Model 1506

Digital Thermometer
Operator Manual

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1 Introduction

1.1 Micro-processor Based

The heart of the 1506 is a powerful 6809 based micro-computer, utilizing high precision (10 digit), high level software (BASIC), to measure resistance and calculate temperature with high resolution and speed. The 1506 can simultaneously communicate with other computers in a high level protocol.

1.2 Dual Sensors

One or two sensors may be used. The dual sensor feature is useful in measuring the difference between two temperatures. To match the instrument's specifications, ultra stable calibrated RTD or thermistor sensors should be used. Besides the RTD and thermistor sensors, any resistive device can be connected to the sensor input, and its resistance be precisely measured. The sensors are connected to the instrument via a preferred 4-wire connection.

1.3 Ratiometric, Auto-zeroing

An integrating, auto-zeroing, ratiometric technique is used to accurately compare sensor resistance to temperature-insensitive standard resistors.

An AC input bridge eliminates undesirable thermocouple effects, while phase-lock to a power-line subharmonic rejects hum.

1.4 Easy Instrumentation Interfacing

Measurements displayed on the front panel are also sent to the optional RS232 port, and to the IEEE-488 buss.

Commands and programming may be entered in identical formats through any of the three interfaces: keypad, IEEE-488, or RS232. Some commands are not available through the IEEE buss.

An analog output provides a 0 to +1.020 volt signal to binding posts suitable for strip chart recorders, etc. The analog output switch (zoom) provides selection of scaling factors for conversion to the analog output signal.

1.5 Uses

These are just some areas in which the Model 1506 can be useful:

- Metrology Labs
- Delta-T Measurements
- Calibration Tool
- Process Control
- Secondary Temperature Standard
- Digital Ohmmeter
- Temperature Monitoring and Control
- Calorimetry
- Thermodynamic Studies
- Standards Labs

2 Operation

2.1 Easy Selection Of Information

2.1.1 The MODE switch selects for display the following functions:

- The measure of either of two sensors (T_1 or T_2).
- The difference between measures T1 or T2(T_1-T_2).
- The minimum or maximum (T_{MIN}, T_{MAX}) of functions T_1, T_2, or T_1-T_2.
- The spread (difference between maximum and minimum) of functions T_1, T_2, or T_1-T_2.
- Reinitialization or clearing (T_{CLR}) of the maxima or minima.

2.1.2 The SCALE switch selects the following units of measure:

- Celsius temperature (C)
- Kelvin temperature (K)
- Fahrenheit temperature (F)
- Rankin temperature (R)
- Ohms resistance (Ω)

2.1.3 The RESOLUTION switch selects the following measurement time-base intervals:

- One second (1)
- Five seconds (5)
- Ten seconds (10)
- One hundred seconds (100)

2.1.4 The ANALOG output switch selects the analog output scale

The analog output is useful in measuring stability of a constant temperature. The output is measured in units/volt. For example, if the units chosen were degrees C then pressing ".1" would set the analog output scale to 0.1°C/V. The range of the analog output is from 0.00V to approximately 1.02 V. The "CENTER" button is used to bring the analog output to the center of its range. So, if the current reading were 25.6789°C and the "CENTER" button is pressed, then .501 V at the output is set to be 25.6789°C. Subsequently pressing the ".1" scale button will then set the output range from 25.6289°C to 25.7289°C at .1°C/V. To use the analog output press the "CENTER" button and wait for

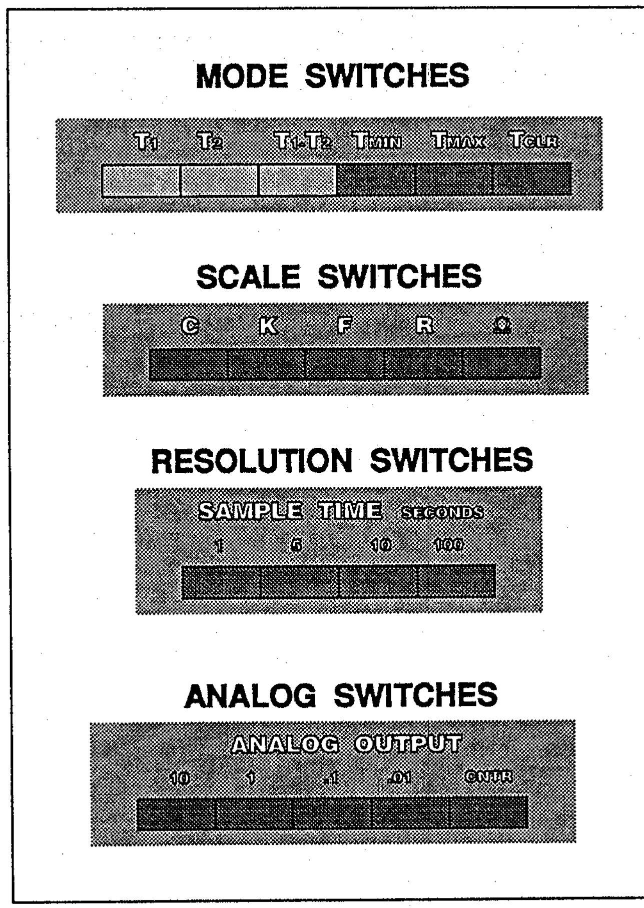

Figure 2-1 Front panel switch functions

two sample periods. The length of time for this is determined by the sample time selected. Then press one of the analog output scale buttons (10-0.1). The last reading prior to selecting the "CENTER" button becomes the center of the analog output range and does not change when selecting any of the analog output scale buttons. If the "CENTER" button is pressed again, the new reading will become the center of the analog output.

2.2 Optional Sliding Average

The display can be programmed to show the sliding, (or "running") average of the last "N" contiguous readings. This is simply the average of the last "N" samples, if "N" samples have been taken. (If fewer than "N" points have been taken, then the display is the average of as many points as have been received, and will be suffixed by a "*".) Individual "N's" are user selectable, one for each of the four measurement time bases. N ranges from 1 to 10.

2.3 Choices Of Information Presentation

- 10-character vacuum-florescent alphanumeric display provides an easy to read display of measurements and scale.
- IEEE-488 standard buss. (Optional)
- RS-232 serial. (Optional)
- Query of 1506 command settings may be made via the IEEE or RS232 interfaces.

A flow diagram of a simple IEEE - interface program for remote control of the Model 1506 is given in the back of this manual.

2.4 Non-volatile Calibration

The "pop down" keypad allows programming of the calibration constants for a specific sensor, to obtain high system accuracy over its range. The display allows visual feedback when programming the constants.

Either Platinum (RTD) or Thermistor Resistance-Temperature equation coefficients are programmed into the 1506 for each sensor.

These calibration constants, with other programming, are stored in battery backed-up memory, and remain stored until changed.

The 1506 can be remotely programmed over any of the three interfaces: keypad; IEEE; or, RS232. Some restrictions apply to the IEEE buss.

3 Programming

3.1 Detailed Keypad/Display Editing

The keypad is used to edit the calibration parameters, while the display prompts and provides feedback. The keypad is stored out of the way on the bottom panel of the 1506, until popped-down with a 1/4 turn thumbscrew.

Editing is entered by depressing "E". Afterward, the E key specifies the exponent in scientific number notation. Each stored parameter will then be displayed, in turn, for examination and/or change. The name and value of the first parameter will be shown on the display, followed by a "?". The value is changed by simply keying in the new value. Mistakes are erased using the "←" key. If the present value is acceptable, no new value is keyed. In either case, the edit of the parameter is finished by depressing the "Enter" (also called the "Return" key). There will be a slight pause after a parameter has been changed while the new value is stored in nonvolatile memory.

Because the display has a limited number of digits, some parameters may be too lengthy to show all at once. In such cases, the first 10 characters will first be displayed, and depressing any key will only cause the balance of the prompt to appear. After the "?" shows, keystrokes are accepted as editing.

The parameters' names, ranges, and meanings are summarized in order as follows:

IEEE (0)=?

(IEEE-488 bus address. Range is 0 to 31.)

BAUD (19200)=?

(RS232 port BAUD rate. Range is 110 to 19200 BAUD.)

N-AVG1=10.?

(1 second sample time reading number for sliding average.
Range 1 to 10.)

N-AVG2=10?

(5 second sample time reading number for sliding average.
Range 1 to 10.)

N-AVG3=10?

(10 second sample time reading number for sliding average.
Range 1 to 10.)

N-AVG4=10?

(100 Second sample time reading number for sliding average.
Range 1 to 10.)

T-1, P-2=(1)?

(First sensor R-T equation type. Enter a "1" for Thermistor or a "2" for Platinum.)

A1.02219473E-03

(First sensor equation coefficient "A".)

B2.56238388E-04

(First sensor equation coefficient "B".)

C1.31622802E-06

(First sensor equation coefficient "C".)

D1.4537444E-07

(First sensor equation coefficient "D".)

E1.618033989E-08

(First sensor equation coefficient "E". This is not displayed nor editable for thermistor sensors.)

T-1, P-2=(1)?

(Second probe R-T equation type. "1" for Thermistor, "2" for Platinum, just as for the first sensor.)

"

"(Here the equation coefficients for the " second sensor are entered.)

"

"

E1.618033989E-08

(Second sensor equation coefficient "E". This is not displayed nor editable for Thermistor sensors.)

