



Sensors Division

# Temposonics® II

Linear Displacement Transducer

*Installation and Instruction Manual for*  
**DIGITAL SYSTEMS**



P/N 550033 Rev. F

## **GENERAL INFORMATION**

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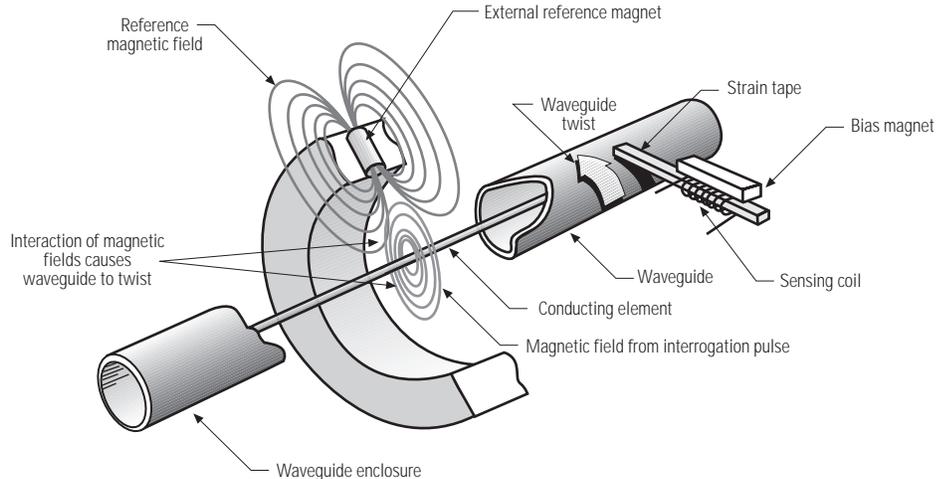
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# 1. Introduction to the Temposonics II Linear Displacement Transducer (LDT)

The Temposonics II LDT precisely senses the position of an external magnet to measure displacement with a high degree of accuracy and resolution. Using the principle of magnetostriction (see Section 1.1, below), the Temposonics II LDT measures the time interval between the initiation of an interrogation pulse and the detection of a return pulse. A variety of interface devices use the data derived from these two pulses and generates an analog or digital output to represent position.

## 1.1 Theory of Operation/Magnetostriction

The interrogation pulse travels the length of the transducer by a conducting wire threaded through a hollow waveguide. The waveguide is spring loaded within the transducer rod and exhibits the physical property of magnetostriction. When the magnetic field of the interrogation pulse interacts 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” (2.5 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 to various measuring devices as the conditioned “return pulse”.



**Figure 1-1**  
**Waveguide Interaction**

## 1.2 Temposonics II LDT Specifications

<i>Parameter</i>	<i>Specifications</i>
Input Voltage:	± 12 to ± 15 Vdc
Current Draw:	<p><b>Transducer Only:</b>            ± 15 Vdc at 100 mA maximum, 25 mA minimum            (current draw varies with magnet position, maximum draw occurs when magnet is at 2 in. (50.6 mm) from the flange and minimum update time is being utilized)</p> <p><b>Transducer with:</b></p> <ul style="list-style-type: none"> <li>• RS-422 Personality Module (RPM): ± 12 to ±15 Vdc at 140 mA maximum</li> <li>• Digital Personality Module (DPM): + 15 Vdc at 150 mA maximum, 75 mA minimum, - 15 Vdc at 100 mA maximum, 25 mA minimum</li> </ul>
Displacement:	Up to 25 feet (7620 millimeters)
Dead Space:	2.5 inches (63.5 millimeters) for stroke lengths up to 179.9 in. 3 inches (76.2 millimeters) for stroke lengths ≥ 180 in.
Electronics Enclosure:	IP-67
Non-linearity:	< ± 0.05% of full scale or ± 0.002 inch (±0.05 mm), whichever is greater
Resolution:	1 ÷ [gradient x crystal freq. (MHz) x circulation]; maximum resolution: 0.006 mm or 0.00025 in.
Repeatability:	Equals resolution
Hysteresis:	0.0008 inch (0.02 mm) maximum
Update Time:	Resolution and Stroke dependent Minimum = [Stroke (specified in inches) + 3] x 9.1 µs
Operating Temperature	
Head Electronics:	- 40 to 150°F (- 40 to 66°C)
Transducer Rod:	- 40 to 185°F (- 40 to 85°C)
Operating Pressure:	3000 psi continuous, 8000 psi static
Digital Outputs (absolute)	TTL level, nominal 0 and 5V, true high, parallel transmission

*Specifications are subject to change without notice. Consult MTS for verification of specifications critical to your application.*

