MTS

Temposonics™ Brand Linear Displacement Transducer System with Direct Digital Output

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Model Coding

The system components (transducer, interface box and counter card) are identified by a model coding system which identifies all construction variables required to complete your system.

The following information is provided to aid in proper wiring and operation of the system purchased. Kindly keep this information in a safe place for future reference:

SALES ORDER_____DATE_____

SYSTEM SERIAL NUMBER (S)	RESOLUTION	RECIRCS.	WIRING TABLE	CRYSTAL
1._____	_____	_____	_____	_____Mhz
2._____	_____	_____	_____	_____
3._____	_____	_____	_____	_____
4._____	_____	_____	_____	_____
5._____	_____	_____	_____	_____
6._____	_____	_____	_____	_____
7._____	_____	_____	_____	_____
8._____	_____	_____	_____	_____
9._____	_____	_____	_____	_____
10._____	_____	_____	_____	_____

Linear Displacement Transducer (LDT)

Model Number ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

STYLE
- 01 = Standard
- 02 = Small Ruggedized head - SRH
- 03 = Flexible
- XX = Special

STROKE UNITS
- 1 = inches and tenths
- 2 = mm
- 3 = inches and eighths

STROKE LENGTH
- E.G. 0120 = 12 inches or 120 mm
- 0365 = 36.5 inches or 365 mm or 36-5/8 inches
- 1200 = 120 inches or 1200 mm

NULL/DEAD SPACE
- 5 = 5 inch D.S. and 2 inch Null - (Standard for strokes up to 200 in.)
- 7 = 7 inch D.S. and 2 inch Null - (Standard for strokes over 200 in.)
- X = Special null and/or dead space

TRANSDUCER CABLE DRIVER (Analog Only)
- 0 = No. ≤ 100 ft signal cable from transducer - (Standard for all digital systems)
- 1 = Yes. > 100 ft signal cable from transducer - (Standard for intrinsically safe)

HEAD ELECTRONICS TEMPERATURE RANGE
- 1 = -40°F to + 180°F (Standard for strokes greater than 12 in., positive pulse)
- 2 = -40°F to + 180°F (New standard for strokes up to 12 in.)
- X = Special temp. range and/or electronics

ENVIRONMENTAL
- 0 = NEMA 1, dust tight (Standard)
- 3 = Intrinsically safe - 6 wire
- 4 = NEMA 6, hermetically sealed
- 5 = NEMA 4, splash proof (Standard with Style 02)
- X = Special

TRANSDUCER CABLE
- 0 = 5 ft with connector - analog (Style 01, 03)
- 1 = 2 ft with connector - digital (Style 01, 03, former std)
- 2 = None - analog (Style 02)
- 3 = None - digital (Style 02)
- 6 = 5 ft pigtails - analog
- 7 = 5 ft pigtails - digital
- 8 = 5 ft with connector - digital (new std.)
- 9 = Other length or connector

Digital Interface Box (DIB)

Model Number ☐☐☐☐☐☐☐☐☐☐☐☐☐☐

TRANSDUCER
First 8 digits of transducer code

STYLE
40 = ± 15 Vdc and = 35°F to = 150°F - (Standard)
41 = ± 15 Vdc and = 40°F to 180°F
42 = Universal ± 15 VDC
43 = ± 12 Vdc and = 35°F to 150°F
44 = ± 12 Vdc and = 40°F to = 180°F
45 = Interface PCB
46 = Universal Interface PCB
XX = Special

MAXIMUM UPDATE TIME MSEC
0 = 1 5
1 = 2.5
2 = 3.0
3 = 3.5
4 = 5 0
5 = 7.5
6 = 10.0
7 = 15.0
8 = 25.0
X = None-Other

INTERROGATION
0 = Internal - (Standard)
1 = External

RECIRCULATIONS
0 = 1
1 = 2
2 = 4
3 = 8
4 = 16
5 = 32
6 = 64
7 = 128

ENVIRONMENTAL
0 = Standard
1 = Splash Resistant
2 = Conformal Coat

Digital Counter Card - Series 60

Model Number ☐☐☐☐☐☐☐☐☐☐☐☐☐

TRANSDUCER
First 8 digits of transducer code

OUTPUT FORMAT
60 = Natural binary - 12 bits
61 = Natural binary - 13 bits
62 = Natural binary - 14 bits
63 = Natural binary - 15 bits
64 = Natural binary - 16 bits
65 = Natural binary - 17 bits
66 = Natural binary - 18 bits
67 = Natural binary - 19 bits (two cards required)
6X = Natural binary (MTS to complete code)
70 = BCD 3 digits (12 bits)
71 = BCD 3.5 digits (14 bits)
72 = BCD 4 digits (16 bits) (two cards required)
73 = BCD 4 5 digits (18 bits) (two cards required)
74 = BCD 5 digits (20 bits) (two cards required)
7X = BCD (MTS to complete code)
XX = Other (Consult MTS Sensors Division)

ORIENTATION
0 = Forward count - (Standard)
1 = Reverse count

DATA VALIDATION
0 = 1 Microsecond latch pulse - (Standard)
1 = 12 Microsecond latch pulse
2 = Latch inhibit input
X = Special (Consult MTS Sensors Division)

RESOLUTION (SCALED)
0 = 0.1 in. (2.5 mm)
1 = 0.01 in. (0.25 mm)
2 = 0.004 in. (0.1 mm)
3 = 0.002 in. (0.05 mm)
4 = 0.001 in. (0.025 mm)
5 = 0.0005 in. (0.0125 mm)
6 = 0.00025 in. (0.0063 mm)
X = Other (Consult MTS Sensors Division)

Digital Counter Card - Series 80

Model Number ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

TRANSDUCER
First 8 digits of transducer code

OUTPUT FORMAT

80 = Natural binary parallel transmission (12 bits)	90 = BCD 3 digits 12 bits (999 max reading)
81 = Natural binary parallel transmission (13 bits)	91 = BCD 3-1/2 digits 14 bits (3999 max reading)
82 = Natural binary parallel transmission (14 bits)	92 = BCD 4 digits 16 bits (9999 max reading)
83 = Natural binary parallel transmission (15 bits)	93 = BCD 4-1/4 digits 17 bits (19999 max reading)
84 = Natural binary parallel transmission (16 bits)	94 = BCD 4-1/2 digits 18 bits (39999 max reading)
85 = Natural binary parallel transmission (17 bits)	95 = BCD 5 digits 20 bits (99999 max reading)
86 = Natural binary parallel transmission (18 bits)	9X = BCD (Ask MTS to complete code)
87 = Natural binary parallel transmission (19 bits)	99 = BCD, other than above
8X = Natural binary (Ask MTS to complete code)	
89 = Natural binary, other than above	

ORIENTATION
0 = Forward count - (Standard)
1 = Reverse count

DATA VALIDATION
0 = 1 Microsecond latch pulse and latch inhibit input (Standard)
1 = 12 Microsecond latch pulse and latch inhibit input
X = Other, or special (Consult MTS Sensors Division)

RESOLUTION (SCALED)

0 = 0.1 in. (2.5 mm for metric strokes)	4 = 0.001 in. (0.025 mm for metric strokes)
1 = 0.01 in. (0.25 mm for metric strokes)	5 = 0.0005 in. (0.0125 mm for metric strokes)
2 = 0.004 in. (0.1 mm for metric strokes)	6 = 0.00025 in. (0.0063 mm for metric strokes)
3 = 0.002 in. (0.05 mm for metric strokes)	9 = Other or unscaled (Consult MTS Sensors Division)
	and specify resolution separately

New Features and Design Changes

- Zero preset by DIP switches - can be reset in the field if desired
- Latch inhibit offered as standard at no charge (pin 24)
- Latch pulse now offered on pin 3 (formerly on pin 24)
- Millimeter resolution is now standard for strokes specified in millimeters
- Card width now 4-1/2 in. (formerly 4-1/4 in.)

Section I
Introduction

The Temposonics brand Linear Displacement Measurement System measures the position of a external magnet to a high degree of precision. The system measures the time interval between an interrogation pulse and a return pulse. The interrogation pulse is transmitted to the transducer. The return pulse is created by the magnet, which is located at the position to be measured. The time difference between pulses is converted to a natural binary or BCD direct digital output signal.

The direct digital output system components include a linear displacement transducer (LDT), a digital interface box (DIB), and a digital counter card. When supplied as a scaled system, these system components are matched and factory calibrated to provide an exact, discrete resolution.
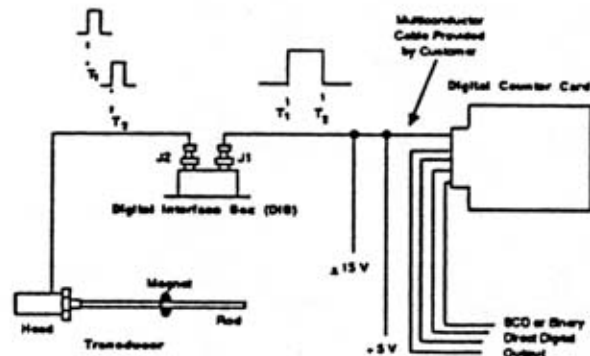

Figure 1-1. Linear Displacement Measurement System Functional Description

Temposonics normally supplies a "full digital" system, consisting of all three system components. If the counter card function is performed in a digital computer, programmable controller, or motion controller (such as the MTS Motion Plus™ TDC series controller), a "half digital" system is often supplied. The half digital system consists of the LDT and digital interface electronics only, with system variables factory set to customer specifications.

1.1 Transducer (LDT)

The interrogation pulse travels the length of the transducer by a conducting wire threaded through the hollow waveguide. The waveguide is spring loaded within the transducer rod and exhibits the physical property of magnetostriction. When the magnetic field of the interrogating pulse interracts with the stationary magnetic field of the external magnet, a torsional strain pulse or "twist" is produced in the waveguide. This strain pulse travels in both directions, away from the magnet. At the end of the rod, the strain pulse is damped within the "dead zone" (5 to 7 inches in length). At the head of the transducer, two magnetically coupled sensing coils are attached to strain sensitive tapes. The tapes translate the strain pulse through coils to an electrical "return pulse". The coil voltage is then amplified in the head electronics before it is sent back to the interface box as the conditioned "return pulse".
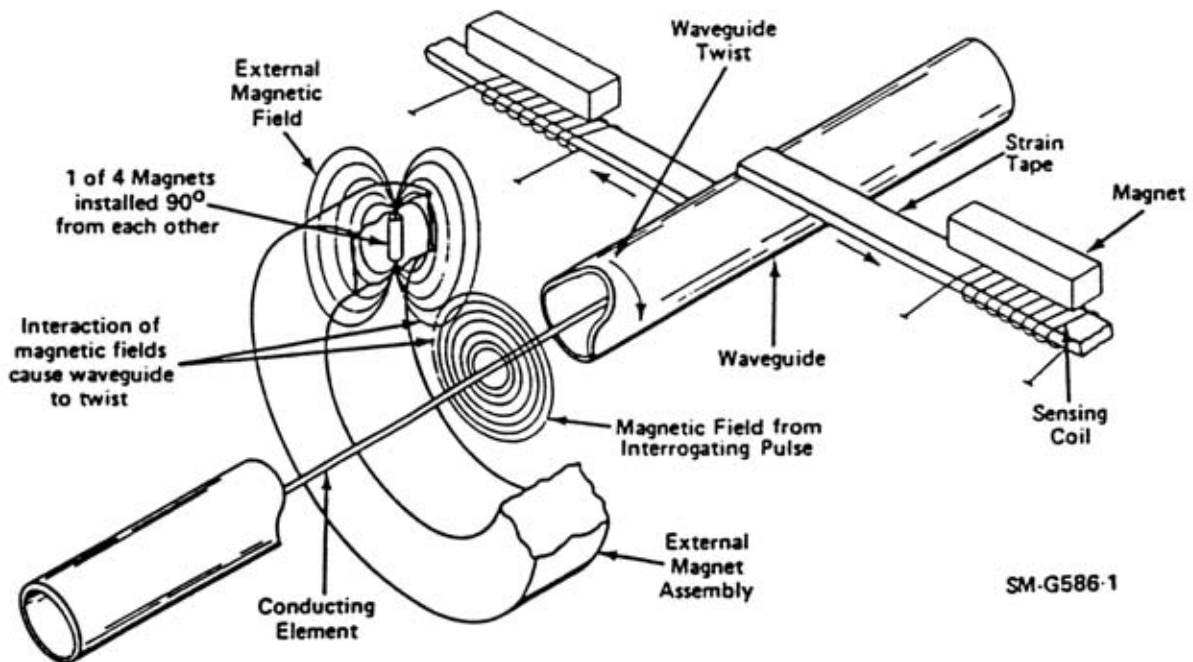

Figure 1-2. Waveguide Interaction

1.2 Digital Interface Box (DIB)

The digital interface box (DIB) (optionally available as a card) contains the intelligence for interrogation and return pulse sensing of the transducer.

The interrogation frequency is factory determined to allow sufficient time for return pulse sensing based upon the transducer stroke and optional recirculations. The frequency of interrogation is controlled by a 555 integrated circuit timer and the required R-C network for the desired time constant. Optionally, an external interrogation pulse input is provided on J-2 for user interrogation and synchronization with the selected receiver device. (Consult MTS Sensors Division for application notes.)

The interrogating pulse turns on a flip-flop, which stays on until the return pulse switches the signal off. The time "length" of the signal is directly proportional to magnet position, and after buffering within the box, the pulse is sent to the counter card as the pulse duration signal (refer to Figure 1-1).

NOTE

The pulse duration output signal is absolute and should not be confused with frequency or "pulse train" type signals, such as provided with encoders. Pulse counting techniques cannot be used.

