CR10 MEASUREMENT AND CONTROL MODULE OPERATOR'S MANUAL

REVISION: 5/95

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SELECTED OPERATING DETAILS

1. **Storing Data** - Data are stored in Final Storage only by Output Processing Instructions and only when the Output Flag is set. (Sections OV4.1.1 and OV4.2.1)

2. **Storing Date and Time** - Date and time are stored with the data in Final Storage ONLY if the Real Time Instruction 77 is used. (Section 11)

3. **Data Transfer** - On-line data transfer from Final Storage to peripherals (printer, Storage Module, etc.) occurs only if enabled with Instruction 96 in the datalogger program. (Sections 4 and 12)

4. **Final Storage Resolution** - All Input Storage values are displayed (*6 mode) as high resolution with a maximum value of 99999. However, the default resolution for data stored in Final Storage is low resolution, maximum value of 6999. Results exceeding 6999 are stored as 6999 unless Instruction 78 is used to store the values in Final Storage as high resolution values. (Sections 2.2.1 and 11)

5. **Floating Point Format** - The computations performed in the CR10 use floating point arithmetic. CSI's 4 byte floating point numbers contain a 23 bit binary mantissa and a 6 bit binary exponent. The largest and smallest numbers that can be stored and processed are 9×10^{18} and 1×10^{-19}, respectively. (Section 2.2.2)

6. **Erasing Final Storage** - Data in Final Storage can be erased without altering the program by using the *A Mode to repartition memory. (Section 1.5.2)

7. **ALL memory can be erased** and the CR10 completely reset by entering 1986 for the number of bytes left in Program Memory. (Section 1.5.2)

8. **The set of instructions** available in the CR10 is determined by the PROM (Programmable Read Only Memory) that it is equipped with. Standard and optional software are identified in Appendix B. If you have ordered optional software that is not covered in the standard manual, the documentation is in Appendix H.

9. **Radiotelemetry Users** - As of February, 1990, CR10 PROMs no longer contain radio frequency interface software. That function is now contained in the RF95 Modem. To make measurements at a phone-to-RF base station using the RF100/RF200 Radio and RF95 Modem, current CR10 software is required. A CR10 with old software can be used with the new RF95 in the "RF95-ME" state, but the datalogger loses the "callback" capability as well as the SDC function.

10. **Changes with the release of OS10-0.1**:

    Wind Vector Instruction 69 has replaced Instruction 76. The options to do sub-interval averaging of the standard deviation of wind direction, $\sigma(\theta)$, and to calculate $\sigma(\theta)$ using the Yamartino algorithm have been added to the previous options (Section 9).

    Intermediate Processing Disable Flag 9 in now set low if a conditional test for setting it high fails (same as Output Flag 0, Section 3.7.2).

    ***D options for saving and loading programs with a cassette tape** are no longer in a standard PROM and must be ordered as a library option PROM (Appendix B).

CAUTIONARY NOTES

1. Damage will occur to the analog input circuitry if voltages in excess of ±16 V are applied for a sustained period. Voltages in excess of ±5V will cause errors and possible overranging on other analog input channels.

2. When using the CR10 with the PS12LA, remember that the sealed lead acid batteries are permanently damaged if discharged below 10.5 V. The cells are rated at a 7 Ahr capacity but experience a slow discharge even in storage. It is advisable to maintain a continuous charge on the PS12LA battery pack, whether in operation or storage (Section 14).

3. When connecting power to the CR10, first connect the positive lead from the power source to the 12 V terminal. Then connect the negative lead to G. Connecting these leads in the reverse order creates the possibility of a short (Section 14).

4. There are frequent references in this manual to Storage Modules. The Storage Modules referred to are the SM192 and SM716. The old SM16 and SM64 Storage Modules will NOT work with the CR10 without a specially modified cable. In addition, the SM16 and SM64 cannot perform many of the functions that the SM192 and SM716 are capable of performing.

5. Voltages in excess of 5.5 volts applied to a control port can cause the CR10 to malfunction.

6. Voltage pulses can be counted by CR10 Pulse Counters configured for High Frequency Pulses. However, when the pulse is actually a low frequency signal (below about 10 Hz) AND the positive voltage excursion exceeds 5.6 VDC, the 5 VDC supply will start to rise, upsetting all analog measurements.

