

**SM192/716 STORAGE MODULE  
INSTRUCTION MANUAL**

**REVISION: 6/14/93**

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## CAMPBELL SCIENTIFIC, INC.

815 W. 1800 N.  
Logan, UT 84321-1784  
USA  
Phone (435) 753-2342  
FAX (435) 750-9540  
www.campbellsci.com

Campbell Scientific Canada Corp.  
11564 -149th Street  
Edmonton, Alberta T5M 1W7  
CANADA  
Phone (403) 454-2505  
FAX (403) 454-2655

Campbell Scientific Ltd.  
Campbell Park  
80 Hathern Road  
Shepshed, Leics. LE12 9RP  
ENGLAND  
Phone (44)-50960-1141  
FAX (44)-50960-1091

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# SECTION 1. SM192/716 STORAGE MODULE OVERVIEW

Campbell Scientific's SM192 and SM716 Storage Modules expand on-site RAM data storage for users of Campbell Scientific dataloggers. They also provide the user with a convenient method of transporting data from the field back to the office. The SM192 and SM716 are compatible with the CR10, 21X, CR7, and CR21 dataloggers as well as the DSP4 Heads Up Display.

This manual contains two broad divisions. This Overview surveys the Storage Modules and their function. It also explains how to quickly begin using an SM for straight-forward data storage operations. The remainder of the manual is a technical reference which describes in detail such operations as: storing CR10 data, storing data from Campbell Scientific's other dataloggers, data retrieval, and datalogger program storage and retrieval.

The Overview should be read by all users, as should Section 5 (Data Retrieval). Users with the CR10 or with the 21X or CR7 with current PROMS should read Section 2, while users of Campbell Scientific's other dataloggers should read Section 3. Section 6 (Storing and Retrieving Datalogger Programs) and Appendix D (Telecommunication Commands) may be used as needed.

**NOTE:** 21X Microloggers released after February 1989, and CR7 dataloggers released after August 1991, contain the OSX and OS7 Series PROMS which support two major SM functions that earlier versions do not:

1. The \*D storage and retrieval of datalogger programs in the SM.
2. The Instruction 96 transfer of binary Final Storage data to the SM with the capability of not sending data until the SM is connected. In older versions of the 21X and CR7 PROMS, the Instruction 96 transfer is simply an ASCII printer dump. Data are sent regardless of whether the SM is or is not connected.

## 1.1 SPECIFICATIONS

<p>Storage Capacity:</p> <p>Model SM192 192,896 bytes</p> <p>Model SM716 716,672 bytes</p> <p>Dimensions: 7.9" X 3.6" X 1.5"</p> <p>Weight: SM192 1.5 lbs</p> <p>SM716 1.9 lbs.</p> <p>Canister: Sealed stainless steel</p> <p>Processor: Hitachi 6303</p> <p>Operating Temp. Range: -35°C to +65°C</p> <p>(-55°C to +85°C available as special order)</p> <p>Baud Rates: 300, 1200, 9600, 76,800</p>	<p>Memory Configuration: User selectable for either ring style or fill and stop. Default is ring style.</p> <p>Power Requirements 5 ±0.4 VDC @ 100 mA (max.)</p> <p>Active Processing 18 mA (avg.)</p> <p>Low Power Standby State 250 µA (avg.)</p> <p>Memory Backup Battery 3.5 VDC Lithium Thionyl Chloride</p> <p>Maintenance: There are no user serviceable parts in the Storage Module. If the SM is not exposed to prolonged temperature extremes while disconnected from a primary power source, the battery will probably last 6 yrs. The Storage Module must be returned to the factory for battery replacement.</p>
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## SECTION 1. SM192/716 STORAGE MODULE OVERVIEW

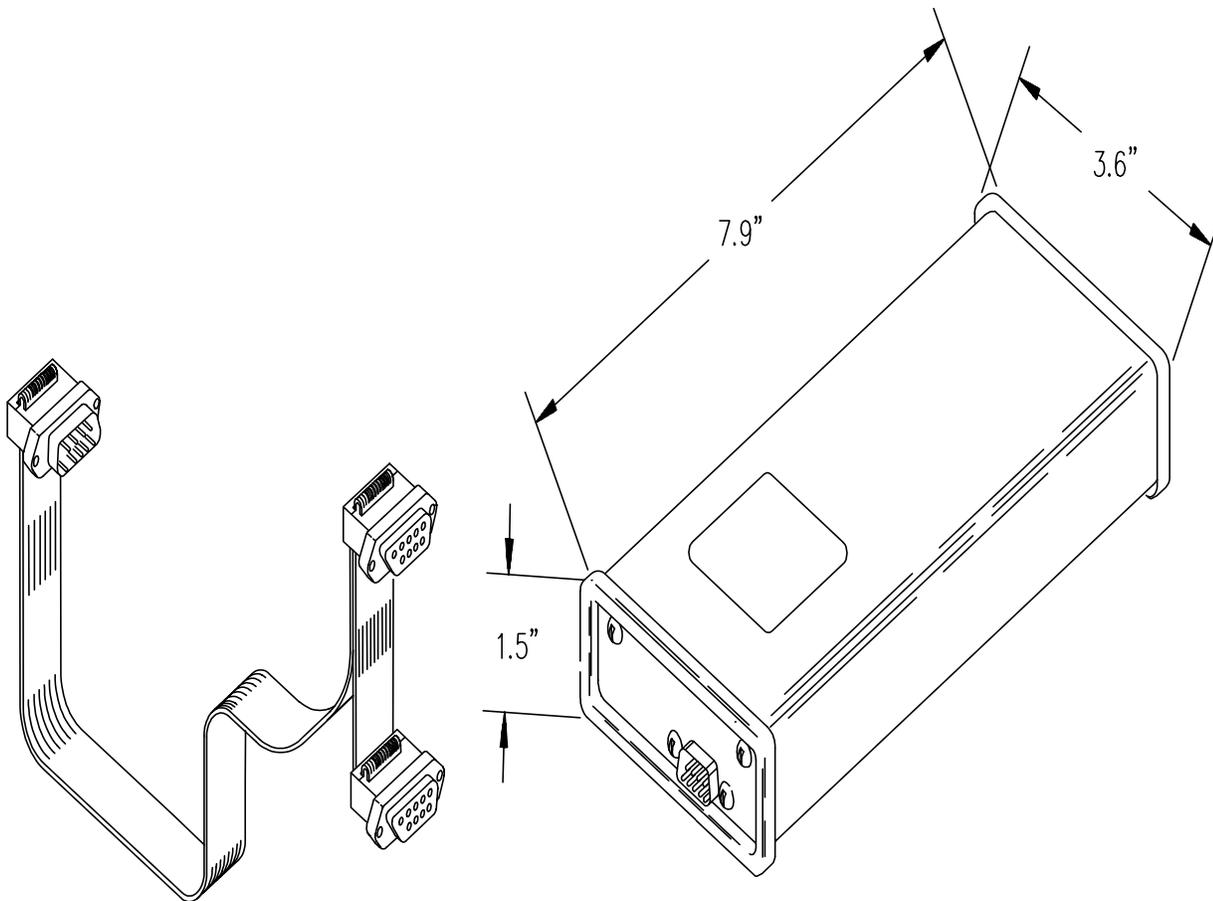


FIGURE 1.2-1. Storage Module and SC12 Cable

### 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.

## SECTION 1. SM192/716 STORAGE MODULE OVERVIEW

Expected Battery Life	SM192	SM716
@ 25C	about 10 yrs.	about 6 yrs.
@ 50C	about 3 yrs.	about 2 yrs.
@ -25C	about 6 yrs.	about 4 yrs.

**NOTE:** These figures apply when:

1. The SM is not connected to a primary power supply (such as a datalogger), and
2. The SM is continuously at one of the above temperatures.

Meeting these conditions is unlikely in normal operation.

### 1.4 FUNCTION

The SM192 and SM716 Storage Modules provide battery-backed, solid-state, RAM data storage to supplement the storage capacity in a datalogger. The Storage Modules can store data from all Campbell Scientific, Inc. dataloggers and from other devices which properly enable them.

All Storage Module operations occur in one of three basic operational modes:

1. Interactive communication with datalogger for data and program storage and retrieval.
2. The Printer Enable Method for data storage with the 21X and CR7 with older PROMS, the CR21, the DSP4, and non-datalogger devices.
3. The Telecommunications Command State for data retrieval and other miscellaneous operations.

#### 1.4.1 OPERATION WITH CURRENT CR10, 21X, AND CR7

Storage Module operations with the current versions of the CR10, 21X, and CR7 are accomplished through the use of an interactive command structure with handshaking (Figure 1.4-1). If the SM is not connected, the datalogger will not send data. The datalogger detects when the SM is connected, and sends the backlogged data the next time it executes Instruction 96.

The SM can store data either under program control (Instruction 96) or under user control (\*8 Mode with CR10, \*9 Mode with 21X and CR7). Datalogger programs can be stored in and retrieved from the Storage Module using the \*D Mode. The CR10 \*9 Mode enables the user to directly execute commands such as: check battery, change address, view data, etc. (Appendix A).

