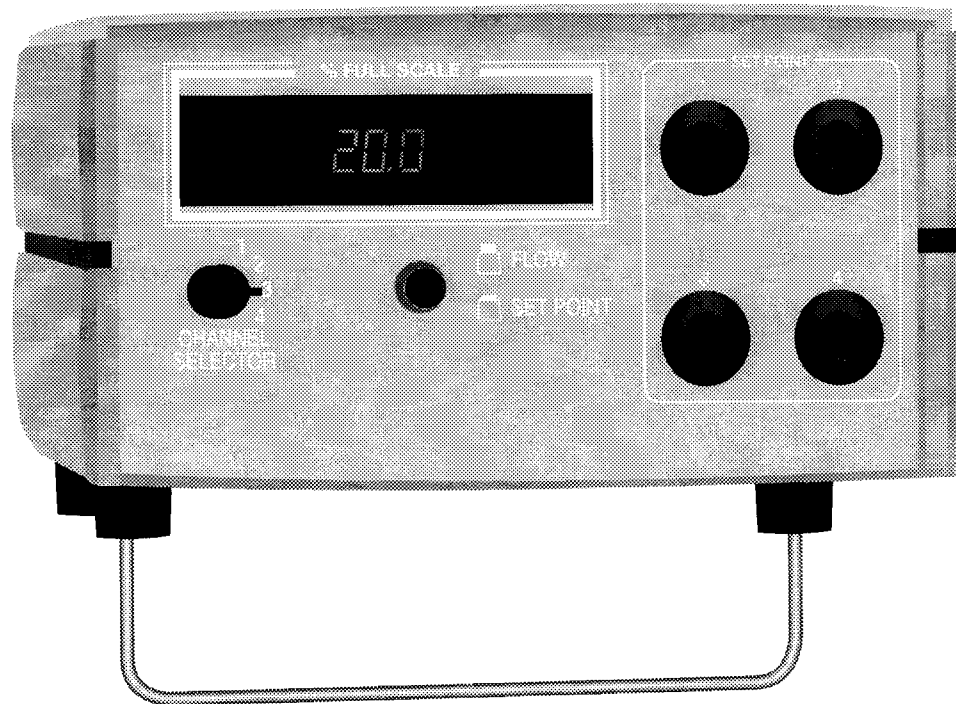


® FMA-78P2 and FMA-78P4

® Electronic Boxes



Operator's Manual



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ELECTRONIC BOXES**

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SECTION 1 INTRODUCTION

The FMA-78P2 and FMA-78P4 are two and four-channel readout/power supply/set point control Electronic Boxes which process 0 to 5 Vdc flow signal inputs from the OMEGA® FMA-700 and FMA-800 Series Mass Flow Controllers and Meters to provide read-out in % of full scale and, if applicable, point control action. Model FMA-78P2 employs two channels which accept flow signal inputs and provides set point control for each channel. Model FMA-78P4 includes four input channels and likewise has a set point control for each channel.

Process flow rates are displayed on a large, bright digital panel meter as a percentage of full scale. The range of these meters is 000.0 to 100.0 %. Set points (for use with the FMA-700 Series Mass Flow Controllers) for any channel may also be displayed on the readout in percentage of full scale flow. Set points are adjustable over the full range by using the 10-turn adjustment controls.

Control action occurs when the process flow value in a given channel matches its respective set point. The FMA-78P series electronic packages have back-panel blend control switches which select either normal (independent) or Automatic Proportional Tracking (APT) mode of operation. APT operation permits setting the flow rate control in one or more channels to be a fixed ratio of the flow rate control in a reference channel, regardless of the process flow rate in that reference channel.

The FMA-78P2 and FMA-78P4 also feature a 0-5 Vdc auxiliary output for chart recording, data acquisition, or computer interfacing.

SECTION 2 INSTALLATION

2.1 UNPACKING

Remove the Packing List and verify that all equipment has been received. If there are any questions about the shipment, please call the OMEGA customer Service Department at (203) 359-1660.

Upon receipt of shipment, inspect the container and equipment for any signs of damage. Take particular note of any evidence of rough handling in transit. Immediately report any damage to the shipping agent.

NOTE

The carrier will not honor any claims unless all shipping material is saved for their examination. After examining and removing contents, save packing material in the event reshipment is necessary.

2.2 REAR PANEL CONNECTIONS

The signal inputs (flow signal line plus common) enter the instrument via the 15-pin connectors (CH1 through CH4) on the rear panel of the FMA-78P2 and FMA-78P4. Refer to Figure 2-1.

The auxiliary outputs are also available at the rear panel via the 25-pin AUX connector, for operation of external meters, recorders, etc.

The FMA-78P2 and FMA-78P4 require 117 Vac \pm 10%, 50/60 Hz line power. Line fuse (rear panel) is rated at 0.5A, Slow Blow.

SECTION 3 OPERATION

3.1 GENERAL

The FMA-78P2 and FMA-78P4 are used to provide a digital display of flow signals for the OMEGA FMA-800 Series Mass Flow Meters, or to provide both flow signal digital readout and set point control action for the OMEGA FMA-700 Series Mass Flow Controllers.

