UniPulse 4412

Electromagnetic Flow Transmitter

Instruction Manual

Part #69-4403-001

Revised February 2003

ISCO®

IMPORTANT - PLEASE READ

⚠ DANGER

The installation and operation of this product may put you at risk of serious injury or even death. Take whatever precautions are necessary to ensure your safety before making an installation or working on one. Never work alone or unsupervised. Install and operate this product in accordance with all applicable safety and health regulations, as well as any appropriate local ordinances.

This product may be installed in confined spaces. Examples of confined spaces are manholes, pipelines, digesters, and storage tanks. These places can be dangerous or fatal if you are not suitably prepared. The primary hazards of confined spaces are the possibility of poisoned air, and the lack of proper ventilation. Work in such places is governed by OSHA 1910.146, and may require a permit before entering. The other major hazard particular to this product is its extreme weight, which makes it dangerous to handle and creates the risk of being crushed or struck by the unit during installation.

This manual may also contain Material Safety Data Sheets (MSDS) for chemical agents supplied or recommended for use with this product. If needed, these sheets will be in the MSDS Appendix. These sheets provide information about possible hazards from the chemicals. Additional MSDS, covering various proprietary agents (name-branded or trademarked mixtures) that can also be used with this product, are available from the manufacturers of those agents.

This manual uses the following notations to set apart hazard warnings and notes:

⚠ DANGER

DANGER describes situations that will result in loss of life or serious personal injury, unless avoided. The emphasis is on clear and immediate threats to your life or safety.

⚠ WARNING

WARNING describes situations that could result in loss of life or serious personal injury, unless avoided. The emphasis here is on the potential for a serious accident.

⚠ CAUTION

CAUTION describes situations that may result in moderate personal injuries, property damage, or damage to the equipment, unless avoided.

☑ Note

NOTES draw your attention to particular features, practices, tips, or other information useful in setting up or operating the product.

Foreword

This instruction manual is designed to help you gain a thorough understanding of the operation of the equipment. Isco recommends that you read this manual completely before placing the equipment in service.

Although Isco designs reliability into all equipment, there is always the possibility of a malfunction. This manual may help in diagnosing and repairing the malfunction.

If the problem persists, call or email the Isco Customer Service Department for assistance. Contact information is provided below. Simple difficulties can often be diagnosed over the phone. If it is necessary to return the equipment to the factory for service, please follow the shipping instructions provided by the Customer Service Department, including the use of the **Return Authorization Number** specified. **Be sure to include a note describing the malfunction.** This will aid in the prompt repair and return of the equipment.

Isco welcomes suggestions that would improve the information presented in this manual or enhance the operation of the equipment itself.

Contact Information

Phone:	(800) 228-4373	(USA, Canada, Mexico)
	(402) 464-0231	(Outside North America)
Repair Service:	(800) 775-2965	(Analytical and Process Monitoring Instruments)
	(800) 228-4373	(Samplers and Flow Meters)
Fax:	(402) 465-3022	
Email address:	info@isco.com	
Website:	www.isco.com	
Return equipment to:	4700 Superior Street, Lincoln, NE 68504-1398	
Other correspondence:	P.O. Box 82531, Lincoln, NE 68501-2531	

UniPulse 4412 Flow Transmitter

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UniPulse 4412 Flow Transmitter

Section 1 Introduction

1.1 Description

The Isco UniPulse 4412 electromagnetic flow meter transmitter (Figure 1-1) is designed specifically for use with Isco's UniMag™, ChemMag™, or WizMag™ flow tubes. 4412 transmitters use a patented UniPulse™ coil excitation method, providing a new standard in magnetic flowmeter performance. The transmitter is normally remote from the flow tube, but it may be used integrally on all sizes of multi-sensor UniMags.

Figure 1-1 UniPulse 4412 Electromagnetic Flow Transmitter

Applications for the 4412 include: closed-pipe flow measurement where only unidirectional (forward) flow measurement is needed; flow measurement where you are interfacing using a 4-20 mA loop, such as to a SCADA; or installations where an on-board display and keypad are required.

The 4412 is available as a non-indicating transmitter, having 4-20 mA and 0-10000 Hz or 0-5000 Hz outputs. The 4412 is available with an optional display for viewing flow rate and total flow in selectable units of measure.

User-friendly electrical test diagnostics for zero and forward span may be performed by an internal switch. The need for a separate "calibration box" is thereby eliminated. Change of range is accomplished digitally using 4-digit internal switches.

An adjustable relay is available as standard for minimum and maximum flow and non-full pipe.

Refer to the appropriate flow tube instruction manual before using the 4412 transmitter.

☑ *Note*

The transmitter is normally supplied dedicated to a particular UniMag or ChemMag flow tube, in which case certain potentiometers are red sealed. Sealed potentiometers should not be adjusted, unless the transmitter is to be used with a new flow tube and then only by a technician familiar with the 4412 transmitter instruction manual.

⚠ DANGER

HAZARD of ELECTROCUTION. Line voltage may be present on any input wire. Test for voltage on all input terminals prior to touching them. Disconnect power from any attached input devices prior to servicing. Mains voltage can kill you.

1.2 Specifications

The specifications for the 4412 flow transmitter are in Table 1-1 below.

Table 1-1 UniPulse 4412 Flow Transmitter Specifications

Size (HxWxD)	Without display: 6.3 x 8.7 x 2.8 inches (16.0 x 22.0 x 7.0 cm) With optional display: 6.3 x 8.7 x 3.8 inches (16.0 x 22.0 x 9.2 cm)
Weight	4.3 lbs (1.9 kg)
Material	Cast aluminum, fusion bonded epoxy enamel painted
Enclosure	NEMA 4X, IP65
Power	104 to 127 volts AC or 208 to 254 volts AC, 50/60 Hz
Power Consumption	10 W typical (including sensors)
Output Power	±15 volts DC, 10 mA (for flow tube preamplifier)
Compatible Isco Flow Tubes	UniMag, ChemMag, WizMag
Sensor Excitation	UniPulse (unipolar pulsed AC), 5A maximum, 80V
Magnetizing Current	1 to 5 A typical
Coil Voltage	Up to 80 V maximum for 16.7 ms (60 Hz supply), 20 ms (50 Hz supply)
Frequency	$^2/_3$ of power supply frequency
Input Impedance	10^{12} Ohms with driven shield capability
Media Conductivity (not including deionized water)	UniMag and WizMag Flow Tubes: 0.5µS/cm minimum ChemMag Flow Tubes: 1µS/cm minimum
Non-full Pipe Detection	Using sensor electrodes or user supplied signal, holds analog output at 4 mA and pulse output at 0, and stops optional totalizer.
Time Constant	0.030 seconds
Display (optional)	Liquid crystal, 4 to 5 digit flow rate, 8 digit totalizer, resettable or non-resettable, 0.38 inches (10 mm) high x 0.19 inches (5 mm) wide characters.
Test Interface	Rotary switch for zero and span tests
Analog Output	Isolated 4 to 20 mA output based on flow rate into a maximum of 800 ohms.
Signal Damping	0.15 to 60 seconds, affects flow rate display and 4 to 20 mA output
Pulse Frequency Output	Non-indicating: 0 to 10,000 Hz, optically isolated, rated 30 volts DC, 50 mA; internal jumper JP7 will output to 0 to 5,000 Hz.
Relay Outputs	Isolated relay contacts, form C activated based on minimum/maximum flow rate, form C activated based on non-full pipe detection, rated 125 volts AC, 1 A, 30 VA.
Maximum Distance Between Flow Transmitter and Flow Tube	For 0.5 to 3 µS/cm: 30 feet (9 m) Above 3 µS/cm: 300 feet or 10xC (90 m or 3xC), whichever is less
Wiring From Flow Transmitter to Flow Tube	30 feet (9 m) standard, 3 twisted shielded pairs, 18 gauge (0.75 mm^2) minimum, Belden 8760 or 9318, Alpha 5610/1801 or 5611/1801 or equivalent.
Operating Temperature	0 to 140°F (–18 to 60°C)
Storage Temperature	–40 to 140°F (–40 to 60°C)

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UniPulse 4412 Flow Transmitter

Section 2 Installation and Operation

2.1 The 4412 Transmitter

The dimensions of the 4412 transmitter are shown in Figure 2-1. Adequate space must provided in order to mount the transmitter on a wall.

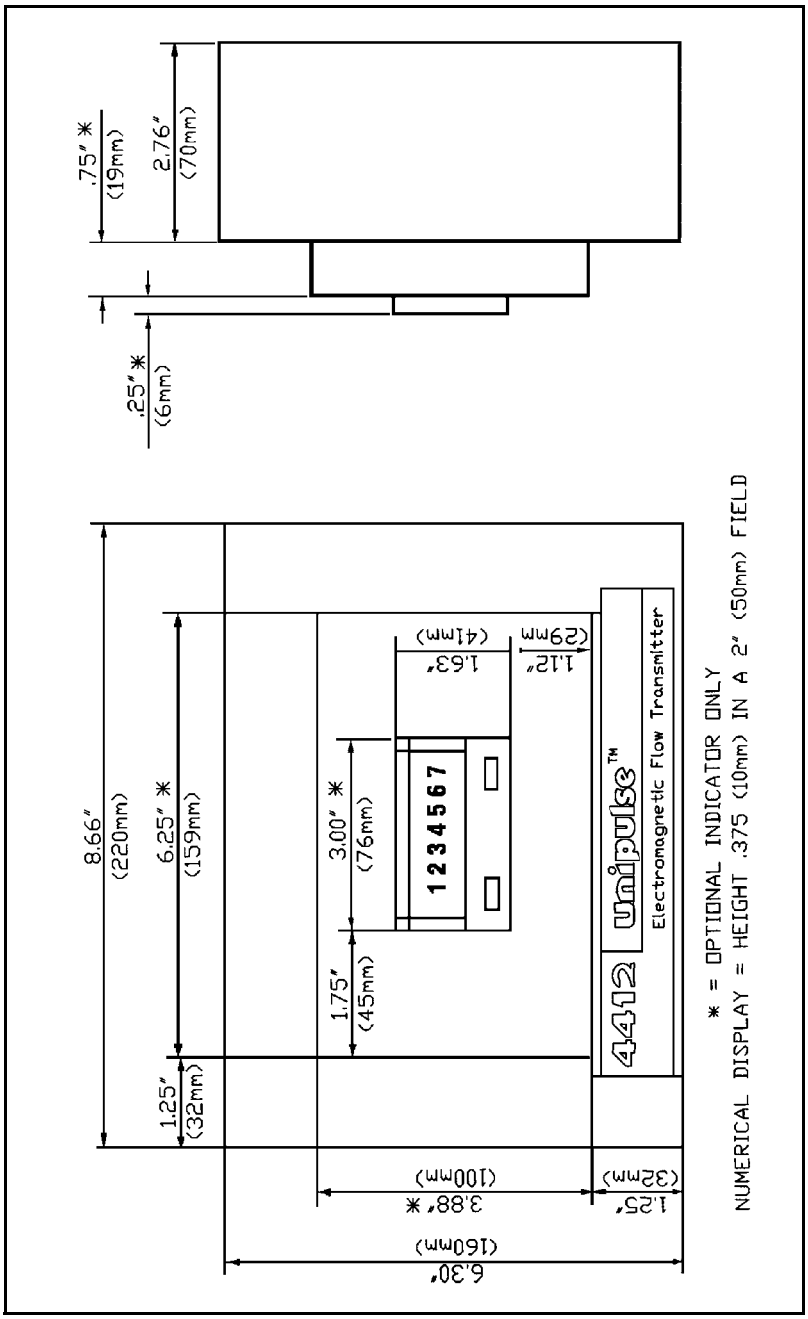


Figure 2-1 Front Panel Dimensions

2.2 Installing the 4412 Transmitter

The following steps outline the procedure for installing the 4412 transmitter. Refer to the sections specified for more detailed instructions of each step.

1. Mount the transmitter (section 2.2.1)
2. Connect the flow tube cables to the transmitter (2.4)
3. Connect power to the transmitter (2.5)
4. Set the damping switch (2.6)
5. Check electrical zero and forward span (2.7.1)
6. Set the minimum and maximum flow alarms and low flow cut-out (2.8)
7. Activate the non full pipe indicator (2.9)
8. Adjust the hydraulic zero (2.10)
9. Calculate and enter the range (R) factor (2.11)

2.2.1 Mounting the transmitter

The 4412 transmitter must be mounted where it will never be submerged in water. When properly installed, the 4412 is dust tight, corrosion resistant, and protected against water jets.

Although the 4412 has high insensitivity to electrical noise, it is preferable to locate it and the flow tube away from high voltage, radio frequency, and similar external noise. It should not be located in direct sunlight and proper ventilation is required to circulate the air in the immediate area around the converter.

If a direct sunlight location is unavoidable, then an opaque sun shield, preferably white, should be installed over the converter. Such shields are available from Isco or your nearest representative.

Location in areas of high moisture content should be avoided to prevent excessive build-up of moisture inside the enclosure and optional indicator. If this is unavoidable, an appropriate heater should be used in the transmitter location.

The ambient air temperature should be within 0°F to +140°F (-18°C to +60°C) for operation. This may be extended to -40°F to + 140°F (-40°C to +60°C) for storage.

> ☑ ***Note***
>
> For use in hazardous locations, the ambient temperature must be between +40°F and +104°F (+5°C and +40°C). The maximum surface temperature is 275°F (135°C).

When remote wall mounted, the transmitter is secured using l/4" (6mm) screws, as indicated in Figure 2-2.