#### 1.4.2 OPERATION WITH DATALOGGERS WITH OLDER PROMS AND NON-DATALOGGER DEVICES (PRINTER ENABLE METHOD)

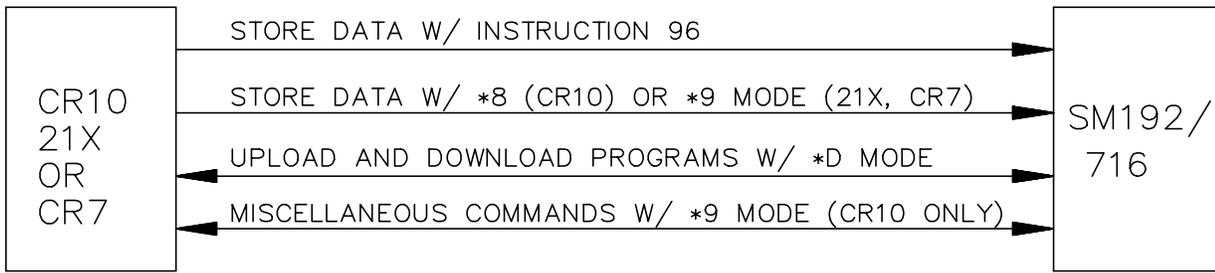
In the Printer Enable Method (Figure 1.4-2), the Storage Module stores all data received (on pin 9) while the printer enable line (pin 6) is high. The Storage Module baud rate must be set to match that of the sending device (Section 1.4.5). The datalogger cannot detect if the SM is connected. Data are sent whether or not the SM is connected.

Data can be stored in the SM under program control (Instruction 96 or \*4) or under user control (\*9 Mode). Operations with the CR21, the DSP4 Heads Up Display and with non-datalogger devices (Appendix C) are also accomplished through the Printer Enable Method (Section 3).

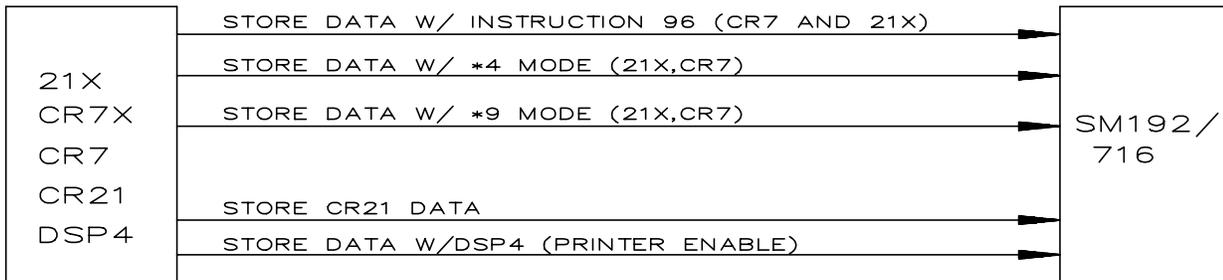
#### 1.4.3 DATA RETRIEVAL/TELECOMMUNICATION COMMAND STATE

Data retrieval and other interactive operations with a computer take place in the Telecommunications command state (Figure 1.4-3). TELCOM (PC208 software) uses the Telecommunications Commands for data retrieval, data storage, storage and retrieval of datalogger programs, SM software switch setting, status checks, battery tests and other functions (Section 5). The commands used by TELCOM are described in Appendix D.

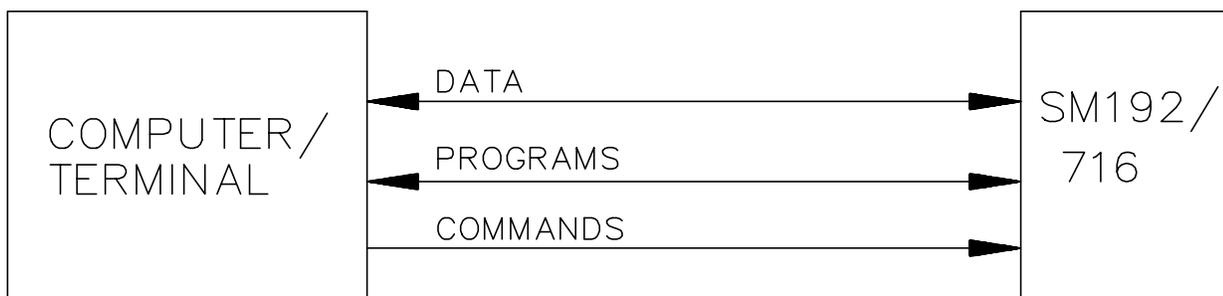
**SECTION 1. SM192/716 STORAGE MODULE OVERVIEW**



**Figure 1.4-1 Operation with Current CR10, 21X, and CR7**



**Figure 1.4-2 Printer Enable Operations**



**Figure 1.4-3 Telecommunications Command State**

### 1.4.4 MEMORY CONFIGURATION

The Storage Module's memory can be configured as either Fill and Stop or Ring style memory. In the Fill and Stop configuration, the Storage Module stops accepting data when its memory is full. No data write-over occurs. In the Ring Memory configuration (the default setting), new data continue to be stored even after the memory is full. New data are written over the oldest data in the memory. The Storage Module's memory configuration can be changed using SMCOM or with Command 4 in the CR10 \*9 Mode.

### 1.4.5 BAUD RATES

When storing CR7, CR10, and 21X data, the Storage Module is set for its default baud rate of 76,800/9600; baud rate matching is automatic and requires no user intervention. Data transfer takes place at 9600 baud.

With other devices, the baud rates of the device and the Storage Module must be matched by the user. Storage Module choices are: 300, 1200, 9600, 76,800, and 76,800/9600 (Section 4.1). With the CR21, the SM must be set to 300 baud. When using the Telecommunications Commands, sending several carriage returns will cause the Storage Module to match the computer's baud rate (300, 1200, or 9600 baud).

### 1.4.6 FILE MARK

File Marks are used to separate data in the Storage Module. A File Mark is automatically placed in the SM's memory when the SM is connected to a power source (datalogger or retrieval interface) or when the datalogger compiles a program containing Instruction 96. For example, if the user has retrieved data from one datalogger, disconnects the SM and then connects it to a second datalogger, a File Mark is placed in the data when the second datalogger is connected. This mark follows the data from the first datalogger and precedes the data from the second.

A File Mark can be placed in the data from SMCOM or the CR10 \*9 Mode Command 3. The Storage Module will not store back to back file marks; if a File Mark is the last thing stored in memory, a second file mark will not be stored.

## 1.5 QUICK START-UP PROCEDURE

This Section describes the basics of storing and retrieving of datalogger data. These operations are discussed in detail in Sections 3, 4, and 5 of this manual.

### 1.5.1 PREPARATION

Before putting the Storage Module into service, connect it to a computer and use SMCOM to reset the SM and test its battery.

If it is not possible to use a PC compatible computer and SMCOM, the user must establish communication between the SM, the available computer, or terminal (Section 5) and reset the SM using the Telecommunications Commands (Appendix D) or use the \*9 Mode in the CR10 (Appendix A).

### 1.5.2 PROGRAM THE DATALOGGER TO SEND DATA TO THE SM

Instruction 96 is used in the datalogger program to send data to the Storage Module. The SM is connected to the datalogger with the SC12 cable. Each time Instruction 96 is executed, Final Storage data accumulated since the last transfer are sent to the Storage Module.

For the CR7 and 21X WITHOUT Instruction 96 the \*4 Mode is used to enable output to a printer. The CR21 automatically outputs printer data at 300 baud each time data is sent to Final Storage.

The DSP4 outputs printer data when the printer function is enabled.

### 1.5.3 MANUAL DUMP

The \*8 Mode in the CR10 or the \*9 Mode in the 21X and CR7 can be used to transfer data to the SM under keyboard control. All of the above options are discussed in greater detail in Section 4.

### 1.5.4 DATA RETRIEVAL

The simplest method of retrieving data from the Storage Module is to use SMCOM. SMCOM is contained in Campbell Scientific's PC208 software. It is written for IBM PC/XT/AT/PS-2's and compatibles. If the user has another type of computer, the SM telecommunications commands can be used to retrieve the data. Data retrieval (including interface devices) is discussed in Section 5.

## SECTION 2. STORING DATA FROM CR10, 21X, AND CR7

*This section covers data storage from the CR10 and from the 21X and CR7 with current software. 21X Microloggers released after February 1989, and CR7 dataloggers released after August 1991, contain the OSX and OS7 Series PROMS which support two major SM functions that earlier versions do not:*

- 1. Datalogger programs can be stored and retrieved in the \*D Mode.*
- 2. Instruction 96, transfer of binary Final Storage data to the SM, will not send data until the SM is connected. In older versions of the 21X and CR7 PROMS, the Instruction 96 transfer is simply an ASCII printer dump. Data are sent regardless of whether the SM is or is not connected.*

*See Section 3 for earlier PROM versions of the 21X and CR7.*

### 2.1 INSTRUCTION 96 -- OUTPUT DATA UNDER PROGRAM CONTROL

Instruction 96 is used to send Final Storage data to a Storage Module under program control. Instruction 96 should be entered into the program table following the Output Processing Instructions. Instruction 96 should be executed each time the table is executed (i.e. the program should not branch around or skip over Instruction 96).

