

9. Communications

This section describes the communications protocol between the 2700 SELECT and a host computer. The 2700 SELECT has an RS-232 serial port. When you install the appropriate hardware interface (e.g., shielded NULL modem cable), the 2700 SELECT communicates in ASCII over this interface.

The protocol used by the 2700 has been designed to be compatible with most computer database applications and most computer interface protocols. The 2700 SELECT can be configured to communicate in **Result Reporting** mode or **Remote Control** mode.

The communications module also provides networking capability. You may configure a 2700 SELECT to operate in either multidrop or non-multidrop environments. Multidrop refers to networking several 2700s and/or other controllers to a host, while non-multidrop (point-to-point) refers to a single 2700 connected to a host/controller.

The non-multidrop configurations of software versions higher than 2.40 maintain compatibility with the earlier software version 2.03. The command format and communication protocols are identical for software versions 2.03 and up.

In sections below you will learn about communications handshaking, software setup, command structure, communication modes and data base format.

Note: The term "2700 SELECT" has been shortened to "2700" in many sentences and figures below. They are synonymous.

9.1 Communications Protocol

The 2700 communicates with a host computer through its RS-232 serial port, acting as a DTE. The handshaking can be hardware or software configured. The method is user-selectable. Figure 9.1 shows the RS-232 signal descriptions and directions with respect to the 2700.

Pin Number	Signal Name	2700 Direction	Signal Function
1	PGND	---	Protective shield ground
2	TXD	Output	Transmit data
3	RXD	Input	Receive data
4	RTS	Output	Request to send
5	CTS	Input	Clear to send
6	DSR	Input	Data set ready
7	SGND	---	Signal return ground
8	DCD	Input	Data carrier detect
20	DTR	Output	Data terminal ready

Figure 9.1
RS-232 Signal Description and Direction

Hardware Handshaking Signals. The four handshaking signals used to control the data flow are RTS/CTS and DTR/DCD. The 2700 drives RTS when it wishes to transmit and waits for CTS before transmitting each character. Likewise, the 2700 asserts DTR when it is ready to receive data and receives only when DCD is asserted. DSR is not used.

Software Handshaking Signals. In the XON/XOFF handshaking protocol, RTS and DTR are always asserted and CTS and DCD are always ignored.

Since the 2700 acts as a DTE, it requires a shielded NULL modem cable to connect to another DTE, such as the PC. Figure 9.2 and Figure 9.3 show possible NULL modem cable connections.

