Eight-Channel Isolated Thermocouple Input Module

M/N 61C605

Industrial
CONTROLS

J-3605-1

RELIANCE ELECTRIC

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CAUTION

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1.0 INTRODUCTION

The products described in this instruction manual are manufactured and/or distributed by Reliance® Electric Industrial Company.

The Eight-Channel Isolated Thermocouple (T/C) Input Module (M/N 61C805) is a Multibus™ analog/digital module used for measuring temperatures. It provides isolation, linearization, and cold junction compensation to up to eight analog input signals from thermocouples. Thermocouple types J, K, T, S, B, E, and R are supported by the module and may be mixed one type per each of two groups of four input channels. Output data is provided in degrees Celsius or Fahrenheit in binary format.

The T/C input module is factory-configured with a memory-mapped base address of 400000 (HEX) and can be used in either an AutoMax/DCS 5000™ or AutoMate® rack. The module is hardware- and software-configurable to meet application requirements. The on-board microprocessor performs internal diagnostics at power-up and sets bits in a status register to indicate the results.

This manual describes the functions and specifications of the T/C input module. It also includes a detailed overview of installation and servicing procedures, as well as examples of programming methods.

1.1 Additional Information

You must become familiar with the instruction manuals which describe your system configuration. This may include, but is not limited to, the following:

- J-3150 AutoMate 30/40 SOFTWARE REFERENCE MANUAL
- J-3663 ReSource AutoMate PROGRAMMING EXECUTIVE
- J-3600 DCS 5000 ENHANCED BASIC LANGUAGE
- J-3601 DCS 5000 CONTROL BLOCK LANGUAGE
- J-3602 DCS 5000 LADDER LOGIC LANGUAGE
- J-3675 AutoMax VERSION 2.0 ENHANCED BASIC LANGUAGE
- J-3676 AutoMax VERSION 2.0 CONTROL BLOCK LANGUAGE
- J-3677 AutoMax VERSION 2.0 LADDER LOGIC LANGUAGE
- J-3630 ReSource AutoMax PROGRAMMING EXECUTIVE, VERSION 1.0
- J-3684 ReSource AutoMax PROGRAMMING EXECUTIVE, VERSION 2.0
- IEEE 518 GUIDE FOR THE INSTALLATION OF ELECTRICAL EQUIPMENT TO MINIMIZE ELECTRICAL NOISE INPUTS TO CONTROLLERS FROM EXTERNAL SOURCES
- ANSI-MC96.1 AMERICAN NATIONAL STANDARD TEMPERATURE MEASUREMENT THERMOCOUPLES MC96.1

1.2 Related Hardware and Software

M/N 61C605 contains one eight-channel isolated thermocouple input module, and an instruction manual.

The following equipment, purchased separately, can be used with the T/C input module:

1. M/N 45C310 – 6 Slot AutoMate Rack
2. M/N 45C311 – 9 Slot AutoMate Rack
3. M/N 45C312 – 10 Slot AutoMate Rack
4. M/N 45C313 – 13 Slot AutoMate Rack
5. M/N 45C314 – 13 Slot AutoMate Rack; Cabinet Mount
6. M/N 45C315 – 16 Slot AutoMate Rack
7. M/N 45C316 – 19 Slot AutoMate Rack
8. M/N 57C331 – 16 Slot AutoMax/DCS 5000 Rack
9. M/N 57C332 – 10 Slot AutoMax/DCS 5000 Rack
10. M/N 61C125 – ReSource Portable Computer
11. M/N 61C127 – Interface Cable (included with item 10)
12. M/N 57C300 – ReSource DCS 5000 Programming Executive; $5\frac{1}{4}$"
13. M/N 57C301 – ReSource DCS 5000 Programming Executive; $3\frac{1}{2}$"
14. M/N 57C304 – ReSource AutoMax Programming Executive; $5\frac{1}{4}$"
15. M/N 57C305 – ReSource AutoMax Programming Executive; $3\frac{1}{2}$"
16. M/N 57C390 – ReSource AutoMax Version 2.0 Programming Executive; $5\frac{1}{4}$"
17. M/N 57C391 – ReSource AutoMax Version 2.0 Programming Executive; $3\frac{1}{2}$"
18. M/N 45C130 – ReSource AutoMate Programming Executive; $5\frac{1}{4}$"
19. M/N 45C131 – ReSource AutoMate Programming Executive; $3\frac{1}{2}$"
20. M/N 45C132 – ReSource AutoMate Documentation Executive

2.0 MECHANICAL/ELECTRICAL DESCRIPTION

The following sections describe the mechanical and electrical characteristics of the T/C input module.

2.1 Mechanical Description

The T/C input module is a printed circuit board assembly that plugs into the backplane of the AutoMate or AutoMax/DCS 5000 rack. It consists of a printed circuit board, a faceplate, and a protective plastic enclosure. The faceplate contains ejector tabs at the top and bottom to simplify removing the module from the rack. Module dimensions are listed in appendix A. See figure 2.0 for the module faceplate.

The faceplate contains a removable terminal block barrier for thermocouple connections. The terminal block is also used for voltage input connections for module calibration.

A "Board OK" LED on the faceplate, when lit, indicates the module has not detected any memory or board failures during its internal diagnostic test at power-up.

Three cutouts on the side of the module allow access to dip switches and jumpers used to select the rack slot location, A/D conversion rate, thermocouple type, and temperature output in Celsius or Fahrenheit. On the back of the module are two edge connectors that attach to the system backplane.

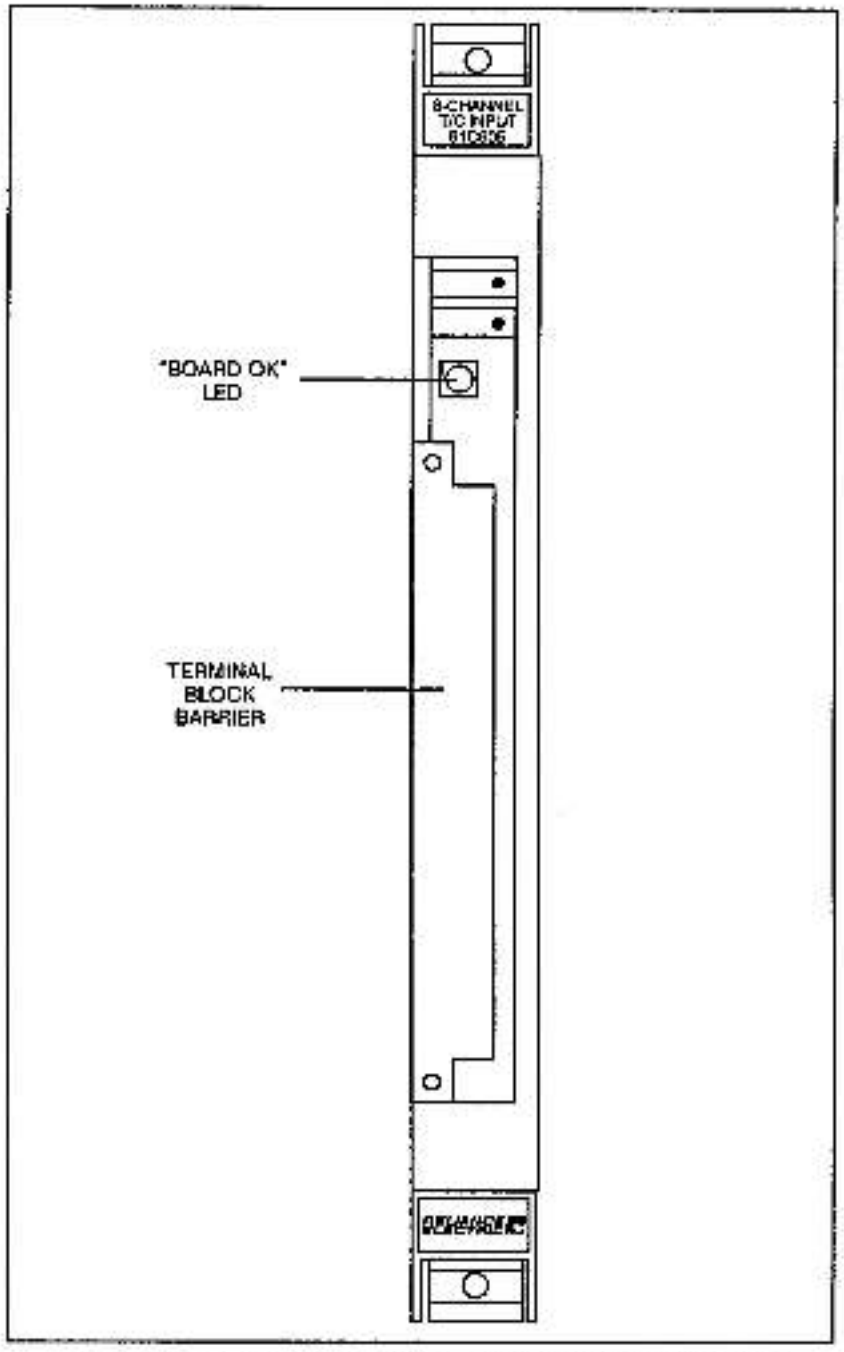

Figure 2.0 – Eight-Channel Isolated Thermocouple Input Module Faceplate

2.2 Electrical Description

Inputs from up to eight channels connect to two signal conditioning modules. The signals are isolated, linearized, and corrected for any cold junction variations. An on-board amplifier amplifies the conditioned signals before they are multiplexed to the A/D converter where the signals are converted to 12-bit digital data. Software in the on-board MC6801 microprocessor performs calculations on the data and provides output in degrees Celsius or Fahrenheit in binary format.

The T/C input module is equipped with a jumper-selectable cold junction compensation circuit (CJC) which allows the thermocouple to operate as though it had an ice point (0°C) reference. The CJC measures temperature using a transducer and provides a voltage output of the ambient temperature measured. This voltage is measured every eight conversions in either random or sequential mode as designated in the user's program. When operated in random channel mode, the channel specified is scanned eight times, followed by the CJC channel. In sequential mode, the T/C input module scans all eight channels followed by the CJC channel. The on-board software adjusts the resultant thermocouple value. The CJC is effective over a range of 0° to +60° Celsius.

