Special Option

Model 3516-S100

32-channel, Scanning A/D Converter

December 30, 2003

*****Special Option*****

Model 3516-S100

The Model 3516-S100 is the same as the Model 3516-C1B and has been modified with 100 Hz filters.

December 30, 2003

CONTENTS

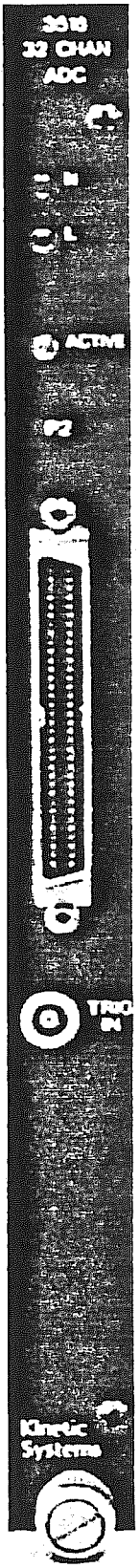
FIGURES

TABLES

32-channel Scanning A/D Converter

Provides 32 16-bit A/D channels w/programmable gain

3516



Features

- 32-channel capability
- 16-bit resolution (one part in 65,536)
- Programmable gain from 1 to 1024
- Programmable number of active channels
- Self-scanning
- External trigger
- Internal buffer memory
- Differential inputs
- High-frequency noise filtering on inputs
- Optional 6Hz lowpass filter available
- Unipolar and bipolar operation
- Strap-selectable inputs for temperature references

Typical Applications

- Temperature measurement
- Pressure measurement
- 4-20 mA control loop monitoring
- General analog monitoring

General Description

The 3516 is a single-width CAMAC module that converts 32 analog voltages into their equivalent digital values. This module contains a high-resolution analog-to-digital converter capable of resolving one part in 65,536. The inputs are scanned, and the results are stored in a 32-word memory, which can be read via the Dataway. The number of active (scanned) channels is software programmable. There are two software-selectable scan modes: Continuous and Single-scan. In Continuous mode, CAMAC Read cycles are asynchronous with the conversion process, eliminating overhead due to testing for converter busy. If it is desirable to synchronize scanning and reading, Single-scan mode can be used. In Single-scan mode, a LAM status is set after the last channel has been converted. In addition, the external trigger input can be used to synchronously trigger a single scan on multiple 3516s.

The 3516 contains a 4-bit, 32-word memory that can be loaded, on a channel-by-channel basis from the Dataway, with an appropriate gain factor for each differential input channel. Eleven gain values, from one to 1024, are available in binary progression. This allows one 3516 to measure a wide variety of input signal types (such as thermocouples, RTDs, high-level inputs, etc.). The C1B option features a single-pole, lowpass filter at the input of each channel. These filters provide a –3dB cutoff frequency of 6Hz.

When channel scanning is initiated, channel inputs are selected in succession. When a channel is selected, the preloaded gain factor is applied to the input signal, the amplified signal is converted, and the resultant binary information is stored in the on-board memory. Conversions take place at the rate of one every 250 microseconds (all 32 channels require eight milliseconds). The memory is configured in a dual-port fashion to facilitate retrieval of data with CAMAC block transfer operations. The 3516 is factory calibrated for inputs of ±10 volts.

All input signals are brought to the module through a 68-position high density SCSI connector mounted on the front panel. The external trigger can be brought in through a single-pin LEMO connector. Alternately, the 3516 may be strapped to accept an external trigger from the Dataway P1, P2, or P3 lines. An N LED flashes whenever the module is addressed, and an ACTIVE light indicates when the module is powered and scanning is

activated. A LAM LED is illuminated when a LAM request is pending.

To facilitate the use of this module in temperature monitoring systems, Channel 1 can be strapped to receive an isothermal reference from a V792-ZA11 Isothermal Termination Panel. Alternatively, this channel may be used to monitor any analog data.

For monitoring 4-20 mA control loop signals, standard practice is to mount a precision 250-ohm resistor external to the module (usually at the termination panel). This allows the 3516 to be removed from the circuit without disturbing the current loop. The V765-ZA11 Termination Panel can be used for this purpose.

