FLUKE®

268XA

Data Acquisition System/Data Logging System

Service Manual

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⚠Caution

This is an IEC safety Class 1 product. Before using, the ground wire in the line cord or rear panel binding post must be connect to an earth ground for safety.

Interference Information

This equipment generates and uses radio frequency energy and if not installed and used in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class B computing device in accordance with the specifications of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation.

Operation is subject to the following two conditions:

- This device may not cause harmful interference.
- This device must accept any interference received, including interference that may cause undesired operation.

There is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of more of the following measures:

- Reorient the receiving antenna
- Relocate the equipment with respect to the receiver
- Move the equipment away from the receiver
- Plug the equipment into a different outlet so that the computer and receiver are on different branch circuits

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commission helpful: How to Identify and Resolve Radio-TV Interference Problems. This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402. Stock No. 004-000-00345-4.

SAFETY TERMS IN THIS MANUAL

This device has been designed and tested to meet the requirements of EN61010-1 (Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use). It is an Installation Category II device intended for operation from a normal single phase supply. The DIO relay controls are rated to 250 V ac CAT I and should not be used in applications that exceed that rating. This Users Manual contains information, warnings and cautions. Use of this equipment in a manner not specified herein may impair the protection provided by the equipment.

Measurement category I is for measurements performed on circuits not directly connected to MAINS. Examples are measurements on circuits not derived from MAINS, and specially protected (internal) MAINS derived circuits.

Measurement category II is for measurements performed on circuits directly connected to the low voltage installation. Examples are measurements on household appliances, portable tools and similar equipment.

⚠ **WARNING** statements identify conditions or practices that could result in personal injury or loss of life.

CAUTION statements identify conditions or practices that could result in damage to equipment.

SYMBOLS MARKED ON EQUIPMENT:

WARNING Risk of electric shock.

Ground (earth) terminal.

Protective ground (earth) terminal. Must be connected to safety earth ground when the power cord is used.

Attention. Refer to the manual. This symbol indicates that information about usage of a feature is contained in the manual. This symbol appears on the Universal Input Module and in the following two places on the device rear panel:

1. Ground Binding Post (to the left of the line power connector).
2. Alarm/Trigger I/O and Digital I/O connectors.

AC POWER SOURCE

The device is intended to operate from an ac power source that will not apply more than 264 V ac rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is required for safe operation.

⚠⚠WARNING

Use the proper fuse. To avoid fire hazard, for fuse replacement use only a 1/2 ampere, 250 V time delay line fuse.

DC POWER SOURCE

The device may also be operated from a 9 V to 45 V dc power source when either the rear panel ground binding post or the power cord grounding conductor is connected properly. The input is protected by a 4 ampere fuse internal to the device. This fuse should only be replaced by a qualified Fluke technician.

GROUNDING THE DEVICE

The device utilizes controlled overvoltage techniques that require the device to be grounded whenever normal mode or common mode ac voltages or transient voltages may occur. The enclosure must be grounded through the grounding conductor of the power cord, or if operated on battery with the power cord unplugged, through the rear panel ground binding post.

USE THE PROPER POWER CORD

Use only the power cord and connector appropriate for the voltage and plug configuration in your country.

Use only a power cord that is in good condition.

Refer power cord and connector changes to qualified service personnel.

⚠⚠WARNING

To avoid possible electric shock or damage to the device:

- **Read manual before operating.**
- **Do not position device so that air flow through side vents is restricted.**
- **Do not use in a manner not specified in this manual or safety protection may be impaired.**
- **Disconnect power cord and ALL other inputs before replacing a fuse.**
- **Position the device where power cord can be disconnected.**
- **Do not exceed maximum voltages.**

⚠⚠WARNING

DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES

To avoid personal injury or death, do not remove the device cover without first removing the power source connected to the rear panel. Do not operate the device without the cover properly installed. There is no need for the operator to remove the cover.

DO NOT ATTEMPT TO OPERATE IF PROTECTION MAY BE IMPAIRED

If the device appears damaged or operates abnormally, protection may be impaired. Do not attempt to operate the device under these conditions. Refer all question of proper device operation to qualified service personnel.

DO NOT ATTEMPT TO SERVICE UNLESS YOU ARE A FLUKE QUALIFIED REPAIR TECHNICIAN

To avoid personal injury or death, remove the AC power cord and all analog and digital connector modules before servicing the device.

Note

All signals must be removed from the analog and digital connector wiring before opening the connector modules.

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Chapter 1
Introduction and Specifications

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Introduction

The 268XA Service Manual supports the performance testing, calibration, servicing, and maintenance of the 2680A Data Acquisition System (DAS), the 2686A Data Logging System (DLS) and modules. See Figure 1-1 for a view of the 268XA.

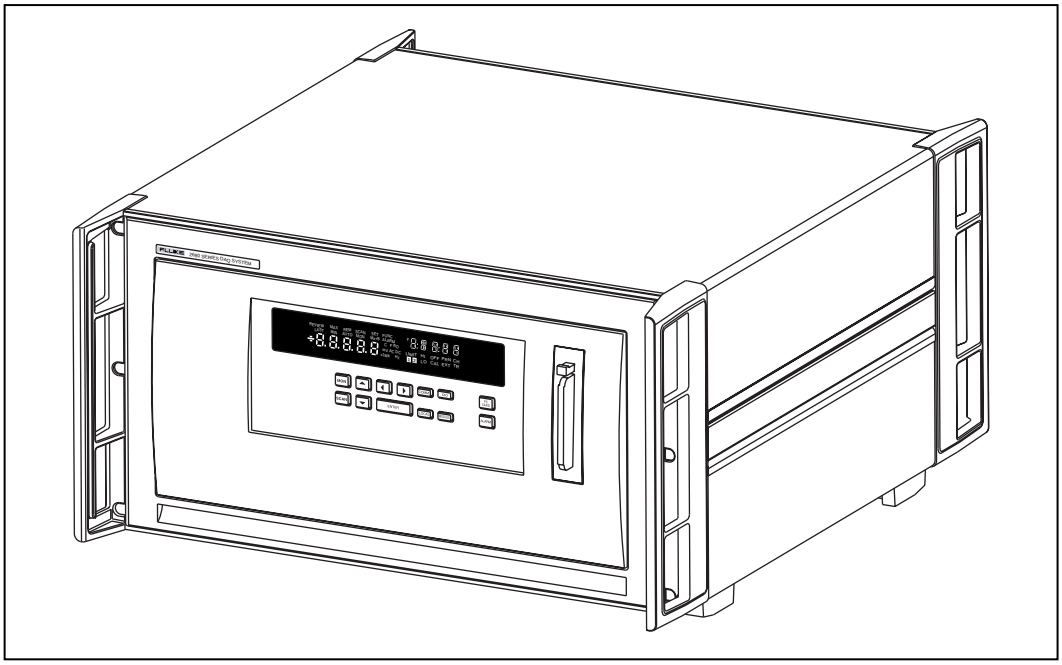
The 2686A comes with a removable PC Card (PCMCIA) for stand-alone storage operation. This socket accepts ATA memory cards up to 2 GB in size.

Each 268XA device can hold from 1 to 6 analog modules. These modules are the Precision Analog module (PAI), Fast Analog module (FAI), and the Digital IO/Relay and Totalizer module (DIO). These modules are all isolated from one another. You can add the DIO module to the device in slot 6 only.

The analog modules measure dc volts, ac volts, ohms, temperature, frequency, and dc current. Temperature measurements use thermocouples, thermistors or resistance temperature detectors (RTDs). The devices also have extensive computed math capability. Besides using data collected from the analog modules and digital totalizer, time can also be used in computed channel calculations.

The system scans 20 to 120 analog channels and calculates the values for up to 60 computed channels. Interval timers, alarm conditions, and/or an external signal input can trigger scans. The Fluke DAQ software configures and controls up to 99 268XA devices via an Ethernet connection. The software provides the means to view scan data and log it into files.

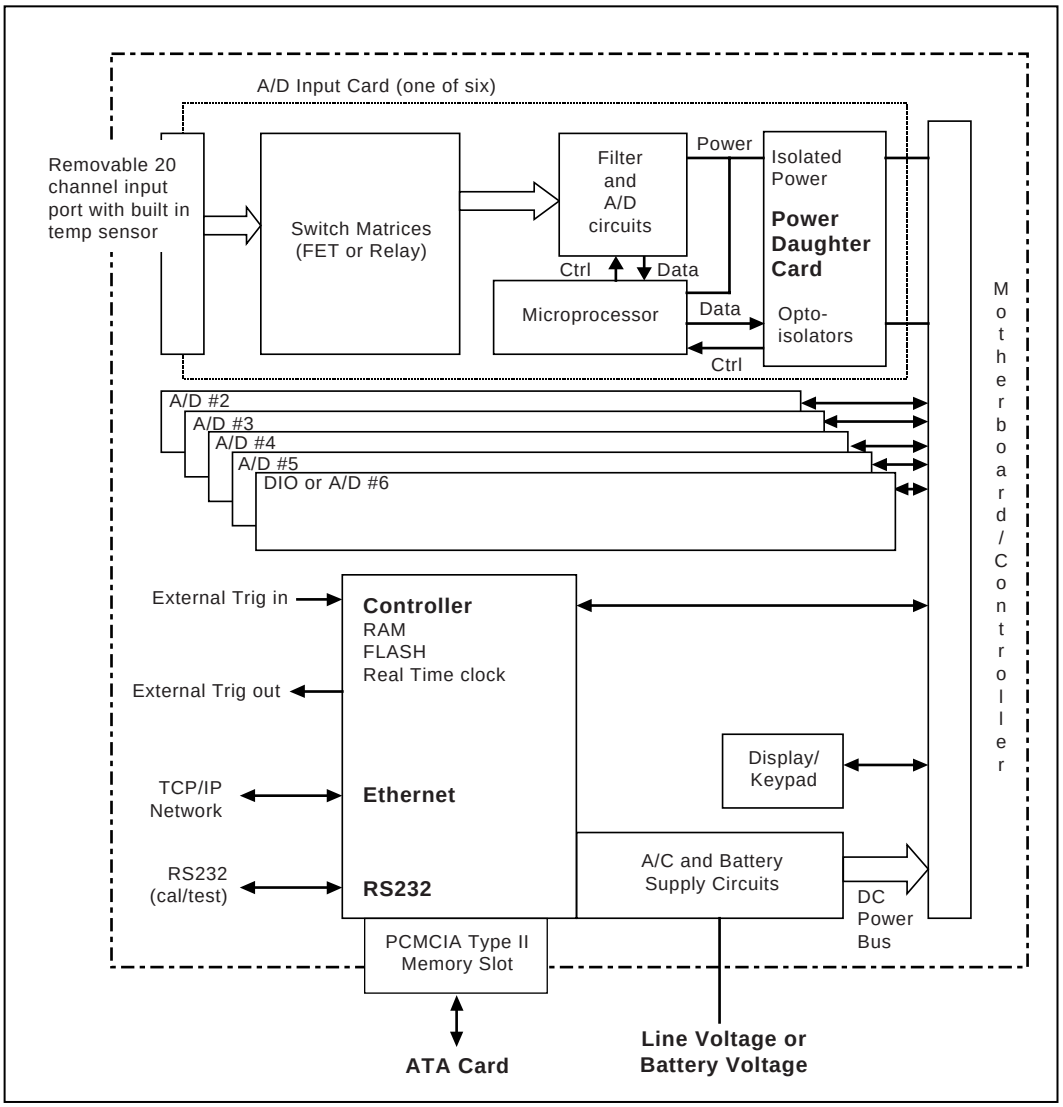
The analog modules that may be used with the 268XA are the FAI module and the PAI module. The PAI modules emphasize precision with 5 ½ digits of resolution, .02% accuracy, and can withstand up to 150 V common mode voltage (300 V on channels 1 and 11). The FAI modules emphasize increased measurement speed with 4 ½ digits of resolution, 0.04% accuracy, and can withstand up to 50 V common mode voltage. Device specifications are provided later in this chapter.



alg46f.eps

Figure 1-1. 2680A/2686A Device

Block Diagrams



alg50f.eps

Figure 1-2. 268XA Chassis

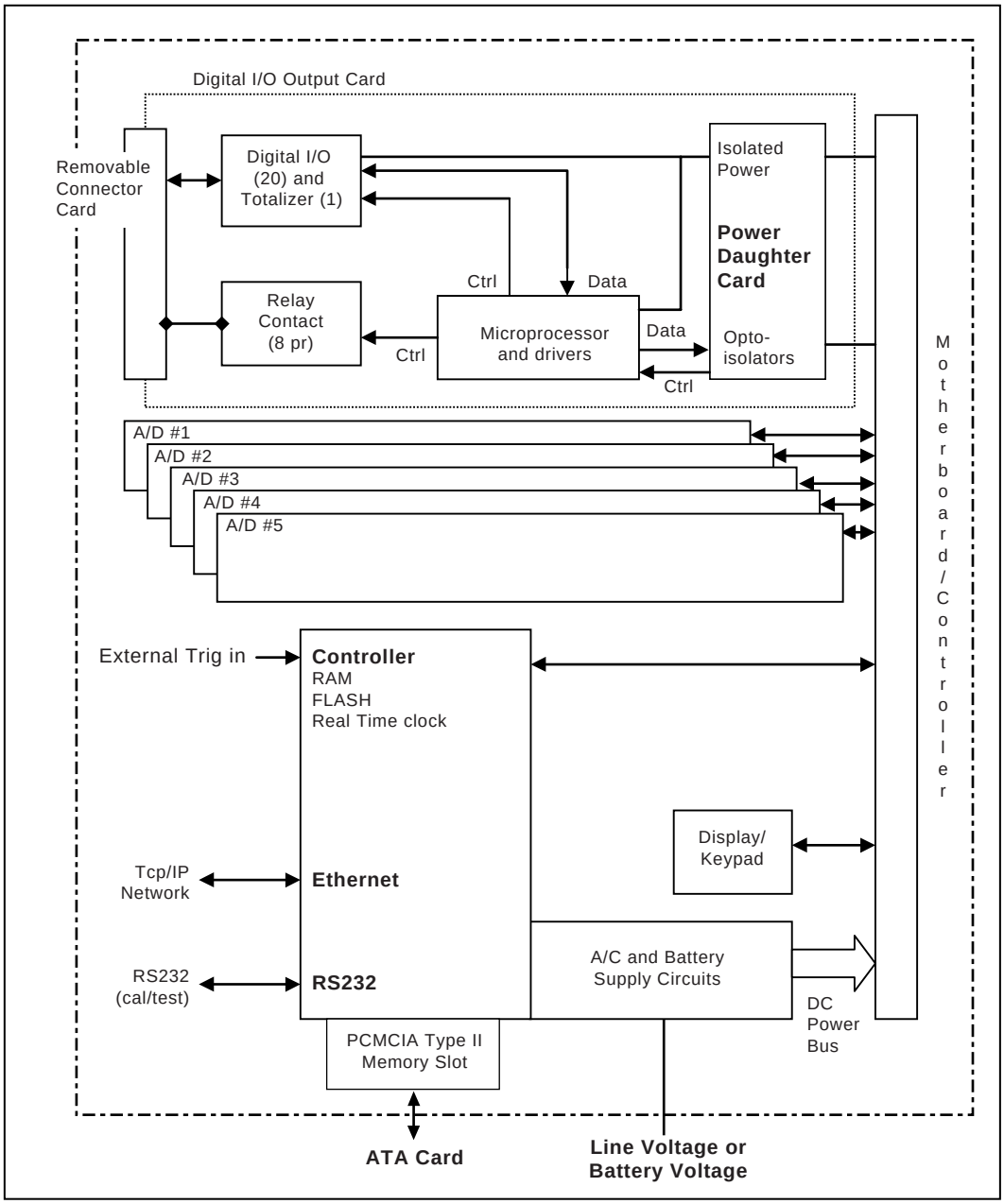


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Figure 1-2. 268XA Chassis (cont)

Specifications

Specifications are divided into four sections. The first section contains the specifications that apply to both the 2680A and 2686A devices. The second section contains specifications that apply only to the Precision A/D Input (PAI) module. The third section contains specifications that apply only to the Fast A/D Input (FAI) module. The last section contains information only for the digital I/O relay and the totalizer (DIO) module.

2680A/2686A Combined Specifications

The following specifications apply to both the 2680A and 2686A devices. The topics include:

- General Specifications
- PAI/FAI Environmental Specifications
- DIO Digital I/O and Totalizer Interface

2680A/2686A General Specifications

Table 1-1 provides the general specifications for the 2680A and 2686A devices.

Table 1-1. 268XA General Specifications

Specification	Characteristic
Input Channel Capacity	Maximum of 120 channels (Precision or Fast Analog Input) per chassis
Optional DIO	20 digital input and outputs channels, 8 double pole-single throw relay channels, a totalizer input, and a totalizer enable input.
Computed Channels	60
Size	473 mm (18.6 in) x 423 mm (17 in) x 237 mm (9.3 in)
Weight	2680A/2686A (empty) 8.5 kg (18.9 lb) 2680A – FAI 0.8 kg (1.8 lb) 2680A – PAI 1.2 kg (2.7 lb) 2680A – DIO 0.8 kg (1.8 lb)
Power	100 – 240 V ac (no switching required), 50 to 60 Hz, 100 VA maximum or optional 9 V dc to 45 V dc, 35 W maximum
EMC	EN50082-2 EN55022-1 EN55011 class A EN610000-4-2,3,4,6,8 EN61326
Safety	EN61010-1, CAT II (DIO is rated CAT I) CSA C22.2 No. 1010.1
Serial Interface	Connector: 9 pin male (DB9) Signals: Tx, Rx, DTR, RTS, GND Modem Control: full duplex Baud rates: 4800, 9600, 19200, 38400 (19,200 default) Data format: 8 data bits, no parity, one stop bit Flow Control: XON/XOFF Echo: off
Common Mode Voltage	Precision Analog Input: 150 (300 on channels 1 and 11) Fast Analog Input: 50 V dc or 30 V ac rms
Operating Temperature Range	-20 °C to 60 °C (-4 °F to +140 °F)
Storage Temperature Range	-40 °C to 70 °C (-40 °F to +158 °F)
Relative Humidity	90% maximum for -10 °C to 28 °C (14 °F to +82 °F) 75% maximum for 28 °C to 35 °C (82 °F to +95 °F) 50% maximum for 35 °C to 60 °C (95 °F to +140 °F) (3 MΩ range, reduce humidity rating by 25% for 1 hour warm-up. 3 MΩ range meets full humidity ratings with 2 hour warm-up)
Altitude	Operating: 2,000 m (6,561 ft) maximum Non-operating: 12,200 m (40,000 ft) maximum
Warm-up Time	1 hour to rated specifications -or- 15 minutes if relative humidity (non-condensing) is 50% or less.

Real-Time Clock and Calendar

The next table provides a summary of the battery powered real-time clock and calendar.

Table 1-2. 268X Real-Time Clock and Calendar

Specification	Characteristic
Accuracy	1 minute per month for 0 °C to 50 °C range
Battery Life	>5 unpowered device years for 20 °C to 28 °C (68 °F to 82.4 °F).

Trigger In Specifications

The following table provides a summary of the Trigger In specifications. The Trigger In input is located on the rear panel connector, terminals Trigger In and Signal GND.

Table 1-3. Trigger In Specification

Specification	Characteristic
Logical High - Trigger not set	Minimum: 2.0 V Maximum: 7.0 V
Logical Low - Trigger set	Minimum: -0.6 V Maximum: +0.8 V
Compatibility	TTL or Contact Closure
Isolation	None (dc coupled)
Minimum Pulse Width	5 µs
Maximum Frequency	Nominal 400 Hz
Repeatability	3 ms

Trigger Out Specifications

The next table provides a summary of the Trigger Out specifications. The Trigger Out output is located on the rear panel connector, terminals Trigger Out and Signal GND.

Table 1-4. Trigger Out Specification

Specification	Characteristic
TTL Logical Zero - Trigger Out Set	0.8 V maximum for an Iout of -1.0 mA (1 LSTTL load)
TTL Logical One - Trigger Out Not Set	3.8 V minimum for an Iout of 0.05 mA (1 LSTTL load)
Non-TTL Logical Zero - Trigger Out Set	1.8 V maximum for an Iout of -20 mA
Non-TTL Logical One - Trigger Out Not Set	3.25 V minimum for an Iout of -50 mA
Pulse Duration (Logic Low)	125 µs
Isolation	None

Master Alarm Output Specification

The following specifications cover the Master Alarm output. The Master Alarm output is located on the rear panel connector, terminals Master Alarm, and Signal GND.

Table 1-5. Master Alarm Output Specification

Specification	Characteristic
Output Voltage - TTL Logical Zero	0.8 V maximum for an Iout of -1.0 mA (1 LSTTL load)
Output Voltage - TTL Logical One	3.8 V minimum for an Iout of 0.05 mA (1 LSTTL load)
Output Voltage - Non-TTL Load Zero	1.8 V maximum for an Iout of -20 mA
Output Voltage - Non-TTL Load One	3.25 V minimum for an Iout of -50 mA

Communication I/O

Communication with 268XA devices can be accomplished through either a 10/100BaseT interface or through an RS-232 port. The 10/100BaseT provides the primary communication interface. The RS-232 is used for calibration and limited debug capability.

2686A PC Card Storage

The 2686A supports a non-volatile PC Card (PCMCIA ATA type card) memory module option. This table provides a list of active channels and the number of scans to memory card capacity. The standard Controller card will store approximately 600,000 readings.

Table 1-6. 2686A - Active Channels and Number of Scans to Card Capacity

Memory Card/ Active Channels	20 ch	40 ch	60 ch	80 ch	100 ch	120 ch
16 MB	100,548	66,765	50,074	40,059	33,382	28,613
128 MB	800,000	528,000	400,000	320,000	264,000	224,000
256 MB	1.6 M	1.056 M	800,000	640,000	528,000	448,000
512 MB	3.2 M	2.112 M	1.6 M	1.28 M	1.056 M	896,000
1 GB	6.2 M	4.224 M	3.2 M	2.56 M	2.112 M	1.792 M
Estimating space: 80 bytes/scan + 4 bytes/channel scanned (allow 4.5% overhead for card formatting)						

Precision Analog Input (PAI) A/D Specifications

This section includes specifications specific to the PAI A/D instrument by measurement function.

Specifications PAI A/D DC Voltage Measurement

The following tables provide PAI A/D specifications for the dc voltage measurement function.

Table 1-7. PAI A/D DC Voltage General Specifications

Specification	Characteristic
Input Impedance	100 MΩ in parallel with 300 pF maximum for ranges <=3 V 10 MΩ in parallel with 100 pF maximum for ranges >3 V
Normal Mode Rejection	50 dB minimum at 50 Hz/60 Hz ±0.1%, Slow Rate
Common Mode Rejection	120 dB minimum at dc, 50 Hz/60 Hz ±0.1%, 1 kΩ imbalance, Slow Rate 80 dB minimum at dc, 50 Hz/60 Hz ±0.1%, 1 kΩ imbalance, Medium and Fast Rates
Channel-to-Channel Cross talk	120 dB minimum Slow Rate (e.g., 30 V dc on channel 1 may cause a 30 μV error on channel 2) 100 dB minimum Medium and Fast Rates (e.g., 1V dc on channel 1 may cause a 10 μV error on channel 2)
Temperature Coefficient	For % input: Add 1/10th the 90-day specification per °C above 28 °C or below 18 °C For floor error (V): Add 1/20th the 90-day specification per °C above 28 °C or below 18 °C
Accuracy at -20 °C	Multiply the -10 °C to +60 °C accuracy specification by 2. After 1 hour warm-up. For accurate between -10 °C and -20 °C, interpolate linearly.
Maximum Input Voltage	The lesser voltage of: 300 V from any terminal on channels 1 and 11 to earth; 150 V from any terminal on channels 2 through 10, and 12 through 20 to earth; 300 V from any terminal on channels 1 and 11 to any other terminal; 150 V from any terminal on channels 2 through 10, and 12 through 20 to any other input terminal

Table 1-8. PAI A/D DC Voltage Range and Resolution Specifications

Range	Resolution	
	Slow	**Fast**
90 mV	0.3 µV	1 µV
300 mV	1 µV	3 µV
3 V	10 µV	30 µV
30 V	100 µV	300 µV
150/300 V	1 mV	3 mV
Note 300 V range applies to channels 1 and 11 only.		

Table 1-9. PAI A/D DC Voltage Accuracy Specifications

Range	Accuracy, 3σ ± (% input + V)					
	18 °C to 28 °C				-10 °C to 60 °C	
	90 Day		1 Year		1 Year	
	Slow	**Fast**	**Slow**	**Fast**	**Slow**	**Fast**
90 mV	.01%+7 µV	.01%+17 µV	.013%+8 µV	.013%+18 µV	.042%+18.2 µV	.042%+44.2 µV
300 mV	.01%+15 µV	.01%+30 µV	.013%+17 µV	.013%+35 µV	.042%+39 µV	.042%+78 µV
750 mV*	.01%+40 µV	.01%+70 µV	.013%+50 µV	.013%+80 µV	.042%+104 µV	.042%+182 µV
3 V	.01%+0.1 mV	.01%+0.2 mV	.013%+0.15 mV	.013%+0.2 mV	.042%+0.26 mV	.042%+0.52 mV
30 V	.01%+1.5 mV	.02%+3 mV	.013%+1.7 mV	.026%+3.5 mV	.042%+3.9 mV	.084%+7.8 mV
150/300 V*	.01%+15 mV	.04%+30 mV	.013%+17 mV	.052%+35 mV	.042%+39 mV	.168%+78 mV
* 300 V range applies to channels 1 and 11 only.						

PAI A/D AC Voltage Measurement Specifications

The following tables provide PAI A/D specifications for the ac voltage measurement function.

Table 1-10. PAI A/D AC Voltage General Specifications

Specification	Characteristic
Input Impedance	1 MΩ in parallel with 100 pF
Maximum Crest Factor	3.0 Maximum 2.0 for rated accuracy
Crest Factor Error	For nonsinusoidal input signals with crest factors between 2 and 3 and pulse widths >=100 μs, add 0.2% to the accuracy specifications.
Common Mode Rejection	80 dB minimum at dc, 50 Hz/60 Hz ±0.1%, 1 kΩ imbalance, Slow Rate
Maximum Input Voltage	The lesser voltage of: 300 V ac rms from any terminal on channels 1 and 11 to earth. 150 V ac rms from any terminal on channels 2 through 10, and 12 through 20 to earth. 300 V ac rms from any terminal on channels 1 and 11 to any other terminal. 150 V ac rms from any terminal on channels 2 through 10 and 12 through 20 to any other input terminal.
Maximum Volt-Hertz Product	$2x10^6$ Volt-Hertz product on any range, normal mode input. $1x10^6$ Volt-Hertz product on any range, common mode input.
Temperature Coefficient	Linear interpolation between 2 applicable points for temperatures between 28 °C and 60 °C, or -10 °C and 18 °C, e.g., if the applicable specification at 28 °C is 2% and the specification at 60 °C is 3%, then the specification at 40 °C is (3%-2%)x(40-28)/(60-28)+2%=2.375%.
Accuracy at -20 °C	Multiply the -10 °C to +60 °C accuracy specification by 2. After 1 hour warm-up. For accuracy between -10 °C and -20 °C, interpolate linearly.
DC Component Error	The presence of a dc voltage will cause an indeterminate error in the reading of the ac voltage on the input.

Table 1-11. PAI A/D AC Voltage Range and Resolution Specifications

Range	Resolution		Minimum Input for
	Slow	Fast	Rate Accuracy
Full Scale	±30,000	±3,000	
300 mV	10 μV	100 μV	20 mV
3 V	100 μV	1 mV	200 mV
30 V	1 mV	10 mV	2 V
150/300 V	10 mV	100 mV	20 V
Note 300 V range applies to channels 1 and 11 only.			

Table 1-12. PAI A/D AC Voltage Accuracy Specifications

Range	Frequency	1 Year Accuracy ± (%input + V) [1]			
		18 °C to 28 °C		-10 °C to 60 °C	
		Slow	Fast	Slow	Fast
300 mV	20 to 50 Hz	3%+.25 mV	6%+.5 mV	3.5%+.25 mV	7%+.5 mV
	50 to 150 Hz	0.4%+.25 mV	1%+.5 mV	0.5%+.25 mV	1.5%+.5 mV
	150 Hz to 10 kHz	0.3%+.25 mV	1%+.5 mV	0.4%+.25 mV	1.5%+.5 mV
	10 kHz to 20 kHz	0.4%+.25 mV	1%+.5 mV	0.7%+.25 mV	1.5%+.5 mV
	20 kHz to 50 kHz	2%+.3 mV	3%+.5 mV	3%+.3 mV	4%+.5 mV
	50 kHz to 100 kHz	5%+.5 mV	5%+1 mV	7%+.5 mV	8%+1 mV
3 V	20 to 50 Hz	3%+2.5 mV	6%+5 mV	3.5%+2.5 mV	7%+5 mV
	50 to 150 Hz	0.4%+2.5 mV	1%+5 mV	0.5%+2.5 mV	1.2%+5 mV
	150 Hz to 10 kHz	0.3%+2.5 mV	1%+5 mV	0.4%+2.5 mV	1.2%+5 mV
	10 kHz to 20 kHz	0.4%+2.5 mV	1%+5 mV	0.5%+2.5 mV	1.2%+5 mV
	20 kHz to 50 kHz	1%+3 mV	1.5%+6 mV	1.5%+3 mV	2%+6 mV
	50 kHz to 100 kHz	2%+5 mV	3%+10 mV	3%+5 mV	4%+10 mV
30 V	20 to 50 Hz	3%+25 mV	6%+50 mV	3.5%+25 mV	7%+50 mV
	50 to 150 Hz	0.4%+25 mV	1%+50 mV	0.5%+25 mV	1.2%+40 mV
	150 Hz to 10 kHz	0.3%+25 mV	1%+50 mV	0.5%+25 mV	1.2%+40 mV
	10 kHz to 20 kHz	0.4%+25 mV	1%+50 mV	0.5%+25 mV	1.2%+40 mV
	20 kHz to 50 kHz	1%+30 mV	1.5%+60 mV	1%+30 mV	2%+50 mV
	50 kHz to 100 kHz, V<20V	2%+50 mV	3%+100 mV	2.5%+50 mV	4%+100 mV
150/300 V	20 to 50 Hz	3%+.25 V	6%+.5 V	3.5%+.25 V	7%+.5 V
	50 to 150 Hz	0.4%+.25 V	1%+.5 V	0.5%+.25 V	1.2%+.4 V
	150 Hz to 2 kHz Vx Hz<2 x10^6	0.3%+.25 V	1.2%+.5 V	0.5%+.25 V	1.4%+.4 V
	2 kHz to 20 kHz, V<100V	0.4%+.25 V	1.6%+.5 V	0.5%+.25 V	1.8%+.4 V
	20 kHz to 50 kHz, V<40V	1%+.30 V	2.0%+.6 V	1.2%+.30 V	2.5%+.5 V
[1] Sinewave inputs>6% of scale and signals with crest factors <2.					

PAI A/D 4-Wire Resistance Measurement Specifications

The following tables provide PAI A/D specifications for the 4-wire resistance measurement function. The 4-wire measurements use 2 input channels a decade apart, e.g., channels 4 and 14.

Table 1-13. PAI A/D 4-Wire Resistance Temperature Coefficient

Specification	Characteristic
Temperature Coefficient	Add 1/10th the 90 day specification per °C above 28 °C or below 18 °C.
Accuracy at -20 °C	Multiply the -10 °C to +60 °C accuracy specification by 2. After 1 hour warm-up. For accuracy between -10 °C and -20 °C, interpolate linearly.

Table 1-14. PAI A/D 4-Wire Resistance Range and Resolution Specifications

	Resolution		Current Applied	Full Scale Voltage	Maximum Voltage Applied by Instrument
Range	Slow	Fast			
300 Ω	1 mΩ	3mΩ	1 mA	300 mV	3.5 V
3 kΩ	10 mΩ	30 mΩ	100 μA	300 mV	3.5 V
30 kΩ	100 mΩ	300 mΩ	10 μA	300 mV	3.5 V
300 kΩ	1 Ω	3 Ω	10 μA	3.0 V	3.5 V
3 MΩ	10 Ω	30 Ω	1 μA	3.0 V	3.5 V

Table 1-15. PAI A/D 4-Wire Resistance Accuracy Specifications

Range	Accuracy, 3σ ± (% input + V)					
	18 °C to 28 °C				-10 °C to 60 °C	
	90 Day		1 Year		1 Year	
	Slow	Fast	Slow	Fast	Slow	Fast
300 Ω	.015%+20 mΩ	.02%+80 mΩ	.02%+50 mΩ	.02%+120 mΩ	.084%+126 mΩ	.084%+336 mΩ
3 kΩ	.02%+.3 Ω	.02%+.8 Ω	.02%+.5 Ω	.02%+1.2 Ω	.084%+1.26 Ω	.084%+3.36 Ω
30 kΩ	.03%+3 Ω	.04%+10 Ω	.03%+5 Ω	.04%+15 Ω	.126%+12.6 Ω	.168%+42 Ω
300 kΩ	.1%+40 Ω	.2%+100 Ω	.1%+60 Ω	.2%+150 Ω	.42%+168 Ω	.84%+420 Ω
3 MΩ [1]	.25%+800 Ω	.5%+10 kΩ	.25%+1 kΩ	.5%+1.5 kΩ	1.05%+3.36 kΩ	2.1%+4.2 kΩ

[1] The 3 MΩ range is susceptible to the absorption of humidity under extreme conditions. If the instrument is operated normally within its specified temperature-humidity range, the 3 MΩ range meets its accuracy specifications. However, if the instrument is "soaked" at 50 °C, 90% relative humidity, the 3 MΩ range may require 1 hour of "dry-out" time at 25 °C, <40% relative humidity for each hour of soak time in order to achieve its specified accuracy.

PAI A/D 2-Wire Resistance Measurement Specifications

The PAI A/D specifications for the two-wire resistance measurement function is based on the four-wire resistance measurement specification (above) except you add a nominal 5 Ω (10 Ω maximum) positive offset. This value varies for each channel and with temperature (nominal +1%/ºC).

PAI A/D 4-Wire RTD per ITS-1990 Measurement Specifications

The following tables provide PAI A/D specifications for the 4-wire Resistance-Temperature Detector (RTD) measurement function. The 4-wire measurements use 2 input channels a decade apart, e.g., channels 4 and 14.

Table 1-16. PAI A/D 4-Wire RTD Temperature Coefficient

Specification	Characteristic
Temperature Coefficient	To calculate RTD accuracy for temperatures between 28 °C and 60 °C, or -10 °C and 18 °C, use a linear interpolation between the two applicable points. For example, if the applicable specification at 28 °C is 0.2 and the specification at 60 °C is 0.75, then the specification at 40 °C is =(.75-.2)x(40-28)/(60-28)+.2=0.406.
Accuracy at -20 °C	Multiply the -10 °C to +60 °C accuracy specification by 2. After 1 hour warm-up. For accuracy between -10 °C and -20 °C, interpolate linearly.

Table 1-17. PAI A/D 4-Wire RTD Specifications

Temperature	Resolution		Accuracy, 3σ				
			90 Day 18 °C to 28 °C		1 Year 18 °C to 28 °C	1 Year –10 °C to 60 °C	
	Slow	Fast	Slow	Fast	Slow	Slow	Fast
-200 °C	0.003 °C	0.007 °C	0.06 °C	0.16 °C	0.09 °C	0.33 °C	0.63 °C
0 °C	0.003 °C	0.007 °C	0.09 °C	0.20 °C	0.13 °C	0.53 °C	0.86 °C
100 °C	0.003 °C	0.007 °C	0.10 °C	0.23 °C	0.16 °C	0.63 °C	0.97 °C
300 °C	0.003 °C	0.007 °C	0.14 °C	0.30 °C	0.21 °C	0.83 °C	1.20 °C
600 °C	0.003 °C	0.007 °C	0.19 °C	0.53 °C	0.30 °C	1.20 °C	1.60 °C

PAI A/D 2-Wire RTD per ITS-1990 Measurement Specifications

The PAI A/D specifications for the two-wire Resistance Temperature Detector (RTD) measurement function is based on the four-wire RTD measurement specification (above) except you add a nominal 5 Ω (approximately 13 °C) positive offset. This value varies for each channel and temperature gradient (nominal +1%/ºC). Also note that the resistance of the RTD wiring adds directly to the error. After 100 million operations of a measurement channel, the offset will increase at an indeterminate rate.

PAI A/D Thermocouple per ITS-1990 Measurement Specifications

The following tables provide PAI A/D specifications for the thermocouple measurement function per ITS-1990.

Table 1-18. PAI A/D Thermocouple General Specifications

Specification	Characteristic
Input Impedance	100 MΩ minimum in parallel with 300 pF
Open Thermocouple Detect	Operates by injecting a small ac signal into the input after each measurement. A thermocouple resistance greater than 1k to 10k is detected as an open input.
Temperature Coefficient	To calculate Thermocouple accuracy for temperatures between 28 °C and 60 °C, or -10 °C and 18 °C, use a linear interpolation between the two applicable points. For example, if the applicable specification at 28 °C is 0.6 and the specification at 60v°C is 1.1, then the specification at 40v°C is =(1.1-0.6)x(40-28)/(60-28)+0.6=0.7875.
Accuracy at -20 °C	Multiply the -10 °C to +60 °C accuracy specification by 2. After 1 hour warm-up. For accuracy between -10 °C and -20 °C, interpolate linearly.

Table 1-19. PAI A/D Thermocouple Specifications

Thermocouple ITS90		Resolution °C	Accuracy ± °C				
			18 °C to 28 °C			-10 °C to 60 °C	
			90 Day	1 Year		1 Year	
Type	Temperature °C		Slow	Slow	Fast	Slow	Fast
B	600 to 900	0.2	1.20	1.40	3.10	1.50	3.20
	900 to 1200	0.2	0.90	1.00	2.20	1.20	2.40
	1200 to 1820	0.1	0.75	1.00	1.90	1.30	2.20
C	0 to 150	0.2	0.80	0.90	1.60	1.00	1.70
	150 to 650	0.1	0.65	0.75	1.40	1.00	1.50
	650 to 1000	.05	0.65	0.85	1.40	1.20	1.80
	1000 to 1800	.05	1.00	1.30	2.10	2.10	2.80
	1800 to 2316	.05	1.60	2.10	3.20	3.40	4.60
E	-100 to –25	.03	0.45	0.50	0.80	0.60	0.80
	-25 to 20	.02	0.35	0.40	0.60	0.50	0.70
	20 to 600	.02	0.30	0.40	0.60	0.50	0.80
	600 to 1000	.02	0.40	0.50	0.70	0.90	1.00
J	-100 to 80	.03	0.45	0.50	0.80	0.60	0.80
	80 to 230	.02	0.35	0.50	0.70	0.60	0.80
	230 to 760	.02	0.40	0.50	0.70	0.80	0.90
K	-100 to –25	.04	0.55	0.60	0.90	0.70	1.00
	-25 to 120	.03	0.40	0.50	0.80	0.60	0.90
	120 to 800	.03	0.50	0.65	0.90	1.00	1.20
	800 to 1372	.03	0.70	1.00	1.30	1.60	1.90
L	-100 to 100	.04	0.90	1.00	2.00	1.30	2.00
	100 to 800	.04	0.50	0.90	1.40	1.20	1.70
	800 to 900	.03	0.50	0.70	1.10	1.30	1.50

Table 1-19. PAI A/D Thermocouple Specifications (cont.)

Thermocouple ITS90		Resolution °C	Accuracy ± °C				
			18 °C to 28 °C			-10 °C to 60 °C	
			90 Day	1 Year		1 Year	
Type	Temperature °C		Slow	Slow	Fast	Slow	Fast
N	-100 to –25	.05	0.65	0.75	1.20	0.80	1.30
	-25 to 120	.05	0.55	0.60	1.00	0.70	1.10
	120 to 1000	.04	0.45	0.60	0.90	1.00	1.20
	1000 to 1300	.03	0.55	0.75	1.00	1.20	1.50
R	250 to 600	0.1	0.90	1.00	2.10	1.20	2.20
	600 to 1500	0.1	0.80	0.90	1.80	1.30	2.00
	1500 to 1767	0.1	0.85	0.85	1.90	1.70	2.50
S	250 to 1000	0.1	0.95	1.10	2.30	1.30	2.40
	1000 to 1400	0.1	0.80	1.00	1.90	1.40	2.30
	1400 to 1767	0.1	1.00	1.30	2.20	1.80	2.80
T	-100 to 0	.04	0.60	0.65	1.00	0.70	1.10
	0 to 150	.03	0.40	0.50	0.80	0.60	0.90
	150 to 400	.02	0.30	0.40	0.60	0.60	0.80
U	-100 to 0	.04	1.50	1.50	2.60	1.60	3.00
	0 to 600	.04	0.60	0.80	1.60	1.10	1.90

Thermistor

		Accuracy ± °C		
		90 Day	1 Year	
Temp °C	Range*	Slow	Slow	
-40 to 150	100 to 100 mΩ	0.3	0.4	18 to 23 °C

Steinhart – Hart Equation: $1/(T\ ^{o}\text{Kelvin}) = A + B*(\ln \Omega) + C*(\ln \Omega)^3$

Default constants are supplied only for a YSI (type 004) 2,252 Ω thermistor, you can enter constants for other thermistors. The ranges of thermistor constants are as follows: A 1.0E-4 to 1.0E-2, B 1.0E-5 to 1.0E-3, and C 1.0E-8 to 1.0E-6.

*Assumes 4-wire measurement for thermistor resistance values below 2 kΩ (above 28 °C for a 2.252 kΩ thermistor).

PAI A/D Frequency Measurement Specifications

The following tables provide PAI A/D specifications for the frequency measurement function.

Table 1-20. PAI A/D Frequency Accuracy Specifications

Range	Frequency Measurement Accuracy, 1 Year, -10 °C to 60 °C			
	Resolution		Accuracy ± (% input + Hz)	
	Slow	Fast	Slow	Fast
15 Hz to 900 Hz	0.01 Hz	0.1 Hz	0.05%+0.02 Hz	0.05%+0.2 Hz
900 Hz to 9 kHz	0.1 Hz	1 Hz	0.05%+0.1 Hz	0.05%+1 Hz
9 kHz to 90 kHz	1 Hz	10 Hz	0.05%+1 Hz	0.05%+10 Hz
90 kHz to 900 kHz	10 Hz	100 Hz	0.05%+10 Hz	0.05%+100 Hz
1 MHz	100 Hz	1 kHz	0.05%+100 Hz	0.05%+1 kHz

Table 1-21. PAI A/D Frequency Sensitivity Specifications

Frequency Measurement Sensitivity (Sinewave)		
Frequency Range	**Minimum Signal**	**Maximum Signal**
15 Hz to 70 kHz	100 mV ac rms	V<150/300 V rms [1] and Vx Hz<$2x10^6$)
70 kHz to 100 kHz	100 mV ac rms	20 V ac rms
100 kHz to 200 kHz	150 mV ac rms	10 V ac rms
200 kHz to 300 kHz	150 mV ac rms	7 V ac rms
300 kHz to 1 MHz	Linearly increasing from 150 mV ac rms at 300 kHz to 2 V ac rms at 1 MHz	Linearly decreasing from 7 V ac rms at 300 kHz to 2 V ac rms at 1 MHz
[1] 300 V range applies to channels 1 and 11 only.		

Fast Analog Input (FAI) A/D Specifications

This section includes specifications specific to the FAI A/D instrument by measurement function.

FAI A/D DC Voltage Measurement Specifications

The following tables provide FAI A/D specifications for the dc voltage measurement function.

Table 1-22. FAI A/D DC Voltage General Specifications

Specification	Characteristic
Input Impedance	100 MΩ in parallel with 300 pF maximum for ranges <=3 V 10 MΩ in parallel with 100 pF maximum for ranges >3 V
Normal Mode Rejection	50 dB minimum at 50 Hz/60 Hz ±0.1%, Slow Rate
Common Mode Rejection	120 dB minimum at dc, 50 Hz/60 Hz ±0.1%, 1 kΩ imbalance, Slow Rate 80 dB minimum at dc, 60 dB at 50 Hz/60 Hz ±0.1%, 1 kΩ imbalance, Medium and Fast Rates
Channel-to-Channel Crosstalk	120 dB minimum Slow Rate (e.g., 30 V dc on channel 1 may cause a 30 µV error on channel 2) 80 dB minimum Medium and Fast Rates (e.g., 1 V dc on channel 1 may cause a 10 µV error on channel 2)
Temperature Coefficient	For % input: Add 1/10th the 90-day specification per °C above 28°C or below 18°C. For floor error (V): Add 1/20th the 90-day specification per °C above 28 °C or below 18 °C.
Accuracy at -20 °C	Multiply the -10 °C to +60 °C accuracy specification by 2. After 1 hour warm-up. For accurate between -10 °C and -20 °C, interpolate linearly.
Maximum Input Voltage	The lesser voltage of: 50 V dc or 30 V ac rms from any input terminal to earth -or- 50 V dc or 30 V ac rms from any input terminal to any other input terminal

Table 1-23. FAI A/D DC Voltage Resolution and Repeatability Specifications

Range	Resolution	
	Slow	Fast
90 mV	3 µV	6 µV
300 mV	1 µV	3 µV
3 V	10 µV	30 µV
30 V	100 µV	300 µV
50 V	1 mV	3 mV

Table 1-24. FAI A/D DC Voltage Accuracy Specifications

Range	Accuracy, 3σ ± (% input + V)					
	18 °C to 28 °C				-10 °C to 60 °C	
	90 Day		1 Year		1 Year	
	Slow	Fast	Slow	Fast	Slow	Fast
90 mV	.01%+20 µV	.01%+50 µV	.013%+23 µV	.013%+50 µV	.042%+52 µV	.042%+130 µV
300 mV	.01%+40 µV	.01%+90 µV	.013%+49 µV	.013%+93 µV	.042%+104 µV	.042%+234 µV
3 V	.01%+.3 mV	.01%+.6 mV	.013%+.38 mV	.013%+.64 mV	.042%+.78 mV	.042%+1.56 mV
30 V	.01%+4 mV	.02%+8 mV	.013%+4.9 mV	.026%+9.5 mV	.042%+10.6 mV	.084%+20.3 mV
50 V	.01%+30 mV	.04%+60 mV	.013%+40 mV	.052%+64 mV	.042%+78 mV	.168%+156 mV

FAI A/D AC Voltage Measurement Specifications

The following tables provide FAI A/D specifications for the ac voltage function.

Table 1-25. FAI A/D AC Voltage General Specifications

Specification	Characteristic
Input Impedance	1 MΩ in parallel with 100 pF
Maximum Crest Factor	3.0 maximum; 2.0 for rated accuracy
Crest Factor Error	For nonsinusoidal input signals with crest factors between 2 and 3 and pulse widths >=100 µs, add 0.2% to the accuracy specifications.
Common Mode Rejection	80 dB minimum at dc, 50 Hz/60 Hz ±0.1%, 1 kΩ imbalance, Slow Rate
Maximum Input Voltage	The lesser voltage of: 30 V ac rms from any input terminal to earth. 30 V ac rms from any terminal input to any other input terminal.
Maximum Volt-Hertz Product	$2x10^6$ Volt-Hertz product on any range, normal mode input. $1x10^6$ Volt-Hertz product on any range, common mode input.
Temperature Coefficient	Linear interpolation between 2 applicable points for temperatures between 28 °C and 60 °C, or -10 °C and 18 °C, e.g., if the applicable specification at 28 °C is 2% and the specification at 60 °C is 3%, then the specification at 40 °C is (3%-2%)x(40-28)/(60-28)+2%=2.375%.
Accuracy at -20 °C	Multiply the -10 °C to +60 °C accuracy specification by 2. After 1 hour warm-up. For accuracy between -10 °C and -20 °C, interpolate linearly.
DC Component Error	The presence of a dc voltage will cause an indeterminate error in the reading of the ac voltage on the input.

Table 1-26. FAI A/D AC Voltage Range and Resolution Specifications

Range	Resolution		Minimum Input for Rate Accuracy
	Slow	Fast	
Full Scale	±30,000	±3,000	
300 mV	10 μV	100 μV	20 mV
3 V	100 μV	1 mV	200 mV
30 V	1 mV	10 mV	2 V

Table 1-27. FAI A/D AC Voltage Accuracy Specifications

Range	Frequency	1 Year Accuracy ± (%input + V) [1]			
		18°C to 28°C		-10°C to 60°C	
		Slow	Fast	Slow	Fast
300 mV	20 to 50 Hz	3%+.25 mV	6%+.5 mV	3.5%+.25 mV	7%+.5 mV
	50 to 150 Hz	0.4%+.25 mV	0.8%+.5 mV	0.5%+.25 mV	1%+.5 mV
	150 Hz to 10 kHz	0.3%+.25 mV	0.8%+.5 mV	0.4%+.25 mV	1%+.5 mV
	10 kHz to 20 kHz	0.4%+.25 mV	1%+.5 mV	0.7%+.25 mV	1.5%+.5 mV
	20 kHz to 50 kHz	2%+.3 mV	3%+.5 mV	3%+.3 mV	4%+.5 mV
	50 kHz to 100 kHz	5%+.5 mV	5%+1 mV	7%+.5 mV	8%+1 mV
3 V	20 to 50 Hz	3%+2.5 mV	6%+5 mV	3.5%+2.5 mV	7%+5 mV
	50 to 150 Hz	0.4%+2.5 mV	0.8%+5 mV	0.5%+2.5 mV	1%+5 mV
	150 Hz to 10 kHz	0.3%+2.5 mV	0.6%+5 mV	0.4%+2.5 mV	1%+5 mV
	10 kHz to 20 kHz	0.4%+2.5 mV	0.8%+5 mV	0.5%+2.5 mV	1%+5 mV
	20 kHz to 50 kHz	1%+3 mV	1.5%+6 mV	1.5%+3 mV	2%+6 mV
	50 kHz to 100 kHz	2%+5 mV	3%+10 mV	3%+5 mV	4%+10 mV
30 V	20 to 50 Hz	3%+25 mV	6%+50 mV	3.5%+25 mV	7%+50 mV
	50 to 150 Hz	0.4%+25 mV	0.8%+50 mV	1.2%+25 mV	1.3%+40 mV
	150 Hz to 10 kHz	0.4%+25 mV	0.8%+50 mV	1.2%+25 mV	1.3%+40 mV
	10 kHz to 20 kHz	0.4%+25 mV	0.8%+50 mV	1.2%+25 mV	1.3%+40 mV
	20 kHz to 50 kHz	1%+30 mV	1.5%+60 mV	1.2%+30 mV	2%+50 mV
	50 kHz to 100 kHz, V<20V	2%+50 mV	3%+100 mV	2.5%+50 mV	4%+100 mV
[1] Sinewave inputs>6% of scale and signals with crest factors <2.					

FAI A/D 4-Wire Resistance Measurement Specifications

The following tables provide FAI A/D specifications for the 4-wire resistance measurement function. The 4-wire measurements use 2 input channels a decade apart, e.g., channels 4 and 14.

Table 1-28. FAI A/D 4-Wire Resistance Temperature Coefficient

Specification	Characteristic
Temperature Coefficient	Add 1/10th the 90 day specification per °C above 28 °C or below 18 °C.
Accuracy at -20 °C	Multiply the -10 °C to +60 °C accuracy specification by 2. After 1 hour warm-up. For accuracy between -10 °C and -20 °C, interpolate linearly.

Table 1-29. FAI A/D 4-Wire Resistance Range and Resolution Specifications

Range	Resolution		Current Applied	Full Scale Voltage	Maximum Voltage Applied by Instrument
	Slow	Fast			
300 Ω	10 mΩ	30 mΩ	1 mA	300 mV	3.5 V
3 kΩ	100 mΩ	300 mΩ	100 µA	300 mV	3.5 V
30 kΩ	1 Ω	3 Ω	10 µA	300 mV	3.5 V
300 kΩ	10 Ω	30 Ω	10 µA	3.0 V	3.5 V
3 MΩ	100 Ω	300 Ω	1 µA	3.0 V	3.5 V

Table 1-30. FAI A/D 4-Wire Resistance Accuracy Specifications

Range	Accuracy, 3σ ± (% input + Ω)					
	18 °C to 28 °C				-10 °C to 60 °C	
	90 Day		1 Year		1 Year	
	Slow	Fast	Slow	Fast	Slow	Fast
300 Ω	.02%+60 mΩ	.02%+.1 Ω	.02%+.1 Ω	.02%+.2 Ω	.084%+.25 Ω	.084%+.42 Ω
3 kΩ	.02%+.6 Ω	.02%+2 Ω	.02%+1 Ω	.02%+3 Ω	.084%+2.5 Ω	.084%+8.4 Ω
30 kΩ	.02%+6 Ω	.2%+200 Ω	.02%+10 Ω	.2%+300 Ω	.084%+25 Ω	.84%+840 Ω
300 kΩ	.5%+80 Ω	1%+2 kΩ	.5%+150 Ω	1%+3 kΩ	2.1%+336 Ω	4.2%+8.4 kΩ
3 MΩ	1.3%+1 kΩ	2%+120 kΩ	1.3%+2 kΩ	2%+200 kΩ	5.46%+4.2 kΩ	8.4%+200 kΩ

FAI A/D 2-Wire Resistance Measurement Specifications

The FAI A/D specifications for the two-wire resistance measurement function is based on the four-wire resistance measurement specification (above) except you add a 700 to 1000 Ω positive offset. This value varies for each channel and temperature gradient (nominal +1%/ºC).

FAI A/D 4-Wire RTD per ITS-1990 Measurement Specifications

The next tables provide FAI A/D specifications for the 4-wire Resistance-Temperature Detector (RTD) measurement function. The 4-wire measurements use 2 input channels a decade apart, e.g., channels 4 and 14. There is no 2-wire RTD capability for the FAI A/D.

Table 1-31. FAI A/D 4-Wire RTD Temperature Coefficient

Specification	Characteristic
Temperature Coefficient	To calculate RTD accuracy for temperatures between 28 °C and 60 °C, or -10 °C and 18 °C, use a linear interpolation between the two applicable points. For example, if the applicable specification at 28 °C is 0.2 and the specifications at 60 °C is 0.75, then the specification at 40 °C =(.75-.2)x(40-28)/(60-28)+.2=.406.
Accuracy at -20 °C	Multiply the -10 °C to +60 °C accuracy specification by 2. After 1 hour warm-up. For accuracy between -10 °C and -20 °C, interpolate linearly.

Table 1-32. FAI A/D 4-Wire RTD Specifications

Temperature	Resolution		Accuracy, 3σ				
			90 Day 18 °C to 28 °C		1 Year 18 °C to 28 °C	1 Year -10 °C to 60 °C	
	Slow	Fast	Slow	Fast	Slow	Slow	Fast
-200 °C	0.03 °C	0.06 °C	0.16 °C	0.25 °C	0.25 °C	0.62 °C	1.10 °C
0 °C	0.03 °C	0.06 °C	0.20 °C	0.31 °C	0.31 °C	0.85 °C	1.30 °C
100 °C	0.03 °C	0.06 °C	0.23 °C	0.34 °C	0.34 °C	0.95 °C	1.40 °C
300 °C	0.03 °C	0.06 °C	0.30 °C	0.41 °C	0.41 °C	1.18 °C	1.70 °C
600 °C	0.03 °C	0.06 °C	0.53 °C	0.63 °C	0.63 °C	1.62 °C	2.12 °C

FAI A/D Thermocouple per ITS-1990 Measurement Specifications

The following tables provide FAI A/D specifications for the thermocouple measurement function per ITS-1990.

Table 1-33. FAI A/D Thermocouple General Specifications

Specification	Characteristic
Input Impedance	100 MΩ minimum in parallel with 300 pF
Open Thermocouple Detect	Operates by injecting a small ac signal into the input after each measurement. A thermocouple resistance greater than 1 kΩ to 10 kΩ is detected as an open input.
Temperature Coefficient	To calculate Thermocouple accuracy for temperatures between 28 °C and 60 °C, or -10 °C and 18 °C, use a linear interpolation between the two applicable points. For example, if the applicable specification at 28 °C is 0.6 and the specification at 60 °C is 1.1, then the specification at 40 °C is =(1.1-0.6)x(40-28)/(60-28)+0.6=0.7875.
Accuracy at -20 °C	Multiply the -10 °C to +60 °C accuracy specification by 2. After 1 hour warm-up. For accuracy between -10 °C and -20 °C, interpolate linearly.

Table 1-34. FAI A/D Thermocouple Specifications

Thermocouple ITS90		Resolution °C	Accuracy ± °C				
			18 °C to 28 °C			-10°C to 60 °C	
			90 Day	1 Year		1 Year	
Type	Temperature °C		Slow	Slow	Fast	Slow	Fast
B	600 to 1200	2	3.60	3.90	8.50	4.00	8.60
	1200 to 1550	2	2.10	2.40	5.00	2.60	5.20
	1550 to 1820	1	2.00	2.30	4.70	2.70	5.00
C	0 to 150	2	1.90	2.00	4.00	2.10	4.20
	150 to 650	1	1.60	1.70	3.50	1.80	3.60
	650 to 1000	.5	1.40	1.70	3.20	2.00	3.50
	1000 to 1800	.5	2.00	2.50	4.50	3.20	5.30
	1800 to 2316	.5	3.10	3.80	6.80	5.10	8.10
E	-100 to -25	.3	0.80	0.90	1.50	1.00	1.60
	-25 to 20	.2	0.70	0.70	1.20	0.80	1.30
	20 to 600	.2	0.60	0.70	1.10	0.80	1.20
	600 to 1000	.2	0.60	0.80	1.20	1.10	1.50

Table 1-34. FAI A/D Thermocouple Specifications (cont.)

Thermocouple ITS90		Resolution °C	Accuracy ± °C				
			18 °C to 28 °C			-10 °C to 60 °C	
			90 Day	1 Year		1 Year	
Type	Temperature °C		Slow	Slow	Fast	Slow	Fast
J	-100 to 80	.3	0.80	0.90	1.60	0.90	1.70
	80 to 230	.2	0.70	0.80	1.40	0.90	1.50
	230 to 760	.2	0.70	0.80	1.30	1.00	1.50
K	-100 to -25	.4	1.00	1.10	2.00	1.20	2.10
	-25 to 120	.3	0.80	0.90	1.70	1.00	1.80
	120 to 1000	.3	0.90	1.10	1.80	1.50	2.20
	1000 to 1372	.3	1.20	1.50	2.30	2.00	2.90
L	-100 to 100	.4	1.20	1.30	2.90	1.60	3.10
	100 to 800	.4	0.90	1.00	2.10	1.20	2.30
	800 to 900	.3	0.70	0.80	1.30	1.00	1.50
N	-100 to -25	.5	1.40	1.50	2.80	1.50	2.90
	-25 to 120	.5	1.10	1.30	2.30	1.30	2.40
	120 to 1000	.4	1.00	1.10	2.00	1.20	2.10
	1000 to 1300	.3	1.00	1.20	1.90	1.60	2.40
R	250 to 600	1	2.40	2.70	5.60	2.80	5.70
	600 to 1500	1	2.00	2.30	4.60	2.40	4.80
	1500 to 1767	1	2.00	2.30	4.50	2.80	5.10
S	250 to 1000	1	2.60	2.80	5.90	2.90	6.00
	1000 to 1400	1	2.00	2.30	4.60	2.60	5.00
	1400 to 1767	1	2.30	2.70	5.30	3.30	5.90
T	-100 to 0	.4	1.10	1.20	2.20	1.30	2.30
	0 to 150	.3	0.90	1.00	1.70	1.00	1.80
	150 to 400	.2	0.70	0.80	1.40	0.80	1.50
U	-100 to 0	.4	2.00	2.10	4.30	2.20	4.60
	0 to 600	.4	1.30	1.40	2.50	1.60	2.60

Table 1-34. FAI A/D Thermocouple Specifications (cont.)

Thermistor				
		Accuracy ± °C		
		90 Day	**1 Year**	
Temp °C	**Range***	**Slow**	**Slow**	
-40 to 150	100 to 100 mΩ	0.4	0.51	18 to 23 °C
Steinhart – Hart Equation: $1/(T\ ^{\circ}Kelvin) = A + B*(\ln \Omega) + C*(\ln \Omega)^3$ Default constants are supplied only for a YSI (type 004) 2,252 Ω thermistor, you can enter constants for other thermistors. The ranges of thermistor constants are as follows: A 1.0E-4 to 1.0E-2, B 1.0E-5 to 1.0E-3, and C 1.0E-8 to 1.0E-6. * Assumes 4-wire measurement.				

FAI A/D Frequency Measurement Specifications

The following tables provide FAI A/D specifications for the frequency measurement function.

Table 1-35. FAI A/D Frequency Accuracy Specifications

Range	**Frequency Measurement Accuracy, 1 Year, -10 °C to 60 °C**			
	Resolution		**Accuracy ± (% input + Hz)**	
	Slow	**Fast**	**Slow**	**Fast**
15 Hz to 900 Hz	0.01 Hz	0.1 Hz	0.05%+0.02 Hz	0.05%+0.2 Hz
900 Hz to 9 kHz	0.1 Hz	1 Hz	0.05%+0.1 Hz	0.05%+1 Hz
9 kHz to 90 kHz	1 Hz	10 Hz	0.05%+1 Hz	0.05%+10 Hz
90 kHz to 900 kHz	10 Hz	100 Hz	0.05%+10 Hz	0.05%+100 Hz
1 MHz	100 Hz	1 kHz	0.05%+100 Hz	0.05%+1 kHz

Table 1-36. FAI A/D Frequency Sensitivity Specifications

Frequency Range	**Minimum Signal**	**Maximum Signal**
15 Hz to 70 kHz	100 mV ac rms	30 V ac rms
70 kHz to 100 kHz	100 mV ac rms	20 V ac rms
100 kHz to 200 kHz	150 mV ac rms	10 V ac rms
200 kHz to 300 kHz	150 mV ac rms	7 V ac rms
300 kHz to 1 MHz	Linearly increasing from 150 mV ac rms at 300 kHz to 2 V ac rms at 1 MHz	Linearly decreasing from 7 V ac rms at 300 kHz to 2 V ac rms at 1 MHz

Digital Input/Output Module

The following specifications apply to the DIO Module. The module contains digital open collector outputs, relay contacts, digital inputs, and totalizer.

⚠⚠Warning

The DIO module is rated as a CAT I device.

Digital Input/Output Specifications

Table specifications provides a summary of the Digital I/O specifications for the 10 Digital I/O lines (0 to 19). Digital I/O is located on the Output Module Digital connector, terminals 0 to 19, and GND. Note that the Master Alarm can be designated as any Digital output channel or one of the four relays outputs (discussed later).

Table 1-37.Digital I/O Specification

Specification	Characteristic
Maximum Input Voltage	30 V
Minimum Input Voltage	-4 V
Isolation	None (dc coupled)
Threshold	1.4 V
Hysteresis	500 mV
Input Debouncing	None or 1.75 ms (selectable)
Output Voltage - TTL Logical Zero	0.8 V maximum for an Iout of -1.0 mA (1 LSTTL load)
Output Voltage - TTL Logical One	3.8 V minimum for an Iout of 0.05 mA (1 LSTTL load)
Output Voltage - Non-TTL Load Zero	1.8 V maximum for an Iout of -20 mA
Output Voltage - Non-TTL Load One	3.25 V maximum for an Iout of -50 mA

Totalizer Input Specifications

The following table provides a summary of the Totalizer Input specifications. The Totalizer Input is located on the Output Module connector, terminals TOI and GND. The totalizer will be able to increment or decrement depending on the input on a separate digital input channel.

Table 1-38. Totalizer Specification

Specification	Characteristic
Maximum Input Voltage	30 V
Minimum Input Voltage	-4 V
Minimum Peak Voltage	2 V
Isolation	Same as for the digital IO lines
Threshold	1.4 V
Hysteresis	500 mV
Input Debouncing	None or 1.75 ms (selectable)
Maximum Transition Rate	5 kHz (Debounce disabled) 500 Hz (Debounce enabled)
Maximum Count for Totalizer	4,294,967,295

Digital Relay Specifications

The next table provides a summary of the relay specifications for the 8 relay contact pairs on the output card. Relay contacts are located on the Output Module connector, terminals X to Y.

Table 1-39. Digital I/O Relay Specification

Specification	Characteristic
Maximum Contact Voltage	250 V ac
Minimum Peak Current	2 A at 30 V dc, 0.4 A at 125 V ac (resistive)
Isolation	1.5 kV between contacts and coil
Debounce time (typical)	5 ms
Contact Operate/release Rate	4 ms max
Fuse	2 A, 250 V, 5mm x 20 mm, Fast Blow Fuse

Options and Accessories

Table 1-40 summarizes the available Models, Options and Accessories.

Table 1-40. Models, Options and Accessories

Model	Description
2680A-FAI	Fast Analog Input Module
2680A-PAI	Precision Analog Input Module
2680A-DIO	Digital I/O Relay with Totalizer Module
2680A-102	Digital Connector Module
2680A-180	Input Module w/o Terminal Strips
2680A-800	16 MB Memory Card
2680A-801	128 MB Memory Card
2680A-802	256 MB Memory Card
2680A-805	512 MB Memory Card
2680A-810	1 GB Memory Card
2680A-BLANK	Blank Module
2680A-APSW	Fluke DAQ Software. Included with the purchase of each chassis.
2680A-DEVSW	Fluke Development Software from InduSoft
2680A-DLL	Fluke DLL Library routines for the development of device drivers
2680A-OPC	Fluke OPC Software. Used to configure a PC to act as an OPC server and provide virtual contact with a 268XA device.

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Theory of Operation

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Introduction

This chapter is intended to provide a detailed description and analysis, where appropriate, of the printed circuit board assemblies (PCAs) used in the 268XA. Figure 2-1 below is an overall block diagram of the communication control system. Note that the blocks labeled "Module #n" can be any valid module type, either FAI, PAI or DIO. The hardware system functionality is independent of the module type.