Most digital interface boxes use a technique termed "recirculations" to improve system resolution. The recirculation number (2, 4, 8, 16, 32, etc) is factory set within the electronics to provide a pulse duration signal multiplier equal to the number of recirculations. The technique uses return pulses to trigger additional interrogation pulses. The number of "recirculation pulses" is determined at the time of order and should not be changed without factory consultation.

1.3 Digital Counter Card

The digital counter card measures the on-time of the interface box pulse duration signal. This is accomplished by using a crystal oscillator with frequency selected to provide the desired resolution (counts per inch).

The leading edge of the pulse duration signal enables the counter registers, and the trailing edge triggers a "latch pulse" to download the count into the output registers. The latch pulse is normally available for the receiver device to interpret as a "data valid" signal; normally low = data valid, TTL level high = data invalid. The latch pulse frequency is the same as the interrogation frequency, and the duration is nominally 1 microsecond. Refer to Figure 3-5.

1-3

Scaling of the counter card is accomplished by matching the counter card crystal frequency to the gradient of the transducer to provide 0.001 inch, 0.0005 inch, etc, per count. Unscaled systems may require scaling within the receiver device, depending upon desired accuracy.
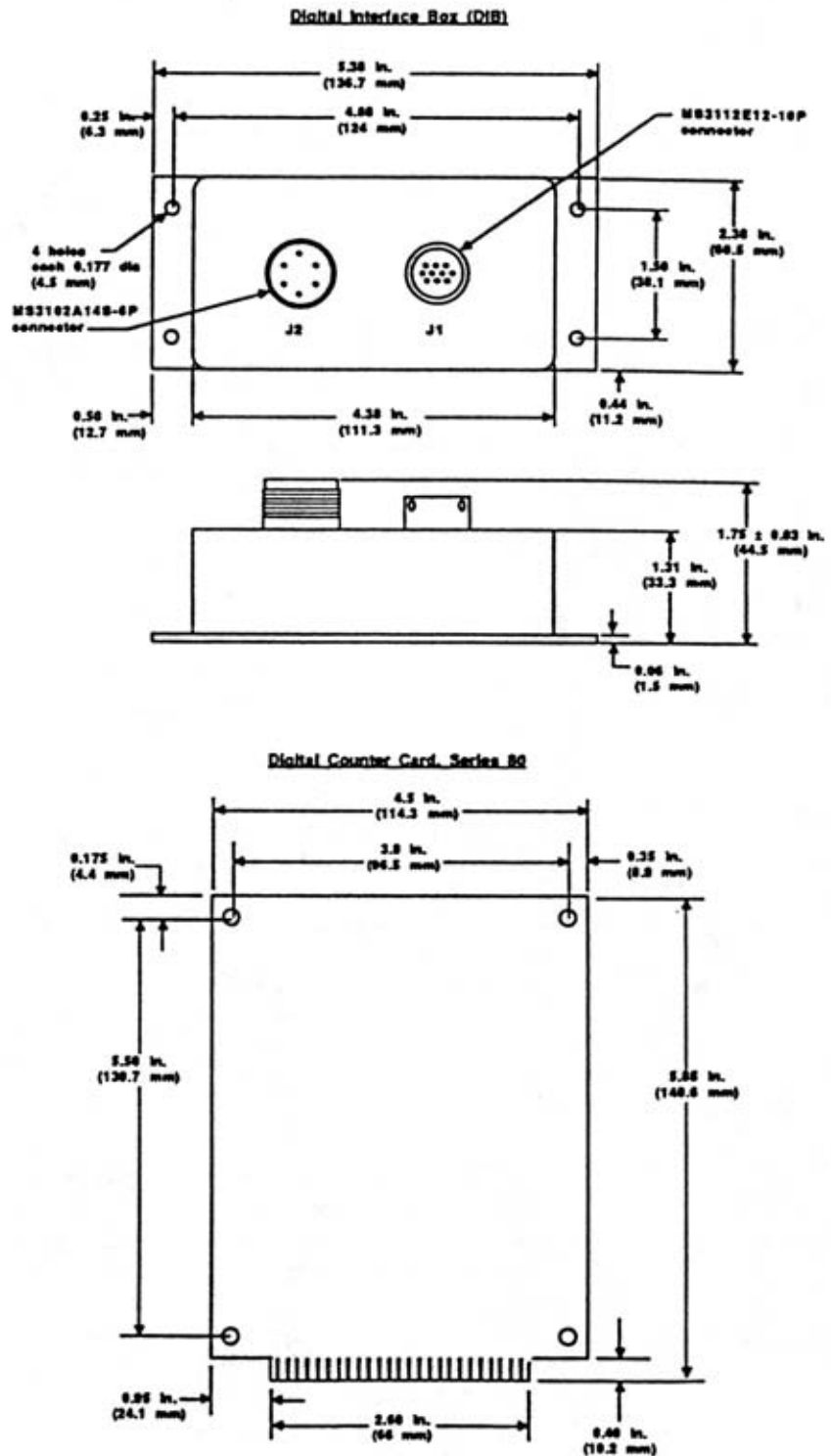

Figure 1-3. Digital Electronics

1.3.1 Scaling

In most cases, the system supplied is a scaled system. Scaling refers to the selection of system component variables so that the natural binary output represents a discrete number of inches per count, such as 0.002 inch, 0.001 inch, or 0.0005 inch per count. For BCD outputs, scaling means that the output reads directly inches (mm, etc), and need not be corrected mathematically.

The system variables that are matched include the transducer stroke, the number of recirculations, the null point, and the counter card crystal oscillator clock. The transducer, interface box and counter card are factory calibrated to provide the desired resolution. The counter card crystal frequency is calculated based upon the transducer velocity gradient, which is unique to the transducer serial number. The zero pre-set is factory set on the counter card, and is also matched to the transducer. To maintain a scaled output, the user should use a transducer and counter card with the same serial number. Substitution of interface boxes of the same stroke and recirculation number does not affect the output reading.

An unscaled system is provided upon request. An unscaled system may require calibration (refer to Subsection 3.4) to mathematically correct the digital output to read in inches, millimeters, etc. The scale factor for unscaled systems is not a discrete number of inches per count, but should be within ±0.2% of the specified resolution for 27-28 MHz systems. For example, an unscaled system specified for 0.001 inches per count may have a scale factor of 0.001002 inches per count (approximately). Similarly, an unscaled BCD output may have a scale factor of 1.002 inches per inch of reading.

Interchanging system components which do not have the same serial number will also result in an unscaled output. Refer to troubleshooting (Subsection 4.4) and Subsection 1.3.3 below.

1.3.2 "Universal" Interface Box or Card

Universal boxes (or cards) are supplied to certain customers upon request. In a universal box, the DIB interrogation pulse timing is set for a certain maximum stroke length, typically from 60 to 72 inches. The box will interrogate at the maximum stroke frequency, but can be used with any transducer with stroke length greater than 12 inches and up to the maximum. (Transducers with ≤ 12 inches are normally negative pulse interrogation and require a pulse change modification within the DIB.) The recirculation setting is also factory set, and will provide published resolution with the proper recirculation number.

The only performance change is that the update time will be that for the maximum stroke length of the interface box (refer to general bulletins). Also note that a small zero shift may occur when used with transducers of different stroke length.

1.3.3 "Universal" Counter Card

A universal counter card differs from a scaled counter card in two ways:

1. The crystal is selected based upon an "average" transducer gradient.

2. The zero pre-setting is selected using a randomly selected transducer with an "average" gradient.

The averaging results in a scale factor within ±0.6% of the specified nominal resolution. The zero position will also be affected, but should be within ±0.1 inches of the specified null position.

To correct for scale and zero offset, refer to Subsection 3.4, System Calibration.

Also note that if a randomly selected counter card is used with a transducer, the system will perform as a "universal" counter card system.

1.3.4 System Component Changes

The following general rules apply when interchanging system components or ordering spare parts:

1. Use system components with matched serial numbers whenever possible.

2. Use the crystal (Y1 or U4 on the counter card) with the transducer that is matched to it.

3. Use the zero pre-set (U5 on the counter card) with the transducer and crystal that is matched to it. (The zero pre-set is a removable 18 pin jumpered DIP socket on Series 60 cards, or two DIP switches on Series 80 cards.)

4. Whenever system components are not matched, or a non-matched crystal (or counter card) is used, a system calibration (refer to Subsection 3.4) should be performed.

5. If interface boxes are interchanged, it is preferable that they be of the same stroke and recirculation setting (refer to Subsection 1.3.2).

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1.3.5 Spare Parts and Inventory Considerations

If ordering a spare transducer, a matched crystal and zero pre-set should be ordered (for Series 60 cards only) to avoid system calibration upon replacement. For Series 80 cards, the zero can be set using DIP switches.

A universal type spare interface box or counter card can be used as a common spare. However, a system calibration should be performed after any system component change.

1.3.6 Receiver Electronics without Scaling Feature

Use of the Temposonics Linear Displacement Measurement system with receiver electronics which does not permit field scaling requires special application considerations. A mechanical means of zero-positioning of the magnet must be designed into the installation, and a unit with scaled output must be used.

1.4 Specifications

Parameter	Specification
Supply Requirements	± 15 Vdc & + 5 Vdc, ± 5%, 1% ripple max. + 15 V at 100 mA – 15 V at 75 mA + 5 V at 1.2 amps (400 mA for DIB; 800 mA counter card)
Electrical Stroke	As specified. Up to 360 inch available
Null Position	Fixed, 2 inches from hex (standard), or as specified
Dead Space	Fixed, 5 or 7 inches from end of rod, as specified
Non-Linearity	± 0.05% full stroke, maximum
Repeatability	Better than ± 0.001% (0.0001 inch minimum)
Hysteresis	0.0008 inch maximum
Temperature Coefficient	0.00018 inch /°F (0.00011 inch for ≤ 12 inches stroke) + 3ppm/°F/ inch stroke - transducer. 5ppm/°F nominal for external electronics
Operating Temperature	– 40 to + 180°F transducer rod + 35 to + 150°F head electronics (≤ 12 inches)* – 40 to + 180°F head electronics (> 12 inches) + 35 to + 150°F digital interface box

Output	TTL compatible, nominal 0 & 5 Vdc, parallel, true high.
	    Source Current: 0.8 mA
	    Sink Current: 16 mA

Operating Pressure	Rated by Factory Mutual for 3000 psi (20.68 MPa) operating pressure, and 8000 psi (55 MPa) peak pressure.
Adjustments	None

*Units shipped after 6-1-88 are suitable for – 40 to + 180°F regardless of stroke.

Specifications are subject to change without notice. Contact MTS for verification of specifications critical to your needs.

Section II
Service

2.1 General

The Temposonics Brand Linear Displacement Measurement System does not require service under normal use. The system is non-contacting, solid state, and performance does not degrade, age or drift over time.

Digital systems have a zero adjustment only. They do not have any field adjustments for scale purposes. The output is factory set during final calibration by selection of the counter card crystal frequency and zero pre-set. If a system configuration change requires a new resolution, the system must be returned to the factory to perform the changes. Alternatively, receiver device software may be reprogrammed to adjust to the new settings in some cases.

If a system performance check is desired, use the calibration procedure in Subsection 3.4.

Section III
Installation

This section describes general installation procedures for the Digital Linear Displacement Transducer measurement system. Specific installation procedures depend on the application. The installation involves environmental considerations, mechanical installation and electronic connections.

3.1 Environmental Considerations

The location of components is determined by the application requirements. The following describe the environments suitable for the component configuration. Ensure the components can withstand the environment where they will be installed.

- A transducer assembly with a blue dust cover over the LDT head is suitable for general purpose applications located indoors.

- A transducer assembly with a ruggedized LDT head cover is suitable for environments exposed to moisture, vibration and outdoor elements.

- The digital interface box must be protected from moisture and vibration.

- The digital counter card is suitable for non-hazardous, environmentally-controlled atmospheres only, such as control rooms or control panels indoors.

- A transducer assembly with the intrinsically safe design (approved for Class I, Division 1, Groups C and D) is available for hazardous areas.

NOTE

The **intrinsically safe** design has special installation requirements which are not covered in this manual. Consult MTS Sensors Division for details.

3.2.1 Mechanical Installation

The mechanical installation includes mounting the transducer, the counter card, electronics box and the permanent magnet. Before installing the transducer assembly, it is necessary to know the null position, stroke length, full-scale position and the dead zone (refer to Figure 3-1).
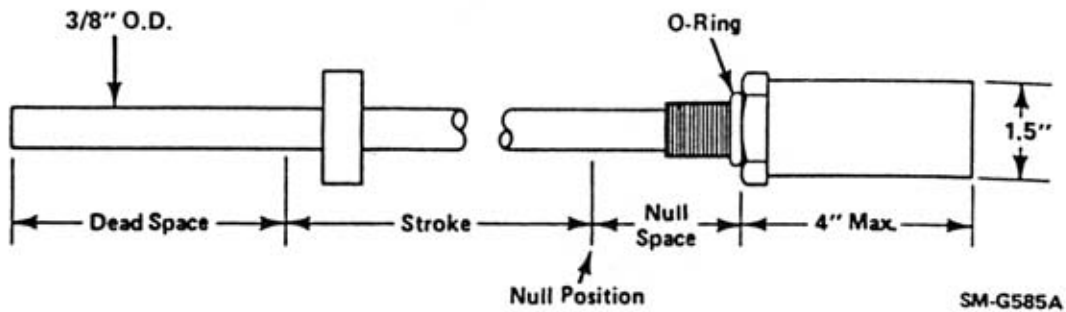
Figure 3-1. LDT Assembly

Take the following steps to install the LDT measurement system:

1. The transducer assembly is mounted to the selected location using the 3/4 inches (19 mm), 16 UNF thread of the transducer. Allow sufficient area to access the hex head to tighten the transducer assembly. Install an O-ring (type MS28778-8 is recommended) in the special groove if a pressure or moisture seal is required.

