average Solar Radiation W/m^2
11 Mean Horizontal Wind Speed m/s
12 Unit Vector Mean Wind Direction (deg)
13 Max Wind Speed m/s
14 Time of Max Wind Speed (hhmm)
15 Direction of Max Wind Speed (deg)
16 Total Rain mm

$$\frac{16\ \text{d.p}}{\text{hr}} \times \frac{24\ \text{hr}}{\text{day}} = \frac{384\ \text{d.p}}{\text{day}}$$

1440 Minute Output (DAILY)

1 Array ID 222
2 Year
3 Day
4 Hour Minute
5 Average Temperature deg C
6 Max Temperature deg C
7 Min Temperature deg C
8 Max Relative Humidity %RH
9 Min Relative Humidity %RH
10 Average Solar Radiation W/m^2
11 Mean Horizontal Wind Speed m/s
12 Unit Vector Mean Wind Direction (deg)
13 Max Wind Speed m/s
14 Time of Max Wind Speed (hhmm)
15 Direction of Max Wind Speed (deg)
16 Total Rain mm
17 Battery Voltage
18 Signature

$$\frac{18\ \text{d.p.}}{\text{day}}$$

402 d.p./day

15 Minute Output (RAINFALL INTENSITY)

1 Array Id 444
2 Year
3 Day
4 Hour Minute
5 Rain Total mm

conditional output
only output's if it rains

Assuming no rain

CR10 $\frac{29,908\ \text{d.p.}}{402\ \text{d.p./day}} = 74$ days

SM192 – $\frac{96,000\ \text{d.p.}}{402\ \text{d.p./day}} = 238$ day

```
Program:  CR10/UT3 Weather Station
Revision: 07 JULY 1994
Filename: C:\FHWA\AZ\WEATHER.DOC
*B Pgm:   4581
Organ.:   USDOT FHWA LTPP
User:     Aramis Lopez
PH#:      703-285-2013


*     1       Table 1 Programs
  01: 3       Sec. Execution Interval

01:  P10      Battery Voltage
  01: 1       Loc [:BattVolt ]

02:  P11      Temp 107 Probe
  01: 1       Rep
  02: 2       IN Chan
  03: 3       Excite all reps w/EXchan 3
  04: 2       Loc [:Temp C   ]
  05: 1       Mult
  06: 0       Offset

03:  P37      Z=X*F
  01: 2       X Loc Temp C
  02: 1.8     F
  03: 10      Z Loc [:Temp F   ]

04:  P34      Z=X+F
  01: 10      X Loc Temp F
  02: 32      F
  03: 10      Z Loc [:Temp F   ]

05:  P4       Excite,Delay,Volt(SE)
  01: 1       Rep
  02: 5       2500 mV slow Range
  03: 3       IN Chan
  04: 2       Excite all reps w/EXchan 2
  05: 15      Delay (units .01sec)
  06: 2500    mV Excitation
  07: 3       Loc [:RH %     ]
  08: .1      Mult
  09: 0       Offset

06:  P3       Pulse
  01: 1       Rep
  02: 1       Pulse Input Chan
  03: 21      Low level AC; Output Hz.
  04: 4       Loc [:Wspd m/s ]
  05: .098    Mult
  06: 0       Offset
```

```
07:  P37       Z=X*F
  01: 4        X Loc Wspd m/s
  02: 2.237    F
  03: 11       Z Loc [:Wspd mph ]

08:  P4        Excite,Delay,Volt(SE)
  01: 1        Rep
  02: 5        2500 mV slow Range
  03: 4        IN Chan
  04: 2        Excite all reps w/EXchan 2
  05: 2        Delay (units .01sec)
  06: 2500     mV Excitation
  07: 5        Loc [:Wdir deg ]
  08: .142     Mult
  09: 0        Offset

09:  P2        Volt (DIFF)
  01: 1        Rep
  02: 23       25 mV 60 Hz rejection Range
  03: 3        IN Chan
  04: 6        Loc [:slr W/m2 ]
  05: 200      Mult
  06: 0        Offset

10:  P3        Pulse
  01: 1        Rep
  02: 2        Pulse Input Chan
  03: 2        Switch closure
  04: 7        Loc [:Rain mm  ]
  05: .01      Mult
  06: 0        Offset

11:  P33       Z=X+Y
  01: 7        X Loc Rain mm
  02: 12       Y Loc Rain inch
  03: 12       Z Loc [:Rain inch]

12:  P37       Z=X*F
  01: 7        X Loc Rain mm
  02: 25.4     F
  03: 7        Z Loc [:Rain mm  ]

13:  P92       If time is
  01: 0        minutes into a
  02: 60       minute interval
  03: 10       Set high Flag 0 (output)

14:  P80       Set Active Storage Area
  01: 1        Final Storage Area 1
  02: 111      Array ID or location

15:  P77       Real Time
  01: 1220     Year,Day,Hour-Minute
```

```
16:  P71       Average
 01: 1         Rep
 02: 2         Loc Temp C

17:  P73       Maximize
 01: 1         Rep
 02: 0         Value only
 03: 2         Loc Temp C

18:  P74       Minimize
 01: 1         Rep
 02: 0         Value only
 03: 2         Loc Temp C

19:  P73       Maximize
 01: 1         Rep
 02: 0         Value only
 03: 3         Loc RH %

20:  P74       Minimize
 01: 1         Rep
 02: 0         Value only
 03: 3         Loc RH %

21:  P71       Average
 01: 1         Rep
 02: 6         Loc slr W/m2

22:  P69       Wind Vector
 01: 1         Rep
 02: 0         Samples per sub-interval
 03: 1         Polar Sensor/(S, D1)
 04: 4         Wind Speed/East Loc Wspd m/s
 05: 5         Wind Direction/North Loc Wdir deg

23:  P73       Maximize
 01: 1         Rep
 02: 10        Value with Hr-Min
 03: 4         Loc Wspd m/s

24:  P79       Sample on Max or Min
 01: 1         Rep
 02: 5         Loc Wdir deg

25:  P72       Totalize
 01: 1         Rep
 02: 7         Loc Rain mm

26:  P92       If time is
 01: 1439      minutes into a
 02: 1440      minute interval
 03: 30        Then Do
```

```
27:  P19        Signature
  01: 8        Loc [:Signature]

28:  P95        End

29:  P92        If time is
  01: 0        minutes into a
  02: 1440     minute interval
  03: 10       Set high Flag 0 (output)

30:  P80        Set Active Storage Area
  01: 1        Final Storage Area 1
  02: 222      Array ID or location

31:  P77        Real Time
  01: 1220     Year,Day,Hour-Minute

32:  P71        Average
  01: 1        Rep
  02: 2        Loc Temp C

33:  P73        Maximize
  01: 1        Rep
  02: 0        Value only
  03: 2        Loc Temp C

34:  P74        Minimize
  01: 1        Rep
  02: 0        Value only
  03: 2        Loc Temp C

35:  P73        Maximize
  01: 1        Rep
  02: 0        Value only
  03: 3        Loc RH %

36:  P74        Minimize
  01: 1        Rep
  02: 0        Value only
  03: 3        Loc RH %

37:  P71        Average
  01: 1        Rep
  02: 6        Loc slr W/m2

38:  P69        Wind Vector
  01: 1        Rep
  02: 0        Samples per sub-interval
  03: 1        Polar Sensor/(S, D1)
  04: 4        Wind Speed/East Loc Wspd m/s
  05: 5        Wind Direction/North Loc Wdir deg
```

```
39:  P73       Maximize
  01: 1        Rep
  02: 10       Value with Hr-Min
  03: 4        Loc Wspd m/s

40:  P79       Sample on Max or Min
  01: 1        Rep
  02: 5        Loc Wdir deg

41:  P72       Totalize
  01: 1        Rep
  02: 7        Loc Rain mm

42:  P70       Sample
  01: 1        Reps
  02: 1        Loc BattVolt

43:  P70       Sample
  01: 1        Reps
  02: 8        Loc Signature

44:  P92       If time is
  01: 0        minutes into a
  02: 15       minute interval
  03: 10       Set high Flag 0 (output)

45:  P80       Set Active Storage Area
  01: 3        Input Storage Area
  02: 28       Array ID or location

46:  P72       Totalize
  01: 1        Rep
  02: 7        Loc Rain mm

47:  P89       If X<=>F
  01: 28       X Loc Rain Int
  02: 2        <>
  03: 0        F
  04: 30       Then Do

48:  P80       Set Active Storage Area
  01: 1        Final Storage Area 1
  02: 444      Array ID or location

49:  P77       Real Time
  01: 1220     Year,Day,Hour-Minute

50:  P70       Sample
  01: 1        Reps
  02: 28       Loc Rain Int

51:  P95       End
```

```
52:  P92        If time is
  01: 0         minutes into a
  02: 1440      minute interval
  03: 30        Then Do

53:  P30        Z=F
  01: 0         F
  02: 0         Exponent of 10
  03: 12        Z Loc [:Rain inch]

54:  P95        End

55:  P96        Serial Output
  01: 71        SM192/SM716/CSM1

56:  P          End Table 1


*      2        Table 2 Programs
  01: 0.0000  Sec. Execution Interval

01:  P          End Table 2


*      3        Table 3 Subroutines

01:  P          End Table 3


*      A        Mode 10 Memory Allocation
  01: 28        Input Locations
  02: 100       Intermediate Locations
  03: 0.0000  Final Storage Area 2


*      C        Mode 12 Security
  01: 0         LOCK 1
  02: 0         LOCK 2
  03: 0000      LOCK 3
```

Page 7 Input Location Assignments (with comments):

Key:
T=Table Number
E=Entry Number
L=Location Number

```
T:  E:  L:
1:  1:  1:  Loc [:BattVolt ]
1:  2:  2:  Loc [:Temp C   ]
1:  5:  3:  Loc [:RH %     ]
1:  6:  4:  Loc [:Wspd m/s ]
1:  8:  5:  Loc [:Wdir deg ]
1:  9:  6:  Loc [:slr W/m2 ]
1: 10:  7:  Loc [:Rain mm  ]
1: 12:  7:  Z Loc [:Rain mm  ]
1: 27:  8:  Loc [:Signature]
1:  3: 10:  Z Loc [:Temp F   ]
1:  4: 10:  Z Loc [:Temp F   ]
1:  7: 11:  Z Loc [:Wspd mph ]
1: 11: 12:  Z Loc [:Rain inch]
1: 53: 12:  Z Loc [:Rain inch]
```

Page 8 Input Location Labels:

1:BattVolt	8:Signature	15:________	22:________
2:Temp C	9:________	16:________	23:________
3:RH %	10:Temp F	17:________	24:________
4:Wspd m/s	11:Wspd mph	18:________	25:________
5:Wdir deg	12:Rain inch	19:________	26:________
6:slr W/m2	13:________	20:________	27:________
7:Rain mm	14:________	21:________	28:Rain Int

UT-3 TOWER-BASED WEATHER STATION INSTALLATION MANUAL

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UT3 TOWER-BASED WEATHER STATION INSTALLATION MANUAL
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FIGURES

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SECTION 1. INSTALLATION INSTRUCTIONS

This manual provides detailed instructions for the installation of a CSI weather station. Once installed, the individual component manuals should be referenced for more comprehensive information.

1.1 SENSOR SITING AND EXPOSURE

Selecting an appropriate site for the weather station is critical in order to obtain accurate meteorological data. In general, the site should be representative of the general area of interest, and away from the influence of obstructions such as buildings and trees.

Some general guidelines for site selection are listed below. The guidelines were condensed from EPA (1988)[1], WMO (1983)[2], and AASC (1985)[3].

1.2 WIND SPEED AND DIRECTION

Wind sensors should be located over open level terrain, and at a distance of at least ten times (EPA) the height of any nearby obstruction (building, tree, etc.).

Standard measurement heights:

3.0 m ± 0.1 m recommended (AASC)
2.0 m ± 0.1 m, 10.0 m ± 0.5 m optional (AASC)
10.0 m (WMO and EPA)

1.3 TEMPERATURE AND RELATIVE HUMIDITY

Sensors should be located over an open level area at least 9 m (EPA) in diameter. The surface should be covered by short grass, or where grass does not grow, the natural earth surface. Sensors should be located at a distance of at least four times the height of any nearby obstruction and at least 30 m (EPA) from large paved areas. Sensors should be protected from thermal radiation, and adequately ventilated.

Situations to avoid include:

- large industrial heat sources
- rooftops
- steep slopes
- sheltered hollows
- high vegetation
- shaded areas
- swamps
- areas where snow drifts occur
- low places holding standing water after rains

Standard measurement heights:

1.5 m ± 1.0 m (AASC)
1.25 - 2.0 m (WMO)
2.0 m temperature (EPA)
2.0 m and 10.0 m for temperature difference (EPA)

1.4 PRECIPITATION

A rain gage should be sited on level ground that is covered with short grass or gravel. In open areas, the distance to obstructions should be two to four times (EPA, AASC) the height of the obstruction.

The height of the opening should be as low as possible, but should be high enough to avoid splashing from the ground. Wind shields, such as those used by the National Weather Service, are recommended for open areas.

Collectors should be heated, if necessary, to properly measure frozen precipitation. The gage must be mounted above the average level of snow accumulation in areas that experience significant snowfall.

Standard measurement heights:

1.0 m ± 1.0 cm (AASC)
30.0 cm minimum (WMO, EPA)

1.5 SOLAR RADIATION

Pyranometers should be located to avoid shadows on the sensor at any time. Reflective surfaces and sources of artificial radiation should be avoided. The height at which the sensor is mounted is not critical.

1.6 SOIL TEMPERATURE

The measurement site for soil temperature should be at least 1 m^2 and typical of the surface of interest. The ground surface should be level with respect to the immediate area (10 m radius).

Standard measurement depths:

10.0 cm ± 1.0 cm (AASC)
5.0 cm, 10.0 cm, 50.0 cm, 100.0 cm (WMO)

SECTION 2. TOOLS REQUIRED

The tools that are required to install a UT3-based weather station are listed below. Tools listed in Section 2.1 are required for the initial tower installation; tools listed in Section 2.2 are required for the instrumentation and general maintenance.

2.1 TOOLS FOR UT3 TOWER INSTALLATION

- Shovel
- Rake
- Pick or digging bar
- Claw hammer
- Hand saw
- Tape measure (12' - 20')
- (2) 9/16" open-end wrenches
- Level (24" - 36")
- Magnetic compass

Materials for concrete form:

- (4) 12" wood stakes
- (1) 2" x 4" x 8' piece of lumber
- (8) 8p double-head nails
- (8) 16p double-head nails
- Concrete trowels
- (2) 1.0 - 1.5" thick x 24" boards to support base above forms (optional)
- Sledge hammer.

2.2 TOOLS FOR INSTRUMENTATION AND MAINTENANCE

- Lock and key for enclosure
- Magnetic declination angle for site (see Appendix A)
- Conduit and associated tools (as required)
- 6' step ladder
- Tape measure (12' - 20')
- Open-end wrenches: 3/8", 7/16", 1/2", (2) 9/16"
- 3/8" nut driver
- Level (24" - 36")
- Pliers
- Magnetic compass
- 12" pipe wrench
- Teflon tape or pipe dope
- Claw hammer
- Felt-tipped marking pen
- Socket wrench and 7/16" deep well socket
- (12) 1/4" washers (for the 015 Crossarm Stand only)
- Allen wrench set
- Straight-bit screwdrivers (small, medium and large)
- Phillips-head screwdrivers (small and medium)
- Small diagonal side-cuts
- Needle-nosed pliers
- Wire strippers
- Pocket knife
- Calculator
- Volt/Ohm meter
- Electrical tape
- 6' step ladder
- Datalogger prompt sheet and manuals
- Station log and pen

SECTION 3. UT3 TOWER INSTALLATION PROCEDURE

The UT3 3 meter Tower provides a support structure for mounting the weather station components. Figure 3-1 shows a typical UT3 equipped with instrumentation enclosure, meteorological sensors, and solar panel.

3.1 BASE INSTALLATION

The UT3 tower attaches to a user supplied concrete foundation as shown in Figure 3-2. The tilt base, anchor bolts, and nuts are included with the tower.

1. Dig a hole 24" square and 24" deep. Lighter soils will require a deeper hole.

2. Construct a concrete form out of 2" x 4" lumber 24" square (inside dimensions). Center the form over the hole and drive a stake centered along the outside edge of each side. Level the form by driving nails through the stakes and into the form while holding the form level.

3. Assemble the anchor bolts and tilt base as shown in Figure 3-3. There should be two nuts below the base and one nut above.

4. Fill the hole and form with concrete. Screed the concrete level with the top of the form. Allow the concrete to setup enough to support the weight of the base*, then position the base (with the anchor bolts attached) over the center of the concrete foundation and press the anchor bolts into the concrete as shown in Figure 3-3. The bottom of the threads should be approximately 1/2" above the concrete. Level the base in both directions using a small level.

   Rather than relying on the concrete to support the base, two boards 1" to 1.5" thick that span the forms can be positioned under the base while the concrete hardens.

5. Remove the form after the concrete has sufficiently hardened. Level the base by adjusting the two lower nuts. Minor adjustments will be required after the tower is attached.

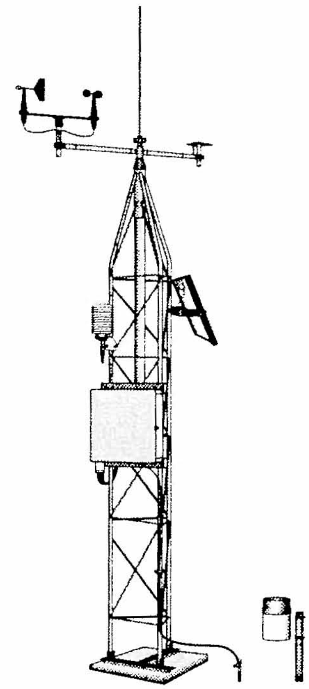


FIGURE 3-1. UT3 Tower-Based Weather Station

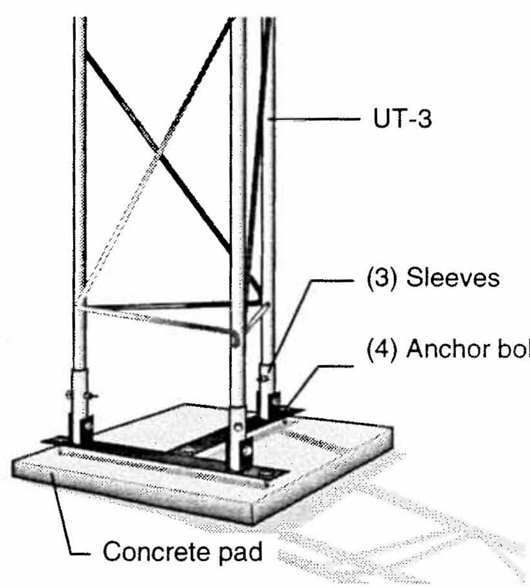


FIGURE 3-2 UT3 Tower and Concrete Foundation

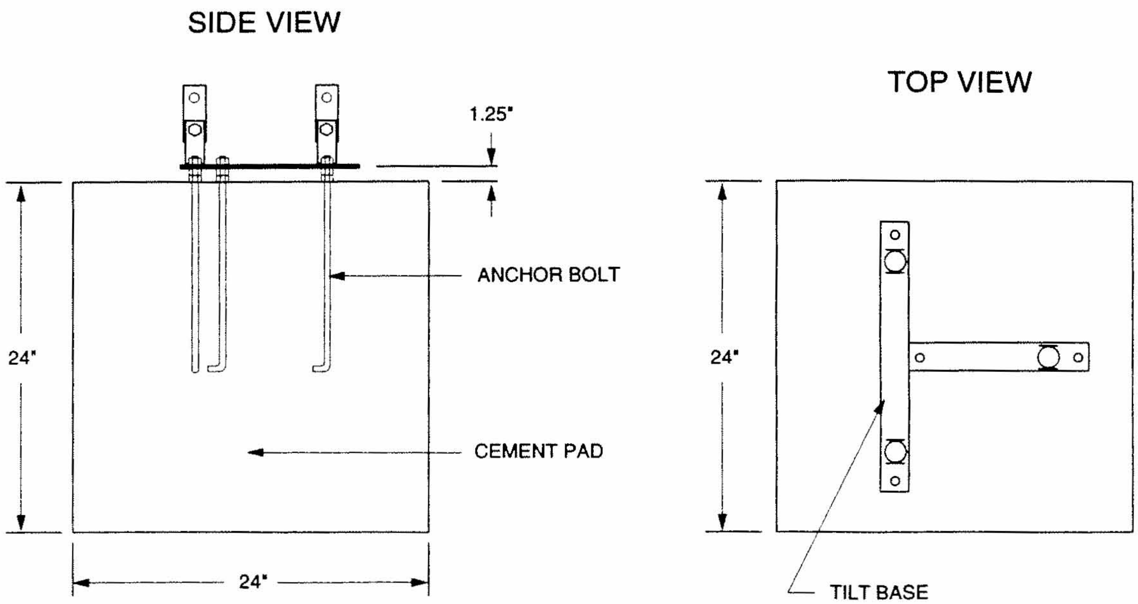


FIGURE 3-3 Concrete Foundation and Anchor Bolts

3.2 TOWER INSTALLATION

1. Install the mast as shown in Figure 3-4. Attach the 3/4" x 10" nipple to the mast using the bell reducer. Loosen the two bolts at the top of the tower and insert the mast. For a 3 m mounting height, the bell reducer should rest against the top of the tower. Tighten the two bolts to secure the mast.

2. Remove the three upper bolts on the aluminum sleeves attached to the base. Loosen the nuts on the three lower bolts and position the sleeves vertically (Figure 3-2).

3. Stand the tower upright and insert the three legs into the sleeves. Align the holes and replace the bolts previously removed.

4. Check the tower for plumb using a level and adjust the leveling nuts as required. When the tower is plumb, use two wrenches to lock the two lower nuts together. Tighten the upper nuts to secure the base.

5. The lower bolt in the rear leg can be removed to allow the tower to be hinged to the ground. If a step ladder is available, it is easier to leave the tower upright.

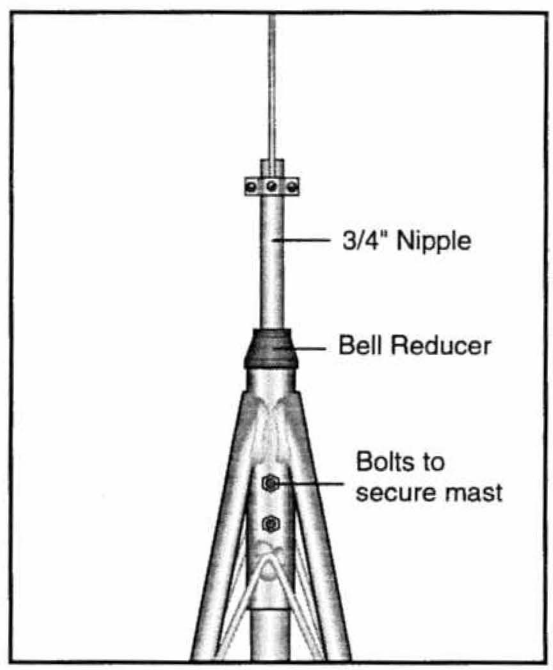


FIGURE 3-4 UT3 Mast

3.3 UT3 TOWER GROUNDING

1. Drive the ground rod close to the tower (where it won't be tripped over) using a fence post driver or sledge hammer. Drive the rod at an angle if an impenetrable hardpan layer exists. In hard clay soils, a gallon milk jug of water can be used to "prime" the soil and hole to make driving the rod easier.

2. Loosen the bolt that attaches the clamp to the ground rod. Insert one end of the 4 AWG wire (approximately 1/2" diameter) between the rod and the clamp and tighten the bolt as shown in Figure 3-5.

3. Attach the tower grounding clamp to a tower leg as shown in Figure 3.5. Loosen the grounding clamp set screw and insert the unattached end of the 4 AWG wire, and one end of the green 12 AWG wire into the hole behind the set screw and tighten the set screw. Route the green wire to where the enclosure will be installed.

4. If the weather station includes an 019ALU crossarm, attach it to the mast as shown in Figure 3-6.

5. Attach the lightning rod to the mast as shown in Figure 3-6.

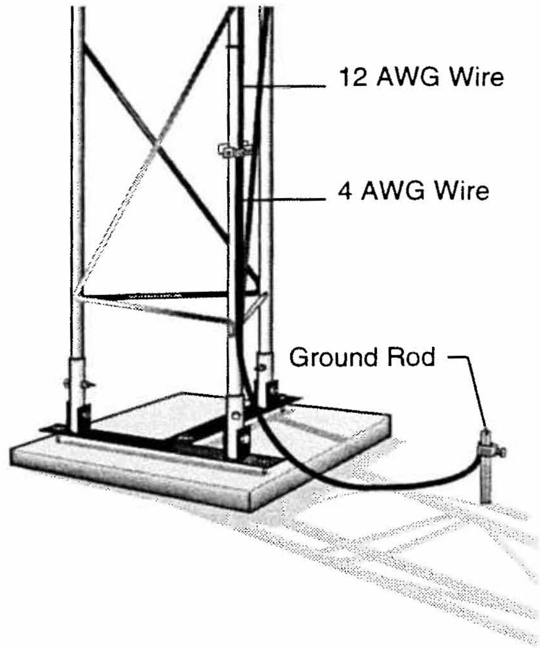


FIGURE 3-5 Tower Grounding

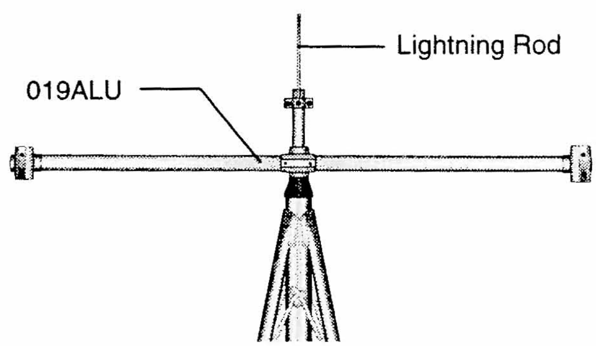


FIGURE 3-6 Lightning Rod and O19ALU Crossarm

SECTION 4. SENSOR MOUNTING BRACKETS

Sensor mounting brackets provide a means of mounting the sensors to the tower. A general orientation of the mounting brackets is shown in Figure 4-1.

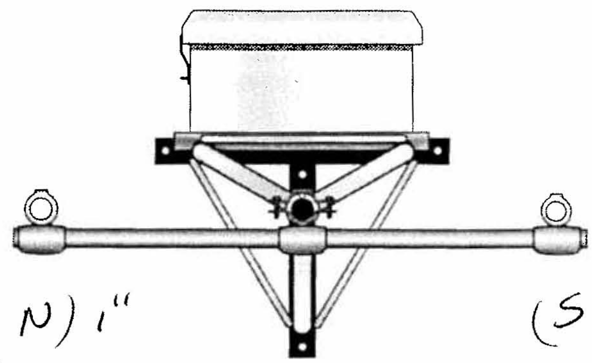
4.1 019ALU CROSSARM SENSOR MOUNT

Attach the 019ALU crossarm to the mast as shown in Figure 4-2.

1. With the middle NU-RAIL connector resting on the bell reducer, orient the 019ALU East-West, with the 3/4" NU-RAIL pointing East. Tighten the set screws.

2. Orient the 019ALU North-South, with the 3/4" NU-RAIL pointing South when used with the 025 Crossarm Stand (Section 4.4).

3. Install the lightning rod to the mast as shown in Figure 4-2. Loosen the two screws on the lightning rod mounting bracket. Position the mounting bracket 2" down from the top of the mast and tighten both screws evenly. Make sure the lightning rod set screw is tight.



(N) 1" (S) 3/4"

FIGURE 4-1. Top View of Tower

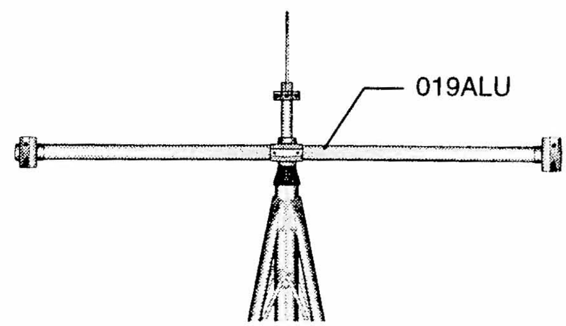


FIGURE 4-2. 019ALU Crossarm and Lightning Rod

4.2 41002, 41004 AND 41301 GILL RADIATION SHIELDS

Attach the Gill Radiation Shield to a tower leg as shown in Figure 4-3.

1. Position the radiation shield on the tower leg that faces the prevailing wind, with the top of the black plastic mounting base 68" above the tower base. Secure the radiation shield to the leg using the U-bolt and nuts provided.

4.3 015 PYRANOMETER MOUNTING ARM

Attach the 015 Pyranometer Mounting Arm to the mast as shown in Figure 4-4.

1. Position the 015 on the south facing lower leg (northern hemishpere), just below the tapered top section. Secure the 015 using the two U-bolts and nuts provided. Three spacing washers (not included) are required between the base and each nut (see Figure 4-4).

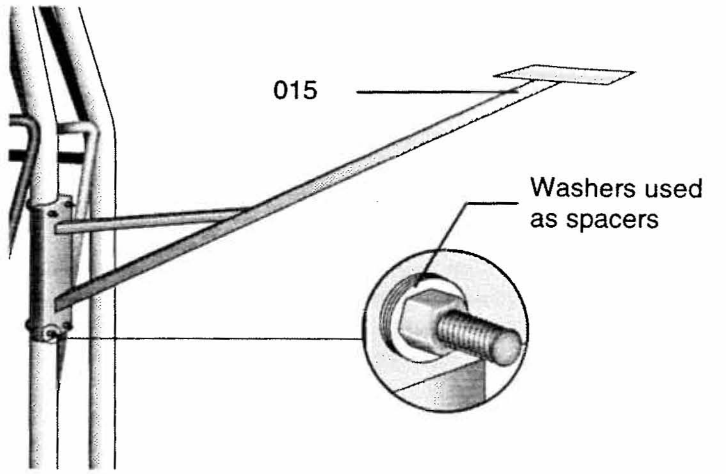


FIGURE 4-4. 015 Pyranometer Mounting Arm

4.4 025 PYRANOMETER CROSSARM STAND

Attach the 025 Pyranometer Crossarm Stand to the 019ALU as shown in Figure 4-5

1. Position the 025 mounting plate 5" above the 3/4 x 3/4" NU-RAIL and tighten the two set screws.

> **NOTE**: The 025 mounts to the 3/4" x 3/4" NU-RAIL (PN 1017) on the 019ALU Crossarm, which may not be available depending on the wind sensor configuration.

1.5m

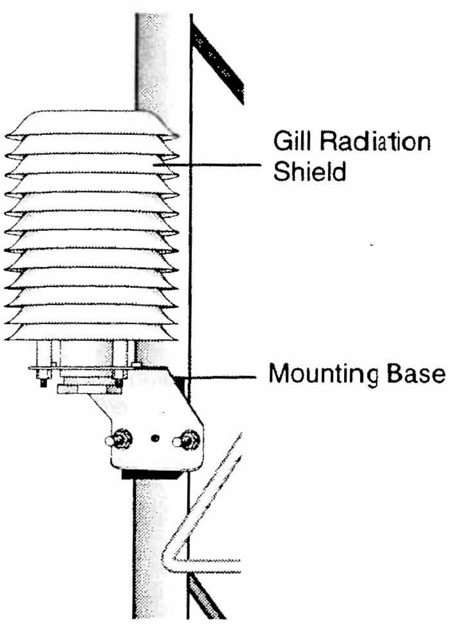


FIGURE 4-3 Gill Radiation Shield

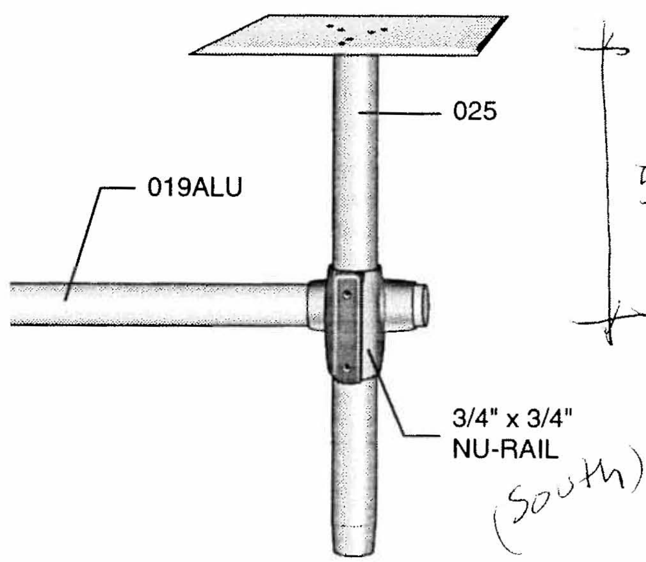


FIGURE 4-5 025 Pyranometer Crossarm Stand

SECTION 5. SENSOR INSTALLATION

Sensors are mounted to the UT3 tower as described below. The sensor leads should be routed down the North-facing tower leg to the enclosure, and secured with cable ties. Instructions for wiring the leads to the datalogger are covered in Section 8.

5.1 014A MET ONE WIND SPEED SENSOR

Mount the 014A sensor to the 019ALU crossarm as shown in Figure 5-1.

1. Insert the base of the sensor through the 3/4" NU-RAIL. Position the sensor 1" below the NU-RAIL and tighten the set screws.

2. Connect the sensor lead to the sensor. A small amount of lithium grease applied to the threads of the connector will prevent problems due to corrosion.

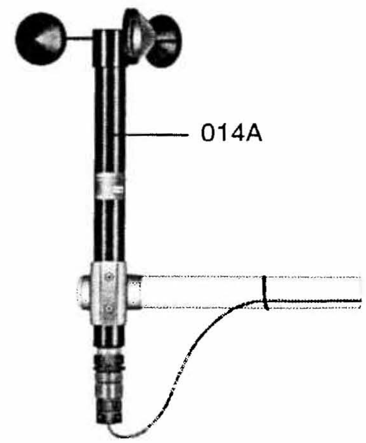


FIGURE 5-1. Met One 014A Wind Speed Sensor

5.2 024A MET ONE WIND DIRECTION SENSOR

Mount the 024A sensor to the 019ALU crossarm as shown in Figure 5-2.

1. Remove the hex-head screw located 3" from the base of the sensor. Insert the base of the sensor through the aluminum bushing provided with the sensor. Align the hole in the bushing with the hole in the sensor and replace the screw.

2. Insert the base of the sensor through the 1" NU-RAIL until the bushing screw rests on the NU-RAIL. Orient the sensor so the counter weight points south and tighten the set screws (see Appendix A for final calibration). Remove the shoulder screw to allow the vane to rotate.

3. Connect the sensor lead to the sensor. A small amount of lithium grease applied to the threads of the connector will prevent problems due to corrosion.

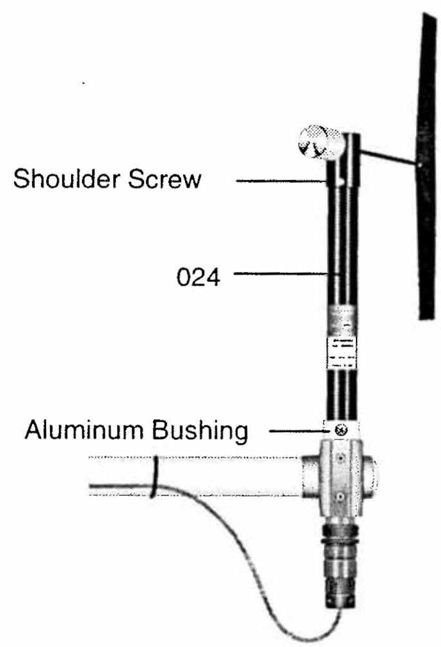


FIGURE 5-2. Met One 024A Wind Direction Sensor

5.3 05103 AND 05305 RM YOUNG WIND MONITORS

Mount the 05103 (or 05305) to the 019ALU crossarm as shown in Figure 5-3.

1. Position the 12" mounting post 5" above the 1" NU-RAIL and tighten the set screws.
2. Slide the orientation ring and the 05103 onto the mounting post. Rotate the sensor base so that the square wiring box points south. Engage the key in the orientation ring with the keyway on the sensor and tighten the band clamps (see Appendix A for final calibration).
3. Remove the plastic nut on the propeller shaft. Slide the propeller onto the shaft (face the side with the lettering out) and replace the nut.

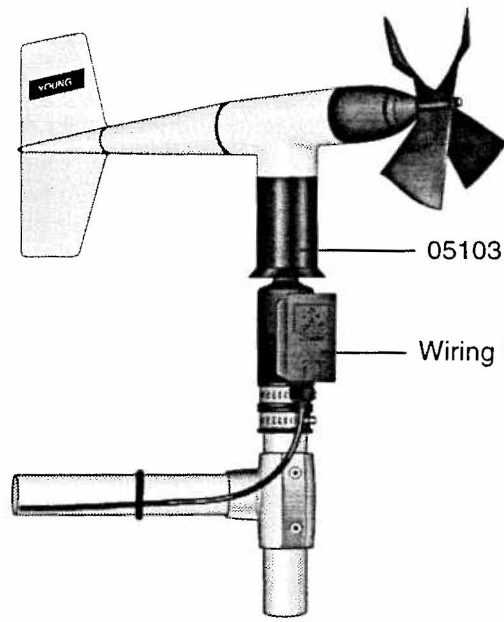


FIGURE 5-3. 05103 RM Young Wind Monitor

5.4 03001 RM YOUNG WIND SENTRY WIND SET

The 03001 can be mounted directly to the mast, or to the 019ALU Crossarm.

5.4.1 03001 MOUNTED TO THE MAST

Mount the 03001 to the mast as shown in Figure 5-4.

1. Slide the crossarm mounting bracket onto the mast. Orient the crossarm so the vane end points north, and tighten the band clamp (see Appendix A for final calibration).
2. Attach the cup assembly to the anemometer shaft using the allen wrench provided.

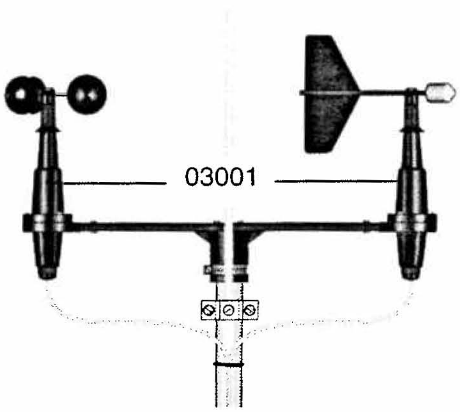


FIGURE 5-4. 03001 Mounted to the Mast

5.4.2 03001 MOUNTED TO 019ALU CROSSARM

Mount the 03001 to the 019ALU crossarm as shown in Figure 5-5.

1. Position the mounting post 5" above the 3/4" NU-RAIL, and tighten the set screws.
2. Slide the crossarm mounting bracket onto the mounting post. Orient the crossarm so the vane end points north, and tighten the band clamp (see Appendix A for final calibration).
3. Attach the cup assembly to the anemometer shaft using the allen wrench provided.

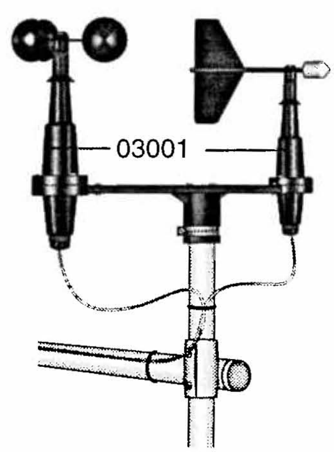


FIGURE 5-5. 03001 Mounted to 019ALU Crossarm

5.5 03101 RM YOUNG WIND SENTRY ANEMOMETER

Mount the 03101 to the 019ALU crossarm as shown in Figure 5-6.

1. Screw the mounting post into the mounting bracket on the sensor.

2. Position the mounting post 5" above the 3/4" NU-RAIL and tighten the set screws.

3. Install the cup assembly to the anemometer shaft using the allen wrench provided.

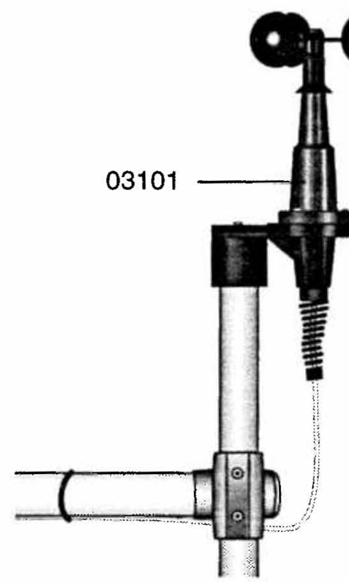


FIGURE 5-6. 03101 RM Young Wind Sentry Anemometer

5.6 LI200~~S~~ LI-COR SILICON PYRANOMETER LI200X

Mount the LI200S Pyranometer to the LI2003S Base and Leveling Fixture as shown in Figure 5-7.

1. Position the base of the LI200S in the mounting flange on the LI2003S, and tighten the set screw with the allen wrench provided. Adjust the three leveling screws flush with the bottom of the LI2003S.

2. Mount the LI2003S to the 025 or 015 (Section 4) using the three mounting screws provided. Do not tighten the screws at this time.