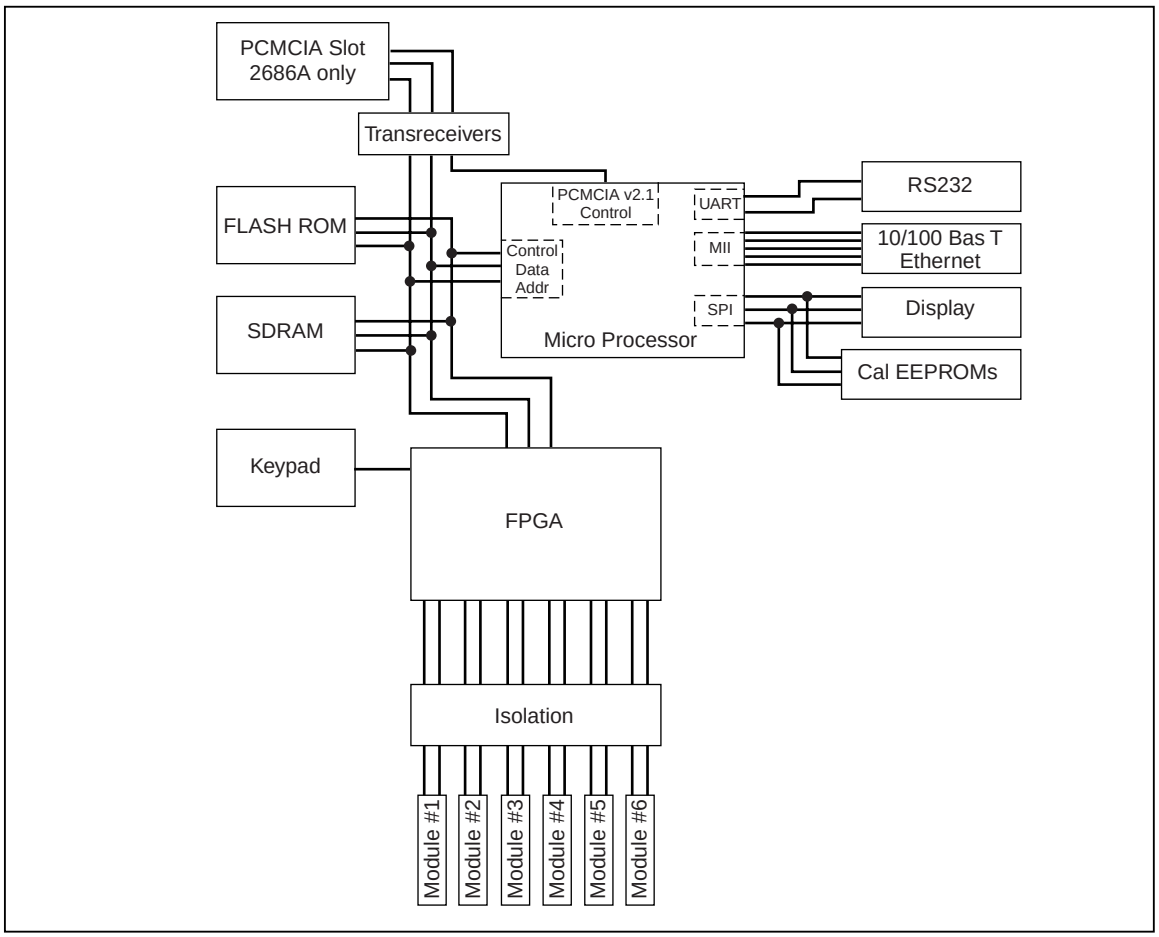

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Figure 2-1. Communication Control System

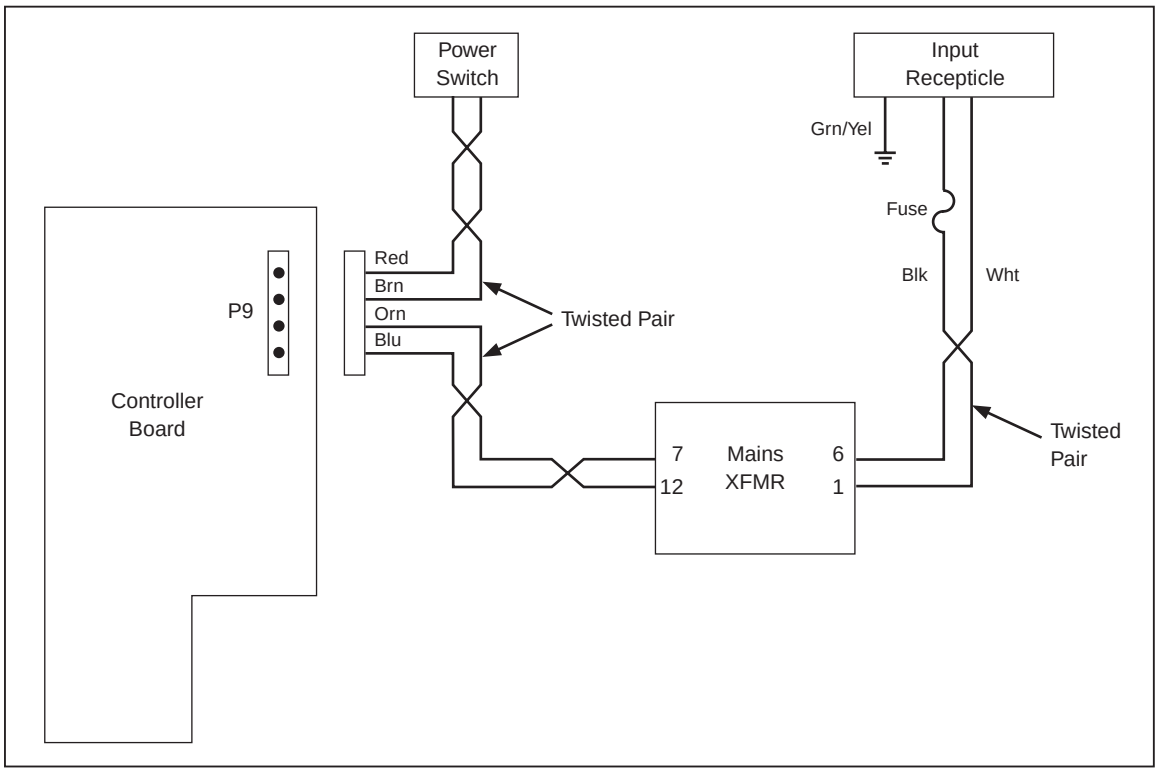

Figure 2-2. 268XA Main Supply Circuit

The 4004 PCA is the main board in the 268XA chassis. It contains the main switching power supply and various secondary power supplies, as well as all of the out-guard digital control circuitry, guard-crossing interface and host computer interface, both 10/100 Base T Ethernet and RS-232. Refer to Chapter 8 for a schematic of the 2680A-4004 board. Table 2-1 provides a summary of all the connectors on the 4004 PCA.

Table 2-1. Controller Connector Description

Connector Reference Designator	Description
P1	DB9 RS232, for calibration only
P2	10/100 Base T Ethernet RJ45
P3	100 pin through hole connector to the backplane PCA (4001)
P4	100 pin surface mount connector to the PCMCIA PCA (4041)
P5	3 pin Mate-N-Lok RS232, for console port connection
P6	8 pin shrouded header for Trigger In/Out, Master Alarm, and DC Power Input
P7	10 pin development debugger header, Not installed on production units
P8	10 pin header for fpga byteblaster, Not installed on production units
P9	4 pin Mate-N-Lok Header from AC transformer secondary, and power switch
P10	2 pin Mate-N-Lok Header for the fan connection

Main Power Supply

The power supply circuitry is contained on page 6 of the 2680-1004 schematic. The main supply consists of 2 switching regulators, U301 and U303. U301 takes either a 9 V to 42 V dc source from P6 pins 1 and 2 or a 10:1 stepped down 50/60 Hz 95 V to 265 V ac line voltage from P9 pins 3 and 4 as an input. It performs a push-pull buck dc-dc conversion, through an N channel FET(Q304), a P channel FET(Q303) and a 50µH inductor(L301), to produce a regulated +5 V, 5 A supply. U301 uses a constant off time architecture, because of this its operating frequency varies from approximately 42 KHz to 85 KHz, depending on the input operating voltage. This is the main out-guard source from which all other supplies, both in-guard and out-guard are produced. The second part of the main supply is produced by U303, a 5 V to 3.3 V buck topology dc-dc converter. Its output, +3.3 V at 1.25 A maximum, is referred to as Vcc throughout the out-guard system. F301 and F302 are surface mount thermistors that serve to protect the instrument from a dc overvoltage, undervoltage, or a negative voltage applied to the dc power input jack on pins 1 and 2 of P6.

The 268XA can take power from a 9 to 45 V battery or from mains ac. The mains power is routed from the IEC line connector at the rear of the instrument to the mains transformer. See Figure 2-2 for an ac power connection diagram. Internally, the mains ac black wire goes through a fuse before reaching the mains transformer. The mains transformer converts the ac input to ~13 V rms. The secondary power of the transformer goes to the power section on the 4004 controller/power supply board. The secondary power is routed through the mains power switch located on the back of the chassis. The primary power is always connected to the mains power.

Secondary Supplies

The power source for the vacuum florescent display primarily consists of a 50KHz differential clock (FIL_CLK and FIL_CLK*), 2 N channel FETs (Q301-2), a transformer (T2) and an linear LDO (low drop out) regulator (U307). The biphase clock source is driven from the FPGA U25 upon its release from configuration. Q301-2 and T2 combine to form an inverting boost DC-DC converter that produces a -30V dc source from the fullwave bridge rectifier(CR304-5) and a 5.3 V ac source that is used for the filament drive. U307, in combination with C313 and CR312, taps off of the primary side of T2 to produce a regulated –5 V dc supply, which is needed by the display controller.

The fan power supply is a boost dc-dc switching regulator (U30). It uses a constant frequency pulse width modulated architecture switching at 1.2 MHz, with a 1 A maximum peak current. Its output is +24 V at 100 mA, this supply was designed to only drive the fan, other circuitry should not be driven from this supply.

Out-Guard Overview

The overall topology of the out-guard control system consists of 2 primary components, the microprocessor (U6) and the fpga (U25). The fpga handles the digital side of the guard crossing for all 6 module slots and the microprocessor handles all of dataflow from the in-guard to the host computer and the PCMCIA slot, as well as calibration and other miscellaneous tasks. There are 2 surface mount LEDs on the 268XA-4004 PCA. The green one (DS7) is a power on light, it comes on when the microprocessor is released from reset. The flashing red one (DS6) is a heartbeat indicator, that will begin flashing after the firmware application has begun operating. The 4004 PCA contains a number of test points and wire points. The test points (TPs) were for use in development and serve no useful purpose for service. The wire points (WPs) that are not chassis connections are connected to digital ground.

Microprocessor

The processor used in the 268XA (U6) is a Motorola MPC855T, see page 2 of the 1004 schematic. Its architecture is very similar to the 683xx series of embedded communications controllers that have been used on many product lines, including NetDAQ and 55xx series calibrators, except that instead of a 16 bit 68000 processor core with no instruction or data cache, the MPC855T has a 32 bit power PC core with 4 Kbytes of both L1 instruction and data cache.

The MPC855T has a dedicated SIU (system interface unit), a CPM (communications processor module) and an FEC (fast Ethernet controller), which all share an internal 32 bit data/address bus. The FEC in combination with buffers in RAM is the MAC (media access controller) for the 10/100 Base T Ethernet interface. It has a dedicated MII (media independent interface) port for connection to the physical layer transceiver. The CPM handles the RS232 and serial peripheral interface (SPI) protocols, the baud rate generators, hardware and software timers, and the interrupt controller. The SIU handles the memory control signals, the internal and external bus interface, the PCMCIA control, and the real time clock. See Figure 2-3 below. The SIU also contains a software watchdog timer. As of the date of this writing it has not been enabled, however provisions have been made to make use of it in a future firmware release.

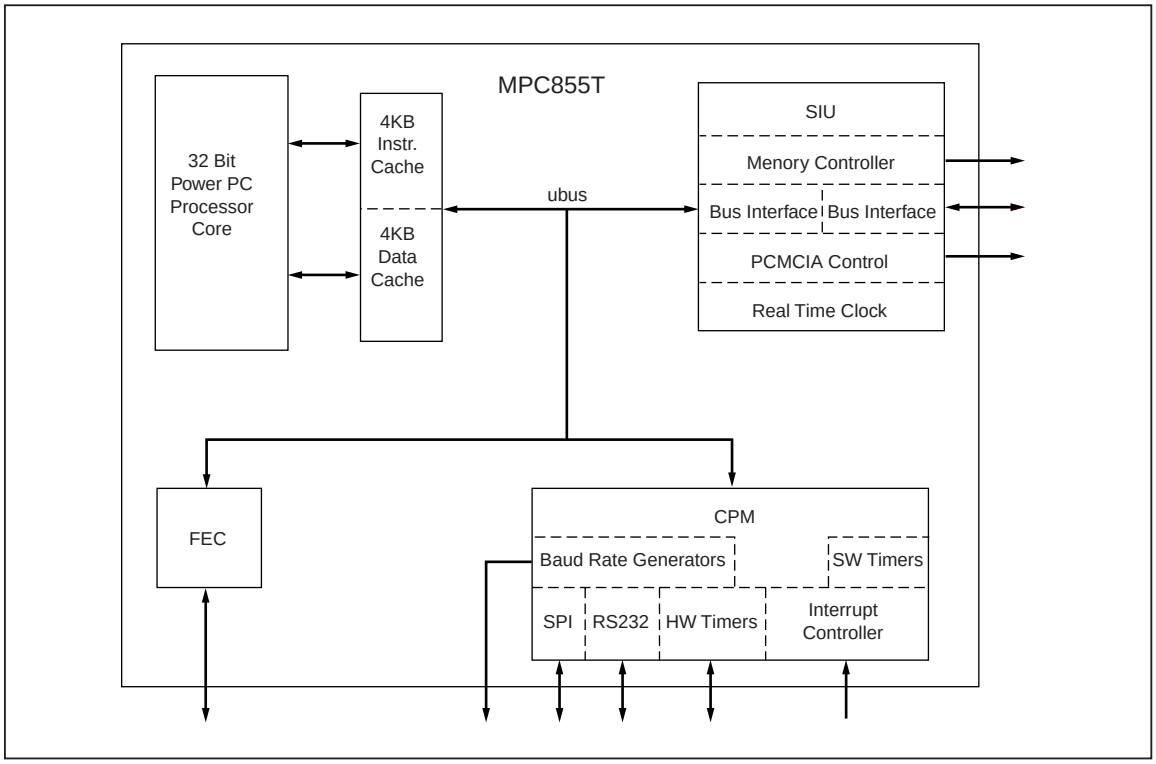

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Figure 2-3. System Interface Unit

There are 4 hardware interrupts that go to the microprocessor in order of precedence they are: 1, GRD_IRQ* fpga interrupt for the guard crossing, 2, DISPLAY_IRQ* communication interrupt from the display controller, 3, KEY_IRQ* fpga interrupt for the keypad scanner, and 4, ENET_IRQ* interrupt from the Ethernet PHY, configurable in firmware.

FPGA

The gate array (U25) in the 268XA is an Altera ACEX series EP1K100QC208-1. It is on page 5 of the 1004 schematic. It has 48Kbits of embedded dual port RAM configurable in 12 blocks of various width/depth combinations, as well as approximately 100K gates. This design uses about 55 % of the logic cells, and about 25 % of the memory bits, spread out over all 12 blocks, and has a maximum clock frequency of 57.4 MHz. The core runs off of a 2.5 V linear regulator from Vcc, while the I/O pins are powered directly from Vcc (+3.3 V).

This FPGA's main function is performing the guard crossing communications for the 6 module slots in the 268XA chassis. The guard crossing uses a 120KBaud UART protocol with 1 start bit, 8 data bits, 1 even parity bit and 1 stop bit. The architecture inside the fpga is highly parallel, each module slot has its own dedicated UART, transmit FIFO, receive FIFO, status and control registers, and interrupt flag.

The transmit FIFO is 2 bytes wide and 3 bytes deep (6 bytes total), the length of 1 guard crossing command frame. The receive FIFO is also 2 bytes wide but is 256 bytes (512 bytes total). Each receive buffer can hold 1 complete scan's worth of data, with all channels configured, before it needs to be read. The status and control registers serve to mask off or enable certain conditions for interrupt to the microprocessor.

The interface to the microprocessor is a 16 bit bi-directional data bus, a 5 bit address, a chip select, read and write enables, a single interrupt line (GRD_IRQ*) and a 6 bit service queue port. When the condition set by the control/status registers becomes valid, the corresponding service queue bit will be set high. The interrupt is the NOR of all the service queue bits. The status/control registers occupy 1 address location per module slot, as do the Rx/Tx FIFOs. See the FPGA design description document, and Figure 2-4 for more details.

The other main entity in the fpga is the keypad scanner. This has its own interrupt (KEY_IRQ*), the keypad state register (8 bits wide) is memory mapped along with the guard crossing registers, the FPGA design description document has the details of the keypad scanner functionality.

In addition to these 2 entities, the guard crossing and the keypad scanner, the fpga contains a clock generation circuit for the display and the in-guard power supplies, as well as the trigger out pulse generator. These items are covered in other sections of this document.

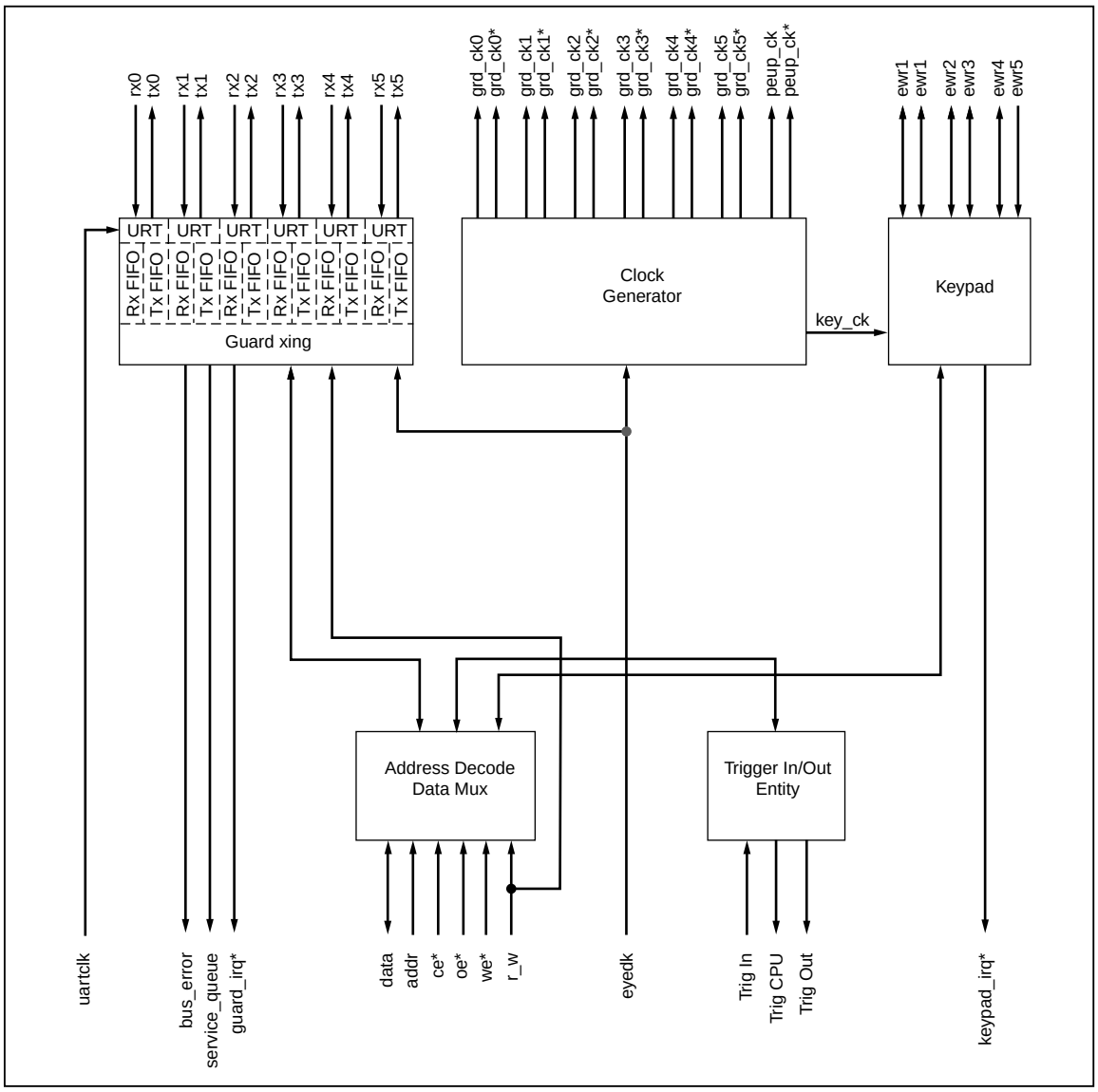


Figure 2-4. FPGA Block Diagram

Other Bus Devices

The microprocessor's external bus controller, in addition to the fpga, communicates with onboard SDRAM, onboard flash ROM and PCMCIA flash memory cards. These additional device interfaces are contained on page 4 of the 1004 schematic. There are 32 MB of onboard SDRAM, configured as 4-8 MB by 8 bit wide devices (U18, 19, 21 and 22). The timing of the row and column address strobes (RAS*, CAS*), chip select (CS1*), write enable (RAMWE*), and byte mask signals (BSA0*-3*) is controlled by a state machine in the microprocessor's SIU. The relative states of these signals determine what mode the SDRAM operates in, 4 word burst, single word access, refresh, etc. There are 4 MB of onboard flash ROM, configured as a single 2 MB by 16 bit wide device (U20). U20 is an Intel Strataflash E28F320J3A.

This particular series of devices is presently available in 2 other sizes, 8 MB and 16 MB, provisions have been made in this design for using those devices if necessary, with minimal required rework. U20 is programmed and powered from Vcc, there is no additional 12 V programming voltage required for Strataflash devices. Support is provided, in the form of bus transceivers and daughter card connector (U4, 5, 10, 28, 29, and P4), for a single PCMCIA slot. The timing and control of the PCMCIA slot is internal to the microprocessor. The hardware on both the 4004 and 4041 PCAs will support all types of type I and type II PCMCIA cards, however the firmware will only support ATA Flash Memory PC-Cards.

Serial Devices

The 268XA controller supports several serial device types, 10/100 Base T Ethernet, RS-232 and multiple SPI devices. These peripherals are described on page 3 of the 1004 schematic.

The Ethernet functionality is split between the physical layer transceiver (PHY) and the microprocessor, which houses the MAC layer and various application layers. The interface between the 2 devices is an industry standard MII port. The PHY device (U17), an AMD 79C874, autonegotiates the Ethernet link speed to either 10 Base Tx or 100 Base Tx, as well as either half or full duplex, depending on the capabilities of the hub that it is talking with. This is transparent to both the firmware and the user. The PHY will attempt to use the fastest mode, full duplex 100 Base Tx, as default and negotiate down in capability if necessary. The LED labeled LNK on the rear panel of the 268XA chassis is a link/speed indicator. It will be green if in 100 Base T mode or red if in 10 Base T mode. There is no duplex or collision indication LED.

There are 2 RS-232 ports on the 268XA controller board. One of them is user accessible from the rear panel at connector P1, and the other (P5) is for development and debug only. P1 is an industry standard Male DB9 connector. The modem control signals RTS, DTR, CTS and DSR are available for use from P1. P5 is a 3 pin mate-n-lok type connector and requires a special cable assembly in order to use. The MAC address, serial number, IP address and other sensitive boot configuration information may be changed from this port. Great care should be used when accessing the 268XA through the P5 RS-232 console port.

The SPI devices in the 268XA system are the display controller on the 45-3201 PCA, and one 2KBit EEPROM per module slot for calibration. These devices all share a common 3 wire synchronous interface, with only one device occupying the SPI bus at any given time. The microprocessor is always the master, and addresses each SPI device independently with a dedicated chip select. The calibration EEPROMs reside on the module power supply PCA (268XA-4031) within each module, see section 5 below for details.

Trigger In/Out, Master Alarm

The trigger in and trigger out functionality is shared by the microprocessor and the fpga. The master alarm output, which is set by the firmware for as long as an alarm condition occurs, is an inverted and protected version of a general purpose microprocessor port pin. The MPC855 writes to a specific address in the gate array when a trigger out pulse is required. The fpga then drives an output pin low and starts a timer for the requisite 125 μs pulse. The trigger input to the microprocessor is a buffered version of the trigger input from the external world. This is necessary because the microprocessor only has falling edge interrupts, and it needs to be interrupted on both edges of the trigger input signal. So, when the trigger input goes low, the microprocessor tells the fpga to invert the signal that it sees so that when the global trigger in signal goes high, the microprocessor will see another falling edge interrupt, as required.

The overvoltage protection for these 3 signals consists of a 49.9 Ω series resistor, a dual diode clamp and a 6 V Zener diode. This scheme will protect the fpga and microprocessor for applied voltages up to +/- 30 V dc. The trigger input buffer is a CMOS Schmidt trigger. The trigger out and master alarm out are driven by NDS351 NMOS FETs with 2 kΩ pull-up resistors to the +5 V rail.

PCMCIA Interface PCA (2686A-4041)

The PCMCIA interface board mainly consists of a type II 3.3 V PCMCIA v2.1 card slot and a set of bi-directional levelshifting buffers. The buffers on this board are driven off of the same supply as the card, which can be either 3.3 V or 5 V. The buffers on 4004 board are always powered from Vcc (3.3 V), as the MPC855T can not tolerate 5 V signal levels. This board also has a 5 V to 12 V boost topology switching regulator that is only turned on if the installed card says that it needs 12 V for programming. This 12 V supply was designed to only provide enough power for the PCMCIA card, no other devices should be powered from this supply. This board plugs into P4 on the 2680A-4004 PCA. It is a daughter card that is only installed if the instrument is a 2686 chassis, as opposed to a 2680 chassis which has no PCMCIA option.

Backplane PCA (268XA-4001)

The backplane PCA is the board that the 6 modules and the display controller PCA physically plug into. It contains minimal circuitry, only that which is needed for signal integrity and ESD protection. It is basically a pass through board for the guard crossing signals from the fpga to the modules, and the SPI bus that goes to the display and the calibration EEPROMs from the MPC855T on the 4004 controller PCA. Refer to the 1001 schematic for reference designators. The backplane PCA contains a number of testpoints that are usable for service. TPs 3, 4, 8 and 11 are connected to the guard crossing signals for module slot #1. 3 and 4 are the UART receive and transmit lines from the outguard fpga. 8 and 11 are the differential guard crossing clocks that drives the in-guard power supply. TPs 13, 12, 1 and 2 are the same signals for module slot #6, respectively. The remaining testpoints on the backplane board are connected to the display controller interface signals. TP15, and 16 are the tri-state buffered SPI clk and transmit signals. TP17 is the master display clock that comes from a baud rate generator on the MPC855T. TP18 is the +5 V power rail. TPs 9 and 10 are the VFD ac power source.

Table 2-2. Backplane Connector Description

Connector Reference Designator	Description
P1	20 pin header for module slot #1
P2	20 pin header for module slot #2
P3	20 pin header for module slot #3
P4	20 pin header for module slot #4
P5	20 pin header for module slot #5
P6	20 pin header for module slot #6
P7	100 pin through hole connector to the controller board
P8	20 pin surface mount header for display connection ribbon cable

Display Interface

The display controller interface on the backplane consists of a tri-stateable levelshifter/buffer, some decoupling capacitors, and the display ribbon cable connector (P8). The levelshifters (U1, 2, 3) need to be tri-stateable because, when the microprocessor is talking to the calibration EEPROMs, the display should not receive those transmissions.

Module Interface

The module interface connectors (P1-6) have a number of passive components surrounding them, these are for ESD protection. The optoisolators that perform the analog side of the guard crossing are on the 4031PCA. Because each module slot has its own dedicated channel in the fpga, the only circuitry that is required on the backplane is a non-inverting buffer (U4) to clean up the edges of the UART receive signals that come from the in-guard system.

Module Power Supply PCA (268XA-4031)

The module power supply PCA contains all of the analog side of the guard crossing hardware. It is located with each module's housing, as a daughter card that plugs into a 2 row, 10 pin header on the module. The power supply design uses a fully isolated push-pull topology, driven from a differential 393 kHz clock source. There are 3 regulated outputs that power the in-guard system +5.2 V (Vdd), -5.2 V (Vss) and +5.6 V (Vddr), each one is derived from a dedicated linear low dropout regulator (U5, U6 and U4, respectively). The isolation transformer, which is rated at 300 V Category 2, is made of circuit board traces on two separate boards, primary coil on the 4031 and secondary coil on the 4032, coupled together by a core that runs through the 4031 PCA and around the 4032 PCA.

The only other circuitry in addition to the power supply itself on the 4031 board are the optoisolators (U2 and U3) and the calibration EEPROM (U7). U2 and U3 on the 4031 PCA are the bridge for the UART communication signals that run between the fpga on the 4004 PCA and the in-guard microcontroller. U7 is a 2Kbit serial EEPROM addressable from the out-guard microprocessor (MPC855T, U6 on the 4004 PCA) via an SPI bus that runs on the Backplane PCA (4001).

Digital Input/Output PCA

The following paragraphs describe the digital input/output as follows:

- Microcontroller
- Digital Input Threshold
- Digital Input Buffers
- Digital Output Drivers
- Relay Output Drivers
- Totalizer Input
- Totalizer Enable

Microcontroller

A Texas Instrument MSP430P337A mixed signal microcontroller is the heart of the DIO PCA. The microcontroller, U4, features bi-directional digital ports, a built in UART and internal timers for controlling operation. A quartz crystal operating at 32.8 kHz provides the main clock signal for the microcontroller. This signal is internally multiplied to 3.6925 MHz for clocking of the microcontroller functions and is also divided down to 8 kHz (XBUF U4 Pin 97) providing a control signal for the debounce PLD; U3.

Internal to the microcontroller is a watchdog timer that is set to a 1 second interval. Should the microcontroller become inoperative for a period of 1 second, the watchdog timer will activate and perform a Power Up Clear (PUC) operation that resets all outputs and restarts the microcontroller. C50 controls the duration of the reset signal.

During power up, U16 provides a reset pulse of approximately 2 seconds to insure that the crystal oscillator (Y1) is given sufficient time to start. U16 also has undervoltage detection such that if the supply voltage to pin 2 drops below 4.5 V, the output will reset. Depressing S1 can manually reset the microcontroller. This applies a ground signal to the reset (RST U4 pin 96) pin of the microcontroller.

U3 is an Atmel ATF750C Programmable Logic Device (PLD) and is configured as a signal debouncer. The Totalizer signal is applied to U3 Pin 13 from the Totalizer Input Protection Buffer circuit (U1 Pin 1 and U18. See Totalizer Input section for more information).

Localized communication to the DIO PCA can be accomplished by connecting a RS-232 terminal to P3 or P4 and moving R35 (a zero ohm resistor) to position R36 (this redirects the receive signal from the mainframe to the microcontroller to the RS-232 port). U2 (Maxim MAX232) accomplishes the bi-directional RS-232 communication. It uses a single supply (+5 Vcc) and internally level shifts the signals to standard RS-232 levels. Communication is controlled by the built in UART in the microcontroller (URXD U4 Pin 51 receive and UTXD U4 Pin 50 transmit) at a rate of 120k bps. Communication is performed in 6 byte packets (bytes 0-4 contain command data while byte 5 is a checksum) and is done in hexadecimal format. You will need a special software program (Perl script) to communicate via P3 or P4 for debug purposes. Using “terminal.exe” or “hyperterminal.exe” in windows will not work as the communication is in ASCII format. U17 is simply an output buffer for driving the opto-isolated A/D power supply.

The MSP430P337A is a One Time Programmable (OTP) device and will be pre-programmed by the supplier however should the need arise, it is possible to program a blank device on board through the JTAG Programming Port P2. A serial-programming adapter supplied by Texas Instruments must be used in order to program the device. R34 must be replaced with a zero ohm resistor so that the programming adapter can control the clock of the microcontroller. After programming is complete, R34 is removed.

Data Input Threshold

The Digital Input Threshold circuit sets the input threshold level for the Digital Input Buffers and the Totalizer Input. A fixed value voltage divider (R5, R6) and a unity gain buffer amplifier (U1) are the main components in the circuit. The voltage from the divider (approximately +1.4 V dc) is then buffered by U1, which sets the input threshold. Capacitor C8 filters the divider voltage at the input of U1.

Digital Input Buffers

Since the 20 Digital Input Buffers are identical in design, only components used for Digital Input 0 are referenced in this description. If the Digital Output Driver (U13 Pin 13) is “off”, the input to the Digital Input Buffer is determined by the voltage level at P6 Pin A1. If the Digital Output Driver is “on”, the input of the Digital Input Buffer is the voltage at the output of the Digital Output Driver.

The Digital Input Threshold circuit and resistor network Z2 determine the input threshold voltage and hysteresis for inverting comparator U8. The inverting input of the comparator (U8 Pin 13) is protected by a series resistor (Z6) and diode CR9. A negative input clamp circuit (Q1, R7, and CR1) sets a clamp voltage of approximately +0.7 V dc for the protection diodes of all Digital Input Buffers. A negative input voltage at P6 Pin A1 causes CR9 to conduct current, clamping the comparator input U8 Pin 13 at approximately 0 V dc. Maximum input voltage is limited to +30 V dc. R8 provides input protection should the input exceed +30 V dc. The maximum current with the output asserted (low) is 500 mA.

The input threshold of +1.4 V dc and a hysteresis of +0.5 V dc are used for all Digital Input Buffers. When the input of the Digital Input Buffer is greater than approximately +1.65 V dc, the output of the inverting comparator is low. When the input then drops below about +1.15 V dc, the output of the inverting comparator goes high.

Digital Output Drivers

Since the 20 Digital Output Drivers are identical in design, the following example description references only the components that are used for the Digital Output (DO<0>).

The microprocessor controls the state of the Digital Output Driver DO<0> by setting the level of the output U4 Pin 59. When U4 Pin 59 is set high, the output of the open-collector Darlington driver (U13 Pin 13) sinks current through current-limiting resistor R80. When U4 Pin 59 is set low, the driver output turns off and is pulled up by Z4 and/or the voltage of the external device that the output is driving. If the driver output is driving an external inductive load, the internal flyback diode (U13 Pin 9) conducts the energy into MOV RV1 to keep the driver output from being damaged by excessive voltage. Capacitor C127 ensures that the instrument meets electromagnetic interference (EMI) and electromagnetic compatibility (EMC) performance requirements.

Relay Output Drivers

Since the 8 Relay Output Drivers are identical in design , the following example description references only the components that are used for the operation of K1.

The output relays are latching relays and therefor must be set/reset individually. The Microprocessor controls the state of the Digital Output Driver DO<20> by setting the level of the output U4 Pin 67. When U4 Pin 67 is set high, the output of the open-collector Darlington driver (U10 Pin 10) sinks current through the K1 Set relay coil; the internal flyback diode (U10 Pin 9) conducts the energy into Vcc to keep the driver output from being damaged by excessive voltage when the relay coil is de-energized.

When U4 Pin 68 is set high, the output of the open-collector Darlington driver (U10 Pin 11) sinks current through the K1 Reset relay coil; the internal flyback diode (U10 Pin 9) conducts the energy into Vcc to keep the driver output from being damaged by excessive voltage when the relay coil is de-energized.

K1 is a latching double pole, double throw relay. The relay is configured in a parallel-ganged configuration; when the relay is closed, P5 Pin B30 will be connected to P5 Pin C29 and P5 Pin B32 will be connected to P5 Pin C31. Fuses F1 and F5 (2A) protect the relay contacts from excessive current.

Totalizer Input

The Totalizer Input circuit consists of Input Protection, a Digital Input Buffer circuit, and a Totalizer Debouncing circuit. The Digital Input Buffer for the Totalizer is protected from electrostatic discharge (ESD) damage by R31 and C48. Refer to the detailed description of the Digital Input Buffer circuit for more information. U1 and U18 provide input buffering for the Totalizer. The output from U18 goes to the debounce PLD; U3

The Totalizer Debounce circuit in the PLD (U3) allows the microcontroller to select Totalizing of either the input signal or the debounced input signal. The buffered Totalizer Input signal (TOT_IN) goes into the PLD at U3 Pin 13.

U3 Pin 9 is the debounce enable control signal, it is active high (HI = Totalizer Debounced, Lo = Totalizer NOT Debounced). The Totalizer output from the PLD is on U3 Pin 23 and this signal goes to the microcontroller (CIN U4 Pin 2). The PLD receives its clock from the microcontroller on Pin 2. The clock frequency is approximately 8 kHz. The signal debouncer is set to approximately 1.75 ms meaning a pulse of less then 1.75 ms will not pass through. In debounce mode, the maximum repetitive frequency of the Totalizer signal is approximately 500 Hz. In non-debounce mode, the maximum repetitive frequency of the Totalizer is approximately 5kHz.

Inside the PLD, the Totalizer signal is routed to a MUX/DEMUX circuit and from there, to a 3-stage shift register. The microcontroller provides an 8kHz clock signal to the PLD (which is divided down to 2 kHz internally). The 2 kHz signal is used to clock the shift register which produces a pulse every 2 ms (500 Hz). This pulse is then compared against the Totalizer signal itself. If the pulse duration of the Totalizer is greater then 1.75 ms, the Totalizer signal is passed to the output of the PLD (U3 Pin 23). If the duration of the Totalizer signal is less then 1.75 ms, it is removed (debounced). Selection of either “debounced” or “non-debounced” input is controlled by the DEBOUNCE_EN control signal (U3 Pin 9). Debounce is selected when DEBOUNCE_EN is high.

From the PLD, the signal (TOTAL) is routed to a 16 bit counter in the microcontroller (CIN U4 P2). The Totalizer counter is a 32 bit counter using a combination of the internal counter and a 16-bit storage register internal to the microcontroller.

Totalizer Enable

Operation of the Totalizer is controlled by the TOT_ENABLE signal. The Totalizer Enable circuit consists of Input Protection, a Digital Input Buffer circuit. The Digital Input Buffer for the Totalizer Enable is protected from electrostatic discharge (ESD) damage by R32 and C49. Refer to the detailed description of the Digital Input Buffer circuit for more information.

The Totalizer Enable signal is active high. Applying a logic low to TOT_ENABLE will disable counting by the Totalizer. TP_ENABLE* is the control signal to the microcontroller (U4 Pin 8); Totalizer counting is enabled when this signal is held low.

A/D Theory of Operations

A/D Converter PCA Block Description

The following paragraphs describe the major blocks of circuitry on the A/D Converter PCAs (FAI and the PAI).

Analog Measurement Processor

The Analog Measurement Processor (A3U30) provides input signal conditioning, ranging, and frequency measurement. This custom integrated circuit is controlled by the inguard A/D Microprocessor (A3U5). The A/D Microprocessor communicates with the main Controller/System Power PCA over a serial interface. Isolation is achieved through the A/D power supply daughter card with a unique dc to dc converter.

Input Protection

This circuitry protects the instrument measurement circuits during overvoltage conditions.

Input Signal Conditioning

Each input is conditioned and/or scaled to a dc voltage for measurement by the A/D converter. DC voltage levels greater than 3 V are attenuated. To measure resistance, a dc current is applied across a series connection of the input resistance and a reference resistance to develop dc voltages that can be ratioed. DC volts and ohms measurements are filtered by a passive filter. AC voltages are first scaled by an ac buffer, converted to a representative dc voltage by an RMS converter, and then filtered by an active filter.

Analog-to-Digital (a/d) Converter

The dc voltage output from the signal conditioning circuits is applied to a multi-slope A/D converter.

The input voltage is applied to a buffer/integrator that charges a capacitor for an exact amount of time. During this time, positive and negative reference voltages are alternately applied to the integrator. The references are switched in a sequence controlled by the A/D Electrically Programmed Logic Device (EPLD) (A3U18), which prevents the integrator from saturating.

The amount of time that each reference is applied to the integrator, and the amount of time required to discharge the capacitor, are measured by digital counter circuits in the A/D EPLD (A3U18). These times are used by the inguard microprocessor (A3U5) to calculate the level of the unknown input signal.

Inguard Microcontroller

This microprocessor (A3U5) and associated circuitry controls all functions on the A/D Converter PCA and communicates with the Controller/System Power PCA. Upon request by the Controller/System Power PCA (also called the out guard processor), the inguard microprocessor selects the input channel to be measured through the channel selection circuitry, sets up the input signal conditioning, commands the A/D EPLD (A3U18) to begin a conversion, stops the measurement, and then fetches the measurement result. The inguard microprocessor manipulates the result mathematically and transmits the reading to the digital kernel.

Channel Selection

This circuitry consists of a set of relays and relay-control drivers. The relays form a tree that routes the input channels to the measurement circuitry. Two of the relays are also used to switch between two-wire and four-wire operation. For signal switching and selection, the PAI uses reed relays, while the FAI uses solid-state relays.

Open Thermocouple Check

Under control of the inguard microprocessor, the open thermocouple check circuit applies a small ac signal to a thermocouple input before each measurement. If an excessive resistance is encountered, an open thermocouple input condition is reported.

Analog Input PCA Block Description

The following paragraphs briefly describe the major sections of the Input Connector PCA, which is the "Universal Input Module" used for connecting the analog inputs to the instrument.

20-Channel Terminals

Twenty HI and LO terminal blocks are provided in two rows, one for channels 1 through 10 and one for channels 11 through 20. The terminals can accommodate a wide range of wire sizes, starting with 12 gauge as the largest size. The two rows of terminal blocks are maintained very close to the same temperature for accurate thermocouple measurements.

Reference Junction Temperature

A semiconductor junction is used to sense the temperature of the thermocouple input terminals. The resulting dc output voltage is proportional to the block temperature and is sent to the A/D Converter PCA for measurement.

A/D Converter PCA Circuit Description

The following paragraphs describe the operation of the circuits on the A3 A/D Converter PCA. See Figure 2-5 for a block diagram. The PAI and FAI A/D Converter PCAs are identical, except for physical signal switching, and both use the following:

- Motorola 68302 microprocessor.
- Flash ROM
- RAM
- Serial Interface to the Main Board.
- A Fluke manufactured Stallion IC (U30) for range selection and frequency measurements.
- Multi-Slope A/D converter comprised of discrete components and an FPGA (Field Programmable Gate Array) (U18).

The difference between the A/D boards is that the PAI uses reed relays, while the FAI uses optically coupled solid state relays.

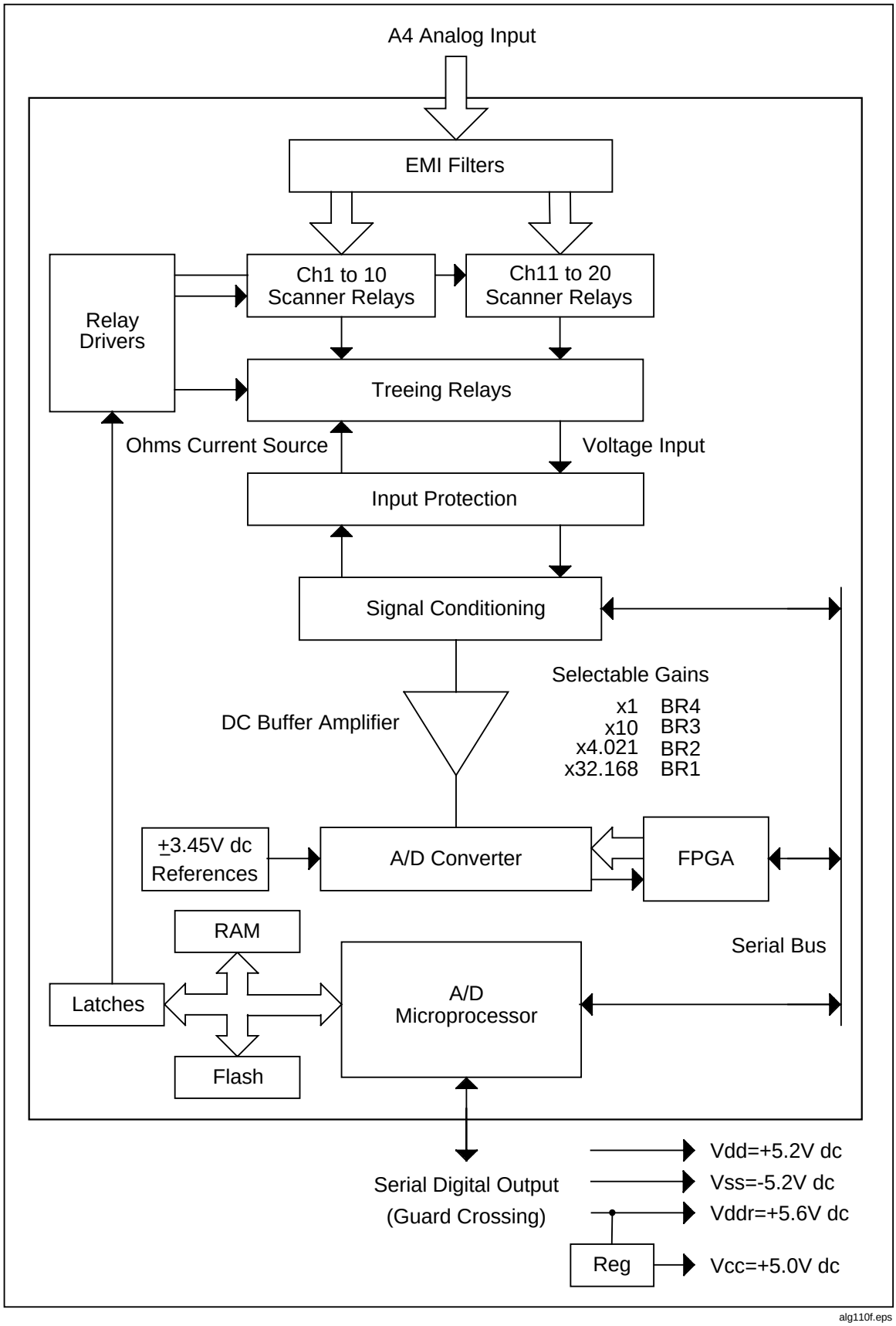


Figure 2-5. A3 A/D Converter Block Diagram

Stallion Chip

The Stallion IC (A3U30) is a Fluke-designed 100-pin CMOS device that performs the following functions under control of the A/D microprocessor (A3U5):

- Input signal routing
- Input signal conditioning
- A/D buffer amplifier range switching
- Frequency measurements
- Active filtering of ac voltage measurements

The Stallion IC design is taken from the NetDAQ design and contains the A/D conversion function using a multi-slope technique.

Two separate signal paths are used. One path is for the functions dcv/ohms/temperature, and other path is used for ac voltages/frequency.

Input Protection

Input protection is provided by series hold-off resistors A3R111, A3R110, A3R138 (thermistor), and A3R132, and related transistor switches used as clamp devices. Excessive voltages develop a current through the resistors that is sensed by the corresponding transistor, which turns on to provide a signal path to ground. For example, an excessive input on the LO SENSE line is sensed by A3R132 (100 kΩ, 3w) and clamped to ground by A3Q17.

Input Signal Conditioning

Each analog input is conditioned and/or scaled to a dc voltage (3 volts or less) for input to the buffer amplifier (A3U27, A3U28 and related devices), which scales the voltage to approximately 3 V Full Scale for measurement by the multi-slope A/D converter circuitry. The gains of the buffer amplifier are x1, x4.021, x10, and x32.168. Accuracy is derived by software calibration constants.

AC volts signal conditioning consists of conversion of an ac level to a scaled and corresponding dc level. The ac level is scaled by resistor network A3Z6 and switches A3Q10 to A3Q16, and is processed by A3U29. Input protection is via A3Z6 and A3CR5.

DC voltages below 3 V can be applied directly to the Stallion IC, while higher dc input voltages are scaled by A3Z7. Ohms inputs are converted to a dc voltage, and ac inputs are first scaled then converted to a dc voltage. Noise rejection is provided by the A/D for dc inputs and an active filter for ac inputs.

Function Relays

For both the PAI and FAI, the function relays A3K25, A3K26, and A3K27 route the input signal to the correct measurement path. They are latching relays and switched when a 6 ms pulse is applied to the set or reset coils. The A/D microprocessor (A3U5) controls the relay drive pulses by putting a data word on the bus and latching it into F/F A3U10. The drive pulses are sent by A3U10 to the appropriate coils.

Channel Selection Circuitry

Channel selection is done using reed relays on the PAI and by optically coupled solid-state relay on the FAI. Channel selection is done by a set of 24 relays organized in a tree structure. Relays A3K1 through K20 select the specific channel 1-20. The selection of relays A3K21 through K24 (Treeing Relays) depends on which bank of 10 channels is being used (both banks are selected for four-wire ohms) and the channel function and range being used.

DC Volts and Thermocouples Measurement Circuitry

For 3 V and lower ranges, the input to Stallion (A3U30) are as follows for signal HI and signal LO inputs:

- HI is a direct input via the HI SENSE line A3R111, A3K26, A3R130, and pin 50 (HI1) input of A3U30.
- LO is an input to LO SENSE via A3R132 to pin 80 (LO2) of A3U30.

For the 30 and 300 volt range, the input to Stallion (A3U30) are as follows for the HI and LO signal inputs:

- The HI signal is scaled by A3Z7. The input is applied to pin 1 of A3Z7 and a 101:1 divider is formed by the 10 MΩ 100 kΩ resistors when switches S3 and S13 are closed. The attenuated HI input is then sent via S24, S64, and S44 to the Buffer Amplifier and then to A/D Converter.
- The LO signal is sensed through A3L52, A3R146, A3K27, A3R119, and S33 and S37.

The outputs from Stallion (A3U30) are as follows:

- HI (pin 20) is to Buffer Amplifier circuitry (A3U27 and A3U28).
- LO (pin 100) is to Buffer Amplifier circuitry (A3U27 and A3U28).

The ranges for the buffer amplifier are shown in Table 2-3 and measurement matrix in Table 2-4. Figure 2-6 shows a simplified signal path for the 300 V dc range.

Table 2-3. Range of Buffer Amplifier

Range	Buffer Range Control Signals (Gain)
90 mV Range	BR1 (x32.168 gain)
300 mV Range	BR3 (x10 gain)
750 mV Range	BR2 (x4.021 gain)
3 V Range	BR4 (x1 gain)
30 V Range	BR3 (x10 gain)
300 V Range	BR4 (x1 gain)

Table 2-4. Measurement Matrix for DC Volts

DC Volt Range	Input to Stallion	Full-Scale Output of Stallion	Gain of DC Buffer Amplifier	Full-Scale DC Volts Input to Multislope A/D	Buffer Range Control Signal
90 mV	Direct	90 mV	32.168	3 V	BR1
300 mV	Direct	300 mV	10.00	3 V	BR3
750 mV	Direct	750 mV	4.021	3 V	BR2
3 V	Direct	3 V	1.000	3 V	BR4
30 V	Divide by 101	300 mV	10.000	3 V	BR3
150/300 V	Divide by 101	3 V	1.000	3 V	BR4

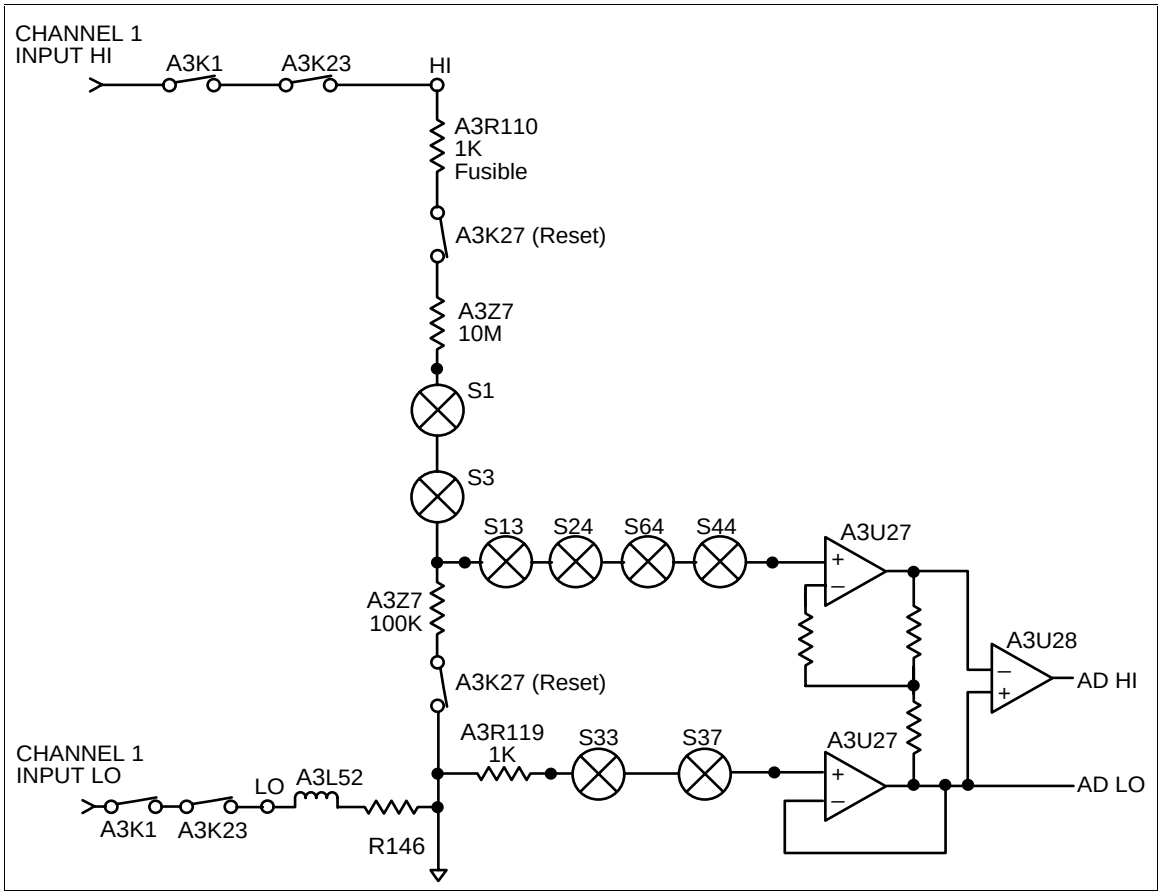


Figure 2-6. DC Volts 300 V Range Simplified Schematic

Ohms and RTD Measurement Circuitry

Resistance measurements are made by sourcing dc current through the unknown resistor and measuring the resultant dc voltage (see Table 2-5). The current source consists of operational amplifier A3U31, FET A3Q19, and switches internal to the Stallion. Four-wire measurements use separate source and sense signal paths to the point of the unknown resistance. This technique eliminates lead wire resistance errors. Figure 2-7 shows a simplified signal path for an RTD four-wire measurement.

Table 2-5. Measurement Matrix for Ohms

Ohms Range	Current Used	Full-Scale Input to Stallion (dc volts)	Full-Scale Output of Stallion (dc volts)	Gain of DC Buffer Amplifier	Full-Scale DC Volts input to Multislope A/D	Buffer Range Control Signal
300 Ω	1 mA	300 mV	300 mV	10	3 V	BR3
3 kΩ	100 μA	300 mV	300 mV	10	3 V	BR3
30 kΩ	10 μA	300 mV	300 mV	10	3 V	BR3
300 kΩ	10 μA	3 V	3 V	1	3 V	BR3
3 MΩ	1 μA	3 V	3 V	1	3 V	BR3

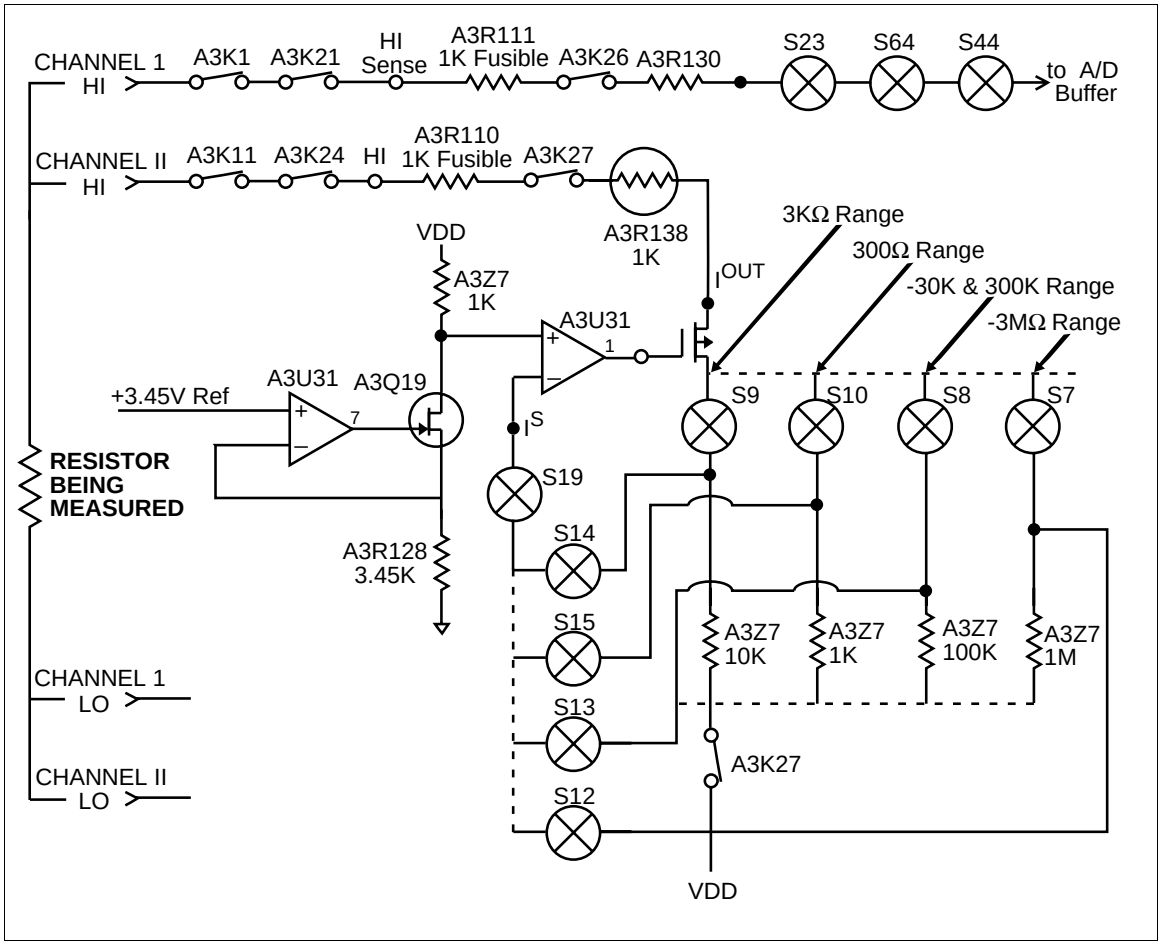


Figure 2-7. RTD Measurement Simplified Schematic

AC Volts Measurement Circuitry.

AC-coupled voltage inputs are scaled by an ac buffer (A3U29), converted to dc by a true RMS ac-to-dc converter (A3U26), filtered by an active ac volt filter, then sent to the Stallion IC, the Buffer Amplifier, and the A/D Conversion Circuitry (see Table 2-6). The HI input is switched to the ac buffer through dc blocking capacitor A3C80. The LO input is sensed through A3L52, A3R146, A3K27, A3R119, and S33 and S37. The gain or attenuation of the ac buffer is selected by A3U30's ACR1-ACR4 outputs. 0 V turns JFETS A3Q10 to A3Q16 ON, while –5 V (V ac) turns the JFETS OFF. Only one line at a time is set at 0 V.

Table 2-6. Measurement Matrix for AC Volts

AC Volt Range	Gain of AC Volts Buffer Amplifier	Full-Scale Output of AC Volts Buffer Amplifier	Full-Scale Output of RMS Converter	Full-Scale Input to Stallion (dc volts)	Full-Scale Output of Stallion (dc volts)	Gain of DC Buffer Amplifier	Full-Scale DC Volts Input to Multislope A/D	Buffer Range Control Signal
300 mV	2.5	0.75 V rms	0.75 V	300 mV	300 mV	10	3 V	BR3
3 V	0.25	0.75 V rms	0.75 V	300 mV	300 mV	10	3 V	BR3
30 V	0.025	0.75 V rms	0.75 V	300 mV	300 mV	10	3 V	BR3
150/300 V	0.0025	0.75 V rms	0.75 V	300 mV	300 mV	10	3 V	BR3

The ac voltage input signal is routed through and scaled by the buffer to obtain a full scale buffer output of 0.75 V rms at A3U29-6. A3R120 and A3C76 provide high frequency compensation on the 300 mV range. The output of the buffer is ac coupled to the input of the ac-to-dc RMS converter. The output of the RMS converter (0.75 V dc) is divided by 2.5 by A3Z2 and sent to the acv filter. The filtered output is sent to pin 31 (ACFO) of the Stallion chip via S41. Full scale input to Stallion is 300 mV dc. Figure 2-8 shows a simplified signal path for the 3 V ac range.

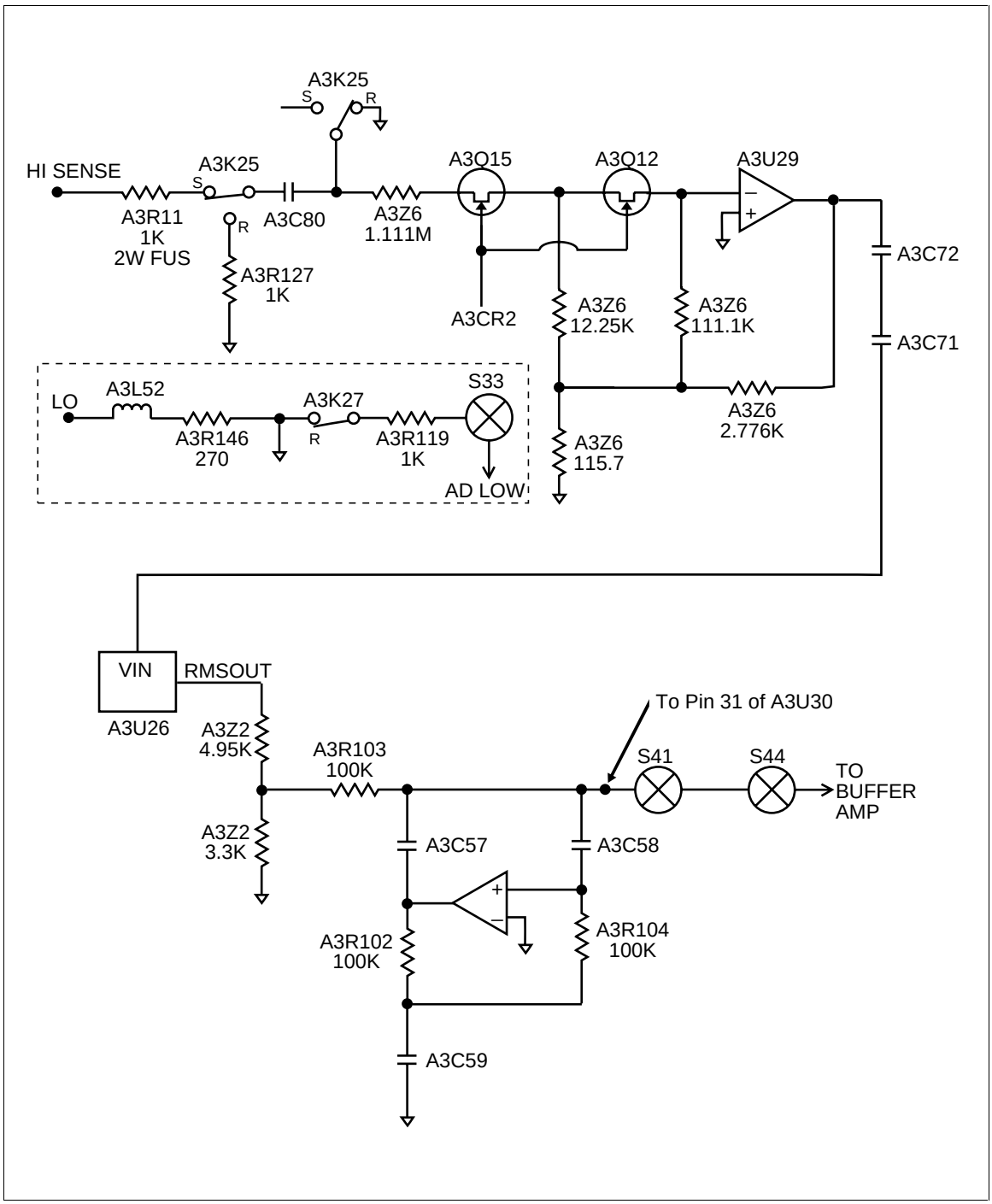


Figure 2-8. AC Volts #V Range Simplified Schematic

Frequency Measurements

The ac input follows the same path as ac volt measurements except the output of the buffer (A3U29) is sent to the Stallion Chip pin 35 (C+). Internal to the Stallion Chip switch S38 sends the C+ input to a frequency comparator and counter.

Active Filter (ACV Filter)

The active filter is used only for V ac measurements to filter out the ac ripple and noise present on the output of the RMS converter. The filter uses an op-amp internal to the Stallion Chip, resistors A3R102, A3R103, and A3R104, capacitors A3C57, A3C58, and A3C59. A3Q6 turns on to discharge the capacitors between measurements.

Voltage Reference Circuit

The voltage reference circuit creates a well-regulated +3.45/-3.45 V dc source for use by the A/D converter, and as a source for ohms and current measurements. The circuit is formed around two dual op-amps A3U12 and A3U20. A3U12 controls balance between +3.45 V dc and -3.45 V dc by adjusting the +3.45 V dc through A3Q2 as the divider between these voltages in resistor pack A3Z1 reads above or below zero. The other half of A3U12 adjusts the absolute voltage difference between the two outputs by regulating the -3.45 V dc so as to produce zero collector-base volts on A3Q5. If the collector voltage rises, then A3Q5 needs more current, which is produced by lowering the -3.45 V dc through A3Q3. Resistor A3R101 and capacitor A3C48 stabilize the loop.

A3U20 is also a dual op-amp. One half provides the regulated 3 mA required to flow into the cathode of the zener diode within A3Q5 by forming a current source with A3Q4. If not supplied from a current source, the current would change with the emitter base voltage of A3Q5. The current source is best visualized as a differential amp sensing both sides of A3R83 and nulling this against the reference voltage. The other side of A3Q20 establishes a reference voltage of 0.493 V dc above the collector of A3Q5 so that the selected resistors A3R64 and A3R65 provide the required current. When A3Q5 is tested, it has a collector current specified for zero TC. This current is converted into resistor values, but requires a known voltage differential to operate properly.

Analog/Digital Converter Circuit

The A/D converter consists of a gate array for control, switches for directing currents, and a reference circuit and reference resistors for providing the currents. The various currents are integrated across capacitor A3C44, and the zero crossing is detected by comparator A3U11 and a logic signal returned to the FPGA (Field Programmable Gate Array). The FPGA contains counters that count the amount of time that the reference currents are applied to the integrator. The input voltage is proportional to the difference in the time required of positive and negative reference currents to null the applied input. The a/d produces about $\pm$35,000 counts for $\pm$3 V dc. It has linear behavior up to 3.4 V dc. This gives a resolution of about 88 µV in the fast measurement mode.