Control action of the FMA-78P2 and FMA-78P4 may take place in the Normal Mode or the Automatic Proportional Tracking (APT) Mode. Normal Mode occurs when the set point control in each channel is connected to a precise and fixed internal reference voltage (Channel 1 is always connected to internal reference voltage). The SET POINT Control is then adjusted to a control point given as a percent of full scale flow.

The APT Mode occurs when one or more set point controls are connected, not to the internal reference voltage, but to a selected channel's signal output. This scheme permits automatic proportional blending of the flow signals. In other words, if Channel 2's set point control is connected to Channel 1's signal output, then Channel 2's flow rate control becomes a fixed ratio of Channel 1's flow rate, even if Channel 1's flow rate falls below its control limits.

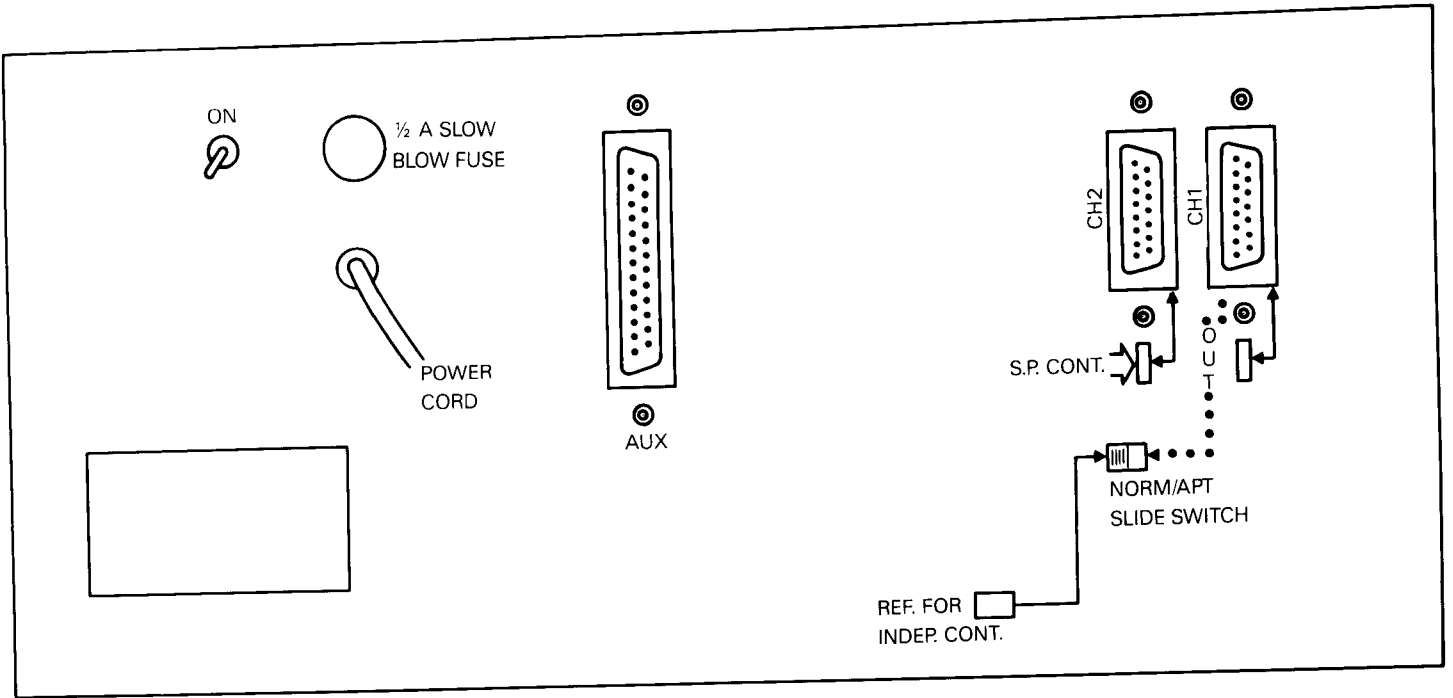


Figure 2-1. Rear Panel Connections (FMA-78P2 is Pictured)

3.2 NORMAL MODE OPERATION

For Normal Mode Operation:

1. Push the Norm/APT slide switch(es) on the rear panel (refer to Figure 2-1) to the left, towards the solid line and reference arrows marked "REF FOR INDEP CONT".
2. Set the CHANNEL SELECTOR Switch (refer to Figure 3-1) to the desired channel and read the digital meter for the process flow signal's percent of full scale flow.
3. Press the FLOW/SET POINT Push Button Switch to display that channel's set point in percent of full scale flow.
4. To change the set point, keep the FLOW/SET POINT Push Button Switch depressed, and adjust the appropriate SET POINT Control (located on the right side of the front panel) until the desired set point value is displayed on the digital meter.

3.3 APT MODE OPERATION

For APT Mode Operation, set the selected Norm/APT slide switch(es) so that the channel(s) which is to "follow" or "track" a given reference channel is set to the right side, towards the dotted line(s). Refer to Figure 2-1.

Considering that Channel 1 is the prime reference (it always has its set point control connected to the internal reference voltage), Channel 2 may be switched to "track" Channel 1; Channel 3 may be switched to "track" Channel 1; Channel 4 may be switched to "track" Channel 1; or Channel 4 may be switched to "track" Channel 3 (a secondary reference Channel).