The T/C input module contains four 8-bit registers. The command register is used to select random or sequential channel mode and normal or calibration mode. The status register provides the results of the memory and hardware test performed at power-up and during operation. The A/D data register contains data from the thermocouples in binary format. The data ready register indicates when valid data and status information is available in the A/D data and status registers. It also indicates if the command register is ready to receive a new command.

At power-up, the microprocessor generates an interrupt that initializes all registers and performs diagnostics to verify the on-board memory. If the power-up diagnostics detect a board failure or memory error, the "Board OK" LED turns OFF and the status register displays the error condition.

Following the diagnostics, the microprocessor loops until an interrupt request is generated by a command request from the host system or the A/D converter. The interrupt causes the microprocessor to read the A/D data, test its validity, and set the corresponding flags. Depending upon the configuration, the A/D interrupt occurs 12.5, 15, 25, or 30 times every second.

3.0 INSTALLATION

This section describes how to install and remove the T/C input module.

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3.1 Initial Installation

Use the following procedure to install the T/C input module:

Step 1. Turn off power to the system. All power to the rack, as well as all power to the wiring leading to the rack, should be off.

Step 2. Set the address switches on the module for the slot in which the module will be located. Refer to appendix D for the location of switches and jumpers. The OFF position of switches correspond to a "0" and the ON position to a "1".

For AutoMate 30/40: Switches S1 and S2 are factory-set to the OFF position and should not be changed. Switch positions 1-4 of S4 should also be OFF. Switch positions 5-8 of S4 should be set as shown in figure 3.0. Setting the switches in this way enables the module to operate from a base address of X0000H, where X is the number of the slot in which the module resides.

Slot #	1	2	3	4	5	6	7	10	11	12	13	14	15	16	17	0
base address (HEX) / Switch	100000	200000	300000	400000	500000	600000	700000	800000	900000	A00000	B00000	C00000	D00000	E00000	F00000	000000
S4-1																-
S4-2																-
S4-3																-
S4-4																-
S4-5	•		+		•		•		•		•		•		•	-
S4-6		•	+			•	•			•	•			•	•	-
S4-7				•	•	•	•					•	•	•	•	-
S4-8								•	•	•	•	•	•	•	•	-

• = Switch is on
- = Illegal slot
+ Factory configuration

Figure 3.0 – AutoMate 30/40 Slot Configuration

For AutoMax/DCS 5000: Switches S1 and S2 are factory-set to the OFF position and should not be changed. Switch positions 5–8 of S4 should also be OFF. Switch positions 1–4 of S4 should be set as shown in figure 3.1. Setting the switches in this way enables the module to operate from a base address of 2X0000H, where X is the number of the slot in which the module resides. Jumpers 63–64, 65–66, 67–68, and 69–70 should be removed. (Instead of completely removing the jumpers from the board, you can place each jumper on one pin only. This will ensure the jumpers will be available should the module ever be used in an AutoMate rack.)

Slot #	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
base address (HEX) / Switch			200000	300000	400000	500000	600000	700000	800000	900000	A00000	B00000	C00000	D00000	E00000	F00000
S4-1	-	-		•		•		•		•		•		•		•
S4-2	-	-	•	•			•	•			•	•			•	•
S4-3	-	-			•	•	•	•					•	•	•	•
S4-4	-	-							•	•	•	•	•	•	•	•
S4-5	-	-														
S4-6	-	-														
S4-7	-	-														
S4-8	-	-														

• = Switch is on
- = Illegal slot

Figure 3.1 – AutoMax/DCS 5000 Slot Configuration

Step 3. Set switches S3-2 and S3-3 on the module to select the A/D conversion rate. The input module provides a choice of four A/D conversion rates: 15 or 30 conversions per second for 60 Hz A-C line frequency, and 12.5 or 25 conversions per second for 50 Hz.

The T/C input module uses an integrating A/D converter. For normal mode rejection of A-C signals on the input signal, operate the input module at a multiple of the A-C line frequency. The module is factory-configured for 15 conversions per second. Operating the module at 25 or 30 conversions per second results in decreased normal mode rejection. Figure 3.2 shows switch selections for A/D conversion.

CONVERSIONS PER SECOND	FREQUENCY	S3 SWITCH POSITION	
		S3-2	S3-3
12.5	50	OFF	OFF
15*	60	OFF	ON
25	50	ON	OFF
30	60	ON	ON

*Factory configuration

Figure 3.2 - A/D Conversion Rate Selection

Step 4. Set switches S3-1 and S3-5 through S3-10 to select the desired thermocouple type for each of the two groups of four input channels. The module is factory-configured for thermocouple type J for all channels. Figure 3.3 shows switch positions for thermocouple selection. Figure 3.4 shows jumper selection for different thermocouple types.

CAUTION

TO ACCESS THE JUMPERS FOR THERMOCOUPLE TYPE SELECTION AND TO DISABLE THE CJC (SEE STEP 5), THE MODULE MUST BE PARTIALLY DISASSEMBLED. ENSURE YOU ARE WORKING IN A STATIC-FREE ENVIRONMENT. HANDLE THE CIRCUIT BOARD BY ITS EDGES ONLY. DO NOT TOUCH THE CONNECTORS ON THE BACK OF THE MODULE. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN DAMAGE TO OR DESTRUCTION OF THE EQUIPMENT.

CHANNEL	SWITCH	THERMOCOUPLE TYPE						
		J*	K	S	T	E	R	B
0-3	S3-8	ON	ON	ON	ON	OFF	OFF	OFF
↓	S3-9	ON	ON	OFF	OFF	ON	ON	OFF
	S3-10	ON	OFF	ON	OFF	ON	OFF	ON
4-7	S3-1	OFF	OFF	OFF	OFF	OFF	OFF	OFF
↓	S3-5	ON	ON	ON	ON	OFF	OFF	OFF
	S3-6	ON	ON	OFF	OFF	ON	ON	OFF
	S3-7	ON	OFF	ON	OFF	ON	OFF	ON

*Factory configuration

Figure 3.3 - Group Channel Thermocouple Selection

CHANNEL NO. RANGE	THERMOCOUPLE TYPE/VOLTAGE	JUMPER SELECTION
0–3	J*, K, T, S, B, R	21–22, 26–27 31–32, 36–37
4–7	J*, K, T, S, B, R	1–2, 6–7 11–12, 16–17
0–3	E	22–23, 27–28 32–33, 37–38
4–7	E	2–3, 7–8 12–13, 17–18
*Factory configuration		

Figure 3.4 – Thermocouple Type Selection

Step 5. Install jumper 42-44 for applications not requiring cold junction compensation. This option is also used when calibrating the module.

Step 6. Set switch S3-4 to select temperature output format in degrees Centigrade or Fahrenheit as follows:

Degree C - S3-4 ON
Degree F - S3-4 OFF

Step 7. Calibrate the module using the procedures defined in section 6.0.

Step 8. Insert the module into the desired slot in the rack. Use a screwdriver to secure the module into the slot.

Step 9. Run the thermocouple wire from the point where the temperature is being sensed to the terminal block barrier. (Refer to appendix C for terminal block analog input connections.) If thermocouple extension wires are required, ensure they adhere to the correct specification for the type of thermocouple used. Refer to ANSI-MC96.1 AMERICAN NATIONAL STANDARD TEMPERATURE MEASUREMENT THERMOCOUPLES MC96.1 as an aid in the assembly and installation of thermocouple extension wire.

Step 10. Turn on power to the rack.

3.2 Module Replacement

WARNING

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Use the following procedure to replace the T/C input module:

Step 1. Turn off power to the rack and all connections.

Step 2. Remove the terminal block (with thermocouples attached) by grasping the terminal block firmly and pulling straight out.

Step 3. Loosen the screws that hold the module in the rack. Take the module out of the slot in the rack.

Step 4. Place the module in the anti-static bag it came in, being careful not to touch the connectors on the back of the module. Place the module in the cardboard shipping container.

Step 5. Take the new module out of the anti-static bag, being careful not to touch the connectors on the back of the module.

Step 6. Remove the terminal block by grasping it firmly and pulling straight out. Place it in the cardboard shipping container with the original module.

Step 7. Configure the module to meet the application requirements (refer to section 3.1).

Step 8. Calibrate the new module according to the procedures defined in section 5.0.

Step 9. Insert the module into the desired slot in the rack. Use a screwdriver to secure the module into the slot.

Step 10. Align the terminal block (with thermocouples attached) with the module and push straight in.

Step 11. Turn on power to the rack.

4.0 PROGRAMMING

This section describes how data is organized in the T/C input module. Section 4.2 shows sample programs for AutoMate and AutoMax/DCS 5000 applications. For more programming information, refer to the AutoMate 90/40 Software Instruction Manual (J-3150), the DCS 5000 Programming Reference Binder (J-3611), or the AutoMax Programming Reference Binder (J-3659).

4.1 Register Assignment

Four 8-bit registers are used to program the T/C input module. Figure 4.0 shows the register assignment. Sections 4.1.1 - 4.1.4 describe each register in detail.

ADDRESS	FUNCTION	REGISTER NAME	DESCRIPTION
Base + 0	Read	Data Ready	Read data ready status
Base + 1	Write	Command	Write analog data command
Base + 1	Read	Status	Read analog data status
Base + 2	Read	A/D Data (Low)	Read analog data low byte
Base + 3	Read	A/D Data (High)	Read analog data high byte

Figure 4.0 - Register Assignment

4.1.1 Data Ready Register

The host system reads bit 7 of this register to determine if valid data and status information is available in the A/D data and status registers. Bit 0 of the data ready register indicates if the command register is ready to receive a new command. Bits 1 through 6 have no significance. Figure 4.1 shows the format of the data ready register.