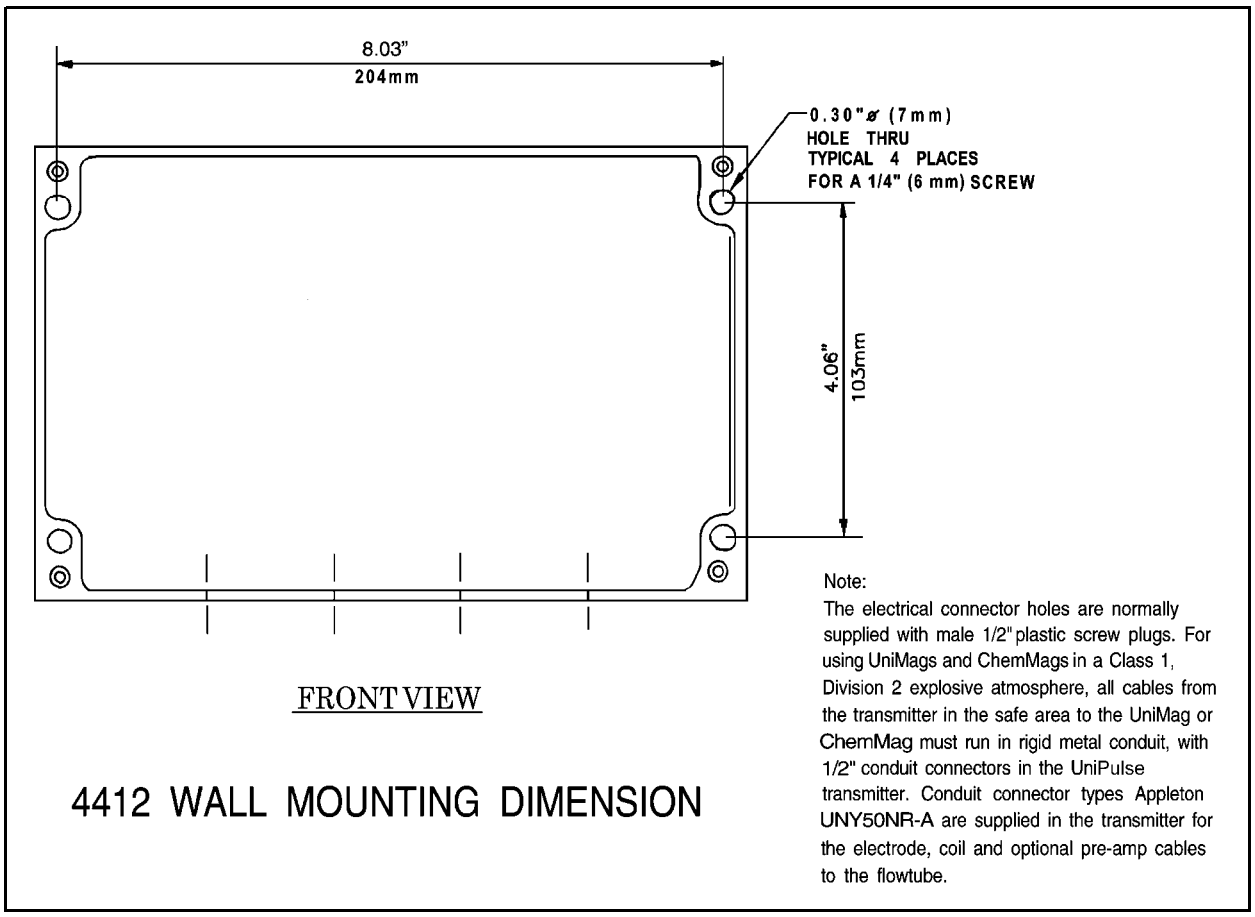


Figure 2-2 Wall Mounting Dimensions

The 4412 transmitter is normally supplied in a NEMA 4X (IP65) enclosure. The enclosure is manufactured from acrylic enameled aluminum, with a screwed on lid. The optional indicator version has a hinged and screw-on lid. The enclosure houses an uppermost analog board and a lower mounted power board.

☑ *Note*

Power and signal wires must be installed through NEMA 4X or IP65 rated couplers in the holes provided in the bottom of the case. All holes must be used to meet the NEMA 4X or IP65 rating requirement. The holes must be blanked off when not used.

2.3 Recommended Cables

Use the following recommended cables (note that cord grip fittings are supplied by the customer):

Transmitter to Flow Tube
See Section 2.4 for recommended cables.

Power Supply
Normal 3-wire multi-stranded 16 gauge power supply cable is recommended, with a minimum core diameter of 0.06" (1.5 mm).

Analog and Relay Outputs
Should be 2-wire multi-stranded 2 x 18 AWG or 2 x 0.75 mm^2. Shielding is not necessary.

Pulse Frequency Optocoupler, Reference Coils, Pre-Amp Supply, Reverse Flow Output Switch
Use 2-core shielded cable such as Belden #8760 or 2 x 0.75 mm^2.

2.3.1 Cable Runs

☑ *Note*

The electrode and coil cables from the flow tube to the transmitter MUST be separated to prevent noise coupling! DO NOT put the electrode cables in the same conduit as the coil cables!

The 4-20mA and pulse frequency output cables may run in the same conduit, but not in the electrodes conduit, nor in the main power conduit.

NEMA 6 and IP68 protected submersible versions of the flow tubes have the cables as flying leads already potted in the junction box. Any additional junction boxes for extended cable lengths must have the terminals for each cable separated, preferably with a metal screen between each terminal. The shields of each respective cable must be connected, but not common grounded in the additional junction box. The junction box should then be potted if outdoors, to prevent moisture forming. The additional box should then be grounded, but not connected to the cable shields.

⚠ WARNING

Do not splice or add additional cable! If additional length is required, contact Isco. Splicing cable will void your warranty.

☑ *Note*

For use of UniMag and ChemMag in Class 1, Division 2 explosive atmospheres all cabling must be run in rigid metal conduit or Teck metal clad cable, with appropriate metal cable connectors. The transmitter must be located in a non-explosive area.

2.3.2 Shrink Fit Sleeves

Each cable from the flow tube specified to NEMA 6 and IP68 have shrink fit sleeves at their free ends. These are to prevent moisture permeating into the cables, which can cause a signal zero offset and instability.

> ☑ ***Note***
>
> It is important that you do not cut the sleeves off the cable during storage of the flow meter until immediately before wiring into the transmitter terminals.

2.4 Connecting the Flow Tube

Install the flow tube in accordance the instructions in its separate user manual. Make sure the serial number of the flow tube, shown on the tag plate on the flow tube, agrees with the serial number on the transmitter tag plate when they have been supplied together. When they have been supplied separately, the transmitter rate indicator and totalizer (if supplied), as well as the range factor, need to be adjusted to the flow calibration requirements.

The maximum distance between the flow tube and transmitter depends on the media conductivity for the given recommended cable.

For media conductivities greater than 3 µS/cm (microSiemens/cm), the distance should be 300 feet or 10 x the media conductivity in µS/cm in feet (90m or 3 x media conductivity (µS/cm) in meters), whichever is less.

For longer distances, the electrode driven shields may be used (terminals 38 and 39), but this will be a special application.

For conductivities < 3 µS/cm, the maximum distance is 30 feet (9 m).

> ☑ ***Note***
>
> Most water based media has a conductivity of 100-800 µS/cm.

2.4.1 Multiple flow tubes

For cable runs from multiple flow tubes to the converter, multiple electrode cables may all run together in the same conduit, but separate from all other cables. Multiple reference and exciter coil cables may all run together in the same conduit, even with other power cables.

The maximum recommended distance for separate multiple runs is 150 feet (50m) or 10 x media conductivity in feet, whichever is less. Multiple flow tubes and cables should be at least 2 feet (0.5m) from each other.

2.4.2 Cable Connections

Connect the flow tube to the 4412 transmitter using two-wire shielded cables. There are three cables Belden #8760 or 2 x $0.75mm^2$ as shown in Figure 2-3. An optional fourth pre-amp cable is available for connection to the ChemMag (refer to Figures 2-3, 2-4, and 2-5).

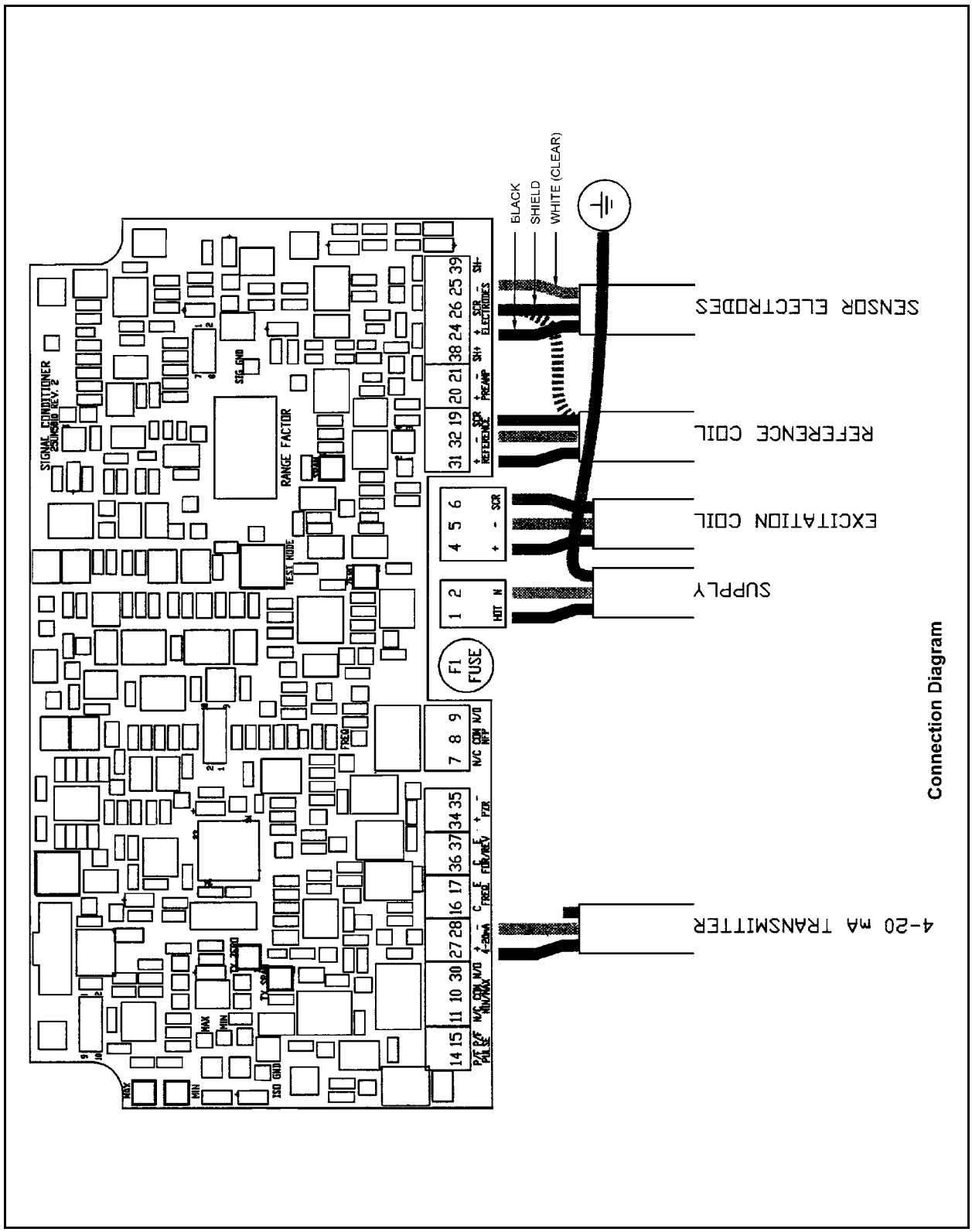


Figure 2-3 Connection Diagram

The circuitry for the 4412 is arranged on a power board (the lower board) and an analog board (the upper board). Use the table below in conjunction with the Connection Diagram in Figure 2-3.

Table 2-1 Terminal Details

Number	Description
1	Power Supply Live (Power Board)
2	Power Supply Neutral (Power Board)
3	Power Supply Ground (Power Board)
4	Coil Supply + (Power Board)
5	Coil Supply - (Power Board)
6	Coil Supply Shield (Power Board)
7	Non-full Pipe Normally Closed (NFP)
8	Non-full Pipe Common (NFP)
9	Non-full Pipe Normally Open (NFP)
10	Min/Max Common (MIN/MAX)
11	Min/Max Normally Closed (MIN/MAX)
30	Min/Max Normally Open (MIN/MAX)
14	Not Normally Used (Pulse)
15	Not Normally Used (Pulse)
16	Transistor Collector Output (C FREQ)
17	Transistor Emitter Output (E FREQ)
19	Pre-amp and Reference Coil Shield (SCR)
20	Pre-amp + ve (PREAMP)
21	Pre-amp - ve (PREAMP)
24	Electrodes Input From Sensor + (ELECTRODES)
25	Electrodes Input From Sensor - (ELECTRODES)
26	Electrodes Shield (ELECTRODES)
27	+Forward Analog Output (4-20mA)
28	-Forward Analog Output (4-20mA)
31	+Reference Coil (REFERENCE)
32	-Reference Coil (REFERENCE)
34	+External Switch for Non-full Pipe (PZR)
35	-External Switch for Non-full Pipe (PZR)
36	Reverse Flow Transistor Switch C (FOR/REV)
37	Reverse Flow Transistor Switch E (FOR/REV)
38	Electrode Driven Shield (SH+)
39	Electrode Driven Shield (SH-)

☑ Note

The cables may be supplied as 1 x 4 core cable for the reference coils and exciter coils and 1 x 4 core for the pre-amp and electrodes. The cable free ends are fitted with a shrink fitted shroud, not to be cut until immediately prior to installation.

☑ Note

ChemMags In Explosive Atmospheres Used With 4412 in Safe Area: For Entela approval conforming to CENELEC Zone 2, EExnAX it is required that the reference coil and exciter coil cable are 4-core IEC approved cable through a single gland. This is normally supplied by Isco Inc.