3. Level the LI2003S using the bubble level and leveling screws, and tighten the mounting screws. **Remove the red protective cap prior to use.**

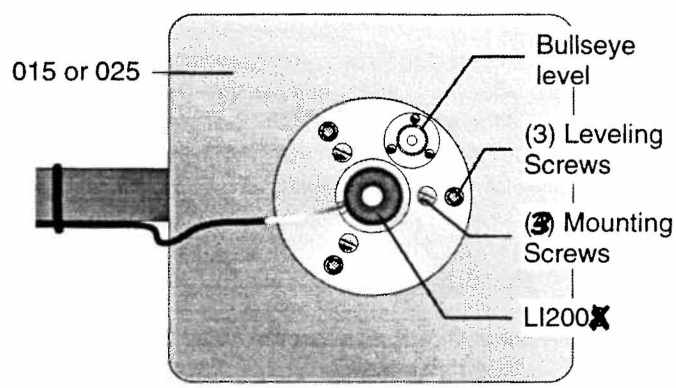


FIGURE 5-7. LI200S and LI2003S Leveling Fixture

5.7 107/108 TEMPERATURE PROBE

Mount the 107 temperature probe inside the 41301 6-Plate Gill Radiation Shield as shown in Figure 5-8.

1. Loosen the two mounting clamp screws on the base of the 41301. Insert the 107 probe through the mounting clamp until the white heat shrink is even with the bottom of the clamp.

2. Tighten the two screws evenly until the clamp is snug against the sensor lead.

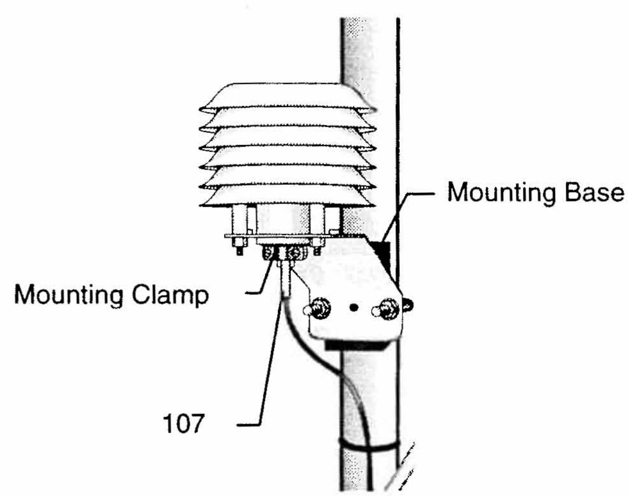


FIGURE 5-8. 107 Temperature Probe

5.8 107B SOIL TEMPERATURE PROBE

1. Select an undisturbed area of ground on the side of the tower that will receive the least amount of traffic. Route the sensor lead from the datalogger to the selected area.

2. Dig a narrow trench next to the sensor lead, ending the trench at least 6" short of the probe tip. Lay the sensor lead into the trench.

3. Use a screwdriver to poke a horizontal hole into the undisturbed soil at the end of the trench at the appropriate measurement depth. Insert the probe tip into the hole and carefully backfill the trench.

4. If bare soil is required, a soil sterilant such as Paramitol® can be applied to the area where the probe is buried. Soil erosion can be a problem when the probe is under bare soil. As the soil erodes, the probe becomes closer to the soil surface resulting in measurement errors. To prevent erosion from occuring, bury a 3' square frame constructed from 2 x 4" lumber around the probe, with the top of the frame even with the soil surface.

5.9 207 PHYSCHEM TEMPERATURE AND RH PROBE

Mount the 207 probe inside the 41004 12-Plate Gill Radiation shield as shown in Figure 5-9.

1. Loosen the two mounting clamp screws on the base of the 41004 shield and rotate the clamps away from the sensor entry hole.

2. Insert the 207 probe into the sensor entry hole. Rotate the clamps over the metal strap on the base of the 207 probe and tighten the clamp screws.

5.10 HMP35C VAISALA TEMPERATURE AND RH PROBE

Install the HMP35C probe inside the 40112 12-Plate Gill Radiation shield as shown in Figure 5-10.

1. Loosen the split plastic nut on the base of the shield. Insert the HMP35C probe through the nut as far as possible and tighten the nut.

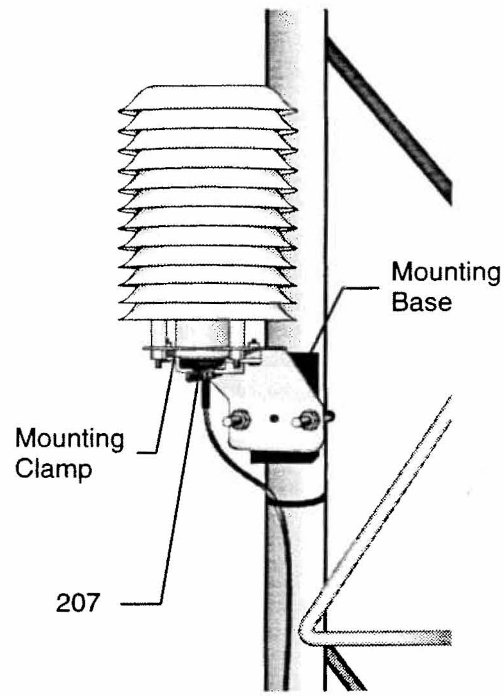


FIGURE 5-9. 207 PhysChem Temperature and RH Probe

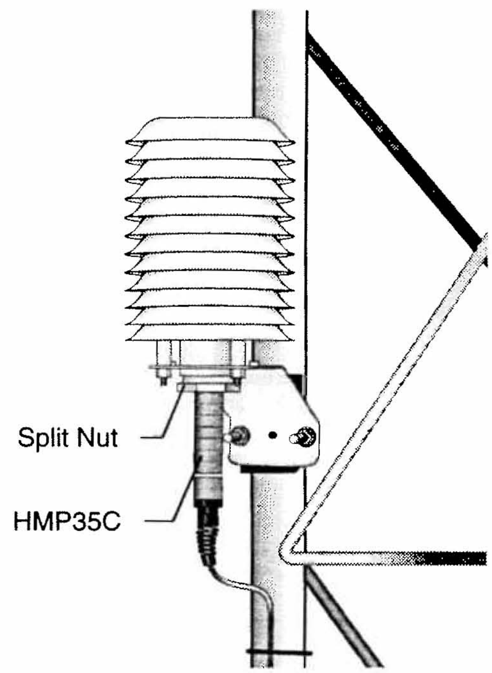


FIGURE 5-10. HMP35C Vaisala Temperature and RH Probe

5.11 PTA427 VAISALA BAROMETRIC PRESSURE SENSOR

Mount the PTA427 sensor to the enclosure backplate as shown in Figure 5-11.

1. Remove the three screws that attach the PTA427 sensor to the mounting plate. Attach the mounting plate to the enclosure back plate with the four screws and nylon grommets provided. The end of the bracket with the two screws should be up.

2. Mount the PTA427 to the mounting plate. Route the sensor lead across the bottom of the enclosure and up the left side to the datalogger.

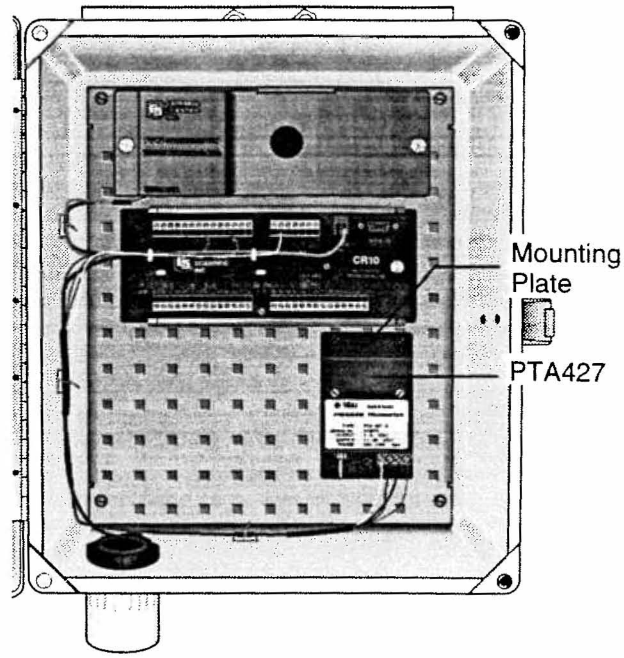


FIGURE 5-11. PTA427 Vaisala Barometric Pressure Sensor

5.12 TE525 TEXAS ELECTRONICS TIPPING BUCKET RAIN GAGE

1. Mount the TE525 rain gage to a vertical pipe as shown in Figure 5-12. Mounting the gage directly to the tower is not recommended.

2. Dig a hole 6" an diameter and 24" deep.

3. Center a 1 1/4" to 2" IPS pipe (length = depth of hole + mounting height) in the hole and fill the hole with concrete. Use a level to plumb the pipe as the hole is filled.

4. After the concrete has cured, attach the TE525 to the top of the pipe with the hose clamps provided. Route the sensor lead to the tripod in plastic or metal conduit.

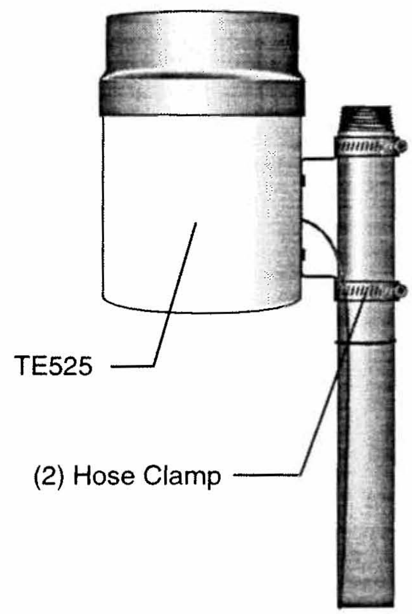


FIGURE 5-12. TE525 Texas Electronics Rain Gage

SECTION 6. ENC 12/14 AND ENCLOSURE

1. Mount the ENC 12/14 enclosure to the tower as shown in Figure 6-1. Position the enclosure on the north side of the mast with the top of the upper mounting bracket 59" up from the tower base. Secure the enclosure with the four U-bolts provided.

2. Route the green 14 AWG wire from the tower grounding clamp (Section 3) to the enclosure grounding lug. Insert the end of the wire into the hole behind the set screw and tighten the screw.

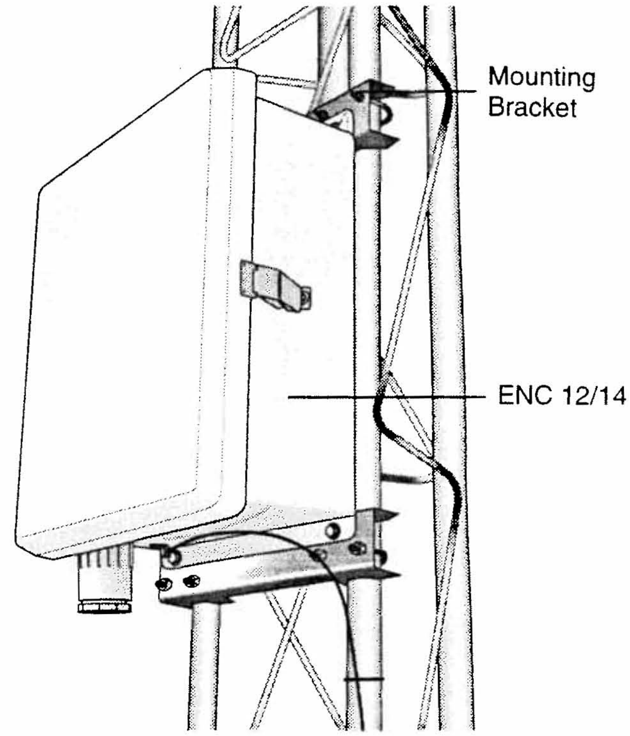


FIGURE 6-1. ENC 12/14 Enclosure

SECTION 7. DATALOGGER AND POWER SUPPLY

Both the CR10 and 21X dataloggers are used for weather station applications. The primary differences are: 1) the CR10 has fewer input channels, 2) the keyboard display (CR10KD) is not an integral part of the CR10, and 3) the CR10 is powered by an external battery.

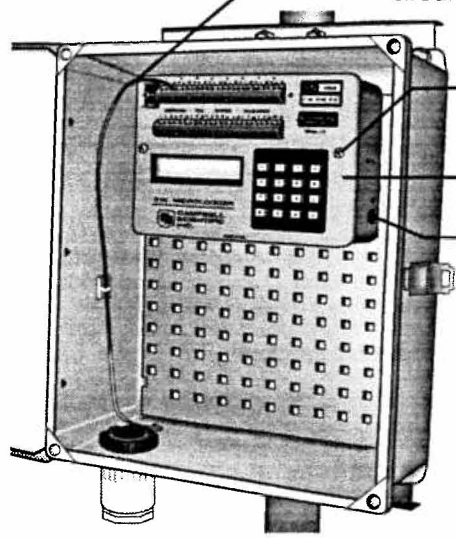


FIGURE 7-1. 21X Mounted Inside of the ENC 12/14 Enclosure

7.1 21X DATALOGGER

The 21X (or 21XL) datalogger mounts to the enclosure backplate as shown in Figure 7-1. Two screws (PN 505) attach the base to the backplate.

7.1.1 21X ALKALINE BATTERIES

The 21X is powered by eight alkaline "D" cell batteries located under the front panel. To install the batteries, remove the two panel screws (Figure 7-1) and the panel assembly (disconnnect the nylon connector) as shown in Figure 7-2. After the batteries are installed the power switch turns the 21X "ON" or "OFF".

> **NOTE:** An external 12V battery must be connected to the 12V and " ⏚ " terminals (on the lower terminal strip) to maintain power prior to changing out the batteries. The power switch should remain "ON".

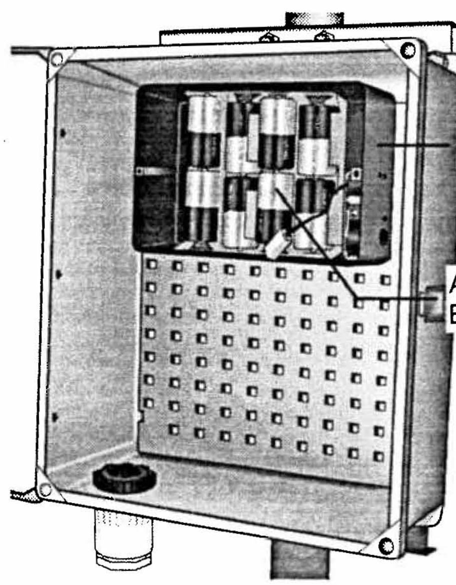


FIGURE 7-2. 21X Alkaline Batteries

7.1.2 21XL SEALED RECHARGEABLE BATTERY

The 21XL base includes a sealed rechargeable battery, charging circuitry, and charge indicating LED (Figure 7-3). The LED and charging jack are located on the right side of the base, next to the power switch. An AC wall transformer (provided) or unregulated solar panel (Section 7.3) should be connected to the charge jack at all times; the red LED should light when voltage is present.

> **NOTE:** The wall transformer converts 120 VAC input to 20 VDC output. The maximum charging current is 300mA.

7.2 CR10 DATALOGGER

The CR10 Datalogger and PS12 12V Power Supply mount to the enclosure backplate as shown in Figure 7-4. Two screws (PN 447) attach the CR10, four screws (PN 505) attach the PS12.

7.2.1 PS12ALK 12 VOLT POWER SUPPLY

The PS12ALK battery pack houses eight alkaline "D" cell batteries. To install the batteries, loosen the two thumb screws and remove the lid to access the battery pack, as shown in Figure 7-4.

1. Remove the battery pack and insert eight alkaline "D" cell batteries, then replace the battery pack. With the PS12 power switch "OFF", plug the battery pack lead into the connector labelled "INT".
2. Make sure the red and black wires attached to the +12V and " ⏚ " terminals on the PS12 are connected to the 12V and "G" terminals on the CR10 Wiring Panel.
3. Turn the power switch to "ON", then replace the PS12 cover.

> **NOTE:** An external 12V battery must be connected to the "EXT" terminal (with the cable provided) to maintain power prior to changing out the batteries. The power switch should remain "ON".

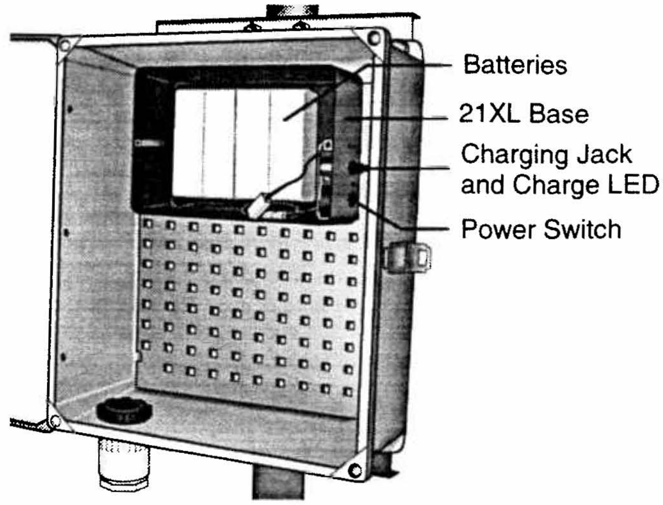


FIGURE 7-3. 21XL Rechargeable Batteries

7.2.2 PS12LA 12V POWER SUPPLY WITH RECHARGEABLE BATTERY

The PS12LA houses a sealed monoblock rechargeable battery. To install the battery, loosen the two thumb screws and remove the lid as shown in Figure 7-5.

1. With the PS12 power switch "OFF", insert the battery and plug the battery lead into the connector labeled "INT".
2. Make sure the red and black wires attached to the +12V and " ⏚ " terminals on the PS12 are connected to the 12V and "G" terminals on the CR10 Wiring Panel.
3. An AC transformer (provided) or unregulated solar panel (Section 7.3) should be connected to the PS12LA at all times. Connect the lead wires to the two terminals labeled "CHG" (no polarity); the red LED should light when voltage is present.

> **NOTE:** The wall transformer converts 120 VAC input to 20 VDC output. Maximum charging current is 300 mA.

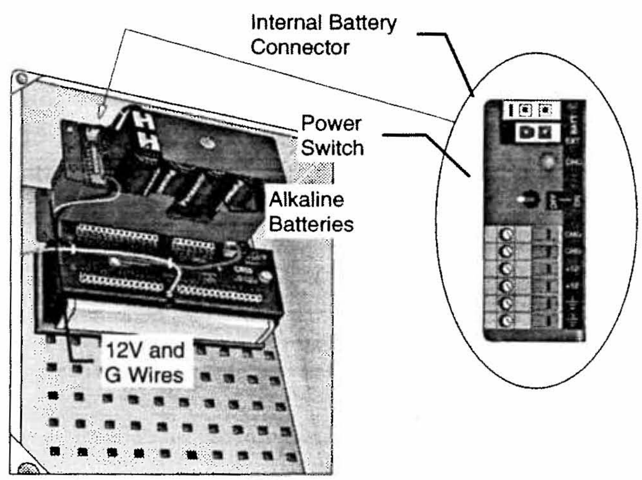


FIGURE 7-4. PS12ALK 12 Volt Power Supply

> **WARNING:** Maximum input voltage into the "CHG" terminals is 26V AC or 26V DC. Don't connect 110 VAC directly to "CHG" terminals.

4. Turn the power switch to "ON", then replace the PS12 cover.

7.3 MSX10/MSX5 SOLAR PANEL

Solar panels purchased from CSI are shipped with a charge plug taped to the back of the panel. The charge plug is only required when used with the 21XL. Refer to the solar panel manual for installation instructions.

1. Mount the MSX10 (or MSX5) solar panel to the CM10 mast as shown in Figure 7-6. When used with the CM6, the solar panel may have to be mounted to a vertical pipe adjacent to the tripod, depending on the available mast space.

2. Position the MSX10 on the south side of the mast (northern hemisphere) with the top of the mounting bracket 9" down from the top of the bell reducer (CM10). Install the U-bolt, muffler clamp, and nuts as shown in Figure 7-6.

3. The solar panel should be orientated to receive maximum insolation over the course of the year. Suggested tilt angles (referenced to the horizontal plane) are listed below.

Site Latitude	Tilt Angle
0 - 10 degrees	10 degrees
11 - 20	Latitude + 5 degrees
21 - 45	Latitude + 10 degrees
46 - 65	Latitude + 15 degrees
> 65	80 degrees

4. After determining the tilt angle, loosen the two bolts that attach the mounting bracket to the panel. Adjust the angle, then tighten the bolts. Secure the lead wire to the mast using wire ties.

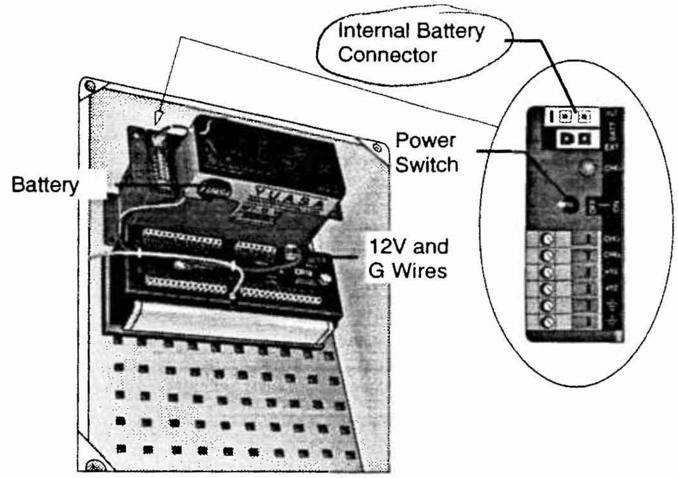


FIGURE 7-5. PS12LA 12 Volt Power Supply

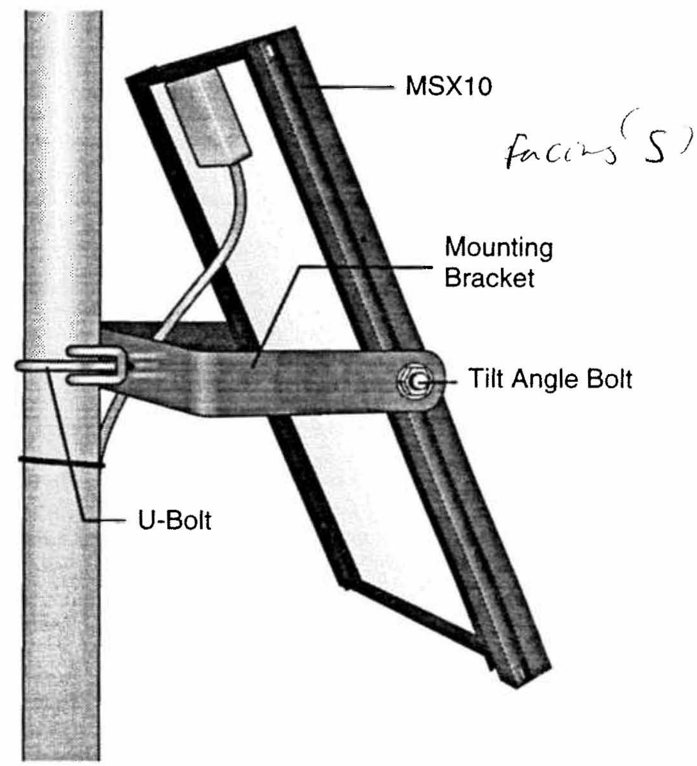


FIGURE 7-6. MSX10 Solar Panel

SECTION 8. SENSOR WIRING

1. After the sensors have been mounted, route the sensor leads through the entry hole in the bottom of the enclosure and to the datalogger. Secure the leads to the left side of the enclosure using cable ties and tabs (Figure 8-1). Any excess cable should be neatly coiled and secured to the tabs.

2. To connect a lead wire, loosen the appropriate screw terminal and insert the lead wire (wires should be stripped 5/16"), and tighten the screw using the screwdriver provided with the datalogger.

   If a datalogger program has been developed, the sensors will have to be wired to the channels specified by the measurement instructions. Refer to the Appendix C for general wiring; wire the excitation and signal leads to the inputs specified by the program.

   If a program has not been developed, WeatherPro (PC100 Software) can be used to generate a program and wiring diagram. Run WeatherPro, and wire the sensor leads as specified by the wiring diagram (which should correlate with the wiring in Appendix C).

   For more complex programming, or when sensors are used which are not supported by WeatherPro, EDLOG (PC208 Software) must be used. Wire the sensors as shown in Appendix C, and develop the program using EDLOG and the measurement instructions listed in Appendix D.

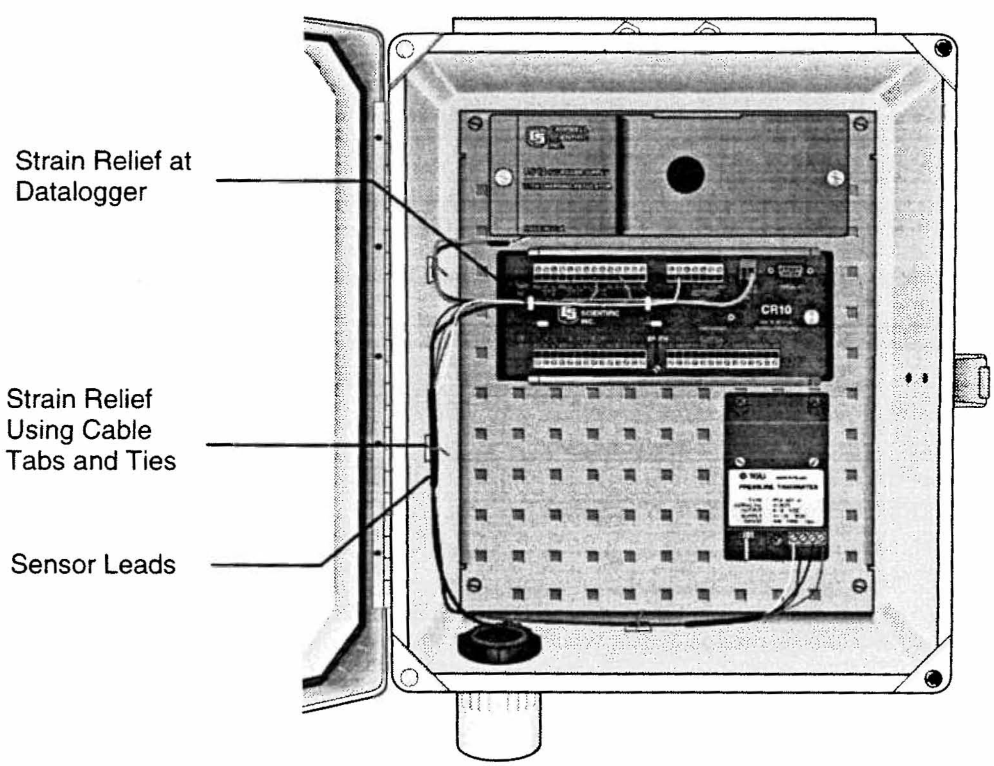


FIGURE 8-1. Routing and Wiring Sensor Leads to the Datalogger

SECTION 9. COMMUNICATION AND DATA STORAGE PERIPHERALS

One or more peripherals (i.e. storage modules, modems, relay drivers, etc.) can be mounted to the enclosure backplate (ENC 10/12, ENC 12/14 or ENC 16/18 enclosures), depending on the enclosure and the size of the peripheral.

9.1 SM192/SM716 STORAGE MODULE

Storage modules extend the amount of memory that is available for storing data, and also provide on-site backup of data and programs.

Mount the SM192 to the enclosure backplate as shown in Figure 9-1.

1. Attach the mounting bracket (PN 6234) to the backplate using the four screws and nylon grommets provided.

2. Connect the storage module to the datalogger's I/O port with an SC12 cable. Place the storage module in the bracket and fasten the Velcro straps.

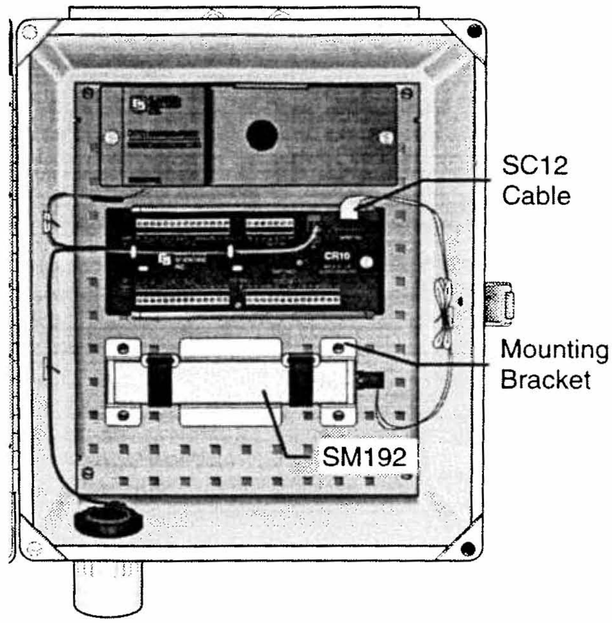


FIGURE 9-1. SM192/SM716 Storage Module

9.2 DC112 PHONE MODEM

The DC112 Phone Modem enables communication between the datalogger and the computer (with a Hayes compatible phone modem) over a dedicated telephone line.

1. Mount the DC112 to the backplate using the four screws and nylon grommets provided.

2. Connect the DC112 to the datalogger's I/O port with an SC12 cable.

3. The telephone company generally provides surge protection, and a patch cord that plugs into the RJ11C jack, or wire that attaches to the "TIP" and "RING" terminals on the DC112 as shown in Figure 9-3. If surge protection has not been provided, the Model 6362 Surge Protector Kit can be installed to the enclosure backplate

Mount the DC112 to the enclosure backplate as shown in Figure 9-2.

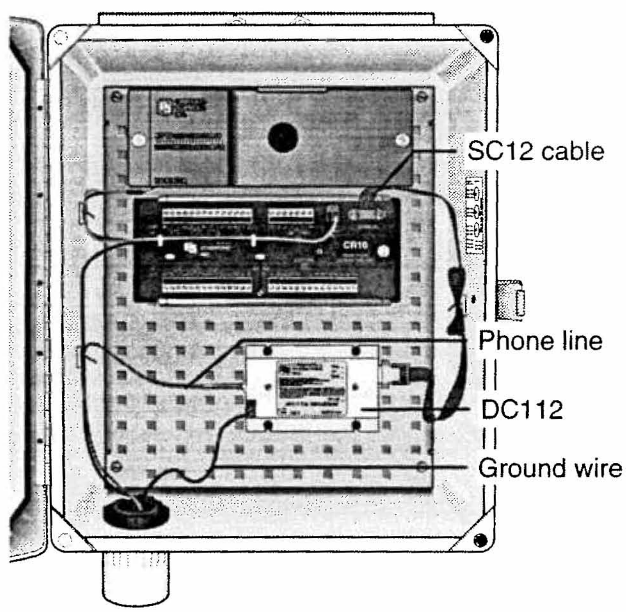


FIGURE 9-2. DC112 Telephone Modem Installation

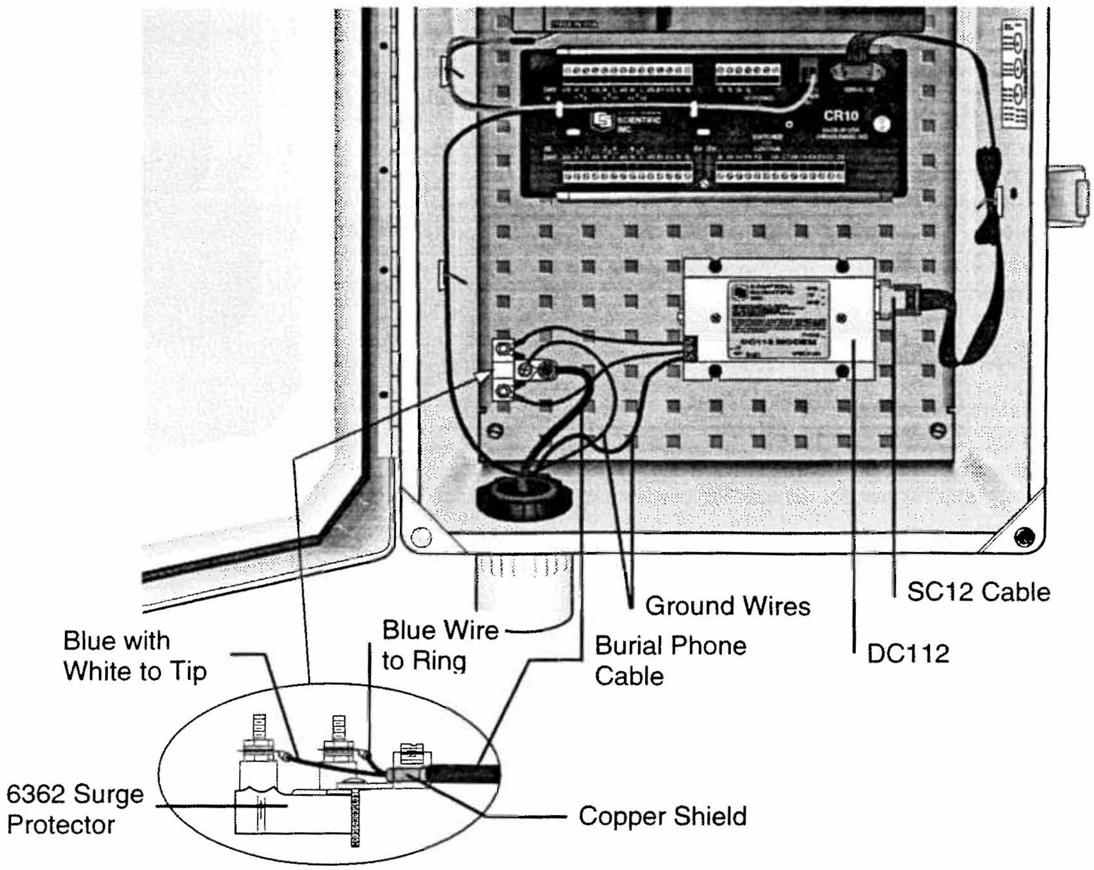


FIGURE 9-3. DC112 Modem with 6362 Surge Protector

9.3 SRM-6A RAD MODEM AND SC932 INTERFACE

Rad Modems enable communication between a datalogger and computer over 4-wire unconditioned telephone line, or cable with two twisted pairs of wires.

The maximum distance between modems is determined by baud rate and wire gauge. At 9600 baud the approximate range is 5.0 miles using 19 gauge wire, 4.0 miles using 26 gauge wire.

Installation requirements depend on the type of cable that is used, and how it is installed (direct burial, conduit, etc.). In general, follow state and local electrical codes.

A recommended rodent-proof burial cable is PN F-02P22BPN, available from ANIXTER. Call ANIXTER at (708) 677-2600 for the name of a local distributor.

9.3.1 SRM-6A AT THE DATALOGGER

1. Attach the SC932 mounting bracket to the enclosure backplate using the four screws and nylon grommets provided as shown in Figure 9-4.
2. Connect the SC932 to the datalogger's I/O port with an SC12 cable.
3. Mount the 6361 Surge Protector to the enclosure backplate using the hardware provided. Connect the ground wire to the enclosure ground lug.
4. Remove the backshell from the SRM-6A. Cut a 12" long piece of modem cable and connect it to the SRM-6A as shown in Figure 9-5. Fasten the cable to the strain relief tab with a cable tie, then replace the backshell. Connect the serial port of the SRM-6A to the SC932 and secure the SRM-6A to the mounting bracket using the velcro straps.

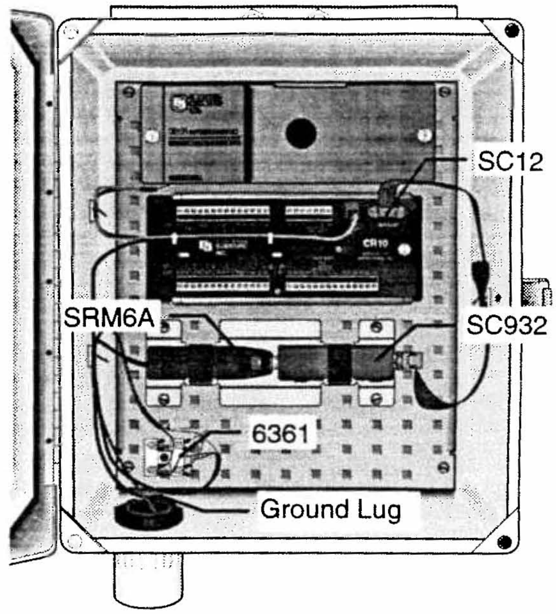
5. Route the cable previously attached to the SRM-6A, and the modem cable (from the other SRM-6A) to the 6361. Connect the cables as shown in Figure 9-5. Strain relief the cables to the side of the enclosure using cable ties and tabs

9.3.2 SRM-6A AT THE COMPUTER

1. Mount the 5563 Surge Protector to a flat surface (close to the computer) using two screws. Ground the center terminal to an earth (or building) ground using a 12 AWG or larger diameter wire.
2. Cut a piece of modem cable long enough to reach from the 5563 to the computer. Remove the backshell from the SRM-6A and connect the cable as shown in Figure 9-5. Fasten the cable to the strain relief tab with a cable tie, then replace the backshell. Connect the serial port to the computer's serial port using a SC25PS cable; 9-pin ports also require PN 7026 adaptor cable.
3. Route the cable from the remote SRM-6A, and the cable from the SRM-6A attached to the computer to the 5563. Connect the cables as shown in Figure 9-5. Strain relief the cables next to the 5563 using cable ties and tabs.

9.4 RF95 RF MODEM AND P50 TRANSCEIVER

Radiotelemetry (RF) enables communications between one or more dataloggers and the computer over an FCC-assigned radio frequency in the VHF or UHF band. The maximum distance between any two communicating stations is approximately 20 miles and must be line-of-sight. Longer distances and rough terrain may require intermediate repeater station(s). Refer to the Radiotelemetry Network Applications manual for RF repeater stations and Phone-to-RF configurations.



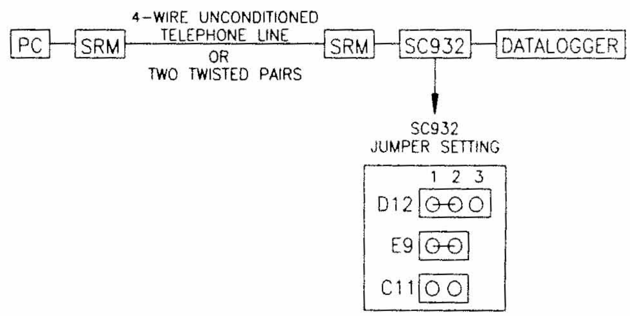


FIGURE 9-4. SRM-6A and SC932 at Datalogger

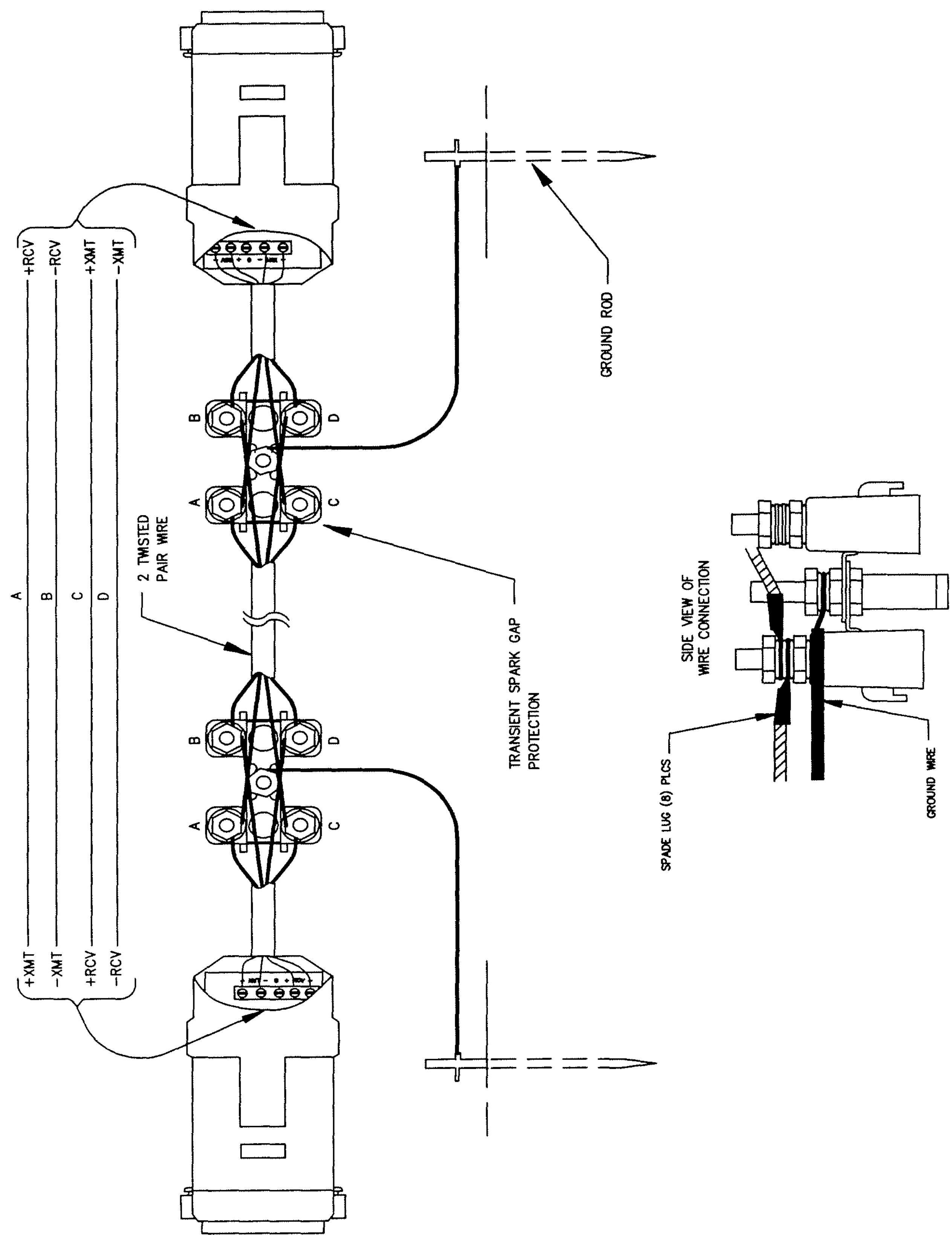


FIGURE 9-5. SRM-6A Wiring

9.4.1 RF95 MODEM AND P50 TRANSCEIVER AT THE DATALOGGER

Mount the RF95 RF Modem and the P50 Transceiver to the enclosure backplate as shown in Figure 9-6.