The measurement cycle consists of four basic periods as shown in Table 2-7. This gives a total measurement time of 833.533 µs. A brief explanation of each state follows. For additional information, refer to “A1 Main to A3 A/D Converter Communications” later in this chapter.

Autozero

Autozero is the state the a/d idles in when not in use. In this state, the signals PREF, NREF, DREF, and INT are all low. The purpose of the state is to remove any remaining charge on A3C44, to charge A3C60 to a voltage so that pin 6 of A3U19 is at zero, and to provide time to return data to the microprocessor. In this state, the input is not connected, A3R94 and A3R95 ground the input, A3U19 produces an error signal, which is amplified by the other halve of A3U19, providing feedback to produce a nulling voltage at A3C60. A3C60 stays charged to this voltage until another cycle is initiated.

Table 2-7. Analog/Digital Converter Measurement Cycle

State	Counts	Time
Autozero	125	200.0 µs
Integrate	307	491.4 µs
Deintegrate1	64	102.4 µs
Deintegrate2	24	38.4 µs
Overhead	n/a	1.333 µs
	Total	**833.533 µs**

Integrate

The integrate state is when the input voltage is actually connected to the integrator. PREF and NREF are each switched off and on 10 to 20 times during this state and DREF is still off, INT is on, AZ is off, and the CMP signal is switching off and on. The primary signal is pin 7 of A3U19, which looks approximately like a triangular wave with 51.2 µs slope when the input voltage is zero. The triangular wave is very irregular at other voltages, moving on an upward or downward slope and reversing direction within the integrate time period. The actual behavior is determined by the algorithm in the FPGA.

This tests the CMP signal at defined times spaced 51.2 µs apart. If the CMP signal is turned off, then NREF is turned on. PREF and NREF are never on at the same time during integrate. First, the existing reference is turned off and a 1-count (1.6 us) period is entered where only the input signal is integrated. Next, a reference of a polarity such as to keep the total number of NREF pulses so far equal to the number of PREF pulses is turned on for 1-count (1.6 µs).

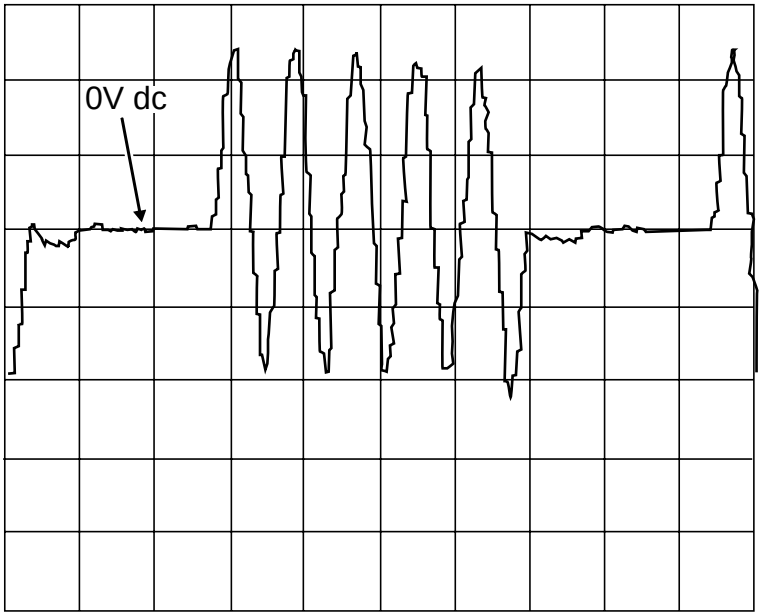
Finally, the reference with a polarity determined by the comparator (CMP) test at the very first of the interval is turned on for the remaining 30 counts (48 µs) of the interval. The beginning first interval is only 16 counts instead of 32 counts. The last state is 35 counts to allow for completing the PREF and NREF pulse count equalization. There are 8 normal intervals of 32 counts. The purpose is to bound the waveform to prevent amplifier saturation, prevent charge injection from being a variable with waveform changes and prevent logic signals themselves from injecting unwanted signals into the summing node.

The integrate state is the primary measuring interval, and during this time the FPGA accumulates counts of how long PREF and NREF have been applied. The count is completed during deintegrate. Typical integrator output waveforms for different inputs are shown in Figure 2-9, Figure 2-10, and Figure 2-11.

Deintegrate1

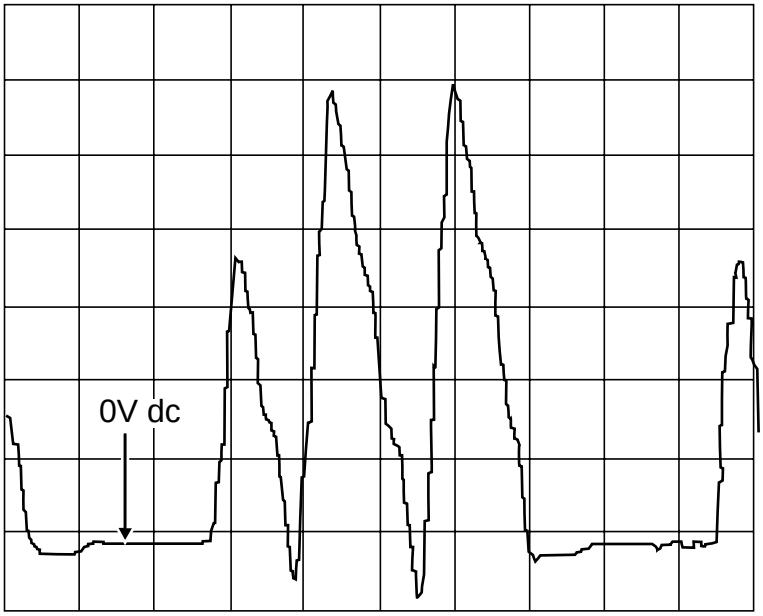
Deintegrate1 is when the remaining charge of the capacitor is removed and the major count is completed. The input is turned off and no longer affects the reading. INT is off, PREF, and NREF continue to switch a few more times, and the signal is brought very close to zero. The previous integrate state ended in a hold (both references off) and this state begins with the PREF signal on. The comparator is examined after each count and as soon as CMP goes low, a hold state begins with both references off. Depending of the level of the signal at the beginning of deintegrate, this can result in PREF being on from 1 to 60 counts. At the end of the hold count NREF, is turned on until CMP drops low.

This can also be anywhere from 1 to 60 counts, but at this point, the output should be within 1 count of reaching zero volts. Next, another hold state is entered into for 1 count, followed by PREF until CMP goes high. This sets up the final DREF to always approach zero from the same direction. A hold state with both references off begins until a total of 64 counts have occurred since deintegrate began. If the magnitude of the signal as it ends integrate is large, this final hold is short. If the signal at the end of integrate is small, the hold is as long as 60 counts.



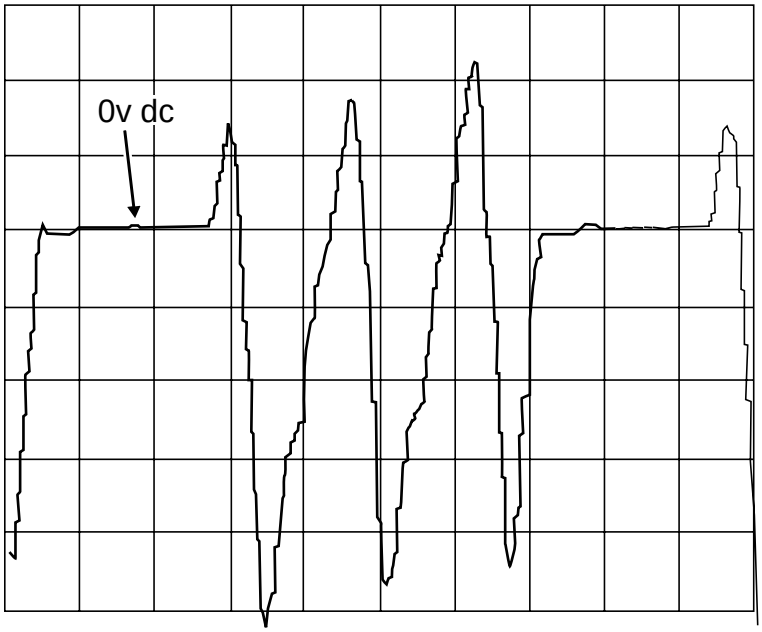
f2-11.eps

Figure 2-9. Integrator Output Waveform for Input Near 0



f2-12.eps

Figure 2-10. Integrator Output Wavefrom for Input Near + Full Scale



f2-13.eps

Figure 2-11. Integrator Output Waveform for Input Near - Full Scale

Deintegrate2

Deintegrate begins with the turning on of DREF. This reference applies 1/16th of the current of NREF so the approach to zero is slower and more accurate. Correspondingly, the internal FPGA counter counts this time at 1/16th the value of NREF time. The count ends as the final state of the comparator (CMP) goes low, indicating that the charge has been removed from the capacitor. This also ends the count accumulation in the FPGA counters. The deintegrate2 state always takes 24 counts even though the data has already been accumulated. This guarantees the entire measurement cycle is of fixed length so that line cycle rejection is maintained. The data is sent to the microprocessor during the following an Autozero state. It is sent with 20 bits each for the PREF and NREF times. In the microprocessor, the voltage is computed based on the difference between P-counts and N-counts.

Overhead

Overhead is a fixed amount of time required for signal settling and processing.

Inguard Digital Kernel Circuitry

The inguard digital kernel circuitry consists of devices A3U2, A3U5, A3U6, A3U7, and A3U10. The memory consists of Flash ROM (A3U6) that contains the internal A/D program and RAM (A3U2). The 68302 microprocessor is A3U5, which communicates with the Controller/System Power PCA, and the Stallion device via the serial lines SB CLK, SB XMIT, and SB RECV. Kernel communications are via the A/D State Machine (FPGA IC, A3U18) using serial lines SB CLK, SB XMIT, and SB RECV (sends measurement commands and reads measurement data).

To start a measurement, A/D TRIGGER* is asserted by the A/D microprocessor A3U5-113. Communication is with Stallion if the processor sets STAL SELECT* low (A3U5 pin 115). The DISCHARGE signal at A3U5-59 is asserted to discharge the filter capacitors, and a data word sent out on the D0-D7 bus controls channel, treeing, and function relays.

Communication with the Controller/System Power PCA is done using the CordxRx line to receive and the CordxTx line to send serial data. On the A/D side, these signals are called RECV DATA and XMIT DATA (pins A3U5-53 and A3U5-54 respectively). The RESET* signal is asserted on power-up for reset and during operation when a break signal is received from A1U4.

The A/D microprocessor guard crossing is bi-directional. When the user finishes defining the channels and intervals and starts scanning, the Controller/System Power PCA downloads all the channel information to the A3 A/D Converter PCA. The Controller/System Power PCA uses the guard crossing to advise the A3 A/D Converter PCA when to start scans, and then return the readings to the Controller/System Power PCA. The arrangement keeps the guard-crossing traffic to a minimum when scanning is taking place allowing peak performance during short scan intervals.

Open Thermocouple Detect Circuitry

The open thermocouple detect circuitry uses devices A3U23 and A3U32. Before every thermocouple measurement, the open T/C check is done by sending a small ac-coupled signal to the thermocouple input. The A/D Microcomputer (A3U5) initiates the open T/C test by asserting OTC_EN and turning ON A3Q20. A 19.2 kHz square wave is sent out the OTCCLK line through A3Q20 and A3C82 to the thermocouple.

The resulting waveform is detected by A3U32 pin 3 and a proportional level is stored on A3C79. If the level is above a threshold level of about 2.7 V (Vth) the resistance at the input is too large (greater than 4 kΩ to 10 kΩ) and open T/C check is asserted by A3U32 pin 7. After a short delay the A/D Microcontroller reads the signal and determines if the thermocouple should be reported to the Controller/System Power PCA as open.

A4 Analog Input PCA Circuit Description

The Input Connector assembly, which plugs into the A/D Converter PCA from the rear of the instrument, provides 20 pairs of channel terminals for connecting measurement sensors. This assembly also provides the reference junction temperature sensor circuitry used when making thermocouple measurements.

Circuit connections between the Input Connector and A/D Converter PCAs are made via connectors A4P1 and A4P2. Input channel and earth ground connections are made via A4P1, while temperature sensor connections are made through A4P2.

Input connections to channels 1 through 20 are made through terminal blocks TB1 and TB2. Channel 1 and 11 HI and LO terminals incorporate larger creepage and clearance distances and each have a metal oxide varistor (MOV) to earth ground to clamp voltage transients. MOVs A4RV1 through A4RV4 limit transient impulses to the more reasonable level of approximately 1800 V peak instead of the 2500 V peak that can be expected on 240 V ac, IEC 664 Installation Category II, ac mains. In this way, higher voltage ratings can be applied to channels 1 and 11 than can be applied to the other rear channels.

Strain relief for the user's sensor wiring is provided both by the Connector PCA housing and the two round pin headers. Each pin of the strain relief headers is electrically isolated from all other pins and circuitry.

Temperature sensor transistor A4Q1 outputs a voltage inversely proportional to the temperature of the input channel terminals. This voltage is 0.6 V dc at 25 °C, increasing 2 mV with each degree decrease in temperature, or decreasing 2 mV with each degree increase in temperature. For high accuracy, A4Q1 is physically centered within and thermally linked to the 20 input terminals. Local voltage reference A4VR1 and resistors A4R1 through A4R3 set the calibrated operating current of the temperature sensor. Capacitor A4C1 shunts noise and EMI to ground.

A31 A/D Power Supply Circuit Description

The A/D power supply is a dc to dc converter that provides not only the +/-5.2 (Vdd/Vss) and +5.6 (Vdd~) supplies to the A/D PCAs but also isolates the boards from one another.

Controller/System Power (Outguard) to A3 A/D Converter (Inguard) Communications

The exclusive means of communication between the inguard and outguard is a bi-directional, asynchronous, optically-isolated serial link. This link operates at a rate of 120,000 baud. The individual bytes are transmitted with eight data bits, one stop bit, and one even parity bit.

The outguard can send either a reset or a command to the inguard. A reset consists of a number of consecutive break characters, and causes a complete reset of the inguard hardware and software. The inguard returns no response to a reset. A command is a six-byte packet (hereafter referred to as a 'command packet') that causes the inguard to perform some action and return one or more six-byte response packets. Transactions between the outguard and inguard are always initiated by the outguard. The inguard never sends data across the guard without being asked to do so.

There are two modes of communication between the inguard and outguard: non-pipelined and pipelined. In the non-pipelined mode, commands and responses are synchronous, i.e., the outguard waits for the response to a command before sending another command. In the pipelined mode, the outguard may send a second command before the first command has completed. The outguard must wait for the response from the first command before sending a third command.

Special Codes

An ACK response packet is arbitrarily defined as the sequence of bytes (42,0,0,0,0,x) where x is the checksum byte. A NAK response packet is defined as (255,255,255,255,255,x) where x is the checksum byte. A break is an all-zeros without stop bits.

Resets

A reset consists of 5 ms of consecutive break characters sent to the inguard. A hardware circuit on the inguard detects this condition and causes a complete reset of the inguard subsystem. The inguard sends no response to a reset. After sending a reset, the outguard must wait a predefined amount of time before attempting further communication with the inguard. This is the same amount of time it waits after a power-up, approximately 3.5 seconds.

Commands

A command consists of a six-byte packet sent from the outguard to the inguard. The most-significant four bits of the first bytes define the following command types:

- Perform Scan.
- Perform a Self-Test.
- Return A/D Main Firmware Version.
- Return A/D Boot Firmware Version.
- Set Global Configuration.
- Set Channel Configuration.
- Do Housekeeping.

The sixth byte is a checksum. The meanings of the remainder of the bits in the command packet vary depending on the command type. The response to all commands is one or more six-byte response packets. The sixth byte in a packet is always the checksum byte; the meaning of the remainder of the bits depends on the command. The only restriction is that a response packet should always be distinguishable from a NAK, i.e., it should never have all bits 1.

Perform Scan

The Perform Command Packet tells the A/D Converter Assembly to do the following:

- Measure Channel Number if set.
- Return BR1 Zero Offset if set.
- Return BR2 Zero Offset if set.
- Return BR3 Zero Offset if set.
- Return BR4 Zero Offset if set.
- Return Reference Junction Reading if set.
- Return Reference Balance (both references off) reading if set.
- Return Reference Balance (both references on) reading if set.
- Return Checksum.

Action Performed The Perform Scan command causes the inguard to measure each channel indicated. These channels must have been previously defined using the Set Channel Configuration command. One response packet is sent to the outguard for each channel measured. If any thermocouple channels are requested in this scan, the first response packet is the reference junction reading. If a requested channel has not been defined, its value is returned as NaN.

There are several bits in the command that exist for debugging purposes only. These bits indicate that the current stored value for the corresponding housekeeping reading should be returned. The actual value returned for these bits depend on the current measurement rate, since a different value is stored for each measurement rate. Note that these bits do not cause any physical measurement to take place, they simply cause the latest values to be returned.

Response Packets Returned The inguard returns one response packet for the reference junction reading if any of the measured channels is a thermocouple channel, followed by a response packet for each channel measured, returned in ascending channel order, followed by a response packet for each housekeeping reading specified by the scan command.

Response Packet Format Each response packet for a Perform Scan command consists of a floating-point number representing the measurement value, the range used to take the measurement, the channel number, and the checksum. The floating-point format used is ANSI/IEEE Std 754-1975 single-precision. Positive and negative overload conditions cause a value of PLUS_OVLD_VAL (0x7f800000) and MINUS_OVLD_VAL (0xff800000), respectively, to be returned. A frequency channel whose input frequency is too low to measure returns 0 Hz. A channel with an open-thermocouple condition causes the value of OTC_VAL (0x7fc00000) to be returned. The inguard waits until it has completed all measurement activity associated with a particular scan before beginning the transmission of the response packets for that scan to the outguard.

The floating-point value returned has a nominal range of -3.0 to +3.0. The outguard must scale this according to the channel function and range to produce the correct volts or ohms. For most ranges, a full-range value is returned as +3.0. For example, on the 300 Ω range, +3.0 represents 300 Ω. For the 90 mV and 750 mV ranges, however, +3.0 represents 93.26 mV and 0.746083 V, respectively. Also, frequency readings always return the actual frequency measured and do not require range-scaling by the outguard.

Perform Self-Test

The Command Packet tells the A/D to perform all self tests. Response Packets Returned always returns a single response packet. The Response Packet Format provides the following:

- A/D self-test result, pass or fail.
- Zero Offset self-test result, pass or fail.
- Reference Balance self-test result, pass or fail.
- Ohms Overload self-test result, pass or fail.
- Open Thermocouple self-test result, pass or fail.
- Checksum

Return Firmware Version

This Command Packet requests version number of the inguard firmware and always returns a single response packet.

Response Packet Format The response consists of five ASCII characters (plus the checksum byte), in the form txxyy, where t is “F” for FFE (FAI) software and “P” for the PFE (PAI); xx are the two digits of the major version number, and yy are the two digits of the minor version number (there is an implicit decimal point between the two). Note that constraining the bytes to be ASCII characters causes the most significant bit of each character to be a 0, making the response packet always distinguishable from a NAK.

Return Boot Firmware Version

This Command Packet Format requests version number of the inguard boot firmware and always returns a single response packet.

Response Packet Format The response consists of five ASCII characters (plus the checksum byte), in the form Bxxyy, where B indicates boot software, xx are the two digits of the major version number, and yy are the two digits of the minor version number (there is an implicit decimal point between the two). Note that constraining the bytes to be ASCII characters causes the most significant bit of each character to be a 0, making the response packet always distinguishable from a NAK.

Set Global Configuration

The Command Packet tells the A/D the following:

- Measurement Rate, fast, medium, or slow
- Power Line Frequency, 50 Hz or 60 Hz
- Scheduled Housekeeping Measurements, Enable or Disable

Action Performed Sets global configuration parameters (instrument measurement rate, AC power line frequency, and enable or disable housekeeping measurements). The default state for the inguard is to measure on the fast rate, assuming 60 Hz, and with scheduled housekeeping measurements enabled. The meaning of "scheduled housekeeping measurements" depends on the current measurement rate.

Response Packets Returned Always returns a single response packet.

Response Packet Format Returns either an ACK packet or a NAK if the command arguments are not recognized.

Set Channel Configuration

The Command Packet tells the A/D the following:

Measurement Function V dc, V ac, 2-Wire Ohms, 4-Wire Ohms, Frequency, Thermocouple, OFF.

Range 90 mV or 300 Ω, 300 mV or 3 kΩ, 3 V or 30 kΩ, 30 V or 300 kΩ, 50 V (FAI), 150/300 V (PAI), or 3 MΩ, 750 mV (reference junction calibration).

The range field is ignored for frequency and thermocouple channels.

Channel Number 0 to 19 (though user sees channel 1 to 20)

Enable Autorange if bit set (ignored for frequency and thermocouple).

Enable Open Thermocouple Detect if bit set.

Checksum Action Performed is configuration of a single channel to the parameters given. The Response Packets Returned always returns a single response packet. The Response Packet Format returns an ACK response packet if the channel was successfully configured; otherwise, it returns a NAK.

Do Housekeeping

The Command Packet tells the A/D to do the following:

- Do all housekeeping readings if bit set.
- Do the next housekeeping reading in the schedule if bit set.
- Prescan: preset the function relays.

Checksum Action Performed is as follows:

- If the Housekeeping bit is 1, the inguard takes a complete set of housekeeping readings for the current measurement rate (there is one set for each rate).

- If the Next bit is 1, the inguard does the next housekeeping reading indicated by its internal schedule. This is the same schedule used for a housekeeping timeout.
- If the Do2 bit is 1, the inguard does the two reference balance readings.
- If the PS bit is 1, the inguard presets the function relays for the first defined channel.

These bits may be set or cleared independently. Note that the actions described above are carried out regardless of whether scheduled housekeeping is "enabled" by the global configuration command.

Response Packets Returned Always returns a single response packet. This packet is not returned until the inguard completes all indicated housekeeping measurements.

Response Packet Format Returns a single ACK packet.

Checksums

The last byte of each command and response packet is its checksum.

Any time a packet that fails its checksum test is received, it is treated as a communication error. The inguard transmits a break and waits to be reset. The outguard resets the inguard.

Errors

Whenever the inguard encounters an unrecoverable error or a guard-crossing communications error (e.g., parity error, overrun), it attempts to send a break character to the outguard and then goes into a loop, ignoring all subsequent commands from the outguard, and waits to be reset by the outguard. This insures that all measurement hardware is properly reset. This type of error could be caused by a glitch in the inguard hardware, which is conceivable but rare.

The inguard returns a NAK whenever it receives an illegal command or a command with illegal parameters. Such an error should never occur and probably indicates a software defect. The exception to this is that an error in a scan command returns a break (instead of a NAK).

Power-Up Protocol

The inguard powers up silently, without sending any kind of unsolicited information to the outguard. The outguard, after powering up, waits 3.5 seconds before attempting to communicate with the inguard, to allow it to complete its initialization procedure and power-on self-tests. The inguard performs only limited self-tests automatically on power-up. The full set of self-tests is performed only in response to a self-test command from the outguard.

Inguard Unresponsive

The inguard does not contain any kind of watchdog timer. If, for whatever reason, the inguard fails to respond after the expected length of time, the outguard should reset the inguard by sending a series of break characters. The "expected length of time" for a scan command is variable depending on the number and types of channels defined, and is calculated by the outguard at run-time.

Inguard Software Description

The major functional blocks of the inguard are given in Figure 2-1. The arrows show the flow of measurement information. There is a control interface (not shown) between the A3U5 A/D microprocessor and every other functional block.

The channel scanner relays select the desired channel to be measured and route it to the function relays. The function relays route the signal to the appropriate portion of the Signal Conditioning circuitry, depending on the function being measured (V ac, V dc, ohms, etc.). The Signal Conditioning circuitry converts the signal into a form that can be measured by the A/D (i.e., a dc voltage with a range of -3 to 3 V).

The A/D converts the analog voltage to a digital value, which is then read by the A3U5 A/D microprocessor. The box labeled A/D microprocessor represents the microcontroller and its associated memory and glue logic, upon which the inguard software runs. It controls all of the other hardware elements on the inguard and handles communication with the outguard.

The primary task of the inguard software is to interpret configuration information and scan requests from the outguard, manipulate the hardware in the appropriate way to obtain the requested measurements, and return the measurement data to the outguard.

Hardware Elements

This section contains information about the various hardware subsystems on the inguard board.

Channel MUX

The channel multiplexing consists of treeing and channel switches, implemented with either FET switches (FAI) or reed relays (PAI). There are two sets of bits associated with these switches. The tree bits must be set to indicate which bank of channels is being used where bank 0 is channels 1 to 10, and bank 1 is channels 11-20. For four-wire ohms measurements, both banks are selected. The position of the tree switches is also a function of the channel function and range being measured.

The channel bits are set to indicate which of the 10 channels within a bank is being selected. To deselect a channel (so that no channels are selected), write 1111 to the channel bits. The tree bits should not be deselected, since this would result in excessive wear of these switches (for the PAI). Table 2-8 gives the bit patterns for the tree bits and Table 2-9 gives the bit patterns for the channel bits.

Table 2-8. Tree Bits

Signal	TR 2	TR 1	TR 0	Switches
2W Ω, V ac, Frequency, V dc, <=3 V, OTC, TC (CH1-10)	1	0	1	K21, K23
2W Ω, V ac, Frequency, V dc, <=3 V, OTC, TC (CH11-20)	1	1	0	K22, K24
V dc >3 V (CH1-10)	0	0	1	K23
V dc >3 V (CH11-20)	0	1	0	K24
4W Ω	1	1	1	K21, K24

Table 2-9. Channel Bits

Channels Enabled	CH3	CH2	CH1	CH0
1, 11	0	0	0	0
2, 12	0	0	0	1
3, 13	0	0	1	0
4, 14	0	0	1	1
5, 15	0	1	0	0
6, 16	0	1	0	1
7, 17	0	1	1	0
8, 18	0	1	1	1
9, 19	1	0	0	0
10, 20	1	0	0	1

The time required for the channel switches to settle is given in Table 2-10. Note that for both the FAI and the PAI, the switches are guaranteed to have a select time that is longer than their deselect time. This means that you can select a new channel at the same time as you deselect the previous channel, without worrying about shorting together the two channels.

Table 2-10. Tree and Channel Switch Settling Times

Description	PAI	FAI
Select	1 ms	150 µs
Deselect	1 ms	120 µs

Function Relays

There are three relays (K25, K26, and K27) that route the signal to different portions of signal-conditioning circuitry on the A/D board. These are relatively slow relays, requiring 6 ms to change position. Each relay has a SET and RESET position, which are configured by pulsing the SET and RESET coils, respectively. Each change of state of the function relays requires two writes by the A3U5 A/D microprocessor: one to set the appropriate bits and energize the relays and another to reset all the bits and de-energize the coils once the relays have switched (after 6 ms).

Table 2-11gives the required relay states and bit patterns for the various measurement functions. Note that after the indicated bit pattern is written and 6 ms have elapsed, a pattern of 000000 should be written. Also note that the two bits associated with any given relay, corresponding to SET and RST, are never set to 1 at the same time. Table 2-12 gives the required time for the relays to settle for a given function.

Table 2-11. Function Relays

Function	K26	K25	K27	F0	F1	F2	F3	F4	F5
V dc, TC, OTC	S	R	R	0	1	1	0	1	0
Ohms	S	R	S	0	1	1	0	0	1
V ac, Frequency	R	S	R	1	0	0	1	1	0

Table 2-12. Function Relay Settling Time

PAI	FAI
6 ms	6 ms

Stallion Chip and Signal Conditioning

The Stallion Chip (A3U30) is a Fluke-custom IC that contains assorted switches, amplifiers, and the frequency counter. The chip contains registers that the A3U5 A/D microprocessor may read and write to configure the chip and obtain frequency readings. Its interface to the A3U5 A/D microprocessor consists of a synchronous serial port. The SCP port of the A3U5 A/D microprocessor is used to program the Stallion, with a clock rate of 3.072 MHz. When reading information from the Stallion (the only time this needs to be done is for frequency readings), the clock rate is reduced to 960 kHz. Due to a limitation of the Stallion chip, the fastest that data may be reliably read from the chip is 1 MHz.

The Stallion switch settings for the various function/range combinations are given in Table 2-13.

Table 2-13. Stallion Switch Settings

Function	Stallion Settings																
	S Switches											Other Switches					
V dc 90 mV	17	23	35	37	39	44	50	64				BR1	ACR4	FPWR	RPCTL		
V dc 300 mV	17	23	35	37	39	44	50	64				BR3	ACR4	FPWR	RPCTL		
V dc 750 mV	17	23	35	37	39	44	50	64				BR2	ACR4	FPWR	RPCTL		
V dc 3 V	17	23	35	37	39	44	50	64				BR4	ACR4	FPWR	RPCTL		
V dc 30V	1	3	13	17	24	33	37	39	44	50	64	BR3	ACR4	FPWR	RPCTL		
V dc HIV	1	3	13	17	24	33	37	39	44	50	64	BR4	ACR4	FPWR	RPCTL		
V ac 300 mV	1	17	18	34	37	39	41	44				BR3	ACR1	FPWR	RPCTL		
V ac 3 V	1	17	18	34	37	39	41	44				BR3	ACR2	FPWR	RPCTL		
V ac 30 V	1	17	18	34	37	39	41	44				BR3	ACR3	FPWR	RPCTL		
V ac HI V	1	17	18	34	37	39	41	44				BR3	ACR4	FPWR	RPCTL		
2W 300Ω	10	15	19	23	35	37	39	44	64			BR3	ACR4	FPWR	RPCTL		
2W 3 kΩ	9	14	19	23	35	37	39	44	64			BR3	ACR4	FPWR	RPCTL		
2W 30 kΩ	8	13	19	23	35	37	39	44	64			BR3	ACR4	FPWR	RPCTL		
2W 300 kΩ	8	12	19	23	35	37	39	44	64			BR3	ACR4	FPWR	RPCTL		
2W 3 MΩ	7	11	19	23	35	37	39	44	64			BR3	ACR4	FPWR	RPCTL		
4W 300Ω	10	15	19	23	35	37	39	44	64			BR3	ACR4	FPWR	RPCTL		
4W 3 kΩ	9	14	19	23	35	37	39	44	64			BR3	ACR4	FPWR	RPCTL		
4W 30 kΩ	8	13	19	23	35	37	39	44	64			BR3	ACR4	FPWR	RPCTL		
4W 300 kΩ	8	12	19	23	35	37	39	44	64			BR3	ACR4	FPWR	RPCTL		
4W 3 MΩ	7	11	19	23	35	37	39	44	64			BR3	ACR4	FPWR	RPCTL		
Freq. 300 mV	1	17	18	26	32	34	38	44	64			ACR1	FPWR	FHYST0	FHYST1	RPCTL	
Freq. 3 V	1	17	18	26	32	34	38	44	64			ACR2	FPWR	FHYST0	FHYST1	RPCTL	
Freq. 30 V	1	17	18	26	32	34	38	44	64			ACR3	FPWR	FHYST0	FHYST1	RPCTL	
Freq. HI V	1	17	18	26	32	34	38	44	64			ACR4	FPWR	FHYST0	FHYST1	RPCTL	
TC	(same as V dc 90 mV)																

Table 2-13. Stallion Switch Settings (cont)

Function	Stallion Settings															
	S Switches											Other Switches				
Zero BR1	23	35	37	39	44	64						BR1	ACR4	ACR5	FPWR	RPCTL
Zero BR2	23	35	37	39	44	64						BR2	ACR4	ACR5	FPWR	RPCTL
Zero BR3	23	35	37	39	44	64						BR3	ACR4	ACR5	FPWR	RPCTL
Zero BR4	23	35	37	39	44	64						BR4	ACR4	ACR5	FPWR	RPCTL
REFBAL2	26	34	37	39	44	64						BR4	ACR4	FPWR	RPCTL	
REFBAL0	26	34	37	39	44	64						BR4	ACR4	FPWR	RPCTL	
REFJUNC	17	21	34	37	39	44	64					BR2	ACR4	FPWR	RPCTL	
OTC Dischg	17	23	34	37	42	43	44	46	64	65		BR1	ACR4	FPWR	RPCTL	

After the input channel has been selected and the Stallion chip programmed appropriately, there is a minimum time required for the signal conditioning circuitry to settle. This settling time varies depending on the function and range being measured, and is given in Table 2-14.

Table 2-14. Signal Conditioning Settling Time

Function	Time
V dc	30 µs
V ac, fast	100 ms
V ac, medium	150 ms
V ac, slow	200 ms
300 Ω	20 µs
3 kΩ	100 µs
30 kΩ	400 µs
300 kΩ	2 ms
3 MΩ	10 ms
Frequency, fast	100 ms
Frequency, medium	150 ms
Frequency, slow	200 µs
Zero, BR1	30 µs
Zero, BR2	30 µs
Zero, BR3	30 µs
Zero, BR4	30 µs
Reference Balance, both references on	30 µs
Reference Balance, both references off	30 µs
Reference Junction	30 µs

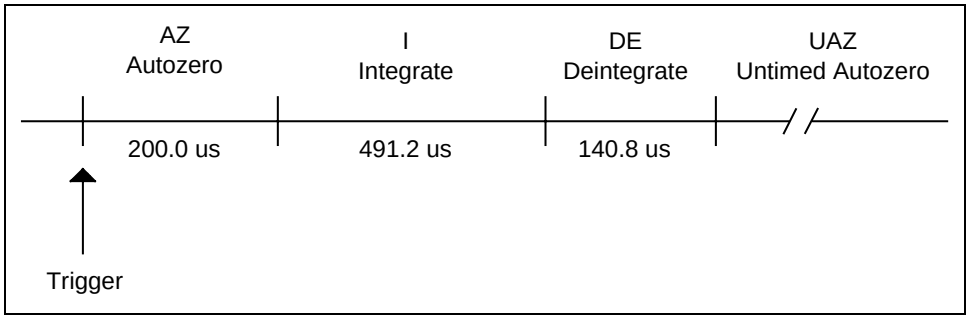
A/D

The multi-slope A/D converter in the instrument uses a hardware state machine (A3U18) to control the switching of the voltage references during the A/D conversion. This state machine also contains the counters that measure how long each reference is switched in, and provides the A3U5 A/D microprocessor with its interface to the A/D. A synchronous serial port is used to transfer the counter contents from the state machine to the A3U5 A/D microprocessor. These counter values can then be manipulated to form an A/D reading. There are two counters, NCOUNT and PCOUNT, which measure how long the negative and positive references, respectively, are switched in.

Timing

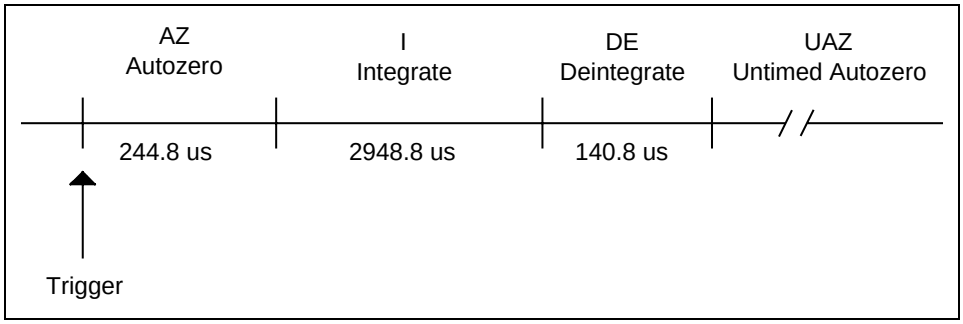
The timing for the FAI and PAI A/Ds is shown in Figures 2-12 and 2-13. These figures apply to normal readings. For Reference Balance readings, the timing for both FAI and PAI is given by Figure 2-13.

After the Trigger signal from the A3U5 A/D microprocessor is recognized, the A/D goes into the Autozero period. Immediately following this are the Integrate and Deintegrate periods. The only time that the input signal is actually being measured by the A/D is during the Integrate period. Therefore, the channel can be deselected and the Stallion programming for the next channel begun during the Deintegrate period. Also, the signal conditioning does not need to be settled until the beginning of integrate. At the end of Deintegrate, if the Trigger signal is still asserted, the A/D immediately begins the Autozero period for the next reading. Otherwise, it enters the Untimed Autozero period, which lasts until the Trigger signal is once again asserted. To take higher resolution measurements, the Trigger signal is left asserted until the required number of readings are obtained. This is also done for V dc readings on the fast rate (FAI only).



f2-14.eps

Figure 2-12. A/D Timing (FAI Normal Reading)



f2-15.eps

Figure 2-13. A/D Timing (PAI Normal Reading, PAI and FAI Reference Balance)

Control Signals

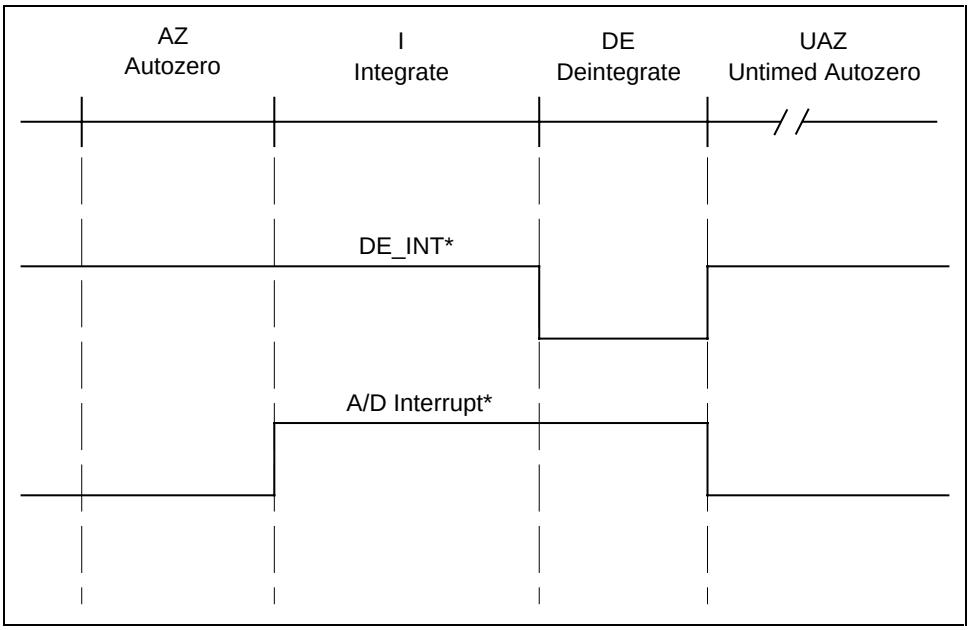
Several signals are used by the A3U5 A/D microprocessor to control and receive state information from the A/D state machine (A3U18). The Trigger line, used to indicate to the A/D when to begin a reading, was discussed previously.

The A/D state machine has several modes of operation: perform conversion (measure input); do a reference balance reading with both references on; or do a reference balance reading with both references off. These modes are selected by the A3U5 A/D microprocessor through a two-bit parallel port, which consists of two data lines and a strobe line. The codes for the commands are given in Table 2-15. To send a command to the A/D state machine, the data lines are set to the values shown, and then latched with a rising edge on the strobe line.

Table 2-15. A/D Command Codes

Command	C1	C0
Measure Signal	0	0
Reference Balance Reading, Both References	0	1
Reference Balance Reading, Neither Reference	1	0

There are two lines from the A/D state machine (A3U18) that indicate its state. These are connected as interrupt request signals to the A3U5 A/D microprocessor. The falling edge of the A/D Interrupt* signal indicates that a reading is complete and the counters are ready to be read. The A/D Interrupt* signal goes high at the beginning of the Integrate period, when the counters are cleared, and the signal is read by the A3U5 A/D microprocessor reads the counters to make sure that they were read in time. The DE_INT* signal indicates the beginning of the Deintegrate period. See Figure 2-14 A/D Status Signals.



f2-16.eps

Figure 2-14. A/D Status Signals

Counters

The counters in the A/D state machine (A3U18) are accessed through a synchronous serial interface. This interface is connected to the SCP port of the A3U5 A/D microprocessor, which is also connected to the Stallion chip. Chip-select lines are used to indicate the device the A3U5 A/D microprocessor is communicating. The counter values from the A/D are transmitted in five bytes. The hardware state machine transmits bytes most-significant bit first. There is no hardware detection of overload. An overload condition is detected by a software check of the PCOUNT and NCOUNT values. The hardware is designed so that there are sufficient guard bits on the A/D counters to avoid overflow.

The counters are cleared at the beginning of the Integrate period. This means that when taking continuous readings, the A3U5 A/D microprocessor has only the length of the Autozero period to read the counters.

Converting Counts to Volts

If we assume perfect voltage references and no offsets, the basic formula for obtaining volts from N and P counts is as follows:

$V = (16P - N)K$

where

V = volts

P = P counts

N = N counts

$K = (0.1)(2)(3.45) / (16) / (307) / (1.6)$ (FAI)

$K = (0.1)(2)(3.45) / (16) / (1843) / (1.6)$ (PAI)

For higher resolution measurements, P and N counts are accumulated for the total number of A/D readings in the measurement and then used in the above formula. We call these Ptot and Ntot. The final voltage is then divided by the number of A/D readings in the measurement.

In reality, we do not have perfect references, so we must apply a scale factor. The scale factor is applied to P counts in the above formula, giving:

$V = (16PS - N)K$

where

S = scale factor

The scale factor is derived from the reference balance readings. See Reference Balance Readings. The scale factor has a nominal value of 1.0, and a typical value between 0.99 and 1.01.

We also must subtract the correct zero offset from the measurement. There are four zero offsets, one for each DC buffer amplifier gain setting (BR1, BR2, BR3, or BR4). The gain setting used for a particular function and range can be determined from the Stallion switch settings (Table11: Stallion Switch Settings). The final formula is:

$V = (16PtotS - Ntot)K - Z$

where

Ptot = P counts (total)

Ntot = N counts (total)

Z = zero offset.

Zero offsets are also covered in “Zero Offset Readings” later in this chapter.

DISCHARGE Signal

The signal DISCHARGE is driven by the A3U5 A/D microprocessor (pin 59) through one of its parallel port pins and controls the discharge of certain filter capacitors. This line is normally left low. It is driven high during the V ac discharge mode. See “V ac Discharge Mode” later in this chapter for more information.

Open-Thermocouple Detector

To check for an open thermocouple input, the appropriate channel is selected with the function relays also set to the appropriate position, and the OTC circuitry is enabled. This is done by setting the OTC_EN bit high and turning on the OTC_CLK signal, with a frequency of 19.2 kHz. OTC_CLK is supplied by the A3U5 A/D microprocessor in the form of the SCC3 baud rate generator (BRG3 pin). After 1.7 ms, the OTC bit is read to determine the status of the channel. A 1 represents an open thermocouple.

After the reading, the OTC_CLK signal is turned off by setting it high. Then the OTC_EN bit is set low.

After deselecting the channel, the measurement circuitry that has been charged by the OTC test must be discharged. This is done by programming Stallion to apply a short between its HI1 pin and ground, setting OTC_CLK low, and setting OTC_EN high. This short is maintained for 500 us. After this, OTC_CLK is set high again, and OTC_EN is set low.

Channel Measurements

The following paragraphs describe the Channel Measurement characteristics.

Reading Rates

The instrument has three reading rates: fast, medium, and slow. These measurement rates allow you to obtain higher resolution and accuracy at the expense of slower measurements. The instrument obtains higher resolution measurements by averaging multiple A/D readings and/or waiting longer for signal conditioning to settle. The number of A/D readings averaged together to obtain a single measurement is given below in Table 2-16. Multiple A/D readings taken to average to obtain a measurement must be taken back-to-back, without interruption, in order to obtain AC line-frequency rejection.

Note that these numbers do not apply to measurement types that do not use the A/D converter. They also do not apply to reference balance readings (see Reference Balance Readings).

Table 2-16. A/D Readings to Average to Obtain a Measurement

Instrument	Reading Rate Fast	Reading Rate Medium	Reading Rate Slow
PAI	1	5 (60 Hz) 6 (50 Hz)	45 (60 Hz) 48 (50 Hz)
FAI	1	4	20 (60 Hz) 24 (50 Hz)

Measurement Types

There are several steps that you must perform at the beginning of any channel measurement:

- Set function relays. See “Function Relays” earlier in this chapter. This is a relatively slow operation and should be done only if the relay positions actually need to change.
- Set tree and channel switches. See “Channel MUX” earlier in this chapter.
- Program Stallion. See “Stallion Chip and Signal Conditioning” earlier in this chapter.
- Wait for channel switches to settle. See Table 2-10, Tree and Channel Switch Settling Times.
- Wait for signal conditioning circuitry to settle. See Table 2-14, Signal Conditioning Settling Time.

After these steps have been carried out, the sequence of operations depends on the measurement function.

V dc, V ac, Ohms

These types of measurements all use the A/D converter. After selecting the channel and configuring the signal conditioning circuitry, the A/D is triggered and, depending on the reading rate, one or more readings taken. The A/D counts are converted to a floating-point value and stored in a buffer for later transmission to the outguard. The channel and tree switches are then deselected.

V dc Fast Rate, FAI

Volts DC on the FAI, fast rate represent a special case. To attain the required throughput, you cannot perform the sequence of steps given above for each channel. Instead, certain characteristics of V dc readings are exploited in order to allow the A/D to be triggered continuously for all the channels in a V dc block. A V dc block consists of a series of channels that are all defined as V dc, with “similar” ranges. Similar range means either the low ranges (90 mV, 300 mV, 750 mV, and 3 V) or the high ranges (30 V and HI V).

For the channels within such a block, we can assume the following:

- No function relay switches are required.
- There is only one Stallion register that must be written to between channels.
- A channel can be selected at the beginning of the deintegrate period of the previous channel, at the same time that the previous channel is deselected.
- There is sufficient time during the deintegrate period to configure the Stallion for the next channel.
- There is sufficient time during the Autozero period of a channel for signal conditioning settling.
- The N and P counters for a channel can be read during the Autozero period of the next channel.

Thermocouples

A thermocouple channel is measured in the same way as a V dc channel, on the 90 mV range. However, before deselecting the channel at the end of the measurement, an open-thermocouple check may be done, if the channel is so configured. An “open” indication from this check causes a value of OTC_VAL to be returned for the channel measurement, regardless of the voltage measured. See Open-Thermocouple Detector.

Thermocouple readings also require an isothermal block reference junction reading to be taken. If any thermocouple channels are measured in a scan, a reference junction measurement is taken first, before any channel measurements.

Reference Junction

The reference junction reading is similar to a V dc reading. However, no channel selection or function relay switching is required; however, the Stallion must be configured. The reference junction reading is converted to a floating-point value and returned to the outguard.

Frequency

There are actually two parts to a frequency measurement. First, a normal V ac measurement is taken using the highest range. You must do this to determine the amplitude of the input signal, and thus the most appropriate gain setting to use for the actual frequency measurement. The frequency measurement circuitry works best with a large amplitude input signal.

Therefore, the gain setting used is one higher than would be used for a normal V ac measurement. For example, if the autosensitivity reading indicates that the input amplitude is 3 V, you take the frequency measurement is taken with the AC buffer amplifier set to the 300 mV range. See Table 2-17, Frequency Sensitivity. For input signals whose measured amplitude is very low, a frequency reading is still attempted, since the frequency response of the V ac measurement circuitry rolls off more quickly at higher frequencies than that of the frequency measurement circuitry.

Table 2-17. Frequency Sensitivity

Measured Amplitude	Range Used for Frequency Measurement
Less than 3 V	ACR1 (300 mV)
Between 3 V and 30 V	ACR2 (3 V)
Greater than 30 V (PAI only)	ACR3 (30 V)

The frequency measurement itself does not use the A/D. Frequency measurements are taken using the Stallion chip. To reduce noise in frequency measurements, the instrument takes eight frequency readings and averages them together to obtain a single frequency measurement.

There is only one frequency range (this is different from sensitivity), and therefore the range field of the channel configuration is ignored for a frequency channel.

The only difference between the three measurement rates for a frequency reading is the length of time allowed for settling. See Table 2-14, Signal Conditioning Settling Time.

If the status bits returned by Stallion indicate a low frequency (PEROVER bit set), a value of 0 Hz is returned. If they indicate a high frequency (PEROVER bit clear and FREQOVER bit set), a value of PLUS_OVLD_VAL (defined in Perform Scan) is returned.

If the FRDY interrupt is not received within 500 ms of starting a frequency measurement, the input signal is assumed to be too low in amplitude or frequency to measure, and a value of 0 Hz is returned.

V ac Discharge Mode

After a frequency or V ac reading, the hardware is configured to discharge certain signal conditioning capacitors, charged during the measurement. This is done to avoid disturbing the measurement of a subsequent V ac or frequency measurement. The function relays are set to the V ac discharge position, as given in Table 2-11, Function Relays, and the DISCHARGE signal is set high. After 6 ms, the DISCHARGE signal is once again set low.

Autoranging

The configuration of each channel includes the state of autoranging for that channel, either enabled or disabled. When performing a measurement on a channel that has autoranging enabled, the instrument first attempts a measurement on the range that was used on that channel for the previous scan. If this results in an overrange or underrange, the instrument up-ranges or down-ranges accordingly. Channels that are configured with autorange enabled, but have not yet been measured start on the highest legal range for the channel's function type.

Autoranging may decrease the measurement rate, since readings on multiple ranges may be required for a single channel. On the slow and medium rates, only the first A/D reading of a measurement is used to determine whether a range change is required.

The actual points where a channel up-ranges or down-ranges varies, depending on the outguard calibration constants. This happens because the overrange/underrange determination is made by the inguard, which is comparing uncalibrated, raw A/D counts. These points are selected so that some overlap exists between ranges, to ensure a certain amount of hysteresis when changing ranges. Also, when autoranging, on a given scan for a given channel, the instrument only up-ranges or down-ranges, not both. This avoids "infinite autoranging," where a channel measurement could hypothetically take forever as the instrument up-ranges and down-ranges continuously on a noisy input.

Overload

A channel can be in either positive or negative overload, depending on the polarity of the input signal. Overload limits are similar to autorange limits in that their actual values can vary, depending on the outguard calibration constants.

Housekeeping Readings

The following paragraphs describe the housekeeping functions, which are called Drift Correction in the user software.

Reading Types

There are two types of housekeeping readings: reference balance and zero offset readings. There are two different reference balance readings and four different zero offset readings.

Reference Balance Readings

Reference balance readings are similar to V dc readings, except that no channel selection is required, and no function relay switching is required. The A/D itself, however, must be configured to operate in a different mode. See Control Signals. After the Stallion chip is configured (to provide an input of 0 V to the A/D), the A/D can be triggered and then read as normal. Note that a reference balance reading has different timing than a normal reading on the FAI; see "Timing" earlier in this chapter. The number of readings to take and average for the different reading rates are given in Table 2-18.

Table 2-18. A/D Reading to Average to Obtain a Reference Balance Measurement

Instrument	Reading Rate Fast	Reading Rate Medium	Reading Rate Slow
PAI	1	5 (60 Hz) 6 (50 Hz)	45 (60 Hz) 48 (50 Hz)
FAI	1	1	5 (60 Hz) 6 (50 Hz)

There are two reference balance readings: one with both references on, and one with both references off. These readings are intended to compensate for unequal voltage references in the A/D. They are used to obtain a scale factor, which is then applied to the P counter for normal measurements.

The scale factor is derived as follows:

S = 1 - {[(16P2 - N2) - (16P0 - N0)]K2}

where

S = scale factor

P2 = P counts (both references on)

N2 = N counts (both references on)

P0 = P counts (both references off)

N0 = N counts (both references off)

K2 = (0.1) / (16) / (1843) / (1.6)

Zero Offset Readings

There are four zero readings: one for each gain setting of the DC buffer amplifier. Zero offset readings are similar to V dc readings, except that no channel selection is required and no function relay switching is required. The Stallion chip must be configured. The A/D is placed in normal measurement mode. The number of readings to average is the same as for a normal reading (see Table 2-18, A/D Readings to Average to Obtain a Measurement). Zero offset measurements are converted to volts in the same way as normal channel measurements, except, of course, that no zero offset is subtracted. The reference balance scale factor is used.

Housekeeping Schedule

Housekeeping readings are always taken in response to a “Do Housekeeping” command from the outguard, as described in “Do Housekeeping” earlier in this chapter.

Setting the HK bit in a configuration command causes the inguard to schedule housekeeping readings on a rotating basis, taking one at the end of each channel scan. It also enables a timer, which is started at the end of a scan or after a configuration command. Whenever the timer expires, the next housekeeping reading in the schedule is measured, and the timer is restarted. The timer is set to expire after 17.476 seconds.

On the medium and slow rate, all six housekeeping readings are scheduled as described in the preceding paragraph. On the fast rate, however, only zero offset readings are scheduled. This is because a single reference balance reading is longer than a normal reading on the fast rate, which would cause scans containing them to take longer.

Self-Tests

There are two series of self-tests performed by the inguard: those done automatically at power-up, and those done in response to a self-test command from the outguard.

Power-Up Self-Tests

On power-up the inguard performs a ROM checksum test and a destructive RAM test. If either of these tests fail, the inguard treats it as a fatal error and enters the boot monitor. No explicit indication of either of these tests failing is given to the outguard.

Self-Test Command

The self-test command from the outguard causes the following tests to be performed, in the order given. If the A/D test fails, the tests that require the A/D (zero offset test, reference balance test, ohms overload test) are not done.

A/D Test

This test simply triggers the A/D and waits for either the A/D interrupt or a timeout. If the timeout occurs before receiving an A/D interrupt, the test fails and the A/D is assumed to be non-functional. The timeout is set to 10 ms, greater than either the PAI or FAI A/D reading time.

Zero Offset Test

The zero offset test measures the four zero offsets, and ascertains that they are within reasonable limits. The test fails if any of the offsets measures greater than 2000 counts (FAI) or 12000 counts (PAI). This is approximately 0.175 V. A typical zero offset measurement is approximately 0.1 V.

Reference Balance Test

The reference balance test measures the two reference balance values. The individual counter values (N counts and P counts) are tested against limits, as are the differences between the counter values. For both references on, each counter must be less than 0x8000, and their difference must be less than 0x6000. For both references off, each counter must be less than 0x2000, and their difference must be less than 0x200.

Ohms Overload Test

For this test, a two-wire ohms measurement is attempted without any channel selected (however the tree and function relays must be set). This should result in an overload. Any other value causes the test to fail.

OTC Test

The OTC test attempts to do an open-thermocouple check with no channel selected. Unless this results in an “open” indication, the test fails.

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Maintenance

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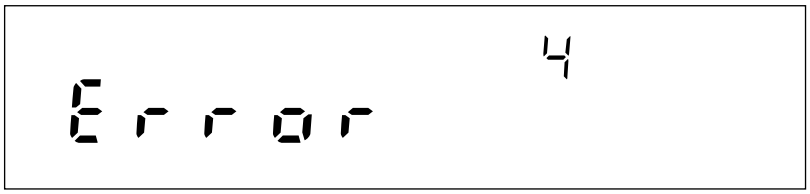
Introduction

Maintenance for the 268XA devices is limited to self-test error code explanations, cleaning, and fuse replacemen. Verification and calibration are discussed in Chapters 4 and 5 respectively.

Self-Test Diagnostics and Error Codes

Self-test diagnostics are performed each time the device is powered up. Any errors encountered during this initial 5 second period are reported on the front panel, as shown below.



If you encounter an error code, refer to Table 3-1 for a brief description of the error. If multiple errors occur, each is shown for about 1 to 2 seconds. For error number 100 or greater, the current configuration does not match the configuration used for the last scan. Details of the configuration check are provided in the following paragraph. For all other errors, try cycling the device power. Otherwise, package the device securely (using the original container, if available), and mail it to the nearest Fluke Service Center. Include a description of the problem. Fluke assumes no responsibility for damage in transit.

During power up, the current module configuration is evaluated against the stored module configuration used for the last scan. If configurations are different, one or more error messages will be generated. This feature helps identify faulty modules or modules that may have been accidentally removed or replaced with a different module in the system. If the configurations do not match, the stored configuration may be reset to the current configuration from the front panel. Resetting the stored configuration will eliminate the unwanted error messages.

You can force the device configuration to match the installed module by pressing the MODULE button at power up. This resets the configuration to the current module mix and the previous configuration is lost. The configuration can also be changed using Fluke DAQ software by down loading a new configuration that is consistent with the module mix. You can accomplish the same thing using Fluke DAQ software to download a new configuration or by sending the *RST command through the RS-232 port.

No channels will be configured and the instrument will not scan until the proper modules are changed or the configuration is changed to match the modules loaded. Stand alone scanning using a PC card configuration has a similar restriction.

If the PC card has a configuration in the scan data that is inconsistent with the current module mix, scanning will not begin. When using a PC card, you must either format the PC card or modify the module mix to match the PC card scan configuration before scanning can begin.

Table 3-1. Self-Test Codes

Self-Test Code	Description
0	No self-test errors
1	Boot block ROM checksum failed
2	Bad outguard main image in ROM
3	Configuration data file corrupt
4	Display test failure
5	Display not responding
6	Module 1 calibration constants corrupt
7	Module 1 calibration procedures incomplete
8	Module 1 A/D failure
9	Module 1 zero offset measurements unreasonable
10	Module 1 reference balance measurements unreasonable
11	Module 1 overload detection failed
12	Module 1 open thermocouple detection failed
13	Communication parameter constants corrupt
14	Ethernet address corrupt
15	RAM constants corrupt
16	Ethernet chip failure
17	Module 2 calibration constants corrupt
18	Module 2 calibration procedures incomplete
19	Module 2 A/D failure
20	Module 2 zero offset measurement unreasonable
21	Module 2 reference balance measurements unreasonable
22	Module 2 overload detection failed
23	Module 2 open thermocouple detection failed
24	No module self-test errors
25	Module 3 calibration constants corrupt
26	Module 3 calibration procedures incomplete
27	Module 3 A/D failure

Table 3-1. Self-Test Codes (cont)

Self-Test Code	Description
28	Module 3 zero offset measurement unreasonable
29	Module 3 reference balance measurements unreasonable
30	Module 3 overload detection failed
31	Module 3 open thermocouple detection failed
32	Module 4 calibration constants corrupt
33	Module 4 calibration procedures incomplete
34	Module 4 A/D failure
35	Module 4 zero offset measurement unreasonable
36	Module 4 reference balance measurements unreasonable
37	Module 4 overload detection failed
38	Module 4 open thermocouple detection failed
39	Module 5 calibration constants corrupt
40	Module 5 calibration procedures incomplete
41	Module 5 A/D failure
42	Module 5 zero offset measurement unreasonable
43	Module 5 reference balance measurements unreasonable
44	Module 5 overload detection failed
45	Module 5 open thermocouple detection failed
46	Module 6 calibration constants corrupt
47	Module 6 calibration procedures incomplete
48	Module 6 A/D failure
49	Module 6 zero offset measurement unreasonable
50	Module 6 reference balance measurements unreasonable
51	Module 6 overload detection failed
52	Module 6 open thermocouple detection failed
100	PAI expected in slot 1
101	FAI expected in slot 1
200	PAI expected in slot 2
201	FAI expected in slot 2

Table 3-1. Self-Test Codes (cont)

Self-Test Code	Description
300	PAI expected in slot 3
301	FAI expected in slot 3
400	PAI expected in slot 4
401	FAI expected in slot 4
500	PAI expected in slot 5
501	FAI expected in slot 5
600	PAI expected in slot 6
601	FAI expected in slot 6
602	DIO expected in slot 6

Cleaning

⚠⚠Warning

Keep the device dry to avoid electrical shock to personnel or damage to the device. To prevent damage, never apply solvents to the device housing.

Wipe the device with a cloth lightly dampened with water or mild detergent. Do not use aromatic hydrocarbons, chlorinated solvents, or methanol-based fluids.

AC Fuse Replacement

The device uses a 1/2 ampere, 250 V, slow blow line fuse in series with the mains power supply. To replace the fuse, refer to Figure 3-1 and the following procedure:

⚠⚠Warning

To avoid electrical shock, do not operate the device without the cover properly installed.

1. Disconnect *all* rear panel cables to the device power, Universal Input modules, and I/O connectors.
2. Locate the fuse holder at the back of the chassis near the power input connector and twist out the fuse.
3. Insert the new fuse into the holder. You *must* use a 1/2 ampere, 250 V time delay line replacement fuse.
4. Reinstall the cables removed in Step 1.

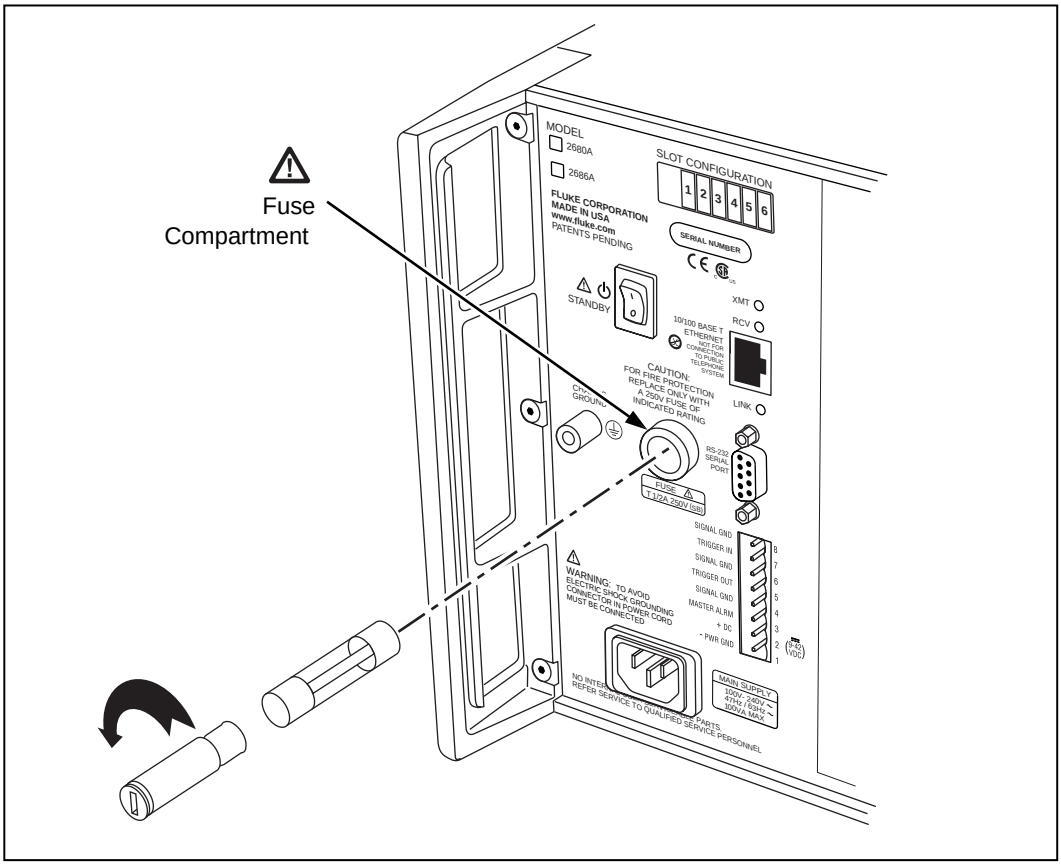


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Figure 3-1. Replacing the Fuse

DC Fuse Replacement

The 2680A/2686A devices use a 4 ampere, 250 V, slow blow fuse in series with the dc supply "+" input. This fuse is mounted on the main controller board inside the chassis. See Figure 3-2 for an illustration of the dc fuse location.

Because of potential high voltages, this fuse should only be replaced by a Fluke qualified technician.

⚠⚠Warning

The 268XA chassis contains high voltages that can be dangerous or fatal. Only qualified personnel should attempt to service the chassis.

1. Disconnect *all* rear panel cables to the device power, Universal Input modules, and I/O connectors.
2. Remove the top cover. The fuse is located on the Contoller/Power supply board near the mains fuse holder.
3. Remove the old fuse.
4. Insert the new fuse into the holder. You *must* use a 4 ampere, 250 V slow blow replacement fuse.
5. Reinstall the top cover.
6. Reinstall the cables removed in Step 1.

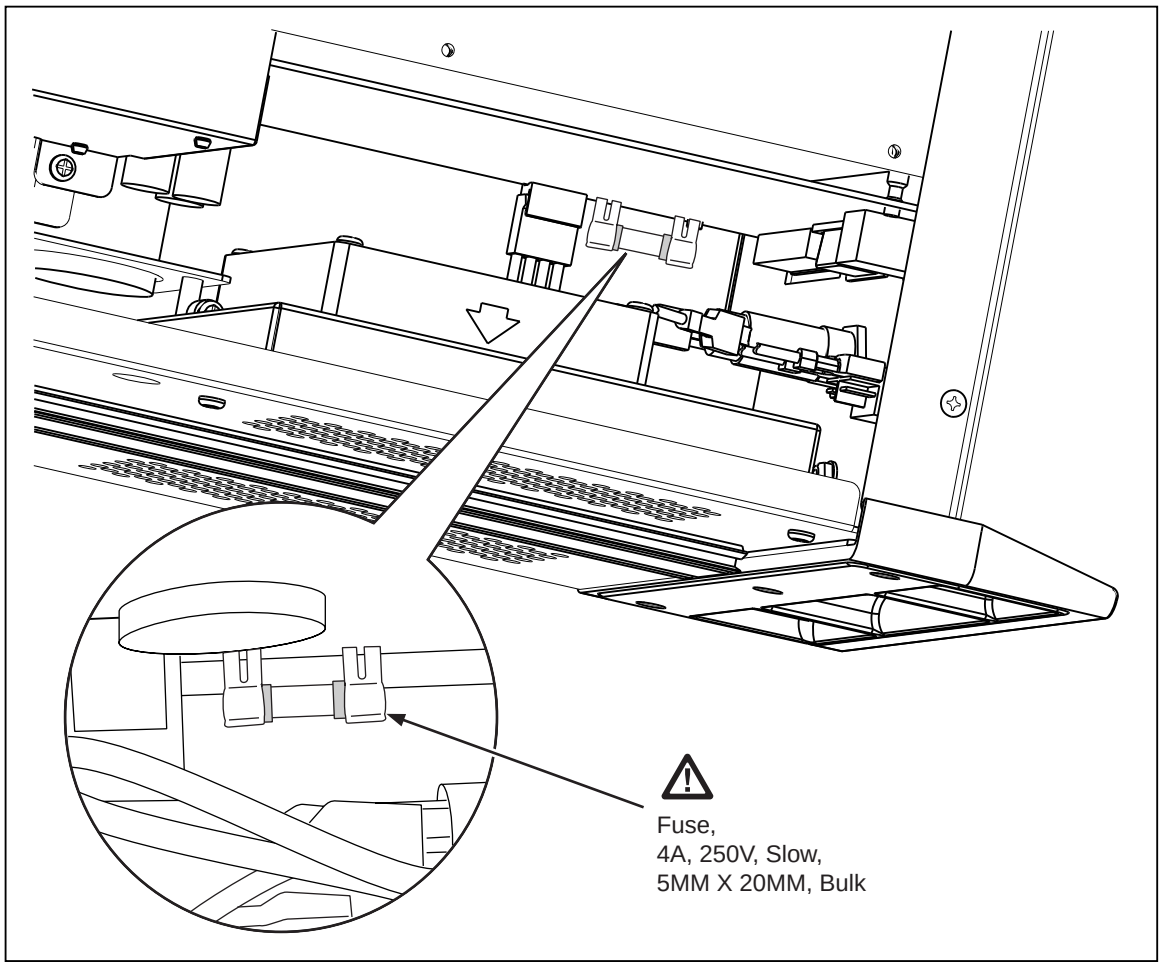

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Figure 3-2. DC Fuse Location

Chapter 4
Performance Verification

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Introduction

When shipped, the 2680A/2686A is calibrated and in operating condition. The following performance test procedures are provided for acceptance testing upon initial receipt or to verify correct device operation. The performance tests must be performed in sequence.

