Model 3518-Z1A

16-bit, Scanning A/D Converter Host

INSTRUCTION MANUAL

January, 1991

Special Option

Model 3518-S002

16-bit, Scanning A/D Converter Host

December, 1992

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

Model 3518-S002

The Model 3518-S002 is the same as the Model 3518-Z1A except that scanning is synchronous at a rate of 125 Hz. The basic operation of the module is not affected.

RMF:rem
December 30, 1992

CONTENTS

KineticSystems Corporation

Standardized Data Acquisition and Control Systems **3518**

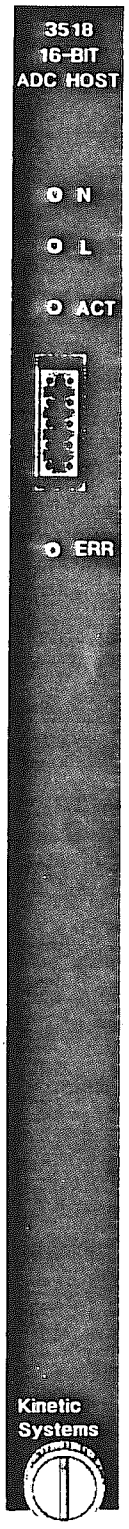
16-bit, Scanning A/D Converter Host

FEATURES

- **Signal conditioning input modules (such as 3564, 3565) accommodated**
- **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**

APPLICATIONS

- **Jet and rocket engine testing**
- **Temperature measurement**
- **Pressure measurement**
- **General analog monitoring**



GENERAL DESCRIPTION

The Model 3518 is a single-width CAMAC module containing a high-resolution analog-to-digital converter capable of resolving one part in 65,536 (16-bits). This module is used in conjunction with companion input conditioning modules (such as the Models 3564 4-channel Strain Gage w/Filter and 3565 8-channel RTD w/Filter) to form a signal-conditioned, scanning A/D subsystem. Up to 32 input channels are accommodated by the 3518. The number of active (scanned) channels is software programmable. The inputs are scanned, and the results are stored in a 32-word memory which can be read via the Dataway. There are two software-selectable scan modes, continuous and single-scan. With continuous mode, CAMAC Read cycles are asynchronous with the conversion process, eliminating any overhead due to testing for a converter busy. If it is desirable to synchronize scanning and reading, the single-scan mode is used. In this mode, a LAM status is set after the last channel has been converted. In addition, external triggering may be used to synchronously trigger a single scan on multiple 3518s.

The 3518 contains a 4-bit, 32-word memory which can be loaded on a channel-by-channel basis from the Dataway with an appropriate gain factor applied to each differential input signal. Eleven gain factors, from one to 1024, are available in a binary progression. This allows one 3518 to measure a wide variety of input signal types (such as thermocouples, RTDs, high-level inputs).

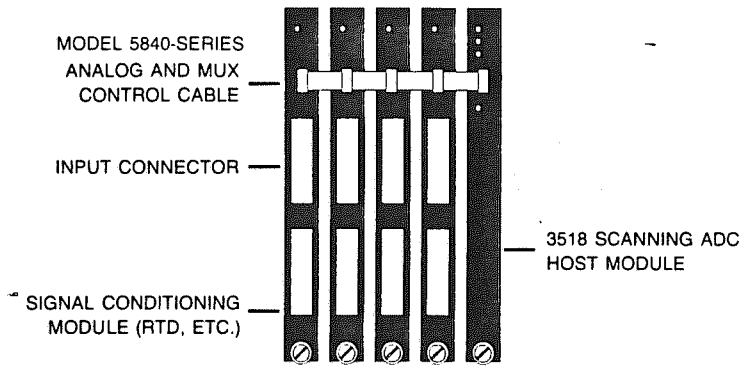
Once channel scanning is initiated, each channel's input is selected, the preloaded gain factor is applied to it, the amplified signal is converted, and the resultant binary information is stored in the on-board memory. Conversions take place at the rate of one every 250 microseconds (all 32 channels in eight milliseconds). The memory is configured in a dual-ported fashion to facilitate retrieval of data with CAMAC block transfer operations. The 3518 is precalibrated for ± 10 volt inputs.