   Pulses whose positive voltage portion exceed 5.6 VDC with a duration longer than 100 milliseconds need external conditioning. See the description of the Pulse count instruction in Section 9 for details on the external conditioning.

7. The CR10 module is sealed and contains desiccant to protect against excess humidity. The Wiring Panel and the connections between the Wiring Panel and the CR10 are still susceptible to humidity. To prevent corrosion at these points, additional desiccant must be placed inside the enclosure. To reduce vapor transfer into the enclosure, plug the cable entry conduit with Duct Seal, a putty-type sealant available at most electrical supply houses. DO NOT totally seal enclosures equipped with lead acid batteries. Hydrogen concentration may build up to explosive levels.

CR10 MEASUREMENT AND CONTROL MODULE OVERVIEW

Campbell Scientific Inc. provides four aids to understanding and operating the CR10:

1. *PCTOUR*
2. *This Overview*
3. *The CR10 Operator's Manual*
4. *The CR10 Prompt Sheet*

PCTOUR is a computer-guided tour of CR10 operation and the use of the PC208 Datalogger Support Software. Much of the material in this Overview is covered in PCTOUR. A copy of PCTOUR is included with every datalogger or PC208 order.

This Overview introduces the concepts required to take advantage of the CR10's capabilities. Hands-on programming examples start in Section OV5. Working with a CR10 will help the learning process, so don't just read the examples, do them. If you want to start this minute, go ahead and try the examples, then come back and read the rest of the Overview.

The sections of the Operator's Manual which should be read to complete a basic understanding of the CR10 operation are the Programming Sections 1-3, the portions of the data retrieval Sections 4 and 5 appropriate to the method(s) you are using (see OV6), and Section 14 which covers installation and maintenance.

Section 6 covers details of serial communications. Sections 7 and 8 contain programming examples. Sections 9-12 have detailed descriptions of each programming instruction, and Section 13 goes into detail on the CR10 measurement procedures.

The Prompt Sheet is an abbreviated description of the programming instructions. Once familiar with the CR10, it is possible to program it using only the Prompt Sheet as a reference, consulting the manual if further detail is needed.

Read the Selected Operating Details and Cautionary Notes at the front of the Manual before using the CR10.

OV1. 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 OV2).
- The CR10 does not have an integral terminal strip. A removable wiring panel (Figure OV1.1-1) 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.

OV1.1 WIRING PANEL

The CR10 Wiring Panel and CR10 datalogger make electrical contact through the two D-type connectors at the (left) end of the CR10.

The Wiring Panel contains a 9-pin Serial I/O port used when communicating with the datalogger and provides terminals for connecting sensor, control, and power leads to the CR10. It also provides transient protection and reverse polarity protection. Figure OV1.1-2 shows the panel and the instructions used to access the various terminals.

