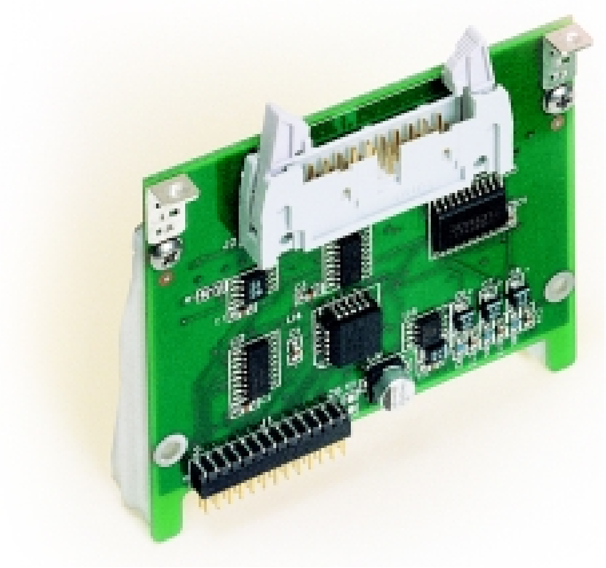

A/D Converter Cards (SR9300 Series)

Smart Star Modular C-Programmable Control System

User’s Manual

010215 - A

Digital I/O Cards User's Manual

Part Number 019-0086 • 010215 - A • Printed in U.S.A.

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TABLE OF CONTENTS

1. A/D CONVERTER CARDS

Chapter 1 describes the features of the A/D converter card, one of the I/O cards designed for the Smart Star embedded control system. The Smart Star embedded control system is described in complete detail in the ***Smart Star User's Manual***.

The Smart Star is a modular and expandable embedded control system whose configuration of I/O, A/D converter, D/A converter, and relay cards can be tailored to a large variety of demanding real-time control and data acquisition applications.

The typical Smart Star system consists of a rugged backplane with a power supply, a CPU card, and one or more I/O cards. The CPU card plugs into a designated slot on the backplane chassis, which has seven additional slots available for I/O cards to be used in any combination. A high-performance Rabbit 2000 microprocessor on the CPU card operates at 25.8 MHz to provide fast data processing.

1.1 A/D Converter Card Features

Three models of A/D converter cards are available, as shown in Table 1. Appendix A provides detailed specifications.

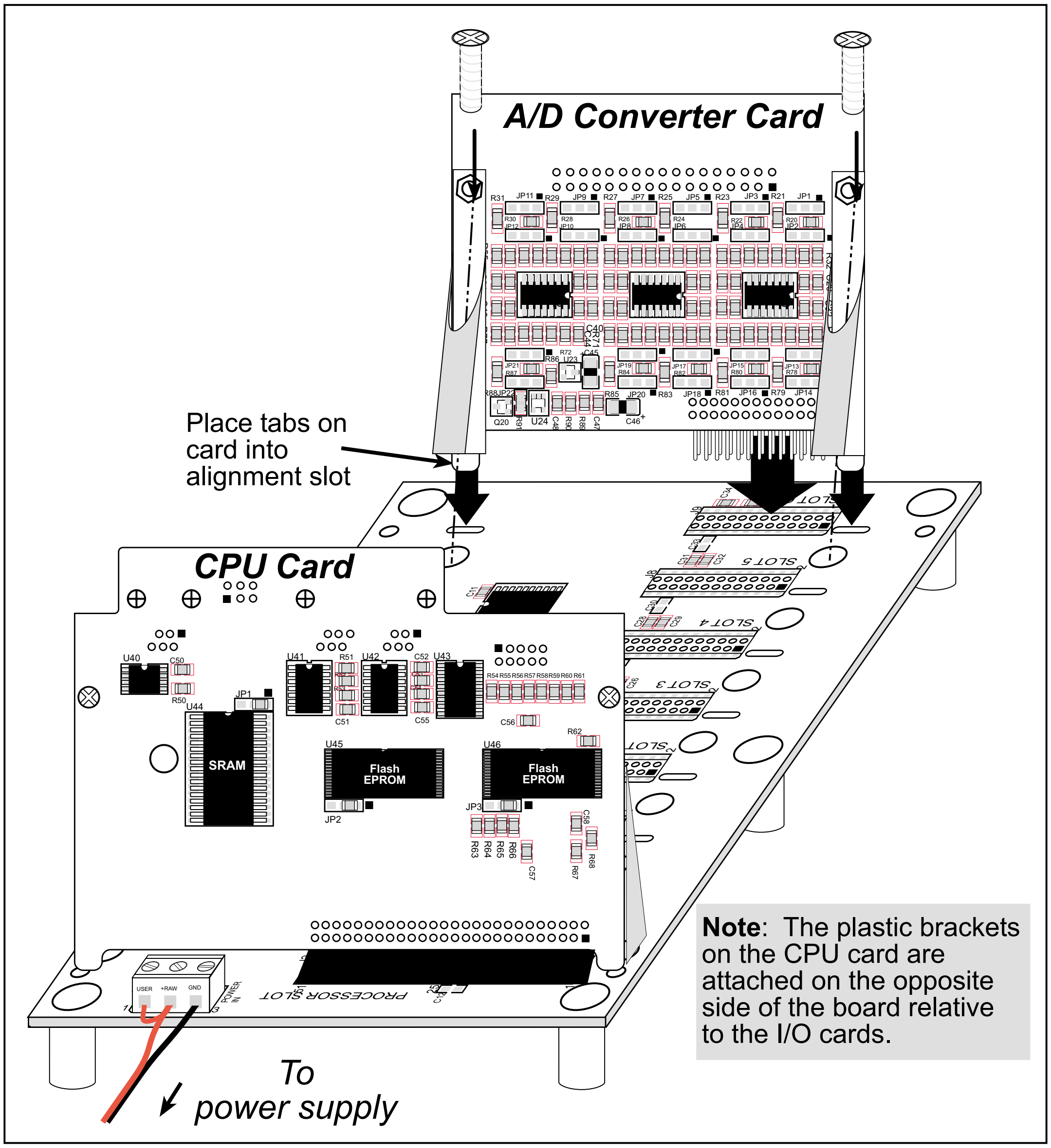
Table 1. Smart Star A/D Converter Cards

I/O Card	Model	Features
A/D Converter	SR9300	12-bit A/D converter, 11 channels, 0 V – 10 V
	SR9310	12-bit A/D converter, 11 channels, -10 V – +10 V
	SR9320	12-bit A/D converter, 11 channels, 4 mA – 20 mA

Appendix A provides detailed specifications.

1.2 Installing A/D Converter Cards

1. Orient the backplane with the CPU card already installed and facing towards you as shown in Figure 1.



Note: The plastic brackets on the CPU card are attached on the opposite side of the board relative to the I/O cards.