The important thing to remember when establishing APT Mode Operation is to follow the dotted lines associated with the slide switches. These lines indicate which channel is "tracking" a particular reference channel. Also note that depressing the FLOW/SET POINT Push Button Switch when the CHANNEL SELECTOR Switch is set to display the channel using APT Mode Operation, will now make the meter display a given ratio of the reference channel's flow signal. That ratio is, of course, determined by the setting of the particular SET POINT Control switched into the APT Mode, and will be read on the meter as a percentage of a percentage.

EXAMPLE:

A Model FMA-78P2 is being operated in the APT Mode with Channel 2 "tracking" Channel 1. Channel 1's SET POINT Control is adjusted to 50.0% of full scale flow. Under these conditions, Channel 2 will go to 50.0% of its full scale too. The major advantage of APT Mode Operation is that changing Channel 1's flow rate will cause the other channels operating in the APT mode to follow Channel 1. In addition for Model FMA-78P4, Channel 4 can be made to track Channel 3 or Channel 1.

3.4 VERIFICATION OF CALIBRATION

The FMA-78P2/P4 are shipped precisely calibrated and ready to use. The digital panel meter can be used to check calibration. Proceed as follows:

1. Set the CHANNEL SELECTOR Switch to CH1.
2. Rotate Channel 1's SET POINT Control fully clockwise.
3. Press the FLOW/SET POINT Push Button Switch.
4. The digital panel meter should display 102.4%.

If this reading is not obtained, the meter has "drifted" slightly, since the reference supply, which is the basis for the FMA-78P2/P4 calibration, is considered extremely accurate and stable (unless it is malfunctioning). To adjust the digital panel meter proceed as follows:

1. "Pop" off the meter's red plastic filter/bezel by placing a small, thin screwdriver blade under the recess at the bottom center of the filter.
2. Set the CHANNEL SELECTOR Switch to CH1.
3. Turn CH1's SET POINT Control fully clockwise.
4. Depress the FLOW/SET POINT Push Button Switch, and keeping it depressed, adjust the meter calibration potentiometer (located to the right of the display digits) until the meter indicates 102.4%.
5. Replace the bezel.