3.2 Press Enter

(Here the 1506 requests that ENTER be keyed. All of the normal user parameters have now been edited. By pressing "E" instead of ENTER, the parameters that

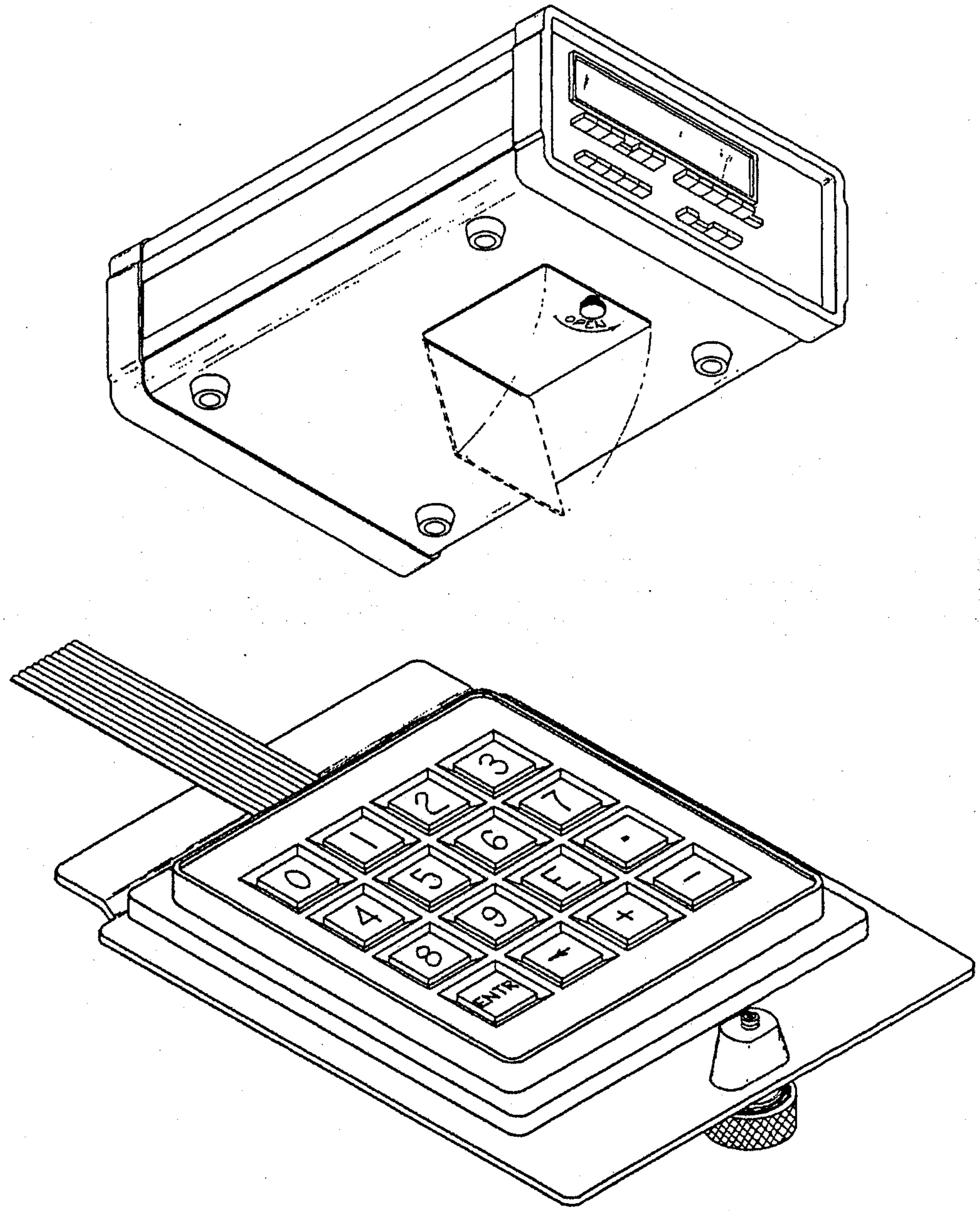

Figure 3-1 Key Pad Access

are normally set at the factory are entered, upon which the instrument's accuracy depends.)

3.3 Edit Ended

(Is displayed until the first new reading has been taken.)

During editing, the display is sent to all three interfaces

(keypad/display, IEEE, RS232); and entries are accepted from the keypad or RS232.

3.4 Remote Programming Commands

Single-character commands from the IEEE bus or the RS232 interface can be used instead of the front panel, for remote programming or querying. Entering a "!" during measurement period aborts the current measurement.

The command mode is entered by keying "B", and is completed with a carriage-return. All commands are single-character. Upper-case commands set modes of operation, while lower-case letters are queries. A list of the commands and queries is given below by alpha numerical order, and by group. (Blank descriptions show unused command codes.) Temperature readings are suspended in the command mode until a RETURN is entered.

- The following are control commands:

!

1 10

2 1

3 .1 (Analog Output)

4 .01

5 CENTER

6

7

8

9

A

B

C Celsius scale

D Delta-t (T1-T2)

E

F Fahrenheit scale

G Unlock the Front Panel Switches

H Lock the Front Panel Switches

I One second resolution

J

K Kelvin scale

L One hundred seconds resolution

M mode "Tmax"

N mode "Tmin"

O Ohms scale

P Present mode (not Max, Min or Spread)

Q

R Rankin scale

S Spread (max-min) mode

T T1 mode

U T2 mode

V Five seconds resolution

W

X Ten seconds resolution

Y

Z Clear (reset Max, Min, or Spread) mode holds

- The following are query commands, and return the present status of the instrument programming. (A single character is returned in reply to each query. The returned character is that upper-case command character that would be used to set the instrument to its present state. For example, if the instrument's scale is Celsius, the response to an "s" query would be the letter, "C", because "C" is the command that sets the instrument into scale Celsius.):

a Analog zoom (returns 1 through 5)

b

c

d

e

f

g

h Mode Hold (Present, Min, Max, Spread)

i

j

k

l Front Panel Lock Status

m Mode (T1, T2, or T1-T2)

n

o

p

q

r Resolution

s Scale

t

u

v

w

x

y

z "clear" flag activity (TRUE, FALSE)

NOTE: The query commands are unavailable using the IEEE buss.

- Functional Group Listings:

m- "mode" switch settings:

T T1

U T2

D T1-T2

h- "mode" holds:

P present (no holdings)

N minimum

M maximum

S spread (max-min)

Z clear, or "reset" per present reading

s- "scale" switch settings:

C Celsius

K Kelvin

F Fahrenheit

R Rankin

O Ohms

r- "resolution" switch settings:

I one second

V five seconds

X ten seconds

L one hundred seconds

a- "analog" zoom switch settings:

1 1

2 .1

3 .01

4 .001

5 center

l- "front panel lock-out" status

G unlock (-ed)

H lock (-ed)

Example of remote programming line:

BPDCX1H

-Sets Present display of differential temperature (T1-T2) in degrees Celsius, at five-second intervals, with minimal analog zoom, and locks-out the front panel (prevents manual interference with remote data acquisition.)

4 Sensor Connections

The sensor connections are made through jacks on the rear panel. Pins 1 and 3 carry current. Pins 2 and 4 transmit voltage. For proper polarity, pin 1 is joined at the sensor to pin 2, and pin 3 is joined to pin 4.