If the device fails a performance test, the device requires service or repair. To perform these tests, you will need a Fluke 5700A Multifunction Calibrator and several other pieces of equipment meeting the minimum specifications given in Table 4-1.

Each of the measurements listed in the following steps assume the device is being tested after a one hour warm-up, in an environment with an ambient temperature of 18 to 28 °C, and a relative humidity of less than 70%.

The digital tests can be run either through the RS-232 port or by using Fluke DAQ software. With most procedures, you can use either method to verify functionality. For the RS-232 tests, you will also need to use a program such as HyperTerminal to perform the test. See Chapter 6 for a complete listing of the RS-232 commands. See the *2680A/2686A Getting Started Guide* or the *2680A/2686A Users Manual* for information on using Fluke DAQ software.

Configuring the Performance Test Setup

Configure the performance test setup as described below. The performance test requires a complete network connection between the host computer and 268XA under test, including a host computer Ethernet interface and installation of the Fluke DAQ software. If you have not yet configured and tested a network connection for the host computer and device, complete the appropriate installation procedure for your network configuration before conducting any performance testing.

1. **Connect the Device and the Host Computer** Connect the supplied Ethernet cross connect cable between the host computer Ethernet port and the 268XA Ethernet port. See Figure 4-1.
2. **Connect the 5700A to Channel 1 of the First Module** When testing each module, connect a cable from the Output VA HI and LO connectors of the 5700A to the Universal Input module terminals for channel 1. Be certain to connect the 5700A HI to terminal H and LO to terminal L. Insert the Universal Input module into the device under test (Figure 4-2 on page 4-15).

Table 4-1. Recommended Test Equipment

Device Type	Minimum Specifications			Recommended Model
Multifunction Calibrator	**DC Voltage**:			Fluke 5700A
	Range: 90 mV to 300 V dc			
	Accuracy: 0.002%			
	AC Voltage:			
	Frequency	Voltage	Accuracy	
	1 kHz	29 mV to 300 V	0.05%	
	100 kHz	15 mV to 300 V	0.5%	
	Frequency:			
	10 kHz	1 V rms	0.01%	
	Ohms:			
	Ohms	Accuracy		
	190Ω	0.005%		
	1.9 kΩ	0.005%		
	19 kΩ	0.005%		
	190 kΩ	0.005%		
	1.9 MΩ	0.005%		
Digital Multimeter	General Purpose Measurement			Fluke 77
Signal Generator	Sine wave. 0.5 to 1 V rms, 10 Hz to 5 kHz			Philips PM5193
Oscilloscope				

Alternative Equipment List

Device Type	Recommended Model
Multiproduct Calibrator	Fluke 5520 (Do not use for FAI ohms calibration below 1.9 kΩ)
Function/Signal Generator	Philips PM5139 or HP33120A or equivalent
Decade Resistance Source	General Resistance RDS 66A or equivalent

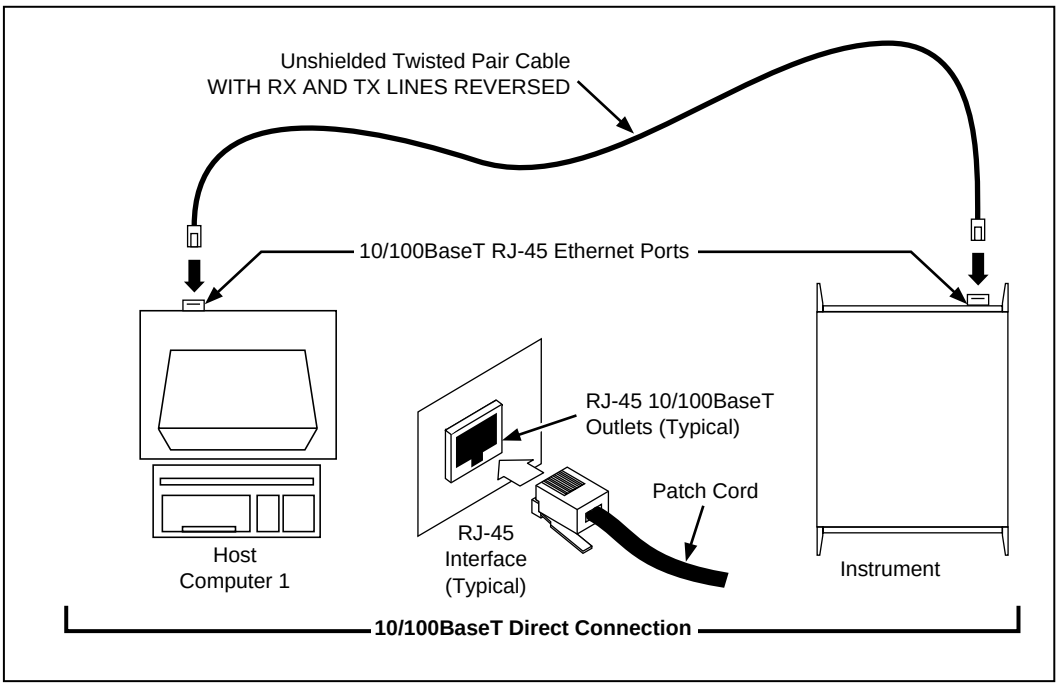

Figure 4-1. Connection Between Device and Host

Initializing the Performance Test Setup

Complete the following procedure to initialize the performance test setup. It is assumed you have configured the host computer and device as described in Configuring the Performance Test Setup, earlier in this chapter. Testing begins with the device and host computer unpowered. This assures that at power-up self-tests are completed successfully, the correct host computer Ethernet port is activated, the host computer configuration is accurately reflected, and other background operations are completed. This procedure clears the device of any existing BCN, Line Frequency, and Network settings.

1. **Apply Device Power with Configuration Reset** Hold down the COMM key on the device front panel and apply power to the device. After the device beeps and momentarily displays "rESEt" (Reset), release the COMM key. If any self-test errors are reported on the front panel display, refer to Self-Test Diagnostics and Error Codes in this chapter. Configuration Reset sets the device to the default parameters: BCN=1, Line Frequency=60, and Isolated Network.

2. **Set the Line Frequency** If the ac power applied to your device is 60 Hz (default), continue to Step 3. If the ac power applied to your device is 50 Hz, complete this step.

   Press the COMM key for three seconds, until a beep is heard and the SET annunciator in the display is lit. Press the up/down arrow keys until LinE (Line Frequency) is displayed in the primary display. Press the ENTER key. Press the up/down arrow keys until 50 (50 Hz) is displayed in the primary display. Press the ENTER key.

3. **Apply Host Computer Power** Apply power to the host computer.

4. **Open Fluke DAQ Software** You can use Start | Programs, double-click on a setup file shortcut on the Windows desktop, or double-click on a setup file name in the Windows Explorer or File Manager.

5. **Select New** Insert the device to be verified – 2680A or 2686A.

6. **Set network type** Set up the device for an isolated network.

Note

Record the IP address of the device before changing from a general to an isolated network type.The type change will overwrite the existing IP address.

7. **Select Module** Select the module and slot locations for each module. For each module, insert a Channel 01 and set the channel to 90 mV dc.
8. **Verify Communications** With the Communications Configuration dialog box still open, select the 268XA on the TreeView list and click the Verify button. The message Connection Successful! is returned for successful communications between the 268XA and host computer. If you receive an error message, refer to Error Codes in Chapter 3. Click OK in the message box and then the Close button in the Communications Configuration File dialog box to return to the Main Window.
9. **Select Reading Rate and Trigger Out** For each module, select Reading Rate = Slow, and check the Trigger Out box.
10. **Connect ALARM/TRIGGER I/O Test Leads** Remove the 8-position ALARM/TRIGGER I/O connector from the device rear panel. Connect a test lead to each line, Master Alarm, Trigger Output, Trigger Input, plus a test lead to the common GND line. For more information, see Alarm/Trigger I/O Connections in Chapter 2.
11. **Connecting a DIO Module** If you have a DIO option module, connect a lead to each of the DIO lines 0 to 19. Connect leads to each relay line K1A to K8A hi lines. Connect K1A to K8A low to GRD. Connect a pair of leads to the totalizer input.

Accuracy Performance Tests

The accuracy performance tests assume you have completed the Performance Test Setup described earlier in this chapter. Do not begin the tests until the device has been temperature stabilized for a minimum of one hour.

The tests for the Master Alarm output, Trigger Output, Trigger Input, and DIO signal lines can either be tested using Fluke DAQ software or using commands through the RS-232 port. For the RS-232 tests, you will also need to use a program such as HyperTerminal to perform the test. HyperTerminal is provided as a standard accessory on Windows systems. The Accuracy Performance Tests include the following:

- Master Alarm Output Test
- Trigger Input Test
- Trigger Output Test
- Volts DC Accuracy Test
- Volts AC Accuracy Test
- Frequency Accuracy Test
- Analog Channel Integrity Test
- Open Thermocouple Response Test
- 2-Wire Resistance Accuracy Test (optional)
- 4-Wire Resistance Accuracy Test
- Digital IO/Relay
- Totalizer

Specific tests for current dc are not included since these functions are derived from V dc.

Master Alarm Output Tests

The Master Alarm signal pin is found on the rear chassis 8-pin terminal block connector. This test checks the Master Alarm output signal line for correct logic level operation. See Figure 3-1 for the Master Alarm signal pin location.

RS-232 Master Alarm Output Test

1. **Connect Test Leads to ALARM/TRIGGER I/O Connector** Remove the 8-position ALARM/TRIGGER I/O connector from the device rear panel. Connect a test lead to each line, Master Alarm, Trigger Output, Trigger Input, plus a test lead to the GND line.
2. **Measure Line** Using a digital multimeter, measure the output of the Master Alarm test lead, referenced to the GND test lead, to check if the voltage is greater than +3.8 V dc.
3. **Set or Clear Master Alarm Bit** To set or clear the Master Alarm bit through the RS232 port use the MAOUT 1 command to turn on the alarm output and the MAOUT 0 command to turn off the alarms output. When the alarm is on, the output should be less than 1 V.

Fluke DAQ Master Alarm Output Test

1. **Connect Test Leads to ALARM/TRIGGER I/O Connector** Remove the 8-position ALARM/TRIGGER I/O connector from the device rear panel. Connect a test lead to each line, Master Alarm, Trigger Output, Trigger Input, plus a test lead to the GND line.
2. **Measure Line** Using a digital multimeter, measure the output of the Master Alarm test lead, referenced to the GND test lead, to check if the voltage is greater than +3.8 V dc.
3. **Verify Configuration Channel 1 for V dc** In Fluke DAQ, verify channel 1 is configured for V dc, 3 V range.
4. **Verify Configuration Channel 1 for Alarms** In Fluke DAQ, verify channel 1 is configured for an Alarm 1 with Alarm Sense=LO, Alarm Value=1 and Digital Output=DO0.
5. **Start Device Scanning** Click the Start Device arrow in the Communication dialog to start device scanning. Scanning is initiated to enable the Master Alarm output. Apply 0 V to channel 1.
6. **Measure Line** Using a digital multimeter, measure the output of the Master Alarm test lead, referenced to the GND test lead, for a voltage less than +0.8 V dc.
7. **Stop Scanning** Click the Stop button to stop device scanning.

Trigger Input Tests

The Trigger Input signal pin is found on the rear chassis 8-pin terminal block connector. This test checks the input signal line for correct level operation.

RS-232 Trigger Input Test

1. **Read Trigger Input Bit** Use the TRIN? command to read the Trigger Input bit through the RS-232 port. A return value of zero indicates that the signal is off (high) and a value of one indicates it is active low (on).

2. **Short the Signal to GND** Use a wire to short the signal to GND to set the active state.

Fluke DAQ Trigger Input Test

1. **Configure Trigger Input** Using the Fluke DAQ software, configure the scan parameters for External Trigger with an Interval 2 of 1 second. Be sure Interval Trigger and Alarm Trigger are not enabled.
2. **Verify Configuration Channel 1 for V dc** In Fluke DAQ, verify channel 1 is configured for V dc, 3 V range.
3. **Start Device Scanning** Click the Start arrow in the Communication dialog to start device scanning, although no measurement scanning takes place because the external Trigger Input is not set.
4. **Set Trigger Input** While monitoring the Module Communication dialog, connect the Trigger Input test lead to the GND test lead. The reported values update once per second. Disconnect the Trigger Input and GND test lead connection.
5. **Stop Scanning** Click the Stop Device button on the Button Bar to stop device scanning.

Trigger Output Tests

The Trigger Output signal pin is found on the rear chassis 8-pin terminal block connector. This test checks the output signal line for correct logic operation.

RS-232 Trigger Output Test

1. **Set Trigger Output Bit** Use the TROUT command to set the Trigger Output bit through the RS-232 port. This command turns on the output for about 200 µs.
2. **Verify Pulse** Use a scope to verify the pulse is present.

Fluke DAQ Trigger Output Test

1. **Configure Interval Trigger** Using the Fluke DAQ software, configure the scan parameters for Interval Trigger with an Interval 1 of 1 second.
2. **Verify Configuration Channel 1 for V dc** In Fluke DAQ, verify channel 1 is configured for V dc, 3 V range.
3. **Measure Unset Trigger Output Line** Using a digital multimeter, measure the output of the unset test lead, referenced to the GND test lead, for a voltage greater than +3.8 V dc.
4. **Verify Trigger Output is Enabled** In Fluke DAQ, select Setup | Device Config. In the Device Configuration dialog box, verify Trigger Out is checked. Click OK to return to the Main Window.
5. **Connect Trigger Output** Connect the Trigger Out test lead to Channel 1 of the scope.
6. **Start Device Scanning** Click the Start arrow in the Communication dialog to start device scanning.
7. **Open Spy** Open the Spy window under the Configuration dialog.
8. **Verify Trigger Out Pulse** Check that the Trigger Out pulse is ~ 125 µs and is repeated every second.

9. **Stop Scanning** Click the Stop Device button on the Button Bar to stop device scanning.

Volts DC Accuracy Test (PAI Module)

For these tests you must move between the Fluke DAQ Configuration dialog and the Communications dialog. Use the Configuration dialog to set up the analog module channels. Use the Spy option of Communications dialog to view the measurements. All testing is done with channel 1.

The following procedure tests the accuracy of the volts dc function for each PAI module in the device. Measurement accuracy applies to all channels, not just the channel used for the test.

1. **Configure Channel 1 for V dc** Using the Fluke DAQ software, configure the PAI channel 1 for V dc, 90 mV range.
2. **Open Spy** Open the Spy window under the Configuration dialog. Select channel 1 for each PAI module you want to test.
3. **Verify Accuracy** Configure the 5700A for the output values below and verify the measurement is between the minimum and maximum values. Change the channel 1 range as required (see Step 1).

PAI Volts DC Range	5700A Output	Minimum Reading	Maximum Reading
90 mV	Short Circuit (Zero)	-0.000008 V	+0.000008 V
90 mV	+90 mV	+0.089980 V	+0.090020 V
90 mV	-90 mV	-0.090020 V	-0.089980 V
300 mV	Short Circuit (Zero)	-0.000017 V	+0.000017 V
300 mV	+300 mV	+0.299944 V	+0.300056 V
300 mV	-300 mV	-0.300056 V	-0.299944 V
3 V	Short Circuit (Zero)	-0.00015 V	+0.00015 V
3 V	+3 V	+2.99946 V	+3.00054 V
3 V	-3 V	-3.00054 V	-2.99946 V
30 V	Short Circuit (Zero)	-0.0017 V	+0.0017 V
30 V	+30 V	+29.9944 V	+30.0056 V
30 V	-30 V	-30.0056 V	-29.9944 V
300 V	Short Circuit (Zero)	-0.017 V	+0.017 V
300 V	+300 V	+299.944 V	+300.056 V
300 V	-300 V	-300.056 V	-299.944 V

Volts DC Accuracy Test (FAI Module)

The following procedure tests the accuracy of the volts dc function for the 268XA. Measurement accuracy applies to all channels, not just the channel used for the test.

1. **Configure Channel 1 for V dc** Using the Fluke DAQ software, configure channel 1 for V dc, 90 mV range.
2. **Open Spy** Open the Spy window under the Configuration dialog.
3. **Verify Accuracy** Configure the 5700A for the output values below and verify the measurement is between the minimum and maximum values. Change the channel 1 range as required (see Step 1).

FAI Volts DC Range	5700A Output	Minimum Reading	Maximum Reading
90 mV	Short Circuit (Zero)	-0.000023 V	+0.000023 V
90 mV	+90 mV	+0.089965 V	+0.090035 V
90 mV	-90 mV	-0.090035 V	-0.089965 V
300 mV	Short Circuit (Zero)	-0.00005 V	+0.00005 V
300 mV	+300 mV	+0.29991 V	+0.30009 V
300 mV	-300 mV	-0.30009 V	-0.29991 V
3 V	Short Circuit (Zero)	-0.0004 V	+0.0004 V
3 V	+3 V	+2.9992 V	+3.0008 V
3 V	-3 V	-3.0008 V	-2.9992 V
30 V	Short Circuit (Zero)	-0.005 V	+0.005 V
30 V	+30 V	+29.991 V	+30.009 V
30 V	-30 V	-30.009 V	-29.991 V
50 V	Short Circuit (Zero)	-0.04 V	+0.04 V
50 V	+50 V	+49.95 V	+50.05 V
50 V	-50 V	-50.05 V	-49.95 V

Volts AC Accuracy Test

The following procedure tests the accuracy of the volts ac function for both the PAI and FAI modules. Measurement accuracy applies to all channels, not just the channel used for the test.

1. **Configure Channel 1 for V ac** Using the Fluke DAQ software, configure channel 1 for V ac, 300 mV range.
2. **Open Spy** Open the Spy window under the Configuration dialog.
3. **Verify Accuracy** Configure the 5700A for the output values below and verify the measurement is between the minimum and maximum values. Change the channel 1 range as required (see Step 1).

Volts AC Range	5700A Output	Minimum Reading	Maximum Reading
300 mV	20 mV@1 kHz	0.0197 V	0.0203 V
300 mV	20 mV@100 kHZ	0.0185 V	0.0215 V
300 mV	300 mV@1 kHz	0.29885 V	0.30115 V
300 mV	300 mV@100 kHz	0.2845 V	0.3155 V
3 V	3 V@1 kHz	2.9885 V	3.0115 V
30 V	30 V@1 kHz	29.885 V	30.115 V
300 V	300 V@1 kHz	298.85 V	301.15 V

Frequency Accuracy Test

The following procedure tests the accuracy of the frequency function for the PAI and FAI modules. Measurement accuracy applies to all channels, not just the channel used for the test.

1. **Configure Channel 1 for Frequency** Using the Fluke DAQ software, configure channel 1 for frequency. There is no range selection for frequency as all frequency measurements use auto-ranging.
2. **Open Spy** Open the Spy window under the Configuration dialog.
3. **Verify Accuracy** Configure the 5700A for the output values below and verify the measurement is between the minimum and maximum values. Change the channel 1 range as required (see Step 1).

Frequency Range	5700A Output	Minimum Reading	Maximum Reading
Autorange Only	1 V@10 kHz	9.994 kHz	10.006 kHz

Analog Channel Integrity Test

The following procedure tests the integrity of each analog channel (2 to 20) to verify each analog channel is capable of making measurements.

1. **Configure Channel for Ohms** Using the Fluke DAQ software, configure channels 2 (then 3, then 4, etc. as this step is repeated) to 20 for Ohms 2W, 300 range [PAI] or 30 k range [FAI].
2. **Connect Test Leads** Remove the Universal Input module from the device, disconnect the test leads and connect them to the channel under test (starting with channel 2). Reinstall the Universal Input module in the device.
3. **Open Spy** Open the Spy window under the Configuration dialog.
4. **Verify Reading** Alternately open and short the test leads observing the measurement for the analog channel under test in the Spy window shows Overload for opened leads and very low resistance for shorted leads (less than 10 Ω for the PAI, or less than 1 kΩ for the FAI).
5. **Repeat Test for each Channel** Repeat steps 2 to 4 for each channel (3, 4, 5, and so forth to channel 20).

Open Thermocouple Response Test

This test checks the Open Thermocouple response.

1. **Connect an 820 Ohm Test Resistor** Remove the Universal Input module from the device and connect an 820 Ω resistor to the channel 1 terminals. Reinstall the Universal Input module.
2. **Configure Channel 1 for Thermocouples** In Fluke DAQ, configure channel 1 for Thermocouples with Range (thermocouple type) K.
3. **Open Spy** Open the Spy window under the Configuration dialog.
4. **Connect a 10 k Ohm Test Resistor** Remove the Universal Input module from the device and connect a 10 kΩ resistor to the channel 1 terminals to simulate an open thermocouple condition. Reinstall the Universal Input module.
5. **Verify Open Thermocouple** The Spy window indicates an open thermocouple detect condition by displaying Open TC in place of a temperature reading.

2-Wire Resistance Accuracy Test (PAI) - Optional

Complete the following procedure to test the accuracy of the resistance function for the PAI using 2 terminals. Measurement accuracy applies to all channels, not just the channel used for the test. The 4-wire resistance accuracy test is more rigorous and you may wish to skip this step and continue to 4-Wire Resistance Accuracy Test described later in this chapter.

1. **Connect the Resistance Source to Channel** 1 Remove the Universal Input module from the device and connect a cable from the Decade Resistance Source to the Universal Input module terminals for channel 1. Reinstall the Universal Input module. You may also use the 5700A resistance calibration output instead of the Decade Resistance Source. Tables are provided for both connections.
2. **Configure Channel 1 for Ohms** In Fluke DAQ, configure channel 1 for Ohms-2W, 300 range.
3. **Open Spy** Open the Spy window under the Configuration dialog.
4. **Verify Accuracy** Configure the Decade Resistance Source for the output values below and verify the Spy window measurement is between the minimum and maximum values. Change the channel 1 range as required (see Step 2).

Resistance Range*	Decade Resistor	Minimum Reading	Maximum Reading
300 Ω	Short Circuit (Zero)	0 Ω	10 Ω
300 Ω	290 Ω	289.86 Ω	300.14 Ω
3 kΩ	Short Circuit (Zero)	0 Ω	10.5 Ω
3 kΩ	2.9 kΩ	2.8986 kΩ	2.9114 kΩ
30 kΩ	29 kΩ	28.983 kΩ	29.027 kΩ
300 kΩ	290 kΩ	289.61 kΩ	290.39 kΩ
3 MΩ	2.9 MΩ	2.8914 MΩ	2.9086 MΩ

*The resistance accuracy in this table makes allowance for up to 0.1 Ω of lead wire resistance plus 0.01% decade resistance tolerance. You must add any additional lead wire resistance present in your setup to the resistance values given in this table.

Resistance Range*	5700A	Minimum Reading	Maximum Reading
300 Ω	Short Circuit (Zero)	0 Ω	10 Ω
300 Ω	190 Ω	189.91 Ω	200.09 Ω
3 kΩ	Short Circuit (Zero)	0 Ω	10.5 Ω
3 kΩ	1.9 kΩ	1.8991 kΩ	1.9109 kΩ
30 kΩ	19 kΩ	18.989 kΩ	19.021Ω
300 kΩ	190 kΩ	189.75 kΩ	190.26 kΩ
3 MΩ	1.9 MΩ	1.8942 MΩ	1.9058 MΩ

*The resistance accuracy in this table makes allowance for up to 0.1 Ω of lead wire resistance. You must add any additional lead wire resistance present in your setup to the resistance values given in this table. Using the 5700A in 2-wire compensation mode eliminates much of the lead resistance errors. See the 5700A Operator's Manual for details.

2-Wire Resistance Accuracy Test (FAI Module) - Optional

Complete the following procedure to test the accuracy of the resistance function for the FAI module using 2 terminals. Measurement accuracy applies to all channels, not just the channel used for the test. The 4-wire resistance accuracy test is more rigorous and you may wish to skip this step and continue to 4-Wire Resistance Accuracy Test described later in this chapter.

1. **Connect the Resistance Source to Channel** 1 Remove the Universal Input module from the device and connect a cable from the Decade Resistance Source to the Universal Input module terminals for channel 1. Reinstall the Universal Input module. You may also use the 5700A resistance calibration output instead of the Decade Resistance Source. Tables are provided for both connections.
2. **Configure Channel 1 for Ohms** In Fluke DAQ, configure channel 1 for Ohms 2W, 30 k range.
3. **Open Spy** Open the Spy window under the Configuration dialog.
4. **Verify Accuracy** Configure the Decade Resistance Source for the output values below and verify the Spy window measurement is between the minimum and maximum values. Change the channel 1 range as required (see Step 2).

Resistance Range*	Decade Resistor	Minimum Reading	Maximum Reading
30 kΩ	Short Circuit (Zero)	700 Ω	1 kΩ
30 kΩ	29 kΩ	29.681 kΩ	30.019 kΩ
300 kΩ	290 kΩ	289.07 kΩ	292.63 kΩ
3 MΩ	2.9 MΩ	2.8607 MΩ	2.9410 MΩ

*The resistance accuracy in this table makes allowance for up to 0.1 Ohm of lead wire resistance plus 0.01% decade resistance tolerance. You must add any additional lead wire resistance present in your setup to the resistance values given in this table.

Resistance Range*	5700A	Minimum Reading	Maximum Reading
30 kΩ	Short Circuit (Zero)	700 Ω	1 kΩ
30 kΩ	19 kΩ	19.686 kΩ	20.014 kΩ
300 kΩ	190 kΩ	189.60 kΩ	192.10 kΩ
3 MΩ	1.9 MΩ	1.8740 MΩ	1.9277 MΩ

*The resistance accuracy in this table makes allowance for up to 0.1 Ω of lead wire resistance. You must add any additional lead wire resistance present in your setup to the resistance values given in this table. Using the 5700A in 2-wire compensation mode eliminates much of the lead resistance errors. See the 5700A Operator's Manual for details.

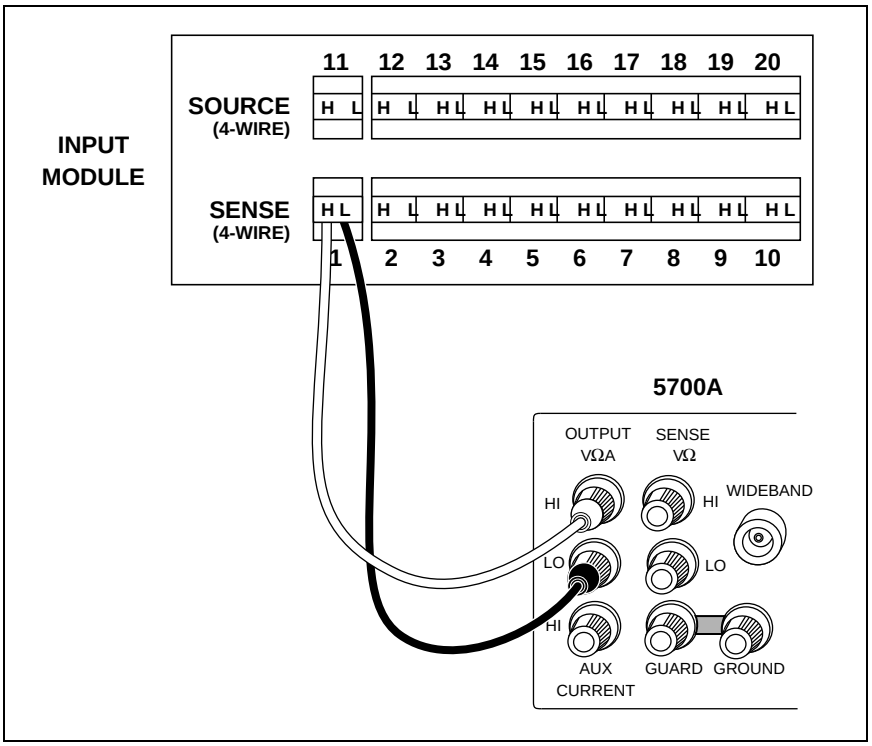

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Figure 4-2. 2-Wire Connections to 5700A

4-Wire Resistance Accuracy Test (PAI Module)

1. **Connect the Resistance Source to Channels 1 and 11** Remove the Universal Input module from the device and connect a cable from the Decade Resistance Source to the Universal Input module terminals for channel 1 (Sense) and channel 11 (Source) as shown in Figure 4-3. Reinstall the Universal Input module. You may also use the 5700A resistance calibration output instead of the Decade Resistance Source. Tables are provided for both connections. Refer to Figure 4-4 for the 5700A 4-wire connections.
2. **Configure Channel 1 for Resistance** In Fluke DAQ, configure channel 1 for Ohms 4W, 300 range.
3. **Open Spy** Open the Spy window under the Configuration dialog.

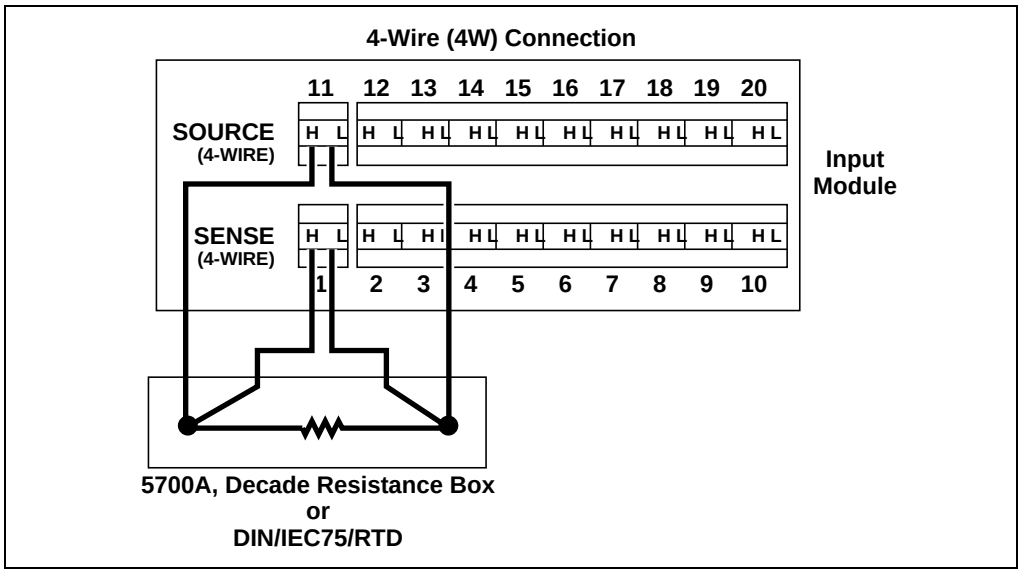

Figure 4-3. 4-Wire Connections to the Universal Input Module (Resistor)

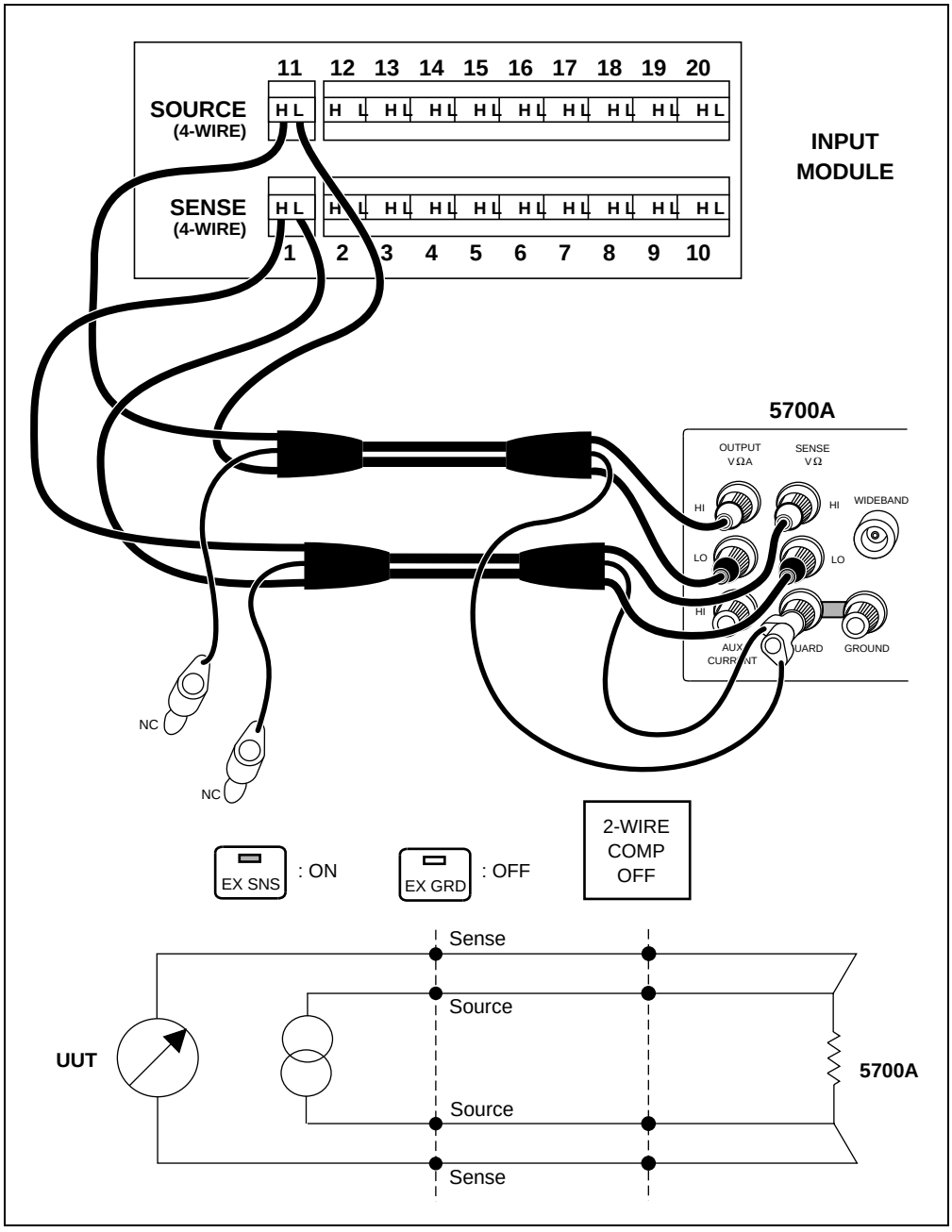

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Figure 4-4. 4-Wire Connections to the Universal Input Module (5700A)

4. **Verify Accuracy** Configure the Decade Resistance Source for the output values below and verify the Spy window measurement is between the minimum and maximum values. Change the channel 1 range as required (see Step 2).

Resistance Range	Decade Resistor	Minimum Reading	Maximum Reading
300 Ω	Short Circuit (Zero)	0 Ω	0.05 Ω
300 Ω	290 Ω	289.861 Ω	290.139 Ω
3 kΩ	Short Circuit (Zero)	0 Ω	0.5 Ω
3 kΩ	2.9 kΩ	2.89849 kΩ	2.90137 kΩ
30 kΩ	29 kΩ	28.9834 kΩ	29.0166 kΩ
300 kΩ	290 kΩ	289.621 kΩ	290.379 kΩ
3 MΩ	2.9 MΩ	2.89146 MΩ	2.90854 MΩ
The resistance accuracy in this table makes allowance for up to 0.01% decade resistance tolerance.			

Resistance Range	5700A	Minimum Reading	Maximum Reading
300 Ω	Short Circuit (Zero)	0 Ω	0.030 Ω
300 Ω	190 Ω	189.912 Ω	190.088 Ω
3 kΩ	Short Circuit (Zero)	0 Ω	0.30 Ω
3 kΩ	1.9 kΩ	1.89912 kΩ	1.90088 kΩ
30 kΩ	19 kΩ	18.9893 kΩ	19.0107 kΩ
300 kΩ	190 kΩ	189.750 kΩ	190.250 kΩ
3 MΩ	1.9 MΩ	1.89425 MΩ	1.90575 MΩ

4-Wire Resistance Accuracy Test (FAI Module)

1. **Connect the Resistance Source to Channels 1 and 11** Remove the Universal Input module from the device and connect a cable from the Decade Resistance Source to the Universal Input module terminals for channel 1 (Sense) and channel 11 (Source) as shown in Figure 4-3. Reinstall the Universal Input module. You may also use the 5700A resistance calibration output instead of the Decade Resistance Source. Tables are provided for both connections. Refer to Figure 4-4 for the 5700A 4-wire connections.
2. **Configure Channel 1 for Resistance** In Fluke DAQ, configure channel 1 for Ohms 4W, 300 range.
3. **Open Spy** Open the Spy window under the Configuration dialog.
4. **Verify Accuracy** Configure the Decade Resistance Source for the output values below and verify the Spy window measurement is between the minimum and maximum values. Change the channel 1 range as required (see Step 2).

Resistance Range	Decade Resistor	Minimum Reading	Maximum Reading
300 Ω	Short Circuit (Zero)	0 Ω	0.1 Ω
300 Ω	290 Ω	289.81 Ω	290.19 Ω
3 kΩ	Short Circuit (Zero)	0 Ω	1.0 Ω
3 kΩ	2.9 kΩ	2.8981 kΩ	2.9019 kΩ
30 κΩ	29 kΩ	28.981 kΩ	29.019 kΩ
300 κΩ	290 kΩ	288.37 kΩ	291.63 kΩ
3 MΩ	2.9 MΩ	2.8600 MΩ	2.9400 MΩ
The resistance accuracy in this table makes allowance for up to 0.01% decade resistance tolerance.			

Resistance Range	5700A	Minimum Reading	Maximum Reading
300 Ω	Short Circuit (Zero)	0 Ω	0.1 Ω
300 Ω	190 Ω	189.86 Ω	190.14 Ω
3 kΩ	Short Circuit (Zero)	0 Ω	1.0 Ω
3 kΩ	1.9 kΩ	1.8986 kΩ	1.9014 kΩ
30 kΩ	19 kΩ	18.986 kΩ	19.014 kΩ
300 kΩ	190 kΩ	188.90 kΩ	191.10 kΩ
3 MΩ	1.9 MΩ	1.8733 MΩ	1.9267 MΩ

Digital Input/Output Tests

All configuration for the Digital Input/Output Tests is done using the Communications dialog. To change DIO settings, click the DIO module icon in the TreeView display. Use the Spy function to monitor DIO settings.

The Digital Input/Output Tests check the 20 Digital I/O lines on the Digital I/O connector for output and input functions. See Figure 4-5 for the layout of the DIO connector module.

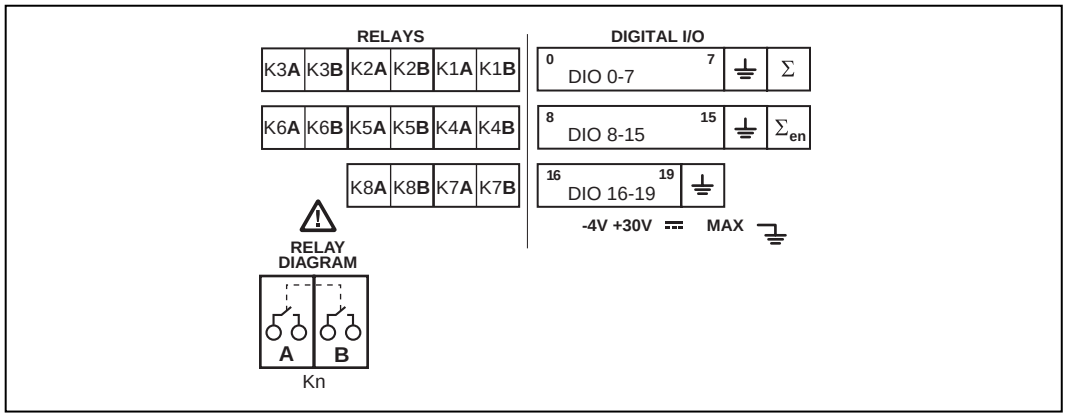

Figure 4-5. DIO Connector Module

RS-232 Digital Input/Output Test

To output bits use the DIO <mask>,<value> command. Set the mask to 1048575. Use the command "DIO?" for input. The value can range from 1 to 1048575 (2^20 - 1).

1. **Set Signal Lines High** Set all of the signal lines high using the DIO 1048575,1048575 command.
2. **Verify Signal** Verify that all of the signal lines are equal to or greater than +3.5 V dc.
3. **Set Signal Line Low** Set all of the signal lines low using the DIO 1048575,0 command.
4. **Verify Signal** Verify that all of the signal lines are less than or equal to 1 V dc. Leave them all low.

5. **Toggle Each Line** Toggle each line and verify that the signal line responds. For example, to toggle DIO0 output, send the command DIO 1048575,1. Physically verify that the signal line is off (high) and then use the DIO? command to read back the setting. Clear the bit using DIO 1048575,0. Physically verify that the signal line is on (low) and then use the DIO? command to read back the setting. To toggle DIO 7, send the command DIO 1048575,128 followed by DIO 1048575,0. To toggle DIO 19, send the command DIO 1048575,524288 followed by DIO 1048575,0. Verify that the correct lines are active.

Fluke DAQ Digital Input/Output Test

1. **Open Communication Dialog** Use the Communication dialog in Fluke DAQ for this test. Click on the DIO module icon in the TreeView display to see the DIO settings. The DIO dialog will only work if the DIO module is installed in the device and has been inserted using the Configuration dialog.
2. **Set Signal Lines Low** Set all of the signal lines active low by clicking on the Set On for each channel. On the screen, there should be an indication that the signal is active.
3. **Verify Signal** Verify that all of the signal lines are less than or equal to 1 V dc.
4. **Set Signal Lines High** Set all of the signal lines high by deselecting them.
5. **Verify Signal** Verify that all of the signal lines are equal to or greater than +3.5 V dc.
6. **Toggle Each Line** Toggle each line and verify that the signal line responds. Verify that the correct lines are active.

DIO Relay/Fuse Tests

RS-232 DIO Relay Fuse Test

Use the RS-232 command RELAY <mask>,<value> command to verify operation of the relays. The mask should always be set to 255. The value can be set from 1 to 255 depending on the bit to be set. For example, to set the relay pair K1A/K1B, send RELAY 1,0. To clear the relay pair, send RELAY 1,1. To set relay pair K8A/K8B, send RELAY 128,0 and to clear the pair send RELAY 128,128.

1. **Connect Test Leads to Digital IO Relays** Remove the DIO Connector module from the DIO rear panel. Connect test leads to the 4 terminals of each relay, KA hi, KA lo, KB hi, and KB lo.
2. **Verify Resistance** In the Communication dialog for the DIO module, select each relay in turn. Using a volt meter, verify that each relay channel has less than 2 Ω of resistance from high to low. A higher resistance value indicates that a fuse needs to be replaced.

Fluke DAQ DIO Relay Fuse Test

1. **Open Communication Dialog** Use the Communication dialog in Fluke DAQ for this test. Click on the DIO module icon in the TreeView display to see the DIO settings. The DIO dialog will only work if the DIO module is installed in the device and has been inserted using the Configuration dialog. Use the relay settings capability shown in the dialog to control the relays.
2. **Set Each Relay Pair** Set each relay pair. R#1 corresponds to the DIO relays K1A/K1B.

3. **Verify Relays Close** Verify that relays close by measuring the contact resistance. A contact resistance less than 1 Ω is good.

Totalizer Tests

The totalizer tests check the correct operation of the totalizer including the direction of counting and the signal level sensitivity. These tests can be run either with RS-232 commands or using Fluke DAQ. For these tests, use the signal generator to generate the counts. The generator will be connected to the totalizer input signal line (Σ). Connect the DIO channel 0 signal line to the totalizer enable line Σen) in the connector module.

If you are using Fluke DAQ to perform the totalizer tests, select the DIO from TreeView in the Configuration dialog. In the DIO Configuration dialog, Set the start count in the DIO Configuration dialog to 0, deselect debounce (if selected), and select direction as up. Click the Communication icon and select the DIO from the TreeView. Deselect the DIO channel 0 (if selected) to enable the totalizer

RS-232 Totalizer Count Test

1. **Initialize Totalizer to Count Up** Initialize the totalizer to count up with the command TOTCFG <direction>,<debounce>, where direction is 1 for up and debounce is 0 for off.
2. **Initialize Totalizer to 0** Initialize the totalizer to 0 with the TOTINIT command.
3. **Read the Totalizer Value** Read the totalizer value with the TOT? command. The value should be zero.
4. **Set DIO** Set DIO 0 to 0 (off) which will enable the totalizer to count.
5. **Set the Generator** Set the generator to 10 Hz and 1 V pp and connect to the totalizer input
6. **Verify Totalizer Count** Verify that the totalizer count increases by about 10 counts per second in a positive direction.
7. **Disconnect Generator** Disconnect the signal generator.

RS-232 Totalizer Count and Enable Test

The enable signal is a hardware signal that must be disabled with an externally connected signal level such as a short to ground)

1. **Initialize Totalizer to 0** Initialize the totalizer to 0 with the TOTINIT command.
2. **Set DIO** Set DIO 0 to 1 (on) to disable the totalizer.
3. **Reconnect Signal Generator** Reconnect the signal generator.
4. **Verify Totalizer Count** Verify that the totalizer count stays at 0.
5. **Disconnect Signal Generator** Disconnect the signal generator.

RS-232 Totalizer Count and Direction Test

1. **Initialize Totalizer to 0** Initialize the totalizer to 0 with the TOTINIT command.
2. **Set Totalizer to Down Count** Set the totalizer to down count with the TOTCFG 0,0 command.
3. **Set DIO** Set DIO 0 to 0 to enable the totalizer.
4. **Reconnect Signal Generator** Reconnect the signal generator.

5. **Verify Totalizer Count** Verify that the totalizer counts from 0 to 4,294,967,295, and then down.
6. **Disconnect Signal Generator** Disconnect the signal generator.

RS-232 Totalizer Count and Debounce Test

1. **Initialize Totalizer to 0** Initialize the totalizer to 0 with the TOTINIT command.
2. **Set Totalizer to Up Count** Set the totalizer to up count with debounce on with the TOTCFG 1,1 command.
3. **Set DIO** Set DIO 0 to 0 to enable the totalizer.
4. **Set Signal Generator** Set the signal generator to 1 kHz at 1 V pp.
5. **Connect Signal Generator** Connect the signal generator.
6. **Verify Totalizer Count** Verify that the totalizer stays at 0+/-1 count.
7. **Disconnect Signal Generator** Disconnect the signal generator.

Testing of the Digital Input/Output signal lines can be done through the RS-232 port (using HyperTerminal or other communication program) or through the Fluke DAQ software. Either method can be used. The Digital Input/Output Test checks the 20 Digital I/O lines through the Digital I/O connector module for correct operation. Measurements of the signal lines may be made using a oscilloscope or a voltmeter.

Fluke DAQ Totalizer Count Test

1. **Go to Spy Window** Go to the Spy Window.
2. **Set Device Number** Set the device number to the BCN number of the device and set the category as totalizer.
3. **Start Spy** Start the Spy with the play button.
4. **Verify Totalizer Value** Verify that the totalizer value is set to zero.
5. **Set Signal Generator** Set the signal generator to 10 Hz and 1 V pp and connect to the totalizer input.
6. **Verify Totalizer Count** Verify that the totalizer count increases by about 10 counts per second in a positive direction.
7. **Stop Spy** Stop the Spy.
8. **Disconnect Signal Generator** Disconnect the signal generator.

Fluke DAQ Totalizer Count and Enable Test

1. **Select DIO** Click on the Communication icon and select the DIO from the TreeView.
2. **Disable Totalizer** Select the DIO channel 0 to disable the totalizer.
3. **Start Spy** Go to the Spy and start the Spy with the play button.
4. **Verify Totalizer Value** Verify that the totalizer value has not changed.
5. **Set Signal Generator** Set the signal generator to 10 Hz and 1 V pp and connect to the totalizer input.
6. **Verify Totalizer Count** Verify that the totalizer count does not change.
7. **Stop Spy** Stop the Spy.

8. **Disconnect Signal Generator** Disconnect the signal generator.
9. **Select DIO** Click on the Communication icon and select the DIO from TreeView.
10. **Enable Totalizer** Deselect the DIO channel 0 to enable the totalizer.

Fluke DAQ Totalizer Count and Direction Test

1. **Configure DIO** In the Configuration dialog, select the DIO from TreeView. In the DIO Configuration dialog, set the start count to 0, deselect debounce (if selected), and select direction as down.
2. **Start Spy** Go to the Spy and start the Spy with the play button.
3. **Verify Totalizer Value** Verify that the totalizer value is has not changed.
4. **Set Signal Generator** Set the signal generator to 10 Hz and 1 V pp and connect to the totalizer input.
5. **Verify Totalizer Count** Verify that the totalizer count decreases by about 10 counts per second.
6. **Stop Spy** Stop the Spy.
7. **Disconnect Signal Generator** Disconnect the signal generator.

Fluke DAQ Totalizer Count and Debounce Test

1. **Configure DIO** In the Configuration dialog, select the DIO from TreeView. In the DIO Configuration dialog, set the start count to 0, select debounce on, and select direction as up.
2. **Start Spy** Go to the Spy and start the Spy with the play button.
3. **Verify Totalizer Value** Verify that the totalizer value has not changed.
4. **Set Signal Generator** Set the signal generator to 1 kHz and 1 V pp and connect to the totalizer input.
5. **Verify Totalizer Count** Verify that the totalizer count does not change by more than 1 count.
6. **Stop Spy** Stop the Spy.
7. **Disconnect Signal Generator** Disconnect the signal generator.

Chapter 5
Calibration

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Introduction

This section of the Service Manual provides a complete set of manual calibration procedures for the 2680A/2686A. The calibration procedures are performed periodically as well as after service or repair. There are no calibration procedures for the 2680A/2686A chassis nor for the DIO module. Only verification tests are run on those items. The calibration is only performed on the analog A/D modules such as the precision A/D input module (PAI) and the fast A/D input module (FAI).

Calibration

The 2680A/2686A device features module calibration that is performed over the RS-232 interface using ASCII characters. It is not necessary to open the module case. Each analog A/D module must be calibrated separately. Using known reference sources, closed-case calibration has many advantages. There are no parts to disassemble, no mechanical adjustments to make, and the module can be calibrated by an automated calibration system. The modules should normally be calibrated on a regular cycle, typically every 90 days to 1 year. The chosen calibration cycle depends on the accuracy specification you wish to maintain. The module should also be calibrated if it fails the performance test or has undergone repair.

The calibration mode requires initialization through a built-in calibration command. To enter the calibration mode, use the command CAL_MODE SPLUNGE. When calibration is enabled, the secondary display shows 'CAL'. To disable the calibration mode, enter CAL_MODE OFF. If you have entered calibration and wish to exit, send CAL_MODE OFF, or just turn the device power off. You cannot stop calibration by entering front panel commands.

Once the device is in calibration mode, closed-case calibration is made for the four calibration groups as follows:

- Volts DC
- Volts AC
- Resistance
- Frequency

Once begun, each group must be completed successfully for the results of the calibration to be made permanent. It is not necessary to perform all calibration groups.

Methods of Calibration

- Calibration takes place using a host computer in a terminal mode. With this method all commands and responses are considered individually.
- Calibration uses the device RS-232 serial interface. It is possible to develop an automatic calibration routine using the RS-232 commands. Procedures cannot be performed over the network interface or from the device front panel.

Preparing for Calibration

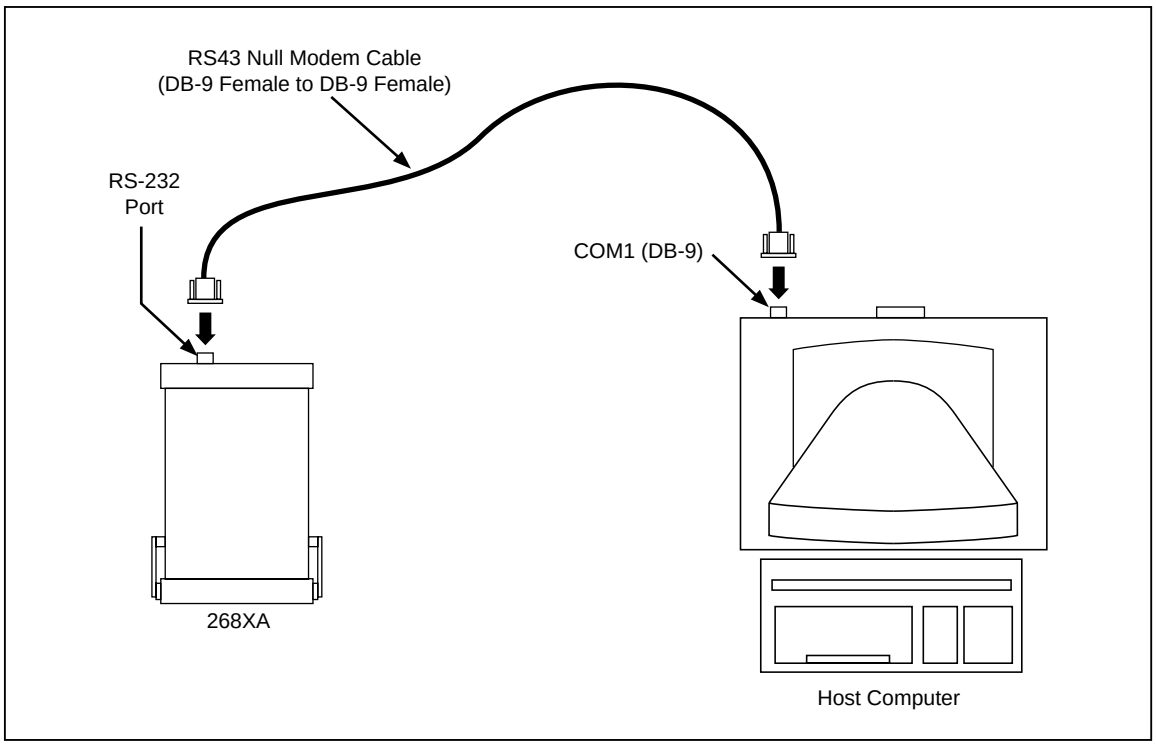
Complete the following procedure to prepare for calibration.

1. Connect the device RS-232 serial port to a host computer COM serial port as shown in Figure 5-1. The "RS" cables used are standard null-modem cables (reversed transmit and receive lines) that may be ordered from Fluke.

2. Wire the Universal Input Module so the high and low inputs to channels 1 and 11 are externally available. In addition, a four-wire short must be applied to channels 2 and 12. (See Figure 5-2.) Plug the module into the device.
3. Power the device and allow at least a 30-minute warm-up period. The device must be stabilized in an environment with an ambient temperature of 22 to 24°C and relative humidity of less than 70%.
4. Using the buttons at the device front panel, set the desired baud rate for the device RS-232 port (see below). This is the only selectable RS-232 parameter. The other device RS-232 parameters are fixed: data bits=8; stops bits=1; parity=none; echo=none; flow control=xon/xoff.

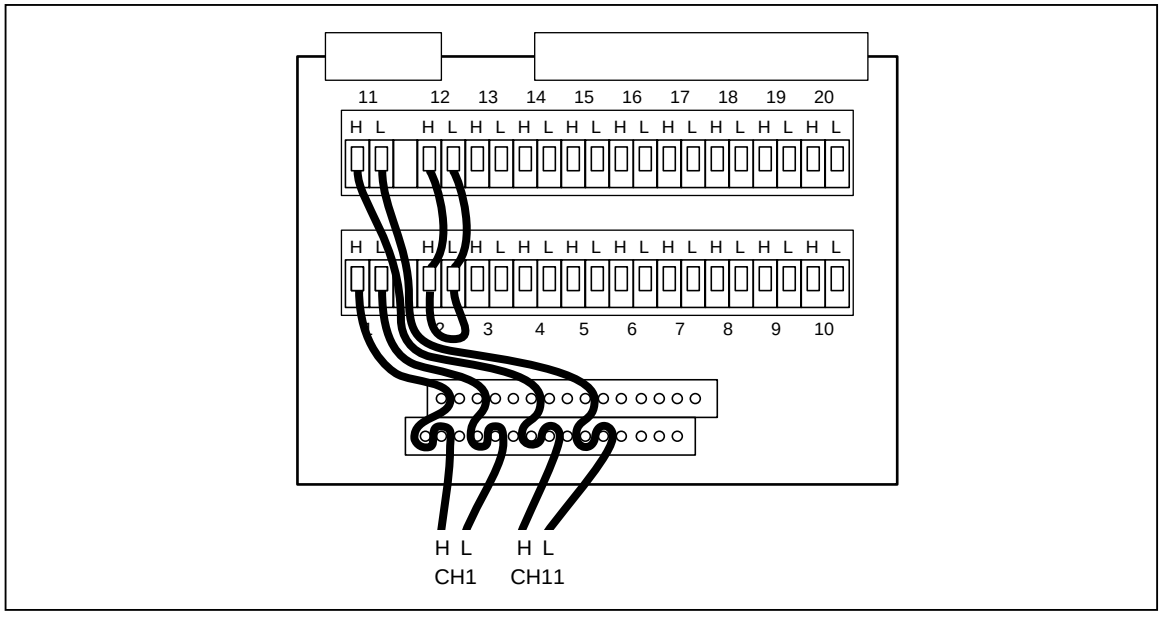
COMM	Press the COMM key to review the baud rate, or press and hold the COMM key for 3 seconds to set the baud rate (the SET annunciator lights).
▲ ▼	Press the up/down arrow keys until rS232 is shown in the primary display (comm is displayed in the secondary display).
ENTER	Press the ENTER key. bAud is displayed in the secondary display and the current baud rate in the primary display.
▲ ▼	Press the up/down arrow keys to select the desired number baud rate: 4800, 9600, 19200, or 38400. The factory default value is 9600 baud.
ENTER	Press the ENTER key to exit. (Pressing any other function key will cancel set operations.)

5. Activate the calibration mode for a particular module by sending the command CAL_MODE SPLUNGE. CAL should show on the primary display. You are now ready to start calibrating a module. Setup the PC in terminal mode (see the section on Manual Calibration Procedure) and then use the calibration commands to work through the procedures (see section on Manual Calibration Commands) .



f4-05.eps

Figure 5-1. Device and Host Computer Calibration Setup



f4-06.eps

Figure 5-2. Universal Input Module Calibration Connections

There are two connection methods used between the leads from the device Universal Input Module and the 5700A Calibrator. The volts dc, volts ac, and resistance functions use the two-wire connection shown in Figure 5-3. The resistance function uses the four-wire connection shown in Figure 5-4.

Ending Calibration

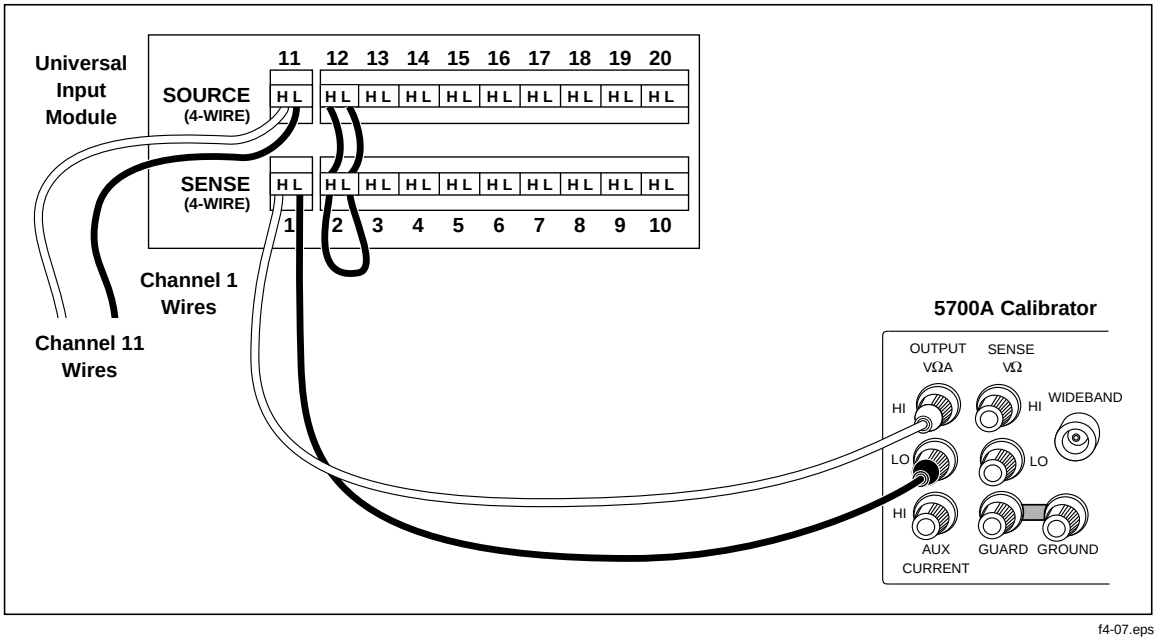
When you are using the manual method of calibration and have completed the calibration of the desired functions (dc volts, ac volts, ohms, and frequency), send CAL_MODE OFF to clear CAL from the primary display.

RS-232 Device Configuration Parameters

When CAL is shown in the 2680A/2686A display, it indicates that you are in the calibration mode. The device configuration parameters are set as listed in Table 5-1.

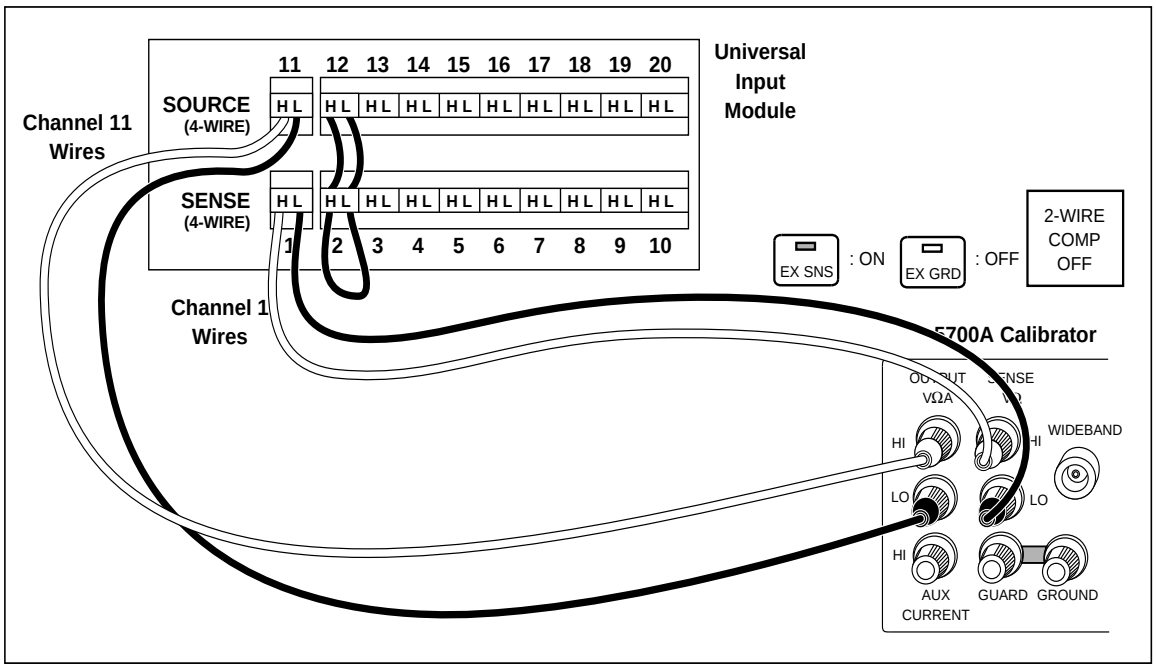
Table 5-1. RS-232 Device Configuration for Calibration Procedures

Parameter	Setting
Channel Configuration	Unique to calibration step
Reading Rate	Slow
Trigger Type	All disabled
Intervals	All disabled
Drift Correction	Enabled
External Trigger Output	Disabled
Temperature Units	Celsius
Queue Overflow Mode	Discard old
Totalizer Debounce	Disabled
Autodisable Scanning	On



f4-07.eps

Figure 5-3. Two-Wire Calibration Connection



f4-08.eps

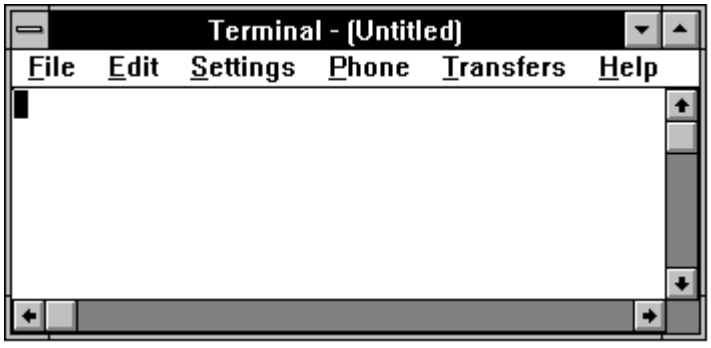
Figure 5-4. Four-Wire Calibration Connection

Manual Calibration Procedure

Manual calibration uses a calibration command set operated over an ASCII terminal or a computer running a terminal emulation program. The following procedure assumes you will be using the Windows Terminal feature of your host computer. If you are using a different terminal, adapt this procedure to suit.

