

# CMT-300

## Programmable Measurement System



**CMT** Corvallis MicroTechnology, Inc.



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# **CMT-300**

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**OWNER'S MANUAL**

**CMT** Corvallis MicroTechnology, Inc.

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## NOTICE

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## SAFETY PRECAUTIONS

General safety precautions as well as specific warnings given in this manual must be observed when operating the CMT-300 Programmable Measurement System. Corvallis Microtechnology, Inc. is not responsible for the user's failure to comply with these requirements.

The user must not open the CMT-300 box. Components should be replaced by qualified maintenance personnel only.

Any circuit containing voltages above 30 VAC or 60 VDC could be a potential shock hazard. Avoid contact with the circuit while it is energized. Do not operate the CMT-300 in the presence of flammable gases or fumes, nor expose it to rain or moisture.

Following are the **Safety Symbols** used on the instrument or in the manual:



This marking adjacent to a terminal indicates that the user must refer to the instruction manual in order to avoid injury and/or damage to the instrument.



This marking adjacent to a terminal indicates that a very dangerous voltage may exist there. Its connecting leads must not be handled while it is energized.

**WARNING** This sign denotes a hazard to the user. It calls attention to a procedure, practice, or the like, which, if not correctly performed or adhered to, could result in injury or death to the user.

**CAUTION** This sign denotes a hazard to the instrument. It calls attention to a procedure, practice, or the like, which, if not performed correctly or adhere to, could result in damage or destruction of part or all of the instrument.

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## INTRODUCTION

The CMT-300 Programmable Measurement System is designed to work in conjunction with the HP-41C/41CV/41CX series calculators as a powerful programmable hand-held measurement system. This device is capable of measuring DC Voltage, true RMS AC Voltage, Resistance, DC Current and true RMS AC Current within the following ranges:

DC Voltage - .2 V, 2 V, 20 V, 200 V, 350 V

AC Voltage - 2 V, 20 V, 200 V, 350 V

Resistance - 2 KOHM, 20 KOHM, 200 KOHM, 2000 KOHM

DC Current - .2 A

AC Current - .2 A

The measurement function and range of operation are selected by means of software commands. You can also work in the autorange mode where the range is set automatically.

The CMT-300 has three input terminals: VOLTS (red) for voltage measurements, A/KOHM (green) for current or resistance measurements, and COM (black), the circuit common. At the other end of the device is a connector that plugs directly into any port of the HP-41. (Before connecting your CMT-300 to the calculator for the first time, be sure to read and follow the instructions given in **Connecting the CMT-300 to the HP-41**, Section 1.)

The CMT-300 comes with a keyboard overlay that labels the HP-41 keys used in the application programs. Two test probes and a spare fuse are also provided.

The built-in software commands of the CMT-300 makes it flexible enough to be customized for many different applications. We have included in the firmware a few applications that we feel will be most frequently used.

One of our application programs (DMM) allows you to use the CMT-300 much like a normal digital

multimeter. Namely, the calculator display is constantly updated with the latest measurement reading. However, it has the added advantage of allowing storage, print out and processing of meter readings via the active calculator keyboard. This and the other application programs will be described in detail later in this manual.

Programmability of the CMT-300 is of immense value when you are using it in conjunction with a transducer. For example, a program can be written to convert the resistance reading of a thermistor to a "degree C" value so that the temperature can be read off the calculator display directly. In this case, the CMT-300 becomes part of a temperature measuring system.

In addition, when used with the HP-41CX calculator, or a HP-41C/CV calculator with a HP 82182A Time Module inserted, the CMT-300 can be programmed to take measurements and log data at specified time points or at regular intervals. In between the measurements, both the calculator and the CMT-300 may be turned off to save battery power. Thanks to its versatility, programmability, low power-consumption and true portability, your CMT-300 can be used as a very handy data acquisition instrument.

We encourage you to read or review the HP41C/41CV/41CX Owner's Manual to familiarize yourself with the use of the calculator. If you plan to use any HP-IL devices or plug-in modules, read the corresponding manuals also.

We welcome your comments and suggestions. Also, if you need further assistance, contact our office at:

Corvallis Microtechnology, Inc.  
Dept. 300-m  
33815 Eastgate Circle  
Corvallis, OR 97333  
Tel.: (503) 752-5456

## Section 1

### GETTING STARTED

#### Connecting the CMT-300 to the HP-41

**CAUTION:** Turn the HP-41 calculator off before inserting or removing the CMT-300 or any other plug-in extensions or accessories. Failure to do so could damage both the calculator and the plug-in module.

The cable connecting the CMT-300 to the plug-in connector has built-in strain relief. Bend it into a shape that allows you to work with the CMT-300 and the HP-41 conveniently.

#### Inserting the CMT-300 Module:

1. Turn the HP-41 off!
2. Remove the port cover of the port you intend to insert the CMT-300 into. Note, however, that you should **never insert the CMT-300 or any other application module into a lower numbered port than a RAM memory module.** (Turn your calculator over to see a map of the ports.)
3. Insert the CMT-300 connector into the selected port. Gently push it in all the way.
4. If you are also using the HP-IL module or other application modules, plug them into any port after the last memory module plugged in. You may leave gaps in the port sequence.
5. Turn the calculator on. If the interface loop is used, be sure all the peripheral devices are properly connected and turned on before turning the calculator on. This will ensure proper auto-addressing.

#### Removing the CMT-300 Module

1. Turn the HP-41 off!
2. Grasp the CMT-300 connector and pull it out.
3. Insert a port cap into the empty port.

## **CMT-300 Operations Overview**

The software provided with the CMT-300 allows you to use the CMT-300 + HP-41 system in many different ways:

### As a Digital Multimeter

The operation of the system as a digital multimeter is explained in Section 2 of this manual.

### As a Data Logging System

The system can be used to log data over a long period of time. The data-logging operation is described in Section 3 of this manual.

### In other Applications

The programming functions provided with the CMT-300 have been made very flexible so that you can easily customize the device for your particular applications.

The basic set of commands are described in Sec. 5 through Sec. 8. A list of useful subroutines is given in Section 9. These functions and subroutines become active in the HP-41 system whenever the CMT-300 is plugged into the HP-41.

All of the CMT-300 programming functions and subroutines may be executed from the display or entered into user programs for remote execution. These may also be assigned to the User keyboard to speed up the process of accessing a function for execution or program entry.

Besides the CMT-300 functions and the standard HP-41 functions, you may also use the functions provided by any other plugged-in module. (Note: Do not use the HP-41C Home Management Pac simultaneously with the CMT-300. These two modules share the same XROM number 09.)

The functions provided in the HP82182A Time Module may be used to achieve timed measurement operations. Also, the various functions provided by the 82160A HP-IL Module are useful for print or mass storage operations.

The application programs that we provide serve as examples of how to use the programming functions to achieve measurement or data logging and processing objectives. In fact, if you wish, you could customize your CMT-300 so that it emulates a rotary-switch type multimeter.

The error and status messages associated with the CMT-300 functions and application programs are listed and explained in Appendix C.

## Section 2

### MULTIMETER OPERATIONS

The application program "DMM" permits you to use the CMT-300 + HP-41 system as a digital multimeter. The front panel of the multimeter is defined by the keyboard overlay provided with your CMT-300. The multimeter labels are on the right-hand side of the keys.

To "turn on" the multimeter, key in the sequence [XEQ] [ALPHA] DMM [ALPHA]. Alternatively, assign "DMM" to a key by pressing [SHIFT] [ASN] [ALPHA] DMM [ALPHA] [destination key]. You can now execute "DMM" by simply pressing the reassigned key in the USER mode.

While the program is running, the display will be constantly updated with a reading until an option key is pressed. When the multimeter is first turned on, it operates in the VDC mode and 100X range. This will be evident from the format of the reading displayed.

As shown on the overlay, the top five rows of keys have the following functions in the "DMM" program\*:

Range Selection	0.1X	1X	10X	100X	1000X
Mode Selection	VDC	ADC	VAC	AAC	KOHM
Other Options	{	LMTS	REF	PROG	STOP
		AR	EM	SAVE	HOLD
		MEDM	REC	STAT	PRT

---

\* This program does not reassign any of the calculator keys, nor does it use any local alpha labels.

To access an option, press the corresponding key while the program is running. Release the key when you hear a beep. (If you clear flag 26 before executing this program, no audible tones will be produced.)

Following is a description of the various options. When prompted for an input within a selected option, key in the appropriate entry, and press [R/S].

Remark: Note that the PRGM annunciator is on while the program is running. More power is consumed while a program is running than when the calculator is idle. A method of obtaining readings without continuously running a program is described in Section 9.

### **Measurement Mode (Function) Selection**

Press a key in the second row to select a measurement function (eg. KOHM). Whenever the mode is switched to VDC, VAC or KOHM, the range will be reset to 100X. When the mode is switched to ADC or AAC the range will be automatically set to .1X. The display will be appropriately reformatted to reflect the change.

When the measurement mode is changed, you will often hear a click. This is due to the relay in the preconditioning circuitry, and is part of the normal operation of the CMT-300.