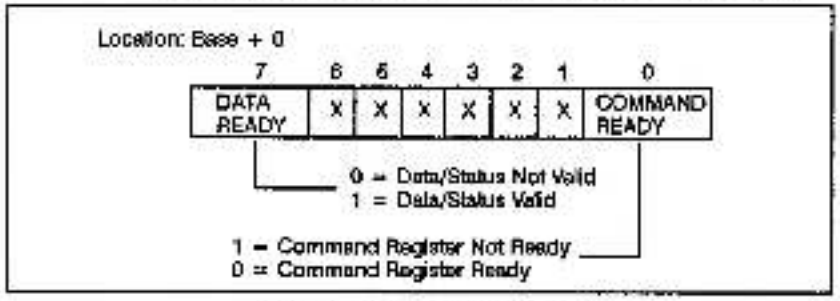


Figure 4.1 – Data Ready Register

4.1.2 Command Register

Bit 7 of the command register determines the operating mode, either normal or calibrating. When operating in normal mode, the on-board microprocessor continuously performs A/D conversions on all eight channels and scans the channel dedicated to the CJC sensor. Calibrating mode is used for module calibration and diagnostics.

Bit 4 selects random or sequential scanning modes. To operate in sequential mode, the command register must be initialized with the starting channel address using bits 0 through 2 and setting bit 4 to a "1". (Refer to figure 4.2 for the command register format and figure 4.3 for channel selection.) Operating in the sequential scanning mode loads data from the channel specified into the A/D data register in binary format. When the host system reads the A/D data register, the module increments the channel address and loads the next channel's data into the A/D data register.

In the random scanning mode, data from the channel specified by bits 0 through 2 of this register is loaded into the A/D data register in binary format. Reading the A/D data register at this time updates the A/D data register with new data. In random mode, the channel address is not incremented.

If the host system switches from random mode to sequential mode, the microprocessor executes a delay routine. This ensures the A/D registers are updated with the most recent data. For most applications, the delay will not be noticeable.

Bit 3 of the command register selects the CJC channel for calibration mode. Bits 0, 1, and 2 should be set to "0" when the CJC channel is selected.

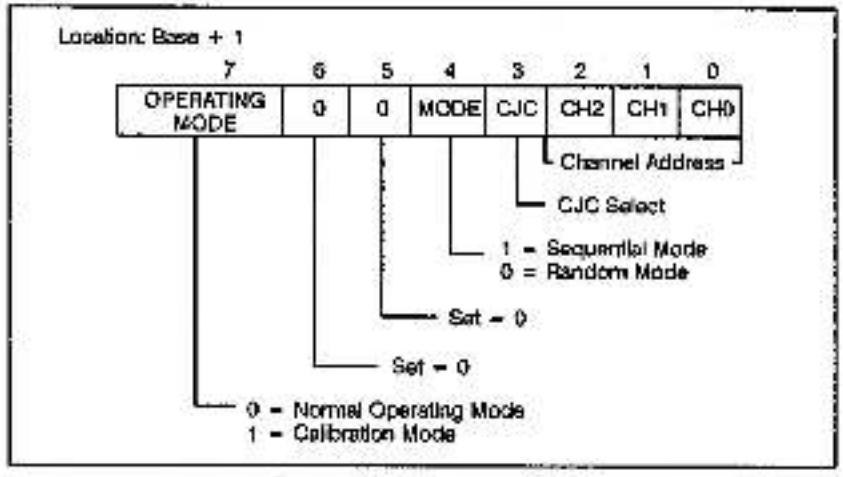


Figure 4.2 - Command Register

CHANNEL NUMBER	CHANNEL ADDRESS BITS		
	CH2	CH1	CH0
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

Figure 4.3 – Channel Selection

4.1.3 Status Register

WARNING

DUE TO THE CRITICAL NATURE OF THE STATUS REGISTERS, THE USER MUST UTILIZE THESE STATUS BITS IN THE APPLICATION PROGRAM. THE APPLICATION PROGRAM MUST ENSURE THAT THE DATA IS NOT READ WHEN AN ERROR IS DETECTED. IN SOME APPLICATIONS IT MAY BE NECESSARY TO STOP THE PROCESS AND TAKE THE PROCESSOR OUT OF THE RUN MODE. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN BODILY INJURY.

Bits 0 through 2 of the status register show the channel number of the data in the A/D data register. Bit 3 determines the temperature output format, either Celsius or Fahrenheit. Bits 4 through 7 indicate error conditions relating to open inputs, CJC and data out of range status, and module hardware malfunctions. The on-board microprocessor loads the status register with status information along with the A/D data register. Your application program must monitor this register to determine the validity of the A/D data. Figure 4.4 shows the format of the status register. Figure 4.5 shows error conditions indicated by the input module.

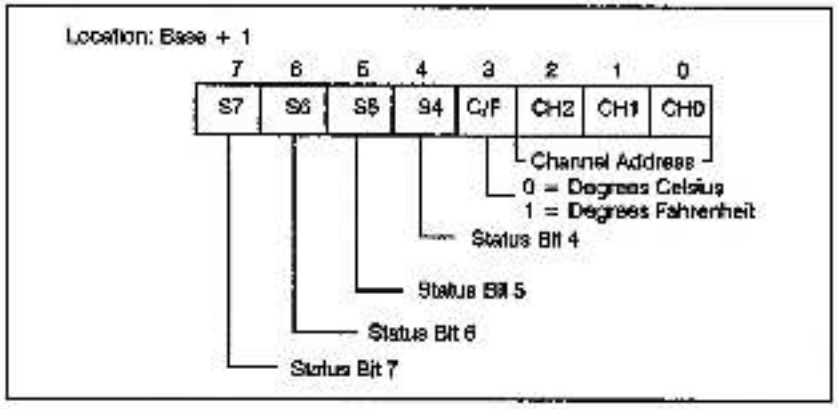


Figure 4.4 - Status Register

STATUS BITS				ERROR DESCRIPTION
S7	S6	S5	S4	
0	0	0	0	No error.
1	0	0	0	Calibration mode.
1	0	0	1	Data out of range.
1	0	1	0	Open wire detection.
1	0	1	1	Board not ready.
1	1	0	0	CJC out of range.
1	1	0	1	CJC and data out of range.
1	1	1	0	CJC and open wire.
1	1	1	1	Memory or board failure.

Figure 4.5 – Description of Error Conditions

The on-board microprocessor tests its internal ROM and RAM on power-up. The status register indicates the "board not ready" status code during the test. Your application program must not write to the command register during the test. If the test fails, the input module sets the status bits indicating memory failure. Hardware and memory failures turn off the "Board OK" LED. The "Board OK" LED will also turn off while the module is in calibration mode.

4.1.4 A/D Data Register

The A/D data register contains the linearized data from a thermocouple. Data is a 12-bit number in binary format. The binary number is the temperature measured in degrees Celsius or Fahrenheit, depending on the selection. Figure 4.6 shows the format of the A/D data register.