2. Install the permanent magnet over the LDT rod. The permanent magnet is mounted to the movable device from which displacement is to be measured. To minimize the effect of ferromagnetic materials (such as iron, nickel, steel, etc) on the magnetic field of the permanent magnet, ensure the minimum spacing requirements are met as shown in Figure 3-2. Any non-magnetic materials can be in direct contact with the permanent magnet. Types of magnets are shown in Figure 3-3.

NOTE

Clearance between the magnet and the LDT rod is not critical. However, contact between the components will cause wear over time. The installation of supports or readjustment of the supports is recommended if the magnet contacts the LDT rod.

3. Move the permanent magnet full-scale to determine if support brackets are required. If the magnet contacts the LDT, mount a support bracket to the end of the LDT. Long transducers may need additional supports to be attached to the transducer rod. Refer to Subsection 3.2.2 for the procedure for installing transducer supports.

4. Mount the digital interface box in a location within reach of the LDT assembly cable. Older systems allow the digital interface box to be mounted within 2 feet of the LDT assembly; systems supplied after 3-1-88, within 100 feet.
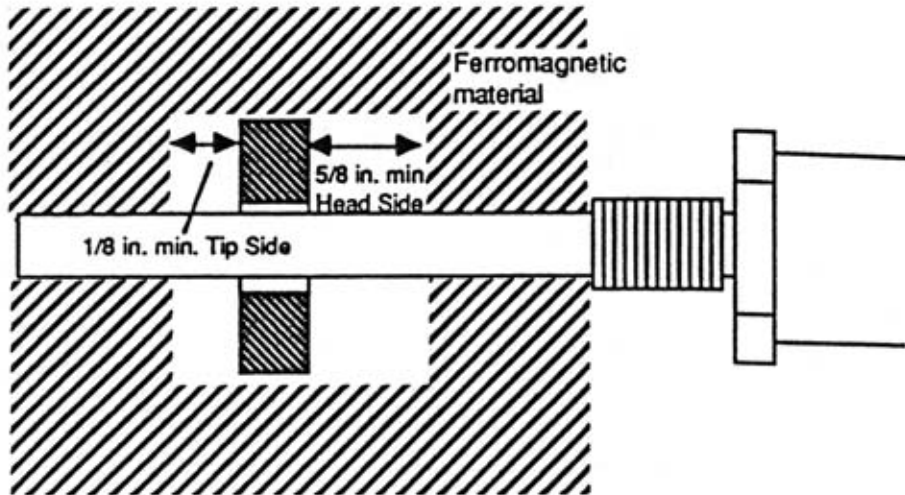
Figure 3-2. Ferromagnetic Material Mounting Specifications
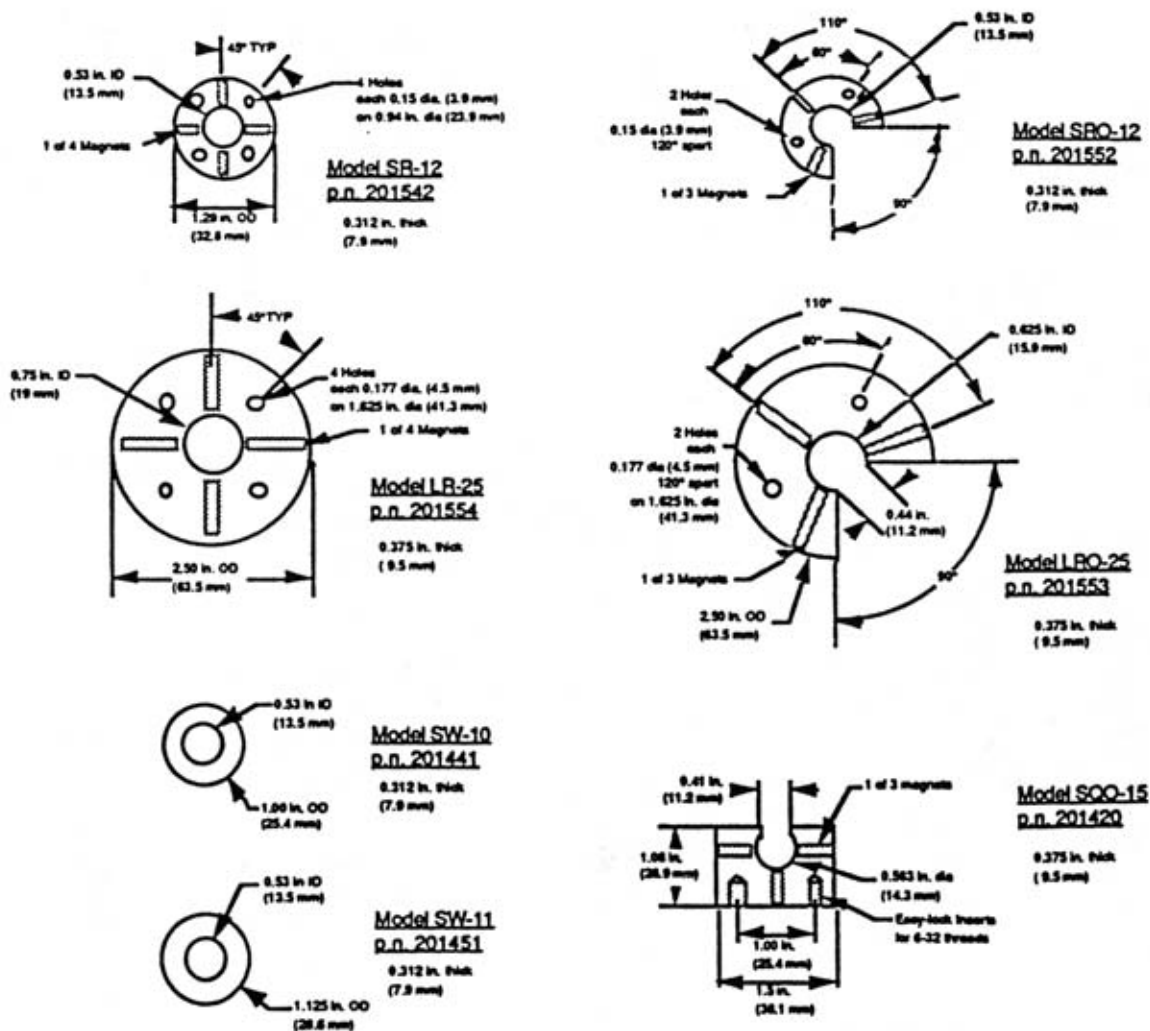
Figure 3-3. Types of Magnets

6. Mount the digital counter card within 300 feet* of the interface box. The card may be mounted in a standard card cage, or can be surface mounted using standoffs. Allow at least one inch on each side of the counter card for proper spacing. It is best to mount the card so that the edge connector is accessible for signal level testing.

NOTE

The counter is matched to the transducer by serial number. Do not interchange counter cards (refer to System Component Matching).

*Consult MTS Sensors Division for longer distances.

3.2.2 Types of Transducer Supports

Long transducers (more than 4 feet long) may require supports to maintain proper alignment between the transducer rod and the permanent magnet. All flexible transducers require supports to maintain the design shape. When transducer rod supports are used, special permanent magnets are required.

Transducer supports attached to the active stroke length must be made of non-ferrous material with a gage thickness which will permit the permanent magnet to pass without obstruction. Transducer supports connected to the dead zone can be any type of material since the permanent magnet should not enter that area. The following are descriptions of several types of transducer supports.

Loop Type Support

Loop type supports are recommended for straight transducers and are also used with channel supports. Loop type supports must be thin enough to permit free movement of the magnet. Figure 3-5 illustrates the fabrication of a loop type support. Figure 3-6 illustrates a typical channel support.

NOTE

When open magnets are used, ensure the transducer rod remains within the inside diameter of the magnet throughout the length of the stroke. If the transducer rod is allowed to leave this zone and enter the cut-out area of an open magnet, the transducer signal will be lost. Figure 3-4 shows correct and incorrect transducer rod positions.
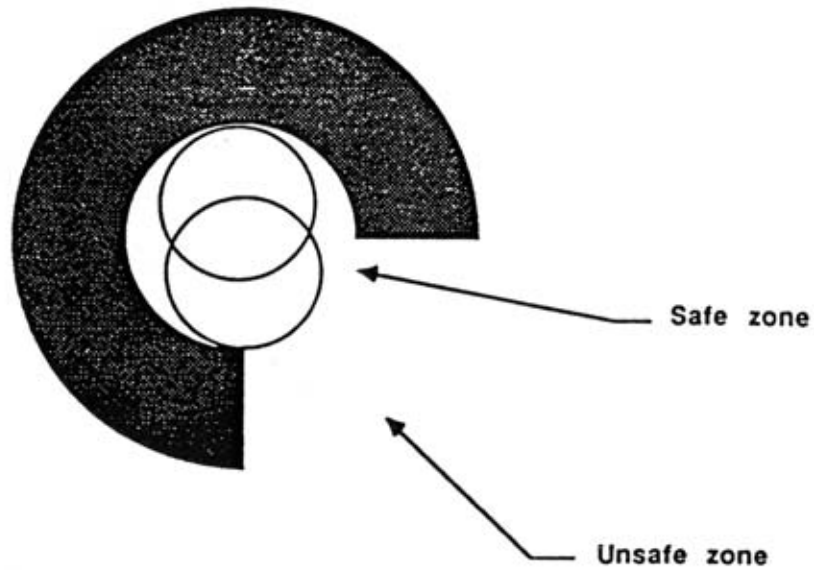
Figure 3-4. Transducer Rod Positions within an Open Magnet

SM-G623-1A
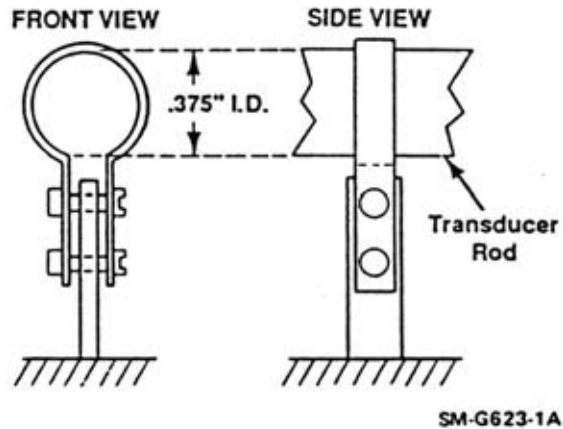
Figure 3-5. Loop Support

Channel Type Support

Channel type supports are typically straight. Loop supports are normally required to keep the transducer within the channel. Figure 3-6 illustrates the channel support. Channel supports are available from various manufacturers ("linear ways") or may be fabricated.
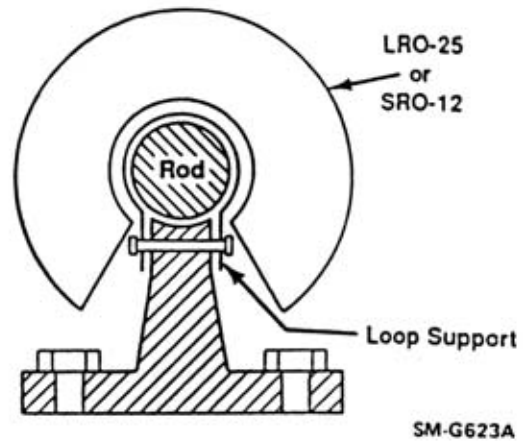
Figure 3-6. Channel Support

Guide Pipe Supports

Guide pipe supports are sections of thin-walled pipe, normally used to support flexible transducers. A guide pipe support is constructed of non-ferrous material to maintain the desired shape. The transducer rod is installed into the pipe, therefore, the inside diameter of the pipe must allow proper clearance to install the rod and the outside diameter must allow for magnet clearance. Refer to the pipe manufacturer's specifications and dimensions (schedule 10, 40, etc) to select pipe in accordance with transducer and magnet specifications and dimensions. Guide pipe is typically supported at each end of the pipe. Figure 3-7 illustrates a guide pipe support.
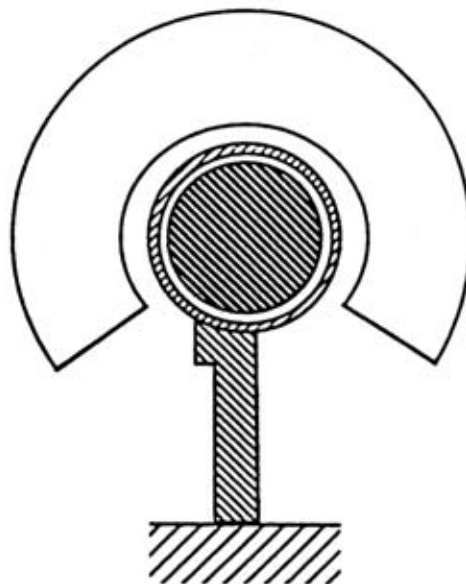
Figure 3-7. Guide Pipe Support

Spring Loading
or Tensioning

The transducer rod (flexible or rigid) can be spring loaded or tensioned using a stationary weight. Attach a spring mechanism or weight to the dead zone of the transducer rod with a clamping device which will not deform the transducer rod. The maximum weight or spring tension is 5 to 7 lbs. Spring loading or tensioning is recommended for installations that do not permit loop type supports and are subject to vibration or abuse.

3.2.3 Flexible Transducer Installation

This subsection provides the installation procedure for flexible transducers. It is necessary to know the null position, stroke length, full-scale position and the dead zone to install the transducer (refer to Figure 3-1). Before installing the flexible transducer, review the following considerations:

- All flexible transducers are custom manufactured for a specific application and installation. The specific requirements are determined prior to ordering, which includes specific curvatures and straight sections at specific distances from the transducer head.