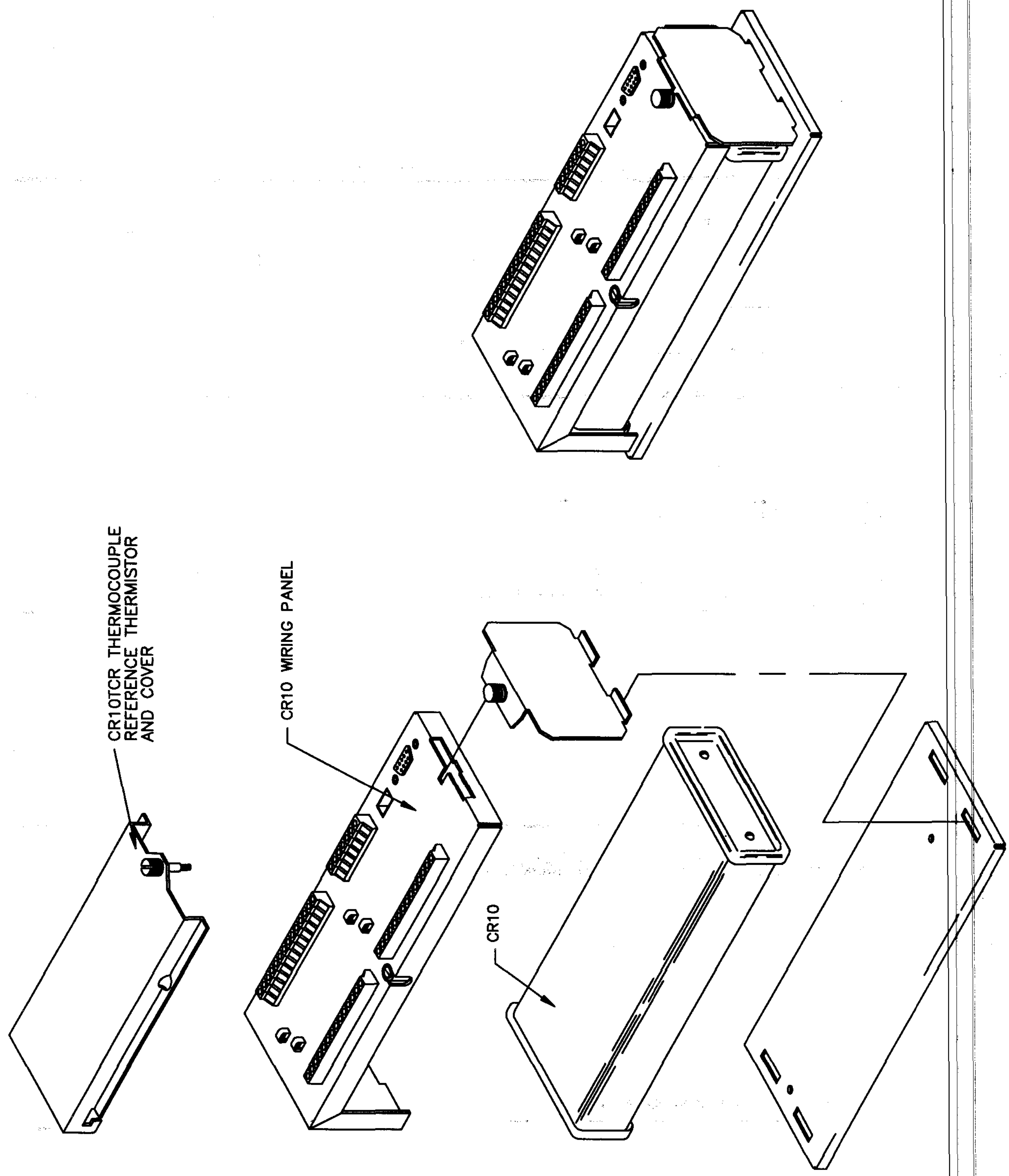

FIGURE OV1.1-1. CR10 and Wiring Panel

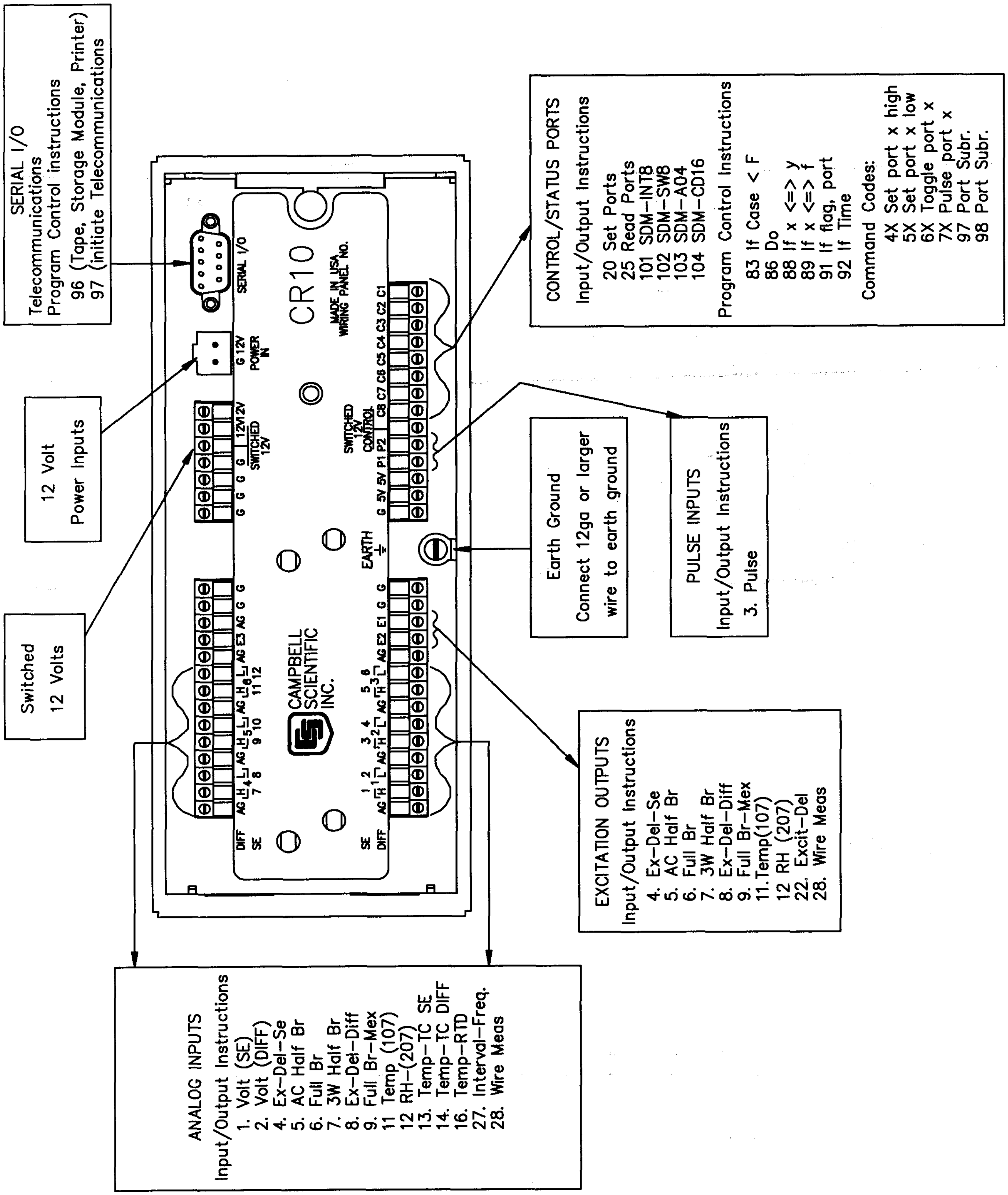

FIGURE OV1.1-2. CR10 Wiring Panel/Instruction Access

OV1.1.1 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. When making single-ended measurements, either the H or L input may be used as an independent channel to measure voltage with respect to the CR10 analog ground (AG). The 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. (The single-ended channel numbers do NOT appear on older wiring panels).

OV1.1.2 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 (Section 9).

OV1.1.3 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 (Section 9, Instruction 3).

OV1.1.4 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: 3V < high < 5.5V; -0.5V < low < 0.8V.

Configured as outputs the ports allow on/off control of external devices. A port can be set high (5V ± 0.1V), set low (<0.1V), toggled or pulsed (Sections 3, 8.3, and 12).

OV1.1.5 ANALOG GROUND (AG)

The AG terminals are analog grounds, used as the reference for single-ended measurements and excitation return.

OV1.1.6 12V AND POWER GROUND (G) TERMINALS

The 12V and power ground (G) terminals are used to supply 12V DC power to the datalogger. The extra 12V and G terminals can be used to connect other devices requiring 12V 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).

OV1.1.7 5V OUTPUTS

The two 5V (±0.2%) outputs are commonly used to power peripherals such as the QD1 Incremental Encoder Interface, AVW1 or AVW4 Vibrating Wire Interface.

The 5V outputs are common with pin 1 on the 9 pin serial connector; 200 mA is the maximum combined output.

OV1.1.8 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 5VDC power line which is used to power peripherals such as the SM192 or SM716 Storage Module or the DC112 Phone Modem. The same 5VDC supply is used for the 5V outputs on the lower terminal strip. Section 6 contains technical details on serial communication.

OV1.1.9 SWITCHED 12 VOLT

Wiring panels introduced in March 1994 include a switched 12 volt output. This can be used to power sensors or devices requiring an unregulated 12 volts. The output is limited to 600 mA current.

A control port is used to operate the switch. Connect a wire from the control port to the switched 12 volt control port. When the port is set high, the 12 volts is turned on; when the port is low, the switched 12 volts is off.