Function Codes

Command		Q	Action
F(0) A(0)	RD1	1	Reads the Converted Data Memory, then increments the memory address
F(1) A(0)	RD2	$\overline{\text{SCAN}}$	Reads the Control Memory, then increments the memory address
F(8) A(0)	TLM	LR	Tests if a LAM request is set (Note 4)
F(9) A(0)	CL1	$\overline{\text{SCAN}}$	Stops channel scanning immediately and initializes the Converted Data Memory Address and Control Memory Address registers to zero.
F(10) A(0)	CLM	1	Clears the LAM status bit
F(11) A(0)	CL2	1	Clears the Control Memory Address register
F(11) A(1)	CL2	1	Clears the Converted Data Memory Address register
F(16) A(0)	WT1	$\overline{\text{SCAN}}$	Writes the Control Memory, then increments the memory address
F(16) A(1)	WT1	$\overline{\text{SCAN}}$	Writes the Last Channel register (data = 0 to 31 for address of last channel)
F(17) A(0)	WT2	$\overline{\text{SCAN}}$	Writes the Control Memory Address register. (Note 5)
F(17) A(1)	WT2	1	Writes the Converted Data Memory Address register. (Note 6)
F(24) A(0	DIS	1	Disables the LAM request
F(24) A(1)	DIS	1	Disables continuous scanning
F(25) A(0)	XEQ	$\overline{\text{SCAN}}$	Initiates a single scan operation, clears the LAM bit
F(26) A(0)	ENB	1	Enables the LAM request
F(26) A(1)	ENB	1	Enables continuous scanning, clears the LAM bit
F(27) A(0)	TST	LS	Tests if a LAM status is set. (Note 3)
Z S1	ZED		Stops channel scanning and initializes the Converted Data Memory and Control Memory Address registers

Notes:
1. X = 1 for all valid addressed commands
2. SCAN = channel scanning not in progress
3. LS = LAM status set
4. LR = LAM request set
5. For control Memory Address register valid addresses are 0 – 31, to represent Channels 1 – 32
6. For Converted Data Memory Address register valid addresses are 0 – 31, to represent Channels 1 – 32

32-channel Scanning A/D Converter

Item	Specifications
General	
Number of Channels	32 differential analog input channels
Gain Ranges	1, 2, 4, 8, 16, 32, 64, 128, 256, 512, and 1024
Input	
Input range	
Common-Mode	±10.5 V
Differential	±10 V
Input protection	±35 V continuous (C1B option), ±25 V continuous (C1A/S100 options)
Input impedance	22MΩ
Resolution	16-bit, no missing codes
Data Format	Two's complement (when configured for ±10 V bipolar range) Straight binary (when configured for 0-10 V unipolar range)
ADC Conversion Rate	4 kHz
External Trigger Source	Front panel single-pin LEMO connector, falling-edge TTL level CAMAC Dataway P1, P2, or P3 lines, falling-edge TTL level
Accuracy	Gain / Full-Scale Range (FSR) / 3516-C1B Accuracy (%FSR) / 3516-S100 Accuracy %FSR) 1 / ±10.000V / 0.035% / 0.020% 2 / ±5.000V / 0.050% / 0.020% 4 / ±2.500V / 0.070% / 0.030% 8 / ±1.250V / 0.080% / 0.030% 16 / ±625.000 mV / 0.080% / 0.040% 32 / ±312.500 mV / 0.090% / 0.040% 64 / ±156.250 mV / 0.090% / 0.050% 128 / ±78.125 mV / 0.100% / 0.065% 256 / ±39.0625 mV / 0.120% / 0.100% 512 / ±19.531 mV / 0.200% / 0.200% 1024 / ±9.766 mV / 0.300% / 0.250%
Noise (@ gain of 1024)	(C1B 11μV rms) (S100 7μV rms)
Crosstalk	(C1B 0.018% of OFF channel signal) - (S100 0.09% of OFF channel signal)
I/O Connector Types	One 68P High Density, one single-pin LEMO
Power Requirements	
+ 6 V	1.5 A
+24 V	80 mA
-24 V	70 mA

Ordering Information

3516-C1A	32-channel, 16-bit A/D Converter without filter
3516-C1B	32 channel, 16-bit A/D Converter with 6 Hz filter
3516-S100	32 channel, 16-bit A/D Converter with 100 Hz filter

Related Products

V765-ZA11	Rack-mount Termination Panel
V792-ZA11	Rack-mount Isothermal Termination Panel
5868-Dxyz	Cable: 68S High Density to 68P High Density

Specifications subject to change without notice.