- Flexible transducers should not be subjected to temperatures above 130°F (54°C) unless specified. The temperature of the transducer rod should not vary more than ±30°F (±16°C) unless specified.

- Flexible transducers should not be subjected to pressures above atmospheric pressure.

- Flexible transducers can be flexed or curved to a minimum diameter of 36 in. (91 cm) during installation.

- Flexible transducers require supports or anchoring to maintain the designed shape. Refer to Subsection 3.2.2 for information to install transducer supports.

- Some long transducers are ordered as flexible units to facilitate shipping and handling only, even though they are used for straight applications.

CAUTION

DO NOT attempt to install a flexible transducer without knowledge of the design installation dimensions. Failure to follow the design dimensions can result in improper operation or transducer damage.

1 in. O.D. Flange.
Install Clamp Here.

1 in. O.D. Polypropelene
Fitting. (Do not loosen!)

Transducer Flexible Rod
Imperial-Eastman Impolene
Tubing, #66-PP-3/8 or similar.

Null Space,
as specified
3 in. mimimum.

Stroke, as specified

Dead Zone,
8 in. minimum,
or as specified.

SM-G623-2A
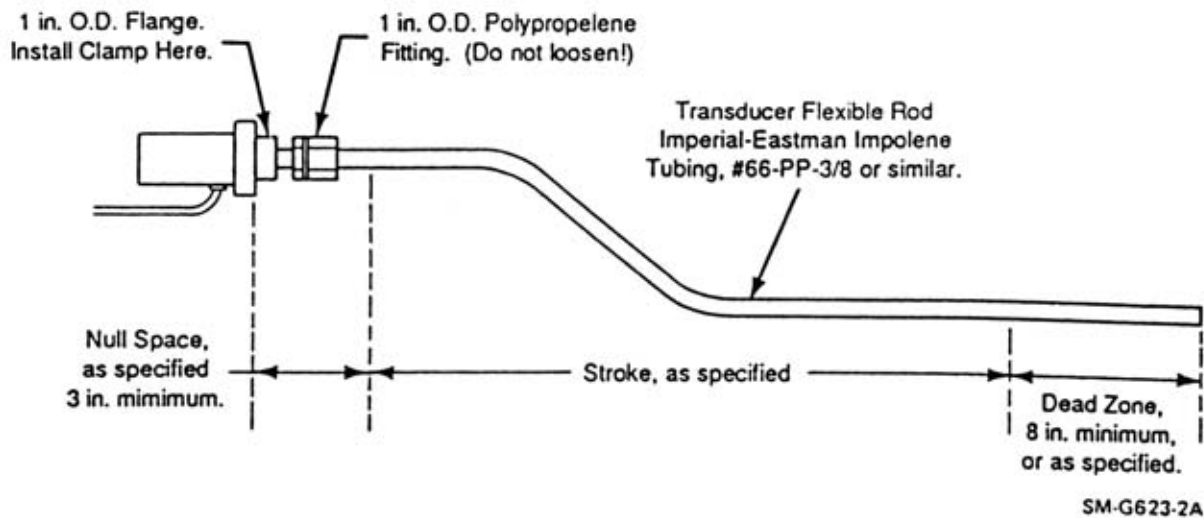
Figure 3-8. Flexible Transducer

Take the following steps to install a flexible transducer:

CAUTION

DO NOT loosen or mount the transducer using the polypropylene fitting near the transducer head. This will cause damage to the transducer.

1. Transducers supplied with a 1 inch O. D. head flange require a U-bolt, flange collar or similar clamping device to keep the transducer head stationary.

   Transducers with a threaded hex can be mounted using the threads. If the transducer must be rotated to engage the threads, ensure the flexible rod can rotate freely. If the rod binds or cannot be rotated, a bracket or threaded flange should be used (hold the transducer stationary and rotate the bracket or flange to engage the threads).

2. Install the permanent magnet over the LDT rod. The permanent magnet is mounted to the movable device from which displacement is to be measured. To minimize the effect of magnetic materials on the magnetic field of the permanent magnet, ensure the minimum spacing requirements are met as shown in Figure 3-2. Only nonmagnetic materials can be in direct contact with the permanent magnet.

3. Mount the digital interface box in a location within reach of the LDT cable. Older systems allow the box to be mounted within 2 feet of the LDT assembly. Newer systems with buffer driver allow the interface box to be mounted within 100 feet of the LDT assembly. All units after 3-1-88 have this driver.

4. Refer to Subsection 3.2.2 for information to install transducer supports.
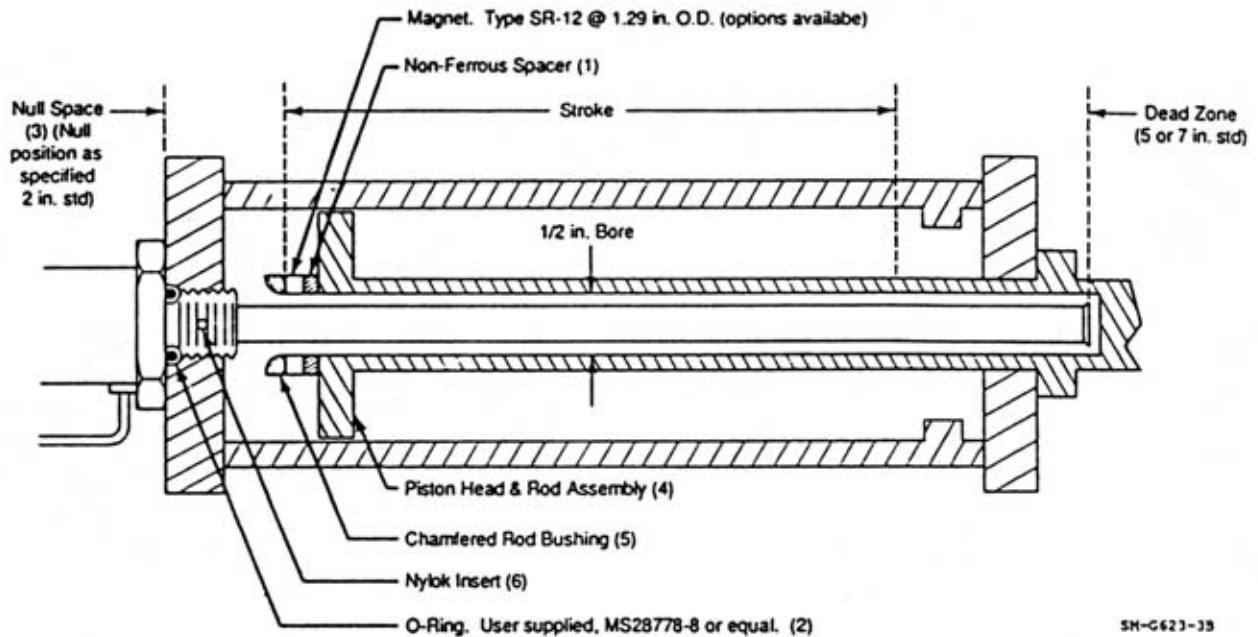
Figure 3-9. Typical Cylinder Installation, Piston at Full Retraction

3.2.4 Cylinder Installation

This subsection provides information for cylinder applications. The rigid transducer installation procedure can be used as a guide for cylinder installations. Figure 3-9 shows a typical cylinder installation. Review the following before attempting a cylinder installation.

1. Use a non-ferrous (plastic, brass, teflon, etc) spacer to provide 1/8 inch (32 mm) minimum space between the magnet and the piston.

2. An O-ring groove is provided at the base of the transducer hex head for pressure sealing. Temposonics uses MIL-standard MS33514 for the O-ring groove. Refer to MIL-standard MS33649, (or SAE J514) for machining of mating surfaces. Use O-ring number MS28778-8 or equal.

3. The null space is customer specified at full retraction according to the installation design and cylinder dimensions. Ensure the magnet can be mounted at the proper null position.

4. The piston head shown in Figure 3-9 is typical. For some installations, depending on the clearances, it may be desired to countersink the magnet.

5. A chamfered rod bushing should be considered for strokes over 5 feet (1.5 meters) to prevent wear on the magnet as the piston retracts. The bushing should be made from teflon or similar material.

6. A nylok self locking insert is provided on the transducer threads. An O-ring groove is provided at the base of the transducer hex head for pressure sealing.

7. The recommended bore for the cylinder rod is 1/2 inch (13 mm). The transducer rod includes a 0.44 inch (12 mm) end plug; a flush end plug is available. Use standard industry practices for machining and mounting of all components. Consult the cylinder manufacturer for applicable SAE or MIL-specs.

CAUTION

DO NOT attempt to loosen the end plug on the transducer. If this plug is loosened or removed, reseal it with Loctite and torque the plug until it is properly seated against the end of the pipe.

3.3 Electronic Connections - General

Electronic connections are made at connectors J2 and J1 of the interface box (DIB) and at pins 1 to 25 of the counter card edge connector.

To ensure system performance to published specifications, wiring procedures and selection rules must be carefully followed.

The following recommendations are supplied for "full digital" systems, which include a Temposonics brand digital counter card. For systems which use a digital counting device in the receiver computer (such as MTS Motion Plus control systems), the counter card is not supplied. Use the following procedures in conjunction with the receiver device manufacturer's recommendations.

3.3.1 Transducer Connections

The LDT is supplied with 5 feet (standard) of integral cable. Ruggedized head designs are supplied with an extension cable. It is recommended to keep the transducer cable as short as possible to avoid possible noise or temperature effects on accuracy.

If an extension cable is required, the following guidelines must be followed:

NEMA 1 (blue cover) transducers

If supplied with 2 feet of integral cable (systems prior to 3-1-88), then, unless extension cable is specified, the digital interface box has not been modified to buffer pulse transmissions. Do not attempt to extend the cable without factory modifications to the interface box.

If supplied with 5 feet or more of integral cable (systems after 3-1-88), the interface box has been modified for pulse buffering, and extension cable can be used as described below.

NEMA 4 and 6 Ruggedized Transducers

All ruggedized transducers require an extension cable with mating connection, supplied by MTS Sensors or by the buyer. If the factory-supplied cable is 5 feet or longer, the interface box has been modified for 100 foot drive capability, and you may use a cable up to 100 feet long.

If the cable supplied is less than 5 feet long, do not attempt to extend the cable further.

Extension Cable

The extension cable is fabricated from Belden number 9931, 9730, or optionally, Belden 83506 teflon covered cable. Substitutes are not acceptable.

The maximum cable length is 100 feet. Construct the extension cable using the color codes shown in Table 3-1, or order from MTS Sensors Division.
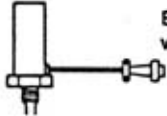
Table 3-1. J2 Connections

J2 Signal/Function	J2 Pin	Wire Color Code	
		Integral Cable or Belden 9931 83506 Extension Cables	Belden 9730 wire/shield
+ 12 to + 14.5 Vdc	A	Green	Black/Blue
DC Common/Ground	B	Black	Black/Red
Return pulse from transducer	C	Brown or Orange	Green/Blue
– 13.5 to – 14.5 Vdc	D	Blue	Black/Green
Interrogation pulse to transducer	E	White	White/Green
11.5 to + 12 Vdc	F	Red	Red/Red
Cable Ground*	–	SHIELD – see below	SHIELD – see below

* Cable Grounds:

1. Cable shields are grounded at one end of cable only.
2. Integral cable shield is connected to circuit ground within transducer head.
3. Extension cable shield should be connected to ground at the electronics box connector only. Apply ground by separate connection to earth ground or by connecting to pin B on the connector which mates to the box.

Table 3-2. J2 Mating Connectors

Transducer Head Connector	Transducer Head Design	Mating Connectors	
		To Transducer Head	To Interface Box
MS 3106A-14S-6S MS 3106E-14S-6S (environmental)	Blue Cover w/integral cable (NEMA 1)	MS 3101A-14S-6P MS 3101E-14S-6P (environmental)	MS 3106A-14S-6S MS 3106E-14S-6S (environmental)
MS 3113H-10-6P (DT1H-10-6PN)	SRH/Hermetically Sealed (NEMA 6)	MS 3116F10-6S (environmental)	MS 3106A-14S-6S MS 3106E-14S-6S (environmental)
MS 3102E-14S-6P	SRH/Environmental (NEMA 4)	MS 3106E-14S6S (environmental)	MS3106A-14S-6S MS 3106B-14S-6S (environmental)
MS 3100F-14S-6P	Ruggedized/ Environmental (Woodit)	MS 3106E-14S-6S (environmental)	MS 3106A-14S-6S MS 3106E-14S-6S (environmental)
MS 3113H-10-6P (DT1H-10-6PN)	Ruggedized/ Hermetically Sealed (Woodit)	MS 3116F10-6S (environmental)	MS 3106A-14S-6S MS 3106E-14S-6S (environmental)

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3.3.2 Digital Interface Box Connections

Figure 3-10 shows the digital interface box connections for J1 to the power supply and receiver device.

Cables should be selected according to the following guidelines, depending upon the overall cable length between the box and counter card.

1. Cable length up to 50 feet: a twisted shielded pair is recommended for the gate signals and interrogation signals (optional). Power signals can be routed using any properly sized multiconductor cable. For areas not subject to electrical noise, a high quality shielded multiconductor cable can be used for all signals, including power.

2. Cable length between 50 and 300 feet: Use a high quality 100 ohm twin axial cable such as Belden 8227 for the positive and negative pulse duration "gate" signals. The power supply wires are routed through an additional multiconductor cable, selected and sized according to industry standards. Wire gage for dc power to the interface box should be selected to ensure minimum possible voltage drop.