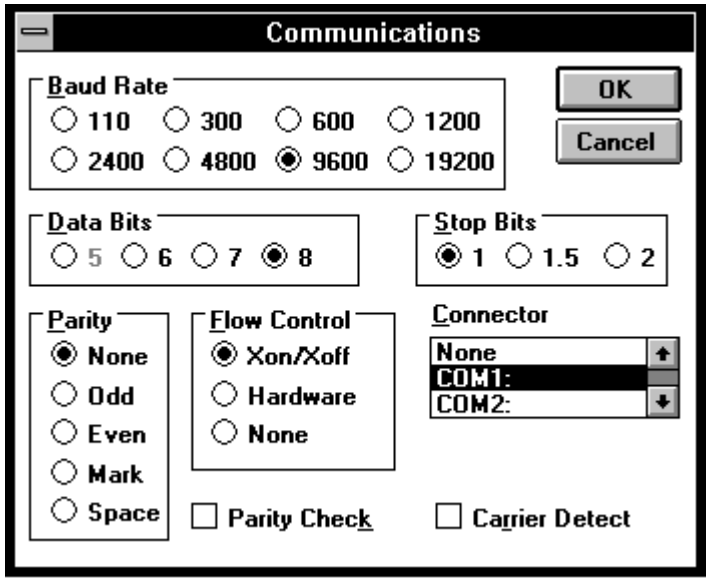
Complete the following procedure to prepare the Windows HyperTerminal feature.

1. Complete the "Preparing for Calibration" procedure earlier in this chapter. Note the device baud rate and host computer COM port that you selected for use.
2. Open Windows to the Program Manager screen on your host computer.
3. Open Terminal (below) from the Accessory group of Program Manager.



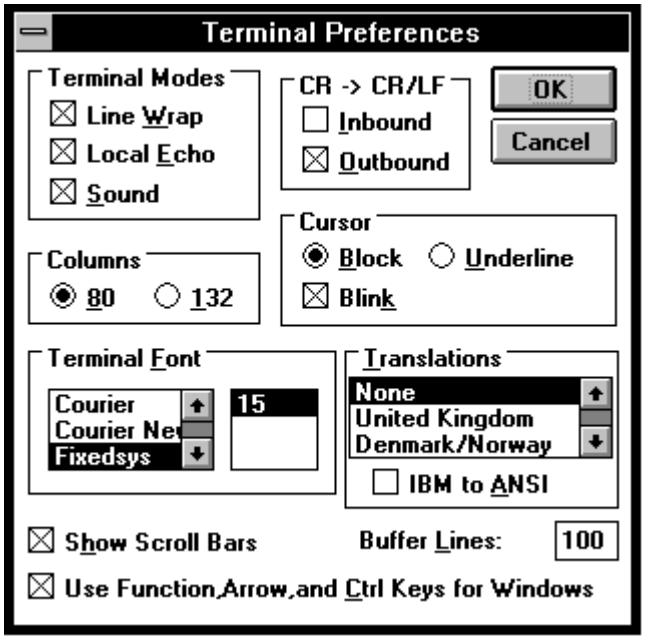
f4-05bmp.bmp

4. Select the Communications command from the Setting menu. Enter the same RS-232 baud rate and host computer COM noted in Step 1. The other parameters are selected as shown below. Click OK.



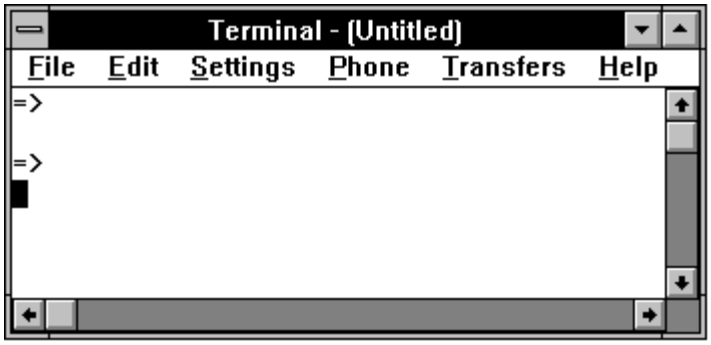
f4-06bmp.bmp

5. Select the Terminal Preferences command from the Settings menu. Check the boxes Local Echo and Outbound (see below). Click OK.



f4-08bmp.bmp

6. Press the <Enter> key a few times and notice the => returns, indicating a successful connection (see below). If you do not receive these returns, the RS-232 link is not operating. Check the communication parameter settings and cabling.



f4-07bmp.bmp

Manual Calibration Commands

The calibration procedures are performed in the terminal mode using the commands CAL, CAL?, CAL_REF, CAL_REF?, CAL_STEP, and CAL_CLR. Refer to Table 5-2 for information regarding these commands. After each command is entered, the terminal returns one of three responses, as shown in Table 5-3.

Table 5-2. Calibration Commands

Command	Description	Cal Mode Only?
CAL x,y	Start calibration of a new function, where x = module slot number (1 to 6) and y = an integer from 1 to 4. For example, CAL 1,1 to select module in slot one and V dc calibration. 1 = V dc 2 = V ac 3 = Resistance 4 = Frequency	Yes
CAL?	Return identifier of currently active calibration procedure. For example, CAL? Might return CAL 3,2 for active calibration of slot 3 in the V ac mode. 0 = No cal procedure currently active 1 = V dc 2 = V ac 3 = Resistance 4 = Frequency	Yes
CAL_REF <value>	Calibrate to <value>, rather than the default calibration reference value.	Yes
CAL_REF?	Return the present calibration reference.	Yes
CAL_STEP?	Calibrate and return the calibrated value of the input.	Yes
CAL_CLR	Reset all calibration constants to nominal values, clearing present calibration. Use with caution. This clears all contents for all functions, V dc, V ac, resistance, and frequency.	Yes

Table 5-3. Manual Calibration Command Responses

Response	Description
=>	indicates the command was executed correctly.
!>	indicates that a device-dependent error was generated and the calibration step could not be executed. Verify that the input to channel 1 is the correct value and polarity, is connected correctly, and the 5700A is in the Operate mode.
?>	indicates the command was entered with incorrect syntax, for example, misspelling the command. Reenter the command using the correct syntax.

V DC Calibration Procedure

The V dc calibration procedure calculates gain and offset calibration constants for all of the V dc ranges. The 750 mV range is not user accessible, but is used to measure the reference junction voltage and must be calibrated.

Complete the following procedure to manually calibrate the V dc function.

1. If you have not already done so, complete the procedure “Preparing for Calibration” earlier in this chapter.
2. Connect the device and 5700A Calibrator as shown in Figure 5-3.
3. Complete the sequence of manual steps shown in Table 5-4. Measuring channel 1 provides the full scale reading, and measuring the short on channel 2 determines the zero offset error. Both readings are accomplished automatically with the CAL_STEP? command.

Table 5-4. Manual V DC Calibration

Command	Response	Action
CAL 1	=>	Puts 268XA in V dc calibration.
CAL_REF?	+90.0000E-3	Use the 5700A to source 90 mV dc.
CAL_STEP?	+90.0000E-3	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.
CAL_REF?	+300.000E-3	Use the 5700A to source 300 mV dc.
CAL_STEP?	+300.000E-3	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.
CAL_REF?	+750.000E-3	Use the 5700A to source 750 mV dc.
CAL_STEP?	+750.000E-3	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.
CAL_REF?	+3.00000E+0	Use the 5700A to source 3 V dc.
CAL_STEP?	+3.00000E+0	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.
CAL_REF?	+30.0000E+0	Use the 5700A to source 30 V dc.
CAL_STEP?	+30.0000E+0	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.
CAL_REF?	+300.000E+0 (PAI) +50.0000E+0 (FAI)	Use the 5700A to source +300 V dc (PAI). Use the 5700A to source +50 V dc (FAI).
CAL_STEP?	+300.000E+0 (PAI) +50.0000E+0 (FAI)	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.

4. Resolve any calibration problems based on the following:

   - An execution error !> is returned by the CAL_STEP? command if the full scale measurement is off by more than 5% from the target or if the zero measurement is off by more than 1% of full scale from the target. When an error is detected, the cal constant is not updated, and the procedure remains at the same step.
   - When CAL_STEP? reports an execution error !> due to an out-of-range measurement, it returns the raw measured reading to give you an indication of what was measured. When CAL_STEP? completes successfully, it returns the reference value.
   - If CAL_STEP? returns an execution error !> while measuring the short circuit on channel 2, the procedure freezes at the internal step that measures the short. This way, you can send a CAL_REF? command and it will return 0 V, indicating that the problem was probably caused by a misapplied short on channel 2.
   - A device-dependent error is returned by the CAL_STEP? command if an internal error such as a measurement timeout is detected. When an error is detected, the cal constant is not updated, and the procedure remains at the same step.
   - An execution error !> is returned by the CAL_REF command if the specified reference is less than 33% of full scale or greater than 100% of full scale.

V AC Calibration Procedure

The V ac calibration procedure calculates gain and offset calibration constants for all of the V ac ranges. Complete the following procedure to manually calibrate the V ac function.

1. If you have not already done so, complete the procedure “Preparing for Calibration” earlier in this chapter.
2. Connect the device and 5700A Calibrator as shown in Figure 5-3.
3. Complete the sequence of manual steps shown in Table 5-5. Measurements are made on channel 1 for each V ac range: one at 10% of full scale and one at 100% of full scale. All ac voltages must be applied at 1 kHz. The V ac gain and offset calibration constants for each range are determined from the two measurements.
4. Resolve any calibration problems based on the following:
   - An execution error !> is returned by the CAL_STEP? command if the full-scale measurement is off by more than 10% from the target or if the low-scale measurement is off by more than 1% of full scale (10% from the target). When an error is detected, the cal constant is not updated, and the procedure remains at the same step.
   - A device-dependent error is returned by the CAL_STEP? command if an internal error such as a measurement timeout is detected. When an error is detected, the cal constant is not updated, and the procedure remains at the same step.
   - An execution error !> is returned by the CAL_REF command for the full scale measurement if the specified reference is less than 33% of full scale or greater than 100% of full scale for any range. An execution error !> is returned by the CAL_REF command for the low scale measurement if the specified reference is less than 10% of full scale or greater than 30% of full scale for any range.

Table 5-5. Manual V AC Calibration

Command	Response	Action
CAL 2	=>	Puts 268XA in V ac calibration.
CAL_REF?	30.0000E-3	Use the 5700A to source 30 mV ac @ 1 kHz
CAL_STEP?	30.0000E-3	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.
CAL_REF?	300.000E-3	Use the 5700A to source 300 mV ac @ 1 kHz
CAL_STEP?	300.000E-3	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.
CAL_REF?	300.000E-3	Use the 5700A to source 300 mV ac @ 1 kHz
CAL_STEP?	300.000E-3	268XA again computes the calibration constant and returns the calibrated reading. Allow several seconds.
CAL_REF?	3.00000E+0	Use the 5700A to source 3 V ac @ 1 kHz
CAL_STEP?	3.00000E+0	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.
CAL_REF?	3.0000E+0	Use the 5700A to source 3 V ac @ 1 kHz
CAL_STEP?	3.0000E+0	268XA again computes the calibration constant and returns the calibrated reading. Allow several seconds.
CAL_REF?	30.0000E+0	Use the 5700A to source 30 V ac @ 1 kHz
CAL_STEP?	30.0000E+0	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.
[**PAI only for remainder of steps**]		
CAL_REF?	30.0000E+0	Use the 5700A to source 30 V ac @ 1 kHz
CAL_STEP?	30.0000E+0	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.
CAL_REF?	300.0000E+0	Use the 5700A to source 300 V ac @ 1 kHz
CAL_STEP?	300.0000E+0	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.

Resistance Calibration Procedure

The resistance calibration procedure calculates gain and offset calibration constants for all of the four-wire ohms ranges. The same calibration constants are used for the corresponding two-wire ohms ranges.

Complete the following procedure to manually calibrate the ohms function.

1. If you have not already done so, complete the procedure “Preparing for Calibration” earlier in this chapter.
2. Connect the device and 5700A Calibrator as shown in Figure 5-4.
3. Complete the sequence of manual steps shown in Table 5-6. The default values were chosen assuming that a Fluke 5700A will be used to supply the reference resistors. For each range, channels 1 and 2 are configured to four-wire ohms and a measurement is made for each channel. Making a four-wire ohms measurement on

channel 1 provides the full scale reading and measuring the four-wire short on channels 2 and 12 determines the zero offset error. The four-wire ohms gain and offset calibration constants are determined from these two measurements.

The 5700A provides a limited set of reference resistors where the best resistor for each range is at 63.3% of full scale. This will give very good results, but making the measurement closer to the full scale value using fixed resistors may give better results. When you are using fixed resistors, you must use the CAL_REF command to tell device the value of the new reference resistor. When you are using fixed resistors, you connect the leads as they are for any four-wire ohms measurement.

4. Resolve any calibration problems based on the following:

   - An execution error !> is returned by the CAL_STEP? command if the full scale measurement is off by more than 5% from the target or if the zero measurement is off by more than 1% of full scale. When an error is detected, the cal constant is not updated, and the procedure remains at the same step.
   - When CAL_STEP? reports an execution error !> due to an out-of-range measurement, it returns the raw measured reading to give you an indication of what was measured. When CAL_STEP? completes successfully, it returns the reference value.
   - If CAL_STEP? returns an execution error !> while measuring the four-wire short on channels 2 and 12, the procedure freezes at the internal step that measures the short. This way, you can send a CAL_REF? command and it will return 0 W, indicating that the problem was probably caused by a misapplied short on channels 2 and 12.
   - A device-dependent error is returned by the CAL_STEP? command if an internal error such as a measurement timeout is detected. When an error is detected, the cal constant is not updated, and the procedure remains at the same step.
   - An execution error !> is returned by the CAL_REF command if the specified reference is less than 33% of full scale or greater than 100% of full scale for any range.

Table 5-6. Manual Resistance Calibration

Command	Response	Action
CAL 3	=>	Puts 268XA in resistance calibration.
CAL_REF?	+190.000E+0	Use the 5700A to source 190 Ω.
CAL_STEP?	+190.000E+0	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.
CAL_REF?	+1.90000E+3	Use the 5700A to source 1.9 kΩ.
CAL_STEP?	+1.90000E+3	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.
CAL_REF?	+19.0000E+3	Use the 5700A to source 19 kΩ.
CAL_STEP?	+19.0000E+3	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.
CAL_REF?	+190.000E+3	Use the 5700A to source 190 kΩ.
CAL_STEP?	+190.000E+3	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.
CAL_REF?	+1.90000E+6	Use the 5700A to source 1.9 MΩ.
CAL_STEP?	+1.90000E+6	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.

Frequency Calibration Procedure

The Frequency calibration procedure calculates a calibration constant that corrects for errors in the frequency counter crystal frequency. It is sufficiently accurate to measure a single frequency point and calculate the scale factor assuming that the other endpoint is 0 Hz.

Complete the following procedure to manually calibrate the frequency function.

1. If you have not already done so, complete the procedure “Preparing for Calibration” earlier in this chapter.
2. Connect the device and 5700A Calibrator as shown in Figure 5-3.
3. Complete the sequence of manual steps shown in Table 5-7. Channels 1 is configured to frequency, and a single measurement is made.

Table 5-7. Manual Frequency Calibration

Command	Response	Action
CAL 4	=>	Puts 268XA in frequency calibration.
CAL_REF?	+10.0000E+3	Use the 5700A to source 3 V ac @ 10 kHz
CAL_STEP?	+10.0000E+3	268XA computes the calibration constant and returns the calibrated reading. Allow several seconds.

4. Resolve any calibration problems based on the following:

- An execution error !> is returned by the CAL_STEP? command if the frequency measurement is off by more than 5% from the target. When an error is detected, the cal constant is not updated, and the procedure remains at the same step.
- When CAL_STEP? reports an execution error !> due to an out-of-range measurement, it returns the raw measured reading to give you an indication of what was measured. When CAL_STEP? completes successfully, it returns the reference value.
- A device-dependent error is returned by the CAL_STEP? command if an internal error such as a measurement timeout is detected. When an error is detected, the cal constant is not updated, and the procedure remains at the same step.

An execution error !> is returned by the CAL_REF command if the specified reference is less than 10 kHz or greater than 100 kHz.

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Diagnostic Testing and Troubleshooting

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Introduction

The 268XA device provides error code information and semi-modular design to aid in troubleshooting. This section explains the error codes and describes procedures needed to isolate a problem to a specific functional area. Finally, troubleshooting hints for each functional area are presented.

First, if the device fails, check the line voltage fuse and replace as needed. If the failure is associated with the dc power, you will need to open the top cover to check the internal dc power fuse. See Chapter 3, Maintenance, for details. If the problem persists, verify that you are operating the device correctly by reviewing the operating instructions in the *268XA Users Manual*.

⚠⚠Warning

Opening the case may expose hazardous voltages. Always disconnect the power cord and measuring inputs before opening the case. In addition, remember that repairs or servicing should be performed only by qualified personnel.

Signal names followed by a '*' are active (asserted) low. Signal names not so marked are active high.

Servicing Surface-Mount Assemblies

The device incorporates Surface-Mount Technology (SMT) for printed circuit assemblies (PCA's). Surface-mount components are much smaller than their predecessors with leads soldered directly to the surface of a circuit board. No plated through-holes are used. Unique servicing, troubleshooting, and repair techniques are required to support this technology. The information offered in the following paragraphs serves only as an introduction to SMT. It is not recommended that repair be attempted based only on the information presented here.

Since sockets are seldom used with SMT, "shotgun" troubleshooting cannot be used; a fault should be isolated to the component level before a part is replaced. Surface-mount assemblies are probed from the component side. The probes should make contact only with the pads in front of the component leads. With the close spacing involved, ordinary test probes can easily short two adjacent pins on an SMT IC.

This Service Manual is a vital source for component locations and values. With limited space on the circuit board, chip component locations are seldom labeled. Figures included in Chapter 8 of this manual provide this information. Also, remember that chip components are not individually labeled; keep any new or removed component in a labeled package.

Surface-mount components are removed and replaced by reflowing all the solder connections at the same time. Special considerations are required.

- The solder tool uses regulated hot air to melt the solder; there is no direct contact between the tool and the component.
- Surface-mount assemblies require rework with wire solder rather than with solder paste. A 0.02Y-inch diameter wire solder composed of 63% tin and 37% lead is recommended. A 60/40 solder is also acceptable.
- A good connection with SMT requires only enough solder to make a positive metallic contact. Too much solder causes bridging, while too little solder can cause weak or open solder joints. With SMT, the anchoring effect of the through-holes is missing; solder provides the only means of mechanical fastening. Therefore, the PCA must be

especially clean to ensure a strong connection. An oxidized PCA pad causes the solder to wick up the component lead, leaving little solder on the pad itself.

Error Detection

At power-up, the device software performs self-tests. If any errors in device operation are detected, they are reported on the device front panel with Error in the primary display and a decimal error code number in the secondary display. If there is more than one error, they are displayed sequentially. Selftest errors can be retrieved from RS-232 commands and the network.

A selftest includes a test of the following items:

- **FLASH** ROM parameters, communication parameters and calibration constants.
- **RAM** Device and channel configuration plus RAM images of FLASH ROM parameters.
- **Ethernet** Ethernet chip and static Ethernet RAM.
- **Display** Display processor and display board
- **Inguard** Specific tests for ROM checksum, RAM, A/D converter, zero offset test, reference balance test, ohms overload test, and open thermal couple
- **Slot configuration check** Specific checks are made to determine if the active module configuration has changed since the device last ran a scan.

A summary of the possible error codes are shown in Table 6-1, including the front panel error code (in decimal) and the corresponding network and RS-232 error code (in hexadecimal). The faults that might cause each error are described in “Troubleshooting the Device” later in this chapter.

Table 6-1. Self-Test Error Codes

Front Panel Err	Self-test Code	Description
	0x00000000	No self-test errors
1	0x00000001	Boot block ROM checksum failed
2	0x00000002	Bad outguard main image in ROM
3	0x00000004	Boot block RAM failed
4	0x00000008	Display test failure
5	0x00000010	Display not responding
6	0x00000020	Module 1 Calibration constants corrupt
7	0x00000040	Module 1 Calibration Procedures Incomplete
8	0x00000080	Module 1 A/D failure
9	0x00000100	Module 1 Zero offset measurements unreasonable
10	0x00000200	Module 1 Reference balance measurements unreasonable
11	0x00000400	Module 1 Overload detection failed
12	0x00000800	Module 1 Open thermocouple detection failed
13	0x00001000	Communication parameter constants corrupt
14	0x00002000	Ethernet address corrupt
15	0x00004000	Ram constants corrupt
16	0x00008000	Ethernet chip failure
17	0x00010000	Module 2 Calibration constants corrupt
18	0x00020000	Module 2 Calibration Procedures Incomplete
19	0x00040000	Module 2 A/D failure
20	0x00080000	Module 2 Zero offset measurements unreasonable
21	0x00100000	Module 2 Reference balance measurements unreasonable
22	0x00200000	Module 2 Overload detection failed
23	0x00400000	Module 2 Open thermocouple detection failed

Table 6-1. Self-Test Error Codes (cont)

Front Panel Err	Self-test Code	Description
Second 32-bit self-test code		
	0x00000000	No self-test error.
32	0x00000001	Module 3 Calibration constants corrupt
33	0x00000002	Module 3 Calibration Procedures Incomplete
34	0x00000004	Module 3 A/D failure
35	0x00000008	Module 3 Zero offset measurements unreasonable
36	0x00000010	Module 3 Reference balance measurements unreasonable
37	0x00000020	Module 3 Overload detection failed
38	0x00000040	Module 3 Open thermocouple detection failed
39	0x00000080	Module 4 Calibration constants corrupt
40	0x00000100	Module 4 Calibration Procedures Incomplete
41	0x00000200	Module 4 A/D failure
42	0x00000400	Module 4 Zero offset measurements unreasonable
43	0x00000800	Module 4 Reference balance measurements unreasonable
44	0x00001000	Module 4 Overload detection failed
45	0x00002000	Module 4 Open thermocouple detection failed
46	0x00004000	Module 5 Calibration constants corrupt
47	0x00008000	Module 5 Calibration Procedures Incomplete
48	0x00010000	Module 5 A/D failure
49	0x00020000	Module 5 Zero offset measurements unreasonable
50	0x00040000	Module 5 Reference balance measurements unreasonable
51	0x00080000	Module 5 Overload detection failed
52	0x00100000	Module 5 Open thermocouple detection failed
53	0x00200000	Module 6 Calibration constants corrupt
54	0x00400000	Module 6 Calibration Procedures Incomplete
55	0x00800000	Module 6 A/D failure
56	0x01000000	Module 6 Zero offset measurements unreasonable
57	0x02000000	Module 6 Reference balance measurements unreasonable
58	0x04000000	Module 6 Overload detection failed
59	0x08000000	Module 6 Open thermocouple detection failed

FLASH ROM Parameter Defaults

The FLASH ROM (System Power/Controller Board 2680A-4004) parameters are reset to defaults following the first power-on and following power-cycles after any FLASH ROM parameters are discovered to be corrupt. These defaults are listed in Table 6-2.

Table 6-2. FLASH ROM Parameter Defaults

Parameter	Default
Base Channel Number	10
Line Frequency	60 Hz
Network Type	Isolated Network
Socket Port Number	4369
IP Address	198.178.246.001
RS-232 Baud Rate	9600
Default Gateway	Off
Calibration Constants	All gains are set to 1.0; all offsets are set to 0.0

Background Testing

Background testing is performed to ensure that communication, configuration, and calibration constants do not become corrupt over time. Every 10 seconds, one of the parameter sets is verified (verifying all parameter sets at once is too CPU intensive). The following parameter sets are checked:

- FLASH ROM communication parameters
- FLASH ROM calibration constants
- FLASH ROM Ethernet address
- RAM device and channel configuration
- RAM pre-computed range scaling and calibration constants used in evaluation
- RAM copy of calibration constants
- RAM copy of Ethernet address

When a parameter set is discovered to be corrupt, the background testing task records the error in the error/status register, and performs any corrective action required. The errors and actions performed on the errors are listed in the below Table 6-3.

Table 6-3. Corrective Action for Background Error Checking

Error	Action
FLASH ROM communication parameters corrupt.	Reset to defaults on next power-up.
FLASH ROM calibration constants corrupt.	Reset to defaults on next power-up.
FLASH ROM Ethernet address corrupt.	Reset to defaults on next power-up. Network interfaces will not activate.
Any RAM constants corrupt.	None.

Retrieving Error Codes using RS-232

You can retrieve error codes from the device using the device rear-panel RS-232 port and an ASCII terminal, or PC running ASCII terminal emulation.

Complete the following procedure to retrieve error codes from the device using an RS-232 connection.

1. Connect the device to a PC COM port and setup the RS-232 parameters and connection as described in the procedure "Manual Calibration Procedure" in Chapter 5.
2. Enter the command *TST? to invoke the device selftest routine and return the result, or just SELFTEST? for the results of the most recent self test. If you use *TST?, allow several seconds for the tests to complete. The *TST? test does not include the RAM test because this test cannot be performed when the device is operating.
3. Observe the returned number after the selftest routine. Refer to Table 6-1 for an analysis of the return. For example, a return of 64 is the same as error code 7 on the front panel display.

Selecting the Diagnostic Tools

This section describes the device diagnostic tool menu and other diagnostic features. The diagnostic tool menu is hidden from the user. There are three separate diagnostic tools that can be selected from the menu, each of which is described below.

Complete the following procedure to select the diagnostic tools.

1. Power the device and allow it to complete the normal power-on sequence.
2. Press and hold the DIO key for 3 seconds until "tool" appears in the secondary display. Note that if you do not have a DIO module, you will not be allowed to run these routines.
3. Use the up/down arrow keys to sequence you through the diagnostic selections:
   - dio (used to set any of the DIO module dio19 to dio0 digital i/o lines)
   - rELAy (used to close any of the DIO module relay 8 to relay 1 lines)
4. Select the desired diagnostic tool using the up/down arrow keys; then press the ENTER key.
5. Press and hold the MODULE key for 3 seconds until "tool" appears in the secondary display.
6. Use the up/down arrow keys to sequence you through the diagnostic selections:
   - ids (used to identify the device type and display the various firmware versions active within the device)
   - conF (used to set scanning rate, function, range and channel)
7. Select the desired diagnostic tool using the up/down arrow keys; then press the ENTER key.

Other diagnostic tools include the display test and COMM parameter reset.

Diagnostic Tool dio

The dio diagnostic tool allows you to change the status of any 20 dio lines dio19 to dio0 located in the DI/O module.

Complete the following procedure to change the status of any dio line.

1. Select the dio diagnostic tool using the procedure “Selecting the Diagnostic Tool Menu.”
2. Use the left/right arrows to select the desired dio line dio19 to dio0. The format is nnnn-nnnn-nnnn-nnnn-nnnn, representing dio lines dio19 to dio0, respectively. The secondary display shows the selected line, for example, dio:19.
3. Use the up/down arrow keys to select the desired dio line status, 0 or 1.
4. In a similar manner, select the desired dio status for each line dio19 to dio0; then press the ENTER key to return to the diagnostic tool menu.
5. Select another diagnostic tool using the up/down arrow key, or exit by pressing the ENTER key. The dio lines remain set after exiting this procedure.

Diagnostic Tool rELAy

The rELAy diagnostic tool allows you to change the status of any 8 relay lines RLY7 to RLY0 located in the DI/O module.

Complete the following procedure to change the status of any relay line.

1. Select the rELAy diagnostic tool using the procedure “Selecting the Diagnostic Tool Menu.”
6. Use the left/right arrows to select the desired relay line RLY7 to RLY0. The format is nnnn-nnnn, representing relay lines RLY7 to RLY0, respectively. The secondary display shows the selected line, for example, RLY:7.
7. Use the up/down arrow keys to select the desired dio line status, 0 or 1.
8. In a similar manner, select the desired dio status for each line RLY7 to RLY0; then press the ENTER key to return to the diagnostic tool menu.
9. Select another diagnostic tool using the up/down arrow key, or exit by pressing the ENTER key. The relay lines remain set after exiting this procedure.

Diagnostic Tool idS

The idS diagnostic tool allows you to view the firmware versions installed in your device.

Complete the following procedure to view the firmware versions in your device.

1. Select the idS diagnostic tool using the procedure “Selecting the Diagnostic Tool Menu.”
2. With inStr shown in the secondary display, and the device model number shown in the primary display, press the up/down arrow keys to sequence through the firmware selections shown in Table 6-4.

Table 6-4. Device Firmware Descriptions

Primary Display*	Secondary Display
2680A -or- 2686A	inStr (Device Model Number)
01.00	Lc (logger GUI compatibility e.g.. embedded is compatible with GUI version 1 or higher)
02.00	diSP (Display CPU Version)
1.2-1	boot (Main Boot Version)
01.00	MAin (Main Software Version)
* The firmware versions shown in this table are typical. Actual firmware versions may vary. ** Field Programmable Gate Array	

3. After viewing the desired information, press the ENTER key to return to the diagnostic tool menu.
4. Select another diagnostic tool using the up/down arrow key, or exit by pressing the MODULE key.

Diagnostic Tool conF

The conF diagnostic tool allows you to configure the reading rate, and channel functions and channel ranges for channels 1 to 20.

Complete the following procedure to configure the reading rate and channel functions.

1. Select the conF diagnostic tool using the procedure “Selecting the Diagnostic Tool Menu”.
2. **Reading Rate** Use the up/down arrow keys to show rAtE in the primary display; then press the ENTER key. Using the up/down arrow keys, sequence through the reading rates SLO (Slow), FASt (Fast), and HALF (Medium), stopping at the desired rate; then press ENTER.
3. Select the conF diagnostic tool using “Selecting the Diagnostic Tool Menu”.
4. **Channel Functions** Use the up/down arrow keys to show chAn in the primary display; then press the ENTER key.
   a. Using the left/right and up/down arrow keys, select the desired channel for configuration (01 to 20); then press the ENTER key.
   b. Using the up/down arrow keys, chose the measurement function for the selected channel; then press the ENTER key.
   c. Using the up/down arrow keys, chose the range for the measurement function (except frequency, which has no range selection); then press the ENTER key.
5. Repeat Step 4 for each channel you wish to configure.
6. Select another diagnostic tool using the up/down arrow key, or exit by pressing the MODULE key.

Diagnostic Display Test

For a constant front panel display with all segments lit, turn off the device, then turn the power on again while holding down the front panel ◄ key. After the device beeps, release the key. The front panel display remains on until any front panel key is pressed. This allows you to inspect the display segments.

COMM Parameter Reset

To reset all the communication parameters to the factory defaults (Table 6-5), turn off the instrument, then turn the power on again while holding down the front panel COMM key. After the device beeps, and the message "rESEt" is displayed for one second, release the key.

Table 6-5. Device Default COMM Parameters

Parameter	Default Setting
Base Channel Number	1
Line Frequency	60 Hz
Network Selection	Isolated Network
Socket Port	4369
Internet Protocol Address	198.178.246.001
Baud Rate	9600

Using the RS-232 Interface

The device supports calibration adjustment and verification using ASCII commands on the RS-232 interface since MET/CAL does not have network capability, and field calibration stations probably won't either. The device also supports several commands for factory testing and several for software testing. The RS-232 interface is also used to download the main software to flash. The user can configure the function, range, and number of terminals for channel one only. RS-232 can be used to get a measurement on channel one. Other configuration elements cannot be set by the user through the RS-232 interface. The user can set master alarm output, trigger out, DIO output, and relay outputs. The user can view the trigger input, relay settings, and DIO input. The user has access to the totalizer value and configuration.

The RS-232 interface does not perform acquisition scans and does not save measured data in the scan queue or last scan record. The computed channels are not accessible. Alarms are not configurable through the RS-232 interface. When calibration is enabled, the secondary display shows “CAL.” The device does not output measurements to an RS-232 printer as Hydra did. The REM annunciator will not be lit.

Command Processing

The device RS-232 interface processes input and output in a manner similar to NetDAQ. The device receives a command or query from the host. The device returns a response to a valid query. The device always returns a prompt after processing an input line (the prompt follows the response in the case of a query).

An input line to the device consists of one or more semicolon-separated commands followed by an input terminator. The device will accept CR/LF or LF as the input terminator. The device reads input into a 350-byte input queue until it finds the input terminator. The device does not echo input. While processing the queued input, the device parses and processes each command in sequence. Therefore, earlier commands can execute even if a later command contains a syntax error.

The prompts have the following meanings:

=> No error. Command was parsed and executed with no errors.

?> Command error. The command contained a syntax error. For example, the command name or an argument contained a type; the command was not a legal command; an argument was of the wrong type; too many or too few arguments were supplied. Since parity is always set to none, parity errors cause garbage in the input buffer, and this will generate a syntax error (at best).

!> Execution or device-dependent error. An execution error occurs when the command was recognized to be an device command but was not legal given the current state of the device, or had an inappropriate parameter value. A device-dependent error occurs when an device-specific limitation is exceeded (such as input queue size), or when the device tries to execute the command but it fails (for example, due to a bad CRC).

If a command cannot be recognized (i.e., syntax error), the device returns the ?> error prompt and does not do any more processing on that command or the remaining contents of the input queue. If a query had already been processed on that line, its response would be sent before the prompt.

If the input queue size is exceeded, the device throws away all further input until it receives a terminator, and generates a device-dependent error. None of the commands in the queue are executed. The device returns the !> prompt when it encounters the input terminator.

If the device receives an input line before its last prompt has been read out of its output queue, the device will generate an execution error, return the !> error prompt instead of whatever prompt it had planned to return, and ignore the second input line.

If an input line contains more than one query command, the responses will be returned in one response line separated by semicolons.

When sending a response or prompt, the device appends an output terminator which is the CR/LF character. The device output can be held off with XON/XOFF.

The string formats and general syntax rules are the same as Hydra's.

The following settings are fixed: eight data bits, no parity, no echo, XON/XOFF flow control, and no CTS flow control. The user can set the baud rate to 4800, 9600, 19200, or 38400.

Device Configuration

The FUNC command is used to select a measurement function, range, and number of terminals on channel one only. When executing the *RST or *TST? command, or when exiting calibration mode, the device sets the configuration to the values shown below in Table 6-6:

Table 6-6. Device Configuration

Configuration Element	Power-on	Reset/Selftest
Channel 1 to 20 configuration: function, range, terminals, TC type, RTD R0	Channel 1 only is V dc, Autorange	Off
Channel 1 to 20 OTC	Off	Off
Channel 21 to 30 Equation	Off	Off
Channel 1 to 30 Mx+B	1x+0	1x+0
Channel 1 to 30 Alarm Limits	Off/0	Off/0
Channel 1 to 30 Alarm Association	None	None
Channel 1 to 30 Alarm Trigger	Disabled	Disabled
Reading Rate	Slow	Slow
Primary Interval	0	0
Conditional Interval	0	0
Alarm-Check Interval	0	0
Primary Interval Triggering	Disabled	Disabled
External Triggering	Disabled	Disabled
Alarm Triggering	Disabled	Disabled
Scan Queue Mode	Overwrite Old Scans	Overwrite Old Scans
Trigger Output	Disabled	Disabled
Temperature Scale (F or C)	C	C
Totalizer Debounce	Disabled	Disabled
Housekeeping (Drift Correction)	Enabled	Disabled
Inactive Client Scan-Disable	Enabled	Enabled

The prompts provide error information. The *TST? query provides failure information. Power-on selftest results can be retrieved with the SELFTEST? query.

Command Set

The device RS-232 command set is shown in Table 6-7: RS-232 Command Set. The calibration commands are described in more detail in Chapter 5. These are: CAL, CAL_CLR, CAL_CONST, CAL_CONST?, CAL_REF, CAL_REF?, and CAL_STEP?. The other commands are described in this chapter. The device does not accept the calibration commands unless calibration mode is enabled. In calibration mode, the device does not accept some non-calibration commands. It is expected that users will make all calibration adjustments and exit calibration mode before performing calibration verification. Calibration verification readings will be made in the slow reading rate, which is the power-on and reset default, therefore no command is provided for setting the rate.

Table 6-7. RS-232 Command Set

Command	Description	Cal	Not Cal
*IDN?	Identification query	*	*
*OPC?	Operation complete query	*	*
*RST	Reset	*	*
*TST?	Self-test query		*
SELFTEST?	Return current self-test results	*	*
CAL	Start calibration procedure for indicated function and input module	*	
CAL?	Return the identifier of any cal procedure in progress	*	
CAL_CONST?	Query the value of a particular calibration constant	*	*
CAL_REF	Specify value to calibrate to in place of default reference value	*	
CAL_REF?	Query the present calibration reference value	*	
CAL_STEP?	Calibrate and query the calibrated value of the input	*	
CAL_DATE?	Calibration date for module	*	*
CAL_MODE	Enable & disable cal mode	*	*
FUNC	Configure function, range, terminals for channel one of specified input module		*
FUNC?	Query function, range, terminals for channel one of specified input module		*
MEAS?	Trigger and query a measurement on channel of previously chosen input module		*
DIO	Set the value of the DIO digital lines 0 through 19		*
DIO?	Get the value of the DIO digital lines 0 through 19		*
RELAY	Set the value of the DIO Relays 1 through 8		*
RELAY?	Get the value of the DIO Relays 1 through 8		*
TOTINIT	Set the value of the DIO Totalizer to 0		*
TOT?	Get the value of the DIO Totalizer		*
TOTCFG	Set the value of the DIO Totalizer Configuration		*
TOTCFG?	Get the value of the DIO Totalizer Configuration		*
RATE	Set the scan Speed (FAST, MEDIUM, SLOW)		*
RATE?	Get the scan Speed (FAST, MEDIUM, SLOW)		*
SERIAL?	Get the serial number for the chassis, AI module, or DIO		*

Table 6-7. RS-232 Command Set (cont)

TRIN?	Query the state of the chassis trigger in line		*
TROUT	Pulse the chassis trigger out line low for 200uS		*
MAOUT	Force the Master Alarm ON or OFF		*
DIO	Set the value of the DIO digital lines 0 through 19		*
DIO?	Get the value of the DIO digital lines 0 through 19		*
RELAY	Set the value of the DIO Relays 1 through 8		*
RELAY?	Get the value of the DIO Relays 1 through 8		*
TOTINIT	Set the value of the DIO Totalizer to 0		*
TOT?	Get the value of the DIO Totalizer		*
TOTCFG	Set the value of the DIO Totalizer Configuration		*
TOTCFG?	Get the value of the DIO Totalizer Configuration		*
RATE	Set the scan Speed (FAST, MEDIUM, SLOW)		*
RATE?	Get the scan Speed (FAST, MEDIUM, SLOW)		*
SERIAL?	Get the serial number for the chassis, AI module, or DIO		*
TRIN?	Query the state of the chassis trigger in line		*
TROUT	Pulse the chassis trigger out line low for 200uS		*
MAOUT	Force the Master Alarm ON or OFF		*

The RS232 commands are described in this chapter using the following format:

Command: The command name and syntax

Description: A description of the command

Parameters: A description of the required and optional parameters

Response: A description of data returned

Restrictions: When the command is allowed/disallowed

Notes: Any additional useful information

Command: *IDN?

Description: Identification query.

Parameters: None

Response: FLUKE, <model>, <serial-number>, <versions>, <module configuration>

<model> = 2680A, 2686A
<serial-number> = programmed serial number
<versions> = YYYYMMDD

<module config> = 6 character string: “P” for PAI; “F” for FAI; “D” for DIO; “-“ for no module installed: ie, “PP-F-D”

Restrictions: None

Notes: None

Command: *OPC?

Description: Operation complete query. *OPC? causes 268XA to output an ASCII ‘1'.

Parameters: None

Response: <state> = 1

Restrictions: None

Notes: *OPC? is used in conjunction with a non-query command to get a response from 268XA when the non-query command is finished executing. For example, sending ‘CAL 1; *OPC?' will get the ‘1' response when 268XA is ready to execute calibration procedure 1.

Command: *RST

Description: Reset. Resets the configuration to the values in 268XA Device Configuration. Clears DIO and other settings.

Parameters: None

Response: None

Restrictions: None.

Notes: If *RST is used in calibration mode, 268XA exits calibration mode. If *RST is used to exit calibration mode before the completion of a calibration procedure for a function (V dc, V ac, OHMS, FREQ), any new calibration constants for that function will not be saved.

Command: *TST?

Description: Self-test query. Initiates asynchronous self-test, blocking while it executes, and then returns the self-test results. This command resets the device configuration and state the same as *RST.

Parameters: None

Response: <self-test-result> = an integer which binary-encodes the self-test results as shown in Table 6-1: self-test codes.

Restrictions: Not allowed in calibration mode.

Command: SELFTEST?

Description: Self-test results query. Returns the self-test results from the last self-test performed. This command can be used to retrieve the power-on self-test results.

Parameters: None

Response: <self-test-result1>,<self-test-result2> = two integers which binary-encodes the self-test results as shown in Tables 6-1: self-test codes.

Restrictions: Not allowed in calibration mode.

Command: CAL

Description: Initiate calibration procedure for the specified measurement function

Parameters: <module number**>,** <procedure>

<module number> = integer 1 - 6

<procedure> =

1 = V dc

2 = V ac

3 = Ohms

4 = Frequency

Response: None

Restrictions: Only allowed in Calibration Mode

Notes: If executed during a calibration procedure, it aborts the current procedure and begins another.

This command returns an execution error if not in the Calibration Mode.

This command returns a device dependent error if an internal error such as a guard crossing error is detected while attempting to determine the device type.

This command returns a device dependent error if it is unable to set the default cal configuration. This could happen if scanning was enabled via the network interface after the cal procedure was initiated.

Command: CAL?

Description: Return the procedure identifier of any calibration procedure in progress

Parameters: none

Response: <module number>, <procedure> (see parameter description for CAL command)

Restrictions: Only allowed in Calibration Mode

Notes: This command returns an execution error if not in the Calibration Mode.

Command: CAL_CONST?

Description: Query the value of a particular calibration constant

Parameters: <module number>,<cal constant number>

<module number> = integer 1 - 6

<cal constant number> = integer 0 - 60 (even integers only)

Response: <value> = floating point calibration constant

Restrictions: None

Notes: The Calibration Constants section describes the calibration constants in detail.

Command: CAL_REF

Description: Specify value to calibrate to in place of default reference

Parameters: <new calibration reference value>

<new calibration reference value> = floating point reference value

Response: None

Restrictions: Calibration mode only

Notes: This command returns an execution error if the specified calibration reference is invalid. The allowable limits for each reference are specified for each procedure in the Calibration Procedures section.

This command returns an execution error if no cal procedure is active.

Command: CAL_REF?

Description: Query the present calibration reference value

Parameters: None

Response: <reference value>

<reference value> = floating point number

Restrictions: Calibration mode only

Notes: This command returns an execution error if no cal procedure is active.

Command: CAL_STEP?

Description: Calibrate and query the calibrated value of the input

Parameters: None

Response: <calibrated value>

<calibrated value> = floating point number

Restrictions: Calibration mode only

Notes: This command returns an execution error if the measured reading is outside of the limits specified for each function in the Calibration Procedures section.

This command returns an execution error if no cal procedure is active.

This command returns a device dependent error if an internal error such as measurement timeout is detected.

If the CAL_STEP? command completes successfully, the "calibrated value" returned is the reference value. If the command fails because the measured reading is outside of the specified limits, the raw measurement is returned.

A device dependent error is returned if an internal error such as a Guard Crossing error, measurement timeout, or a configuration failure is detected. No value is returned in this case.

This command sets the EST_BUSY bit in the error status register while changing the device configuration. The scan queue is also cleared.

Command: CAL_DATE?

Description: Query the calibration date for a particular module

Parameters: <module number> = integer 1 - 6

Response: MM/DD/YYYY HH:MM:SS.000, ie, 4/5/2002 09:06:32.000

Restrictions: None.

Notes: None.

Command: FUNC <channel>, <function> [, <range> [, <terminals>]]

FUNC <channel>, TC, <thermocouple type>, <check OTC flag>

FUNC <channel>, THERM, AUTO, <terminals>, <coeff. a> <coeff. b> <coeff. c>

FUNC <channel>, RTD, AUTO, <terminals>, <R0 value>, [alpha value]

Description: Configure the measurement function, range, and number of terminals for a channel.

Parameters:

<channel> = 1xx, 2xx, 3xx, 4xx, 5xx, 6xx (where xx = 01 – 20)
<function> = OFF, V dc, V ac, OHMS, FREQ, TC, THERM, RTD
<range> = 1, 2, ... 5, AUTO
<terminals> = 2 or 4 for OHMS
<thermocouple type> = J, K, …
<check OTC flag> = 0: don't check; 1: check
<coeff. a> <coeff. b> <coeff. c>
<R0 value>, [alpha value]

Response: None.

Restrictions: Not allowed in calibration mode.

<range> and <terminals> may not be specified with <function> = OFF.

<terminals> may not be specified with <function> = V dc, V ac, or FREQ.

<terminals> must be specified with <function> = OHMS.

<range> must be specified for V dc, V ac, and OHMS.

<range> may be specified for FREQ, but it is not used.

a <range> value which is 'na' in Table 6-8: Range Settings generates an execution error.

Notes: On the 268XA PAI, channels 1 and 11 can measure 300V while the other channels can measure only 150V. When configuring for 4-wire ohms, only channels 1-10 can be used; channels 11-20 must be OFF or a device dependent error is generated.

Thermocouple: FUNC 101, TC, K, 1
Thermistor: FUNC 102, THERM, AUTO, 2, 0.0014733, 0.0002372, 1.074E-07
RTD: FUNC 103, RTD, AUTO, 2, 3.74-E03

If no module is installed for the requested channel, then a device dependent error is generated.

Table 6-8. Range Settings

<range>	FAI V dc	PAI V dc	FAI V ac	PAI V ac	FAI 2-WIRE Ω	PAI 2-WIRE Ω	4-WIRE Ω	FREQ
1	300 mV	300 mV	300 mV	300 mV	na	300 Ω	300 Ω	opt
2	3 V	3 V	3 V	3 V	na	3k Ω	3 kΩ	opt
3	30 V	30 V	30 V	30 V	30 kΩ	30 kΩ	30 kΩ	opt
4	50 V	300 V/ 150 V	na	300 V	300 kΩ	300 kΩ	300 kΩ	opt
5	90 mV	90 mV	na	na	3 MΩ	3 MΩ	3 MΩ	opt
6	750 mV	750 mV	na	na	na	na	na	opt

Command: FUNC? <channel>

Description: Query the measurement function, range, and number of terminals for a channel.

Parameters: <channel> = 1xx, 2xx, 3xx, 4xx, 5xx, 6xx (where xx = 01 – 20)

Response: <function> [, <range> [, <terminals>]]

<function> = OFF, V dc, V ac, OHMS, FREQ, TC, THERM, RTD
<range> = 1, 2, ... 5, AUTO
<terminals> = 2 or 4
<thermocouple type> = J, K, …
<check OTC flag> = 0: don't check; 1: check
<coeff. a> <coeff. b> <coeff. c> = Coefficients used in Steinhart-Hart equation
<R0 value> = RTD resistance at 0 degrees C
[alpha value] = Alpha coefficient for custom (non-standard) RTD

Restrictions: Not allowed in calibration mode.

Notes: None.

If the channel is not configured or the input module is not installed, this query returns just OFF.

When <function> is OFF, <range> and <terminals> are not returned.

When <function> is FREQ, <range> is always returned as AUTO.

When <function> is V dc, V ac, or FREQ, <terminals> is not returned.

When <function> is OHMS, <terminals> is always returned.

When <function> is TC, response is "TC, AUTO, <thermocouple type>, <check OTC flag>"

When <function> is RTD, response is "RTD, AUTO, <terminals>, <R0 value> [,alpha value]"

When <function> is THERM, response is THERM, AUTO, <terminals>, <coeff a>, <coeff b>, <coeff c>

Command: MEAS? <channel>

Description: Takes a measurement on a channel and returns the measured value

Parameters: <channel> = 1xx, 2xx, 3xx, 4xx, 5xx, 6xx (where xx = 01 – 20)

Response: <measurement> = IEEE-488.2 NR3 ASCII representation of a floating point value:

leading sign;
5 or 6 digits with embedded decimal point for FAI and PAI respectively, padded with leading and trailing zeroes if necessary;
'E';
a signed exponent of -3, +0, +3, or +6.

For example +115.67E+0.

An overload condition is indicated by a value of +001.00E+9 or -001.00E+9 in the FAI, +001.000E+9 or -001.000E+9 for the PAI.

Restrictions: Not allowed in calibration mode.

If the channel is not configured, the channel is not one listed above, or the input module is not installed, this command generates an execution error and does not return a value.

Notes: While processing this query, 268XA does not return a response or a prompt until the measurement has been taken.

268XA generates a device dependent error if the measurement does not arrive after 30 seconds.

Open thermocouples return a +999.99[9]E+9.

Command: DIO <mask>, <value>

Description: Set the value of the DIO Digital lines 0 through 19

Parameters: <mask> integer from 1 to 1048575 ($2^{\wedge 20} - 1$); <value> integer from 1 to 1048575 ($2^{\wedge 20} - 1$)

Response: None

Restrictions: None.

Notes: To set all lines high: "1048575, 1048575"; to set all low: "1048575, 0".

Command: DIO?

Description: Get the value of the DIO Digital lines 0 through 19

Parameters: None

Response: 0 to 1048575 ($2^{\wedge 20} - 1$)

Restrictions: None.

Notes: 0: all lines low; 1: line 0 high, all other lines low; 2: line 1 high, all other lines low; 3: lines 0 and 1 high, all other lines low; …; 1048575: all lines set high

Command: RELAY <mask>, <value>

Description: Set the value of the DIO Relays 1 through 8

Parameters: <mask> integer from 1 to 255 ($2^{\wedge 8} - 1$); <value> integer from 1 to 255 ($2^{\wedge 8} - 1$)

Response: None

Restrictions: None.

Notes: "1" is reset and "0" is set; to set all relays: 255, 0; to reset all relays: 255, 255

Command: RELAY?

Description: Get the value of the DIO Relays 1 through 8

Parameters: None

Response: 0 to 255 ($2^{\wedge 8} - 1$)

Restrictions: None.

Notes: 0: all Relays Set; 1: Relay 1 Reset, all other Relays Set; 2: Relays 2 Set, all other Relays Reset; 3: Relays 1 and 2 Set, all other Relays Reset; …; 255: all Relays Set

Note on DIO Relays/Digital lines programming:

Serial control for the individual DIO Relays or Digital lines is based on bit values. For the relays, the firmware decided that "1" is reset and "0" is set; for the digital lines, “1” is high and “0” is low. Relay 1/DIO line 0 has bit value 2^0 =1, Relay 2/DIO line 1 has bit value 2^1 = 2, Relay 3/DIO line 2 has bit value 2^2 = 4, …, Relay 8/DIO line 7 has bit value 2^7 = 128, DIO line 19 has bit value 2^19 = 524,288. The arguments for RELAY or DIO are <mask>, <value>. To Set Relays 2 and 3, the arguments would be “6, 0” and to Reset “6, 6”. To Set all relays: “255, 0”; Reset all: “255, 255”. Similarly, to set DIO lines 2 and 3 high: “12, 12”; to set lines 2 and 3 low, “12, 0”. To set all lines high: “1048575, 1048575”; to set all low: “1048575, 0”.

Command: TOTINIT <value>

Description: Set the value of the DIO Totalizer

Parameters: <value> integer from 0 to $2^{\wedge 32}$ (4,294,967,296)

Response: None

Restrictions: None.

Notes: None.

Command: TOT?

Description: Get the value of the DIO Totalizer

Parameters: None

Response: 0 to $2^{\wedge 32}$ (4,294,967,296)

Restrictions: None.

Notes: None.

Command: TOTCFG <direction>, <debounce>

Description: Set the value of the DIO Totalizer configuration

Parameters: <direction> = 0 for down, 1 for up; <debounce> = 0 for off, 1 for on

Response: None

Restrictions: None.

Notes: None.

Command: TOTCFG?

Description: Get the value of the DIO Totalizer configuration

Parameters: None

Response: : <direction> = 0 for down, 1 for up; <debounce> = 0 for off, 1 for on

Restrictions: None.

Notes: For direction = 0 (decrement) and count = 0, with totalizer line pulsed, the TOT? count will wrap ($2^{\wedge 32}$)

Command: RATE <module>, <rate>

Description: Set the scan speed

Parameters: <module> integer from 1 to 6, <rate> = FAST, MEDIUM, SLOW

Response: None

Restrictions: None.

Notes: None.

Command: RATE? <module>

Description: Get the scan speed

Parameters: : <module> integer from 1 to 6

Response: FAST, MEDIUM, SLOW

Restrictions: None.

Notes: None.

Command: SERIAL? <module>

Description: Get the serial number for a module

Parameters: <module> integer from 1 to 6

Response: programmed serial #

Restrictions: None.

Notes: Use *IDN? To retrieve chassis serial number

Command: TRIN?

Description: Query the state of the Chassis Trigger In line

Parameters: none

Response: 0 for high state, 1 for low state

Restrictions: None.

Notes: None.

Command: TROUT

Description: Pulse the Chassis Trigger Out line low for 200usec

Parameters: none

Response: none

Restrictions: None.

Notes: None.

Command: MAOUT <1 or 0>

Description: Force the Master Alarm ON (Logic Low) or OFF (Logic High)

Parameters: 1 (ON - Logic Low) or 0 (OFF - Logic High)

Response: None.

Restrictions: None

Notes: None.

Troubleshooting the Device

The following paragraphs describe an organized method of device troubleshooting. The overall approach is to start with power-up self-test error codes and then proceed too increasingly detailed procedures. Begin troubleshooting with "General Troubleshooting." These procedures locate about 90% of the device faults. The remaining faults require sleuthing that is beyond the scope of this manual. For these cases, review Chapter 2 "Theory of Operation" and approach the difficulty in a logical manner adapting the troubleshooting procedures, as required. As a last resort, contact Fluke (see Chapter 7) for assistance.

General Troubleshooting

General troubleshooting uses the device response to self-test as a clue to the fault location. If the device completes self-test and displays an error code on the front panel, refer to Table 6-9. If the device appears dead and will not even self test, refer to Table 6-10. If the device passes self test but is not operating correctly, then refer to "Troubleshooting the A/D Converter PCA" for analog problems, and "Troubleshooting the Sys/Ctrl PCA" for master alarm, trigger in, and trigger out problems.

Table 6-9. Relating Selftest Errors to Device Problems

Error Code	Error Code Description	Suspect Assembly	Error Code Discussion
1	Bad boot software image in FLASH ROM.	Sys/Ctrl PCA	**Background** The System Power/Controller Board FLASH memory device, U20, is divided into sections. One of these sections is the memory for the boot software, which is used for device initialization. After the device is initialized, the main code takes over and runs the device. **Failure** For this error to occur, the boot software is either missing or is corrupted and must be reloaded. **Correction** Reloading the boot software is a factory procedure only. The only recourse is to order a new U20 device programmed at the factory if the software is corrupted. Also see “Troubleshooting the Device.”
2	Bad main software image in FLASH ROM.	Sys/Ctrl PCA	**Background** The System Power/Controller FLASH memory device is divided into sections. One of these sections is the main software that runs the device. **Failure** For this error to occur, the main software is either missing or is corrupted and must be reloaded. This failure is detected by a boot monitor condition, which means the boot software completed but the main software did not take over device operation. **Correction** Reloading the main software is discussed in “Updating Embedded Device Firmware” later in this chapter. Also, see “Troubleshooting the Digital Kernel.”
3	RAM test failure.	Sys/Ctrl PCA	**Background** The System Power/Controller uses static RAM devices U18-22. The boot software uses a portion of RAM1 as a memory device. **Failure** For this error to occur, the RAM devices did not function correctly during the boot process. Either the RAM devices failed, or the address decoding for the RAM devices failed. Most of the address decoding is located internal to the SYS/CTRL microprocessor, while the RAM enable signal, CS1*, is generated by U6 microprocessor. **Correction** Check the enable signal at the RAM devices, including the RAMWE*, read/write signals. If the inputs are correct, the devices themselves are suspect. If the inputs are incorrect, work backwards towards the signal source and locate the device that is not performing. Also, see “Troubleshooting the Digital Kernel.” Check the SYS/CTRL U20 to make sure the proper CS1* memory select enable and RAMWE* strobes are produced.

Table 6-9. Relating Selftest Errors to Device Problems (cont)

Error Code	Error Code Description	Suspect Assembly	Error Code Discussion
4	Display test failure.	A2 Display PCA [Note 1]	**Background** The SYS/CTRL microprocessor requests the A2 Display PCA to run a self-test and report the results. **Failure** For this error to occur, the A2 Display PCA is able to communicate with Sys/Ctrl microprocessor but the Display self-test is "fail." **Correction** Almost certainly the A2 Display PCA has a problem. Refer to paragraph "A2 Display PCA Troubleshooting."
5	Display not responding.	A2 Display PCA [Note 1]	**Background** The SYS/CTRL microprocessor requests the A2 Display PCA to run a self-test and report the results. **Failure** For this error to occur, the A2 Display PCA did not respond to the SYS/CTRL microprocessor request to run a self-test. Neither "pass" nor "fail" was reported as if the A2 Display PCA is dead or missing. **Correction** Check the ribbon-cable connection, P8, between Backplane and the display board. Also, check back to the P7 connector on the SYS/CTRL PCA. Check the power supply levels to the A2 Display PCA. Refer to paragraph "A2 Display PCA Troubleshooting.
6	Module 1 Calibration constants corrupt.	Module PCA	**Background** Each module of the 2680A/2686A contains its own calibration constants on the A/D Power daughter card. The A/D U7 FLASH memory device contains the calibration constants. The calibration constants are used by the A/D converter. **Failure** For this error to occur, the calibration constants stored in A/D Power PCA U7 have become corrupted. **Correction** If the only problem is calibration values, start the calibration procedures in Chapter 5. One other possibility is a A/D Power PCA U7 device failure.

Table 6-9. Relating Selftest Errors to Device Problems (cont)

Error Code	Error Code Description	Suspect Assembly	Error Code Discussion
7	Module 1 Procedures Incomplete.	Module PCA	**Background** Each module of the 2680A/2686A contains its own calibration constants on the A/D Power daughter card. The A/D U7 FLASH memory device contains the calibration constants. The calibration constants are used by the A/D converter. **Failure** For this error to occur, you may have started a calibration routine and then didn't complete it. When you start a calibration routine, it sets a "start" flag; when you complete a calibration routine, it sets a "finish" flag. If the software detects a start flag and no finish flat, you will receive this error. **Correction** If the only problem is calibration values, complete the calibration procedures in Chapter 5. One other possibility is a A/D Power PCA U7 device failure.
8	Module 1 A/D failure.	A/D Converter and DIO PCA	**Background** The SYS/CTRL processor requests the inguard module to run a self-test and report the results. **Failure** For this error to occur, the module PCA did not respond to the SYS/CTRL microprocessor request to run a self-test. Neither "pass" nor "fail" was reported as if the module PCA is dead or missing. **Correction** Check that the module is properly plugged into the backplane. Next, check that the power levels to the module are the correct levels. Finally, check that the power supply voltages generated by the power circuitry on the module is generating the correct level of voltage. The SYS/CTRL FPGA could be damaged for the interface with the module PCA, or possibly the optics opto-isolator devices A/D Power PCA U2 or U3 for the serial data guard crossing are damaged. (Note that the guard crossing serial data is similar to RS-232, except it uses normal logic levels instead of RS-232 logic levels.) Another possibility is the digital kernel on the module PCA has failed. See "Troubleshooting the A/D Converter PCA."
9	Module 1 zero offsets test failed.	A3 A/D Converter PCA	**Background** Each measurement function, V dc, V ac, resistance, and frequency is subject to some sort of signal conditioning and if this circuitry fails, it could introduce an expectedly large offset error. **Failure** This error suggests a problem in the signal conditioning path, rather than the A/D converter itself. **Correction** Check the components for each signal conditioning method, depending the function that has failed. You can, for example, apply different functions, i.e., V ac, V dc, resistance or frequency, and note which function measures incorrectly. Then look in the signal conditioning components for the failure. Be sure A3W8 jumper is in place.

Table 6-9. Relating Selftest Errors to Device Problems (cont)

Error Code	Error Code Description	Suspect Assembly	Error Code Discussion
10	Module 1 reference balance test failed.	A3 A/D Converter PCA	**Background** The A/D converters uses two very precise voltages for operation: +3.45 V dc and -3.45 V dc. These voltages are applied to resistor network A3Z1-1 and A3Z1-3, with a balanced output at A3Z1-2. When the two reference voltages are exact, the A3Z1-2 output is nearly zero. **Failure** This error occurs when the output of the balance reference check at A3Z1-2 is not nearly zero. **Correction** Troubleshoot the reference voltage circuitry at A3U12 and A3U20 and related components. Check the inputs and outputs of A3U12 and A3U20 and look for an incorrect output, indicating a device failure.
11	Module 1 overload detection failed.	A3 A/D Converter PCA	**Background** This self-test is created by configuring for an ohms measurement, with treeing relays pulled in, but no channel relays are set. This creates an overload measurement as the A/D converter tried to measure the resistance of an open circuit. **Failure** The error occurs when the A/D converter did not detect an overload condition for measuring an open circuit. **Correction** There is a problem in the ohms conditioning circuitry or possibly a problem in the A3U30 Stallion device. The dc buffer might also be affected. Normally, this error occurs in conjunction with other errors. If there are not other errors, then the signal conditioning circuitry is more likely at fault. Also, check the ohms current source at A3U31 and related components. When the precision 1 mA current sink is operating correctly, the voltage across A3R128 is exactly 3.45 V dc and the voltage across A3Z7-9 and A3Z7-11 is 1.00 V dc. If all the voltages are correct, the A3U30 Stallion device becomes more suspect.

Table 6-9. Relating Selftest Errors to Device Problems (cont)

Error Code	Error Code Description	Suspect Assembly	Error Code Discussion
12	Module 1 open thermocouple detect failed.	A3 A/D Converter PCA	**Background** The open thermocouple detect circuit checks on the amount of a 19.2 kHz voltage developed across a “thermocouple.” Similar to the overload detection, the self-test does not set any channel relays and the detection circuit should detect the “open” thermocouple. **Failure** For this error to occur, the open-thermocouple circuit has failed to detect the simulated open thermocouple condition. **Correction** Check the circuitry formed by the open thermocouple detect circuit formed by A3U32 peak detector and comparator and associated components operates by applying a 19.2 kHz clock from A3U5 via A3C82 into the measurement line. It checks on the amount of 19.2 kHz voltage is developed. If the developed voltage exceeds a certain level, this is detected as an open thermocouple with a logic output at A3U32-7. Similar to the overload detection, the self-test does not set any channel relays and the detection circuit should detect the “open” thermocouple. Also, check the relays in the circuit path.
13	Communication parameters corrupt.	Sys/Ctrl PCA	**Background** The SYS/CTRL stores the RS-232 communication parameters (baud rate) in the flash memory and receives/transmits data through U8 to the microprocessor, U6. **Failure** For this error to occur, the RS-232 parameter is no longer stored in flash. **Correction** Check SYS/CTRL U20 is operating correctly and has the correct level of voltages to it.
14	Ethernet address parameter corrupt.	Sys/Ctrl PCA	**Background** The SYS/CTRL U20 FLASH memory device is divided into sections. One of these sections is the memory for the Ethernet address. This is a unique address assigned at the time of manufacturer. **Failure** For this error to occur, the Ethernet address is either missing or is corrupted and must be reloaded, or the addressing is missing. **Correction** Reloading the Ethernet address is a factory procedure only. The only recourse is to order a new SYS/CTRL U20 device programmed at the factory if the Ethernet address is corrupted. Also, check SYS/CTRL U20 for I/O and memory decoding. See “Troubleshooting the Device” for more information.

Table 6-9. Relating Selftest Errors to Device Problems (cont)

Error Code	Error Code Description	Suspect Assembly	Error Code Discussion
15	RAM constants corrupt.	Sys/Ctrl PCA	**Background** The SYS/CTRL stores constants in flash memory, U20, which are transferred to RAM for use in operation. **Failure** For this error to occur, the constants may be improperly stored in the SYS/CTRL RAM or flash. **Correction** This might happen if there is a problem with SYS/CTRL power supply, RAMs, or the SYS/CTRL U20 flash chip itself.
16	Ethernet chip failure.	Sys/Ctrl PCA	**Background The Ethernet controller (SYS/CTRL U17)** supports 10/100BASET transceiver operation. **Failure** For this error to occur, the self-test that simulates Ethernet activity has to fail. **Correction** Check Ethernet operation using both 10/100BASE-T. If the Ethernet interface operates over 10BASE-T but not 100 Base-T, then the Ethernet transceiver SYS/CTRL T1is suspect. If Ethernet does not operate over 10 or 100Base-T interface, then SYS/CTRL U17 is suspect. Also, check SYS/CTRL U20 for I/O and memory decoding. See “Troubleshooting the Digital Kernel” for more information.
17	Module 2 Calibration constants corrupt.	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
18	Module 2 Procedures Incomplete.	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
19	Module 2 A/D failure.	A/D Converter and DIO PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
20	Module 2 zero offsets test failed.	A3 A/D Converter PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
21	Module 2 reference balance test failed.	A3 A/D Converter PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
22	Module 2 overload detection failed.	A3 A/D Converter PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.

Table 6-9. Relating Selftest Errors to Device Problems (cont)

Error Code	Error Code Description	Suspect Assembly	Error Code Discussion
23	Module 2 open thermocouple detect failed.	A3 A/D Converter PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
Second 32-bit self-test code			
0	No Self-test errors		
32	Module 3 Calibration constants corrupt	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
33	Module 3 Calibration Procedures Incomplete	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
34	Module 3 A/D failure	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
35	Module 3 Zero offset measurements unreasonable	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
36	Module 3 Reference balance measurements unreasonable	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
37	Module 3 Overload detection failed	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
38	Module 3 Open thermocouple detection failed	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
39	Module 4 Calibration constants corrupt	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
40	Module 4 Calibration Procedures Incomplete	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.

Table 6-9. Relating Selftest Errors to Device Problems (cont)

Error Code	Error Code Description	Suspect Assembly	Error Code Discussion
41	Module 4 A/D failure	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
42	Module 4 Zero offset measurements unreasonable	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
43	Module 4 Reference balance measurements unreasonable	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
44	Module 4 Overload detection failed	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
45	Module 4 Open thermocouple detection failed	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
46	Module 5 Calibration constants corrupt	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
47	Module 5 Calibration Procedures Incomplete	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
48	Module 5 A/D failure	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
49	Module 5 Zero offset measurements unreasonable	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
50	Module 5 Reference balance measurements unreasonable	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.