Figure 1. Installing A/D Converter Cards on the Backplane

2. Position the A/D converter card above the backplane over any unused slot position (**SLOT 0** to **SLOT 6**) as shown in Figure 1. Note the slot number and the type of I/O card since Dynamic C addresses the I/O cards by slot number.
3. Carefully insert the A/D converter card header into the slot on the backplane and line up the tabs on the card with the slots on the backplane as shown in Figure 1.
4. Use the two 4-40 screws supplied with the A/D converter card to ensure that the plastic brackets anchor the relay card firmly on the backplane. Tighten the screws as needed.

1.3 User Interface

Figure 2 shows the circuit used to condition the analog signal before it goes to the A/D converter chip. Depending on the model of A/D converter card you have, it is designed to handle analog inputs of 0 V to 10 V, -10 V to +10 V, or 4–20 mA. The two different voltage ranges are handled with different gain resistors, R_g: 23.7 kΩ for the SR9300 and 12.1 kΩ for the SR9310. The input shown in Figure 2 is configured differently for the SR9320, which handles analog inputs of 4–20 mA.

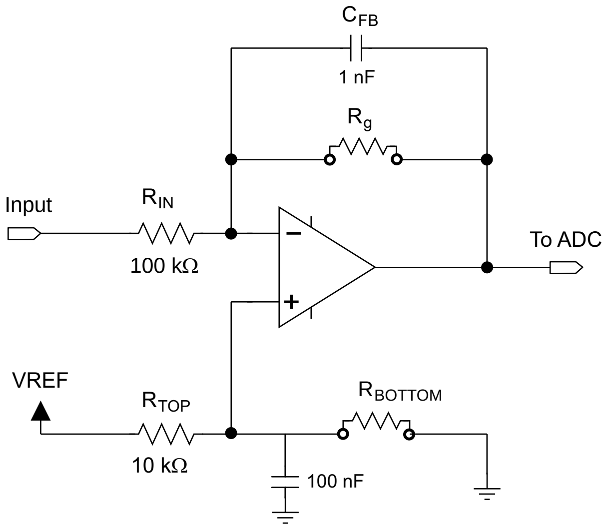


Figure 2. Analog Input Amplifier Circuit

Figure 3 shows the complete pinout for the user interface on header J2. Note that pin 1 is indicated by a small arrow on the ribbon cable connector.

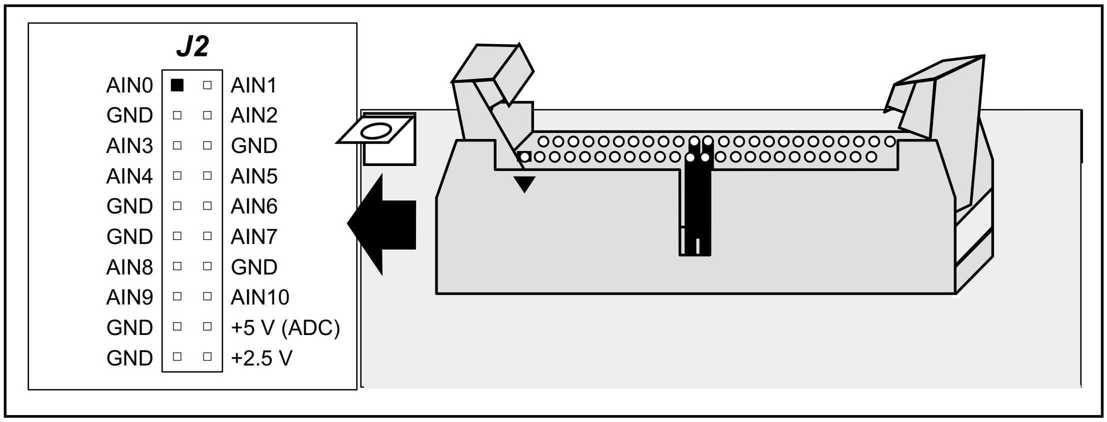
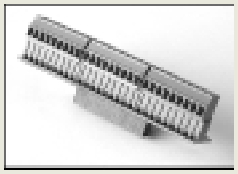
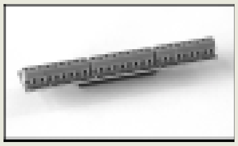


Figure 3. A/D Converter Card User Interface Pinout

1.4 User Connections

Connections to the A/D converter cards are made via a ribbon cable connector or optional field wiring terminals that are either pluggable or have screw terminals. Table 2 lists the the Z-World part numbers for the FWTs.

Table 2. Guide to FWT Selection

FWT Description	**I/O Cards**	**Z-World Part Number**	
		Pluggable Terminals 	**Screw Terminals** 
FWT18	A/D Converter	101-0421	101-0425

Appendix B, “Field Wiring Terminals,” provides further information on FWTs, including their dimensions and pinouts.

1.5 Power Distribution

Figure 4 shows the power distribution on the A/D converter card.