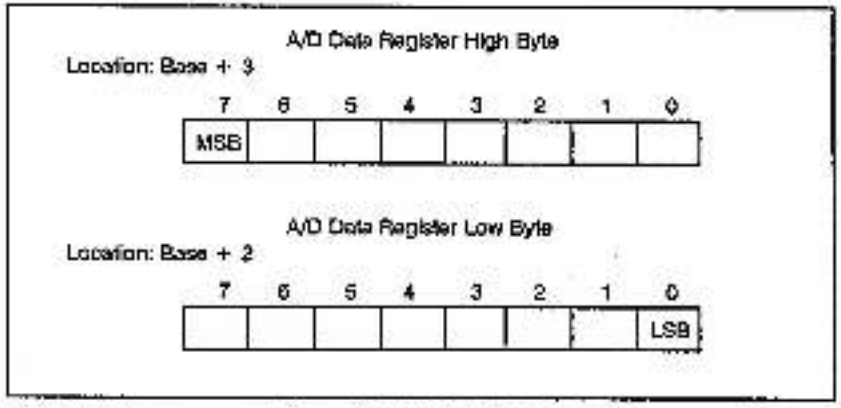


Figure 4.6 - A/D Data Register

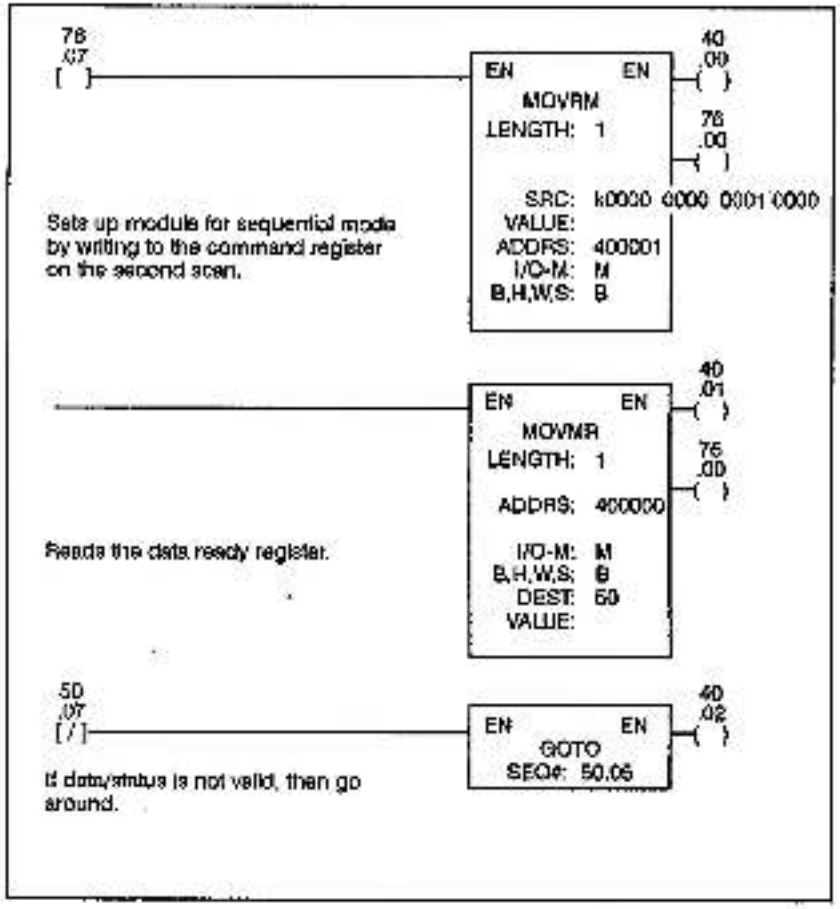
4.2 Sample Programs

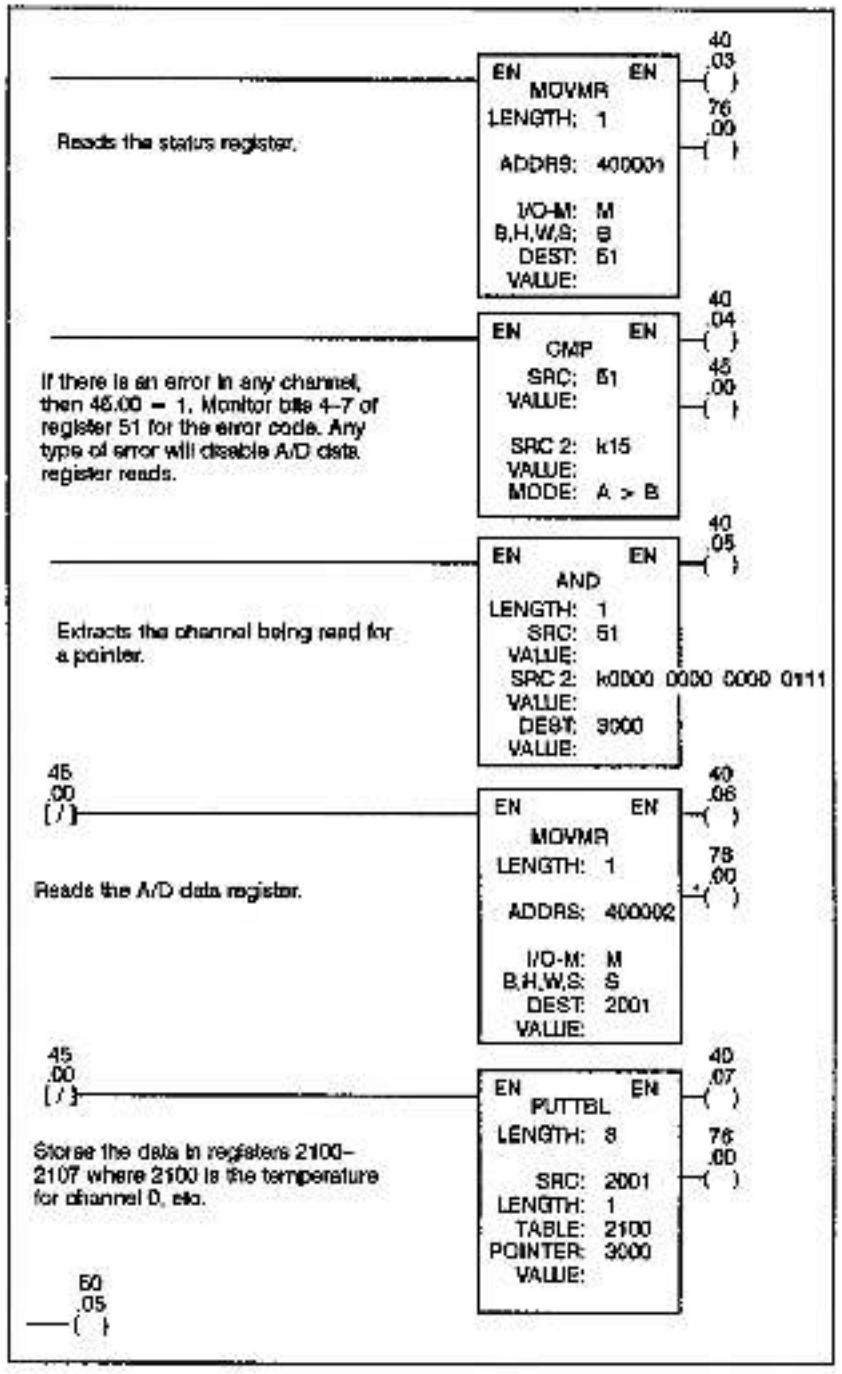
This section provides programming samples for both AutoMate and AutoMax/DCS 5000 applications.

4.2.1 AutoMate 30/40 Sample Program

The following sample program is used to read thermocouple temperatures on a T/C input module configured for Multibus address 400000 (HEX) in slot 4. The program sets the module to operate in sequential mode. MOVMR and MOVRM instruction blocks are used to access the module. The status register is read before the A/D data register to provide error information and the data's channel address. This program is written for use with an AutoMate 30. If it is used with an AutoMate 40, the coil addresses must be changed.

Read the following program thoroughly before beginning any programming.




Reads the status register.
EN
MOVMR
LENGTH: 1
ADDRS: 400001
I/O-M: M
B,H,W,S: S
DEST: 51
VALUE:
40 .03
76 .00
If there is an error in any channel, then 46.00 = 1. Monitor bits 4–7 of register 51 for the error code. Any type of error will disable A/D data register reads.
EN
CMP
SRC: 51
VALUE:
SRC 2: k15
VALUE:
MODE: A > B
40 .04
46 .00
Extracts the channel being read for a pointer.
EN
AND
LENGTH: 1
SRC: 51
VALUE:
SRC 2: k0000 0000 0000 0111
VALUE:
DEST: 3000
VALUE:
40 .05
46 .00
Reads the A/D data register.
EN
MOVMR
LENGTH: 1
ADDRS: 400002
I/O-M: M
B,H,W,S: S
DEST: 2001
VALUE:
40 .06
76 .00
46 .00
Stores the data in registers 2100–2107 where 2100 is the temperature for channel 0, etc.
EN
PUTTBL
LENGTH: 8
SRC: 2001
LENGTH: 1
TABLE: 2100
POINTER: 3000
VALUE:
40 .07
76 .00
50 .05

4.2.2 AutoMax/DCS 5000 Sample Program

The following sample program is used to read the thermocouple temperatures on the T/C input module configured for Multibus address 240000 (HEX) in slot 4. The program sets the module to operate in sequential mode. The basic functions IOREAD and IOWRITE are used to access the module.

Read the following program thoroughly before beginning any programming.

```
395   LOCAL     I%                      \Index
400   LOCAL     DATA_RDY%               \Data Ready register
405   LOCAL     STATUS%                 \Status register
410   LOCAL     I%                      \Index
415   LOCAL     INPUTS%(8)              \Input data (1 per channel)
420   LOCAL     ERRORS%(8)              \Error status (1 per channel)
997   REM
998   REM       Set up the module for sequential mode by writing to the
999   REM       command register on the second scan.
1000  DELAY 0 TICKS
1005  IOWRITE( 1, 010H, 0240001H)
1690  REM
1697  REM       Run task every 58.5 msec. If the data is ready, read it.
1698  REM       Otherwise, wait until the next scan.
1699  REM
2000  START EVERY 7 TICKS                          \Run the task every 38.5 msec
2005  DATA_RDY% = IOREAD%( 1, 0240000H)            \Read data ready register (0)
2010  IF BIT_CLR( DATA_RDY%, 7) THEN GOTO 5000     \Skip if not ready
2994  REM
2995  REM       Read the status register (1). This contains the number
2996  REM       of the channel that was read and any error conditions that
2997  REM       may have occurred. Error status and data are stored by
2998  REM       channel number in the arrays "ERRORS" and "INPUTS".
2999  REM
3000  STATUS% = IOREAD%( 1, 0240001H)              \Read status register (1)
3005  I% = STATUS% AND 07H                         \Get channel number
3010  ERRORS%( I%) = STATUS% AND 0F0H              \Save error status
3015  IF ERRORS%( I%) = 0 THEN &
        INPUTS%( I%) = IOREAD%( 2, 0240000H)       \Read data for this channel
5000  END
```

4.3 Restrictions

This section describes limitations and restrictions on the use of the module.

4.3.1 Rack Slot Location

This module cannot be used in a Remote I/O rack. A processor must be present in the same rack as the module. The module may not be used in slots 0 or 1 in an AutoMax/DCS 5000 rack or slot 0 in an AutoMate rack.

4.3.2 AutoMax/DCS 5000 Monitor Functions

Do not use the I/O Monitor function of the AutoMax/DCS 5000 programming terminal when application software is running. This will interfere with the software handshake that the application software uses to communicate with the module and will result in incorrect data being read. Use the Variable Monitor function.

5.0 DIAGNOSTICS AND TROUBLESHOOTING

This section describes how to troubleshoot the T/C input module. If the problem cannot be corrected using the following procedures, the unit is not user-serviceable.

WARNING

ONLY QUALIFIED ELECTRICAL PERSONNEL FAMILIAR WITH THE CONSTRUCTION AND OPERATION OF THIS EQUIPMENT AND THE HAZARDS INVOLVED SHOULD INSTALL, ADJUST, OPERATE, AND/OR SERVICE THIS EQUIPMENT. READ AND UNDERSTAND THIS MANUAL IN ITS ENTIRETY BEFORE PROCEEDING. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

5.1 The "Board OK" LED is OFF

The "Board OK" LED on the face of the module should be ON when the module is receiving correct input power and has passed its internal diagnostics after power-up. If it is OFF, it may be due to poor backplane connections or the module may be in calibration mode. It may also indicate the module has detected a memory error or hardware failure during diagnostics. Use the following procedure to isolate the problem:

Step 1. Read the status register for error codes. (Refer to figure 4.6.) This can be accomplished by running the calibration program provided on the disk with the module.

Step 2. If the status register indicates the module is in calibration mode, write "0" to bit 7 of the command register to exit calibration mode. Exiting calibration mode should cause the module to enter normal operating mode.

Step 3. If the status register indicates the module has detected a memory error or hardware failure, cycle power.