FRONT PANEL

The analog input signal from the companion signal conditioning modules and the multiplexer control signals to these modules are contained in a 10-wire flat ribbon cable that is connected via the 3518 front panel. The KineticSystems Model 5840-Series of 10-conductor, flat-ribbon cable assemblies mates directly to the front-panel connector. The external trigger is brought in through a single-pin LEMO connector. Alternately, the 3518 may be strapped to accept an external trigger from the Dataway P1, P2, or P3 lines. An N LED flashes whenever the 3518 is addressed, and an ACTIVE LED is lighted when the module is powered and scanning is activated. A LAM LED is lighted when a LAM request ispending, and an ERROR LED flashes when a multiplexer address conflict exists in the companion modules. All input multiplexers are disabled until the error condition is resolved by correct switch settings in the companion modules.

11 Maryknoll Drive • Lockport, IL 60441 • (815) 838 0005 • TWX 910 638 2831 • FAX (815) 838 4424

TYPICAL ANALOG SUBSYSTEM



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 whether a LAM request is set. (See Note 4.)
F(9)·A(0)	CL1	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. (See Note 5.)
F(17)·A(1)	WT2	1	Writes the Converted Data Memory Address register. (See 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 whether a LAM status is set. (See Note 3.)
Z·S2	ZED		Stops channel scanning and initializes the Converted Data Memory and Control Memory Address registers; sets Last Channel register = 31.

Notes:
1. X = 1 for all valid addressed commands.
2. $\overline{\text{SCAN}}$ = 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.

POWER REQUIREMENTS

+24 volts — 80 mA
−24 volts — 70 mA
+6 volts — 1.5 A

ORDERING INFORMATION

Weight: .89 kg. (1 lb. 14 oz.)

Model 3518-Z1A — 16-bit, Scanning A/D Converter Host

Accessories — Model 3563 16/32-channel Thermocouple Signal Conditioner
Model 3564 4-channel Strain Gage Signal Conditioner
Model 3565 8/16-channel RTD Signal Conditioner
Model 3569 16/32-channel Analog Multiplexer
Model 5840-Series Cable Assemblies

3518 SPECIFICATIONS

Input Impedance - 22 MΩ

Overvoltage Protection - ±35V

Common Mode Rejection - 110dB at DC to 1Hz
6dB/Octave rolloff to 70dB at 1KHz

Cross talk - 0.005% of OFF channel signal

TABLE 1 - 3518 TOTAL ERROR[1]

	G = 1	G = 16	G = 512	G = 1024
Quantization Error (% of FSR)	±0.0008	±0.0008	±0.0008	±0.0008
Linearity Error (% of FSR)	±0.003	±0.003	±0.003	±0.003
Gain Error[2] (%of FSR)	(±0.203)	(±0.203)	(±0.203)	(±0.203)
Offset Error[2] (% of FSR)	(±0.2)	(±0.2)	(±0.21)	(±0.224)
Differential Linearity (% of FSR)	±0.003	±0.003	±0.003	±0.003
Gain Non-Linearity (% of FSR)	±0.0022	±0.0022	±0.01	±0.01
Droop Error (% of FSR)	±0.0001	±0.0001	±0.0001	±0.0001
Total Error[3] (% of FSR)	**±0.0048**	**±0.0048**	**±0.011**	**±0.011**

NOTES:

1 Calculated by Root-Sum-Square method:

$$(E_{RSS} = \sqrt{e^2_1 + e^2_2 + e^2_3 \ \ldots})$$

2 Error may be nulled through calibration.

3 Assumes that Gain and Offset errors have been nulled through calibration. Note that for increased accuracy at a desired gain, Offset Error may be calibrated at the Gain of interest. Table 2 shows the effect of gain on the Offset Error produced by the Programmable Gain Amplifier.

