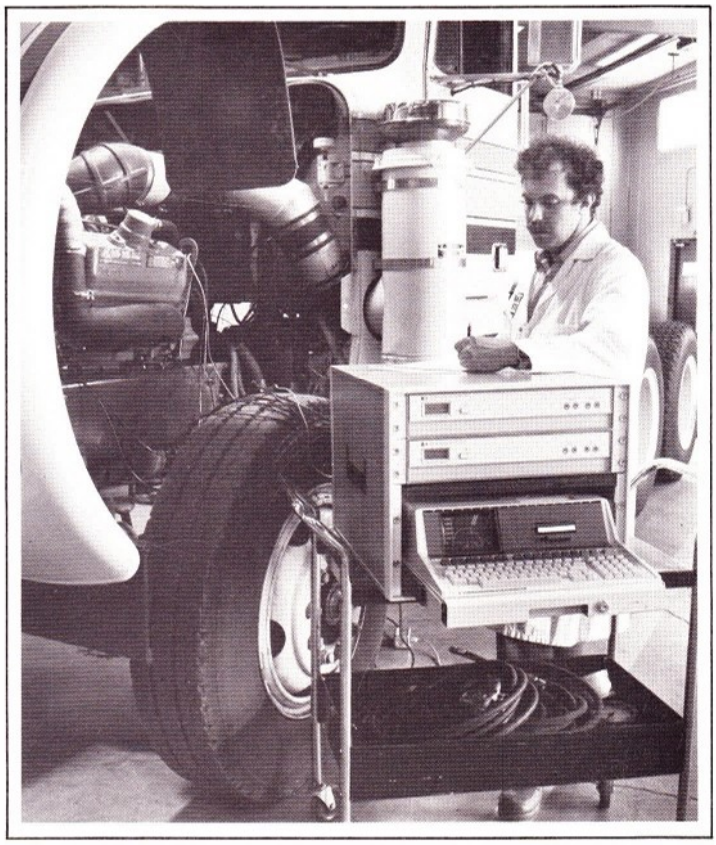
# 3421A Data Acquisition/Control Unit



# Using The 3421A/41CV Data Acquisition Pac and The 3056DL Data Logger

## Product Note 3421A-1

HEWLETT PACKARD

# Contents



3056DL Data Logger

3421A with 41CV and 44468A Data Acquisition Pac

# I. Introduction

## Overview

The HP 3421A Data Acquisition/Control Unit provides low cost automated measurement and control for your bench and portable test needs. Fully programmable via either HP-IL* or HP-IB**, the 3421A can be combined with controllers such as the HP 41CV handheld calculator or HP 85F computer to solve a wide range of data acquisition tasks. You can scan and measure up to 30 channels of DC and AC voltage, resistance, temperature and frequency; or read and write digital information and actuate control signals.

Affordable automated measurements are easily obtained by using the 3421A with the 44468A Data Acquisition Pac, or by using the 3421A as part of the 3056DL Data Logger.

The 44468A Data Acquisition Pac provides special software routines to control the 3421A using the 41CV handheld calculator and 82182A Time Module. With the key overlays that are provided, the 41CV can act as a dedicated 3421A system controller, performing complete transducer measurements and linearizations with just a few key strokes. You can combine the 3421A and 44468A with the 82161A Digital Cassette Drive and the 82162A Thermal Printer for a very low cost automated HP-IL data acquisition system complete with measurement, computation, data storage, and printout.

The 3056DL combines the 3421A, 85F computer, and easy-to-use operating software for a powerful solution to your data logging requirements. Menu-oriented software allows you to get started immediately with your measurements without learning a programming language. The 3056DL's computational power and graphics capability turns your data into the results you need. Special linearizations or custom functions can also be added as subroutines to the operating software.

The 3421A measures voltage and resistance using a built-in A/D converter with 3½ - 5½ digits of selectable resolution. Temperature measurements may be made with type J, K, T, E, R, and S thermocouples, thermistors or RTD's. Transducer frequency outputs to 10kHz may be measured with the 3421A's built-in counter. These quantities are measurable either from the front terminals or through up to three 10 channel scanner assemblies. Digital I/0 and breadboard assemblies are also available for sensing, control or custom applications. All assemblies use removable wiring connectors for easy interchange of measurement configuartions.

Internal battery power allows the 3421A to go wherever the measurement requires. For remote data logging, you can use an HP-IL system controlled by the 41CV and the Time Module to conserve battery life. Your system can turn itself off with a "power down" mode, and then automatically "power up" on command from the Time Module to periodically log a new set of readings.

Calibration of the 3421A is simplified by eliminating all internal adjustments. Just connect your standards and store calibration constants in nonvolatile memory. Calibration is performed using either the HP-IL or HP-IB interface. Complete calibration without adjustments or removal of the 3421A's covers lowers your cost of ownership.

*HP-IL (Hewlett-Packard Interface Loop): HP's new serial interface designed for small, low cost measurement systems. See Section II for more information.

**HP-IB (Hewlett-Packard Interface Bus): Not just IEEE-488, but the hardware, documentation and support that delivers the shortest path to a measurement system.

## Operating Characteristics

These operating characteristics provide a brief overview of the capabilities of the 3421A. Complete specifications are given in Section IV.

**Measurement Functions:** DCV, ACV, Resistance, Temperature and Frequency.

**DCV:** 300mV – 300V full scale; 1μV sensitivity (max).

**ACV:** 3V – 30V full scale; 100μV sensitivity (max). Range may be extended to 300V with the addition of internal attenuators.

**Resistance:** 2 or 4-wire configuration; 300Ω – 30MΩ full scale; 1mΩ sensitivity (max).

**Temperature:**

Thermocouple Types – T (linearization included in 3421A)
– J, K, T, E, R, S, (linearization with 44468A or 3056DL)

Thermistors –
Type 44004, 2.25KΩ @ 25°C (linearization with 44468A or 3056DL)

RTD - $\alpha$ = 0.00385 (linearization with 44468A or 3056DL).

**Frequency:** 1Hz – 10kHz frequency range; totalize to 65,535 counts.

**Optional Assemblies:** Each 3421A may contain up to 3 of the following option assemblies.

**Multiplexer Assembly:** 10 channel, 2-wire scanner. Up to 2 channels per assembly may be configured as actuator switches (252 VAC, 2 Amp max). Assembly includes thermocouple reference junction compensation measurement.

**Digital I/0 Assembly:** 8 input and 8 output lines. Inputs are optically isolated; 24V and 25mA max. Outputs are isolated open collector; 42V and 300mA max.

**Breadboard Assembly:** Allows user-designed circuits for custom functions such as multiple channel counters or special signal conditioning.

# II. Using the 44468A Data Acquisition Pac

## Introduction

The 44468A Data Acquisition Pac puts convenient measurement and control in the palm of your hand by turning the 41CV into a dedicated system controller for your 3421A. A special 41CV Control ROM included in the pac allows you to automatically log data by simply responding to a few prompting questions in the 41CV's display. The 82182A Time Module used with the pac offers automatic periodic measurements, and saves battery life by permitting the data logger system to "power down" into a "sleep mode" between each periodic scan or measurement sequence. The 3421A and 41CV, used with the Data Acquisition Pac and Time Module, can be combined with the 82161A Digital Cassette Drive and 82162A Thermal Printer for a complete, battery powered data logging system.

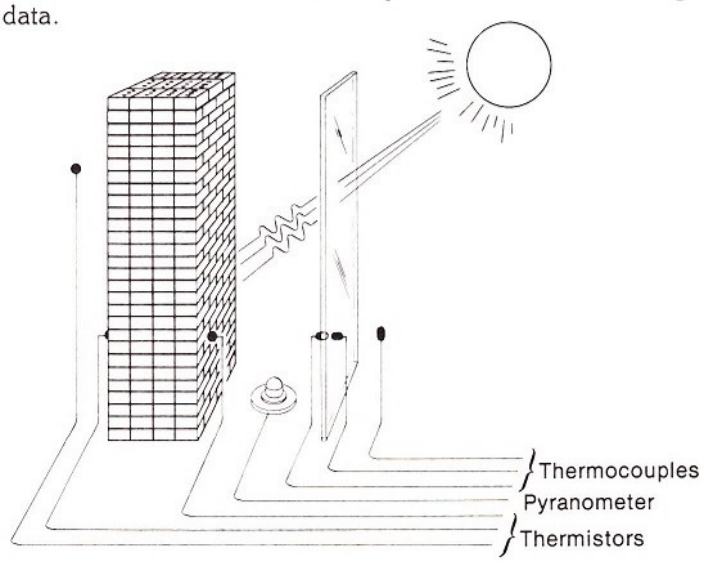
The 44468A's Control ROM also contains a "3421A Front Panel" routine offering complete measurements or control functions on the 41CV keyboard. This "Front Panel" routine provides a convenient way to check or debug your system.

## Data Logger (DL)

The Control ROM's Data Logger (DL) routine offers very low cost data acquisition in a system that you can start using immediately – just a few keystrokes on the special keyboard overlay for the 41CV and you're logging data. The Data Logger routine uses the 3421A's Option 020 Multiplexer Assembly to measure up to 30 channels in your system. The DL routine also uses the 82182A Time Module and 82160A HP-IL Module. A method of recording data is also needed, such as the 82161A Digital Cassette Drive and/or the 82162A Thermal Printer.

### Example: A passive solar collection system

Using the DL routine is as easy as answering a few questions to define your measurement functions and channels. As an example, we can look at a data logger to be used to monitor a passive solar collection system. We will define the measurements to be made, set up the DL routine, and log data.



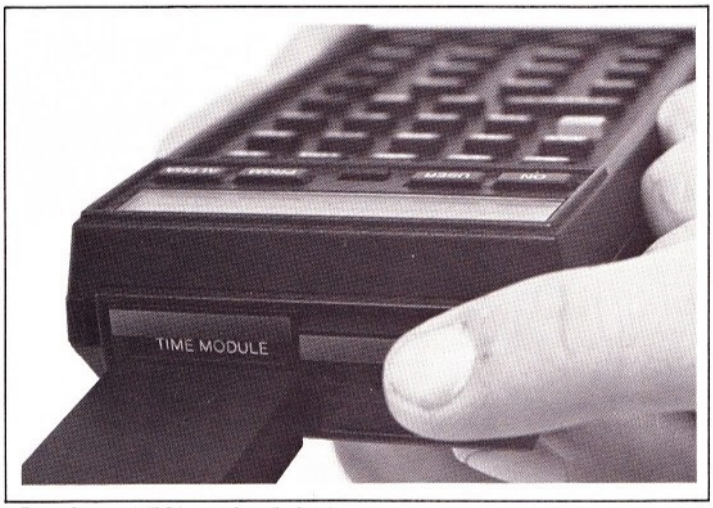

Our solar collection system consists of a thermal mass (a brick wall) which acts as a solar collector and radiator. The sun shines through a large window and heats the brick wall, which in turn radiates its stored heat at night.

Some of the things we might want to measure in this system are the outside and inside ambient temperatures, heat flow through the window, solar radiation, and heat flow through the brick wall collector/radiator.

Outside temperature measurements will be made with type T thermocouples, and inside temperatures will be measured with type 44004 thermistors. Solar radiation will be measured with a silicon cell pyranometer that produces a DC voltage output directly proportional to radiation intensity. (For now we will only monitor the voltage as a qualitative measure of whether the sun is out or not. Later we will see how to turn this measured voltage into a radiation intensity measured in watts per square meter ($W/m^2$)). Heat flow can be calculated after measuring the temperature difference between the two surfaces of the wall or window. We can define the data logger measurement functions shown below to do this.

| | | |
|---|---|---|
| **Channel 2** | T-type Thermocouple | outside ambient temperature (C°). |
| **Channel 3** | T-type Thermocouple | outside window surface temperature (°C). |
| **Channel 4** | T-type Thermocouple | inside window surface temperature (°C). |
| **Channel 5** | Pyranometer (DC Voltage) | solar radiation intensity. |
| **Channel 6** | Thermistor (type 44004) | inside ambient temperature (°C). |
| **Channel 7** | Thermistor (type 44004) | exposed wall surface temperature (°C). |
| **Channel 8** | Thermistor (type 44004) | interior wall surface temperature (°C). |


41CV with 44468A ROM and overlays, 82182A Time Module, and 82160A HP-IL Module.




Data Logger (DL) overlay (below)


## Procedure

We can now set up the data logger to make these measurements. Our data logger will use both the Digital Cassette Drive for permanent data storage and Thermal Printer for a convenient hard copy output.

First, key in XEQ ALPHA SIZE ALPHA 070 on the 41CV to reserve data storage registers used by the DL routine. Initialize the tape cassette (see "Recording Data with the 82161A Digital Cassette Drive") and set the correct time and date for the system (see "82182A Time Module Basics"). Also, the printer should be in its "MAN" (Manual) mode. Then just follow these steps:

1. Make sure the Control ROM, 82182A Time Module, and 82160A HP-IL Module are plugged into the 41CV. (Turn the 41CV OFF before inserting or removing ROM's or modules). Connect the 3421A, 41CV, 82161A, and 82162A trogether via the HP-IL in a single, continuous loop. Put the 82161A and 82162A in STANDBY (the 41CV will power them up automatically), and turn ON the 3421A and 41CV.
2. Key in XEQ ALPHA D L ALPHA on the 41CV. The DL routine will begin with the 41CV display showing

   | HP3421A |
   |---|

   and

   | DATA LOGGER |
   |---|

This title will be printed on the 82162A Thermal Printer also. Now the 41CV will present a series of questions used to define the measurements. Put the DL overlay on the 41CV keyboard to answer these questions.

3. | NEW? Y/N | asks if this is a new setup. Since it is, respond with Y R/S

(R/S is the Run/Stop key which resumes the routine after pausing for an input).

4. | FIRST CH? | asks for the number of the first measurement channel. We will measure the thermocouples on channels 2 - 4 first, so respond with 2 R/S
5. | LAST CH? | asks for the last channel number of this measurement sequence. In our case, the last thermocouple is on channel 4, so respond with 4 R/S

# 82182A Time Module Basics

The 82182A provides time-keeping and alarm functions for the 44468A DL routine, causing the system to "power up" at the beginning of each measurement scan or pass. The 82182A itself can act as a timer, alarm clock, calendar, and stop watch. Detailed information on the Time Module may be found in the 82182A Owner's Manual (Part No. 82182-90001).

## Setting the Time and Date

For your measurements to occur at the correct time and date, set the time and date before running the DL routine. To set the time of day, place the time to be set in the 41CV's x register with a format of HH.MMSS, then XEQ ALPHA SETIME ALPHA. The clock starts running when you key in the second ALPHA. (9:17 a.m. is represented by 09.1700, and 4:58 p.m. is represented by 16.5800). You can display the current time by executing ■ ON.

The date may be represented in a MM.DDYYYY format (default condition) or a DD.MMYYYY format. You can choose the format with either XEQ ALPHA MDY ALPHA or XEQ ALPHA DMY ALPHA. To set the date, place the present date in the 41CV's x register and XEQ ALPHA SETDATE ALPHA.

# Recording Data With The 82161A Digital Cassette Drive

The 82161A provides the battery powered mass storage for your 44468A DL routines by interfacing to the 41CV via HP-IL. Each Mini Data Cassette (82176A) used with the 82161A can store up to 131 kbytes of information. Detailed information on using the 82161A may be found in the 82160A HP-IL Module Owner's Manual (Part No. 82160-90001) and the 82161A Owner's Manual (Part No. 82161-90002).

## Getting Started

To use the 82161A with the 44468A DL routine, just connect the tape drive to your system with HP-IL cables and put the 82161A in its "STANDBY" mode. Before you begin logging data, erase and initialize the tape with the 41CV's NEWM command. To allow for the maximum allowable number of data files (447), XEQ ALPHA NEWM ALPHA 447. Once you have initialized the tape with NEWM, you are ready to execute the DL program.

## Data Organization and Capacity

Measurement results are stored on tape with one data file for each pass or measurement scan. The file for each pass is composed of registers containing the date, time, and results of the pass. Each pass, or data file, is organized as shown in Table A.

Table A. Tape Cassette Data File Organization

| Register | Contents |
|---|---|
| 0 | Date of measurement pass |
| 1 | Time that measurement pass began |
| 2 | Sequence 1 measurement function |
| 3 | Sequence 1, 1st measured value |
| 4 | Sequence 1, 2nd measured value |
| 5 | Sequence 1, 3rd measured value |
| • | • |
| • | • |
| • | • |
| n | Sequence 1, last measured value |
| n+1 | Sequence 2 measurement function |
| n+2 | Sequence 2, 1st measured value |
| • | • |
| • | • |
| • | • |
| p | Sequence 2, last measured value |
| p+1 | Sequence 3, measurement function |
| p+2 | Sequence 3, lst measured value |
| • | • |
| • | • |
| • | • |
| x | Last Sequence, last measured value |

The maximum number of passes that can be stored on one tape cassette depends on the number of registers used per pass, which in turn depends on both the number of channels measured and the number of sequences measured. Table B shows the maximum number of scans or passes that can be stored on tape.