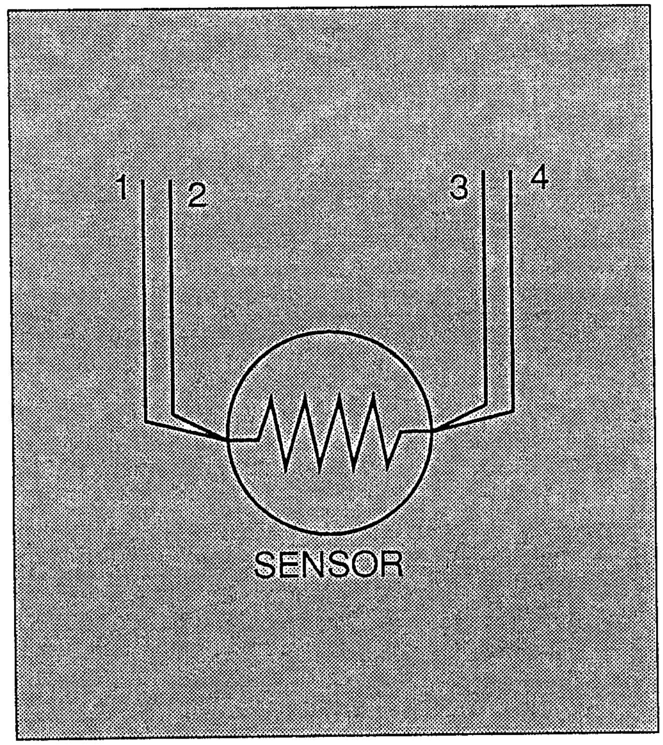

Figure 4-1 Sensor Connection

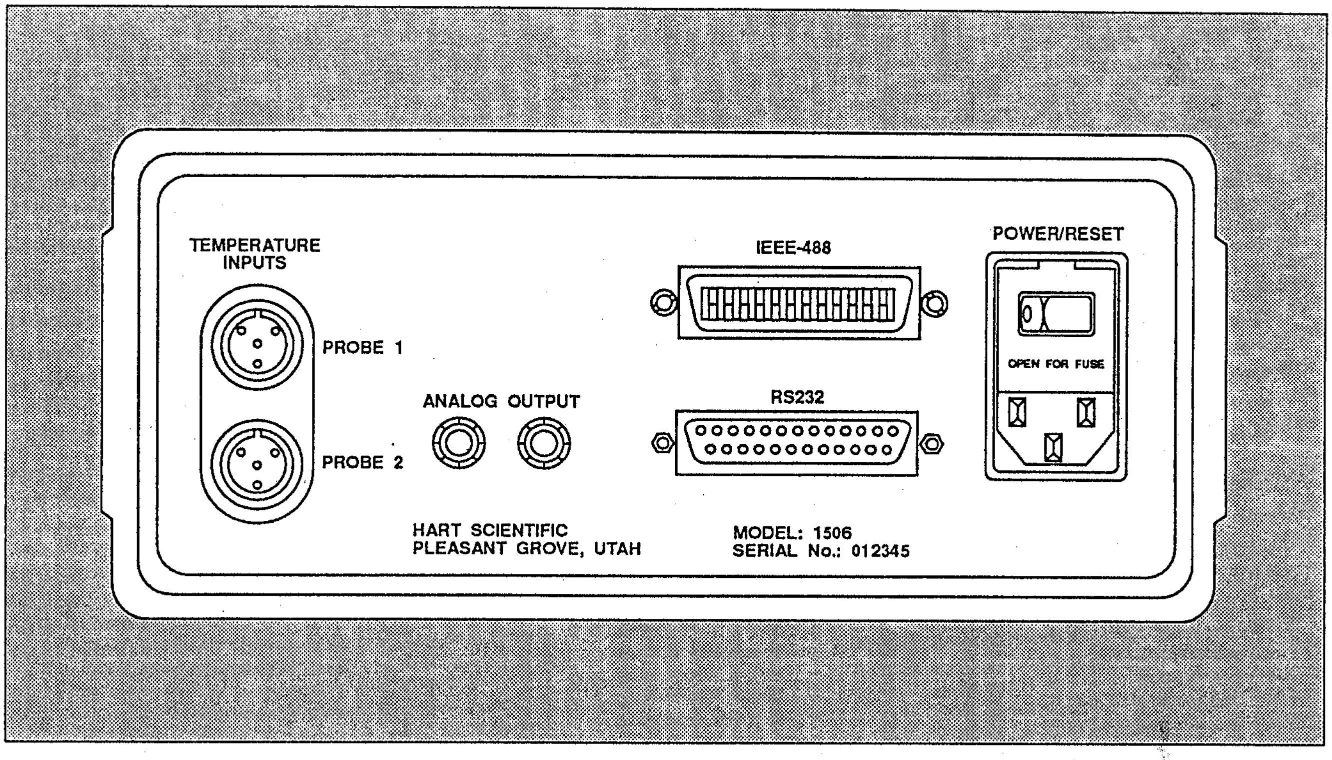

Figure 4-2 Rear Panel

5 Specifications

Range:	PRT -180 to 650 C Thermistor -10 to 110 C
Sensors:	PRT 100 to 1000 Ohms at 0 C Thermistor 100 to 100K Ohms at25C
Resolution:	0.001 C to 0.00001 C all scales
Repeatability:	±0.005°C
Temperature Coefficient:	±0.0001°C/C
Ambient Operating Temperature:	10 to 40°C
System Accuracy (-50 to 250°C):	Probe Typical Guaranteed CP-10 +0.015 C +0.030 C CP-Pt +0.020 C +0.040 C
Weight:	20 pounds
Size:	11"W x 6"H x 15"D
Power:	105-125 VAC
Resistance-Temperature Technique for PRT & Thermistor	$T = A + BR + C[R^2] + D[R^3] + E[R^4]$ $T = \frac{1}{A + BLNR + C[LNR]^2 + D[LNR]^3}$

6 RS232C Serial Interface

RS232C Serial Interface: Interface for Programming, querying, and output. EIA standard voltage levels. Eight bit characters, no parity, one stop bit. Standard 128-character ASCII set (upper and lower case). BAUD rates programmable to 19200. Standard female DB-25S connector. Pins:

2- Received Data (To the 1506).

3- Transmitted Data (From the 1506).

4- Clear to Send input (Open or + if unused).

5- Data Terminal Ready output.

7- Signal Ground.

6.1 RS232C Interface Connections between IBM Compatible Computer and 1506 Thermometer

Computer With DB25 Serial Connector

1506 DB25 Connector Pins	Computer DB25 Connector Pins
RX 2	2 TX
TX 3	3 RX
Signal Ground 7	7 Signal Ground
	5 CTS
	6 DSR
	20 DTR

Computer With DB9 Serial Connector

1506 DB25 Connector Pins	Computer DB9 Connector Pins
TX 3	2 RX
RX 2	3 TX
Signal Ground 7	5 Signal Ground
	4 DTR
	6 DSR
	8 CTS

NOTE: Be sure to jumper DTR, DSR and CTS together at the computer connection; otherwise, the computer may not receive data from the 1506 thermometer.

7 Hart Scientific RS-232/Curve Fit Program Disk

The HART disk contains two types of programs: curve fit programs and RS-232 computer/Model 1506 interface programs. GWBASIC.EXE must be available to run the RS232.BAS program. Instructions for running this program will appear on the screen when the program is executed.

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PROBE CURVE FIT PROGRAM

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The curve fit program has two commands PTL and THM to fit resistance and temperature to Platinum and Thermistor probes.

To use these two programs you must first create a data file with the following information:

Number of points

resistance in ohms for Point #1

degrees Celsius for Point #1

resistance on ohms for Point #2

degrees Celsius for Point #2

(repeat for each of the points)

lowest temperature

highest temperature

temperature increment

serial number for probe

The file called PT111.5IN is an example of what this file should look like.

To create this file use the DOS COPY CON: command (see your MS/PC- DOS manual for instructions) or a pure ASCII word processor (such as Word Star in non-document mode).

To print the values to the printer, enter the following command:

PTL "filename" (platinum)

THM "filename" (thermistor)

If you want to display the values to the screen only, use the following command:

PLAT "filename" (platinum)

THERM "filename" (thermistor)

8 Certification of Resistance Accuracy

Model 1506 Micro-Thermometer			
Serial No.			
The following calibraiton values were observed and are traceable to NIST (National Institute for Standards and Technology).			
Standard Resistance	**Actual**	**Measured**	**Error**
L&N 100Ω		(Stnd1)	
Vishay 200Ω		(Stnd1)	
Vishay 1KΩ		(Stnd2)	
Vishay 2KΩ		(Stnd2)	
Vishay 10KΩ		(Stnd3)	
The standard resistances observations were made by comparison with: Schlumberger Solartron Precision DMM - Model: 7801 S/N: 000259, NIST test number 241233.			

9 Calibration Values

Calibration Constants		Offset Values	
Standard #1		1 Sec.	
Standard #2		5 Sec.	
Standard #3		10 Sec.	
Standard #4	N/A	100 Sec.	

CAUTION: The above values are used to calibrate your 1506 thermometer. Do not change these values while in the edit mode for this will change the calibration of the instrument. Refer to Appendix A "Calibration Procedure" for details.

Approved by ______________________________ Date: _______________

10 Trouble Shooting

Temperature reads incorrectly or when 1506 is powered up it always comes up with IEEE on the display. This is usually caused by a power line failure or power line "glitch". To correct this problem, get into the edit mode by using the keypad that is on the bottom of the 1506. This is done by depressing the "E" button. Step through the program to be certain that the probe coefficients and probe type (thermistor or platinum) are correct. See Section 3 for a detailed procedure for doing this. Follow this procedure up to, but not including, "press enter" statement. Instead of pressing "ENTER" press the letter "E". This will get you into the "second edit routine" where the calibration values reside for the 1506. For detailed instructions, refer to the calibration procedure in this manual. Be sure to heed the warning in the calibration procedure. Check both the resistance standards and offset values that are in Section 9. If they are incorrect, enter the correct values. If your 1506 always comes up in the edit mode when the unit is turned on, when you see "Test=0", change this value to a "1", then push "ENTER" to get out of the edit mode. Get back to the "test=1" and change this value back to "0". Turn the unit off, then back on again. The 1506 should now be reading the correct temperature. If not, call the customer service department at Hart Scientific.

11 Appendix A

11.1 Calibration Procedure

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CALIBRATION PROCEDURE FOR

1506 (1006) DIGITAL THERMOMETER

This document explains how to calibrate the 1506 digital thermometer. Calibration consists of entering three standard resistors values, and four zero-offset values. These values are unique to every 1506 thermometer and determine the accuracy of measurement.

To calibrate the 1506 we first must put the 1506 in the test mode and have the RS232 hooked up. To do this we need to go into the edit mode, and while we are in the edit mode it is a good time to explain further some of the commands.

It should be noted that before a value can be changed a question mark "?" must first be displayed at the end of the value being changed.

To get into the edit mode you must enter an upper case "E"., This can be entered from the keypad, or from the terminal hooked up on the RS232. The first item that appears on the screen and the display of the 1506 is the IEEE 488 address location.

The next item is N-AVG 1 through 4 (sliding average) for each sample time.

The next item is "T-1,P-2=(1.)?". This is to signify if probe 1 is a thermistor or a platinum probe. The number if the brackets is the way the probe is currently set. As shown, this probe would be a thermistor. If the probe is to be changed, then enter a "1" or a "2", and a RETURN (ENTER).

A note about probes. A thermistor has four constants, and a platinum probe has five.

The next item is something like "STD#3. 20000.5". This won't be the same as it is for your 1506 (see section 9 for your values), but it is similar. The above example shows that the standard resistor is number 3 and its value is 20000.5 ohms. Standard resistor choices are:

Standard #1 is close to 200 ohms.

Standard #2 is close to 2000 ohms.

Standard #3 is close to 20000 ohms.

These values are all set at the factory at the time of calibration, and the actual value of the resistor should not have to be changed. Later it will be explained how these numbers are derived. It should be noted that the 1506 does not have auto ranging. To change standards it must be done at the keypad or at the terminal. Each standard has a range of accurately measuring resistance. The 200 ohm standard is most accurate from 0 ohms to 100 ohms, the 2000 ohm standard is most accurate from 100 ohms to 1000 ohms, and the 20000 ohm standard is most accurate from 1000 ohms to 10000 ohms. So, with this information and the range of resistance of the probe, a choice can be made for which standard to use.

The next item is "A". This is the first constant of the probe that is on the probe sheet.

The next item is "B". This is the second constant of the probe that is on the probe sheet.

The next item is "C". This is the third constant of the probe that is on the probe sheet.

The next item is "D". This is the fourth constant of the probe that is on the probe sheet.

If a platinum probe is to be used, then there will be another constant displayed. In other words, if the T-1,P-2 is set to a "2", then it will prompt you for this fifth constant "E", which will be on the platinum probe sheet.