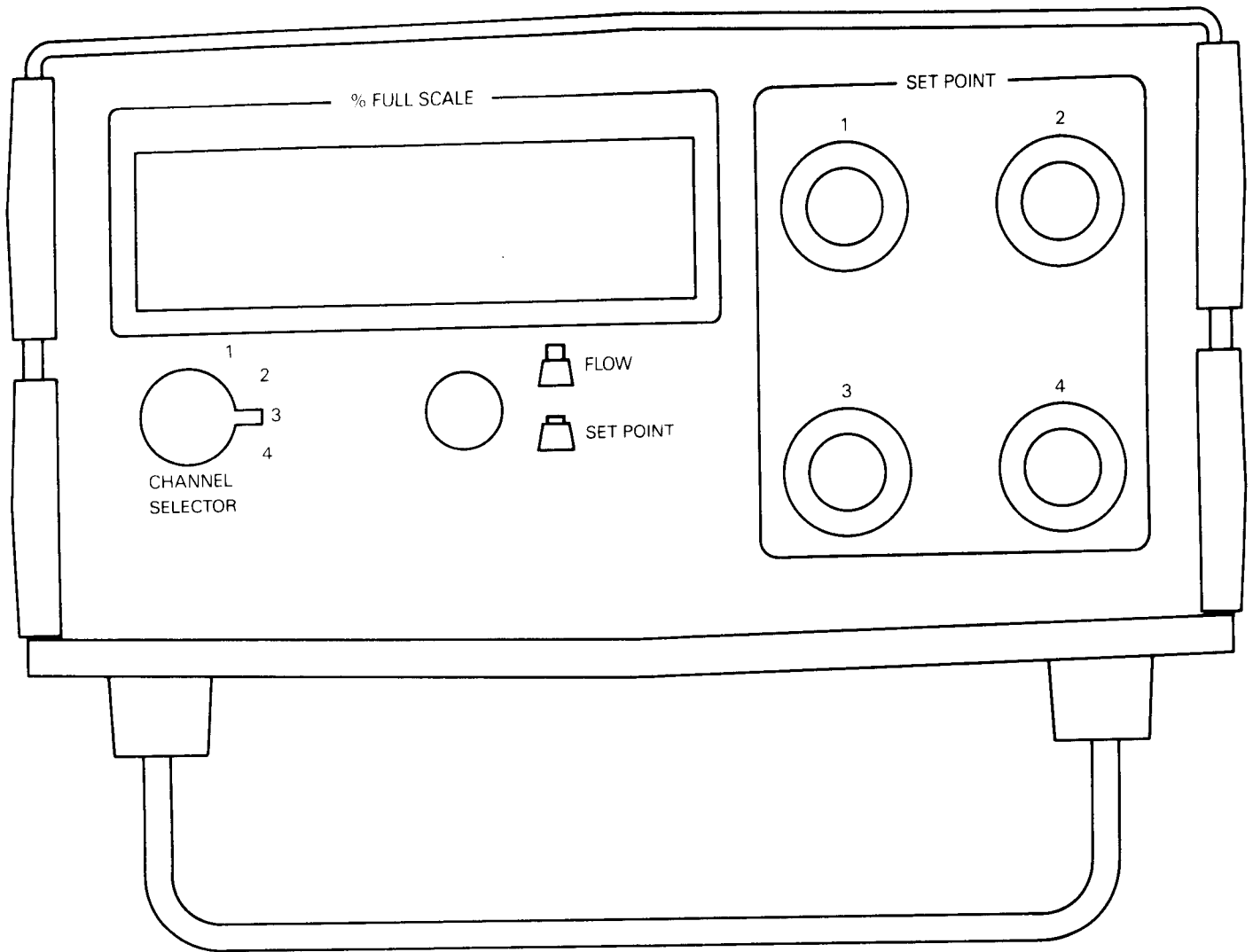


Figure 3-1. Front Panel Controls

3.5 FMA-78P2/P4 CALIBRATION

This procedure should not be necessary, but may be conducted if there is reason to believe the equipment is, or may be, out of calibration. Calibration of the FMA-78P2 or FMA-78P4 simply means adjusting the +5.120 Vdc reference supply for $-5.120 \text{ Vdc} \pm .0025 \text{ V}$. Proceed as follows:

1. Connect a 4½ digit, 0.05% accurate, digital meter to test points TPA and TPB, located between the 5.120 Vdc Adjustment Control (R4) and Connector 3J1 on the Power Supply PC. Board (refer to Power Supply Component Layout).
2. Adjust potentiometer R4 until the test meter reads $5.120 \text{ Vdc} \pm .0025 \text{ V}$.
3. Perform the Verification of Calibration procedure discussed in paragraph 3.4.
4. Calibration is now complete.

SECTION 4 THEORY OF OPERATION

4.1 GENERAL

Flow signals from individual FMA-700 Series Mass Flow Controllers or FMA-800 Series Mass Flow Meters are processed by the FMA-78P2 and FMA-78P4 for digital display of gas flow rates in % of full scale and, if applicable, standard point control action of field located control valves, or APT operation of control valves. All of this is accomplished by four modular circuit assemblies. These modules are designated as follows: 1) Power Supply Module; 2) Signal Conditioning Module; 3) Interconnect Module (includes Interconnect PC Board, rear panel, and rear panel components); 4) Front Panel Module (includes meter, selector switches, and set point controls).

4.2 POWER SUPPLY MODULE (Refer to Power Supply Schematic)

This module is comprised of a PC. Board and an "L" shaped chassis which mounts to the PC. Board and off-board power transformer. The power supply provides three regulated supplies: +5 Vdc, +15 Vdc and -15 Vdc, plus a precise +5.120 Vdc reference supply. They operate all functional circuitry within the FMA-78P2 and FMA-78P4. The +5 Vdc is specifically intended to operate the digital meter.

The 117 Vac primary winding of power transformer X1 is fed from the AC line cord, ½ A line fuse, ON/OFF switch and a pair of quick-disconnect type connectors J2-1 to J2-3.

The +5 Vdc three-terminal regulator, U1 receives its applied voltage from the full-wave rectifier/filter CR2, CR3 and C1. Capacitor C2 serves as a transient suppressor.

Regulators U2 and U3 form the basis for the dual +15 and -15 Vdc supplies. The positively oriented rectifier diodes (part of CR5) apply their full-wave voltage to filter capacitor C3. Capacitor C6 acts to suppress transients. Note that the negatively oriented rectifier diodes (part of CR5) are the counterparts of those previously mentioned. Likewise, capacitors C4 and C5 (in parallel) plus C7 are the counterparts of C3 and C6 respectively.

The regulator (U4) used to develop the precise reference voltage (5.120 Vdc) is a LM 317LZ. Resistor R1 sets a voltage across it, as established by the output terminals of U4. The total voltage across R1 and R2 is close to 5.120 V. Adjustment potentiometer R4 and resistor R3 set the junction of R1 and R2 such that the final output voltage across filter capacitor C8 is exactly 5.120 Vdc.

4.3 SIGNAL CONDITIONING MODULE (Refer to Interconnect and Signal Conditioning Board Schematic)

The purpose of the Signal Conditioning Module is to multiplex (switch) up to four input signals into a single output meter signal. Set point signal levels are also available at the input of the multiplexer and may be selected for display on the digital meter.

Multiplexers U1 and U2 electronically switch eight analog signal inputs to a single output. A three bit binary code applied to pins 9 through 11 determines which inputs are switched to the output. Flow signals are applied to the first four inputs of U1. The common return lines for these flow signals are applied to the four inputs on U2. The four set point signal levels are applied to the second set of inputs on U1. They are also fed from this same location out to their respective FMA-700 Series Mass Flow Controllers via connector 2J1, the Interconnect PC. Board and channel input connectors 1J1 and 1J2 (Model FMA-78P2) and 1J1 through 1J4 (Model FMA-78P4).

The binary switching code for the IC Multiplexers U1 and U2 is defined in the Chart of Table 4-1. Keep in mind switching code inputs C, B, and A (pins 9, 10 and 11) relate to binary weighting columns 2, 2, 2 respectively. Also remember that the "C" code input on IC U2 (pin 9) is connected directly to ground and is the only input which is not switched. Examples of flow and set point selection are given following Table 4-1.