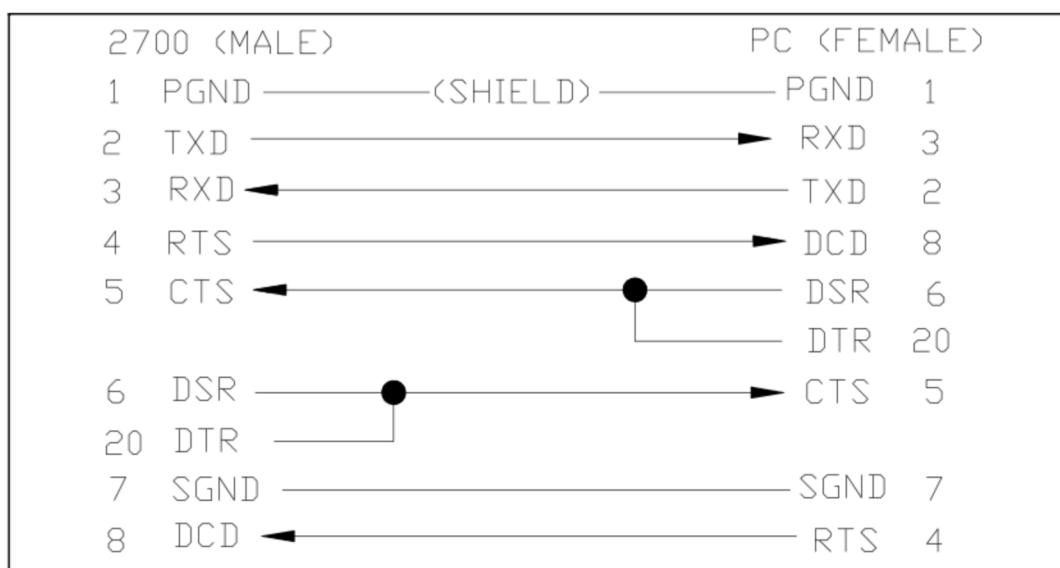


Figure 9.2
Full Handshaking DTE Interface

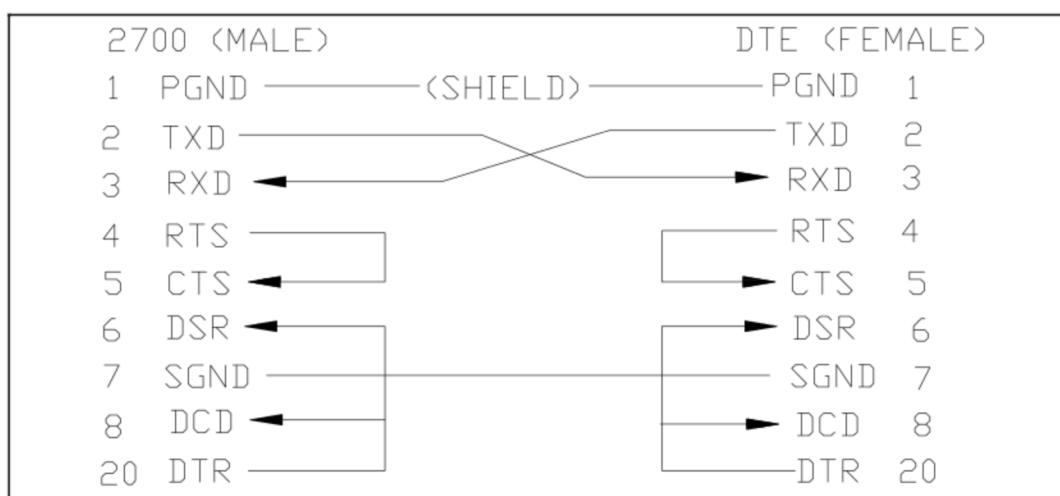


Figure 9.3
Three Wire DTE Interface

You can select the 2700 handshaking protocol, RTS/CTS or XON/XOFF. In addition, you can select baud rate, data length (bits per character), parity, stop bit, and configuration (multipoint or point-to-point). For information on communications setup, see Section 4.2, Menu Setup. The communications menu is a submenu of General setup.

Listed below are the default settings and options for each communications parameter mentioned above. The default value is listed first. The options are in parentheses.

Baud rate:	9600	(4800, 2400, 1200, 600, 300)
Data Length:	7	(8)
Parity:	Even	(odd, low, high, none)
Stop Bit:	1	(2)
Handshake:	RTS/CTS	(XON/XOFF, None)
Configuration:	non-multidrop	(multidrop)

Data and Command Format. The 2700 behaves like a "slave" to the host computer. It never talks to the host unless in response to a command from the host. The 2700 will respond with an ASCII < BEL> followed by the display of an error code, or "?" for an illegal command.

A command is defined to be a string of printable upper case ASCII characters. Blanks are ignored.

Command Grammar. The command grammar is shown below. Abbreviations include ESC (escape), cmd (command), addr (address), arg (argument) and cr (carriage return).

<ESC> & <cmd> [arg] <cr>	(non-multidrop)
<ESC> <addr> <cmd> [arg] <cr>	(multidrop)

In this grammar, < addr> is a single byte (binary) node address that you assign to the 2700 SELECT. You make the assignment via the instrument keypad. The 2700 SELECT only responds to commands with the < addr> field that matches the assigned address.

A command may require one or more arguments. If multiple arguments are given, they must be separated by a semicolon (;). Two consecutive semicolons indicate a NULL argument, in which case, depending on the command, a default parameter is supplied.

The 2700 responds to a legal command with a status acknowledgment (A), or an error code (1,2,6,7,8 or 9) The interpretations of the status characters are discussed under Communications Commands, Remote Control Commands (in Section 9.3).