Table 6-9. Relating Selftest Errors to Device Problems (cont)

Error Code	Error Code Description	Suspect Assembly	Error Code Discussion
51	Module 5 Overload detection failed	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
52	Module 5 Open thermocouple detection failed	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
53	Module 6 Calibration constants corrupt	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
54	Module 6 Calibration Procedures Incomplete	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
55	Module 6 A/D failure	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
56	Module 6 Zero offset measurements unreasonable	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
57	Module 6 Reference balance measurements unreasonable	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
58	Module 6 Overload detection failed	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
59	Module 6 Open thermocouple detection failed	Module PCA	**Background** Same as for module 1. **Failure** Same as for module 1. **Correction** Same as for module 1.
Note 1 Obviously if the display is not operating, the display may not show an error code. You can extract the error codes via the RS-232 interface. See “Retrieving Error Codes using RS-232.”			

Table 6-10. Hints for Troubleshooting "Dead" Devices

Possible Fault	Discussion
Blown Fuse	If the device is completely dead, you may have blown the line fuse. There is also a fuse inline with the DC voltage input for battery input protection. Either power input can operate without the other working. See Chapter 3 for fuse replacement instructions.
Power Supply	Self-test starts with the outguard Sys/Ctrl PCA. If self-test won't even begin, then something is wrong either at the Sys/Ctrl PCA or with a power supply voltage. If the A/D Power module PCA has a short circuit of some kind, it could load down a power supply voltage such that the current limiting feature is folding the supply back. For example, the +5.6 V dc Vdd supply might only measure 1.2 V dc. This in turn would kill the Sys/Ctrl PCA. To check this possibility, turn the device power off; then pull out all of the modules. Power the device again. If this time the device goes into self test, then you need to troubleshoot the modules and look for the load that is pulling the power supply down. See "Power Supply Troubleshooting." [Power Supply - look for overwarm devices]
Dead A2 Display PCA	It may appear that self-test didn't begin because the display is dead and therefore didn't shown anything. To verify the display is dead, extract the error code over the RS-232 port instead of from the front panel display. (See "Retrieving Error Codes using RS-232.")
Dead SYS/CTRL Microprocessor	If the SYS/CTRL microprocessor or related component in the kernel has failed, self-test will not initialize. See "Troubleshooting the Digital Kernel." Check the power supply and crystal oscillator, U13.
Power-On Reset	If the input line voltage is too low, the SYS/CTRL Power-On Reset/Power-Fail Detector, U1, might be generating a POREST* (power-on reset) condition. Alternatively, if for some other reason the output of the raw dc supply falls below approximately 8.25 V dc (measured at SYS/CTRL U301 pin 2 with the power switch on). Locate the low voltage or missing voltage condition.

Sys/Ctrl PCA Troubleshooting

The following paragraphs provide troubleshooting hints for the Sys/Ctrl PCA. Use this material in conjunction with Chapter 2, "Theory of Operation."

⚠⚠Warning

To avoid electric shock, disconnect all power and channel inputs from the device before performing any troubleshooting operations.

Troubleshooting the Sys/Ctrl PCA Digital Kernel

The processor on the SYS/CTRL card is a MPC855T packaged in a ball grid array. Its pin are unreachable for trouble shooting. Consequently, all references to signal pins will be the peripheral components. When the device is first powered, the resident RAM portion of the SYS/CTRL microprocessor begins to initialize the digital kernel. This activity may be monitored at one of the SYS/CTRL microprocessor chip select outputs, for example, CS1* at U18-21. If there is brief chip-select activity and then the activity stops, this indicates that the SYS/CTRL microprocessor tried to start operation, but one or more of the outboard devices did not respond and the SYS/CTRL microprocessor was unable to continue initialization. If there is no chip-select activity when power is first applied to the device, then the SYS/CTRL microprocessor may be damaged.

If the problem seems to be in the outboard devices, then probe them with a logic analyzer or oscilloscope looking for missing signals or dc power, or by touch to find a device that is excessively warm. (Be careful to touch only the case of the device and not the pins.) These devices include SYS/CTRL U20, Flash Memory, SYS/CTRL U18-22, Static RAM, SYS/CTRL U31, real-time Clock, SYS/CTRL U1, Power Monitor, SYS/CTRL U20 WE*, Flash write enable, and related logic devices such as AND gates, OR gates, and inverters.

Check the SYS/CTRL crystal frequency at U13 pin 3 to make sure there is a clock input to the SYS/CTRL microprocessor. The crystal frequency should measure 4.19 MHz.

Check that U20 WEO* only occurs when storing system constants like RS232 baud rate. During normal operation, WEO* should not be active. If active, find the cause for the presence.

Check U18-22 RAS*, CAS*, and CS1* occur frequently. If these signals are not present, a whole host of address problems may occur, including IO and Flash write and read strobes.

Troubleshooting the RS-232 Interface

If the device RS-232 port does not seem to operate, be sure you have selected the correct RS-232 baud rate for the interface with a terminal or PC running terminal emulation software. If everything seems to be correct, troubleshoot the RS-232 interface, in particular, look at U8 pin 8 for the receive (RX) input and pin 7 for the transmit (TX). Work backwards to the U6 RS232 traces (RXD1 and TXD1, respectively). Check for +/- output levels and bit rate.

Troubleshooting the Ethernet Interface

If Ethernet interface does not operate properly, there are several things to check. When the interface is hooked to a network, the Link LED should light (green) and the RECV LED should blink red. If that does not happen, check U17 pins for a nominal +5 V dc. U17 is powered by power supply component U303. Check that U16 provides the correct 25 MHz frequency to U17. Finally, if there still is an Ethernet problem, the fault could be caused by the U17 Ethernet Controller itself .

Troubleshooting the Keypad, Master Alarm Output, Trigger Input, and Trigger Out Lines

When the device is powered, the U25 Field Programmable Gate Array is programmed by the contents of the flash ROM U9 as part of the initialization routine. Thus programmed, the FPGA interfaces with the keys portion of the A2 Display PCA and the backplane communication bus for every module slot. Check that the backplane is plugged snugly into the SYS/CTRL card and the display cable is securely connected to the backplane card. U25 controls the rear panel master alarm output, trigger output, and trigger input lines. If there are any problems in this area, check the drivers Q1, master alarm output, and Q2, trigger output, and receiver, U11 pin 2, trigger input, for correct signal operation. Check the power supply voltages. Note that the fanout for the trigger output line is increased by SYS/CTRL Q1 and Q2 so that this output can be connected to 20 trigger input lines without overloading the signal. If there are problems with loading of the trigger output line, check SYS/CTRL Q1, or Q2.

Troubleshooting the Power Supply

To troubleshoot the power supply circuits, check each voltage, proceeding from the raw dc supply through the 5V switcher and subsequent regulator circuits. If one of the supplies is folded back due to excessive current draw, remove PCBs from the SYS/CTRL card to see if this unloads the power supply. If this works, then troubleshoot the bad board. When tracking down power supply loads, use a sensitive voltmeter and look for resistive drops across filter chokes, low value decoupling resistors, and circuit traces. Also, check for devices that are too warm.

A2 Display PCA Troubleshooting

The following provides troubleshooting hints for the A2 Display PCA. Use this material in conjunction with Chapter 2, “Theory of Operation.” A Display Extender Cable is available from Fluke (PN 867952) for use during troubleshooting.

⚠⚠Warning

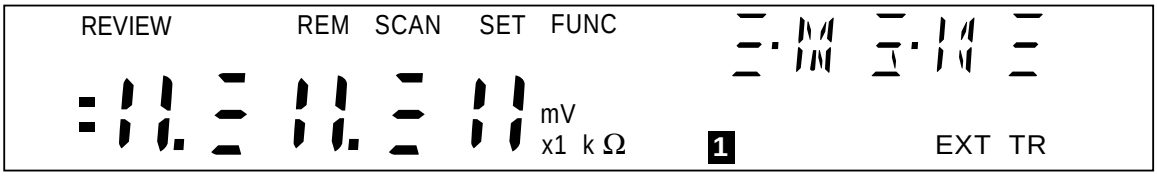
To avoid electric shock, disconnect all channel inputs from the device before performing any troubleshooting operations.

The Display Controller reads the DTEST* and LTE* inputs to determine how to initialize the display memory. DTEST* and LTE* default to logic 1 and logic 0, respectively, to cause all display segments to be initialized to "on". DTEST* is connected to test points A2TP4, and LTE* is connected to A2TP5. Either test point can be jumpered to VCC (A2TP6) or GND (A2TP3) to select other display initialization patterns. Display Test Patterns #1 and #2 are a mixture of "on" and "off" segments with a recognizable pattern to aid in troubleshooting. When either of the special display patterns is selected, the beeper is also sounded for testing without interaction with the Microprocessor. Table 6-11 indicates the display initialization possibilities.

Table 6-11. A2 Display PCA Initialization Routines

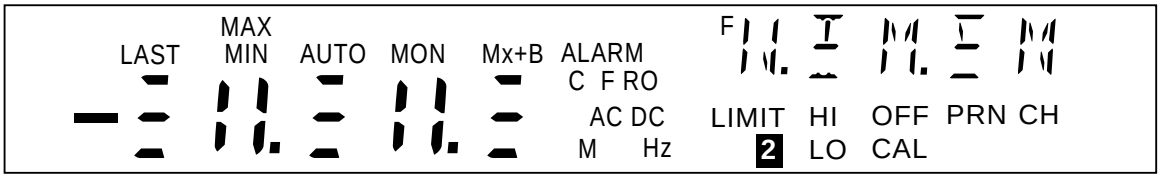
A2TP4 DTEST*	A2TP5 LTE*	Power-Up Display Initialization
1	1	All segments OFF
1	0	All segments ON (default)
0	1	Display Test Pattern #1
0	0	Display Test Pattern #2

Figures 6-1 and 6-2 show Display Test Patterns #1 and #2, respectively.



f5-01.eps

Figure 6-1. Display Test Pattern #1



f5-02.eps

Figure 6-2. Display Test Pattern #2

When the device display is initially powered up, all display segments should come on automatically. If this display does not appear, proceed with the following steps:

Note

If the display is operational but has problems when front-panel buttons are pressed, proceed directly to step 9.

1. Check the three power supplies with respect to GND on the Display Assembly.

   Vcc (A2U1-21) +4.9 V dc
   Vee (A2U1-4) -5.0 V dc
   Vload (A2U1-5) -30.0 V dc

2. Check the filament drive signals FIL1 and FIL2; these connect to the last two pins on each end of A2DS1. These signals should be 5.4 V ac with FIL2 biased to be about 6.8 V dc higher than the Vload supply (nominally a -23.2 V dc level). FIL1 and FIL2 should be 180 degrees out of phase. If the dc bias of FIL2 is not at about -23.2 V dc, the display segments that should be "off" will show a shadowing (or speckling) effect.

3. Check the clock signal CLK1 at A2TP2, A2U1-2, and A2U4-3. This signal should be a 512-kHz square wave (1.953 microseconds per cycle). This signal depends on an E clock signal (also known as DCLK) of 1.024 MHz from the Main Assembly. If the E clock is not correct, the problem may be in the Sys/Ctrl PCA or in the ribbon cable system connecting the two assemblies.

4. Check the state of the RESET signal (A2U1-1). This signal should be low once the reset time is completed (after power-up). Also verify that the RESET* signal (A2U6-3) is high after the reset time is completed.
5. Verify that the DISRX signal (A2U1-39) goes low after RESET (A2U1-1) goes low. If this sequence does not occur, communication to the Microprocessor is held off with the DISRX signal high. If DISRX stays high but is not shorted to VCC, A2U1 must be faulty.
6. Verify activity for both the DISTX and DSCLK signals. These signals are driven by the Microprocessor and must be transitioning for the Display Controller to receive commands from the Microprocessor.
7. If all segments of a particular digit do not turn on at power-up, the grid drive from A2U1 may not be connected properly to A2DS1. Grids are numbered from 10 to 0 (left to right as the display is viewed). For a digit to be enabled, the respective grid drive signals (GRID(10:0)) must be at approximately Vcc (+4.9 V dc.) For a digit to be disabled, the drive must be at Vload (-30.0 V dc.)
8. If a segment under each of several (or all) grids fails to be turned on (or off) properly, one of the anode drive signals may not be connected properly from A2U1 to A2DS1. When an anode signal is at Vcc, and a grid signal is at Vcc, the corresponding segment on the display is illuminated.
9. If the Microprocessor has difficulty recognizing front-panel button presses, the switch scanning signals SWR1 through SWR6 should be checked. When no switch contacts are being closed, the switch scanning lines should have about 20 kΩ of resistance between each other (through two 10 kΩ pull-up resistors to Vcc). Unless one of the switches is closed, none of the switch scanning lines should be shorted directly to GND at any time.

Variations in the Display

Under normal operation, the display presents various combinations of brightly and dimly lit annunciators and digits. However, you may encounter other, random irregularities across different areas of the display under the following circumstances:

- After prolonged periods of displaying the same information.
- If the display has not been used for a prolonged period.

This phenomenon can be cleared by activating the entire display and leaving it on overnight (or at least for several hours). Use the following procedure to keep the display fully lit:

1. With power OFF, press and hold the left arrow key, then press power ON.
2. Wait a moment for the device to beep, then release the key. The entire display will now stay on until you are ready to deactivate it.
3. At the end of the activation period, press any button on the front panel; the device resumes the mode in effect prior to the power interruption (Active or Inactive.)

PCMCIA PCA Troubleshooting

The PCMCIA interface board mainly consists of a card holder and a set of bi-directional level shifting buffers. The buffers on this board are driven off the same supply as the card, which can be either 3.3 V or 5 V. The buffers on A4 board are always powered from Vcc (3.3 V). This board also has a 5 V to 12 V boost topology switching regulator that is only turned on if the installed card says that it needs 12 V for programming. This 12 V supply was designed to only provide enough power for the PCMCIA card, no other devices should be powered from this supply. This board plugs into P4 on the 2680A-4004 PCA. It is a daughter card that is only installed if the device is a 2686 chassis, as opposed to a 2680 chassis that has no PCMCIA option.

A/D Power Supply PCA Troubleshooting

To access this card for test, the user may need the 2680A-7001K Extender kit, p.n. 1619174. This module is used to isolate module communication and power signals from the earth referenced SYS/CTRL PCA. It is located inside each module's housing, as a daughter card that plugs into a 2 row, 10 pin header on every module. The power supply design uses a differential 393 KHz clock source generated on the SYS/CTRL card, U25, and arrives to the PCA on P1 pins 9 and 19. There are 3 regulated outputs +5.2 V (Vdd), -5.2 V (Vss) and +5.6 V (Vddr), each one is derived from a dedicated linear low dropout regulator (U5, U6 and U4, respectively).

The other circuitry on the A31 board are the optoisolators (U2 and U3) and the calibration EEPROM (U7). U2 and U3 on the A31 PCA are used in the communication between U17, FPGA, on the SYS/CTRL PCA and the module's in-guard micro controller. U7 is a 2Kbit serial EEPROM addressable from the out-guard microprocessor (SYS/CTRL PCA) via an SPI bus that runs on the Backplane PCA . Communication with any A/D power module only occurs after a module has been initialized. There after, communication occurs every scan cycle.

DIO Module Troubleshooting

To access this card for test, the user may need the 2680A-7001K Extender kit, PN 1619174. No calibration is required for this module. Problems can occur either with communication to the SYS/CTRL card or with individual DIO, relay, or totalizer inputs. A Texas Instrument MSP430P337A micro controller, U4, is the heart of the DIO PCA. A quartz crystal operating at 32.8 kHz provides the main clock signal for the micro controller. This signal is internally multiplied to 3.6925 MHz for clocking of the micro controller functions and is divided down to 8kHz (XBUF U4 Pin 97) providing a control signal for the debounce PLD; U3.

Internal to the micro controller is a watchdog timer that is set to a 1 second interval. Should the micro controller become inoperative for a period of 1 second, the watchdog timer will activate and perform a Power Up Clear (PUC) operation that resets all outputs and restarts the micro controller. C50 controls the duration of the reset signal.

During power up, U16 provides a reset pulse of approximately 2 seconds to insure that the crystal oscillator (Y1) is given sufficient time to start. U16 also has undervoltage detection such that if the supply voltage to pin 2 drops below 4.5V, the output will reset. Depressing S1 can manually reset the micro controller. This applies a ground signal to the reset (RST U4 pin 96) pin of the micro controller.

U3 is a Programmable Logic Device (PLD) and is configured as a signal debouncer. The Totalizer signal is applied to U3 Pin 13 from the Totalizer Input Protection Buffer circuit (U1 Pin 1 and U18). See "Totalizer Input" for more details.

Digital Input Buffers

The Digital Input Threshold circuit sets the input threshold level for the Digital Input Buffers and the Totalizer Input. A fixed value voltage divider (R5, R6) and a unity gain buffer amplifier (U1) are the main components in the circuit. The voltage from the divider (approximately +1.4 V dc) is then buffered by U1, which sets the input threshold. Capacitor C8 filters the divider voltage at the input of U1.

The 20 Digital Input Buffers are identical in design but only components used for Digital Input 0 are referenced in this description. If the Digital Output Driver (U13 Pin 13) is "off", the input to the Digital Input Buffer is determined by the voltage level at P6 Pin A1. If the Digital Output Driver is "on", the input of the Digital Input Buffer is the voltage at the output of the Digital Output Driver.

The Digital Input Threshold circuit and resistor network Z2 determine the input threshold voltage and hysteresis for inverting comparator U8. The input threshold of +1.4 V dc and a hysteresis of +0.5 V dc are used for all Digital Input Buffers. When the input of the Digital Input Buffer is greater than approximately +1.65 V dc, the output of the inverting comparator is low. When the input then drops below about +1.15 V dc, the output of the inverting comparator goes high.

Digital Output Drivers

Since the 20 Digital Output Drivers are identical in design, the following example description references only the components that are used for the Digital Output (DO<0>).

The Microprocessor controls the state of the Digital Output Driver DO<0> by setting the level of the output U4 Pin 59. When U4 Pin 59 is set high, the output of the open-collector Darlington driver (U13 Pin 13) sinks current through current-limiting resistor R80. When U4 Pin 59 is set low, the driver output turns off and is pulled up by Z4 and/or the voltage of the external device that the output is driving.

Relay Output Drivers

Since the 8 Relay Output Drivers are identical in design , the following example description references only the components that are used for the operation of K1. The output relays are latching relays and therefor must be set/reset individually. The Microprocessor controls the state of the Digital Output Driver DO<20> by setting the level of the output U4 Pin 67. When U4 Pin 67 is set high, the output of the open-collector Darlington driver (U10 Pin 10) sinks current through the K1 Set relay coil; the internal flyback diode (U10 Pin 9) conducts the energy into Vcc to minimize overshoot. When U4 Pin 68 is set high, the output of the open-collector Darlington driver (U10 Pin 11) sinks current through the K1 Reset relay coil; the internal flyback diode (U10 Pin 9) conducts the energy into Vcc again to minimize overshoot. K1 is a latching double pole, double throw relay. The relay is configured in a parallel-ganged configuration; when the relay is closed, P5 Pin B30 will be connected to P5 Pin C29 and P5 Pin B32 will be connected to P5 Pin C31. Fuses F1 and F5 (2A) protect the relay contacts from excessive current. Check continuity when the relay is closed. It should not exceed a few ohms.

Totalizer Input

The Totalizer Debounce circuit in the PLD (U3) allows the micro controller to select totaling either the input signal or the debounced input signal. The buffered Totalizer Input signal (TOT_IN) goes into the PLD at U3 Pin 13. U3 Pin 9 is the debounce enable control signal. It is active high (HI = Totalizer Debounced, Lo = Totalizer NOT Debounced). The Totalizer output from the PLD is on U3 Pin 23 and this signal goes to the micro controller (CIN U4 Pin 2). The PLD receives its clock from the micro controller on Pin 2. The clock frequency is approximately 8 kHz. The signal debouncer is set to approximately 1.75 ms meaning a pulse of less then 1.75 ms will not pass through. In debounce mode, the maximum repetitive frequency of the Totalizer signal is approximately 500 Hz. In non-debounce mode, the maximum repetitive frequency of the Totalizer is approximately 5 kHz.

If the pulse duration of the Totalizer is greater then 1.75ms, the Totalizer signal is passed to the output of the PLD (U3 Pin 23). If the duration of the Totalizer signal is less than 1.75ms, it is removed (debounced). Selection of either “debounced” or “non-debounced” input is controlled by the DEBOUNCE_EN control signal (U3 Pin 9). Debounce is selected when DEBOUNCE_EN is high. From the PLD, the signal (TOTAL) is routed to a 16 bit counter in the micro controller (CIN U4 P2). The Totalizer counter is a 32 bit counter using a combination of the internal counter and a 16-bit storage register internal to the micro controller.

Totalizer Enable

Operation of the Totalizer is controlled by the TOT_ENABLE signal. The Totalizer Enable signal is active high. Applying a logic low to TOT_ENABLE will disable counting by the Totalizer. TP_ENABLE* is the control signal to the micro controller (U4 Pin 8); Totalizer counting is enabled when this signal is held low.

Digital Output PCA Troubleshooting

The Digital Output Connector PCA has no active components. It consists of the A62 PCB and screw type terminal blocks. Melted traces from excessive current or contamination from foreign matter getting between traces are about the only problems that this module can have. Both problems can be troubleshot with a DMM.

A3 A/D Converter Module Troubleshooting

To access this card for test, the user may need the 2680A-7001K Extender kit, p.n. 1619174. The following paragraphs provide troubleshooting hints for the A3 A/D Converter PCA. Use this material in conjunction with Chapter 2, “Theory of Operation.”

⚠⚠Warning

To avoid electric shock, disconnect all channel inputs from the device before performing any troubleshooting operations.

A3 Kernel

If the microprocessor detects a fault, it drives the HALT* signal low and in essence halts itself. Monitor the HALT* line and if it is not steady and toggles between low and high, then there is most certainly a problem with the A3 kernel. In this instance, check the pull-up resistors for the data and addressing lines, and then signal conditions at the kernel devices. Incorrect jumper settings (Table 6-12) can also cause kernel problems.

Table 6-12. A3 A/D Converter PCA Jumper Positions

Jumper	If Missing	If in Place
W5	VBOOT enable at A3Q1 (this jumper is in place when loading new A/D firmware. If you forgot to remove the jumper, you would receive this error)	VBOOT disable at A3Q1 prevents A3U6 from initializing (error 7 is reported at the front panel, or error 64 over the RS-232 interface)
W6	Flash disabled (error 7 is reported at the front panel, or error 64 over the RS-232 interface)	Flash enable
W8	A/D HI disable, between the dc buffer amplifier and a/d converter (A/D converter failure)	A/D HI enable, between the dc buffer amplifier and a/d converter (A/D converter operate)
Normal jumper position is shown in bold.		

Break/Reset Circuit

Check the break/reset circuit formed by A3U1 and A3U3, and related components. The result line at A3U1-7, IG RESET* (Inguard Reset). At power up, IG RESET* should stay low for about 250 ms and then go high for normal operation. If IG RESET* fails to go high, then troubleshoot the reset circuit. When IG RESET* goes high, the signal HALT* at A3U1-1 should also go high. HALT* is an I/O pin on the A3U5 microprocessor.

Out of Tolerance Readings

Out-of-tolerance readings may occur although self-test passed. This could be an out of calibration problem due to too long a cycle between device calibrations, or due to a failure. Clues come from the range and function where the problem occurs. If the problem is all functions and all ranges, this points to A/D converter problems, in particular the precision voltages used for measurements. To locate problem, complete the Performance Test in Chapter 4 and note which parameters are out of tolerance. If all parameters are out of tolerance, this points towards a failure in the A/D converter circuitry, in particular, dc power supply voltages that are incorrect. If only certain functions or ranges are out of tolerance, then the problem may be in the treeing and channel select relays, or signal conditioning circuitry, or A3U30 Stallion device and related circuit elements. When you have identified the functions and ranges that are not correct, note the signal paths on the schematic and look for a common element.

For dc volt problems that affect all channels, look for faults in the dc buffer and Stallion device. For dc volt problems on individual channels or groups of channels, check the channel select (PAI only) and treeing relays.

For resistance problems, check the dc volts characteristics first. If there are no problems, then the difficulty is not in the dc buffer circuitry. This would suggest a problem in the ohms conditioning circuit or the A3U30 Stallion device.

For ac volt problems, check the V dc characteristics first. If there are no problems, then the difficulty is probably in the ac-to-dc conversion circuitry.

Troubleshooting Relay Problems

Both the PAI and FAI use mechanical reed relays for signal switching, although the FAI uses solid-state relays for channel selection. The mechanical relays have a life of 100,000,000 operations. If you use your device in long-duration, high-speed measurement runs at high voltages and high common mode voltages, then the relays may start to act up after a few years. This includes failure to open, failure to close, excessive contact resistance, and so forth. If your device is not subject to these extremes, then relay failures become less likely. An example of a relay failure occurs when the reading on one channel affects the readings on another channel (beyond the normal effects of cross-talk for ac measurements). This is especially true for dc volts, resistance, or thermocouple measurements. If a group of channels is causing problems, particular for channels 1 to 10, and 11 to 20, then it may be a bus problem (bank1 and bank2). If the banks are interacting, the treeing relays A3K21 to A3K24 may be at fault. You may find it easier to measure relay conditions by removing the A3 A/D Converter PCA and measuring at the bottom of the PCA. However, removing the PCA could unstick a stuck relay and complicate relay troubleshooting. Also, for relay troubleshooting, applying +1 V dc to the even channels and –1 V dc to the odd channels can assist you in signal tracing. Crossed relays, for example, might cause a 0 V reading where you expected +1 V.

A4 Analog Input PCA Troubleshooting

The A4 Analog Input PCA is essentially a passive assembly of terminal blocks, with the exception of a small active network formed around A4Q1 that provides a temperature reference for thermocouple measurements. If thermocouple measurements are out of tolerance, A4Q1 may be suspect.

To verify the operation of A4Q1, connect multimeter test leads across A4R2 (marked and clearly visible in the open module) and power the device. At normal room temperatures, the voltage across A4R2 is a nominal 1 V dc. If the measured voltage is 0 V, A4Q1 is probably open and should be replaced. For this test, you may find it easier if you remove the cover portion of the Universal Input Module by gently lifting one of the tabs the form the cover hinge and removing the cover.

⚠⚠Warning

To avoid electric shock, disconnect all channel inputs from the device before performing any troubleshooting operations.

The A4Q1 circuit is calibrated at the factory by adjusting the potentiometer A4R3. Do not disturb this adjustment unless you have replaced A4Q1. If you have replaced A4Q1, allow the device to stabilize in an ambient temperature of exactly 22*C and then adjust A4R3 for a reading of 1.00 V dc across A4R2.

Troubleshooting Calibration Failures

The paragraphs in this section describe troubleshooting actions when there is a calibration failure. Calibration of the device through the computer interface is described in Chapter 5 of this manual. Generally, a calibration failure is indicated by a Device Dependent Error and a "!>" prompt after a CAL_STEP? command. These indications occur if the analog input varies from what the device expects to see by more than +/-5% or +/-15%, depending on the calibration step.

Before suspecting a fault with the device, verify that the calibration is being conducted properly.

- Check the connections between the source and the device. Are all the connections in place?

- Check the output of the calibration source. Does it equal the value called for by this calibration step?
- Check the calibration source. Is it in operate mode? Has it reverted to standby?

If a calibration step has failed, the device remains on that step so that the output from the calibration source may be corrected or the calibration reference value (CAL_REF) being used by the device may be changed if it was improperly entered. The calibration step may be repeated by sending the CAL_STEP? command to the device again.

Calibration of the device utilizes a simple "calibration by function" approach. If you suspect calibration errors, but the device does not exhibit the symptoms mentioned above, verify that you are observing the following calibration rules:

- Independent calibration of any function results in the storage of calibration constants for that function only.
- Once calibration is begun, all steps for that function must be completed before the calibration constants are stored. If all steps are not completed and the procedure is terminated, no constants for that function are stored; only calibration constants for previously completed functions are stored.

Retrieving Calibration Constants

If a calibration error is suspected, the stored constant can be retrieved and verified over the RS232 interface using the "CAL_CONST?" command. Acceptable A/D calibration constants for each function and range are listed in Table 6-13. The equations below specify how to calculate the V dc, V ac, and Resistance gain and offset calibration constants:

Gain = (highTarget - lowTarget) / (highMeas - lowMeas)

Offset = -((lowMeas * Gain) - lowTarget)

Where:

highTarget = high scale target value

lowTarget = low scale (or zero) target value

highMeas = high scale measured value

lowMeas = low scale (or zero) measured value

Table 6-13. A/D Module Calibration Constants

CAL Constant Number	Function	Function Range	Comment	Minimum Allowable Value	Maximum Allowable Value
0	V dc	90 mV	Gain	+0.95000E+0	+1.05000E+0
2	V dc	90 mV	Offset	-0.00090E+0	+0.00090E+0
4	V dc	300 mV	Gain	+0.95000E+0	+1.05000E+0
6	V dc	300 mV	Offset	-0.00300E+0	+0.00300E+0
8	V dc	3 V	Gain	+0.95000E+0	+1.05000E+0
10	V dc	3 V	Offset	-0.03000E+0	+0.03000E+0
12	V dc	30 V	Gain	+0.95000E+0	+1.05000E+0
14	V dc	30 V	Offset	-0.30000E+0	+0.30000E+0
16	V dc	50 V (FAI) 150/300 V (PAI)	Gain	+0.95000E+0	+1.05000E+0
18	V dc	50 V (FAI) 150/300 V (PAI)	Offset	-0.50000E+0 -3.00000E+0	+0.50000E+0 +3.00000E+0
20	V dc	750 mV	Gain	+0.95000E+0	+1.05000E+0
22	V dc	750 mV	Offset	-0.00750E+0	+0.00750E+0
24	V ac	300 mV	Gain	+0.90000E+0	+1.10000E+0
26	V ac	300 mV	Offset	-0.00300E+0	+0.00300E+0
28	V ac	3 V	Gain	+0.90000E+0	+1.10000E+0
30	V ac	3 V	Offset	-0.03000E+0	+0.03000E+0
32	V ac	30 V	Gain	+0.90000E+0	+1.10000E+0
34	V ac	30 V	Offset	-0.30000E+0	+0.30000E+0
36	V ac	N/A (FAI) 150/300 V (PAI)	Gain	+0.90000E+0	+1.10000E+0
38	V ac	N/A (FAI) 150/300 V (PAI)	Offset	-3.00000E+0	+3.00000E+0
40	Resistance	300 Ω	Gain	+0.95000E+0	+1.05000E+0
42	Resistance	300 Ω	Offset	-3.00000E+0	+3.00000E+0
44	Resistance	3 kΩ	Gain	+0.95000E+0	+1.05000E+0
46	Resistance	3 kΩ	Offset	-3.00000E+1	+3.00000E+1
48	Resistance	30 kΩ	Gain	+0.95000E+0	+1.05000E+0
50	Resistance	30 kΩ	Offset	-3.00000E+2	+3.00000E+2
52	Resistance	300 kΩ	Gain	+0.95000E+0	+1.05000E+0
54	Resistance	300 kΩ	Offset	-3.00000E+3	+3.00000E+3
56	Resistance	3 MΩ	Gain	+0.95000E+0	+1.05000E+0
58	Resistance	3 MΩ	Offset	-3.00000E+4	+3.00000E+4
60	Frequency	All	CFC*	+0.95000E+0	+1.05000E+0
*CFC = crystal frequency correction					

The frequency counter calibration constant is simply the Gain constant calculation where the lowTarget and lowMeas are both assumed to be zero.

FrequencyConstant = targetFreq / measFreq

To retrieve the calibration constants, set up the device in the manual calibration configuration described in “Manual Calibration Procedure“ in Chapter 5. Then retrieve the desired calibration constant with the CAL_CONST? xx,yy command, where xx denotes the module number and yy the calibration constant number shown in Table 6-13. Each constant reflects the correction applied to the uncompensated measurement result as an offset or as a gain multiplier. For example, CAL_CONST? 1,8 might return +998.939E-3 indicating the uncompensated value for the 3 V dc range is multiplied by 0.998939 to achieve specification.

FlukeDAQ Software

Device software consists of the following components: main firmware, main FPGA firmware, and graphical user interface. These programs can be updated as required. If you would like to know if the software for your device is the most current, check the Fluke web pages under support, software downloads, and then data acquisition. At the time of this printing, the versions of code are as follows: main embedded code - 01_00.vxWorks, FPGA code - fpga_rev71.rbf, GUI - FlukeDAQ2_02.exe (a self extracting Windows application).

Main Firmware This is a closed-case procedure and it is not necessary to open the device to load the Main Firmware. The Main Firmware is identical for both model devices.

Main FPGA Firmware This is a closed-case procedure and it is not necessary to open the device to load the FPGA Firmware. The FPGA Firmware is identical for both models of the device.

Graphical User Interface (GUI) This is a self extracting Windows application and is identical for both models.

Module Firmware For completeness, the embedded code in the modules are not a closed-case procedure. It is necessary to open the module to load the Firmware. The module Firmware is different for each module. At this time there are no plans to provide the module firmware online and upgrade is only possible through the Fluke Service Centers.

Firmware is stored in the device in electrically erasable and programmable memory devices. You may contact the factory directly: Fluke Data Acquisition Sales Support, (425) 446-5493 or FAX, (425) 446-5992.

To determine which versions of the Main and A/D firmware are on your device, see “Diagnostic Tool idS” earlier in this chapter.

Chapter 7
Replaceable Parts

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Introduction

This chapter contains lists of replaceable parts for the 268XA Data Acquisition/Data Logging System devices. Parts are listed by assembly. Each assembly is accompanied by an illustration showing the location of each part and a number which you can use to locate a part in the parts list. The parts lists provide the following information:

- Reference Numbers refer to the circle numbers on the illustrations.
- Reference Designators refer to information provided in Chapter 2, Theory of Operation.
- Fluke Part Number.
- Description.
- Any special notes.

♻ Ni-Cd *Note*

This device may contain a Nickel-Cadmium battery. Do not mix with the solid waste stream. Spent batteries should be disposed of by a qualified recycler or hazardous materials handler. Contact your Fluke service center for recycling information.

How to Obtain Parts

Electrical components may be ordered from the Fluke Corporations and its authorized representatives by using the part number designated in the replacement parts lists. To order parts directly from Fluke Corporation, call (toll-free) 1-800-526-4731. Outside the US, replacement parts can be ordered through your local service center. Parts price information is available from the Fluke Corporation or its representatives.

To ensure prompt delivery of the correct part, include the following information when you place an order.

- Fluke Part Number
- Description
- Quantity
- Device model and serial number

Service Centers

To contact Fluke, call one of the following telephone numbers:

USA: 1-888-99-FLUKE (1-888-993-5853)
Canada: 1-800-36-FLUKE (1-800-363-5853)
Europe: +31 402-675-200
Japan: +81-3-3434-0181
Singapore: +65-738-5655
Anywhere in the world: +1-425-446-5500

Or, visit Fluke's Web site at www.fluke.com.

Parts Lists

The following tables list the replaceable parts for the 268XA devices.

⚠Caution
PCAs may be subject to damage by static discharge.

Table 7-1. 2680A Final Assembly Parts List

Number	Part Number	Reference Designator	Description
2 ⚠	109322		FUSE,FUSE,.25X1.25,0.5A,250V,SLOW
3	424416	A65MP9	HOLDER,HLDR,FUSE,1/4 X 1-1/4,LOPROFILE,PNLMT
4	1598923		2680A-4004 PCA, SYSTEM POWER AND CONTROLLER
5	295105		SCREW,SCREW,CAP,SCKT,SS,8-32,.375
6	109998	A65W1	5500A-4417,WIRE, BINDING POST TO FASTON
7	1619985		2680A-8002, 2680A FRONT PANEL DECAL
8	1598783		2680A-4001,PCA, BACK PLANE
9	284174	A99MP1	LC1 LINE CORD,NORTH AM,10A,5-15/IEC,18/3,SVT,7.5 FT
10	102889	A65E3	5440A-8197-01,BINDING HEAD, PLATED
12	1629527	A64MP1-2	2680A-8004,EXTRUSION, SIDE
13	1592964	A64MP19	2680A-2001 CHASSIS BASE
13	1592973	A64MP17	2680A-2002 FRONT PANEL
13	1593023	A64MP15	2680a-2007 TOP COVER
13	1593089	A64MP16	2680A-2018 CAPACITOR RETAINER
13	1610329	A64MP14	2680a-2003 BOTTOM COVER
13	1610334	A64MP18	2680A-2004 REAR PANEL
13	1610341	A64MP13	2680A-2005 TRANSFORMER HOLD DOWN
13	1665293	A64MP20	2680A-2012 FAN BRACKET
13	1999161	A64MP21	2680A-2022 DISPLAY BRACKET
14	1629530	A64MP4-5	2680A-8005,INSERT, PLASTIC SIDE
15	1886377		LABEL, 268X ROYALTY, VX WORKS
16 ⚠	1883699		FUSE,4A,250V,SLOW,5MM X 20MM,BULK
17	1672604		2680A-BLANK,BLANK MODULE
18	1619332	A63S1	2680A-8001,KEYPAD
20	110619	A65E1	NUT,NUT,HEX,BR,1/4-28
22	1619972	A63MP7	2680A-8003,LENS
23	821439		BATTERY,PRIMARY,LITHIUM-MNO2,3.0V,0.560AH,CR2450,COIN,PC PINS,24X5MM,BULK
25	800649	A65MP10	SWITCH,ROCKER,DPST
27	1633194	A64MP6	CABLE ASSEMBLY,FLAT,20 COND,MICRO MODUL RECEPT,FERRITE,12 IN,PROTECTED BULK
28	1610650	A64T1	TRANSFORMER,POWER,230V,50/60HZ,8.43:1,130W,CHASSIS MOUNT,BULK

⚠ To ensure safety, use exact replacement only.

Table 7-1. 2680A Final Assembly Parts List (cont)

Number	Part Number	Reference Designator	Description
29	1560703	A63MP2	FLUKE 45-4021-01, ,ASSEMBLY DISPLAY
30	1593113	A63MP3-4 A65MP4-5	2680A-2021,HANDLE PLASTIC 8.75 IN.
31	868786	A64MP9-12	5700A-2043-01,BOTTOM FOOT, MOLDED, GRAY #7
32	1593092	A63MP6	2680A-2019,FRONT BEZEL
34	102707	A65E2	5440A-8198-0,BINDING POST, STUD, PLATED
35	1629384	A65MP7	POWER ENTRY MODULE,LINE FILTER,A/C INLET,PANEL SNAP-IN,1A,250VAC
36	1610899	A64W2	2680A-4401,POWER INPUT CABLE
38	761213		5700A-2501,FAN & CONNECTOR ASSY
39	854351	A64MP24	GROMMET,GROMMET,EXTRUDED,POLYETHYLENE,.085
40	159756		SCREW,6-32,1.250,PAN,PHILLIPS,STEEL,ZINC-CLEAR,LOCK
41	152140		SCREW,6-32,.250,PAN,PHILLIPS,STEEL,ZINC-CLEAR,LOCK
43	114116		SCREW,SCREW,FH,P,LOCK,STL,8-32,.375
44	494641		SCREW,SCREW,WH,P,THD FORM,STL,5-20,.312
46	320093		SCREW,SCREW,FHU,P,LOCK,MAG SS,6-32,.250
51	1595629		CAPACITOR,ELECTROLYTIC,ALUMINUM,22000UF,+-20%,50V,35X50 CASE WITH 4 LEADS,BULK
52	1606839		CAPACITOR,ELECTROLYTIC,ALUMINUM,470UF,+-20%,63V,LOW IMPEDANCE,12.5X30RADIAL,BULKPurchased Item
53	1631800		CONNECTOR,TERMINAL BLOCK,5MMCTR,SOCKET PLUG,8 POS,BULK
54	1623031		2680A-APSW,FLUKEDAQ - 2680 SOFTWARE - EXTRA COPY
55	1667862		2680A-8010,PC-MCIA DECAL
56	1643733		2680A-4404,LINE FILTER / FUSE JUMPER
62	769422		LC3 LINE CORD,CONT EURO,10A,CEE-7/IEC,1MM/3,2.5M
63	1777348		CONNECTOR ACCESSORY,D-SUB JACK SCREW,4-40,.250 L,W/FLAT WASHER
65	172080		CABLE ACCESSORY,CABLE ACCESS,TIE,4.00L,.10W,.75 DIA
66	1777885		CABLE ASSEMBLY,8 COND,8 POS MOD PLUG EACH END,CAT5E CROSSOVER,RED,2M,BULK
67	871512		2620A-4406,T/C CABLE,ASSY
68	1631254		MANUAL,2680A/2686A GETTING STARTED

Table 7-2. 2686A Final Assembly Parts List

Number	Part Number	Reference Designator	Description
2 ⚠	109322		FUSE,FUSE,.25X1.25,0.5A,250V,SLOW
3	424416	A65MP9	HOLDER,HLDR,FUSE,1/4 X 1-1/4,LOPROFILE,PNLMT
4	1598923		2680A-4004 PCA, SYSTEM POWER AND CONTROLLER
5	295105		SCREW,SCREW,CAP,SCKT,SS,8-32,.375
6	109998	A65W1	5500A-4417,WIRE, BINDING POST TO FASTON
7	1667870		2686A-8001,2686A FRONT PANEL DECAL
8	1598783		2680A-4001,PCA, BACK PLANE
9	284174	A99MP1	LC1 LINE CORD,NORTH AM,10A,5-15/IEC,18/3,SVT,7.5 FT
10	102889	A65E3	5440A-8197-01,BINDING HEAD, PLATED
12	1629527	A64MP1-2	2680A-8004,EXTRUSION, SIDE
13	1592964	A64MP19	2680A-2001 CHASSIS BASE
13	1592973	A64MP17	2680A-2002 FRONT PANEL
13	1593023	A64MP15	2680a-2007 TOP COVER
13	1593089	A64MP16	2680A-2018 CAPACITOR RETAINER
13	1610329	A64MP14	2680a-2003 BOTTOM COVER
13	1610334	A64MP18	2680A-2004 REAR PANEL
13	1610341	A64MP13	2680A-2005 TRANSFORMER HOLD DOWN
13	1665293	A64MP20	2680A-2012 FAN BRACKET
13	1999161	A64MP21	2680A-2022 DISPLAY BRACKET
14	1629530	A64MP4-5	2680A-8005,INSERT, PLASTIC SIDE
15	1886377		LABEL, 268X ROYALTY, VX WORKS
16 ⚠	1883699		FUSE,4A,250V,SLOW,5MM X 20MM,BULK
17	1672604		2680A-BLANK,BLANK MODULE
18	1619332	A63S1	2680A-8001,KEYPAD
19	1259450		FACTORY BASE WARRANTY, 1 YEAR
20	110619	A65E1	NUT,NUT,HEX,BR,1/4-28
22	1619972	A63MP7	2680A-8003,LENS
23	821439		BATTERY,PRIMARY,LITHIUM-MNO2,3.0V,0.560AH,CR2450,COIN,PC PINS,24X5MM,BULK
25	800649	A65MP10	SWITCH,ROCKER,DPST
27	1633194	A64MP6	CABLE ASSEMBLY,FLAT,20 COND,MICRO MODUL RECEPT,FERRITE,12 IN,PROTECTED BULK

⚠ To ensure safety, use exact replacement only.

Table 7-2. 2686A Final Assembly Parts List (cont)

Number	Part Number	Reference Designator	Description
28	1610650	A64T1	TRANSFORMER,POWER,230V,50/60HZ,8.43:1,130W,CHASSIS MOUNT,BULK
29	1560703	A63MP2	FLUKE 45-4021-01, ,ASSEMBLY DISPLAY
30	1593113	A63MP3-4 A65MP4-5	2680A-2021,HANDLE PLASTIC 8.75 IN.
31	868786	A64MP9-12	5700A-2043-01,BOTTOM FOOT, MOLDED, GRAY #7
32	1593092	A63MP6	2680A-2019,FRONT BEZEL
34	102707	A65E2	5440A-8198-01,BINDING POST, STUD, PLATED
35	1629384	A65MP7	POWER ENTRY MODULE,LINE FILTER,A/C INLET,PANEL SNAP-IN,1A,250VAC
36	1610899	A64W2	2680A-4401,POWER INPUT CABLE
38	761213		5700A-2501,FAN & CONNECTOR ASSY
39	854351	A64MP24	GROMMET,GROMMET,EXTRUDED,POLYETHYLENE,.085
40	159756		SCREW,6-32,1.250,PAN,PHILLIPS,STEEL,ZINC-CLEAR,LOCK
41	152140		SCREW,6-32,.250,PAN,PHILLIPS,STEEL,ZINC-CLEAR,LOCK
42	152173		SCREW,6-32,.500,PAN,PHILLIPS,STEEL,ZINC-CLEAR,LOCK
43	114116		SCREW,SCREW,FH,P,LOCK,STL,8-32,.375
44	494641		SCREW,SCREW,WH,P,THD FORM,STL,5-20,.312
45	1886599		SPACER,ROUND,SOLID,.438 HEIGHT,.270 OD,NYLON,SNAP
46	320093		SCREW,SCREW,FHU,P,LOCK,MAG SS,6-32,.250
47	1572080		CONNECTOR,PC-CARD,HEADER,4.3MM HIGH BOTTOM MNT,RT ANG PLUG,RT BUTTON,68 PIN,TRAY Purchased Item
48	1593014		2680A-2006,PC-MCIA BRACKET
49	1598950		2680A-4041,PCA, PCMCIA INTERFACE
50	1778376		MEMORY CARD,FLASH,PC CARD,ATA TYPE II,16MB,CARD,BULK
51	1595629		CAPACITOR,ELECTROLYTIC,ALUMINUM,22000UF,+-20%,50V,35X50 CASE WITH 4 LEADS,BULK
52	1606839		CAPACITOR,ELECTROLYTIC,ALUMINUM,470UF,+-20%,63V,LOW IMPEDANCE,12.5X30RADIAL,BULKPurchased Item
53	1631800		CONNECTOR,TERMINAL BLOCK,5MMCTR,SOCKET PLUG,8 POS,BULK
54	1623031		2680A-APSW,FLUKEDAQ - 2680 SOFTWARE - EXTRA COPY
56	1643733		2680A-4404,LINE FILTER / FUSE JUMPER
57	1282991		SCREW,M2,12MM,PAN,TORXPLUS,STEEL, ZINC-CHROMATE

Table 7-2. 2686A Final Assembly Parts List (cont)

Number	Part Number	Reference Designator	Description
62	769422		LC3 LINE CORD,CONT EURO,10A,CEE-7/IEC,1MM/3,2.5M
63	1777348		CONNECTOR ACCESSORY,D-SUB JACK SCREW,4-40,.250 L,W/FLAT WASHER
65	172080		CABLE ACCESSORY,CABLE ACCESS,TIE,4.00L,.10W,.75 DIA
66	1777885		CABLE ASSEMBLY,8 COND,8 POS MOD PLUG EACH END,CAT5E CROSSOVER,RED,2M,BULK
67	871512		2620A-4406,T/C CABLE,ASSY
68	1631254		MANUAL,2680A/2686A GETTING STARTED

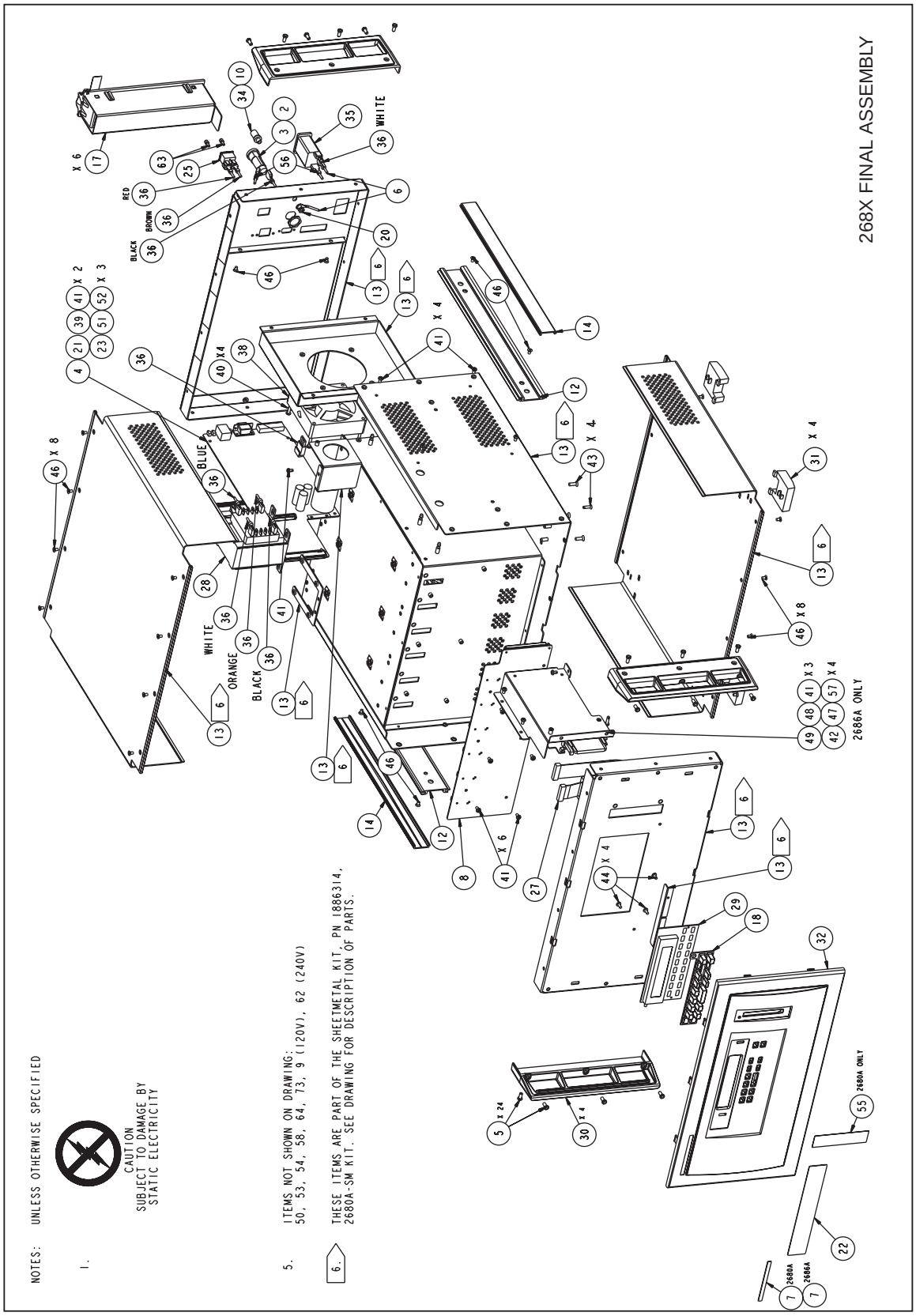

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Figure 7-1. 268XA Final Assembly

Table 7-3. Blank Module Parts List

Number	Part Number	Reference Designator	Description
2	1593050		2680A-2015, MODULE REAR PANEL
3	1669653		2680A-2013,BLANK MODULE BRACKET
4	1669889		2680A-8011,BLANK MODULE DECAL

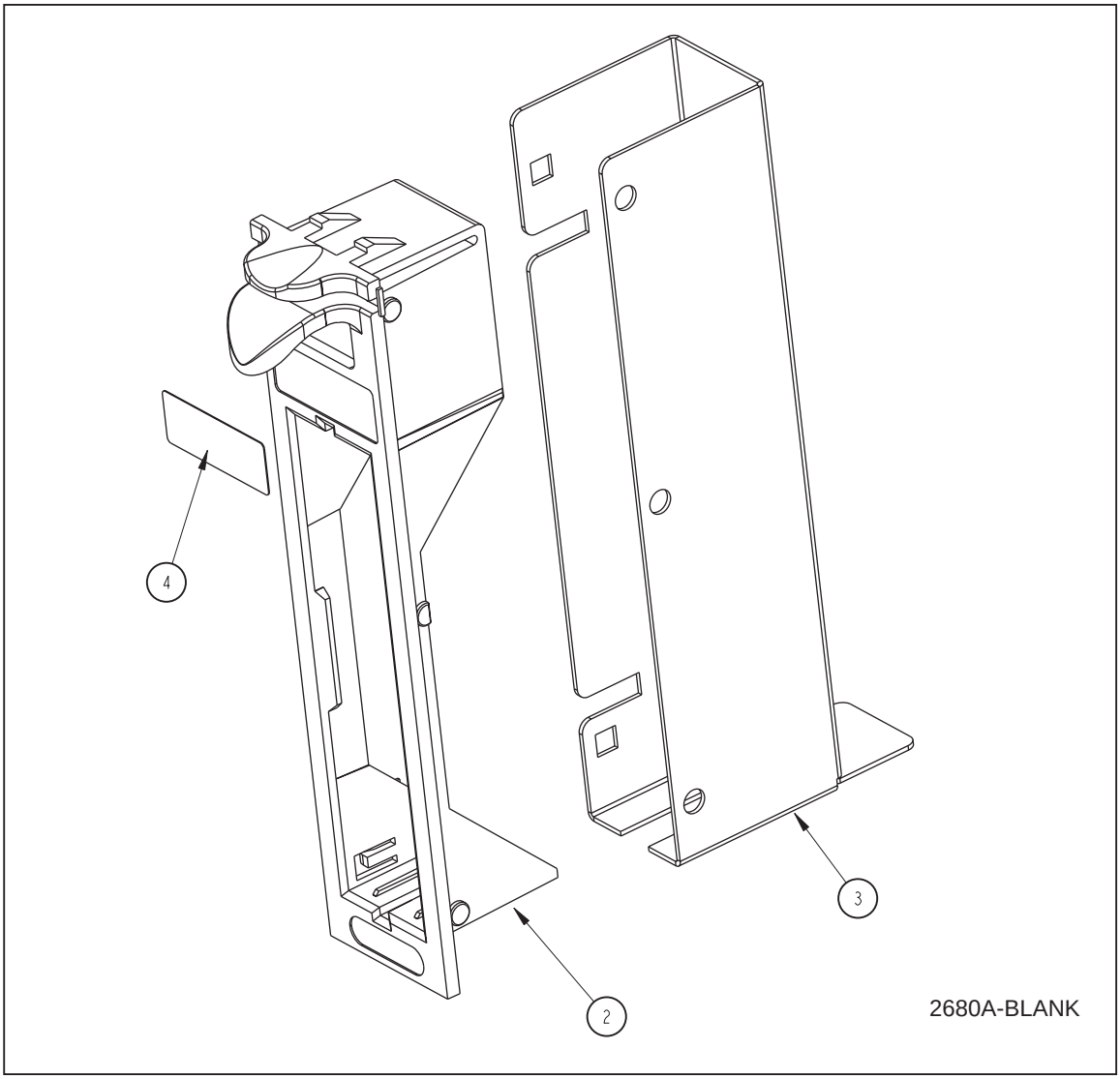

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Figure 7-2. Blank Module

Table 7-4. DIO Module Parts List

Number	Part Number	Reference Designator	Description
2	1598906		2680A-4006,PCA, DIGITAL IO AND RELAY
3	1593050		2680A-2015, MODULE REAR PANEL
4	152173		SCREW,6-32,.500,PAN,PHILLIPS,STEEL,ZINC-CLEAR,LOCK
5	1593045		2680A-2011, FAI/PAI MODULE COVER
6	376822		SCREW,SCREW,PH,P,LOCK,SS,6-32,.750
7	1610886		2680A-2008, DIO MODULE BASE
8	152140		SCREW,6-32,.250,PAN,PHILLIPS,STEEL,ZINC-CLEAR,LOCK
9	1593197		2680A-4031, PCA, A/D POWER SUPPLY
10	1599011		2680A-4062,PCA, OUTPUT
11	698027		Y9XXX-8002,BAG, LARGE ACCESSORY
12	874107		2620A-2007,ISOTHERMAL CASE,BOTTOM
13	874110		2620A-2008,ISOTHERMAL CASE,TOP
14	876479		SCREW,SCREW,KNURL,SL,CAPT,STL,6-32,.500
15	1592575		2680-3032,PCB, A/D TRANSFORMER
16	1599066		MAGNETIC MATERIAL,FERRITE,CORE,PLANAR E,UNGAPPED,14X3.5X5MM,BULK
17	460972		FUSE,FUSE,5X20MM,2A,250V,FAST
18	1667837		2680A-8007,DIO MODULE DECAL
19	1641934		2680A-8006, DIO CASE DECAL

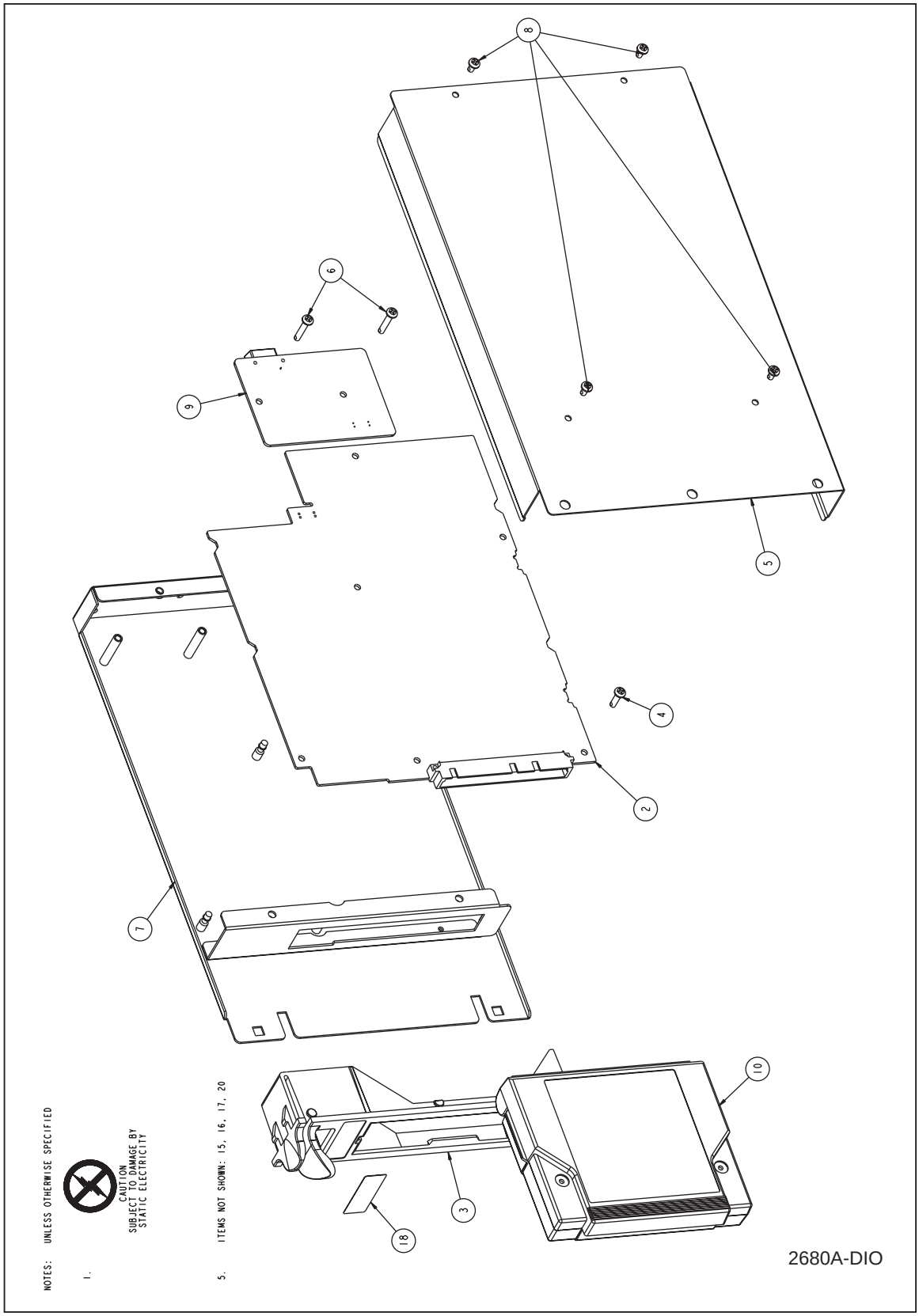

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Figure 7-3. DIO Module

Table 7-5. FAI Module Parts List

Number	Part Number	Reference Designator	Description
2	1593050		2680A-2015, MODULE REAR PANEL
4	152173		SCREW,6-32,.500,PAN,PHILLIPS,STEEL,ZINC-CLEAR,LOCK
5	1593045		2680A-2011, FAI/PAI MODULE COVER
6	376822		SCREW,SCREW,PH,P,LOCK,SS,6-32,.750
7	152140		SCREW,6-32,.250,PAN,PHILLIPS,STEEL,ZINC-CLEAR,LOCK
8	1593038		2680A-2010, FAI/PAI MODULE BASE
9	939723	A45MP203	2645A-4003M,A/D PWB ASSY (FFE)
10	757294	A45MP95-96	JUMPER,JUMPER,REC,2 POS,.100CTR,.025 SQ POST
11	1593197		2680A-4031, PCA, A/D POWER SUPPLY
12	949537		2620A-4004A,INPUT PWB ASSY,A4
13	698027		Y9XXX-8002,BAG, LARGE ACCESSORY
14	874107		2620A-2007,ISOTHERMAL CASE,BOTTOM
15	874110		2620A-2008,ISOTHERMAL CASE,TOP
16	1669892		2680A-8012,ISOTHERMAL CASE DECAL
17	876479		SCREW,SCREW,KNURL,SL,CAPT,STL,6-32,.500
18	1592575		2680-3032,PCB, A/D TRANSFORMER
19	1599066		MAGNETIC MATERIAL,FERRITE,CORE,PLANAR E,UNGAPPED,14X3.5X5MM,BULK
20	1667855		2680A-8009, FAI MODULE DECAL
23	802306		FTCL-8001-01,LABEL,CALIB, CERTIFICATION SEAL

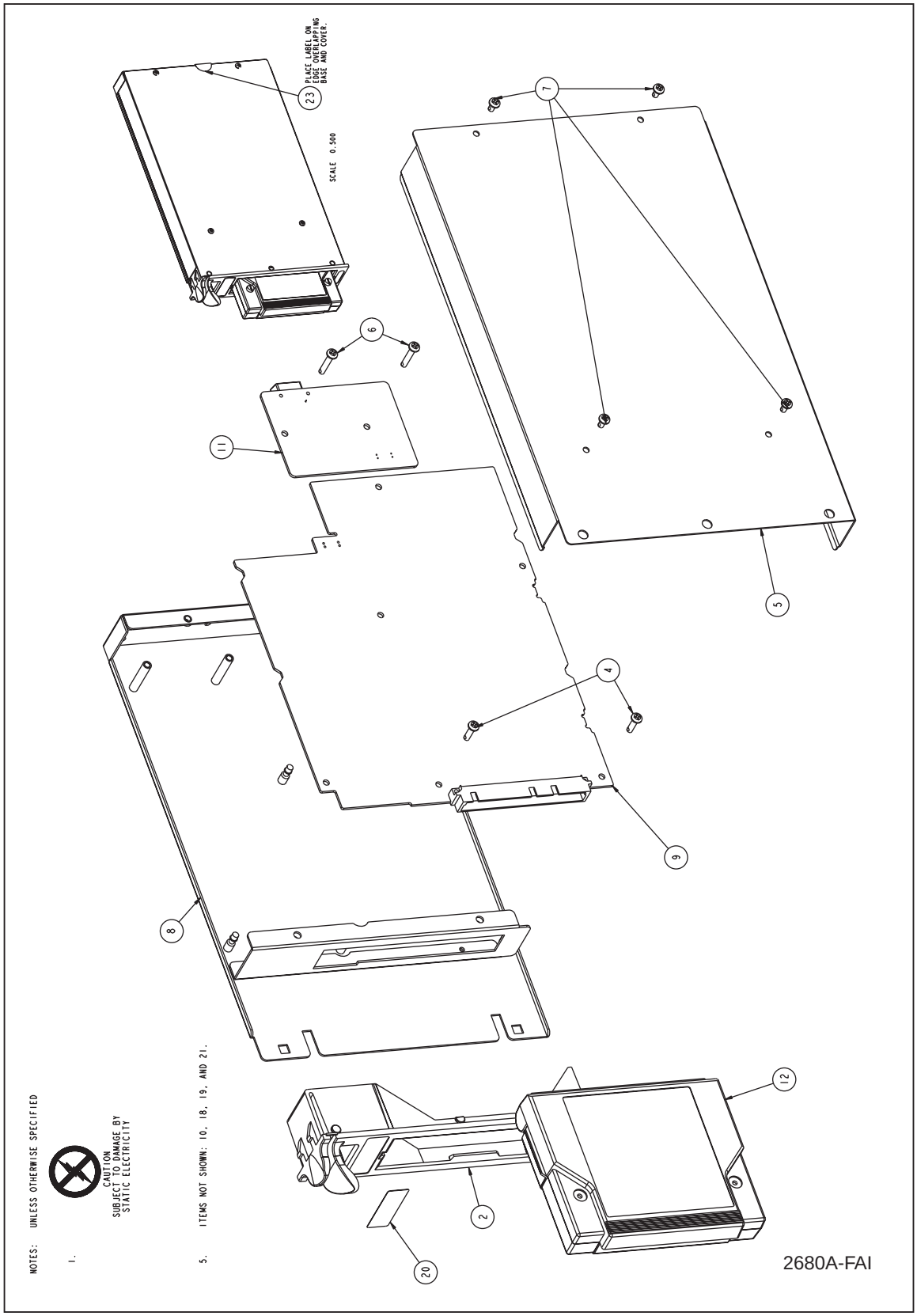

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Figure 7-4. FAI Module

Table 7-6. PAI Module Parts List

Number	Part Number	Reference Designator	Description
2	939728	A40MP203	2640A-4003M,A/D, PWB ASSY (PFE)
3	1593050		2680A-2015, MODULE REAR PANEL
5	152173		SCREW,6-32,.500,PAN,PHILLIPS,STEEL,ZINC-CLEAR,LOCK
6	1593045		2680A-2011, FAI/PAI MODULE COVER
7	376822		SCREW,SCREW,PH,P,LOCK,SS,6-32,.750
8	152140		SCREW,6-32,.250,PAN,PHILLIPS,STEEL,ZINC-CLEAR,LOCK
9	1593038		2680A-2010, FAI/PAI MODULE BASE
10	757294	A40MP95-96	JUMPER,JUMPER,REC,2 POS,.100CTR,.025 SQ POST
11	1593197		2680A-4031, PCA, A/D POWER SUPPLY
12	939744	A40MP260	2640A-2007,COVER, RELAYS
13	949537		2620A-4004A,INPUT PWB ASSY,A4
14	698027		Y9XXX-8002,BAG, LARGE ACCESSORY
15	874107		2620A-2007,ISOTHERMAL CASE,BOTTOM
16	874110		2620A-2008,ISOTHERMAL CASE,TOP
17	1669892		2680A-8012,ISOTHERMAL CASE DECAL
18	876479		SCREW,SCREW,KNURL,SL,CAPT,STL,6-32,.500
19	1592575		2680-3032,PCB, A/D TRANSFORMER
20	1599066		MAGNETIC MATERIAL,FERRITE,CORE,PLANAR E,UNGAPPED,14X3.5X5MM,BULK
21	1667843		2680A-8008, PAI MODULE DECAL
23	802306		FTCL-8001-01,LABEL,CALIB, CERTIFICATION SEAL