Ten digits plus exponent is the maximum number of digits that can be entered from the probe constants.

The next five items will be a repeat of the last five items only these will be for probe 2 (six items if it is to be a platinum probe). The items apply the same as they did for probe 1.

The screen and the display will show "PRESS ENTER" after the last constant for the probe has been entered. If at this point "ENTER" is pressed, the 1506 will proceed to start taking resistance or temperature measurements. This is the general way that the edit mode is ended. If the standard resistance values are to be changed, you must proceed further into the edit process. To do this, instead of "ENTER", another upper case "E" must be entered, either by the keypad or the keyboard.

WARNING: Any change from this point on can change the values given for the standard resistors, and the zero-offset. This will change the way the 1506 operates and the accuracy of the resistance readings taken.

The first item that comes up after entering the secondary edit mode is the value for Standard #1, given as "200.001=STD 1?". This shows that Standard #1 has the value of 200.001 ohms. To change this value, enter the new value after the question mark and press return. This is the same for all four standard resistor constants. At present, we are not using the 200000 ohm standard, which has not been calibrated.

After the standards, the next item involved setting the resistance standard for a thermistor probe for T_1, INPUT #1 1T- STD=3. (The value for standard "3" is displayed after pressing "ENTER"). Standard 3 is typically used for a thermistor probe.

The next item involves setting the resistance standard for a platinum probe for T_1, INPUT 1P-STD=1. (The value for standard "1" is displayed after pressing "ENTER"). Use standard 1 for a 100Ω platinum probe and standard 2 for a 500Ω platinum probe.

After setting the standards for T_1 input the process is repeated for T_2 input.

After the standard resistors, there are four offset values, one for each sample time. This offset value will be explained later.

The last item in the edit mode is called test. Changing this mode allows the 1506 to output to the terminal, either the readings on the display, or the entire calibration readings. When the 1506 is in the normal operating mode, test=0. In this mode, what is printed to the terminal from panel display is also printed to the terminal. To calibrate the 1506, test must be set to "1". This then prints to the terminal a variety of items, such as standard frequency, zero frequency, unknown frequency, raw ohms, etc.

The 1506 uses a ratiometric technique to allow for a more accurate resistance measurement. The follow formula is used:

$$\frac{sf-zf}{sr} = \frac{uf-zf-0}{ur}$$

Where:
sf is the standard frequency seen as s= on terminal
zf is the zero frequency seen as z= on terminal
uf is the unknown frequency seen as U on terminal
0 is the zero-offset (different value for each sample time)
sr is the standard resistance
ur is the unknown resistance

When the 1506 test=1, then the terminal screen will look something like Figure 11-1:

This type of output is printed to the screen each time a reading is taken, at the sample time specified. These values are the ones that are used in the formula above, where "s" is the standard frequency, "z" is the zero frequency, and "U" is the unknown frequency. The other values that are displayed are as follows:

Resolution- is the sample time that the 1506 is set to. For example:

1 is 1 second scale

2 is 5 second scale

3 is 10 second scale

4 is 100 second scale

RAW ohms- is the value of the unknown resistance if the zero- offset "0" is left out of the above formula.

unknwnval- is the unknown frequency "U" minus the zero-offset, so that the new formula would be:

$$\frac{sf-zf}{sr} = \frac{ufl-zf}{ur}$$

```
s=1064365. z=185. U=532342. resolution=3 RAW ohms=100.005591
unknwnval=532342.. Hz, ohms=100.000705 100.00071 Analog=.100000705
```

Figure 11-1 Terminal Screen

The unknown frequency "ufl" is "uf - 0". This offset will be different for each sample time. The zero-offset is to allow for the difference between the internal resistance on the analog board and external resistance. This difference is shown by shorting the probe connector on the 1506 with a shorting plug, and then looking at the difference in the zero frequency and the unknown frequency.

ohms- (on the same line as the unknwnval) is the resistance reading, and the same value that is printed to the front display if the 1506 is reading in ohms.

The next line is what is printed to the front panel of the 1506. If in the "C" mode (Celsius), then the value on this line is the computed Celsius temperature value of the resistance on the the above line. If the 1506 is in the ohms mode, then this line will be the truncated value of the above line.

The last line on the output to the terminal is the analog output. This number is the voltage that will be on the analog output on the rear panel. The range of this voltage is from 0 to 1 volt. (see section 2.1.4)

11.2 Calibration

To calibrate the 1506 at least four standard resistors will be needed, and their resistance known to .001%. These four values should be 10, 100, 1000, 10000 ohms.

The values that need to be calibrated on the 1506 are:

standard #1 the 200 ohm standard

standard #2 the 2000 ohm standard

standard #3 the 20,000 ohm standard

0-offset #1 the offset on the 1 sec. range

0-offset #2 the offset on the 5 sec. range

0-offset #3 the offset on the 10 sec. range

0-offset #4 the offset on the 100 sec. range.

Each of these values affect all the others, so that if one is changed, then it could mean that all the values will need to be changed.

The way in which we are presently doing our calibration is as follows: The 1506 is set to standard #2 "2000 ohms". It does not matter what this value is at this time. The sample time is set to 100 seconds. First, a 1000 ohm resistor is plugged into the rear panel and the standard frequency, zero frequency, and the unknown frequency are taken and recorded. Next a 100 ohm resistor is plugged into the rear panel, and these readings taken and recorded. These readings are at the high end and low end range of the 2k ohm standard, where best accuracy is achieved. Then, solving the equations for the two unknowns (zero-offset "0" and standard resistor "sr") using the two equations we derive the 2k ohm standard and the zero-offset for the 100 second sample time. This procedure is repeated for the 200 ohm and the 20,000 ohm standards.

The calculated value of the zero-offset will be different for each standard. Though they will be different, they should be close to the same value. Since there is only one zero-offset for each sample time, the zero-offset that is entered into the 1506 is only to be used on one standard range, it should be closest to offset in that range.

After the offset for the 100 second range is finalized, the standards can then be recomputed by solving the equation above for the standard resistor "sr".

Once the standard resistors are known, the 0-offset on the other sample times can be found, using the equation and solving for the zero- offset "0". This should be done with the sample time set and getting, a reading on each standard resistor. These offsets should be compared to see that all will be in the same range for the three standards.

A note should be made about the readings that are output to the terminal. These readings take a while to settle when changing from one standard to another, to a different sample time, or changing the unknown value. Also, there will be some small drift in the readings themselves, so a sample of several readings should be taken and an average should be done. An example would be, the sample time is 100 seconds, the standard is 1999.93 ohms (this is the 2k standard), and we are trying to find the 0-offset value for the 10 second sample time. We perform our calculation on several 0-offset samples, which might be:

29 28 29 26 32 27 28 29 30

The average of these numbers would be 28.6, so the value to be used for the 0-offset on the 2k standard and the 100 second sample time, would be 29. If the average using the 10 second sample time on the 200 ohm scale were 27, and the 20,000 scale were 30, then the average of all three standards would be 28.7, so either 28 or 29 would be used for the final value on the 100 second sample time.

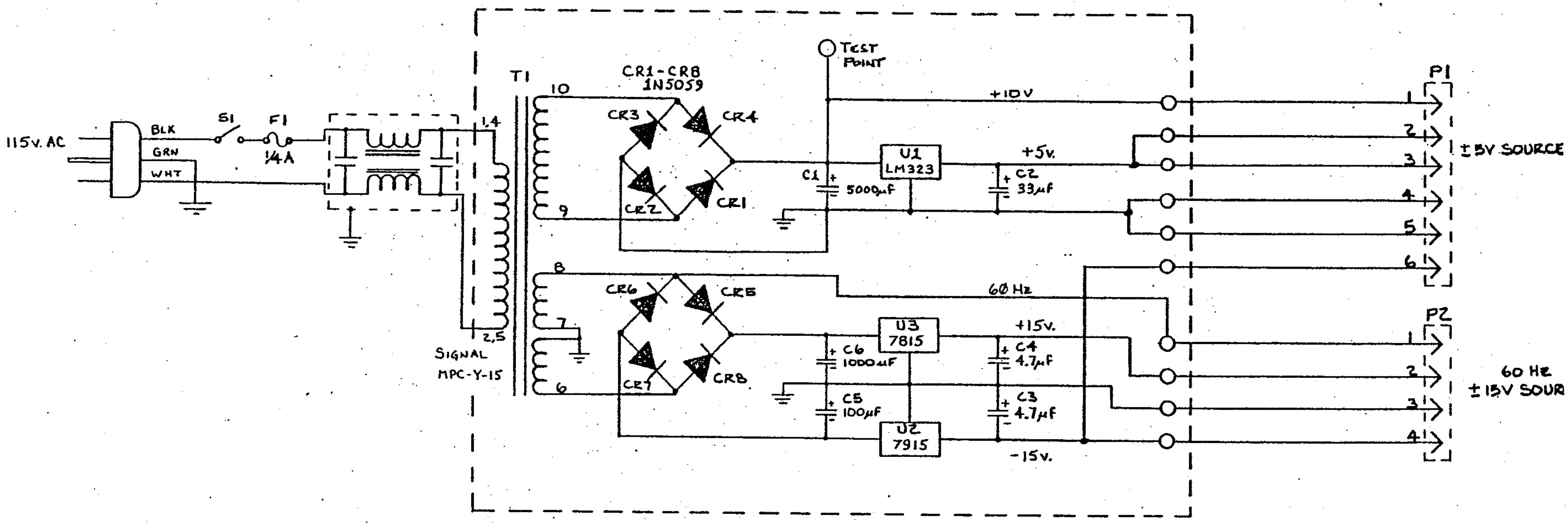
After all seven of the values to be calibrated have been entered into the memory, then resistors with known values are checked to see if the resistance reading accuracy is linear from the low end to the high end of that range.