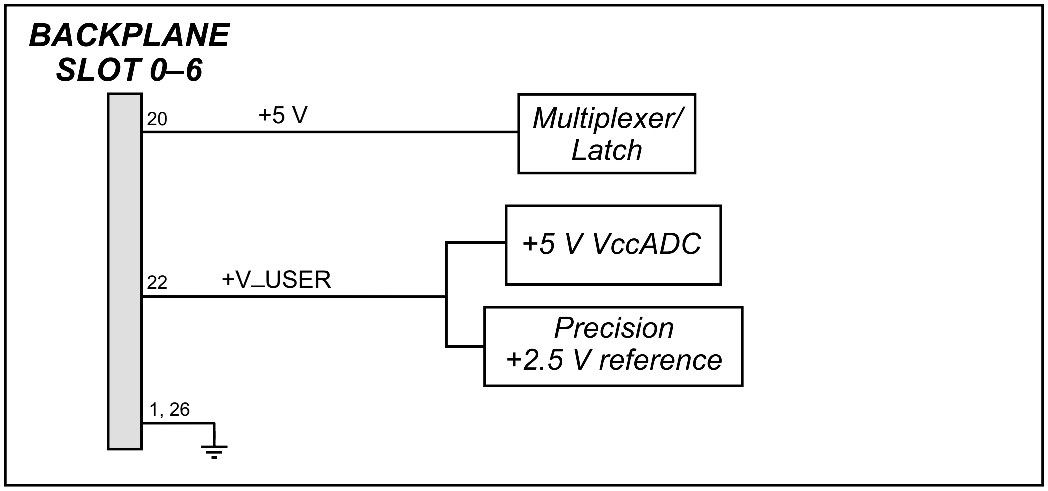


Figure 4. A/D Converter Card Power Distribution

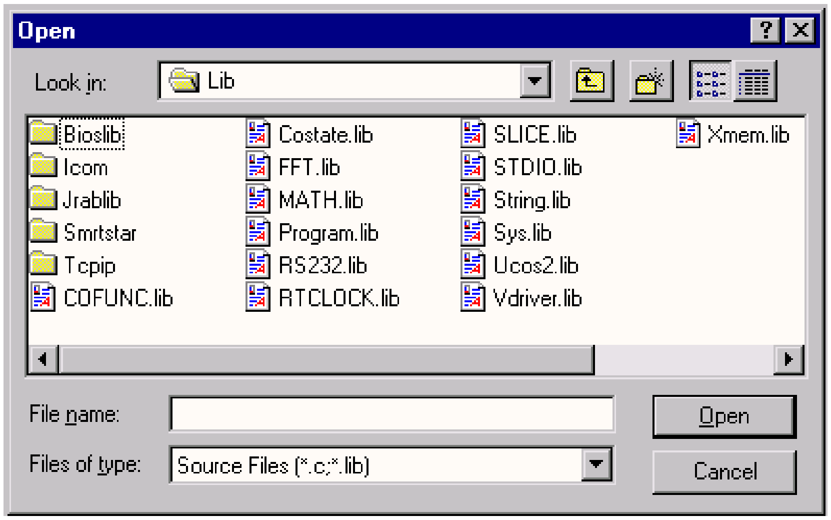
2. SOFTWARE

Dynamic C Premier is an integrated development system for writing embedded software. It runs on an IBM-compatible PC and is designed for use with Z-World controllers and other controllers based on the Rabbit microprocessor.

Chapter 2 provides the libraries, function calls, and sample programs related to the Smart Star A/D converter cards.

2.1 Dynamic C Libraries

With Dynamic C running, click **File** > **Open**, and select **`Lib`**. The following list of Dynamic C libraries and library directories will be displayed.



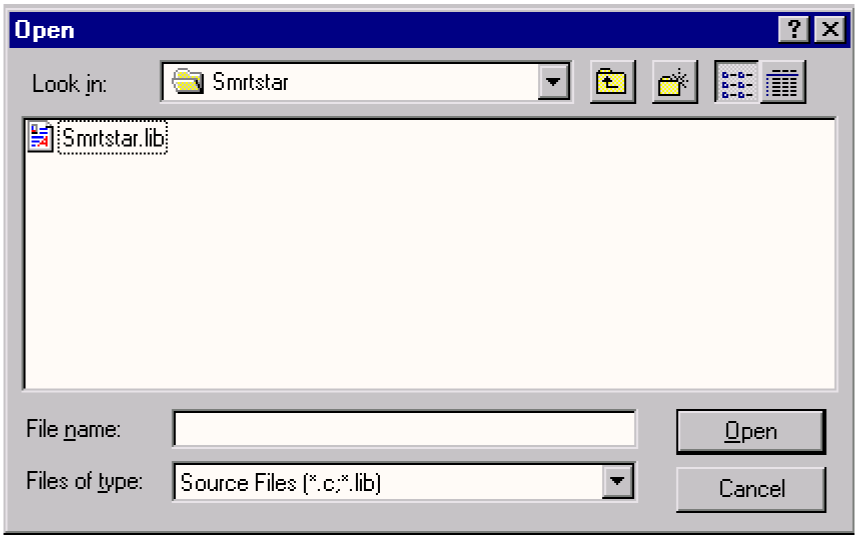
One library directory is specific to the Smart Star.

- **`SMRTSTAR`**—libraries associated with features specific to the Smart Star control system.

Other functions applicable to all devices based on the Rabbit 2000 microprocessor are described in the ***Dynamic C Premier User's Manual***.

2.1.1 Library Directories

The **SMRTSTAR** directory contains libraries required to operate the Smart Star control system.



- **SMRTSTAR.LIB**—This library supports all the functions needed by the Smart Star systems including digital I/O cards, relay cards, D/A converter and A/D converter cards, and serial communication.

Functions dealing with the A/D converter cards are described in this manual. Functions relevant to the other I/O cards are described in the manual specific to the I/O card. Functions dealing with the backplane and the CPU card are described in the ***Smart Start (SR9000) User's Manual***.

2.2 Smart Star A/D Converter Card Function APIs

`int anaInEERd(int channel);`

The A/D converter card calibration constants, gain, and offset are stored in the factory in the upper half of the EEPROM on the A/D converter card. Use this function to read the A/D converter card calibration constants, gain, and offset from the upper half of the EEPROM on the A/D converter card

Parameters

`channel` is the analog input channel. **`channel`** should be passed as

`channel = (slotnumber * 128) + (channelnumber)`

where **`slotnumber`** is 0–6, and **`channelnumber`** is 0–10

or

`channel = ChanAddr(slotnumber, channelnumber)`

where **`slotnumber`** is 0–6, and **`channelnumber`** is 0–10.

Return Value

0 if successful.
-1—control command unacceptable.
-2—EEPROM address unacceptable.

See Also

`anaInEEWr`

`int anaSaveCalib();`

The calibration constants may also be saved in the flash memory on the Smart Star CPU card. Doing so will speed up A/D conversions since a memory access from flash memory will be faster than from EEPROM. Use **`anaSaveCalib`** to save the current set of calibration constants for the analog input and output channels in the Smart Star flash memory. The calibration constants stored in flash memory can then be accessed at any time with the **`anaLoadCalib`** function.

If the factory-set calibration are not used, customer-measured calibration constants should first be established using the **`anaInCalib`** function.

Return Value

None.

See Also

`anaLoadCalib, anaInCalib`

`int anaLoadCalib();`

Reads a complete set of calibration constants for the analog input and output channels from the Smart Star flash memory on the CPU card. These should be set using the **`anaInCalib`** or **`anaInEERd`** function, then saved to flash memory using the **`anaSaveCalib`** function.

Return Value

None.

See Also

`anaSaveCalib, anaInCalib`

`void anaInCalib(int channel, int value1, float volt1,int value2, float volt2);`

Used to recalibrate the response of the A/D converter channel as a linear function using the two conversion points provided. Gain and offset constants are calculated and placed into the global table **`_adcCalib`**.

Parameters

`channel` is the A/D converter input channel (0–10). **`channel`** should be passed as

`channel = (slotnumber * 128) + (channelnumber)`

where **`slotnumber`** is 0–6, and **`channelnumber`** is 0–10

or

`channel = ChanAddr(slotnumber, channelnumber)`

where **`slotnumber`** is 0–6, and **`channelnumber`** is 0–10.

`value1` is the first A/D converter value.

`volt1` is the voltage corresponding to the first A/D converter value.

`value2` is the second A/D converter value.

`volt2` is the voltage corresponding to the first A/D converter value.