### **Range Selection**

Press a key in the first row to select the desired range. The display will be reformatted to reflect the change. Any attempt to access an invalid range for a given mode will be ignored. For example, the range remains .1X for the ADC mode no matter which key in the first row has been pressed. An out-of-range reading will be displayed as "OVLD" by the HP-41.

## LIMITS

This option allows you to specify the upper and lower limits of a range of interest. If the upper limit is higher than the lower limit, a beep will be sounded when a reading falls outside of these limits. If the upper limit specified is lower than the lower limit, the calculator will beep when a reading is inside the limits. This option can be very useful in component testing.

To activate this option, press the [LMTS] key. Flag 05 will be set when this option is active.

When prompted with "UPPER LMT?", key in the desired value and press [R/S]. If you do not key in any value before pressing [R/S], that parameter will remain the same as before. The default upper limit is  $9 \times 10^9$ .

You will then be prompted with "LOWER LMT?". Respond as for the first prompt. The default lower limit is  $-9 \times 10^9$ .

To abort this option, press [LMTS] again and input the same value (eg. 0) for both prompts.

Remark: If you will be invoking the REFERENCE or CUSTOM PROGRAM options described below, specify the upper and lower limits with respect to the values obtained after the readings have been modified by those operations.

## REFERENCE

This option allows you to compare the readings against a given reference value. There are 3 possible modes:

- 1) OFFSET mode - the displayed reading represents the actual reading less the reference value. This is the default mode.

- 2) PERCENT mode - the reading taken is displayed as a percentage of the reference value.
- 3) DB mode - the reading taken is compared with the reference value, and the result is expressed in decibels:

$$\text{Result} = -10 \log(\text{Reading}/\text{Reference})$$

To select this option, press the [REF] key. When prompted with "MODE?O,%,DB", key in O, % (this is a shifted key), or DB to select one of the modes described above. If you entered an irrelevant character, the OFFSET mode is selected. If you do not specify a mode before pressing [R/S], the mode will remain the same as previously set.

The reference value may be entered in two ways. If you enter a value via the keyboard when prompted with "REF=?", that value will be taken as the reference. The following readings will be adjusted according to the mode chosen. The user flag 01 will be set to indicate that one of the reference modes is active.

If you press [R/S] without first entering a value, the program expects a measurement result to be stored as the reference. In this case, flag 01 is not set. Instead, flag 02 will be displayed to indicate that a reading is to be stored as the reference. Program execution returns to the main loop, displaying unadjusted readings. Press [STOP] when the desired reading is obtained. Then press [R/S] to continue. The last displayed reading will be stored as the reference value. Flag 02 will be cleared and flag 01 will be set.

To abort this option, press the [REF] key and specify 0 as the reference value.

Remark: When both the CUSTOM PROGRAM (see below) and the REFERENCE options are active, the former will be executed first. Therefore, the reference value should be specified with respect to the

values obtained after the readings have been modified by the custom program. If the reference is to be a measured value, take the measurement when the CUSTOM PROGRAM option is active.

## CUSTOM PROGRAM

When this option is in effect, every reading will be processed by a specified custom program before being displayed. To select this option, press [PROG]. Enter the program name when prompted with "PROG NAME?".

The program name may consist of up to 6 ALPHA characters except comma (,), period (.), and colon (:). Do not use the single letters A through J and a through e as program names. Make sure that the names of your programs are different from the alpha labels used by the CMT-300. (Refer to Appendix B, Section 9, as well as the function table on the back cover of this manual.)

The "DMM" program uses the data register 00 as a temporary storage for the measurement data. Recall the reading from register 00 to use in the custom program. The processed reading should be stored back to register 00 by the custom program. If the readings are to be formatted differently, specify the new format parameters in the custom program by means of the commands FMTLBL, FMTRES and FMTSCL.

Following is an example of a custom program. It will convert the voltage output of a particular rotating-cup anemometer into windspeed readings. (Appendix A contains a few more examples.)

01 LBL <sup>T</sup> WNDSPD	Program name.
02 RCL 00	Recall reading.
03 42.5	
04 *	Data conversion.
05 0.4	
06 +	

07 STO 00	Store processed readings back to register 00.
08 T <sub>MPH</sub>	New label.
09 ASTO X	Store new label into X.
10 FMTLBL	Store new label into the format label buffer.
11 END	

Flag 04 will be set to indicate that the CUSTOM PROGRAM option is active. If a non-existent program is specified as the custom program, flag 04 will be cleared the first time the calculator tries to execute that program.

To exit this mode of operation, enter the letter "N" when prompted with the program name.

Remark: When writing a custom program to be used within the "DMM", make sure that the data registers and/or user flags used do not interfere with those used by "DMM". Program usage information for "DMM" is given in Appendix B.

## STOP

When the [STOP] key is pressed, the unformatted reading in the X-register will be displayed. The formatted reading will be placed in the ALPHA register.

The HP-41 keyboard can be used as usual after the [STOP] key has been pressed. Any of the normal keyboard functions, functions assigned to the User keyboard, or programs of the proper format can be accessed to operate on the reading in the X-register. You may, for example, store the reading into a data register by executing the STO command.

Press [R/S] to resume program operation.

Remark: The initialization procedure of the "DMM" program turns off the LMTS, REFERENCE, CUSTOM PROGRAM AND HOLD options. If you wish to continue working under the same conditions, do not stop the

program with [R/S] and then restart the program from the beginning. Rather, use the [STOP] key to stop the program, and press [R/S] to return to the main loop of the program. Or, after you have stopped the program using [R/S], restart it by keying in [XEQ][ALPHA]ML[ALPHA].

### **AUTORANGE**

To activate the autorange option, press [AR]. Flag 03 will be displayed to indicate that this option is in effect. Any time the range is changed by pressing one of the keys in the top row, the AUTORANGE mode becomes inactive.

### **EXTENDED MEMORY**

This option allows you to create a data file in the Extended Memory. The Extended Memory registers are provided by the HP82180A Extended Functions/Memory Module. They are also available in the HP-41CX calculator. When the [EM] key is pressed, you will be prompted with "FL NAME?" and "FL SIZE?". If you specify a file name that already exists in the Extended Memory, or a file size too large to fit into the Extended Memory, the prompts will be repeated. If you decide not to create a file after pressing [EM], just press [R/S] when prompted.

The current Extended Memory data file will be the one last created or accessed by you.

### **SAVE**

When [SAVE] is pressed, the displayed reading will be stored into the current Extended Memory data file. If the file is full, the calculator beeps, the message "FL FULL" will be displayed, and the reading will not be saved.

## **HOLD**

When this option is active, the user flag 00 will be set. The display will "freeze" when the signal becomes steady, ie. when successive readings differ by less than a specified amount.

When the [HOLD] key is pressed, you will be prompted with the value you wish to store as the criterion for steady state ("DIFF=?"). After a value has been entered and the [R/S] key has been pressed, the HOLD option is activated. If no value is entered, the previous criterion remains effective. The default criterion is 0.

You are allowed at least a few seconds to position the test probes after you press the [R/S] key. Alternatively, position the probes or make the necessary connections before pressing the [R/S] key.

When steady state is reached, a chirp is sounded, and you are in the same state as if you had pressed [STOP]. This allows you to remove the test leads and check or process the reading as desired. To abort the HOLD option, either wait until the steady state is reached or press [STOP].

Remark: The HOLD option is executed after the CUSTOM PROGRAM and REFERENCE options. As a result, the criterion should be specified with respect to the options that are in effect.

## **MASS STORAGE MEDIUM**

To set up a data file in a HP-IL mass storage device, press [MEDM]. You will be prompted with "FL NAME?" and "FL SIZE?". If you specify a file name that already exists in the mass storage medium, or a file size too large to fit into the medium, the prompts will be repeated. If you decide not to create a file after pressing [MEDM], just press [R/S] when prompted.

## RECORD

When [REC] is pressed, the currently displayed reading will be stored into the data file last created on the mass storage medium. If the file is full, the calculator beeps, the message "FL FULL" will be displayed, and the reading will not be saved.

## STATISTICS

This option allows you to review the statistical values of a set of data accumulated by means of the [ $\Sigma+$ ] key. When the [STAT] key is pressed, the total number (N) of data accumulated from the X-register, the mean value (MEAN) and the standard deviation (SDEV) will be given. These will be printed if an HP-IL printer is present in the system. Otherwise, these results will be displayed one by one. Press [R/S] to view the next result.

Be sure to clear the statistical registers before starting to accumulate a new set of data. Do this by pressing the yellow SHIFT key and then [CL  $\Sigma$  ].

Remark: Refer to the HP-41 Owner's Manual for instructions on how to use the statistical functions to accumulate data.

## PRT

When the [PRT] key is pressed, the displayed formatted reading will be printed if an HP-IL printer is present in the system.

\*\*\*\*\*

The "DMM" program requires a number of data storage registers to store the pertinent parameters. The location of these registers is given in Appendix B.