1. Remove the four screws that attach the lid to the RF95 modem. Remove the lid, then remove the single screw that secures the circuit board to the base. Remove the circuit board, and mount the base to the enclosure backplate using the two screws and plastic grommets provided

2. Set the dip switches on the circuit board to the appropriate Station ID (Table 9.1, each RF95 must have a unique station ID). Switch 9 should be in the "OPEN" postition except for when the RF95 is connected to a DC112 phone modem in a Phone-to-RF configuration. Reassemble the circuit board and lid. Do not tighten the four lid screws at this time.

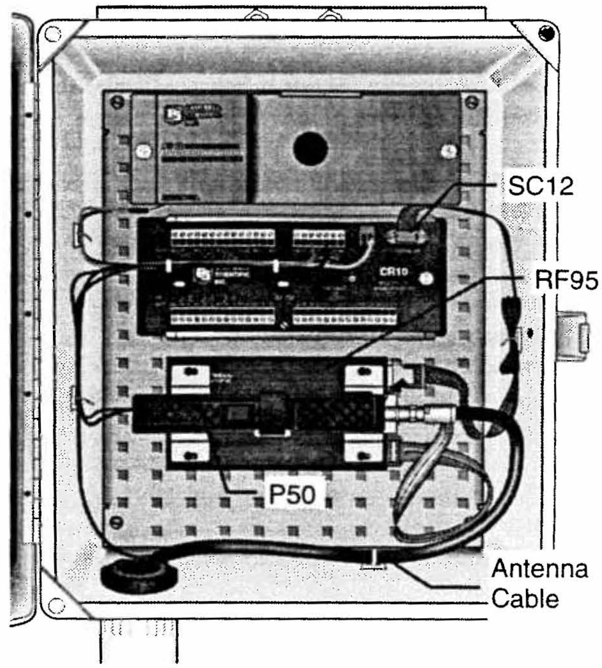


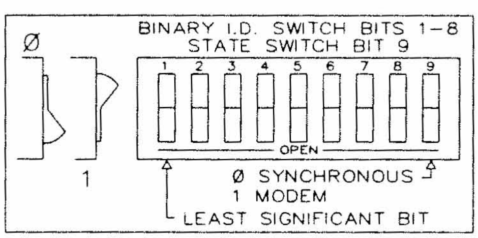
FIGURE 9-6. RF95 RF Modem and P50 Transceiver

TABLE 9.1. Station ID Numbers and Corresponding Switch Settings**

Station ID	Switch Settings 1234	56789	Station ID	Switch Settings 1234	56789
0	0000	0000X	140	0011	0001X
10	0101	0000X	150	0110	1001X
20	0010	1000X	160	0000	0101X
30	0111	1000X	170	0101	0101X
40	0001	0100X	180	0010	1101X
50	0100	1100X	190	0111	1101X
60	0011	1100X	200	0001	0011X
70	0110	0010X	210	0100	1011X
80	0000	1010X	220	0011	1011X
90	0101	1010X	230	0110	0111X
100	0010	0110X	240	0000	1111X
110	0111	0110X	250	0101	1111X
120	0001	1110X	*255	1111	1111X
130	0100	0001X			

** Station ID 255 is reserved for phone-to-RF base stations.*

*** See Appendix A in the Radiotelemetry Network Applications Manual for a table of switch settings.*



3. Attach the P50 mounting bracket to the RF95 lid, then tighten the four lid screws. Secure the P50 to the mounting bracket using the velcro strap.

4. Turn the P50 volume switch to "OFF", then route the red and black wires to the PS12. Connect the red wire to the "12V", and the black wire to " ⏚ ". Connect the multicolored cable from the P50 to the mating connector on the RF95 (make sure the keyway is properly aligned). Connect the RF95 to the datalogger using an SC12 cable.

5. Mount the antenna to the mast and route the cable to the enclosure. Connect the antenna cable to the P50, then set the P50 controls as shown in Figure 9-7.

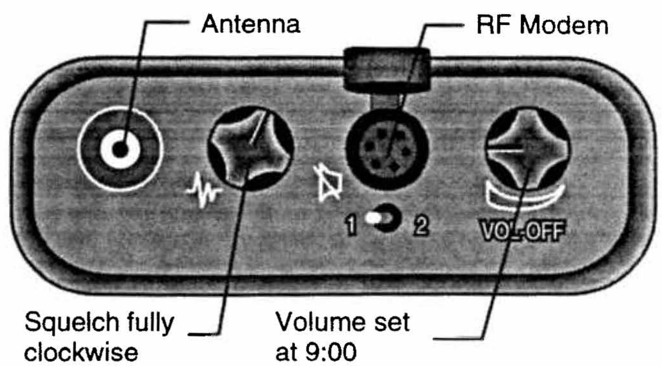
9.4.2 RF232 RF Base Station

1. Install the base station antenna according to the manufacturer's specifications. Route the antenna cable to the RF232.

2. With the power cord disconnected, remove the four screws that attach the RF232 lid. Remove the lid, and install the P50 transceiver as shown in Figure 9-8. Connect the red wire to the "12V" terminal, and the black wire to the " ⏚ " terminal inside the RF232. Connect the multi-colored ribbon cable to the RF modem; make sure that the keyway is properly aligned.

3. Connect the antenna cable to the BNC connector on the P50. Adjust the volume and squelch controls as shown in Figure 9-7. Reassemble the RF232 lid using the screws previously removed.

4. With the power switch "OFF", connect the power cord to 110V AC. Connect the serial port to the computer's serial port using an SC25PS cable; 9-pin ports also require PN 7026 adaptor cable. Toggle the power switch to "ON" to operate the RF232.



CAUTION: The antenna must be connected before transmission or the P50 transceiver may be damaged.

FIGURE 9-7. P50 Transceiver Control Settings

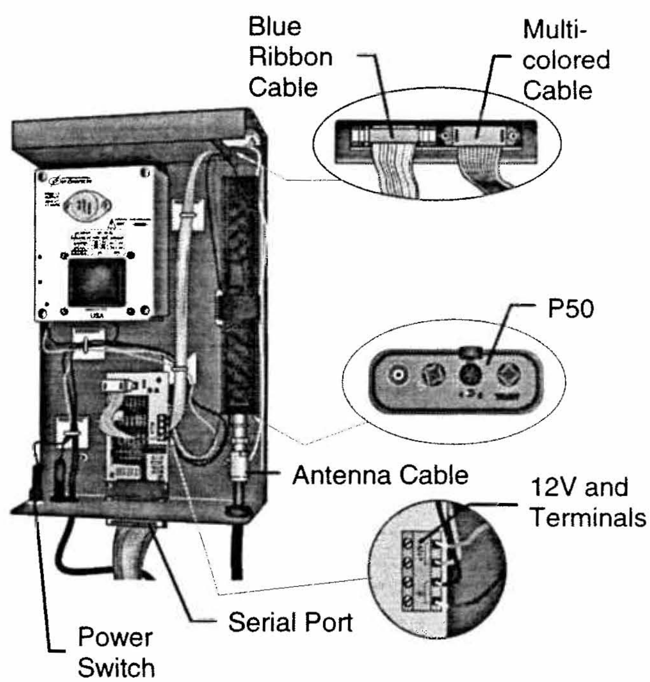


FIGURE 9-8. RF232 Base Station Installation

9.5 MD9 MULTIDROP INTERFACE

The MD9 Multidrop Interface enables communication with one or more dataloggers and the computer over a single 75 ohm coaxial cable. An MD9 network can be connected directly to the computer, or can be connected to a telephone modem (refer to the MD9 Manual) and accessed remotely.

Total coax length may be up to three miles. Since each MD9 attenuates the signal 0.2 db, the maximum length depends on the number of MD9s in the network (refer to the MD9 manual).

Coaxial cable and BNC connectors may be ordered from CSI, or purchased locally (Belden Type 9100 RG59/U or equivalent). Call Belden Wire and Cable at (317) 983-5200 for the name of a local distributor.

Installation requirements depend on the type of cable that is used, and how it is installed (direct burial, conduit, etc.). In general, follow state and local electrical codes.

9.5.1 MD9 MULTIDROP INTERFACE AT THE DATALOGGER

Mount the MD9 to the enclosure backplate as shown in Figure 9-9.

1. Remove the two screws that attach the lid to the MD9. Remove the lid, and the single screw that attaches the circuit board to the base. Remove the board and mount the base to the enclosure backplate using the two screws and nylon grommets provided.

2. Set the dip switches on the circuit board to the appropriate Station ID (Table 9.2, each MD9 must have a unique ID), and baud rate (default is 9600). Reassemble the circuit board and lid using the screws previously removed.

3. Route the coaxial cable(s) to the MD9. Connect the cable(s) to the MD9 using the BNC "T" provided. The first and last MD9s of the network must be terminated with 75 ohm Coax Terminators (Model MD9CT) to prevent signal reflection.

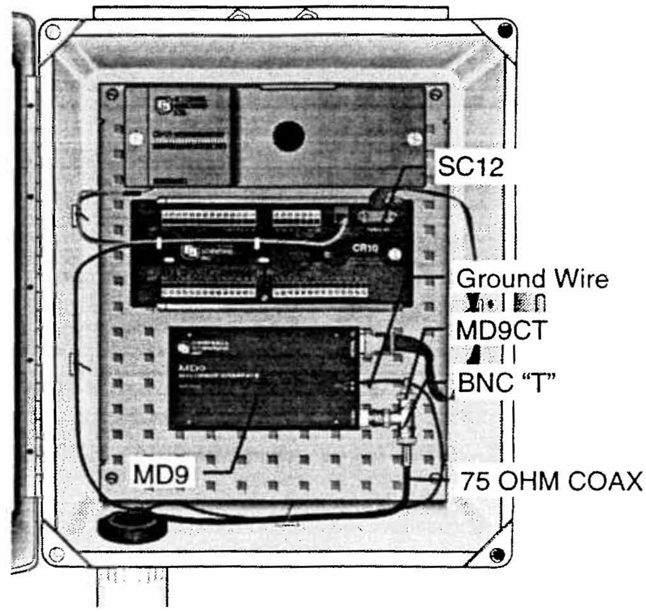
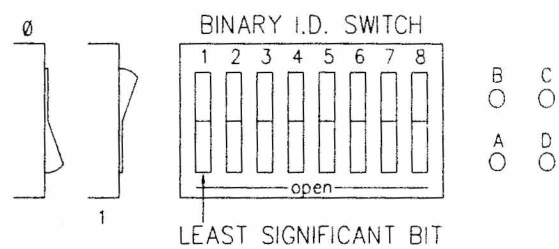


FIGURE 9-9. MD9 Multidrop Interface

TABLE 9.2 Station ID Numbers and Corresponding Switch Settings



9600 Baud	1200 Baud	300 Baud
A-B Short	A-B Open	A-B Short
C-D Short	C-D Short	C-D Open

SWITCH	STATE	INDICATES	DECIMAL VALUE WHEN OPEN
1	CLOSED	0	1
2	OPEN	1	2
3	OPEN	1	4
4	OPEN	1	8
5	CLOSED	0	16
6	CLOSED	0	32
7	CLOSED	0	64
8	CLOSED	0	128

NOTE: Addresses 1-254 are valid for an MD9 connected to a datalogger or computer. Address 255 is used only when the MD9 is connected to a telephone modem.

4. Connect the green ground wire to the "⏚" terminal on the MD9, and to datalogger ground. Connect the MD9 to the datalogger with an SC12 cable.

9.5.2 MD9 MULTIDROP INTERFACE AT THE COMPUTER

Connect the MD9 and the SC532 9 Pin Peripheral to RS232 Interface to the computer as shown in Figure 9-10.

1. Route the coaxial cable to the MD9; connect the cable and an MD9CT to the MD9 using the BNC "T" provided.

2. Connect the MD9 to the SC532 with an SC12 cable. Connect the SC532 to the computer's serial port using an SC25PS cable; 9-pin ports also require PN 7026 adaptor cable.

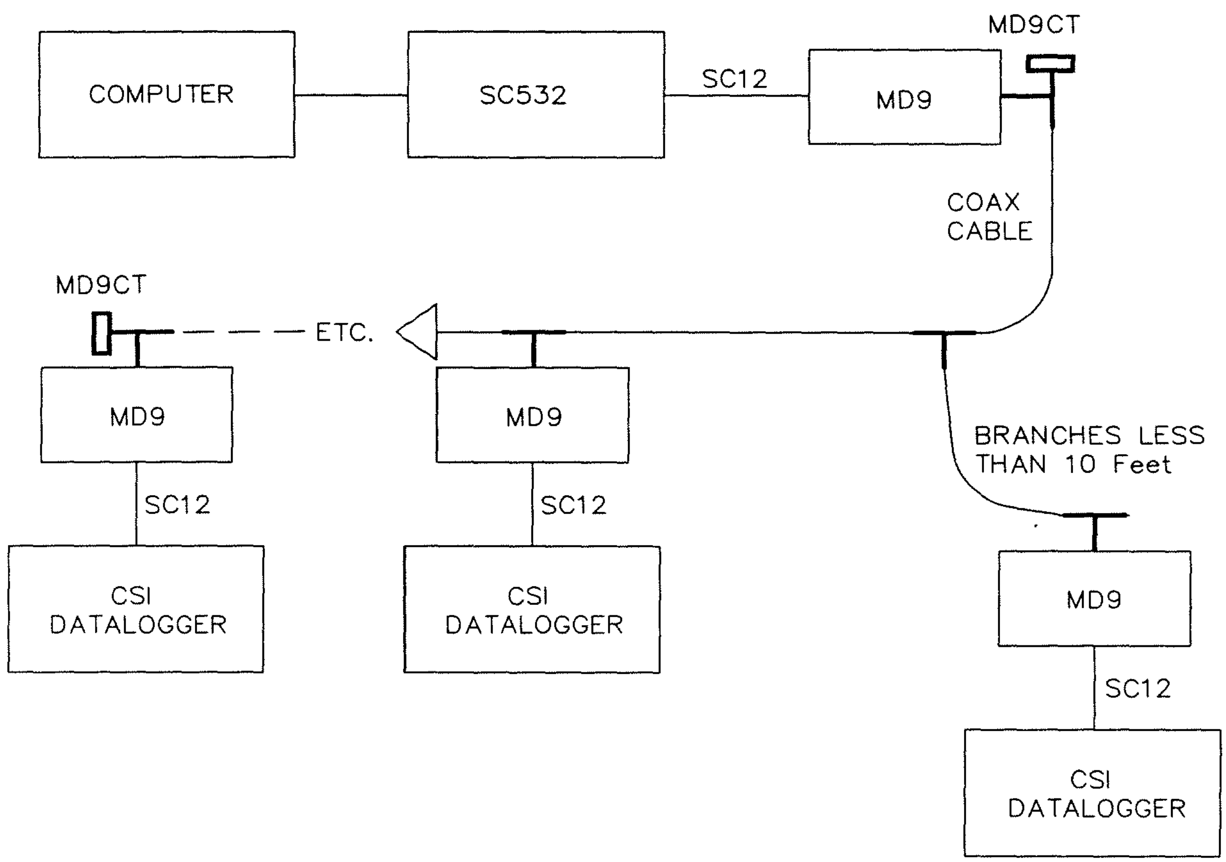


FIGURE 9-10. MD9 Multidrop Interface at the Computer

SECTION 10. PROGRAMMING THE DATALOGGER

After the sensors have been wired, the datalogger must be programmed before it will measure the sensors and store data. WeatherPro (PC100), or EDLOG (PC208), are computer programs that can be used for creating datalogger programs.

WeatherPro is simple to use and is recommended for basic weather station programming. WeatherPro prompts the user for the sensor type, desired units (i.e. °C or °F), and the output interval(s) over which the measurements are to be processed.

EDLOG requires a basic understanding of the datalogger and programming. EDLOG should be used for more complex programming (i.e. multiplexing, conditional outputs, control, etc.), or when sensors not supported by WeatherPro are used.

After a program has been developed, there are three ways to program the datalogger:

1. Key the program in using the datalogger's keypad (refer to the Overview Section in the datalogger's manual).

2. Load a program from the SM192/SM716 Storage Module (refer to the *D Mode in the datalogger's manual and SMCOM in the PC208 manual).

3. Download a program using GRAPHTERM or TERM (PC208 Software) through the SC32A interface, or other modem interface (refer to the PC208 manual).

SECTION 11. SEALING AND DESSICATING THE ENCLOSURE

CSI enclosures include an Enclosure Supply Kit with the following items:

(4) Desiccant packs
(1) Humidity indicator tab
(6) 4-inch cable ties
(6) 8-inch cable ties
(4) Cable tabs
(1) 4 oz. sealing putty

The Enclosure Supply Kit is used to strain relief the sensor leads, and to seal and desiccate the enclosure as shown in Figure 11-1.

1. Secure the sensor leads to the left side of the enclosure and to the datalogger using cable ties and tabs.

2. Seal around the sensor leads where they enter the enclosure. Place a roll of putty around the sensor leads and press it around the leads and into the coupling to form a tight seal.

3. Remove the RH indicator tab and two desiccant packs from the sealed plastic bag. Remove the backing from the indicator tab and attach the tab to the right side of the enclosure.

   The humidity indicator tab has three colored circles which indicate the percentage of humidity. Desiccant packs inside the enclosure should be replaced with fresh packs when the upper dot on the indicator begins to turn pink. The indicator tab does not need to be replaced unless the colored circles overrun.

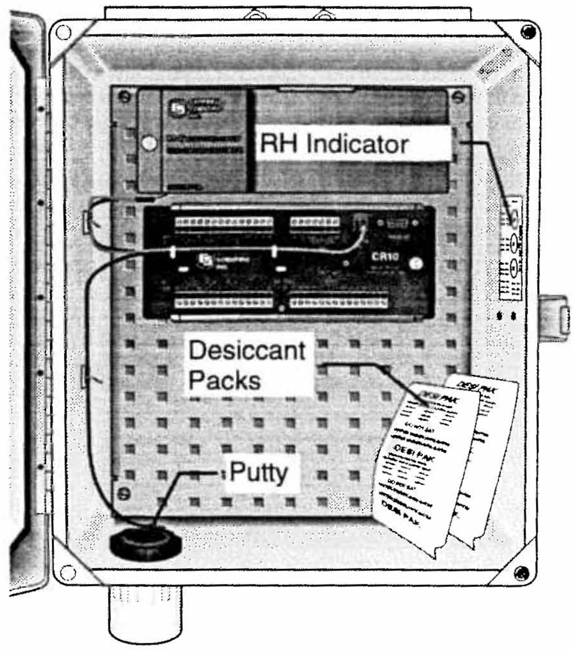


FIGURE 11-1. Enclosure Supply Kit

Desiccant packs can be re-activated

write Don't use Temp range on Packs.

200 °F ~ 14 → 18 hrs.

SECTION 12. MAINTENANCE

Proper maintenance of the weather station components is essential in order to obtain accurate data. Equipment must be in good operating condition, which requires a program of regular inspection and maintenance. Routine and simple maintenance can be accomplished by the person in charge of the weather station. More difficult maintenance such as sensor calibration, sensor performance testing (i.e. bearing torque), and sensor component replacement, generally requires a skilled technician, or that the instrument be returned to the factory.

A station log should be maintained for each weather station that includes serial numbers, dates that the site was visited, and maintenance that was performed.

12.1 DATALOGGER MAINTENANCE

The CR10 and 21X dataloggers require a minimum of routine maintenance. A few preventative maintenance steps will optimize battery life and decrease the chances of datalogger failure.

12.2 BATTERIES

Instruction 10 can be used to measure battery voltage. By recording battery voltage the user can determine how long a fresh set of batteries will last (see the Installation Section of the datalogger Operator's Manual for cold temperature effects on alkaline batteries).

When alkaline batteries are used, the battery voltage should not be allowed to drop below 9.6V DC before replacement. An external battery must be used to maintain power to the datalogger when changing batteries, otherwise the clock, program, and data will be lost (refer to the Installation Section of the datalogger's Operator's Manual for details). When not in use, remove the eight cells to eliminate potential corrosion of the contact points, and store in a cool dry place.

The PS12LA or 21XL should be connected to the AC transformer or unregulated solar panel at all times. The charge indicating diode should be "ON" when voltage to the charging circuitry is present. Be aware of battery voltage that consistently decreases over time, which indicates a failure in the charging circuitry.

12.3 DESICCANT

Campbell Scientific, Inc. enclosures include an Enclosure Supply Kit that includes (4) desiccant packs, and an RH indicator tab (Section 11). Change the desiccant packs when the upper circle on the tab starts to turn pink. Desiccant may be ordered through Campbell Scientific, Inc. (DSC 20/4), or, used packs can be recharged following manufacturer's recommendations.

Desiccant packs inside of the dataloggers do not require replacement under normal conditions.

12.4 SENSOR MAINTENANCE

Sensor maintenance should be performed at regular intervals, depending on the desired accuracy and the conditions of use. A suggested maintenance schedule is outlined below.

1 week

- Check the pyranometer for level and contamination
- Visually inspect the wind sensors and radiation shield

1 month

- Check the rain gage funnel for debris and level
- Do a visual/audio inspection of the anemometer at low wind speeds
- Check the filter and base of 207 temperature/humidity sensor

6 months

- Clean the temperature/humidity sensor
- Clean the Gill Radiation Shield

1 year

- Replace bearings
- Calibrate the rain gage
- Calibrate the HMP35C probe
- Replace the RH chip in the 207 probe; inspect the gold plated contacts for corrosion

2 years

- Calibrate the pyranometer (some users suggest yearly)
- Calibrate the temperature sensor
- Replace the wind vane potentiometer and bearings

4 - 5 years

- Replace sensor cables as required

General Maintenance

- An occasional cleaning of the glass on the solar panel will improve its effeciency.
- Check sensor leads and cables for cracking, deterioration, proper routing, and strain relief.
- Check the tripod for structural damage, proper alignment, and for level/plumb.

APPENDIX A. WIND DIRECTION SENSOR ORIENTATION

A.1 DETERMINING TRUE NORTH AND SENSOR ORIENTATION

Orientation of the wind direction sensor is done after the datalogger has been programmed to measure the sensor, and the location of True North has been found. Orientation is most easily done with two people, one to aim and adjust the sensor, while the other observes the wind direction displayed by the datalogger.

1. Establish a reference point on the horizon for True North (or other direction relative to True North). True North is usually found by reading a magnetic compass and applying the correction for magnetic declination as discussed below. Other methods employ observations using the North Star or the sun, and are discussed in the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV - Meteorological Measurements[4].

A general map showing magnetic declination for the contiguous United States is shown in Figure A-1. Magnetic declination for a specific site can be obtained from a USGS map, local airport, or through a computer service offered by the USGS called GEOMAG (recommended). Section A.2 has a listing of the prompts and the declination determined by GEOMAG for a site near Logan, Utah.

Declination angles east of True North are considered negative, and are subtracted from 0 degrees to get True North as shown Figure A-2. Declination angles west of True North are considered positive, and are added to 0 degrees to get True North as shown in Figure A-3.

As an example, the declination for Logan, Utah is 16° East (Figure A-1). True North is 360° - 16°, or 344° as read on a compass.

2. Sighting down the instrument center line, aim the nose cone (propeller), or counterweight (vane) at True North. Display the input location for wind direction using the *6 Mode of the datalogger, or, the Monitor Mode of TERM or GraphTerm with an on-line PC.

3. Loosen the band clamps or set screws that secure the base of the sensor to the mast or crossarm. While holding the vane position, slowly turn the sensor base until the datalogger indicates 0 degrees. Tighten the band clamps or set screws loosened previously.

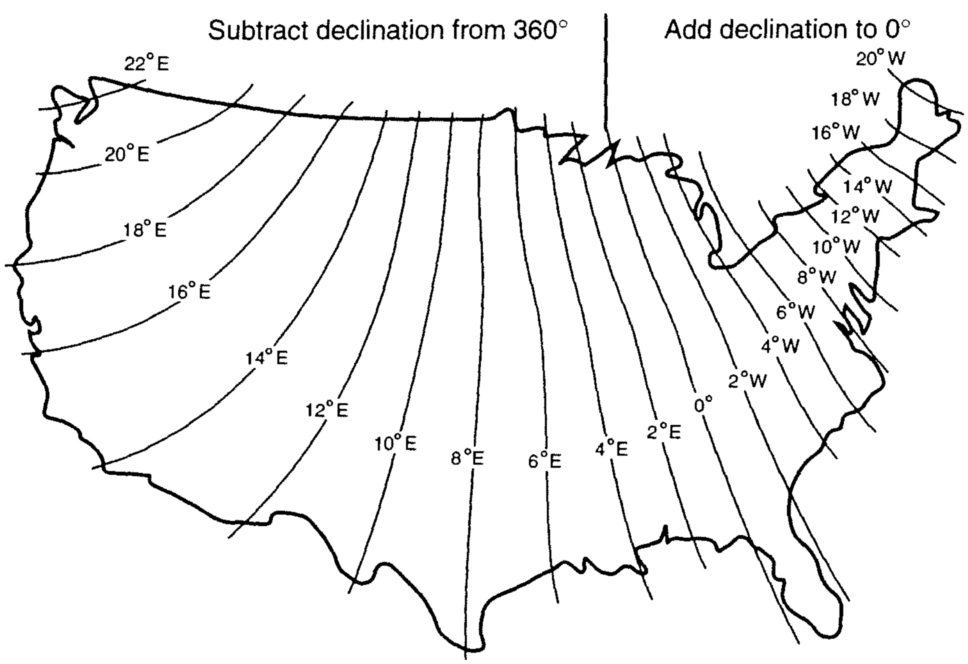


FIGURE A-1. Magnetic Declination for the Contiguous United States

4. Engage the orientation ring indexing pin in the notch at the instrument base (05103 and 05305 sensors only), and tighten the band clamp on the orientation ring.

A.2 PROMPTS FROM GEOMAG

GEOMAG is accessed by calling 1-800-358-2663 with a computer and telephone modem, and communications program such as TERM or GraphTerm (PC208 Software). GEOMAG prompts the caller for site latitude, longitude, and elevation, which it uses to determine the magnetic declination and annual change. The following Menu and prompts are from GEOMAG:

MAIN MENU

Type
- Q for Quick Epicenter Determinations (QED)
- L for Earthquake Lists (EQLIST)
- M for Geomagnetic Field Values (GEOMAG)
- X to log out

Enter program option: M

Would you like information on how to run GEOMAG (Y/N)? N

Options:

1 = Field Values (D, I, H, X, Z, F)
2 = Magnetic Pole Positions
3 = Dipole Axis and Magnitude
4 = Magnetic Center [1] : 1

Display values twice	[N]: press return
Name of field model	[USCON90]: press return
Date	[current date]: press return
Latitude	: 42/2 N
Longitude	: 111/51/2 W
Elevation	: 4454
Units (m/km/ft)	: ft

Example of report generated by GEOMAG:

Model: USCON90	Latitude: 42/2 N
Date : 7/27/93	Longitude: 111/51/2 W
	Elevation: 4454.0 ft

D
deg min

15 59.6

Annual change:

0 -6.1

The declination in the example above is listed as 15 degrees and 59.6 minutes. Expressed in degrees, this would be 15.99 degrees. As shown in Figure A-1, the declination for Utah is east, so True North for this site is 360 - 15.99, or 344 degrees. The annual change is -6.1 minutes.

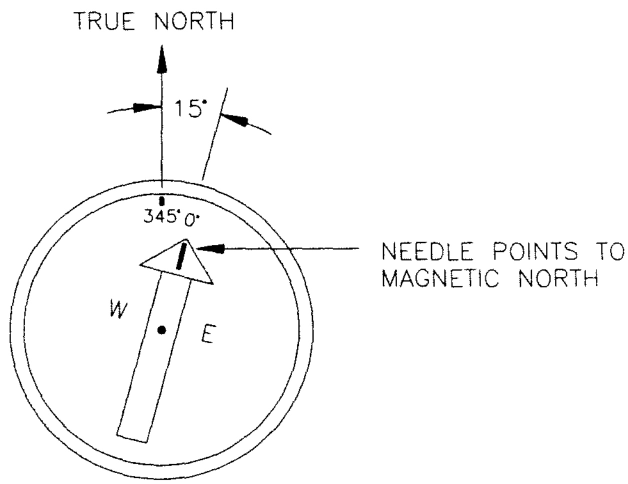


FIGURE A-2. Declination Angles East of True North

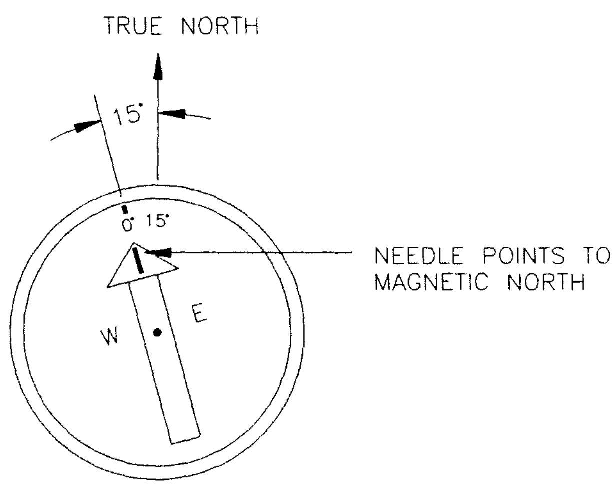


FIGURE A-3. Declination Angles West of True North

APPENDIX B. TROUBLESHOOTING

B.1 NO RESPONSE FROM DATALOGGER USING THE KEYPAD.

A. Make sure the battery has been installed, and the power switch is "ON" (Section 7).

B. Use a voltmeter to measure the voltage on the 12V and G terminals on the datalogger; the voltage must be between 9.6 and 16V DC.

C. Disconnect any sensor or peripheral wires connected to the 5V and 12V terminals.

D. Disconnect any communications or storage peripherals from the datalogger.

E. Reset the datalogger by turning the power switch to "OFF", then to "ON".

F. If still no response, call Campbell Scientific.

B.2 NO RESPONSE FROM DATALOGGER THROUGH SC32A OR MODEM PERIPHERAL.

At the datalogger:

A. Make sure the battery has been installed, and the power switch is "ON" (Section 7).

B. Use a voltmeter to measure the voltage on the 12V and G terminals on the datalogger; the voltage must be between 9.6 and 16V DC.

C. Make sure the datalogger is connected to the modem, and the modem is properly configured and cabled (Section 9).

At the computer:

D. Make sure the Station File is configured correctly (PC208 Manual).

E. Check the cable(s) between the serial port and the modem. If cables have not been purchased through Campbell Scientific, check for the following configuration using an ohm meter:

25-pin serial port:

computer end	modem end
2	2
3	3
7	7
20	20

9-pin serial port:

computer end	modem end
2	3
3	2
4	20
5	7

F. Make sure the modem is properly configured and cabled (Section 9).

G. If still no response, call Campbell Scientific.

B.3 -99999 DISPLAYED IN AN INPUT LOCATION.

A. Make sure the battery voltage is between 9.6 and 16V DC.

B. Verify the sensor is wired to the analog channel specified in the measurement instruction (Single-Ended channels are not labeled on the wiring panel and are numbered sequentially starting at 1H; 1L is Single-Ended channel 2).

C. Make sure the Range parameter in the measurement instruction covers the full scale voltage output by the sensor.

B.4 UNREASONABLE RESULTS DISPLAYED IN AN INPUT LOCATION.

A. Inspect the sensor for damage and/or contamination.

B. Make sure the sensor is properly wired to the datalogger.

C. Check the multiplier and offset parameters in the measurement instruction.

B.5 6999 OR 99999 STORED IN FINAL STORAGE (OR STORAGE MODULE).

A. Final Storage format limitations exceeded (any number larger than 6999 in low resolution, or 99999 in high resolution format is stored as the maximum number). Change the datalogger program.

APPENDIX C. SENSOR WIRING

Sensors are wired to the datalogger as shown below. Sensor lead color is listed on the left, and the datalogger input channel that it should be wired to is listed on the right. The wiring correlates with WeatherPro (PC100, which creates a datalogger program and wiring diagram), and the measurement instructions in Appendix D.

C.1 014A MET ONE WIND SPEED SENSOR

Black	P1
White	G
Clear	G

C.2 024 MET ONE WIND DIRECTION SENSOR

Black	E2
Red	2L (S.E. channel #4)
White	*AG
Clear	G

C.3 03101 / 03001 RM YOUNG WIND SENTRY

Anemometer

Black	P1
Clear	G
Shield	G

Vane

Black	E2
Red	2L (S.E. channel #4)
Clear	*AG
Shield	G

C.4 05103 / 05305 RM YOUNG WIND MONITOR

Black of red/ black pair	G
Black of green/ black pair	*AG
Green	2L (S.E. channel #4)
Black	E2
Red	P1
Clear	G

C.5 105T TYPE T THERMOCOUPLE (CR10 REQUIRES 10TCRT)

Blue	5H (Differential channel #5)
Red	5L

Wire second 105T to 6H and 6L

C.6 107, 107B TEMPERATURE PROBES

Black	E3
Red	5H (S.E. channel #9)
Purple	*AG
Clear	G

Wire the black wires of additional probes to E3, and the red wires to S.E. channels 10, 11, and 12 sequentially

C.7 108, AND 108B TEMPERATURE PROBES

Black	E3
Red	5H (S.E. channel #9)
Purple	*AG
Clear	G

Wire the black wires of additional probes to E3, and the red wires to S.E. channels 10, 11, and 12 sequentially

C.8 10TCRT THERMOCOUPLE REFERENCE THERMISTOR (CR10 ONLY)

Black	E3
Red	1H
Clear	*AG

C.9 207 PHYSCHEM TEMPERATURE AND RH PROBE

Black	E3
Red	1L (S.E. channel #2, Temp)
White	2H (S.E. channel #3, RH)
Purple	*AG
Clear	G

C.10 227 SOIL MOISTURE BLOCK (NOT SUPPORTED BY WEATHERPRO)

Black	E1
Red	4L (S.E. channel #8)
White	*AG
Clear	G

C.11 237 WETNESS SENSING GRID (NOT SUPPORTED BY WEATHERPRO)

Black	E1
Red	6L (if available, S.E. channel #12)
Purple	*AG
Clear	G

C.12 HMP35C VAISALA TEMPERATURE AND RH PROBE

Black	E3
Orange	1L (S.E. channel #2 Temp)
Green	2H (S.E. channel #3 RH)
Purple	*AG
White	*AG
Clear	G
Red	12V
Yellow	E2

C.13 LI200S LI-COR SILICON PYRANMOMETER

Red	3H (Differential channel #3)
Black	3L
Clear	G

C.14 PTA427 VAISALA BAROMETRIC PRESSURE SENSOR

Red	+12V
Purple	G
Orange	4H (S.E. channel #7)
Clear	G
Yellow	E2
White	AG (not used with 21X)

C.15 Q6 NET RADIOMETER (NOT SUPPORTED BY WEATHERPRO)

Red	6H (if available, Diff. channel #6)
Black	6L

C.16 TE525 AND TE525MM TEXAS ELECTRONICS TIPPING BUCKET RAIN GAGE

Black	P2
White	G
Clear	G

* Wire to any ground terminal on the 21X or CR7 dataloggers.

APPENDIX C. SENSOR WIRING

Sensors are wired to the datalogger as shown below. Sensor lead color is listed on the left, and the datalogger input channel that it should be wired to is listed on the right. The wiring correlates with WeatherPro (PC100, which creates a datalogger program and wiring diagram), and the measurement instructions in Appendix D.

C.1 014A MET ONE WIND SPEED SENSOR

Black	P1
White	G
Clear	G

C.2 024 MET ONE WIND DIRECTION SENSOR

Black	E2
Red	2L (S.E. channel #4)
White	*AG
Clear	G

C.3 03101 / 03001 RM YOUNG WIND SENTRY

Anemometer

Black	P1
Clear	G
Shield	G

Vane

Black	E2
Red	2L (S.E. channel #4)
Clear	*AG
Shield	G

C.4 05103 / 05305 RM YOUNG WIND MONITOR

Black of red/ black pair	G
Black of green/ black pair	*AG
Green	2L (S.E. channel #4)
Black	E2
Red	P1
Clear	G

C.5 105T TYPE T THERMOCOUPLE (CR10 REQUIRES 10TCRT)

Blue	5H (Differential channel #5)
Red	5L

Wire second 105T to 6H and 6L

C.6 107, 107B TEMPERATURE PROBES

Black	E3
Red	5H (S.E. channel #9)
Purple	*AG
Clear	G

Wire the black wires of additional probes to E3, and the red wires to S.E. channels 10, 11, and 12 sequentially

C.7 108, AND 108B TEMPERATURE PROBES

Black	E3
Red	5H (S.E. channel #9)
Purple	*AG
Clear	G

Wire the black wires of additional probes to E3, and the red wires to S.E. channels 10, 11, and 12 sequentially

C.8 10TCRT THERMOCOUPLE REFERENCE THERMISTOR (CR10 ONLY)

Black	E3
Red	1H
Clear	*AG

C.9 207 PHYSCHEM TEMPERATURE AND RH PROBE

Black	E3
Red	1L (S.E. channel #2, Temp)
White	2H (S.E. channel #3, RH)
Purple	*AG
Clear	G

C.10 227 SOIL MOISTURE BLOCK (NOT SUPPORTED BY WEATHERPRO)

Black	E1
Red	4L (S.E. channel #8)
White	*AG
Clear	G

C.11 237 WETNESS SENSING GRID (NOT SUPPORTED BY WEATHERPRO)

Black	E1
Red	6L (if available, S.E. channel #12)
Purple	*AG
Clear	G

C.12 HMP35C VAISALA TEMPERATURE AND RH PROBE

Black	E3
Orange	1L (S.E. channel #2 Temp)
Green	2H (S.E. channel #3 RH)
Purple	*AG
White	*AG
Clear	G
Red	12V
Yellow	E2

C.13 LI200S LI-COR SILICON PYRANMOMETER

Red	3H (Differential channel #3)
Black	3L
Clear	G

C.14 PTA427 VAISALA BAROMETRIC PRESSURE SENSOR

Red	+12V
Purple	G
Orange	4H (S.E. channel #7)
Clear	G
Yellow	E2
White	AG (not used with 21X)

C.15 Q6 NET RADIOMETER (NOT SUPPORTED BY WEATHERPRO)

Red	6H (if available, Diff. channel #6)
Black	6L

C.16 TE525 AND TE525MM TEXAS ELECTRONICS TIPPING BUCKET RAIN GAGE

Black	P2
White	G
Clear	G

* Wire to any ground terminal on the 21X or CR7 dataloggers.

APPENDIX D. MEASUREMENT INSTRUCTIONS

Measurement instructions for standard Campbell Scientific, Inc. sensors are listed below. Input channels (analog, pulse, excitation, and control) correlate with the wiring in Appendix C.

Each instruction must have a unique Input Location, which is updated each time the sensor is measured. You may want to change the Input Locations from those given in the examples to be contiguous starting with location 1.

D.1 014A MET ONE WIND SPEED SENSOR

	P3	Pulse
01:	1	Repetitions
02:	1	Pulse Input Channel
03:	22	Switch Closure configuration
04:	4	Input Location
05:	*0.8	Multiplier (meters/sec)
06:	*0.447	Offset

* For miles/hr, change multiplier to 1.789 and offset to 1.0

D.2 024 MET ONE WIND DIRECTION SENSOR

	P4	Excite,Delay,Volt (Single-Ended)
01:	1	Repetitions
02:	14	250 Mv fast Range
03:	4	Single-Ended Input Channel
04:	2	Excitation Channel
05:	2	Delay (units = .01 sec)
06:	500	Excitation Mv
07:	5	Input Location
08:	0.144	Multiplier (degrees)
09:	0	Offset

D.3 03101/03001 RM YOUNG WIND SENTRY

Wind Speed:

	P3	Pulse
01:	1	Repetitions
02:	1	Pulse Input Channel
03:	21	Low Level ac/output Frequency (Hz)
04:	4	Input Location
05:	*0.750	Multiplier (meters/sec)
06:	*0.2	Offset

*For miles/hour, change the multiplier to 1.677, and offset to 0.4.