Return Value

0 if successful, -1, if not able to make calibration constants.

See Also

`anaIn, anaInVolts`

`int anaInEEWr(int channel);`

Writes the calibration constants, gain, and offset to the upper half of the EEPROM on the A/D converter card.

Parameters

`channel` is the analog input channel. **`channel`** should be passed as

`channel = (slotnumber * 128) + (channelnumber)`

where **`slotnumber`** is 0–6, and **`channelnumber`** is 0–10

or

`channel = ChanAddr(slotnumber, channelnumber)`

where **`slotnumber`** is 0–6, and **`channelnumber`** is 0–10.

Return Value

0 if successful.
-1—control command unacceptable.
-2—EEPROM address unacceptable.
-3—data value unacceptable.

See Also

`anaInEERd, _anaInEEWr`

`int anaIn(int channel);`

Reads the state of an analog input channel.

Parameters

`channel` is the analog input channel to read. **`channel`** should be passed as

`channel = (slotnumber * 128) + (channelnumber)`

where **`slotnumber`** is 0–6, and **`channelnumber`** is 0–10

or

`channel = ChanAddr(slotnumber, channelnumber)`

where **`slotnumber`** is 0–6, and **`channelnumber`** is 0–10.

Return Value

A value corresponding to the voltage on the analog input channel, 0–4095.

See Also

`anaInCalib, anaInVolts`

`int anaInVolts(int channel);`

Reads the state of an analog input channel and uses the previously set calibration constants to convert the state to volts.

Parameters

`channel` is the analog input channel. **`channel`** should be passed as

`channel = (slotnumber * 128) + (channelnumber)`

where **`slotnumber`** is 0–6, and **`channelnumber`** is 0–10

or

`channel = ChanAddr(slotnumber, channelnumber)`

where **`slotnumber`** is 0–6, and **`channelnumber`** is 0–10.

Return Value

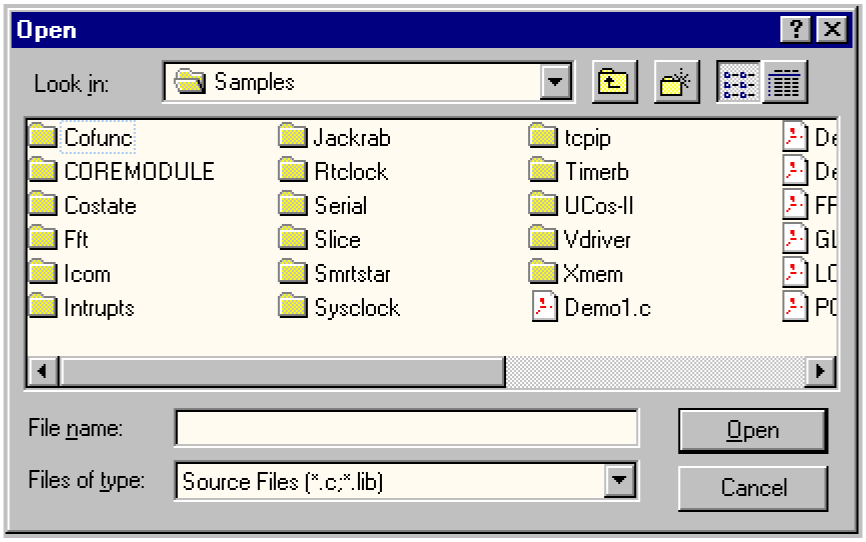
A voltage value corresponding to the voltage on the analog input channel, 0–4095.

See Also

`anaIn, anaInCalib`

2.3 Sample Programs

Sample programs are provided in the Dynamic C **`Samples`** folder, which is shown below.



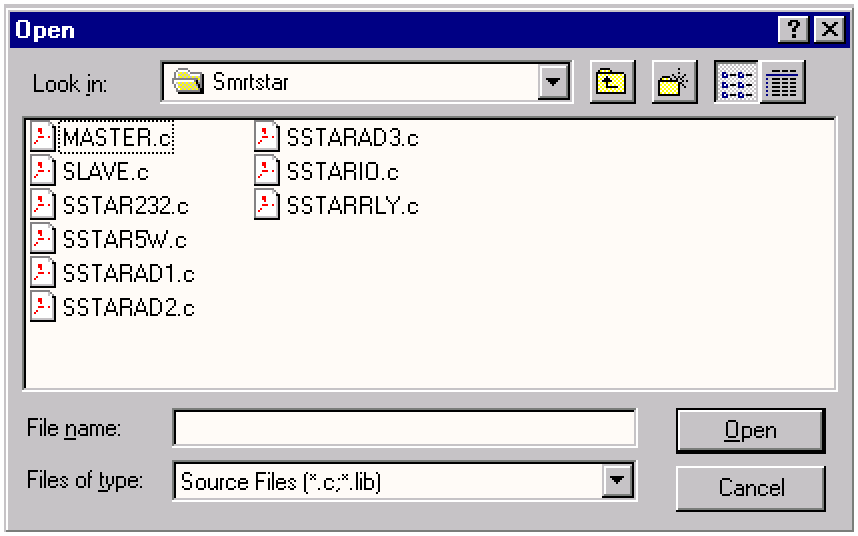
Look in: Samples

Files of type: Source Files (*.c;*.lib)

The various folders contain specific sample programs that illustrate the use of the corresponding Dynamic C libraries. For example, the sample program **`PONG.C`** demonstrates the output to the **STDIO** window.

The **`SMRTSTAR`** folder provides sample programs specific to the Smart Star control system. Each sample program has comments that describe the purpose and function of the program. Follow the instructions at the beginning of the sample program.

Let’s take a look at sample programs for the relay card in the **`SMRTSTAR`** folder.



Look in: Smrtstar

Files of type: Source Files (*.c;*.lib)

- **`SSTARAD1.C`**—Demonstrates how to calibrate an A/D converter channel using two known voltages, and defines the two coefficients, gain and offset. These coefficients are then read back to compute the equivalent voltage.
- **`SSTARAD2.C`**—Reads and displays voltage and equivalent values of each A/D converter channel. Calibrations must have been previously stored into flash memory before running this program. See sample program **`SSTARAD3.C`**.
- **`SSTARAD3.C`**—Demonstrates how to calibrate all A/D converter channels using two known voltages and defines the two coefficients, gain and offset. These coefficients are then read back to compute the equivalent voltage and are saved to flash memory.

2.4 Using Dynamic C

To run a sample program, open it with the **File** menu (if it is not still open), compile it using the **Compile** menu, and then run it by selecting **Run** in the **Run** menu. The CPU card must be in Program Mode (see Section 3.1, “Switching Between Program Mode and Run Mode,” in the ***Smart Start (SR9000) User’s Manual***) and must be connected to a PC using the programming cable as described in Section 2.3, “Programming Cable Connections,” in the ***Smart Start (SR9000) User’s Manual***.