Step 4. If you are unable to read the register at all, it may be due to improper backplane connections. Turn off power to the rack. Pull the module out about 2" and then re-insert it securely into the rack. Turn on power to the rack and repeat steps 1 through 3 if necessary.

Step 5. If the above procedures do not resolve the problem, replace the module.

5.2 Bus Error

If the system has a problem accessing the module through the backplane bus, error code 31 or 16 will appear on the DCS 5000 processor module's LEDs. Error code 31 or 56–58 will appear on the AutoMax processor module's LEDs. A "1" in any bit location of register 3764 in the A30 or 17964 in the A40 indicates the slot address of the module that cannot be accessed.

The most common cause of a bus error is incorrectly set address switches. Other possible causes are a missing module, a module in the wrong slot, or a malfunctioning module. It is also possible that the user is attempting to read or write to the wrong registers on the module.

NOTE: Register 3765 in an A30 and register 17565 in an A40 may indicate a missing module on power-up. This will not affect the operation of the module or execution of the application program.

Use the following procedure to isolate a bus error:

Step 1. Verify that the T/C input module is in the correct slot.

Refer to section 4.3.1, Rack Slot Locations.

Step 2. Verify the address switches have been set correctly.

Refer to figure 3.0 for the AutoMate 30/40 or figure 3.1 for AutoMax/DCS 5000 for the correct settings of the address switches.

Step 3. Verify that the application software has been written correctly.

Verify that your application program is referencing the registers on the proper module. Refer to the address that corresponds to the switch settings in figure 3.0 or 3.1. Confirm that each channel has been configured correctly.

For AutoMax/DCS 5000 applications, verify that the T/C input module slot corresponds to the registers read/written in the application task.

Step 4. Verify that the hardware is working correctly.

One at a time, swap out the T/C input module, the processor module(s), and the backplane. After each swap, if the problem has not been corrected, replace the original item before swapping out the next item.

5.3 Incorrect Data

If the data read is different than expected, it is possible the module is in the wrong slot or malfunctioning, or that there is a programming error. It is also possible that the input is wired incorrectly or the switches have not been set correctly for the thermocouple type used. Use the following procedure to isolate the problem.

Step 1. Verify that the T/C input module is in the correct slot.

Refer to section 4.3.1, Rack Slot Locations.

Step 2. Verify that the switches have been set correctly.

Refer to figure 3.0 for the AutoMate 30/40 or figure 3.1 for AutoMax/DCS 5000 for the correct settings of the address switches.

Refer to figures 3.3 and 3.4 for the switch and jumper positions for different thermocouple types.

Step 3. Verify that the application software has been written correctly.

Verify that your application program is referencing the registers on the proper module. Refer to the address that corresponds to the switch settings in figure 3.0 or 3.1. Confirm that each channel has been configured correctly.

For AutoMax/DCS 5000 applications, verify that the T/C input module slot corresponds to the registers read/written in the application task.

Step 4. Verify that the input is wired to the correct device.

Confirm that all connections at the terminal block are tight. Refer to appendix C for a definition of the analog input connections. Make certain that each input channel is wired to the correct field device.

Ensure the thermocouple wiring is isolated from other wiring or metals. Since the thermocouple uses the voltage differential between two metals to measure temperature, the introduction of other metals (copper wiring, etc.) will affect the measurement.

If thermocouple extension wires are used, ensure they adhere to the correct specification for the type of thermocouple used. Refer to ANSI-MC96.1 AMERICAN NATIONAL STANDARD TEMPERATURE MEASUREMENT THERMOCOUPLES.

Step 5. Verify that the hardware is working correctly.

One at a time, swap out the T/C input module, the processor module(s), and the backplane. After each swap, if the problem has not been corrected, replace the original item before swapping out the next item.

Step 6. Verify that the module is properly calibrated. To ensure accurate readings, the module should be calibrated every three months and each time a different thermocouple type is used. Refer to section 6.0 for calibration procedures.

6.0 CALIBRATION

DANGER

ONLY QUALIFIED ELECTRICAL PERSONNEL FAMILIAR WITH THE CONSTRUCTION AND OPERATION OF THIS EQUIPMENT AND THE HAZARDS INVOLVED SHOULD INSTALL, ADJUST, OPERATE, AND/OR SERVICE THIS EQUIPMENT. READ AND UNDERSTAND THIS MANUAL IN ITS ENTIRETY BEFORE PROCEEDING. FAILURE TO OBSERVE THIS PRECAUTION COULD RESULT IN SEVERE BODILY INJURY OR LOSS OF LIFE.

WARNING

INSERTING OR REMOVING THIS MODULE MAY RESULT IN UNEXPECTED MACHINE MOTION. TURN OFF POWER TO THE MACHINE BEFORE INSERTING OR REMOVING THE MODULE. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN BODILY INJURY.

CAUTION

TO ACCESS THE JUMPERS AND POTENTIOMETERS FOR CALIBRATION, THE MODULE MUST BE PARTIALLY DISASSEMBLED. ENSURE YOU ARE WORKING IN A STATIC-FREE ENVIRONMENT. HANDLE THE CIRCUIT BOARD BY ITS EDGES ONLY. DO NOT TOUCH THE CONNECTORS ON THE BACK OF THE MODULE. FAILURE TO OBSERVE THESE PRECAUTIONS COULD RESULT IN DAMAGE TO OR DESTRUCTION OF THE EQUIPMENT.

Calibration must be performed only by engineers, experienced technicians, or computer operators who have operational understanding of the T/C input module. Due to varying storage times and conditions, Reliance Electric recommends calibrating the module before it is used for the first time. To ensure accurate readings, the module should be calibrated every three months and each time a different thermocouple type is used.

6.1 Equipment Preparation and Set Up

The equipment required for calibration is a precision D-C voltage source, a temperature probe or thermometer, a digital voltmeter, and a small screwdriver to adjust the potentiometers. A personal computer and ReSource Programming Executive are also required. The programs necessary to perform the following calibration procedures are printed in appendices G and H.

The calibration program reads and displays the contents of the command, status and A/D data registers. Bit 7 of the command register is used to select calibration mode. Bits 0 through 3 are used to select the input channel. Refer to figure 4.2 for the command register format and figure 4.3 for channel selection. Refer to figure 4.4 for the status register format and figure 4.5 for a description of error conditions. Refer to figure 4.6 for the format of the A/D data register.

The "Board OK" LED will remain off when operating in calibration mode. To exit calibration mode, write "0" to bit 7 of the command register. Exiting calibration mode causes the module to return to normal operating mode.

Refer to the assembly drawing in appendix D for the location of potentiometers and jumpers. When an instruction calls for the removal of jumpers, it is recommended the jumper be placed on one of the pins for easier retrieval.

Use the following procedure to prepare the module for calibration:

Step 1. Stop any application program(s) that may be running. Before going to step 2, note that you may have to re-load the operating system and application programs for AutoMax processors on power-up.

Step 2. Verify all power to the rack, as well as all power to the wiring leading to the rack, is off.

Step 3. Refer to figure 6.0 and use a screwdriver to disassemble the module.

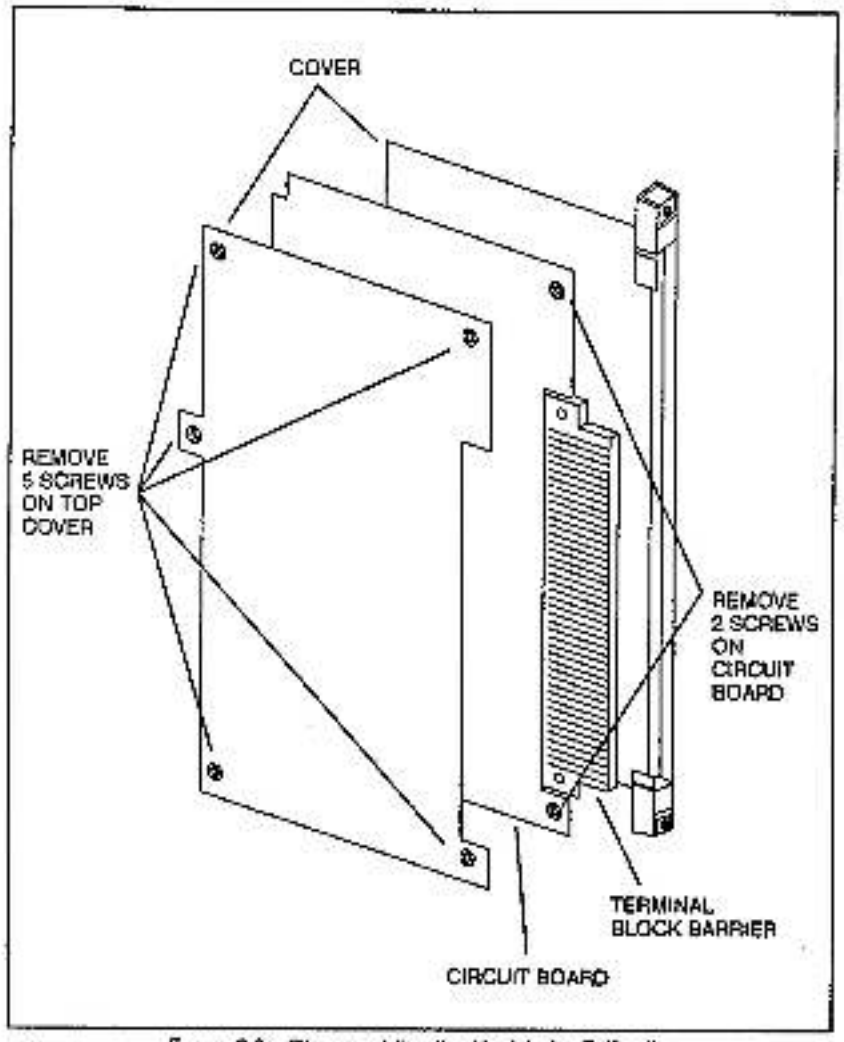


Figure 6.0 - Disassembling the Module for Calibration

Step 4. Insert the circuit board into the rack. A Multibus extender card will make it easier to locate and reach the potentiometers and jumpers but is not necessary. If you do not have an extender card, you must have enough room to the right of the card to reach the pots and jumpers.