Wind Direction:

	P4	Excite,Delay,Volt (Single-Ended)
01:	1	Repetitions
02:	5	2500 Mv slow Range
03:	4	Single-Ended Input Channel
04:	2	Excitation Channel
05:	2	Delay (units = .01 sec)
06:	2500	Excitation Mv
07:	5	Input Location
08:	0.142	Multiplier (degrees)
09:	0	Offset

D.4 05103/05305 RM YOUNG WIND MONITOR

Wind Speed:

	P3	Pulse
01:	1	Repetitions
02:	1	Pulse Input Channel
03:	21	Low Level AC/output Frequency (Hz)
04:	4	Input Location
05:	*	Multiplier
06:	0	Offset

* Multipliers (using range code 21)

	05103	05305
miles/hr	0.2192	0.2290
meters/sec	0.098	0.1024

Wind Direction:

	P4	Excite,Delay,Volt (Single-Ended)
01:	1	Repetitions
02:	5	2500 Mv slow Range
03:	4	Single-Ended Input Channel
04:	2	Excitation Channel
05:	2	Delay (units = .01 sec)
06:	2500	Excitation Mv
07:	5	Input Location
08:	0.142	Multiplier (degrees)
09:	0	Offset

D.5 105T TYPE T THERMOCOUPLE PROBE

	P14	Thermocouple (Differential)
01:	*1	Repetitions
02:	1	Range 2.5 mV slow Range
03:	5	Differential Input Channel
04:	1	Type T Thermocouple
05:	15	Reference Input Location
06:	22	Input Location

07:	**1	Multiplier (degrees C)
08:	**0	Offset (degrees C)

* For two probes set Repetitions to 2, and wire the second probe to differential channel 6.

** For degrees F, change multiplier to 1.8 and offset to 32.

D.6 107/107B TEMPERATURE PROBES

	P11	Temp 107 probe
01:	*1	Repetitions
02:	9	Single-Ended Input Channel
03:	3	Excitation Channel
04:	11	Input Location
05:	**1	Multiplier (degrees C)
06:	**0	Offset (degrees C)

* For more than one probe, set Repetitions equal to the number of probes. Wire additional probes to Excitation channel 3, and S.E. channels 10, 11, and 12.

** For degrees F, change multiplier to 1.8 and offset to 32.

D.7 108/108B TEMPERATURE PROBES

	P5	AC Half Bridge
01:	*1	Repetitions
02:	14	250 mV, Fast Range
03:	9	Single-Ended Input Channel
04:	3	Excitation Channel
05:	2000	Excitation mV
06:	11	Input Location
07:	200	Multiplier
08:	0	Offset

	P55	Polynomial
01:	*1	Repetitions
02:	11	X Location
03:	11	F(X) Location (temp. in degrees C)
04:	-26.97	C0
05:	69.635	C1
06:	-40.66	C2
07:	16.573	C3
08:	-3.455	C4
09:	0.301	C5

* For more than one probe, set Repetitions equal to the number of probes. Wire additional probes to Excitation channel 3, and S.E. channels 10, 11, and 12.

** To convert temperature to Fahrenheit:

	P37	Z = X*F
01:	11	X Loc
02:	1.8	F
03:	11	Z Location (degrees F)

	P34	Z = X+F
01:	11	X Location
02:	32.0	F
03:	11	Z Location (degrees F)

** Repeat Instructions 37 and 34 for each probe using input locations 12, 13, and 14.

D.8 10TCRT THERMOCOUPLE REFERENCE THERMISTOR

	P11	Temp 107 probe
01:	*1	Repetitions
02:	1	Single-Ended Input Channel
03:	3	Excitation Channel
04:	15	Input Location
05:	1	Multiplier (degrees C)
06:	0	Offset (degrees C)

D.9 207 PHYSCHEM TEMPERATURE AND RH PROBE

Temperature:

	P11	Temp 107 probe
01:	1	Repetition
02:	2	Single-Ended Input Channel
03:	3	Excitation Channel
04:	2	Input Location
05:	*1	Multiplier (degrees C)
06:	*0	Offset (degrees C)

Relative Humidity:

	P12	R.H. (207)
01:	1	Repetitions
02:	3	Single-Ended Input Channe
03:	3	Excitation Channel
04:	2	Input Location for Temperature
05:	3	Input Location
06:	1	Multiplier (%RH)
06:	0	Offset

* P12 uses temperature in degrees Celsius to calculate RH. To record temperature in degrees Fahrenheit, the following instructions may be used, but they must follow P12:

	P37	Z = X*F
01:	2	X Loc
02:	1.8	F
03:	2	Z Location (degrees F)

	P34	Z = X+F
01:	2	X Location
02:	32	F
03:	2	Z Location (degrees F)

D.10 227 SOIL MOISTURE BLOCK

	P5	AC Half Bridge
01:	1	Repetitions
02:	14	250 mV fast Range
03:	8	Single-Ended Input Channel
04:	1	Excitation Channel
05:	250	Excitation mV
06:	10	Input Location
07:	1	Multiplier
08:	0	Offset
	P59	Bridge Transform
01:	1	Repetitions
02:	10	Input Location
03:	1	Multiplier
	P89	If X < F
01:	10	X Location
02:	4	<
03:	17.009	F
04:	30	Then Do (convert Kohms to Bars)
	P55	Polynomial
01:	1	Repetitions
02:	10	X Location
03:	10	F(X) Location (temp. In degrees C)
04:	0.15836	C0
05:	6.1445	C1
06:	-8.4189	C2
07:	9.2493	C3
08:	-3.1685	C4
09:	0.33392	C5

P95 End (for Then Do command)

D.11 237 WETNESS SENSING GRID

	P5	AC Half Bridge
01:	1	Repetitions
02:	13	250 mV fast Range
03:	12	Single-Ended Input Channel
04:	1	Excitation Channel
05:	2500	Excitation mV
06:	19	Input Location
07:	1.0	Multiplier
08:	0.0	Offset
	P42	Z = 1/X
01:	19	X Location
02:	19	Z Location
	P34	Z = X+F
01:	19	X Location
02:	-101.0	F
03:	19	Z Location (block resistance in Kohms)

D.12 HMP35C VAISALA TEMPERATURE AND RH PROBE

Temperature:

	P11	Temp 107 probe
01:	1	Repetitions
02:	2	Single-Ended Input Channel
03:	3	Excitation Channel
04:	2	Input Location
05:	*1	Multiplier (degrees C)
06:	*0	Offset

* For degrees F, change multiplier to 1.8 and offset to 32.

Relative Humidity:

	P4	Excite,Delay,Volt (Single-Ended)
01:	1	Repetitions
02:	5	2500 Mv slow Range
03:	3	Single-Ended Input Channel
04:	2	Excitation Channel
05:	15	Delay (units = .01 sec)
06:	2500	Excitation Mv
07:	3	Input Location
08:	0.1	Multiplier (%RH)
09:	0	Offset

D.13 LI200S LI-COR SILICON PYRANMOMETER

	P2	Volt (Differential)
01:	1	Repetitions
02:	3	25 Mv slow Range
03:	3	Differential Input Channel
04:	6	Input Location
05:	*	Multiplier
06:	0	Offset

* Multiplier calculation:

Units	Multiplier
kJ/m2	(1/C)*t
kW/m2	(1/C)
cal/cm2	(1/C)*t*(0.0239)
cal/(cm2*min)	(1/C)*(1.434)

C = (LI-COR calibration) * 0.1
t = datalogger program execution interval in seconds

D.14 PTA427 VAISALA BAROMETRIC PRESSURE SENSOR

	P4	Excite,Delay,Volt (Single-Ended)
01:	1	Repetitions
02:	5	2500 Mv slow Range
03:	7	Single-Ended Input Channel
04:	2	Excitation Channel
05:	300	Delay (units = .01 sec)
06:	2500	Excitation Mv
07:	8	Input Location
08:	0.104	Multiplier (mbars)
09:	*800	Offset

* Refer to the PTA-427 Manual for adjusting the offset for site elevation.

To convert pressure from mbar to in. Hg:

	P37	Z = X * F
01:	8	X Location
02:	0.02953	F
03:	8	Z Location (in. Hg)

D.15 Q6 NET RADIOMETER

	P2	Volt (Differential)
01:	1	Repetitions
02:	4	250 mV slow Range
03:	6	Differential Input Channel
04:	20	Input Location
05:	*	Multiplier (Watts/m2)
06:	0	Offset

* Use the sensor calibration provided by the manufacturer.

D.16 TE525 AND TE525MM TEXAS ELECTRONICS TIPPING BUCKET RAIN GAGE

	P3	Pulse
01:	1	Repetitions
02:	2	Pulse Input Channel
03:	2	Switch Closure configuration
04:	7	Input Location
05:	*0.01	Multiplier (.01" per tip)
06:	0	Offset

* Change multiplier to 0.1 for TE525MM

APPENDIX E. EXAMPLE WEATHER STATION PROGRAM FILES

Appendix E contains files that were created using PC208 Datalogger Support Software. The files include a CR10 program (Section E.1), GRAPHTERM Station File (Section E.2), and SPLIT Parameter File (Section E.3). The files are meant to be used as examples only.

E.1 CR10 PROGRAM

The following program was developed using EDLOG. Independent comment lines were added (Ctrl N) to document sensor wiring, input location usage, and output array definition.

Program: C:\PC208 WS.DOC - CR10 SN XXXX program

Sensor wiring:

107 temperature probe

black	E3
red	1L (S.E. #2)
clear	G

05305 Wind Monitor

black (of red/black)	G
black (of green/black)	AG
green	2L (S.E. #4)
black	E2
red	P1

TE525 rain gage

red	P2
black	G

Input location usage (input locations were changed from those listed in Section 11 to be contiguous starting with location 1):

Loc	Description
1	Wind speed - m/s
2	Wind direction - degrees
3	Air temperature - degrees C
4	Precipitation - mm
5	Battery - volts

Output array definition:

Hourly arrays:

Element	Description
1	60 - array ID
2	year
3	Julian day
4	hour - minute
5	average temperature
6	average wind speed
7	average wind direction
8	standard deviation of wind direction
9	total precipitation

24-hour arrays:

Element	Description
1	24 - array ID
2	year
3	Julian day
4	hour - minute
5	average temperature
6	maximum temperature
7	minimum temperature
8	total precipitation
9	sample battery voltage

```
*       1       Table 1 Programs
01:     2       Sec. Execution Interval
```

Measure the sensors:

```
01:       P3      Pulse (05305 wind speed)
  01:      1      Rep
  02:      1      Pulse Input Chan
  03:     21      Low level AC; Output Hz.
  04:      1      Loc [:w spd m/s]
  05:  .0980      Mult
  06:      0      Offset

02:       P4      Excite,Delay,Volt(SE)
                  (05305wind direction)
  01:      1      Rep
  02:      5      2500 mV slow Range
  03:      4      IN Chan
  04:      2      Excite all reps w/EXchan 1
  05:      2      Delay (units .01sec)
  06:   2500      mV Excitation
  07:      2      Loc [:w dir deg]
  08:      1      Mult
  09:      0      Offset
```

```
03:    P11        Temp 107 Probe
 01:      1       Rep
 02:      2       IN Chan
 03:      3       Excite all reps w/EXchan3
 04:      3       Loc [:temp C  ]
 05:      1       Mult
 06:      0       Offset

04:     P3        Pulse (TE525 rain gage)
 01:      1       Rep
 02:      2       Pulse Input Chan
 03:      2       Switch closure
 04:      4       Loc [:rain .01]
 05:       .01    Mult
 06:      0       Offset

05:    P10        Battery Voltage
 01:      5       Loc [:bat volts]
```

60 minute processing; the Output Flag is set high every 60 minutes, followed by the output processing instructions:

```
06:    P92        If time is
 01:      0       minutes into a
 02:     60       minute interval
 03:     10       Set high Flag 0 (output)

07:    P80        Set Active Storage Area
 01:      1       Final Storage Area 1
 02:     60       Array ID or location

08:    P77        Real Time
 01:   1220       Year,Day,Hour-Minute

09:    P71        Average
 01:      1       Rep
 02:      3       Loc temp C

10:    P69        Wind Vector
 01:      1       Rep
 02:      0       Samples per sub-interval
 03:     00       Polar Sensor/(S, D1, SD1)
 04:      1       Wind Speed/East Loc w
                  spd m/s
 05:      2       Wind Dir./North Loc w dir
                  deg

11:    P72        Totalize
 01:      1       Rep
 02:      4       Loc rain .01
```

24-hour processing:

```
12:    P92        If time is
 01:      0       minutes into a
 02:   1440       minute interval
 03:     10

13:    P80        Set Active Storage Area
 01:      1       Final Storage Area 1
 02:     24       Array ID or location

14:    P77        Real Time
 01:   1220       Year,Day,Hour-Minute

15:    P71        Average
 01:      1       Rep
 02:      3       Loc temp C

16:    P73        Maximize
 01:      1       Rep
 02:      0       Value only
 03:      3       Loc temp C

17:    P74        Minimize
 01:      1       Rep
 02:      0       Value only
 03:      3       Loc temp C

18:    P72        Totalize
 01:      1       Rep
 02:      4       Loc rain .01

19:    P70        Sample
 01:      1       Reps
 02:      5       Loc bat volts
```

E.2 EXAMPLE GRAPHTERM STATION FILE

GRAPHTERM is used to transfer PC time to the datalogger, download a program, monitor input locations, and collect data. Each datalogger requires a Station File, which specifies the datalogger type, COM port, baud rate, and interface device(s), as shown in this example.

```
          Telecommunication Parameters for Station:   LOGGER
                                  Datalogger Type:   CR10
          Use Asynchronous Communications Adapter:   COM1
                        Communications Baud Rate:   9600
                                 Data File Format:   Comma delineated ASCII
                   Final Storage Collection Area:   Area 1
Interface Device:
#1: SC32A
```

E.3 EXAMPLE SPLIT PARAMETER FILE

The CR10 program in Section E.1 stores hourly and daily data. Instruction 80 sets the array id (first element of the array) of the hourly arrays to 60. The SPLIT Parameter File listed below splits out the hourly arrays (when element 1 is 60), and the Julian day is between 60 and 91. Two files are created; HOURLY.PRN contains comma delineated ASCII data, HOURLY.RPT contains field formatted data with a report and column headings.

HOURLY.PAR:

Name(s) of input DATA FILES(s):	LOGGER.DAT/L
Name of OUTPUT FILE to generate:	HOURLY.PRN/R
START reading in HW.DAT:	3[60]
STOP reading in HW.DAT:	3[91]
COPY from HW.DAT:	1[60]
SELECT element #(s) in HW.DAT:	2,DATE(3;2),4..9
HEADING for report:	HOURLY WEATHER STATION DATA
HEADINGS for HW.DAT, col. # 1:	year
column # 2:	month\day
column # 3:	hour\minute
column # 4:	avg\temp\deg C
column # 5:	avg\w spd\m/s
column # 6:	avg\w dir\deg
column # 7:	std dev\w dir
column # 8:	total\rain\mm

References

[1] EPA, (1987). On-Site Meteorological Program Guidance for Regulatory Modeling Applications, EPA-450/4-87-013. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711.

[2] WMO, (1983). Guide to Meteorological Instruments and Methods of Observation. World Meteorological Organization No. 8, 5th edition, Geneva, Switzerland.

[3] The State Climatologist, (1985) Publication of the American Association of State Climatologists: Height and Exposure Standards for Sensors on Automated Weather Stations, v. 9, No. 4 October, 1985.

[4] EPA, (1989). Quality Assurance Handbook for Air Pollution Measurement Systems, EPA Office of Research and Development, Research Triangle Park, North Carolina 27711.

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APRIL 5, 1993

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TABLE OF CONTENTS

SECTION 16. SPLIT PROCESSING EXAMPLES

LIST OF TABLES

LIST OF FIGURES

CR10/PC208 TRAINING MANUAL

The CR10/PC208 Training Manual introduces the user to the more commonly used functions and aspects of the CR10 datalogger and the PC208 Software. The manual is divided into two sections, which were condensed from the CR10 Operator's Manual and the PC208 Datalogger Support Software Manual. Within these sections, any reference that does not begin with TM will be for one or the other of these manuals.

TM1. PHYSICAL DESCRIPTION

The CR10 is a fully programmable datalogger/controller in a small, rugged, sealed module. Programming is very similar to Campbell Scientific's 21X and CR7 dataloggers. Some fundamental physical differences are listed below.

- The CR10 does not have an integral keyboard/display. The user accesses the CR10 with the portable CR10KD Keyboard Display or with a computer or terminal (Section TM3).

- The CR10 does not have an integral terminal strip. A removable wiring panel, the CR10WP (Figure TM1.1-1) performs this function and attaches to the two D-type connectors located at the end of the module.

- The power supply is external to the CR10. This gives the user a wide range of options (Section 14) for powering the CR10.

TM1.1 WIRING PANEL - MODEL CR10WP

The CR10WP Wiring Panel and CR10 datalogger (Figure TM1.1-1) make electrical contact through the two D-type connectors at the (left) end of the CR10.

The Wiring Panel (Figure TM1.1-2) provides a 9-pin Serial I/O port used when communicating with the datalogger, and terminals for connecting sensor, control, and power leads to the CR10. It also provides transient protection and reverse polarity protection.

TM1.1.1 ANALOG INPUTS

The terminals labeled 1H to 6L are analog inputs. These numbers refer to the high and low inputs to the differential channels 1 through 6. In a differential measurement, the voltage on the H input is measured with respect to the voltage on the L input (Figure TM1.1-3). Either the H or L input may be used as a single-ended analog input to measure voltage with respect to the

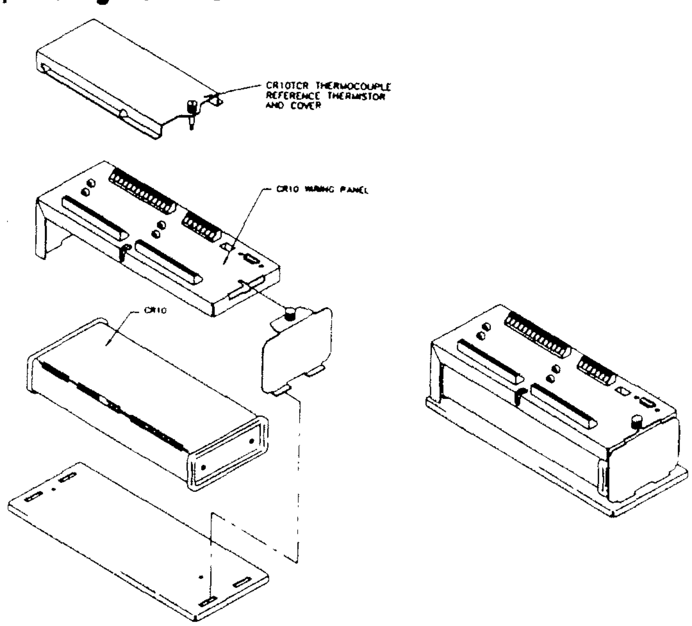


FIGURE TM1.1-1. CR10 and Wiring Panel

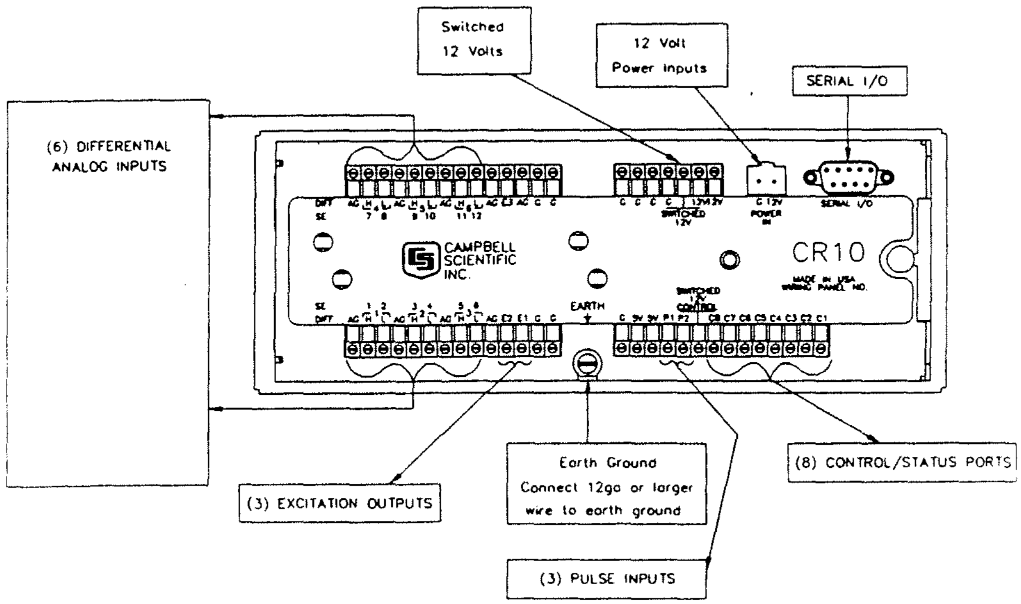


FIGURE TM1.1-2 CR10 Wiring Panel

CR10 analog ground (AG) (Figure TM1.1-4). The twelve single-ended channels are numbered sequentially starting with 1H; e.g., the H and L sides of differential channel 1 are single-ended channels 1 and 2; the H and L sides of differential channel 2 are single-ended channels 3 and 4, etc. (Table TM1.1-5). The single-ended channel numbers do NOT appear on the panel.

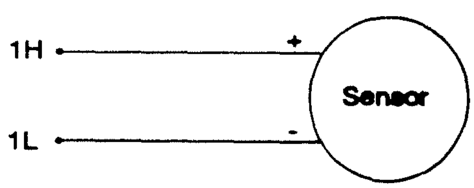


FIGURE TM1.1-3 Voltage Measured on Differential Channel 1

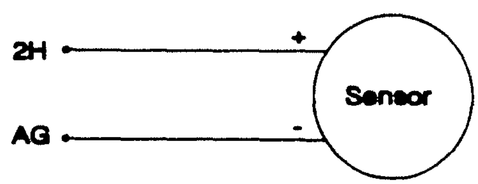


FIGURE TM1.1-4 Voltage Measured on Single-Ended Channel 3

TM1.1.2 SWITCHED EXCITATION OUTPUTS

The terminals labeled E1, E2, and E3 are precision, switched excitation outputs used to supply programmable excitation voltages for resistive bridge measurements. DC or AC excitation at voltages between -2500 mV and +2500 mV are user programmable (Figure TM1.1-6, Section 9).

TABLE TM1.1-5 Differential and Single-Ended Channel Numbers

DIFFERENTIAL CHANNEL	SINGLE-ENDED CHANNEL
1H	1
1L	2
2H	3
2L	4
3H	5
3L	6
4H	7
4L	8
5H	9
5L	10
6H	11
6L	12

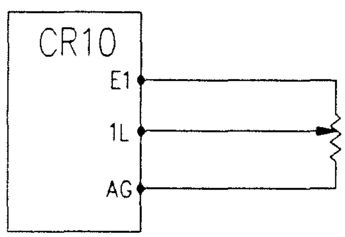


FIGURE TM1.1-5 Potentiometer from Wind Vane Excited by Excitation Channel #1

TM1.1.3 PULSE INPUTS

The terminals labeled P1 and P2 are the pulse counter inputs for the CR10. They are programmable for switch closure, high frequency pulse, or low level AC (Figure TM1.1.3-1, Section 9, Instruction 3).

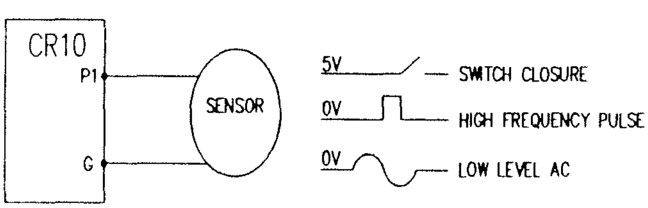


FIGURE TM1.1-6 Three Pulse Input Types

TM1.1.4 DIGITAL I/O PORTS

Terminals C1 through C8 are digital Input/Output ports. On power-up they are configured as input ports, commonly used for reading the status of an external signal. High and low conditions are: 3 V < high < 5.5 V; -0.5 V < low < 0.8 V.

Configured as outputs the ports allow on/off control of external devices. A port can be set high (5 V± 0.1 V), set low (<0.1V), toggled, or pulsed (Sections 3, 8.3, and 12).

TM1.1.5 ANALOG GROUND (AG)

The AG terminals are analog grounds, used as the reference for single-ended measurements and excitation return.

TM1.1.6 12V AND POWER GROUND (G) TERMINALS

The 12 V and power ground (G) terminals are used to supply 12 VDC power to the datalogger. The extra 12 V and G terminals can be used to connect other devices requiring 12 V power.

The G terminals are also used to tie cable shields to ground, and to provide a ground reference for pulse counters and binary inputs. For protection against transient voltage spikes, power ground should be connected to a good earth ground (Section 14.3.1).

TM1.1.7 5 V OUTPUTS

The two 5 V (±0.2%) outputs are commonly used to power peripherals such as the QD1 Incremental Encoder Interface.

The 5 V outputs are common with pin 1 on the 9 pin serial connector; 200 mA is the maximum current that can be sourced.

TM1.1.8 SERIAL I/O

The 9 pin serial I/O port contains lines for serial communication between the CR10 and external devices such as computers, printers, Storage Modules, etc. **This port does NOT have the same configuration as the 9 pin serial ports currently used on many personal computers.** It has a 5 VDC power line which is used to power peripherals such as the SM192 or SM716 Storage Module, or the DC112 Phone Modem.

TM1.2 CONNECTING POWER TO THE CR10

The CR10 can be powered by any 12 VDC source. First connect the positive lead from the power supply to one of the 12 V terminals and then connect the negative lead to one of the power ground (G) terminals. The Wiring Panel power connection is reverse polarity protected.

See Section 14 for details on power supply connections.

CAUTION: The metal surfaces of the CR10, CR10WP Wiring Panel, and CR10KD Keyboard Display are at the same potential as power ground. To avoid shorting 12 volts to ground, connect the 12 volt lead first, then connect the ground lead.

TM2. INTERNAL MEMORY

The CR10 has 64 K bytes of Random Access Memory (RAM), divided into five areas. The use of the Input, Intermediate, and Final Storage in the measurement and data processing sequence is shown in Figures TM2-1 and TM2-2. While the total size of these three areas remains constant, memory may be reallocated between the areas to accommodate different measurement and processing needs (*A Mode, Section 1.5). The size of the 2 additional memory areas, system and program, are fixed. The five areas of RAM are:

1. **Input Storage** - Input Storage holds the results of measurements or calculations. Each time the measurement or calculation is made, the input location is updated. Input Storage defaults to 28 locations. Additional locations can be assigned using the *A Mode (Section 1.5).

2. **Intermediate Storage** - Provides temporary storage for the processing of averages, maximums, minimums, histograms, etc. Intermediate storage is automatically accessed by the instructions and cannot be accessed by the user. The default allocation is 64 locations.

3. **Final Storage** - Final processed values are stored here for transfer to printer, tape, solid state Storage Module or for retrieval via telecommunication links. Data are stored in a ring-type memory which holds approximately 29,900 low resolution data values.

4. **System Memory** - used for overhead tasks such as compiling programs, transferring data etc. The user cannot access this memory.

5. **Program Memory** - available for user programs entered in program tables 1 and 2, and Subroutine Table 3.

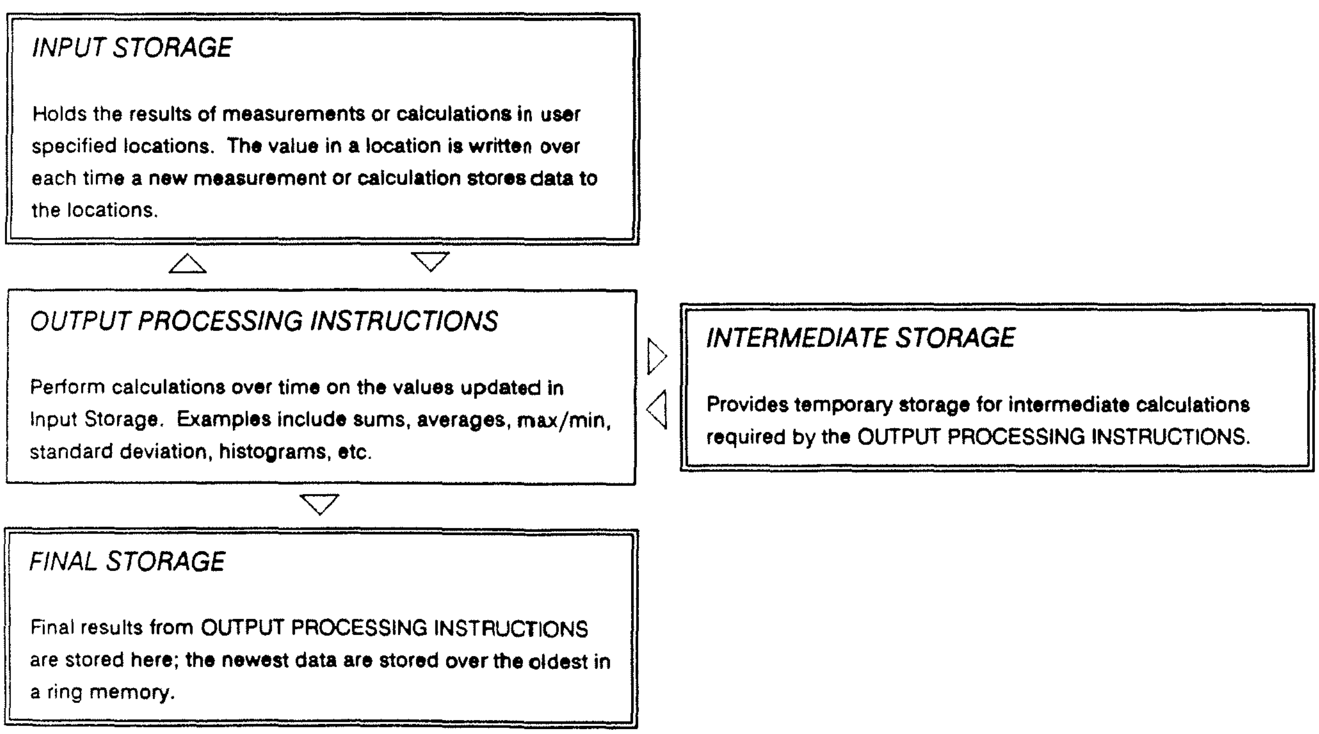


FIGURE TM2-1. CR10 Input, Intermediate and Final Storage Areas

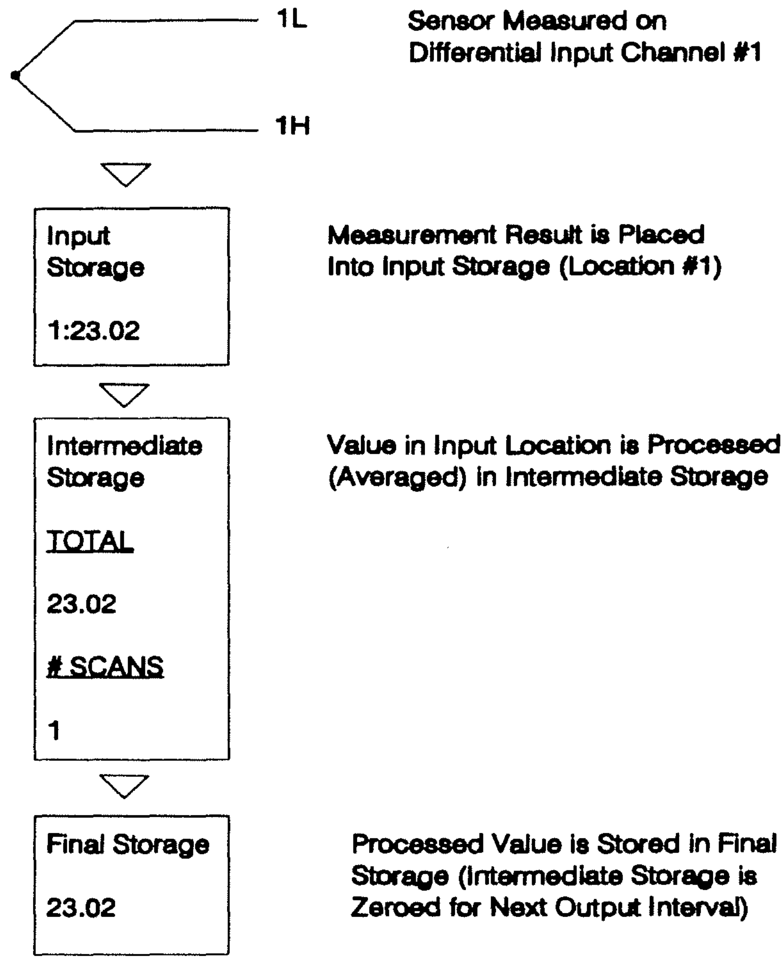


FIGURE TM2-2. Thermocouple measurement example using Input, Intermediate and Final Storage.

TM2.1. MEMORY AND PROGRAMMING CONCEPTS

The CR10 must be programmed before it will make any measurements. A program consists of a group of **instructions** entered into a **program table**. The program table is given an **execution interval** which determines how frequently that table is executed. When the table is executed, the instructions are executed in sequence from beginning to end. After executing the table, the CR10 waits the remainder of the execution interval and then executes the table again.

The interval at which the table is executed generally determines the interval at which the sensors are measured. The interval at which data are processed and stored is separate from how often the table is executed, and may range from samples every execution interval to processed summaries output hourly, daily, or on longer or irregular intervals.

TM2.2 PROGRAM TABLES, EXECUTION INTERVAL AND OUTPUT INTERVALS

Programs are entered in Tables 1 and 2. Subroutines, called from Tables 1 and 2, are entered in Subroutine Table 3 (Figure TM2.2-1). The size of each table is flexible, limited only by the total amount of program memory.

Table 1 and Table 2 have independent execution intervals, entered in units of seconds with an allowable range of 1/64 to 8191 seconds. Subroutine Table 3 has no execution interval; subroutines are only executed when called from Table 1 or 2.

Table 1. Execute every x sec. $0.0156 \leq x \leq 8191$	Table 2. Execute every y sec. $0.0156 \leq y \leq 8191$	Table 3. Subroutines
Instructions are executed sequentially in the order they are entered in the table. One complete pass through the table is made each execution interval unless program control instructions are used to loop or branch execution.	*Table 2 is used if there is a need to measure and process data on a separate interval from that in Table 1.*	*A subroutine is executed only when called from Table 1 or 2.*

FIGURE TM2.2-1. Program and Subroutine Tables

TM2.2.1 THE EXECUTION INTERVAL

The execution interval specifies how often the program in the table is executed, which is usually determined by how often the sensors are to be measured. *Unless two different measurement rates are needed, use only one table.* A program table is executed sequentially starting with the first instruction in the table and proceeding to the end of the table.

Each instruction in the table requires a finite time to execute. If the execution interval is less than the time required to process the table, an execution interval overrun occurs; the CR10 finishes processing the table and waits for the next execution interval before initiating the table. When an overrun occurs, decimal points are shown on either side of the G on the display in the LOG mode (*0). Overruns and table priority are discussed in Section 1.1.

TM2.2.2. THE OUTPUT INTERVAL

The interval over which measurements are processed before being output to Final Storage is called the output interval. The output interval can be independent from the execution interval, other than the fact that it must occur when the table is executed (e.g., a table cannot have a 10 minute execution interval and output every 15 minutes).

TM2.2.3 USE OF FLAGS: OUTPUT AND PROGRAM CONTROL

There are 10 flags which may be used in CR10 programs (Table TM2.2-1). Two of the flags are dedicated to specific functions: Flag 0 causes Output Processing Instructions to write to Final Storage, and Flag 9 disables intermediate processing. Flags 1-8 may be used as desired in programming the CR10. Flags 0 and 9 are automatically set low at the beginning of the program table. Flags 1-8 remain unchanged until acted on by a Program Control Instruction or until manually toggled from the *6 Mode.

TABLE TM2.2-1. Flag Description

Flag 0	-	Output Flag
Flag 1 to 8	-	User Flags
Flag 9	-	Intermediate Processing Disable

Flags are set with Program Control Instructions. The Output Flag (Flag 0) and the intermediate processing disable flag (Flag 9) will always be set low if the set high condition fails. The status of flags 1-8 does not change when a conditional test is false.

The program listed in Figure TM2.2-2 uses User Flag 1 and the Output Flag, Flag 0. Flag 1 must be high for the program to execute. Flag 0 is set high on a 1-minute and 5-minute interval.

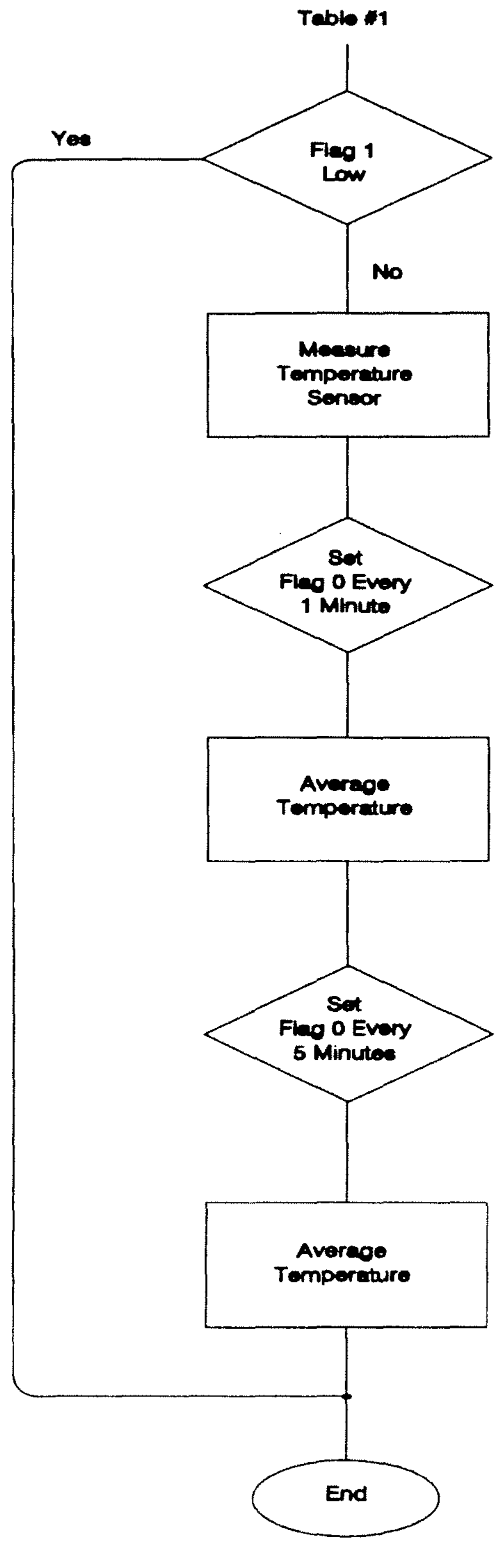


FIGURE TM2.2-2 Sample Program using Flags 1 and 0 (Output Flag)

TM2.3 INSTRUCTION FORMAT

The CR10 is programmed by entering instructions into the program tables. Instructions are identified by an instruction number. Each instruction has a number of parameters that give the CR10 the information it needs to execute the instruction.

The CR10 Prompt Sheet has the instruction numbers in red, with the parameters briefly listed in columns following the description. Some parameters are footnoted with further description under the "Instruction Option Codes" heading.

For example, Instruction 73 stores the maximum value that occurred in an Input Storage location over the output interval. The instruction has three parameters (1) REPetitionS, the number of sequential Input Storage locations on which to find maxima, (2) TIME, an option of storing the time of occurrence with the maximum value, and (3) LOC the first Input Storage location operated on by the Maximum Instruction. The codes for the TIME parameter are listed in the "Instruction Option Codes".

The repetitions parameter specifies how many times an instruction is to be repeated; the input channel and input Loc are incremented by (1) with each repetition. For example, four 107 thermistor probes may be measured with a single Instruction 11, Temp-107, with four repetitions. Parameter 2 specifies the input channel of the first thermistor (the probes must be connected to sequential channels). Parameter 4 specifies the Input Storage location in which to store measurements from the first thermistor.

TM2.3.1 CR10 INSTRUCTION TYPES

There are four types of Instructions which are used to program the CR10. Each type, including an example, is described below. Detailed descriptions of the instructions are given in Sections 9-12. A generalized programming sequence using the four types of instructions is shown in Figure TM4.3-1.

1. **INPUT/OUTPUT INSTRUCTIONS** (1-28, 101-104, Section 9) measure the sensors and place the results in Input Storage. Multiplier and offset parameters allow conversion of linear signals into engineering units. Figure TM2.3-1 lists Instruction 2 and its parameters and range options.

P2	Volt	(DIFF)
	00	Reps
	00	Range Option
	00	IN Chan
	00	LOC:
	0.0000	Multiplier
	0.0000	Offset

FIGURE TM2.3-1 Input/Output Instruction 2

Parameter 2 is the voltage range and integration time to use for the measurement. Use the lowest voltage range that will accomodate the signal to be measured. The CR10 makes voltage measurements by integrating the input signal for a fixed time prior to the digital (A/D) conversion. In general, the slow integration time provides the most accurate measurement. The fast integration time minimizes time skew between measurements and increases throughput rate. The 60Hz or 50Hz rejection times are used when the input signals are subjected to electrical noise, such as from fluorescent lighting, power lines, motors, etc.

Instructions 1 - 14 RANGE codes:

Slow (w.72 ms Integration time)	Fast (250 us Integration time)	60 Hz rejection	50 Hz rejection	Full Scale
range				
1	11	21	31	2.5 mV
2	12	22	32	7.5 mV
3	13	23	33	25 mV
4	14	24	34	250 mV
5	15	25	35	2500 mV

2. **PROCESSING INSTRUCTIONS** (30-66, Section 10) perform numerical operations on values located in Input Storage and store the results back in Input Storage. These instructions can be used to develop high level algorithms to process measurements prior to Output Processing. Figure TM2.3-2 lists Instruction 33 and its parameters.