Table B. Maximum Passes Storable on Tape

| No. Registers per Pass | Maximum No. Passes Storable |
|---|---|
| 4 (min. possible) | 2039 |
| 10 | 1164 |
| 13 | 959 |
| 16 | 815 |
| 24 | 582 |
| 33 | 440 |
| 62 (max. possible) | 247 |

(Note: These values reflect tape storage capacity only. Battery power availability may limit the total number of measurements to less than shown above.)

## Retrieving Stored Data

Once data is stored on tape, it may be recalled into the 41CV at some later time for processing. To retrieve the data, first obtain a directory of the tape contents by keying XEQ ALPHA DIR ALPHA on the 41CV. The printer will provide a copy of the directory showing data files named "1", "2", "3", etc., corresponding to the measurement scans or passes performed. The number of registers contained in each data file is also listed.

To retrieve Pass 3, place "3" in the ALPHA register, place zero in the 41CV's x register, and XEQ ALPHA SEEKR ALPHA. This positions the tape at the beginning of Pass 3. To read the registers of this data file into 41CV data registers "bbb" through "eee", place the number "bbb.eee" into the 41CV's x register and XEQ ALPHA READRX ALPHA. In our example, to place the 12 registers of a pass into 41CV registers 050 through 061, "bbb.eee" = 050.061. The measured values can now be recalled for further manipulation or to be printed from the 41CV registers. To get a printout, again place "bbb.eee" (050.061 in our example) in the 41CV's x register and XEQ ALPHA PRREGX ALPHA. A sample printout is shown below.

```
Register 050 R50= 12.08198200  Date of Pass (Dec 08, 1982)
Register 051 R51= 14.20000000  Time Pass began (2:20 PM)
             R52= "TYPE T"     1st sequence: Type T
                                 Thermocouples
             R53= 6.201560000  ┐
             R54= 11.159370000 ├ Measured temperatures (°C)
             R55= 14.428310000 ┘
             R56= "DCV    "    2nd sequence: DC Voltage
             R57= 0.709418000  Measured Voltage (VDC)
             R58= "2W THM"     3rd sequence: 2-wire
                                 thermistors
             R59= 22.24680000  ┐
             R60= 28.95310000  ├ Measured temperatures (°C)
Register 061 R61= 21.91370000  ┘
```

## Erasing Recorded Data

To erase the entire tape, simply do another XEQ ALPHA NEWM ALPHA 447. To erase an individual file containing a pass, place the pass number ("1", "2", "3", etc.,) in the 41CV's ALPHA register and XEQ ALPHA PURGE ALPHA.

6. **FUNCTION?** asks which measurement function is to be done on channels 2 – 4. We want to use T-type thermocouples, so respond with [T]

The 41CV display and the Thermal Printer show channels 2 – 4 with a T thermocouple (TTC) as our first measurement sequence.

7. **FIRST CH?** now asks for the first channel in the next sequence. We want to measure the pyranometer on channel 5, so respond with [5] [R/S]

8. **LAST CH?** asks for the last channel of this sequence. Since we have only one pyranometer, channel 5 is also the last channel and we can simply respond with [R/S]

9. **FUNCTION?** asks for the measurement function on channel 5. The pyranometer's output is a DC voltage, so respond with [DCV]

10. **FIRST CH?** starts the definition of the last sequence, using thermistors on channels 6,7,and 8. Respond with [6] [R/S]

11. **LAST CH?** Respond with [8] [R/S]

12. **FUNCTION?** Since we will measure temperature on channels 6 – 8 with a 2.25kΩ thermistor, respond with [THM]

13. **FIRST CH?** Since our set up is now complete, we have no more sequences to define. We can move onto the next question by responding with [R/S]

14. **RECORD Y/N** asks if data is to be recorded on tape or not. To record the data using the 82161A Digital Cassette Drive, respond with [Y] [R/S]

15. **PRINT? Y/N** asks if the measurment results are to be printed, along with the time and date of the measurement. To get the printout, respond with [Y] [R/S]

16. **INTERVAL?** asks for the time interval between complete measurement scans or passes (in our example, a complete scan includes channels 2 – 8). If we want a complete pass every 10 minutes, respond (using a HH.MMSS format) with 00.10 [R/S]

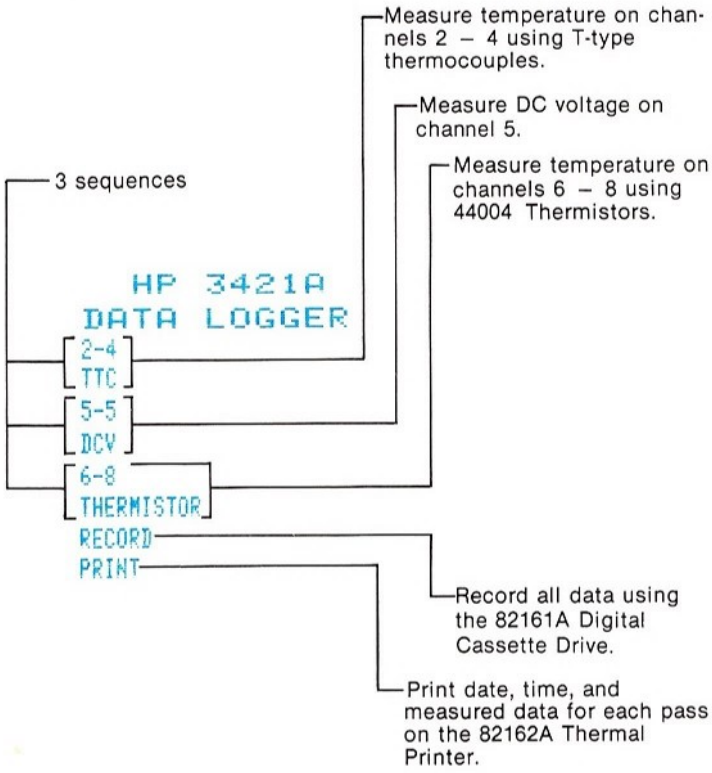
17. **ITERATIONS?** asks how many complete passes are to be done. To cover a 4 hour time period, with 10 minute intervals, we need 24 iterations.
    24 [R/S]

18. **START TIME?** asks for the time of day at which the first pass is to start. If we want to measure from 2:00 PM until 6:00 PM, the start time will be 14.00 (HH.MMSS).
    14.00 [R/S]

19. **START DATE?** asks for the date on which the first pass is to start. If we choose December 8, 1982, then using a MM.DDYYYY format, respond with
    12.081982 [R/S]
    A format of DD.MMYYYY can also be used – see "82182A Time Module Basics".

We have now completed the set-up defining our measurements. The entire data logging system now automatically "powers down" in a "sleep mode" to conserve battery power. At the designated start date and time, the Time Module will automatically "wake up" the system, commencing the first measurement sequence.

The Thermal Printer provides a record of the data logger configuration:

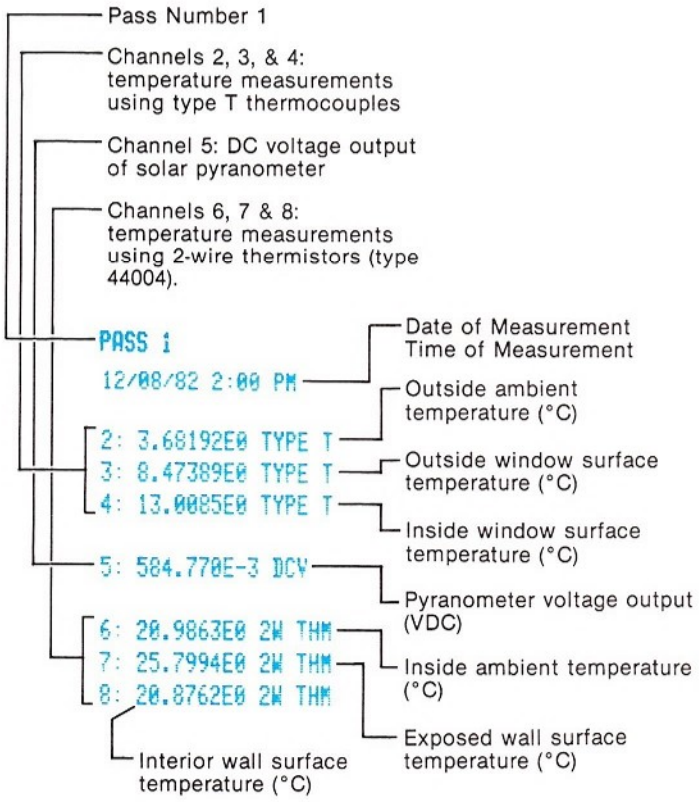



If desired, we could modify this data logger setup. Inserting or deleting channels is easily accomplished using the "EDITOR" included in the DL Routine (see "Editing and User Functions" below).

## Measurement Results

When the start date and time are reached, the data logging system is automatically turned on from an alarm generated by the Time Module. The tape will rewind and be initialized (space for data files are marked on the tape) for about 30 seconds. The printer will show the measurement scan or pass number ("PASS 1", "PASS 2", etc.), and the date and time of the pass. Each measurement is printed

with notations indicating the channel number and measurement function. The results of our first pass would be printed as follows:




All of this data would also be stored on tape and could be retrieved later (see "Recording Data with 82161A Digital Cassette Drive) for analysis and processing.

At the end of the measurement pass, the system automatically "powers down" to preserve battery life. The second pass would begin 10 minutes after the first pass began, or in our example, at 14.10 or 2:10 p.m. A complete scan or measurement pass would occur every 10 minutes, producing a printout of the results as shown below, and being stored on tape.

```
PASS 2
12/08/82 2:10 PM

2: 4.82146E0 TYPE T
3: 9.69573E0 TYPE T
4: 13.7629E0 TYPE T

5: 649.336E-3 DCV

6: 21.8114E0 2W THM
7: 27.0216E0 2W THM
8: 21.6563E0 2W THM
 •
 •
 •
PASS 24
12/08/82 5:50 PM

2: -2.16447E0 TYPE T
3: 5.66249E0 TYPE T
4: 11.6378E0 TYPE T

5: 3.4540E-3 DCV

6: 20.0414E0 2W THM
7: 20.7763E0 2W THM
8: 23.3581E0 2W THM
```

With just a few keystrokes used to answer some 41CV prompting questions, you can be up and logging quickly, obtaining the data you need to understand your experiment or process. The 44468A's Data Logger routine offers a wide range of functions for precise measurements of temperature, voltage, resistance, and frequency in a low cost, portable HP-IL system.

## System Timing

The exact timing of measurements in a setup greatly depends on the nature of the setup itself. Whether the printer or tape cassette (or both) are used, the number and type of measurement sequences, and the number of channels in each sequence all affect system timing. General 3421A timing and measurement speed information is provided in Section IV, Specifications and Accessories.

Times for some of the events that occur for the passive solar system data logger are shown in Table A. This is an example of a system measuring 7 channels (3 thermocouples, 1 DC voltage, and 3 thermistors), and recording and printing the data. This 7 channel scan was performed 24 times over a 4-hour period (every 10 minutes).

As the measurement scans or passes continue, data is stored farther down the tape, causing the tape access time to grow longer. This causes the total "pass time" (the time from power-up to power-down of a pass) to gradually become longer as the passes progress, as seen by the "power down" time in Table A.

### Table A. System Timing for 44468A DL Solar System Data Logger

| Event | Time (HH.MMSS) | | | | |
|---|---|---|---|---|---|
| | Pass 1 | Pass 2 | Pass 4 | Pass 12 | Pass 24 |
| **Power-Up** | 14.0000 | 14.1000 | 14.3000 | 15.5000 | 17.5000 |
| **Print Pass #** | 14.0024 | 14.1025 | 14.3026 | 15.5029 | 17.5041 |
| **Channel 2** | 14.0037 | 14.1038 | 14.3039 | 15.5044 | 17.5056 |
| **Channel 3** | 14.0042 | 14.1044 | 14.3044 | 15.5049 | 17.5101 |
| **Channel 4** | 14.0046 | 14.1048 | 14.3049 | 15.5054 | 17.5105 |
| **Channel 5** | 14.0100 | 14.1102 | 14.3103 | 15.5108 | 17.5120 |
| **Channel 6** | 14.0114 | 14.1116 | 14.3117 | 15.5121 | 17.5134 |
| **Channel 7** | 14.0118 | 14.1120 | 14.3122 | 15.5125 | 17.5139 |
| **Channel 8** | 14.0122 | 14.1124 | 14.3126 | 15.5130 | 17.5143 |
| **Power-Down** | 14.0136 | 14.1137 | 14.3138 | 15.5142 | 17.5155 |

## Editing and User Functions

You may want to add or delete measurement sequences to your setup, or add a custom function to your logging routine. The 44468A DL routine's EDITOR and USER FUNCTION capabilities make this easy. In our passive solar system example, we would want to convert the measured DC voltage output of the pyranometer into radiation intensity in $W/m^2$. Also, we might want to open the last measured channel at the end of the pass to help protect the data logger system, in case a transient should occur on that channel during the power-down period.

We will add two special routines, or USER FUNCTIONS, to perform these new tasks. These routines will simply be two standard 41CV programs stored in the memory of the 41CV. The first routine, called "USER5", will make the measurement on channel 5, send the reading to the 41CV, and convert it from VDC to $W/m^2$. The result will be printed and stored on tape automatically. Entering "USER5" into the 41CV is accomplished with the following keystrokes. (Remove the overlay from the keyboard first.)

| | |
|---|---|
| ON | |
| USER | (turns off the USER mode to prevent running the DL routine). |
| ■ GTO · · | |
| PRGM | (puts the 41CV into the PROGRAM mode). |

Now enter the program:

| | |
|---|---|
| ■ LBL ALPHA USER5 ALPHA | (the program's name, or label, is USER5) |
| ALPHA DCV5 ALPHA<br>XEQ ALPHA OUTA ALPHA | (outputs "DCV5" to the 3421A, causing it to measure DC voltage on channel 5) |
| XEQ ALPHA IND ALPHA | (Inputs the measured value into the 41CV's x register) |
| ENTER↑ | (moves the value into the 41CV's y register) |
| 71.7 EEX CHS 6<br>÷ | (divides the measured voltage by a conversion factor of 71.7μV per $(W/m^2)$ to obtain radiation intensity) |
| ■ RTN | (returns the 41CV to the DL routine) |
| GTO · · | (41CV END statement) |
| PRGM | (exits PROGRAM mode) |

A listing of "USER5" produced by the 82162A printer:

```
01♦LBL "USER5"
02 "DCV5"
03 OUTA
04 IND
05 ENTER↑
06 71.7 E-6
07 /
08 RTN
09 END
```

The second routine, called "USER8", will open the last measured channel (channel 8) at the end of the measurement scan or pass. We enter "USER8" into the 41CV with the keystrokes:

| | |
|---|---|
| PRGM<br>■ LBL ALPHA USER8 ALPHA | (the program label is "USER8") |
| ALPHA OPN8 ALPHA<br>XEQ ALPHA OUTA ALPHA | (output "OPN8" to the 3421A to open channel 8) |
| 0 | (Zero put in 41CV x register) |
| ■ RTN | (returns the 41CV to the DL routine) |
| ■ GTO · · | (41CV END statement) |
| PRGM | (exits PROGRAM mode) |

"USER 8" listing:

```
01♦LBL "USER8"
02 "OPN8"
03 OUTA
04 0
05 RTN
06 END
```

Now we can edit our DL routine to add these two routines. To start the setup of DL, put the 41CV back into the USER mode and execute DL by keying USER and DL on the overlay.

The DL routine will begin and ask the setup questions that we saw before in the 41CV's display:

| | |
|---|---|
| HP3421A<br>DATA LOGGER<br>NEW? Y/N | Since we are gong to edit the previous setup, we answer NO by responding with N R/S |
| EDIT? Y/N | asks if we want to edit the setup. Since we do, respond with Y R/S |
| -*-EDITOR-*- | starts the EDIT routine. |
| COMMAND? | asks which EDITOR command you wish to use. To get a listing of our present setup, we can respond with LIST R/S and get a printout showing our setup configuration: |

```
   HP 3421A
DATA LOGGER
-*-EDITOR-*-
LIST
0: 2-4, TYPE T
1: 5-5, DCV
2: 6-8, 2W THM
```

EDITOR sequence reference numbers

Since the pyranometer will now be measured in the "USER5" routine, we will first delete this measurement from the standard DL setup (reference number 1). When the 41CV asks

| |
|---|
| COMMAND? |

we can delete the DCV measurement by responding with

DELETE R/S The 41CV will answer with

| |
|---|
| DELETE |

and

| |
|---|
| NUMBER? |

which asks for the reference number of the sequence to be deleted. We respond with 1 R/S

| |
|---|
| DELETE 1 |

The sequence measuring DC voltage on channel 5 has now been deleted. Now we can insert "USER5" in its place to allow measurement of the pyranometer in ($W/m^2$). When the 41CV asks

| |
|---|
| COMMAND? |

we can obtain a new listing of the setup showing the deletion of channel 5 by responding with LIST R/S

The listing shows the present status of the setup.

```
LIST
0: 2-4, TYPE T
1: 6-8, 2W THM
```

| |
|---|
| COMMAND? |

allows us to insert "USER5" by responding with INSERT R/S.