INTRODUCTION

The Model 3516-C1B is a 32 channel 16-bit Analog-to-Digital Converter, with eleven digital programmable gain settings for each channel. Each channel also features a single-pole, low pass filter on the input. These filters provide a -3dB cutoff frequency of 6Hz. The module is fully tested and calibration is done at unity gain with an input range of ±10 volts. There are strap locations to change the Bipolar input range to 0-10 volt Unipolar range.

BIPOLAR/UNIPOLAR

The Model 3516-C1B can be strapped for ±10 volt Bipolar range, or 0 to 10 volt Unipolar range. For Bipolar, the module should be strapped STP10, STP11, and STP12 to the left, STP9 to the right and SW1 position 5 to the right. For Unipolar, the module should be strapped STP10, STP11, and STP12 to the right, STP9 to the left and SW1 position 5 to the left. (See Figures 3 & 4, pages 11 & 12 for Strap Locations)

OFFSET/GAIN ADJUSTMENT

The Model 3516-C1B is strapped and calibrated for the ±10 volt range. If the module is to be used in the 0 to 10 volt range, it may be necessary to recalibrate (adjust) the Model 3516-C1B using the procedure outlined below. Note that a DC power source with sufficient resolution and accuracy will be required to provide the calibration input voltages. A cable/ termination panel assembly will also be required to connect the output of the DC source to the 3516 channel inputs.

After connecting the DC source to the 3516 channel inputs, perform the following list of commands:

1.) Set each channel's gain to 1 by first performing an F(17)(A0) command with data of 0 to set the Control Memory Address register to channel 1. Then using the F(16)A(0) command, data of 0 is written to Control Memory bits 0-3 to set a gain of 1. After an F(16)A(0) command, the Control Memory Address register will increment by one allowing the user to execute another F(16)A(0) to the set the next consecutive channel's gain.
2.) Perform an F(16)A(1) command with data of 31 to set channel 32 in the Last Channel register.
3.) Set the DC voltage source to 0.000076 volts which is the zero transition voltage (0.000076V = ½ LSB above ground, 1 LSB=152.587μV).
4.) Perform an F(26)A(1) command to enable continuous scanning.
5.) Using the F(17)A(1) and F(0)A(0) commands, loop on reading each channel's converted data. Average all 32 channel's data and display the averaged data value in counts.
6.) Adjust the offset potentiometer PT3 for 0.5 counts.
7.) Set the DC voltage source to +9.999771 volts (+9.999771V = Full Scale – 3/2 LSB, 1 LSB = 152.587μV).

8.) Using the F(17)A(1) and F(0)A(0) commands, loop on reading each channel's converted data. Average all 32 channel's data and display the averaged data value in counts.
9.) Adjust the gain potentiometer PT4 for 65534.5 counts. Note that most systems will consider data bit 16 to be a sign bit. For Unipolar range, bit 16 will be a data bit; therefore, if a negative value is read, just add 65536 to adjust it (-1.5 + 65536 = 65534.5).

The same procedure should be used for the ±10 volt Bipolar range, except for offset adjustment, set the DC voltage source to –0.000153 volts and adjust PT3 for –0.5 counts. For gain adjustment, set the DC voltage source to +9.999542 volts and adjust the gain potentiometer PT4 for 32766.5 counts which is the last positive code transition (+9.999542V = Full Scale – 3/2 LSB = 1 LSB = 305.175μV).