P33		Z = X + Y
	0000	X Loc
	0000	Y Loc
	0000	Z Loc

FIGURE TM2.3-2 Processing Instruction 33

3. **PROGRAM CONTROL INSTRUCTIONS** (83-98, Section 12) are used for logic decisions and conditional statements. They can set flags, compare values or times, execute loops, call subroutines, conditionally execute portions of the program, etc. Figure TM2.3-3 lists Instruction 92 and its parameters and command code options.

P92		If Time
	00	T into Interval
	0000	Interval
	0000	Command

<u>Command Codes</u>

0	=	Go to end of Program Table
1..9	=	Call Subroutine 1..9
79..99	=	Call Subroutine 79..99
1x	=	Set high Flag x
2x	=	Set low Flag x
4x	=	Set high Port x
5x	=	Set low Port x
6x	=	Toggle Port x
7x	=	Pulse Port x
30	=	Then do
31	=	Exit Loop if true
32	=	Exit Loop if false

FIGURE TM2.3-3 Program Control Instruction 92

P92 is used to set the Output flag high based on a fixed time interval, i.e. 60 minutes. Output is usually desired on the even interval, so Parameter 1, time into the interval, is 0. The time interval (Parameter 2), in minutes, is how often output will occur; i. e. the Output Interval. The command code (Parameter 3) is 10, causing Flag 0 to be set high. The time interval is synchronized to 24 hour time.

4. **OUTPUT PROCESSING INSTRUCTIONS** (69-82, Section 11) are the only instructions which store data in Final Storage . Input Storage values are processed over time to obtain averages, maxima, minima, etc. Figure TM2.3-4 lists Instruction 71 and its parameters.

P71		Average
	00	Reps
	0000	Loc

FIGURE TM2.3-4 Output Processing Instruction 71

There are two types of processing done by Output Instructions: **Intermediate** and **Final** (Figure TM2.3-5). **Intermediate processing** normally takes place each time the instruction is executed. For example, when the Average Instruction is executed, it adds the values from the input locations being averaged to running totals in Intermediate Storage. It also keeps track of the number of samples.

Final processing occurs only when the Output Flag is high. The Output Processing Instructions check the Output Flag. If the flag is high, final values are calculated and output. With the Average, the totals are divided by the number of samples and the resulting averages sent to Final Storage. Intermediate locations are zeroed and the process starts over. *The Output Flag, Flag 0, is set high by a Program Control Instruction which must precede the Output Processing Instructions in the user entered program.*

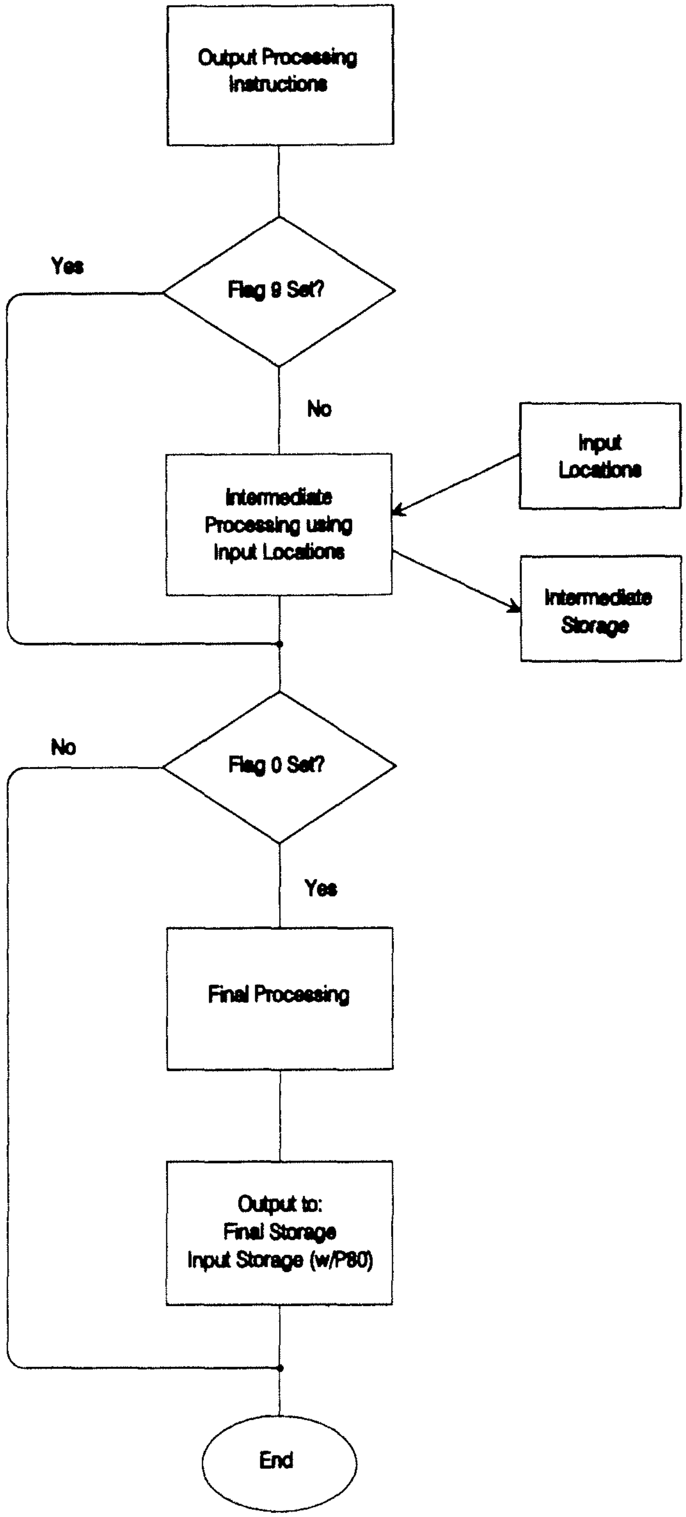


Figure TM2.3-5 Intermediate and Final Processing

TM3. COMMUNICATING WITH THE CR10

An external device must be connected to the CR10's Serial I/O port to communicate with the CR10. This may be either Campbell Scientific's portable CR10KD Keyboard Display or a computer with the SC32A RS232 Interface and the PC208 Datalogger Support Software.

TM3.1 CR10 KEYBOARD/DISPLAY

The SC12 cable (supplied with the CR10KD) is used to connect the Keyboard/Display to the 9 pin Serial I/O port on the CR10.

If the Keyboard/Display is connected to the CR10 prior to being powered up, the "HELLO" message is displayed while the CR10 checks memory. The size of the usable system memory is then displayed (96 for 96K bytes of memory). When the CR10KD is plugged in after the CR10 has powered up, the display is meaningless until "*" is pressed to enter a mode.

TM4. PROGRAMMING THE CR10

The CR10 is programmed one of two ways: 1) Instructions are keyed directly into the program tables using the CR10KD (Section TM5), and 2) the program is developed on a PC and then downloaded to the CR10 using CSI's PC208 Datalogger Support Software (Section TM9).

TM4.1 FUNCTIONAL MODES

CR10/User interaction is broken into different functional MODES (e.g., programming the measurements and output, setting time, manually initiating a block data transfer to Storage Module, etc.). The modes are referred to as Star (*) Modes since they are accessed by first keying *, then the mode number or letter. Table TM4-1 lists the CR10 Modes.

TABLE TM4.1-1. * Mode Summary

Key	Mode
*0	LOG data and indicate active Tables
*1	Program Table 1
*2	Program Table 2
*3	Program Table 3, subroutines only
*5	Display/set real time clock
*6	Display/alter Input Storage data, toggle flags
*7	Display Final Storage data
*8	Start Manual Data Dump
*9	Storage Module Commands
*A	Memory allocation/reset
*B	Signature/status
*C	Security
*D	Save/load Program

TM4.2 KEY DEFINITION

Keys and key sequences have specific functions when using the CR10KD keyboard display. Table TM4.2-1 lists these functions. In some cases, the exact action of a key depends on the mode the CR10 is in and is described with the mode in the manual.

TABLE TM4.2-1. Key Description/Editing Functions

Key	Action
0-9	Key numeric entries into display
*	Enter Mode (followed by Mode Number)
A	Enter/Advance
B	Back up
C	Change the sign of a number or index an input location to loop counter
D	Enter the decimal point
#	Clear the rightmost digit keyed into the display
#A	Advance to next instruction in program table (*1, *2, *3) or to next Output Array in Final Storage (*7)
#B	Back up to previous instruction in program table or to previous Output Array in Final Storage
#D	Delete entire instruction
#0	(then A or CR) Back up to the start of the current array.

TM4.3 PROGRAMMING SEQUENCE

In routine applications, the CR10 is programmed to measure sensor output signals, process the measurements over some time interval and store the processed results. A generalized programming sequence is (Figure TM4.3-1):

1. Enter the execution interval. In most cases, the execution interval is determined by the desired sensor scan rate.
2. Enter the Input/Output instructions required to measure the sensors.
3. If processing in addition to that provided by the Output Processing Instructions is required, enter the appropriate Processing Instructions

```
*      1         Table 1 Program
  01:  1         Sec. Execution Interval

01:  P2          Volt (DIFF)
  01:  1         Reps
  02:  2         Range Option
  03:  1         IN Chan
  04:  1         Loc:
  05:  1         Mult
  06:  -500      Offset

02:  P37         Z = X*F
  01:  1         X Loc
  02:  .05       F
  03:  1         Z Loc:

03:  P92         If time is
  01:  0         minutes into a
  02:  1         minute interval
  03:  10        Set high Flag 0 (output)

04:  P77         Real Time
  01:  0110      Option

05:  P71         Average
  01:  1         Reps
  02:  1         Loc
```

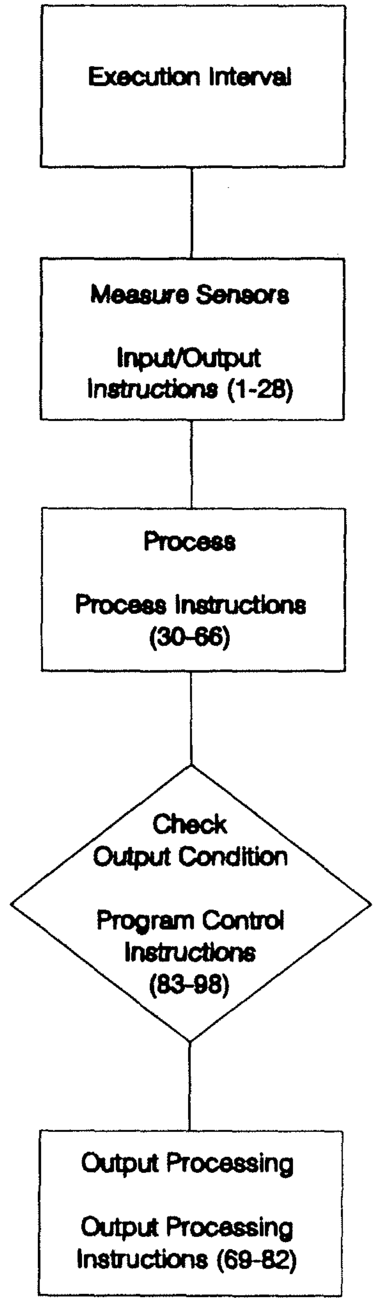


FIGURE TM4.3-1 CR10 Program Structure

4. Enter the Program Control Instruction to test the output condition and set the Output Flag when the condition is met. For example, use

   Instruction 92 to output based on time.

   Instruction 86 to output every execution interval.

   Instruction 88 or 89 to output based on a comparison of values in input locations.

   This instruction must precede the Output Processing Instructions which store data in Final Storage. Instructions are described in Sections 9 through 12.

5. Enter the Output Processing Instructions to store processed data in Final Storage. The order in which data are stored is determined by the order of the Output Processing Instructions in the table.

6 Repeat steps 4 through 6 for other output intervals.

> **NOTE**: The program must be executed for output to occur. Therefore, the interval at which the Output Flag is set must be evenly divisible by the execution interval. For example, with a two minute execution interval and a five minute output interval, the program will only be executed on the even multiples of the five minute intervals, not on the odd. Data will be output every ten minutes instead of every five minutes.

Execution intervals and output intervals set with Instruction 92 are synchronized with real time.

TM5. PROGRAMMING EXAMPLES

Connect the CR10KD, and then hook up the power leads as described in Section TM1.2.

The display will show:

Display	Explanation
HELLO	On Power-up, the CR10 displays "HELLO" while it checks the memory (this display occurs only with the CR10KD).
after a few seconds delay	
:96	The size of the machine's total memory (RAM plus 32 K of ROM), in this case 96K

TM5.1 SAMPLE PROGRAM 1

When using a type T thermocouple, the copper lead (blue) is connected to the high input of the differential channel, and the constantan lead (red) is connected to the low input.

A thermocouple produces a voltage that is proportional to the difference in temperature between the measurement and the reference junctions.

To make a thermocouple (TC) temperature measurement, the temperature of the wiring panel or the reference junction must be measured. The CR10 takes the reference temperature, converts it to the equivalent TC voltage relative to 0°C, adds the measured TC voltage, and converts the sum to temperature through a polynomial fit to the TC output curve (Section 13.4).

Instruction 11 is used to measure the Model 10TCRT Thermistor which is the reference junction temperature.

Instruction 14 directs the CR10 to make a differential TC temperature measurement. The first parameter in Instruction 14 is the number of times to repeat the measurement. Enter 1, because in this example there is only one thermocouple. If there was more than 1 TC, they could be wired to sequential channels and the number of thermocouples entered for repetitions. The CR10 would automatically advance through the channels sequentially and measure all of the thermocouples.

Parameter 2 is the voltage range to use when making the measurement. The output of a type T thermocouple is approximately 40 microvolts per degree C difference in temperature between the two junctions. The ± 2.5 mV scale will provide a range of $+2500/40 = +62.5$ °C (i.e., this scale will not overrange as long as the measuring junction is within 62.5 °C of the panel temperature). The resolution of the ± 2.5 mV range is 0.33 μV or 0.008 °C.

Parameter 3 is the analog input channel on which to make the first, and in this case, only measurement.

Parameter 4 is the code for the type of thermocouple used. This information is located on the Prompt Sheet or in the description of Instruction 14 in Section 9. The code for a type T (copper-constantan) thermocouple is 1.

Parameter 5 is the Input Storage location in which the reference temperature is stored. Parameter 6 is the Input Storage location in which to store the measurement (or the first measurement; e.g., if there are 5 repetitions and the first measurement is stored in location 3, the final measurement will be stored in location 7). Parameters 7 and 8 are the multiplier and offset. A multiplier of 1 and an offset of 0 outputs the reading in degrees C. A multiplier of 1.8 and an offset of 32 converts the reading to degrees F.

It's a good idea to have both the manual and the Prompt Sheet handy when going through this example. You can find the program instructions and parameters on the Prompt Sheet and can read their complete definitions in the manual.

CR10 PROGRAMMING EXAMPLE #1

INSTRUCTIONS: Develop a program based on the following criteria:

EXECUTION INTERVAL

1 second

MEASURE

Reference Junction temperature (C)
Type T thermocouple (C)
Battery Voltage (volts)

PROCESSING

TC temperature in degrees C

1 MINUTE OUTPUT

Array ID
Time (hour-minute)
Average reference junction temperature (C)
Average TC temperature (C)
Sample battery voltage (volts)

A worksheet has been provided on the next page which has the program instructions for this example. Pencil in the parameters, and then do the following:

Wire the 10TCRT and type T thermocouple to the wiring panel.

*5 - set real-time clock
*1 - enter program
*6 - verify sensor measurements
*7 - verify final storage data
*0 - log data mode

CR10 PROGRAMMING EXAMPLE #1 WORKSHEET

TABLE #1

01: Execution interval (secs)

1: P11 Measure reference junction temperature (C)
1:
2:
3:
4:
5:
6:

2: P14 Measure type T thermocouple (C)
1:
2:
3:
4:
5:

```
     6:
     7:
     8:

 3:  P10     Measure battery voltage (volts)
     1:

 4:  P92     Set output flag (flag 0) high every minute
     1:
     2:
     3:

 5:  P77     Output time (hour-minute)
     1:

 6:  P71     Output average reference junction temperature (C)
     1:
     2:

 7:  P71     Output average thermocouple temperature (C)
     1:
     2:

 8:  P70     Output sample battery voltage (volts)
     1:
     2:
```

The following data was collected using the first programming example. Each array of data contains five elements in the "comma delineated ASCII" format. The elements of the array are in the same order that the output processing instructions follow the instruction that set the output flag.

```
104,1438,25.77,26.43,11.48
104,1439,25.74,29.38,11.45
104,1440,25.73,32.19,11.43
104,1441,25.73,28.33,11.44
104,1442,25.74,25.74,11.46
104,1443,25.74,25.8,11.44
104,1444,25.74,25.61,11.44
104,1445,25.74,25.81,11.45
104,1446,25.75,25.53,11.45
104,1447,25.75,25.47,11.45
104,1448,25.77,25.41,11.45
104,1449,25.77,32.65,11.45
104,1450,25.78,32.67,11.46
104,1451,25.79,26.2,11.45
104,1452,25.8,26.56,11.47
```

Element	Description
1	array ID (Table 1, instruction #4)
2	time (hour-minute)
3	average reference temp (C)
4	average thermocouple temp (C)
5	sample battery volts (volts)

TM5.2 EDITING AN EXISTING PROGRAM

When editing an existing program in the CR10, entering a new instruction inserts the instruction; entering a new parameter replaces the previous value.

To insert an instruction, enter the program table and advance to the position where the instruction is to be inserted (i.e., P in the data portion of the display) key in the instruction number, and then key A. The new instruction will be inserted at that point in the table, advance through and enter the parameters. The instruction that was at that point and all instructions following it will be pushed down to follow the inserted instruction.

An instruction is deleted by advancing to the instruction number (P in display) and keying #D (Table TM4.2-1).

To change the value entered for a parameter, advance to the parameter and key in the correct value, then press A. Note that the new value is not entered until A is keyed.

TM5.3 CR10 PROGRAMMING EXAMPLE #2

INSTRUCTIONS: Develop a program based on the following criteria:

EXECUTION INTERVAL

1 second

MEASURE

Reference junction temperature (C)
Type T thermocouple (C)
Battery voltage (volts)

PROCESSING

Convert TC temperature to degrees F (in addition to degrees C)

1 MINUTE OUTPUT

Array ID
Julian Day
Time (hour-minute)
Average reference junction temperature (C)
Average TC temperature (C)
Average TC temperature (F)
Sample battery voltage (volts)

5 MINUTE OUTPUT

Array ID
Julian Day
Time (hour-minute)
Average reference junction temperature (C)
Maximum TC temperature (F)
Minimum TC temperature (F)
Sample battery voltage (volts)

A worksheet has been provided on the next page for program development. After the program has been developed, do the following:

Wire the 10TCRT and type T thermocouple to the appropriate input terminals on the wiring panel.

*5 - set real-time clock
*1 - enter program
*6 - verify sensor measurements
*7 - verify final storage data

CR10 PROGRAMMING EXAMPLE #2 WORKSHEET

TABLE #1

01: Execution interval (secs)

1: P10 Measure battery voltage (volts)
1:

2: P11 Measure reference junction temperature (C)
1:
2:
3:
4:
5:
6:

3: P14 Measure Type T thermocouple - degrees C
1:
2:
3:
4:
5:
6:
7:
8:

4: P37 Convert TC temp to degrees F
1:
2:
3:

5: P34 Z = X + F
1:
2:
3:

6: P92 Set output flag (flag 0) high every minute
1:
2:
3:

7: P77 Julian day, hour-minute
1:

8: P71 Average reference junction temp (C)
1:
2:

9: P71 Average TC temp (C)
1:
2:

10: P71 Average TC temp (F)
1:
2:

11: P70 Sample battery (volts)
1:
2:

12: P92 Set output flag (flag 0) high every 5 minutes
1:
2:
3:

13: P77 Julian day, hour-minute
1:

14: P71 Average reference junction temp (C)
1:
2:

15: P73 Maximum TC temp (F)
1:
2:
3:

(Continued on next page.)

16: P74 Minimum TC temp (F)
 1:
 2:
 3:

17: P70 Sample battery voltage (volts)
 1:
 2:

The following data was collected using the second programming example:

106,149,819,22.87,23.51,74.3,11.44
106,149,820,22.88,24.44,76,11.42
112,149,820,22.88,77.4,74.3,11.42
106,149,821,22.89,24.47,76.1,11.42
106,149,822,22.91,25.02,77,11.41
106,149,823,22.94,23.84,74.9,11.41
106,149,824,22.96,23.49,74.3,11.41
106,149,825,22.98,23.31,74,11.42
112,149,825,22.94,77.9,73.5,11.42

Each array of data contains seven elements in the "comma delineated ASCII" format. The elements of the array are in the same order as the output processing instructions that follow the instruction which set the output flag. There are two different array id's, 106 for the 1-minute data, and 112 for the 5-minute data. The elements represent:

5-minute arrays:

Element Description

1 array ID (112)
2 Julian day
3 time (hour-minute)
4 average reference temp (C)
5 maximum thermocouple temp (F)
6 minimum thermocouple temp (F)
7 sample battery voltage (volts)

1-minute arrays:

Element Description

1 array ID (106)
2 Julian day
3 time (hour-minute)
4 average reference temp (C)
5 average thermocouple temp (C)
6 average thermocouple temp (F)
7 sample battery voltage (volts)

TM6. DATA STORAGE AND RETRIEVAL

TM6.1 FINAL STORAGE AND MEMORY POINTERS

Final Storage is that portion of memory where final processed data are stored. It is from Final Storage that data is transferred to your computer or external storage peripheral.

Final Storage can be represented as ring memory (Figure TM6.1-1) on which the newest data are written over the oldest data.

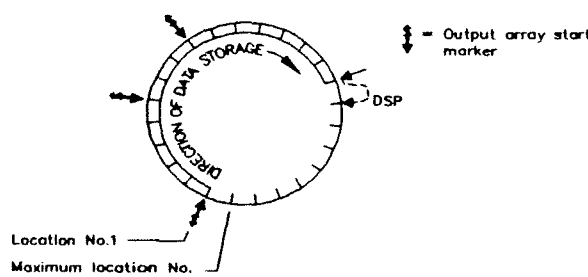


FIGURE TM6.1-1. Ring Memory Representation of Final Data Storage

The Data Storage Pointer (**DSP**) is used to determine where to store each new data point in the Final Storage area. The DSP advances to the next available memory location after each new data point is stored.

Data are stored in Final Storage before being transmitted to an external device. There are 5 pointers which are used to keep track of data transmission. These pointers are:

1. Display Pointer (**DPTR**)
2. Tape Pointer (**TPTR**)
3. Printer Pointer (**PPTR**)
4. Telecommunications (Modem) Pointer (**MPTR**)
5. Storage Module Pointer (**SPTR**)

TM6.1.1 DATA OUTPUT FORMAT AND RANGE LIMITS

Data is stored internally in Campbell Scientific's Binary Final Storage Format (Appendix C.2). Data may be sent to Final Storage in either LOW RESOLUTION or HIGH RESOLUTION format.

TM6.1.2 RESOLUTION AND RANGE LIMITS

Low resolution data is a 2 byte format with 4 significant digits and a maximum magnitude of +6999. High resolution data is a 4 byte format with 5 significant digits and a maximum possible output value of +99999 (see TM6.1-2).

TABLE TM6.1-2. Resolution Range Limits of CR10 Data

Resolution	Zero	Minimum Magnitude	Maximum Magnitude
Low	0.000	+0.001	+6999.
High	0.0000	+ .00001	+99999.

TM6.1.3 PRINTER OUTPUT FORMATS

Printer output can be sent in Final Storage Format (Appendix C.2), Printable ASCII, or Comma Delineated ASCII. These ASCII formats may also be used when data from the Storage Modules, Cassette Tape, or Telecommunications are stored on disk with Campbell Scientific's PC208 software.

TM6.1.4 PRINTABLE ASCII FORMAT

In the Printable ASCII format each data point is preceded by a 2 digit data point ID and a + or - sign. The ID and fixed spacing of the data points make particular points easy to find on a printed output. This format requires 10 bytes per data point to store on disk. Example:

```
01+0115 02+0189 03+1200 04+089.6
01+0115 02+0189 03+1300 04+091.3
01+0115 02+0189 03+1400 04+092.7
01+0115 02+0189 03+1500 04+094.1
```

TM6.1.5 COMMA DELINEATED ASCII

Comma Delineated ASCII strips all IDs, leading zeros, unnecessary decimal points and trailing zeros, and plus signs. Data points are separated by commas. Arrays are separated by Carriage Return Line Feed. Comma Delineated ASCII requires approximately 6 bytes per data point. Example:

```
1,234,1145,23.65,-12.26,625.9
1,234,1200,24.1,-10.98,650.3
```

TM6.2 EXTERNAL STORAGE PERIPHERALS

External data storage devices are used to provide a data transfer medium that the user can carry from the test site to the lab and to supplement the internal storage capacity of the CR10, allowing longer periods between visits to the site. The standard data storage peripherals for the CR10 are the cassette tape (Section 4.3) and the Storage Module (Section 4.5). Output to a printer or related device is also possible (Section 4.4).

Data output to a peripheral device can take place ON-LINE (automatically, as part of the CR10's routine operation) or it can be MANUALLY INITIATED. On-line data transfer is accomplished with Instruction 96 (Section 4.1). Manual initiation is done in the *8 Mode (Section 4.2).

TM6.2.1 ON-LINE DATA TRANSFER - INSTRUCTION 96

All on-line data output to a peripheral device is accomplished with Instruction 96. This instruction must be included in the datalogger program for on-line data transfer to take place. Instruction 96 should follow the Output Processing Instructions.

Instruction 96 has a single parameter which specifies the peripheral to send output to. Table TM6.2.1-1 lists the output device codes.

TABLE TM6.2-1. Output Device Codes for Instruction 96 and *8 Mode

CODE	DEVICE
00	Tape. Data transferred in blocks of 512 Final Storage locations
	PIN ENABLED PRINTER
4x	Printable ASCII
5x	Comma delineated ASCII
6x	Binary
	x = BAUD RATE CODES 0 300 1 1200 2 9600 3 76,800
7N	Storage Module N (N=address, 1...8)

TM6.2.2 MANUALLY INITIATED DATA OUTPUT - *8 MODE

Data transfer to a peripheral device can be manually initiated in the *8 Mode (Table TM6.2-2). This process requires that the user have access to the CR10 through a terminal or the Campbell Scientific Keyboard/Display.

If external storage peripherals (cassette, Storage Module, etc.) are not left on-line, the maximum time between site visitations and data retrieval must be calculated to ensure that data placed in Final Storage are not lost due to write-over.

TABLE TM6.2-2. *8 Mode Entries

Key	Display ID:DATA	Description
*8	08:00	Key 1 or 2 for Storage Area. (This window is skipped if no memory has been allocated to Final Storage Area 2.)
A	01:XX	Key in Output Device Option. See Table TM6.2-1.
A	02:XXXXX	Start of dump location. Initially the TPTR, SPTR or PPTR location; a different location may be entered if desired.
A	03:XXXXX	End of dump location. Initially the DSP location; a different location may be keyed in if desired.
A	04:00	Ready to dump. To initiate dump, key any number, then A. While dumping, "04" will be displayed in the ID field and the location number in the Data field. The location number will stop incrementing when the dump is complete.

TM6.3 DATA RETRIEVAL OPTIONS

There are several options for data storage and retrieval. These options are covered in detail in Sections 2, 4, and 5. Figure TM6.3-1 summarizes the various possible methods.

Regardless of the method used, there are three general approaches to retrieving data from a datalogger.

1) On-line output of Final Storage data to a peripheral storage device. On a regular schedule, that storage device is either "milked" of its data or is brought back to the office/lab where the data is transferred to the computer. In the latter case, a "fresh" storage device is usually left in the field when the full one is taken so that data collection can continue uninterrupted.

2) Bring a storage device to the datalogger and milk all the data that has accumulated in Final Storage since the last visit.

3) Retrieve the data over some form of telecommunications link, whether it be RF, telephone, short haul modem, or satellite. This can be performed under program control or by regularly scheduled polling of the dataloggers. Campbell Scientific's TELCOM program automates this process for IBM PC/XT/AT/PS-2's and compatibles.

Regardless of which method is used, the retrieval of data from the datalogger does NOT erase those data from Final Storage. The data remain in the ring memory until:

- they are written over by new data (Section 2.1)
- memory is reallocated (Section 1.5)
- the power to the datalogger is turned off.

TM7. CR10 MEASUREMENTS

TM7.1 FAST AND SLOW MEASUREMENT SEQUENCE

The CR10 makes voltage measurements by integrating the input signal for a fixed time and then holding the integrated value for the analog to digital (A/D) conversion. The A/D conversion is made with a 13 bit successive approximation technique which resolves the signal voltage to

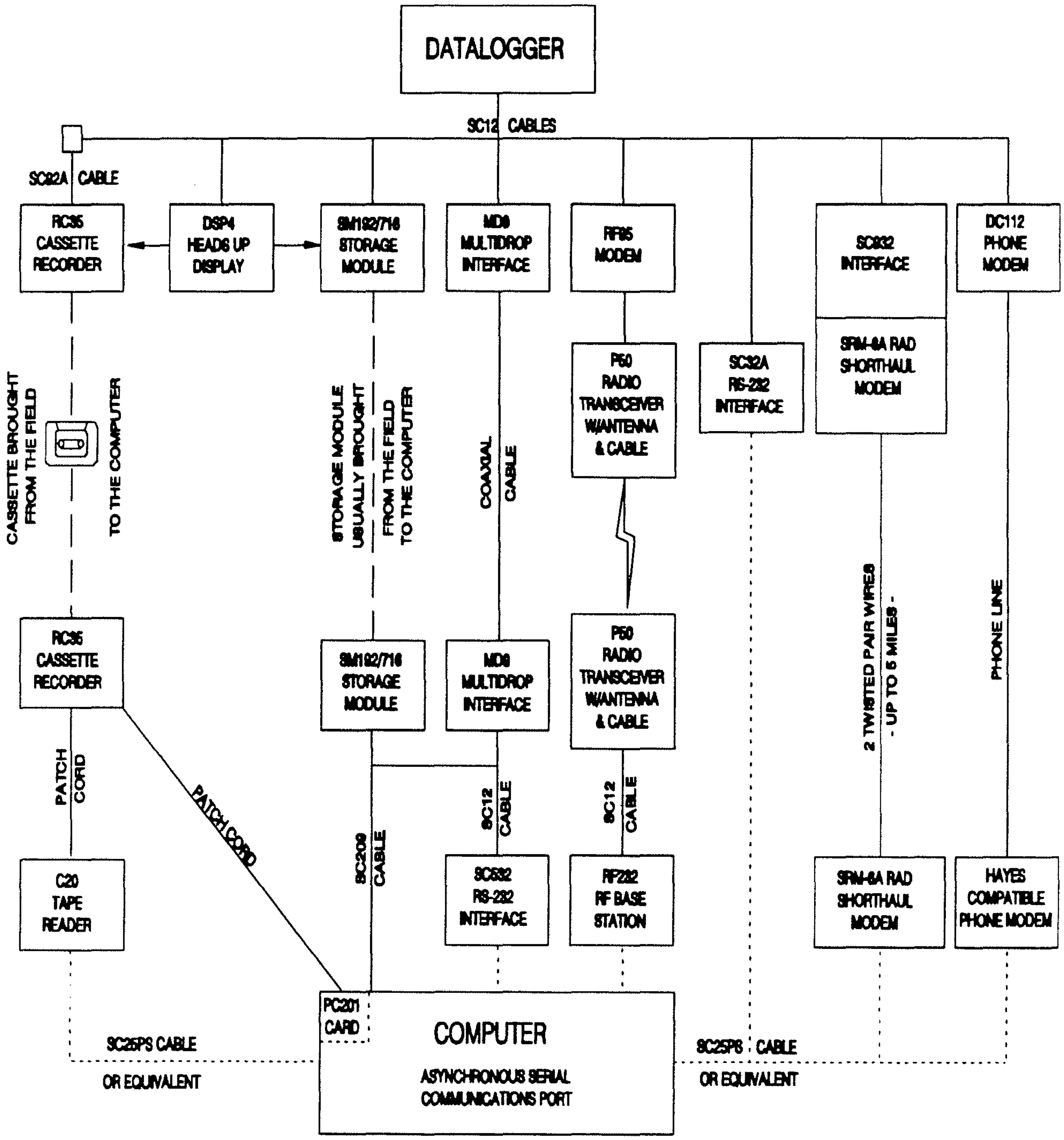


FIGURE TM6.3-1. Data Retrieval Hardware Options approximately one part in 7500 of the full scale range on a differential measurement (e.g., 1/7500 x 2.5V = 333 uV). The resolution of a single-ended measurement is one part in 3750.

Integrating the signal removes noise that could create an error if the signal were instantaneously sampled and held for the A/D conversion. There are two integration times which can be specified for voltage measurement instructions, the slow integration (2.72 ms), or the fast integration (250 us). The slow integration time provides a more noise-free reading than the fast integration time. Integration time is specified in the Range Code of the measurement instruction.

Instructions 1 - 14 RANGE codes:

Slow (2.72 ms integration time)	Fast (250 us integration time)	60 Hz rejection	50 Hz rejection	Full Scale range
1	11	21	31	± 2.5 mV
2	12	22	32	± 7.5 mV
3	13	23	33	± 25 mV
4	14	24	34	± 250 mV
5	15	25	35	±2500 mV

One of the most common sources of noise is 60 Hz from AC power lines. Where 60 Hz noise is a problem, range codes 21 - 25 should be used. Two integrations are made spaced 1/2 cycle apart (Figure TM7.1-1), which results in the AC noise integrating to 0. Integration time for the 2500mV range is 1/10 the integration time for the other gain ranges (2.72msecs). For countries with 50 Hz power Range codes 31 - 35 are used for 50 Hz rejection.

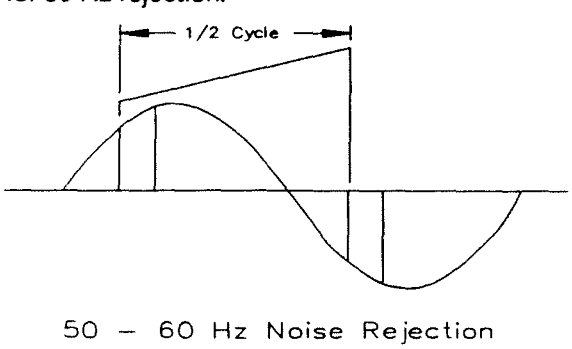


FIGURE TM7.1-1. 50 and 60 Hz Noise Rejection

There are several situations where the fast integration time is preferred. The fast integration time minimizes time skew between measurements and increases the throughput rate. The current drain on the CR10 batteries is lower when the fast integration time is used. The fast integration time should ALWAYS be used with the AC half bridge (Instruction 5) when measuring AC resistance or the output of an LVDT. An AC resistive sensor will polarize if a DC voltage is applied, causing erroneous readings and sensor decay. The induced voltage in an LVDT decays with time as current in the primary coil shifts from the inductor to the series resistance; a long integration time would result in most of the integration taking place after the signal had disappeared.

TM7.2 SINGLE-ENDED AND DIFFERENTIAL VOLTAGE MEASUREMENTS

> **NOTE:** The channel numbering on the CR10 panel refers to differential channels. Either the high or low side of a differential channel can be used for single-ended measurements. Each side must be counted when numbering single-ended channels; e.g., the high and low sides of differential channel 4 are single-ended channels 7 and 8, respectively.

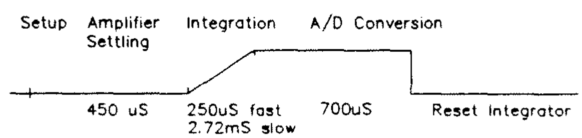


FIGURE TM7.2-1. Timing of Single-Ended Measurement

The timing and sequence of a single-ended measurement is shown in Figure TM 7.2-1. A single-ended measurement is made on a single input which is referenced to ground. A single integration is performed for each measurement. A differential measurement measures the difference in voltage between two inputs. The measurement sequence on a differential measurement involves two integrations: First with the high input referenced to the low, then with the inputs reversed (Figure TM 7.2-2). The CR10 computes the differential voltage by averaging the magnitude of the results from the two integrations and using the polarity from the first. An exception to this is the differential measurement in Instruction 8 which makes only one integration.

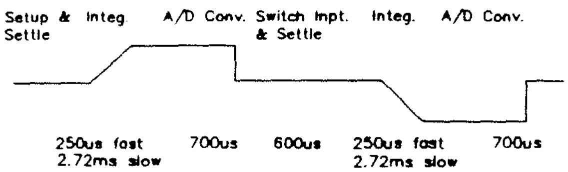


FIGURE TM7.2-2. Differential Voltage Measurement Sequence

In order to make a differential measurement, the inputs must be within the CR10 common mode range of ±2.5 V. The common mode range is the voltage range, relative to CR10 ground, within which both inputs of a differential measurement must lie in order for the differential measurement to be made. For example, if the high side of a differential input is at 2 V and the low side is at 1 V relative to CR10 ground, there is no problem; a measurement made on the +2.5 V range would indicate a signal of 1 V. However, if the high input is at 2.8 V and the low input is at 2 V, the measurement cannot be made because the high input is outside of the common mode range. The CR10 will indicate the overrange with the maximum negative number (Section 3.5.)

If a differential measurement is used on a sensor that is not referenced to CR10 ground through a separate connection (e.g., a net radiometer), a jumper wire should be connected between the low side of the differential input and ground to hold the sensor in common mode range.

A differential measurement has better noise rejection than a single-ended measurement. Integrating the signal in both directions also reduces input offset voltage due to thermal effects in the amplifier section of the CR10. Input offset voltage on a single-ended measurement is less than 5 microvolts; the input offset voltage on a differential measurement is less than 1 microvolt.

A single-ended measurement is quite satisfactory in cases where noise is not a problem and care is taken to avoid ground potential problems. Channels are available for twice as many single-ended measurements. A single-ended measurement takes about half the time of a differential measurement, which is valuable in cases where rapid sampling is a requirement.

> **NOTE:** Sustained voltages in excess of +16 VDC applied to the analog inputs will damage the CR10 input circuitry.

TM7.3 BRIDGE RESISTANCE MEASUREMENTS

There are 6 bridge measurement instructions included in the standard CR10 software. Figure TM 7.3-1 shows the circuits that would typically be measured with these instructions. In the diagrams, the resistors labeled R_s would normally be the sensors, and those labeled R_f would normally be fixed resistors. Circuits other than those diagrammed could be measured, provided the excitation and type of measurements were appropriate.

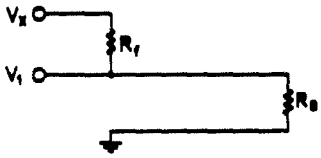
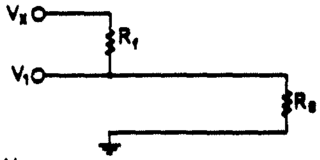
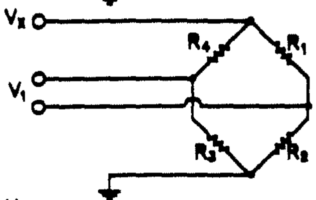
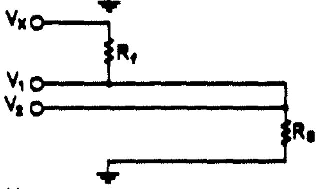
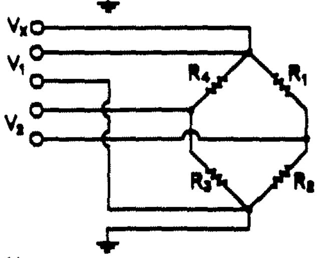
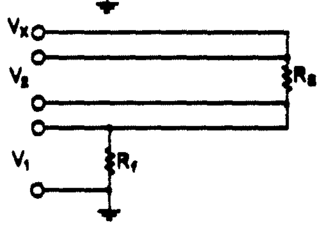
INSTR. #	DIAGRAM	DESCRIPTION	RESULT = X
4		DC HALF BRIDGE WITH USER ENTERED SETTLING TIME	$X = V_1 = V_x \frac{R_s}{R_s+R_f}$
5		AC HALF BRIDGE EXCITATION ALTERNATES POLARITY FOR ION DEPOLARIZATION	$X = \frac{V_1}{V_x} = \frac{R_s}{R_s+R_f}$
6		4 WIRE FULL BRIDGE	$X = 1000 \frac{V_1}{V_x} = 1000 \left(\frac{R_3}{R_3+R_4} - \frac{R_2}{R_1+R_2}\right)$
7		3 WIRE HALF BRIDGE	$X = \frac{2V_2 - V_1}{V_x - V_1} = \frac{R_s}{R_f}$
9		6 WIRE FULL BRIDGE WITH EXCITATION LEAD COMPENSATION	$X = 1000 \frac{V_2}{V_1} = 1000 \left(\frac{R_3}{R_3+R_4} - \frac{R_2}{R_1+R_2}\right)$ (V_1 ON 2.5 V RANGE)
9		4 WIRE HALF BRIDGE	$X = \frac{V_2}{V_1} = \frac{R_s}{R_f}$ (V_1 NOT ON 2.5 V RANGE)

FIGURE TM7.3-1. Circuits Used with Instructions 4-9

TABLE TM7.3-1. Comparison of Bridge Measurement Instructions

Instr. #	Circuit	Description
4	DC Half Bridge	The delay parameter allows the user entered settling time compensate for capacitance in long lead lengths. No polarity reversal. One single-ended measurement. Measured voltage is output.
5	AC Half Bridge	Rapid reversal of excitation polarity for ion depolarization. One single-ended measurement at each excitation polarity. Ratiometric output.
6	4 Wire Full Bridge	One differential measurement at each excitation polarity. Ratiometric output.
7	3 Wire Half Bridge	Compensates for lead wire resistance, assuming resistance is same in both wires. Two single-ended measurements at each excitation polarity. Ratiometric output.
8	Differential Measurement with Excitation	Makes a differential measurement without reversing excitation polarity. Used for fast measurements on loadcells, PRTs etc. Resolution and common mode rejection worse than 6 if used with delay = 0. Measured voltage output.
9	6 Wire Full Bridge or 4 Wire Half Bridge	Compensates for lead wire resistance. Two differential measurements at each excitation polarity. Ratiometric output.