OV1.2 CONNECTING POWER TO THE CR10

The CR10 can be powered by any 12VDC source. First connect the positive lead from the power supply to one of the 12V 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 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.

OV2. 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 starting at the beginning.

The interval at which the table is executed generally determines the interval at which the sensors are measured. The interval at which data are 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.

Figure OV2.1-1 represents the measurement, processing, and data storage sequence, and the types of instructions used to accomplish these tasks.

OV2.1 INTERNAL MEMORY

The CR10 has 64K 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 Figure OV2.1-1. 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. The *6 Mode is used to view Input Storage locations for checking current sensor readings or calculated values. Input Storage defaults to 28 locations. Additional locations can be assigned using the *A Mode (Section 1.5).

2. **Intermediate Storage** - Certain Processing Instructions and most of the Output Processing Instructions maintain intermediate results in Intermediate Storage. Intermediate storage is automatically accessed by the instructions and cannot be accessed by the user. The default allocation is 64 locations. The number of locations can be changed using the *A Mode.

3. **Final Storage** - Final processed values are stored here for transfer to printer, solid state Storage Module or for retrieval via telecommunication links. Values are stored in Final Storage only by the Output Processing Instructions and only when the Output Flag is set in the users program. Approximately 29,900 locations are allocated to Final Storage on power up. This number is reduced if Input or Intermediate Storage is increased.

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.