### 1.3 Specifications for Temposonics II LDTs over 180 Inches

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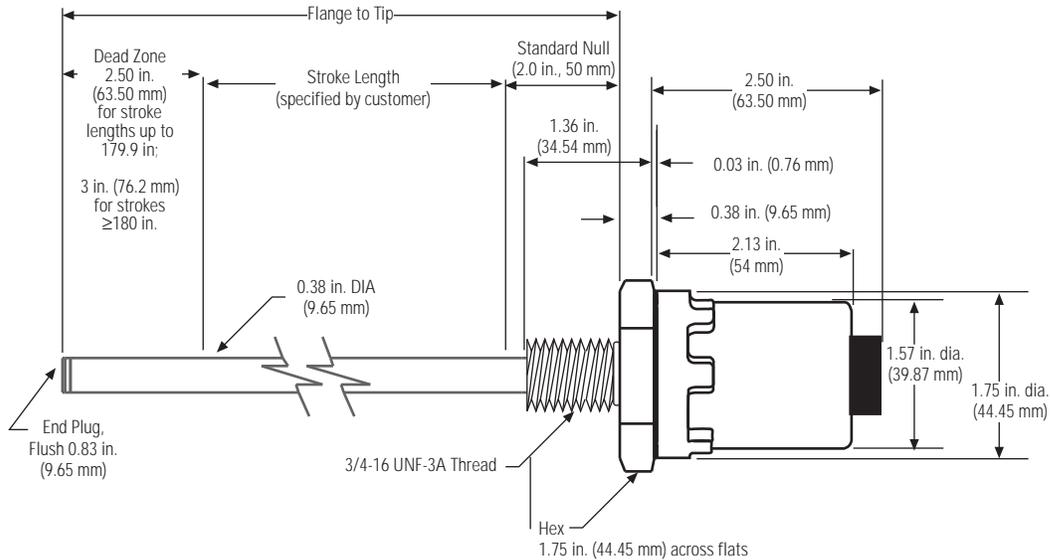
Below is a list of specifications that pertain to Temposonics II transducers with active stroke lengths of 180 inches (4572 mm) to 300 inches (7620 mm). Special versions of the Analog Output Modules (AOM) and Digital Interface Boxes (DIB) are required to interface with transducers over 180 inches in length. Contact an MTS Applications Engineer for details before ordering.

<i>Parameter</i>	<i>Specifications</i>
Input Voltage:	<ul style="list-style-type: none"><li>• Maximum: <math>\pm 15</math> Vdc, <math>\pm 5\%</math> at 100 mA</li><li>• Minimum: <math>\pm 15</math> Vdc at 25 mA (current draw varies with magnet position, maximum draw occurs when magnet is 2 inches (50.8 mm) from the flange and minimum update time is being used)</li></ul>
Dead Space:	3 in. (76.2 mm)
Cable Length:	<ul style="list-style-type: none"><li>• Maximum cable length for neuter version transducer (i.e., Temposonics II without an integrated Personality Module) which requires the use of external interface electronics (Analog output Module, Digital Interface Box or other signal conditioners) is 250 ft.</li><li>• Maximum cable length for Temposonics II transducers with Personality Modules RPM: 1640 feet (500 meters) using external interrogation DPM: 300 feet (90 meters) using external interrogation</li></ul>
Magnet Requirement:	Part Number: 201554 or 201553 ONLY

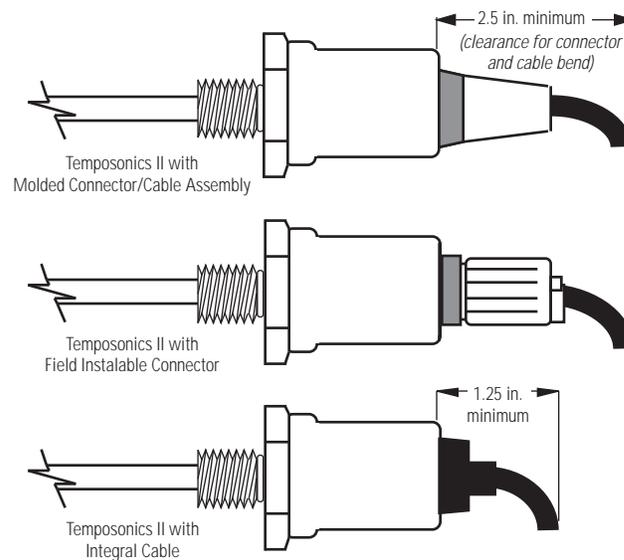
## 2. Temposonics II LDT Installation

Before beginning installation, be sure you know the following dimensions (as illustrated in Figures 2-1 to 2-3a-c.):