**TABLE 4-1
SWITCHING CODE FOR IC MULTIPLEXERS U1 & U2**

	CH NO.	BINARY CODE			IC INPUT PIN SELECTED
		C	B	A	
SET PT. & FLOW COM.	1	0	0	0	13
	2	0	0	1	14
	3	0	1	0	15
	4	0	1	1	12
FLOW SIG.	1	1	0	0	1
	2	1	0	1	5
	3	1	1	0	2
	4	1	1	1	4

Assume that a binary code of 110 is applied to the control input of U1. Since pin 9 is grounded on U2, its C, B, and A code inputs would read 010. This means that channel 3's flow signal and common return line are switched through Op-amp buffers U3A and U3B (LM 324) respectively. Also note that the control inputs for U1 and U2 which are not held low (zero volts) by the front panel CHANNEL SELECTOR Switch connected via 2J6, are pulled high to Vcc (+12 Vdc) by resistors RN3-1, RN3-2 and RN3-3.

Depressing the FLOW/SET POINT Switch on the front panel activates (via pin 9 on U1) the second group of signal levels applied to U1's inputs, namely the set point signals. The CHANNEL SELECTOR Switch programs the one desired to be displayed on the digital meter. For example, with the FLOW/ SET POINT Switch undepressed and the CHANNEL SELECTOR Switch set to CH1, IC U1's C, B and A code input will be 100. This means the first flow signal and its common return are being selected. By depressing the FLOW/SET POINT Switch, the code now becomes 000, causing the first set point to be selected. In other words, changing the binary 2 weighting column (Code C) from a "1" to a "0" switches the digital meter's display from flow signals to set point signals.

The 5 Vdc (maximum flow signal at the output of unity gain buffer U3A is divided down to a 1 Vdc (maximum) signal by resistors R3 and R4. The common return line reference level for flow signal is fed from unity gain buffer U3B to a resistor network consisting of R1, R2 and Zero Control R6. This control (R6) adjusts the common return line level to exactly zero volts with no flow signal applied. Signals present between the two output lines are applied to the digital panel meter via connector 2J4.

Op-amp U3C serves as an inverting amplifier with a gain of X1 to convert its +5.12 Vdc input signal to a -5.12 Vdc output level. Both polarities of 5.12 Vdc are required for zero control R6. Op-amp U3D is connected as a unity gain buffer to apply a +12 Vdc level, divided down from +15 Vdc by resistors R5 and RN3-8, to CMOS Multiplexers U1 and U2 as = Vcc. Connector 2J2 applies to the various power supply voltages to the Signal Conditioning PC. Board, which are carried through to connector 2J3, for application to field located FMA-700 and FMA-800 Series Mass Flow Controllers and Meters.

4.4 INTERCONNECT MODULE (Refer to Rear Panel Schematic)

All signals to and from the "outside world" are made via the Interconnect Module. Therefore, consider this module as an input/output PC. Board with attached connectors and switches, which are mounted to the back panel.

Four sets of input/output signals are available on the 26 pin connector 1J6. Each set relates to a given channel. They include: 1) a 0 to 5 Vdc flow input signal; 2) its common return; 3) the set point output signal and; 4) an auxiliary control input. Also note four slide switches, SW1 through SW4 are present in the schematic and are located on the back panel. Further note that these switches allow the set point lines to be connected to the internal reference voltage (5.120 Vdc) or to the output signal of Channel 1. Channel 1, of course, is always referenced to the internal 5.120 Vdc reference voltage. The possible combinations for referencing are as follows: CH2 to CH1, CH3 to CH1, CH4 to CH1 or CH4 to CH3. This arrangement relates to the APT Mode control feature.

The four individual channel input/output connectors (1J1 through 1J4) located on the rear panel are designated CH1, CH2 etc., and connect to the previously mentioned 26 pin connector 1J6 via PC. foils on the Interconnect PC. Board. The plus and minus 15 Vdc supplies along with the +5.120 Vdc referenced voltage enter the Interconnect PC. Board via connector 1J7 and exit via 1J1 through 1J4.

Connector 1J5 is designated AUX and is mounted on the rear panel. It supplies 0 to 5 Vdc flow signals to external meters, recorders, etc., when required. The last items to be noted here are the ON/OFF power switch and power line FUSE, also located on the rear panel.