The cables are marked “coils”, “electrodes”, and “reference”. The cable colors are connected to the converter terminals as detailed in Table 2-2. If the cables are not labeled, measure the resistance between the Black and Clear wires on each cable. The sensor coil cable resistances are given in Section 2.4.3.

Table 2-2 Cable Connections

Exciter Coils	Electrodes	Reference	ChemMag Pre-Amp
Black to 4	Black to 24	Black to 31	Black to 20
White to 5	White to 25	White to 32	White to 21
Shield to 6	Shield to 26	Shield to 19	Shield to 19
Note: IEC Hazardous Location cables may have other colors, but they will be labelled.			

The coils and electrodes of multiple sensors are connected in parallel in the flow tube junction box. The pre-amp cable is an option with ChemMag flow tubes and is wired according to Table 2-2.

☑ Note

The cable shielding should not be cut more than 1 inch (2.5 cm) from the terminals. The cable itself should be cut no longer than needed to connect the converter to the junction box.

⚠ WARNING

The UniMag and ChemMag flow tubes are approved by Entela to CSA and UL standards for use in a Class 1, Division 2 explosive atmosphere, with the 4412 transmitter located in a safe area. It is a requirement of approval to CSA and UL standards that rigid conduit or Teck metal clad cable is used for the connection of the 4412 transmitter to the UniMag or ChemMag flow tube assembly. Metal 1/2" conduit connectors type UNYSONR-A are supplied in the flow tube junction box and 4412 transmitters for the coils, electrodes, reference coil, and optional pre-amp cables.

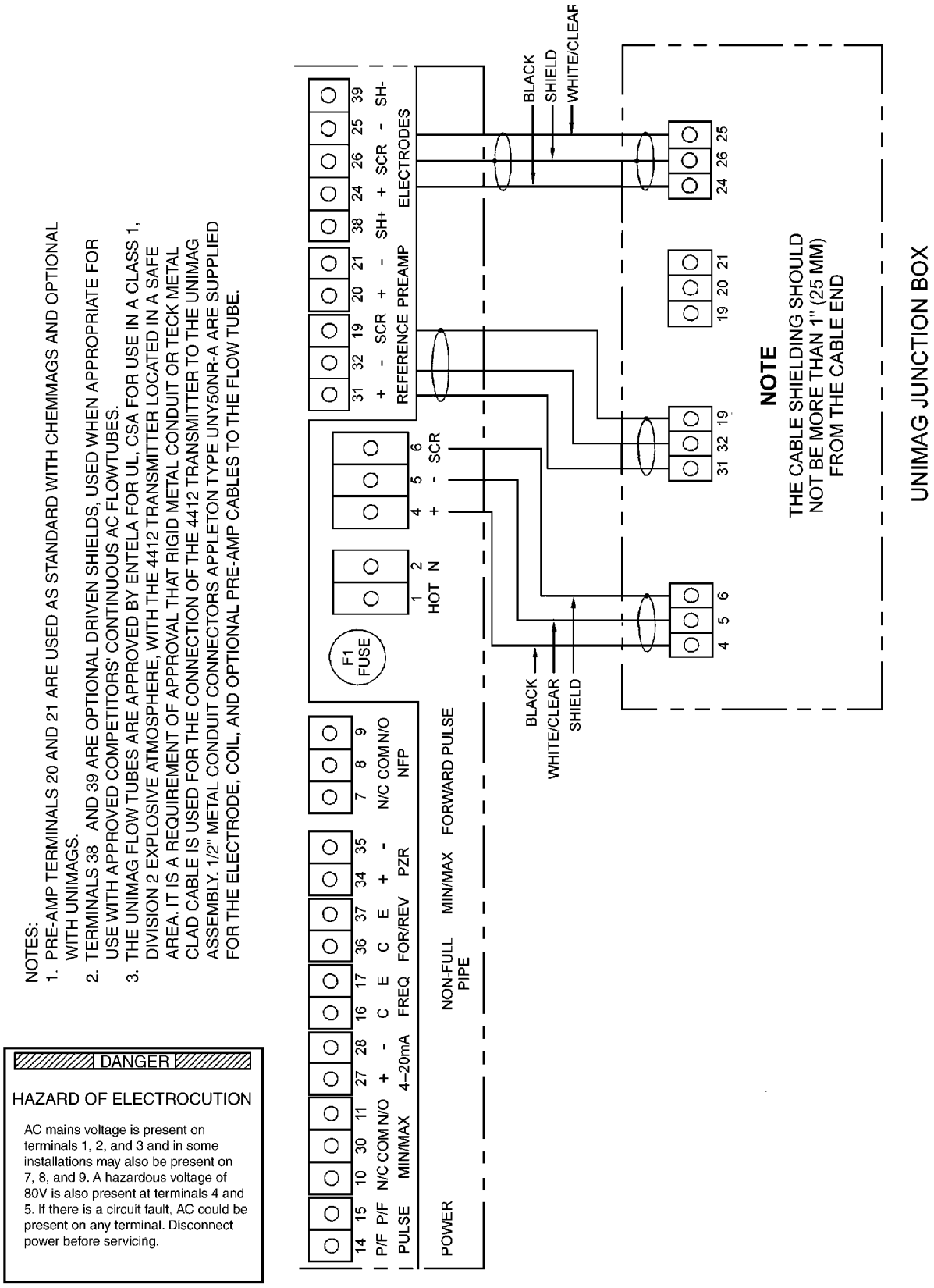


Figure 2-4 UniMag Junction Box Connections

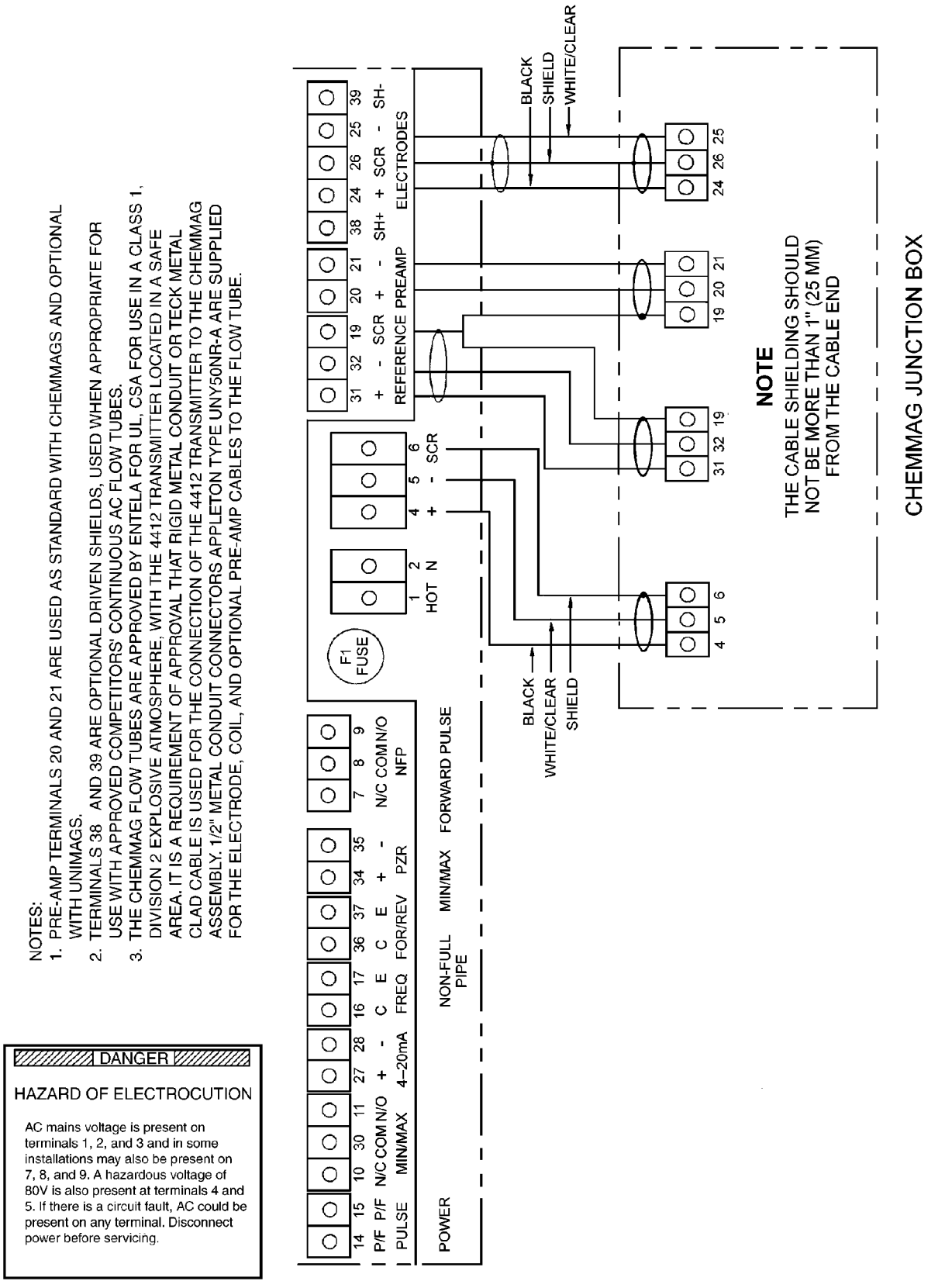


Figure 2-5 ChemMag Junction Box Connections

2.4.3 Sensor Coil Resistances

When checking for correct wiring, note that the sensor coils have the following resistances:

- 2" and 3" (50 and 80 mm) are approximately 20 Ohms per pair of coils (40 Ohms per sensor).
- 6" (150 mm) sensors are approximately 5 Ohms/pair (10 Ohms per sensor).
- 8" (200 mm) sensors are approximately 2.5 Ohms/pair (5 Ohms per sensor).
- 12" (300 mm) sensors are approximately 4 Ohms/pair (8 Ohms per sensor).
- The ChemMag coil is approximately 100 Ohms.
- Single sensor UniMag reference coils are 10 K Ohms and multiple sensor reference coils are 6.6 K Ohms.

2.5 Connecting the Power Supply

Check for the correct power supply and connect it to the 4412 terminals 1 (live H), 2 (neutral N), and the case ground. Follow safety precautions.

The main power switch SW1 is located in the bottom left hand corner of the lower power board. When switched to the right, it is suitable for 115 Vac, to the left 230 Vac.

⚠ DANGER

HAZARD of ELECTROCUTION. AC line voltage is present on terminals 1, 2, and the case ground. (see Figure 2-3). A hazardous voltage of nominally 80V is also present on coil terminals 4 & 5. In some installations, AC line voltage may also be present on terminals 7, 8, and 9. Disconnect power before opening case or front panel, or before servicing.

To avoid electrical shock, installation and service should be done by qualified personnel. Incorrect handling of the 115/230 VAC power supply can kill you. For this reason, service of components subject to high voltage should be carried out only when the power has been disconnected.

2.6 Damping (Response Time) Adjustment:

This adjustment is made using a 4-step switch located in the top left corner of the Analog Board (Figure 2-6, and also A-1 and A-2). The damping or response time is 5 x time constant.

The four steps are:

0 = 0.15 seconds
1 = 10 seconds
2 = 20 seconds
3 = 60 seconds

> ☑ ***Note***
>
> The damping is automatically set to minimum when the Test Mode Switch (Section 2.7) is used for electronic zero, span, or reverse span status.

2.7 Test Mode Switch

The Test Mode switch is located on the analog board (Figure 2-6, and also Figures A-1 and A-2). There are four rotary positions on the Test Mode switch, as detailed in Table 2-3 and also on the analog board layout.

Table 2-3 Test Mode Switch Positions

Position	Mode
0	Normal Operation*
1	Zero Test
2	Forward Span Test
3	Not Used

* Used also for hydraulic zero check.

> ☑ ***Note***
>
> The reference coil of the sensor(s) must be connected to the transmitter for testing.

2.7.1 Fine Tuning Electrical Zero and Span

Checking of zero and span is done using the Test Mode switch described above. The electrical zero and span tests confirm a satisfactory electrical condition of the 4412 transmitter.

As you step through the test procedure outlined in this section, refer to the Analog Board Layout (Figures 2-6, A-1, A-2), Jumper Position Diagram (Figures 2-7, A-3, A-4), and the Test Points Diagram (Figures 2-8, A-5, A-6).

For electrical zero and forward span testing the flow tube may be empty or full. The reference coil of the sensor(s) must be connected to the transmitter. A digital range switch (RANGE FACTOR or R) is located on the analog board (Figures 2-6, A-1, A-2). When the transmitter is supplied together with a flow tube, the Range Factor switch is set according to the required flow range, the flow units, and a sensor calibration factor C.