Step 5. Apply power to the rack.

Step 6. Use an RS-232 cable to connect the personal computer to the AutoMate or AutoMax/DCS 5000 processor.

Step 7. Run the ReSource programming executive.

Step 8. For AutoMax, load the operating system and application program to the processor if it displays "LD".

Step 9. Load the calibration program appropriate for AutoMate or AutoMax/DCS 5000 application. For AutoMax/DCS 5000, use CAL605.BAS. For AutoMate, use CAL605.90E. (Note: Since AutoMate processors can store only one program, the calibration program will overwrite anything already in the processor.)

Step 10. For AutoMate, select Point Monitor from the Monitor menu and monitor the following registers:

2000 - Command Register
51 - Status Register
2001 - A/D Data Register

Step 11. For AutoMax, select Monitor Variable from the On-Line Programming Menu and display the following variables previously defined in the sample application program:

CMD_REG% - Command Register
STS_REG% - Status Register
A2D_REG% - A/D Data Register

Step 12. Proceed to section 6.2 to begin calibration procedures. For AutoMate applications, use Point Monitor to write values to registers. For AutoMax/DCS 5000, use Monitor Variable.

6.2 A/D Reference Calibration

Use the following procedure to calibrate the A/D converter's reference voltage.

1. Refer to the assembly drawing in appendix D and connect the digital voltmeter's positive (+) terminal to the lead of R96 closest to C29. Connect the negative (-) terminal to analog ground (TP4).
2. Adjust potentiometer R9 to read 2.048V on the digital voltmeter.

6.3 Output Offset Adjust – Isolation Amplifier

Use the following procedure to calibrate the isolation amplifier's offset voltage.

1. Connect the digital voltmeter's positive (+) terminal to TP7. Verify the negative (-) terminal is connected to TP4.
2. Remove jumper plugs 39-40 of channel 0 and 19-20 of channel 4.
3. Connect the voltage source to channel 0 and set the voltage output to 0.00 mV.
4. Select calibration mode and channel 0 by writing 80 HEX to the command register. Adjust potentiometer R40 to read 0.0000V on the digital voltmeter.
5. Connect the voltage source to channel 4 and set the voltage output to 0.00 mV.
6. Select calibration mode and channel 4 by writing 84 HEX to the command register. Adjust potentiometer R19 to read 0.0000V on the digital voltmeter.
7. Re-insert jumper plugs 39-40 and 19-20.

6.4 Offset Adjust for Individual Channel

Use the following procedure to calibrate the offset voltage for each channel.

1. Verify the digital voltmeter's positive (+) terminal is connected to TP7 and the negative (–) terminal is connected to TP4.
2. Connect the voltage source to channel 0 and set the voltage output to 0.00 mV. Select calibration mode and channel 0 by writing 80 HEX to the command register. Adjust potentiometer R55 to read 0.000V on the digital voltmeter.
3. Follow the same procedure for channels 1 through 7. Connect the voltage source to each channel and set the voltage output to 0.00 mV. Use figure 6.1 to select calibration mode for each channel and identify each channel's corresponding offset adjust potentiometer. Adjust each potentiometer to read 0.000V on the digital voltmeter.

CHANNEL NUMBER	WRITE TO COMMAND REGISTER (HEX)	POTENTIOMETER
0	80	R55
1	81	R51
2	82	R46
3	83	R41
4	84	R35
5	85	R30
6	86	R25
7	87	R20

Figure 6.1 – Channel Offset Adjust Potentiometers

6.5 Gain Adjust for Individual Channel

Use the following procedure to calibrate the gain for each channel.

1. Verify the digital voltmeter's positive (+) terminal is connected to TP7 and the negative (–) terminal is connected to TP4.
2. Connect the voltage source to channel 0 and set the voltage output to 50.00 mV. Select calibration mode and channel 0 by writing 90 HEX to the command register. Adjust potentiometer R60 to read 4.000V on the digital voltmeter.
3. Follow the same procedure for channels 1 through 7. Connect the voltage source to each channel and set the voltage output to 50.00 mV. Use figure 6.2 to select calibration mode for each channel and identify each channel's corresponding gain adjust potentiometer. Adjust each potentiometer to read 4.000V on the digital voltmeter.

CHANNEL NUMBER	WRITE TO COMMAND REGISTER (HEX)	POTENTIOMETER
0	90	R60
1	91	R56
2	92	R50
3	93	R45
4	94	R39
5	95	R34
6	96	R29
7	97	R24

Figure 6.2 – Channel Gain Adjust Potentiometers

6.6 CJC Calibration

Use the following procedure to calibrate the CJC.

1. Connect the digital voltmeter's positive (+) terminal to TP3. Verify the negative (–) terminal is connected to TP4.
2. Select calibration mode and CJC channel by writing 88 HEX to the command register.
3. Measure the temperature of TC1 (located near J1) with a temperature probe or thermometer within +/–0.5°C. Multiply the Celsius reading by 20.48 mV and record the result. (A typical result is 512 mV at 25°C.)
4. Adjust potentiometer R10 so that the reading on the digital voltmeter is equal to the result from step 3.

6.7 Thermocouple Calibration

Use the following procedure to fine tune offset and gain adjustments for each channel for thermocouple inputs. During this procedure, the "Board OK" LED will be on.

1. Install jumper plug 43–44 to disable CJC.
2. Connect the voltage source to channel 0 and set the voltage output to 0.00 mV (.491 mV for B-type thermocouple).
3. Select channel 0 and random mode by writing 00 HEX to the command register and display the A/D data register. If the temperature does not read "0" ("300" for B-type thermocouple), adjust offset potentiometer R56 until it does.
4. Set the voltage source for full scale output based on the type of thermocouple you are using. Refer to figure 6.3. Observe the A/D data register and adjust gain potentiometer R60 to coincide with the full scale temperature. Monitor the status bits and verify that there is no "DATA OUT OF RANGE" error (refer to figure 4.6). If there is, adjust R60 so that the temperature decreases enough to remove the error condition.
5. Follow the same procedure for channels 1 through 7. Use figure 6.4 to select random mode for each channel and identify each channel's corresponding offset adjust potentiometer. Use figure 6.5 to identify each channel's gain adjust potentiometer.
6. Remove jumper plug 43–44 to enable CJC.

THERMOCOUPLE TYPE	FULL SCALE VOLTAGE (mV)	FULL SCALE TEMP. (DEG. C)
J	42.922	760
K	49.999	1232
T	20.869	400
S	18.686	1768
E	13.814	1020
R	21.109	1768

Figure 6.3 - Full Scale Thermocouple Settings

CHANNEL NUMBER	WRITE TO COMMAND REGISTER (HEX)	POTENTIOMETER
0	00	R58
1	01	R51
2	02	R46
3	03	R41
4	04	R35
5	05	R30
6	06	R25
7	07	R20

Figure 6.4 – Channel Offset Adjust Potentiometers

CHANNEL NUMBER	WRITE TO COMMAND REGISTER (HEX)	POTENTIOMETER
0	00	R60
1	01	R55
2	02	R50
3	03	R45
4	04	R39
5	05	R34
6	06	R29
7	07	R24

Figure 6.5 – Channel Gain Adjust Potentiometers For Thermocouple Calibration

Appendix A

Technical Specifications

Ambient Conditions

- Operating Temperature 0° to +60°C (+32° to +140°F)
- Storage Temperature -20° to +80°C (-4° to +176°F)
- Relative Humidity 0 to 80% (Non-condensing)

Maximum Module Power Dissipation

- 6 Watts

Dimensions

- Height 11.75 inches (298 mm)
- Width 1.25 inches (32 mm)
- Depth 7.75 inches (197 mm)
- Weight 1 pound, 2 ounces (.51 kg)