You will be prompted to resize the data memory of the calculator if the program finds it too small to accommodate the necessary parameters. When resizing the data memory, take into consideration any data storage registers that will be used by a custom program or data storage operations. After you have resized the data memory by means of the SIZE command, press [R/S] to continue.

### **Making Measurements**

**WARNING:** Voltages within the measuring range of this instrument are dangerous and can be fatal. Do not make measurements in high voltage and high power circuits unless qualified to do so.

For maximum safety, do not touch test leads, circuit or instrument while power is applied to the circuit being measured.

**CAUTION:** If you attempt to measure voltages above 350V, you may damage this instrument.

To make measurements in the multimeter mode, execute "DMM". The initial setting is for measuring DC voltages in the 100X range.

The display will automatically indicate the correct polarity. If the measured quantity exceeds the maximum of the range selected, the over-range condition will be indicated on the display as "OVL".

## **Voltage Measurements**

1. Press [VDC] if you are measuring DC voltages, [VAC] if you are measuring AC voltages.
2. Press the appropriate range key or press [AR] to let the multimeter autorange.
3. Plug the red test lead into the VOLTS (red) jack, and the black test lead into the COM (black) jack.
4. Connect the test probes to the circuit being measured.
5. The display is read directly for the measured DC or AC voltage.

## **Resistance Measurements**

1. Press the [KOHM] key.
2. Press the appropriate range key. (Note: .1X is not a valid range for this measurement mode.)
3. Plug the red test lead into the A/KOHM (green) jack, and the black test lead into the COM (black) jack.
4. Connect the test probes to the resistance being measured.
5. Read the calculator display directly for the measured resistance.

## **Current Measurements**

**CAUTION:** The fuse will blow if the current flowing into the A/KOHM (green) terminal exceeds 0.5A.

1. Press [ADC] to measure DC currents, and [AAC] to measure AC currents.
2. The range will be automatically set to .1X, the only valid range for current measurements.
3. Plug the red test lead into the A/KOHMS (green) jack, and the black test lead into the COM (black) jack.
4. Connect the test probes to the circuit being measured.
5. Read the calculator display directly for the measured current.

## Section 3

### AUTOMATIC DATA LOGGING

The application programs "DLOG" (Data Log) and "PSSR" (Print/Store/Save/Record) permit data logging to be carried out without user intervention. Once the initial conditions have been set up, you can leave the system alone. The HP-41 and the CMT-300 will be turned on to make measurements at a specified time or at given time intervals. Both devices will be turned off automatically between measurement runs. The HP82182A Time Module will be required if the HP-41C or HP-41CV calculator is to be used to run this program.

You may store the measurement results in the HP-41 memory (data registers or Extended Memory), on a mass storage medium (tape or disk), or by means of any other storage device compatible with the system.

The keys used in this operation are defined by the keyboard overlay provided with your CMT-300. The labels are on the right-hand side of the keys. While the "DLOG" program is running, the following options\* are available:

Range Selection	.1X	1X	10X	100X	1000X
Mode Selection	VDC	ADC	VAC	AAC	KOHM
Autorange	AR				

To execute this program, key in the sequence [XEQ] [ALPHA] DLOG [ALPHA]. Alternatively, assign "DLOG" to a key by pressing [SHIFT] [ASN] [ALPHA] DLOG [ALPHA] [destination key]. You can now execute "DLOG" by simply pressing the reassigned key in the USER mode.

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\* This program does not reassign any of the calculator keys, nor does it use any local alpha labels.

## Running the Program

Execute "DLOG" as described above. You may choose more than one method for storing data.

### NO. OF FNS?

Key in the number of measurement functions to be used. Then press [R/S]. The CMT-300 allows two devices to be connected to its terminals simultaneously. You could, for example, connect a thermistor between the KOHM and the COM terminals, and the voltage output from a rotating-cup anemometer between the VOLTS and the COM terminals.

For as many times as the number of measurement functions specified, you will be prompted with the mode and range of measurement as well as the program to be used to process the data. Thus it is possible to process the same set of measurement results using different custom programs.

If you press [R/S] without first keying in a number, this parameter will default to 1.

The number of data storage registers required for running the "DLOG" program is  $17 + 3 \times (\text{No. of Fns.})$ . You will be prompted to resize the data memory if it is too small.

### PRINT?Y/N

Type the letter "Y" if you wish the readings to be printed on a HP-IL printer as they are taken. Then press [R/S]. If not, just press [R/S], and this option will not be selected.

The user flag 00 will be set if your response to this prompt is "Y".

### STORE?Y/N

Type the letter "Y" if you wish the readings to be stored into the data registers of the HP-41. Then

press [R/S]. If not, just press [R/S], and this option will not be selected.

If this option is selected, you will be prompted with "REG. NO.?". Specify the location of the first data register to be used for storing the measurement results. Check to see that this data register lies beyond the block of registers used by the data-logging programs, the data manipulation program (see Appendix B) and any custom programs that will be called. Also, make sure you have sufficient data storage registers available. The user flag 05 will be set if your response to this prompt is "Y".

#### **SAVE?Y/N"**

Type the letter "Y" if you wish the readings to be saved in a data file in the Extended Memory. Then press [R/S]. If not, just press [R/S], and this option will not be selected. The user flag 01 will be set if your response to this prompt is "Y".

#### **RECORD?Y/N**

Type the letter "Y" if you wish to save the readings in a data file in a mass storage device (such as the HP82161A Digital Cassette Drive). Then press [R/S]. If not, just press [R/S], and this option will not be selected. The user flag 02 will be set if your response to this prompt is "Y".

(A Mini Data Cassette Tape can hold up to about eighteen thousand readings. Plug the HP82161A Digital Cassette Drive into an electrical outlet if you expect a long data-logging session.)

#### **FL NAME?**

Key in up to 6 ALPHA characters that you wish to name the data file with. The same name will be used for the data file in the Extended Memory and

that on the mass storage medium. Therefore, if you are storing data both into the Extended Memory and onto the mass storage medium, you will only be prompted once for the file name.

#### **OTHER?Y/N**

This option allows you to use a method of data storage other than those included in this program. This will also accommodate storage devices that may be developed for the HP-41 in the future.

Flag 06 will be set if your response to this prompt is "Y". When prompted with "NAME?" key in the name of the custom program in which the particular data storage operations are implemented. All the data will be acted upon equally by this program.

The name of the custom program may consist of up to 5 alpha characters. Because of the way the custom program will be called by the data-logging programs, the custom program should be made up of 3 parts, each designed to perform a specific operation. Suppose the program is named "STORE". It should contain two subprograms, named "STOREA" and "STOREB", and have the following structure:

LBL<sup>T</sup>STORE

Create a storage file for the data. The number of registers required will be provided in the X-register when this program is called. (Leave this part blank if the storage medium is not organized into files.)

Return to the main program.

LBL<sup>T</sup>STOREA

Copy the contents of the HP-41 registers 01 through 04 into the first 4 registers of the designated storage area.

Return to the main program.

LBL<sup>T</sup>STOREB

Recall the data from the HP-41 register 00 and store it into the next register of the chosen storage device.

Increment storage register pointer, if necessary.  
Return to the main program.  
End of the program "STORE".

### **MODE?**

Press one of the keys in the second row to select the mode of measurement. Release the key when you hear a beep. If you press an irrelevant key, the action will be ignored. This prompt will appear as many times as the number of measurement functions specified above.

If you do not select a mode within 10 seconds, the program will stop, as evidenced by the disappearance of the PRGM annunciator from the display. In that case, press [R/S] to return to the mode selection process.

### **RANGE?**

Press one of the keys in the top row to select the range for the measurement function chosen. Press [AR] if autoranging is desired instead. Release the key when you hear a beep. If you press an irrelevant key, the action will be ignored. You will be prompted for this parameter once for every measurement function specified.

If you do not select a range within 10 seconds, the program will stop, as evidenced by the disappearance of the PRGM annunciator from the display. In that case, press [R/S] to return to the range selection process.

### **REF?Y/N**

If your response to this prompt is "Y", the "DLOG" program will immediately take a reading of the system offset for the present mode/range setting. This will be used to correct the readings taken later in the same mode/range combination. Therefore, if this option is to be selected, have the

measurement setup ready to measure "background" (reference) data before answering this prompt. For example, if you are taking resistance data and want to have the offset subtracted from each reading, touch the leads together before pressing "Y" and then [R/S].

### **PROG NAME?**

Key in the name of the custom program you wish to use to modify the readings. The program name may be up to 6 ALPHA characters long. The custom program should not be named by the single letters A through J and a through e.

If you do not wish the readings to be modified, just press [R/S].

This prompt will appear once for each measurement function specified.

(See Appendix A for some examples of custom programs.)

\*\*\*\*\*

At this point, have the measurement setup ready so that data may be taken and stored or printed.

To understand the operations of the timer module, consult the HP-41CX Owner's Manual or the Owner's Manual for the Time Module.