- Null Space
- Stroke
- Dead Zone

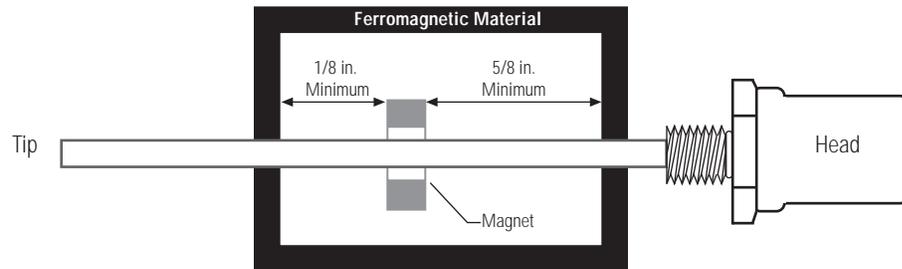


**Figure 2-1**  
**Temposonics II Dimension**

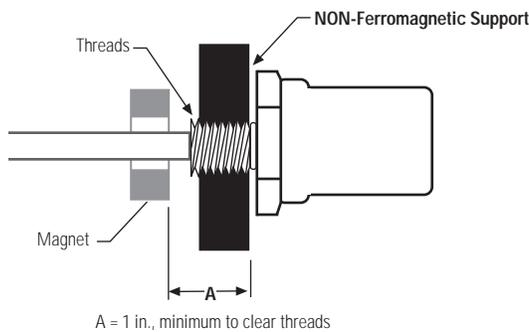


**Figure 2-2**  
**Temposonics II Connector/Cable Clearance Requirements**

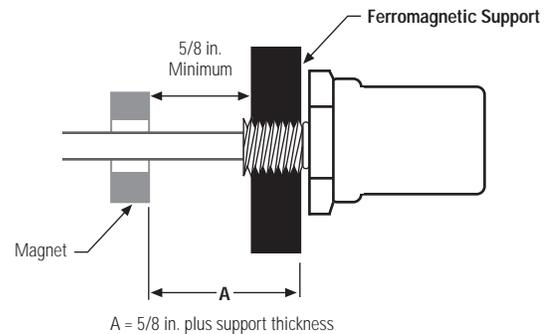
1. Use the 3/4 inch (19 mm), 16 UNF thread of the transducer to mount it at the selected location. Leave room to access the hex head. If a pressure or moisture seal is required, install an O-ring (type MS 28778-8 is recommended) in the special groove. Use the hex head to tighten the transducer assembly.
2. Install the permanent magnet over the LDT rod. Mount the permanent magnet to the movable device whose displacement will be measured. To minimize the effect of magnetic materials (i.e. iron, steel, etc.) on the magnetic field of the permanent magnet, ensure the minimum spacing requirements are met as shown in Figure 2-4. (Any non-magnetic materials can be in direct contact with the permanent magnet without affecting performance.)



**Figure 2-3a**  
**Minimum Magnet Clearance Using Magnetic Supports**



**Figure 2-3b**  
**Minimum Null Space Using Non-Magnetic Support**



**Figure 2-3c**  
**Minimum Null Space Using Magnetic Support**

**Notes:**

1. The magnet must not contact ferromagnetic materials (such as iron or steel). Clearances are required between the surface of the magnet and ferromagnetic material, as shown. Non-ferrous material (such as copper, brass, or 300 series stainless steel) may contact the magnet without affecting transducer performance.
2. Standard Null Space is 2 inches. There is no maximum limit for Null Space. Less than 2 inches can be specified if magnet clearances meet requirements illustrated above.

**NOTE:**

*Clearance between the magnet and the transducer 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 transducer rod.*

4. Move the permanent magnet full-scale to check that it moves freely. If not (if the magnet rubs on the transducer) you can correct this by mounting a support bracket to the end of the transducer. Long transducers may need additional supports to be attached to the transducer rod. Transducer supports are described later in this section.

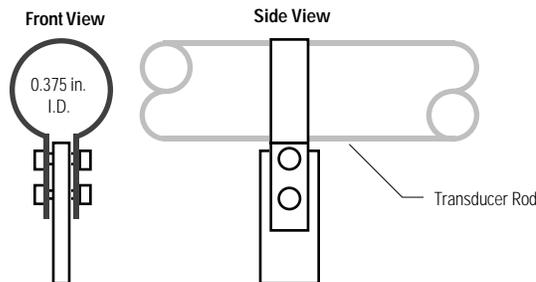
## **2.1 Types of Transducer Supports**

Long transducers (48 inches or longer) may require supports to maintain proper alignment between the transducer rod and the permanent magnet. When transducer rod supports are used, special, open-ended permanent magnets are required.