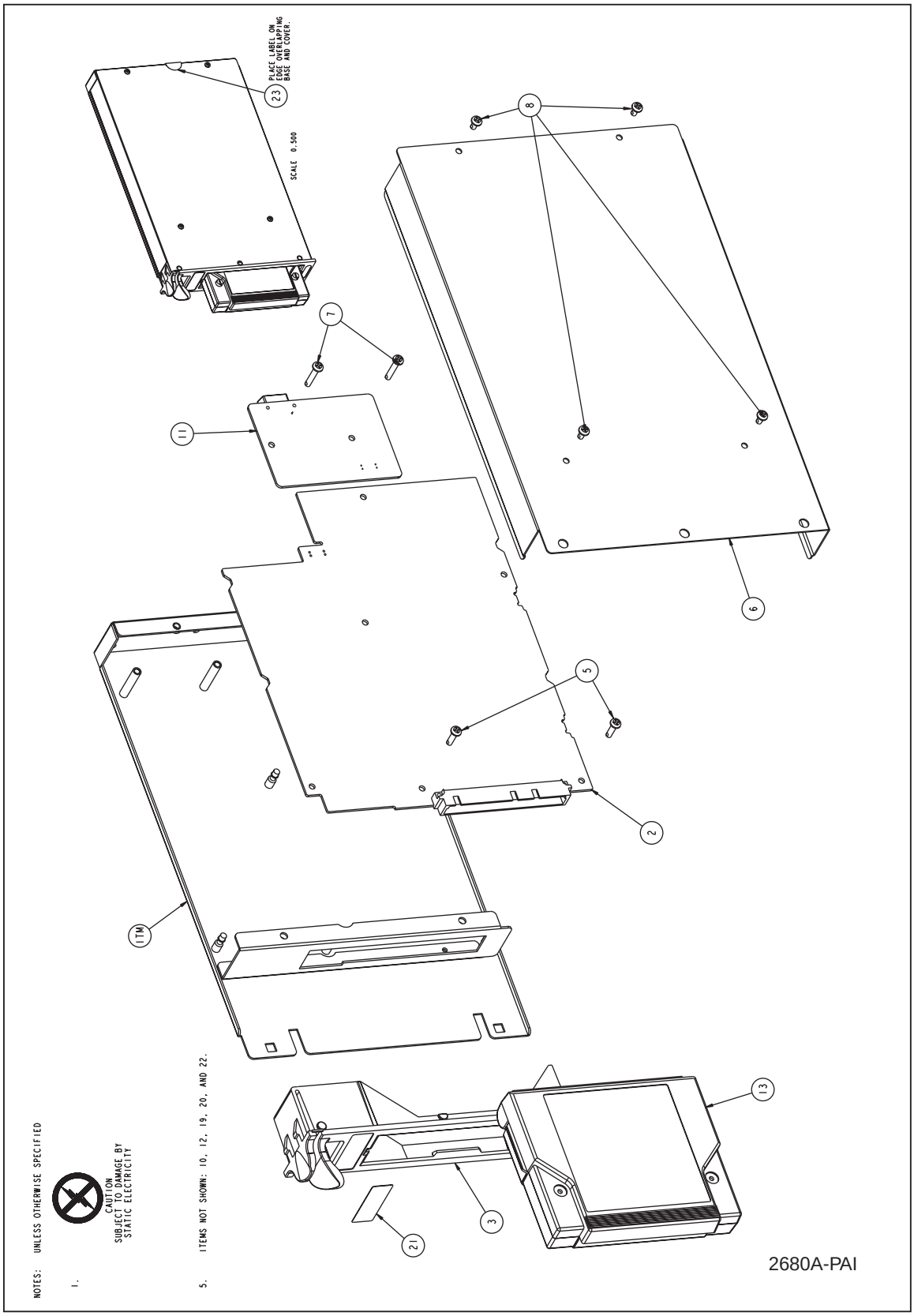

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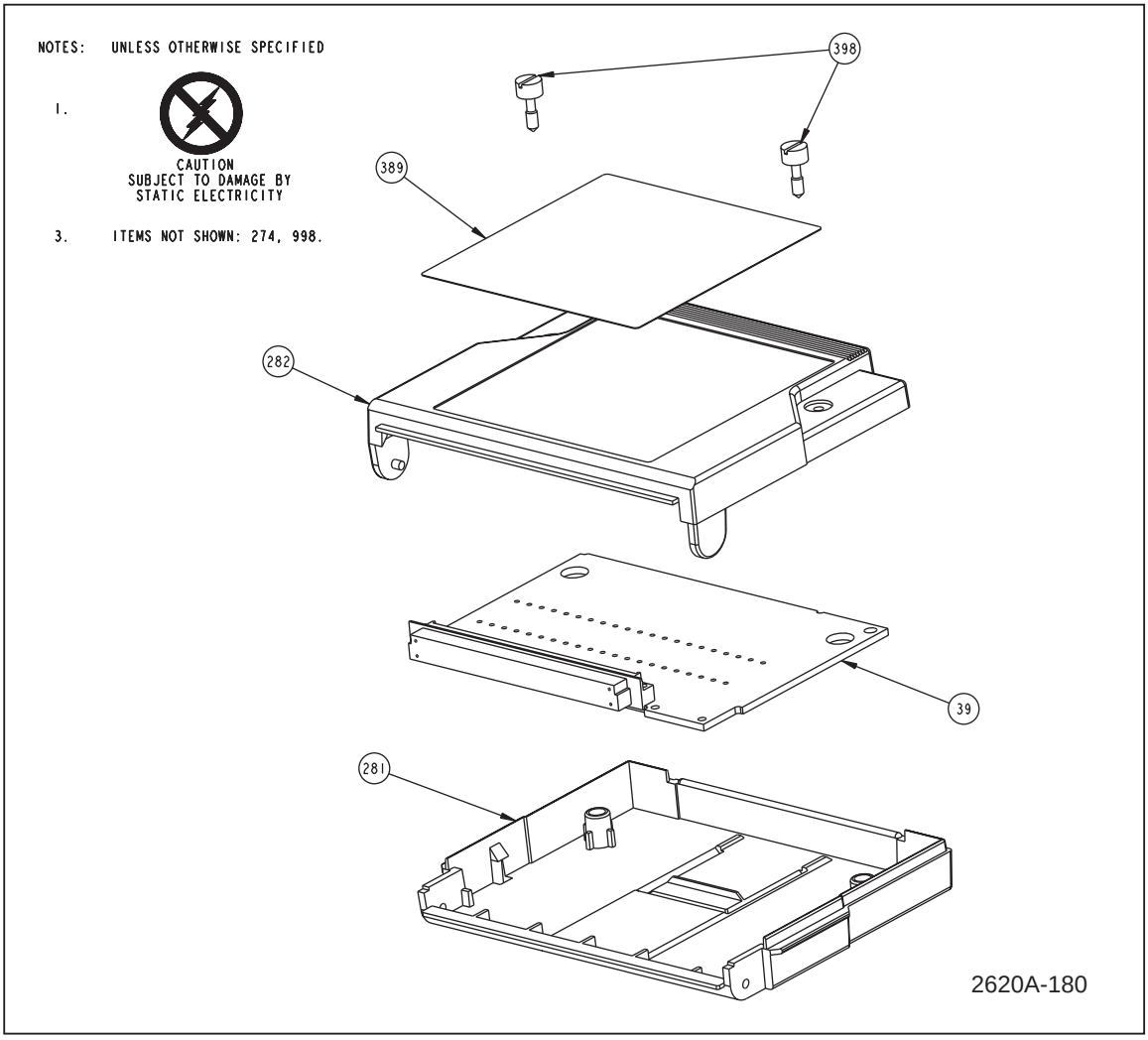
Figure 7-5. PAI Module

Table 7-7. Isothermal Input Parts List

Number	Part Number	Reference Designator	Description
39	949537	A04MP204	2620A-4004A,INPUT PWB ASSY,A4
274	698027	A14MP90	Y9XXX-8002,BAG, LARGE ACCESSORY
281	874107	A14MP2	2620A-2007,ISOTHERMAL CASE,BOTTOM
282	874110	A14MP3	2620A-2008,ISOTHERMAL CASE,TOP
389	1669892		2680A-8012,ISOTHERMAL CASE DECAL
398	876479	A14H65	SCREW,SCREW,KNURL,SL,CAPT,STL,6-32,.500
998	1259450		FACTORY BASE WARRANTY, 1 YEAR



alg104f.eps

Figure 7-6. Isothermal Input

Chapter 8
Schematics

Figure	Title	Page
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8-2.	Controller/System Power PCA	8-5
8-3.	Digital I/O PCA	8-11
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8-11.	Analog Input Connector PCA	8-39
8-12.	Display PCA	8-41

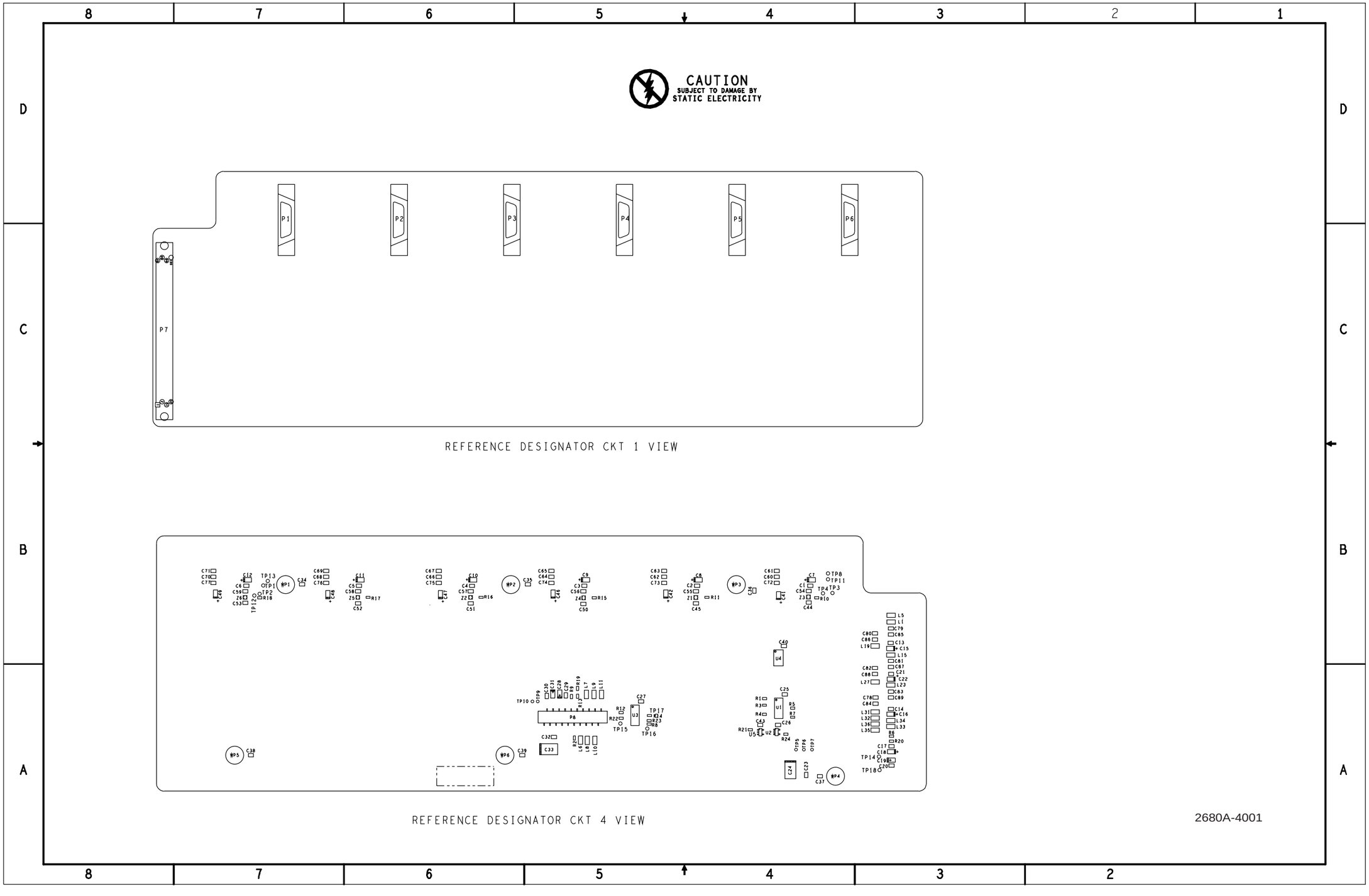

Figure 8-1. Backplane PCA

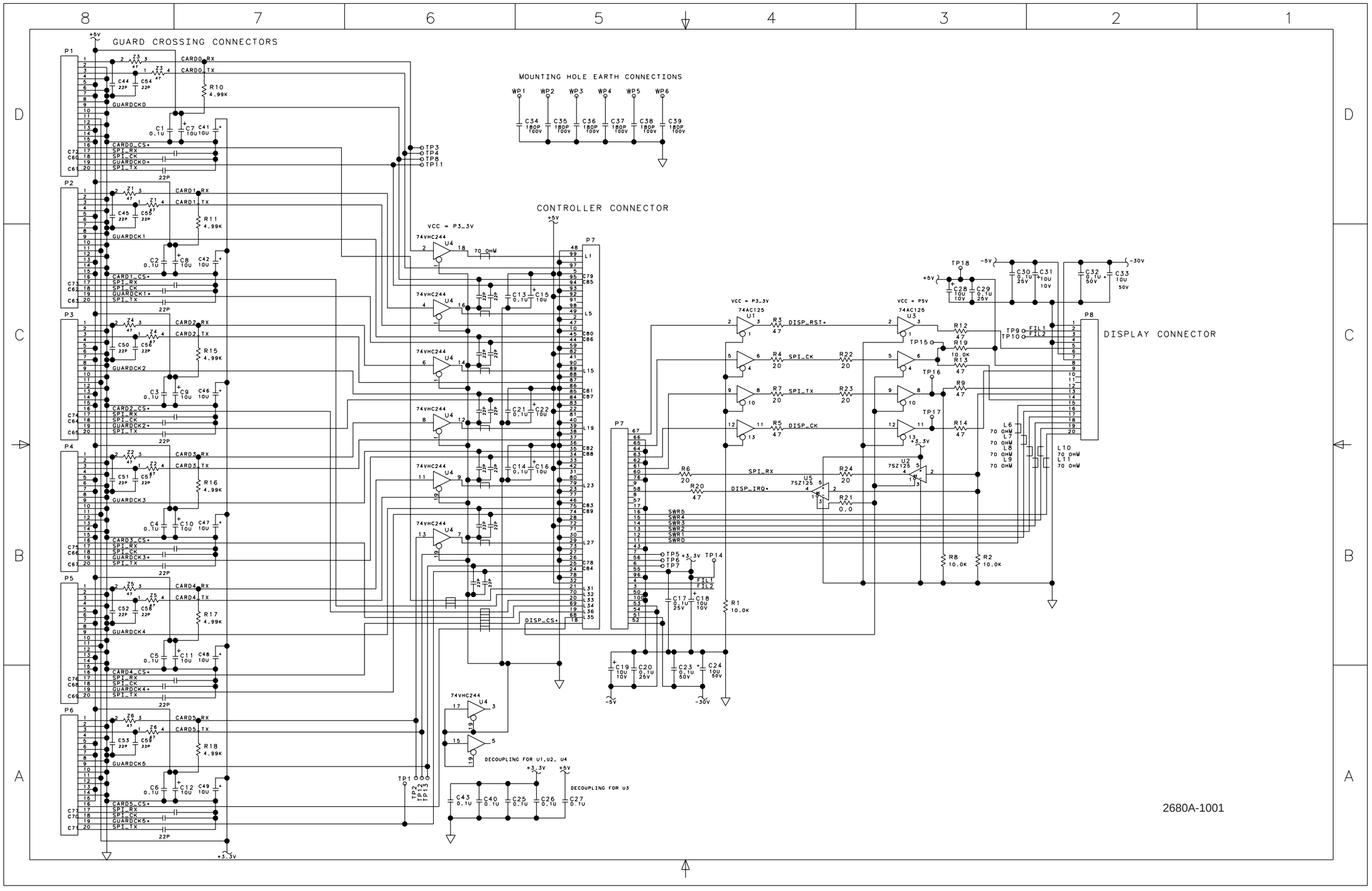

Figure 8-1. Backplane PCA (cont)

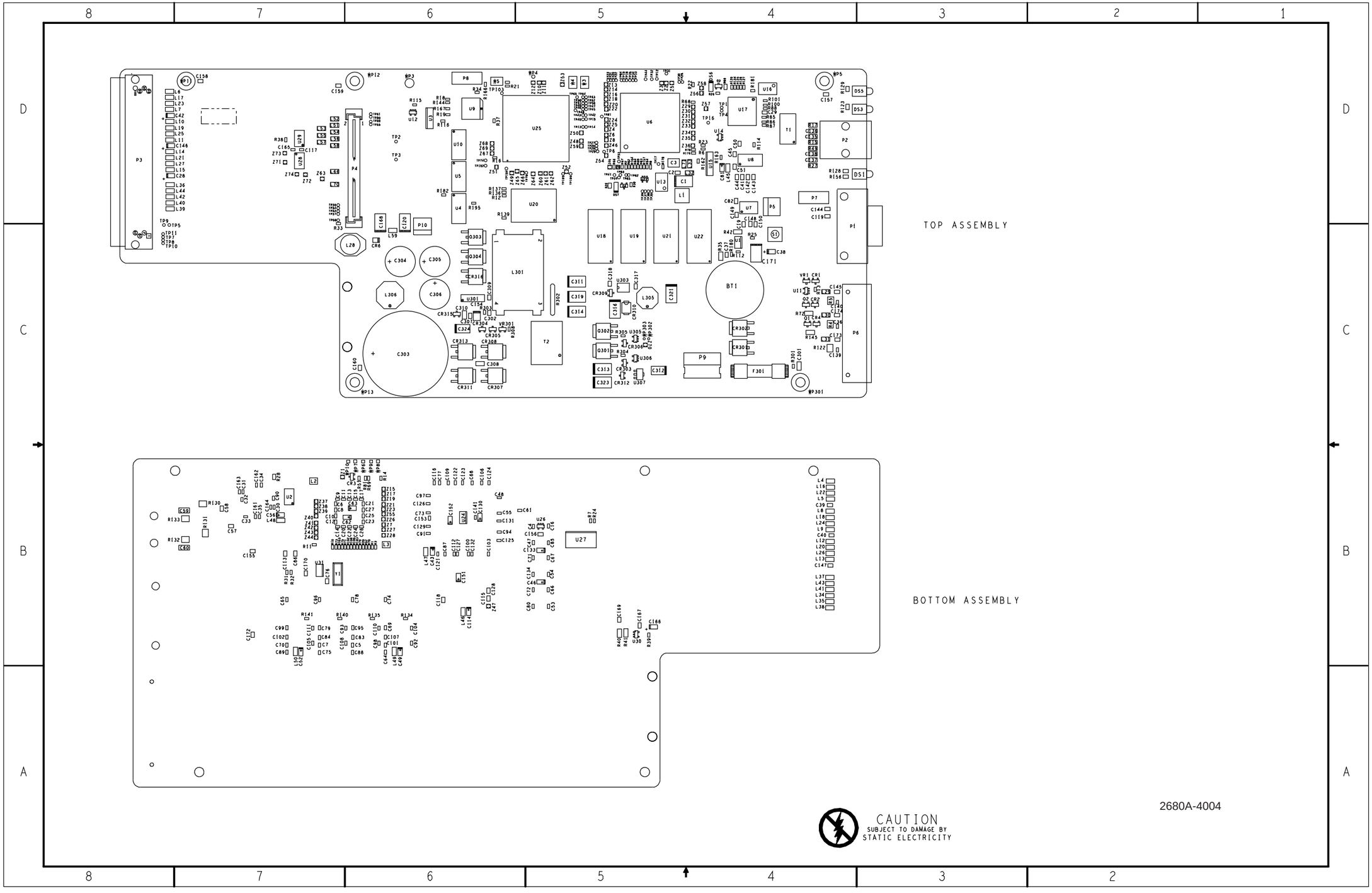

Figure 8-2. Controller/System Power PCA

REF DES	PARTNAME	GND	VCC	VCC_U6
U2,U28,U29	244_VHC	10	20	
U4,U5,U10	16245_LCX	4,10,15 21,28,34 39,45	7,18,31 42	
U6	MPC855_ALT	F6,F7,F8 F9,F10 F11,F12 F13,F14 G6,G7,G8 G9,G10 G11,G12 G13,G14 H6,H7,H8 H9,H10 H11,H12 H13,H14 J6,J7,J8 J9,J10 J11,J12 J13,J14 K6,K7,K8 K9,K10 K11,K12 K13,K14 L6,L7,L8 L9,L10 L11,L12 L13,L14 M6,M7,M8 M9,M10 M11,M12 M13,M14 N6,N7,N8 N9,N10 N11,N12 N13,N14 P6,P7,P8 P9,P10 P11,P12 P13,P14		A8,H19,M1 W8,E5,E6 E7,E8,E9 E10,E11 E12,E13 E14,E15 F4,F5,F15 F16,G5 G15,H5 H15,J5 J15,K5 K15,L5 L15,M5 M15,N5 N15,P4,P5 P15,P16 R5,R6,R7 R8,R9,R10 R11,R12 R13,R14 R15,T14
U27	240_AC	10	20	

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Figure 8-2. Controller/System Power PCA (cont)

BACKPLANE CONNECTOR

PERIPHERIALS

10/100 BASE-T ETHERNET TRANSCEIVER

SPI DRIVERS AND CONNECTOR FOR THE VACUUM FLOURESCENT DISPLAY AND CALIBRATION EEPROMS

RS232 TRANSCEIVER

BUFFERS AND PROTECTION FOR EXTERNAL TRIGGER IN AND OUT AND MASTER ALARM OUTPUT

2680A-1004
(2 of 5)

Figure 8-2. Controller/System Power PCA (cont)

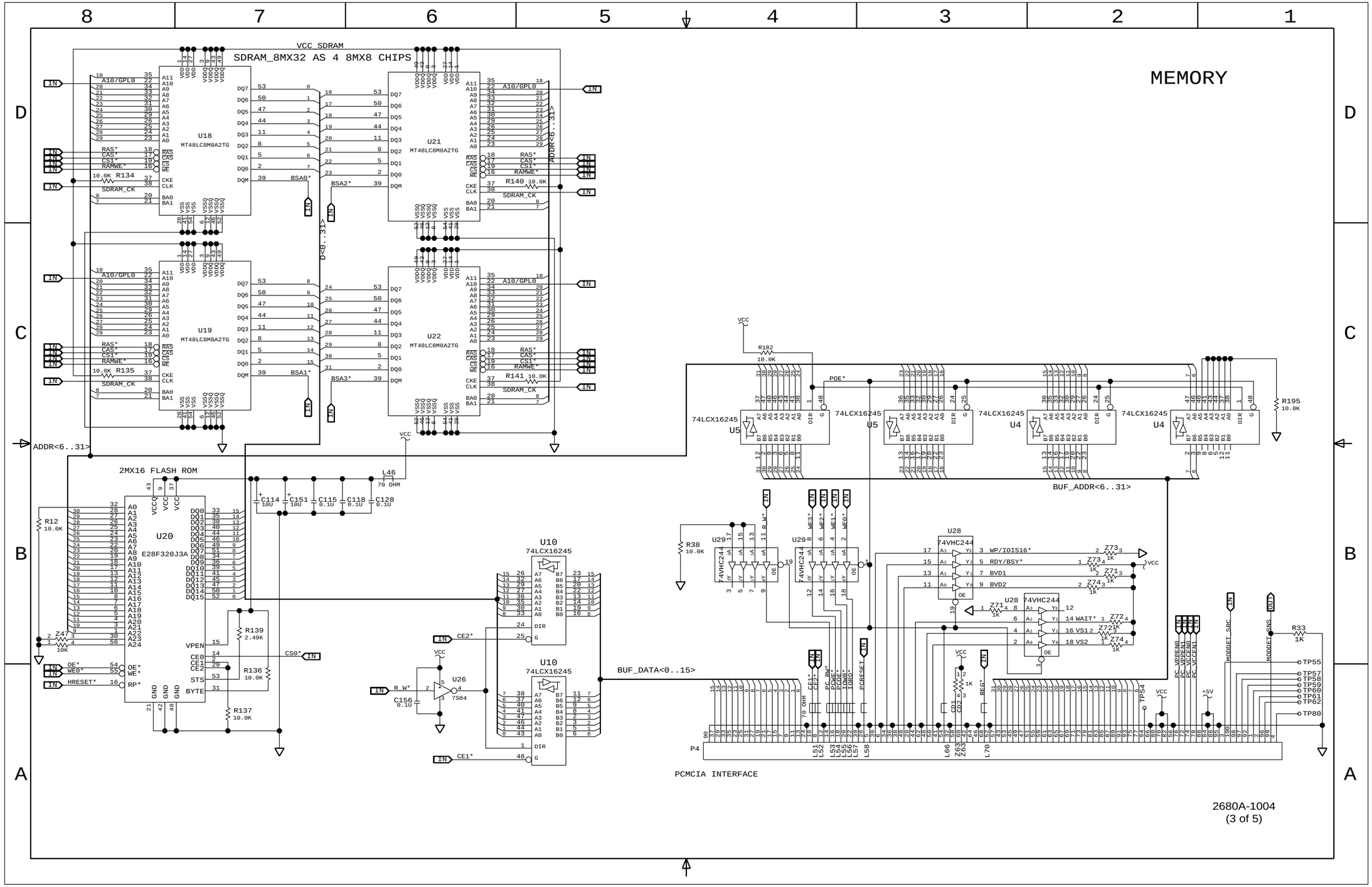


Figure 8-2. Controller/System Power PCA (cont)

FPGA AND SUPPORT

2680A-1004
(4 of 5)

Figure 8-2. Controller/System Power PCA (cont)

POWER SUPPLIES AND DECOUPLING

DC INPUT FROM REAR PANEL (9-42V)

AC INPUT FROM XFMR SECONDARY

DECOUPLING FOR U17

DECOUPLING FOR SDRAM U18.19,21,22

LOCAL SUPPLY FOR U6, 1 CAP PER 2 POWER PINS

DECOUPLING FOR U2 - U5, U10 - U12, 1 CAP PER POWER PIN

5V TO 24V, 100MA FAN SUPPLY

DISPLAY FILAMENT 5.3VAC

FAN CONNECTOR

2680A-1004
(5 of 5)

Figure 8-2. Controller/System Power PCA (cont)

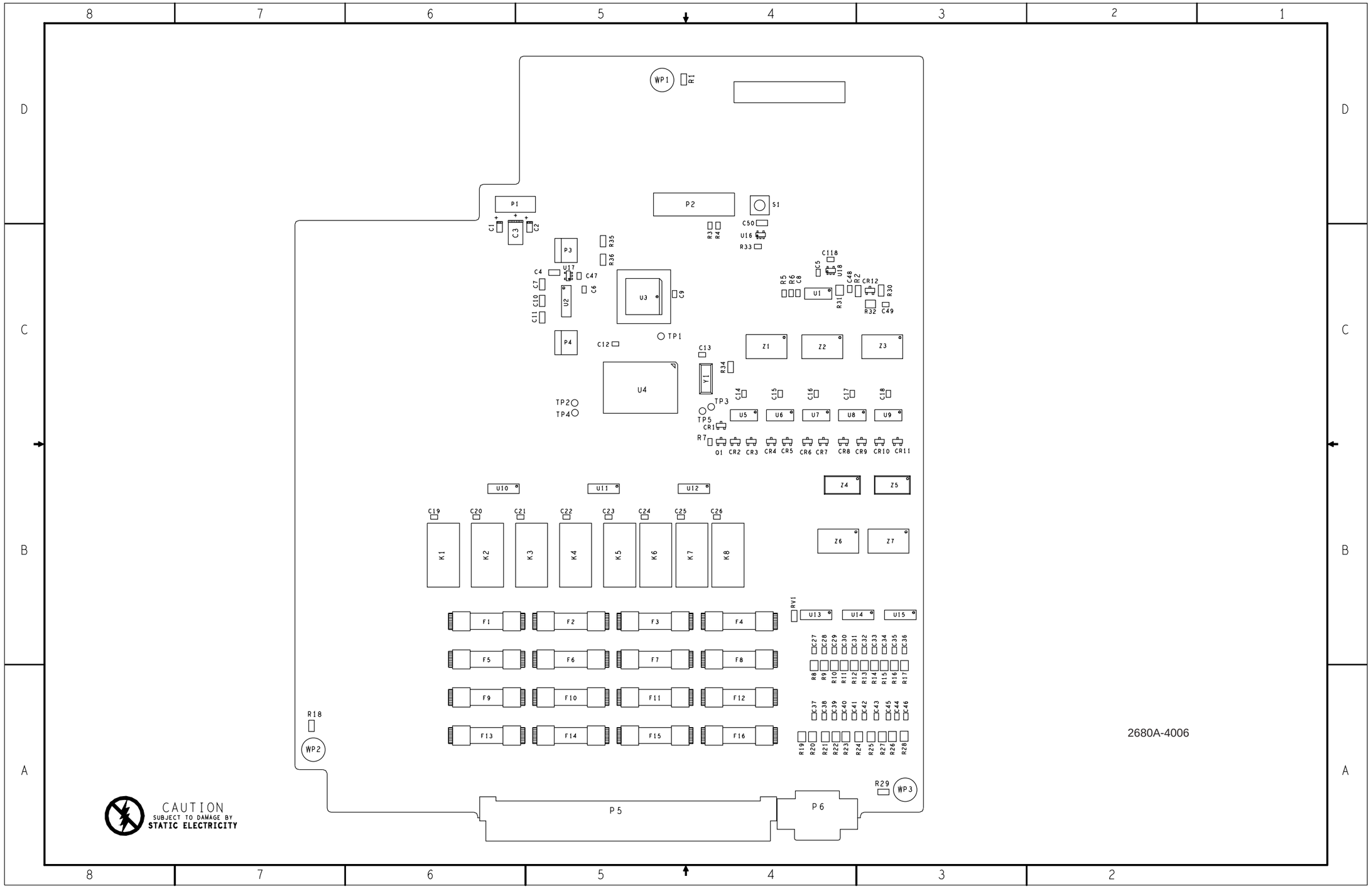
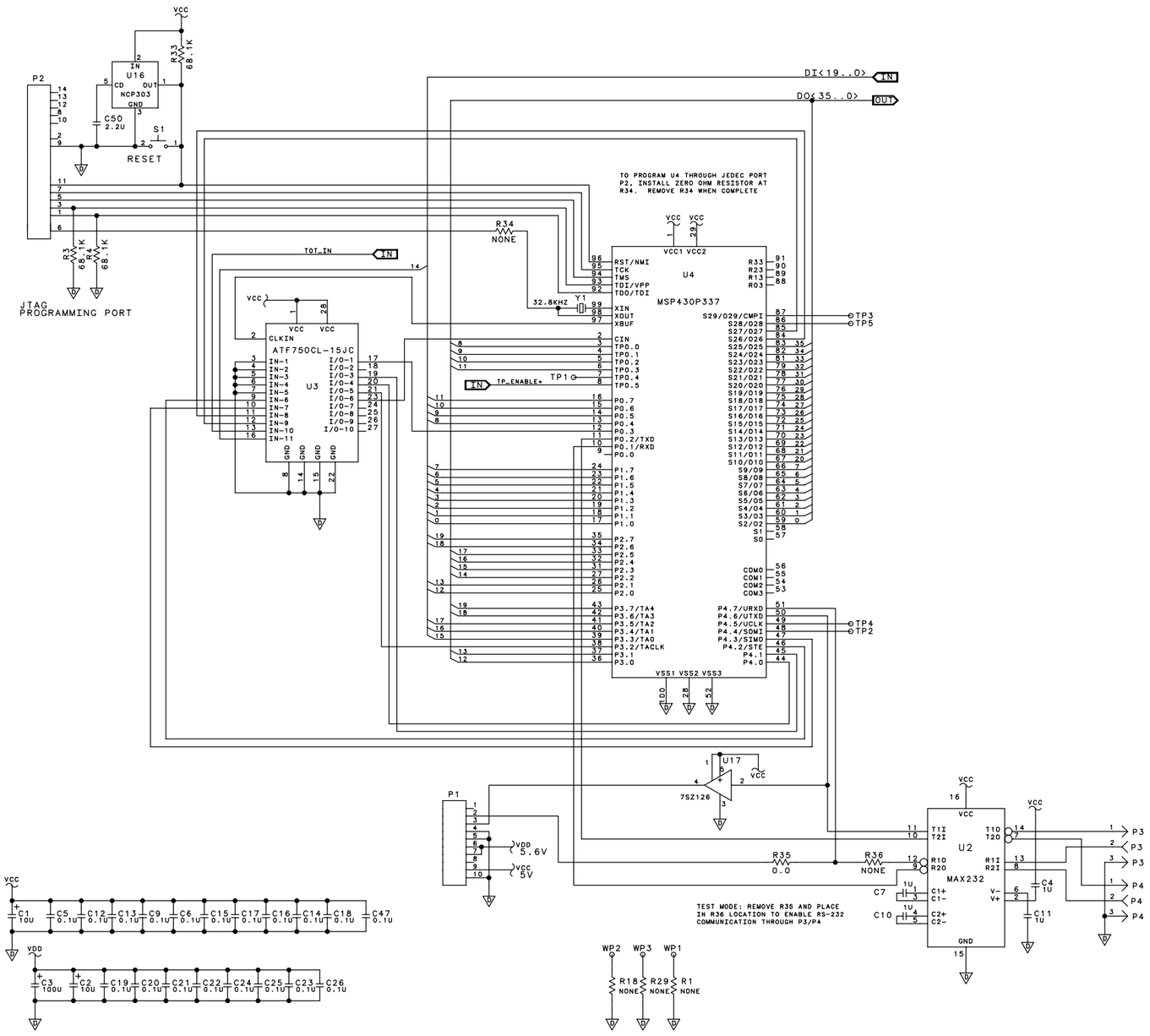


Figure 8-3. Digital I/O PCA

NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RESISTANCE IS IN OHMS.
2. ALL CAPACITANCE IS IN MICRO-FARADS.



2680A-1006
(1 of 3)

Figure 8-3. Digital I/O PCA (cont)

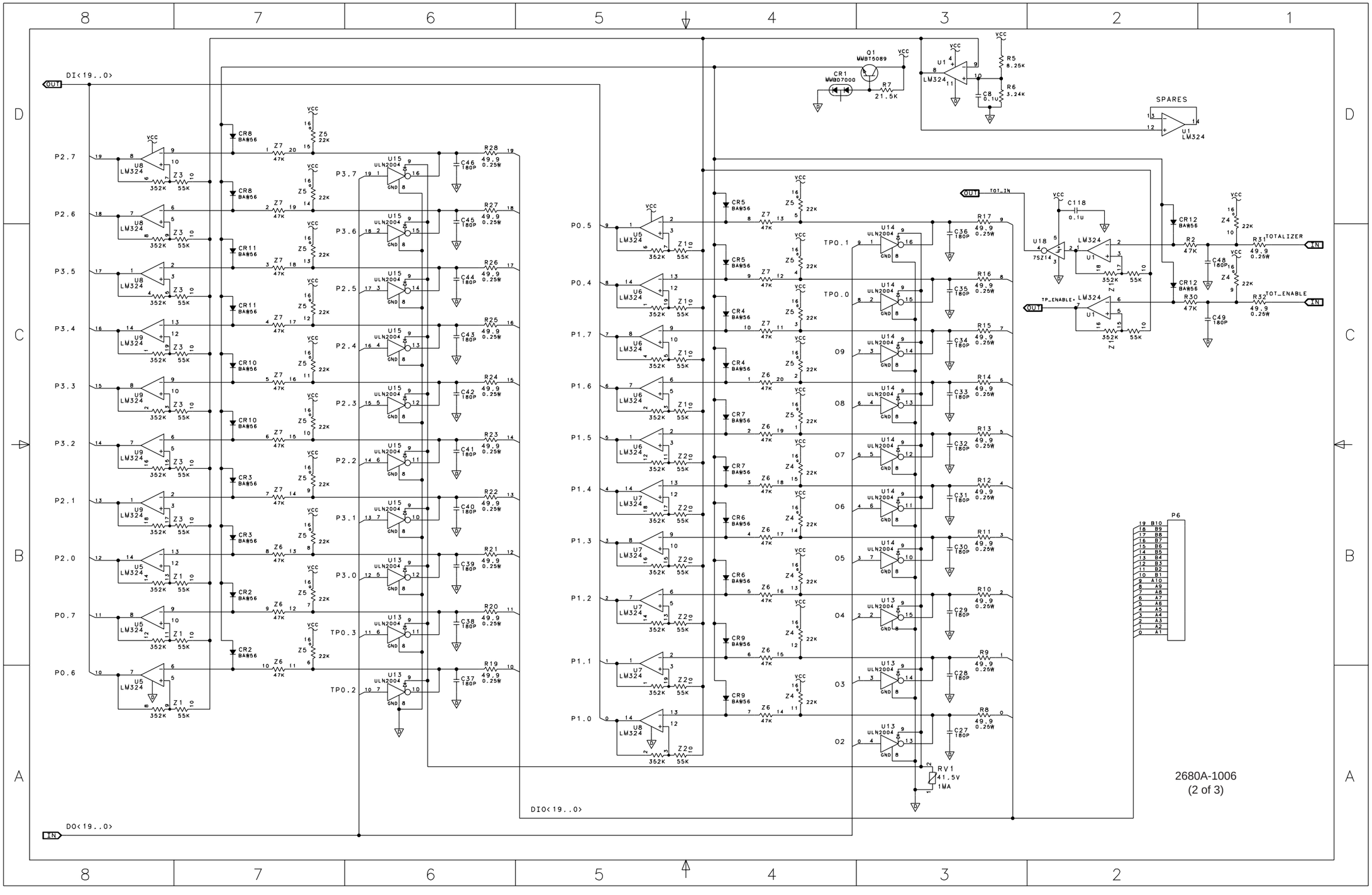


Figure 8-3. Digital I/O PCA (cont)

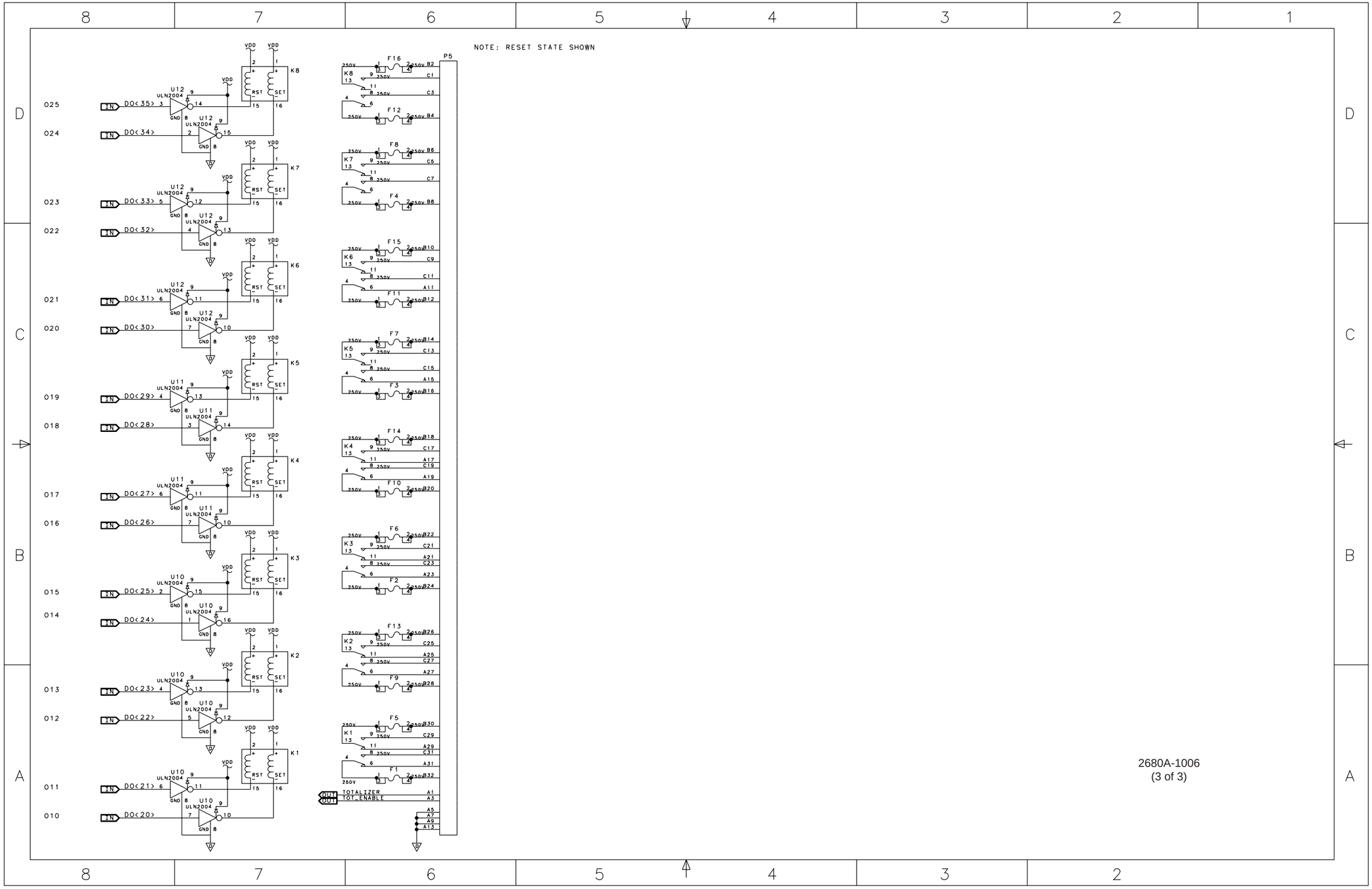


Figure 8-3. Digital I/O PCA (cont)

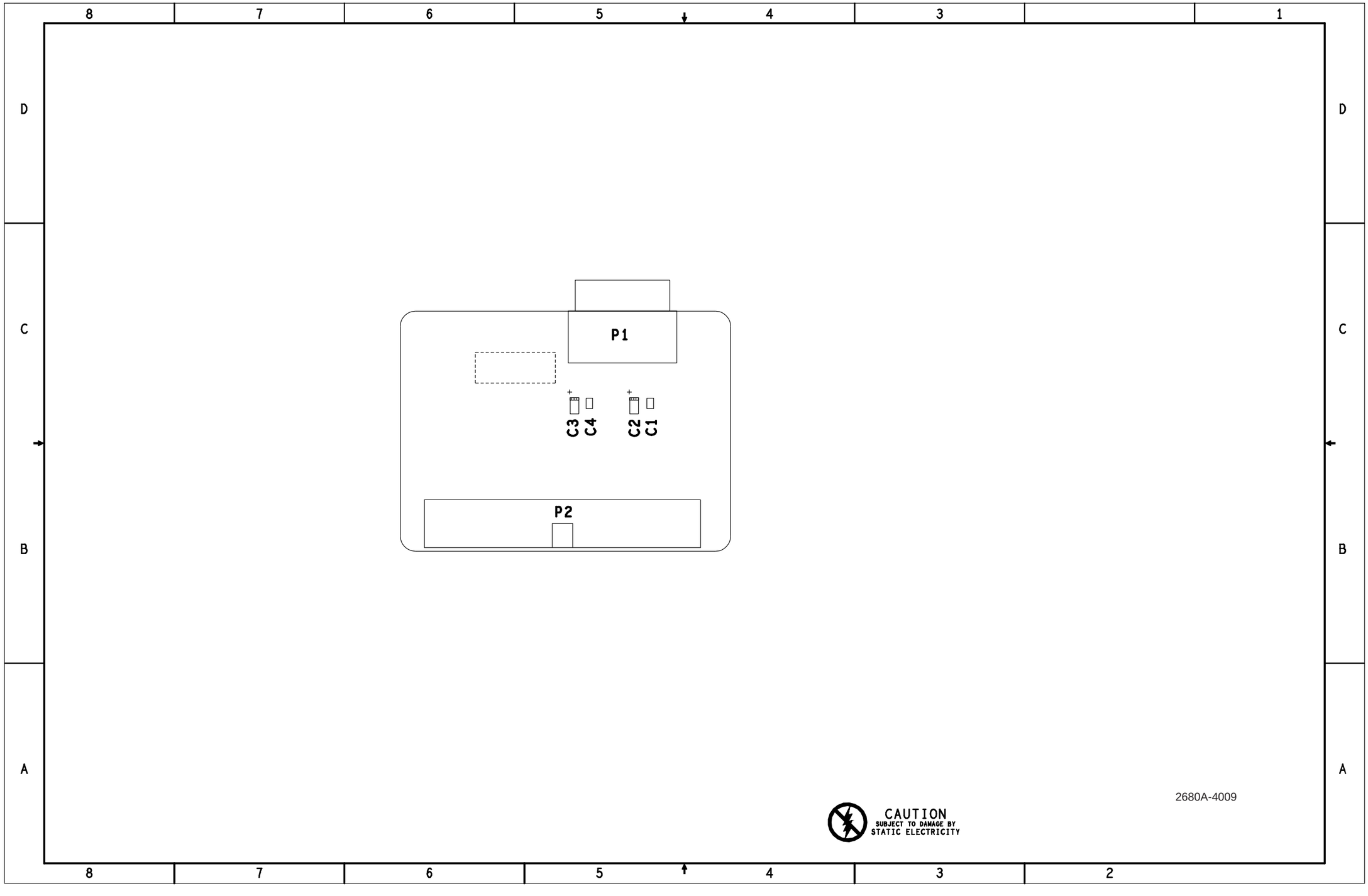
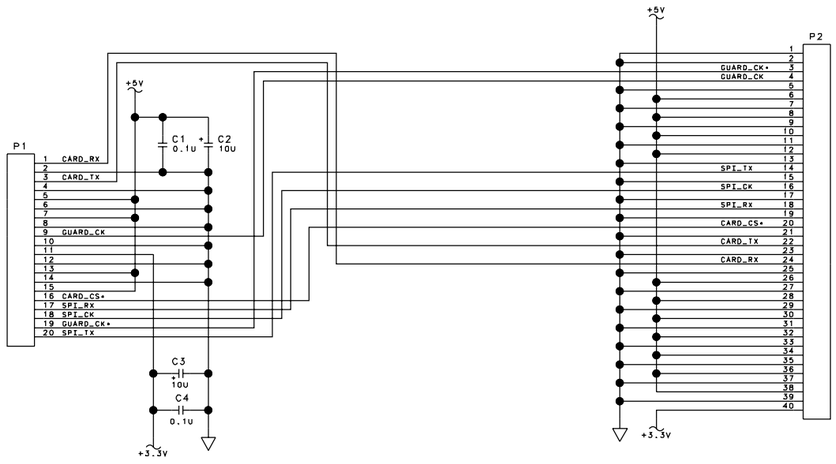


Figure 8-4. Backplane Extender PCA



2680A-1009

Figure 8-4. Backplane Extender PCA (cont)

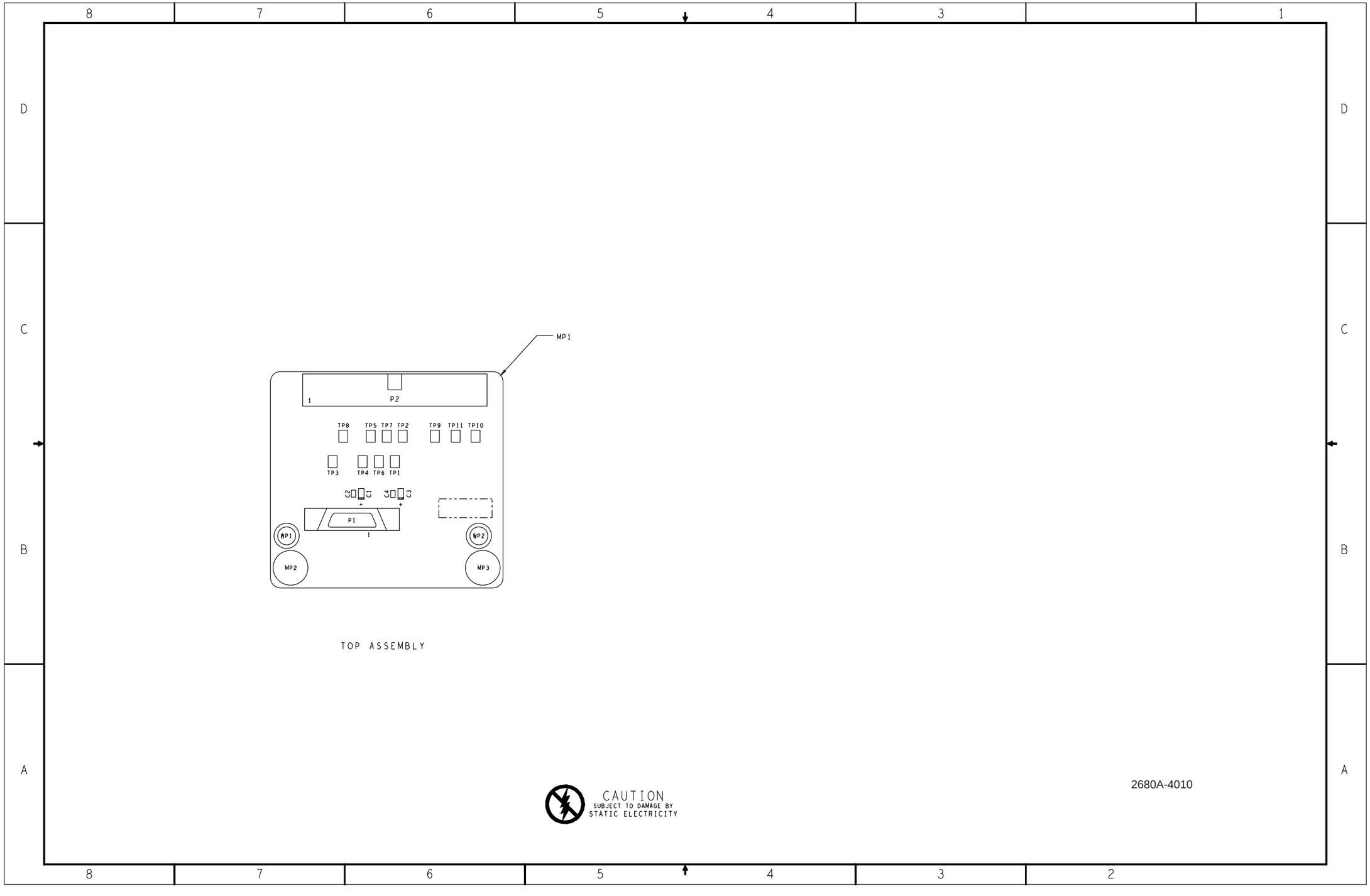


Figure 8-5. Extender PCA

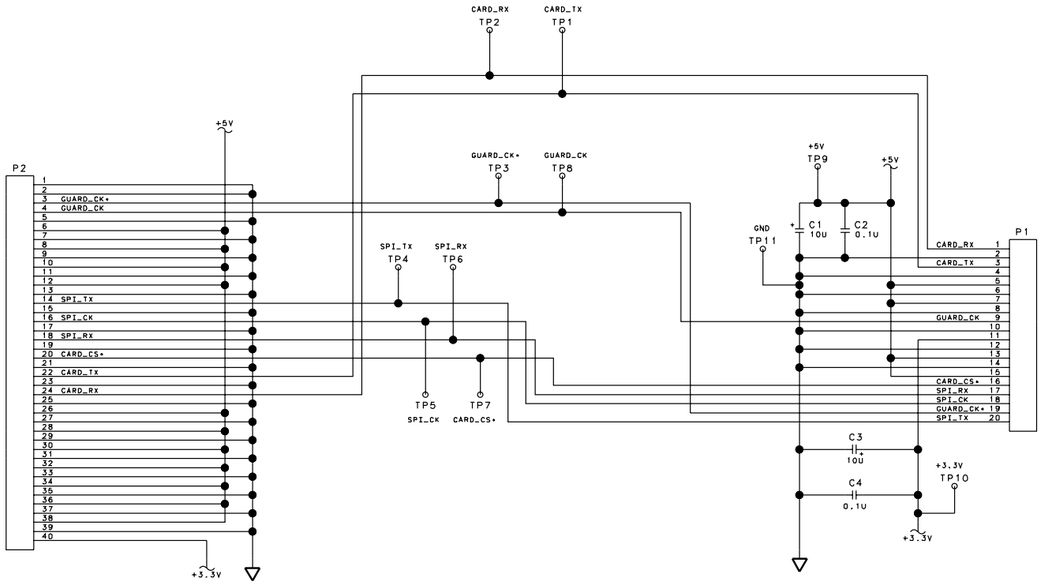
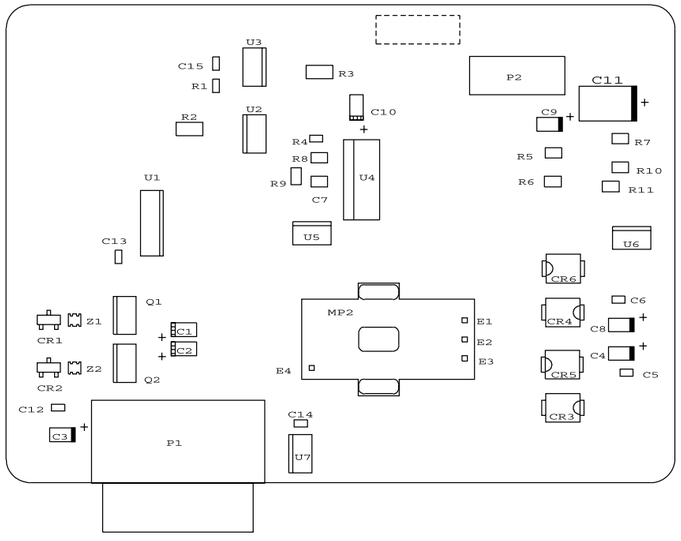


Figure 8-5. Extender PCA (cont)



2680A-4031

CAUTION
SUBJECT TO DAMAGE BY
STATIC ELECTRICITY

Figure 8-6. A/D Supply Assembly

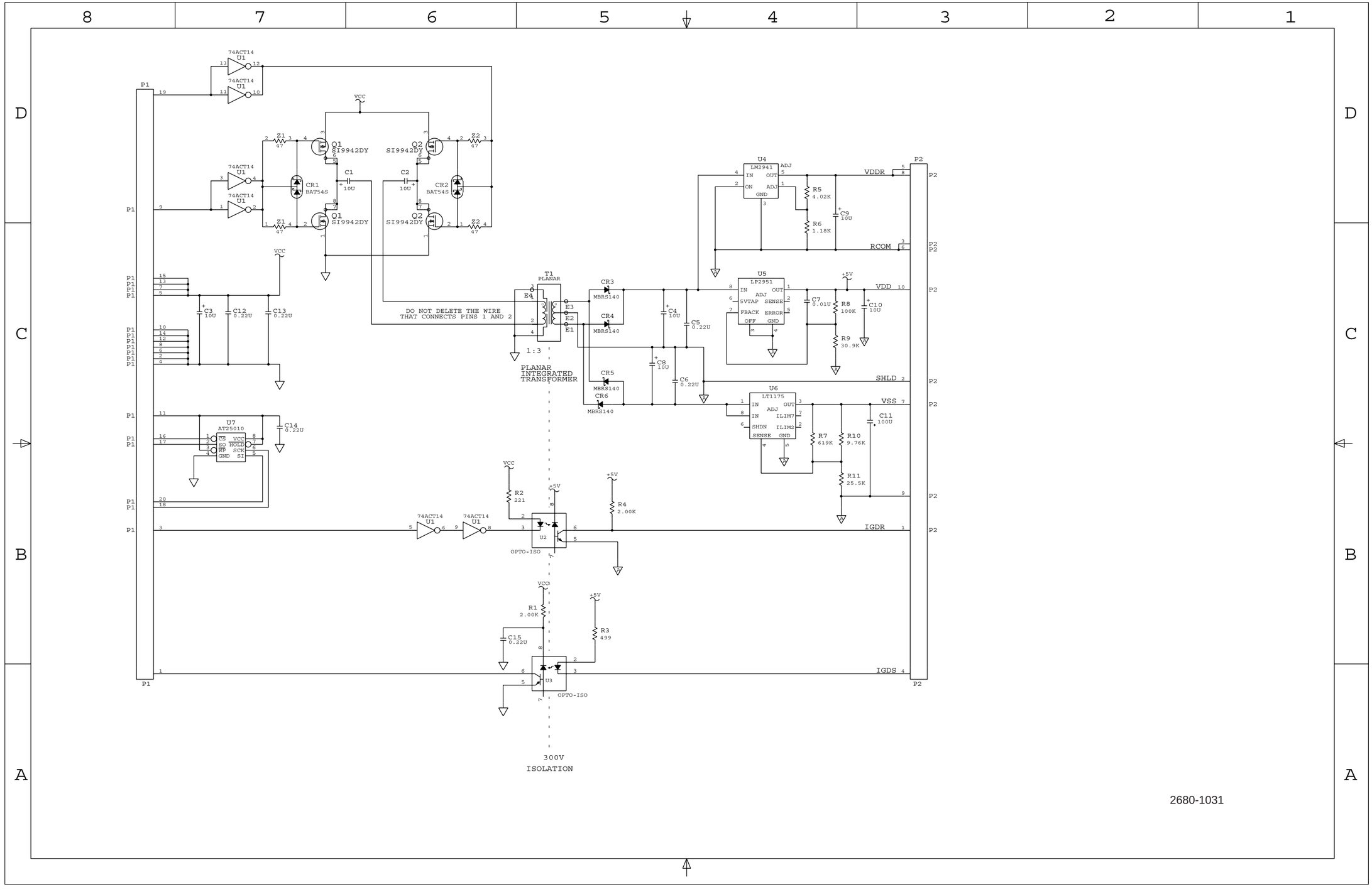


Figure 8-6. A/D Supply Assembly (cont)

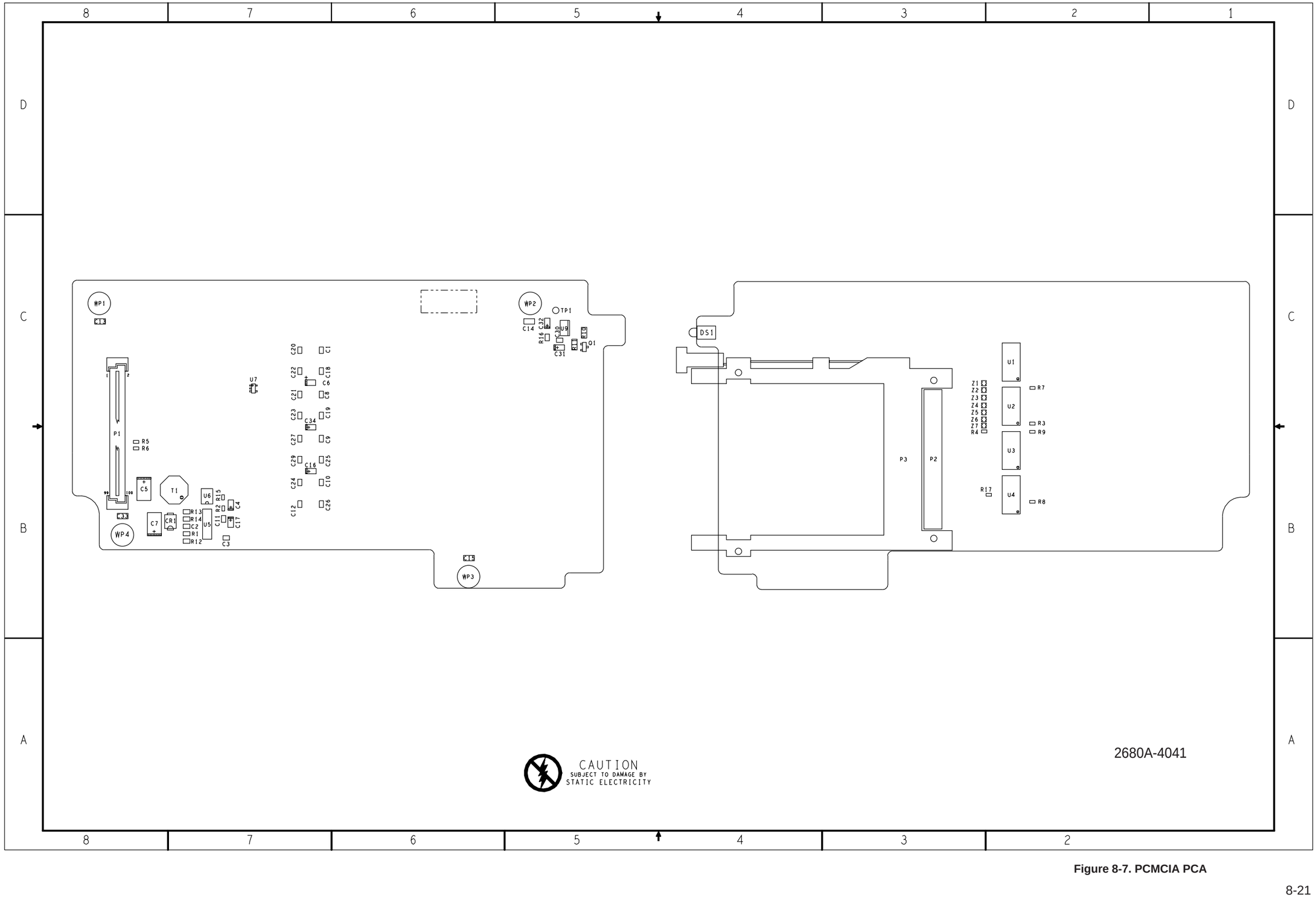


Figure 8-7. PCMCIA PCA

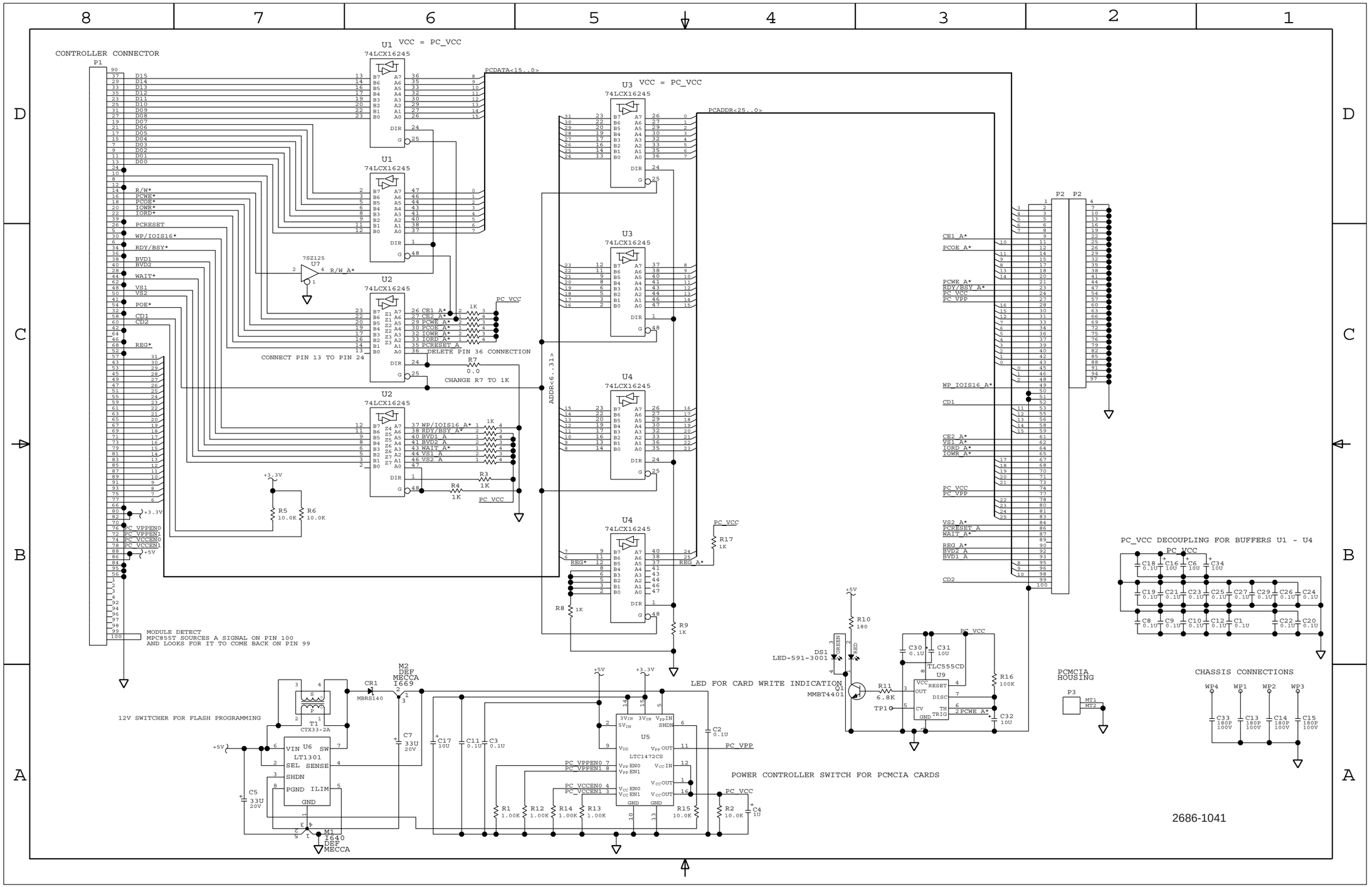
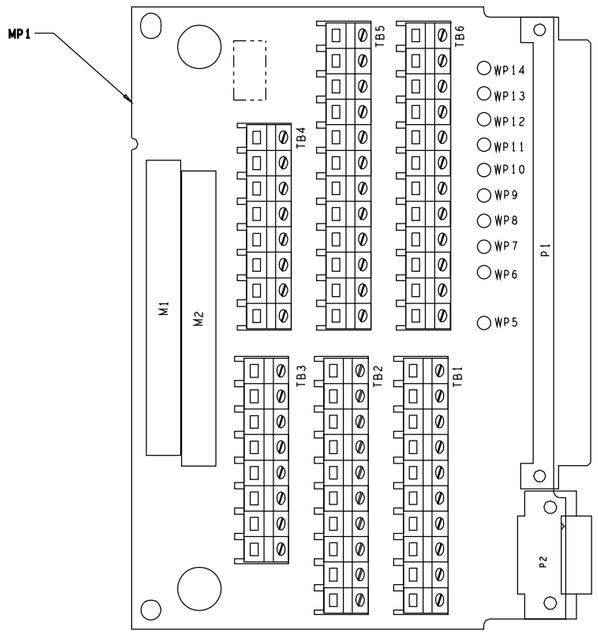