3.3.3 Digital Counter Card Connections

Tables 3-3, 3-4, and 3-5 show the counter card output connection tables. In order to select the proper table, the following order variables must be known.

A) Stroke _____ inches (mm)
B) Resolution _____ inches (mm)
C) Recirculations _____ =N
D) Output format _____ BCD ____ natural binary
E) Optional inputs/
   outputs _____ latch inhibit (input)

The counter card divider, if supplied, is determined knowing A, B, and C, and is obvious from the table description.

<u>Series 60 Counter Cards</u>
Refer to Figure 3-10 for power input (+5 Vdc) and interface box gate signal connections.

Pin 24 on the counter card is normally connected to the latch pulse (output), and is normally low; high during update of output.

Optionally, a latch inhibit (input) is supplied on pin 24. By applying a ground (sink) to pin 24, the updating of the binary output is frozen and the output does not change.

Series 80 Counter Cards (available 6/88)
Latch inhibit input is now standard on pin 24 for all Series 80 counter cards. No connection or TTL high allows updating to continue.

Figure 3-10. Signal and Power Wiring, Digital Systems
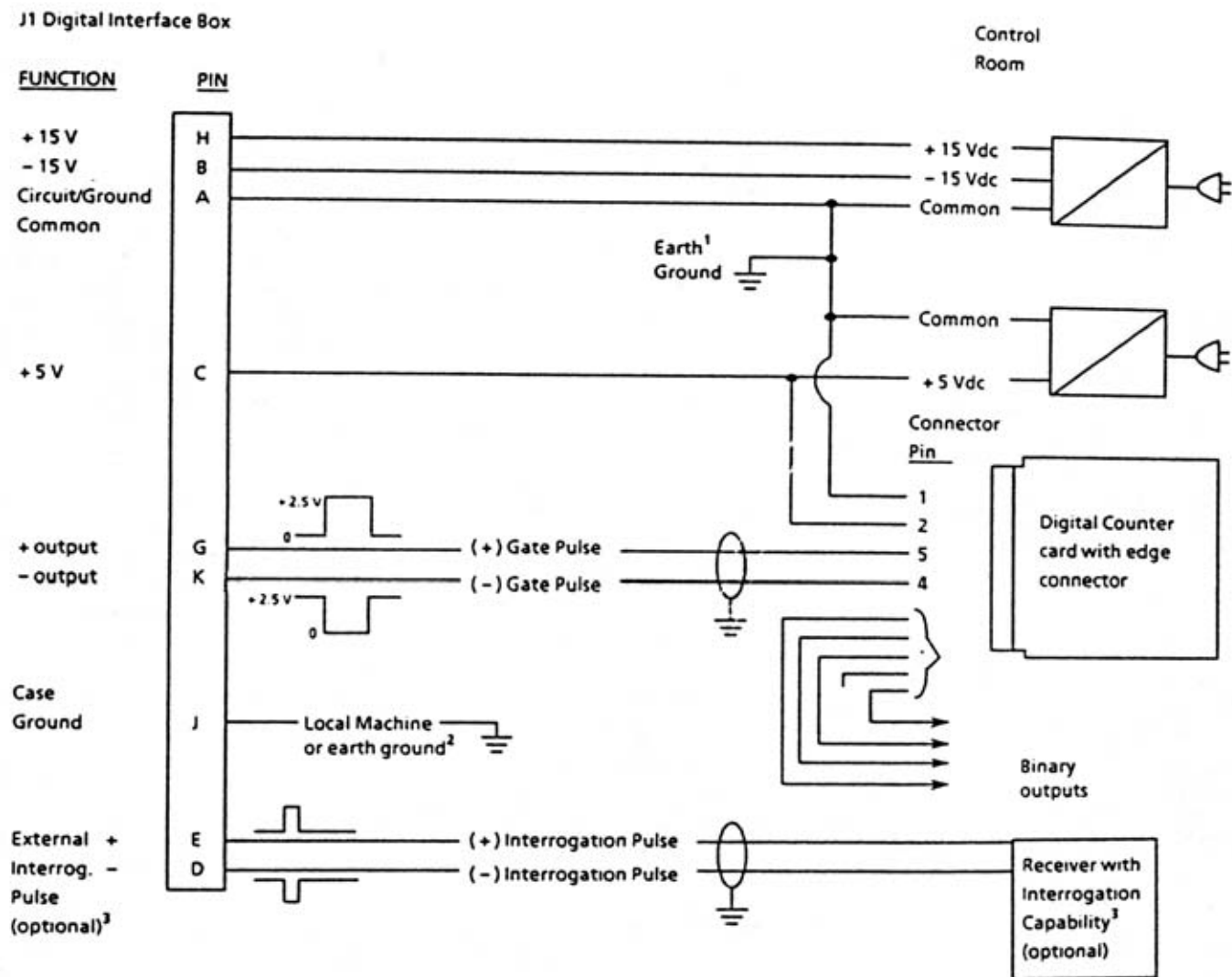
[1] It is common practice to apply earth ground to power supply common terminals near power supply

[2] Case ground is normally applied by installation of box to machine or local equipment

[3] Must be specified with order

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Table 3-3. J1 Connections

J1 Signal/Function	J1 Pin
dc Common	A
– 15 Vdc Power	B
+ 5 Vdc Power	C
External Interrogation Pulse – (Optional)	D
External Interrogation Pulse + (Optional)	E
+ Gate Output	G
+ 15 Vdc Power	H
Case Ground	J
– Gate Output	K
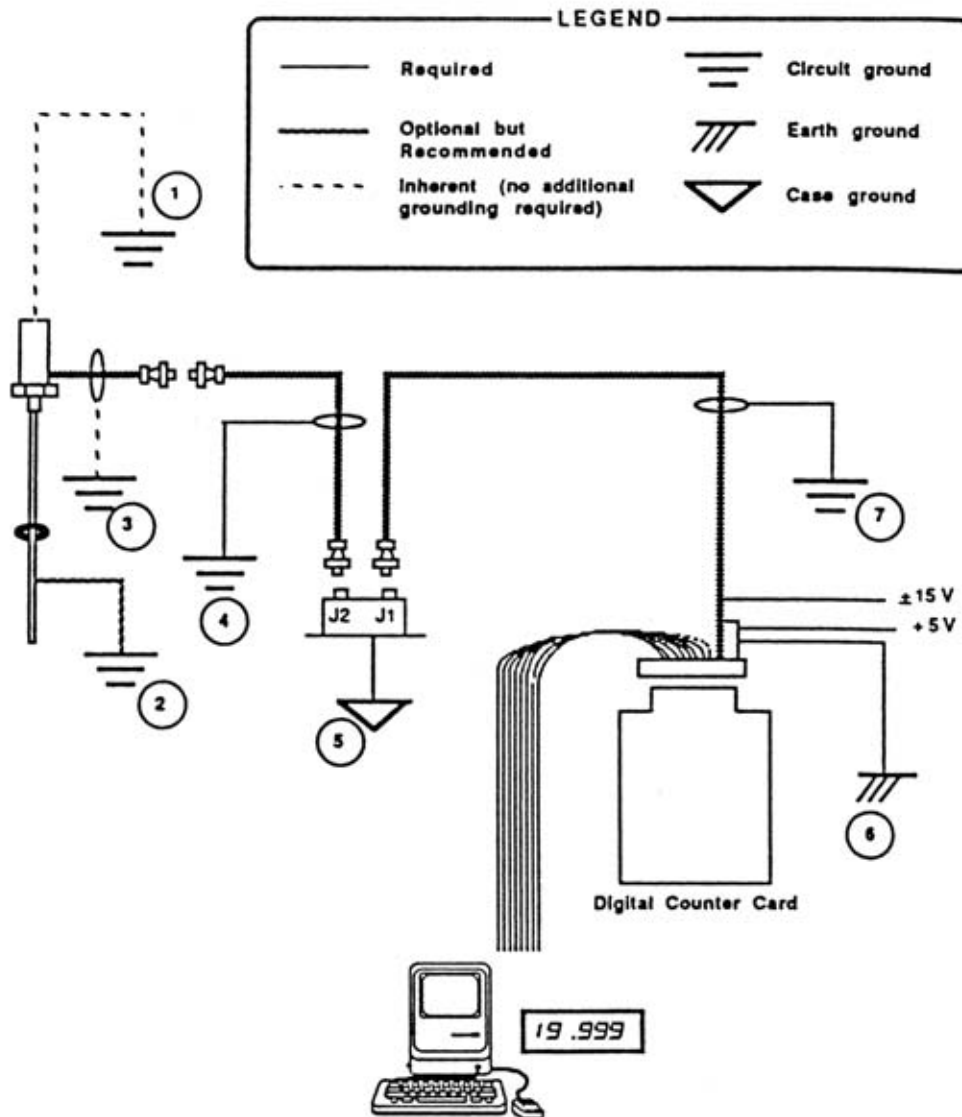
1. Blue dust cover (NEMA 1) is at circuit ground. Do not apply additional ground. Stainless steel or aluminum ruggedized head cover (NEMA 4, NEMA 6) is at same potential as transducer rod.

2. It is good practice to apply a machine, local, or earth ground to the transducer rod.

3. Transducers with integral cable have circuit ground applied to the cable shield. The ground does not pass through the connector to the extension cable or digital interface box.

4. Connect extension cable shield to circuit ground or local earth ground.

5. Digital interface box case is floating with respect to all grounds. It is good practice apply a local, earth or machine ground to this case.

6. Circuit or "reference" ground is established by connecting the power supply common(s) to earth ground. Do not apply additional grounds to circuit ground (at the transducer head, integral cable shield, or digital box output cable).

7. Digital interface box outputs should be shielded and grounded.

Figure 3-11. Required and Recommended Grounding

Table 3-4 is based upon a counter card with [÷1] divider (factory set). A single card is capable of 18 bits natural binary output maximum.

For the 27-28 MHz crystal, the resulting resolution and recirculations vs stroke are as follows:

1. For 0.000125 inches, N=32 recirculations, stroke up to 32 inches.

2. For 0.00025 inches, N=16 recirculations, stroke up to 65 inches.

3. For 0.0005 inches, N=8 recirculations, stroke up to 131 inches.

4. For 0.001 inches, N=4 recirculations, stroke up to 262 inches.

5. For 0.002 inches, N=2 recirculations, stroke up to 524 inches.

6. For 0.004 inches, N=1 recirculations.

Table 3-4. Counter Card Output (÷1)

Pin	Bit Weight	Decimal Value	Bit	Maximum Counts vs Number of bits*
10	LSB		2^0	1 = 1 bit
9			2^1	3 = 2 bit
8			2^2	7 = 3 bit
7			2^3	15 = 4 bit
14			2^4	31 = 5 bit
13			2^5	63 = 6 bit
12			2^6	127 = 7 bit
11			2^7	255 = 8 bit
18			2^8	511 = 9 bit
17			2^9	1023 = 10 bit
16			2^{10}	2047 = 11 bit
15			2^{11}	4095 = 12 bit
20			2^{12}	8191 = 13 bit
21			2^{13}	16,383 = 14 bit
22			2^{14}	32,767 = 15 bit
19			2^{15}	65,535 = 16 bit
23			2^{16}	131,071 = 17 bit
25	MSB*		2^{17}	262,143 = 18 bit

*   MSB determined by dividing stroke by resolution and comparing to maximum counts. For example, 25 inches/0.001 = 25,000. This requires a maximum count of 32,767, yielding an MSB at pin 22.

Table 3-5 is based upon a counter card with [÷2] divider (factory set). A single card is capable of 17 bits natural binary output maximum.

For the 27-28 MHz crystal, the resulting resolution and recirculations vs stroke are as follows:

1. For 0.000125 inches, N=64 recirculations, stroke up to 16 inches.

2. For 0.00025 inches, N=32 recirculations, stroke up to 32 inches.

3. For 0.0005 inches, N=16 recirculations, stroke up to 65 inches.

4. For 0.001 inches, N=8 recirculations, stroke up to 131 inches.

5. For 0.002 inches, N=4 recirculations, stroke up to 262 inches.

6. For 0.004 inches, N=2 recirculations, stroke up to 524 inches.

7. For 0.008 inches, N=1 (or none) recirculations.

Table 3-5. Counter Card Output (÷2)

Pin	Bit Weight	Decimal Value	Bit	Maximum Counts vs Number of bits*
9	LSB		2^0	1 = 1 bit
8			2^1	3 = 2 bit
7			2^2	7 = 3 bit
14			2^3	15 = 4 bit
13			2^4	31 = 5 bit
12			2^5	63 = 6 bit
11			2^6	127 = 7 bit
18			2^7	255 = 8 bit
17			2^8	511 = 9 bit
16			2^9	1023 = 10 bit
15			2^{10}	2047 = 11 bit
20			2^{11}	4095 = 12 bit
21			2^{12}	8191 = 13 bit
22			2^{13}	16,383 = 14 bit
19			2^{14}	32,767 = 15 bit
23			2^{15}	65,535 = 16 bit
25	MSB*		2^{16}	131,071 = 17 bit

* MSB determined by dividing stroke by resolution and comparing to maximum counts. For example, 25 inches/0.001 = 25,000. This requires a maximum count of 32,767, yielding an MSB at pin 19.

Table 3-6 is based upon a counter card with [÷4] divider (factory set). A single card is capable of 16 bits natural binary output maximum.