With the exception of Instructions 4 and 8, which apply an excitation voltage then wait a specified time before making a measurement, all of the bridge measurements make one set of measurements with the excitation as programmed and another set of measurements with the excitation polarity reversed. The error in the two measurements due to thermal emfs can then be accounted for in the processing of the measurement instruction. The excitation is switched on 450s before the integration portion of the measurement starts and is grounded as soon as the integration is completed. Figure TM 7.3-2 shows the excitation and measurement sequence for Instruction 6, a 4 wire full bridge.

Excitation is applied separately for each phase of a bridge measurement. For example, in Instruction 6, as shown in Figure TM 7.3-2, excitation is switched on for the 4 integration periods and switched off between integrations.

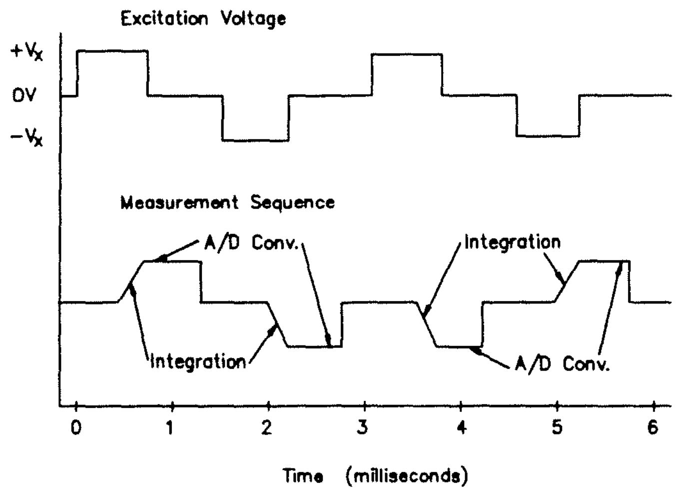


FIGURE TM7.3-2. Excitation and Measurement Sequence for 4 Wire Full Bridge

TM7.4 RESISTANCE MEASUREMENTS REQUIRING AC EXCITATION

Some resistive sensors require AC excitation. These include the 207 Relative Humidity Probe, soil moisture blocks, water conductivity sensors, and wetness sensing grids. The use of DC excitation with these sensors can result in polarization, which will cause an erroneous measurement, and may shift the calibration of the sensor and/or lead to its rapid decay.

The AC half bridge Instruction 5 (incorporated into the 207 relative humidity measurement Instruction 12) reverses excitation polarity to provide ion depolarization and, in order to minimize the time excitation is on, grounds the excitation as soon as the signal is integrated (Figure TM 7.4-1). The slow integration time should never be used with a sensor requiring AC excitation because it results in the excitation lasting about 1.5 times as long, allowing polarization to affect the measurement.

TM8. PROGRAMMING EXAMPLES

The following examples are intended to illustrate the use of Program Control Instructions, flags, and Output Processing Instructions executed within a loop. These examples are not complete programs to be taken verbatim.

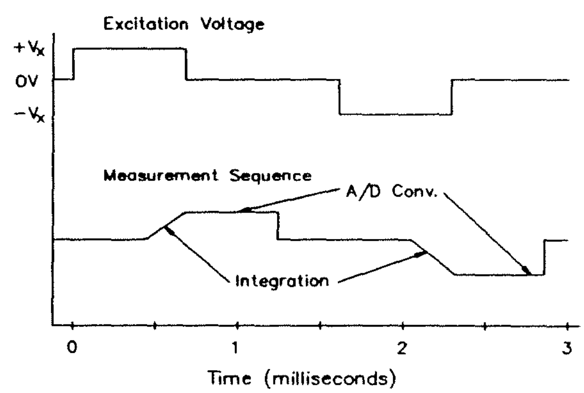


FIGURE TM7.4-1. AC Excitation and Measurement Sequence for AC Half Bridge

TM8.1 IF THEN/ELSE COMPARISONS

Program Control Instructions can be used for If then/else comparisons. When Command 30 (Then do) is used with Instructions 83 or 88-92, the If Instruction is followed immediately by instructions to execute if the comparison is true. The Else Instruction (94) is optional and is followed by the instructions to execute if the comparison is false. The End Instruction (95) ends the If then/else comparison and marks the beginning of the instructions which are to be executed regardless of the outcome of the comparison (Figure TM8.1-1).

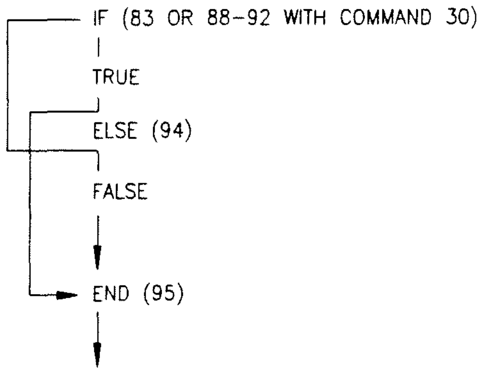


FIGURE TM8.1-1 If Then/Else Execution Sequence

If Then/Else comparisons may be nested to form logical AND or OR branching. Figure TM8.1-2 illustrates an AND construction. If conditions A and B are true, the instructions included between IF B and the first End Instruction will be executed. If either of the conditions are false, execution will jump to the corresponding End Instruction, skipping the instructions between.

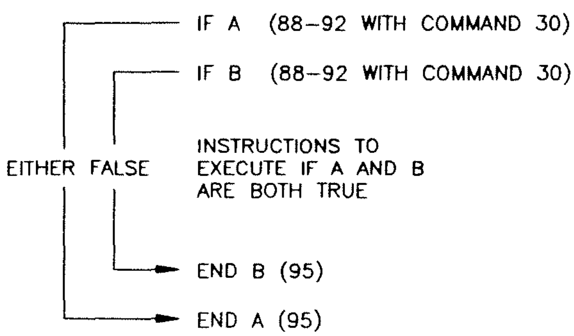


FIGURE TM8.1-2. Logical AND Construction

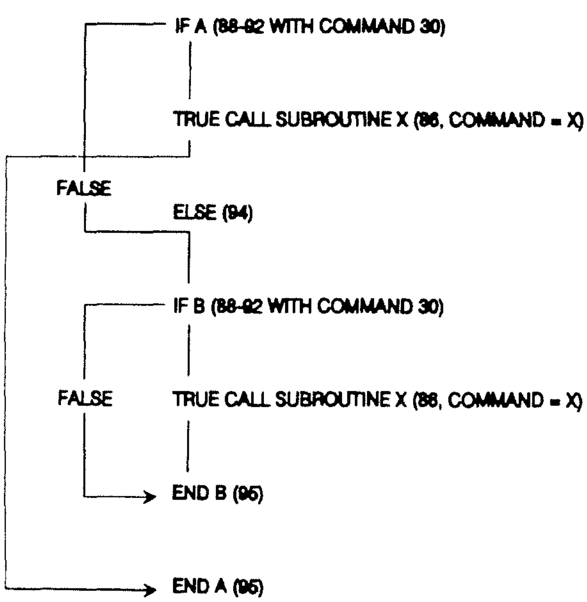


FIGURE TM8.1-3. Logical OR Construction

A logical OR construction is also possible. Figure TM8.1-3 illustrates the instruction sequence that will result in subroutine X being executed if either A or B is true.

TM8.2 PROGRAMMING EXAMPLE: CONTROLLING PROGRAM TABLE EXECUTION USING A FLAG

Program instructions following Instruction 91 are not executed when flag 1 is low. Toggle flag 1 using the *6 Mode.

* 1	Table 1 Programs
01: 1	Sec. Execution Interval
01: P91	If Flag/Port
01: 21	Do if flag 1 is low
02: 00	Go to end of Program Table
02: P11	Temp 107 Probe
01: 1	Rep
02: 1	IN Chan
03: 1	Excite all reps w/EXchan 1
04: 1	Loc [:ref temp]
05: 1	Mult
06: 0	Offset
03: P14	Thermocouple Temp (DIFF)
01: 1	Rep
02: 1	2.5 mV slow Range
03: 11	IN Chan
04: 1	Type T (Copper-Constantan)
05: 1	Ref Temp Loc ref temp
06: 2	Loc [:tc temp C]
07: 1	Mult
08: 0	Offset

TM8.3 PROGRAMMING EXAMPLE: EXECUTING THE AVERAGE INSTRUCTION WITHIN A LOOP

Every 60 seconds thermocouple temperature is measured and stored in location 2. Instruction 89 executes the loop when the temperature is less than 32.0. An input location is used as a counter, the output flag is set high and the counter is zeroed when the count = 30.

The average instruction gets executed each time through the loop, the last time the output flag is set, so the average is stored in final storage.

```
*        1          Table 1 Programs
 01: 60             Sec. Execution Interval

01:P11              Temp 107 Probe
 01:    1           Rep
 02:    1           IN Chan
 03:    1           Excite all reps w/EXchan 1
 04:    1           Loc [:ref temp ]
 05:    1           Mult
 06:    0           Offset

02:P14              Thermocouple Temp (DIFF)
 01:    1           Rep
 02:    1           2.5 mV slow Range
 03:    2           IN Chan
 04:    1           Type T (Copper-Constantan)
 05:    1           Ref Temp Loc ref temp
 06:    2           Loc [:tc temp C]
 07:    1           Mult
 08:    0           Offset

03:     P89         If X<=>F (check if
                    temperature is < 32.0)
 01:    2           X Loc tc temp C
 02:    4           <
 03:    32.0        F
 04:    30          Then Do

04:     P30         Z=F (zero counter prior to
                    loop)
 01:    0           F
 02:    3           Z Loc [:counter  ]

05:     P87         Beginning of Loop
 01:    0           Delay
 02:    30          Loop Count

06:P14              Thermocouple Temp (DIFF)
 01:    1           Rep
 02:    1           2.5 mV slow Range
 03:    2           IN Chan
 04:    1           Type T (Copper-Constantan)
 05:    1           Ref Temp Loc ref temp
 06:    2           Loc [:tc temp C]
 07:    1           Mult
 08:    0           Offset

07:     P32         Z=Z+1
 01:    3           Z Loc [:counter  ]

08:     P89         If X<=>F (check input
                    location used as counter)
 01:    3           X Loc counter
 02:    3           >=
 03:    30          F
 04:    10          Set high Flag 0 (output)

09:     P71         Average (average
                    thermocouple temperature)
 01:    1           Rep
 02:    2           Loc tc temp C

10:     P95         End (of loop)

11:     P95         End (if temp < 32.0)
```

SECTION TM9. PC208 TRAINING MANUAL

INTRODUCTION

The PC208 Datalogger Support Software package contains five separate programs. Each program serves an integral function from program development to report generation.

This section of the Training Manual describes the more commonly used functions of the EDLOG, GRAPHTERM, TELCOM, SPLIT, and SMCOM programs. Programming exercises are included at the end of each description that will be used to:

1. *Develop a datalogger program using EDLOG.*
2. *Program the datalogger using GRAPHTERM.*
3. *Collect data from the datalogger using GRAPHTERM/TELCOM.*
4. *Check real time measurements from the datalogger using GRAPHTERM.*
5. *Generate a report of data collected, or analyze the data using SPLIT*
6. *Collect and store data/programs from the SM192/SM716 storage modules using SMCOM.*

TM9.1 NOTATION USED IN THIS MANUAL

The following notation will be used to indicate how PC208 software commands should be formatted:

- Whenever reference is made to command entries, they will be set off by single quotation marks (e.g., 'SPLIT'). The entry lies between the ' ' delimiters. The symbols ' ' are not entered as part of the command.
- Command entries shown with capital letters must be entered exactly as shown (i.e. 'GRAPHTERM'). You must supply any items shown in lower case letters. For example, you should enter the name of your file when 'filename' is shown in this format.
- Items in square brackets ([]) are optional unless noted otherwise. If you want to include optional information, you do not need to type the brackets, only the information inside the brackets.

TM9.2 PC208 FILE TYPES

Default extension names are assigned to files generated by the PC208 Software. Table TM9.2-1 summarizes these extensions.

TABLE TM9.2-1. File Types Used With PC208 Software

EXTENSION TYPE	MNEMONIC of EXT. and SOFTWARE that generated file	DESCRIPTION/USES
.DAT	raw **DATa** TELCOM, SMCOM	Data as received from datalogger. Format can be printable ASCII, or Final Storage Format.
.STN	**STatioN** parameter TELCOM, GRAPHTERM	Parameters necessary to call datalogger.
.DOC	datalogger program **DOC**umentation EDLOG	Documentation of datalogger program.
.DLD	**DownLoaD** program to datalogger	EDLOG generates this down-loadable file.
.RPT	data **RePorT** file SPLIT	Produced by SPLIT for subsequent printing or use in a standard text editor.
.PRN	**PRiN**table data file SPLIT	Produced by SPLIT for subsequent use by Lotus or other spreadsheet programs.
.PAR	**PAR**ameter file SPLIT	Contains parameters used by SPLIT for data selection and processing.

SECTION TM10. EDLOG

TM10.1 OVERVIEW

EDLOG is used to develop and document programs for CR10, 21X, and CR7 dataloggers. Output files can be used to program the dataloggers. EDLOG is written for use on IBM personal computers with at least 256 K of RAM memory and an 80 column by 25 line monitor.

Instructions and parameters are entered with the same characters that are used to program the datalogger directly. EDLOG automatically describes the instructions and prompts for the parameters. The user may add additional comments as desired. Cursor movement commands are listed in Table TM10.2-1.

TM10.1.1 GETTING STARTED

Enter 'EDLOG' on the command line to load and execute the program. The PC must be logged onto the disk and directory containing EDLOG, or the appropriate "path" must be specified per the PC-DOS Manual. EDLOG prompts for a ".DOC filename:". The filename is not entered with an extension, but may include drive and path specifications (e.g., '[D:][\path\]filename'). EDLOG adds the extension .DOC. EDLOG loads the file, or if the file does not already exist, loads a Starter program for the designated datalogger. The Starter program becomes the root of the new file to be edited. If '*' is entered in place of the filename, EDLOG will show the .DOC filenames for the specified drive and directory path. Next EDLOG prompts:

Enter Datalogger Type (CR10, 21X, or CR7):

TM10.1.2 INSTRUCTION AND COMMENT FIELDS

The document file is divided into instruction and comment fields. At the beginning of the file are comment lines where the user may define outputs and flag and channel usage. Additional comment lines may be added (Section TM10.2.2).

Below these comments is the body of the program. This is divided into Program Tables 1, 2, and 3, *A Memory allocation and *C Security options. On the left of each of these lines is datalogger ID information which cannot be edited. This field includes Mode, Entry number and Parameter number information. The next field to the right is the Instruction field where the actual programming is done. These first two fields correspond to the ID and Data fields of the datalogger display.

On the right is the Comment field. Each Instruction, Mode, and Parameter line includes some protected comments about that line which cannot be edited. These comments may become more specific once entries have been made in the Instruction field. The user may add to the comment part of the line. However, the length of entered comment is limited. When the limit is reached, EDLOG will not accept additional text, and another comment line must be added (Ctrl N).

TM10.2 HELP– F1

F1 is the Help key. When uncertain what to enter for a specific parameter, press the Help key. Help is only available in the parameter field. If the help you are looking for exists, it will be displayed, otherwise nothing will happen. The default comments contain the word "Option" for parameters where help is available. However, once a particular option is selected, the default comment is ordinarily updated and will no longer contain the word "Option". The Help key will continue to display the helps for that parameter.

TM10.2.1 FILE COMMANDS– F2

When the F2 Key is pressed, the file command menu is displayed. Select a command by pressing the first letter of the command or move the cursor to the command with the arrow keys and press return.

TM10.2.2 EDIT FUNCTIONS– F3

When the F3 key is pressed, EDLOG displays the main editing features for EDLOG. The feature listing disappears when the cursor is advanced to the next line. Table TM10.2-1 gives a summary of editing features and commands.

TABLE TM10.2-1. Editing Command Summary

Help	F1
File Commands	F2
Edit Functions	F3
Go To *Mode Always	F4
Insert Comment Line	Ctrl N
Delete Comment Line	Ctrl Y
Enter Location Label	Ctrl L ("Loc:" In Comment)
Mark Instruction	Ctrl Kb
Delete Instruction	Ctrl Ky
Copy/recall Instruction	Ctrl Kc (Cursor On Program #)
Write To Library File	Ctrl Kw
Read Library File	Ctrl Kr
Cursor:	
Left	Ctrl S Or Left Arrow
Right	Ctrl D Or Right Arrow
Up	Ctrl E Or Up Arrow
Down	Ctrl X Or Down Arrow
Page Up	Ctrl R Or Pgup
Page Down	Ctrl C Or Pgdn
Go To Parameter Field	Ctrl F or Shift Tab

TM10.2.3 GO TO– F4

F4 is used to go directly to some point in the program being edited. When F4 is pressed, EDLOG will display the list of * Modes and wait for the user to select one.

TM10.2.4 INSERT INSTRUCTION

The user can insert a Program Instruction when the cursor is in the Instruction field of any line starting with "xx: P".

TM10.3 COMMENT AND INSTRUCTION MOVE COMMANDS

TM10.3.1 ENTER LOCATION LABEL– Ctrl L

Ctrl L is used to enter labels for the first 254 Input Storage locations. Once an Input Location is labeled, EDLOG will insert the label into the comment field of every line which references that Input Location.

Ctrl L is active only on parameters that assign locations to store measurements or processed data. The comment for those lines will always have the word "Loc:". Comments which have the word "Loc" but no ":" represent locations from which data is extracted for processing or output. Ctrl L will not be active on these lines but a Label already created elsewhere will be included in the comment once the Location number is entered.

When Ctrl L is pressed on a valid line, EDLOG will prompt for the Label within a 9 character window. If the Label was already assigned, the current Label assignment will also be displayed. If no Label is entered, Return will leave the Label unchanged.

TM10.3.2 INSERT COMMENT LINE– Ctrl N

Ctrl N inserts a comment line below the line which the cursor is on. Comment lines are the same length as the Comment field of parameter entry lines and are left justified.

TM10.4 FILE COMMANDS

When the F2 Key is pressed, the file command menu is displayed. Select a command by pressing the first letter of the command or move the cursor to the command with the arrow keys and press enter.

TM10.4.1 QUIT

If the program has been changed since being loaded or saved, EDLOG will ask the user whether it should be saved before exiting EDLOG. If the program has not been changed, EDLOG will exit immediately.

TM10.4.2 EDIT

EDIT puts EDLOG in the Program editing mode.

TM10.4.3 SAVE

If the .DOC extension of the filename already exists on disk it will be renamed to a .BAK filename before the new .DOC file is saved. In addition to saving the file being edited (.DOC), EDLOG creates a file with the same filename but with the extension .DLD.

The .DLD, or download file, is used to program the datalogger. The program is loaded through the datalogger's telecommunication *D or H modes with TERM. The file can also be written to storage module for transfer to the datalogger.

Location Labels are stored as comment lines in the .DLD file. If the .DOC file is re-edited, EDLOG uses the Labels from the .DLD file. The Location Labels are also used by TERM for the monitor option.

TM10.4.4 PRINT

The file being edited is sent to the default print device or to a Printable.DOC File (.PDF) The file being edited is printed first. Next is a summary of Table and Entry numbers of Instructions which store data in Input Storage Locations. The last page is a list of Label assignments for the first 99 Input Storage Locations. The file being edited does not have to be saved before printing. The .DOC file is not a text file; it cannot be printed or edited with other editors. A .PDF file can be edited with a text editor. However, the .PDF file cannot be substituted for a .DOC file in EDLOG.

TM10.4.5 LOAD NEW .DOC FILE

EDLOG will ask if the current file should be saved before asking for the next file to be edited. If no filename is entered, EDLOG will exit to the operating system when the Enter key is pressed.

TM10.4.6 DOCUMENT .DLD FILE

Datalogger programs are often entered and edited from the keyboard. EDLOG will also allow program input from disk file. The benefit of the file driver facility is to document existing datalogger programs created without EDLOG. This file may be created by uploading a program from the datalogger to the PC (SAVE option in TERM).

After pressing D for file input, EDLOG asks for the .DLD filename. The file must have the extension .DLD.

EDLOG will take the program from the file and document the program. If Location Labels are included in the file, they will be inserted into the text where referenced. At the end of the file, EDLOG will return to the keyboard entry mode.

TM10.5 EDLOG EXERCISE

Develop a datalogger program using EDLOG and the information provided in Section TM5.3 for Programming Example #2. The following Edlog generated program has been provided as an example:

Program: 10pgm2.dld - CR10 sample program #2
Flag Usage:
Input Channel Usage:
Excitation Channel Usage:
Control Port Usage:
Pulse Input Channel Usage:
Output Array Definitions:

Wiring:

1H Analog input lead of 10TCRT
E3 Excitation lead of 10TCRT
AG Analog ground lead of 10TCRT
5H blue wire of thermocouple
5L red wire of thermocouple

Input Location Usage:

Location

1 CR10 Battery - voltage
2 Reference temperature - degrees C
3 Type T thermocouple - degrees C
4 Type T thermocouple - degrees F

Output array definition:

1-minute arrays

Element	Description
1	106 - array ID
2	Julian Day
3	Hour-Minute
4	Avg reference junction temp - C
5	Avg TC temp - C
6	Avg TC temp - F
7	Sample battery - volts

5-minute arrays

Element	Description
1	112 - array ID
2	Julian Day
3	Hour-Minute
4	Avg reference junction temp - C
5	Maximum TC temp - F
6	Minimum TC temp - F
7	Sample battery - volts

```
*      1        Table 1 Programs
 01:   1        Sec. Execution Interval

01:   P10       Battery Voltage
 01:   1        Loc [:bat volts] (Input location for measurement)

02:   P11       Temp 107 Probe (Measure reference junction temp)
 01:   1        Rep
 02:   1        IN Chan
 03:   3        Excite all reps w/EXchan 3
 04:   2        Loc [:reftemp C]
 05:   1        Mult
 06:   0        Offset

03:   P14       Thermocouple Temp (DIFF)
 01:   1        Rep
 02:   1        2.5 mV slow Range
 03:   5        IN Chan (Analog channel TC is wired to)
 04:   1        Type T (Copper-Constantan)
 05:   2        Ref Temp Loc reftemp C
 06:   3        Loc [:TC temp C] (Input location for measurement)
 07:   1        Mult (Multiplier for degrees C)
 08:   0        Offset

04:   P37       Z=X*F (Convert TC temp from degrees C to F)
 01:   3        X Loc TC temp C
 02:   1.8      F
 03:   4        Z Loc [:TC temp F]
```

05:	P34	Z=X+F
01:	4	X Loc TC temp F
02:	32	F
03:	4	Z Loc [:TC temp F]
06:	P92	If time is (Set output Flag high every minute)
01:	0	minutes into a
02:	1	minute interval
03:	10	Set high Flag 0 (output)

ONE MINUTE PROCESSING

07:	P77	Real Time
01:	0110	Day,Hour-Minute
08:	P71	Average (Reference junction temp)
01:	1	Rep
02:	2	Loc reftemp C
09:	P71	Average (TC temp C)
01:	1	Rep
02:	3	Loc TC temp C
10:	P71	Average (TC temp F)
01:	1	Rep
02:	4	Loc TC temp F
11:	P70	Sample (battery voltage)
01:	1	Reps
02:	1	Loc bat volts

5 MINUTE PROCESSING

12:	P92	If time is (Set output flag high every 5 minutes)
01:	0	minutes into a
02:	5	minute interval
03:	10	Set high Flag 0 (output)
13:	P77	Real Time
01:	0110	Day,Hour-Minute
14:	P71	Average (Reference temperature C)
01:	1	Rep
02:	2	Loc reftemp C
15:	P73	Maximize (TC temp F)
01:	1	Rep
02:	0	Value only
03:	4	Loc TC temp F
16:	P74	Minimize (TC temp F)
01:	1	Rep
02:	0	Value only
03:	4	Loc TC temp F
17:	P70	Sample (battery voltage)
01:	1	Reps
02:	1	Loc bat volts

SECTION TM11. GRAPHTERM

GRAPHTERM is used to establish communications between a computer and CSI dataloggers. A "Station File" is created for each datalogger that specifies the datalogger type, COM port, baud rate, and interface device(s). GRAPHTERM can also be used to:

* *Monitor the datalogger's "real-time" data values*
* *Download a Program to Datalogger*
* *Download PC Time to Datalogger Clock*
* *Collect Data*
* *Display Sensor Measurements Graphically*

TM11.1 THE STATION FILE

Enter 'GT' on the command line to load and execute the program.

GRAPHTERM asks you to:

Enter Station Name (add /E to alter Parameters):

The station file defines the datalogger and the communication path to be used. Once the necessary parameters have been entered, a file is saved with the station name plus the .STN extension. The parameters will not have to be entered the next time the station is used. The station parameters of an existing station can be edited by appending /E to the station name (i.e., 'LOGGER/E' for the station with the name "LOGGER").

When a new station name (e.g., "LOGGER") is entered or the /E option is exercised, GRAPHTERM will prompt:

Telecommunications Parameters For Station:	**LOGGER**	
Datalogger Type:	**CR10**	**Security Code: 0**
Use Asynchronous Communications Adapter:	**COM1**	
Communications Baud rate:	**9600**	
Data File Format:	**Comma delineated ASCII**	
Final Storage Collection Area:	**Area 1**	

Interface Device:

"None" after datalogger type will be highlighted. Press the space bar to scroll through the datalogger type options. Press **Return** to select the desired option and advance to the next parameter. Once again, you may scroll the options by pressing the space bar, and enter the choice by pressing return.

11.1.1 Datalogger Type:

Options: **CR10** **Security Code: 0**
21X
CR7
300 Series **Security Code: 0**

11.1.2 Use Asynchronous Communications Adapter:

Options: **COM1**
COM2
COM3
COM4

GRAPHTERM will allow you to use COM1, COM2, COM3, or COM4 in communicating with a station.

11.1.3 Communications Baud rate:

Options: **300**
1200
9600

11.1.4 Data File Format

Options: **Comma Delineated ASCII**
As stored in datalogger

"Comma Delineated ASCII" strips all IDs, leading zeros, unnecessary decimal points and trailing zeros, and plus signs. Values are separated by commas. Arrays are separated by carriage return line feed. Comma Delineated ASCII requires approximately 6 bytes per data point.

Example:

1,234,1145,23.65,-12.26,625.9
1,234,1200,24.1,-10.98,650.3

"As Stored in Datalogger" stores data in the file exactly as received from the datalogger. This is in binary Final Storage Format. See the datalogger operator's manual for a description of the Final Storage format.

11.1.5 FINAL STORAGE COLLECTION AREA

The CR10 datalogger may be programmed to have two Final Storage areas. You must select Area 1 (default) or Area 2 (optional) Final Storage Area. If another datalogger is selected, this parameter will automatically be labeled "not applicable."

11.1.6 INTERFACE DEVICE

Options:	**End**	
	SC32A	
	Hayes Modem	**Number:**
	RF Modem	**Path**
	MD9	**Addr:**
	RAD Modem	
	SC95 Short Haul	
	Generic Modem	**Number:**

Up to three interfaces can be between the computer and the datalogger. After the first interface device is entered, GRAPHTERM will prompt for interface device "#2:", etc.

After the interface device(s) is selected, type control P (the control and P keys) to save the station file and bring up the GraphTerm OPTIONS menu. "Escape" will bring up the OPTIONS menu without saving the station file. The station file parameters are described below.

TM11.2 GRAPHTERM OPTIONS

The GRAPHTERM OPTIONS menu will appear after specifying the desired station.

The options available will depend upon the datalogger type. The more commonly used options are described below:

GRAPHTERM OPTIONS

C- Call station
T- Terminal emulator
D- Download program to datalogger
K- PC time to datalogger clock
M- Monitor Input Locations
U- Collect uncollected data
E- Edit station parameters
V- View graphics File

TM11.2.1 C – CALL STATION

The C OPTION establishes communication with the selected station. If the station is a datalogger, the C option will get the datalogger to return the "*" command prompt, after which GRAPHTERM will automatically go into the terminal emulator option.

TM11.2.2 T – TERMINAL EMULATOR

T is the terminal emulator option and is available for any datalogger type. Keyboard entries are transmitted out the selected COM port and characters received are displayed on the monitor Escape returns GRAPHTERM to the options menu.

TM11.2.3 D – DOWNLOAD PROGRAM TO DATALOGGER

The D OPTION will program the datalogger from a disk file. The datalogger will be called automatically if it is not on line when the D option is executed. Entering '[path]*' will get a list of files with the .DLD extension.

After successful programming (no datalogger compile errors), GRAPHTERM options are displayed. If a datalogger compile error is found, TERM will disconnect the datalogger. The program is erased from the datalogger before disconnecting.

TM11.2.4 K - PC TIME TO DATALOGGER CLOCK

The K option will set the datalogger clock using the computers time. The K option is not available for the CR21.

When 'K' is keyed, GRAPHTERM will show the datalogger time, the PC time, and will prompt:

Set the datalogger time to PC time? (Y/N):

If 'Y' is keyed, GRAPHTERM will set the datalogger clock and return to the Options Menu. If 'N' is keyed, then the 'K' option is aborted and returned to the Options Menu.

TM11.2.5 M -- MONITOR INPUT LOCATIONS

The M option digitally monitors up to 33 of the first 254 input locations, shows input location assignments for up to three graphs, and allows the user to see and change the status of the datalogger's user flags and control ports. Monitoring and graphics are described in Section 4.

TM11.2.6 U -- COLLECT UNCOLLECTED DATA

The U option will collect all data stored in the datalogger since the last retrieval of data; (GraphTerm keeps track of where it leaves off after each data collection). Data collected with the U option is automatically appended to the file StationFilename.DAT. That is, the data file consists of the same name as the current station file with a .DAT extension.

The data are stored in the .DAT file in the format selected in the station file: comma delineated ASCII or binary (same as in the datalogger).

TM11.2.7 E -- EDIT STATION PARAMETERS

The E option allows the user to edit the parameters of the current station or establish/edit the parameters for another station.

TM11.2.8 V -- VIEW GRAPHICS FILE

The V option will display any file that has been captured with the view save command in graphics mode. The view save command stores a "snapshot" of the graph screen to a data file named V_STNFIL.OOO, where STNFIL the station file name (or the first six characters of it). Each time a new screen is saved, the file extension is incremented.

When the V option is selected, GraphTerm will prompt "Graphics screen file name:". A directory of all screen files can be displayed by entering a "*". After entering the filename of an existing graphics file, the image will be displayed. At this point, the Up Arrow and Down Arrow keys will automatically display the next and previous graphics file respectively. That is, the Up Arrow automatically increments the extension of the screen file and displays it while the Down Arrow will decrement the file extension and display it.

TM11.3 MONITORING AND GRAPHING INPUT DATA

When "M" is keyed, GraphTerm will do one of the following:

1. Request the name of the file containing Input Location Labels for this station. (Default file is the station name.) Enter "*" to list all .DLD files.

2. Go immediately into the Monitor option (without prompting for file) if the "D" (Download) option was selected previous to the Monitor option. The Location Labels of the file downloaded will be used automatically.

3. Go immediately into the Monitor option (without prompting for file) if the "M" (Monitor) option was selected previously. The Location Labels specified previously will be used automatically.

Exit M option by pressing Escape. Monitor will end automatically after communication with the datalogger is broken and a time out has elapsed.

TM11.3.1 LOCATIONS

The Input locations displayed can be changed by keying 'L' and, when TERM prompts "**Locations:**", the desired location numbers separated by commas.

A total of 33 input locations may be displayed at one time. Continuous locations may be specified by the first number followed by two periods, then the last number. For example, 1..33 would display the first 33 Input locations, or 1..11, 22..32, 89..99 would display locations 1 through 11, 22 through 32, and 89 through 99.

TM11.3.2 F1..F8 – FLAG SET

The user flag status is shown below the input location data. High flags are displayed in reverse video. Keys F1 through F8 toggle user flags 1 through 8 respectively.

TM11.3.3 D – DIGITS DISPLAYED

The default resolution of the displayed data will default to 3 digits; by pressing the "D" key, an additional digit will be displayed. A maximum of 6 digits can be displayed.

TM11.3.4 T – TERMINAL EMULATOR

While in the monitor option, a user can get into the terminal emulator option by pressing the "T" key. The top portion of the screen will be windowed for this purpose. While in this mode, the input locations on the screen will not be updated until the Terminal Emulator option is exited by pressing Escape.

TM11.3.5 PORT TOGGLE

The port status is displayed with the numbers 1 through 8. When a port is set high (5 volts), the corresponding number will be displayed in reverse video; the user can set port 1 high or low by pressing "P" and then "1". When the "P" key is pressed, a "P" will be displayed on the screen indicating that GraphTerm is waiting for the port number.

TM11.3.6 INPUT VALUE LOAD

To load a fixed value into an Input location, press the "I" key; a prompt at the bottom of the screen will read "Change Input Location value 11:". Input location eleven will be displayed in reverse video when the monitor mode is entered. To enter a new value in location eleven, simply enter the number after the prompt and press return; the number is then entered into Input location eleven.

TM11.3.7 COLLECT DATA

This option is identical to the "U" command on the main menu with the exception that a collection interval may be entered, if desired. Refer to Section 3.8 for details on the "U" command.

TM11.4. G – GRAPHICS MODE

The "G" option acts as a toggle to either enter or exit the Graphics Mode. All graphs are displayed as per the current Graph Specifications file (See the "L" option). Once in Graphics Mode, the following options are available:

TM11.4.1 H – HELPS SHOW/REMOVE

"H" acts as a toggle that will either display or hide the help box in the upper right hand corner of the graphics screen.

TM11.4.2 G – GRAPH ENTER/EXIT

"G" acts as a toggle to either enter or exit the Graphics Mode.

TM11.4.3 R – RE-SCALE

Causes all graphs that are set to auto-scaling to be re-scaled. In other words, any value that has gone off scale will be re-scaled to a power of ten that will allow them to fit on the graph. The "R" command has no effect on a fixed scale graph. A full height vertical line is drawn on each auto-scale graph to mark the re-scaling position.

TM11.4.4 L - L (GRAPH SPECIFICATION SCREEN)

The ability to graph up to all three graphs simultaneously depends on the graphics adapter in the computer. VGA can display up to three graphs; EGA and Hercules will display up to two, and CGA will display one graph. The input locations to be displayed in each column/graph are controlled by the "L" option.

When the "L" option is selected, the Graph Specification Screen will be displayed. This is where each graph is defined in terms of what input locations to display digitally and graphically, whether to emphasize bar graphs or trend plots, the name of the graph specifications file, the graphing interval, and y-axis scaling with upper and lower limits.

To move the cursor to the desired parameters, use the "UP ARROW" and "DOWN ARROW" keys. As you move from parameter to parameter, notice that there is a highlighted Help Line at the top of the display that provides specific information and limitations for the current parameter. Enter or edit the setting for any parameter by typing the desired entry. The current setting will be deleted and replaced with what you type. The "DEL" key acts as a toggle and will either delete or restore the current setting. The "BACKSPACE" key will delete one character at a time from the setting. These command keys, their functions, and the Help Line are all displayed for quick reference at the top of the Graph Specification Screen.

Type ^P (control and P keys) to save the setup file to disk and return to the monitor mode. Pressing escape will return to the monitor mode without saving the setup file. If the setup file has not already been saved it will be saved if the graphics mode is entered.

The following is a description of each of the parameters that appear on the Graph Specification Screen.

Graph Setup File: This is the filename (with a .LOC extension automatically added) under which the current graph specifications will be saved when the graphics mode is entered. The file StationFilename.LOC also contains the last graph specifications that were used and is automatically re-loaded when the monitor mode is entered. To automatically load a particular graph specification, the Graph Setup Filename can be entered as a command line parameter after the "L" command (Section 5).

Graphing Interval: Specifies how often to update the graph with input storage data in seconds. All graphs use the same interval. Entering "0" will put GraphTerm into an auto-detect mode where the graphing interval is automatically adjusted based on how often the data is changing. Manually setting the interval from 1 to 900 seconds allows control of how much time is represented on the X-axis of the graphs.

Bar Graph Pixel Width: Provides a means for setting the width of the bars on the graph. The default value is 6, and the legal settings include 0 to 38 pixels. Bars greater than 7 pixels get labeled with the first character of the location label; above 17 pixels with 2 characters; above 25 pixels with 3 characters; and above 33 pixels with 4 characters. The default setting of 6 pixels allows the bars to be thought of as "pens" on a strip chart to help identify each data trace. There is only one pixel setting for all graphs.

The remaining parameters are repeated for each of the graphs.

Graph Type: Defines whether Auto or Fixed scaling is to be applied to the graph. The default setting is Auto, which stands for auto-scaling mode. In this mode, all parameters are graphed between an upper and lower limit that disregards the power of ten of the data point. For example, suppose you were graphing 2 points, one ranges from 32.0 to 50.0 and the second from 645.0 to 995.0. In Auto mode, with the upper and lower limits left at their default settings of +10.0 and -10.0 respectively, parameter one would be plotted between 3.2 and 5.0; parameter 2 would be scaled between 6.4 and 9.9.

With fixed scaling, values are plotted against the absolute scale that is defined by the values entered for Upper and Lower Limits.

Locations: Specifies which locations are to be digitally displayed and graphed. The maximum number of locations that can be displayed per graph is 11. The number graphed (see below) is a subset of this list and is specified as the number of locations beginning at the top of the list to graph. Therefore, it is important to list the locations that you wish to graph and digitally display first, followed by the locations that will be digitally displayed only.

A list of the selected input locations with labels (assigned in EDLOG) is displayed at the right side of the screen. Use the "F1" and "F2" keys to display and scroll the list of all available locations.

Continuous locations may be specified by the first number then two periods and the last number. For example, 1..11 would display the first 11 input locations, or 1..4,7..9,22..25 would display locations 1 through 4, 7 through 9 and 22 through 25. Individual locations can be strung together with commas (e.g. 1,7,23,4,66,3,21,33).

Number Graphed: This setting controls the number of input locations, beginning at the start of the list as specified in "**Locations:**", to graph.

Lower Limit: Sets the lower limit for the graph defaults to -10). The allowable (non zero) range is ±0.0001 to ±100,000 with 2 digits of resolution. This setting is used in both Auto and Fixed scaling modes.

Upper Limit: Sets the upper limit for the graph defaults to 10). The allowable (non zero) range is ±0.0001 to ±100,000 with 2 digits of resolution. This setting is used in both Auto and Fixed scaling modes.

TM11.4.5 V – VIEW SAVE TO FILE

Saves the current graph display as a file named MONSCR.000 with the extension incremented each time a new screen is saved. The screen image is saved in a compacted format that requires between 8K and 30 Kbytes of disk space. This function takes about 30 seconds when running on a 20 MHz 386 PC. The disk drive light stops flashing when the function is complete. Pressing ESC aborts the function.

TM11.5 COMMAND LINE PARAMETERS

GraphTerm allows command line parameters. Several options are only available from the command line. The command line can be incorporated into a batch file (extension ".BAT") for repeated execution.

Standard commands are entered in the sequence that they would be issued in running the program a step at a time. For example, the command

GT d:\path\station D d:\path\program M Q

runs GraphTerm, calls the datalogger at the selected station, programs it from the designated program file, then monitors input locations with labels from the program file. When Escape is pressed or communication with the datalogger is broken, GraphTerm ends. Separate command line parameters with spaces. The command line can be up to 128 characters long. Commands like "C" can be spelled out to "Call", or "D" to "Download" on the command line. Only the first letter of the word is used by GraphTerm.

TM11.6 GRAPHTERM EXERCISE

1. Connect the datalogger to the computer's serial port using the SC32A RS232 Interface.
2. Create a GRAPHTERM Station File named "LOGGER" and execute the following Options:

   K - PC Time to Datalogger Clock

   D - Download Program to Datalogger (developed previously with EDLOG)

   M - Monitor Input Locations

   U - Collect Uncollected Data

SECTION TM12. TELCOM

TELCOM is used to retrieve and store data from CSI dataloggers. TELCOM can be executed one of two ways: 1) in the "attended" mode, where the user initiates a call to the datalogger, and 2) in the "unattended" mode, where TELCOM controls the computer and calls the datalogger on a pre-defined interval.

A Station File is created for each datalogger which specifies the datalogger type, COM port, baud rate, and interface device. This information is automatically loaded into the Station File if a TERM Station File with the same name already exists. Additional parameters specify what data is to be collected, how it is stored, and how frequently the datalogger is called.

TM12.1. STATION PARAMETERS

To edit the station parameters, run TELCOM by typing '**TELCOM**' on the command line and pressing the carriage return. (The file TELCOM.EXE must be on the default drive and directory or the path specified.) The screen will display:

Telecommunications Program ver. X.X
Copyright (C) 1986, Campbell Scientific, Inc.

Options which may be entered following the station or script file name:

/E = Edit parameters	/BSIZE = Specify Block Size
/C = Call datalogger now	/G = Get all data from datalogger
/W = Wait for wake up time	/D = unattended Done
/A port = Answer modem ring	/F name = alternate data file

To end, press Enter key without a file name

Enter station or script file name:

Enter the station file name. Follow it by one or more of the Options that are listed above and described below. The drive and directory path specification (see PC-DOS manual) must precede the station name if the data, error, and station files are to exist on a drive or directory other than the default (e.g., 'B:name' or 'C:[path]name').