ISOTHERMAL REFERENCE

For temperature monitoring systems using the Model 3516-C1B and the V792-ZA11, channel 1 on the Model 3516-C1B may be strapped to receive the Isothermal Reference from the V792-ZA11 Isothermal Panel. To use the Isothermal Reference, load jumper straps J1, J2, J3 and J4 see Figures 3 & 4, pages 11 & 12 for Strap Locations. The isothermal channel has an adjustment pot which is adjusted for room temperature of 25°C or 298°K. Every 1 mV change will correspond to 1°K.

EXAMPLE: At room temperature 298°K the ADC module will be 298 mV.

When the module is not used for temperature monitoring channel:

Channel Number 1 should be strapped STP1 and STP2.

MEASURING TEMPERATURES

Monitoring T/C channels is a little more complicated than reading standard analog inputs. Several additional steps need to be performed before the actual temperature can be determined. These steps are defined below.

The input circuit of a thermocouple is shown in Figure 1. Tj1 represents the true T/C. J4 represents the transition from T/C wire to copper on the Isothermal Panel. This creates two additional thermocouples. The junction CHx, represents the T/C input to the 3516. The junction REFx, represents the reference channel of the Isothermal Panel. The value of these is required in order to accurately calculate the true T/C temperature.

The inputs in detail:

1) The Reference channel.

   a. Selecting the proper gain. This is important in order to get the best input voltage range and increase accuracy. If the Reference Panel is expected not to exceed 39 degree Celsius, then a gain of 32 will work fine.

   b. Calculating the temperatures. A sequence of events is performed to calculate the actual input temperature. The first of which is to calculate the reference channel. The reference channel is calibrated at the factory for 25 Degrees Celsius or 298 Kelvin. In terms of actual volts, the input is .298 volts. Every .001 volt change is equivalent to 1 Kelvin. To find out what the actual temperature we would perform this sequence of events:

      i) Read the reference channel to get the raw count value.

      ii) Convert the raw count value to millivolts, using the following formula:
      mv = count value * .000009536
      (3516 Gain of 32 = 9.536μVolts/LSB)

      iii) Convert the mv value to degrees C, using the following formula:

      Degrees C = mv - 273

   If we were to read 31774 counts from the reference channel we would calculate the following:

   i) .303 = 31774* .000009536

   ii) 30 = 303 - 273

   Plugging in the numbers above we find that the reference panel is 30 degrees Celsius. Knowing this we can now look at the actual T/C channel.

2. The Thermocouple channel.

   a) Selecting the proper gain. This is important in order to get the best input voltage range and increase accuracy. If the T/C is expected to be with certain range, then you could adjust the range to narrow the band and increase the accuracy. Typically, a gain of 256 would be fine. Again, this depends on the type of thermocouple and the range you are going to measure.

b) Calculating the temperature. As in the previous example, we had to convert the raw value to an engineering unit. Use the following formula:

i) Read the thermocouple channel to get the raw count value.

ii) Convert the raw count value to millivolts, using the following formula:

mv = count value * .000001192
(3516 Gain of 256 = 1.192 μVolts/LSB)

iii) Convert the mv value to degrees C. There are several ways to calculate this. For this example we would look up the value in the NIST Standards manual for Thermocouple References.

If we were to read 19715 counts from the T/C channel, we would calculate the following:

i) 19715 * .000001192 = .0235 or 23.5 mv

ii) Looking at the Thermocouple Reference Table for a J type T/C, we find

23.5 mv = 430 Degrees C

c) Calculating the Actual temperature. Now that we have the temperature for the reference channel and the thermocouple channel, we can now determine the real temperature. Using the initial formula, we can plug in the numbers.