The 41CV responds with

| |
|---|
| INSERT |

and

| |
|---|
| AFTER NUMR? |

To place "USER5" between the thermocouple sequence and the thermistor sequence, insert "USER5" after reference number 0 by responding with 0 R/S.
The 41CV responds with

| |
|---|
| AFTER 0 |

and

| |
|---|
| FIRST CH? |

which asks for the first channel of the inserted function. We can respond with 5 R/S and then follow with the following questions and responses.

| | |
|---|---|
| LAST CH? | R/S |
| FUNCTION? | R/S |
| PRESS FN KEY | R/S |

| | |
|---|---|
| USER 0-83? | 5 R/S identifies USER5 as the user function inserted. (Up to 84 user functions can be defined). |
| USER5 | |
| FIRST CH? | R/S moves us on to the next EDITOR function. |

| | |
|---|---|
| COMMAND? | We can obtain a new listing of our setup with LIST R/S, giving |

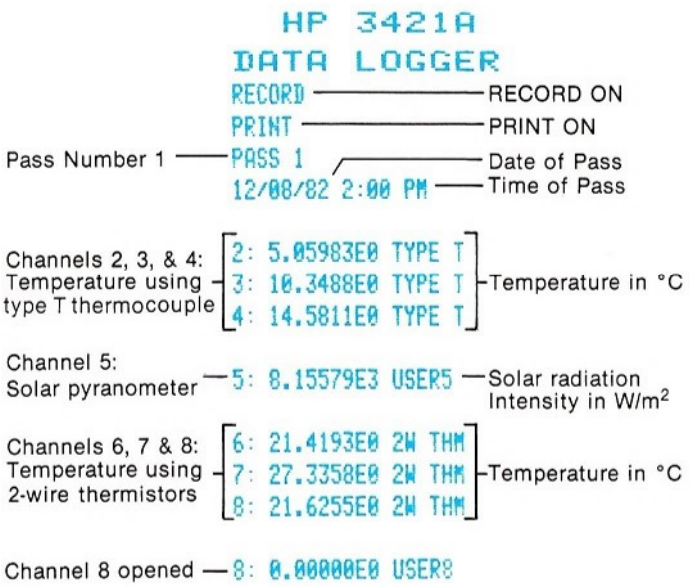
```
LIST
0: 2-4, TYPE T
1: 5-5, USER5
2: 6-8, 2W THM
```

Now we can add "USER5" to open channel 8 by inserting it after sequence reference number 2:

| | |
|---|---|
| COMMAND? | INSERT R/S |
| INSERT | |
| AFTER NUMR? | 2 R/S |
| AFTER 2 | |
| FIRST CH? | 8 R/S |
| LAST CH? | R/S |
| FUNCTION? | R/S |
| PRESS FN KEY | R/S |
| USER 0-83? | 8 R/S identifies "USER8" as the routine inserted at the end of the setup. |
| USER8 | |
| FIRST CH? | R/S moves us on to the next EDITOR function. Since we have added "USER5" and "USER 8", we can exit the EDITOR mode with "END" command: |

| | |
|---|---|
| COMMAND? | END R/S |
| END | |
| *END EDITOR* | Shows the end of the EDITOR and we can finish the setup by asnwering the 41CV questions to define INTERVAL, ITERATIONS, START TIME, and START DATE. |

When we run this new data logger setup we get measurement results printed as follows (one scan or pass shown).




You can quickly and easily modify your setup as your data logging requirements change. For more detailed information on editing and user functions, please refer to the 44468A Data Acquisiton Pac Manual.

## DL Keyboard Definitions

E T — Type T Thermocouple

(Shift) E T — (Shift) Type E Thermocouple

K J — Type J Thermocouple

(Shift) K J — (Shift) Type K Thermocouple

R S — Type S Thermocouple

(Shift) R S — (Shift) Type R Thermocouple

4WRTD RTD — RTD ($\alpha$ = 0.00385), 2-Wire Measurement

(Shift) 4WRTD RTD — (Shift) RTD ($\alpha$ = 0.00385), 4-Wire Measurement

4WTHM THM — Thermistor (type 44004), 2-Wire Measurement

(Shift) 4WTHM THM — (Shift) Thermistor (type 44004), 4-Wire Measurement

DCV — DC Voltage (5½ digits, autoranging)

ACV — AC Voltage (4½ digits, autoranging)

2WΩ — Resistance (2-Wire configuration; 5½ digits, autoranging)

4WΩ — Resistance (4-Wire configuration; 5½ digits, autoranging)

FRQ — Frequency (1 sec. gate time; 5½ digits)

DL — Starts the DL routine from the beginning.

LOG — Moves DL routine to cassette/printer setup point.

R/S — Run/Stop: Continues DL routine after it has stopped for a response to a question.

All other key definitions are the same as for the standard 41CV.

# Front Panel (FP)

The Control ROM's Front Panel (FP) routine provides push-button, single channel measurements and control functions using the FP overlay on the 41CV keyboard. You can easily check temperature, voltage, resistance, or frequency on a channel, or read and write digital information during system debugging.

Front Panel (FP) key overlay


## Procedure

To use the FP routine, just connect the 41CV and 3421A via HP-IL, take the 41CV out of USER mode, and [XEQ] [ALPHA] FP [ALPHA] The 41CV display will show

| |
|---|
| *INITIALIZE* |

followed by

| |
|---|
| ***3421A*** |

and then

| |
|---|
| ----- |

The 3421A will reset to its power-on state.

Place the FP overlay on the 41CV keyboard and you are ready to make measurements. (You may need to execute [SCI] [5] to assure full resolution).

To measure DC voltage on channel 5, simply press [DCV]; the 41CV will display

| |
|---|
| *DCV* |

followed by

| |
|---|
| *CHANNEL?* |

Just key in [5] [R/S]. Channel 5 will close and the 3421A will continuously make DC voltage measurements on channel 5 and display them on the 41CV.

To measure resistance on channel 7 press [2WΩ], causing the 41CV to display

| |
|---|
| *TWO* |

(Two Wire Ohms) and

| |
|---|
| *CHANNEL?* |

[7] [R/S]

The 41CV displays continuously updated readings of resistance on channel 7.

To measure resistance via the front panel terminals, first open channel 7: [OPN]

| |
|---|
| *OPN* |

| |
|---|
| *CHANNEL?* |

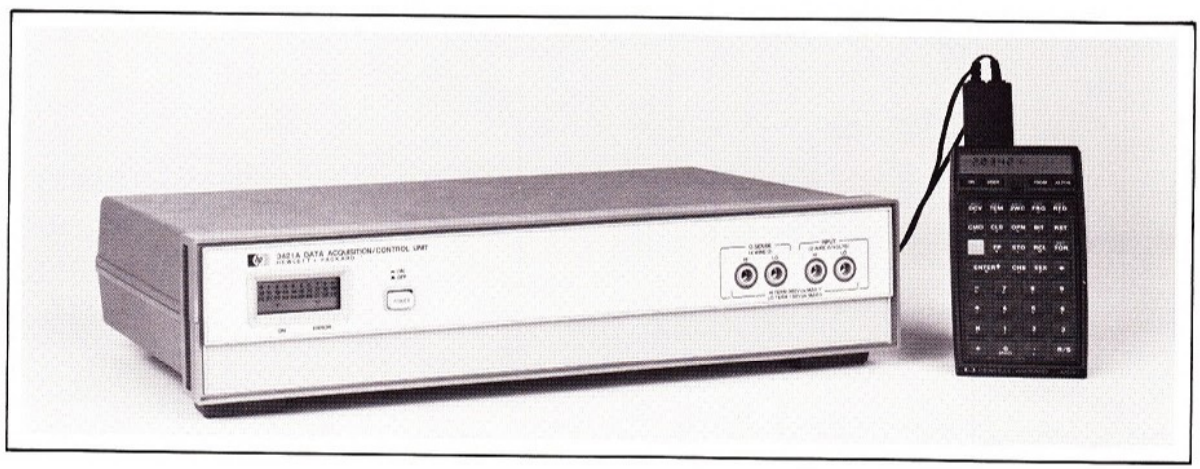
[7] [R/S]

Then command a resistance measurement without a channel number: [2WΩ]

| |
|---|
| *TWO* |

| |
|---|
| *CHANNEL?* |

[R/S]



To measure temperature (using a type T thermocouple) on channel 2: [TEM]

| |
|---|
| *TEM* |
| *CHANNEL?* |

[2] [R/S]

If we also have type T thermocouples on channels 3 and 4, we can increment the channel

[FOR] opens channel 2 and closes and measures on channel 3.

[FOR] moves the measurement forward from channel 3 to 4.

[REV] reverses the measured channel from 4 back to 3.

[OPN]

| |
|---|
| *OPN* |
| *CHANNEL?* |

[3] [R/S] opens channel 3 so all channels are open.

To read the value of the 3rd bit of the Opt. 050 Digital I/O Assembly in slot 1 (bit 12), press [BIT] , which prompts

| |
|---|
| *BIT* |
| *CHANNEL?* |

and

[1] [2] [R/S]

The 41CV will display the value of the bit (0 or 1).

## FP Keyboard Definitions

ACV DCV — DC Voltage (5½ digits, autoranging).

(Shift) ACV DCV — (Shift) AC Voltage (4½ digits, autoranging).

REF TEM — Temperature (°C) using type T thermocouple.

(Shift) REF TEM — (Shift) Measures reference junction temperature for TEM function.

4WΩ 2WΩ — Resistance (2 wire configuration, 5½ digits, autoranging).

(Shift) 4WΩ 2WΩ — (Shift) Resistance (4 wire configuration, 5½ digits, autoranging).

TOT FRQ — Frequency (1 sec. gate time, 5½ digits).

(Shift) TOT FRQ — (Shift) Totalize (65,535 counts maximum).

WRT RED — Read a digital byte (8 bits) from the specified slot.

(Shift) WRT RED — (Shift) Write a byte (8 bits) to the specified slot. The 8 bits are represented by a decimal number between 0 and 255. [Slot No., Bits Value].

CLS — Close the specified channel (scanner, actuator, or digital).

OPN — Open the specified channel (scanner, actuator, or digital).

BIT — Reads the values of the specified bits (numbered 00-07, 10-17, and 20-27).

RST — Resets the 3421A to its turn-on state.

FP — Restarts the FP routine.

REV FOR — Increments the closed scanner forward by one channel.

(Shift) REV FOR — (Shift) Decrements the closed scanner in reverse by one channel.

R/S — Run/Stop (Continues FP routine after pausing for a response).

All other key definitions are the same as for the standard 41CV.

# General HP-IL Operation With The 41CV

The 3421A may also be used with the 41CV handheld calculator on the HP-IL without using the Control ROM provided by the 44468A Data Acquisition Pac. You can program measurement and control sequences, and send measurement readings and digital inputs to the 41CV controller.

The Hewlett-Packard Interface Loop (HP-IL) is a 2-wire serial interface for control of instruments and other devices. HP-IL systems provide easy automation of bench measurements and portable field testing. The controller and all the devices in the system are connected in series, forming a continuous loop communications circuit. Any information (instructions or data) that is transferred among HP-IL devices is passed from one device to the next around the loop (one direction only). If the information is not intended for a particular device, that device simply passes the information on to the next device in the loop. When the proper device receives the information, that device responds as directed.

The 3421A may be connected anywhere in the interface loop, which may contain up to 30 devices. When installing or removing the 3421A (or any other device), ALWAYS turn off the calculator first. Then simply disconnect the loop in one place and connect the 3421A at that point. The interface cables must form a continuous loop. All HP-IL connectors are designed to ensure proper orientation and indicate the direction of information transfer.

More information on HP-IL and programming with the 41CV may be found in the 3421A Application, Programming and Configuration Manual (HP Part No. 03421-90000), in the 41C/CV Owner's Handbook and Programming Guide (HP Part No. 00041-90313) and in the 82160A HP-IL Module Owner's Manual (HP Part No. 82160-90001).

## Interface Control Commands And Device Selection (Addressing)

When the 41C/CV calculator is turned on, it will automatically assign an address to each device depending on its position in the loop. The first device in the loop after the calculator (in the direction of information flow) will have an address of "1". The second device will have an address of "2", and so on around the loop. The calculator has an address of "0". This means that the 41C/CV will automatically change the address of the 3421A from 09 (factory preset address) to a number corresponding to the 3421A's location in the loop. (The 3421A must be turned on before the 41C/CV is turned on for the automatic addressing to occur).

In general, a device must be "SELECTED" by its loop address before any command or information can be sent to it. The following HP-IL control operations define when you need to "SELECT" a device and how the selection is accomplished.

## AUTOIO

The AUTOIO mode allows commands unique to a device in the loop to be sent to that device, regardless of which device has been "SELECTED" . For many applications, the AUTOIO mode eliminates the need to "SELECT", or address, each device before sending commands to it. As an example, suppose you wanted to measure the DC voltage on channel 6 by sending the "DCV6" command. If no other device in the loop (such as a printer or tape cassette drive) could respond to the "DCV6" command, then it would not matter which device is selected when the "DCV6" command was sent. All devices except the 3421A would ignore the "DCV6"; only the 3421A would respond to it.

The AUTOIO mode is implemented with the following 41C/CV keystroke sequence.

[XEQ] [ALPHA] AUTOIO [ALPHA]

## MANIO

The MANIO mode requires each device to be "SELECTED", or addressed, before a command is sent to that device, regardless of whether any other loop device could respond to that command.

41C Command:

[XEQ] [ALPHA] MANIO [ALPHA]

## SELECT

The SELECT command determines which loop device is the selected device, i.e., which device will receive the commands. If the loop is in the AUTOIO mode and if the selected device cannot respond to the transmitted command, the command is passed on around the loop until it reaches a device that can respond to it. The x register of the 41C/CV must contain the loop address of the device to be selected before SELECT is executed.

41C/CV Command:

[XEQ] [ALPHA] SELECT [ALPHA]

## FINDID

The FINDID (FIND IDentity) function searches for a device with a specific identity and determines the loop address of that device. The device identity is placed in the Alpha register of the 41C/CV calculator before FINDID is executed. For the 3421A the identity is: "HP3421A". The decimal address of the device is returned to the x register of the 41C/CV.

41C/CV Command:

[ALPHA] HP3421A [ALPHA]

[XEQ] [ALPHA] FINDID [ALPHA]

## PWRDN

The PWRDN (Power-Down) command puts the 3421A, and all other devices capable of power-down, into their standby condition, minimizing power consumption. This allows you to gain extended battery life by automatically turning off your system when not actually logging data. When the 3421A receives this command, it stores its channel status in RAM before powering down. All multiplexers and actuator channels remain in their previous state. All digital output ports are returned to their high impedance (open) state. Also, the totalize mode is turned off. The 3421A will return to its full power-on state when there is any communications through the HP-IL.

41C/CV Command:

[XEQ] [ALPHA] PWRDN [ALPHA]

## PWRUP

The PWRUP command is used to return all powered-down instruments to their full operating power conditions. Actually, the 3421A will power-up when there is any communication through the HP-IL. When the 3421A powers-up, it first checks its status to see if any changes have occurred during power-down. If any changes have occurred, the 3421A will go through its normal power-on reset and self test routine. If nothing has changed, the 3421A remains in the same state that it was in prior to power-down, except as mentioned for PWRDN. Note that the power-up command has no effect on instruments manually turned off.

41C/CV Command:

[XEQ] [ALPHA] PWRUP [ALPHA]

## Sending Commands To the 3421A

Simply decide what you want the 3421A to do and select the appropriate HP-IL command codes.

For example, to measure DC voltage on a group of channels, just send the command code for DC volts ("DCV") followed by the channel list. Taking DC measurements on channels 3, 4, 5, 6, 8, 12, 13 and 14 is done with the following keystrokes on the 41CV.

1. Put the command codes into the 41C/CV's ALPHA register.

[ALPHA] DCV3-6, 8, 12-14 [ALPHA]

2. Output the contents of the ALPHA register to the 3421A using the OUTA command:

[XEQ] [ALPHA] OUTA [ALPHA]

**Some Other Examples:**

[ALPHA] TEM 0-9 [ALPHA]

Measure temperature on channels 0-9 using type T thermocouples. The 3421A automatically measures the reference junction and converts the thermocouple voltage into temperature in degrees Celsius.

[ALPHA] WRT 1,203 [ALPHA]

Write an 8-bit digital byte to the output port of the card in slot 1; the 8-bits will be set to 11 001 011, represented by the decimal value of 203.

Each of these commands would be followed by [XEQ] [ALPHA] OUTA [ALPHA] on the 41C/CV.