More complete information on Dynamic C is provided in the ***Dynamic C Premier User’s Manual***.

APPENDIX A.

A/D CONVERTER CARD SPECIFICATIONS

Appendix A provides the specifications for the Smart Star A/D converter card.

A.1 Electrical and Mechanical Specifications

Figure A-1 shows the mechanical dimensions for the A/D converter card.

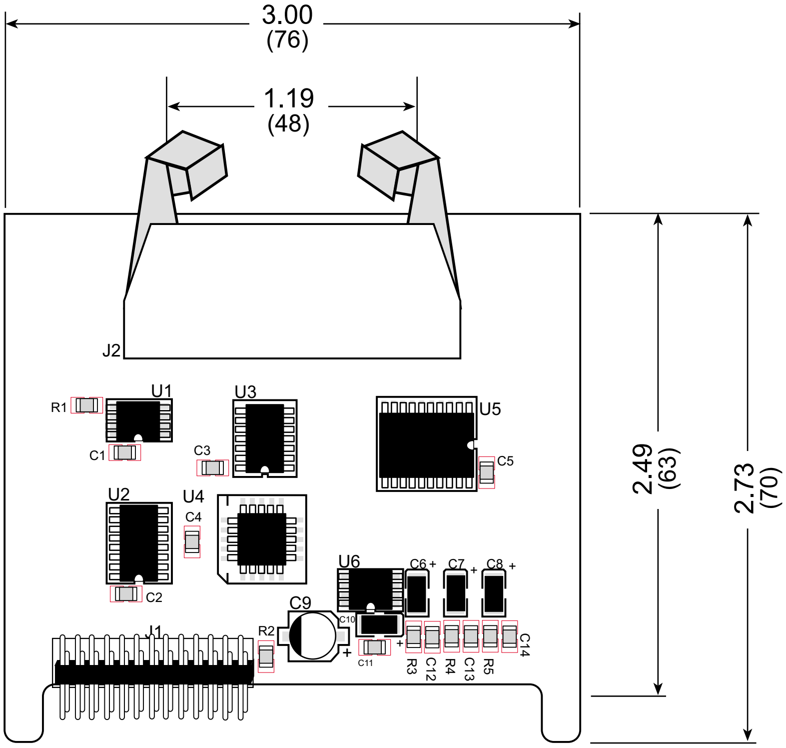


Figure A-1. Relay Card Dimensions

All diagram and graphic measurements are in inches followed by millimeters enclosed in parentheses.

Table A-1 lists the electrical, mechanical, and environmental specifications for the A/D converter card.

Table A-1. A/D Converter Card Specifications

Parameter	Specification
Board Size	2.73" × 3.00" × 0.44" (70 mm × 76 mm × 11 mm)
Connectors	one 2 × 10 latch/eject ribbon connector, 0.1 inch pitch
Operating Temperature	–40°C to +70°C
Humidity	5% to 95%, noncondensing
Power Requirements	5 V DC at 40 mA from backplane (+5 V supply) 9 V to 30 V DC, 35 mA at 24 V DC, **+RAW/+V_USER** from backplane
Number of Inputs	11 conditioned channels
Analog Input Ranges	0 V to +10 V, -10 V to +10 V, 4 mA to 20 mA
Resolution	12 bits (0–4095)
Conversion Time (including Dynamic C)	0.2 ms/channel
Input Stability	±½ count
Input Impedance	100 kΩ min. for 0 V to +10 V range
Linearity Error (end to end)	±1 count

APPENDIX B.

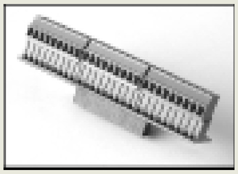
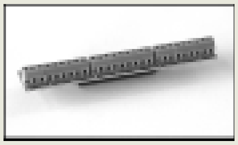
FIELD WIRING TERMINALS

Appendix B explains how to prepare the connector on an I/O card to accept a field wiring terminal, and how to secure the field wiring terminal to the I/O card. The dimensions for the field wiring terminals are included.

B.1 Selecting and Installing a Field Wiring Terminal

Connections to the I/O cards are made via a ribbon cable connector or optional field wiring terminals that are either pluggable or have screw terminals. Three different Field Wiring Terminals (FWTs) are available. Table B-1 lists the I/O cards and the Z-World part numbers for the corresponding FWTs.

Table B-1. Guide to FWT Selection

FWT Description	**I/O Cards**	**Z-World Part Number**	
		Pluggable Terminals 	**Screw Terminals** 
FWT27	Digital I/O (SR9200 series) Relay (SR9510)	101-0420	101-0424
FWT18	A/D Converter (SR9300 series) D/A Converter (SR9400 series)	101-0421	101-0425
FWT18R	Relay (SR9500)	101-0422	101-0426

Before you can install the FWT you selected for your I/O card, you must remove the tabs from the connector on the I/O card. To do so, move the tab inwards as shown in Figure B-1. Then insert a screwdriver into the space below the tab on the side of the connector and gently nudge the tab up and out. If you are careful, the tab will remain intact to be saved and snapped back in place for future use.

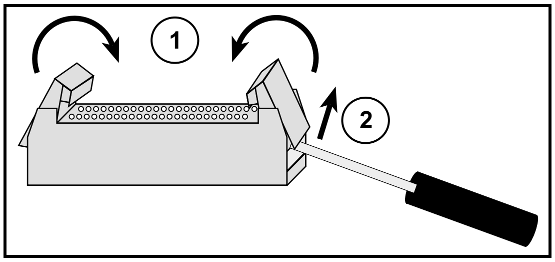


Figure B-1. Remove Tabs from Connector on I/O Card

Plug the FWT connector into the connector on the A/D converter card. Be sure to position the pluggable or screw connectors so that the edge of the FWT they are on faces outwards from the A/D converter card as shown in Figure B-2. Position the mylar insulator above the FWT as shown in Figure B-2 to protect the header pins on the printed circuit board, and secure the FWT using the two 4-40 × ¼ screws supplied.

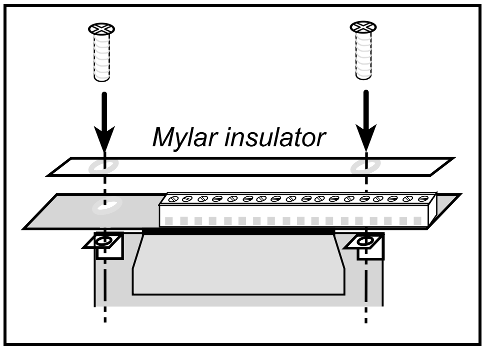


Figure B-2. Secure FWT to I/O Card

B.2 Dimensions

Figure B-3 shows the FWT dimensions.