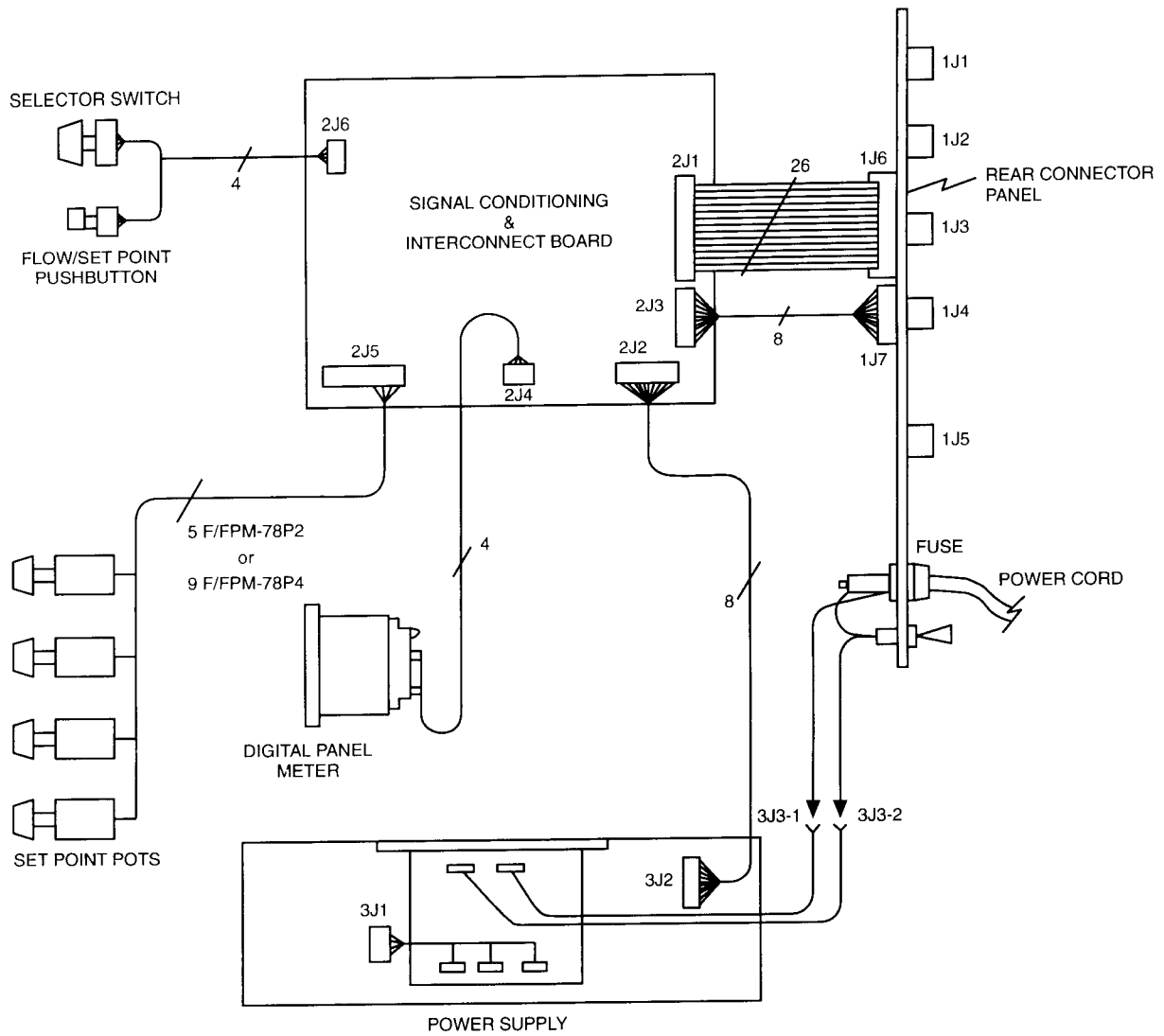
4.5 FRONT PANEL MODULE (Refer to Interconnect and Signal Conditioning Board Schematic)

The digital display meter, CHANNEL SELECTOR Switch, FLOW/ SET POINT Switch and SET POINT Controls (CH1 through CH4) along with their respective cable/connector assemblies make up the Front Panel Module.