To create or edit a station file named "LOGGER", type 'LOGGER/E' and press **ENTER**. Telcom will then prompt for the station parameters:

Station File Name:	**logger**
Datalogger or Command Type:	CR10
Security Code:	0
Fix Datalogger Clock Using PC Clock:	No
Final Storage Area to Collect From:	1st Area
Data Collection Method:	Since Last Call;Append File;
Nbr of Arrays to Backup on First Call:	0
Data File Format:	Comma Delineated ASCII
Primary Call Interval (minutes):	1440
Recovery Call Interval #1 (minutes):	15
Repetitions of Recovery Interval #1:	4
Recovery Call Interval #2 (minutes):	1440
Maximum Time Call Will Take (minutes):	10
Next Time To Call:	10/09/91 11:02:00
Interface Devices:	
COM1 Baud Rate:	1200

The parameters listed above are the default values. Some of the parameters will change or disappear as different options are selected. The cursor will be on the first parameter (i.e., "CR10"). Press the space bar to toggle the option. To change the value of numerical parameters, the new value must be keyed in. Select a parameter by pressing the "Enter" key ('CR') and the cursor will advance to the next parameter. The cursor can be moved up and down with the arrow keys. Additional editing commands are given in Table 5-1.

When all parameters have been entered correctly, save the file by keying the control and P keys (^P). If the "Next Time To Call" has passed, TELCOM will call the station, retrieve any data, and prompt for another station name. **End TELCOM by pressing 'CR' when a station name is requested.** A detailed description of each of the station parameters follows.

Datalogger or Command Type:

Options:

CR10	**Security Code: 0**
21X	**Security Code: 0**
CR7	**Security Code: 0**
DOS Command	

The CR10, 21X, and CR7 with the 700X Control Module have the option of requiring a security code before allowing certain functions. If security is enabled in the datalogger, the code must be entered to allow TELCOM to reset the clock or collect data (CR10 level 3 only).

Data Collection Method:

Options: **Since Last Call; Append File;**
[Since Last Call; Create File;]
Most Recent Arrays; Create;
[Most Recent Arrays; Append;]

The CR10 datalogger may be programmed to have two Final Storage areas. After selecting the data collection method, you must select the 1st (default) or 2nd (optional) Final Storage Area or the SM192/SM716 Storage Module.

When **"Since Last Call; Append File;"** is selected, TELCOM will keep track of where it leaves off each time it calls in the "station.STN" file. The next time it calls it will collect everything stored since the previous time. Before bringing in new data that TELCOM checks the last four data points of the previous data collected matches what is still in the datalogger Final Storage. If the data are not the same, TELCOM collects the number of arrays specified in "Nbr of Arrays to Backup on First Call". Data retrieved are added to the end of the data (.DAT) file.

The **"Since Last Call; Create File;"** option also collects all new data; however, only the data collected during the most recent call are stored in the data file. Each time data are collected, any existing data (name.DAT) file is renamed to "name.BAK". Any existing backup file (name.BAK) is destroyed.

Data File Format:

Options: **Comma Delineated ASCII**
Printable ASCII
Same as Received From Datalogger

"Comma Delineated ASCII" strips all IDs, leading zeros, unnecessary decimal points and trailing zeros, and plus signs. Data points are separated by commas. Arrays are separated by Carriage Return Line Feed. Comma Delineated ASCII requires approximately 6 bytes per data point.

Example:

1,234,1145,23.65,-12.26,625.9
1,234,1200,24.1,-10.98,650.3

"Printable ASCII" is described in the datalogger manual. Each data point is preceded by a two digit ID and a + or -. This format requires ten bytes per data point.

"Same as Received from Datalogger" stores data in the file exactly as received from the datalogger. This is in binary Final Storage Format, which is described in the datalogger manual.

Fix Datalogger Clock Using PC Clock:

Options: **No**
Check Only & Report When 30 sec off
When 30 sec off

When "**No**" is selected, TELCOM will not check or reset the clock.

"**Check Only & Report When 30 sec off**" allows the operator to key in the actual number of seconds once the option has been selected. TELCOM will check the clock each time the station is called and will make an entry in the error file stating the time and error whenever the datalogger clock is off by more than the number of seconds entered. TELCOM will not reset the clock.

When the datalogger clock is reset, it will change the time interval over which output is calculated. For example, if the time is set back 2 minutes within an hour interval, that interval will be 62 minutes instead of 60. Output processing such as averages will still be valid because the datalogger keeps track of the number of samples. Totalized values will include more or fewer samples than normal.

If a pulse count instruction is being executed on an interval greater than once a second, resetting the time may significantly alter the number of counts within the interval in which time is reset.

"When 30 sec off" also allows the operator to key in the actual number of seconds once the option has been selected. TELCOM will reset the datalogger clock and enter the PC time and the incorrect datalogger time in the error file.

Primary Call Interval (minutes):

In unattended operation, the primary call interval is the amount of time that separates one good call of a station from the next.

Recovery Call Interval #1 (minutes):

This interval is used when communication errors occur during unattended operation. When a problem develops which prevents PC from communicating with the station, TELCOM will start trying to get through at this interval.

If TELCOM fails to retrieve data after the number of tries specified in the next parameter, it will change to Recovery Interval #2 (usually slower) and continue trying to contact the station at this slower interval.

Repetitions of Recovery Interval #1:

This is the number of times TELCOM will try at Interval #1 before going to Interval #2. Once communication is re-established and all data is retrieved, the number of tries is reset.

RECOVERY CALL INTERVAL #2(minutes):

This interval is used after all repetitions at the Interval #1 have failed to get through to the datalogger. Interval #2 will remain in use until the problem with the station is corrected and a good call is completed.

Maximum Time Call Will Take (minutes):
Maximum Time Command Will Take (minutes):
or
Maximum Time Out of Telcom (minutes):

The maximum length of time a call will take is a function of the amount of Final Storage the datalogger has, the baud rate, and the communications overhead. If you divide the number of data points the datalogger can store by the baud rate, you get a reasonable number to use here.

COM PORT

Options: **COM1**
COM2
COM3
COM4

TELCOM will allow you to use either COM1, COM2, COM3, or COM4 in communicating with a station.

Baud Rate:

Baud rate is restricted to what the datalogger or modem will support. This must match the modem and datalogger used. TELCOM will support 300, [600], 1200, [2400], [4800], and 9600 baud.

Interface Devices:

Options:	**End**	
	Hayes modem	**Number:**
	MD9	**Address:**
	RF Modem	**Path:**
	Short Haul Modem	

The prompts for the telephone "Number", MD9 "Address", or RF Modem "Path" will not appear until the interface device is selected. It is possible to go through more than one of these devices to get to a datalogger. The devices are entered in order from the computer to the datalogger.

If you are using the **SC32A** or RAD Modems, select "End" as the interface device.

TM12.2 COMMANDS USED BY TELCOM FOR DATA RETRIEVAL

Data are retrieved from the datalogger when TELCOM is executed with the appropriate station file. Parameters in the station file list the COM port and interface devices required for communication with the datalogger. Once communication has been established, the datalogger returns an (*), which denotes that it is in telecommunications mode and ready to receive commands.

TELCOM sends commands to position the Modem Pointer (MPTR), and commands to bring in blocks of data, which are signature checked to ensure data integrity. Telecommunication Commands that are used by TELCOM are listed in Table TM12.2-1 (Section 5.1 in the CR10 Manual).

TABLE TM12.2-1 Telecommunication Commands Used by TELCOM

A — STATUS, datalogger returns:

R+xxxxx F+xxxxx Vxx Exx xx Mxx L+xxxxx Cxxxx

where:

- R - Data Storage Pointer (DSP)
- F - Final Storage Locations used
- V - Datalogger Version
- E - E08 and Overrun Errors
- M - Memory Status
- L - Location of Modem Pointer (MPTR)
- C - Checksum

[F.S. loc. no.]G	MOVE MPTR, TELCOM positions the modem pointer to bring in data since the previous call (or as specified by the station file.)
[no. of loc.]F	BINARY DUMP, number of final storage locations to send, starting at MPTR.
[no. of arrays]B	BACK-UP, MPTR is backed up specified number of Output arrays, and advanced to the nearest start of array.

TM12.3 TELCOM OPTIONS

Once a station file has been created for a station, it can be called by running TELCOM and simply entering the station name. There are several options that may be selected when entering the station name. The options are specified by following the name with '/' and one or more of the letters designating the option.

The '/E' (Edit parameters) option allows the user to edit the parameters in an existing station or script file.

The '/C' (Call now) option forces TELCOM to call the specified station NOW whether or not it is time to call.

The '/W' (Wait for wake up time) option is used to force TELCOM to wait for the next time to call.

TM12.4 TELCOM EXERCISE

1. Connect the datalogger to the SC32A RS232 Interface, and then connect the SC32A to the computer's serial port.

2. Execute the TELCOM program. When prompted for a Station File name, type "LOGGER", followed with the /E Option. A Station File with default parameters will be displayed. Edit the station parameters using the following example:

Station File Name	: LOGGER
Datalogger or Command Type	: CR10 Security Code: 0
Fix Datalogger Clock Using PC Clock	: No
Final Storage Area to Collect From	: 1st Area
Data Collection Method	: Since Last Call; Append File;
Nbr of Arrays to Backup on First Call	: 0
Data File Format	: Comma Delineated ASCII
Primary Call Interval (minutes)	: 1440
Recovery Call Interval #1 (minutes)	: 15
Repetitions of Recovery Interval #1	: 4
Recovery Call Interval #2 (minutes)	: 1440
Maximum Time Call Will Take (minutes)	: 10
Next Time To Call	: 08/01/91 00:02:00
Interface Devices	:
COM2 Baud Rate	: 9600
End	

3. Save the Station Parameters by entering ^P, and exit TELCOM by hitting the Enter key when prompted for a Station File name.

4. Collect data from the datalogger using the "attended mode" (/C Option):

   A. Type TELCOM on the command line and press the Enter key. When prompted for a Station File name, type LOGGER/C. The datalogger is called, and the data are retrieved and stored as specified by the Station Parameters.

   B. TELCOM can also be executed from the command line. At the DOS prompt, type TELCOM LOGGER/C.

5. Collect data from the datalogger using the "unattended mode" (/W Option):

   A. Type TELCOM LOGGER/E at the DOS prompt to edit the Station Parameters.

   B. Change the primary call interval to (1) minute, and set the "Next Time To Call" parameter to the current time. Save the changes by entering ^P. Exit TELCOM by pressing the Enter key when prompted for a Station File name.

   C. At the DOS prompt, type TELCOM LOGGER/W. Every minute the datalogger is called and the new data are retrieved. Following each call, TELCOM adds the "call interval" to the "Next Time to Call" parameter and then waits for the next time to call.

SECTION TM13. SPLIT

TM13.1 OVERVIEW

SPLIT is a general purpose data reduction program. Input files (maximum of 8) are accessed by SPLIT, specific operations are performed on the data, and the results are output to an OUTPUT file. When SPLIT is loaded, a list of prompts/questions are brought to the screen. When answered, these prompts define what files are accessed, what operations are performed, and what file the results are output to. The completed set of prompts with instructions may be saved as a parameter file (name.PAR). The parameter file may be called into SPLIT for future use.

TM13.2 GETTING STARTED

Enter 'SPLIT' on the command line to load and execute the program. The PC must be logged onto the disk and directory containing SPLIT or the appropriate "path" must be specified per the PC-DOS Manual. As soon as SPLIT is loaded, it requests information necessary to find, process, and store the data specified. Once this information is supplied, it can be saved in a parameter file for later use.

Type 'SPLIT' on the command line after the drive prompt. SPLIT will load and display the following:

Name(s) of Input DATA FILES(s):
Name of OUTPUT FILE to generate:
START reading in:
STOP reading in:
COPY from:
SELECT elements #(s) in:
HEADING for report:

Enter and/or edit entries to the right of the colons. Type in the name of your file that contains the datalogger data and press return. We will not enter additional parameters at this time. Press the F2 key to display command options at the top of the screen (Section 4.6). They are EDIT, RUN, SAVE, QUIT, and LOAD new parameter file. Select an option by pressing the first letter of the command or by using the arrow keys to move the cursor to the option you want and then pressing return. Press **R** for RUN and SPLIT will put your raw data file in columns on your screen.

TM13.3 SPLIT PARAMETER FILE ENTRIES

TM13.3.1 Name(s) of Input DATA FILE(s):

Enter the name(s) of the input file(s) on this line. Input files must be formatted in Comma Delineated ASCII, Final Storage Format, Field Formatted ASCII (SPLIT default output format), Printable ASCII, or Raw A/D data (refer to special Burst Mode Instruction in Campbell Scientific datalogger manual).

Table TM13.3-1 provides an example of Printable ASCII, Comma Delineated, and Field Formatted input file types. The data in the various formats are identical. Each line of data represents an "Output Array", starting with an Output Array ID (in this case 115). Each data point in the Output Array is referred to as an "element". The element number is given in the Printable ASCII format, and implied in the other formats. Data presented in Table TM13.3-1 is used for example purposes in Sections TM13.3.3 through TM13.3.5.

TABLE TM13.3-1. Printable ASCII, Comma Delineated and Field Formatted Input File Format Types

COMMA DELINEATED

115,189,1200,89.6,55.3,25.36,270
115,189,1300,91.3,61.5,27.25,255.4
115,189,1400,92.7,67.7,15.15,220.1
115,189,1500,94.1,69,20.35,260.6

FIELD FORMATTED

115	189	1200	89.6	55.3	25.36	270
115	189	1300	91.3	61.5	27.25	255.4
115	189	1400	92.7	67.7	15.15	220.1
115	189	1500	94.1	69	20.35	260.6

TABLE TM13.3-1. *(cont.)*

PRINTABLE ASCII

01+0115 02+0189 03+1200 04+089.6 05+055.3 06+25.36 07+270.0
01+0115 02+0189 03+1300 04+091.3 05+061.5 06+27.25 07+255.4
01+0115 02+0189 03+1400 04+092.7 05+067.7 06+15.15 07+220.1
01+0115 02+0189 03+1500 04+094.1 05+069.0 06+20.35 07+260.6

where:

Element 1 = Output Array ID# (115)
Element 2 = Julian day (189)
Element 3 = hour, minute
Element 4 = average temperature in deg. F
Element 5 = average soil temperature in deg.F
Element 6 = average wind speed in mph
Element 7 = wind direction in degrees

Each time it executes, SPLIT keeps track of the number of bytes it reads from the input file and saves this information in the parameter file. SPLIT can start where it last left off by appending to the input filename. This is specified by appending the Input filename with '/LAST' or '/L'. This feature may be used to process only the new data from a file in which new data is being appended periodically (e.g., a data file generated by TELCOM).

> **CAUTION**: When using the /L option, if START and STOP conditions (Sections 4.3.3, 4.3.4) are specified, they must exist in the newly appended data or SPLIT will never begin execution.

TM13.3.2 Name of OUTPUT FILE to Generate

Enter an OUTPUT filename to create a file. The file is created on the default drive or directory unless the filename is preceded with an alternate drive or directory. SPLIT will assign this file an extension of .PRN if an extension is not specified by the user. Whenever an OUTPUT filename is entered, regardless of extension, an OUTPUT file is created when the "RUN" option in the Command Menu is selected. OUTPUT options may be specified to alter the default OUTPUT to the file. To specify an option, the file name must be appended with a slash (/) and the OUTPUT option. Some of the commonly used options are listed in Table TM13.3-2.

TABLE TM13.3-2. Output Options

OPTION	DESCRIPTION
/[comment]	Store comment if input data is blank or Out of Range.
/G	Outputs only those arrays containing one or more Out of Range elements.
/P	Print output file. Cannot be used with /R option.
/R	Write report (.RPT) file to disk. Cannot be used with /P.

More than one option can be specified, but /R and /P cannot both be specified. Each option must be preceded by the slash.

/[comment] "Comment" is stored if data are blank, bad, or out of range. The brackets are part of the entry.

EXAMPLE: LOGAN.PRN/[""]

/G Outputs only those arrays containing one or more Out of Range elements. If the /R or the /P options are enabled with the /G option, an asterisk precedes the Out of Range value in the .RPT file or the printed file, respectively.

EXAMPLE: LOGAN.PRN/G

/P Sends the OUTPUT data to an on-line printer. The default file is also made. This option cannot be used with the /R option.

EXAMPLE: LOGAN.PRN/P

/R This option writes a report file to disk with the extension name .RPT that can be printed later. The default file is also made. The .RPT file includes the report headings and column headings. This option cannot be used with the /P option.

EXAMPLE: LOGAN.PRN/R

Sends OUTPUT to file and gives extension name .RPT.

TM13.3.3 START reading in

A starting point may be specified to begin processing data. If "START reading in" is left blank, SPLIT will start processing data at the beginning of the data file. The starting point can be any element within the array or a combination of elements within an array.

For example, the data in Table TM13.3-1 contains 7 elements per OUTPUT array represent ing hourly data. Assume that this data file contains one month of hourly data. To start processing data at 1500 hours on the first day, our START value is expressed as 3[1500], where 3 is the third element within the array and 1500 is the value of that third element.

The syntax can be expressed as:

e_i[val_i]

where e_i = element within the array

val_i = the value of that element.

Logical "and" and "or" statements can be used when specifying the START condition (STOP and COPY conditions also). A logical "and" statement means that all conditions must be true for the statement to be true. The logical "or" statement means that if any of the conditions are true then the statement is true. SPLIT allows up to 6 "or" statements with up to 3 "and" statements per "or". A simple logical "and" example follows:

2[189]and3[1200]

Element 2 must equal 189 and element 3 must equal 1200.

TM13.3.4 STOP reading in

The STOP value is expressed with the same syntax as the START value with the exception that there is no time sync. If this parameter is left blank, then SPLIT will execute until the END OF FILE (EOF). Logical "and" and "or" statements can be used when specifying the STOP condition (Section TM13.3.3).

The STOP condition specifies when to stop processing data. This feature allows segments of data to be removed from large data files.

TM13.3.5 COPY from

After the START condition is satisfied, and before the STOP condition is met, the COPY condition must be satisfied before any data will be processed according to SELECT line instructions (Section TM13.3.6). If the COPY condition is left blank, all arrays are processed between the START and STOP values. Syntax for the COPY condition is similar to the START and STOP values mentioned above. Logical "and" and "or" statements can be used when specifying the Copy condition.

TM13.3.6 SELECT element #(s) in

The SELECT line specifies which elements of an Output Array are selected for processing and/or OUTPUT to the specified OUTPUT file. The SELECT line becomes operable only after the START and COPY conditions are met, and before the STOP condition is satisfied. If the SELECT line is left blank, then SPLIT will output all output arrays meeting the START and COPY conditions.

Element numbers may be entered individually (e.g. 2,3,4,5,6,7) or in groups (e.g. 2..7) if sequential. Range limits (lower to upper boundary conditions) may be placed on elements or groups of elements specified in the SELECT or COPY lines. For example, 3[3.7..5],4..7[5..10] implies that element 3 is selected only if it is between 3.7 and 5, inclusive, and elements 4,5,6, and 7 must be between 5 and 10, inclusive. Range testing is a quick way to identify data problems.

Processing is accomplished through arithmetic operators, math functions, spatial functions, and time series functions. The following is a list of operators, math functions, and Time Series functions supported by SPLIT.

OPERATORS			OPERATOR PRECEDENCE ORDER (3 = high, 1 = low)
+ -	=	addition, subtraction	1
* /	=	multiplication, division	2
x Mod y	=	Modulo divide of x by y	2
^	=	exponentiation	3

EXAMPLES OF SYNTAX FOR MATHEMATICAL OPERATORS

3*5	multiply element 3 by element 5
3/5	divide element 3 by element 5
(3..5)/(8..10)	same as 3/8, 4/9, 5/10
3+5	add element 3 to element 5
3-5	subtract element 5 from element 3
(3,9,5)-(8,7,10)	same as 3-8, 9-7, 5-10
3*2.0	multiply element 3 by a fixed number 2

MATH FUNCTIONS

Abs(x)	= Absolute value of x
Arctan(x)	= Arc tangent of x (in degrees)
Cos(x)	= Cosine of x (in degrees)
Exp(x)	= Exponential (ex)
Frac(x)	= Fractional portion of x
Int(x)	= Integer portion of x
Ln(x)	= Natural log of x
Sin(x)	= Sine of x (in degrees)
SpaAvg(x..y)	= Spatial average of elements x through y
SpaMax(x..y)	= Spatial max of elements x through y
SpaMin(x..y)	= Spatial min of elements x through y
SpaSd(x..y)	= Spatial std. deviation of elements x through y
Sqrt(x)	= Square root of x

TIME SERIES FUNCTIONS

Avg(x;n)	= Average
Blanks(x;n)	= Number of blanks in element
Count(x;n)	= Number of data points in element
Max(x;n)	= Maximum
Min(x;n)	= Minimum
Sd(x;n)	= Standard deviation
Smpl(x;n)	= Sample raw value
SmplMax(x;y;n)	= Sample (y) on a maximum (x)
SmplMin(x;y;n)	= Sample (y) on a minimum (x)
Total(x;n)	= Totalize

NOTE: *x* can be an element or a valid expression. *n* is optional and is the number of arrays to include in the function.

SPECIAL FUNCTIONS

Crlf = Insert carriage return line feed in Output file.

Date(doy;y) = Convert Julian day to calendar date, where doy=day of year and y=year. For example: Date (149;1991.) converts to Julian day 149 to 05-29

TM13.3.7 SUMMARY OF SELECT LINE SYNTAX RULES

- A fixed numeric value must include a decimal point "." or be in scientific notation. There are some exceptions to this as noted below.

- Scientific notation has the format "mantissa E power of ten (e.g., 3E5 = 3 x 10^5).

- Element numbers are entered without a decimal point.

- Commas separate SELECT line parameters (e.g., 2,3,(3+4)/3.2,6).

- Two decimal points are used to select consecutive elements between starting and ending elements (e.g., 3..6, refers to the elements 3,4,5, and 6).

- A set is a group of 2 or more elements and/or expressions separated by commas and enclosed by parentheses. No member of a set can include parentheses. Therefore, a set cannot include a set or a function as one of its members. For example:

- A single expression can operate on a set of elements. For example, the expression (3..6,8)/2.0 is the same as 3/2.0, 4/2.0, 5/2.0, 6/2.0, 8/2.0; (3..6)/(2..5) is the same as 3/2, 4/3, 5/4, 6/5.

- The element or expression which is the argument of a math or Time Series function, must be enclosed in parentheses. A range of elements can be specified, resulting in as many outputs as elements (e.g., Avg (3..5,7) will output 4 averages).

- Square brackets are used to enclose an allowable range for a value (e.g., 3[3.6..12] indicates that the allowable range for element 3 is from 3.6 to 12). Whole numbers within brackets do not require a decimal point. Table 4.3-5 explains how Out of Range values are treated.

- The count in a Time Series function is optional and does not require a decimal point.

- Semicolons are used in Time Series functions to separate the elements or expressions from the count which determines the interval. Sample on maximum and sample on minimum require two elements or expressions also separated by a semicolon.

TM13.3.8 HEADINGS for report:

A report heading can be entered here to be output to a printer or .RPT file (OUTPUT line options /P and /R, respectively). Headings are never included in the standard output to disk (.PRN or user named extension OUTPUT file). A report heading is required before column headings can be entered. A report heading can have several lines but is limited to a total of 255 characters including backslashes and carriage returns. '/' denotes a new heading line for the report.

TM13.3.9 HEADINGS for column

If a report Heading is specified, then SPLIT will ask for column heading prompts for each column specified in the SELECT parameter are brought to the screen. These headings are limited to a field width one less than the Output field width. A '\' denotes a new line.

TM13.4 HELP OPTION

When SPLIT is called from the DOS command line, it enters the EDIT mode. In the EDIT mode, the F1 key is used to get help on the parameter line that the cursor is currently on. The HELP messages explain the options available and provide examples. The HELP messages appear at the top of the screen. If more information is available than is displayed "<cont>" will show at the bottom of the message. Press any key except ESC to continue the message. If it is the end of the message, the cursor will return to the parameter being edited. The user can get out of the HELP option at any time by pressing the ESC key.

TM13.5 COMMAND LINE ENTRIES

Existing parameter files can be invoked from the command line. For instance, if a parameter file named "LOGAN" already exists, the command line 'SPLIT LOGAN' loads SPLIT, finds the parameter file LOGAN, and enters EDIT mode. To execute and run the PARameter file, add '/R' to the Parameter filename. SPLIT allows the user to select different parameters by entering them on the command line after the parameter filename. For example:

SPLIT LOGAN/R TEST.DAT TEST.PRN

Replaces the INPUT and OUTPUT filenames in LOGAN.PAR, with Test.dat and Test.prn respectively.

TM13.6 SPLIT EXERCISE

The following data were collected using Programming Example #2 (Section TM5.3), and will be referenced in the following exercise:

```
106,149,819,22.87,23.51,74.3,11.44
106,149,820,22.88,24.44,76,11.42
112,149,820,22.88,77.4,74.3,11.42
106,149,821,22.89,24.47,76.1,11.42
106,149,822,22.91,25.02,77,11.41
106,149,823,22.94,23.84,74.9,11.41
106,149,824,22.96,23.49,74.3,11.41
106,149,825,22.98,23.31,74,11.42
112,149,825,22.94,77.9,73.5,11.42
106,149,826,23,23.42,74.2,11.42
106,149,827,23.03,23.4,74.1,11.42
106,149,828,23.06,23.56,74.4,11.42
106,149,829,23.08,23.44,74.2,11.42
106,149,830,23.1,23.59,74.5,11.42
112,149,830,23.05,74.8,73.8,11.42
106,149,831,23.14,23.41,74.1,11.42
106,149,832,23.16,23.49,74.3,11.42
```

Each array of data contains seven elements in the "comma-delineated ASCII" format. The first element is the Array ID; 106 specifies that the output flag was set (which generated the array) by the 6th instruction in program table 1. The order that the output processing instructions follow the instruction that set the output flag determines the sequence of the array elements.

The two types of arrays contained in the sample data are described below:

1-minute arrays:

Element	Description
1	array ID 106
2	Julian Day
3	time (hour-minute)
4	average reference temp (C)
5	average thermocouple temp (C)
6	average thermocouple temp (F)
7	sample battery voltage (volts)

5-minute arrays:T

Element	Description
1	array ID (112)
2	Julian day
3	time (hour-minute)
4	average reference temp (C)
5	maximum thermocouple temp (F)
6	minimum thermocouple temp (F)
7	sample battery voltage (volts)

SPLIT EXERCISE:

Create a Split Parameter File that will access the file LOGGER.DAT, (data from Programming Example #2, Section TM5.3), and perform the following functions:

A. Create two output files: 1) PGM2DAT.prn in the comma-delineated ASCII format, and 2) PGM2DAT.RPT with report and column headings.

B. Process ten-minutes of raw 1-minute data, starting and stopping at specific times.

C. Output array elements 2..7 to the Output File. Convert Julian Day (element 2) to Month/Day format.

The following Split parameter file has been provided for an example:

Name(s) of input DATA FILES(s)	: C:\PC208\LOGGER.DAT
Name of OUTPUT FILE to generate	: C:\PC208\PGM2DAT.PRN/R
START reading in testpgm2.dat	: 3[820]
STOP reading in testpgm2.dat	: 3[831]
COPY from testpgm2.dat	: 1[106]
SELECT element #(s) in testpgm2.dat	: DATE(2;1991.),3..7
HEADING for report	: 1-MINUTE DATA FROM PROGRAM EXAMPLE #2
HEADINGS for testpgm2.dat, col. # 1	: DATE
column # 2	: HR-MIN
column # 3	: REFTEMP\AVG C
column # 4	: TC TEMP\AVG C
column # 5	: TC TEMP\AVG F
column # 6	: BATTERY\VOLTS

Split creates files PGM2DAT.PRN and PGM2DAT.RPT. Display the files using the DOS type command, or edit the files with a word processor. The data and format should be similar to the files that are listed below:

PGM2DAT.PRN data file:

```
5 29   820   22.88  24.44     76  11.42
5 29   821        22.8924.47 76.1  11.42
5 29   822   22.91  25.02     77  11.41
5 29   823   22.94  23.84   74.9  11.41
5 29   824   22.96  23.49   74.3  11.41
5 29   825   22.98  23.31     74  11.42
5 29   826      23  23.42   74.2  11.42
5 29   827   23.03   23.4   74.1  11.42
5 29   828  23.06  23.56  74.4  11.42
5 29   829  23.08  23.44  74.2  11.42
```

PGM2DAT.RPT data file:

1-MINUTE DATA FROM PROGRAM
EXAMPLE #2

DATE	HR-MIN	REFTEMP AVG C	TC TEMP AVG C	TC TEMP AVG F	BATTERY VOLTS
5 29	820	22.88	24.44	76	11.42
5 29	821	22.89	24.47	6.1	11.42
5 29	822	22.91	25.02	77	11.41
5 29	823	22.94	23.84	74.9	11.41
5 29	824	22.96	23.49	74.3	11.41
5 29	825	22.98	23.31	74	11.42
5 29	826	23	23.42	74.2	11.42
5 29	827	23.03	23.4	74.1	11.42
5 29	828	23.06	3.56	74.4	11.42
5 29	829	23.08	3.44	74.2	11.42

TM14. SMCOM

TM14.1 OVERVIEW

SMCOM is used to collect and store data and/or programs from the SM192 and SM716 Storage Modules. A hardware interface is required, either the SC532 Storage Module Interface or the PC201 Card with the SC209 cable. An older interface, the SM232A, can also be used.

TM14.2 GETTING STARTED

Enter 'SMCOM' on the command line to load and execute the program. The PC must be logged onto the current drive and directory containing SMCOM, or the appropriate "path" must be specified. SMCOM then prompts with menus, with options which are selected by entering the appropriate number or letter. The menus displayed by SMCOM are listed below with the more commonly used options in bold type.

TM14.3 SMCOM MENUS

SMCOM Ver. X.X
Copyright (c) 1986, 1987, 1988, 1989, 1990

Serial Port Options:

1 -- Com1
2 -- Com2
3 -- Com3
4 -- Com4

Option:

Is the SM232 or SM232A interface being used? (Y/**N**):

SMCOM Options:

T -- Terminal emulator.
A -- Collect all data files.
U -- Collect uncollected data files.
N -- Collect newest data file.
L -- Collect one data file starting at display pointer L.
P -- Collect program files.
D -- Store a .DLD program file.
F -- Store a file.
E -- Erase and reset storage module.
S -- Switch settings.
Q -- Quit

Option:

Root collection file name (6 characters max):

File Formats:
F -- Final storage (FS) format
D -- FS converted to ASCII arrays with IDs
C -- FS converted to comma delineated ASCII arrays
A -- As stored (8 bit data)
P -- As stored (strip parity)
Esc -- Escape
Format:

SECTION TM15. PROGRAMMING EXAMPLE FOR A WEATHER STATION

TM15.1 OVERVIEW

This manual section lists files that were created using PC208 software for a typical weather station application. The files are meant to be used as examples, and include:

* TM15.2 CR10 program listing
* TM15.3 Term Station File
* TM15.4 Telcom Station File
* TM15.5 Split parameter files
* TM15.6 Batch files for executing PC208 programs (created using a word processor)

TM15.2 CR10 WEATHER STATION PROGRAM

The following program (PGMCR10.DOC) was developed using EDLOG. Independent comment lines were added (Ctrl N) to document sensor wiring, input location usage, and output array definition.

Sensor wiring:

107 temperature probe

black---------------- E1
red ------------------ 1H (S.E. #1)
purple --------------- AG
clear ---------------- G

05305 Wind Monitor

black (of red/black) ---------------------- G
black (of green/black)--------------------- AG
green ------------------------------------- 1L (S.E. #2)
black-------------------------------------- E2
red --------------------------------------- P1

TE525 rain gage

red-------P2
black-----G

Input location usage:

Loc	Description
1	Air temperature - degrees C
2	Wind speed - m/s
3	Wind direction - degrees
4	Precipitation - mm
5	Battery - volts

Output array definition:

Hourly arrays:

element	Description
1	60 - array ID
2	year
3	julian day
4	hour - minute
5	average temperature
6	average wind speed
7	average wind direction
8	standard deviation of wind direction
9	total precipitation

24-hour arrays:

element	Description
1	24 - array ID
2	year
3	julian day
4	hour - minute
5	average temperature
6	maximum temperature
7	minimum temperature
8	average wind speed
9	maximum wind speed
10	wind direction of max wind speed
11	total precipitation
12	sample battery voltage

```
*         1          Table 1 Programs

   01: 2             Sec. Execution Interval

01:    P11           Temp 107 Probe
   01:    1          Rep
   02:    1          IN Chan
   03:    1          Excite all reps w/EXchan 1
   04:    1          Loc [:temp C   ]
   05:    1          Mult
   06:    0          Offset

02:    P3            Pulse
   01:    1          Rep
   02:    1          Pulse Input Chan
   03:    21         Low level AC; Output Hz.
   04:    2          Loc [:w spd m/s]
   05:    .0980      Mult
   06:    0          Offset
```

```
03:  P4          Excite,Delay,Volt(SE)
  01:  1         Rep
  02:  5         2500 mV slow Range
  03:  2         IN Chan
  04:  2         Excite all reps w/EXchan 2
  05:  2         Delay (units .01sec)
  06:  2500      mV Excitation
  07:  3         Loc [:w dir deg]
  08:  1         Mult
  09:  0         Offset

04:  P3          Pulse
  01:  1         Rep
  02:  2         Pulse Input Chan
  03:  12        Switch closure
  04:  4         Loc [:rain mm  ]
  05:  .254      Mult
  06:  0         Offset

05:    P10       Battery Voltage
  01:  5         Loc [:bat volts]

       60 minute processing:

06:    P92       If time is
  01:  0         minutes into a
  02:  60        minute interval
  03:  10        Set high Flag 0 (output)

07:    P80       Set Active Storage Area
  01:  1         Final Storage Area 1
  02:  60        Array ID or location

08:    P77       Real Time
  01:  1220      Year,Day,Hour-Minute

09:    P71       Average
  01:  1         Rep
  02:  1         Loc temp C

10:    P69       Wind Vector
  01:  1         Rep
  02:  0         Samples per sub-interval
  03:  00        Polar Sensor/(S, D1, SD1)
  04:  2         Wind Speed/East Loc w spd m/s
  05:  3         Wind Direction/North Loc w dir deg

11:    P72       Totalize
  01:  1         Rep
  02:  4         Loc rain mm
```

24 hour processing:

```
12:     P92          If time is
  01:     0          minutes into a
  02:     1440       minute interval
  03:     10         Set high Flag 0 (output)

13:     P80          Set Active Storage Area
  01:     1          Final Storage Area 1
  02:     24         Array ID or location

14:     P77          Real Time
  01:     1220       Year,Day,Hour-Minute

15:     P71          Average
  01:     1          Rep
  02:     1          Loc temp C

16:     P73          Maximize
  01:     1          Rep
  02:     0          Value only
  03:     1          Loc temp C

17:     P74          Minimize
  01:     1          Rep
  02:     0          Value only
  03:     1          Loc temp C

18:     P71          Average
  01:     1          Rep
  02:     2          Loc w spd m/s

19:     P73          Maximize
  01:     1          Rep
  02:     0          Value only
  03:     2          Loc w spd m/s

20:     P79          Sample on Max or Min
  01:     1          Rep
  02:     3          Loc w dir deg

21:     P72          Totalize
  01:     1          Rep
  02:     4          Loc rain mm

22:     P70          Sample
  01:     1          Reps
  02:     5          Loc bat volts

23:     P            End Table 1
```

TM15.3 GRAPHTERM STATION FILE

The following GRAPHTERM station file (LOGGER.STN) specifies the datalogger, COM port, baud rate, and interface device (End is used with the SC32A RS232 interface). Afer the station file has been created, GRAPHTERM Options are used to transfer PC time to the CR10, download a program, and to monitor input locations.

Telecommunication Parameters for Station:	Logger
Datalogger Type:	CR10 Security Code: 0
Use Asynchronous Communications Adapter:	COM1
Communications Baud Rate:	9600
Data File Format:	Comma delineated ASCII
Final Storage Collection Area:	Area 1

Interface Device:
#1: End

TM15.4 TELCOM STATION FILE

The following TELCOM station file (LOGGER.STN) is used to retrieve data from the CR10. Execute the station file with the /c option to retrieve the data since last call and append file LOGGER.DAT.

Station File:	logger
Datalogger or Command Type:	CR10
Data Collection Method:	Since Last Call; Append File;
Nbr of Arrays to Backup on First Call:	0
Data File Format:	Comma Delineated ASCII
Fix Datalogger Clock Using PC Clock:	No
Primary Call Interval (minutes):	1440
Recovery Call Interval #1 (minutes):	15
Repetitions of Recovery Interval #1:	4
Recovery Call Interval #2 (minutes):	1440
Maximum Time Call Will Take (minutes):	10
Next Time To Call:	11/01/89 10:47:00

Interface Devices:
COM1 Baud Rate: 9600
End

TM15.5 SPLIT PARAMETER FILES

HOURLY.PAR parameter file splits out arrays that have an array ID of (60) and writes the arrays to files HOURLY.PRN and HOURLY.RPT. The file HOURLY.RPT contains the report and column headings.

Name(s) of input DATA FILES(s):	logger.dat/L
Name of OUTPUT FILE to generate:	hourly.PRN/R
START reading in HW.DAT:	
STOP reading in HW.DAT:	
COPY from HW.DAT:	1[60]
SELECT element #(s) in HW.DAT:	2,DATE(3;2),4..9
HEADING for report:	HOURLY WEATHER STATION DATA
HEADINGS for HW.DAT, col. # 1:	year
column # 2:	month\day
column # 3:	hour\minute
column # 4:	avg\temp\deg C
column # 5:	avg\w spd\m/s
column # 6:	avg\w dir\deg

column # 7:	std dev\w dir
column # 8:	total\rain\mm

DAILY.PAR parameter file splits out arrays that have an array ID of (24), and writes the arrays to files DAILY.PRN and DAILY.RPT. The file DAILY.RPT contains the report and column headings.

Name(s) of input DATA FILES(s):	logger.dat/L
Name of OUTPUT FILE to generate:	daily.PRN/R
START reading in HW.DAT:	
STOP reading in HW.DAT:	
COPY from HW.DAT:	1[24]
SELECT element #(s) in HW.DAT:	2,DATE(3;2),4..12
HEADING for report:	24-HOUR SUMMARY OF WEATHER STATION DATA
HEADINGS for HW.DAT, col. # 1:	year
column # 2:	month\day
column # 3:	hour\minute
column # 4:	avg\temp\deg C
column # 5:	max\temp\deg C
column # 6:	min\temp\deg C
column # 7:	avg\w spd\m/s
column # 8:	max\w spd\m/s
column # 9:	smpl\w dir\max ws
column # 10:	total\rain\mm
column # 11:	smpl\bat\volts

TM15.6 BATCH FILES FOR EXECUTING PC208 PROGRAMS

The following batch files were created using a word processor. Batch files execute PC208 programs when the file name (without the .BAT extension) is entered on the command line.

PGM.BAT - calls station LOGGER, downloads PC time and program PGMCR10.DLD, and exits to DOS.

```
GraphTerm Logger K Y D pgmcr10 Q
```

MONITOR.BAT - calls station LOGGER, enters the monitor mode using lables from file PGMCR10.DLD, and displays locations 1 through 5. When escape is entered, the user is returned to DOS.

```
GraphTerm logger M pgmcr10 LOCS 1..5 Q
```

REPORT.BAT - calls station LOGGER and retrieves the data since last call, and appends file LOGGER.DAT. Split parameter files HOURLY.PAR and DAILY.PAR are executed which generate final reports as specified in parameter files HOURLY.PAR and DAILY.PAR.

```
Telcom logger/c
Split hourly/r ; daily/r
```

SECTION TM16. SPLIT PROCESSING EXAMPLES

TM16.1 OVERVIEW

This manual section contains four Split processing examples:

* TM16.2 Example #1 - start time relative to PC time
* TM16.3 Example #2 - checking for out-of-range elements
* TM16.4 Example #3 - verticle procesing
* TM16.5 Example #4 - "time sync" verticle processing

The following data set was used for the four Split processing examples. The array marked with an (*) was removed for Example #4, and the seventh element was changed to -6999 for Example #2.