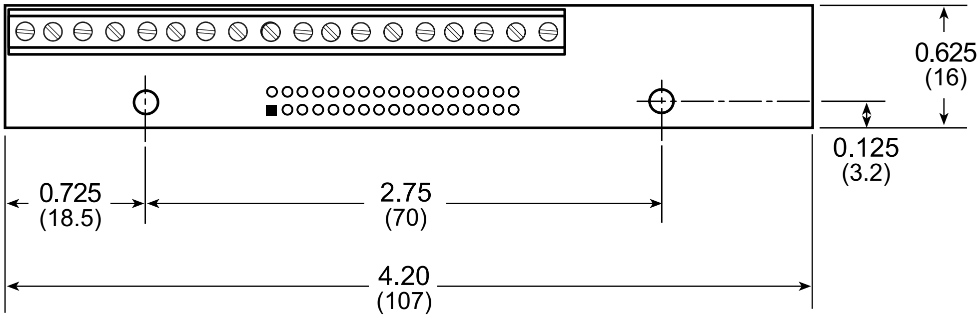


Figure B-3. FWT Dimensions

All diagram and graphic measurements are in inches followed by millimeters enclosed in parentheses.

B.3 Pinouts

Figure B-4 shows the pinout for the FWTs used on the A/D converter cards. Note that AIN0 is not available when using a FWT.

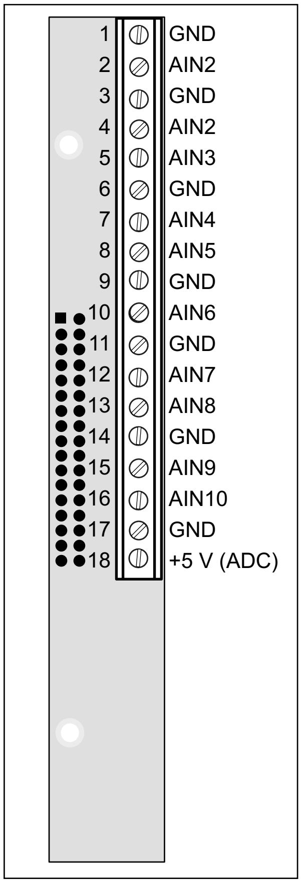


Figure B-4. FWT Pinout for A/D Converter Cards

APPENDIX C.
SMART STAR SLOT ADDRESS LAYOUT

Appendix C provides information about the register addresses for the various I/O card slots on the backplane. The information in this appendix will be of interest to more advanced users.

The slots on the Smart Star backplane are accessed as external registers via the Rabbit 2000's assembly **`IOE`** prefix or via standard Rabbit BIOS functions. More convenient functions specific to the Smart Star control system have been written to provide more flexibility; for example, there is now a provision for the automatic update of shadow registers for each slot and for each register.

The Smart Star design routes four address bits to each slot, providing 16 register addresses for each slot. These bits are passed through as bits 0–3 of the register address.   The slot number itself is assigned to bits 6–8 of the address. In addition, the backplane design requires that bits 13 and 14 be high and that bit 9 be low. The simplest way to enforce this is to use a base address of 0x6000. Table C-1 provides the address layout for accessing the Smart Star backplane slots, where S*n* is the binary representation of the slot number (0–6), R*n* is the binary representation of the register numbers (0–15), and *X* means the value does not matter.

Table C-1. Smart Star External Register Address Bitmap

A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
0	1	1	0	*X*	*X*	0	S2	S1	S0	*X*	*X*	R3	R2	R1	R0

This bit mapping of the external register address provides the register addresses for each slot as listed in Table C-2.

Table C-2. Slot External Register Addresses

Slot Number	Address Range
0	0x6000–0x600F
1	0x6040–0x604F
2	0x6080–0x608F
3	0x60C0–0x60CF
4	0x6100–0x610F
5	0x6140–0x614F
6	0x6180–0x618F

C.1 A/D Converter Card Channel Layout

The A/D converter card contains a single 11-input 12-bit A/D converter, TLC2543. The method of interfacing to this chip is a combination of single-bit writes via board registers and synchronous clocked serial access via the CPU card's serial port B, which is extended across all eight slots. In addition, a serial EEPROM is installed on the A/D converter card to store the calibration constants.

Table C-3. A/D Converter Card Control Registers

Address	Data Bits	Value	Description
0x0	Write D7–D0	D7–D4 selects input channel, D3–D0 selects conversion channel	Load A/D converter with data byte
0x0	Read D1	0	A/D converter end of conversion signal
		1	A/D converter busy
0x1	Write D0	0	Enable A/D conversion
		1	Disable A/D conversion
0x2	Write D0	0	EEPROM clock line low
		1	EEPROM clock line high
0x3	Write D0	0	EEPROM data line low
		1	EEPROM data line high
0x0	Read D2	0	EEPROM acknowledge signal
		1	EEPROM busy

INDEX

SCHEMATICS

090-0086 A/D Converter Card (SR9300) Schematic

090-0102 FWT18 Schematic

REVISION HISTORY			REVISION APPROVAL			
REV	ECO	DESCRIPTION	PROJECT ENGINEER	APPROVAL DATE	DOCUMENT CONTROL	APPROVAL DATE
A	----	PROTOTYPE RELEASE, TRACKS A/W @ REV-A	----	----	----	----
B	E11217	INITIAL RELEASE TRACK A/W @ REV-B				