T/C - Reference Channel = Tj1

430 - 30 = 400 Degrees Celsius

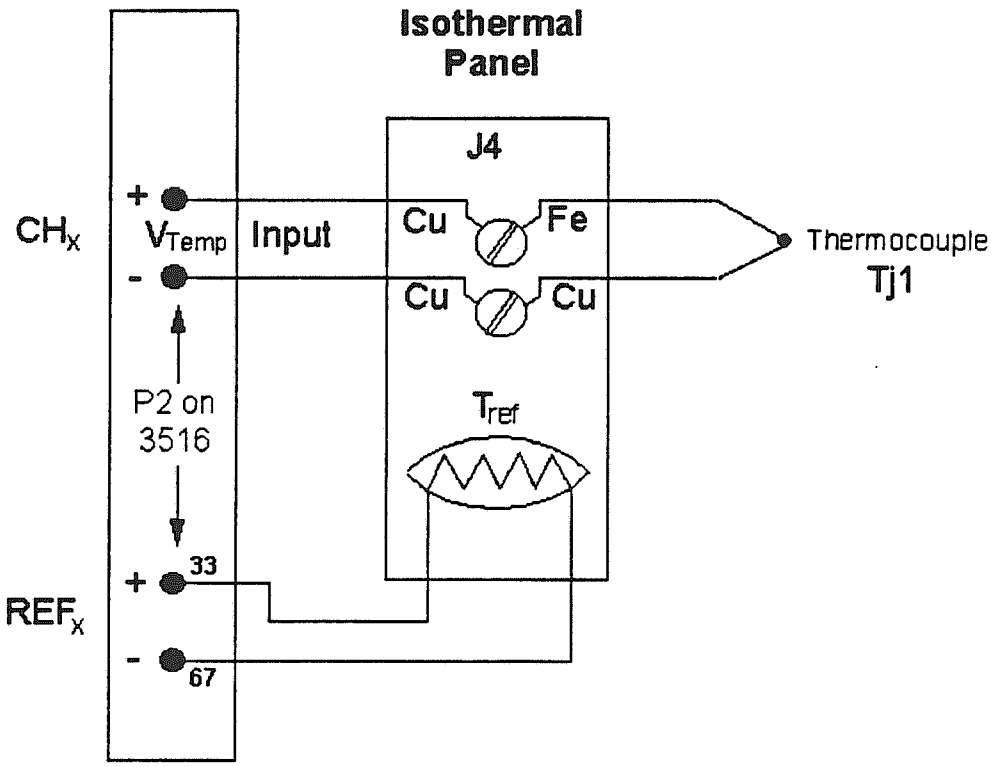


FIGURE 1 - 3516 Isothermal Panel

SYSTEM SETUP

The first step in using the Model 3516-C1B is to set the appropriate gain factor for each channel. The Control Memory of the Model 3516-C1B contains the GAIN settings for each of the 32 channels. This is a 4-bit memory which can be loaded from the CAMAC dataway. By using the F(17)A(0) command, the Control Memory Address Register is written with the selected channel. Data will range from 0-31 to represent channels 1-32. Then, using the F(16)A(0) command, the appropriate GAIN factor is written to the selected channel. There are eleven GAIN settings, from one to 1024, available in a binary progression, as listed below:

CONTROL MEMORY

BIT 3	BIT 2	BIT 1	BIT 0

CONTROL MEMORY GAIN FACTORS FOR BIPOLAR RANGE

DATA	GAIN FACTOR	RANGE	LSB
0	1	±10.000v	305.175µv
1	2	±5.000v	152.580µv
11	4	±2.500v	76.290µv
101	8	±1.250v	38.150µv
110	16	±625.000mv	19.073µv
1000	32	±312.500mv	9.536µv
1001	64	±156.250mv	4.768µv
1011	128	±78.125mv	2.384µv
1100	256	±39.0675mv	1.192µv
1101	512	±19.530mv	596.046nv
1111	1024	±9.765mv	298.023nv

CONTROL MEMORY GAIN FACTORS FOR UNIPOLAR RANGE

DATA	GAIN FACTOR	RANGE	LSB
0	1	+10.000v	152.580μv
1	2	+5.000v	76.290μv
11	4	+2.500v	38.250μv
101	8	+1.250v	19.073μv
110	16	+625.000mv	9.536μv
1000	32	+312.500mv	4.768μv
1001	64	+156.250mv	2.384μv
1011	128	+78.125mv	1.192μv
1100	256	+39.0675mv	596.046nv
1101	512	+19.530mv	298.023nv
1111	1024	9.765mv	149.011nv

After an F(16)A(0) command, the Control Memory Address Register will increment by one, thereby allowing the user to execute another F(16)A(0) to the next consecutive channel. This feature eliminates the need to execute another F(17)A(0) command to set the next channel. It is advisable at this point, if any of the 32 channels will not be used; to set those channel gain factors to one. If the need arises, each channel gain factor may be verified by the command F(1)A(0). This command is preceded by the F(17)A(0) to the Control Memory Address Register. The F(1)A(0) command will also increment the Control Memory Address Register to the next consecutive channel. This will allow for convenient verification of all gain factors.