Figure 8-7. PCMCIA PCA (cont)



2680A-4062

CAUTION
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STATIC ELECTRICITY

Figure 8-8. Output PCA

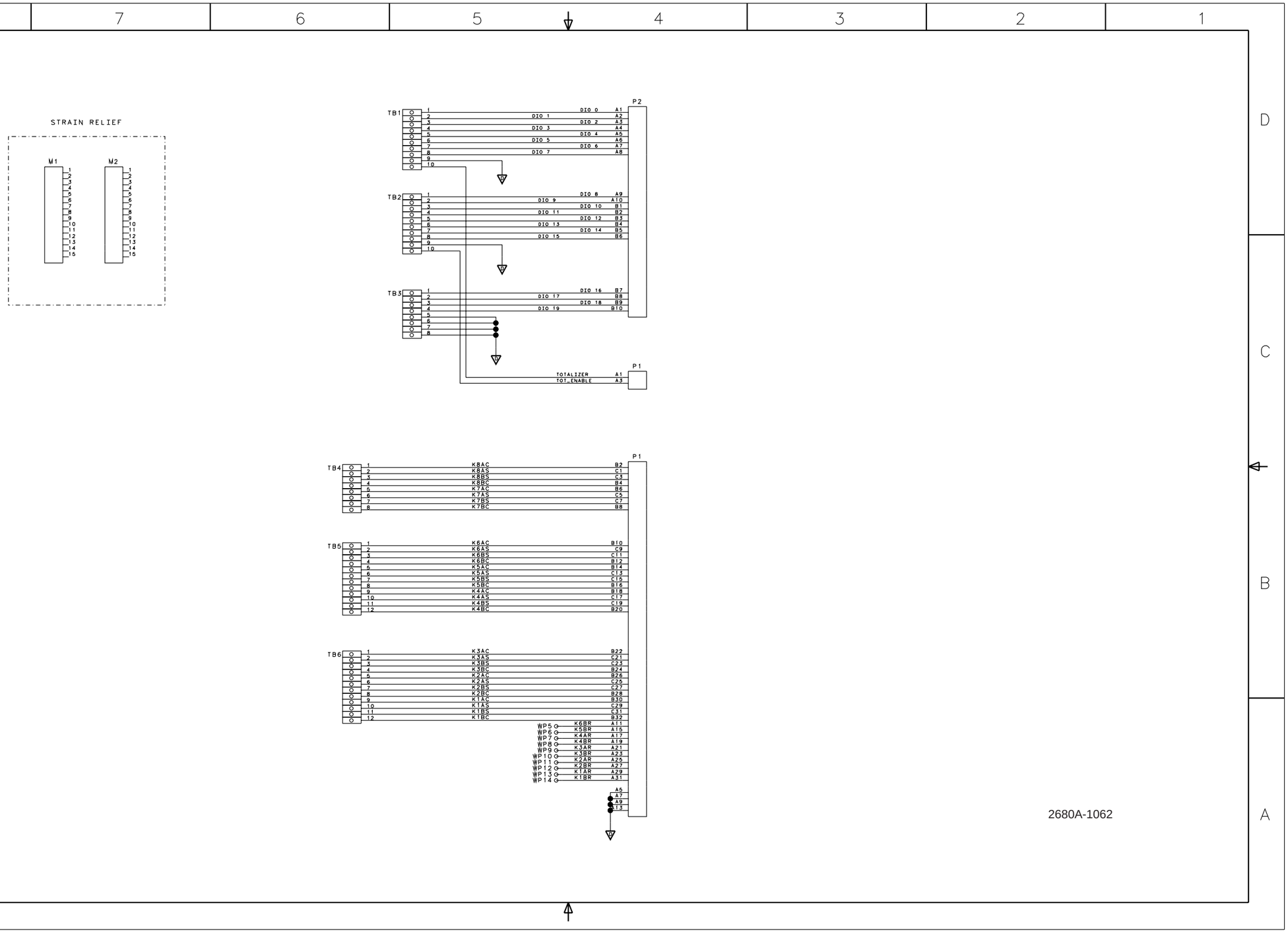


Figure 8-8. Output PCA (cont)

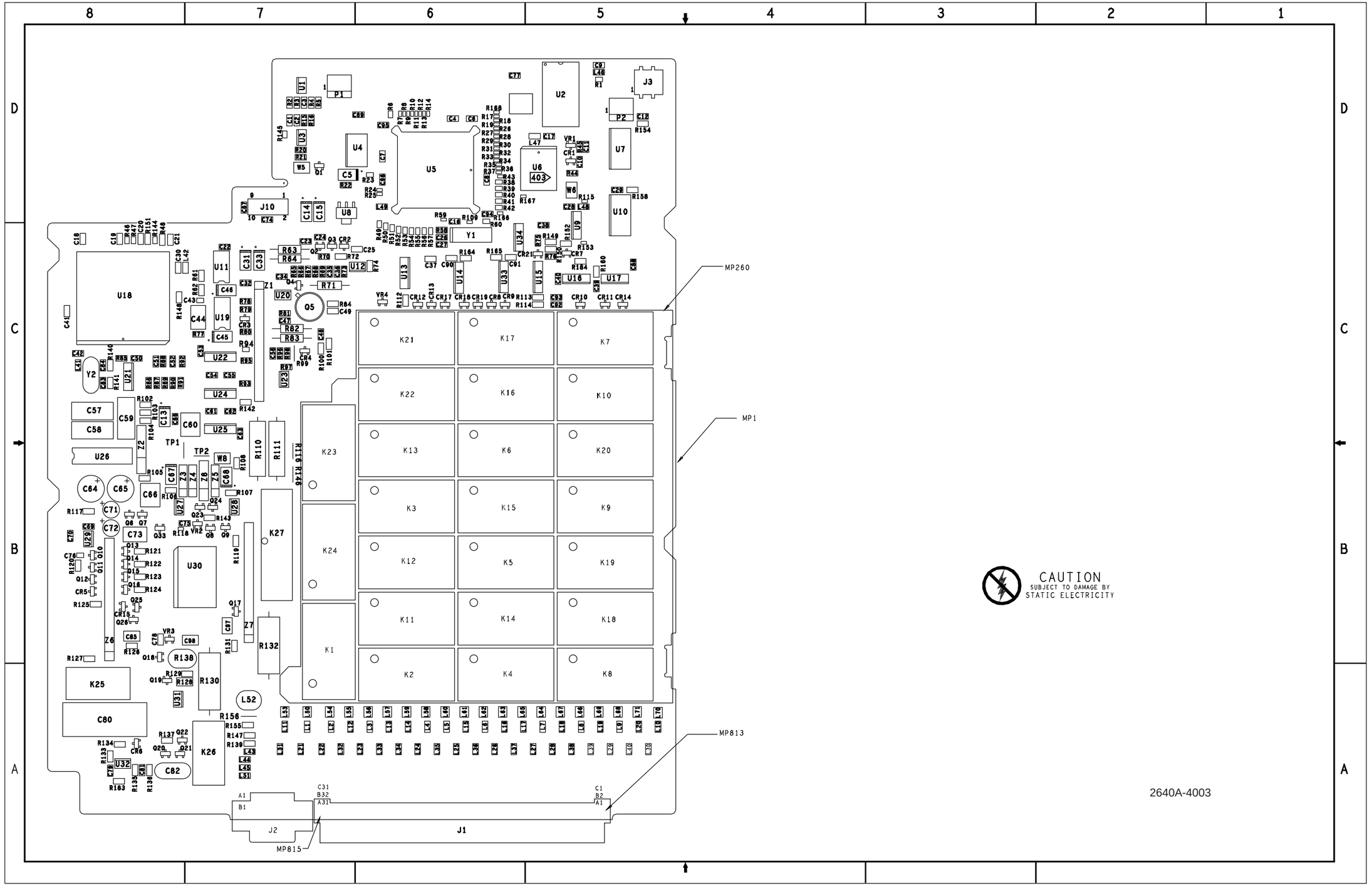
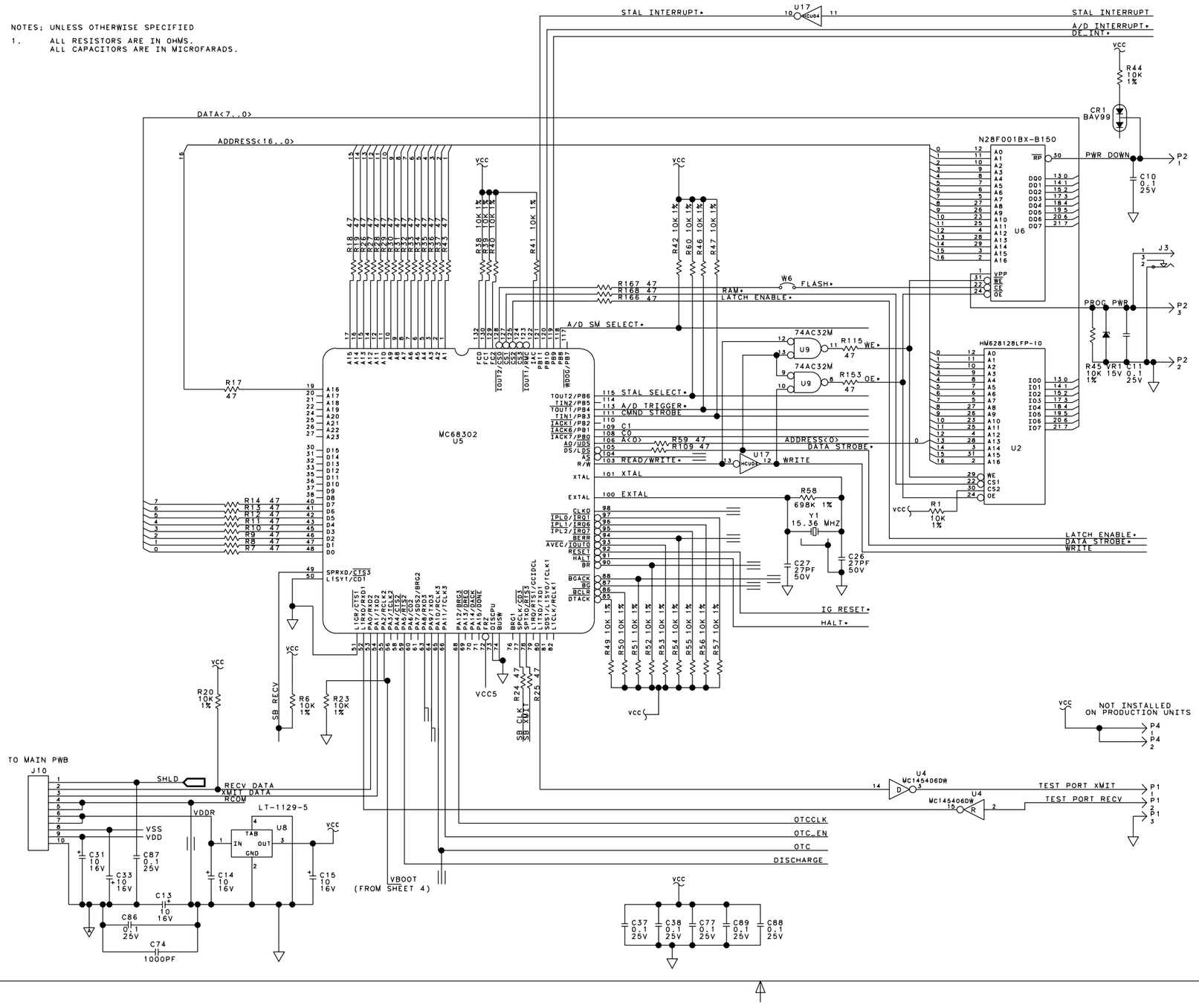


Figure 8-9. A/D (PFE) PCA

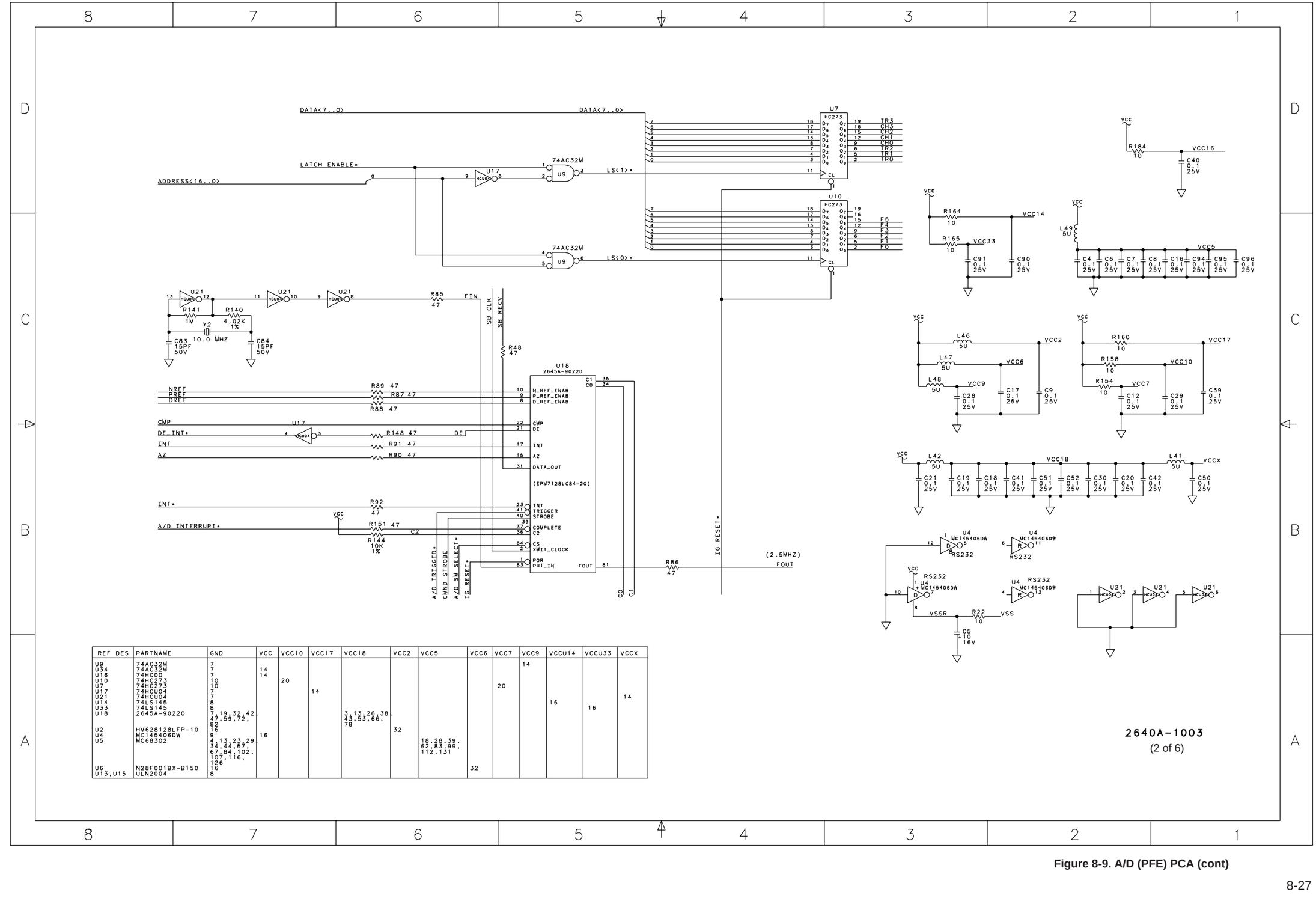
NOTES; UNLESS OTHERWISE SPECIFIED

1. ALL RESISTORS ARE IN OHMS.
   ALL CAPACITORS ARE IN MICROFARADS.



2640A-1003
(1 of 6)

Figure 8-9. A/D (PFE) PCA (cont)



REF DES	PARTNAME	GND	VCC	VCC10	VCC17	VCC18	VCC2	VCC5	VCC6	VCC7	VCC9	VCCU14	VCCU33	VCCX
U9	74AC32M	7									14			
U34	74AC32M	7	14											
U16	74HC00	7	14											
U10	74HC273	10		20										
U7	74HC273	10								20				
U17	74HCU04	7			14									
U21	74HCU04	7												14
U14	74LS145	8										16		
U33	74LS145	8											16	
U18	2645A-90220	7,19,32,42,47,59,72,82				3,13,26,38,43,53,66,78								
U2	HM62B128LFP-10	16					32							
U4	MC145406DW	9	16											
U5	MC68302	4,13,23,29,34,44,57,67,84,102,107,116,126						18,28,39,62,83,99,112,131						
U6	N28F001BX-B150	16							32					
U13,U15	ULN2004	8												

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(2 of 6)

Figure 8-9. A/D (PFE) PCA (cont)

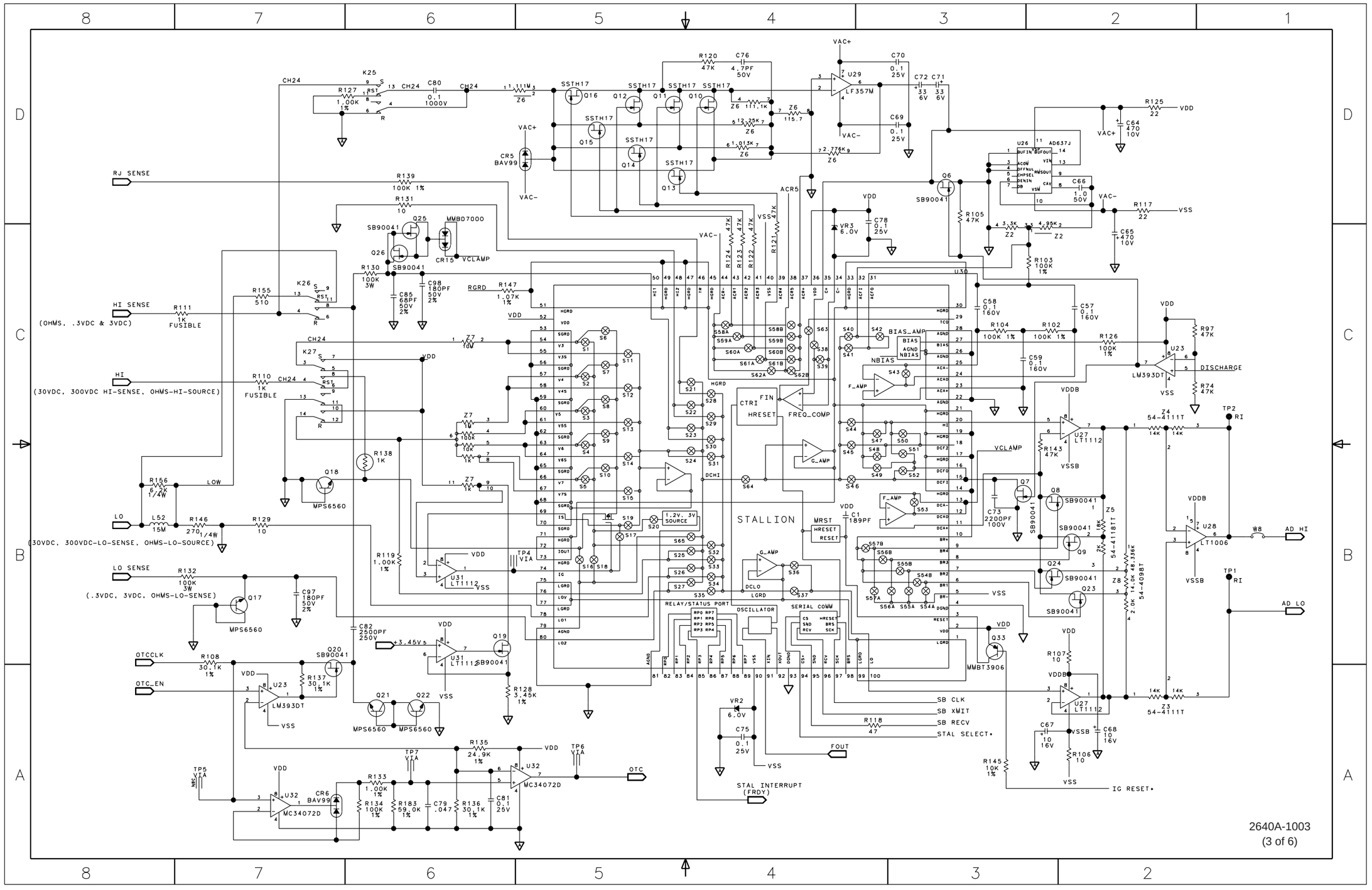


Figure 8-9. A/D (PFE) PCA (cont)

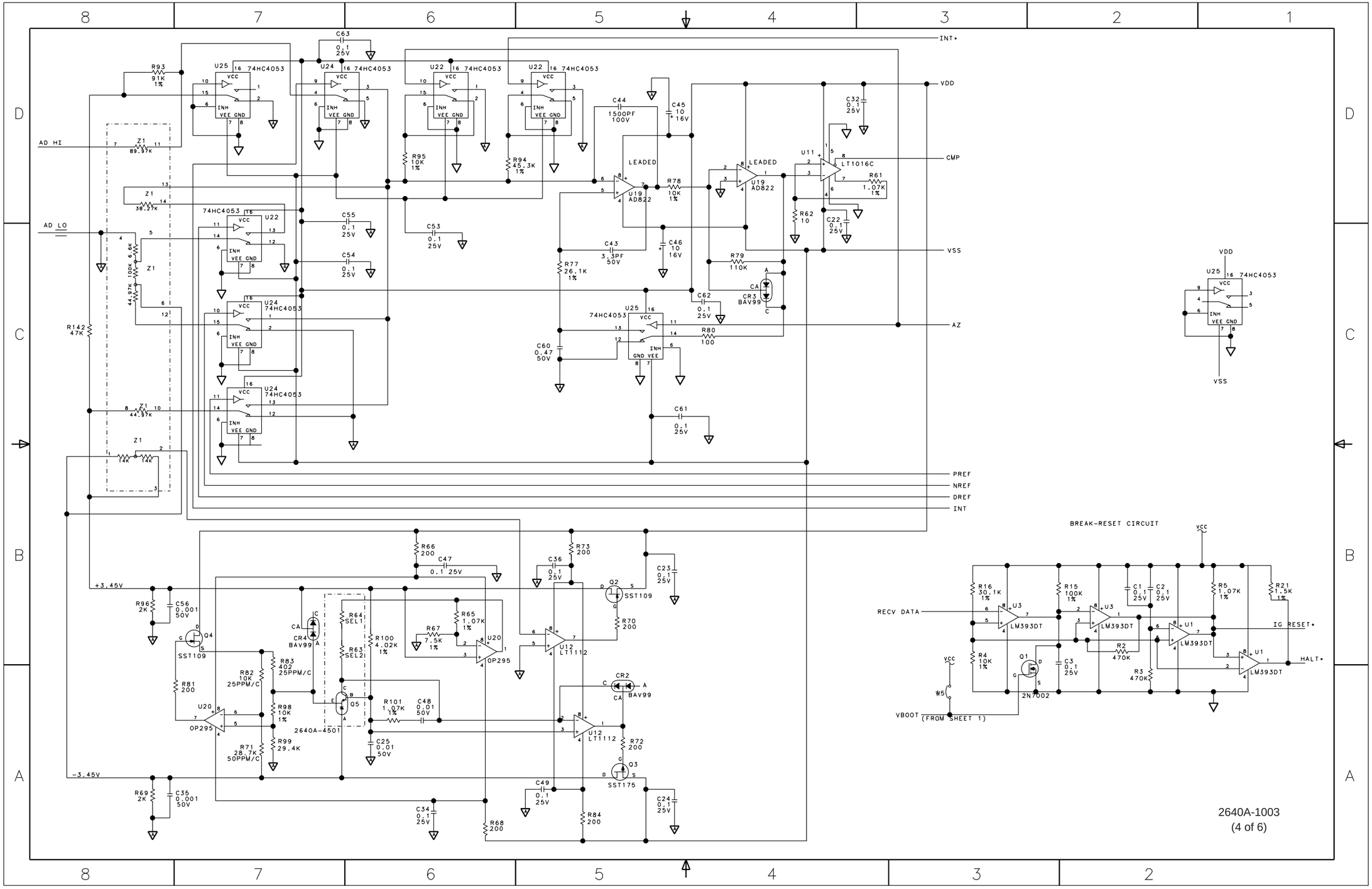
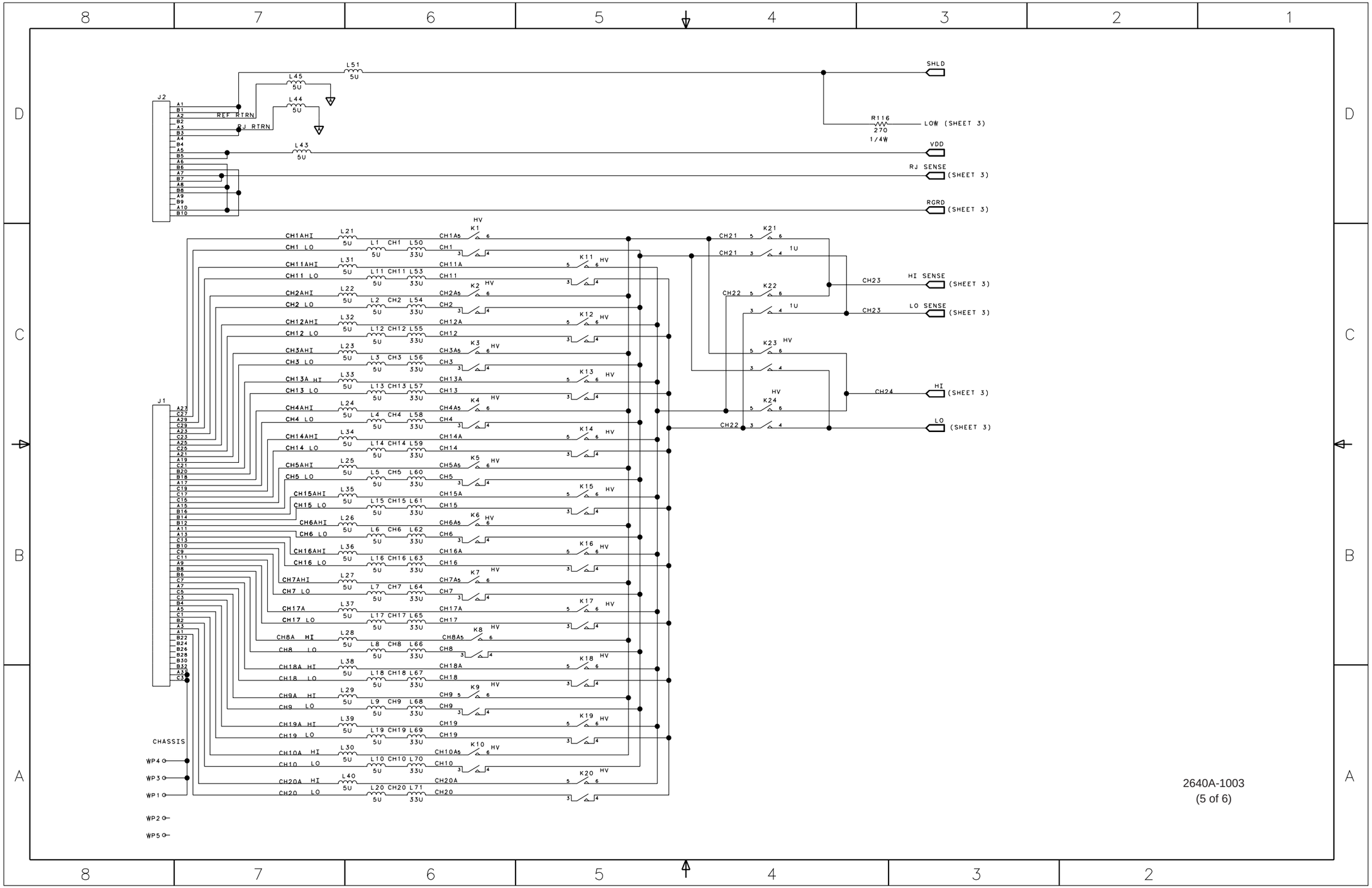


Figure 8-9. A/D (PFE) PCA (cont)



2640A-1003
(5 of 6)

Figure 8-9. A/D (PFE) PCA (cont)

CH0	CH1	CH2	CH3	CHANNELS ENABLED
0	0	0	0	1,11
1	0	0	0	2,12
0	1	0	0	3,13
1	1	0	0	4,14
0	0	1	0	5,15
1	0	1	0	6,16
0	1	1	0	7,17
1	1	1	0	8,18
0	0	0	1	9,19
1	0	0	1	10,20
0	1	0	1	NONE
1	1	0	1	NONE
0	0	1	1	NONE
1	0	1	1	NONE
0	1	1	1	NONE
1	1	1	1	NONE

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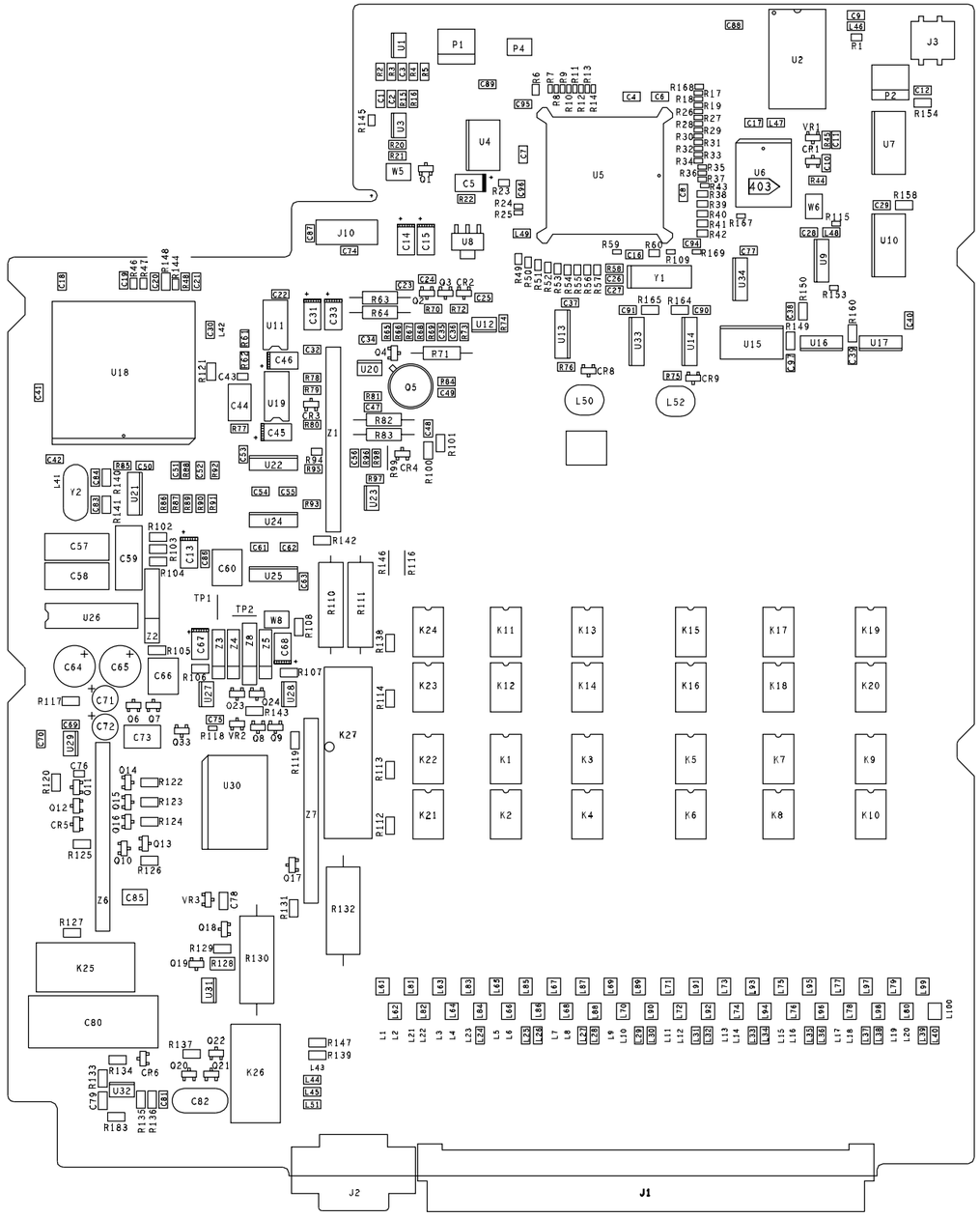
(6 of 6)

Figure 8-9. A/D (PFE) PCA (cont)



CAUTION
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STATIC ELECTRICITY

2645A-4003

Figure 8-10. A/D (FFE) PCA

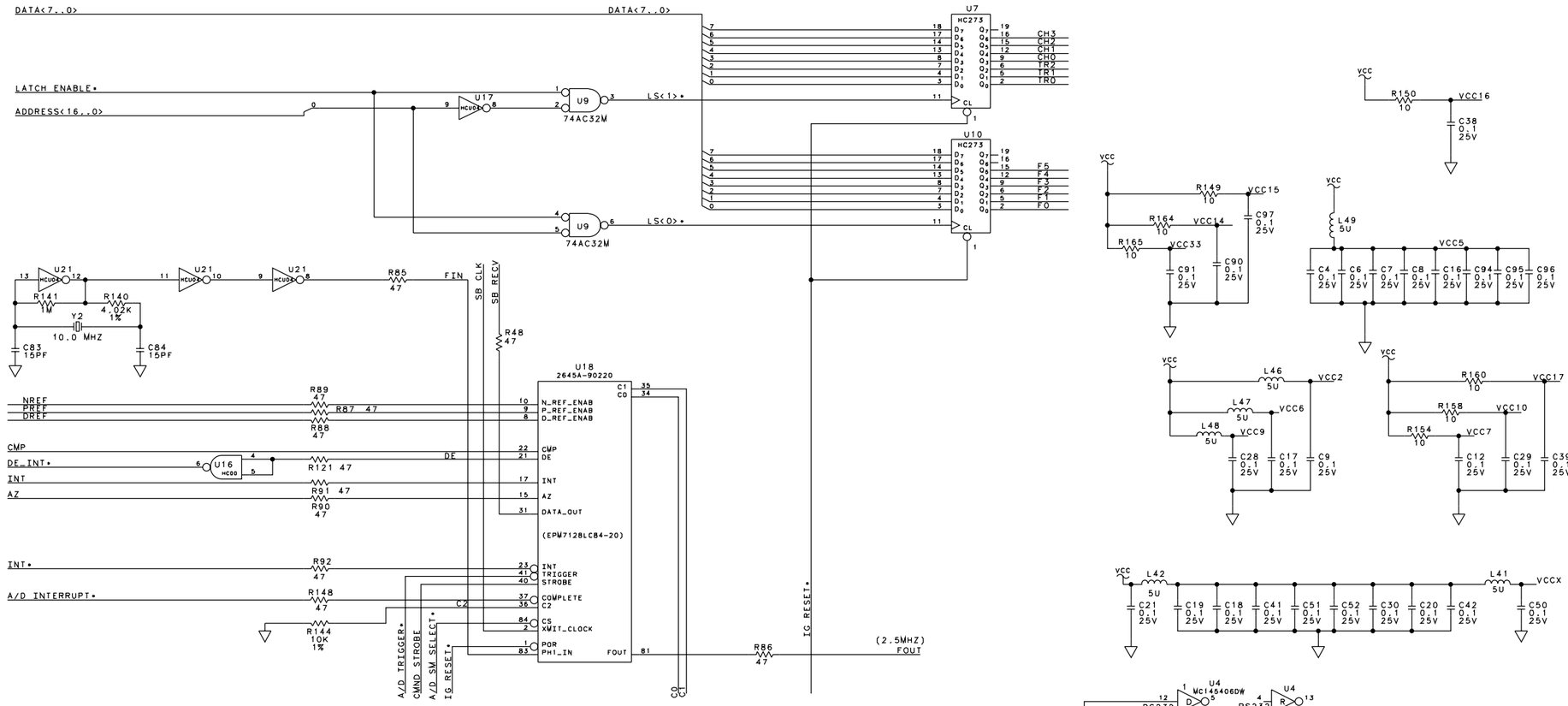
NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTORS ARE IN OHMS.
   ALL CAPACITORS ARE IN MICROFARADS.

STAL INTERRUPT•
STAL INTERRUPT
A/D INTERRUPT•
DE_INT•
DATA<7..0>
ADDRESS<16..0>
A<16>
VCC
R17 47
R18 47 R19 47 R27 47 R28 47 R29 47 R30 47 R31 47 R32 47 R33 47 R34 47 R35 47 R36 47 R37 47 R38 47
R58 10K 1% R59 10K 1% R40 10K 1%
R41 10K 1%
R42 10K 1% R60 10K 1% R46 10K 1% R47 10K 1%
R167 47
R168 47
R169 47
A/D SM SELECT•
RAM•
LATCH ENABLE•
W6 FLASH•
74AC32M U9
R115 47 WE•
R153 47 OE•
115 STAL SELECT•
113 A/D TRIGGER•
111 CMND STROBE
109 C1
108 C0
106 A<0>
R59 47
R109 47
ADDRESS<0>
DATA STROBE•
WRITE
U17 HCU04
101 XTAL
100 EXTAL
R58 698K 1%
15.36 MHZ
Y1
C27 27PF 50V
C26 27PF 50V
IG RESET•
HALT•
R49 10K 1% R50 10K 1% R51 10K 1% R52 10K 1% R53 10K 1% R54 10K 1% R55 10K 1% R56 10K 1% R57 10K 1%
N28F001BX-B150 U6
HW628128LFP-10 U2
R44 10K 1%
CR1 BAV99
PWR DOWN
P2 1
C10 0.1 25V
J3
PROG PWR
P2 3
P2 2
R45 10K 1%
VR1 15V
C11 0.1 25V
R14 47 R13 47 R12 47 R11 47 R10 47 R9 47 R8 47 R7 47
MC68302 U5
SPRXD/CTS3
L1SY1/CD1
R20 10K 1%
R6 10K 1%
R23 10K 1%
SB RECV
VCC5
R24 47 R25 47
SB CLK
SB XMIT
VBOOT (FROM SHEET 4)
TO MAIN PWB J10
SHLD
RECV DATA
XMIT DATA
RCOM
VDDR
VSS
VDD
LT-1129-5 U8
C31 10 16V
C87 1000PF
C33 10 16V
C14 10 16V
C15 10 16V
C13 10 16V
C86 0.1 25V
C74 1000PF
OTCCLK
OTC_EN
OTC
DISCHARGE
U4 MC145406DW
RS232
TEST PORT XMIT
TEST PORT RECV
P1 1
P1 2
P1 3
NOT INSTALLED ON PRODUCTION UNITS
P4 1
P4 2
C37 0.1 25V C40 0.1 25V C77 0.1 25V C88 0.1 25V C89 0.1 25V
VDS_LIB=flatlib

2645A-1003
(1 of 6)

Figure 8-10. A/D (FFE) PCA (cont)



REF	PARTNAME	GND	VCC	VCC10	VCC14	VCC15	VCC16	VCC17	VCC18	VCC2	VCC33	VCC5	VCC6	VCC7	VCC9	VCCX
U15	74AC240M	10				20									14	
U9	74AC32M	7	14													
U34	74AC32M	7					14									
U16	74HC00	7		20												
U10	74HC273	10						14						20		
U7	74HC273	10														14
U17	74HCU04	7			16						16					
U21	74HCU04	7														
U14	74LS145	8														
U33	74LS145	8														
U18	2645A-90220	7,19,32,42,47,59,72,82							3,13,26,38,43,53,66,78							
U2	HM628128LFP	16								32						
U4	MC145406DW	9														
U5	MC68302	4,13,23,29,34,44,52,67,84,102,107,116,126														
U6	N28F001BX	16														
U13	ULN2004	8														

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(2 of 6)

Figure 8-10. A/D (FFE) PCA (cont)

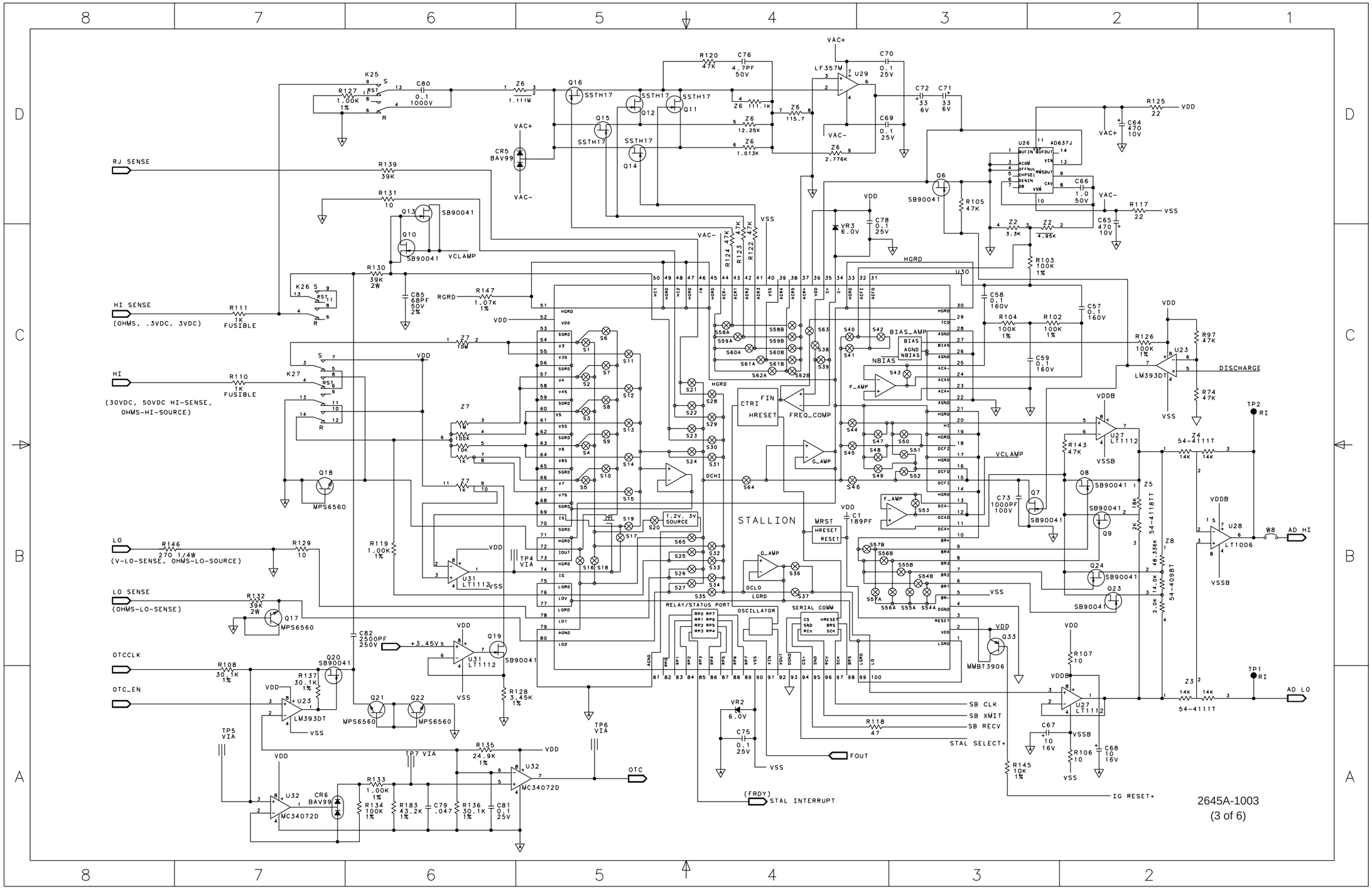
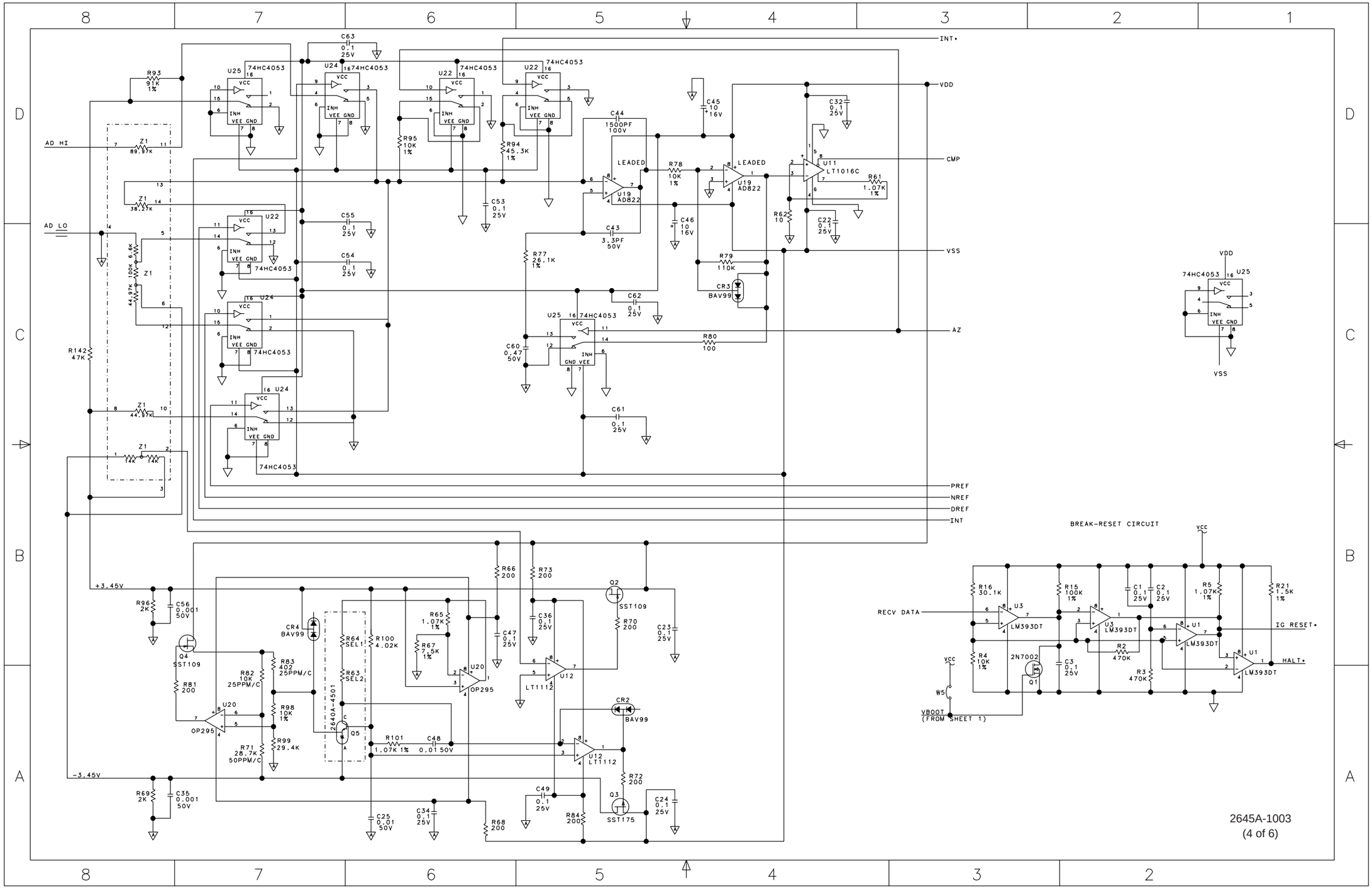


Figure 8-10. A/D (FFE) PCA (cont)



2645A-1003
(4 of 6)

Figure 8-10. A/D (FFE) PCA (cont)

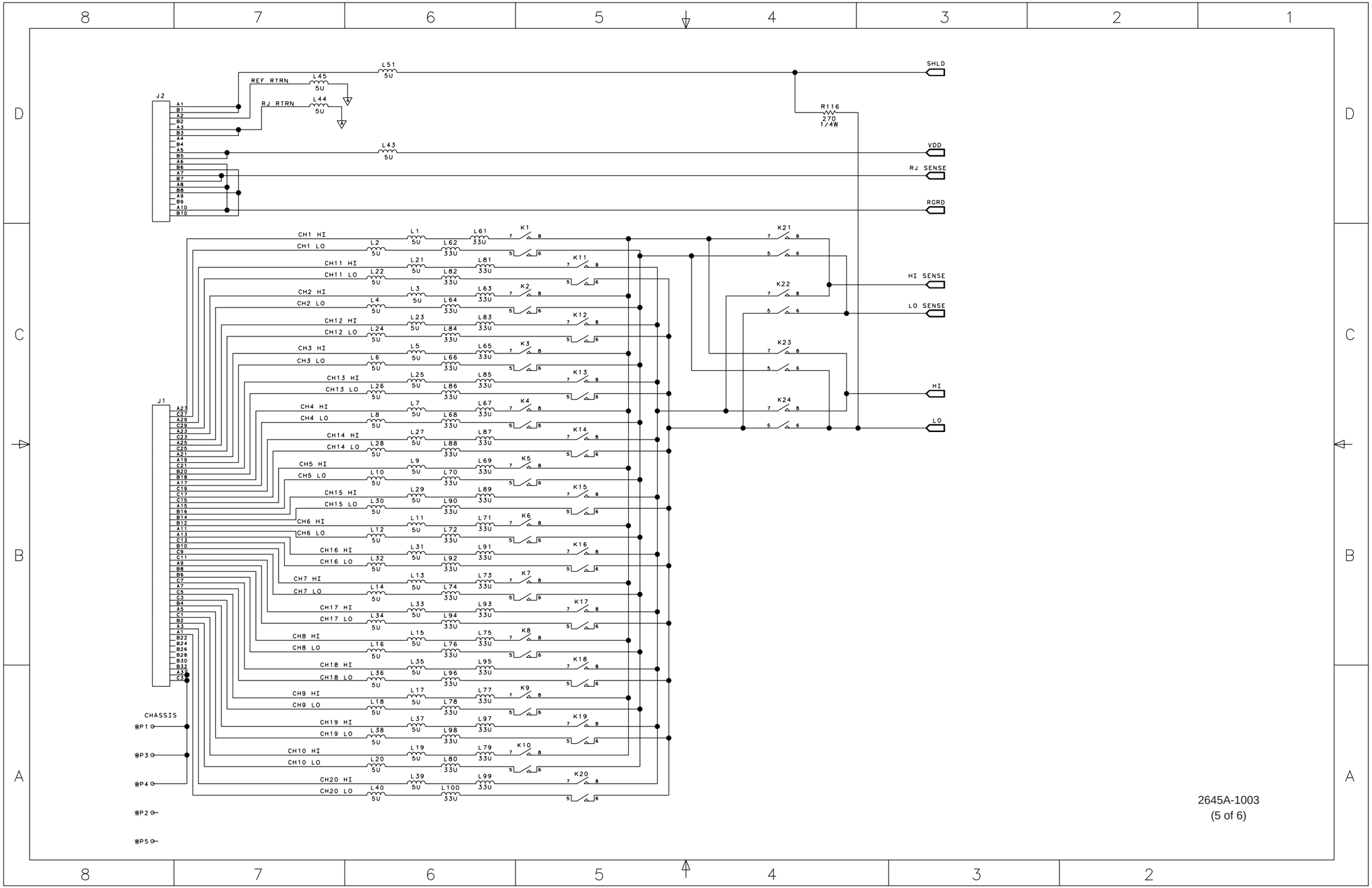


Figure 8-10. A/D (FFE) PCA (cont)

CH0	CH1	CH2	CH3	CHANNELS ENABLED
0	0	0	0	1,11
1	0	0	0	2,12
0	1	0	0	3,13
1	1	0	0	4,14
0	0	1	0	5,15
1	0	1	0	6,16
0	1	1	0	7,17
1	1	1	0	8,18
0	0	0	1	9,19
1	0	0	1	10,20
0	1	0	1	NONE
1	1	0	1	NONE
0	0	1	1	NONE
1	0	1	1	NONE
0	1	1	1	NONE
1	1	1	1	NONE

700p29_topress.zip

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Figure 8-10. A/D (FFE) PCA (cont)

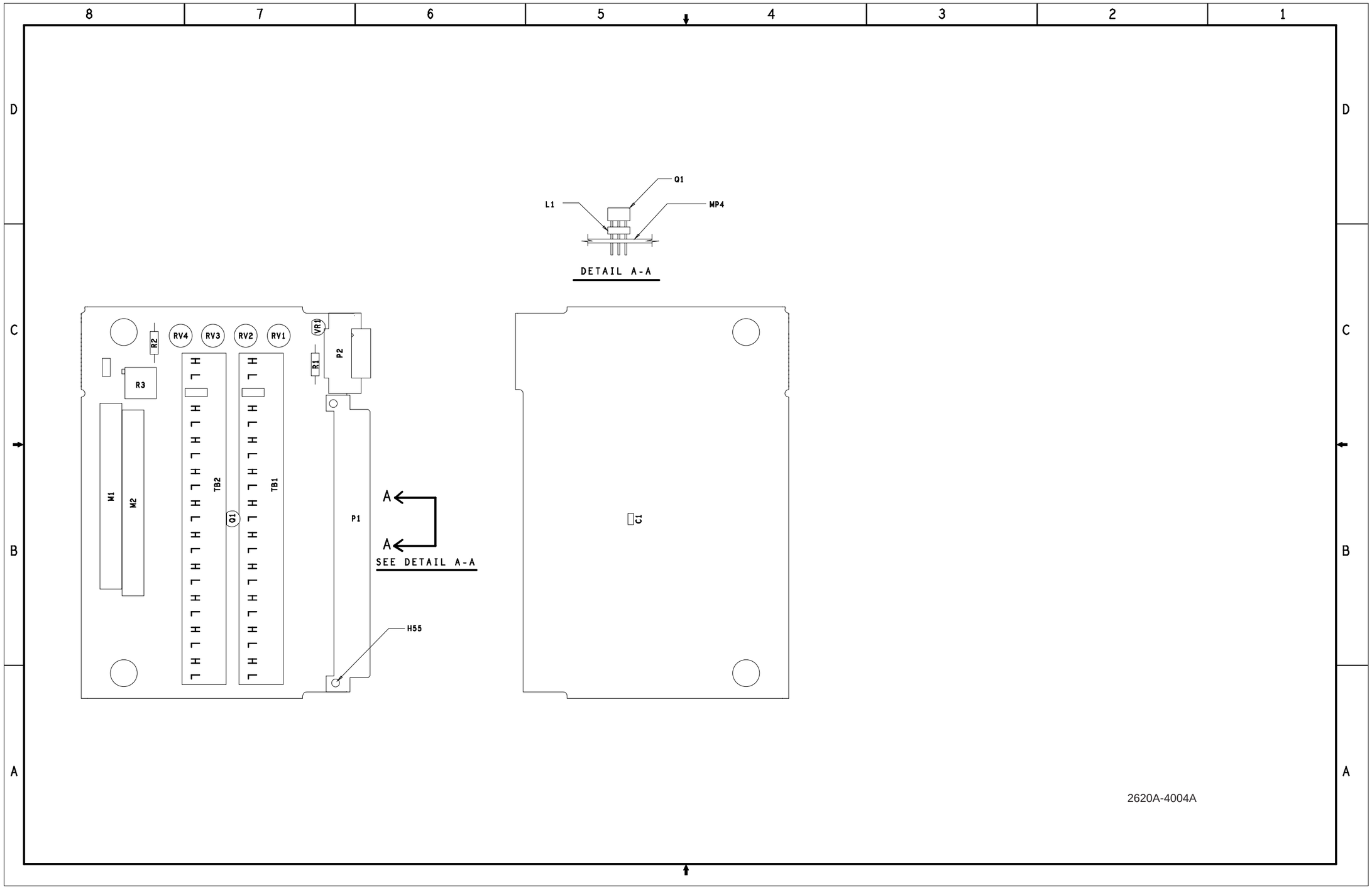

Figure 8-11. Analog Input Connector PCA

NOTES:
UNLESS OTHERWISE SPECIFIED.
1. ALL CAPACITOR VALUES ARE IN MICROFARADS.

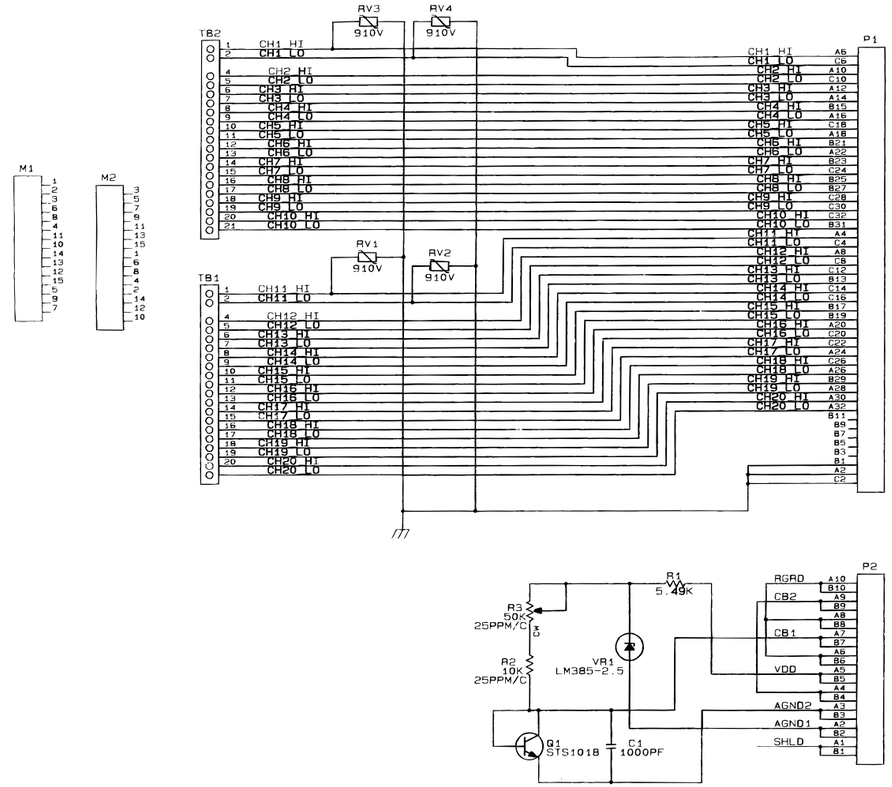

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Figure 8-11. Analog Input Connector PCA (cont)

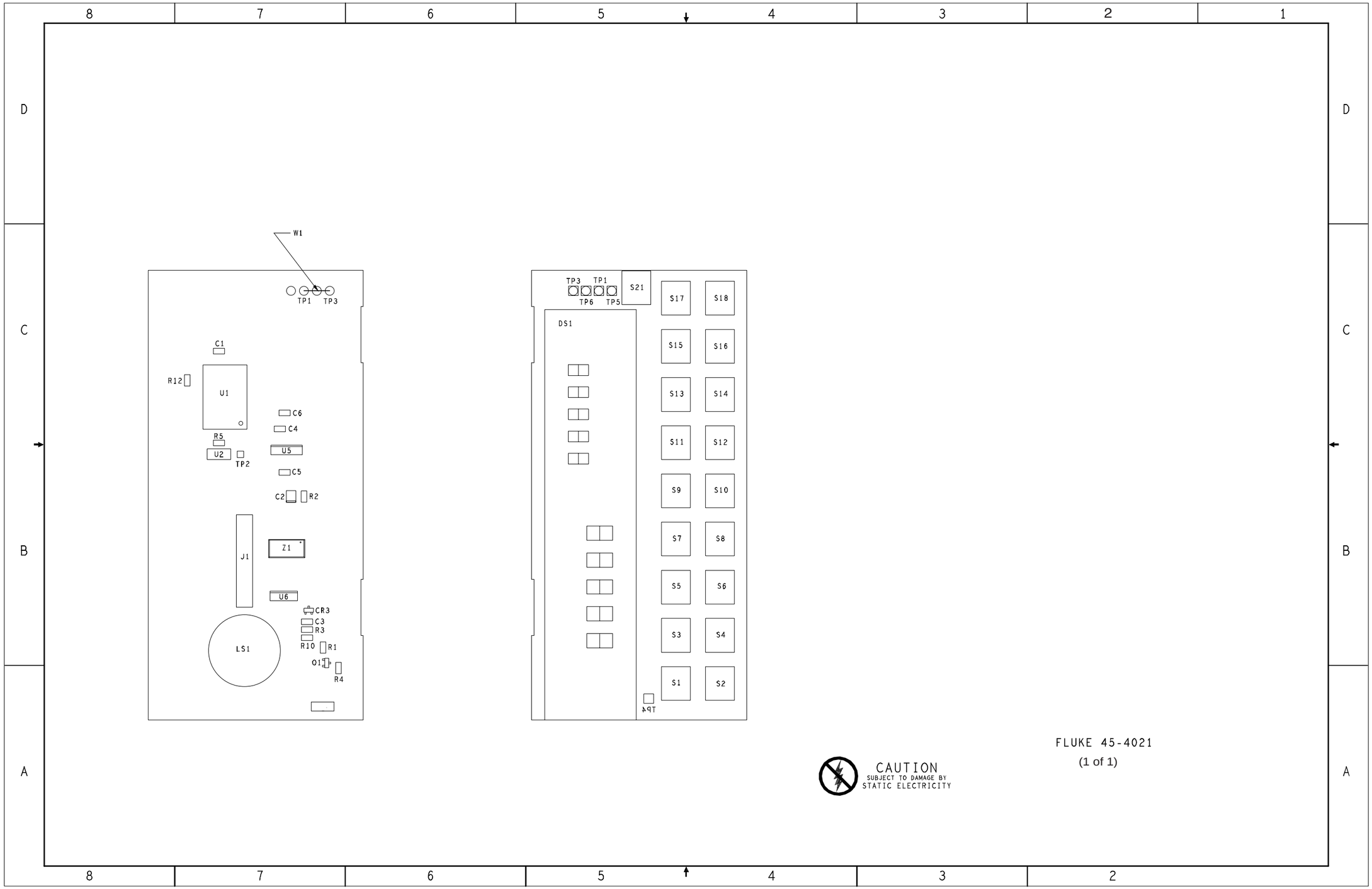

Figure 8-12. Display PCA

NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RESISTANCE IS IN OHMS.
2. ALL CAPACITANCE IS IN MICRO-FARADS.

REF DES	PARTNAME	GND	VCC
U5	74HC423	8	16
U6	74HC132	7	14

REFERENCE DESIGNATON	
LAST USED	NOT USED
C6	
CR3	CR1,2
DS1	
J1	
LS1	
Q1	
R12	R6-9,11
S21	S19,20
TP6	
U6	U3,4
Z1	

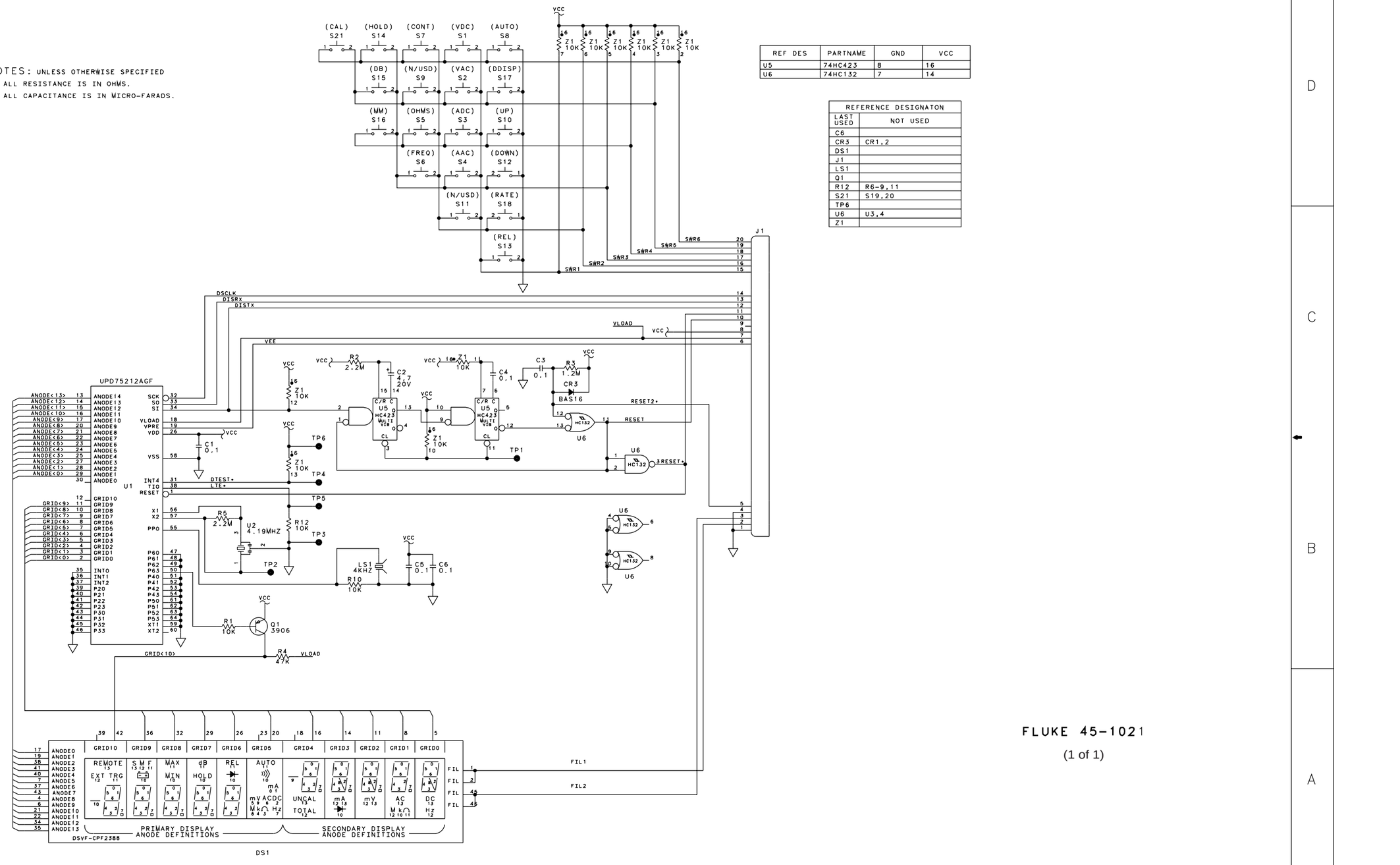

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Figure 8-12. Display PCA (cont)