You can assign the OUTput Alpha function to a single key on the 41C/CV, eliminating the need to key in [XEQ] [ALPHA] OUTA [ALPHA] each time you send a command. To assign this function to the Σ+ key, just do this:

ASN
[■] (shift) [XEQ] [ALPHA] OUTA [ALPHA] [Σ+]

Then to output the ALPHA register, just put the 41C/CV into USER mode and press the assigned key:

[USER] [Σ+]

## Receiving Data From The 3421A

The 3421A has the ability to talk to the HP 41C/CV, giving the results of measurements or status information. We previously saw that the "DCV6" command took a DCV measurement on channel 6. Now we will see how to read back the measured voltage into the 41C/CV. The complete sequence of commands would be:

[ALPHA] DCV6 [ALPHA]
[XEQ] [ALPHA] OUTA [ALPHA]
[XEQ] [ALPHA] IND [ALPHA]

The IND (INput Decimal) command reads the measurement from the selected device and places it into the x register of the 41C/CV. The reading is then ready to be processed or operated on by the calculator.

# III. Using the 3056DL Data Logger

## Introduction

The 3056DL provides a very powerful solution to your data logging problems by combining the 3421A and 85F computer with easy to use operating software. The flexibility and friendliness of the 3056DL allows the first time user to log data without learning a computer language. Just respond to a series of questions and software "menu" choices presented on the 85F's screen to perform the logger setup, to make measurements, and obtain results. Or if desired, add BASIC subroutines for more sophisticated custom functions. Measurement results can be printed, stored on tape, or presented in graphical form with plots or histograms.

Checking or debugging your setup is easy with the 3056DL's "Front Panel" routine which allows you to manually test individual channels.

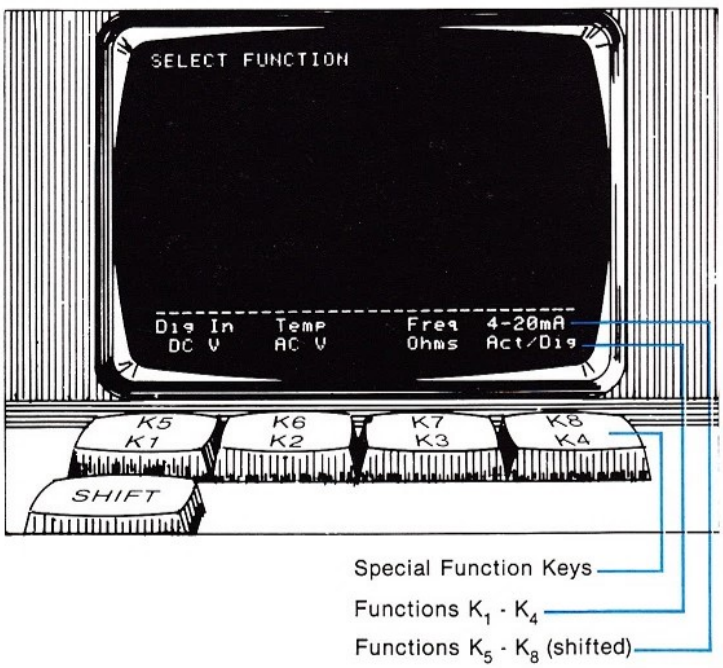
## 85F Special Function Keys

When configuring a 3056DL logger setup, you are presented with a series of "menus" on the screen of the 85F. Each menu is a list of routines or functions from which you choose the desired action. An example of a menu would be the following one where the measurement function is chosen.

The menu consists of these functions:

| Special Function Key | Measurement Function |
|---|---|
| $K_1$ | DC Volts |
| $K_2$ | AC Volts |
| $K_3$ | Ohms |
| $K_4$ | Actuator/Digital Output |
| $K_5$ | Digital Input |
| $K_6$ | Temperature Functions |
| $K_7$ | Frequency |
| $K_8$ | 4-20mA Current Measurement |

85F Display and special function keys.




To choose a DC voltage measurement, just press the corresponding special function key [K1]. To select a frequency measurement, simply press Shift & [K7] simultaneously. (The top row of menu choices correspond to the shifted special function keys).

## Example: Thermal Characterization of a Floppy Disc Drive

Putting the 3056DL to work collecting data only requires answering a series of prompting questions presented on the screen of the 85F computer. As an example, we can look at an automated experiment which looks at some thermal characteristics of a floppy disc drive prototype used in a personal computing system. We will define the measurements to be made, illustrate the ease of setting up the 3056DL, and give an example of the results that could be obtained from the experiment.

To achieve optimum performance and reliability from our prototype, we need to measure heat rise at several points inside the disc drive during operation. This information will contribute to a design that minimizes heat rise in critical areas. In addition to measuring temperatures at several points inside the prototype, we would also want to measure ambient temperature and humidity, power consumption, and ventilation air flow rate at the exhaust port. We will use one of the prototype interior temperatures to control when the prototype is to be turned on or off, starting a new heat-rise cycle.

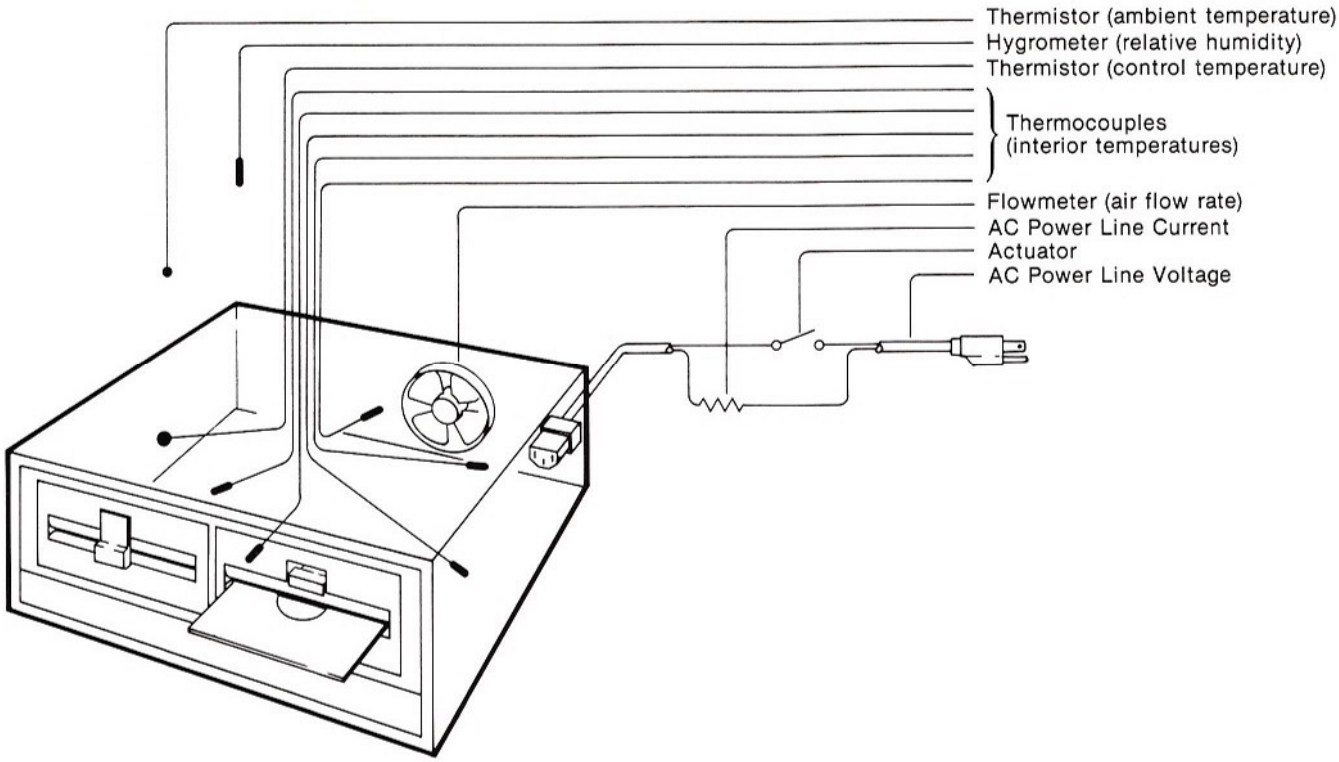
Temperatures inside the prototype will be measured with type T thermocouples. Ambient temperature and the prototype interior temperature which controls power to the disc drive will be measured using type 44004 thermistors (2.25KΩ).

When the "control temperature" rises to its maximum steady-state value of 30°C, a programmed high limit for that measurement is reached. The 3056DL then opens an actuator channel, causing the prototype to be turned off. When the prototype's interior temperature decreases to ambient (21.5°C), another programmed low limit will cause the actuator channel to close, turning on the prototype to begin a new heat rise cycle.

Air flow can be monitored by measuring the frequency output of a flow meter at the air exhaust port. Humidity can be measured using a hygrometer that produces a 0-5V DC signal to be measured and converted into % relative humidity by the 3056DL.

Power consumption (in VA) can be derived from measurements of AC line voltage and current. We will measure current by looking at the voltage across a low value resistor placed in series with the line. The 3056DL can easily be setup to automatically make the necessary conversions on the AC voltage measurements to provide total VA consumption.

We can now define the measurement and control functions shown below to perform our experiment.




| | | | |
|---|---|---|---|
| (Group 1) | **Channel 2** | Thermistor (type 44004) | control temperature (°C) |
| (Group 2) | **Channel 3** | Thermistor (type 44004) | ambient temperature (°C) |
| (Group 3) | **Channel 4** | Hygrometer | relative humidity (%) |
| (Group 4) | **Channels 5-9** | Type-T Thermocouples | interior temperatures (°C) |
| (Group 5) | **Channel 11** | Flowmeter | air flow rate (CFM) |
| (Group 6) | **Channel 12** | AC Voltage | power line voltage (Volts AC) |
| (Group 7) | **Channel 13** | AC Current Shunt | power line current (Amps AC) |
| | **Channel 1** | Actuator to turn prototype on/off | |

The measurements are organized into groups according to the function to be performed. The "control temperature" measurement is set up as a separate group since a controlling action will occur based on its value.

# Procedure

Now we are ready to set up our data logger for these measurements. Our discussion will illustrate the setup of Group 4, which measures the prototype interior temperatures.

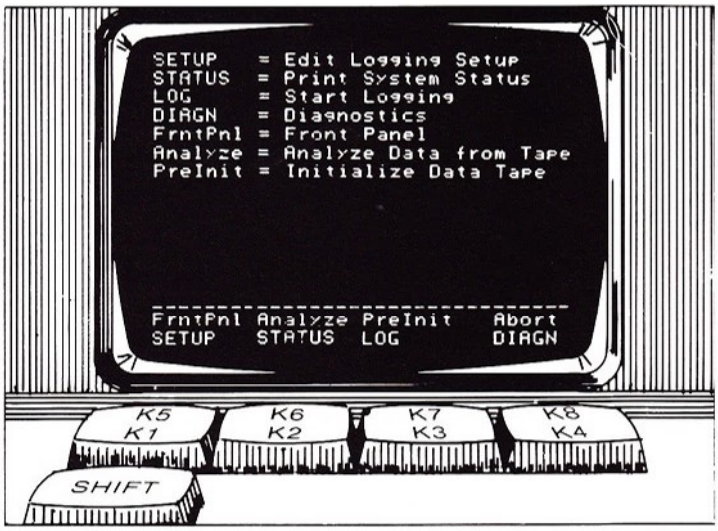
The 85F computer should be used with the 82903A 16K Memory Module and the Advanced Programming ROM. The configuration of the logger may be set up using only the computer; the 3421A can be connected later, via either HP-IL or HP-IB, when you're ready to begin logging.

The 3056DL software talks and listens to the 3421A at address 901 (see "General Operation with the 85F" for more information on addressing). If the 3421A's optional HP-IB interface is used, it may be necessary to set the 3421A's address to 01 and the HP-IB select code to 9.

To start the data logger setup, just insert the 3056DL program tape cartridge into the 85F and turn on the 85F. An "auto-start" routine is automatically loaded into the computer to begin the setup procedure.

The 85F's display will present a menu from which we can choose to initially set-up the logger, commence measurements, analyze recorded data and perform other functions.

## 85F Display

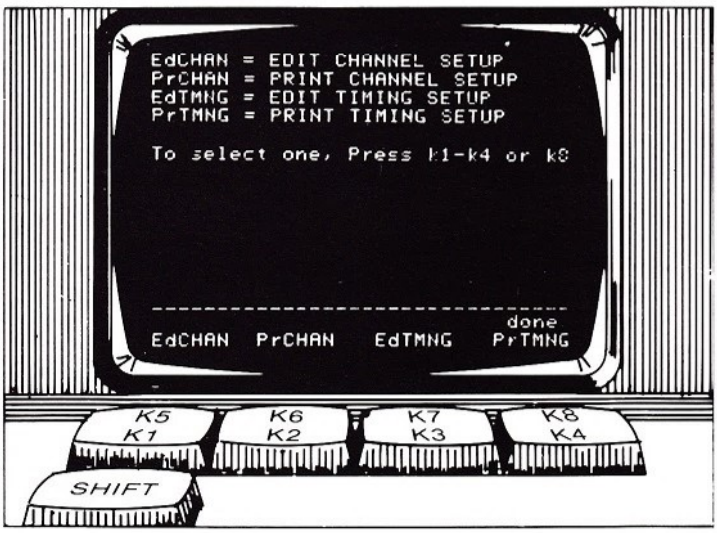



### Response

SETUP (Press $K_1$)

Since we are just beginning the configuration of Group 4, we'll choose SETUP, which allows us to define or modify the channel groups and timing of the measurements. The 85F now loads the SETUP routine into memory from the tape. The next menu is presented on the display; we can choose to define (or edit) either channel or timing setups, or to obtain a printout of these setups.

## 85F Display

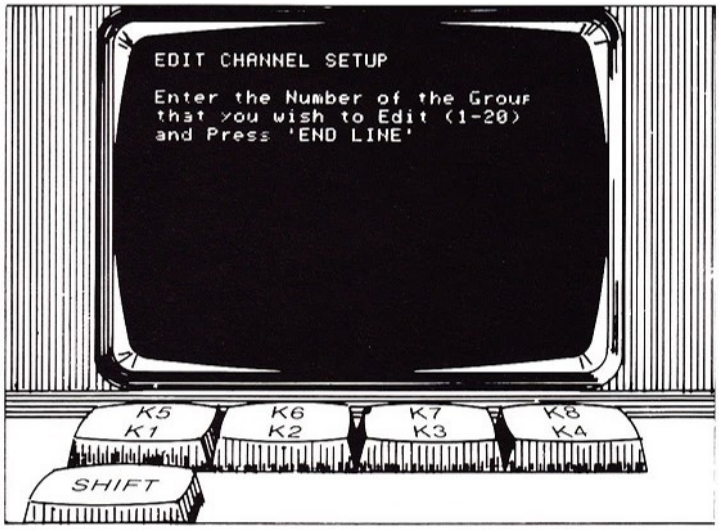



### Response

EdCHAN (Press $K_1$)

We will begin defining Group 4 with EdCHAN. The 85F loads this routine and presents the next menu, where we enter the number of the group to be defined or modified.

## 85F Display

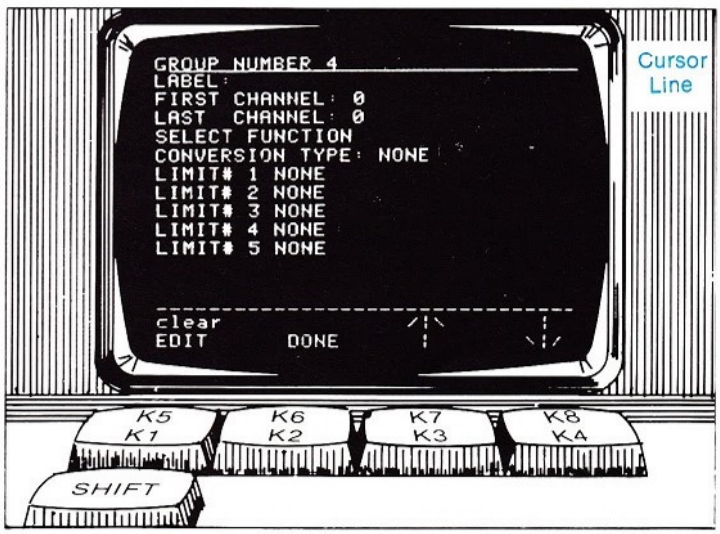



### Response

4 END LINE (END LINE enters the number into the 85F).

The 85F then responds with the next menu:

## 85F Display

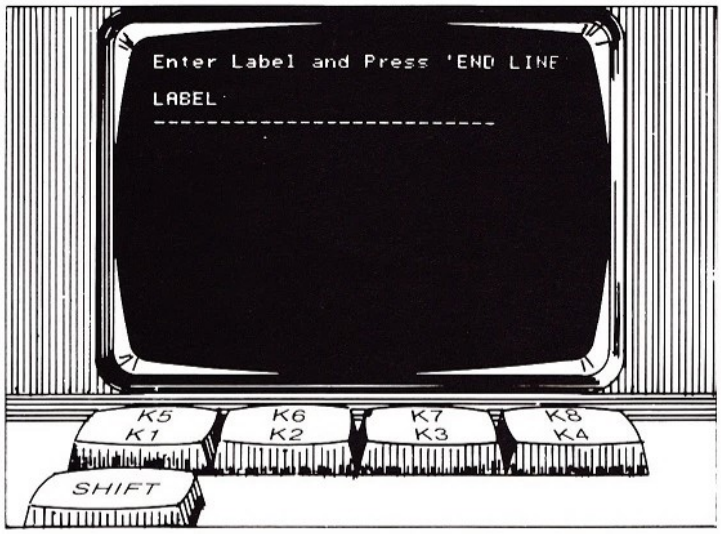



### Response ↓ EDIT

The cursor line may be moved up or down with the ↑ and ↓ keys (K3 and K4). This cursor line determines which parameters (FIRST CHANNEL, LAST CHANNEL, LIMIT #1, etc.), will be defined when EDIT is pressed.