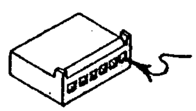
The 1506 should be run for some time and checked again to see if it has drifted from the accuracy it started with. Also, the keypad should be checked to see if it is functional, and that Probe one measures the same as Probe two. If there is a difference between the two probes, it may mean that the 1506 might need to be run longer to burn in, or there may be a problem with the analog board.

Before shipping the 1506, the constants for the probes to be used with it need to be entered, and the entire unit needs to be checked against one of the in-house standard probes for accuracy in temperature measurement. The edit mode needs to be entered again, and test=1 changed to test=0 so that it is no longer printing everything to the terminal. Also, before the 1506 is shipped, it should be set to the proper standard and constants for the type of probe being shipped with it.

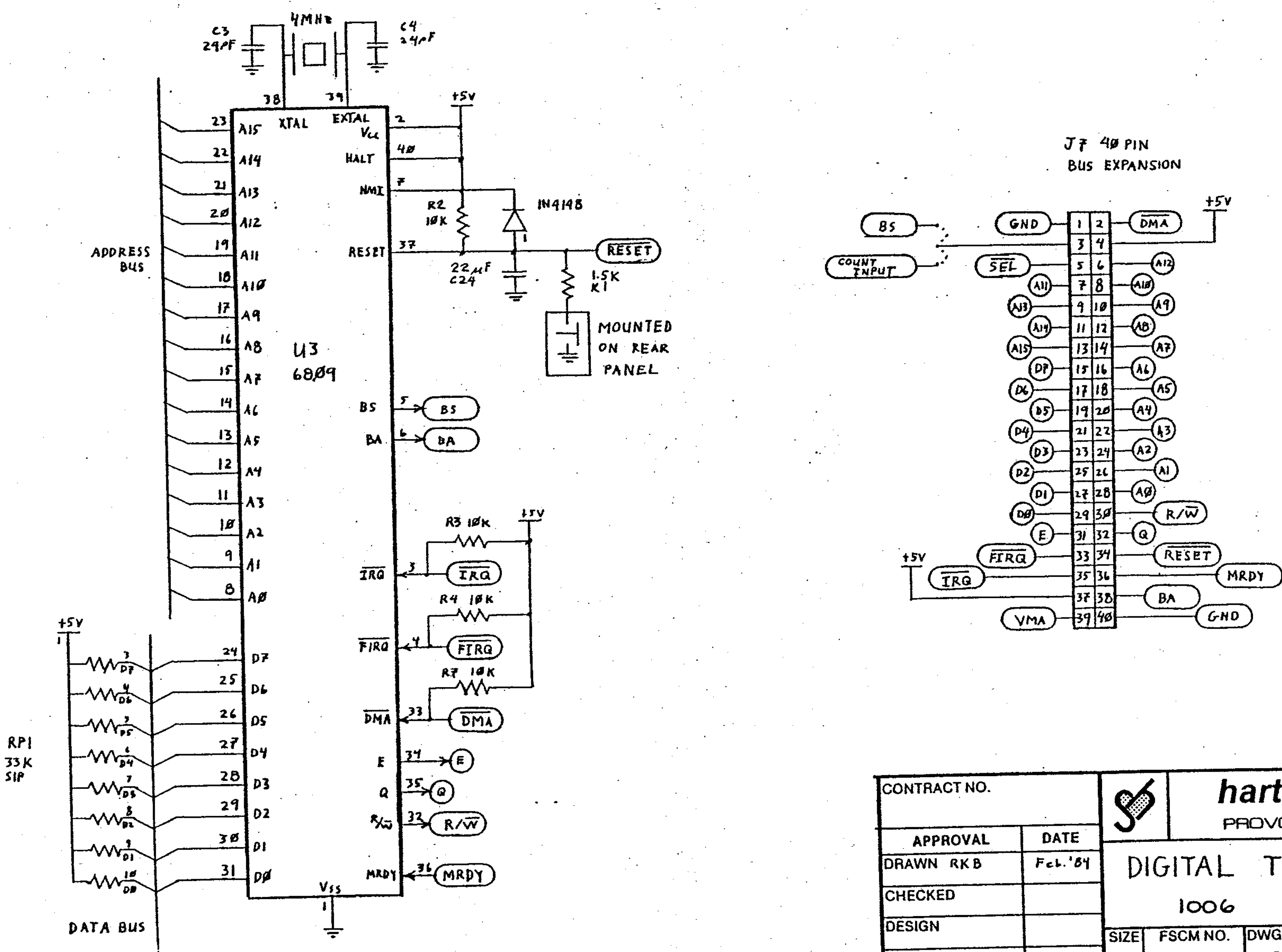
12 Appendix B

Schematics





CONTRACT NO.		hart scientific PROVO, UTAH 84601			
APPROVAL	DATE	DIGITAL THERMOMETER POWER SUPPLY 1006			
DRAWN D.P.P.	13 Oct. '81				
CHECKED RMH	5.3.82				
DESIGN		SIZE	FSCM NO.	DWG. NO.	RE
ENGINEER		B		B009-2507	A
RELEASE		SCALE: —		SHEET 1 OF 1	