Transducer supports attached to the active stroke length must be made of a non-ferrous material, thin enough to permit the permanent magnet to pass without obstruction. Because the permanent magnet does not enter the dead zone, supports connected within the dead zone may be made of any material. The main types of supports are loop, channel, and guide pipe supports.

### **2.1.1 Loop Supports**

Loop supports are fabricated from non-ferrous materials, thin enough to permit free movement of the magnet. Loop supports are recommended for straight transducers. They may be used alone or with channel supports. Figure 2-4 illustrates the fabrication of a loop support.



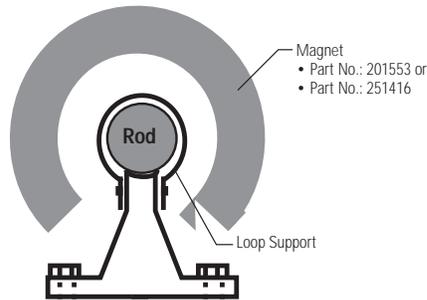
**Figure 2-4**  
**Loop Support**

**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 enter the cut out area of an open magnet, the transducer signal could attenuate or be lost. See Figure 2-7.*

### 2.1.2 Channel Supports

Channel supports, being typically straight, are normally used with rigid transducers. A channel support consists of a straight channel with loop supports mounted at intervals. The loop supports are required to keep the transducer within the channel. Figure 2-5 shows a channel support. Channel supports are available from various manufacturers or may be fabricated.

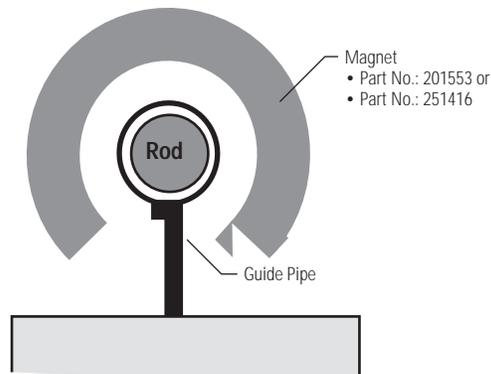


**Figure 2-5**  
**Channel Support**

### 2.1.3 Guide Pipe Supports

Guide pipe supports are normally used for flexible transducers. A guide pipe support is constructed of non-ferrous material, straight or bent to the desired shape. As shown in Figure 2-6, both inside and outside dimensions of the pipe are critical:

- Because the transducer rod is installed inside the pipe, the inside diameter of the pipe must be large enough to clear the rod.



**Figure. 2-6**  
**Guide Pipe Support**

- The outside diameter of the pipe must be small enough to clear the magnet.

Refer to pipe manufacturers' specifications and dimensions (schedule 10, 40, etc.) to select the appropriate size pipe. Guide pipe is typically supported at each end of the pipe.

## 2.2 Open Magnets

When using an open magnet, make sure the rod is positioned at all times within the “active” zone of the magnet. The transducer cannot operate properly unless the entire stroke of the transducer rod is located within this zone. The active zone, as shown in Figure 2-7, lies within the inside diameter of the magnet.