For the 27-28 MHz crystal, the resulting resolution and recirculations vs stroke are as follows:

1. For 0.000125 inches, N=125 recirculations, stroke up to 8 inches.

2. For 0.00025 inches, N=64 recirculations, stroke up to 16 inches.

3. For 0.0005 inches, N=32 recirculations, stroke up to 32 inches.

4. For 0.001 inches, N=16 recirculations, stroke up to 65 inches.

5. For 0.002 inches, N=8 recirculations, stroke up to 131 inches.

6. For 0.004 inches, N=4 recirculations, stroke up to 262 inches.

7. For 0.008 inches, N=2 recirculations, stroke up to 524 inches.

8. For 0.016 inches, N=1 (or none) recirculations.

Table 3-6. Counter Card Output (÷4)

Pin	Bit Weight	Decimal Value	Bit	Maximum Counts vs Number of bits*
8	LSB		2^0	1 = 1 bit
7			2^1	3 = 2 bit
14			2^2	7 = 3 bit
13			2^3	15 = 4 bit
12			2^4	31 = 5 bit
11			2^5	63 = 6 bit
18			2^6	127 = 7 bit
17			2^7	255 = 8 bit
16			2^8	511 = 9 bit
15			2^9	1023 = 10 bit
20			2^{10}	2047 = 11 bit
21			2^{11}	4095 = 12 bit
22			2^{12}	8191 = 13 bit
19			2^{13}	16,383 = 14 bit
23			2^{14}	32,767 = 15 bit
25	MSB*		2^{15}	65,535 = 16 bit

* MSB determined by dividing stroke by resolution and comparing to maximum counts. For example, 25 inches/0.001 = 25,000. This requires a maximum count of 32,767, yielding an MSB at pin 15.

When ordered as BCD, the counter card provides a BCD output. BCD code is a binary method of representing decimal numbers. The BCD code for a decimal number is a string of four-bit binary numbers, each of which represents one decimal digit. Only the following binary groups are used:

Decimal	Binary	Decimal	Binary
0	0000	5	0101
1	0001	6	0110
2	0010	7	0111
3	0011	8	1000
4	0100	9	1001

For example, the decimal number 8.74 is encoded in BCD as a 12-bit binary number:

8	.	7	4	=	8.74
1000	.	0111	0100	=	1000.01110100

In many cases, the BCD code for a stroke length yields a range of BCD numbers where some bits never change value. For example, 19.999 inches is represented in BCD by the 20-bit number

$$00011001.100110011001$$

Notice that, for all values from 0 up to 19.999, the first three bits will likewise be zero. This means that the remaining 17 bits are sufficient to encode a stroke of 19.999 inches; that is, one 18-bit counter card is sufficient.

Table 3-7 lists the maximum stroke length versus number of significant bits for a resolution of 0.001 inch.

Table 3-7. BCD Representations of Stroke

X (maximum stroke length in inches)	BCD Value of X	Required Number of Bits
7.999 (or 8)	0111.1001 1001 1001	15
9.999 (10)	1001.1001 1001 1001	16
19.999 (20)	0001 1001.1001 1001 1001	17
39.999 (40)	0011 1001.1001 1001 1001	18*
79.999 (80)	0111 1001.1001 1001 1001	19*
99.999 (100)	1001 1001.1001 1001 1001	20*
199.999 (200)	0001 1001 1001.1001 1001 1001	21*

*An additional counter card is used for this range.

Table 3-8 can be used to determine connections for BCD output digital counter cards.

To determine the applicable connections, you must know the stroke length and resolution. Subtract the resolution from the stroke length to obtain a maximum reading (column 1). Refer to column 7 to determine the decimal equivalent of each digit, knowing the desired decimal position. An example is worked out in Figure 3-12.

Table 3-8. BCD Output Connections

(1) Max reading	(2) No. of active bits	(3) Active Digits	(4) Pin connections Card A	(4) Pin connections Card B	(5) Binary Weight	(6) Digit	(7) Check Appropriate Column Resolution			other
			8		1	1 Least Significant	.0001	.001	.01	
			7		2					
			14		4					
		1	13		8					
			12		1	2	.001	.01	.1	
			11		2					
			18		4					
		2	17		8					
			16		1	3	.01	.1	1.	
			15		2					
			20		4					
999	12	3	21		8					
1999	13	3-1/4	22		1	4	.1	1.	10.	
3999	14	3-1/2	19		2					
7999	15	3-3/4	23		4					
9999	16	4	25		8					
19999	17	4-1/4	9*	8	1	5	1.	10	100.	
39999	18	4-1/2		7	2					
79999	19	4-3/4		14	4					
99999	20	5		13	8					
199999	21	5-1/4		12	1	6 Most Significant	10.	100.	10000.	
399999	22	5-1/2		11	2					
799999	23	5-3/4		18	4					
999999	24	6		17	8					

* Used only with 4-1/4 digits. For 4-1/2 or more digits, 5th digit is on card B.

Example: Order Specification: Stroke = 200 inches
                                   Resolution = .001 inches

Result: Maximum reading will be 199.999 inches (200 inches) this yields 5-1/4
           digits, where the "1" is considered 1/4 of a digit. Go to column 1 and
           find 199999 = maxreading. The connections will be per (4), where the
           Least Significant digit is pins 8, 7, 14, and 13, card A. The Most
           Significant digit is pin 12 on card B. The next LSD is pins 8, 7, 14, and 13
           on card B. Pin 9 is not used, due to footnote. Resolution for pin 12 is
           100 place; for the 5th digit is 10 place; etc. Refer to middle column (7)

The following connection table is provided for BCD output digital counter card(s). To determine the applicable connections, the resolution and stroke length must be known, yielding a maximum reading; column 1. Refer to column 7 to determine the decimal equivalent of the particular digit in question, knowing the desired decimal point position.

(1) Max reading	(2) No. of active bits	(3) Active Digits	(4) Pin connections Card A	Card B	(5) Binary Weight	(6) Digit	(7) Check Appropriate Column Resolution			
										other
			8		1	1				
			7		2	Least	.0001	001	.01	
			14		4	Significant				
		1	13		8					
			12		1					
			11		2	2				
			18		4		.001	.01	.1	
		2	17		8					
			16		1					
			15		2	3				
			20		4		.01	.1	1.	
999	12	3	21		8					
1999	13	3-1/4	22		1					
3999	14	3-1/2	19		2	4				
7999	15	3-3/4	23		4		.1	1.	10.	
9999	16	4	25		8					
19999	17	4-1/4	9*	8	1					
39999	18	4-1/2		7	2	5				
79999	19	4-3/4		14	4		1.	10	100.	
99999	20	5		13	8					
199999	21	5-1/4		12	1	6				
399999	22	5-1/2			2	Most				
799999	23	5-3/4			4	Significant	10.	100.	10000.	
999999	24	6			8					

* Used only with 4-1/4 digits. For 4-1/2 or more digits, 5th digit is on card B.

Figure 3-12. Sample BCD Output Connection Table

3.3.4 Wiring Procedure

The general wiring and checkout procedure is as follows:

1. Route the power and signal cables to the interface box. Do not run near high voltage lines or contacting equipment. Mark the power supply wires at the interface box J1 connector end of cable and connect the panel end of cable to the proper power supply terminals.

2. Connect the (+) and (-) gate signal wires to the counter card edge connector. Do not connect the edge connector to the card at this time.

3. Solder all cable wires to the appropriate J1 pins on the MS3116F12-10S box mating connector. Use heat shrink tubing over each solder connector to protect the connections from shorts. Make sure that cable shields do not make contact with the connector pins or the connector shell. Apply tape or a rubber boot over any exposed cable shield before tightening the cable clamps. Check for wiring shorts between pins after connector assembly.

CAUTION

Be sure all connections are correct before applying power. Voltages applied to the gate signal connector pins G or K (or optional D, E) will damage interface box.

4. Turn on power to the power supplies and take voltage readings on the J1 female connector between the appropriate pins. Check all other pins to ensure that no voltage is present.

5. Solder to the binary output on the digital counter card edge connector using ribbon cable or suitable wire harness.

6. Solder the 5 Vdc power supply to pins 1(-) and 2(+) on the counter card edge connector. Apply heat shrink tubing to the connector terminals to protect from shorts to other terminals.

7. Connect the power supply common for the ±15 V and +5 Vdc supplies together and ground them to earth ground. Refer to Figure 3-10.

8. Connect the counter card edge connector to the card. Connect the MS connector to the interface box J1 connector.

9. Plug in the transducer cable into the J2 interface box connector.

10. Apply power, and observe readings at the receiver device while moving the magnet along the transducer rod. If readings are satisfactory, go to Subsection 3.4 system calibration.

3.4 System Calibration

There are no adjustments on the interface box or the transducer. Instead, the system is calibrated at the counter card or by external means. The scaling (inches per count) is determined by a fixed frequency crystal oscillator, while the zero point is determined by resettable DIP switches on the counter card. Generally, the system components do not show shift, age, or drift over time, and recalibration is not necessary. However, calibration may be used to compensate for mechanical wear on external mechanical parts connected to the magnet or the transducer.

3.4.1 Re-zeroing the Series 80 Digital Counter Card

On Series 80 counter cards, the zero point is preset at the factory, using a pair of DIP switches, S1 and S2. Zero is set at 2 inches from the hex flange of the transducer, or at a distance specified by the customer. If reverse output is specified, the zero point is set at 5 inches or 7 inches from the tip of the transducer rod. The DIP switches are normally covered with RTV or otherwise protected, to prevent accidental resetting.

There are three ways of changing the zero setting:

a. **Mechanical Offset.**
The zero position can be adjusted by changing the mechanical offset of the magnet relative to the transducer rod. This requires a coupler device which permits a screw adjustment of the magnet.

The installer fabricates a coupler device to hold the magnet. The coupler should include adjustment screws that allow fine adjustments of the magnet along the transducer rod. Move the magnet to obtain a zero reading.

If the coupler does not allow magnet position adjustment, it can sometimes be used to lock the magnet in place, while shims or washers are used to move the transducer relative to the magnet (Do not attempt this if the unit is installed in a hydraulic cylinder).

b. **Software Programming.**
In some applications it is possible (and preferable) to maintain a zero offset in software at the receiver. This permits quick re-zeroing without adjusting the magnet or resetting the DIP switches.

For the detailed procedure, consult the manual for the receiver device. Move the magnet to the desired zero position and set the receiver reading to zero.

In most cases, the zero offset is determined by adding the binary complement to the reading observed with the magnet in the desired zero position.

c. Resetting the Counter Card with DIP Switches
For this procedure, the receiver device must be capable of reading each of the Counter Card output bits. For example, the System CRT or LED display may be connected to each bit connection on the input module. If this is not possible, a string of LEDs must be connected to the Counter Card connector to read each active bit (Refer to Figure 4-1 for a typical connection). Figures 3-13 and 3-14 show DIP switches S1 and S2, along with tables for determining the switch settings.

Binary Output

Take the following steps (Refer to Figure 3-13):

1. Before changing any DIP switch positions, record the factory-set positions for reference.

2. Move the magnet to the desired null position. Clamp it in place to prevent movement.

3. Reset all switch segments to the LO (closed) position, taking note of alignment marks on the board.

4. If a P.L.C. or readout device indicates the equivalent counts, write this value in row A of the diagram in Figure 3-11. Then convert this number to binary and write it in row B. To ensure that the count is correct, move the magnet through its stroke and observe the count change. For example, a 24-inch stroke unit with 0.001 resolution should yield a 24,000 count change.

   Alternatively, read each active bit on the counter card output and record into row B of the diagram.

5. Determine the complement of the binary number in row B, by changing 1s to 0s and 0s to 1s. Write this complement into row C.

6. Use the number from row C to mark the columns E and F. If the corresponding bit from C is 1, mark and X in column E (open or HI). If the corresponding bit is 0, mark an X in column F (closed or LO).

7. Turn off power, then set each switch segment to the value (HI or LO) indicated by the Xs in columns E and F.

8. Apply power to the system and check that the output is now zero.

Pin Number*																			
Bit	2^{17}	2^{16}	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}	
A. Reading in Counts																			(if available)
B. Reading in binary																			(from LEDs or binary of A)
C. Complement																			(complement of B)
*Use Tables 3-4 to 3-8 to determine pin numbers																			

If value in row C is 1, mark X in column E.
If value in row C is 0, mark X in column F.

Dip switch settings should be viewed with the edge card connector facing upward.

Figure 3-13. Setting DIP Switches (Binary System)

Take the following steps (Refer to Figure 3-14):

1. Before changing any DIP switch positions, record the factory-set positions for reference.

2. Move the magnet to the desired null position. Clamp it in place to prevent movement.

3. Reset all switch segments to the LO (closed) position, taking note of alignment marks on the board.

4. If a CRT or other readout device indicates a decimal value (in inches, mm, or other units), convert this value from decimal to BCD binary, and record it in row B of the diagram in Figure 3-14. (Decimal-to-BCD conversion is explained on page 3-20.)

   Alternatively, read each active bit on the counter card output and record this BCD number in row A of the Diagram. Then convert row A to decimal, and record it in row B.

5. Subtract each digit in row B from 9, and record the result in row C.

6. Convert row C into BCD binary and record the result in row D.

7. Use the number from row C to mark the columns E and F. If the corresponding bit from C is 1, mark an X in column E (open or HI). If the corresponding bit is 0, mark an X in column F (closed or LO).