\*\*\*\*\*

### **INTERVAL?**

Key in the interval between measurement sequences in the form HHHH.MM, where HHHH may be up to but less than 10,000 hours. The smallest allowable time interval is 1 minute (specified as 0.01).

This time interval will be the repeat interval of the alarms that will wake up the HP-41 and the CMT-300 to make the measurements.

If no value has been keyed in before you press [R/S], this parameter defaults to 0, and there will be no repetition of the measurement sequence.

### **ITERATIONS?**

Key in the number of measurement sequences to be made. Any integer up to 999 is a valid input. If you do not key in any value, this parameter defaults to 1.

### **START TIME?**

Specify the time data logging is to begin in the format HH.MM. For example, if you specify 22.03, then data logging will begin at 10:03 p.m. on the date specified below.

If you do not input any value, the data-logging operation will start immediately.

### **START DATE?**

Specify the day data logging is to begin in the format MM.DDYyyy. If you do not input any value, this parameter will default to the present date. Valid dates are from the current date to Dec.31, 2199.

This prompt will be bypassed if you did not input a value when prompted with "START TIME?".

\*\*\*\*\*

At this point, the necessary files for storing the data will be created if you have answered "Y" to "SAVE?Y/N" or "RECORD?Y/N". If you used a file name that already exists, or if the file size is too large, the program will stop, and the corresponding error message will appear. To correct the duplicate file error, place the new file name in the ALPHA register, and press [R/S] to continue. If the file size is too large, you could execute "ALARM" to specify fewer itera-

tions, or replace the mass storage medium used to store the data with a new one.

If you have chosen the option of storing data to the data storage registers, the program will check to see if you have sufficient data registers available. If not, you will be prompted to resize the data memory to the appropriate size. Press [R/S] after executing the SIZE command.

Now the alarms for waking up the calculator will be set. The calculator and the CMT-300 will be turned off automatically, and the HP-IL devices used will be in a powered-down state. When the first measurement sequence is due, the devices will be automatically powered up to do the job.

The program "PSSR" will be called by the program "DLOG" to carry out the measurement, printing and/or logging operations.

In case the HP-41 batteries run low during a data-logging session, the alarms will be deleted, and the calculator and the CMT-300 will be turned off automatically. This will prevent the memory contents of the calculator from being deleted because of low power.

Remark: The "DLOG" program deletes all alarms from memory before setting the alarms for the measurements. This is to prevent existing alarms from interfering with the measurements. If you have important alarms in memory, consult the Owner's Manual for the HP-41CX or the Time Module on procedures for saving the alarm parameters.

## Location of Stored Data

The entries of a data file created by "DLOG" in the Extended Memory or on a mass storage medium will be arranged in the following order. (We assume that 2 measurement functions were used.)

Date on which the first measurement was made

Time at which the first measurement was made

Repeat interval of alarms

Iterations (No. of measurement sequences)

(1st measurement sequence) 1st measurement result  
2nd measurement result

(2nd measurement sequence) 1st measurement result  
2nd measurement result

(3rd measurement sequence) 1st measurement result  
2nd measurement result

·  
·  
·

(This is how the print-out will appear if the PRINT option was selected.)

If the STORE option was selected, the first 4 parameters and the measurement results are stored in the data register block starting at the register you specified while running the "DLOG" program.

If the OTHER option was selected, make sure the program used takes care of storing these 4 parameters along with the data. The "iterations" parameter will be used when the program "SPP" (Section 4) is used to analyze and/or process the stored data.

The number and type of measurement functions used are not stored along with the data. You should keep a record of this information along with the file name or the location of the block of registers used for storing the data.

## Section 4

### DATA MANIPULATION

The program "SPP" (Statistics/Print/Plot) allows you to process measurement results that have been stored by means of the data-logging process described in Section 3.

You are given the option to print the measurement results, plot the data points, or process the data by means of a specified program. A simple statistical analysis will also be performed on the data. (This is necessary for finding the maximum and minimum values to be plotted.)

To execute this program, key in the sequence [XEQ] [ALPHA] SPP [ALPHA]. Alternatively, assign "SPP" to the User keyboard and press the reassigned key in the USER mode.

The "SPP" program requires 28 registers for storing pertinent parameters. You will be prompted to resize the data memory if it is not large enough to run this program. After you have resized the data memory, press [R/S] to continue.

#### Running the Program

Execute "SPP" as described above. You will be prompted for the following inputs. Except for the first prompt, press [R/S] after keying in a response.

#### SOURCE?

Use one of the following keys to specify where the data is coming from. Release the key when you hear a beep.

[STO] : Data storage registers of the HP-41.  
[EM]: An Extended Memory data file.  
[MEDM]: An HP-IL mass storage device.  
[SAVE] : Some other data storage device.

If you press an irrelevant key, the action will be ignored.

If you do not press a key within 10 seconds, the program will stop automatically, as evidenced by the disappearance of the PRGM annunciator from the display. In that case, press [R/S] to go back to the step of specifying data source.

#### **REG. NO?**

You will see this prompt if you pressed [STO] in response to **SOURCE?** Enter the location of the first register of the block of registers used in "DLOG" for data storage. (This is where the date information is stored.)

#### **FL NAME?**

If the data comes from a data file in the Extended Memory or on a mass storage medium, key in the name of the data file.

#### **NAME?**

If the data has been stored by some other means, key in the name of the program you will use to retrieve the data.

The name of the custom program may consist of up to 5 alpha characters. Because of the way the custom program will be called by the "SPP" program, the custom program should be made up of 2 parts, each designed to perform a specific operation. Suppose the program is named "GET". It should contain a subprogram named "GETA", and have the following structure:

LBL<sup>T</sup>GET

Place the "iterations" parameter (stored as the 4th entry) into the HP-41 data register 18.

Set up an appropriate counter.

Return to the main program.

LBL<sup>T</sup>GETA

Increment the counter by the number of measurement functions used.

Retrieve the data and store it into register 19 of the HP-41.

Return to the main program.

End of the program "GET".

## **NO. OF FNS.?**

Key in the number of measurement functions used in each measurement sequence. If you press [R/S] without first keying in a number, this parameter will default to 1.

## **FN. NO.?**

Specify which measurement result you are interested in among those in a measurement sequence. For example, suppose a data file contains sequences of voltage and resistance data, with the voltage preceding the resistance in each sequence. To analyze the resistance data, you would specify 2 as the function number.

This parameter will default to 1 if you press [R/S] without first keying in a number.

## **LABEL?**

Input the name you wish to use to label this collection of data.

## **PRINT?Y/N**

Key in "Y" if you would like to have a hard copy of the data made by an HP-IL printer connected to the system.

## **PLOT?Y/N**

Key in "Y" if you would like to have the data plotted on a HP-82162A Thermal Printer.

If this option is selected, a statistical analysis will automatically be performed on the data to find the maximum and minimum values to be plotted.

If you set flag 07 before pressing [R/S], the program will skip over the portion of calculating the statistical results. You may use this technique to save time when you are certain that the maximum and minimum values of the data to be plotted have already been stored in registers 01 and 00, respectively.

### **PROG?Y/N**

This option allows you to process the data using a custom program. Input "Y" if you would like to have the data presented in a different way than described above.

### **PROG NAME?**

This prompt will be displayed if you input "Y" to the above prompt. Key in the name of the program to be used to operate on each data point. The data will be in the X-register when this program is called.

\*\*\*\*\*

If your response to "PROG?Y/N" is "Y", the custom program will be called to operate on each data point as it is retrieved. The retrieved value is stored in register 19 of the HP-41. It will be recalled to the X-register when the custom program is called.

If an HP-IL printer is in the system, the statistical results will be printed. Otherwise, the results will be displayed one by one. Press [R/S] to display the next result.

The statistical results will follow a print-out of the data if the print option has been selected.

The plot will come last if it has been selected along with the other options. The axis of the plot is located mid-way between the maximum and minimum data values. Note that a plot cannot be made if the maximum and minimum data values are equal.

In case the HP-41 batteries run low during a long data-processing session, the calculator and the CMT-300 will be turned off automatically. This will prevent the memory contents of the calculator from being deleted because of low power.

## Section 5

### SETTING THE MODE AND RANGE

The valid measurement modes and ranges of the CMT-300 are as tabulated below:

	.1X	1X	10X	100X	1000X
VDC	.2	2	20	200	350
ADC	.2				
VAC		2	20	200	350
AAC	.2				
KOHM		2	20	200	2000

**MODEX** - Set mode by X.

This function sets the mode of measurement according to the X-register contents. The mode may be specified in either of two forms:

Alpha =	VDC	ADC	VAC	AAC	KOHM
Numeric =	0	1	2	3	4

To specify the mode in the numeric form, simply place the corresponding numeral in the X-register. To specify the mode in the alpha form, key in the name in the ALPHA mode, and execute ASTO X.

This function will ignore any attempt to set the mode to an invalid specifier in the X-register. In this case, the present mode will be left unchanged, and the error will be reflected by the error number returned by the command ERROR? (Refer to the description of ERROR? in Section 8.)