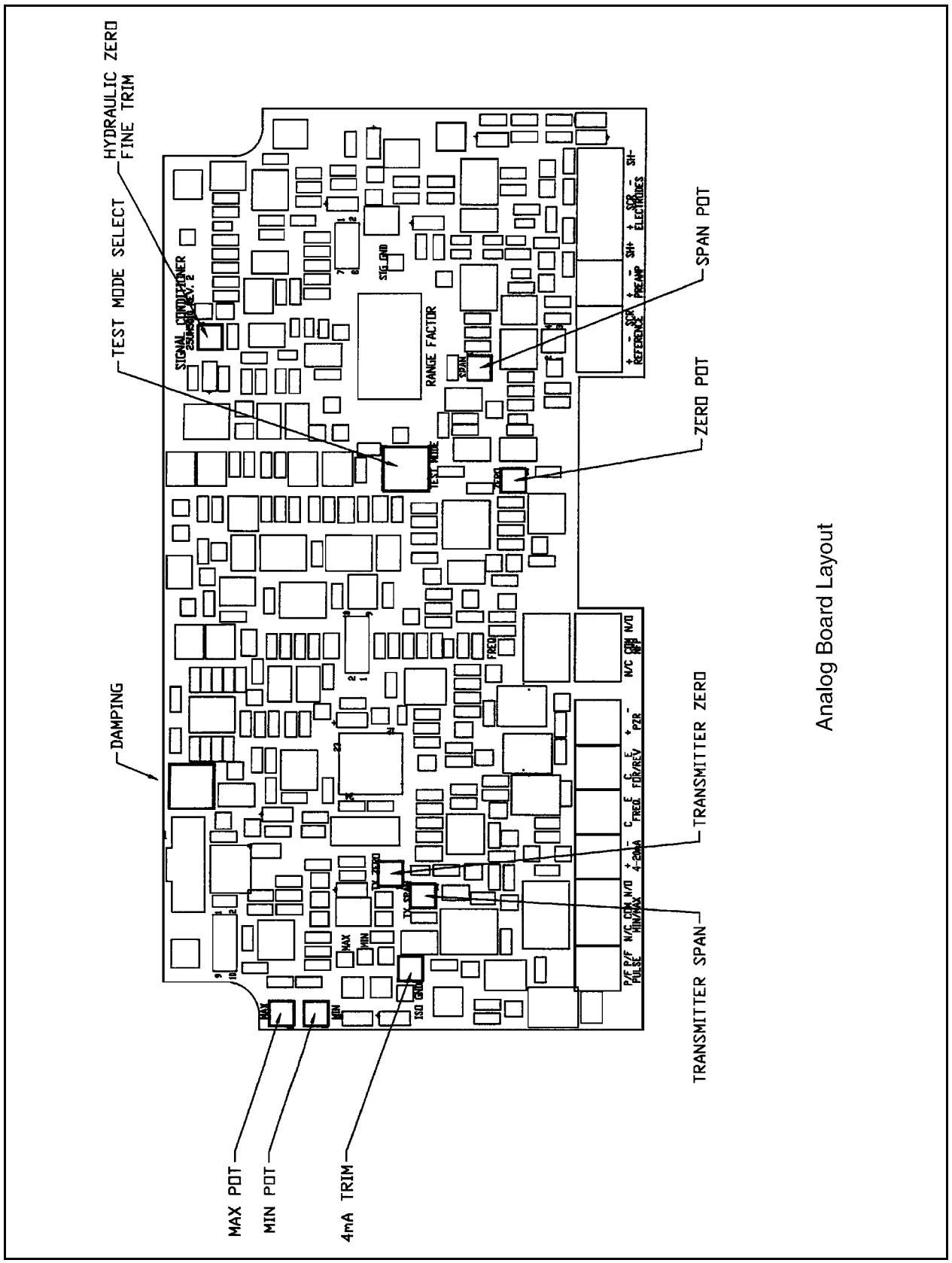


Figure 2-6 Analog Board Layout

> **☑ Note**
>
> The damping is automatically set to minimum when the Test Mode switch is set to other than position 0. This reduces the time for readings to settle.

Follow the steps below to fine tune the electrical zero and span:

1. Connect the frequency meter between TP9 (+) and TP2 (-). See the Analog Board Test Points Diagram (Figure 2-8).
2. Connect a digital multimeter between test points TP12 (+) and TP13 (-).
3. If the 4-20mA output terminals are not connected to other instrumentation, they must be shorted with a wire link.
4. Set the Test Mode switch to position 1. The minimum cut-out should operate.
5. Adjust the 4mA TRIM potentiometer so that the output current is 4.00mA (40.00mV at TP12 and TP13) with the minimum cutout active.
6. Make a note of the RANGE FACTOR (you will need to set it back to its original value when you are done with the calibration) and then set the thumb wheel switch to 50.
7. Set the TEST MODE switch to position 2.
8. Remove JP3 and store it in a safe place (it will be replaced following calibration).
9. Remove JP5 and store it in a safe place (it will be replaced following calibration). This will disable the MIN set point so that it does not interfere with the zero calibration.
    a. Adjust the ZERO pot so that the frequency is 100 Hz.
    b. Adjust the TRANSMITTER ZERO pot so that the output current is 4.16mA (41.6 mV).
    c. Set the RANGE FACTOR to 5000.
    d. Adjust the SPAN pot so that the frequency is 10kHz. (*If a frequency meter is not available, you can set the Range Factor to 5000 and adjust the SPAN until the display equals your maximum flow rate.*)
    e. Adjust the TRANSMITTER SPAN pot so that the output current is 20.00mA (200 mV).
10. Set the RANGE FACTOR back to 50 and repeat steps a) through e) until no further adjustment is necessary.
11. Set the RANGE FACTOR to the original value noted above.
12. Replace JP3 and JP5.
13. Set the TEST MODE switch to position 0 to measure flow (or to check hydraulic zero in accordance with Section 2.10).

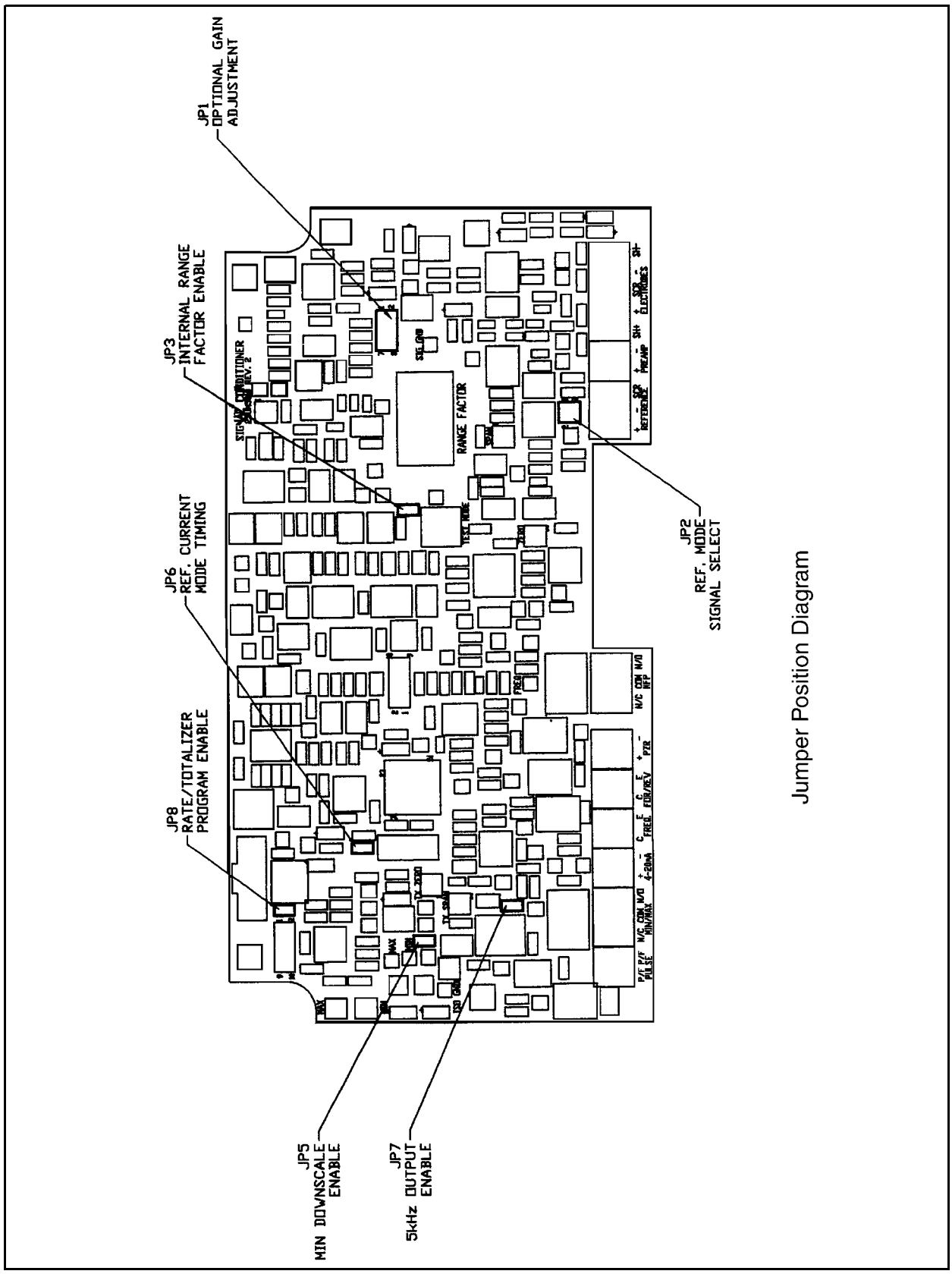


Figure 2-7 Jumper Position Diagram

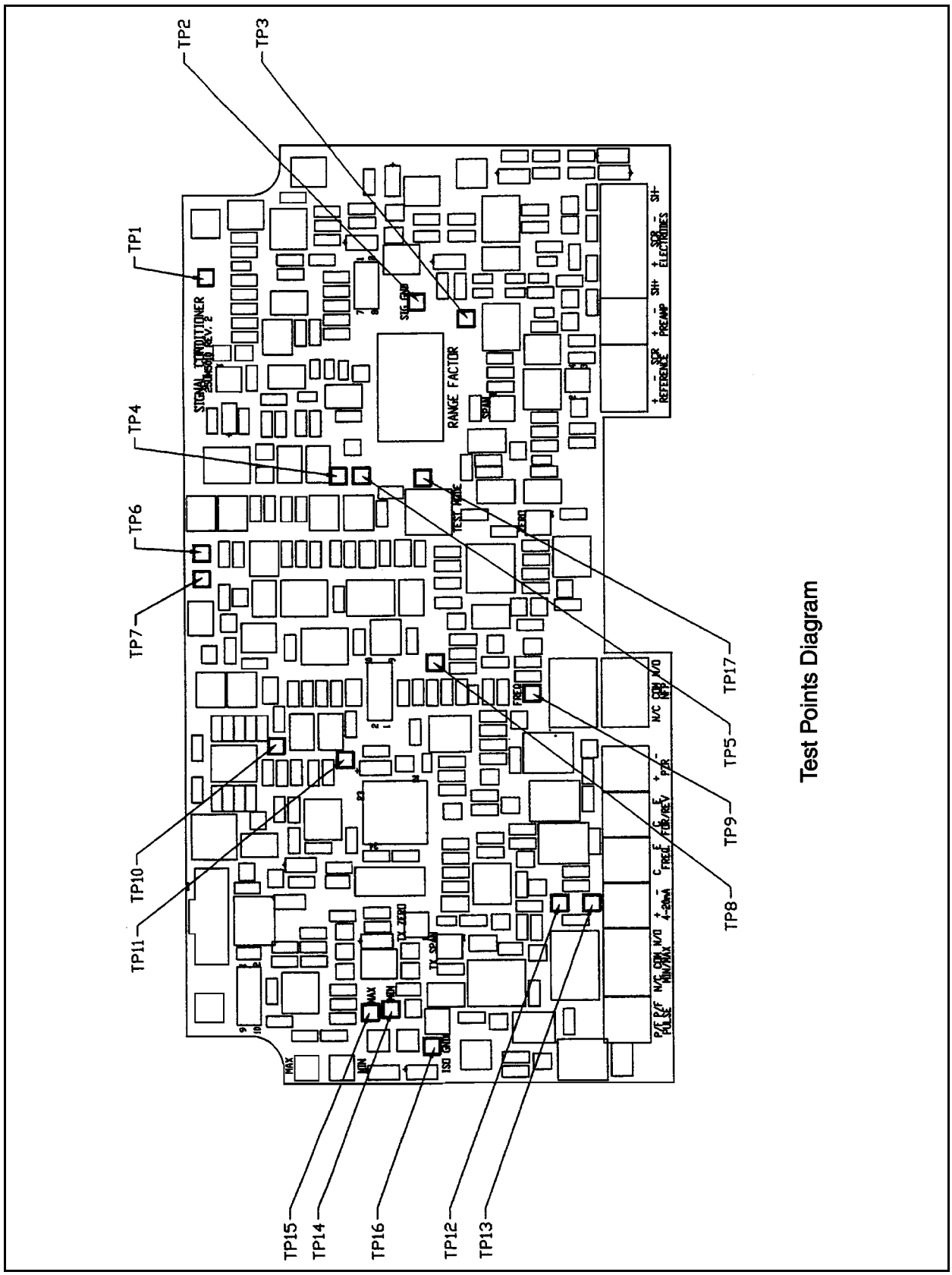


Figure 2-8 Test Points Diagram

2.8 Min/Max Alarm Contact Setting

The min/max alarm is a changeover contact and operates from terminals 10, 11, and 30, and is labeled MIN/MAX (refer to the Connection Diagram in Figure 2-3). The normally closed terminal 11 is marked N/C and terminal 10 is marked common.

The normally open terminal 30 is marked N/O. It may be used for on/off flow control or as a low flow cutoff for deleting erroneous pulse frequency outputs associated with low flows at typically 1 or 2% of full scale.

> ☑ ***Note***
>
> The relay is de-energized when flow is above MIN set point and below MAX set point.

2.8.1 Minimum Flow Alarm

Connect a multimeter to test points TP14(+) and TP16 (ground) on the analog circuit board and measure the voltage across the points (refer to the Test Points Diagram, Figure 2-8, or Figures A-5 and A-6).

Adjust the "MIN" potentiometer until the desired minimum percentage is attained.

The outputs are 0-2V. The potentiometer is turned to provide the required percentage of full scale, as a percentage of 2V. 0 volts = 0% flow and 2 volts = 100% flow. To determine the minimum flow alarm trigger voltage, multiply the desired minimum flow percentage by 2 volts.

For example:

To set the minimum setpoint to 2% of full scale:

1. Turn the 'MIN' potentiometer to provide a contact that opens at 0.02 x 2V = 0.04V output across test points TP14 and TP16.
2. The contact will then open at 2% of full scale flow at the appropriate terminals.