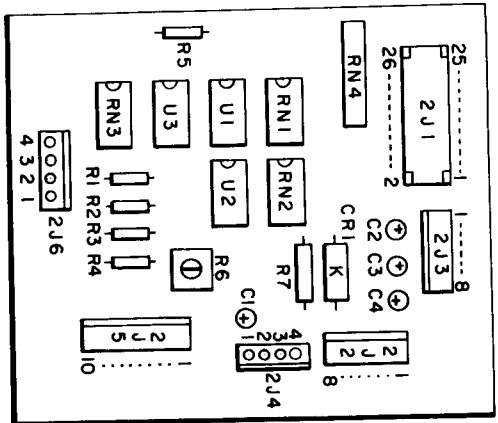
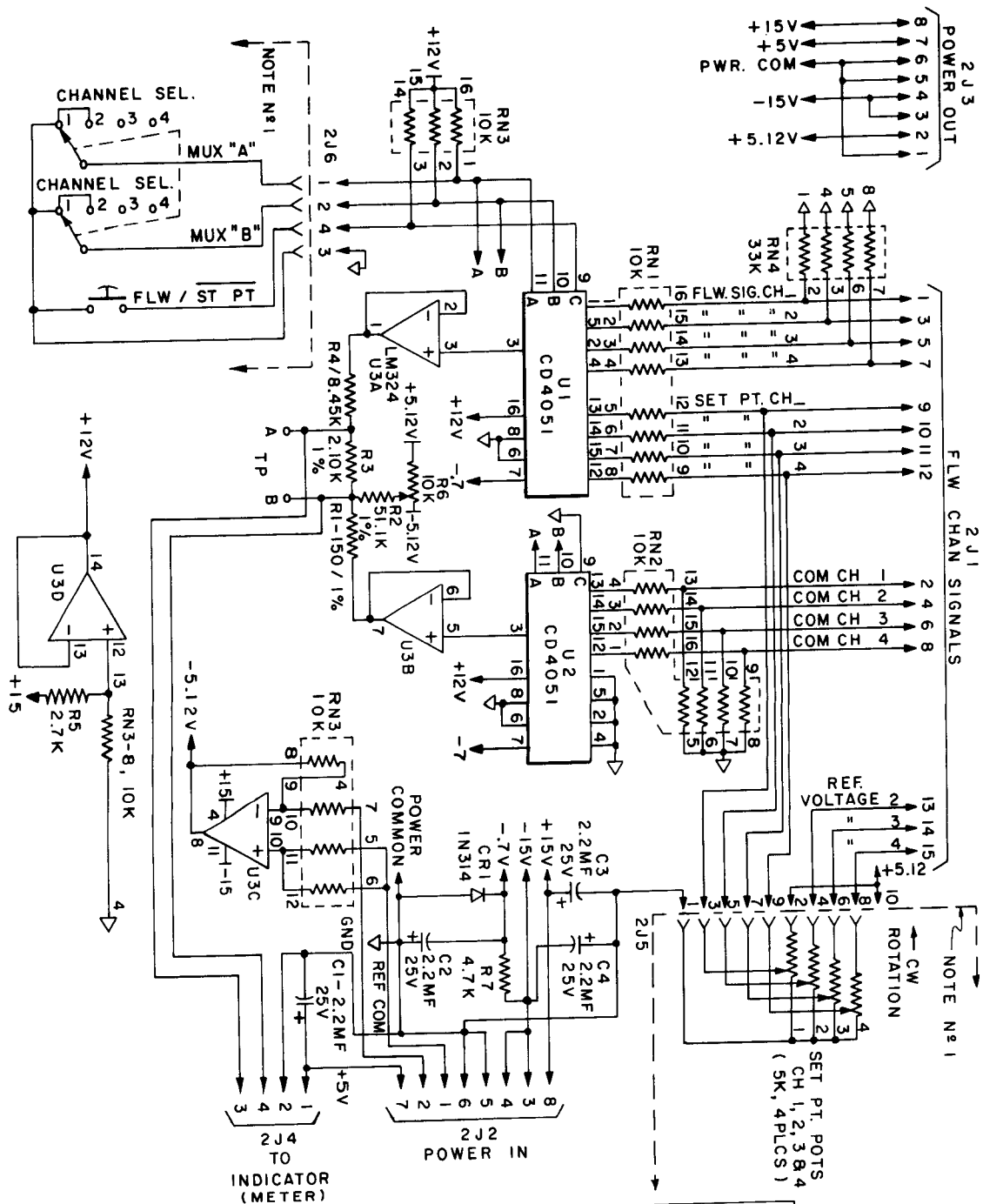
The actual range of the digital meter is zero to 1.999 Vdc . Shifting the decimal point two places to the right enables the meter to read 100.0% for a 1.000 Vdc flow signal input. The CHANNEL SELECTOR Switch is a four position, two pole, rotary switch which establishes a two column binary code (2 and 2) to program the appropriate coding inputs on IC U1 and U2 of the Signal Conditioning Module. The FLOW/SET POINT Push Button Switch selects flow signals (1 in the 2 column) or set point levels (0 in the 2 column). Set point potentiometers are 10-turn controls which provide a continuous 0 to 5.120 Vdc level to the inputs of IC U1 noted above, as well as the field located FMA-700 Series Mass Flow Controllers. Keep in mind that 5.120 Vdc divided down 5:1 equals 1.024 Vdc, which in turn equals a displayed value of 102.4% on the digital meter. Refer to the theory discussion on the Signal Conditioning Module, paragraph 4.3 for further details.