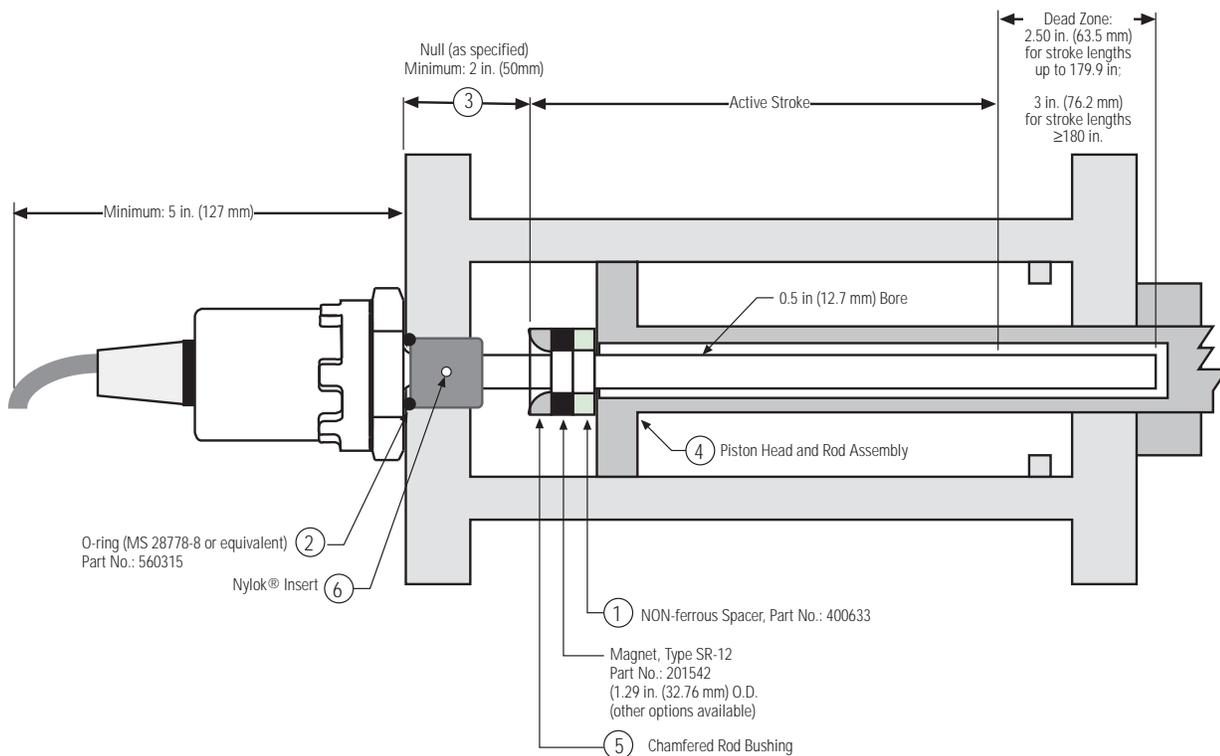


**Figure 2-7**  
**Active Zone for Open Magnets**

## 2.3 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.

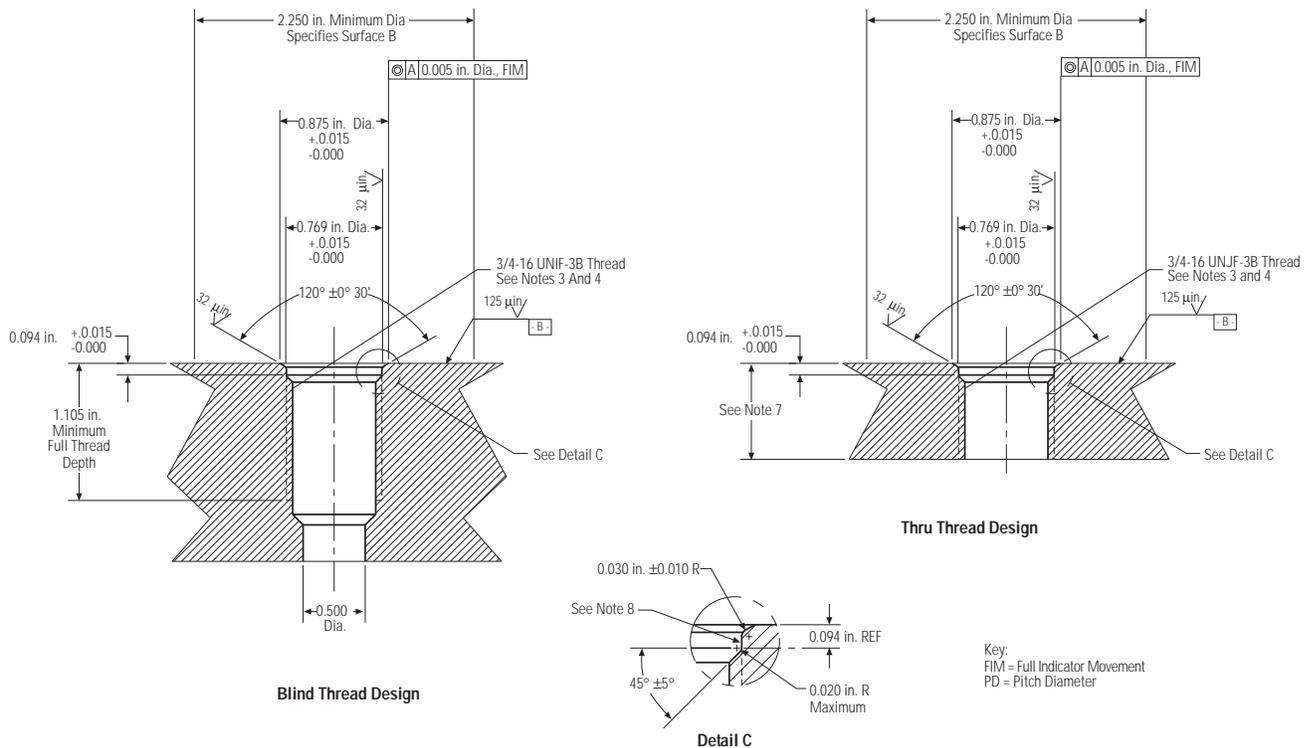
## 2.4 Cylinder Installation



**Figure 2-8**  
**Typical Cylinder Installation**

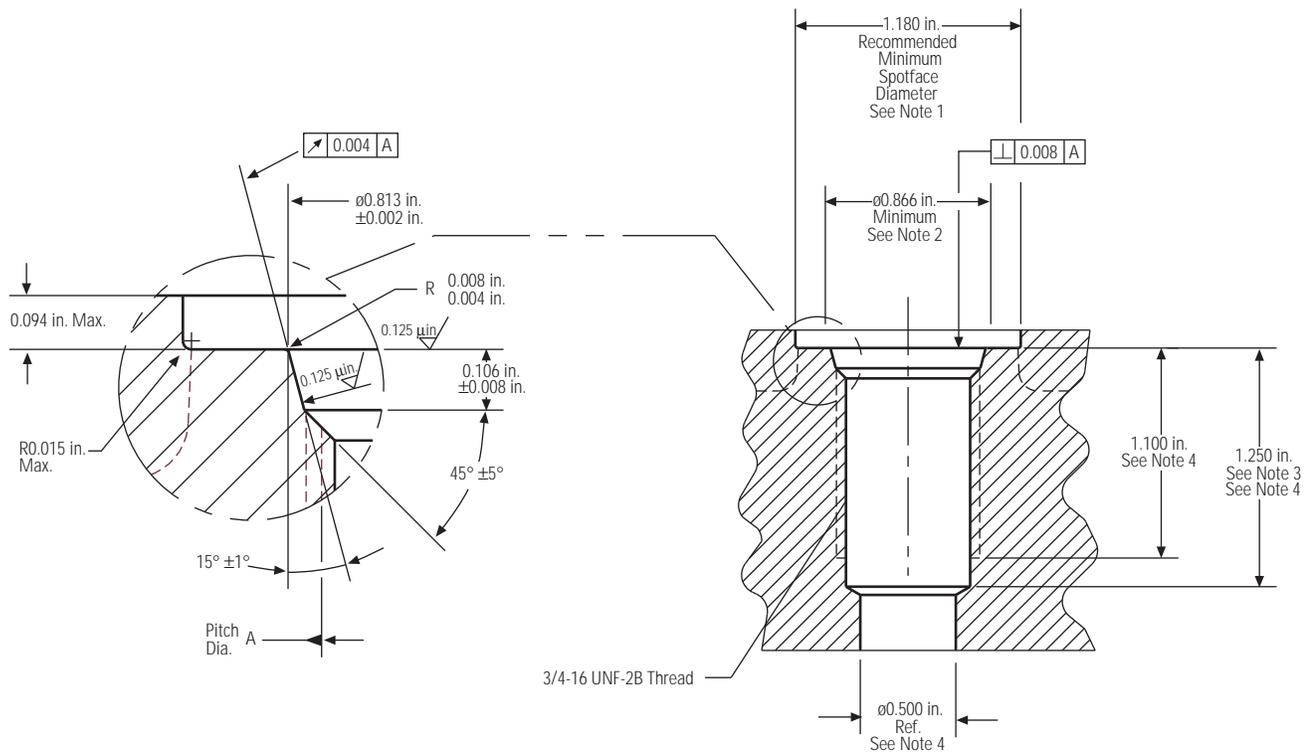
Figure 2-8 shows a typical cylinder installation. Review the following before attempting this type of installation.

- Use a non-ferrous (plastic, brass, Teflon®, etc.) spacer [1] to provide 1/8 inch (32 mm) minimum space between the magnet and the piston.
- An O-ring groove [2] is provided at the base of the transducer hex head for pressure sealing. MTS uses mil-standard MS33514 for the O-ring groove. Refer to mil-standard MS33649 or SAE J514 for machining of mating surfaces.
- The null space [3] is specified according to the installation design and cylinder dimensions. The analog output module provides a null adjustment. Make sure that the magnet can be mounted at the proper null position.
- The piston head [4] shown in Figure 2-8 is typical. For some installations, depending on the clearances, it may be desired to countersink the magnet.
- A chamfered rod bushing [5] 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.
- A Nylok self locking insert [6] is provided on the transducer threads. An O-ring groove is provided at the base of the transducer hex head for pressure sealing.
- The recommended bore for the cylinder rod is 1/2 inch (13 mm). The transducer rod includes a 0.375 inch flush (9.53 mm) end plug. Use standard industry practices for machining and mounting of all components. Consult the cylinder manufacturer for applicable SAE or military specifications.