CONTRACT NO.	
APPROVAL	DATE
DRAWN RKB	Feb. '84
CHECKED	
DESIGN	
ENGINEER	
RELEASE	

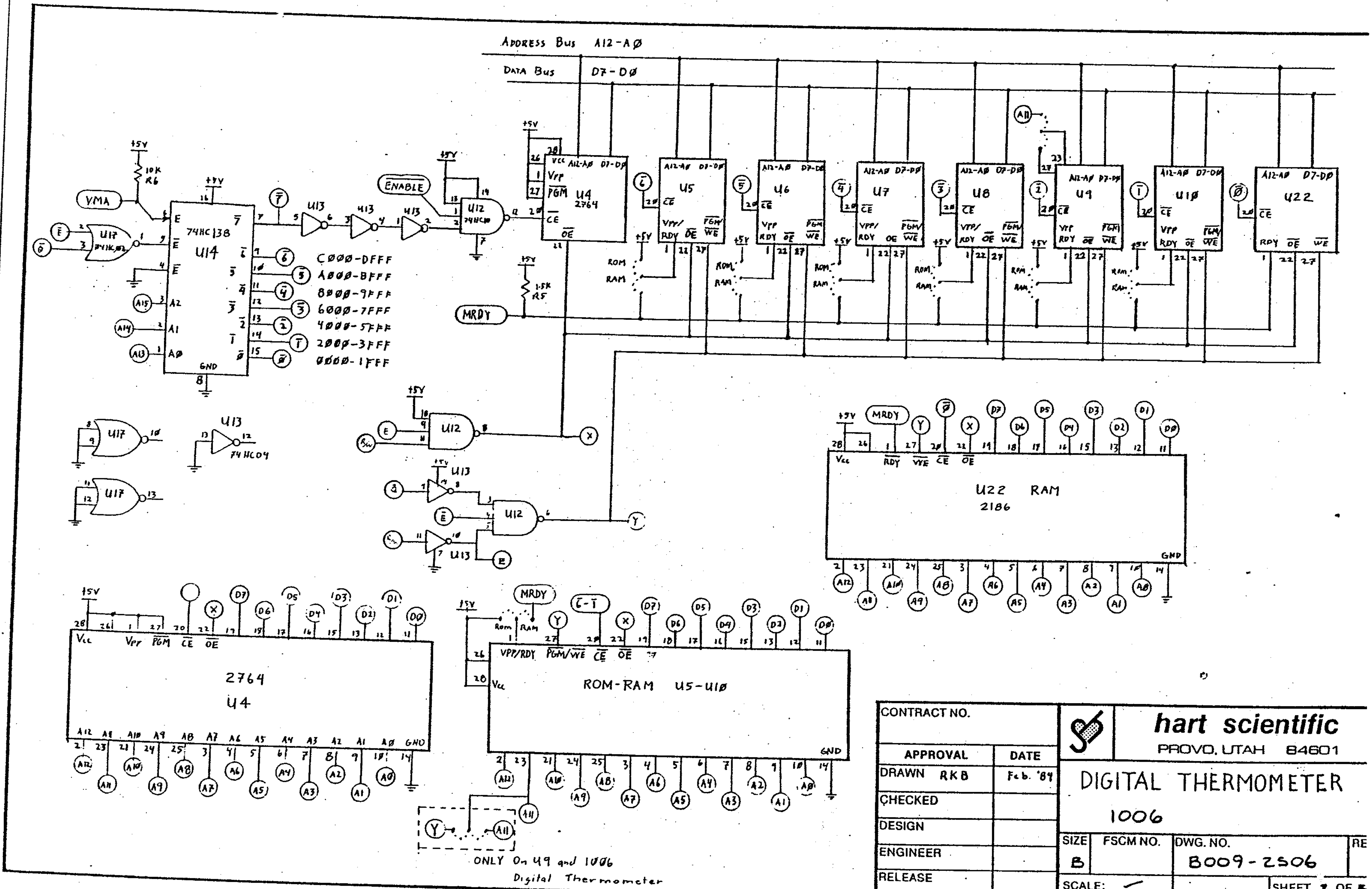
hart scientific

PROVO, UTAH 84601

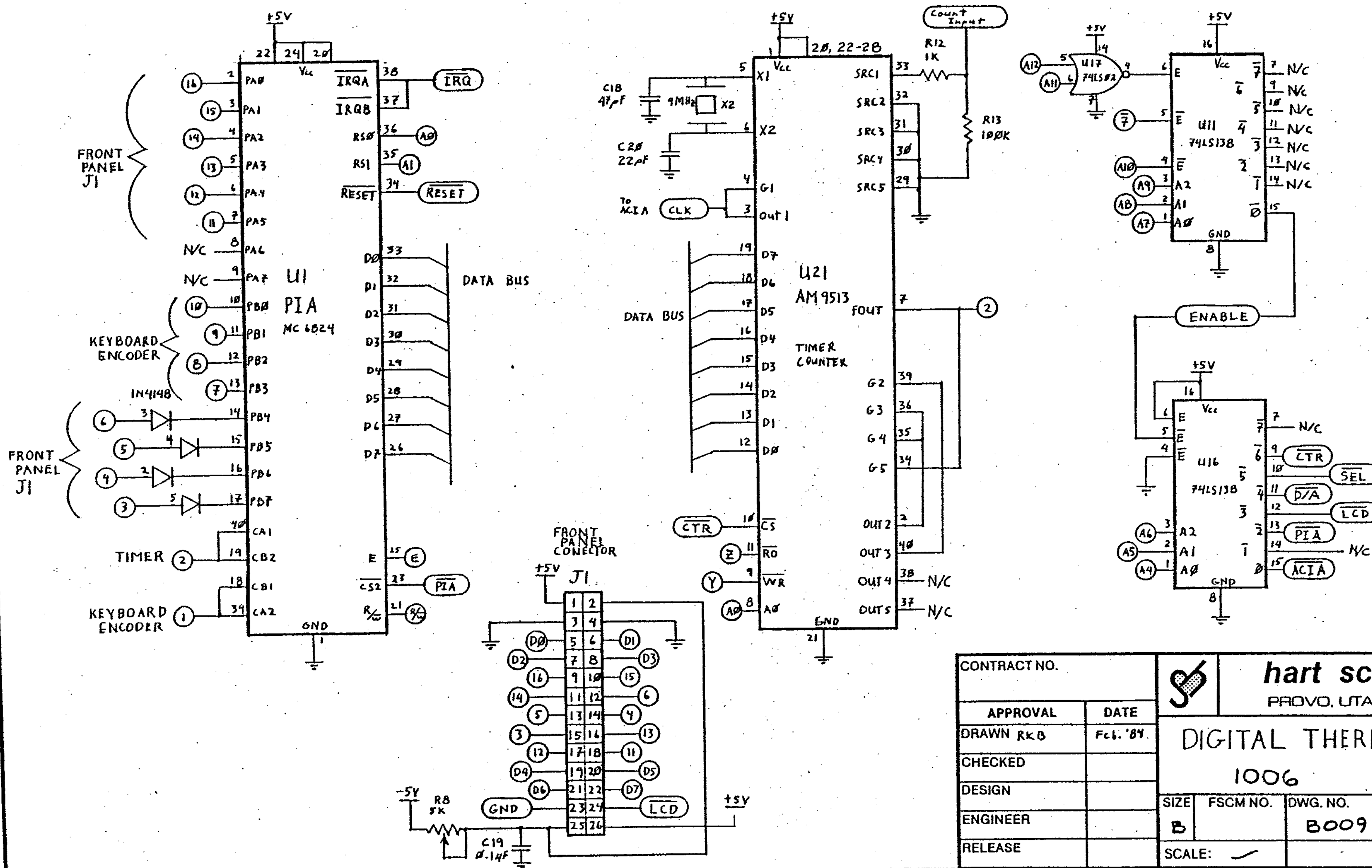
DIGITAL THERMOMETER

1006

SIZE	FSCM NO.	DWG. NO.	REV
B		B009 - 2306	
SCALE: —		SHEET 1 OF 5	



CONTRACT NO.		hart scientific PROVO, UTAH 84601
APPROVAL	DATE	DIGITAL THERMOMETER 1006
DRAWN RKB	Feb. '84	
CHECKED		SIZE: B
DESIGN		FSCM NO.
ENGINEER		DWG. NO. B009-2506
RELEASE		SCALE: —
		SHEET 2 OF 5



CONTRACT NO.		hart scientific PROVO, UTAH 84601			
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DRAWN RKB	Feb. '84				
CHECKED		SIZE	FSCM NO.	DWG. NO.	REV
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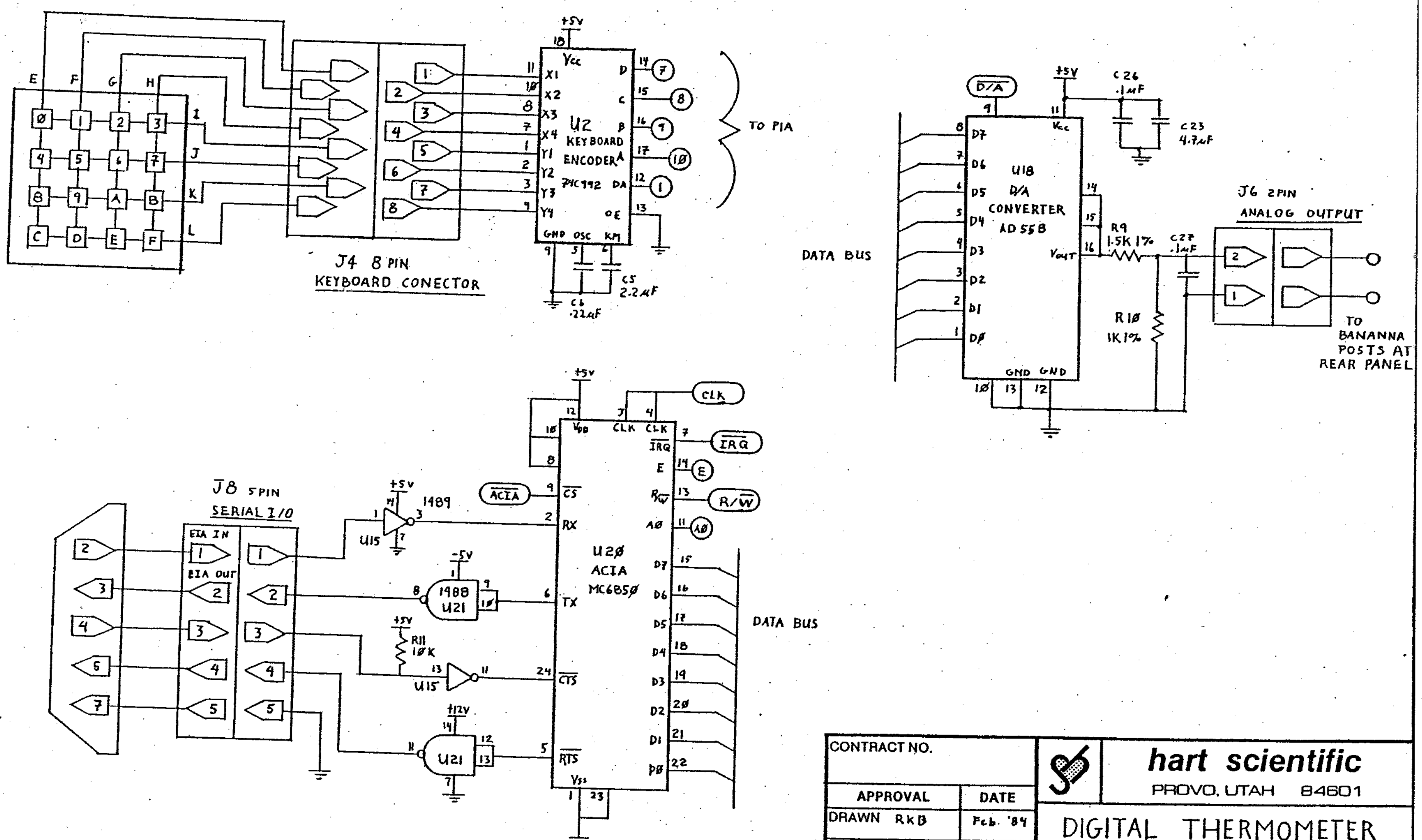
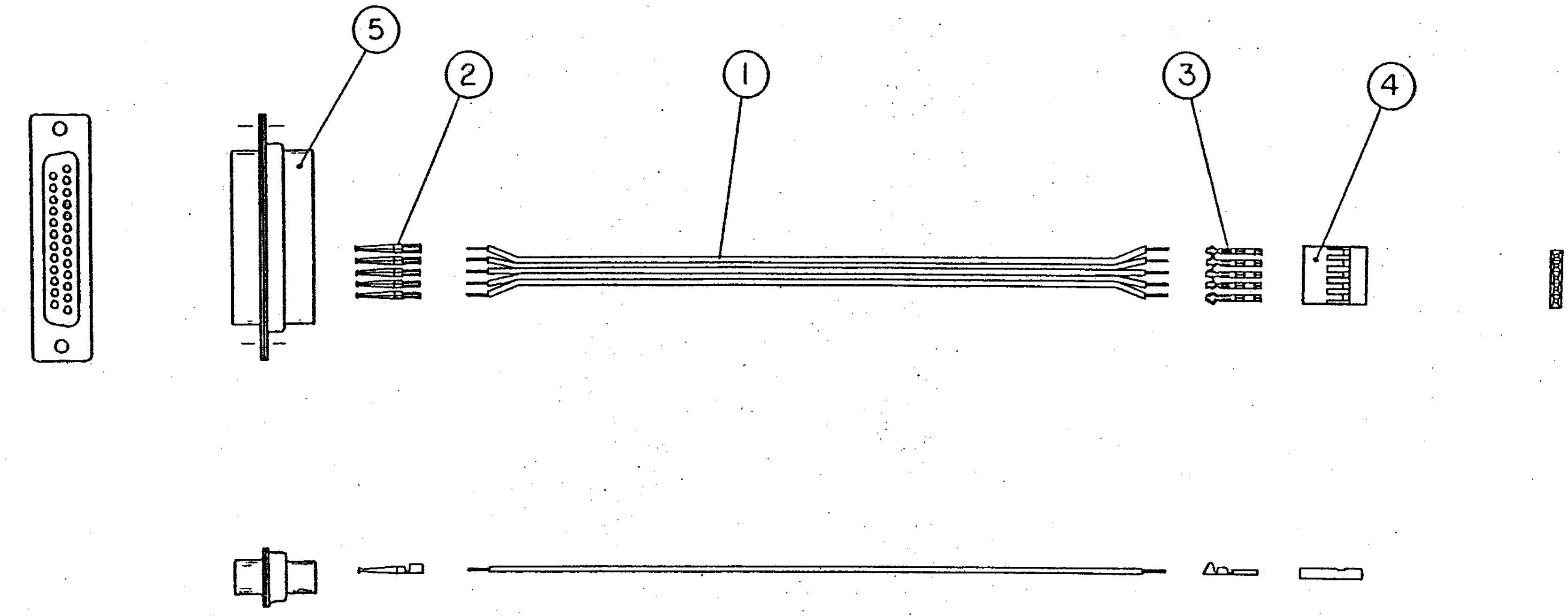
ENGINEER		SCALE: —		SHEET 3 OF 5	
RELEASE					