Error Codes

- Code 1 a) 2700 is not in remote control mode. This condition generally indicates that you invoked the TN1 command (enter Run Mode remotely) when the 2700 was not in remote mode. You must first successfully invoke TR1 (turn on remote control mode). You may need to check 2700 status to determine the exact meaning of the error. See Communications Commands (Section 9.3) for more information.
- b) 2700 is in remote control mode but not in Run Mode. This condition generally indicates that you requested that the 2700 Sample or Calibrate when the 2700 was not in Run Mode. You must first successfully invoke TN1 command (enter Run Mode remotely).
- Code 2 2700 is busy in RUN mode.
- Code 6 assignment of station # is out of range ($s < 1$ or $s > 5$).
- Code 7 purge time of zero is assigned when Station #5 ($s=5$) is assigned (monitor accessory).
- Code 8 zero turntable position number is assigned ($t, n = 0$ or default $t, n = 0$).
- Code 9 a) sample or calibration results were not found when requested.
 b) 2700 is not in RUN mode.
 c) 2700 is in "halt condition". A halt condition can be caused by a cal error, baseline error or other fatal system error.

The internal receiver buffer in the 2700 is 80 characters long. A string longer than 80 characters without the terminating CR., will cause this buffer to overflow. When this occurs, the 2700 will reset the receiver buffer, ignore the previous 80 characters and start to receive the new command. Most commands are 2 or 3 characters long. Thus, there is no real restriction with this buffer size.

9.2 Communications Modes

The 2700 can be placed in one of two communications modes: Result Reporting Mode or Remote Control Mode. The selection between modes is made by the remote host. The default mode at power-up is Result Reporting Mode.

2700 Data Base. The 2700 keeps a data base of 32 sample results and 1 calibration result in its battery-backed RAM (random access memory). Only the most recent sample or calibration result is shown on the instrument display. However, a remote host can ask for any of these results at any time. This data base can be cleared by the host in Remote Control Mode (see Section 9.3, Communications Commands).

Result Reporting Mode. Result Reporting Mode is designed for use with a computer system that gathers sample results from various analyzers and records the results in a central data base. In this mode, the host can always talk to the 2700 and get the result records.

The host requests the results by either sending the sample ID number and getting the result record or by querying the unit for any untransmitted result in the data base.

Remote Control Mode. Remote Control Mode is designed primarily for industrial and research applications where process control may be an important consideration.

In Remote-Control mode, the instrument is in RUN Mode and under control of the host computer. The instrument keypad is disabled; thus, the operator cannot run a sample or calibration locally at the 2700.

The host tells the 2700 to run a sample or a calibration. The samples may be assigned to run at Station #1 (Cal Well), Station #2 (Test Tube Holder), Station #4 (Turntable) or Station #5 (Monitor Accessory). See page 9-14 for more information.

Calibrations are typically assigned to run at Station #1, but may be assigned to Station #2 or even assigned to Stations #1 and #2 together in dual chemistry applications. **The remote host cannot change calibration station assignments; they must be made locally at the 2700 SELECT.**

9.3 Communications Commands

Data Transmission Records. The data report format from "2700 to HOST" is transmitted as shown in the example below. Information includes:

- » time
- » date
- » temperature (sample chamber)
- » node address (re: multidrop mode; instrument identification)
- » ID (sample identification number)
- » chemistry (assigned to probe)
- » value (sample or calibration reading)
- » unit of concentration (nA current for calibrations)
- » error codes

Notes:

- A "-1" in the ID column specifies calibration report.
- A "-2" in the ID column specifies monitor report.
- A "-3" in the ID column specifies parameter information request.

A back-slash "\\" in the column preceding the carriage return <CR> indicates that more information from that reading continues on the next line.

If two lines of information are combined, the first is black probe data, the second is white probe data. In single channel units, this will not be a concern.

In Figure 9.4, several examples show how information for a dual channel 2700 SELECT may appear when transmitted. Again, the ruler line is for reference only and does not appear on the record.

The first example shows a multidrop 2700 report with the assigned address of "123".

The second example shows a non-multidrop 2700 report. Note that the only difference between this and the first example is the node address field.

The third example shows a calibration report. The sample ID field of a cal report is always "-1".