To give this measurement group a label for future reference, move the cursor line down to LABEL using the ↓ key. Then press EDIT which prompts the next display:

## 85F Display

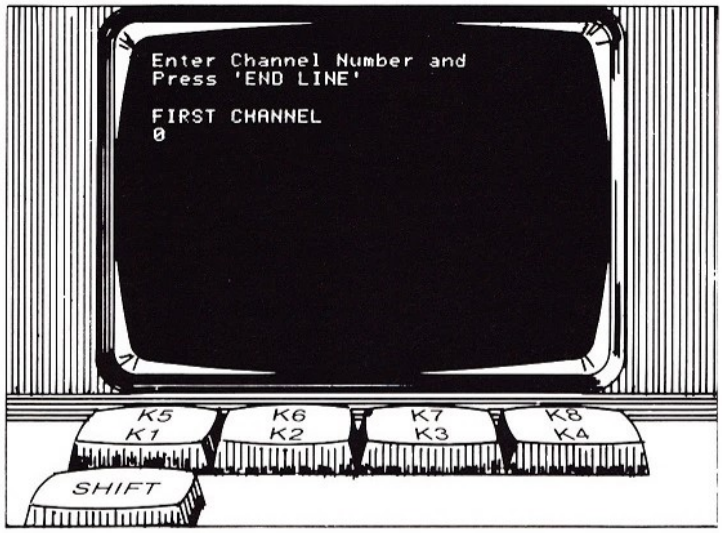



## Response

PROTOTYPE TEMPS [END LINE]

Group 4 now has the label "PROTOTYPE TEMPS". The 85F returns to the previous menu so we can define the next parameter, which is the number of the first channel of group 4.

## 85F Display

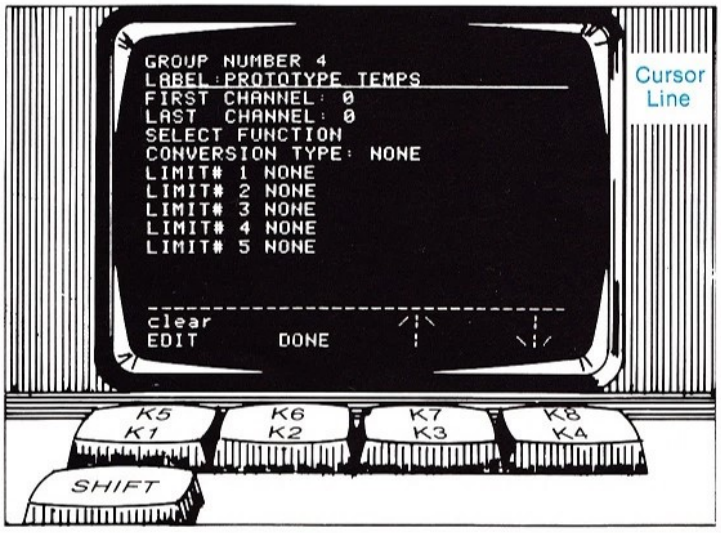



## Response

[5] [END LINE]

This sets channel 5 as the FIRST CHANNEL; the 85F then responds with:

## 85F Display

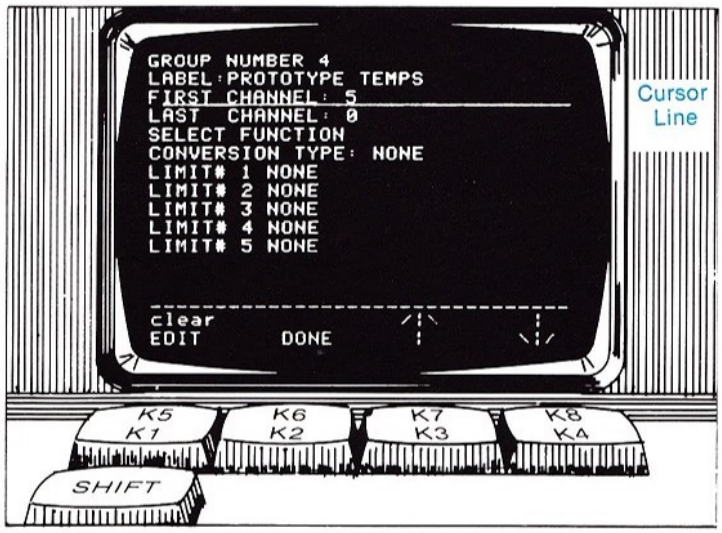



## Response

[↓] [EDIT]

This selects FIRST CHANNEL for EDITing. The 85F responds with the next display:

## 85F Display

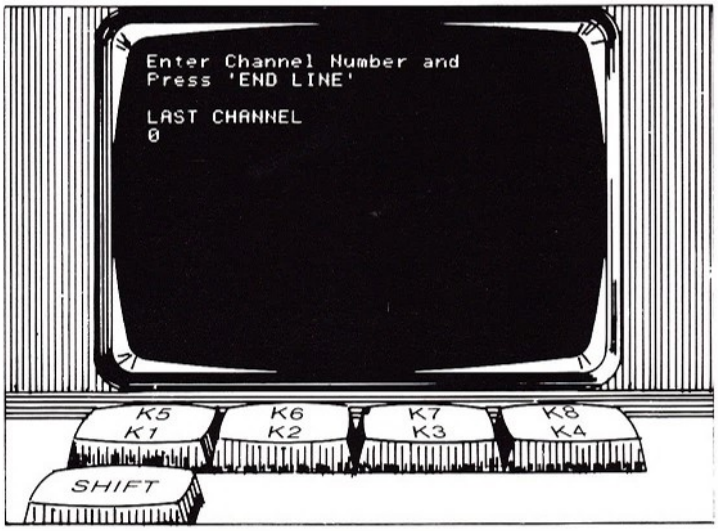



## Response

[↓] [EDIT]

This selects LAST CHANNEL for EDITing, and the 85F responds with:

## 85F Display

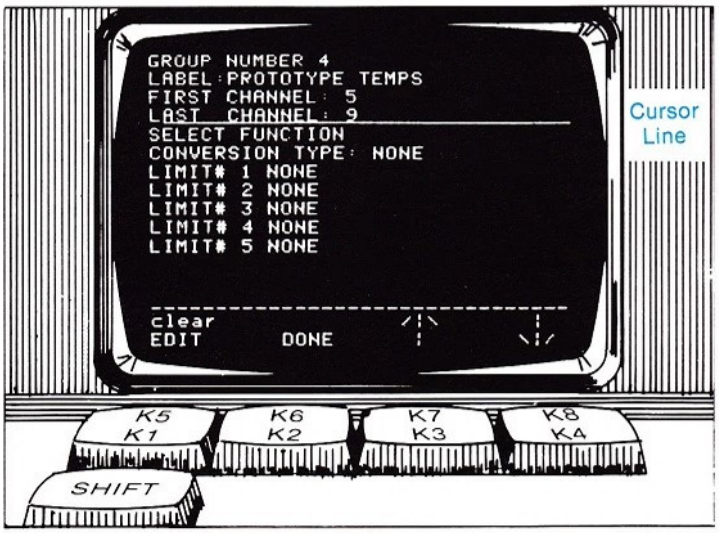



## Response

9 END LINE

This sets channel 9 as the LAST CHANNEL of Group 4. The 85F then responds with:

## 85F Display

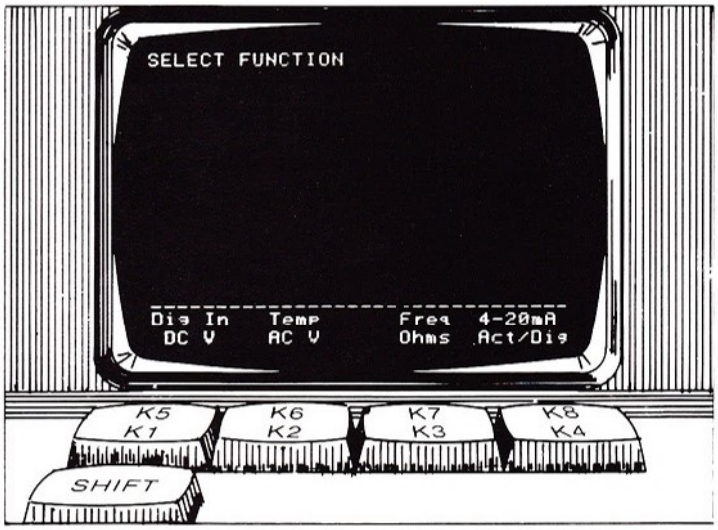



## Response

↓ EDIT

Now we edit, or define, the function to be performed by Group 4. The 85F responds with:

## 85F Display

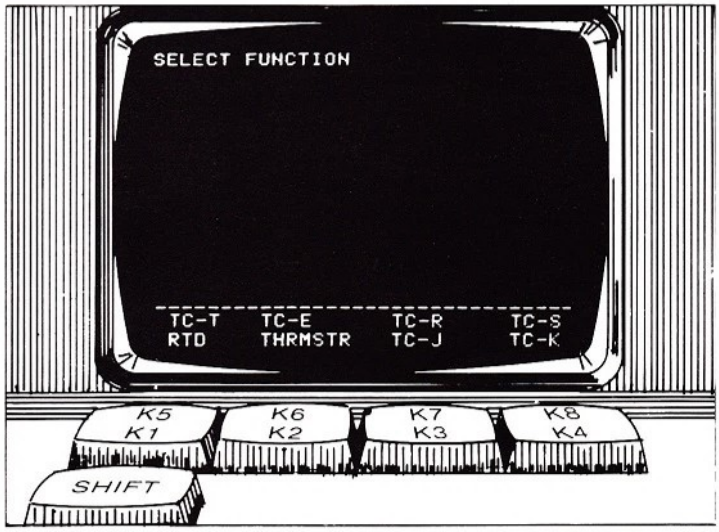



## Response

Temp

This selects Group 4 to measure temperature. The particular type of transducer to be used is chosen from the next menu:

## 85F Display

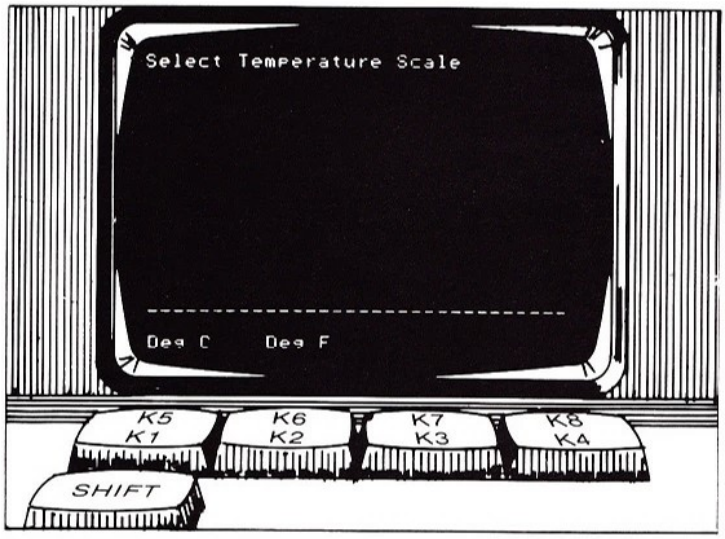



## Response

TC-T

This selects type T thermocouples for Group 4. The 85F responds with a choice of temperature units:

## 85F Display

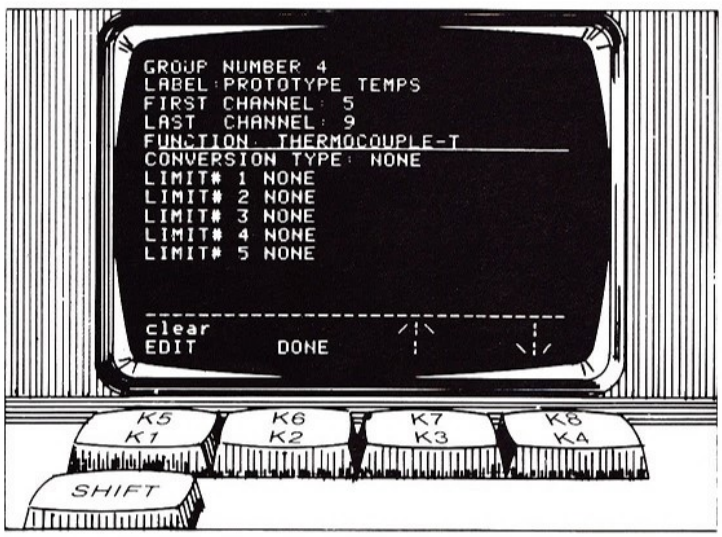



## Response

Deg C

The 85F now returns to the Group 4 channel setup menu. Since the 3056DL automatically makes thermocouple measurements in units of °C or °F, we don't need any further conversion of the measurements in Group 4. Also, the temperatures measured on channels 5 - 9 won't control any actions, so we won't use any limit functions. Thus we are done with the channel setup of Group 4:

## 85F Display

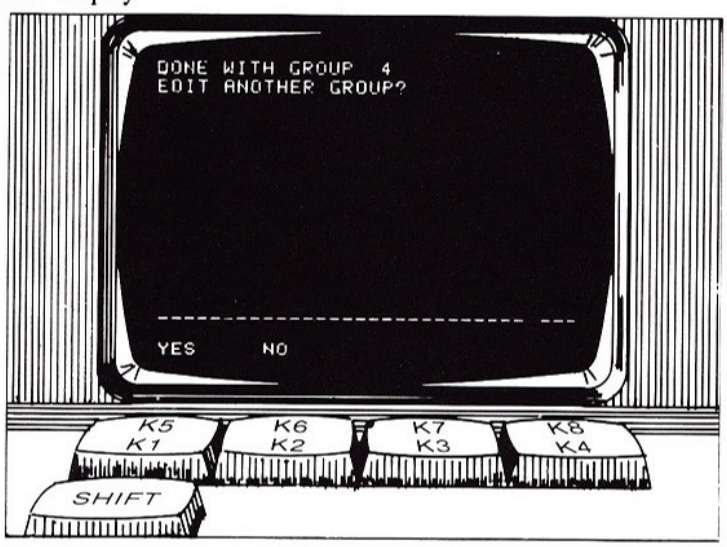



## Response

Done

The 85F asks if we want to edit the channel setup of another group:

## 85F Display

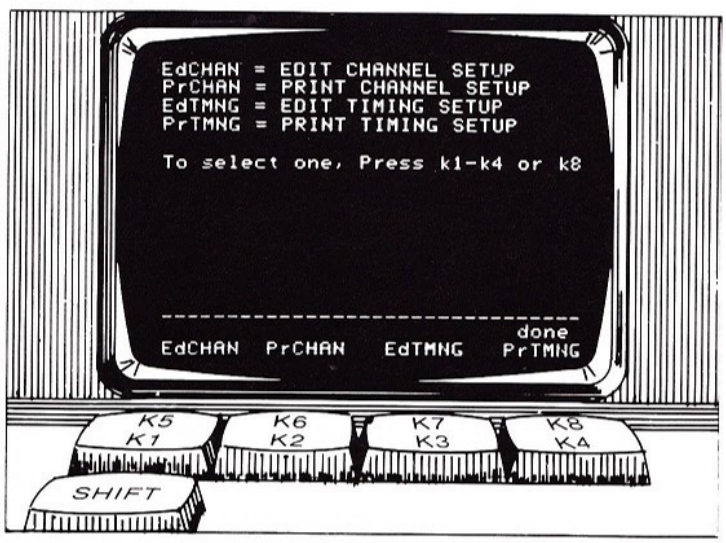



## Response

NO

We will move on to define the timing setup that will be used with the channel setup for Group 4. (Running the complete experiment would require us to also set up the other 6 channel groups is a similar manner. We could continue the setup by answering YES, but will confine our discussion here to Group 4.) The 85F responds by returning to the main SETUP menu:

## 85F Display

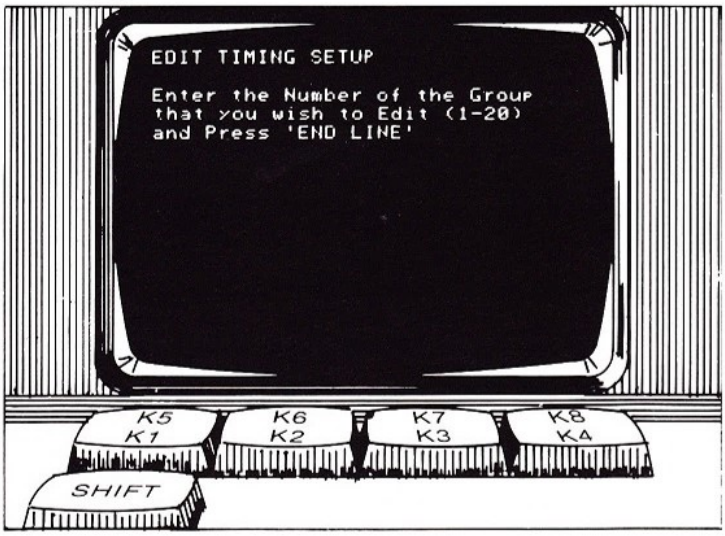



## Response

EdTMNG

We will now define the timing setup for Group 4. The EdTMNG routine defines the timing of the measurements and how the data is output (displayed, printed or stored on tape). The 85F asks for the number of the group whose timing is to be defined:

### 85F Display

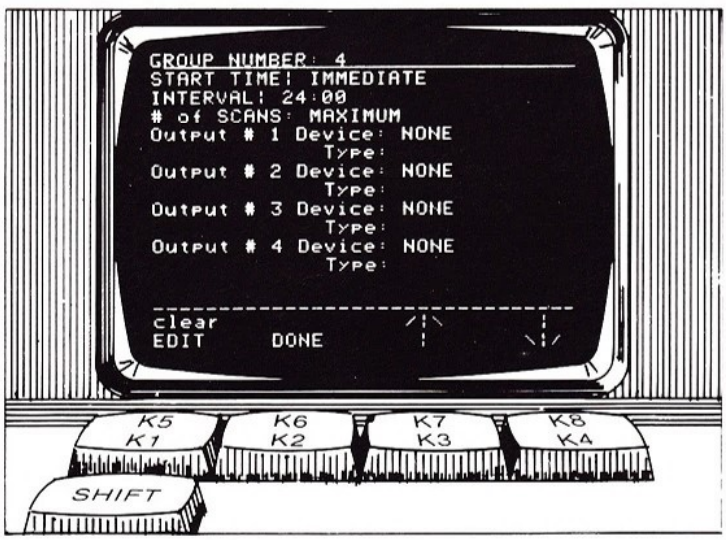



### Response

4 END LINE

The 85F responds by presenting the main timing setup menu. We will again use the cursor line and the EDIT key to define the parameters of the timing setup:

### 85F Display

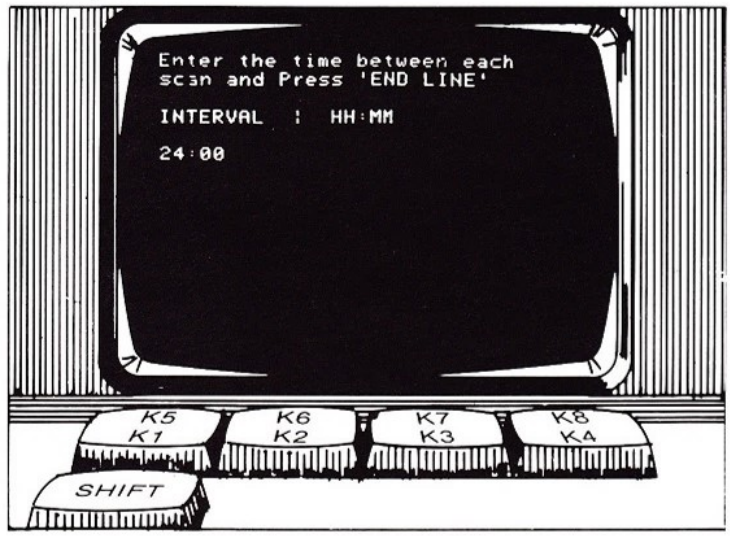



### Response

↓ ↓ EDIT

We will choose an "IMMEDIATE" START TIME so logging will begin when we run the "Log" routine, rather than waiting for a specific programmed time and date to begin. We'll also scan the thermocouples every minute for 10 minutes, for a total of 10 scans. Data will be printed and stored on tape (for later analysis and plotting). We will first define the INTERVAL using the cursor line and the EDIT key. The 85F responds with:

### 85F Display

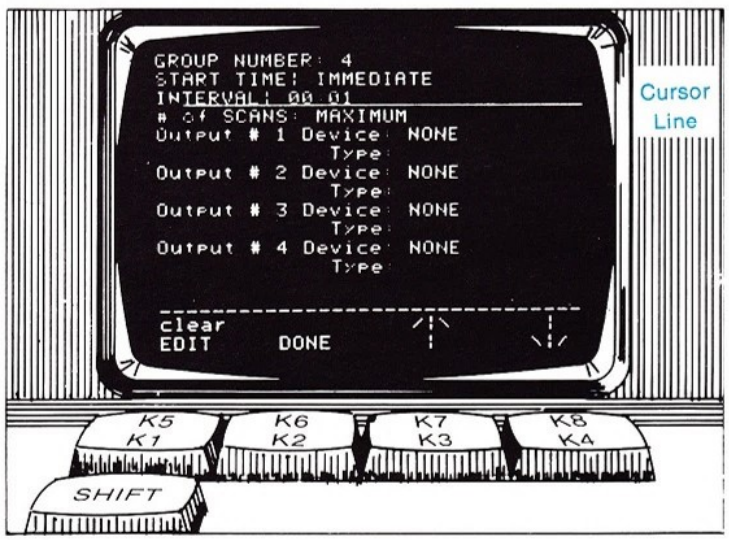



### Response

00.01 End LINE

The 3056DL will scan the 5 thermocouples every minute. The 85F responds with the group timing setup menu:

### 85F Display

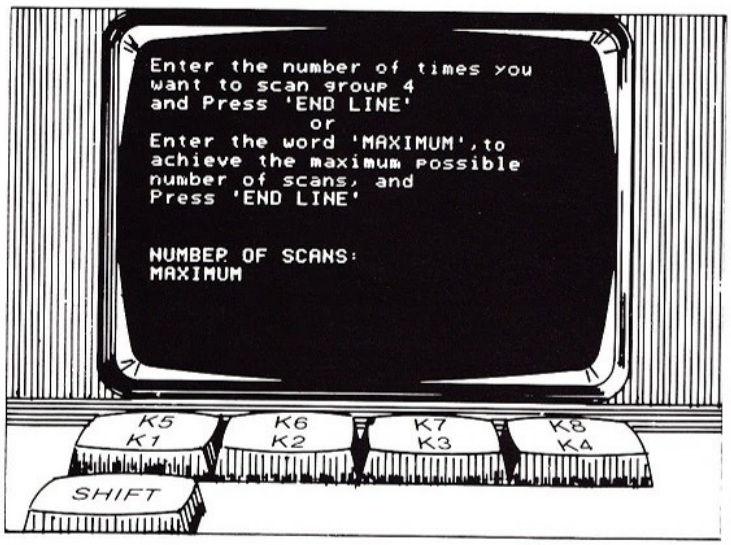



### Response

↓ EDIT

The 85F responds by asking for the number of scans to be performed:

## 85F Display

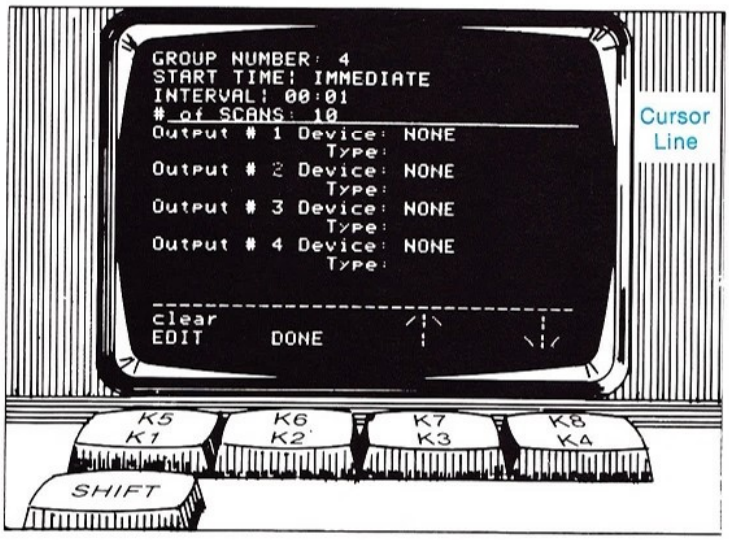



## Response

10 END LINE

Now that we have set Group 4 to be scanned 10 times, the 85F returns the timing menu:

## 85F Display

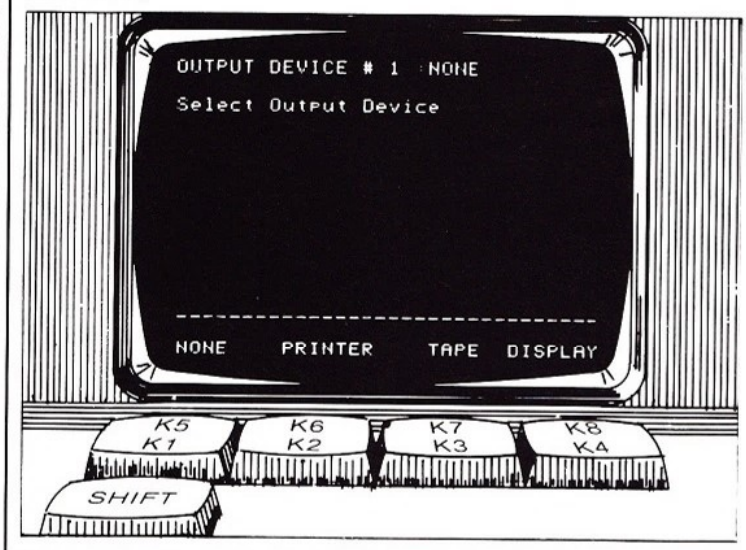



## Response

↓ EDIT

"Output Device" specifies what is to be done with the measurement data. We can print it, store it on tape, or simply display it on the 85F's screen.

## 85F Display

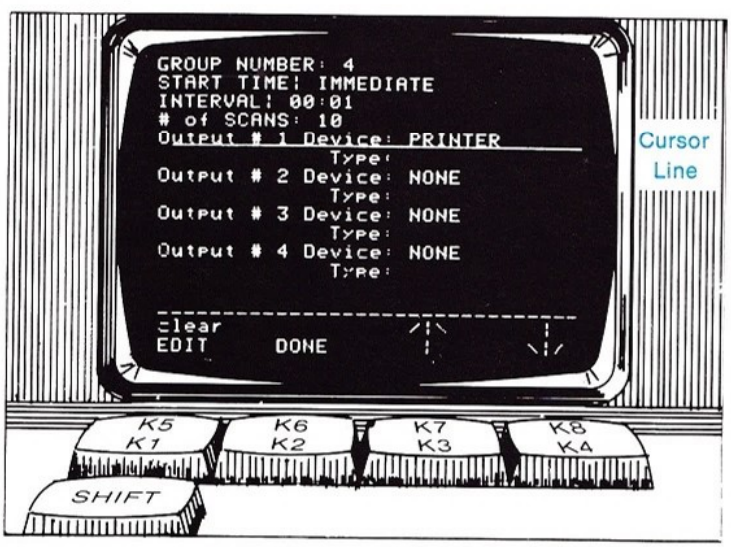



## Response

PRINTER

We'll print the data and store it on tape for later recall & manipulation. The 85F returns to the timing menu:

## 85F Display

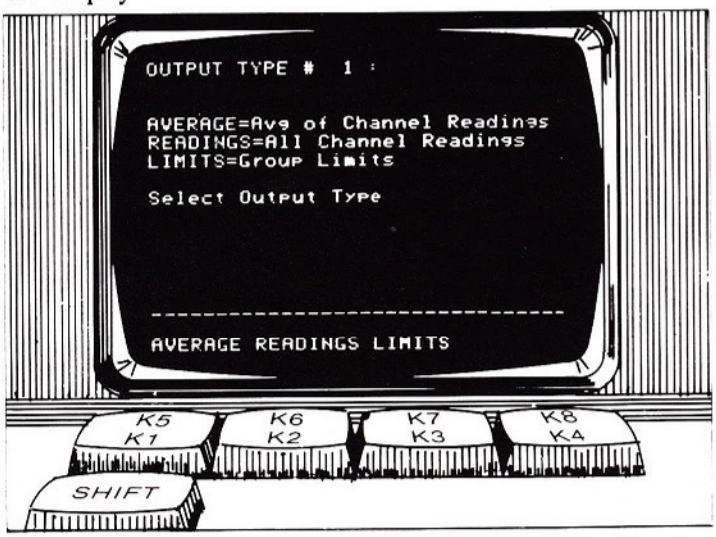



## Response

↓ EDIT

The 85F responds with a choice of what data is to be printed. We can print all 5 channels, print the average of the 5 channels, or if we had some limit functions in Group 4, we could print only those measurements that exceeded the limits.

85F Display

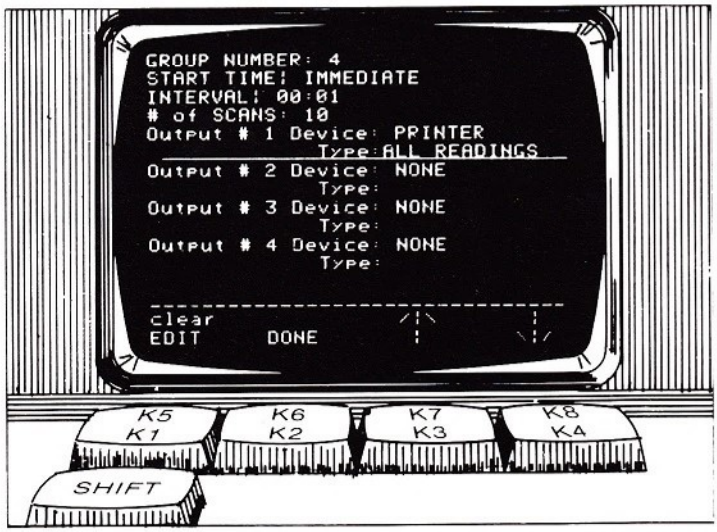



Response

READINGS

This will print all 5 thermocouple readings for each scan. The 85F then returns to the timing menu:

85F Display

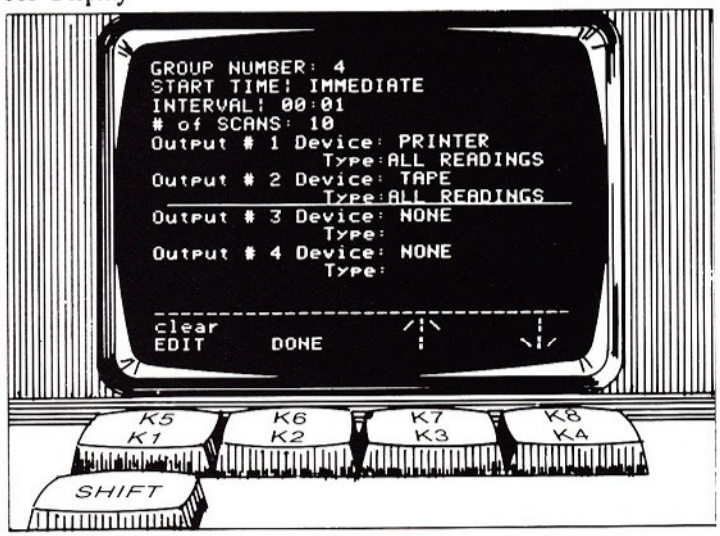



Response

↓ EDIT

Following the same procedure that we just used, we can define "Output #2 Device" to be the tape cartridge, and can store all measurements on tape. When we have done this, the 85F again returns to the main timing menu:

85F Display

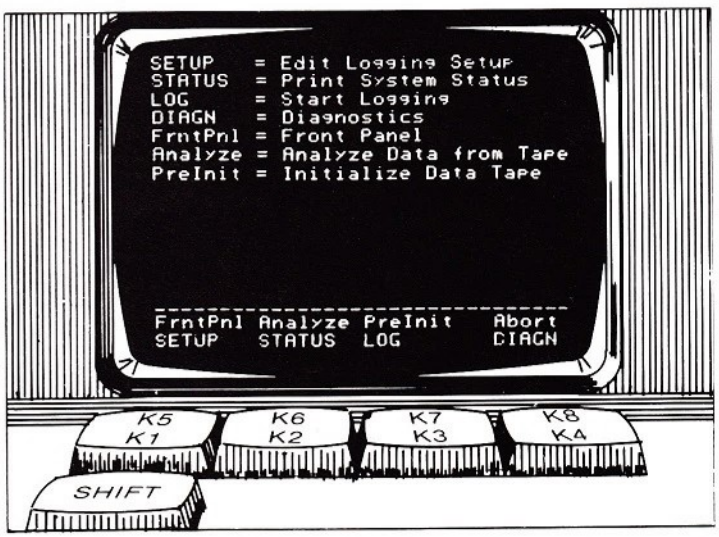



Response

DONE

This completes the timing setup for Group 4. The 85F will ask if we want to define another group; since we are only interested in Group 4, we would reply with a NO, and the 85F would respond by returning to the main setup menu. We would respond by indicating that we are done with the Group 4 setup; the 85F would then present the main 3056DL menu:

85F Display

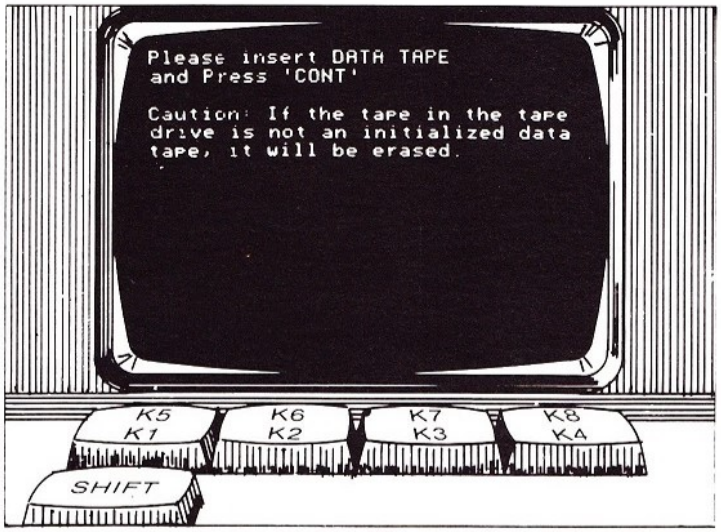



Response

LOG

We are now ready to log data. When LOG is presssed, the measurement routine is stored in the 85F and the 3421A is reset. Since we are storing data on tape for later analysis, the 85F will request you to insert a data storage tape for initialization:

## 85F Display




## Response

Insert the data tape and press CONT

The 85F will automatically prepare the tape for data storage and will store our channel and timing setups on this data tape. When the tape has been initialized, the 3056DL is ready to begin measurements at the selected start time. (In our example, we want to start the experiment immediately).