CONTRACT NO.		hart scientific PROVO, UTAH 84601		
APPROVAL	DATE	DIGITAL THERMOMETER 1006		
DRAWN RKB	Feb. '84			
CHECKED				
DESIGN				
ENGINEER		SIZE B	FSCM NO.	DWG. NO. B009-2506	REV.
RELEASE		SCALE: —		SHEET 4 OF 5	

REVISIONS				
LTR.	DESCRIPTION	BY	APPROVAL	DATE



ITEM NO.	QTY REQ'D	FSCM NO.	PART OR IDENFIYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL SPECIFICATION

MATERIAL OR PARTS LIST

DIMENSIONS ARE IN INCHES
UNLESS OTHERWISE SPECIFIED
DO NOT SCALE DRAWING

TOLERANCES
.XX± .XXX±
ANGLES ±
MACH. FINISH:
BREAK EDGES:
REMOVE ALL BURRS
FINISH:

CONTRACT NO.

APPROVAL		DATE
DRAWN	DVF	10-18-84
CHECKED		
DESIGN		
ENGINEER		
RELEASE		

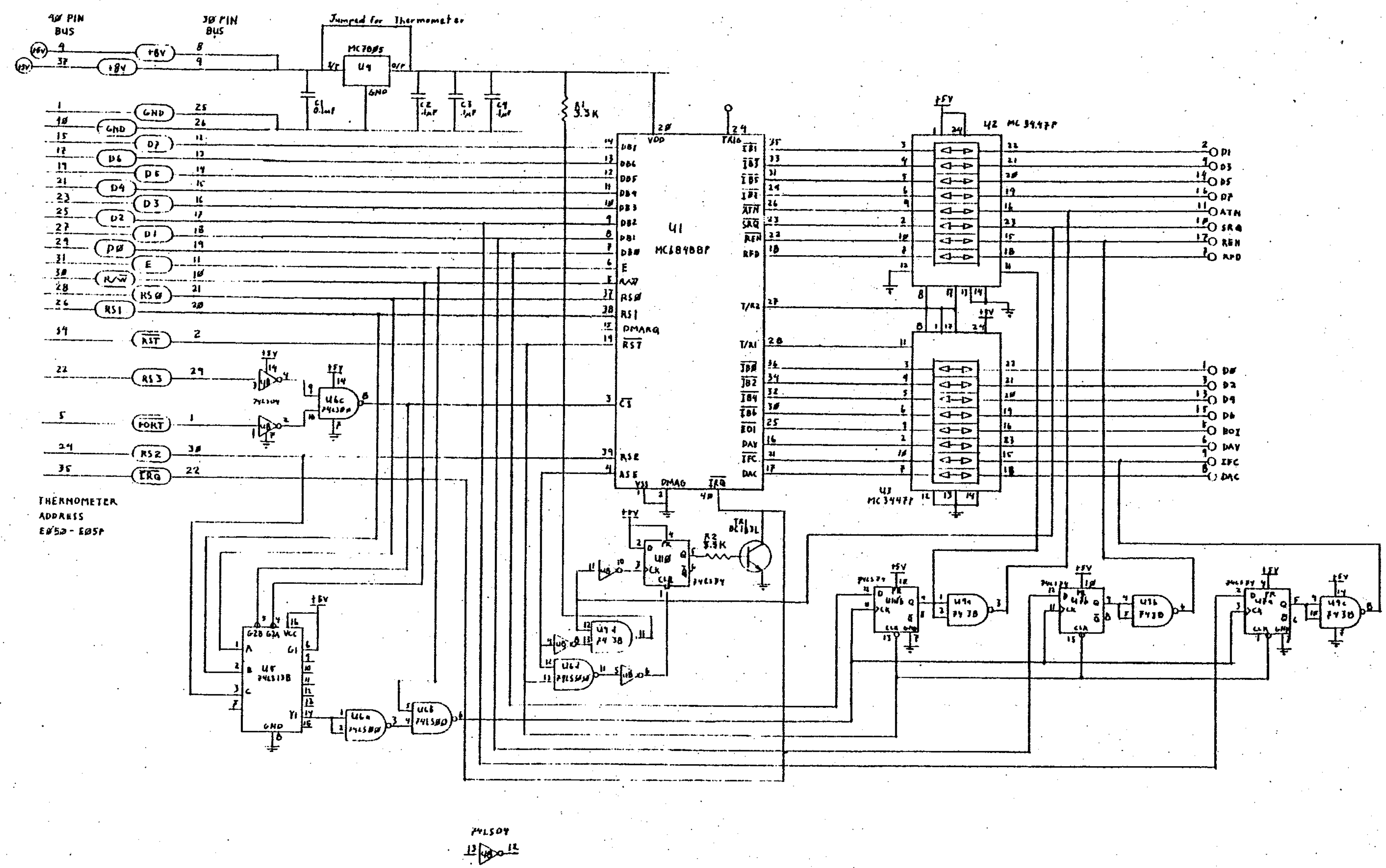
1006	
NEXT ASSY.	USED ON
APPLICATION	

Hart Scientific
PROVO, UTAH
84601
(801) 375-7221

1006 RS232 CABLE ASSY

SIZE	FSCM NO.	DWG NO.	REV.
B		B009-1005	

SCALE FULL SHEET 1 OF 1

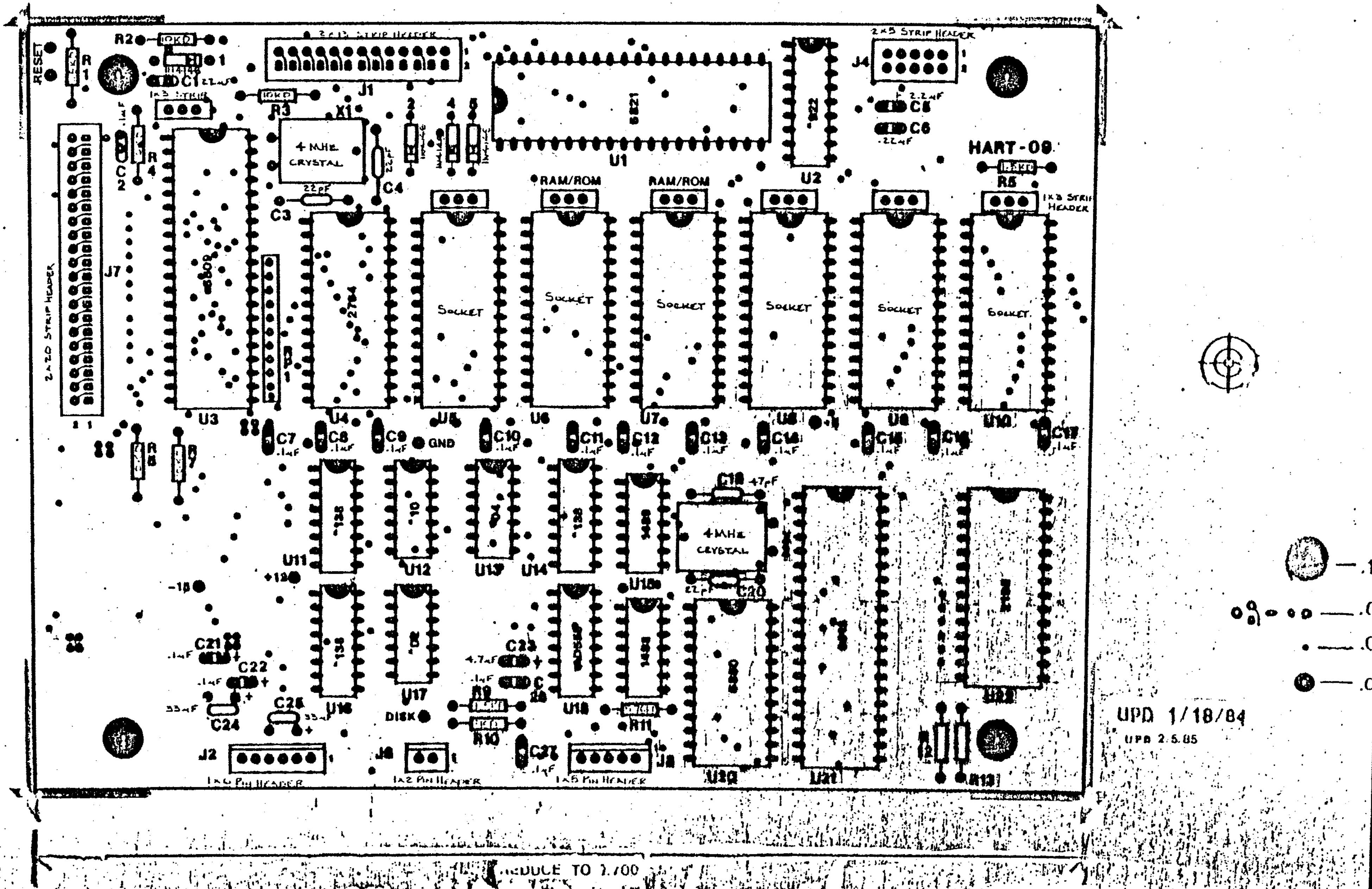


CONTRACT NO.	
APPROVAL	DATE
DRAWN RKB	2-Feb 81
CHECKED	
DESIGN	
ENGINEER	

hart scientific
PROVO, UTAH 84801

IEEE BUS CONTROLLER