The fourth example shows a monitor report. Similar to the cal report, the sample ID field in this report is always "-2".

```
123456789012345678901234567890123456789012345678901234567890123456789012345  
13:22:34 02/13/98 23.56 123 123456789 H202 12345.78 mmol/L 0000\ <cr><lf>  
13:22:34 02/13/98 23.56 123 123456789 H202 12345.78 mmol/L 0000 <cr><lf>  
13:22:34 02/13/98 23.56 123456789 H202 12345.78 mmol/L 0000\ <cr><lf>  
13:22:34 02/13/98 23.56 123456789 H202 12345.78 mmol/L 0000 <cr><lf>  
15:12:04 02/13/98 23.56 123 -1 H202 45.78 nA 0000\ <cr><lf>  
15:12:04 02/13/98 23.56 123 -1 H202 15.28 nA 0F01 <cr><lf>  
12:02:34 02/13/98 24.86 -2 H202 12345.78 mmol/L 0000\ <cr><lf>  
12:02:34 02/13/98 24.86 -2 H202 345.78 g/L 0000 <cr><lf>
```

Figure 9.4
2700 SELECT Data Report Format

NOTE: The specific information above is not intended to appear realistic, but rather to account for all characters and spaces in the report format. See Figure 9.5 for specific field location information.

The fields of the data transmission records are more specifically defined below in Figure 9.5. A ruler line is used simply to help you identify the offset and field widths in the report. We have used the following symbols to depict changes from early 2700 software vs versions 2.41 and higher. The symbol '*' indicates a change. The symbol '**' indicates an addition. The symbol '***' labels the choice NONE to indicate that when this choice is made, the remainder of that line fills with blanks.

Each field is identified by a number series just below the ruler line. These field numbers help you visualize column width.

123456789 123456789 123456789 123456789 123456789 123456789 123456789 12345 11:11:11 22/22/22 33333 444 555555555 6666 77777777 88888888 9999\<cr><lf> 11:11:11 22/22/22 33333 444 555555555 6666 77777777 88888888 9999 <cr><lf>			
FIELD NO.	OFFSET COLUMN	WIDTH (BYTE)	DESCRIPTIONS
01	01	08	Time
02	10	08	Date
03	19	05*	Temperature
04**	25	03	Node Address**
05	29	09	Sample ID: 0 = no ID -1 = Cal Report -2 = Monitor Sample Report -3 = Information Report
06	39	04	Probe Chemistry Assignment: None*** no chemistry DEX Dextrose LAC L-Lactate SUC Sucrose LTOS Lactose GAL Galactose H2O2 Hydrogen Peroxide ETOH Ethanol MEOH Methanol GLMT L-Glutamate GLMN Glutamine CHOL Choline
07	44	08	Sample or Calibration Result
08	53	08	Sample or Calibration Concentration Unit
09	62	04	Error Code (hexadecimal)
10	66	01	Continuation character: '\'' more data follows <space> end of record

Figure 9.5
Report Format Field Information

Command Description. For quick reference, the communications commands are divided into five functional groups: process, report database, database management, control and report system information. For details on process commands, see "Remote Control Commands", later in this section.

PROCESS

PC	Process calibration
PS1	Process sample from calibration well (Station #1)
PS2	Process sample from test tube holder (Station #2)
PS4	Process turntable batch (Station #4)
PS5	Process monitor sample (Station #5)

REPORT DATABASE

RC	Report calibration result
RS	Report sample result
RS#	Report sample result with sample ID number
RY	Report status of instrument
RX	Report last transmission

DATABASE MANAGEMENT

RZ	Clear database memory
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CONTROL

TR0	Turn remote control off
TR1	Turn remote control on
TP0	Turn 2700 printer off
TP1	Turn 2700 printer on
MPt	Change pump purge time
MTt	Change monitor time interval
MRt	Change precal time interval
MOt	Change postcal time interval
MSs	Change monitor station #
PA	Abort Turntable Sampling
TN0	Exit Run Mode; Enter Standby Mode
TN1	Enter Run Mode from any mode (Standby or Menu)

REPORT SYSTEM INFORMATION

V0	Report instrument model number
V1	Report software version number
V2	Report software revision date
RM	Report system time, date and measurement parameters
RI	Report instrument setup information

Common Commands. The commands below can be invoked in either Remote Control Mode or in Result Reporting Mode, unless otherwise stated. Available commands are those in the Report Database and Report System Information categories above.