**Instruction:** 96  
**Parameter:** 01: 7X - CR10 option 7X sends the data to the Storage Module with address "X".  
X = 1 - 8  
30 - 21X and CR7 use option code 30 to send data to Storage Module.

When output to the Storage Module is enabled with Instruction 96, the Storage Module(s) may either be left on-site and periodically exchanged, or brought to the site to milk the data from the datalogger.

The datalogger is capable of recognizing whether or not the Storage Module is connected. Each time Instruction 96 is executed and there is data to output, the datalogger checks for the presence of the Storage Module. If one is not present, no data are sent; the datalogger continues its other operations without advancing its Storage Module Pointer.

When the user finally does connect the Storage Module to the datalogger, two things happen:

1. Immediately upon connection, a File Mark is placed in the Storage Module Memory at the position of the Module's Storage Reference Pointer (SRP). The File Mark allows the operator to distinguish blocks of data from different dataloggers or from different visits to the field.
2. During the next execution of Instruction 96, the datalogger recognizes that the Storage Module is present, outputs all of the data stored since the previous output, and updates the Storage Module Pointer to the DSP location. This transfer occurs in binary at 9600 baud.

Under optimum conditions, the datalogger outputs 480 low resolution data points per second; a full 64K CR10 takes over one minute to complete the data transfer. If the execution interval is less than one minute, the data transfer will be interrupted and will take longer to complete.

## SECTION 2. STORING DATA FROM CR10, 21X, AND CR7

**CAUTION:** Be sure to complete the data transfer *before* making any changes in the datalogger program. Changing a program and then compiling it will advance the datalogger's Storage Module Pointer to the position of the DSP. If this is done before connecting the Storage Module to allow the datalogger to transfer the data, the old data will *NOT* be automatically transferred to the Storage Module. Also, the Instruction 96 data transfer will not take place while the datalogger is in communication with another device, e.g. a computer or an active CR10KD.

To be certain that the SM has been connected during an execution of Instruction 96, the user can:

1. Leave the SM connected longer than the execution interval of the Program Table that includes Instruction 96, *or*
2. Use the SC90 9 pin Serial Line Monitor. The SC90 contains an LED which lights during data transmission. The user connects the SM to the datalogger with the SC90 on the line and waits for the LED to light. WHEN THE LED GOES OFF, data transfer is complete and the SM can be disconnected.

To avoid data loss, data must be retrieved before the datalogger's ring memory wraps around and begins to write over the oldest data.

### 2.1.1 MULTIPLE STORAGE MODULES WITH CR10

The CR10 uses synchronous addressing to communicate with multiple peripherals (CR10 Manual, Sections 6.2 and 6.6). Up to 8 Storage Modules can be connected to a single CR10. Each is assigned an address, 1 through 8. Addresses are assigned in the \*9 Mode (Command 10), or in the Telecommunications Command State (the L Command). These are discussed in Appendixes A and D of this manual, respectively. The default Storage Module address on reset (as sent from the factory) is #1. This will be sufficient for most users.

At a given time, only one Storage Module will execute commands directed to SM #1. If there is no Storage Module with address #1, the Storage Module with the lowest numbered address will execute the commands sent to SM #1. Commands directed to addresses other than #1 can be executed *ONLY* by the SM with the correct address. Do *NOT* connect Storage Modules with the same address to a CR10 at the same time.

If only one Storage Module is used with the CR10, its address should be #1. When multiple Storage Modules are used in a CR10 system, each should be assigned its own address and set to Fill and Stop. Instruction 96 is used in the CR10 program to send data to Storage Module address #1. The lowest numbered Storage Module will fill up first, followed by the next lowest address, and so on. Alternatively, data can be sent to specific Storage Modules via direct addressing by the CR10 (using a separate Instruction 96 for each SM).

Instruction 96 can be entered two or more times in a program to sort data to specific Storage Modules. Three important considerations are:

1. All Storage Modules to be used must be connected to the CR10 with SC12 cables.
2. Time must be allowed between the execution of multiple 96 commands to Storage Modules. Add 5 msec to the time it takes to store the number of bytes to be transmitted (1 msec per byte) before executing the next Instruction 96 which addresses a different Storage Module.
3. Use of the keyboard or telecommunications during the execution of the Instruction 96 may backlog the data to be sent to the Storage Modules. In this event, during the next execution of Instruction 96 all backlogged data will be sent to the Storage Module addressed in that instruction.

## SECTION 2. STORING DATA FROM CR10, 21X, AND CR7

### 2.1.2 USE OF TWO STORAGE MODULES WITH 21X OR CR7

For large volumes of data, two SMs can be connected to the 21X or CR7. Use SMCOM to set one SM as Fill and Stop, and the other as Ring Memory.

## 2.2 \*8 AND \*9 MODE -- KEYBOARD INITIATED DATA TRANSFER

### 2.2.1 \*8 MODE - CR10

The \*8 Mode is used to manually initiate a Final Storage Data transfer from the CR10 to an external peripheral. Data transfer rate is 9600 baud. Refer to the discussion of the \*8 Mode (Section 4.2) in the CR10 Operator's Manual for full details.

### 2.2.2 \*9 MODE - 21X OR CR7

The F\*9 Mode in the 21X and CR7 dataloggers is used to transfer a specified block of data from Final Storage to the Storage Module. Consult the appropriate datalogger manual for details. This function is different from the \*9 Mode in the CR10.

## 2.3 STORING BURST MEASUREMENT DATA FROM THE CR10 OR 21X

The BURST Measurement is a special datalogger instruction used to make high rate analog voltage measurements. Two options are available for data retrieval with this instruction: 1) Data are stored in datalogger Input Storage Locations or 2) Raw data are sent out the datalogger serial port. In the second case, the Storage Module can capture the data at 76,800 baud.

BURST data is output by the datalogger in a unique format which includes calibration measurements at the beginning and end of the series of measurements. SPLIT will translate this BURST data. (Section 4.3.1 in the PC208 manual.)

### 2.3.1 BURST DATA WITH CR10

The CR10 requires a special PROM to use the BURST Measurement Instruction (23). Keying a "3" in the second digit from the right in Parameter 04 of Instruction 23 selects the Storage Module as the destination of the BURST data. All SM's connected should be set to Fill and Stop and have consecutive addresses. The BURST data will be sent to the first available (lowest addressed) Storage Module, followed by the next lowest addressed, and so on.

### 2.3.2 BURST DATA WITH 21X

To send BURST Measurement (Instruction 23) data to the Storage Module from the 21X, set the Destination option (Parameter 04) to 2 for Serial port output at 76,800 baud.

## SECTION 3. THE PRINTER ENABLE METHOD OF DATA STORAGE

Data from the 21X and CR7 with PROMS older than the OSX and OX7 series PROMS and from the CR21 and DSP4 are stored in the Storage Module via the Printer Enable Method, i.e., data on the TD line (pin 9) are stored while the PE line (pin 6) is high. This is also the method of data storage with non-datalogger devices.

The Storage Module defaults to the Printer Enable Method each time it is powered up by 5 VDC applied to Pin 1 of its 9-pin "D" connector. Up to two Storage Modules can be connected to the 21X, CR7, or CR21 dataloggers at one time. If two are connected, one should be set to Fill and Stop, and the other configured as Ring Memory. Storage Module-to-Storage Module dumps are not possible with the Printer Enable Method.

**NOTE:** If the PE line is high when power is applied, the SM will not store data until the next time PE goes high. Also, if power to the SM is interrupted during a transmission, data since the last time PE went high will be lost.

### 3.1 BAUD RATES

In the Printer Enable Method, the user must ensure that the baud rates of the Storage Module and the datalogger are matched. The CR21 has a fixed baud rate of 300. Other Campbell Scientific Inc. dataloggers have selectable baud rates.

The Storage Module baud rate is software selectable, and may be set using SMCOM. Data can be sent to the Storage Module at baud rates of 300, 1200, 9600, 76,800, and 76,800-with-9600-fall back.

The 76,800-with-9600-fall back configuration is the default setting after an SM reset. When in this setting, the SM can automatically change from capturing data at 76,800 baud to capturing data at 9600 baud. This feature allows the use of two different baud rates in a single program. The practical application of this would be in a program which generates both BURST data at 76,800 baud and "normal" data at 9600 baud.

Baud rate errors, i.e., baud rate mismatches between the datalogger and the Storage Module, cause the Storage Module to increment its error counter and enter a low power standby state.

### 3.2 STORING DATA FROM THE 21X AND CR7 (ALL VERSIONS PRIOR TO OSX AND OS7 RELEASE)

Instruction 96 is the recommended method for the CR7 and the 21X with Extended Software. The \*4 Mode can also be used for this data transfer but Instruction 96 is more efficient. For

large volumes of data two SMs can be connected to the datalogger. Use SMCOM to set one as Fill and Stop, and the other as Ring Memory.

There are two additional methods of outputting printer data to the SM from the 21X and CR7:

1. The \*4 Mode
2. The \*9 Mode (**NOTE:** This \*9 Mode is different from the \*9 Mode in either the CR10 or CR21).

**CAUTION:** Do not use Instruction 96 (ASCII option), \*4 or \*9 to output arrays with more than 100 elements if the Storage Module is configured to encode the data. The 101st, 201st, 301st, etc., data points will each be interpreted as a start-of-array and the data following these points will be meaningless.