Upon start-up, the default measurement mode of the CMT-300 is the VDC mode. It remains in effect until a MODEX command is executed. The active mode will be stored in a buffer. The buffer is deleted the first time the calculator is turned on without the CMT-300 module in place. Otherwise, it remains intact, and the measurement mode defaults to the buffer contents when the calculator is turned on.

Whenever the measurement mode is set to VDC, VAC or KOHM, the range will be automatically reset to 100X. The range defaults to .1X when the mode is set to AAC or ADC.

Whenever the MODEX command is executed, the format resolution and scale buffers will be reset to the default values of 4 and 1, respectively, and the alpha label for the specified mode (eg. ADC) will be stored into the format label buffer. (See Section 6 for a description of the format parameters.)

**MODEN?** - Return active mode to X in numeric form.

This function returns the present setting of the mode in numeric form to the X-register.

**MODEA?** - Return active mode to X in alpha form.

This function returns the present setting of the mode in alpha form to the X-register.

**RANGEX** - Set range by X.

This function sets the range according to the X-register contents. The range may be specified in either of two forms:

Alpha =	.1X	1X	10X	100X	1000X
Numeric =	-1	0	1	2	3

To specify the range in the numeric form, simply place the corresponding numeral in the X-register. To specify the range in the alpha form, key in the corresponding name in the ALPHA mode, and execute ASTO X.

This function will ignore any attempt to set the range to an invalid specifier in the X-register. In this case, the present range will be left unchanged, and the error will be reflected by the error number returned by the command ERROR? (Refer to the description of ERROR? in Section 8.)

The default range of the CMT-300 upon start-up is 100X (default mode is VDC). It remains in effect until a RANGE<sub>X</sub> command is executed. The active range will be stored in a buffer. The range buffer contents will be used to set the range when the calculator is turned on. The buffer will be deleted the first time the calculator is turned on without the CMT-300 plugged-in.

Whenever the mode is set to VDC, VAC or KOHM, the range defaults to 100X. The range defaults to .1X when the mode is set to ADC or AAC.

**RANGN?** - Return active range to X in numeric form.

This function returns the present range setting in numeric form to the X-register.

**RANGA?** - Return active range to X in alpha form.

This function returns the present range setting in alpha form to the X-register.

**NRNGN?** - Return next range to X in numeric form.

This function returns the next valid range for the active mode to the X-register in numeric form. For example, if the active mode is KOHM and the present range is 1000X, NRNGN? will return 0 to the X-register.

**NRNGA?** - Return next range to X in alpha form.

This function returns the next valid range for the active mode to the X-register in alpha form. For example, if the active mode is AAC, NRNGA? will return .1X to the X-register.

One way of using this function is to follow it with VIEW<sub>X</sub> and then RANGE<sub>X</sub> in a program. This will cause the next valid range to be displayed while the CMT-300 is set to that range automatically.

## Section 6

### READING AND FORMATTING THE DATA

When a measurement value is read, the result is placed in the X-register as a normalized floating point number. Functions are provided to format the reading as desired.

The default format parameters are such that after formatting, the label reflects the mode of measurement, and the position of the decimal point gives an indication of the range the CMT-300 is operating in. For example, a DC voltage reading in the 100X range will be in the form:

sddd.d VDC

where "s" is either a blank (implied + sign) or the - sign, and "d" represents a single digit. Thus the readings 120.5 VDC and   3.0 VDC both indicate that you are working in the 100X range. Similarly, a DC current reading in the .1X range will have the format:

s.dddd ADC

**READX** - Return average of X readings to X.

This function switches the CMT-300 to a powered-up state if it is in a powered-down state. (The CMT-300 is in a powered-down state whenever the HP-41 is idle.) This function takes a number of readings as specified in the X-register, and returns the averaged result to the X-register as a normalized floating-point number. Before executing this function, place the specifier (eg. 1) in the X-register. The maximum allowable value of the specifier is 999.

The measurement result will have been corrected by an appropriate calibration constant in the delta table before it is returned to the X-register. The command for storing the calibration constants

into the delta table buffer will be described in Section 7.

If any one of the readings is out of range, the function will be terminated, and an impossible reading will be returned to the X-register. Out-of-range readings will be displayed as:

Range	.1X	1X	10X	100X	1000X
Out-of-range reading	.2000	2.000	20.00	200.0	2,000

An error number will be returned when the ERROR? command is executed after an out-of-range error has occurred. (See Section 8.)

This function may be aborted by pressing the [R/S] key.

**AUTORD** - Average X readings in autorange mode.

This function turns on the CMT-300 as in READX. It incorporates autoranging. Measurements are made on successive valid ranges until one is found where the reading is between full scale and 9% of full scale (except for the lowest range). Then the number of readings specified in the X-register is taken. The averaged result will be returned to the X-register as a normalized floating-point number after it has been corrected by the appropriate calibration constant in the delta table.

The maximum allowable value of the specifier in the X-register is 999. Out-of-range readings will be handled the same way as for READX.

This function may be aborted by pressing the [R/S] key.

**HI/LO** - Return extremes of X readings to Y and X.

This function turns on the CMT-300 as in READX, and takes the number of readings specified in the

X-register. It returns the highest and lowest of these values to the Y- and X-registers, respectively. The returned readings will have been adjusted with the calibration constants in the delta table.

If the specifier in the X-register has an absolute value less than 2, it will default to 2 for this function. The maximum allowable value of this specifier is 999.

Out-of-range readings will be handled the same way as for READX, except that in this case the impossible reading will be in the Y-register unless all readings are out of range.

This function may be terminated by pressing the [R/S] key.

**FMTRES** - Set format resolution by X.

This function sets the format resolution buffer to the positive integer portion of the number placed in the X-register. The format resolution parameter determines the number of digits displayed when a reading is formatted with the FORMAT command described below.

The default format resolution is 4.

**FMRES?** - Return format resolution to X.

This function returns the active format resolution parameter to the X-register.

**FMTSCL** - Set format scale by X.

This function sets the format scale buffer to the number placed in the X-register. The specifier in the X-register may be any positive or negative floating point number. When the FORMAT command is executed, the reading to be formatted will be divided by the format scale parameter. The default format scale is 1.

**FMSCL?** - Return format scale to X.

This function returns the active format scale parameter to the X-register.

**FMTLBL** - Set format label by X.

This function sets the format label buffer to an alpha label in the X-register. The label will be appended to a reading when it is formatted with the FORMAT command described below.

To place an alpha label in the X-register, key in the label in the ALPHA mode, then execute ASTO X. If an alpha label has been stored in data register nn, execute RCLnn before executing FMTLBL. It is possible to use an empty string as format label.

To set the format label buffer to the label appropriate to the active measurement mode, execute MODEA? before executing FMTLBL. (MODEA? has been described in Section 5.)

Whenever the MODEX command is executed, the alpha label of the specified mode will be stored into the format label buffer.

**FMLBL?** - Return format label to X.

This function returns the active format label to the X-register.

**FORMAT** - Format X with format parameters.

This function formats the X-register contents according to the parameters stored in the format buffers. The formatted result will be placed in the ALPHA register. The ALPHA register is cleared at the beginning of this function.

Suppose the reading in the X-register is 15.02. If the format parameters are 3 (resolution), 10 (scale), and DEG C (label), then the formatted result in the ALPHA register will be 1.50 DEG C.

## Section 7

### TESTING THE SYSTEM

The following functions permit you to test the condition of the CMT-300 ROM as well as the calibration of the system. Any adjustments to the calibration can be stored as calibration constants (delta settings) in the delta table buffer of the CMT-300. These values are used to correct readings taken in the corresponding mode/range combination. The buffer is deleted the first time you turn on the HP-41 without the CMT-300 plugged in. When the CMT-300 is subsequently plugged in (after the HP-41 has been turned off), the delta buffer is initialized to 0s.

**CAUTION:** Electronic calibration should only be executed by qualified service personnel. Refer to Section 10 for service information.

**TSTROM** - Test CMT-300 ROM.

This function tests the CMT-300 ROM. At the completion of the execution of this function, the display should show a label followed by OK. Otherwise, the unit requires servicing. (Section 10)

**DELTA** - Set up delta table with X.

This function stores the value in the X-register into the delta table buffer at the location assigned to the active mode/range combination. This value will be used to correct readings taken in the same mode/range combination. The DELTA command is useful when different offsets are required for different mode/range combinations.

**DELTA?** - Return effective delta setting to X.

This function returns to the X-register the delta setting used for the active mode and range.

## Section 8

### MISCELLANEOUS FUNCTIONS

**ERROR?** - Return error number to X.

This function returns to the X-register a number that indicates which of the following types of errors have occurred since this function was last executed. Each type of error is represented by a unique number:

Range error	1
Mode error	2
Out-of-range error	4

The error number returned by **ERROR?** is the sum of the numbers corresponding to the different types of errors that have occurred. For example, the error number 6 shows that one or more mode errors as well as one or more out-of range errors have occurred.

The error number is automatically reset to 0 when **ERROR?** is executed.

When this function is executed from the keyboard, the message YES or NO will be displayed. To see the corresponding error number, press the [ ← ] key.