TABLE 2 - OFFSET ERROR AT PGA

Gain	Offset Error, % of FSR
1	±0.0001
16	±0.0016
512	±0.05
1024	±0.1

TABLE 3 - 3518 DRIFT vs TEMPERATURE

		3606					Total Drift			
	ADC 76	G=1	G=16	G=256	G=512	SHC 76	G=1	G=16	G=256	G=512
Gain (ppm of FSR/°C)	±15	±10	±10	±10	±10	±5	±18.7	±18.7	±18.7	±18.7
Offset[1] (ppm of FSR/°C)	±10	±0.005	±0.8	±12.8	±25.6	±4.3	±10.9	±10.9	±16.8	±27.8
Linearity (ppm of FSR/°C)	±3	--	--	--	--	--	±3	±3	±3	±3

1 ±10V input range (FSR)

2 ADC76 - 16 bit ADC

3606 - Programmable Gain Instrumentation Amp

SHC76 - Sample and Hold Amplifier

Model 3518-Z1A

The Model 3518 is a 16-bit Analog-to-Digital Converter host module. The 3518 is used in conjunction with companion signal conditioning modules (such as the Model 3564, 4-channel Strain Gage with filter and the Model 3565, 8-channel RTD with filter) to form a scanning A/D subsystem. The control signals to the signal conditioning modules and the analog signals from the signal conditioning modules are bussed between the 3518 and associated modules via a 10 wire flat ribbon cable, Model 5840 M000-V000. Up to 32 input channels are accommodated by the 3518 with eleven digital programmable gain settings for each channel. 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 3518-Z1A can be strapped for ±10 volt Bipolar range, or 0 to 10 volt Unipolar range. For Bipolar, the module should be strapped I, D, and C, and for Unipolar, the module should be strapped G, F, and A. (See Figure 1 for Strap Locations)

OFFSET/GAIN ADJUSTMENT

The Model 3518 is strapped and calibrated for ±10 volt range. If the module is to be used in the 0 to 10 volt range, it may be necessary to recalibrate the Model 3518 using the following procedure:

Connect the 3518 to a voltage-input signal conditioning module (3563 or 3569).

F(17)A(0)	Data 0 To initialize control memory address
F(16)A(0)	Data 0
F(26)A(1)	Start continuous scan

Next loop on these two commands:

F(17)A(1)	Data 0 To initialize converted data memory address
F(0)A(0)	Reading First Channel

OFFSET: To adjust the OFFSET, a voltage of +0.00007 volts should be connected to the first channel of the signal conditioning module. Adjust the OFFSET pot (PT1) until the LSB flashes. (Bit 1)

GAIN: To adjust gain, a voltage of +9.9999 volts should be connected to the first channel of the signal conditioning module. Adjust the gain pot (PT2) until bits 2-16 are on and the LSB flashes.

The same procedure should be used for the ±10 volt range, except use -9.9998 volts for OFFSET and adjust the OFFSET pot for bit 16 on and LSB flashing. For GAIN adjustment use +9.9995 volts and adjust the gain pot until bits 2-15 are on and the LSB flashes.

NOTE: 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 data value is read, just add 65536 to adjust it.

EXAMPLE: If +6 volts on Unipolar range returns -26213 (decimal), add 65536 to get 39323, which, if multiplied by the Unipolar LSB of 152.58 μV, equals approximately 6 volts.