When **Report Status (RY)** is invoked, the command obtains the 2700 status. The status includes communications mode, sample result status, calibration result status, machine status and remote command status. Below is a summary of responses and the interpretations.

Host to 2700:	RY	Report status of instrument
2700 to Host:		
Communications mode	R	Result reporting mode
	C	Remote control mode
	—	Unknown
Sample status result	U	Results exist not sent to host
	N	No unsent results
Calibrate status result	U	Last cal not sent to host
	N	No unsent calibration results
Machine status	I	Idle in Run Mode
	S	Processing sample
	C	Processing calibration
	A	Processing autocalibration
	M	Processing manual sample
	P	Processing precal cycle
	N	Processing monitor cycle
	T	Processing postcal cycle
	F	Flushing and aborting error cycle
	B	Stabilizing baseline current
	K	Stabilizing calibration current
	E	Stabilizing motors
	H	Aborting Run Mode
	R	In Run Mode
	Y	In Standby Mode
	D	In Main Menu Mode
Remote command status	I	Idle, no pending command
	S	Sam command received. Pending
	C	Cal command received. Pending
	—	Unknown

An example status line may appear as follows:

CNUII

The information stated is that the 2700 is under remote control (C), no sample results are in memory (N), calibration results remain unsent (U), the 2700 is idle in Run mode (I) and there are no remote commands pending (I).

When **Report Last Transmission (RX)** is invoked, the last transmission of the 2700 is sent to the host. It is used when the response received by the 2700 contains an unknown character, is not in the correct format, or whenever in doubt due to communications error.

Host to 2700: RX Report last transmission

2700 to Host: [last transmitted record]

When **Report Calibration Result (RC)** is invoked, the 2700 sends back time, date, chamber temperature, probe chemistry and probe current from the last calibration cycle. The calibration cycle may be a user-activated calibration cycle, computer-demanded cycle or an autocalibration cycle. If no result is found, the 2700 sends back error code "9".

Host to 2700: RC Report last calibration result

2700 to Host: [cal result] (see format in Figure 9.4)

When **Report Sample Result (RS)** is invoked, the 2700 sends back the last sample processed. When combined with an ID number, the 2700 searches its database and sends back the most recent matching ID result. After the result has been transmitted, its entry in the database is marked as sent. Another request for the same sample ID result will cause the 2700 to send the next most recent result for the matching ID result. If no result is found, the 2700 sends back error code "9".

If the host has received the result in error due to a data transmission error, it should request retransmission using the RX command.

Host to 2700: RS Report last sample result

2700 to Host: [sam result] (see format in Figure 9.4)

Host to 2700: RS< ID> Report sam ID result
(max = 9 digits)

2700 to Host: [sam result] (see format in Figure 9.4)

Remote Control Commands. The commands outlined above in the "Process" category can be invoked **only** in Remote Control Mode. If the system is not in the Remote Control Mode, you must first invoke the **Turn Remote Control On (TR1)** command.

Note: For each command from Host to 2700, the 2700 sends back an acknowledgment (A) or an error code. Error codes may require invoking the Report Status (RY) command to gain further information on machine status.

Host to 2700:	TR1	Turn on remote control mode
2700 to Host:	A	Acknowledge. 2700 switched to Remote Control.
	2	2700 busy in Run Mode.
	9	2700 is in a "halt" condition (page 9-4).

You should invoke this command from Standby or Menu mode. If you attempt to enter Run Mode by pressing the RUN key locally, then invoke the TR1 command prior to successful calibration, **you may not successfully enter remote control mode**.

Alternatively, you may enter Run Mode locally by pressing RUN and waiting for successful calibration. Then invoke the TR1 command to enter remote control mode.

In a similar manner, you can invoke the **Turn Remote Control Off (TR0)** command to return to Result Reporting Mode.

In the Remote Control Mode you may elect to invoke the **Turn 2700 Printer Off (TP0)** command. The 2700 responses are outlined below.