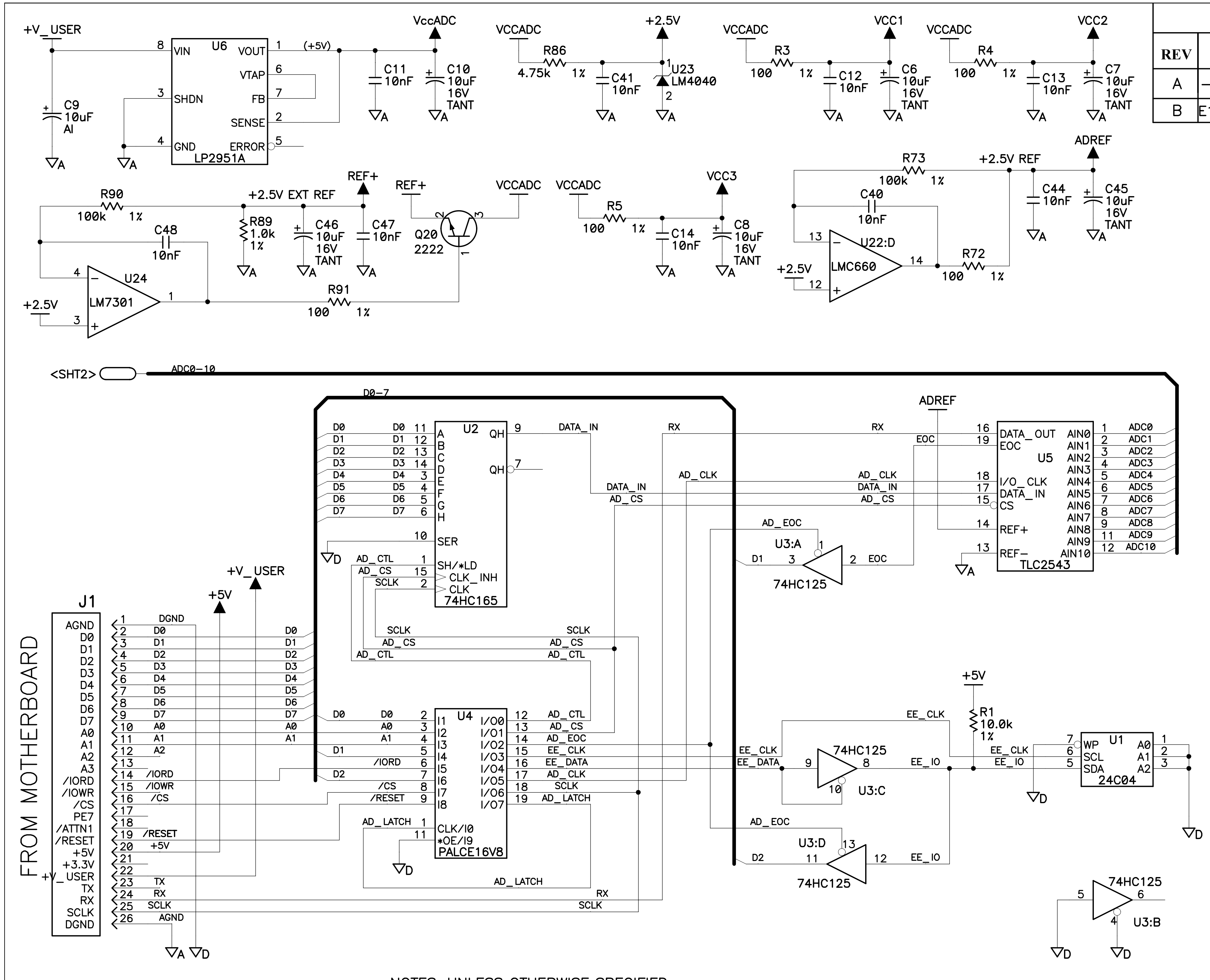
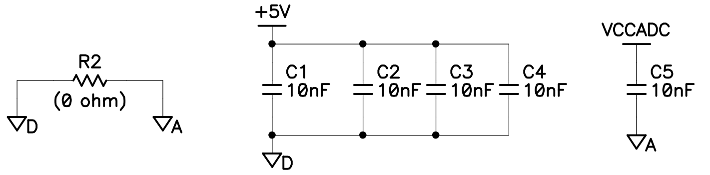


TABLE A

REF DES	DEVICE	DEVICE VOLTAGE INFORMATION									DEVICE: FILTER CAP REF DES(s)
		AGND	DGND	+5V	VCC1	VCC2	VCC3	ADREF	VCCADC	NC	
U1	24C04		4	8							C1
U2	74HC165		10	20						1,6,11,16	C2
U3	74HC125		7	14							C3
U4	PALCE16V8		10	20							C4
U5	TLC2543	10							20		C5, C44
U6	LP2951A										
U20	LMC660	11			4						C12
U21	LMC660	11				4					C13
U22	LMC660	11					4				C14
U23	LM4040										C41
U24	LM7301	2							5		C11



STUFFING TABLE

	CIRCUIT	PART	MODEL SR9300	MODEL SR9310
A/D INPUT CONDITIONING	GAIN RESISTOR	R32,39,40,47,48,55, R56,63,64,71,77	23.7k 1%	12.1k 1%
	BIAS RESISTOR	R34,37,42,45,50,53 R58,61,66,69,75	39.2k 1%	8.06k 1%
	EXCITATION SELECT OR 4-20mA SELECT	JP2,JP4,JP6,JP8 JP10,JP12,JP13 JP15,JP17,JP19 JP21	NOT INSTALLED	NOT INSTALLED
	EXCITATION VOLTAGE SELECT	JP1,JP3,JP5,JP7 JP9,JP11,JP14, JP16,JP18,JP20 JP22	NOT INSTALLED	NOT INSTALLED

NOTES: UNLESS OTHERWISE SPECIFIED;

1. ALL RESISTOR VALUES ARE IN OHMS, 1/10W, 5%
2. ALL CAPACITORS ARE 50VDC OR HIGHER.
3. THE ORIGINATION SOURCE OF A VOLTAGE IS REPRESENTED BY (VCC), AND ALL REFERENCES TO THAT VOLTAGE ARE REPRESENTED BY (VCC).

4 OUTLINED CIRCUIT MAY NOT BE STUFFED DEPENDING ON MODEL, SEE STUFFING CHART FOR CLARIFICATION.

5. COMPONENT VALUES SHOWN WITH AN ASTERISK (*) FOLLOWING THE VALUE, MAY HAVE DIFFERENT VALUES, OR MAY NOT BE STUFFED DEPENDING ON MODEL. SEE STUFFING CHART FOR CLARIFICATION..

APPEND THE FOLLOWING DOCUMENTS WHEN CHANGING THIS DOCUMENT:

DRAWING CONTENT:	
DRAWN BY: (INITIAL RELEASE) RAF	18JUN99
REVISED BY: KAH	19Nov00
APPROVALS: INITIAL RELEASE	
PROJECT ENGINEER:	
ENGINEERING MANAGER:	
SIGNATURES	DATE