> ☑ ***Note***
>
> The 2% minimum setpoint is normally factory set.

2.8.2 Maximum Flow Alarm

Measure the voltage across test points TP15(+) and TP16 (ground). Adjust the "MAX" potentiometer until the desired maximum percentage is attained.

To determine the maximum flow alarm trigger voltage, multiply the desired maximum flow percentage by 2 volts.

2.8.3 Low Flow Cut-Out

The setting of the 'MIN' potentiometer automatically cuts off all pulse frequency outputs below the set point. This also applies to the forward flow counter and rate indicator on the front panel. The analog output goes to 4 mA.

2.9 Non-Full Pipe Detection Setting

In horizontally installed flowmeters a changeover contact at terminals 7/8/9 is actuated when the media falls below the uppermost pair of flowmeter electrodes (non-full pipe). This will also

function if the electrodes cable is cut. The factory setting is such that the contact will NOT function should the uppermost electrodes become uncovered. To actuate this function, remove jumper JP9 (see the Jumper Position Diagram in Figure 2-7 or Figures A-3 and A-4).

The changeover contact actuation is checked as follows when a non-full pipe condition prevails:

1. Connect a multimeter between the COM terminal 8 and N/O NPP (terminal 9).
2. Set the TEST MODE switch to position 0.
3. Ensure that the NPP relay operates (continuity meter shows relay closure).
4. Ensure that the output frequency is 0 Hz and the output current is 4.00 mA.

> ☑ ***Note***
>
> The minimum contact set to typically 1-2% of full scale and the non-full pipe function will prevent erroneous totals and analog/digital outputs.

2.9.1 Positive Zero Return (PZR)

A Positive Zero Return (PZR) function may be used as an alternative to the non-full pipe indicator.

Terminals 34 (+) and 35 (-) may be connected to an external normally open switch. When closed, the external switch will drive the 4-20 mA output to 4 mA and the pulse frequency output to 0 Hz. The optional rate indicator and totalizer will be driven to zero.

2.10 Hydraulic Zero

For critical applications it is recommended that you check to see if the hydraulic zero (no flow in a full pipe) is the same as the electrical zero.

> ☑ ***Note***
>
> The flow tube must be completely full of media and there can be NO hydraulic motion in the Flow Tube at the time of this calibration. If both these conditions cannot be met, DO NOT attempt to do this calibration.

To check this, set the Test Mode switch to position 0 and check the analog output. It should be 0.00 volts measured across TP11(+) and ground TP2(-).

In the rare event it is not zero (there may be slight leaks in the pipe or valve), then the Hydraulic Zero Fine Trim potentiometer may be adjusted accordingly. Refer to the Analog Board Layout (Figure 2-6, and also Figures A-1 and A-2).

2.11 Setting The Range (R) Factor

The Range Factor (R) is digitally set to determine the required full scale of the flow tube. (See the appropriate flow tube data sheet for the various flow ranges.) The high precision range factor is entered using the thumb switch marked RANGE FACTOR located on the analog board (see Analog Board Layout, Figure 2-6, and also Figures A-1 and A-2).

The range factor is calculated by its relationship with the flowmeter calibration factor C, which appears on the flow tube nameplate.

$$R = \frac{100 * C}{\text{Range}}$$

. . .where the range is the full scale in gallons per minute (gpm)

$$R = \frac{22.73 * C}{\text{Range}}$$

. . . where the range is the full scale in m^3/hr

$$R = \frac{.144 * C}{\text{Range}}$$

. . . where the range is the full scale in millions of gallons per day (mgd)

Determine the range factor to four figures and set it digitally in the switch marked Range Factor (see Analog Board Layout, Figure 2-6).

If a range change is required, you can calculate the range using the following formula:

$$R_{new} = R_{old} \times \frac{\text{Range old}}{\text{Range new}}$$

2.12 Jumper Settings

The jumper settings for normal function (default) is as shown in Table 2-4.

Table 2-4 Jumper Settings

Conditioner Board		
Jumper	**Function**	**Default**
JP1	Optional gain adjustment	1-2
JP2	Reference mode signal selection	1-2
JP3	Internal calibration “R Factor” enable	linked
JP5	Min function downscale enable	linked
JP6	Reference current mode timing enable	open
JP7	5k Hz output frequency enable	open
JP8	Rate/totalizer programming enable	open
JP9	Non-full pipe sensing	linked
Power Board		
Jumper	**Function**	**Default**
JP1	Reference signal selection	1-2, 3-4

2.13 Reference Settings

The 4412 Transmitter can be configured to operate in two different reference modes (see Table 2-5). When used with Isco flow tubes compatible with the UniPulse™ technology, the reference coil mode is used as standard.

Table 2-5 Reference Settings

	Conditioner Board (top)		Power Board (bottom)
Mode	**JP2**	**JP6**	**JP1**
Reference Coil	1-2	open	1-2, 3-4
Reference Current	3-4	linked	5-6, 7-8

2.14 Pulse Frequency Output

For non-indicating versions of the 4412, the standard pulse frequency output is set at 0-10000 Hz. By inserting a link on the analog board jumper JP7 (see Figure 2-7) the output frequency becomes 0-5000 Hz. It is not scalable The output is taken from terminals 16 and 17 via an optically isolated open collector, rated 30 Vdc max, 50mA max.

On indicating versions of the 4412, the pulse frequency output is normally 0-5,000 Hz, fed to the indicator unit from the analog board. On indicating versions the totalizer is scalable, however, scaling the totalizer does not alter the 0-5k Hz or 0-10k Hz output.

UniPulse 4412 Flow Transmitter

Section 3 Optional Indicator Unit

3.1 Overview

The 4412 is available with an optional display for viewing flow rate and total flow in selectable units of measure (see Figure 3-1).

This section contains instructions that pertain to 4412s that have this optional indicator.

Figure 3-1 4412 With Optional Indicator

The specifications for the indicator unit are given in Table 3-1 below.

Table 3-1 Indicator Specifications

Internal Battery	3V, Lithium
Life Expectancy of Battery	5+ years
Battery Replacement Part	36367-202
Display	0.43" / 109mm high, non-backlit
Totalizer	
Type	UP counting
Digits	8
Scaler	0.0001 - 100.0000
Decimal Point	5 positions, programmable
Rate Indicator	
Digits	4/5, (4 calculated, 5 displayed with fixed 0 in LSD)
Scaler Range	.001 to 9999
Decimal Point	4 positions, programmable

The indicator unit is a combination UP counting totalizer and rate meter. The totalizer has an eight digit display. The front-panel reset key is normally disabled, but can be enabled by the user if needed (Section 3.5).

The rate meter has an eight digit LCD display (see Figure 3-2). A programmable rate scaler and decimal point allow for display of rate in any engineering terms.

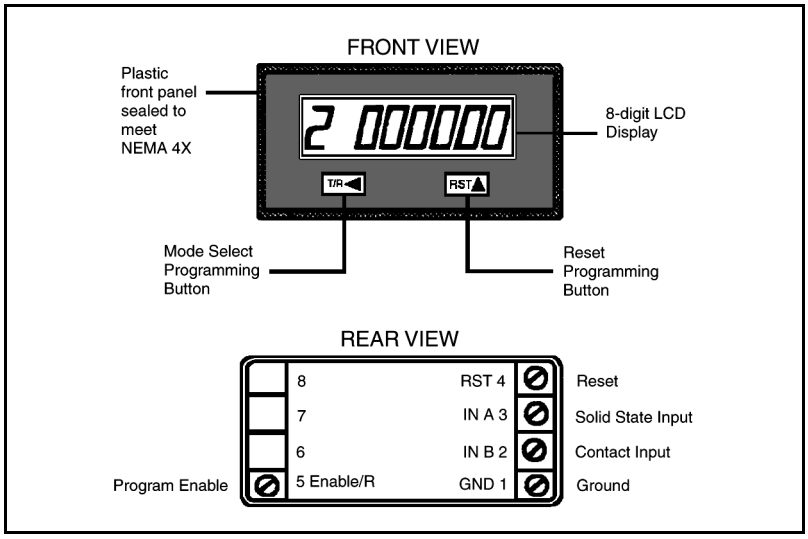


Figure 3-2 LCD Display for Indicator Unit

3.2 Application

The indicator unit is designed to show both total and process rate. Certain programming and wiring decisions must be made to complete your application. We recommend the following sequence:

1. Answer the following questions:
   - What engineering units should the rate meter be scaled to?
   - How many pulses per volume amount is required?
   - Is a decimal point needed on the count and/or rate display?
   - Should the front-panel reset key be active or inactive? (Normally it is set to disabled at the factory.)
2. Calculate the count scale factor and the rate scale factor. (These are normally factory set.)

3.3 Mounting

The indicator unit should be mounted onto the 4412 as shown in Figure 3-3.

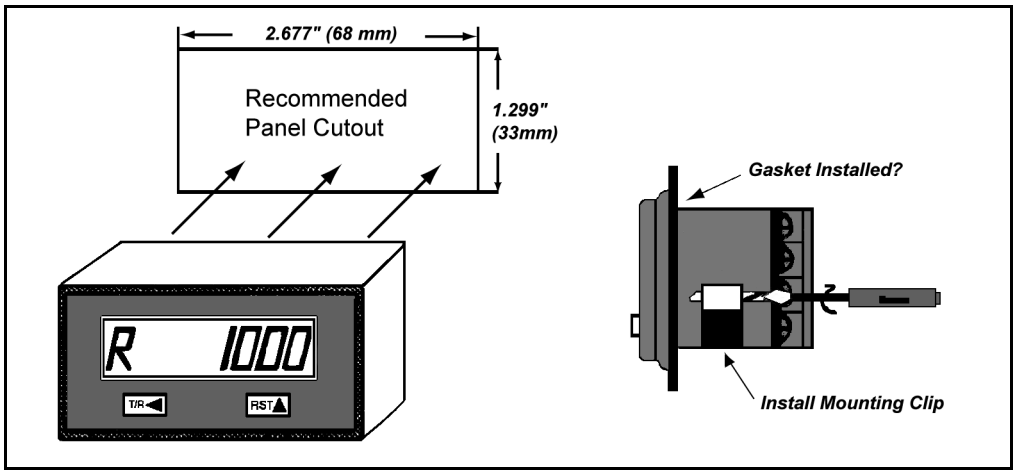


Figure 3-3 Mounting the Indicator Unit

3.4 Front Panel Keys

Press the T/R key on the front panel to toggle between the totalizer and rate meter screens.

Note

The RST reset key is normally disabled when not in program mode. See Section 3.13, for instructions on enabling it.

3.5 Program Mode

To enter the program mode, a shorting jumper is placed on JP8 (see Figures 2-7, A-3 and A-4). We suggest removing JP9 and placing it on JP8. When programming is done, remove JP9 and return to its original position on the board; the unit will leave program mode and return to normal display mode.

There are six program-mode screens in the indicator unit. Press and hold the T/R key while repeatedly pressing RST the key to advance to successive screens.

Table 3-2 Programming Screens

Screen	Function
1	Count Scale Factor (Section 3.7)
2	Totalizer Decimal Point (Section 3.8)
3	Rate Scale Factor (Section 3.10)
4	Rate Meter Decimal Point (Section 3.11)
5	Rate Display Multiplier (Section 3.12)
6	Reset Key Enable/Disable (Section 3.13)

3.6 Calculating the Count Scaler

The Count Scaler (CS) is used to obtain a particular count rate (*e.g.* 1 pulse/10 gallons), given a particular full scale flow rate (*e.g.*, gpm). The Count Scaler has six digits available with an adjustable decimal point.

Count Scaler range : 0.0001 to 99.9999.

Count Scaler (CS) Formula:

a) when flow is in gpm

$$CS = \frac{gpm \times ppg}{3000}$$ where ppg is pulses/gallon

b) when flow is in m^3/h

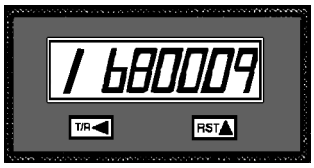
$$CS = \frac{m^3/h \times ppm^3}{180000}$$ where ppm^3 is pulses/m^3

c) when flow is in ml/min

$$CS = \frac{ml/min \times ppml}{3000}$$ where ppml is pulses/ml

3.7 Programming The Count Scale Factor

The first screen in the program mode (see below) is used to enter the count scale factor.



The far right digit will be flashing. Press the RST key until reaching the desired digit value.

Note

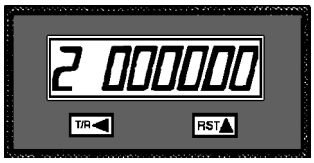
Pressing and holding the RST key will cause the numbers to auto scroll.

Next press the T/R key to move the flashing digit one place to the left. Change this digit to the desired value with the RST key.

Repeat this process until all digits are set correctly.

3.8 Programming The Totalizer Decimal Point

The second screen (see below) is used to enter the decimal point display on the totalizer screen.



Press and hold the T/R key and then press the RST key to move from screen one to screen two.

Press the RST key to move the decimal point to the desired position.

3.9 Calculating the Rate Scale Factor

The rate meter calculates rate by measuring the time interval between input pulses, converting to a frequency (F = l/t), and multiplying the product by the rate scaler.

The rate scaler is programmed to convert the count input frequency into the desired rate units for display (e.g. gpm, m^3/h, etc.).

Rate Scaler Range: 0.001 to 9999

Rate Scaler (RS) formula:

$$RS = \frac{\text{Max. Flow Rate x DPF}}{50}$$

where:

Max. Flow Rate may be in any units (e.g. gpm, m^3/h, ml/minute).