- NOTES:
1. Dimensions and tolerances based on ANSI Y14.5-1982.
  2. MTS has extracted all pertinent information from MS33649 to Generate this document.
  3. PD must be square with surface B within 0.005 FIM across 2.250 dia minimum.
  4. PD must be concentric with 2.250 dia within 0.030 FIM and with 0.769 dia within 0.005 FIM.
  5. Surface texture ANSI B46.1-1978
  6. Use o-ring MTS part number 560315 for correct sealing.
  7. The thru thread design shall have sufficient threads to meet strength requirements of material used.
  8. Finish counter-bore shall be free from longitudinal and spiral tool marks. Annular tool marks up to 32 micro-inches maximum will be permissible.

**Figure 2-9a**  
**O-ring Boss Detail**



**NOTES:**

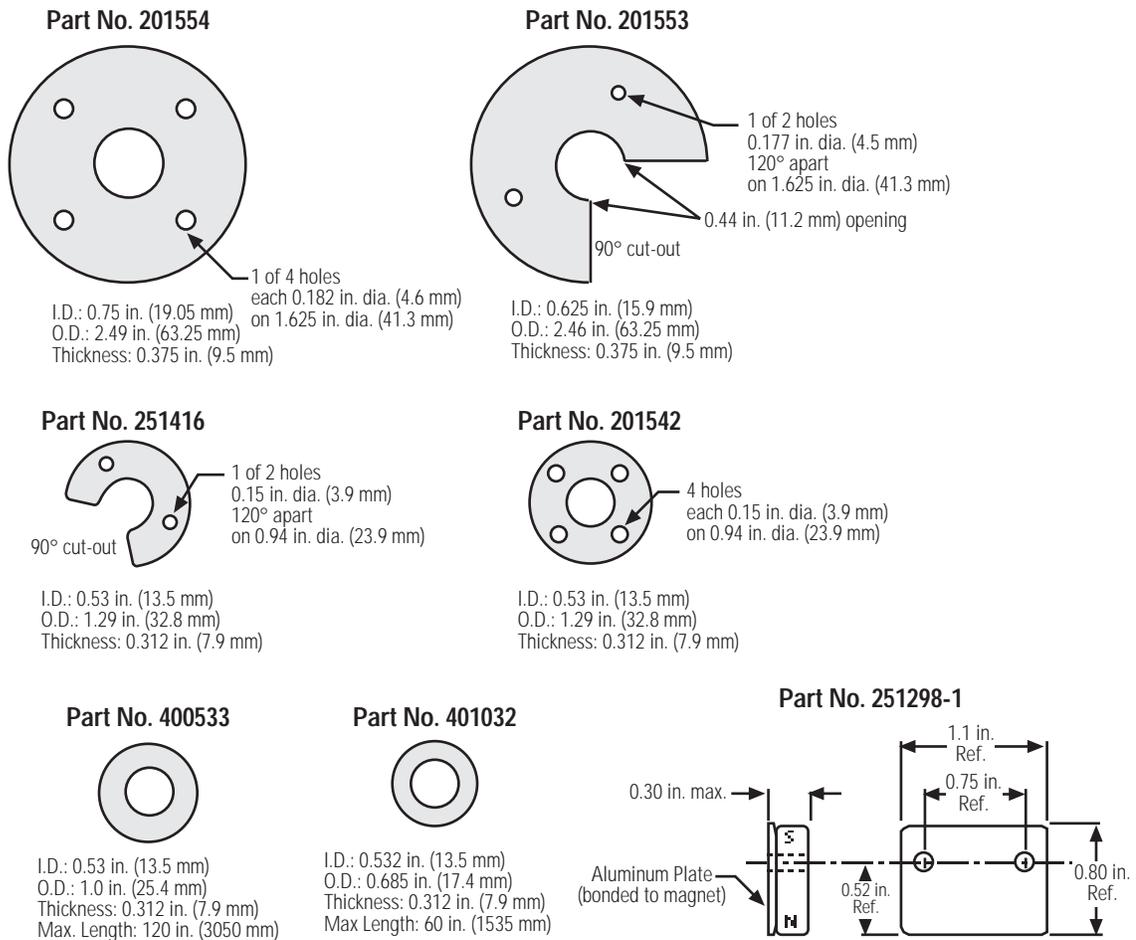
1. If face of port is on a machined surface, dimensions 1.180 and 0.094 need not apply as long as R0.008/0.004 is maintained to avoid damage to the O-ring during installation.
2. Measure perpendicularity to A at this diameter.
3. This dimension applies when tap drill cannot pass through entire boss.
4. This dimension does not conform to SAE J1926/1.