NOTE: In order to execute the CAMAC commands, F(1)A(0), F(16)A(0), and F(17)A(0), the Model 3516 scanning must be disabled.

SCANNING FORMATS

Once all the gains are set, the module is ready to start scanning. There are two scanning formats. The first format is a single scan operation initiated by an F(25)A(0) command. In this format, the module will scan all 32 channels once, store the converted data on each channel, and then set the LAM status to indicate that the single scan operation is complete. The second format is continuously scanned, and the converted data for each channel is updated every 8 milliseconds.

READING

The module 3516-C1B has the capabilities of being read while the module is in a scanning process. The first step is to write the Converted Data Memory Address Register with the selected channel to be read. This is done by using the F(17)A(1) command with data of 0-

31 to represent channels 1-32. After the selected channel address is written, the F(0)A(0) command will read the 16-bit 2's complement word stored for that channel. The read command will also increment the Converted Data Memory Address Register to the next consecutive channel thus allowing all channels to be read without having to execute other F(17)A(1) commands.

DISABLING SCAN

There are two ways of disabling the scanning process. The first method is by executing an F(9)A(0) which is the STOP IMMEDIATE command. When this command is initiated, the module will stop scanning after the present channel is converted. The Converted Data Memory Address Register and the Control Memory Address Register will be reset to zero and the LAM Status Bit will be set to indicate that scanning has been disabled. The other method is the F(24)A(1) command which will disable scanning after all 32 channels have been scanned. For example, if the Model 3516-C1B scanning sequence is at channel 9 when the F(24)A(1) is executed, the module will continue on until the channel 32 is scanned. The LAM Status Bit will be set to indicate that scanning is disabled.

LAMS

The model 3516-C1B contains one LAM Status Bit to indicate that the scanning process has been disabled. To test for the LAM Status Bit, the F(27)A(0) command is used. If the bit is set, a AQ@ response of 1 will be returned for the F(27)A(0). The module may also generate a LAM Request Signal on the CAMAC dataway. An F(26)A(0) command is executed to enable the LAM Request Signal and an F(24)A(0) is used to disable the LAM Request Signal. To test for the LAM Request Signal, the F(8)A(0) command is used. If LAM Request is set, a AQ@ response of 1 will be returned for the F(8)A(0).

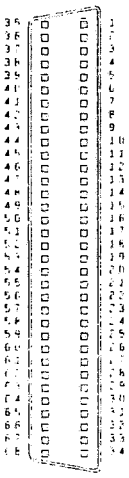
Clearing of the model 3516-C1B LAM Bit may be done in several ways. One way is by the F(10)A(0) command. Another is the F(25)A(0) single scan command, and another is the F(26)A(1) enable scan command.

CLEARING ADDRESS REGISTERS

To minimize software overhead, two clear commands have been added to the 3516-C1B module. The F(11)A(0) command is used to clear the address register for the control memory. The F(11)A(1) command is used to clear the address register for the converted data memory.

Please note that both F(11) commands rely on the CAMAC write data lines being pulled up on the backplane. The CAMAC standard specifies that the write lines cannot be driven during a control command. Therefore, these commands will not work with a non-standard crate controller that puts data out on the write lines during an F(11) or other control command.