Alternatives:

1. Program the datalogger such that no output array has more than 100 elements.
2. Use Instruction 96 (CR7X and Extended 21X) to output the data in Final Storage Format so no encoding takes place.
3. Disable the encode option and store data as is, in ASCII. However, this uses 6 times as much memory as Final Storage Format.

## SECTION 3. THE PRINTER ENABLE METHOD OF DATA STORAGE

### 3.2.1 INSTRUCTION 96 - OUTPUT UNDER PROGRAM CONTROL

Instruction 96, available in the CR7X and in the Extended Software PROMs for the earlier versions of the 21X, is used to send Final Storage data to the Storage Module under program control. Instruction 96 should follow the Output Processing Instructions in the program table. Consult the datalogger manual for details about using Instruction 96. Do NOT use both the \*4 Mode and Instruction 96 to activate a device in a datalogger program.

**Instruction:** 96

**Parameter:** 01:22

**Explanation:** Option 22 selects binary printer output at 9600 baud. The left digit specifies the device option and the right, the baud rate. Refer to the datalogger manual for details.

### 3.2.2 \*4 MODE - OUTPUT DEVICE ENABLE

The \*4 Mode is used to enable the output of Final Storage data to a printer. The Storage Module will capture this printer output.

Select option "X1" in window 1, and set the baud rate at 9600 (option 02) in window 2 (to match the Storage Module's default setting). Data are written to the Storage Module each time data are sent to Final Storage.

### 3.2.3 \*9 MODE - KEYBOARD INITIATED DATA TRANSFER

The \*9 Mode in the 21X and CR7 dataloggers is used to transfer a specified block of data from Final Storage to the Storage Module. Consult the appropriate datalogger manual for details. This function is different from the \*9 Mode in the CR10.

**NOTE:** The baud rate settings for the datalogger (set in the \*4 Mode) and for the Storage Module (set from SMCOM) must be compatible.

### 3.3 STORING DATA FROM THE CR21

Each time the CR21 outputs data to Final Storage, the data are also sent (in ASCII) to pin 9, the TD (transmit data) line, at 300 baud. So, Final Storage data are written to the Storage Module automatically when it is properly configured and

connected to the CR21. Use SCOM to set the Storage Module baud rate to 300 to collect CR21 data. The Encode/Decode switch should be set to Encode (default). To backlog CR21 data while it is temporarily disconnected from the Storage Module, enter the \*9 Mode (in the CR21). When the Storage Module has been re-connected, re-enter the \*0 Mode. Refer to the CR21 Manual for details.

## 3.4 SPECIAL DATA STORAGE OPERATIONS

### 3.4.1 DSP4 HEADS UP DISPLAY

In addition to real-time monitoring of datalogger measurements, the DSP4 Heads Up Display can be used with the CR10, 21X, and the CR7 dataloggers to store and retrieve data and programs. With the DSP4 printer function enabled, datalogger Final Storage data can be sent to the Storage Module in ASCII at either 300 or 1200 baud or at 9600 baud in Final Storage Format. Refer to the DSP4 Instruction Manual for more details regarding the Printer Options.

### 3.4.2 STORING BURST MEASUREMENT DATA FROM THE 21X

The BURST Measurement is a special datalogger instruction available in an optional software PROM to make high rate analog voltage measurements. Two options are available for data retrieval with this instruction: 1) Data are stored in datalogger Input Storage Locations or 2) Raw data are sent out the datalogger serial port. In the second case, the Storage Module can capture data at 76,800 baud. This can occur in the default baud rate setting or the Switch settings can be configured to 76,800 baud (L command, Appendix D).

When the BURST Measurement (Instruction 23) is used with the 21X, select the Destination (Parameter 04) option as 2 for Serial port output at 76,800 baud to send data to the Storage Module. BURST data is output by the datalogger in a unique format which includes calibration measurements at the beginning and end of the series of measurements. SPLIT will translate this BURST data (Section 4.3.1 in the PC208 Manual).

## SECTION 4. STORAGE MODULE MEMORY AND DATA ENCODING

### 4.1 FILE MARKS

File Marks are used to separate data in the Storage Module. A File Mark is automatically placed in the SM's memory when the SM is connected to a power source (datalogger or retrieval interface) or when the datalogger compiles a program containing Instruction 96. For example, if the user has retrieved data from one datalogger, disconnects the SM and then connects it to a second datalogger, a File Mark is placed in the data when the second datalogger is connected. This mark follows the data from the first datalogger and precedes the data from the second.

A File Mark can be placed in the data from SMCOM or the CR10 \*9 Mode Command 3. The Storage Module will not store back to back file marks; if a File Mark is the last thing stored in memory, a second file mark will not be stored.

### 4.2 POINTERS

The SM has several internal pointers which are used to keep track of data for both storage and retrieval operations.

The **Display Location Pointer (DLP)** is used to display Storage Module data. Ordinarily, when the SM is connected to a datalogger, the DLP will be at the beginning of the current file. The DLP can be positioned anywhere within the data, using the nnnnnnG command (Appendix D). Data can then be "dumped" to the user device using one of the appropriate commands (nnnnC, nnnnD, or nnnnF). The dump will begin at the DLP and continue until it reaches the **Storage Reference Pointer (SRP)** or until the next File Mark.

The **Storage Reference Pointer (SRP)**, indicates the next location to be written to in the Storage Module. If not changed by user commands, it will always be at the end of data in the Storage Module. It can be moved through use of the 3H command (Appendix D), however, this can be dangerous since the next data written to the Storage Module will write over data at the SRP. Typically, the 3H command is used only during testing.

The **Dump Pointer** is an internal Storage Module pointer used for keeping track of the current start-of-dump for Storage Module-to-Storage Module data dumps and for the data retrieval options of the SMCOM program. The user can move the Dump Pointer with the 4H command (Appendix D). The Dump Pointer marks the end point of the previous data dump and thus the start-of-dump location for the next dump. Moving this pointer "loses" this reference point, which can cause problems with subsequent dumps.

### 4.3 DATA FORMAT AND INPUT BUFFER

Data can be stored in either the Campbell Scientific Inc. Final Storage Format (binary) or in the Printable ASCII format. The default setting of the Storage Module is to encode ASCII data into binary; one low resolution data point requires two bytes. Storing ASCII data requires 10 bytes per data point. The encode option can be disabled by a software switch (see Telecommunications Commands, Appendix D). Each asynchronous byte is 8-bits plus 1 start and 1 stop bit. The idle state (stop bit) is 0 VDC. RS-232C logic levels, if applied, are clipped to 0 and 5 VDC.

The Storage Module has a 2800 byte Input Storage buffer. Data transmissions of any length can be stored at 9600 baud (or slower), allowing only 5 msec between transmissions for "housekeeping" tasks. A transmission is defined here as all data sent to the Storage Module at one time while PE is high.

When sending data at 76,800 baud, a continuous transmission must not be larger than about 7500 bytes, or the input buffer will be overrun and data will be lost. In addition, if a second transmission occurs before the previous transmission's data have been processed and stored, all data in the previous *and* the current transmission will be lost.

The maximum possible data storage rate is approximately 5600 bytes each second (2800 low resolution data points). Transmissions of data at 76,800 baud must be broken up into segments small enough to stay within this limit. Processing time required by the Storage Module for each byte is 210 usec while

## SECTION 4. STORAGE MODULE MEMORY AND DATA ENCODING

receiving data plus 110 usec for each byte remaining in the input buffer after transmission is complete. As an example, it takes 130 msec to transmit 1000 bytes at 76,800 baud. The Storage Module has time to store 619 bytes (130 msec divided by 210 usec/byte) before the transmission has ended. That will leave 381 bytes in the input buffer when the PE line drops. The SM will take 42 msec (381 bytes times 110 usec/byte) plus 5 msec overhead to process and store the remaining bytes. This results in a total of 177 msec to receive and store 1000 bytes at 76,800 baud.

Bytes from the Storage Module input buffer are permanently stored in byte-pairs. The Campbell Scientific Inc. dataloggers' Final Storage Format data are always grouped in pairs. Printable ASCII and general purpose data transmissions may have a single byte left in the input buffer when the PE line drops. In this case, the byte is left in the input buffer until another transmission occurs. It will be paired with the first byte and stored in permanent storage with the current data.

If a single byte remains in the input buffer when power is disconnected from the Storage Module, it will be stored with a null character (ASCII Code 0) as the second byte the next time external power is applied. A File Mark is stored at power-up. If there is an added null character, it will be placed before a File Mark.

## SECTION 5. DATA RETRIEVAL

*Data retrieval is accomplished on PCs using SMCOM. Other computers require a software program which makes use of the Storage Module Telecommunications Commands (Appendix D). This process requires both a hardware interface and a software program.*

### 5.1 HARDWARE

There are four interfaces which enable communication between a computer and the Storage Module:

1. The SC532 Peripheral to RS232 Interface
2. The PC201 Tape Read, Clock, Serial I/O Card (requires SC209 cable)
3. The CR10 (not possible with other dataloggers)
4. The SM232A Storage Module RS232 Interface

The PC201 Card functions *ONLY* with IBM PC/XT/AT's and compatibles. The SC532 can function with any computer having an RS232 port BUT both the PC201 and the SC532 require a software program to raise the CLK/HS and PE lines (by raising pins 20 and 4, respectively, on the computer) in order to activate the SM (Section 5.2). SMCOM program performs this function automatically. The SM232A functions with any RS232 computer or terminal which raises the DTR line when powered up.