ID	DAY	HR-MIN	WIND SPEED	WIND DIR	TEMP	RH		RAIN
10	300	900	.09	240.73	19	100.5		0
10	300	1000	3.904	306.8	.316	99.9		0
10	300	1100	5.124	340.8	.343	98.8		0
10	300	1200	5.267	338.1	.319	98.3		.06
10	300	1300	3.789	1.449	.97	95.3		21
10	300	1400	4.16	714.03	1.251	95.4		.12
10	300	1500	3.69	12.38	1.476	94.2		.01
10	300	1600	3.155	7.83	1.531	94.5		0
10	300	1700	3.758	4.319	1.365	95.2		0
10	300	1800	4.175	.344	.807	95.9		0
10	300	1900	4.686	2.59	1.034	89.5		.01
10	300	2000	3.674	339.2	.79	91.1		0
10	300	2100	4.479	350.2	.709	85.6		0
10	300	2200	6.536	10.2	.351	88.1		0
10	300	2300	6.758	9.92	-.316	88		0
10	300	2400	4.662	4.817	-.395	86.9		0
10	301	100	5.046	354.9	-.729	81.1		0
10	301	200	4.728	336.1	-1.011	85.1		0
10	301	300	6.381	337.3	-1.192	79.1		0
10	301	400	6.079	346.6	-1.442	78.1		0
* 10	301	500	6.89	341.1	-1.801	77.6	**-6999**	0
10	301	600	5.188	337.5	-2.251	80		0
10	301	700	3.714	327.5	-3.01	84.1		0
10	301	800	3.674	319.4	-3.233	83		0
10	301	900	3.892	332.9	-2.144	75.6		0
10	301	1000	3.421	356	-.892	71.2		0
10	301	1100	3.733	345.9	-.165	60.19		0
10	301	1200	4.216	332.6	.524	56.25		0
10	301	1300	3.694	353	1.071	54.94		0
10	301	1400	2.845	17.89	1.289	54.45		0
10	301	1500	2.4	21.1	1.414	56.7		0
10	301	1600	2.644	281.9	-.753	92.8		0
10	301	1700	1.997	108.7	-.974	88.8		0
10	301	1800	1.123	48	-.867	79.3		0
10	301	1900	1.204	359.8	-1.424	81		0

10	301	2000	.945	347	-2.757	85.2	0
10	301	2100	.882	198.2	-3.646	88.3	0
10	301	2200	1.156	170.6	-4.236	87	0
10	301	2300	1.506	110.4	-4.544	86.3	0
10	301	2400	1.4	143.9	-4.548	86.6	0
10	302	100	1.561	154.8	-4.323	83.7	0
10	302	200	2.274	117.1	-3.259	79.6	0
10	302	300	2.531	131.3	-3.265	84.5	0
10	302	400	2.427	84.9	-3.545	87.3	0
10	302	500	2.3	124.7	-3.537	86	0
10	302	600	1.476	146.5	-3.602	90.4	0
10	302	700	1.263	358.3	-3.855	94.6	0
10	302	800	1.361	348.6	-3.795	94.8	0
10	302	900	1.172	335.9	-3.355	92.7	0
10	302	1000	1.558	341.2	-2.792	89.1	0
10	302	1100	2.473	.547	-2.014	86.7	0
10	302	1200	2.546	333.2	-1.02	80	0
10	302	1300	1.933	335.4	-.509	77.3	0
10	302	1400	2.373	2.37	.6	69.41	0
10	302	1500	3.121	39.35	1.274	60.68	0
10	302	1600	4.596	81.5	1.119	57.81	0
10	302	1700	6.67	90.3	.162	58.97	0
10	302	1800	7.81	95.7	-.681	59.5	0
10	302	1900	8.63	96.8	-1.29	58.96	0
10	302	2000	9.81	98.1	-1.866	58.09	0
10	302	2100	10.24	97.2	-2.057	58.44	.01
10	302	2200	10.46	104.6	-2.361	58.12	0
10	302	2300	10.26	108.3	-2.938	58.62	0
10	302	2400	10.5	116.5	-3.488	56.86	0
10	303	100	10.77	116	-3.731	56.5	0
10	303	200	9.6	105.3	-3.756	55.75	0
10	303	300	7.76	108	-3.821	55.04	0
10	303	400	6.146	92	-3.886	53.94	0
10	303	500	4.747	84.8	-4.134	58.91	0
10	303	600	3.199	99	-5.02	54.04	0
10	303	700	2.907	54.42	-5.517	75.9	0
10	303	800	1.714	358.4	-7.13	65.93	0
10	303	900	2.716	.063	-5.585	72	0
10	303	1000	1.891	24.4	-4.006	51.82	0
10	303	1100	4.927	96.5	-1.895	48.09	0
10	303	1200	2.437	34.49	-1.368	49.41	0
10	303	1300	2.017	.797	-.841	48.87	0
10	303	1400	1.925	357	-.344	49.03	0
10	303	1500	2.142	9.61	.026	49.19	0
10	303	1600	2.056	7.38	.201	50.17	0
10	303	1700	3.173	357.9	-.238	52.63	0
10	303	1800	2.926	349.6	-2.473	65.99	0
10	303	1900	4.255	350.1	-3.86	69.22	0
10	303	2000	3.594	356.3	-4.869	73.6	0
10	303	2100	2.724	309.4	-5.648	76.2	0
10	303	2200	2.304	268.3	-6.037	76.5	0
10	303	2300	1.654	217	-6.762	81.6	0
10	303	2400	2.564	195.5	-7.63	84.5	0
10	304	100	1.21	164.8	-8.15	85.3	0

10	304	200	2.168	175	-8.3	85	0
10	304	300	1.76	180.2	-8.42	84.7	0
10	304	400	1.854	174.6	-8.74	84.3	0
10	304	500	1.78	180	-8.9	84.9	0
10	304	600	1.02	17.7	-8.61	85.7	0
10	304	700	.972	35.82	-8.82	87.5	0
10	304	800	1.469	186.4	-7.5	85.3	0

TM16.2 SPLIT PROCESSING EXAMPLE #1

The following parameter file splits data from file CSI1.DAT with a start time relative to PC time (PC date minus one day, at 100 hours). 24 hourly arrays are split, ending at 2400 hours. The COPY parameter is based on the array ID, element 1. Julian day is converted to month-day using the DATE function.

Name(s) of input DATA FILES(s):	CSI1.DAT
Name of OUTPUT FILE to generate:	CSI2.PRN/R/S
START reading in CSI1.DAT:	2[-1]::AND3[100]
STOP reading in CSI1.DAT:	3[100]
COPY from CSI1.DAT:	1[10]
SELECT element #(s) in CSI1.DAT:	DATE(2;1991.),3..8
HEADING for report:	DATA FOR OCTOBER 30, 1991
HEADINGS for CSI1.DAT, col. # 1:	DATE
column # 2:	TIME
column # 3:	WIND\SPEED
column # 4:	WIND\DIR.
column # 5:	TEMP
column # 6:	RH
column # 7:	PRECIP

Output file (CSI2.RPT) created by SPLIT:

DATA FOR OCTOBER 30, 1991

DATE	TIME	WIND SPEED	WIND DIR.	TEMP	RH	PRECIP
10 30	100	10.77	116	-3.731	56.5	0
10 30	200	9.6	105.3	-3.756	55.75	0
10 30	300	7.76	108	-3.821	55.04	0
10 30	400	6.146	92	-3.886	53.94	0
10 30	500	4.747	84.8	-4.134	58.91	0
10 30	600	3.199	99	-5.02	54.04	0
10 30	700	2.907	54.42	-5.517	75.9	0
10 30	800	1.714	358.4	-7.13	65.93	0
10 30	900	2.716	.063	-5.585	72	0
10 30	1000	1.891	24.4	-4.006	51.82	0
10 30	1100	4.927	96.5	-1.895	48.09	0
10 30	1200	2.437	34.49	-1.368	49.41	0
10 30	1300	2.017	.797	-.841	48.87	0
10 30	1400	1.925	357	-.344	49.03	0
10 30	1500	2.142	9.61	.026	49.19	0
10 30	1600	2.056	7.38	.201	50.17	0
10 30	1700	3.173	357.9	-.238	52.63	0

10 30	1800	2.926	349.6	-2.473	65.99	0
10 30	1900	4.255	350.1	-3.86	69.22	0
10 30	2000	3.594	356.3	-4.869	73.6	0
10 30	2100	2.724	309.4	-5.648	76.2	0
10 30	2200	2.304	268.3	-6.037	76.5	0
10 30	2300	1.654	217	-6.762	81.6	0
10 30	2400	2.564	195.5	-7.63	84.5	0

TM16.3 SPLIT PROCESSING EXAMPLE #2

The following parameter file splits data from file CSI1.DAT with a start time based on Julian day 301, and array ID 10. The /G option outputs only those arrays containing one or more Out-Of-Range elements to the output file(s). Julian day is converted to month-day using the DATE function. The range for each element is specified in brackets on the Select element line.

Name(s) of input DATA FILES(s):	CSI1.DAT
Name of OUTPUT FILE to generate:	CSI3.PRN/R/G/S
START reading in CSI1.DAT:	2[301]AND1[10]
STOP reading in CSI1.DAT:	
COPY from CSI1.DAT:	
SELECT element #(s) in CSI1.DAT:	SMPL(DATE(2;1991.),3,4[0..27],5[0..360],6[-20..38],7[0..100]
HEADING for report:	CSI HOURLY QC REPORT
HEADINGS for CSI1.DAT, col. # 1:	DATE
column # 2:	TIME
column # 3:	WIND\SPEED
column # 4:	WIND\DIR.
column # 5:	TEMP
column # 6:	RH

Output file (CSI3.RPT) created by split:

CSI HOURLY QC REPORT

DATE	TIME	WIND SPEED	WIND DIR.	TEMP	RH
10 28	500	6.89	341.1	-1.801	* -6999

TM16.4 SPLIT PROCESSING EXAMPLE #3

The following parameter file splits data from file CSI.DAT with a start and stop time based on Julian day. Time Series Functions perform verticle processing on selected elements based on a count of 24 (24 hourly arrays).

Name(s) of input DATA FILES(s):	CSI1.DAT
Name of OUTPUT FILE to generate:	CSI4.PRN/R/S
START reading in CSI1.DAT:	2[301]AND1[10]
STOP reading in CSI1.DAT:	2[302]
COPY from CSI1.DAT:	
SELECT element #(s) in CSI1.DAT:	SMPL((DATE(2;1991.));24),MAX(6;24), MIN(6;24),MAX(4;24),SMPLMAX(4;5;24), TOTAL(8;24)
HEADING for report:	24-HOUR SUMMARY FOR OCT. 30, 1991
HEADINGS for CSI1.DAT, col. # 1:	DATE
column # 2:	TEMP\MAX
column # 3:	TEMP\MIN
column # 4:	WIND\SPD\MAX
column # 5:	WIND\DIR\MAX WS
column # 6:	PRECIP\TOTAL

Output file (CSI4.RPT) created by SPLIT:

24-HOUR SUMMARY FOR OCT. 30, 1991

DATE	TEMP MAX	TEMP MIN	WIND SPD MAX	WIND DIR MAX WS	PRECIP TOTAL
10 28	1.414	-4.548	6.89	341.1	0

TM16.5 SPLIT PROCESSING EXAMPLE #4

This example uses SPLIT's time "sync" function which is specified by: 1) the time elements in the Start condition (the syntax is: ei[day]:ei[hrmn];ei[seconds]), and 2) the time interval (interval to sync to) in the copy condition. With the time sync function, the time series functions in the SELECT line remain synchronized even when a complete array is missing from the input data (the array marked with an * in the input data file was removed for this example).

Name(s) of input DATA FILES(s):	CSI2.DAT
Name of OUTPUT FILE to generate:	CSI5.PRN/R/S
START reading in CSI2.DAT:	2[301]:3[100]:
STOP reading in CSI2.DAT:	2[304]
COPY from CSI2.DAT:	3[60]
SELECT element #(s) in CSI2.DAT:	SMPL(DATE(2;1991.);4),SMPL(3;4),MAX (4;4),SMPLMAX(4;5;4),AVG(6;4),AVG (7;4),TOTAL(8;4)
HEADING for report:	4-HOUR DATA (TIME SERIES PROCESSING)
HEADINGS for CSI2.DAT, col. # 1:	DATE
column # 2:	TIME
column # 3:	MAX\WIND\SPEED
column # 4:	MAX\SPEED\DIREC.
column # 5:	AVG\TEMP
column # 6:	AVG\RH
column # 7:	TOTAL\PRECIP

Output file (CSI5.RPT) created by SPLIT:

4-HOUR DATA (TIME SERIES PROCESSING)

DATE	TIME	MAX WIND SPEED	MAX SPEED DIREC.	AVG TEMP	AVG RH	TOTAL PRECIP
10 28	400	6.381	337.3	-1.0935	80.85	0
10 28	800	5.188	337.5	-2.8313	82.367	0
10 28	1200	4.216	332.6	-.66925	65.81	0
10 28	1600	3.694	353	.75525	64.723	0
10 28	2000	1.997	108.7	-1.5055	83.575	0
10 28	2400	1.506	110.4	-4.2435	87.05	0
10 29	400	2.531	131.3	-3.598	83.775	0
10 29	800	2.3	124.7	-3.6973	91.45	0
10 29	1200	2.546	333.2	-2.295	87.125	0
10 29	1600	4.596	81.5	.621	66.3	0
10 29	2000	9.81	98.1	-.91875	58.88	0
10 29	2400	10.5	116.5	-2.711	58.01	.01
10 30	400	10.77	116	-3.7985	55.308	0
10 30	800	4.747	84.8	-5.4503	63.695	0
10 30	1200	4.927	96.5	-3.2135	55.33	0
10 30	1600	2.142	9.61	-.2395	49.315	0
10 30	2000	4.255	350.1	-2.86	65.36	0
10 30	2400	2.724	309.4	-6.5193	79.7	0

ADDITIONAL INFORMATION/NOTES:

1-minute Array Description:

Seven elements:

#1	#2	#3	#4	#5	#6	#7
Array ID	Julian Day	Hour Minute	Ref Temp C Avg	TC Temp C Avg	TC Temp F Avg	Battery Volts Smpl
106	239	1400	22.47	22.81	73	10.61

5-minute Array Description:

Seven elements:

#1	#2	#3	#4	#5	#6	#7
Array	Julian Day	Hour Minute	Ref Temp C Avg	TC Temp F Max	TC Temp F Min	Battery Volts Smpl
112	239	1400	22.47	73	73	10.61

Comma Delineated ASCII data from file DATA.DAT:

```
106,239,1400,22.47,22.81,73,10.61
112,239,1400,22.47,73,73,10.61
106,239,1401,22.49,22.77,73,10.65
106,239,1402,22.49,22.6,72.7,10.66
106,239,1403,22.49,22.57,72.6,10.67
106,239,1404,22.51,22.45,72.4,10.46
106,239,1405,22.53,22.56,72.6,10.49
112,239,1405,22.5,73.1,71.3,10.49
106,239,1406,22.56,22.77,73,10.51
106,239,1407,22.56,22.76,73,10.7
106,239,1408,22.57,22.72,72.9,10.7
106,239,1409,22.58,22.76,73,10.7
106,239,1410,22.59,22.75,73,10.7
112,239,1410,22.57,73.1,72.8,10.7
106,239,1411,22.6,22.69,72.8,10.7
106,239,1412,22.61,22.66,72.8,10.7
106,239,1413,22.61,22.66,72.8,10.7
106,239,1414,22.62,22.75,72.9,10.7
106,239,1415,22.64,22.77,73,10.69
112,239,1415,22.61,73.1,72.7,10.69
106,239,1416,22.65,22.75,73,10.7
106,239,1417,22.67,22.77,73,10.7
106,239,1418,22.69,22.86,73.1,10.7
106,239,1419,22.7,22.85,73.1,10.7
106,239,1420,22.71,22.9,73.2,10.7
112,239,1420,22.68,73.3,72.9,10.7
```

106,239,1421,22.72,22.93,73.3,10.7
106,239,1422,22.74,22.96,73.3,10.69
106,239,1423,22.76,23.03,73.5,10.69
106,239,1424,22.78,23.08,73.5,10.69
106,239,1425,22.8,23.04,73.5,10.69
112,239,1425,22.76,73.6,73.2,10.69
106,239,1426,22.8,23.02,73.4,10.69
106,239,1427,22.81,23.03,73.5,10.7
106,239,1428,22.82,23.11,73.6,10.69
106,239,1429,22.84,23.13,73.6,10.69
106,239,1430,22.86,23.16,73.7,10.68
112,239,1430,22.83,73.7,73.4,10.68
106,239,1431,22.87,23.11,73.6,10.69
106,239,1432,22.88,23.12,73.6,10.69
106,239,1433,22.89,23.12,73.6,10.68
106,239,1434,22.9,23.09,73.6,10.69
106,239,1435,22.91,23.1,73.6,10.69
112,239,1435,22.89,73.7,73.5,10.69
106,239,1436,22.93,23.08,73.6,10.7
106,239,1437,22.94,23.11,73.6,10.69
106,239,1438,22.96,23.16,73.7,10.69
106,239,1439,22.97,23.19,73.7,10.69
106,239,1440,22.98,23.2,73.8,10.68
112,239,1440,22.96,73.8,73.5,10.68
106,239,1441,22.99,23.23,73.8,10.69
106,239,1442,23.01,23.24,73.8,10.68
106,239,1443,23.02,23.31,74,10.69
106,239,1444,23.04,23.35,74,10.69
106,239,1445,23.05,23.41,74.1,10.69
112,239,1445,23.02,74.2,73.8,10.69
106,239,1446,23.07,23.43,74.2,10.69
106,239,1447,23.08,23.36,74.1,10.69
106,239,1448,23.09,23.3,73.9,10.69
106,239,1449,23.1,23.29,73.9,10.69
106,239,1450,23.1,23.24,73.8,10.69
112,239,1450,23.09,74.[illegible],73.8,10.69
106,239,1451,23.1,23.2,73.8,10.69
106,239,1452,23.11,23.22,73.8,10.69
106,239,1453,23.11,23.18,73.7,10.69
106,239,1454,23.12,23.23,73.8,10.69
106,239,1455,23.13,23.3,73.9,10.68
112,239,1455,23.11,74,73.7,10.68
106,239,1456,23.15,23.33,74,10.69
106,239,1457,23.17,23.36,74,10.69
106,239,1458,23.17,23.39,74.1,10.68
106,239,1459,23.19,23.45,74.2,10.68
106,239,1500,23.21,23.56,74.4,10.68
112,239,1500,23.18,74.5,73.9,10.68
106,239,1501,23.22,23.59,74.5,10.69
106,239,1502,23.23,23.57,74.4,10.69
106,239,1503,23.27,23.74,74.7,10.68
106,239,1504,23.31,23.71,74.7,10.58
106,239,1505,23.33,23.65,74.6,10.7
112,239,1505,23.27,75.5,74.4,10.7
106,239,1506,23.33,23.62,74.5,10.7

Split Processing Example #1:

```
 Name(s) of input DATA FILES(s): data.dat
Name of OUTPUT FILE to generate: ex#1.prn/r
      START reading in data.dat: 3[1400]
       STOP reading in data.dat:
             COPY from data.dat: 1[106]
SELECT element #(s) in data.dat: 1..7
             HEADING for report: 1-Minute Data
HEADINGS for data.dat, col. # 1: Array\ID
                     column # 2: Julian\Day
                     column # 3: Hour\Minute
                     column # 4: Ref\Temp C\Avg
                     column # 5: TC\Temp C\Avg
                     column # 6: TC\Temp F\Avg
                     column # 7: Battery\Volts\Smpl
```

Data from file EX#1.RPT:

1-Minute Data

Array ID	Julian Day	Hour Minute	Ref Temp C Avg	TC Temp C Avg	TC Temp F Avg	Battery Volts Smpl
106	239	1400	22.47	22.81	73	10.61
106	239	1401	22.49	22.77	73	10.65
106	239	1402	22.49	22.6	72.7	10.66
106	239	1403	22.49	22.57	72.6	10.67
106	239	1404	22.51	22.45	72.4	10.46
106	239	1405	22.53	22.56	72.6	10.49
106	239	1406	22.56	22.77	73	10.51
106	239	1407	22.56	22.76	73	10.7
106	239	1408	22.57	22.72	72.9	10.7
106	239	1409	22.58	22.76	73	10.7
106	239	1410	22.59	22.75	73	10.7
106	239	1411	22.6	22.69	72.8	10.7
106	239	1412	22.61	22.66	72.8	10.7
106	239	1413	22.61	22.66	72.8	10.7
106	239	1414	22.62	22.75	72.9	10.7
106	239	1415	22.64	22.77	73	10.69
106	239	1416	22.65	22.75	73	10.7
106	239	1417	22.67	22.77	73	10.7
106	239	1418	22.69	22.86	73.1	10.7
106	239	1419	22.7	22.85	73.1	10.7
106	239	1420	22.71	22.9	73.2	10.7
106	239	1421	22.72	22.93	73.3	10.7
106	239	1422	22.74	22.96	73.3	10.69
106	239	1423	22.76	23.03	73.5	10.69
106	239	1424	22.78	23.08	73.5	10.69
106	239	1425	22.8	23.04	73.5	10.69

Split Processing Example #2:

```
 Name(s) of input DATA FILES(s): data.dat
Name of OUTPUT FILE to generate: ex#2.prn/r
      START reading in data.dat: 2[239]and3[1400]
       STOP reading in data.dat: 3[1501]
             COPY from data.dat: 1[106]
SELECT element #(s) in data.dat: date(2;1992.),3,5-4
             HEADING for report: 1-Minute Delta Temperature Data
HEADINGS for data.dat, col. # 1: Month\Day
                     column # 2: Hour\Minute
                     column # 3: TC\Temp C\Delta
```

Data from file EX#2.RPT:

1-Minute Delta Temperature Data

Month Day	Hour Minute	TC Temp C Delta
8 26	1400	.34
8 26	1401	.28
8 26	1402	.11
8 26	1403	.08
8 26	1404	-.06
8 26	1405	.03
8 26	1406	.21
8 26	1407	.2
8 26	1408	.15
8 26	1409	.18
8 26	1410	.16
8 26	1411	.09
8 26	1412	.05
8 26	1413	.05
8 26	1414	.13
8 26	1415	.13
8 26	1416	.1
8 26	1417	.1
8 26	1418	.17
8 26	1419	.15
8 26	1420	.19
8 26	1421	.21
8 26	1422	.22
8 26	1423	.27
8 26	1424	.3
8 26	1425	.24
8 26	1426	.22
8 26	1427	.22
8 26	1428	.29
8 26	1429	.29

Split Processing Example #3:

```
 Name(s) of input DATA FILES(s): data.dat
Name of OUTPUT FILE to generate: ex#3.prn/r
      START reading in data.dat: 2[239]and3[1400]
       STOP reading in data.dat: 3[1501]
             COPY from data.dat: 1[106]
SELECT element #(s) in data.dat: date(2;1992.),3,4*1.8+32.,7
             HEADING for report: 1-Minute CR10 Temperature/Battery
                                 Data
HEADINGS for data.dat, col. # 1: Month\Day
                     column # 2: Hour\Minute
                     column # 3: Ref\Temp F\Avg
                     column # 4: Battery\Volts\Smpl
```

Data from file EX#3.RPT:

1-Minute CR10 Temperature/Battery Data

Month Day	Hour Minute	Ref Temp F Avg	Battery Volts Smpl
8 26	1400	72.446	10.61
8 26	1401	72.482	10.65
8 26	1402	72.482	10.66
8 26	1403	72.482	10.67
8 26	1404	72.518	10.46
8 26	1405	72.554	10.49
8 26	1406	72.608	10.51
8 26	1407	72.608	10.7
8 26	1408	72.626	10.7
8 26	1409	72.644	10.7
8 26	1410	72.662	10.7
8 26	1411	72.68	10.7
8 26	1412	72.698	10.7
8 26	1413	72.698	10.7
8 26	1414	72.716	10.7
8 26	1415	72.752	10.69
8 26	1416	72.77	10.7
8 26	1417	72.806	10.7
8 26	1418	72.842	10.7
8 26	1419	72.86	10.7
8 26	1420	72.878	10.7
8 26	1421	72.896	10.7
8 26	1422	72.932	10.69
8 26	1423	72.968	10.69
8 26	1424	73.004	10.69
8 26	1425	73.04	10.69
8 26	1426	73.04	10.69
8 26	1427	73.058	10.7
8 26	1428	73.076	10.69
8 26	1429	73.112	10.69
8 26	1430	73.148	10.68

Split Processing Example #4:

```
 Name(s) of input DATA FILES(s): ex#1.prn
Name of OUTPUT FILE to generate: ex#4.prn/r
      START reading in ex#1.prn: 2[239]and3[1401]
       STOP reading in ex#1.prn: 3[1501]
             COPY from ex#1.prn: 1[106]
SELECT element #(s) in ex#1.prn: smpl(date(2;1992.);5),smpl(3;5),
                                 avg(5;5),avg(7;5)
             HEADING for report: 5-Minute Thermocouple/Battery
                                 Voltage Data
HEADINGS for ex#1.prn, col. # 1: Month\Day
                     column # 2: Hour\Minute
                     column # 3: TC\Temp C\Avg
                     column # 4: Battery\Volts\Avg
```

Data from file EX#4.RPT:

```
    5-Minute Thermocouple/Battery Voltage Data

       Month    Hour      TC Battery
         Day  Minute  Temp C   Volts
                         Avg     Avg
    --------------------------------
        8 26    1405   22.59  10.586
        8 26    1410  22.752  10.662
        8 26    1415  22.706  10.698
        8 26    1420  22.826    10.7
        8 26    1425  23.008  10.692
        8 26    1430   23.09   10.69
        8 26    1435  23.108  10.688
        8 26    1440  23.148   10.69
        8 26    1445  23.308  10.688
        8 26    1450  23.324   10.69
        8 26    1455  23.226  10.688
        8 26    1500  23.418  10.684
```

AUTOMATED WEATHER STATION (AWS) INSTALLATION
ARIZONA D.O.T. OPEN HOUSE
Phoenix, Arizona
July 20-21, 1994

AWS Roles and Responsibilities

ACTIVITY	PRIMARY RESPONSIBILITY	SECONDARY RESPONSIBILITY
AWS Purchase Software License	FHWA Highway Agency	n/a n/a
AWS Installation Site Nomination and Layout Plan Site Approval Site Preparation (concrete foundations, conduits, fence) AWS Installation	 Highway Agency FHWA Highway Agency RCOC	 RCOC TAC RCOC Highway Agency
AWS Data Handling and Processing Collection (upload of data, backup, and mail/modem to TAC) IMS Upload and QA Checks	 RCOC and/or Highway Agency TAC	 Highway Agency and/or RCOC RCOC
AWS Maintenance Routine (cleaning and mowing) Major (replacement of parts)	 Highway Agency RCOC	 RCOC FHWA (funding)
Technical Support	TAC and AWS Equipment Supplier	FHWA

Notes:
FHWA = Federal Highway Administration
TAC = LTPP Technical Assistance Contractor
RCOC = LTPP Regional Coordination Office Contractor

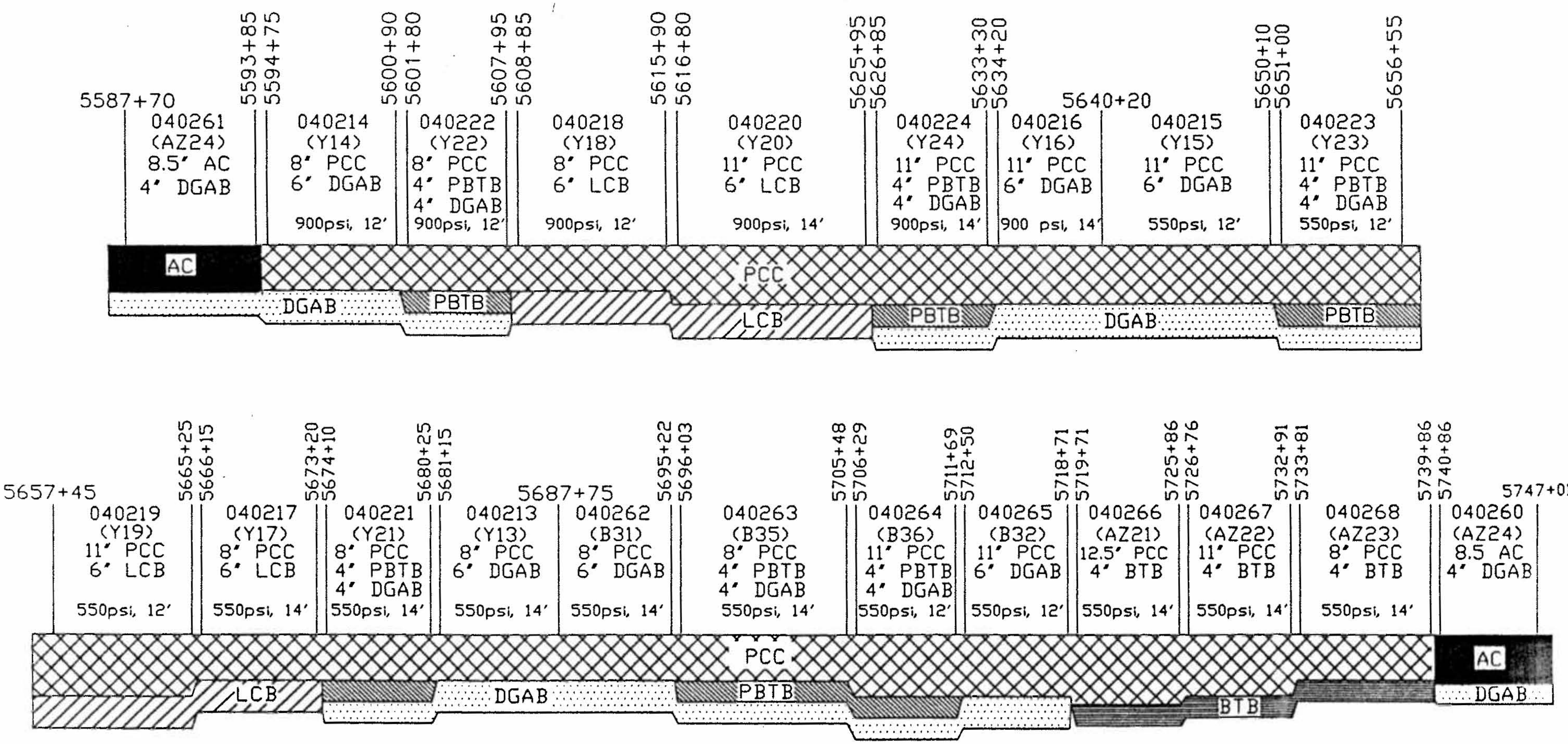
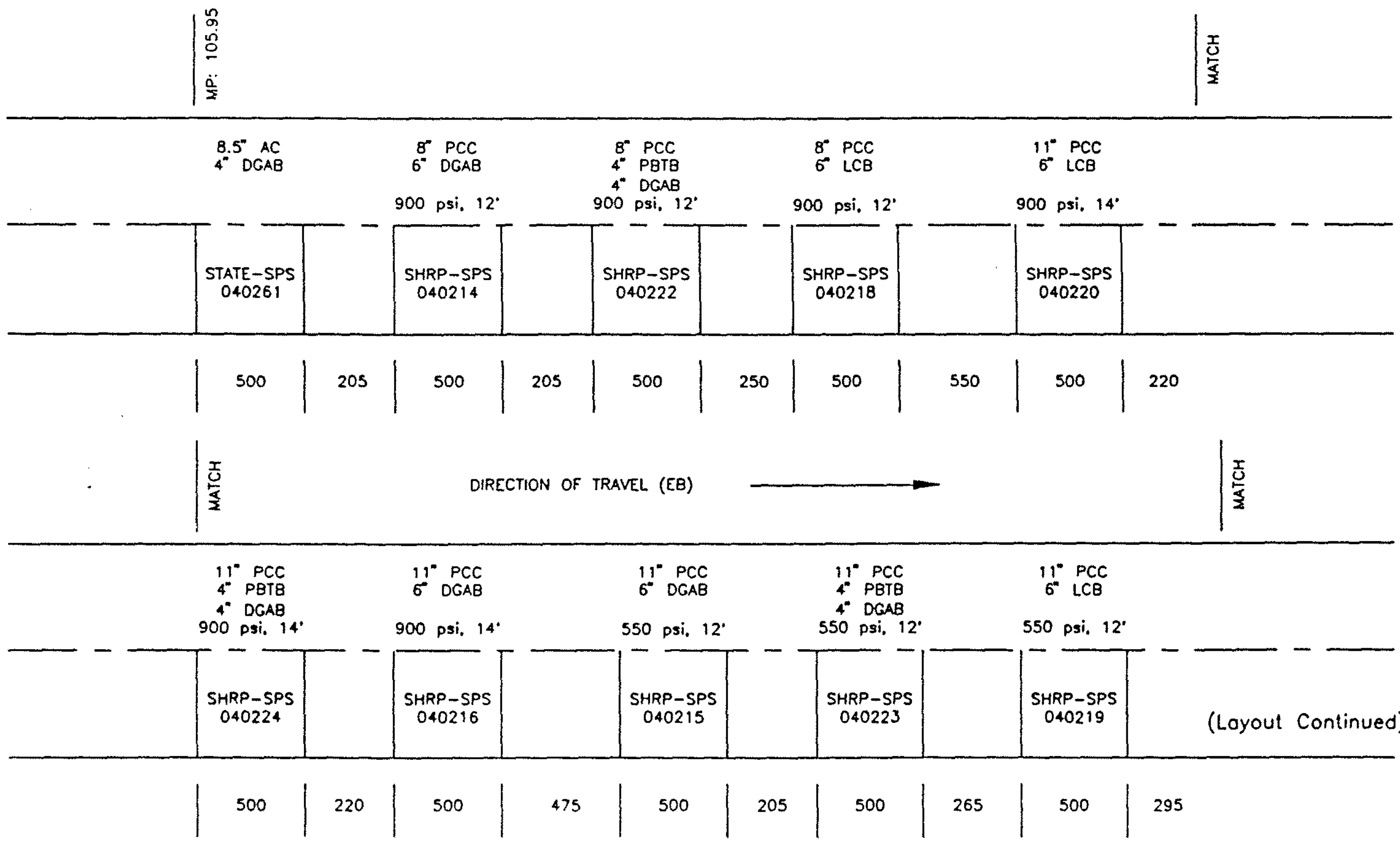


Figure 1. Layout of experimental test sections, Arizona SPS-2 project, Ehrenberg-Phoenix Highway.

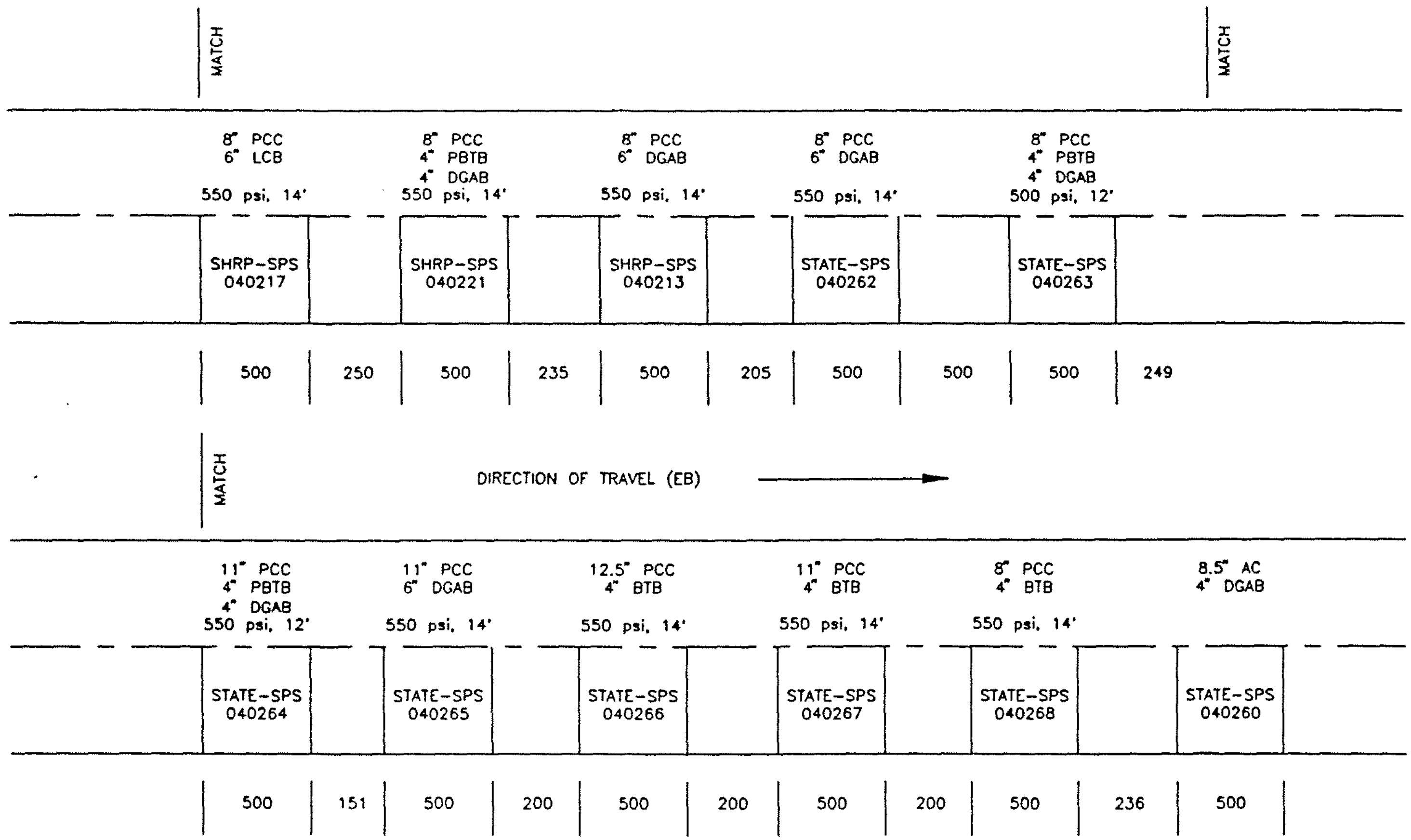
SPS-2 TEST SECTION LAYOUT
040200, PHOENIX, ARIZONA
I-10 EASTBOUND
02/14/94



Current Markings: Bench mark "hub" placed in PCC shoulder at start and end of each PCC section.
Signs on fenceline at start of sections.

NOT TO SCALE

SPS-2 TEST SECTION LAYOUT (Continued)
040200, PHOENIX, ARIZONA
I-10 EASTBOUND
02/14/94



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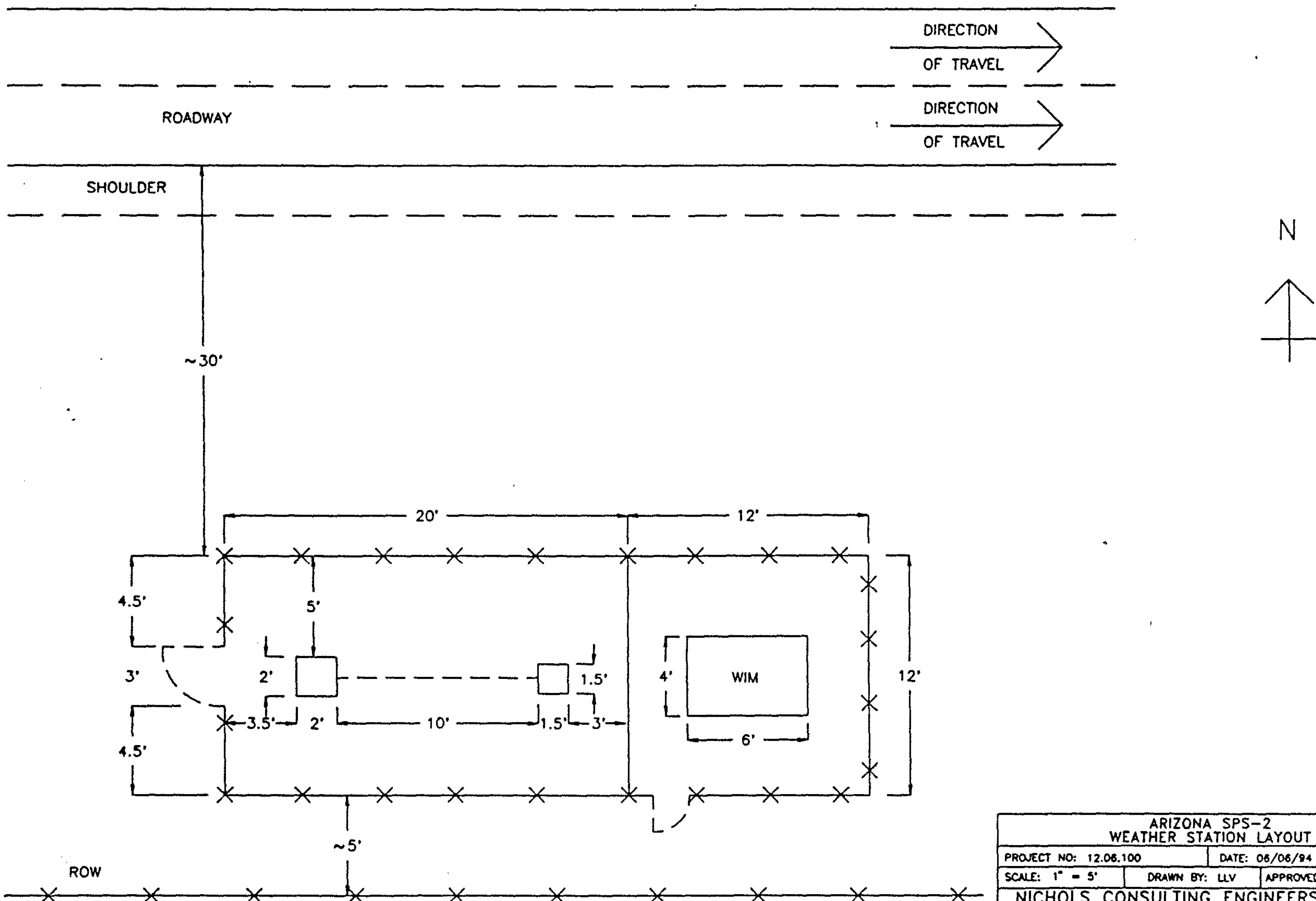

REVISIONS

ARIZONA SPS-2 WEATHER STATION LAYOUT		
PROJECT NO: 12.06.100	DATE: 06/06/94	
SCALE: 1" = 5'	DRAWN BY: LLV	APPROVED BY: DJF

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