Figure 2 - 68 Pin High Density Connector P2



P2

Note: Connector P2 is orientated with pin 1 and 35 on the bottom (connected mounted upside down)

Table 1 - 68 Pin High Density Connector: P2 Pinout

Pin #	P3 Description	Pin #	P3 Description	Pin #	P3 Description
1	Channel 1 +	13	Channel 13 +	25	Channel 25 +
35	Channel 1 -	47	Channel 13 -	59	Channel 25 -
2	Channel 2 +	14	Channel 14 +	26	Channel 26 +
36	Channel 2 -	48	Channel 14 -	60	Channel 26 -
3	Channel 3 +	15	Channel 15 +	27	Channel 27 +
37	Channel 3 -	49	Channel 15 -	61	Channel 27 -
4	Channel 4 +	16	Channel 16 +	28	Channel 28 +
38	Channel 4 -	50	Channel 16 -	62	Channel 28 -
5	Channel 5 +	17	Channel 17 +	29	Channel 29 +
39	Channel 5 -	51	Channel 17 -	63	Channel 29 -
6	Channel 6 +	18	Channel 18 +	30	Channel 30 +
40	Channel 6 -	52	Channel 18 -	64	Channel 30 -
7	Channel 7 +	19	Channel 19 +	31	Channel 31 +
41	Channel 7 -	53	Channel 19 -	65	Channel 31 -
8	Channel 8 +	20	Channel 20 +	32	Channel 32 +
42	Channel 8 -	54	Channel 20 -	66	Channel 32 -
9	Channel 9 +	21	Channel 21 +	33	Isothermal Ref-
43	Channel 9 -	55	Channel 21 -	67	Isothermal Ref+
10	Channel 10 +	22	Channel 22 +	34	Ground
44	Channel 10 -	56	Channel 22 -	68	Ground
11	Channel 11 +	23	Channel 23 +		
45	Channel 11 -	57	Channel 23 -		
12	Channel 12 +	24	Channel 24 +		
46	Channel 12 -	58	Channel 24 -		

Figure 3 shows the factory setting for ±10-volt Bipolar Range, and temperature compensation disabled.