System Power Requirements

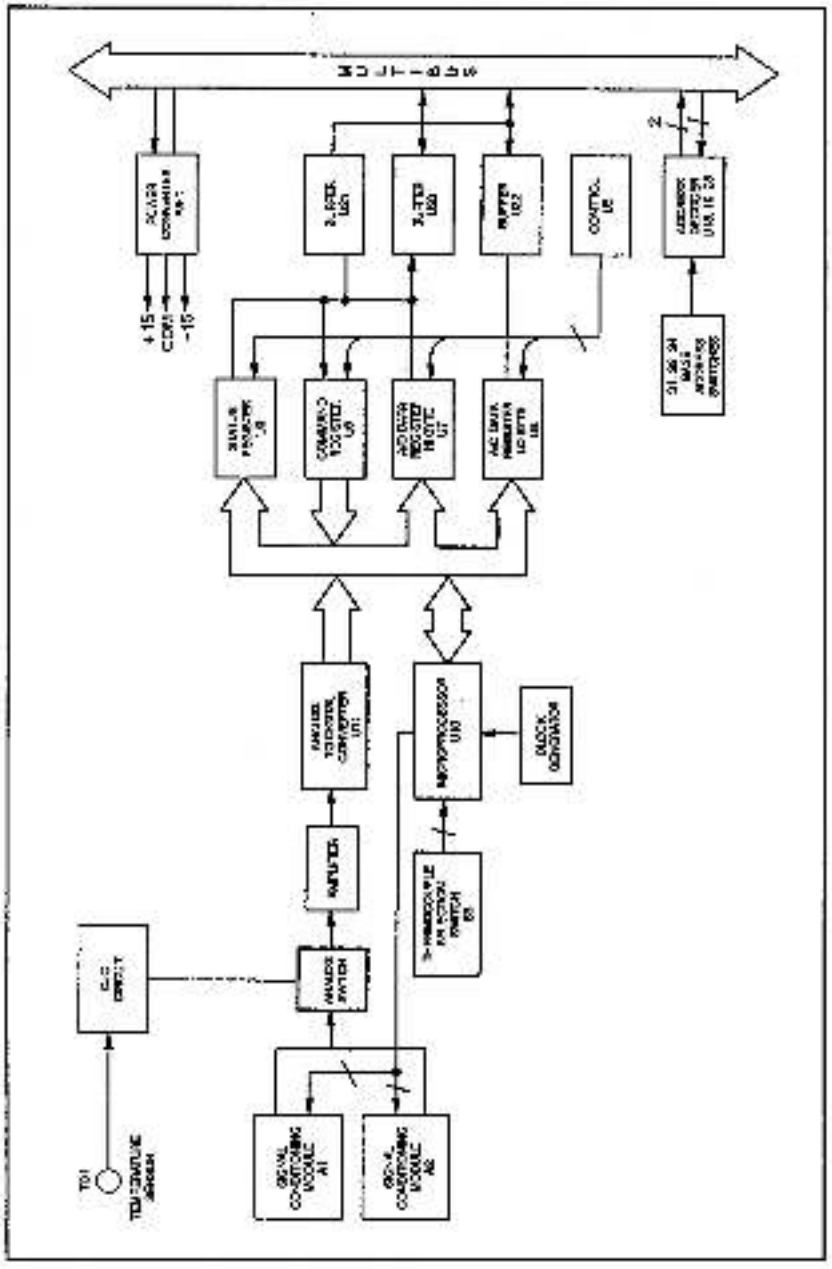
- +5 VDC: 1600 ma

A/D Specifications

• Number of input channels	8
• Type of input	Differential
• Thermocouple inputs	J,K,T,S,B,E,R
• Resolution	12 bits
• Input impedance	100 megohms
• Input bias current, maximum	8 nanoamps
• Common mode voltage range, maximum	750V RMS (channel-ground) 750V RMS (channel-channel)
• A-C or D-C isolation, peak maximum	+/-1000V
• Common mode rejection ratio, minimum Rs = 1K f = 0.01 to 100 Hz	128 dB
• Normal mode rejection at 50/60 Hz, minimum	55 dB
• Maximum safe differential voltage without damage	130V RMS
• Input lead resistance effects	None
• Voltage range accuracy, maximum	0.03%FSR
• Voltage range gain drift, maximum	45 ppm/°C

Appendix B

Hardware Block Diagram



Appendix C

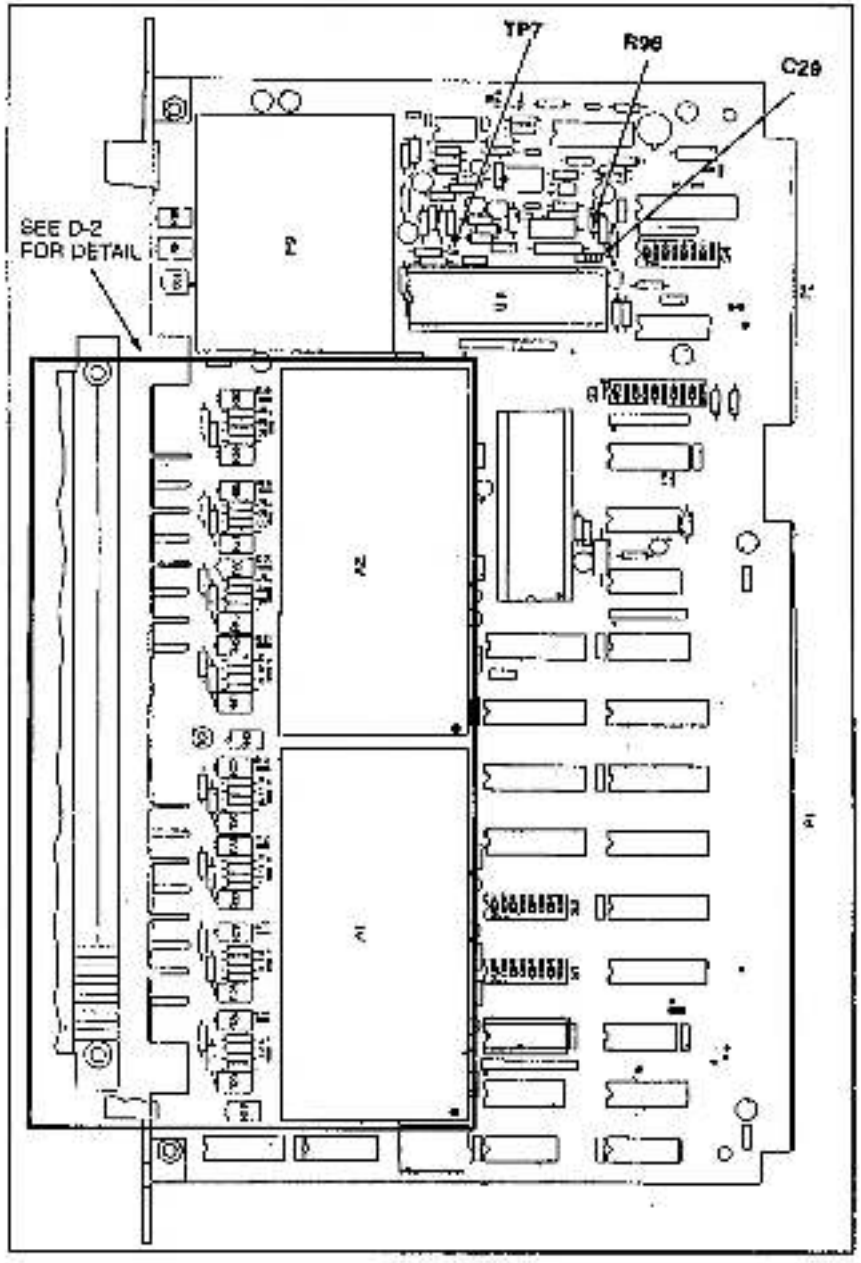
Terminal Block Analog Input Connections

PIN	SIGNAL	PIN	SIGNAL
1	NC	2	NC
3	NC	4	CHANNEL 0 HIGH
5	CHANNEL 0 LOW	6	NC
7	CHANNEL 1 HIGH	8	CHANNEL 1 LOW
9	NC	10	CHANNEL 2 HIGH
11	CHANNEL 2 LOW	12	NC
13	CHANNEL 3 HIGH	14	CHANNEL 3 LOW
15	NC	16	NC
17	NC	18	NC
19	NC	20	NC
21	NC	22	NC
23	CHANNEL 4 HIGH	24	CHANNEL 4 LOW
25	NC	26	CHANNEL 5 HIGH
27	CHANNEL 5 LOW	28	NC
29	CHANNEL 6 HIGH	30	CHANNEL 6 LOW
31	NC	32	CHANNEL 7 HIGH
33	CHANNEL 7 LOW	34	NC
35	NC	36	NC

NC = NO CONNECTION

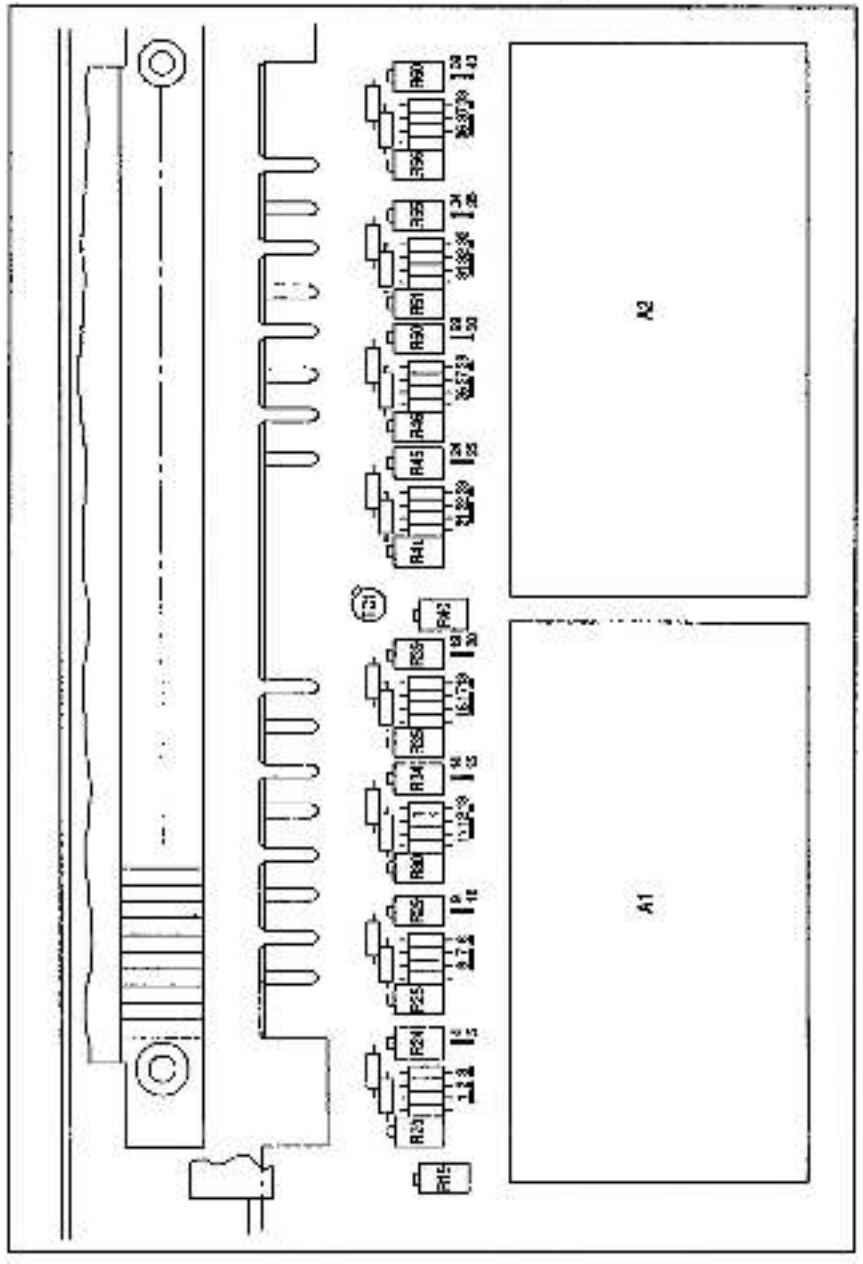
Appendix D

Assembly Drawing



Appendix D

Assembly Drawing (Detail)