#### 5.1.1 SC532

A standard 25-pin ribbon cable links the SC532 to the computer's 25-pin serial port. If the computer has a 9-pin serial port, a 9-pin to 25-pin adaptor cable is required. Campbell Scientific Inc.'s SC12 9-pin ribbon cable links the Storage Module to the SC532 (Figure 5.1-1).

The SC532 requires 12 VDC (nominal) which is usually furnished by plugging the AC/DC adaptor

unit into a standard 120 VAC outlet. The use of battery power is possible and is described in the SC532 manual.

#### 5.1.2 SC209/PC201

The SC209 - Storage Module connector cable (available from Campbell Scientific Inc.) links the 9-pin port on the Storage Module to the 34 pin connector on the PC201 card (Figure 5.1-2).

#### 5.1.3 VIA CR10

The Storage Module is linked to the CR10 by the SC12 cable. SMCOM establishes communication between the computer and the CR10 over direct cable or telecommunication link (Figure 5.1-3).

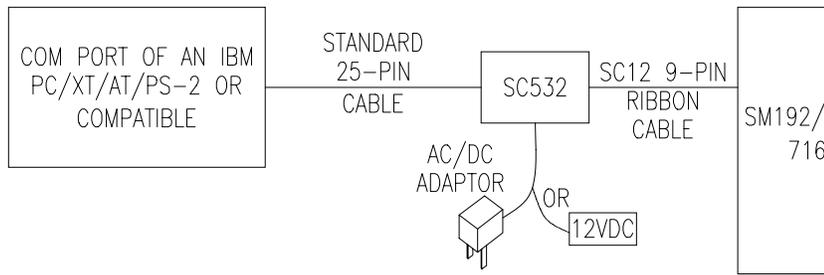
#### 5.1.4 SM232A

The AC adaptor is plugged into a 120 VAC outlet. The serial port of the terminal/computer is connected to the "TO TERMINAL" connector on the SM232A with a 25-pin cable. An SC12 9-pin ribbon cable, links the Storage Module to the "TO STORAGE MODULE" connector on the SM232A. The central toggle switch is placed in the "DATA TO TERMINAL AND MODEM" position; the other toggle switch in the "TRANSPARENT" position. (Figure 5.1-4).

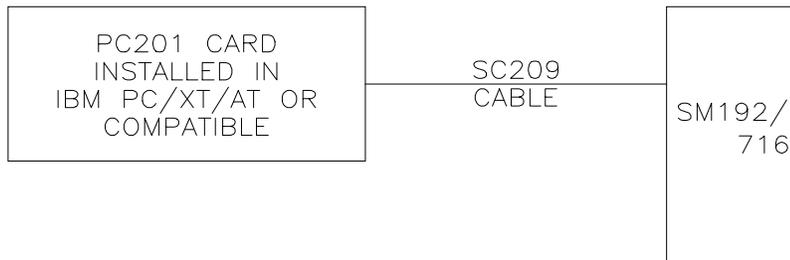
### 5.2 SOFTWARE

SMCOM (PC208 Software) is used with IBM PC/XT/AT/PS-2 or compatibles. It functions with any of the hardware interfaces listed in Section 5.1. SMCOM automates the storage and retrieval of data and programs and also has a terminal emulator for the manual execution of telecommunications commands.

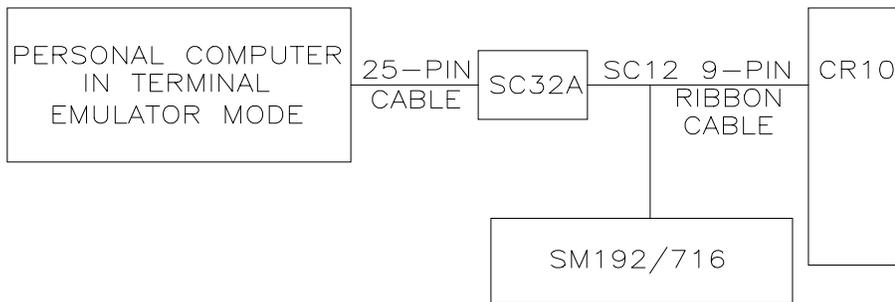
**SECTION 5. DATA RETRIEVAL**



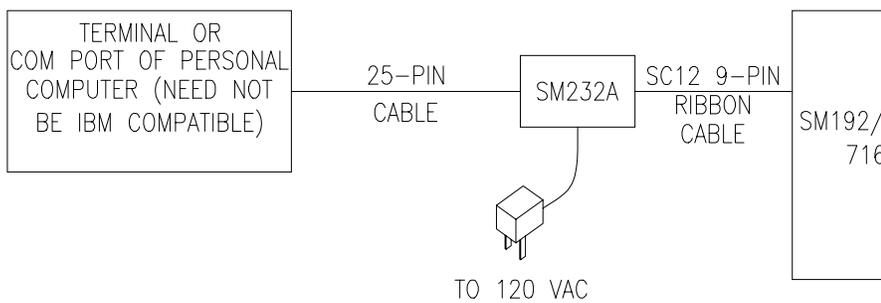
**5.1-1 Storage Module Connected With SC532**



**5.1-2 Storage Module Connected to PC201 Card**



**5.1-3 Communication Via the CR10**



**5.1-4 Storage Module Connected With SM232A**

Complete details on the operation of SMCOM are contained in the PC208 manual.

When using a computer other than an IBM PC/XT/AT/PS-2 or compatible, the SM232A is the recommended interface. It has a manually operated switch to raise the Storage Module's PE and CLK/HS lines. Thus the user's program doesn't need to raise pins 4 and 20 on the computer (as is necessary with the SC532 Interface). With the SM232A and a commercially available terminal emulator program the user may manually execute the telecommunications commands to retrieve data to disk. However, when this method is used to retrieve large data files, there is a risk of overrunning the computer's input buffer and losing data. To prevent this, the user can do one of the following.

1. Select a terminal emulator program which has X-ON, X-OFF capability.
2. Use the C, D or F command to have the Storage Module send the data in blocks small enough to avoid this problem.
3. Write a program which requests the data in blocks small enough to avoid the problem.
4. Select a baud rate slow enough for the computer to keep up with the data.

### 5.3 DATA RETRIEVAL STEPS

#### 5.3.1 IBM PC/XT/AT/PS-2'S AND COMPATIBLES

- a. With IBM PC/XT/AT's and compatibles, use either the PC201, SC532 or SM232A. The IBM PS-2 will not accept the PC201 Card but is compatible with the SC532.
- b. Make the appropriate connections (Section 5.1).
- c. Execute SMCOM (PC208 manual).

#### 5.3.2 NON-IBM COMPATIBLES

The following instructions apply to a configuration using a terminal emulator program and the SM232A. It is assumed for this example

that the terminal emulator software has X-ON, X-OFF capability.

1. Make the connections between the SM232A and the computer/terminal as shown in 5.1-4. Refer to the SM232A Instruction Manual for further details. Enable X-ON, X-OFF in the terminal emulator.
2. Place the toggle switch on the SM232A in the TRANSPARENT position. This switch should be left in this position until the Data Terminal Ready (DTR) line of the terminal/computer is raised high. In the case of a terminal, this happens when the terminal is powered, connected to the SM232A, and set to receive 8-bit (plus 1 start / 1 stop bit) data at a valid baud rate. In a computer, executing a terminal emulator program drives DTR high under software control.
3. Once DTR is high, move the switch from TRANSPARENT to UNLOAD (raising CLK/HS and enabling PE), which activates the Storage Module.
4. Send several carriage returns to synchronize baud rates and receive the Storage Module prompt: CR, LF, %.
5. Type in the appropriate telecommunication commands (Appendix D) to collect the desired data file(s). (Prior to sending the last carriage return to execute the C, D, or F command, place the terminal emulator in the receive a file mode.)

The telecommunications commands are used here to:

- a. Position the DLP (Display Location Pointer) at the desired beginning point of the data transfer (one of the G commands).
- b. Collect the desired file(s) using the C, D, or F command.

## SECTION 5. DATA RETRIEVAL

6. Send the last carriage return to execute the data retrieval.

The same fundamental procedures used in a manually executed data transfer form the basis of SMCOM's data retrieval options. They can also be employed in a user-written program to automate data retrieval for non-IBM compatible computers.

Appendix B contains a sample flow diagram. It can serve as the basis for a user-written data retrieval program.

### 5.3.3 CR10 TELECOMMUNICATIONS INTERFACE

Make the connections (Figure 5.1.3) and establish communications with the CR10. Send the command "XM,CR" to the CR10 (where X is the Storage Module address 1..8). If the connections are correctly made and the Storage Module is properly addressed, it will send back "CR, LF, %." If the attempt to establish communications fails, the CR10 will return "\*\*".

Once the "%" is received, the Storage Module telecommunications commands (Appendix D) may be used as described above. SMCOM may be used when the connection to the CR10 is through the SC32A Optically Isolated R5232 Interface.