DPF is the decimal point factor corresponding to the desired decimal point location on the run mode screen:

Display	DPF
XXXX	1
XXX.X	10
XX.XX	100
X.XXX	1000

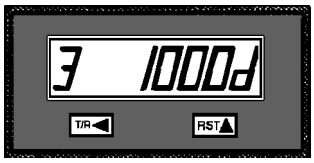
Example 1:

A ChemMag has a max. flow rate of 3 gpm. Display the flow rate to 2 decimal places (XX.XX).

$$RS = \frac{3.00 \times 100}{50} = 6$$

3.10 Programming The Rate Scale Factor

The third program mode screen (see below) allows you to enter the rate scale factor.



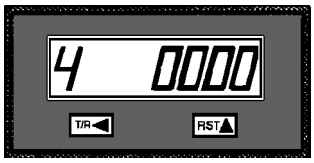
The small "d" appears on the right of the display when it is time to enter the decimal point position for the rate scaler.

> **Note**
>
> This decimal point is used for the rate scaler only and will not appear on the rate meter screen.

Press the RST key to change the first digit to the correct value. Then press the T/R key to select the next digit to be changed. Repeat this process until all the digits are correct. When the "d" appears, press the RST key until the decimal point is in the desired location.

3.11 Rate Meter Decimal Point

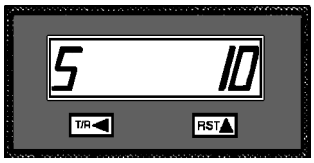
The fourth program mode screen (see below) is used to enter the decimal point position for the rate meter run-mode display. The display will show the screen number (4) and four zero's.



Press the RST key until the decimal point is in the correct position.

3.12 Rate Display Multiplier

The fifth screen (see below) is used to select the rate display multiplier of one or ten. Selecting rate x10 will add a zero to the far right of the display. This zero will not changed value and does not affect the decimal point position.

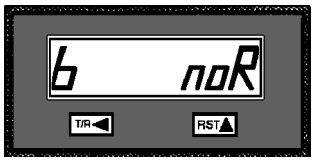


The display will show the screen number (5) on the left side, and a 1 or 10 on the right side.

Press the RST key to select 1 or 10.

3.13 Enable/Disable Totalizer Reset

The sixth screen is used to enable or disable the RST key on the front panel, which is normally disabled so the totalizer count cannot be reset.



The display will show the screen number (6) on the left side, and a "noR" if disabled, or "R" if enabled. If the Totalizer Reset key is enabled, the totalizer count can be reset by pressing the RST key when not in program mode.

Press the RST key to toggle between the two choices.

3.14 Indicator Unit Battery Safety

The lithium battery that powers the indicator unit contains inflammable materials such as lithium organic solvent, and other chemical ingredients.

⚠ CAUTION

Explosion or fire may result if the battery is not handled correctly.

To avoid an accident follow these guidelines:

- Do not stack batteries
- Do not heat batteries above 95°C
- Do not disassemble batteries
- Do not recharge lithium batteries
- Do not apply pressure to, or deform batteries
- Do not solder to batteries
- Do not dispose of batteries in fire
- Insert battery with correct polarity

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UniPulse 4412 Flow Transmitter

Section 4 Troubleshooting

4.1 Overview

Troubleshooting refers to the determination of the cause of a problem in your 4412. By following the steps outlined in this section, you may be able to resolve your situation without further assistance. However, if you find that the problem persists or you are unable to resolve it on your own, contact Isco's Service Department.

⚠ DANGER

HAZARD of ELECTROCUTION. AC line voltage is present on terminals 1,2, and 3. (See Figure 2-3). A hazardous voltage of nominally 80V is also present on coil terminals 4 and 5. In some installations, AC line voltage may also be present on terminals 7, 8 and 9.

Disconnect power before opening case or front panel, or before servicing. To avoid electrical shock, installation and service should be done by qualified personnel. Incorrect handling of the 115/230 VAC power supply can kill you. For this reason, service of components subject to high voltage should be carried out only when the power has been disconnected.

4.2 Basic Check of Transmitter and Flow Tube

Connect the flow tube to the transmitter as described in Section 2.4. Turn power on with care, making sure the main power switch SW1 is in the correct voltage position (Section 2.5).

Check zero and span as detailed in Section 2.7.1. If this is unsatisfactory, either the flow tube or transmitter or both are at fault. Proceed to determine fault source as follows:

- Check at the transmitter ends of the flow tube cables; between 4 or 5 and shield 6 of the sensor. There should be a minimum of 10 Meg Ohms (typically > 20 Meg Ohms). Alternatively, for media-covered electrodes, between 24 and shield 26 and between 25 and shield 26 the resistances should be approximately the same, but between lOOk-5Meg Ohms. If the electrode of a sensor has shorted, the analog output signal will be approximately half.
- In the unlikely event the flow tube tests are unacceptable, the flow tube is defective or flooded. Remove the cover plates and dry it out. If this has no effect, then it requires replacement. If sensors are acceptable, the fault lies with the transmitter.

Multiple sensors are normally wired in parallel with the following values:

Sensor coils may be checked by measuring the resistances as follows:

- 2" and 3" (50 and 80 mm) are approximately 20 Ohms per pair of coils (40 Ohms per sensor).
- 6" (150 mm) sensors are approximately 5 Ohms/pair (10 Ohms per sensor).
- 8" (200 mm) sensors are approximately 2.5 Ohms/pair. (5 Ohms per sensor).
- 12" (300 mm) sensors are approximately 4 Ohms/pair. (8 Ohms per sensor).
- The ChemMag coil is approximately 100 Ohms.
- Single sensor UniMag reference coils are 10 K Ohms and multiple sensor reference coils are 6.6 K Ohms.

Make sure the cables are not damaged or moisture laden.

4.3 Problem Solving

Use Table 4-1 below to identify problems and their most likely solution. If you are still unable to resolve your problem, contact the Isco Service Department.

Table 4-1 Troubleshooting

Problem	Solution
Power Fuse Keeps Blowing	Check that the power supply is not 'too high (do not increase Fl fuse value). The transmitter is probably faulty and requires replacement of circuit board.
Transmitter Is Overheating	Check to see if: • the supply voltage is over tolerance. • a flow meter has a short circuit. There should be a minimum of 10 Megohms between shield and coils. • the fuse Fl could be blown. Replace fuse Fl. Do not increase the fuse value.
Erratic Signal	When the electrical zero and span tests are satisfactory, but in operation the signal is erratic, the probability is that the media level has fallen to the point where the flow tube electrodes are exposed. Make sure there is a head of media above the electrodes. You can remove jumper JP9 (Figure A-4) to activate Non-Full Pipe Detect. Alternatively, make sure the flow meter is correctly grounded.
Output Greater Than 20-mA	This may indicate moisture entering the cable ends and/or the flowmeter coils. (This may be corrected by drying the unit out with a heater or a hair dryer). Check sensor as described in Section 4.1.
No Fault Flow Sensor, Zero/Span Test Unacceptable	• Check the maximum load for the 4-20mA output. The maximum load is 800 Ohms • Check for irregularity in voltage supply or under power. • Check electrode wire connections 24/25/26 (Section 2.4). For other faults, see the separate flow meter instructions.

Table 4-1 Troubleshooting (Continued)

Problem	Solution
No Change in Display	• Check fuse F1. • Check the coil wire connections.
Will Not Read Flow	If the electronic tests pass, but the unit will not read the flow: • Check the flow direction. • Check the electrode connections. • Switch the black (24) and white (25) connections (Section 2.4).
Incorrect Flow Readings	If flow readings are incorrect, check the Range Factor and display settings. The rate scaler formula is: $RS = \frac{\text{Max. Flow Rate x DPF}}{50}$ The count scaler formula, when flow is in gpm, is: $CS = \frac{\text{gpm x ppg}}{3000}$ where ppg is pulses/gallon You can also verify the electrode wiring for 24/25/26 (Section 2.4). Another item to check is the Hydraulic Zero TP 11 (+) and TP 2 (-). Adjust the Hydraulic Zero trim pot. This must be done with the flow stopped and the pipe full. (Section 2.10)
Fluctuating Flow Rates	If flow rates are fluctuating: • Check for a cable splice. Do not use butt connectors or wire nuts. • Check to see if the electrodes are exposed to air. • There may be an uneven ground potential. Use grounding rings or cathode-protect the flow tube (electrically bypass the flow tube by attaching a cable from the upstream flange to the downstream flange) • Separate the coil and electrode cables.
Transmitter Faults	Connect the flow tube (or coil simulation) and transmitter as detailed in Section 2.4. Turn power on with care. If the transmitter does not function, check fuse Fl. The value of this fuse should be 0.5A for 115 Vac or 0.25A for 230/240Vac.

4.4 Test Points

The test points are shown in Figure 4-1 (and also A-5 and A-6), and described in Table 4-2. The waveforms may be supplied on request. They require an oscilloscope with ground TP2. These tests should be performed with the assistance of trained Isco technicians, and only when a transmitter is considered faulty, to help trace the defective components. Voltages are measured across the following test points and TP2 (ground).

Keep in mind that faulty boards are normally easier to replace than spending time analyzing the fault, especially with surface mount components.

Table 4-2 Test Points

Test Point	Function	Required Equipment
TP1	Amplified electrode signal - stage 1	Oscilloscope
TP2	Signal ground	
TP3	Reference integrator output	Oscilloscope
TP4	Autozero correction signal	Digital Multimeter
TP5	Amplified electrode signal - stage 2	Oscilloscope
TP6	Flow signal integrator output - channel A	Oscilloscope
TP7	Flow signal integrator output - channel B	Oscilloscope
TP8	Damped flow signal - unidirectional	Digital Multimeter
TP9	Frequency output	Digital Multimeter
TP10	Reference signal	Digital Multimeter
TP11	Undamped flow signal - bidirectional	Digital Multimeter
TP12	40−200m V output current monitor +	Digital Multimeter
TP13	40−200m V output current monitor -	Digital Multimeter
TP14	Min set point	Digital Multimeter
TP15	Max set point	Digital Multimeter
TP16	Isolated output signal ground	

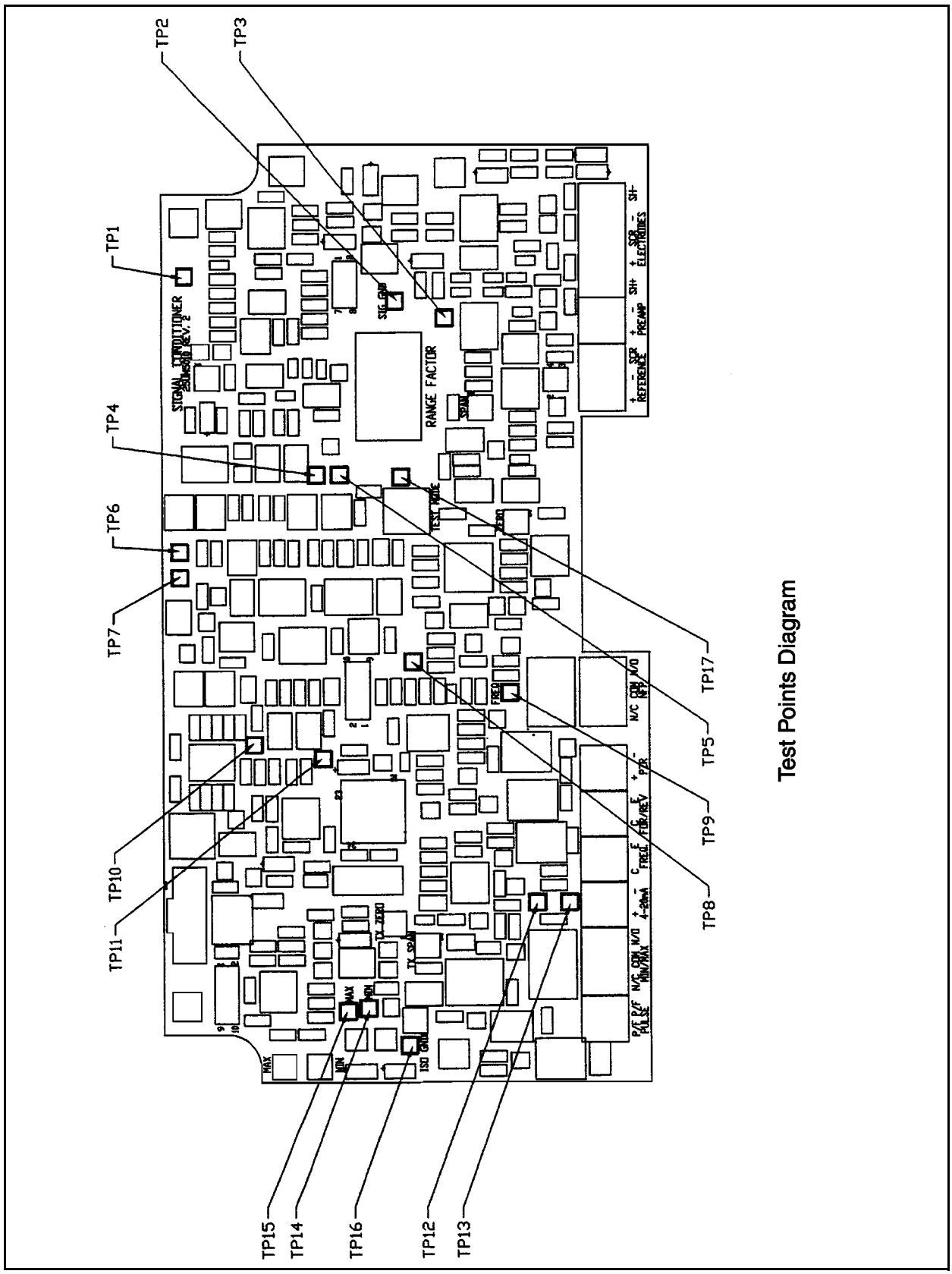

Figure 4-1 Test Points Diagram

4.5 Electrolytic Electrode Cleaning

⚠ WARNING

NOTE THAT ELECTROLYTIC ELECTRODE CLEANING IS NOT PERMISSABLE IN HAZARDOUS LOCATIONS!