SECTION 5 SPECIFICATIONS

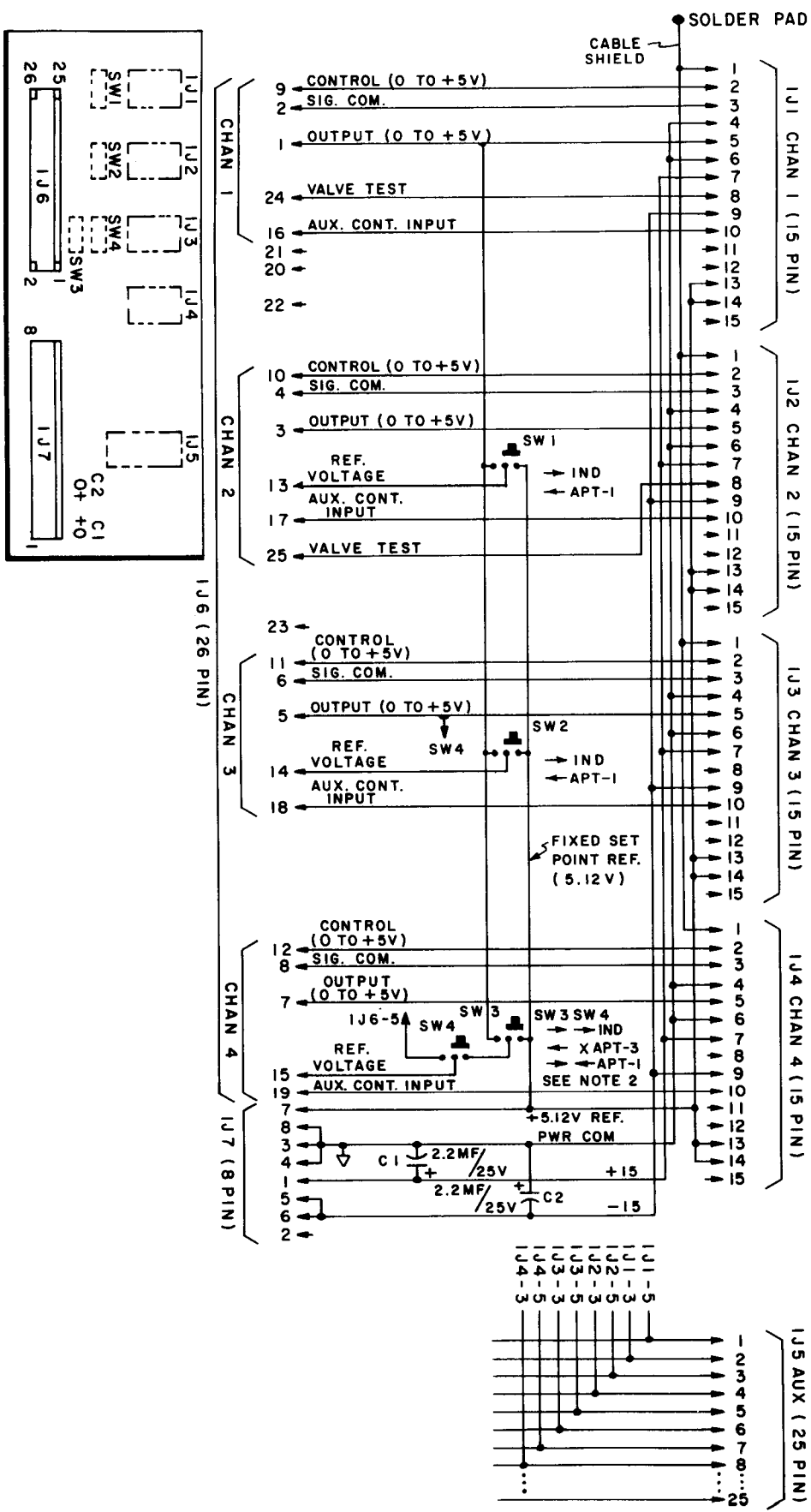
FUNCTION:	Processes 0 to 5 Vdc flow signal inputs from the FMA-700 and FMA-800 Series Mass Flow Controllers and Meters to provide read-out in % of F.S. and, if applicable, point control action.
INPUTS:	Model FMA-78P2 — two channels; Model FMA-78P4 — four channels; Inputs (flow signal line plus common) enter instrument via connectors (CH1 through CH4) on rear panel.
SET POINTS:	One set point per channel, adjustable from 0 to 100% F.S. with 10-turn control
DISPLAY:	Bright red 3½ digit (0.56 in high) read-out with 0.1% resolution
AUX. OUTPUTS:	Available at rear panel via AUX connector for operation of external meters, recorders, etc.
APT CONTROL:	Automatic Proportional Tracking control switches located on rear panel permit fixed internal reference for all set point channels or selected signal references for all set point channels except the first channel.
POWER REQUIRED:	117 Vac ±10%, 50 to 60 Hz, 50 Watts. Line fuse (rear panel) is rated at 0.5A. Slow Blow.
DIMENSIONS:	W: 8½" x H: 4⅞" x D: 9¾"



FMA-78P2 & FMA-78P4 INTERCONNECTION DIAGRAM



FMA-78P2 & FMA-78P4 INTERCONNECT AND SIGNAL CONDITIONING BOARD SCHEMATIC



NOTES:
 1) - MODEL P2-SW2, SW3, SW4, I.J3 AND I.J4 NOT INSTALLED.
 2) - IND SIGNIFIES INDEPENDENT CONTROL. APT SIGNIFIES AUTOMATIC PROPORTIONAL TRACKING OF ANOTHER CHANNEL OUTPUT. "X" SIGNIFIES "DON'T CARE".
 ⇄ INDICATES SWITCH POSITION.

FMA-78P2 & FMA-78P4 REAR PANEL SCHEMATIC



WARRANTY

OMEGA warrants this unit to be free of defects in materials and workmanship and to give satisfactory service for a period of **13 months** from date of purchase. OMEGA Warranty adds an additional one (1) month grace period to the normal **one (1) year product warranty** to cover handling and shipping time. This ensures that our customers receive maximum coverage on each product. If the unit should malfunction, it must be returned to the factory for evaluation. Our Customer Service Department will issue an Authorized Return (AR) number immediately upon phone or written request. Upon examination by OMEGA, if the unit is found to be defective it will be repaired or replaced at no charge. However, this WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive corrosion; or current, heat, moisture or vibration; improper specification; misapplication; misuse or other operating conditions outside of OMEGA's control. Components which wear or which are damaged by misuse are not warranted. These include contact points, fuses, and triacs.

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1. P.O. number under which the product was PURCHASED,
2. Model and serial number of the product under warranty, and
3. Repair instructions and/or specific problems you are having with the product.

FOR **NON-WARRANTY** REPAIRS OR **CALIBRATION**, consult OMEGA for current repair/calibration charges. Have the following information available BEFORE contacting OMEGA:

1. Your P.O. number to cover the COST of the repair/calibration,
2. Model and serial number of product, and
3. Repair instructions and/or specific problems you are having with the product.

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