SYSTEM SETUP

CHANNEL SELECTION REGISTER AND SWITCH SETTINGS

The 3518 performs the A/D conversion and provides the control function for a family of signal conditioning modules. The 3518 acts as a signal conditioner host and interfaces to any combination of 3563, 3564, 3565 and 3569 modules through a single, 10-pin, front panel connector. Since all of the signal conditioning modules share this common bus, address switches must be set on each module to enable the analog output onto the bus at the appropriate times. The 3518 is capable of digitizing 32 channels of analog input. The output from a given signal conditioning module may lie anywhere within the 3518's 32-channel spectrum. The starting channel and number of channels to be scanned are switch selectable in groups of four at the signal conditioning module. Figure 1 shows a sample configuration involving multiple types of signal conditioning modules. When setting these switches at each signal conditioning module, care must be taken to insure that no two modules occupy the same portion of the 3518's address spectrum. If an overlap condition does occur, the 3518 will detect it and flash the ERROR LED until the configuration is corrected. The 3518 will also disable all signal conditioners during the overlap period to protect the equipment. Refer to the individual signal conditioner manuals for more detail on configuring each module.

Model 3518-Z1A

CHANNEL	INPUT	START ADDR. SWITCH	SCAN SIZE SWITCH
0 1 2 3	3564-V1A Filtered Strain Gage (4)	0	0
4 5 6 7 8 9 10 11 12 13 14 15	3563-V1D Filtered Thermocouple (12)	1	2
16 17 18 19 20 21 22 23	3565-V1A Filtered RTD (8)	4	1
24 25 26 27 28 29 30 31	3569-V1D Filtered Analog (8)	6	1

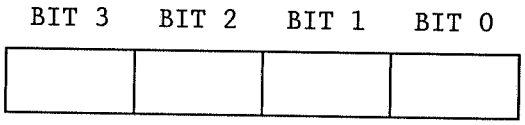
FIGURE 1

Programmable Scan Size

The next step in using the Model 3518 is to select the number of channels to be scanned. Any number of channels, from 1 to 32, is allowable. The F(16)A(1) command is used to write the number of active channels to the 3518. Data of 0 to 31 is used to select a scan size from 1 to 32. Note that the 3518 will automatically default to scanning all 32 channels after a crate-Z and on power-up.

The next step is to set the appropriate gain factor for each channel. The Control Memory of the Model 3518 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



CONTROL MEMORY GAIN FACTORS FOR BIPOLAR RANGE

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

CONTROL MEMORY GAIN FACTORS FOR UNIPOLAR RANGE

DATA	GAIN FACTOR	RANGE	LSB
0	1	+10.000 v	152.580 μv
1	2	+ 5.000 v	76.290 μv
11	4	+ 2.500 v	38.150 μv
101	8	+ 1.250 v	19.073 μv
110	16	+625.000 mv	9.536 μv
1000	32	+312.500 mv	4.768 μv
1001	64	+156.250 mv	2.384 μv
1011	128	+78.125 mv	1.192 μv
1100	256	+39.0675mv	596.046 nv
1101	512	+19.530 mv	298.023 nv
1111	1024	+ 9.765 mv	149.011 nv

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) 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 3518 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 or by an external trigger. In this format, the module will scan all 32 channels once, store the converted data or each channel, and then set the LAM status to indicate that the single scan operation is complete. The second format is continuous scanning which is initiated by an F(26)A(1) command. In this mode, the channels are continuously scanned, and the converted data for each channel is updated every 8 milliseconds.

EXTERNAL TRIGGER

An External Trigger source may be used to initiate a single scan operation. Scanning will start on the falling edge of the TTL level trigger pulse. The 3518 may be strapped for the following external trigger options:

- Ignore external trigger
- Receive trigger pulse from P1 Dataway connector
- Receive trigger pulse from P2 Dataway connector
- Receive trigger pulse from P3 Dataway connector
- Receive trigger pulse from front panel LEMO connector

Refer to Figure 1 for the 3518 strap locations.

READING

The module 3518 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 3518 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 3518 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 "Q" response of one 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 "Q" response of one will be returned for the F(8)A(0).

Clearing of the model 3518 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 3518 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.