⚠ DANGER

HAZARD of ELECTROCUTION. AC line voltage is present on terminals 1,2, and 3. (See Figure 2-3). A hazardous voltage of nominally 80V is also present on coil terminals 4 and 5. In some installations, AC line voltage may also be present on terminals 7, 8 and 9.

Disconnect power before opening case or front panel, or before servicing. To avoid electrical shock, installation and service should be done by qualified personnel. Incorrect handling of the 115/230 VAC power supply can kill you. For this reason, service of components subject to high voltage should be carried out only when the power has been disconnected.

Due to the high signal to noise ratio of the 4412 transmitter, there is normally no need to clean electrodes. For example, they may be left coated in normal greasy water applications.

However, if you notice that flow rates are dropping off, you may want to take full advantage of the 4412's high magnetizing current (>1A peak to peak) and frequency (nominal 40 Hz) in the coils to electrolytically clean greasy build-up.

1. Remove the electrode cable 24/25/26 and place in parallel in the terminals of coil cable 4/5/6 from the 4412 transmitter.
2. Do not remove cable 4/5/6.
3. After approximately 30 seconds to 1 minute, remove the electrode cables and reconnect into terminals 24/25/26 for normal operation.
4. The electrodes have now been electrolytically cleaned.

⚠ CAUTION

This procedure must NOT be performed with ChemMags, or UniMags fitted with a pre-amp. Damage to the pre-amp will occur.

UniPulse 4412 Flow Transmitter

Appendix A Circuit Board Layouts

A.1 Circuit Board Layouts

The following pages contain illustrations and photographs of the upper analog board in the 4412. The illustrations can also be found in Section 2, but are repeated here for your convenience.

The following layouts are presented in this section:

- Analog Board Layout - Figures A-1 and A-2
- Jumper Positions - Figures A-3 and A-4
- Test Positions - Figures A-5 and A-6