This function may be used as a conditional in a program. The following program step will be executed if **ERROR?** returns a non-zero number. Otherwise it is skipped.

**RCLKY?** - Return keycode to X if key down.

This function checks to see if a key is being pressed down. If one is, the corresponding keycode is returned to the X-register. If not, the number -1 is returned.

This function is designed to be used as a conditional in a program. If a key is down when RCLKY? is executed, the following program step will be executed. Otherwise, that program step will be skipped.

**KYDWN?** - Skip next step if key not down.

This function is designed to be used as a conditional in a program. It checks to see if a key is down. If one is, the following program step will be executed. Otherwise, that program step will be skipped.

One way of using this function in a program is to follow it with a STOP command. When a key is detected to be down, the program will be stopped, and the function corresponding to that key will be executed.

**DMMOFF** - Turn off CMT-300.

This function turns off the CMT-300. It can be used to conserve battery power. The CMT-300 is automatically turned off at the end of a running program or at the end of a read function executed from the keyboard. The DMMOFF can be used within a program to turn off the CMT-300 while the program goes on to perform other tasks.

**KYASN** - Assign function to User keyboard.

This function assigns a function or a label to the User keyboard. Place the function or label in the ALPHA register, and the keycode of the key to be reassigned in the X-register before executing this function. Refer to the HP-41 Owner's Manual for a description of the keycodes.

**F<>X** - Exchange flags 00 through 07 with X.

This function places into the X-register the decimal equivalent of the binary number representing the status of the user flags 00 through 07. In

addition, it sets the user flags 00 through 07 according to the binary equivalent of the integer portion of the original X-register contents.

Any number from 0 through 999 in the X-register is valid, but only the lower eight bits of its binary equivalent will be used to set the flags.

**A>X** - Copy ALPHA left digit as decimal to X.

This function shifts the leftmost byte out of the ALPHA register, and places its decimal equivalent in the X-register.

Suppose the ALPHA register contains "ABC" when this function is executed. The number 65 will be returned to the X-register. This number is the decimal ASCII code of the character "A". It can be used as a basis for comparison and decision making. The ALPHA register now contains "BC".

**CLALMS** - Clear all alarms.

This function clears all alarms that have been previously set.

To save time in deleting alarms, you may wish to assign this function to the User keyboard so it will be handy when needed. Refer to the HP-41CX or the HP82182A Time Module Owner's Manual for instructions on setting alarms.

**VIEWA** - View ALPHA without a blink.

This function places the first 12 characters of the ALPHA register into the display. This function may be used to view most HP-41C keyboard characters. Only the upper-case letters of the alphabet may be viewed by means of this function.

Unlike the AVIEW function of the HP-41, this function does not produce a noticeable blink in the display. Note also that the VIEWA command is not associated with the HP-IL printer operations.

## Section 9

### USEFUL SUBROUTINES

Following are some subroutines constructed from the basic programming functions. These may be used as building blocks in the application programs that you write. If you assign these to the User keyboard, you can set the mode, set the range, or obtain a single reading by pressing the corresponding key in the USER mode. (Very little power is consumed if you operate the CMT-300 in this manner.)

- VDC** - Set mode to VDC for measuring dc voltage.
- ADC** - Set mode to ADC for measuring dc current.
- VAC** - Set mode to VAC for measuring ac voltage.
- AAC** - Set mode to AAC for measuring ac current.
- KOHM** - Set mode to KOHM for measuring resistance.
- 1X** - Set range to .1X.
- 1X** - Set range to 1X.
- 10X** - Set range to 10X.
- 100X** - Set range to 100X.
- 1000X** - Set range to 1000X.
- READ4** - Returns formatted reading with 3 1/2 digit resolution.
- READ5** - Returns formatted reading with 4 1/2 digit resolution.
- AR4** - Same as READ4, but with autoranging.
- AR5** - Same as READ5, but with autoranging.
- OFFSET-** Takes a reading and stores it in the delta table buffer at the location designated for the active mode and range. The system offset will be subtracted from each reading taken in the same mode/range combination. This function facilitates the process of system calibration test. It is also useful in applications where a different offset is required for each mode/range combination.

## Section 10

### MAINTENANCE INFORMATION

#### Initial Inspection

When you first receive the device, examine the package for signs of damage. Check to see that the device is in good mechanical condition.

If there is any mechanical damage, notify our office. If the shipping container is damaged, notify the carrier as well as our office.

The package includes the CMT-300 box (with the plug-in connector connected to it via a cable), a pair of test probes, a spare fuse, as well as a keyboard overlay.

#### Care of the Unit

- \* Always turn off the calculator before connecting or disconnecting the CMT-300 module.
- \* Keep the electrical contacts of the module clean. When necessary, carefully brush or blow the dirt out of the contact area. Do not use any liquid for cleaning the contacts.
- \* Store the unit in a clean, dry place.
- \* Observe the temperature specifications:

Operating: 0 to 45 deg. C (32 to 113 deg. F)

Storage: -20 to 55 deg. C (-4 to 131 deg. F)

#### Replacing the Fuse

##### Procedure:

1. Turn off the HP-41.
2. Disconnect test leads from external circuit connections.

3. Locate the fuse to the right of the green terminal.
4. Use a screw driver to remove the fuse holder. Replace the fuse with a 5 mm x 20 mm 0.5A/250V medium-blow fuse.
5. Reinsert and screw in the fuse holder.

**WARNING:** Using an incorrect fuse will reduce the protection of the instrument, and can be hazardous to the user as well as the instrument.

### **Resetting the HP-41**

In case of a disruption of calculator operation, you can usually recover from it by resetting the HP-41. To do so, follow the instructions given on p. 242 of the HP-41C/41CV Owner's Handbook and Programming Guide, or p. 385 of the HP-41CX Owner's Manual.

### **Power Consumption**

The CMT-300 draws very little current from the HP-41 batteries. However, the life of the battery pack will be reduced considerably if you run a program (eg. "DMM") continuously or use other peripheral devices that draw power from the HP-41.

To ensure proper operation of the CMT-300, replace all batteries when the battery annunciator goes on. Consult your HP-41 manual regarding procedures for replacing the batteries.

If you use peripherals frequently, it is advisable to use a HP82120A Rechargeable Battery Pack instead of the disposable battery pack.

## Specifications

### DC VOLTAGE

#### Input Characteristics:

Range	Max. Reading	Resolution
.2 V	+/- .1999 V	100 $\mu$ V
2 V	+/- 1.999 V	1 mV
20 V	+/- 19.99 V	10 mV
200 V	+/- 199.9 V	100 mV
350 V	+/- 350 V	1 V

#### Input Resistance:

.2 V range:  $> 10^{10}$  Ohms  
2 V, 20 V, 200 V, 350 V ranges:  $> 10$  MOhms

#### Maximum Input Voltage: (non-destructive)

VOLTS to COM: +/- 500 V (DC + peak AC)  
VOLTS or COM to Earth Ground: +/- 500 V  
(DC + peak AC)

#### Measurement Accuracy:

+/- (% of reading + number of counts)

Range	Accuracy
.2 V	.05 + 5
2 V	.25 + 2
20 V	.25 + 2
200 V	.25 + 2
350 V	.25 + 2

#### Full Range Step Response: (to rated accuracy)

.2 V range: 5 seconds  
Other ranges: 1 second

**AC VOLTAGE**  
(true rms responding)

Input Characteristics:

Range	Max. Reading	Resolution
2 V	+/- 1.999 V	1 mV
20 V	+/- 19.99 V	10 mV
200 V	+/- 199.9 V	100 mV
350 V	+/- 350 V	1 V

Input Impedance:

All ranges: > 10 MOhm shunted by < 100 pF

Maximum Input Voltage: (non-destructive)

VOLTS to COM: 500 V (DC + peak AC)

VOLTS or COM to Earth Ground: +/- 500 V  
(DC + peak AC)

Measurement Accuracy:

+/- (% of reading + number of counts)  
Accuracy is for sine wave inputs only,  
>10% of full scale.

Frequency	2V	20V	200V	350V
20-100 Hz	1.0 + 10	1.0 + 5	1.0 + 5	1.0 + 5
20-500 Hz		1.0 + 5	1.0 + 5	1.0 + 5
20-1 KHz		1.0 + 5	1.0 + 5	1.0 + 5
20-5 KHz				1.0 + 5

Crest Factor: > 4:1 at full scale

Full Range Step Response: (to rated accuracy)

All ranges: 5 seconds

## RESISTANCE

### Input Characteristics:

Range	Max. Reading	Resolution	Open Ckt. Volt.
2 KOhm	1.999 KOhm	1 Ohm	< .8 V
20 KOhm	19.99 KOhm	10 Ohm	< .8 V
200 KOhm	199.9 KOhm	100 Ohm	< .8 V
2000 KOhm	1999. KOhm	1000 Ohm	< .8 V

### Maximum Input Voltage: (non-destructive)

A/KOHM to COM: +/- 220 VDC or 250 VAC (rms)

A/KOHM to Earth Ground: +/- 500 V (DC + peak AC)

### Measurement Accuracy:

All ranges: +/- .15% of input + 2 counts

### Full Range Step Response: (to rated accuracy)

2000 KOHM range: 7 seconds

All other ranges: 3 seconds

## DC CURRENT

### Input Characteristics:

Range	Max. Reading	Burden Voltage
.2 A	+/- .1999 A	.3 V max.