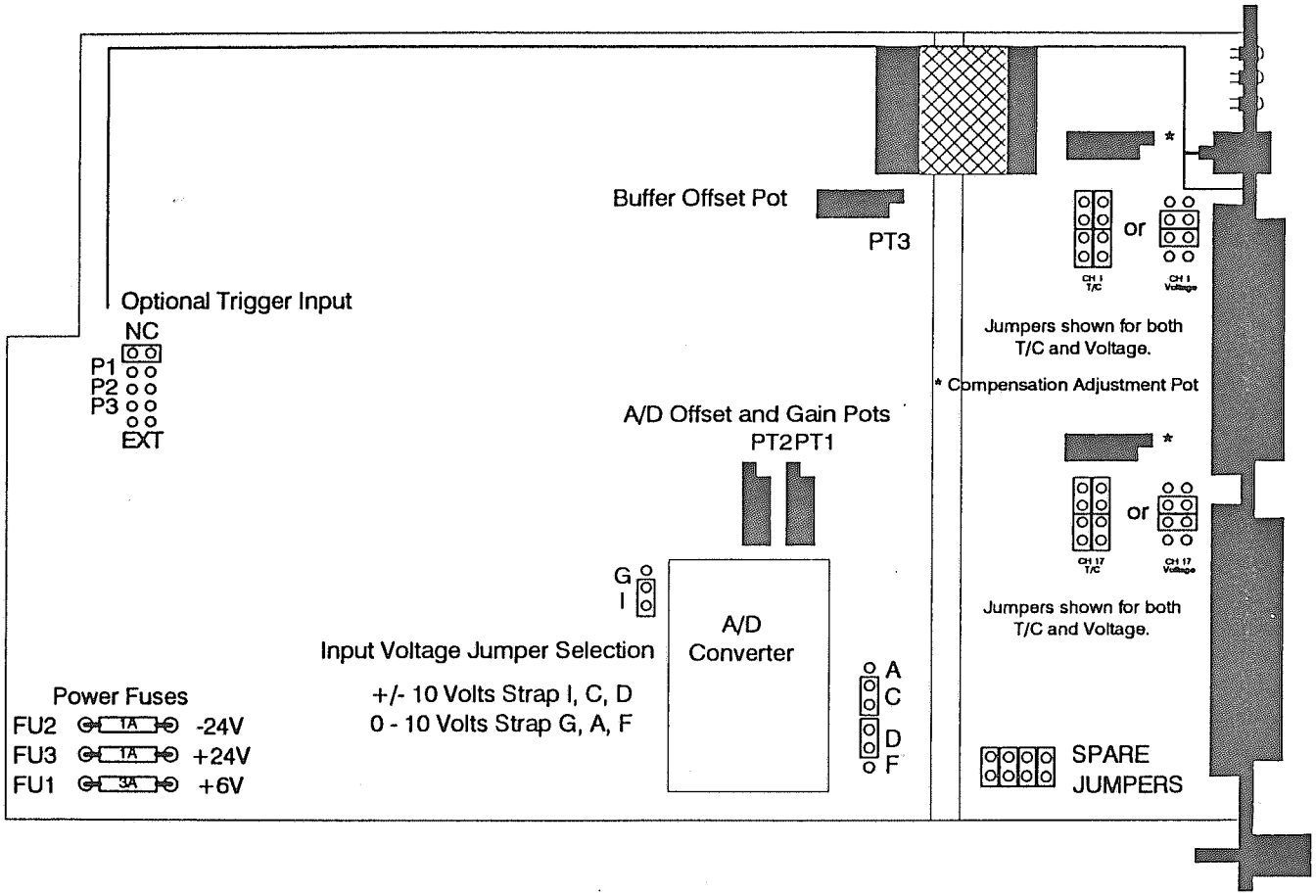
FRONT PANEL CONNECTOR

Pin No.	Signal
1	Ground
2	Signal
3	Return
4	Ground
5	Ground
6	Unused
7	Increment
8	Clear Channel
9	Error
10	Overlap Detect

Model 3518 Front Panel Connector

Model 3518-Z1A

Figure 1 shows the factory setting for ±10 volt Bipolar Range and no external trigger.



MODEL 3518 STRAP LOCATIONS

FIGURE 1