# Measurement Results

As each scan is completed, the printer provides a record showing measured temperatures, channel numbers, and the time and date of the scan.

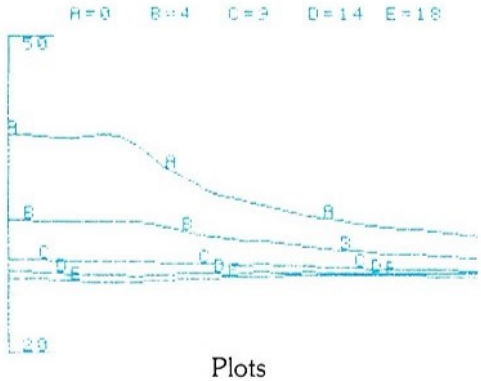
Group Label → `********** GROUP # 4 **********`
`PROTOTYPE TEMPS`
Scan # → `SCAN # 1 00:22:00 : 00/00/00` ← Time & Date

```
CHANNEL READINGS
Channel 5     18.175     DEG C
Channel 6     17.814     DEG C
Channel 7     18.623     DEG C
Channel 8     17.958     DEG C
Channel 9     18.272     DEG C
```

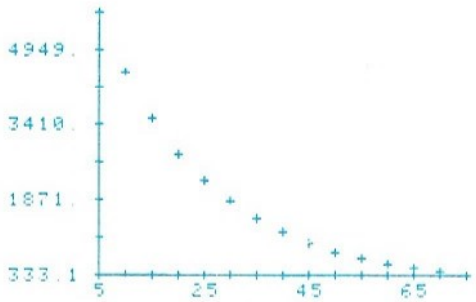
← Measured Temperatures

```
********** GROUP # 4 **********
   PROTOTYPE TEMPS
SCAN # 2  00:23:00 : 00/00/00

CHANNEL READINGS
Channel 5     25.188     DEG C
Channel 6     24.929     DEG C
Channel 7     18.163     DEG C
Channel 8     21.447     DEG C
Channel 9     24.841     DEG C
                 .
                 .
                 .
********** GROUP # 4 **********
   PROTOTYPE TEMPS
SCAN # 8  00:29:00 : 00/00/00

CHANNEL READINGS
Channel 5     31.944     DEG C
Channel 6     27.952     DEG C
Channel 7     26.957     DEG C
Channel 8     32.303     DEG C
Channel 9     28.885     DEG C
                 .
                 .
                 .
********** GROUP # 4 **********
   PROTOTYPE TEMPS
SCAN # 10  00:31:00 : 00/00/00

CHANNEL READINGS
Channel 5     21.986     DEG C
Channel 6     27.523     DEG C
Channel 7     27.081     DEG C
Channel 8     23.454     DEG C
Channel 9     27.407     DEG C
```

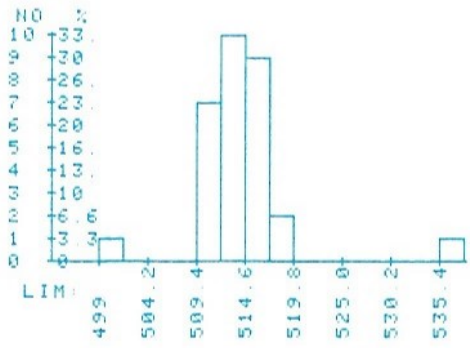
When we have finished logging data, we can return to the main 3056DL menu and use the "Analyze" routine to generate histograms, graphs or other plots such as those shown below. Graphic analysis provides a powerful and direct insight into your experiment or process without the burden of manual data reduction.




Plots




Graphs




Histograms

# General Operation With The 85F

The 3421A may also be controlled by the 85F computer for a variety of measurement and control functions without the 3056DL software being used. The 3421A and 85F provide friendly measurement automation using BASIC language with either HP-IL or HP-IB interfaces. The primary difference in using the 3421A with HP-IL or HP-IB is in the method of selecting or addressing communication to or from the 3421A.

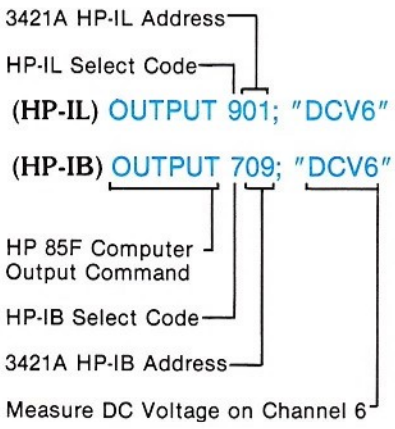
## Addressing

Each device that you connect to the interface, whether it be HP-IL or HP-IB, has a unique address. The address provides a convenient way for the computer to send or receive data from a particular device even when there are several devices connected to the interface. Three digits (901 for HP-IL or 709 for HP-IB) specify the address of the 3421A. The first digit (9 or 7) is the interface select code; it determines which of the 85F's interface cards is active. The 82938A HP-IL interface card for the 85F has a standard select code of 9, while the 82937A HP-IB card has a standard select code of 7.

The 3421A HP-IL address of 901 assumes that the 3421A is the first device connected in the interface loop following the 85F in the direction of information flow around the loop. If the 3421A were the fifth device in the loop, its address would be 905.

## Sending Commands To The 3421A

Simply decide what measurement or control function that you want the 3421A to perform and select the appropriate command codes for that function. Then send those command codes to the 3421A using the 85F's OUTPUT statement. For example, to measure DC voltage, you could choose the command code "DCV". To specify the channels on which this measurement is to occur, simply list the channel numbers after the command code. Thus to measure the DC voltage on channel 6, you would use the following statement:




The 3421A would automatically store the voltage reading in its internal memory. Some other examples:

**(HP-IL)** OUTPUT 901; "TEM 3-6, 8, 12-14"

**(HP-IB)** OUTPUT 709; "TEM 3-6, 8, 12-14"

Measure temperature on channels 3, 4, 5, 6, 8, 12, 13 and 14 using Type T Thermocouples. The 3421A automatically measures the reference junction and converts the thermocouple voltage into temperature in degrees Celsius.

**(HP-IL)** OUTPUT 901; "WRT 2,155"

**(HP-IB)** OUTPUT 709; "WRT 2,155"

Write an 8-bit digital byte to the output port of the card in slot 2; the 8 bits will be set to 10 011 011, represented by the decimal value of 155.

## Receiving Data From the 3421A

When addressed, the 3421A can talk to the 85F, giving the results of measurements or status information. You previously took a DC voltage measurement on channel 6 with the "DCV6" command. To read the measured value back into 85F from the 3421A, use the 85F's ENTER statement. The complete measurement program would be:

**(HP-IL)**

```
10 OUTPUT 901; "DCV6"
20 ENTER 901; A
30 DISP A
40 END
```

**(HP-IB)**

```
10 OUTPUT 709; "DCV6"
20 ENTER 709; A
30 DISP A
40 END
```

The 3421A is addressed to talk by the ENTER command. The measurement result is stored in the variable A and then displayed on the 85F's CRT.

# IV Specifications and Accessories

## 3421A Mainframe Specifications

The 3421A has an integrating 5½ – 4½ – 3½ digit multimeter, a frequency counter and thermocouple compensation all built in. It measures Vdc, Vac, Ω, frequency and temperature. All specifications are for relative humidity ≤85% at 30°C. See operating manual for 95% 40°C specifications.

**Internal buffer capacity:** 30 readings
**Channel display:** LCD 30 channels plus power and error indicators
**Electronic calibration enabled by rear panel switch**
**Front terminals connected to multiplexer common**

### DC Voltage

| Range | Maximum Display (5½ digit) | 5½ Digit Resolution | Input Resistance ≤30°C, 85%RH | 5½ Digit *Accuracy ± (%Reading + Counts) 23°C ± 5°C 90 Days | 1 Year | Temperature Coefficient ± (%Reading + Counts)/°C (0 – 18°C, 28 – 55°C) 5½ Digit | 4½ Digit | 3½ Digit |
|---|---|---|---|---|---|---|---|---|
| 0.3 V | .301000 | 1 μV | ≥$10^{10}$Ω | .009 + 6 | .02 + 6 | .0008 + .5 | .0008 + .05 | .0008 + 0 |
| 3 V | 3.01000 | 10 μV | ≥$10^{10}$Ω | .009 + 3 | .02 + 3 | .0008 + .05 | .0008 + 0 | .0008 + 0 |
| 30 V | 30.1000 | 100 μV | 10 MΩ ± 1% | .009 + 3 | .02 + 3 | .0008 + .5 | .0008 + .05 | .0008 + 0 |
| 300 V | 301.000 | 1 mV | 10 MΩ ± 1% | .009 + 3 | .02 + 3 | .0008 + .05 | .0008 + 0 | .0008 + 0 |
| Auto | | | | | | | | |

*For 4½ and 3½ digits, change number of counts to 1.

**Noise Rejection:** For noise of 50 or 60 Hz ± 0.1%, 1 KΩ unbalance in low lead. Auto zero on

| | 5½ Digit | 4½ Digit | 3½ Digit |
|---|---|---|---|
| AC NMR | 80 | 59 | 0 |
| AC ECMR | 140 | 120 | 60 |
| DC CMR: | 140 dB | | |

**Maximum Input Voltage:**
± 350 V peak Hi-earth or Hi-Lo
± 150 V peak Lo-earth

### Resistance

The 3421A makes 2-wire or 4-wire measurements, with either 5½, 4½ or 3½ digit resolution.

| Range | Maximum 5½ Digit Reading | 5½ Digit Resolution | Measurement Current ± 2.7% | Accuracy 5½ Digits ± (%Reading ± Counts) 23°C ± 5°C 90 Days | 1 Year | Temperature Coefficient (%Reading + Counts)°C 0 – 18°C, 28 – 55°C 5½ Digit | 4½ Digit | 3½ Digit |
|---|---|---|---|---|---|---|---|---|
| 300 Ω | 301.000 | 1 mΩ | 1 mA | .012 + 6 | .017 + 6 | .0009 + 0.5 | .0009 + .05 | .0009 + 0 |
| 3 KΩ | 3.01000 | 10 mΩ | 1 mA | .011 + 3 | .016 + 3 | .0009 + .05 | .0009 + 0 | .0009 + 0 |
| 30 KΩ | 30.1000 | 100 mΩ | 100 μA | .011 + 3 | .016 + 3 | .0009 + .05 | .0009 + 0 | .0009 + 0 |
| 300 KΩ | 301.000 | 1 Ω | 10 μA | .011 + 3 | .016 + 3 | .0009 + .05 | .0009 + 0 | .0009 + 0 |
| ** 3 MΩ | 3.01000 | 10 Ω | 1 μA | .014 + 3 | .018 + 3 | .0021 + .05 | .0021 + 0 | .021 + 0 |
| ** 30 MΩ | 30.1000 | 100 Ω | 100 nA | .12 + 3 | .12 + 3 | .021 + .05 | .021 + 0 | .0021 + 0 |
| Auto | | | | | | | | |

**Add .07% Reading (3 MΩ Range) and 0.7% Reading (30 MΩ Range) when using the 3½ digit mode.

Measurement accuracy is for 4-wire mode, 5½ digits, auto zero on. For 4½ or 3½ digits, use number of counts = 1. For 2-wire mode, add a maximum of 4Ω offset.

**Non-destructive overload:** ±300V peak

**Maximum Open Circuit Voltage:** 6.5 volts

### Operating Information

| | 3421A | 41CV | 82161A Cassette Drive | 82162A Printer | 85F | 16" Rack |
|---|---|---|---|---|---|---|
| Operating Temperature | 0 – 55°C | 0 – 45°C | 10 – 40°C | 0 – 45°C | 5 – 40°C | — |
| Storage Temperature | –40 to +75°C | –20 to +65°C | –40 to +75°C | –40 to +55°C | –40 to +65°C | — |
| Humidity | ≤ 85%, 30°C | | 20 – 80% | | 5 – 80%, 40°C | — |
| Min. Battery Life | | | | | | |
| Continuous | 12 hrs (HP-IL) 6 hrs (HP-IB) | 34 hrs. | 1.8 hrs. | 1.4 hrs. | — | — |
| Sleep Mode | 2 mos. | 2 mos. | 1 mo. | 1 mo. | — | — |
| Weight kg (lbs.) | 7 kg (15) | 0.25 kg (.5) | 0.8 kg (1.7) | 0.8 kg (1.7) | 9.1 (20) | 18 (40) |
| Shipping Weight | 10 (22) | 2 (4.5) | 2 (4.5) | 2 (4.5) | 16.8 (37) | 32 (70) |
| Dimensions cm (in.) | | | | | | |
| Length | 27.2 (10.7) | 14.2 (5.6) | 17.8 (7) | 17.8 (7) | 48.3 (19) | 63.7 (25.2) |
| Width | 42.6 (16.8) | 7.9 (3.11) | 13.2 (5.2) | 13.2 (5.2) | 42 (16.5) | 50 (19.8) |
| Height | 10.2 (4) | 3.3 (1.3) | 6.1 (2.4) | 6.1 (2.4) | 15.3 (6) | 42.3 (16.8) |
| Power Consumption | 6 w | — | 3 w | 2.5 w | 40 w | — |

# Mainframe Specifications (cont'd)

## AC Volts

The 3421A has 3 and 30 volt ac ranges. For convenient ac line voltage measurements up to 300 VRMS, use the 10:1 attenuators on the Option 020 input card. Eight of the 10 available channels can accommodate the 10:1 divider. Each Option 020 comes configured with the 10:1 divider on channel 2. For seven additional dividers, order the 44469A accessory.

The ac converter is average responding and operates in either 3½- or 4½-digit mode.

**Input Characteristics**

| Range | Maximum Display (4½ Digit) | 4½ Digit Resolution | Input Resistance | Maximum Input Voltage |
|---|---|---|---|---|
| 3 V | 3.0100 | 100 μV | 10MΩ ± 1% | Hi-Lo ±30V peak |
| 30 V | 30.100 | 1 mV | 10MΩ ± 1% | Lo terminal to earth: ±150V peak |

**AC Specifications*: ± (% Reading + Counts) (90 days)**

| | 30 Hz – 1 kHz | 45 Hz – 500 Hz | Temperature Coefficient ± (%Reading + Counts)/°C 0 – 18°C, 28 – 55°C |
|---|---|---|---|
| 3½ Digits | 1 + 6 | 0.5 + 6 | .01 + .7 |
| 4½ Digits | 1 + 60 | 0.5 + 60 | .01 + 7 |

*These specifications assume: $V_{in} \geq 0.3V$ (3V Range)
$V_{in} \geq 3V$ (30V Range)

**High Voltage Divider (44469A):**
$Z_{in}$: 1 MΩ ± 1%
$C_{in} \leq 25$ pF
Add 1% Reading error when using divider

**Maximum Input Voltage:**
301 V RMS (±425 V peak) Hi-Lo
±350 V peak – Hi terminal to earth.
±150 V peak – Lo terminal to earth.