## SECTION 6. STORING AND RETRIEVING DATALOGGER PROGRAMS

CR10, 21X, and CR7 programs can be uploaded and downloaded between the datalogger and the Storage Module in the \*D Mode. (OSX and OS7 series PROMS required for 21X and CR7.) SMCOM (or telecommunications commands) allows programs to be transferred between the computer and the SM. Using these capabilities, a program can be developed in the computer, stored in the SM, and then carried to the field and downloaded to the DATALOGGERS.

The SM can store up to 8 programs. They are numbered 1 through 8 and are protected against being written over by data.

With the release of the OS series PROMS (OS10, OSX, OS7), the DATALOGGERS were given the capability of automatically loading program 8 if the Storage Module were connected to the datalogger when the datalogger is powered on.

21X and CR7 PROMS prior to the current OSX and OS7 versions do not have the capability to store and directly load programs from the SM. Programs may be transferred via DSP4 Heads Up Display (Section 6.3).

### 6.1 \*D MODE - WITH DATALOGGER

The \*D Mode is used to transfer programs between the datalogger and Storage Module. The commands in Table 6.1-1 are used to save, retrieve, or clear programs from the Storage Module. See the appropriate datalogger manual for further details on the \*D Mode.

**TABLE 6.1-1 \*D Mode Keyboard Commands**

Key	Display	Description
*D	13:00	Enter *D Mode
7XA	7X:00	Address Storage Module X
1YA		Store Program in SM as Y(Y=1..8)
2YA		Load Program Y from SM
3YA		Erase Program Y from SM
	13:0000	command completed

The program is stored, retrieved, or erased by referring to a program number (1...8) in the Storage Module. If a program to be retrieved does not exist in the Storage Module, the error message "E99" will be displayed. After a program is erased the space becomes available for data storage.

The 21X or CR7 must have only one Storage Module connected when storing and retrieving programs.

### 6.2 SMCOM - WITH COMPUTER

SMCOM has options to automatically store, retrieve, and erase datalogger programs. If you cannot use SMCOM, the Storage Module telecommunications commands are described in Appendix D.

### 6.3 USING DSP4 HEADS UP DISPLAY TO STORE AND RETRIEVE DATALOGGER PROGRAMS

In addition to real-time monitoring of datalogger measurements, the DSP4 Heads Up Display can be used with the CR10, 21X (including pre-OSX versions with Extended Software) and the CR7 dataloggers to store and retrieve data and programs. The DSP4 Load and Save program commands will allow loading and saving CR10, 21X, and CR7 datalogger programs in the Storage Module.

The DSP4 Flag buttons 1...8 will execute the Load or Save command using the Storage Module as the medium. Up to 8 datalogger programs can be saved at one time in the Storage Module. The program to be saved or loaded is selected by pressing the appropriate push button switch. Refer to the DSP4 Instruction Manual for more details.

## APPENDIX A. CR10 \*9 MODE -- STORAGE MODULE COMMANDS

The CR10 \*9 Mode is used to issue commands to the Storage Module using the CR10KD keyboard/display or a terminal/computer. These "commands" are analogous in many respects to the datalogger functional (\*) Modes. For example, command 7 is used to review stored data, and 8 is used to transfer data between two Storage Modules connected to a CR10.

The key sequences for the \*9 commands have a generalized format. Using Command #1 as an example:

After about 1 minute with the SM192 or 4 minutes with the SM716, the number of good RAM chips will be displayed:

01:06	6 RAM chips in SM192
01:22	22 RAM chips in SM716

Most commands have at least one response. Advance through the responses and return to 9X:00 (ready to accept another \*9 command) by keying "A". Exit the \*9 Mode by keying "\*" and the character of the mode you want to switch to ("\*0" to go to the log mode).

<u>KEY</u>	<u>DISPLAY</u>	<u>EXPLANATION</u>
*9	09:01	Enter *9 Mode
X	09:X	Key in the address (x=1 through 8) of the SM to be given the command.
A	9X:00	Enter the SM address, x; ready to accept a command.
1	9X:1	Key in Command #1, Reset SM.
A	01:0000	Enter Command #1. Ready for instruction to effect Command #1.
248	01:248	Key in 248 to effect Command #1.
A	01:	Execute SM Reset.

**TABLE A.1. \*9 Commands for Storage Module**

<u>COMMAND</u>	<u>DISPLAY</u>	<u>DESCRIPTION</u>
1	01:0000	RESET, enter 248 to erase all data and programs and reset pointers. While erasing, the SM checks memory.
	01:XX	The number of good chips is then displayed (6 for SM192, 22 for SM716). The time required to reset an SM192 is approximately 60 seconds; SM716 takes nearly 4 minutes.
3	03:01	INSERT FILE MARK, at the position of the SRP if a file mark wasn't the last thing placed in the data. 1 indicates that the mark was inserted, 0 indicates that it wasn't.
4	04:XX	DISPLAY/SET MEMORY CONFIGURATION, enter the appropriate code to change configuration 0=ring, 1=fill and stop.

## APPENDIX A. CR10 \*9 MODE - STORAGE MODULE COMMANDS

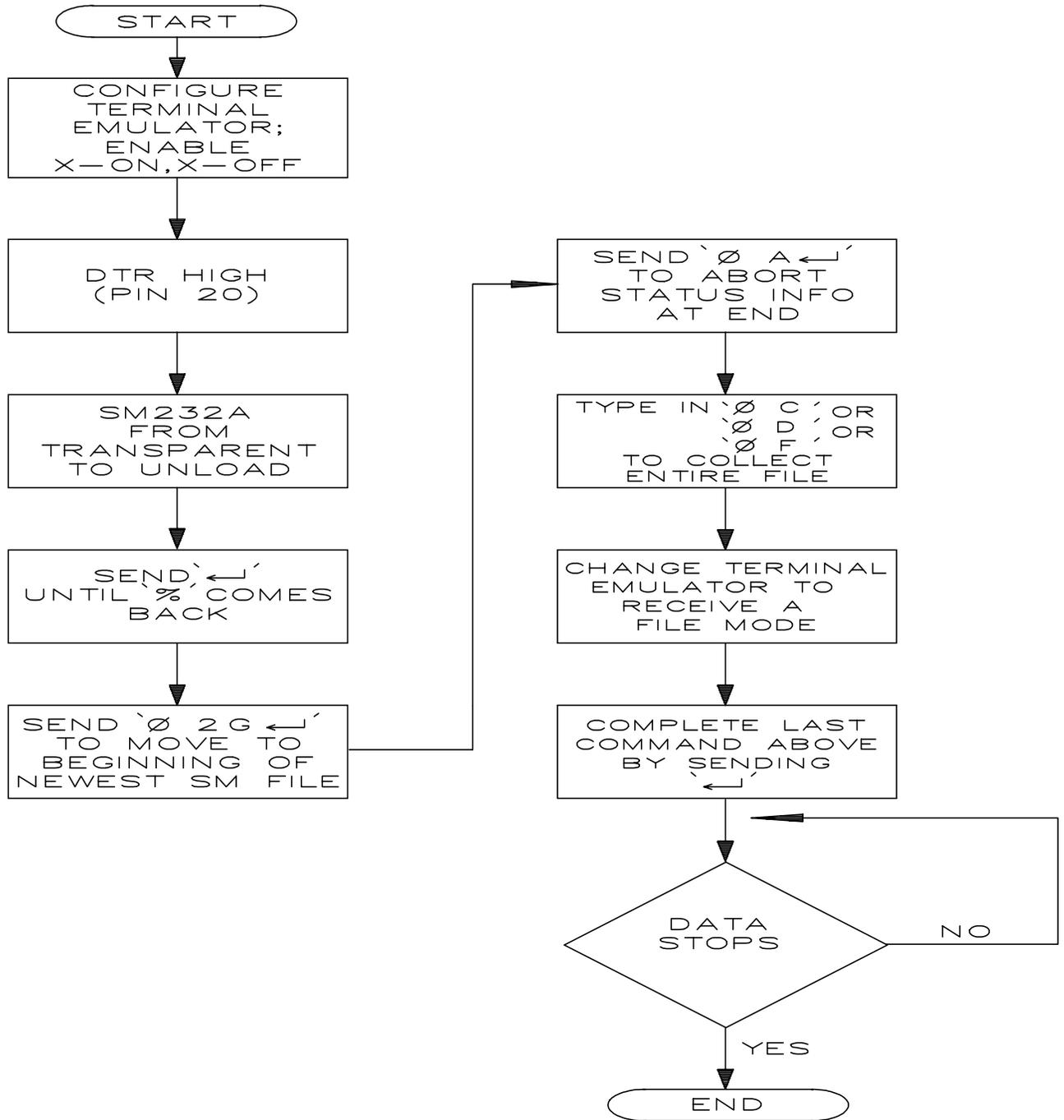
<u>COMMAND</u>	<u>DISPLAY</u>	<u>DESCRIPTION</u>
5	01:ABCD  AB CD 02:ABCD AB C D 03:A0CD A 0 C D 04:X.XXXX	DISPLAY STATUS (A to advance to each window) Window 1:  SRP location (chip no.) Total good RAM chips (1-22) Window 2: DLP location (chip no.) Unloaded Batt. Chk. 0=low, 1=OK No. of Programs stored (Max=8) Window 3: Errors logged (up to 9) Not Used Memory Config. (0=ring, 1=fill & stop) Memory Status (0=not full, 1=full) PROM signature (0 if bad PROM)
6	06:0X	BATTERY CHECK UNDER 100 OHM LOAD (0=low, 1=OK)
7	07:00           07:XXXXXX	DISPLAY DATA - select the Storage Module Area with the following codes: 0 Dump pointer to SRP 1 File 1, current file 2 File 2, previous to file 1 3 File 3, previous to file 2 4 File 4, previous to file 3 5 File 5, previous to file 4 7 Display location pointer to SRP 9 Oldest data to SRP 1-5 will loop within file boundaries, 0, 7, 9 allows display to cross boundaries. If no file is found, the display returns "07:00". At this point, another file can be entered by entering the correct code. Key A to advance to first data. If another location is keyed in, SM will jump to 1st start of array following that location. Review data with: A Advance and display next data point B Backup one data point # Display location, C to return to data #A Advance to next start of Array #B Backup to start of Array #D Return to 9X:00
8	08:00 01:XXXXXX  02:XXXXXX  03:XX	DUMP TO ANOTHER STORAGE MODULE Select Area as in 7 above First Loc. in area selected. To alter, enter location of start dump. Final Loc. in area selected. To alter, enter location of end dump. Enter destination SM address (1 through 8). The end-of-dump location will be shown when the transfer is complete. If 000000 returns, there was an error in transmission.