8. Turn off power, then set each switch segment to the value (HI or LO) indicated by the Xs in columns E and F.

9. Apply power to the system and check that the output is now zero.

Digit	10³				10²				10¹				10⁰				Not Used		
Bit	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0	2^3	2^2	2^1	2^0			
Pin Number	25	23	19	22	21	20	15	16	17	18	11	12	13	14	7	8	9	10	
A. Reading in BCD																			(from LEDs, if used)
B. Reading in Decimal																			(from BCD indicator, if used)
C. 9 - Decimal																			Subtract B from 9
D. Converted to BCD																			Convert C to BCD

If value in row D is 1, mark X in column E.
If value in row D is 0, mark X in column F.
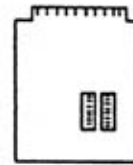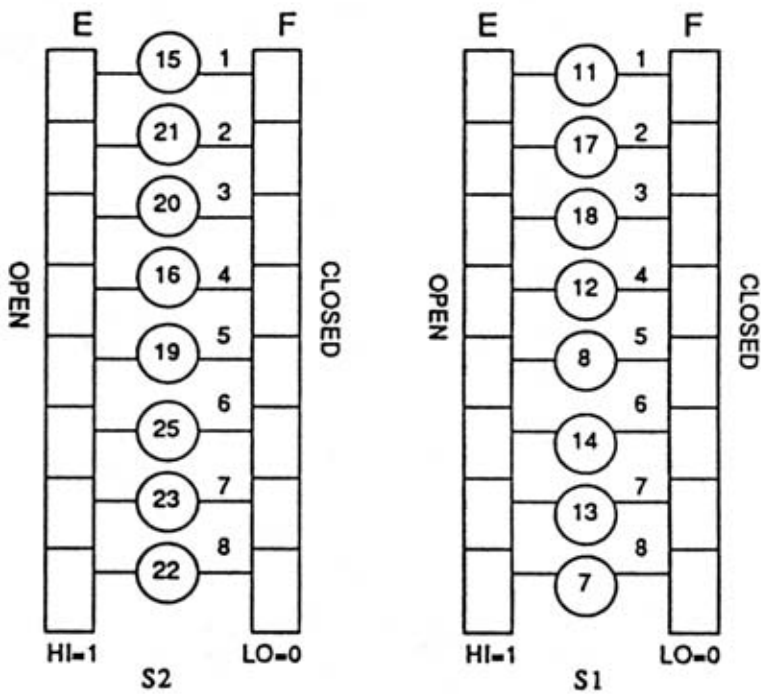
Dip switch settings should be viewed with the edge card connector facing upward.

If a second counter card is provided (for 5 or 6 digit BCD), use this table in addition to the table above

Digit	10⁴			
Bit	2^3	2^2	2^1	2^0
Pin Number	13	14	7	8
A. Reading in BCD				
B. Reading in Decimal				
C. 9 - Decimal				
D. Converted to BCD				

Figure 3-14. Setting DIP Switches (BCD System)

3.4.2 Re-zeroing the Series 60 Digital Counter Card (former design)

The Series 60 Counter Card does not contain any internal adjustment for zero setting in the field. Re-zeroing this card can only be done by mechanical offset or software programming. These procedures are described earlier in Subsection 3.4.1.

3.4.3 Scaling Series 60 and Series 80 Digital Counter Cards

1. Scaling is not normally required for Digital Counter Cards, because most digital systems are supplied as scaled systems. (Refer to the earlier Subsection 1.3.1 for a discussion of scaling.)

2. Scaling is required for systems supplied as "unscaled" systems, or if the counter card is not matched to the transducer serial number. Scaled systems will have a discrete scale factor, such as 0.001 inches per count, and do not require scale factor determination.

    To determine the scale factor (or to check system performance), move the magnet to a known measured position on the transducer near full stroke. Observe the output and record it.

    The scale factor is determined by dividing the measurement by the observed number of counts or the observed output in BCD. As an example,

Measurement	=	36.000 inches
Reading	=	35,420 counts (or 35.420 in BCD)

    $$\text{Scale Factor} = \frac{36}{35,420} = 0.0010163 \text{ inches per count (inches per inch in BCD)}$$

3. For systems that will be used for only one or more discrete positions, move the magnet to the known measured positions that will be repeated during system operation. Observe and record each reading.

    Compare each observed reading to the measured reading and record results. Use the observed readings in software programming as the set point or control points.

    For greater system accuracy, repeat this step and average the readings.

    NOTE

    To obtain maximum system accuracy, perform the above procedures at or near the actual system operating conditions.

4. For systems that are used for continuous readings or variable set points, apply the scale factor in Step 2 to software programming so that each reading is multiplied by the scale factor (consult receiver device manual). Continue to Step 5.

5. Move the magnet to a known, measured position at or near half of stroke. Observe the reading and compare to the measurement. If the reading varies by more than ±0.05% full stroke, repeat Step 2 using a different measurement near full stroke. Check the new scale factor by performing Step 5 again.

NOTE

To obtain maximum system accuracy, several scale factors should be calculated using different measurements and the factors should be averaged. Readings should be taken at or near actual system operation conditions.

6. If the readings do not relate to the stroke position, or appear erratic, refer to Section 4 for troubleshooting information.

Section IV
Troubleshooting

This section consists of troubleshooting procedures to be used when operational problems are encountered.

NOTE

The following procedures are for general troubleshooting purposes. Purchase of replacement components should not be determined solely upon results of these tests. Consult MTS Temposonics for recommendations before purchasing replacement system components.

4.1 General

If the output signal is erratic or unchanging (random), the first procedure is to turn off power and recheck Subsections 3.3.1, 3.3.2, and 3.3.3 for possible errors in mechanical or electrical installation. Once all procedures have been checked, continue for diagnostic test procedures to determine the cause of fault.

The possible causes of faulty output are listed below in order of frequency (probability) of occurrence, and should be checked in order.

		References
1.	Improper power supply/power connection	Figure 3-10 and Subsection 4.2
2.	Mismatched system components*	Subsection 1.3
3.	Ground loops/improper grounding*	Figure 3-11
4.	Improper wiring procedure for J-1 on DIB power and signal connections	Figure 3-10
5.	Improper wiring procedure for J2 on DIB to transducer	Subsection 3.3.1
6.	Improper wiring procedure for counter card connections*	Subsection 3.3.3
7.	Incorrect receiver device or software*	Subsection 4.4
8.	Improper magnet mounting*	Subsection 3.2
9.	EMI noise, affecting transducer, transducer cable, or DIB/counter card cable*	Figures 3-10 and 3-11
10.	Circuit fault within interface box	
11.	Circuit fault within counter card	
12.	Circuit fault within transducer	

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* Will cause erratic or unstable output

The equipment required for diagnostic testing is:

1. Analog or digital voltmeter
2. Circuit tester or ohmmeter
3. Oscilloscope, 50 mHz (15 mHz minimum)
   (dual channel preferred)

4.2 Power Supply Check

This procedure will determine if the power supply rating is sufficient, or if there is a voltage drop occurring in the field wiring.

Perform the following procedure to check power supply voltage and connections <u>at the interface box.</u>

1. Remove power and disconnect J-1 10 pin connector from interface box. Also remove edge connector from counter card. Turn power on and check open circuit voltages at the connector pins of the box mating connector.

2. Pin H should read +15 with respect to A.
   Pin B should read -15 with respect to A.
   Pin C should read +5 with respect to A.

3. Check power supply voltages under load as follows: Connect a 150 ohm resistor (or similar 1.5 watt, 12-15 Vdc load between pins H and A and read the voltage across t resistor. The value should be 14.25 Vdc minimum.

4. Connect a 220 ohm resistor (or similar 1 watt, 12-15 Vdc load*) between pins B and A and read the voltage across the resistor. The value should be -14.25 Vdc minimum.

5. Connect a 10 to 12 ohm resistor (or similar 2 watt, 5-6 Vdc load*) between pins B and A and read the voltage across the resistor. The voltage should read +4.75 Vdc minimum.

Perform the following procedure to check the power supply voltage and connections <u>at the 5 volt power supply.</u>

1. Connect a 4 ohm, 5 watt resistor (or similar 1.2 amp load*) across the +5 Vdc terminals of the power supply. The voltage should be +4.75 Vdc minimum.

2. Reconnect the counter card and digital interface box. Read the voltage at the counter card edge connector, pin 2 with respect to pin 1. The voltage should read +4.75 Vdc minimum.

---

* Automotive 12 or 6 Vdc bulbs of the proper wattage are acceptable alternatives.

4.3 Wiring

Improper wiring between the transducer and J-2 box connector or the counter card and J-1 box connector can cause either an erratic output or complete loss of output signal.

The following instructions should be followed to check all connections.

1. Disconnect or remove dc power to the system.

2. Trace all wiring from the counter card to the interface box. Refer to Figure 3-8, and instructions Subsection 3.3.2 for proper connection diagrams and cable types.

3. Trace all wiring from the transducer to the interface box J-2 connector. Ensure that maximum cable length and type is observed. Refer to Table 3-1A and installation Subsection 3.3.1 for color codes, cable numbers etc.

4. Check system grounds. Figure 3-11 shows a typical circuit diagram with the required and optional grounds. Ensure that circuit ground is made at one location only to avoid ground loops. If erratic or unstable output is encountered, recheck all earth grounds and cable grounds.

5. Connect an oscilloscope to the + and − gate signals at the counter card edge connector, pins 5 and 4 with respect to circuit ground pin 1. Check for presence of each gate separately, since loss of either gate will cause loss of output. If the pulse width modulates with change in magnet position, continue to Subsection 4.4 for counter card testing.

4.4 Counter Card Digital Output Test Procedure

The counter card output, (14-18 bits typical), is a true high TTL level signal nominal 0 to 5 volts dc.

The receiver device must be selected to interface with the TTL level signal of the counter card. Most devices offer a TTL input option or a specific model selection designed for TTL only.

If the user suspects an improperly selected or malfunctioning receiver device, the counter card output may be tested using LED's.

Perform the following procedure:

1. Disconnect the receiver device from the binary output of the counter card. This is usually performed at the receiver device input terminals.

2. Connect 4 or more LED's between the binary output ¦
   power supply ground as shown in Figure 4-1. Select ¦
   (or digit) which will give a reading which is eas
   interpreted. (Four of the "middle" bits for natural bina
   tenths or units place for BCD). The LED's should be rat
   for 3-5 Vdc, 50 mA maximum. The LEDs light when the
   is high. (Note that output voltage will drop under load - s
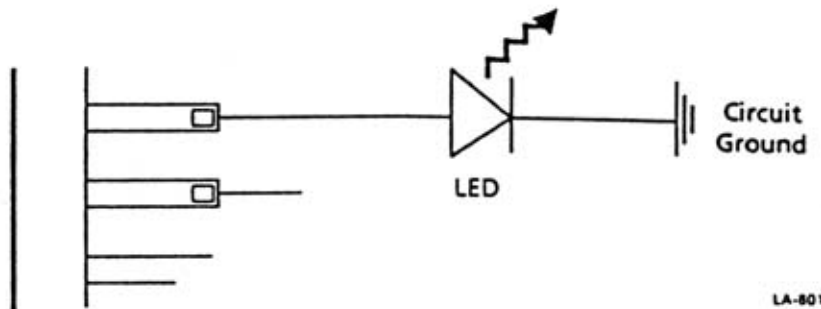   TTL data books.)

Figure 4-1. Testing Counter Card Output

3. With the above test set-up procedure, some of the LED'
   should light immediately. If no LED's light, move th
   magnet through the stroke of the transducer and ensure t'a
   one or more LED's light. If none respond, recheck the   in;
   of the LED's and the power supply connections to the
   card (pins 1 and 2).

4. To check the counter card reading move the magnet betwee:
   two measured positions on the stroke, and record the LEI
   readings, as "hi" or "lo". Take the complement of the
   readings, and calculate the decimal equivalent of the
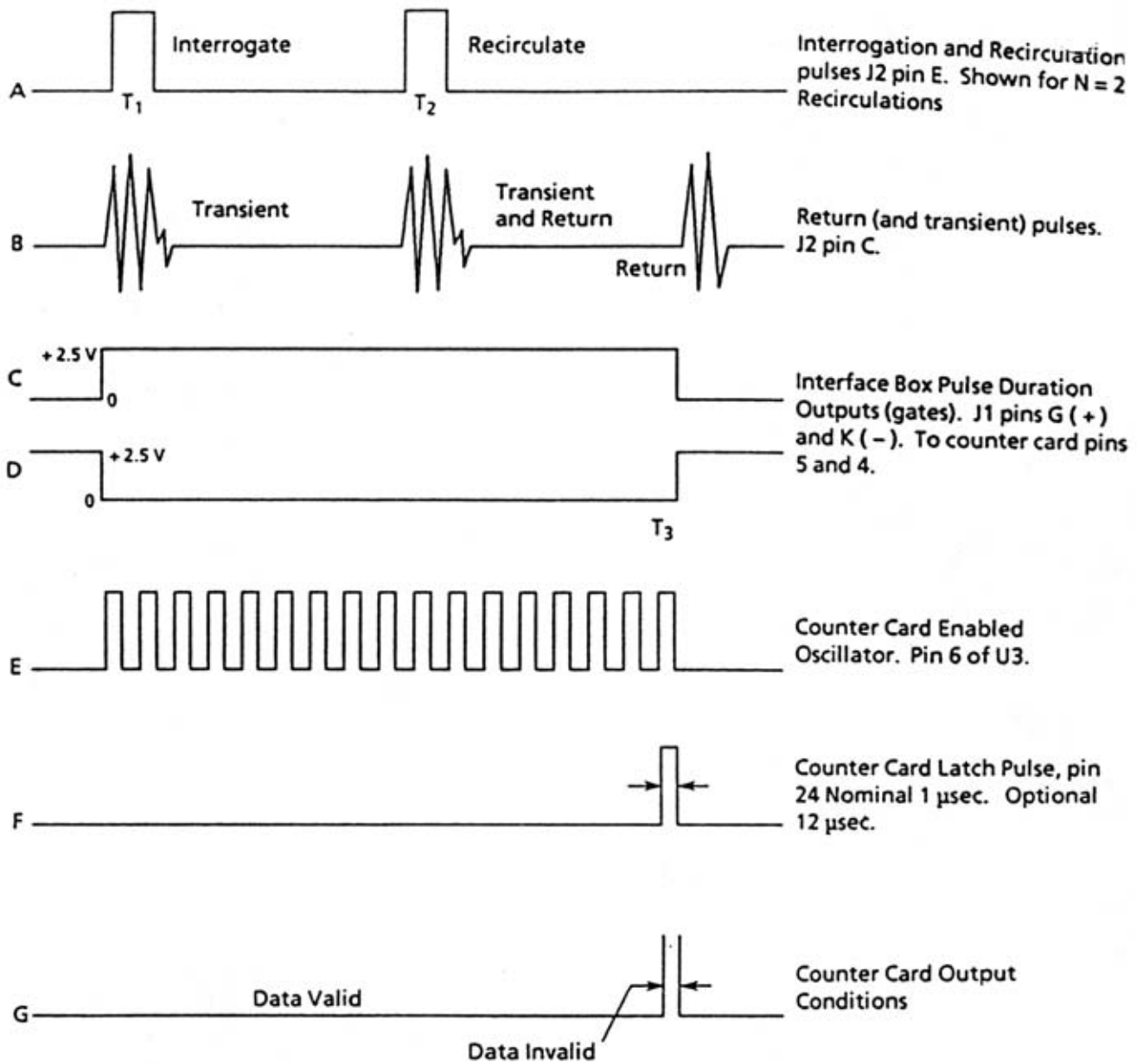   readings. For example, in natural binary, a decima
   equivalent is:

Table 4-1. LED Test

Bit Number	LED	Complement (A)	Decimal Weight (B)	A x B
2^{8*}			0.001	
2^9	Hi = 1	Lo = 0	0.512	0
2^{10}	Lo = 0	Hi = 1	1.024	1.024
2^{11}	Hi = 1	Lo = 0	2.048	0
2^{12}	Lo = 0	Hi = 1	4.096	4.906
			Sum =	5.930 Inches of stroke
* Shown for reference purposes				

Repeat this table for position 2, and compare the inches of stroke measured to the inches of stroke observed.