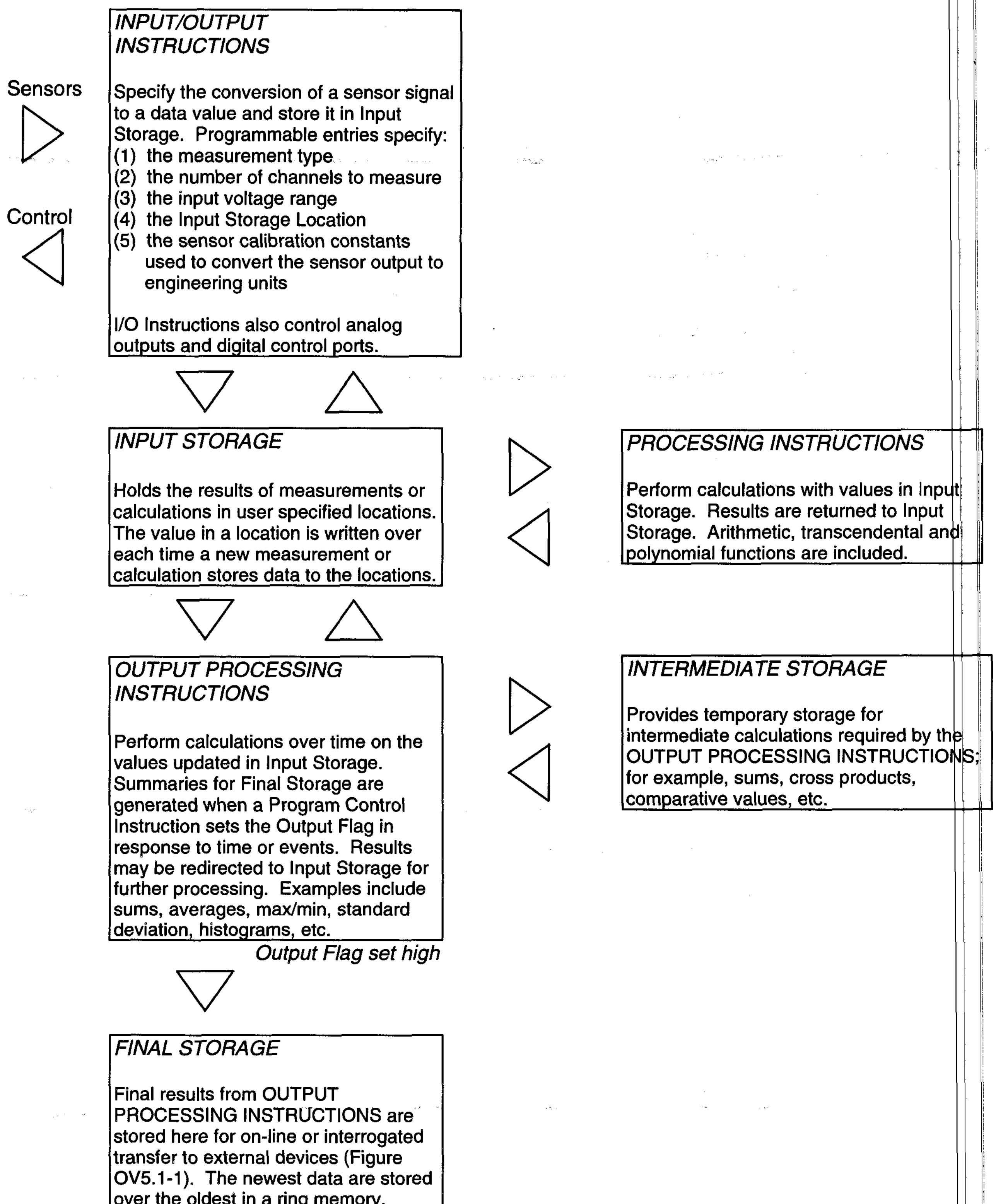

FIGURE OV2.1-1. Instruction Types and Storage Areas

OV2.2 CR10 INSTRUCTION TYPES

Figure OV2.1-1 illustrates the use of three different instruction types which act on data. The fourth type, Program Control, is used to control output times and vary program execution. Instructions are identified by numbers.

1. **INPUT/OUTPUT INSTRUCTIONS** (1-28, 101-104, Section 9) control the terminal strip inputs and outputs (the sensor is the source, Figure OV1.1-2), storing the results in Input Storage (destination). Multiplier and offset parameters allow conversion of linear signals into engineering units. The Digital I/O Ports are also addressed with I/O Instructions.

2. **PROCESSING INSTRUCTIONS** (30-66, Section 10) perform numerical operations on values located in Input Storage (source) and store the results back in Input Storage (destination). These instructions can be used to develop high level algorithms to process measurements prior to Output Processing.

3. **OUTPUT PROCESSING INSTRUCTIONS** (69-82, Section 11) are the only instructions which store data in Final Storage (destination). Input Storage (source) values are processed over time to obtain averages, maxima, minima, etc. There are two types of processing done by Output Instructions: **Intermediate** and **Final.**

   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.*

4. **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.

OV2.3 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. The size of each table is flexible, limited only by the total amount of program memory. If Table 1 is the only table programmed, the entire program memory is available for Table 1.

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.

OV2.3.1 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.

Table 1. Execute every x sec. $0.0156 \le x \le 8191$
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.
Normal Order: MEASURE PROCESS CHECK OUTPUT COND. OUTPUT PROCESSING

Table 2. Execute every y sec. $0.0156 \le y \le 8191$
Table 2 is used if there is a need to measure and process data on a separate interval from that in Table 1.

Table 3. Subroutines
A subroutine is executed only when called from Table 1 or 2.
Subroutine Label Instructions End
Subroutine Label Instructions End
Subroutine Label Instructions End

FIGURE OV2.3-1. Program and Subroutine Tables

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.

OV2.3.2. THE OUTPUT INTERVAL

The interval at which output occurs is 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).

A single program table can have many different output intervals and conditions, each with a unique data set (Output Array). Program Control Instructions are used to set the Output Flag. The Output Processing Instructions which follow the instruction setting the Output Flag determine the data output and its sequence. Each additional Output Array is created by another Program Control Instruction checking a output condition, followed by Output Processing Instructions defining the data set to output.

OV3. COMMUNICATING WITH 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/terminal.

The CR10KD is powered by the CR10 and connects directly to the serial port via the SC12 cable (supplied with the CR10KD). No interfacing software is required.

To communicate with any device other than the CR10KD, the CR10 enters its Telecommunications Mode and responds only to valid telecommunications commands. Within the Telecommunications Mode, there are 2 "states"; the Telecommunications Command state and the Remote Keyboard state. Communication is established in the Telecommunications command state. One of the commands is to enter the Remote Keyboard state.

The Remote Keyboard state allows the keyboard of the computer/terminal to act like the CR10KD keyboard. Various datalogger modes may be entered, including the mode in which programs may be keyed in to the CR10 from the computer/terminal.

Campbell Scientific's PC208 Datalogger Support Software facilitates the use of IBM PC/XT/AT/PS-2's and compatibles for communicating with the CR10. This package contains a program editor (EDLOG), a terminal