Accuracy: +/- (1% of input + 1 count)

Overload Protection: .5A/250V fuse

### Full Range Step Response: (to rated accuracy)

1 second

**AC CURRENT**  
(true rms responding)

Input Characteristics:

Range	Max. Reading	Burden Voltage
.2 A	+/- .1999 A	.3 V max.

Accuracy:

+/- (2% of input + 5 counts);  
20 Hz to 10 KHz (10% to 100 % of range)

Overload Protection: .5A/250V fuse

Full Range Step Response: (to rated accuracy)

3 seconds

**Warranty Information**

WARRANTY

This CMT product is warranted against defects in material and workmanship for a period of 90 days from the date of shipment. During this period, Corvallis Microtechnology, Inc. will, at its option, either repair or replace products which prove to be defective.

Buyer shall prepay shipping charges to return the product to CMT for warranty service, repair or replacement. Buyer shall pay all shipping charges, duties, and taxes for products returned to CMT from any country outside the U.S.A.

CMT does not warrant that the operation of this device and the firmware and software installed in it will be error-free.

## LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects or malfunctions resulting from improper or inadequate maintenance by buyer, buyer-supplied interfacing, unauthorized modification, misuse, or operation outside of the environmental specifications for the product.

No other warranty is expressed or implied. Corvallis Microtechnology specifically disclaims the implied warranties of fitness for a particular purpose.

### **Service Information**

The CMT-300 is shipped from the factory completely calibrated, and should not require calibration during normal use. With age and use at different temperature extremes, the CMT-300 could drift and require calibration. In this case, ship the unit in for service.

### **Shipping Instructions**

Do not ship any product back to CMT without first contacting us about your problem. We do not accept any unauthorized returns.

After obtaining a return authorization number, ship the product in a protective package to avoid damage. (Use the original shipping container and cushioning material.) In-transit damage is not covered by the warranty.

When returning the unit for service, repair or replacement, be sure to include your name and address. Also enclose a description of the problem and the system setup when the problem occurred.

For warranty service or repair, return the sales receipt with the unit.

## Appendix A

### PROGRAM EXAMPLES

#### 1. Read and Store

This program allows you to manually trigger a measurement. The measured value will be displayed and automatically stored in a data register. The block of registers used for storing data starts at register 22. You may change this parameter in line 02. Register 21 is the temporary storage of the address of the register used for storing measurement data.

To measure a different electrical quantity, replace line 04 with a different subroutine name. (See Section 9 for a list of the available subroutines.) Similarly, the range specified in line 05 may be varied.

The program stops after each measurement and data storage operation has been completed. Press [R/S] to take the next data point.

01	LBL <sup>T</sup> RS	Program name.
02	21	Counter.
03	STO 21	Store counter in register 21.
04	XEQ <sup>T</sup> VDC	Set mode to VDC.
05	XEQ <sup>T</sup> 100X	Set range to 100X.
06	LBL 01	Measurement loop begins.
07	1	
08	ST+21	Increment counter by 1.
09	READ4	Take a reading.
10	FORMAT	Format the reading.
11	VIEWA	View the formatted reading.
12	STO IND 21	Store unformatted data into the register whose address is in register 21.
13	STOP	Stop.
14	GTO 01	Go to beginning of measurement loop.
15	END	

## 2. Display Temperature

This program makes use of the program "THM" supplied in the CMT-300 ROM. "THM" converts the resistance of a thermistor (5 KOHM @25 deg C) into a temperature reading in deg C. It is useful for measuring temperatures in the range of -73 deg C to +150 deg C. "THM" can be used as a custom program in "DMM" and "DLOG".

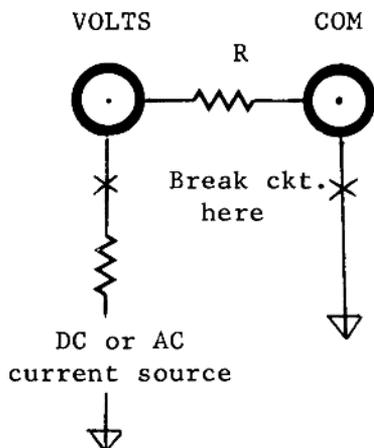
Connect the thermistor across the A/KOHM and COM terminals of the CMT-300. The program "DSPT" will display the temperature reading continuously. To stop the program, press [R/S].

01	LBL <sup>T</sup> DSPT	Program name.
02	4	
03	MODEX	Set mode to KOHM.
04	1	
05	RANGEX	Set range to 10X.
06	LBL 01	Measurement loop begins.
07	1	
08	READX	Take a reading.
09	STO 00	Store reading in register 00.
10	XEQ <sup>T</sup> THM	Call subroutine "THM" to do resistance-temperature conversion. Result is placed in register 00.
11	RCL 00	Recall contents of register 00 to the X-register.
12	FORMAT	Format the value recalled.
13	VIEWA	Display formatted result.
14	GTO 01	Go to beginning of measurement loop.
15	END	

## 3. Current Measurements

The CMT-300 can directly measure currents up to 200 mA only. However, other current ranges can be created by the following procedure.

Place a current shunt across the VOLTS and COM terminals of the CMT-300 as shown below.



Measure the voltage produced by the unknown current flowing through the current shunt. Reformat the readings to reflect the value of the unknown current.

The following table lists the format scales and labels appropriate for the various resistance values used when the CMT-300 is operating in the .2V range. (Refer to the format commands given in Section 6.)

Resistance	FMTSCL	FMTLBL	Max. Reading
.01 Ohm	.01	ADC	+/- 20.00 ADC
.1 Ohm	.1	ADC	+/- 2.000 ADC
1 Ohm	1	ADC	+/- .2000 ADC
or			
1 Ohm	.001	MADC	+/- 200.0 MADC
10 Ohm	.01	MADC	+/- 20.00 MADC
100 Ohm	.1	MADC	+/- 2.000 MADC
1K Ohm	1	MADC	+/- .2000 MADC
or			
1K Ohm	.001	UADC	+/- 200.00 UADC
10K Ohm	.01	UADC	+/- 20.00 UADC

The program below illustrates how the above-mentioned feature can be used to provide a 2 mA full-scale range. A 100 Ohm resistor is connected between the VOLTS and COM input terminals. The accuracy of the reading is the combined accuracy of the CMT-300 .2V range and the 100 Ohm resistor used.

```
01  LBLT100OHM      Program name.
02  0
03  MODEX           Set mode to VDC.
04  -1
05  RANGEX         Set range to .2V.
06  TMADC           Place label in ALPHA register.
07  ASTO X        Copy label to the X-register.
08  FMTLBL        Set format label.
09  .1
10  FMTSCL        Set format scale.
11  LBL 01        Read loop begins.
12  1
13  READX         Take one reading.
14  FORMAT        Format the reading.
15  VIEWA        Display formatted reading.
16  GTO 01        Go to beginning of read loop.
17  END
```

This program may be modified so that it can be called as a custom program by "DMM" and "DLOG". Make sure you are working in the VDC mode and .1X range before invoking the following program.

```
01  LBLTMADC3       Program name.
02  TMADC           Place label in ALPHA register.
03  ASTO X        Copy label to the X-register.
04  FMTLBL        Set format label.
05  .1
06  FMTSCL        Set format scale.
07  END
```

Remark:

The above procedure for creating ranges for current measurement applies equally well to AC and DC currents.

## Appendix B

### PROGRAM DATA

#### DMM

ALPHA Labels: DMM, ML, FM, OPT

Data Registers

- 00 Data temporary storage
- 01 Custom program name
- 02 REF value
- 03 REF mode specified by the user (0, %, DB)
- 04 HOLD criterion
- 05 Lower limit of range of interest
- 06 Upper limit of range of interest
- 07 Extended Memory file name
- 08 Extended Memory file size
- 09 Mass storage file name
- 10 Mass storage file size
- 11 to 16  
Statistical registers
- 17 "%" mode selected
- 18 "DB" mode selected
- 19 Temporary storage for reading taken in HOLD mode

Flags (Flags 00-09 are cleared at the beginning of the program.)

- 00 set: HOLD option active
- 01 set: REFERENCE option active
- 02 set: Measured REFERENCE value to be stored
- 03 set: Autorange option active
- 04 set: Custom program option active
- 05 set: LIMITS option active
- 06 set: "%" mode selected
- 07 set: "DB" mode selected
- 08 & 09 : Reserved for custom programs.