## Counter

**Input Characteristics**
Max. input voltage: 300V
Input impedance: 10 MΩ ± 1%
Min. pulse width (5V): 50 μs, 5% duty cycle min.
Sensitivity: 600 mV p-p
Counter will trigger on zero crossing and TTL waveforms

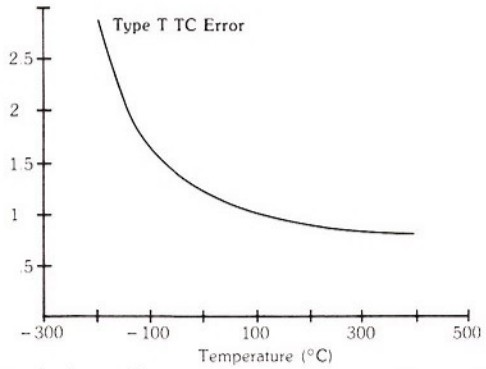
**Frequency Counter Mode**
Frequency Range:
1 Hz – 10 kHz (Rise time ≤ 1.5 ms)
10 Hz – 10 kHz (Rise time ≥ 1.5 ms)
Accuracy: ± (0.05% reading + 1 count)
Resolution: varies with gate time and frequency
Maximum Resolution: 65,535 counts
Gate Time: 0.1, 1 or 10 sec.

**Totalize Mode**
Maximum number of counts: 65,535
Minimum pulse period: 100 μS

## Thermocouple Thermometer

Type T thermocouple linearization is built in. For other thermocouple types, the reference junction temperature is available. Conversions are made via 44468A Data Acquisition Pac in the 41C/CV and via the 3056DL software in the 85F.

**Type T Thermocouple Linearization**
Range: –200°C to +400°C
Accuracy:




(includes reference junction error, thermal offset, dvm error and curve fit. It does not include wire errors).

Temperature Coefficient: .05°C/°C (0 – 18°C, 28 – 55°C)

**Reference Junction**
Accuracy: ±1°C (23°C ± 5°C)
Temperature Coefficient: .05°C/°C (0 – 18°C, 28 – 55°C)

## Mainframe Reading Rates

These rates reflect the time to read and store information in the 30-reading buffer of the 3421A. They do not include computer transfer time.

| | DCV, Ω | | ACV | | | |
|---|---|---|---|---|---|---|
| | Auto Zero On | Auto Zero Off | Auto Zero On | Auto Zero Off | Freq. | Type T Thermocouple |
| Repeat Readings on the Same Channel: | | | | | | |
| 5½ digit: | 2 | 4 | – | – | 0.1 | 0.95 |
| (readings/sec) 4½ digit: | 14 | 22 | 0.3 | 0.3 | 0.9 | 0.95 |
| 3½ digit: | 28 | 35 | 0.4 | 0.4 | 8.0 | 0.95 |
| Read Different Channels: | | | | | | |
| 5½ digit: | 2 | 3.8 | – | – | 0.1 | 0.95 |
| (channels/sec) 4½ digit: | 13 | 18 | 0.3 | 0.3 | 0.9 | 0.95 |
| 3½ digit: | 21 | 24 | 0.4 | 0.4 | 7.0 | 0.95 |

# System Specifications - 3056DL

These rates assume 30 readings taken on a fixed range with no function change. Speeds are independent of channel sequence. Rates include scan time, A/D conversion time, and the time to transfer the reading to the 85F. Rates apply for either HP-IB or HP-IL.

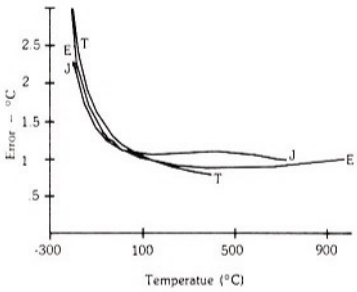
## DVM Reading Rates (readings/second)

| | DCV,Ω | | | | |
|---|---|---|---|---|---|
| | Auto Zero Off | Auto Zero On | ACV | Frequency | Type T Thermocouple |
| 5½ Digit | 3.2 | 1.8 | – | 0.1 | 0.9 |
| 4½ Digit | 9 | 8 | 0.3 | 0.8 | 0.9 |
| 3½ Digit | 11 | 10 | 0.4 | 5.8 | 0.9 |

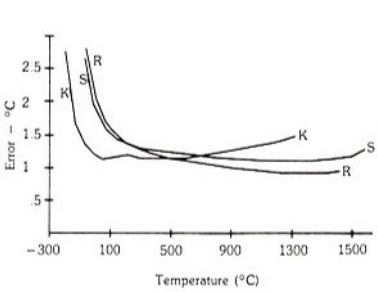
## Temperature Errors

These errors include the linearization error of the 3056DL software, thermal offset voltages, A/D error and reference junction error. They do not include transducer errors.

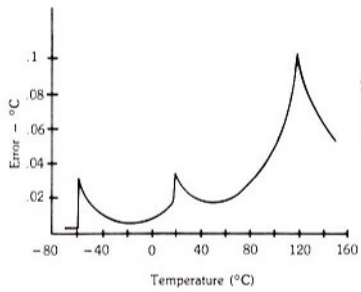
**J,E,T Thermocouples**



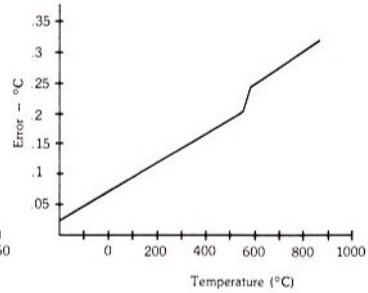

**K,R,S Thermocouples**




**2.25 kΩ Thermistor**




**100 Ω Platinum RTD α = .00385**




# System Specifications - 3421A/41CV

## Reading Rates

These rates assume 30 readings taken on a fixed range with one function. Since the 3421A has a channel list which you preprogram, speeds are independent of channel sequence.

Reading rates include the scan time, A/D conversion time, and the time to transfer the reading into a 41CV register.

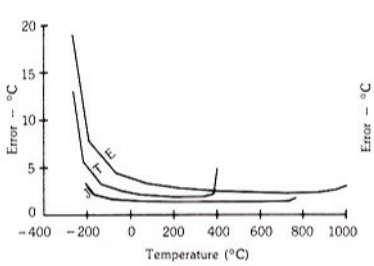
## DVM Reading Rates (channels/sec)

| | DCV,Ω | ACV | Frequency | Thermocouple Type T |
|---|---|---|---|---|
| 5½ Digit | 1.0 | – | 0.1 | 0.6 |
| 4½ Digit | 1.9 | 0.3 | 0.6 | 0.6 |
| 3½ Digit | 2.0 | 0.3 | 1.7 | 0.6 |

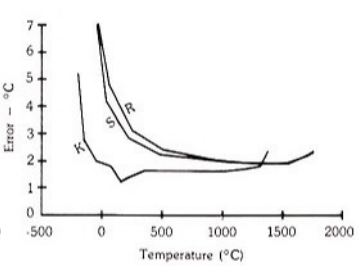
## Temperature Accuracy

These errors include the linearization error of the 44468A Data Acquisition Pac, thermal offset voltage, A/D error and reference junction error. They do not include transducer error.

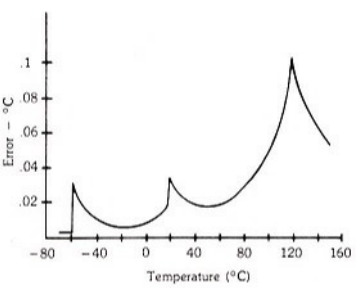
**J,E,T Thermocouples**



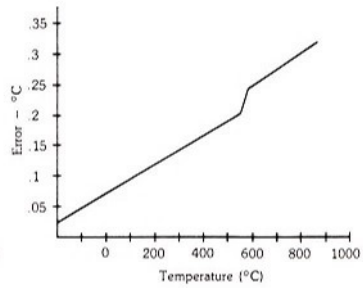

**K,R,S Thermocouples**



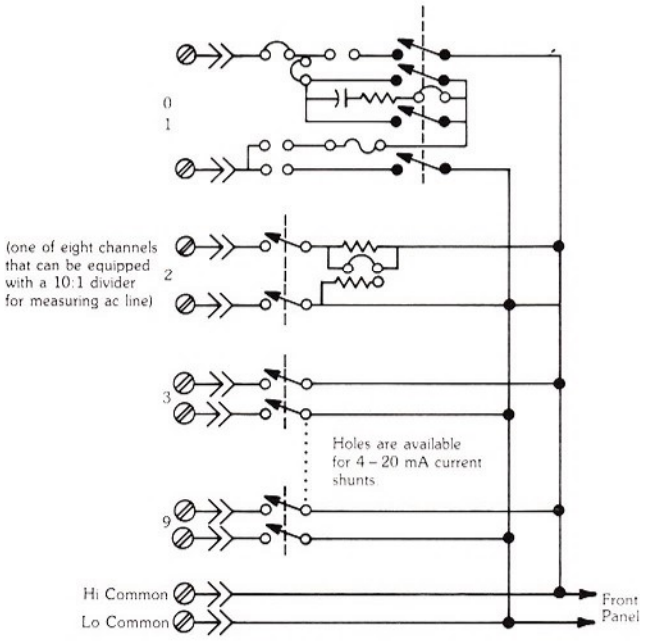

**2.25 kΩ, Thermistor**




**100 Ω Pt RTD α = .00385**



# Option 020 Multiplexer Assembly




## Option 020 Specifications

### Multiplexer Mode (switches 0 – 9, 1 – 9 or 2 – 9)

**Operation:** break before make
**Maximum Voltage:**
301 Vdc 150 VA max
252 VRMS ac
**Contact Resistance:** $\leqslant 1.4\Omega$
**Thermal Offset:** $\leqslant 3\ \mu V$ with HI shorted to LO
**Switch Life:** $5 \times 10^6$ operations
**Switch Capacitance:**
Open contact: $\leqslant 15$ pF
Hi – Lo: $\leqslant$ 90 pF with 1 Option 020
$\leqslant$130 pF with 2 Option 020
$\leqslant$170 pF with 3 Option 020
Channel to channel: $\leqslant 30$ pF
**Isolation Resistance**
Hi – Lo, Hi – Earth, Lo – Earth $\geqslant 10^{11}\Omega$
**Frequency Response**
3 dB point, 50Ω source $\geqslant$ 1 MHz
3 dB point, 1 MΩ source $\geqslant$ 1 KHz

### Actuator Mode (switches 0 & 1 only)

**Maximum Voltage:**
30 Vdc
252 VRMS ac
**Maximum Current:** 2 amps
**Contact Resistance:** $\leqslant 1.4\Omega$
**Switch Life:** $5 \times 10^6$ operations with proper contact protection

Actuator relays do not change state when power is lost, so failsafe programming on critical processes should be designed accordingly.

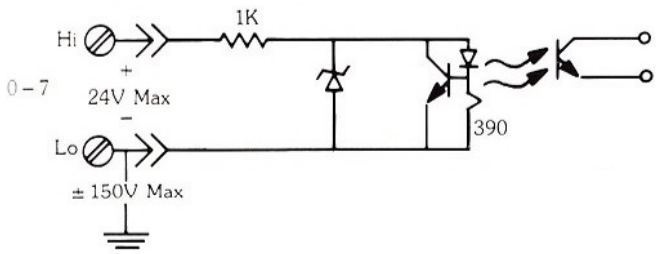
# Option 040 Breadboard Assembly

**Board Space:** 95 sq. cm. (14.75 sq. in.)
**Maximum Voltage:** ±360 V
**Power Available:** 5 V, 35 mA; 6 V, 150 mA
**Hole Sizes:** .046
**Grid:** .100″
**Connectors:** 22 pin edge (solder)
**Component Lead Length:** $\leqslant 0.25$
**Component Lead Height:** $\leqslant 0.5$″
**Maximum Power Dissipation:** $\leqslant 0.5$ watts

# Option 050 Digital I/O Assembly

## INPUT SECTION

(8 identical inputs)




**Voltage Levels:**

| | Min. | Max. |
|---|---|---|
| Low State | | 0.8 V |
| High State | 2.4 V | 24 V |

**Input Current:**

| | Min. | Max. |
|---|---|---|
| Low State | | 100 μA |
| High State | 800 μA | 25 mA |

**Logic Polarity:** Positive true

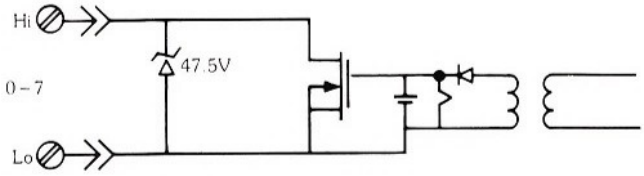
**Monitor Mode:** (Generates SRQ)
Minimum pulse width: 10 mS
Trigger latch: High or low level
Trigger masking: Any combination of the 8 bits

Maximum Time From Trigger to SRQ: 1 – 10 mS

Entire 8 bits latched when trigger received.

## OUTPUT SECTION

(8 identical outputs)




| Input Command | Output |
|---|---|
| Logic 1 | $R_O \leq 2\Omega$<br>$I \leq 300$ mA<br>Power ≤ 180m watt |
| Logic 0 | $R_O \geq 10^7\Omega$<br>$V_O \leq 42V$ |

Each bit is individually controlled and isolated.

# Accessories

## Field Installation Kits

44461A Add HP-IB Interface
44462A 10-channel multiplexer assembly with thermocouple reference, includes connector block (same as Opt. 020)
44463A Extra connector block for thermocouple multiplexer card
44464A Breadboard Assembly, includes connector block (same as Opt. 040)
44465A 8 bit in/8 bit out digital I/O Assembly, includes connector block (same as Opt. 050)
44466A Extra connector block for digital card or breadboard card
44468A Data Acquisition Pac for 3421A/41CV
44469A Seven pairs of resistors for 10:1 300 Vac divider (one pair comes standard with each Option 020)

## Other Products Available

34118A Test Lead Kit
10833A 1 Meter HP-IB Cable
10833B 2 Meter HP-IB Cable
10833C 4 Meter HP-IB Cable
10833D 0.5 Meter HP-IB Cable
82167A 0.5 Meter HP-IL Cable
82167B 1 Meter HP-IL Cable
82167D 5 Meter HP-IL Cable
44468A 3421A Data Acquisition Pac for 41CV to allow fast programming of the 3421A the HP 41C or HP 41CV.
82160A HP-IL Interface for 41C/CV
82937A HP-IB Interface for HP series 80 computers
82938A HP-IL Interface for HP Series 80 Computers
82153A Wand
82045A Extra printer paper for 82162A
82176A Extra cassettes for 82161A
82182A Time Module for 41CV
82170A Quad memory Module for 41C

# 3421A COMMAND CODES

| Command | Description |
|---|---|
| DCV*x,y....z* | DC Volts, 5½ digits, autoranging. Scans, measures, and stores readings from channels *x,y....z*. (DCV3, 6-8,14 measures channels 3,6,7,8,&14) |
| ACV*x,y....z* | AC Volts, 4½ digits, autoranging. |
| TWO*x,y....z* | Two-wire Ohms, 5½ digits, autoranging. |
| FWO*x,y...z* | Four-wire Ohms, 5½ digits, autoranging. |
| TEM*x,y....z* | Temperature (T-thermocouple), 5½ digits. |
| FRQ*x,y....z* | Frequency, 5½ digits, 1 sec. gate time. |
| BIT*x,y....z* | Read digital input bits *x,y....z*. |
| TOT*x* | Totalize (count events) on channel *x*. |
| CLS*x* | Close channel *x*, or set digital output bit *x*. |
| OPN*x* | Open channel *x*, or clear digital output bit *x*. |
| CLP*x* | Close channel pair *x* and *x+10*. |
| REF*x* | Measure reference junction temperature on card where channel *x* is located. |
| WRT*i,abc* | Write an 8 bit byte to the digital output port in slot *i*. The byte will have a decimal value of *abc* (0-255). |
| RED*i* | Read the decimal value (0-255) of the digital input byte in slot *i*. |

HEWLETT PACKARD

**For more information,** call your local HP Sales Office or nearest Regional Office: • Eastern (201) 265-5000; • Midwestern (312) 255-9800; • Southern (404) 955-1500; • Western (213) 970-7500; • Canadian (416) 678-9430. Ask the operator for instrument sales. Or write Hewlett-Packard, 1501 Page Mill Road, Palo Alto, CA 94304. **In Europe:** Hewlett-Packard S.A., 7, rue du Bois-du-Lan, P.O. Box, CH 1217 Meyrin 2, Geneva, Switzerland. **In Japan:** Yokogawa-Hewlett-Packard Ltd., 29-21, Takaido-Higashi 3-chome, Suginami-ku, Tokyo 168.

Printed in U.S.A.

DATA SUBJECT TO CHANGE

5953-6914