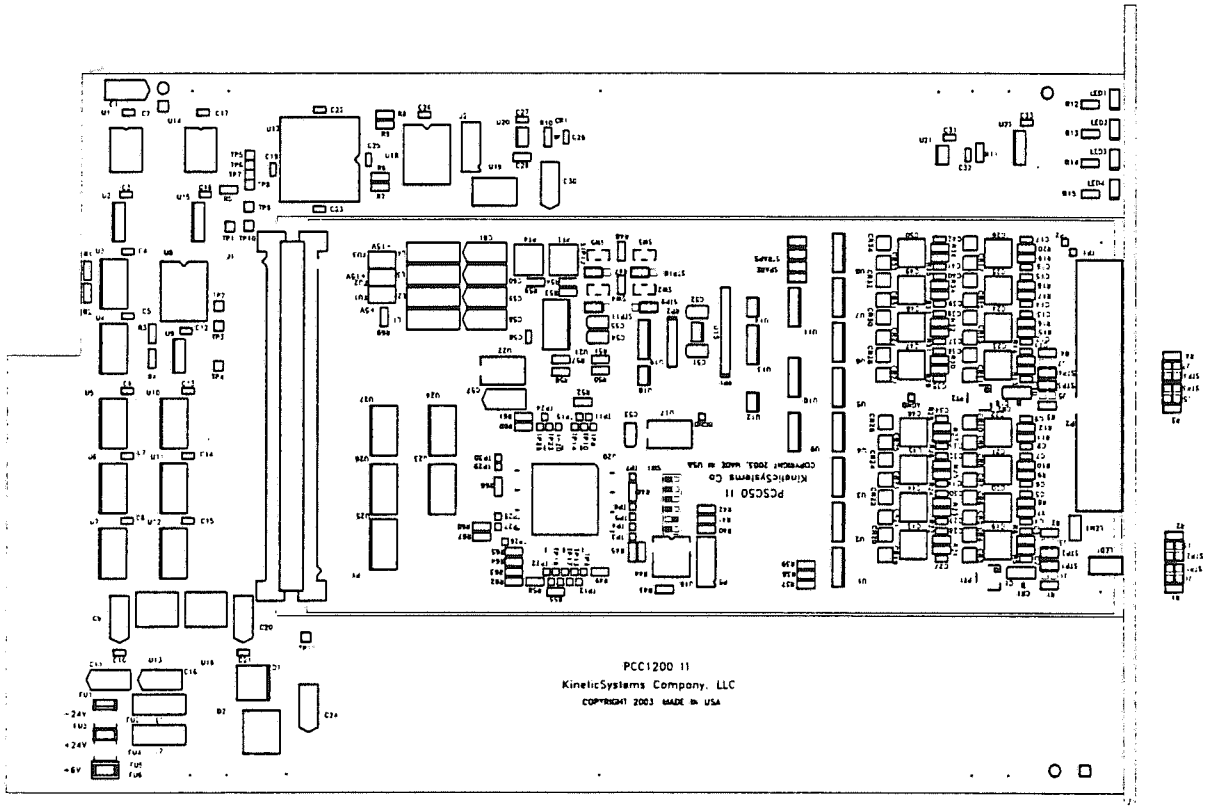


FIGURE 3 - MODEL 3516-C1B STRAP LOCATIONS

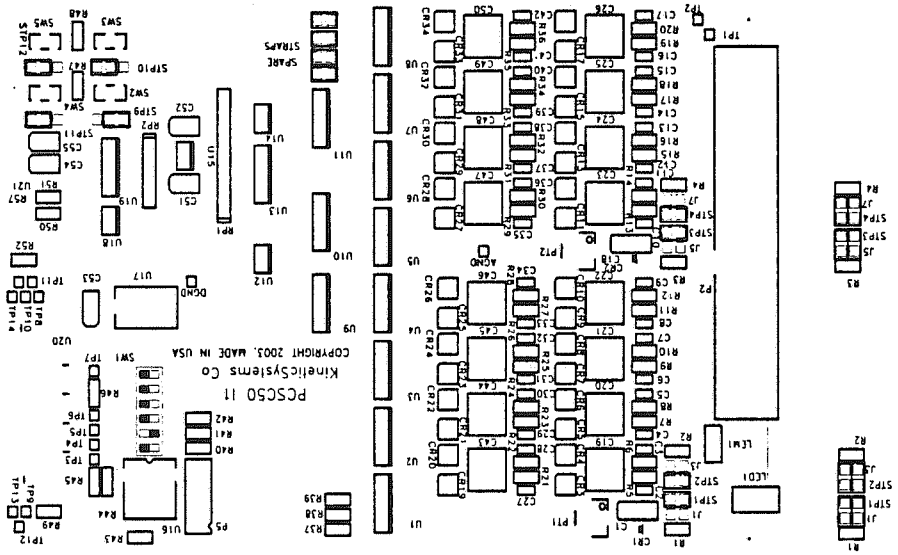


FIGURE 4 - MODEL 3516-C1B Strap Location - Close-up View
Module is inverted when plugged into adapter.

WARRANTY

KineticSystems Company, LLC warrants its standard hardware products to be free of defects in workmanship and materials for a period of one year from the date of shipment to the original end user. Software products manufactured by KineticSystems are warranted to conform to the Software Product Description (SPD) applicable at the time of purchase for a period of ninety days from the date of shipment to the original end user. Products purchased for resale by KineticSystems carry the original equipment manufacturer's warranty.

KineticSystems will, at its option, either repair or replace products that prove to be defective in materials or workmanship during the warranty period.

Transportation charges for shipping products to KineticSystems shall be prepaid by the purchaser, while charges for returning the repaired warranty product to the purchaser, if located in the United States, shall be paid by KineticSystems. Return shipment will be made by UPS, where available, unless the purchaser requests a premium method of shipment at their expense. The selected carrier shall not be construed to be the agent of KineticSystems, nor will KineticSystems assume any liability in connection with the services provided by the carrier.

The product warranty may vary outside the United States and does not include shipping, customs clearance, or any other charges. Consult your local authorized representative or reseller for more information regarding specific warranty coverage and shipping details.

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1. Contact KineticSystems and discuss the problem with a Technical Service Engineer.
2. Obtain a Return Authorization (RA) Number.
3. Initiate a purchase order for the estimated repair charge if the product is out of warranty.
4. Include a description of the problem and your technical contact person with the product.
5. Ship the product prepaid with the RA Number marked on the outside of the package to:

KineticSystems Company, LLC
Repair Service Center
900 North State Street
Lockport, IL 60441

Telephone: (815) 838-0005
Facsimile: (815) 838-4424
Email: tech-serv@kscorp.com