TITLE

SCHEMATIC DIAGRAM
SR9300 SERIES
12-BIT 11-CHANNEL
A/D CONVERTER

SIZE **B**

DWG NO. 090-0086

SCALE NONE

RELEASE DATE

SHEET 1 OF 2

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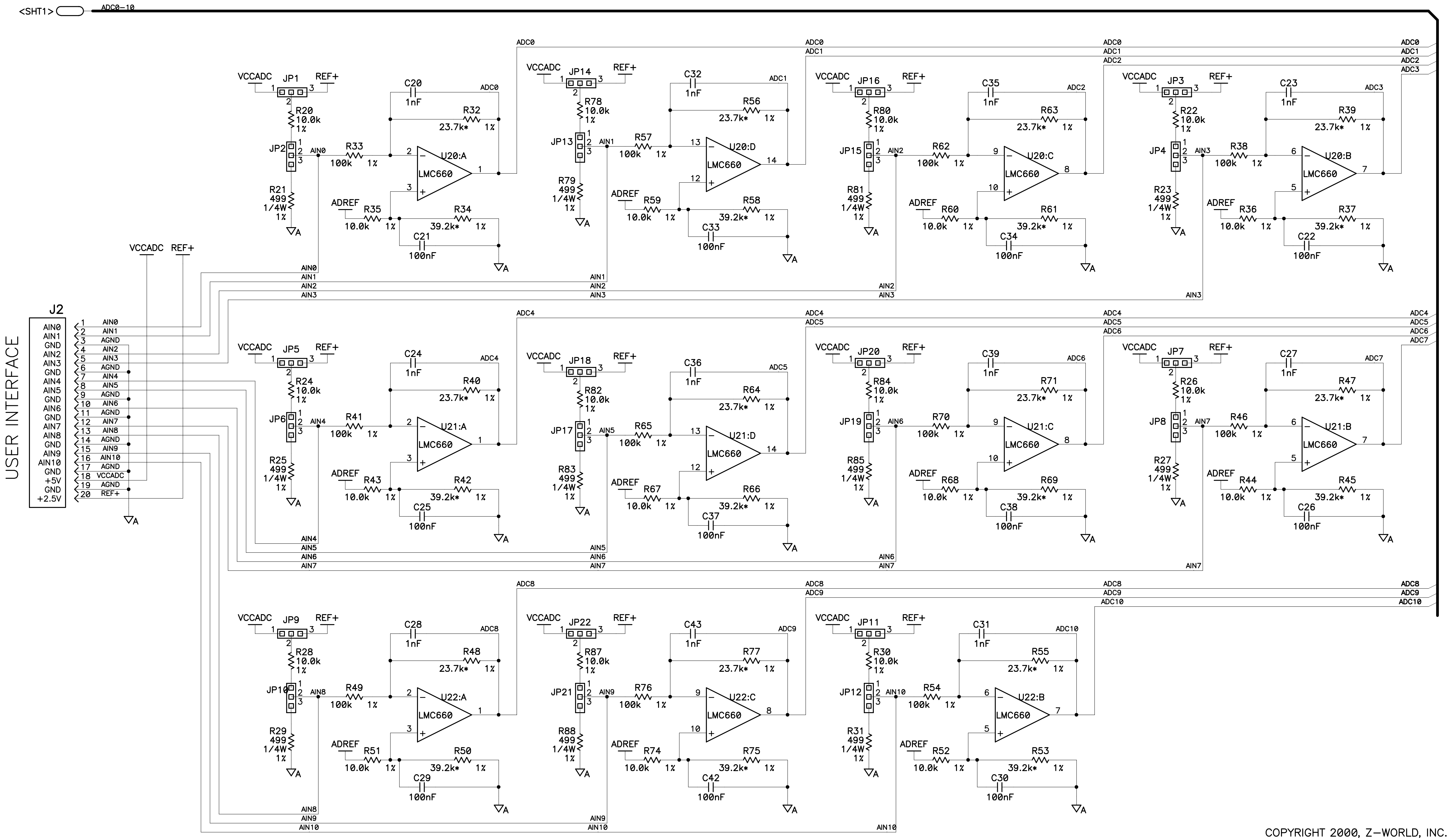

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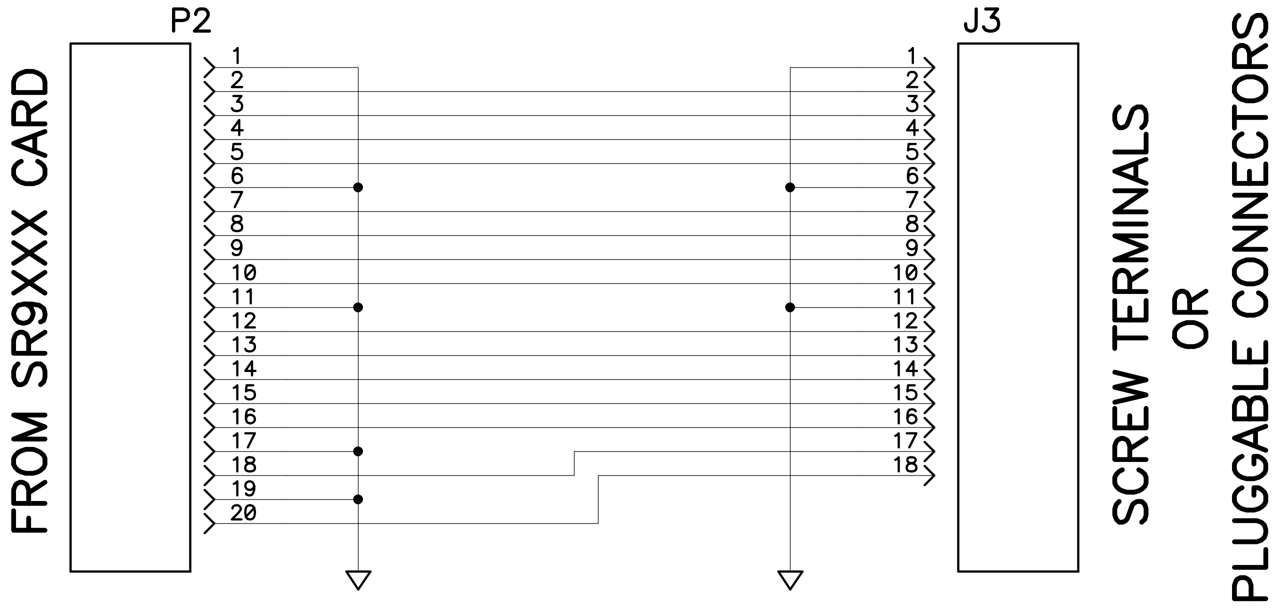
SIZE B	DWG NO. 090-0086		
SCALE NONE	REV LTR A	SHEET 2	OF 2

REVISION HISTORY			REVISION APPROVAL			
REV	ECO	DESCRIPTION	PROJECT ENGINEER	APPROVAL DATE	DOCUMENT CONTROL	APPROVAL DATE
A	E11217	INITIAL RELEASE				



APPEND THE FOLLOWING DOCUMENTS WHEN CHANGING THIS DOCUMENT:

DRAWING CONTENT:

DRAWN BY: (INITIAL RELEASE) KEITH HOEK	08DEC99
REVISED BY: KEITH HOEK	26Sep00
APPROVALS: INITIAL RELEASE	
PROJECT ENGINEER:	
ENGINEERING MANAGER:	
SIGNATURES	**DATE**

TITLE SCHEMATIC DIAGRAM
SR9XXX
18 POSITION
FIELD WIRING TERMINAL

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SIZE **A**
DWG NO. 090–0102

SCALE **NONE**
RELEASE DATE
SHEET 1 OF 1