#### THM

ALPHA Label: THM

Data Registers: None

Flags: None

## DLOG & PSSR

ALPHA Labels: DLOG, WA, WB, ALARM, PSSR

### Data Registers

00 Temporary data storage  
01 Date on which the first measurement is made  
02 Time at which the first measurement is made  
03 Alarm repeat interval  
04 Number of iterations of a given measurement  
05 Alarm start time  
06 Alarm start date  
07 Indirect address of mode/range code  
08 N, number of measurement functions  
09 Control number formed from contents of 08  
10 File name  
11 Indirect address for REF values  
12 Indirect address for program names  
13 Indirect address for data registers  
14 Control number formed from contents of 04  
15 Name of program for custom storage operation  
16 Control number for timing prompts  
17 to 16+N  
    Addresses for mode/range codes  
17+N to 16+2N  
    Addresses for REF values  
17+2N to 16+3N  
    Addresses for program names

Total number of registers required to run the program is  $17 + 3N$ , where N is the total number of measurement functions used. This does not include the data registers to be used for the "STORE" option.

Flags (Flags 00-07 are cleared at the beginning and the end of the program.)

00 set: PRINT option selected  
01 set: Save to Extended Memory  
02 set: Record to mass storage medium  
03 set: Autorange ON  
04 set: Data files already set up  
05 set: Store to data registers  
06 set: Store data by "other" means  
07 : Reserved for custom programs

## SPP

ALPHA Labels: SPP, DS, WC, PLOTD

### Data Registers

- 00 Maximum value of data (Ymax)
- 01 Minimum value of data (Ymin)
- 02 Plot column width (160)
- 03 Plotting symbol: x
- 04 Location of X-axis:  $(Y_{max} + Y_{min})/2$
- 05 Scratch
- 06 X-value
- 07 Scaling multiplier
- 08 Xmin
- 09 Xmax
- 10 X-increment
- 11 Label of data collection; plot name
- 12 to 17 Statistical registers
- 18 Number of iterations, control number
- 19 Data temporary storage
- 20 Number of measurement functions (initially used as control number for timing prompts)
- 21 Function number
- 22 Name of file in Extended Memory or on mass storage medium
- 23 Starting register number of data register block used for the STORE option in DLOG
- 24 Program name for PROG option
- 25 Same as 23, used in plotting data
- 26 Name of program used for retrieving data from "other" storage device
- 27 Address for data storage register number

Flags (Flags 00-09 are cleared at the beginning of the program.)

- 00 set: Print option selected
- 01 set: Data comes from Extended Memory
- 02 set: Data comes from mass storage medium
- 03 set: Data comes from data storage registers
- 04 set: Data comes from "other" storage device
- 05 set: Plot option selected
- 06 set: PROG option selected
- 07 set: Skip statistical analysis
- 08 & 09 : Reserved for custom programs

## Appendix C

### ERROR AND STATUS MESSAGES

Following is a summary of the error and status messages related to the CMT-300 functions and application programs. For an explanation of other messages that might appear, consult the manuals for the calculator and any other module that you have in the system setup.

Message	Functions or Programs	Meaning
DATA ERROR	DMM	No data has been accumulated in the statistical registers; LN function in DB mode cannot operate on 0 or negative numbers.
	FMTLBL	Numeric data in X.
	FORMAT	Alpha data in X.
	THM	Conversion formula cannot operate on numbers less or equal to 0.
	F<>X	Contents of X > 999.
DUP FL	DLOG	File with the same name already exists in the Extended Memory.
DUP FL NAME	DLOG	File with the same name already exists on the mass storage medium.
END OF FL	SPP	End of Extended Memory file has been reached.
END OF FILE	SPP	End of mass storage file has been reached.
FL FULL	DMM	Extended Memory or mass storage file is full.
FL NOT FOUND	SPP	Specified file does not exist in Extended Memory or mass storage medium.
KEYCODE ERR	KYASN	The key specified by the keycode does not exist or is not assignable.

MEDM FULL	DLOG	File storage space is too small for the file.
NAME ERR	DLOG	No file name specified.
NO	ERROR?	The result of a conditional test is false.
	KYDWN?	No key is down.
	RCLKY?	No key is being pressed.
NO BUFFER	-all-	The buffer has been deleted. This happens after you do a "master clear", or if you did not turn off the HP-41 before inserting the CMT-300 module. Turn the HP-41 off and then on to clear this condition.
NONEXISTENT	-all-	CMT-300 or peripheral addressed not plugged in.
	AUTORD	X > 999.
	DMM	Register specified does not exist in main memory or extended memory.
	FMTRES	X > 999.
	HI/LO	X > 999.
	READX	X > 999.
NO ROOM	DLOG	File too large to fit into Extended Memory; program memory too small to accomodate alarms.
NO TIMER	DLOG	Time Module is not plugged into the HP-41C/CV.
OVL D	DMM	Measured value is out of range.
ROM	-all-	ROM (Read-Only-Memory) contents cannot be altered.
TRY AGAIN	-all-	Enlarge program memory to hold CMT-300 buffer.
	DLOG	Error occurred in specifying alarm parameters.
YES	ERROR?	The result of a conditional test is true.
	KYDWN?	A key is down.
	RCLKY?	A is pressed and the key code is returned to X.

Addendum  
(CMT-300 Manual)

Page 17

On the 7th to the last line, change nineteen to eighteen.

Page 18

You may wish to set up a data storage register counter in the first part of the program "STORE".

Page 21

If you are using the HP 82161A Digital Cassette Drive to log data, specify the START TIME such that enough time is allowed for the mass storage file to be created before the data-logging operation actually begins.

Page 34

After line 22, add:

The number of digits displayed to the right of the decimal point = format resolution parameter - (active range parameter) - 1  
(If this number turns out to be negative, it defaults to 0.)

Therefore, if you want the formatted result to show 2 digits to the right of the decimal point, irrespective of the range, specify the format resolution in a custom program as follows:

```
2
RANGN?
+
1
+
FMTRES
```

Page 35

The example given under FORMAT works only if the range is set to 0.

Page 36

After executing the TSTROM function, turn the HP-41 off and then on again to reset the CMT-300.

Page 40

The subroutines READ4, READ5, AR4, AR5 and OFFSET will terminate when two successive readings are identical. If the subroutines have been called by a main program, control will be returned to the main program when a steady signal has been obtained.

If the signal does not settle down, press [R/S] when a satisfactory reading has been obtained. If the subroutine is used in a program, the program will stop when you press [R/S]. In this case, press [PRGM], and then press [SST] until you get to RTN. Now, press [PRGM] and then [R/S] to continue program execution.

If it is necessary to stop the subroutine OFFSET to obtain a reading, be sure to follow the above procedure to continue program execution so that the delta setting will be stored.



\*\*\* Important \*\*\*

Some HP-41CX owners may experience difficulties while using repetitive alarms. For example, the data-logging process may suddenly stop after a number of iterations. If this happens, contact Service Department, Hewlett-Packard Company, 1000 N.W. Circle Blvd., Corvallis, OR 97330, and request a capacitor update. (Make sure that the above problem is not due to low battery power in any of the devices used in your system setup.)

The PSSR program (used for logging data) has been written with the assumption that measurements will be made on fairly stable signals. When measuring high resistances or low voltages, it takes some time for the circuit to stabilize. To obtain reliable readings in logging such signals, modify the PSSR as follows. Use the COPY command to copy the PSSR program from The CMT-300 ROM to the HP-41CX memory. Lengthen the pause at line 119 by adding a few more PSE commands or by means of a loop.





## Application Programs

**DMM** Digital Multimeter  
**DLOG** Data Logging Program  
**SPP** Statistics/Print/Plot

## Setting the Mode and Range

**MODEX** Set mode by X.  
**MODEN?** Return active mode to X in numeric form.  
**MODEA?** Return active mode to X in alpha form.  
**RANGEX** Set range by X.  
**RANGN?** Return active range to X in numeric form.  
**RANGA?** Return active range to X in alpha form.  
**NRNGN?** Return next range to X in numeric form.  
**NRNGA?** Return next range to X in alpha form.

## Reading and Formatting the Data

**READX** Return average of X readings to X.  
**AUTORD** Average X readings in autorange mode.  
**HI/LO** Return extremes of X readings to Y and X.  
**FMTRES** Set format resolution by X.  
**FMRES?** Return format resolution to X.  
**FMTSCL** Set format scale by X.  
**FMSCL?** Return format scale to X.  
**FMTLBL** Set format label by X.  
**FMLBL?** Return format label to X.  
**FORMAT** Format X with format parameters.

## Testing the System

**TSTROM** Test CMT-300 ROM.  
**DELTA** Set up delta table with X.  
**DELTA?** Return effective delta table entry to X.

## Miscellaneous Functions

**ERROR?** Return error number to X.  
**RCLKY?** Return keycode to X if key down.  
**KYDWN?** Skip next step if key not down.  
**DMMOFF** Turn off CMT-300.  
**KYASN** Assign function to User keyboard.  
**F<>X** Exchange flags 00 through 07 with X.  
**A>X** Copy ALPHA left digit as decimal to X.  
**CLALMS** Clear all alarms.  
**VIEWA** View ALPHA without a blink.