## APPENDIX A. CR10 \*9 MODE - STORAGE MODULE COMMANDS

<u>COMMAND</u>	<u>DISPLAY</u>	<u>DESCRIPTION</u>
9	XXXXXXXX 87654321	DISPLAY ADDRESSES OF CONNECTED SM'S 1 = occupied, 0 = unoccupied (Addresses 8-1 from left to right)
10	10:0X	CHANGE ADDRESS X is current address, enter yA to change and then display address where y=1...8.

# APPENDIX B. SAMPLE FLOW DIAGRAM FOR DATA RETRIEVAL PROGRAM

GET THE LAST FILE



## APPENDIX C. NON-DATALOGGER APPLICATIONS

All non-datalogger Storage Module operations are accomplished through the Printer Enable Method. The Storage Module can store data from devices other than dataloggers and computers providing that power and control requirements are met. Refer to Section C.3 for information on the pin configuration for the Storage Module's 9 pin D connector.

### C.1 USING TELECOMMUNICATIONS COMMANDS TO SEND DATA FROM A COMPUTER TO STORAGE MODULE

Once communication has been established between the Storage Module and a computer (Section 5), the 0/H command stores all data on the Storage Module's transmit data (TD) line until the PE (pin 6) and CLK/HS (pin 7) lines go low. This feature is used to transfer a data file from the computer to the Storage Module.

External power must remain applied for at least 5 milliseconds following data transmission for "housekeeping." The SM stores 2 bytes at a time, so if the total number of bytes transmitted is an odd number, a NULL character will be added at the end of the transmission.

**NOTE:** This command is not available when using the CR10 as the telecommunications interface to the Storage Module.

### C.2 OTHER NON-DATALOGGER DEVICES

The Printer Enable Method (Section 4) is used for non-datalogger SM applications. The PE

line must be low when power is applied or removed. If a switch is used to enable data storage, the switch must be debounced. Figure C.1 depicts debounced circuitry sufficient for this purpose:

The user should be aware of 3 cases of transmitting bytes which have special meaning to the Storage Module in the Printer Enable Mode. These cases only apply to non-datalogger applications.

1. In the 76,800 with 9600 fall back baud rate option, the byte 80 HEX must not be the first byte transmitted at 76,800 baud after the PE line (Pin 6) goes high. As a first byte, 80 HEX causes the baud rate to falsely be set at 9600 baud. There is no such restriction when transmitting at other baud rates. Campbell Scientific Inc. dataloggers never transmit 80 HEX as the first byte.

2. The HEX byte-pair 7C01 is a File Mark. This sequence should only be used to separate data in the Storage Module.

3. The binary byte-triplet 01111101 XXXXXXXX 1XXXXXXX (X = unimportant information), is a control code reserved by the Storage Module to mark the beginning of a stored datalogger program. The "0/F" telecommunication command (Continuous Binary Dump) can be used to collect files which contain this code.

**NOTE:** The precautions described in Section 4.5, Data Format and Input Buffer, apply.

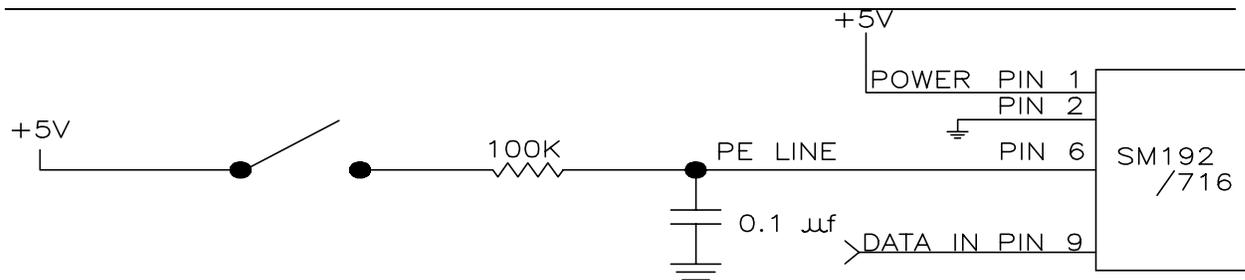


FIGURE C.1 Manual Switch Debounce Circuitry

### C.3 STORAGE MODULE 9-PIN CONNECTOR

The pins on the 9 pin sub-miniature D connector on the Storage Module are numbered 1 through 9 on the white plastic base. A general description of the function of each pin follows:

- Pin 1 (Input) 5 VDC Supply provides power to the Storage Module. Requires  $5 \pm 0.4$  VDC @ 100 mA. Processor held in reset when external power falls below 4.6 VDC. Internal battery supplies memory retention power when external power drops below 3 VDC. Damage to SM hardware can occur if input on Pin 1 exceeds 5.5 VDC. Low power standby mode current drain is about 250  $\mu$ A.
- Pin 2 (Input) Power and signal GROUND.
- Pin 3 (Output) RING LINE. Not used.
- Pin 4 (Output) RECEIVE DATA (RD) line. The SM transmits its responses to Telecommunications commands asynchronously (0 to 5 VDC) on this line. Data format is 8-bit, 1 start bit and 1 stop bit. Refer to Section 3.1 for baud rate options. This line is held high while the SM is active in the Printer Enable Method (data storage).
- Pin 5 (Input) MODEM ENABLE line. Not used.
- Pin 6 (Input) PRINTER ENABLE (PE) in Printer Enable Method or SYNCHRONOUS DEVICE ENABLE (SDE) line in CR10 Method. If the SM is externally powered, the PE line is high (5 VDC) and Pin 7 (CLK/HS) is low (0 VDC), the processor is set to receive data asynchronously on Pin 9 (TD). When the PE line is dropped, data remaining in the input buffer are stored and the location pointers are saved. The processor then enters an inactive, low power, standby state.

**NOTE:** If the processor is still active from a previous transmission of data and the PE line is raised again, the processor will be forced to its inactive state; data from the previous transmission will be lost and the current transmission will be ignored. Normal operation will return with the next low to high PE transition. Switch bounce on the PE line can cause the processor to go inactive after the PE line stabilizes in its high state.

- Pin 7 (Input) CLOCK/HANDSHAKE (CLK/HS) line. For data storage, CLK/HS must be low. For data retrieval, using Telecommunications Commands (Appendix D) CLK/HS must be high when the processor is activated by the PE line going high. CLK/HS must remain high during Telecommunications. To exit the Telecommunications Command State, lower both the PE and CLK/HS lines.
- Pin 8 (Input) TAPE ENABLE line. Not used.
- Pin 9 (Input) TRANSMIT DATA (TD) Data is received by the SM on this line. Data is received asynchronously ( 0 to 5 VDC) 8-bit, 1 start and 1 stop bit. The idle state (stop bits) on this line is 0 VDC. The first byte transmitted to the SM should be more than 200 microseconds after the PE line has activated the processor.

## APPENDIX D. TELECOMMUNICATIONS COMMANDS

The SM Telecommunications Commands can be used over links through the CR10 or with the Storage Module connected to an interface such as the SC532, the SM232A, or the PC201. Establishing communication between the Storage Module and a computer/terminal is discussed in Section 5. The commands permit data storage and retrieval, switch setting, status checks, battery tests, and other functions.

The Storage Module is ready for a command when it sends its prompt, <cr><lf> %. The successful execution of a command is indicated by the SM returning a <cr><lf> %. (With several commands, the "<cr> <lf> %" is preceded by the SM status line as described for the A command.) If just a "%" is returned, the command was in error. "Ctrl-S" (XOFF) will temporarily halt Storage Module responses to commands; "Ctrl-C" will abort the response. If using Graph Term or TERM, there may be a delay for "Ctrl-S" and "Ctrl-C" to take effect due to the program's buffer capacity.