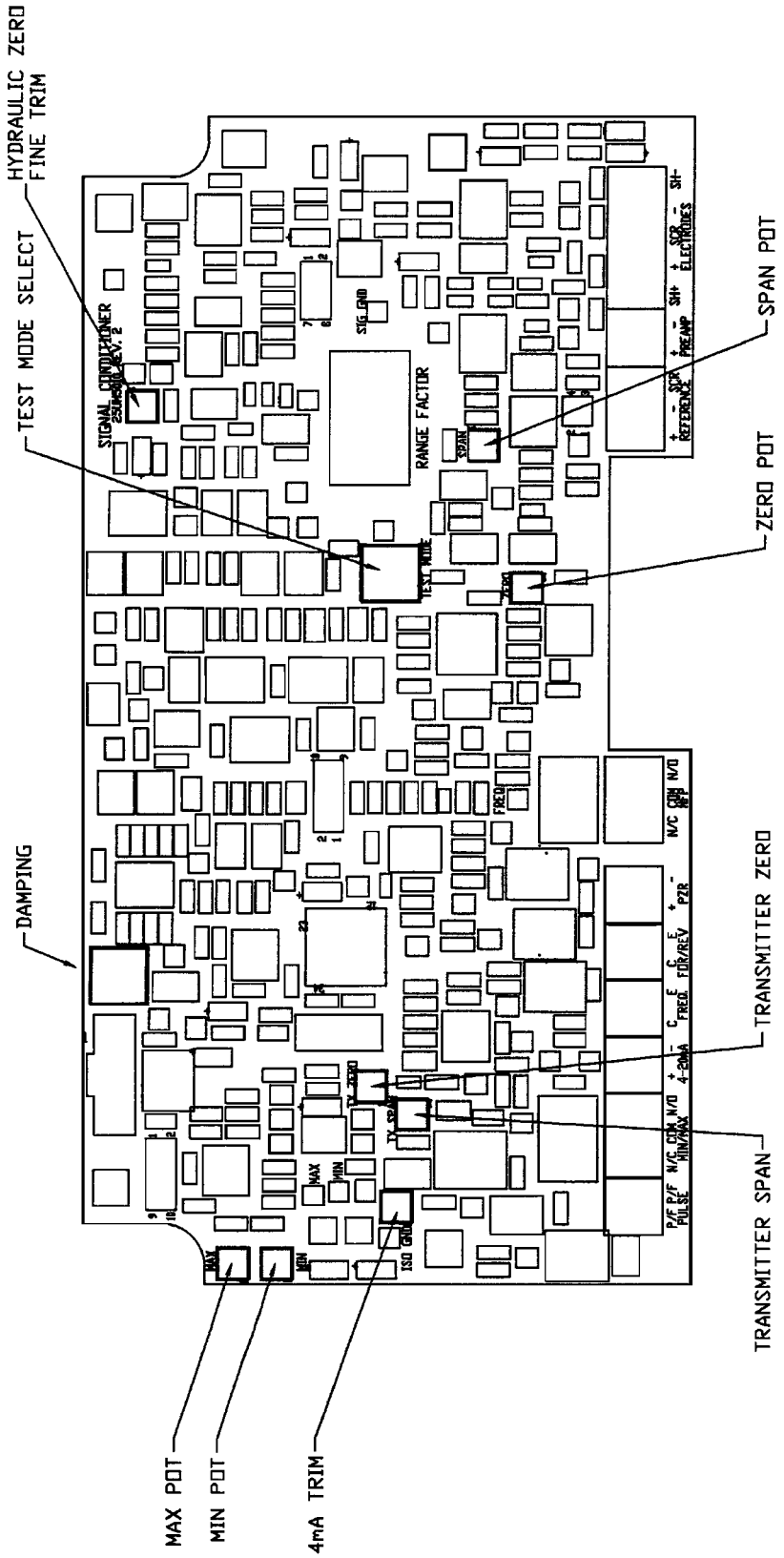

Figure A-1 Illustration of Analog Board Layout

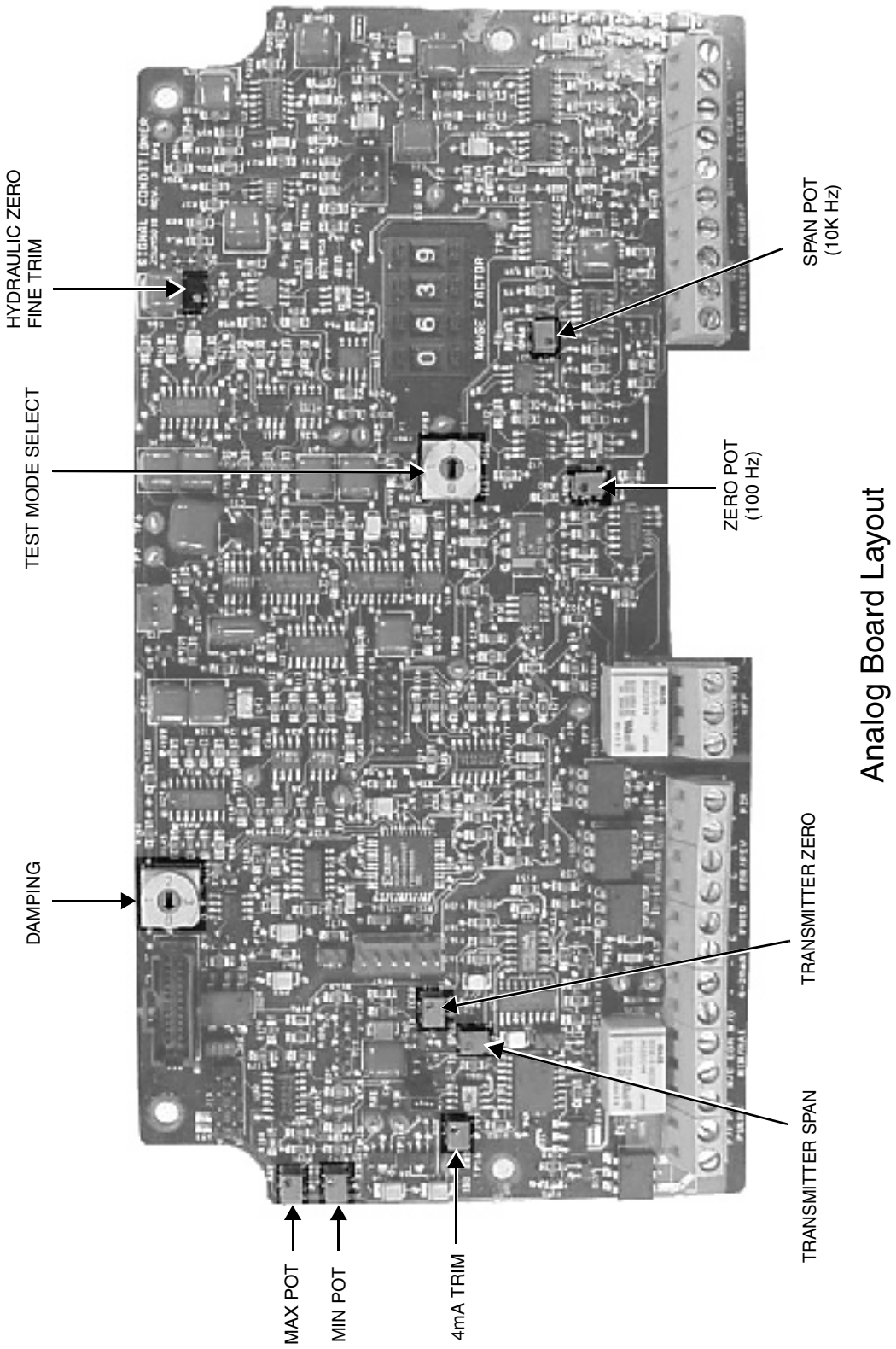

Figure A-2 Photo of Analog Board Layout

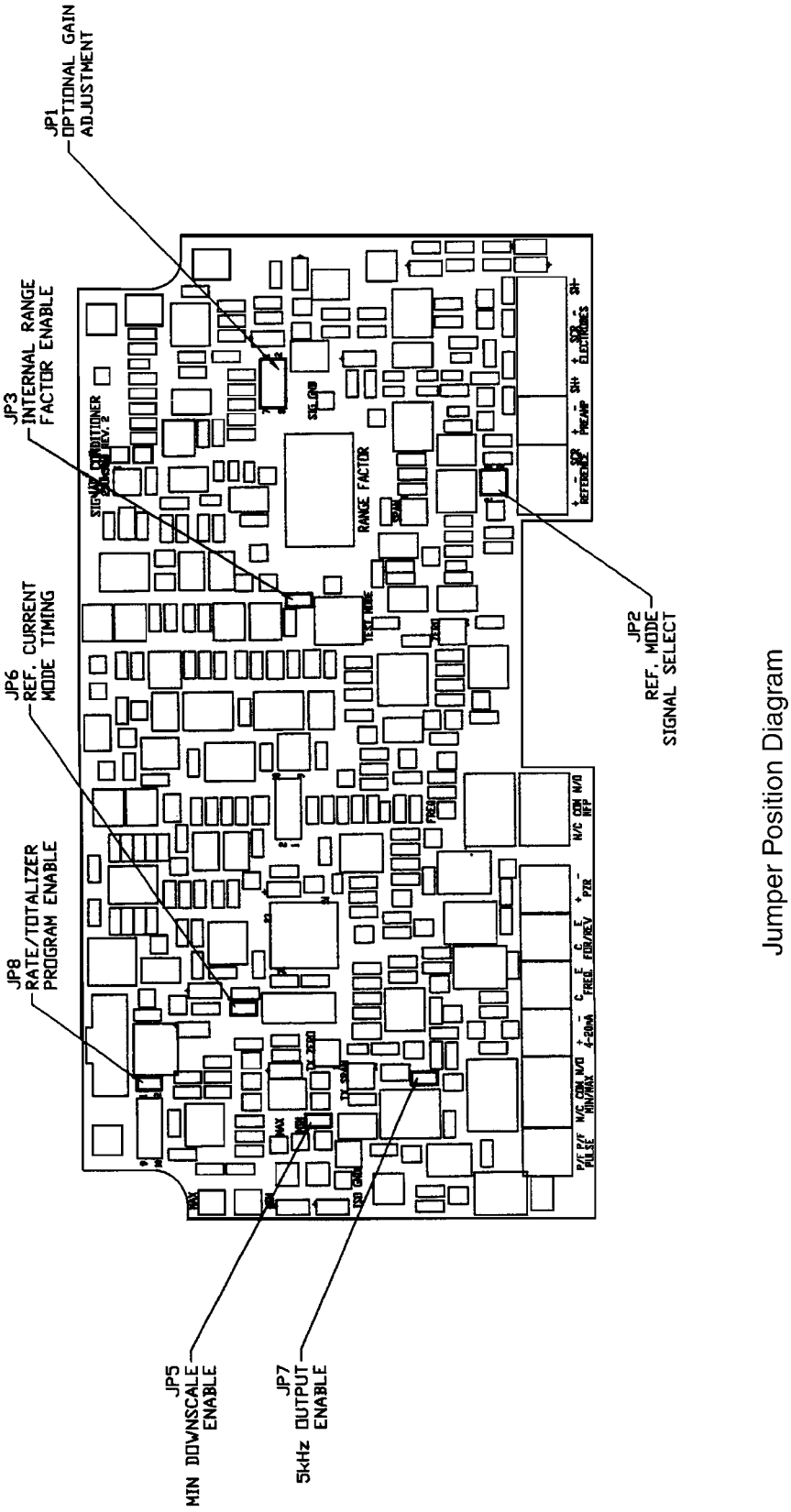

Figure A-3 Illustration of Jumper Positions

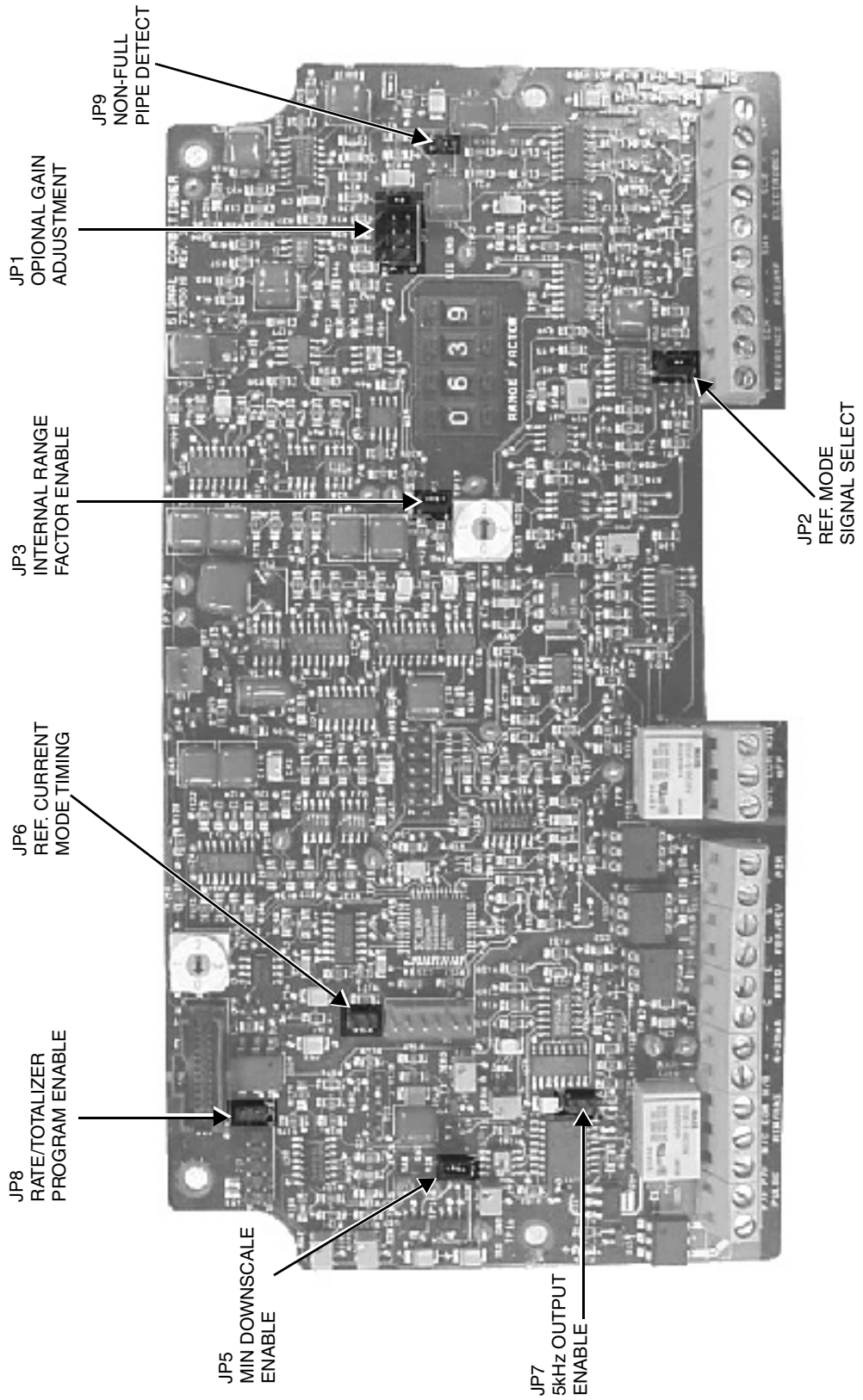

Figure A-4 Photo of Jumper Positions

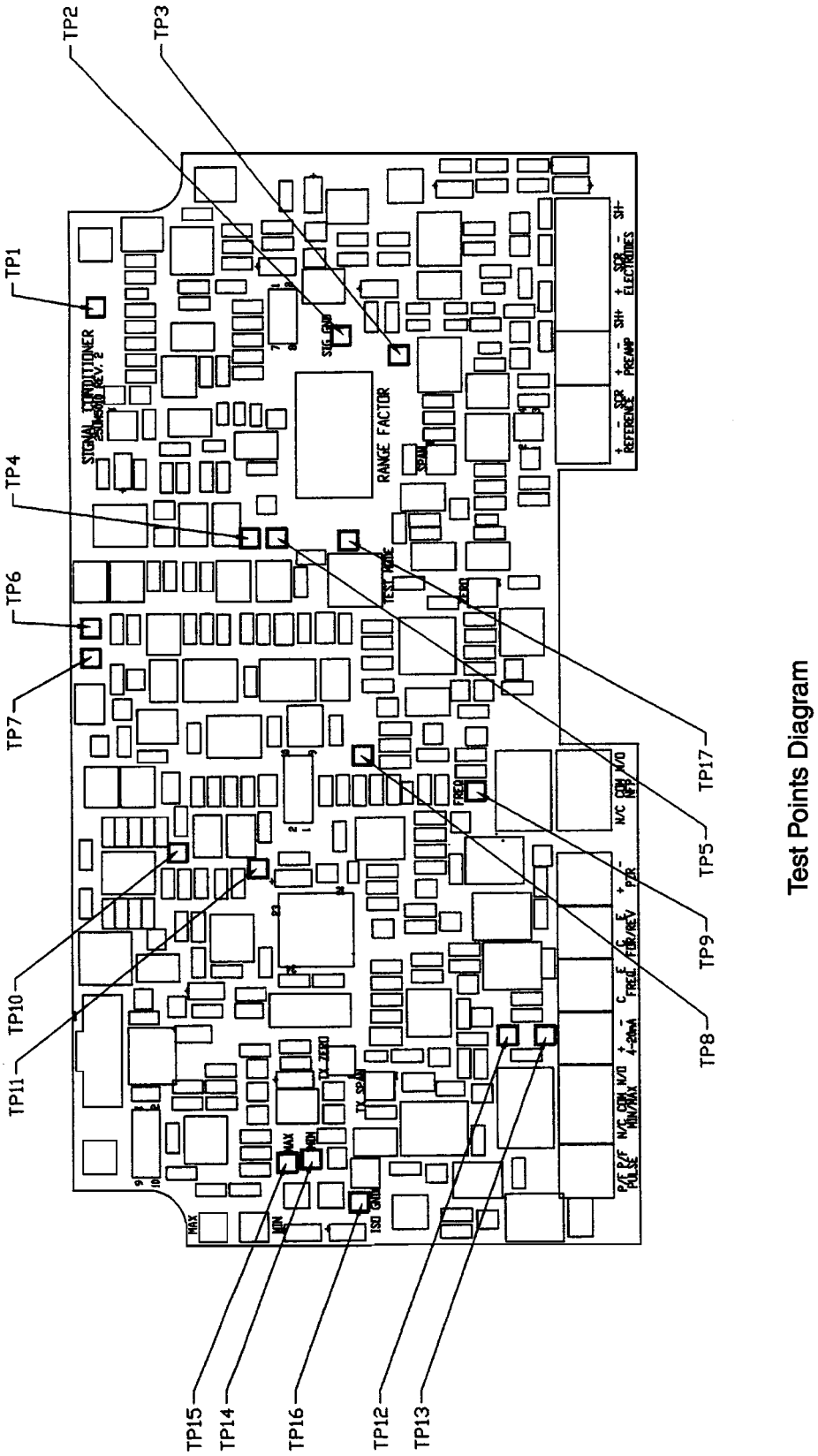

Figure A-5 Illustration of Test Positions

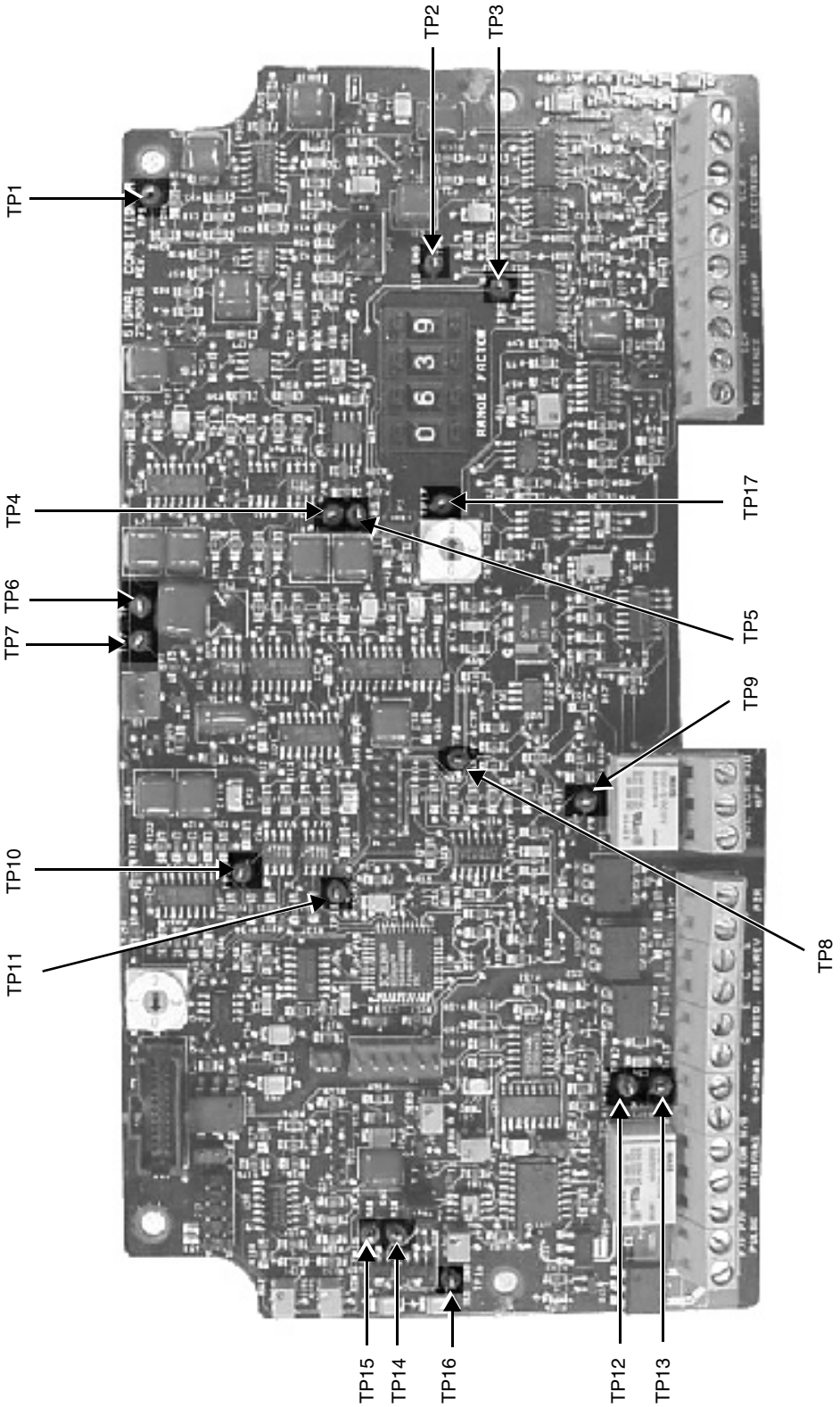

Figure A-6 Photo of Test Positions

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Isco Limited Warranty *

For Isco Electromagnetic Flow Meters

Isco warrants its electromagnetic flow meters to be free from defects in material and workman-ship under normal use and service for the following periods from the date of purchase:

UniMag flow tubes only:	10 years
UniMag sensors:	5 years
ChemMags and WizMags:	1 year
4411 and 4412 transmitters:	2 years
4430 Flow Meter: (in non-full pipe system)	2 years

The customer must give notice of any defect to Isco within the warranty period, thoroughly sanitize the product, return the product intact, and prepay transportation charges. The obligation of Isco under this warranty is limited to repair at its factory or replacement. This warranty shall not apply to any product which is repaired or altered outside of the Isco factory without authorization by Isco, or which has been subject to misuse, negligence, accident, or incorrect wiring by others. This warranty applies only if the user has followed the application and installation recommendations set forth by Isco.

Note: (1) Isco may recommend materials that come in contact with the media; however, Isco does not guarantee their compatibility for any specific application. The customer, in the end, is responsible for compatibility of all solutions that will come in contact with the flow tubes and sensors. (2) For accuracy of calibrated spare UniMag sensors, see Recommended Spare Parts in the UniMag Instruction Manual, or consult Isco.

This warranty is expressly in lieu of all other warranties and obligations and Isco specifically disclaims any warranty of merchantability or fitness for a particular purpose. Any changes in this warranty must be in writing and signed by a corporate officer.

The warrantor is Isco, Inc. 4700 Superior, Lincoln, NE 68504, U.S.A.

*** This warranty applies to USA customers. Customers in other countries should contact their Isco dealer for warranty service.**

In the event of problems with an Isco electromagnetic flow meter, the first step should be to contact the Isco Service Department at the toll-free Repair Service number (800) 228-4373. Many problems can be diagnosed and corrected over the phone, or by e-mail, more quickly than by an on-site service call. Before returning a product, contact Isco for a Return Authorization Number (RAN#) and shipping instructions.

Phone: Repair service: (800) 228-4373 (**samplers and flow meters**)
Sales & General Information (800) 228-4373 (USA and Canada)

E-mail: service@isco.com **Web site:** www.isco.com

Fax: (402) 465-3001

Shipping Address: Isco, Inc. - Attention Repair Service
4700 Superior Street
Lincoln NE 68504 USA

Mailing address: Isco, Inc.
PO Box 82531
Lincoln NE 68501 USA

September 2002, Rev A P/N 60-4402-001

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