NOTE

A change in reading between 2 points on the stroke is a general indication of proper system operation.

A — Interrogate · Recirculate · T_1 · T_2 — Interrogation and Recirculation pulses J2 pin E. Shown for N = 2 Recirculations

B — Transient · Transient and Return · Return — Return (and transient) pulses. J2 pin C.

C — +2.5 V · 0 · **D** — +2.5 V · 0 · T_3 — Interface Box Pulse Duration Outputs (gates). J1 pins G (+) and K (–). To counter card pins 5 and 4.

E — Counter Card Enabled Oscillator. Pin 6 of U3.

F — Counter Card Latch Pulse, pin 24 Nominal 1 μsec. Optional 12 μsec.

G — Data Valid · Data Invalid — Counter Card Output Conditions

$T_3 = 9.05$ μsec/inch $\times$ N $\times$ (position + 4.5 inches)   (approximate)

LA-A137

Figure 4-2. System Level Signal Timing

Temposonics™ Brand Linear Displacement Transducer System with Direct Digital Output

Supplement

The following procedures were developed after the printing of the Temposonics™ Brand Linear Displacement Transducer System with Direct Digital Output manual. This publication is designed to be used as a supplement to Section IV Troubleshooting.

NOTE

The MTS Customer Service Department should be consulted before attempting any repairs in the field. Failure to consult MTS will void the warranty.

4.5 Power Supply Check

1. Disconnect DIB from 10-pin connector.

2. Turn power supply on and check the following voltages on J1 (10-pin) mating connector with respect to pin-A (gnd):

    pin H = +15Vdc
       B = -15Vdc
       C = +5Vdc

3. If voltages are correct, turn power off and connect 10-pin back to DIB.

4.6 Digital Interface Box (DIB)

1. With power off, disconnect transducer from DIB.

2. Turn power on. Check the following voltages on pin-B (gnd) on J2 (6-pin) of the DIB.

    Pin A = +12 to +15Vdc
       D = -13.5 to -15Vdc
       F = +11.5 to +12Vdc

3. If any voltage is missing or is not within specification, send the DIB to the factory for repair. If voltages are correct go to step 4.

4. With power on, use an oscilloscope to check the interrogation signal to the transducer on J2 pin-E on the DIB. If no signal is present, send the box to the factory for repair. If the signal looks like the example below, go to step 5.

pos.(+) pulse transducer

neg.(-) pulse transducer

4-8
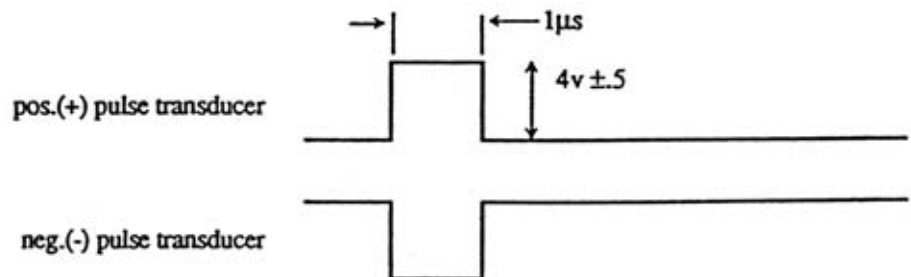
5. Hook oscilloscope to pin-C on the transducer cable. The return pulse and recirculations should be present. Go to step B6 if these signals are present. Send the DIB to the factory for repair if the signals are not present. Below is an example of a DIB with 4 recirculations.

Volts/div: 1v
Time/div: 5μs (delay mode)

rec 1   rec 2   rec 3   rec 4   return pulse

6. Look at the gate signals on pins G(+) and K(-) on the J1 connector. A complimentary 0 volts low 5 volt high TTL level output should be present. Send the DIB to the factory for repair if gate signals are not present.

4.7 Modifying a DIB from INTERNAL interrogation to EXTERNAL Interrogation

Consult drawings 650110 and 250068.

1. Remove the 4 cover screws on the DIB.

2. Remove cover with PCB connected. Turn component side up with J1 to the left and J2 to the right as you face the board.

3. Remove the 555 timer from the bottom of the 16-pin DIP socke (position U1B) pins 1-4 and 13-16.

4. Install a 9637 IC* on the top side of the same 16-pin DIP socket (position U1) pins 5-8 and 9-12.

5. Install a 100Ω resistor between pins D and E of J1-10 pin connector (or E1 and E2).

4.8 Modifying a DIB from EXTERNAL interrogation to INTERNAL Interrogation

Consult drawings 650110 and 250068.

1. Remove the 4 cover screws on the DIB.

2. Remove cover with PCB connected. Turn component side up with J1 to the left and J2 to the right as you face the board.

3. Remove the 9637 IC from the top side of the 16-pin DIP socket (position U1B) pins 5-8 and 9-12.

4. Install a 555 timer** on the bottom side of the same 16-pin DIP socket (position U1) pins 1-4 and 13-16.

5. Install the proper value (or next highest available value) resistor in R1 location. Use the following formula to determine the resistor value:

   R1 (KΩ) - [T(msec) x 14.43] - 1

6. Install R2 (499Ω) , C1 (.1µF) and C13 (.01µF) if R1 is not present.

* IC 9637 is manufactured by Texas Instruments P/N UA9637 ACP
** The 555 Timer is manufactured by RCA P/N LM555CN

4.9 Changing Recirculations

1. Remove the 4 cover screws on the DIB.

2. Locate the jumper wire in the center of the PCB attached to "0" and some other number ranging from 1 to 8. There are 8 possible points.

3. Use the chart below to change from 0 to X to get N (number of desired circulations).

4. Install U3 (74161) for recirculations above 8.

Jumper from 0 to X		N
0 to 1	=	1
0 to 2	=	2
0 to 3	=	4
0 to 4	=	8
0 to 5	=	16
0 to 6	=	32
0 to 7	=	64
0 to 8	=	128

NOTE

Any DIB having a high number of circulations can be changed to a lower number without having an effect on the interrogation pulse timing.
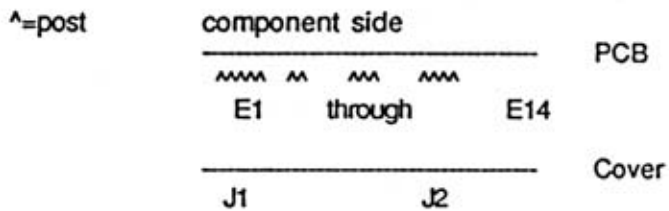
4.10   Changing Polarity

This procedure is used when connecting a negative pulse transducer to a positive pulse DIB, or when connecting a positive pulse transducer to a negative pulse DIB.
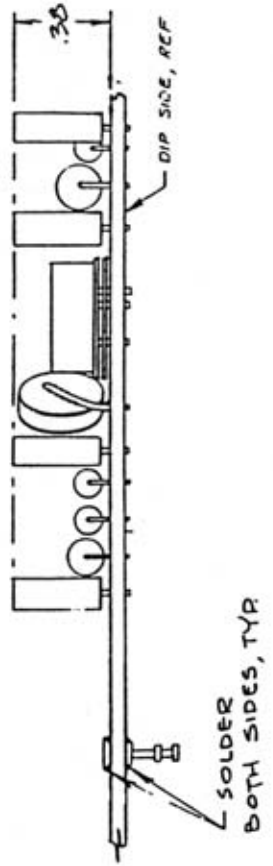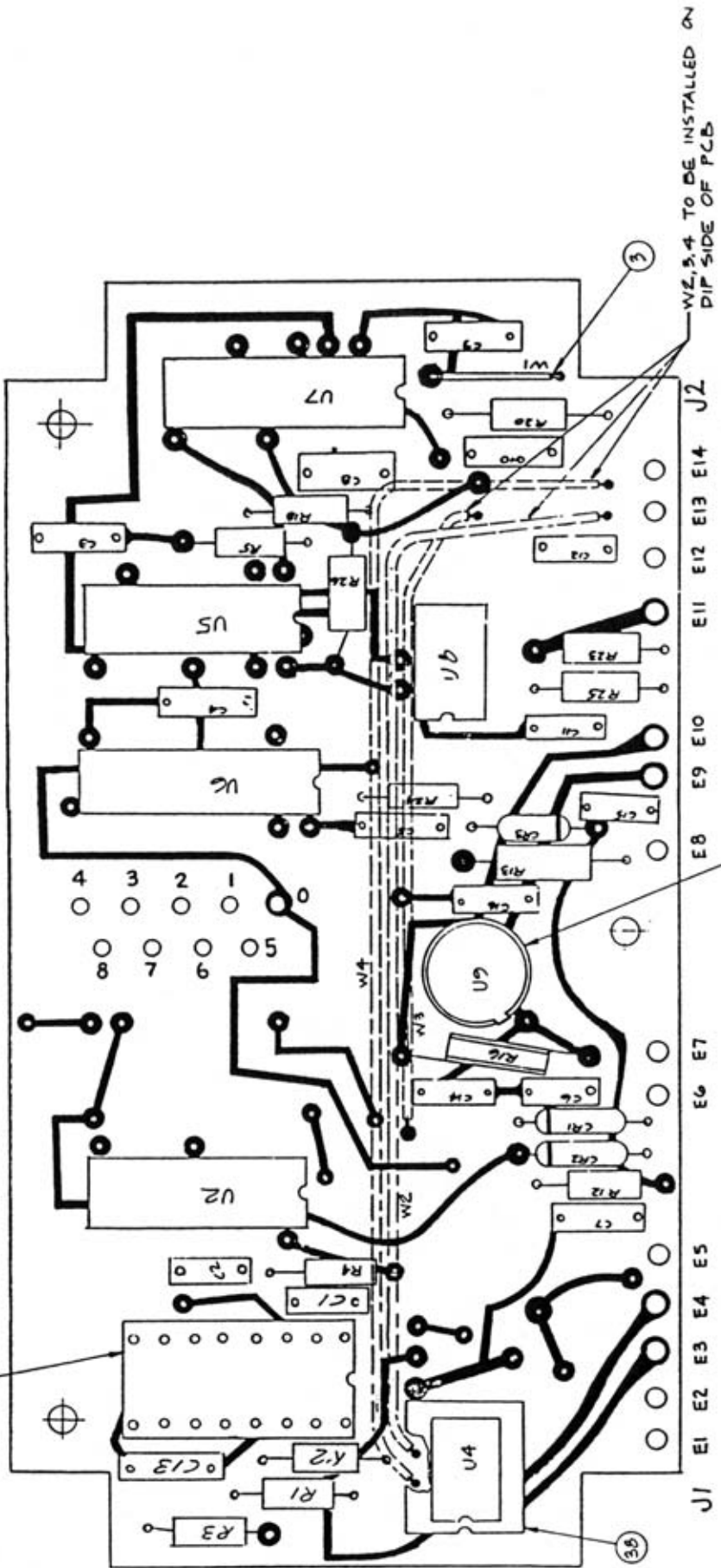
The polarity of the interrogation pulse is determined by the type of driver within the transducer head electronics. The serial number on the transducer ends in a P (positive) or N (negative). The polarity is indicated by the 10th digit in the transducer model number.

1.   Remove the 4 cover screws on the DIB.

2.   Remove cover with PCB connected. Turn component side up with J1 to the left and J2 to the right as you face the board.

3.   Make one connection to pin-E on the J2, 6-pin connector, which represents the (+) or (-) pulse.

Example: post E14 to J2 pin-E is (+) polarity
post E13 to J2 pin-E is (-) polarity

^=post   component side
                ------------------------------------ PCB
                ʌʌʌʌ ʌʌ   ʌʌʌ   ʌʌʌ
                 E1   through   E14

                ------------------------------------ Cover
                 J1   J2

NOTES:
1 - MASK ALL UNPOPULATED HOLES BEFORE SOLDERING
2 - REF SCHEMATIC # 650109

W2,3,4 TO BE INSTALLED ON DIP SIDE OF PCB

SOLDER BOTH SIDES, TYP.

DIP SIDE, REF

MTS.