The descriptions of some commands refer to the Storage Module pointers (Section 4.2). The **Display Location Pointer (DLP)** is used to display Storage Module data. The **Storage Reference Pointer (SRP)**, indicates the next location to be written to in the Storage Module. The **Dump Pointer** is an internal Storage Module pointer used for keeping track of the current start-of-dump for Storage Module-to Storage Module data dumps and for the data retrieval options of the SMCOM program.

Storage Module Telecommunications Commands are similar to datalogger Telecommunications Commands and consist of numbers and CAPITAL letters. In the following list, Telecommunications Commands are on the left and their description on the right.

**A STATUS:** Returns **V**ersion number, **S**witch settings, number of **P**rograms stored, number of good **M**emory chips, number of **E**rrors logged (max. = 255), number of **A**vailable storage locations, number of locations **F**ull, **S**torage **R**eference Pointer, **D**isplay **L**ocation Pointer, and **C**hecksum (sum of all transmitted ASCII

characters since last %; wraps around at 8192 bytes).

Example: **V1 S1401 P0 M6 E0 A96448 F1 R2 L2 C1980** is the expected response to the A command after the SM192 has been reset.

Example: **V1 S1401 P0 M22 E0 A358336 F1 R2 L2 C2071** is the expected response to the A command after the SM716 has been reset.

**NOTE:** Refer to the L command for a discussion of the switch settings.

**0A INHIBIT STATUS:** Returns status line without carriage return, line feed, and prompt (%) following. Signature or status is inhibited on subsequent commands other than A that normally display signature or status. Command A restores normal status function.

**nnnnB** Move the DLP back nnnn output arrays from its current position. If it is fewer arrays to the beginning of the file (File Mark), the DLP will be placed at the beginning. B is the same as 1B. Status is displayed following execution of command.

**nnnnC** COMMA DELINEATED ASCII DUMP: Dump nnnn output arrays from the location of the DLP. The dump will stop if the next file mark or the Storage Reference Pointer is reached. "C" is the same as "1C". "0C" means dump continuously. Status is displayed following execution of command.

**nnnnD** PRINTABLE ASCII DUMP: Dump nnnn output arrays to the next File Mark from the location of the DLP. The dump will stop if the Storage Reference Pointer is reached. "D" is the same as "1D". "0D" means dump continuously. The status is displayed following command execution. Until the start of an array is found, the element ID's will show "xx".

**E NO LOAD BATTERY TEST:** The state of the battery is compared to a 2.5 VDC reference without loading the battery. The Storage Module returns "1" if above 2.5 VDC or "0" if below. If "0" is returned, the data should be retrieved from the SM prior to disconnecting

## APPENDIX D. TELECOMMUNICATIONS COMMANDS

external power. The battery should then be replaced.

**100E** LOADED BATTERY TEST: The state of the battery is compared to a 2.5 VDC reference after a 100 Ohm load is connected for 1 second. The Storage Module returns "1" if above 2.5 VDC or "0" if below. If the loaded test returns "0" and the unloaded test, "1", the battery has residual capacity, and should be replaced as soon as possible. This test uses approximately 3 minutes of the useful life of the battery.

**nnnnF** BINARY DUMP: Dump nnnn locations (2 bytes each) until the next File Mark from the location of the DLP. The dump will stop if the Storage Reference Pointer is reached, followed by 2 bytes displaying the Campbell Scientific Inc. signature of the transmitted data. No data conversion is made. Stored programs are jumped over. "F" is the same as "1F". "0F" means dump continuously and do not jump over stored programs. Status is not displayed following command execution.

**nnnnnnG** GO TO LOCATION nnnnnn: Use this command to position the Display Location Pointer to any location in the Storage Module. The Status is then displayed.

**0nG** GO TO FILE MARK n (n = 1...5): File Mark 1 is the beginning of the most current file. File Mark 2 is the beginning of the file before the most current file in the SM, etc. Addresses of the last 5 files are maintained in memory for rapid access. The command 03G would move the Display Location Pointer (DLP) to File Mark 3. The status is then displayed.

**08G** GO TO DUMP POINTER: The Display Location Pointer (DLP) is advanced to the Dump Pointer position. The Dump Pointer is set to the beginning of memory when the SM is reset. It is advanced only by the CR10 (\*9) Storage Module-to-Storage Module Dump command, the "4H" command, or by the SMCOM program "A" or "U" options.

**09G** GO TO NEXT FILE: The Display Location Pointer (DLP) is advanced to the beginning of the next file. The DLP is advanced as the SM reads through the data until a File Mark or the Storage Reference Pointer is encountered. For long files, the delay involved could be noticeable. The status is displayed

following command execution. This command can be used to locate every file in the Storage Module.

**0H** STORE: The Storage Module will store all data received on the Transmit Data line (TD) until the SM is deactivated when the PE (Pin 6) and CLK/HS (Pin 7) lines go low. External power must remain applied for at least 5 msec following data transmission for "housekeeping". The SM stores 2 bytes at a time, so if the total number of bytes transmitted is an odd number, a NULL character will be added at the end of the transmission. This command is not available in telecommunications through the CR10.

**3H** MOVE STORAGE REFERENCE POINTER: Moves the Storage Reference Pointer (SRP) to the same location as the Display Location Pointer. The Display Location Pointer is set with the nnnnnnG command. Status is displayed following command execution.

**CAUTION:** This command is not intended for general use. The next transmitted data is written to the SM beginning at the current location of the Storage Reference Pointer. Thus, data will be written-over if the "SRP" is moved backwards.

**4H** MOVE DUMP POINTER TO DISPLAY LOCATION POINTER: The Dump Pointer is moved to the current position of the Display Location Pointer. Refer to command "08G" regarding the Dump Pointer. This command is not intended for general use.

**9H** STORE FILE MARK IN DATA: Used to designate a new area of memory in the Storage Module. File Marks are automatically placed in the data upon application of external power (5 VDC) or when a CR10 program with Instruction 96 is compiled. Status is displayed following command execution.

**nl** DUMP PROGRAM n (n = 1...8): If program "n" is found, the Storage Module dumps it to the user device, otherwise it sends a null program (30 05 05 HEX) followed by a prompt without a carriage return and line feed.

## APPENDIX D. TELECOMMUNICATIONS COMMANDS

**nJ STORE PROGRAM n** (n = 1...8): The Storage Module responds with "<" after which the SM will store program data received on its TD line, recording its start position in the program directory. Subsequent data does not write over stored datalogger programs unless the directory entry is cleared or modified. Programs MUST start with the Start ASCII character (7D HEX) and end with two Ctrl-E (05 05 HEX) characters. Status is displayed following command execution. This command is not available when communicating with the Storage Module using an RF Modem.

**n0nJ CLEAR PROGRAM n** (n = 1...8): Clears directory entry for program "n" and frees the memory space for data storage.

Example: To clear program 7, the command is 707J. Status is displayed following command execution.

**1248K RESET STORAGE MODULE:** Resets all pointers, tests RAM memories, and places a File Mark at the beginning of memory.

**CAUTION:** ALL DATA IS LOST IN THE STORAGE MODULE. If a bad RAM memory is encountered, the Storage Module will use only the good RAM up to the bad RAM. The number of good RAM memories is indicated in the Status. During Reset, a plus (+) for each RAM written to, and a minus (-) for each RAM successfully read is output by the Storage Module. An "X" is output for each RAM which cannot be read successfully. If the Storage Module returns a "%" without a "<cr><lf>," the memory test failed. Otherwise, the status is displayed following command execution.

**abfeL SWITCH SETTINGS:** "a" is the Storage Module Address Switch. When used with a CR10 or 21X, this switch can be set to 1...8. The address has no effect when used with other Campbell Scientific Inc. dataloggers. *Following reset, the SM address defaults to 1.*

"b" is the Baud Rate Switch for the Printer Enable Method of storing data. The Baud Rate Switch setting is ignored in CR10 applications. The Baud Rate options are:

<u>Switch</u>	<u>Baud Rate</u>
0	300
1	1200
2	9600
3	76800
4	76800/9600

*The Baud Rate Switch defaults to "4" following SM Reset.*

"f" is the Fill and Stop/Ring Memory Status Switch. If set to "0," the memory is ring type. If "1," the memory is set to Fill and Stop and once memory is full, further efforts to write to the SM are aborted. *The memory status switch defaults to "0" (ring memory) following SM Reset.*

"e" is the Encode ASCII Switch. If set to "1," the SM will encode incoming Printer Enable Method Printable ASCII data to Final Storage Format (binary) data. Final Storage Format data is stored as is. If switch is "0," incoming data is stored as is regardless of the format. This permits storage of ASCII data. At 76,800 baud, incoming data is stored as is, regardless of switch setting. The Switch has no effect in the CR10 Method. *The Encode switch defaults to "1" following SM Reset.*

Entering 9 for switch settings leave the switch setting unchanged. Example: 9990L would only disable the Encode ASCII function. Since position is important, the 9's are used to fill the first 3 spaces without changing the settings.

**M or \* DISCONNECT:** The Storage Module is deactivated to a low power standby mode. If the communications interface is the CR10, the CR10 prompt will be returned.

**N PROM SIGNATURE:** Returns the Storage Module PROM signature. If this command returns "0," the PROM is bad.