Host to 2700:	TP0	Turn 2700 printer off
2700 to Host:	A	Acknowledge. 2700 printer turned off.
	1	2700 is not in Remote Control Mode.

In a similar manner, you may use **TP1** to turn the 2700 printer on.

Commands to Exit/Enter Run Mode remotely. You may use the commands described below to enter and exit Run Mode, however, always verify that you are in Remote Control Mode prior to invoking these commands.

When you invoke **TN0 (Exit Run Mode)**, the instrument exits Run Mode and switches to Standby Mode or, if there is a "halt condition", to Menu Mode. Standby Mode may be used to conserve reagents in certain applications. Menu Mode positions you to remotely recover from most error conditions.

Host to 2700:	TN0	Exit Run Mode and switch to Standby Mode or Menu Mode.
2700 to Host:	A	Acknowledge. 2700 exits Run Mode.
	1	2700 is not in Remote Control Mode.
	2	2700 is busy in Run Mode.

When you invoke **TN1 (Enter Run Mode)**, the instrument enters Run Mode from Standby or from "Menu Mode". You may use this command to re-enter Run Mode after using the TN0 command or to reinitialize the instrument after a "halt condition" such as an error resulting from unstable calibration or similar problems.

Host to 2700:	TN1	Enter Run Mode from Standby or Menu mode.
2700 to Host:	A	Acknowledge. 2700 switches to Run Mode.
	1	2700 is not in Remote Control Mode.
	9	2700 is not in Run Mode, but is attempting to enter Run Mode from a halt condition.

IMPORTANT: These commands are designed to be used when the 2700 is in Remote Control mode. In writing control programs, verify that the instrument is in Remote Control mode before invoking these commands.

The calibration commands and sample process commands are outlined below. The "process sample" commands are described together, the only difference among the different commands being the station from which the sample is aspirated (#1, #2, #4, #5). Station #3 is theoretically possible, but not practical in remote control mode.

When you invoke the **Process Calibration (PC)** command, the Host commands the 2700 to run a calibration cycle. If the 2700 is running an autocalibration, calibration stabilization or baseline stabilization, the command is acknowledged and the sample is processed as soon as the instrument finishes the existing task.

Host to 2700:	PC	Process calibration
2700 to Host:	A	Acknowledge. Calibration in process or pending upon completion of current task.
	1	2700 is not in Remote Control Mode.
	2	2700 is busy processing last PC or PS command.

When you invoke the **Process Sample (PS)** command, the Host commands the 2700 to sample from one of four locations depending on the specific command (PS1, PS2, PS4 or PS5). If the 2700 is running an autocalibration, calibration stabilization or baseline stabilization, the command is acknowledged and the sample is processed as soon as the instrument finishes the existing task.

Host to 2700:	PS	Process sample at PS1, PS2, PS4 or PS5.
2700 to Host:	A	Acknowledge. Sample in process or pending upon completion of current task.
	1	2700 is not in Remote Control Mode.
	2	2700 is busy processing last PC or PS command.
	9	For PS2 command, Test Tube Holder switch is off.

The PS command may take three optional arguments:

PS[s][;t][;n]

In these arguments **s** is the station number from which to sample. If **s** is not given, or NULL, the currently assigned sample station is used.

The character **t** is the turntable starting position, which is only valid when **s = 4**. Remember, station #4 is the turntable sampling position. If **t** is not provided or NULL, the default starting position will be used.

The character **n** is the number of turntable positions to be sampled, which also is only valid when **s = 4**. If **n** is not given or NULL, the default value will be used.

When the **Clear Database Memory (RZ)** command is invoked, all of the sample results maintained by the 2700 database are cleared. It is useful when the remote host is first switched to Remote Control Mode and wants to "forget" all previous samples that have been taken by an operator.

Host to 2700:	RZ	Clear 2700 database memory
2700 to Host:	A	Acknowledge. Result data cleared.
	1	2700 is not in Remote Control Mode.

When you invoke the **RM (Report Parameters)** command the instrument reports to you the current system time, date and measurement parameters. For ease of deciphering this information, the report format is almost identical to that of the sample and calibration reports. The only difference is that the Error Field, beginning at column 62, contains additional information about the calibration parameters.