1006 & 9000

SIZE	FSCM NO.	DWG. NO.	REV
C		C009-E509	



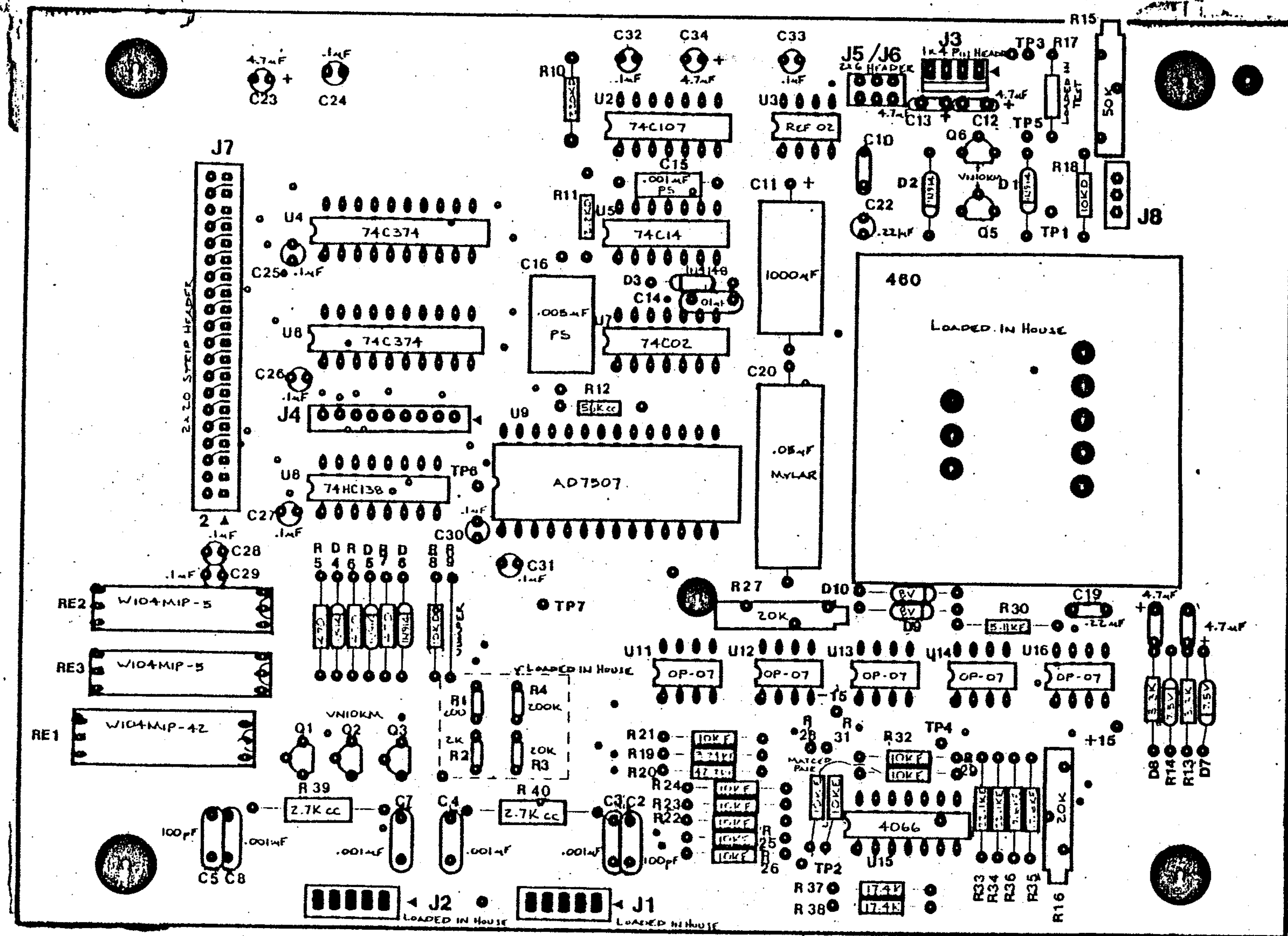
REDUCE TO 2.700

CONTRACT NO.	
APPROVAL	DATE
DRAWN DWF	6-26-85
CHECKED	
DESIGN	
ENGINEER	
RELEASE	

PROVO, UTAH 84601 (801) 375-7221

1006 COMPUTER BOARD LOADING DIAGRAM

SIZE	FSCM NO.	DWG NO.	REV.
C		C009 - 2L01	B
SCALE 2X		SHEET 1 OF	



NOTE:

CC = CARBON COMP 5% M.F.
D = 1% M.F.
E = .1% M.F.

● =.026
=.032
=.050
=.156

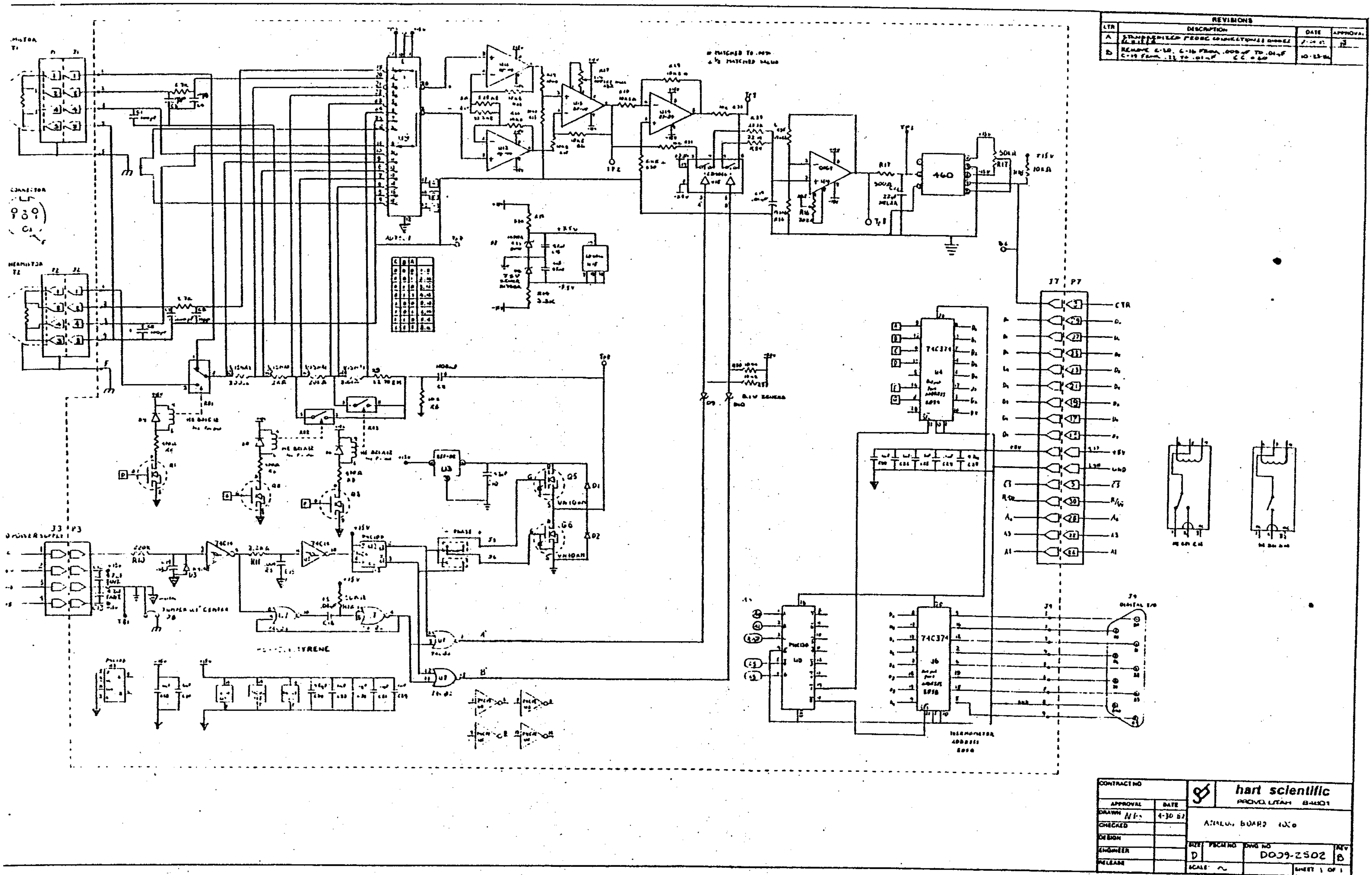
REDUCTION 2/1

CONTRACT NO.	
APPROVAL	DATE
DRAWN DWF	6-24-85
CHECKED	
DESIGN	
ENGINEER	

Hart Scientific
PROVO, UTAH
84601
(801) 375-7221

1006 ANALOG LOADING

SIZE	FSCM NO.	DWG NO.	REV.
C		C009-2102	B


REVISIONS
LTR
DESCRIPTION
DATE
APPROVAL
hart scientific
PROVO, UTAH 84601
ANALOG BOARD
CONTRACT NO
APPROVAL
DATE
DRAWN
4-30-87
CHECKED
DESIGN
ENGINEER
RELEASE
SIZE
FSCM NO
DWG NO
D
D039-2502
REV
B
SCALE
SHEET 1 OF 1
460
74C374
U9
U3
U4
U6
U7
U8
J7
P7
J3
P3
J2
P2
J1
P1
J9
CTR
+5V
GND
A3
A1
R17
R11
R12
Q5
Q6
D1
D2
D3
D9
D10
TP1
TP2
TP8
12.1V ZENERS
THERMOMETER ADDRESS