Appendix E

Thermocouple Temperature Accuracy (Maximum)

Thermocouple Type	Temperature Range (Degrees C)	Input Voltage Range (mV)	Accuracy (Degrees C)
J	-200 to -100	-7.890 to -4.632	+/-3
	-100 to +760	-4.632 to +42.922	+/-1
K	-200 to -100	-5.891 to -3.553	+/-3
	-100 to +1232	-3.553 to +49.968	+/-1
S	0 to +300	0.000 to +2.323	+/-6
	+300 to +1768	+2.323 to +18.698	+/-3
T	-200 to 0	-5.603 to 0.000	+/-3
	0 to +400	0.000 to +20.869	+/-1
E	-270 to -200	-9.835 to -8.824	+/-10
	-200 to 0	-8.824 to 0.000	+/-3
	0 to +1000	0.000 to +76.358	+/-1
R	0 to +300	0.000 to +2.400	+/-4
	+300 to +1769	+2.400 to +21.108	+/-2
B	+300 to +500	+0.431 to +1.241	+/-5
	+500 to +1000	+1.241 to +4.633	+/-3
	+1000 to +1820	+4.633 to +13.814	+/-2

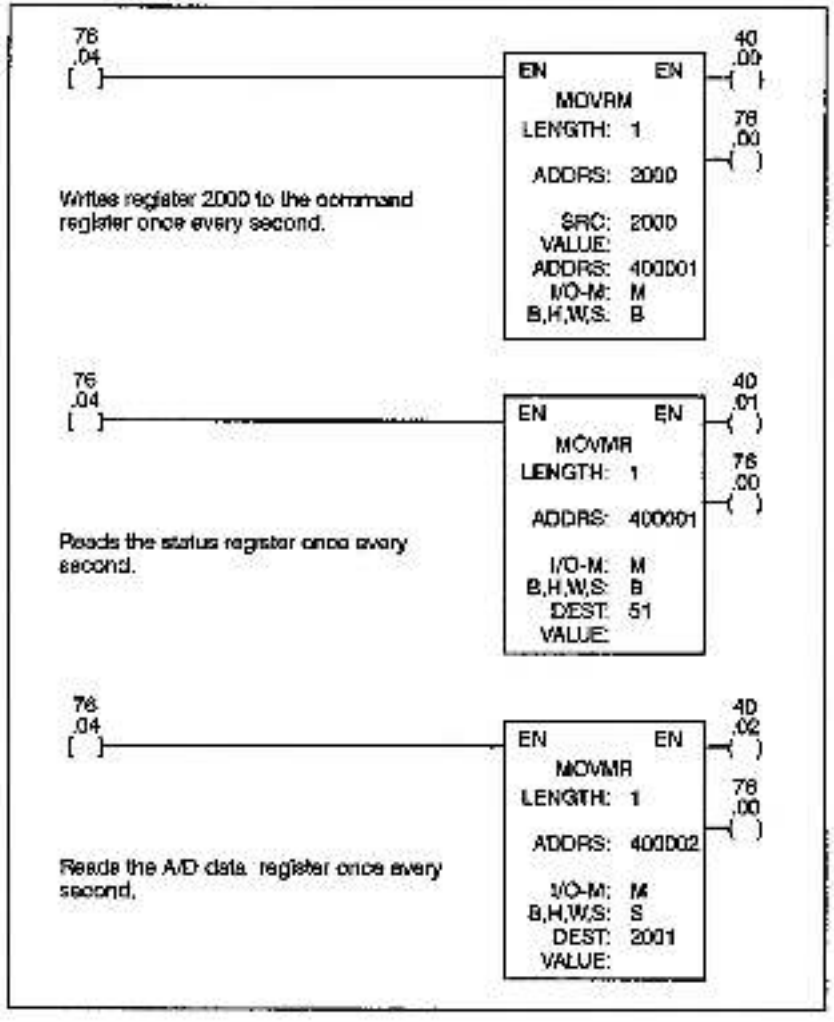
Appendix F

Time and Temperature Related Drift

Thermocouple Type	Time Related Drift (Degrees C/6 Months)	Temperature Related Drift (Degrees C/Degree C)
J	+/-0.2	+/-0.1
K	+/-0.25	+/-0.15
S	+/-1.0	+/-0.3
T	+/-0.25	+/-0.1
E	+/-0.2	+/-0.15
R	+/-0.8	+/-0.3
B	+/-1.0	+/-0.3

Appendix G

AutoMate Calibration Program



Appendix H

AutoMax/DCS 5000 Calibration Program

```
00010  REM TITLE: CAL805.BAS
00020  REM
00030  REM The following program is used to calibrate one 51C805 module
00040  REM at a time. There is no configuration task for this BASIC task.
00050  REM
01000  REM * * * VARIABLE DECLARATION * * *
01010  REM
01020  LOCAL BASE_ADDR                          \ memory mapped address
01030  LOCAL MEM_COM■                           \ memory command
01040  LOCAL RD@                                \ read command
01050  LOCAL WR@                                \ write command
01060  LOCAL SIZE%                              \ size of data to/from module
01070  LOCAL BYTE%                              \ byte length
01080  LOCAL DBYTE%                             \ double byte length
01110  LOCAL TRY1%                              \ # of retries for COMMAND bit not ready
01120  LOCAL TRY2%                              \ # of retries for STATUS bit not ready
01130  LOCAL ERROR%                             \ MONITOR this to check for an error
01140  LOCAL ADDRESS!                           \ variable to module access routine
01150  LOCAL SLOT%                              \                 "
01160  LOCAL DAT%                               \                 "
01170  LOCAL REGISTER%                          \                 "
01180  LOCAL CHANNEL%                           \                 "
01200  LOCAL STS_REG%                           \ status register
01210  LOCAL A2D_REG%                           \ A/D register
01220  LOCAL CMD_REG%                           \ command register
01230  REM
02000  REM * * * VARIABLE INITIALIZATION * * *
02010  REM
02020  BYTE% = 1                                \ byte variable
02030  DBYTE% = 2                               \ double byte variable
02040  RD@ = TRUE                               \ read Boolean
02050  WR@ = FALSE                              \ write Boolean
02060  BASE_ADDR = 20300001                     \ memory mapped boards
02070  TRY1% = 0                                \ clear try1 variable
02080  TRY2% = 0                                \ clear try2 variable
02090  ERROR% = 0                               \ clear error variable
02100  SLOT% = 4                                \ USER DEFINED
02110  CMD_REG% = 0                             \ clear command register variable
02120  REM
02130  REM
10000  REM + + + + + MAIN ROUTINE + + + + +
10010  REM
10020  DELAY 1 SECONDS
10040  REM
10050  REM This routine checks the COMMAND ready bit
10060  REM
10070        REGISTER% = 0                      \ data ready register
10080        MEM_COM%@ = RD@                    \ read command
10090        SIZE% = BYTE%                      \ byte length
10100        TRY1% = 0                          \ clear try1 variable
10110        GOSUB 30000                        \ module access routine
10120        IF (DAT% AND 01H) = 0 THEN 10210   \ is bit #0 set?
10130        TRY1% = TRY1% + 1                  \ increment try1 variable
10140        IF TRY1% > 20 THEN ERROR% = 1 \ GOTO 10210                    &
                                                \ 110 msec timeout (20 ticks)
10160        DELAY 1 TICKS
10170        GOTO 10110
10180  REM
10190  REM This routine writes to the COMMAND register
```

```
10200  REM
10210        REGISTER% = 1                          \ command register
10220        MEM_COM$ = WR$                         \ write command
10230        SIZE% = BYTE%                          \ byte length
10240        DAT% = CMD_REG%                        \ command register variable
10250        GOSUB 30020                            \ module access routine
10260  REM
10270  REM This routine checks the slots READY bit
10280  REM
10290        REGISTER% = 0                          \ data ready register
10300        MEM_COM$ = RD$                         \ read command
10310        SIZE% = BYTE%                          \ byte length
10320        TRY2% = 0                              \ clear try2 variable
10330        GOSUB 30020                            \ module access routine
10340        IF (DAT% AND 80H) = (80H) THEN 10430   \ is bit #7 set?
10350        TRY2% = TRY2% + 1                      \ increment try variable.
10370        IF TRY2% > 20 THEN ERROR% = 2 \ GOTO 10430                    &
                                                    \ 110 msec timeout (20 ticks)
10380        DELAY 1 TICKS
10390        GOTO 10340
10400  REM
10410  REM This routine reads the STATUS register
10420  REM
10430        REGISTER% = 1                          \ status register
10440        MEM_COM$ = RD$                         \ read command
10450        SIZE% = BYTE%                          \ byte length
10460        GOSUB 30020                            \ module access routine
10470        STS_REG% = DAT%                        \ status register variable
10480  REM
10490  REM Reads the A/D register
10500  REM
10510        REGISTER% = 2                          \ data register
10520        MEM_COM$ = RD$                         \ read command
10530        SIZE% = DBYTE%                         \ double byte length
10540        GOSUB 30020                            \ module access routine
10550        A2D_REG% = DAT%                        \ stores temperature in variable
10560        GOTO 10020                             \ continues main routine
10570  REM
30000  REM * * * MODULE ACCESS ROUTINE * * *
30010  REM
30020  ADDRESS1 = BASE_ADD# + (100001 * SLOT%) + REGISTER%        \ derives address
30030  IF MEM_COM$ = WR$ THEN IOWRITE(SIZE%,DAT%,ADDRESS1)        \ module write
30040  IF MEM_COM$ = RD$ THEN DAT% = IOREAD%(SIZE%,ADDRESS1)      \ module read
30050  RETURN
32767  END
```

For additional information
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