Host to 2700:	RM	Report instrument parameters.
2700 to Host:	A	Acknowledge.
	1	2700 is not in Remote Control Mode.

Figure 9.6 shows you the report format. The first line is basically a ruler. The second and third lines identify each field by an upper case letter (A,B,C,etc.). The number of characters in each field is the field width.

```
123456789|123456789|123456789|123456789|123456789|123456789|123456789|12345
```

```
AA:AA:AA BB/BB/BB CCCCC DDD EEEEEEEE FFFF GGGGG.GG HHHHHHHH II J\<cr><lf>
AA:AA:AA BB/BB/BB CCCCC DDD EEEEEEEE KKKK LLLLL.LL MMMMMMM NN O <cr><lf>
```

In the fields above the characters represent the following:

- A: current system time (hh:mm:ss, 24 hour clock)
- B: current system date (mm/dd/yy or dd/mm/yy, depends on format)
- C: not used. Always *****.
- D: comm node address if multidrop. Blank for point-to-point.
- E: measurement parameter report ID. Always "-3".

- F: black channel chemistry abbreviation
- G: black channel calibration standard value
- H: black channel calibration concentration unit
- I: black channel calibration endtime (15 to 90 seconds)
- J: black channel calibration station number (1 to 5)

- K: white channel chemistry abbreviation
- L: white channel calibration standard value
- M: white channel calibration concentration unit
- N: white channel calibration endtime (15 to 90 seconds)
- O: white channel calibration station number (1 to 5)

Figure 9.6
RM Command Report Format

When you invoke the **RI (Report Information)** command, the instrument uploads the instrument setup that is not reported by the RM command, except communications and local control parameters. The information reported by this command is coded to conserve space. You must know the codes listed in Figure 9.7 to understand these setup parameters. The report is divided into several categories similar to "PrntSetup" (Print Setup) in the 2700 SELECT menu option. Note, all fields in this report are right-justified.

```
123456789|123456789|123456789|123456789|123456789|123456789|123456789|123456789|  
a b c dd e f g hh iiii jjjj kkk llll mmm nnn o p qqqq rrrr ssss tttt <cr>
```

Interpretation:

General

- a: radix (0 for ".", 1 for ",")
- b: date format (0 for mm/dd/yy; 1 for dd/mm/yy)
- c: bottle level sensor flag (0 for off; 1 for on)
- d: sample size (5 to 65µL)
- e: sample station (1 to 5)
- f: calibration method (0 for single; 1 for dual)

Autocal

- g: autocal on chemistry error flag (0 for off; 1 for on)
- h: temperature shift between autocals
- i: time interval between autocals (0 to 65535 minutes)
- j: number of samples between autocals (0 to 30000)
- k: cal shift allowed between cals

RunMode

- l: autostandby time (0 to 30000 hours)
- m: default starting turntable position (0 to 255)
- n: default number of turntable test tubes loaded (0 to 255)
- o: turntable fluid detection flag (0 for off; 1 for on)

Monitor

- p: monitor station number (1 to 5)
- q: monitor time interval (0 to 65535 minutes)
- r: monitor precal time (0 to 65535 minutes)
- s: monitor postcal time (0 to 65535 minutes)
- t: external pump purge time (0 to 65535 minutes)

Figure 9.7
RI Command Report Format

Additional remote control commands related to changing the external monitoring parameters and aborting a turntable run are described below.

Monitor Parameter Modification Commands (MP, MT, MR, MO, MS). You may use the commands described below to change monitor setup parameters remotely.

- MPt** change external pump purge time to t, where t is in seconds
- MTt** change monitor time interval to t, where t is in minutes
- MRt** change precal time interval to t, where t is in minutes
- MOt** change postcal time interval to t, where t is in minutes
- MSs** change monitor station number to s

Abort Turntable Sample Command (PA). You may use this command to abort turntable samples in progress. Recall, you initiate the turntable sampling using the PS command. You cannot use the 2700 SELECT [CANCEL] key to abort the run, since the 2700 SELECT keypad is disabled in remote control mode.