**Figure 2-9b**  
**Port Detail (SAE J1926/1)**

## 2.5 Installing Magnets

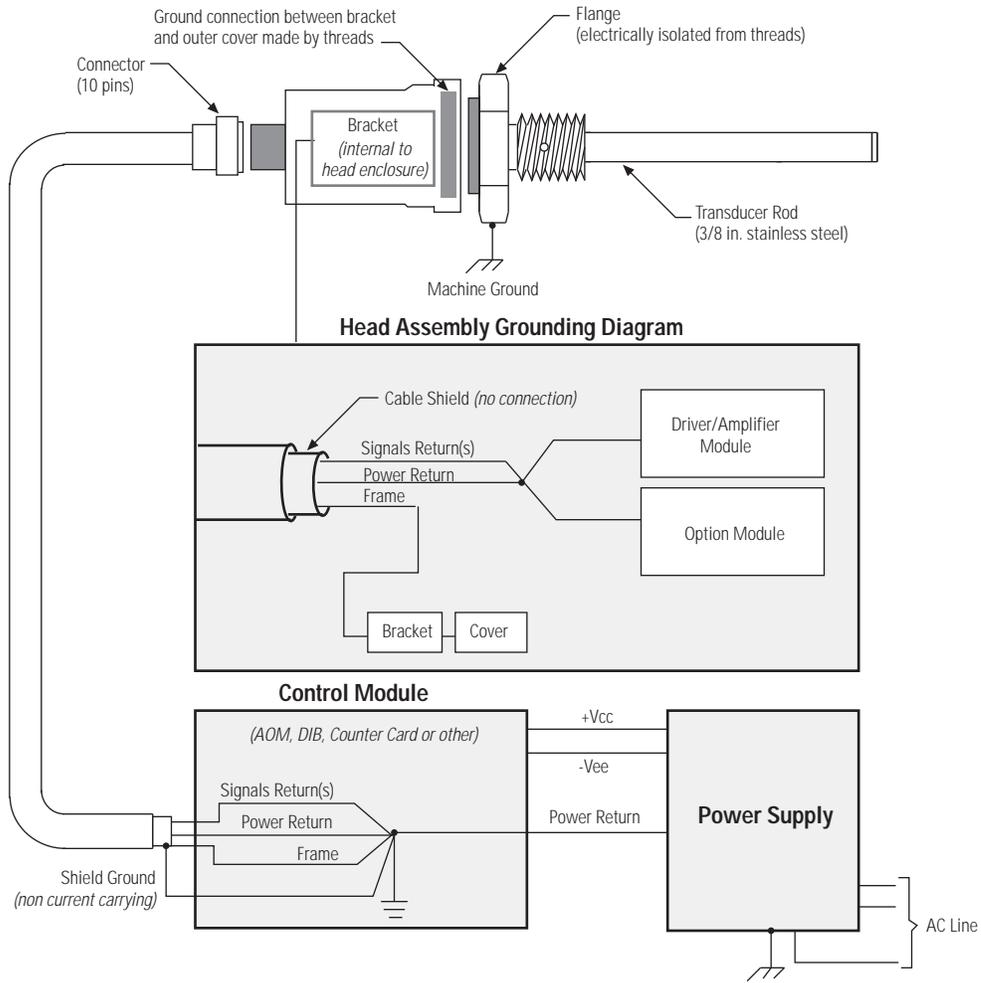
Figure 2-10 below shows the standard magnet types and dimensions. The circular magnet with an outside diameter of 1.29 inches and 0.53 inch inside diameter (Part No. 201542) is the most common and is suitable for most applications. Larger magnets, with an outside diameter of 2.5 inches are typically only used with Temposonics transducers that exceed 180 inches in stroke length. Magnets with a 90 degree cut-out are used in applications that require intermediate supports along the transducer rod.

If upon installation, the null adjustment is inadequate, you can design a coupler with adjustments to mount the magnet to the measured member.



**Figure 2-10**  
**Magnet Dimensions**

### 3. Grounding

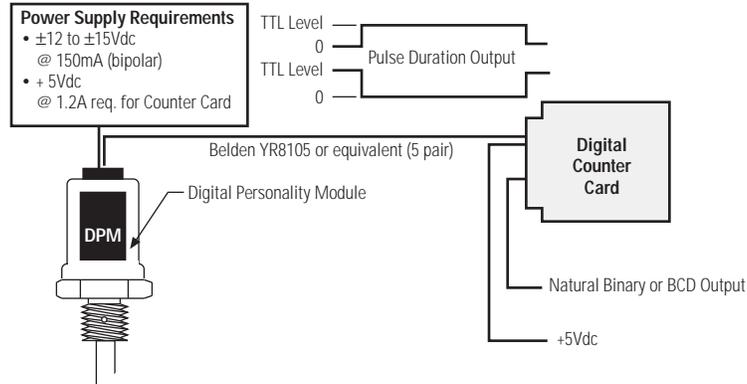


**Figure 3-1**  
**Grounding**

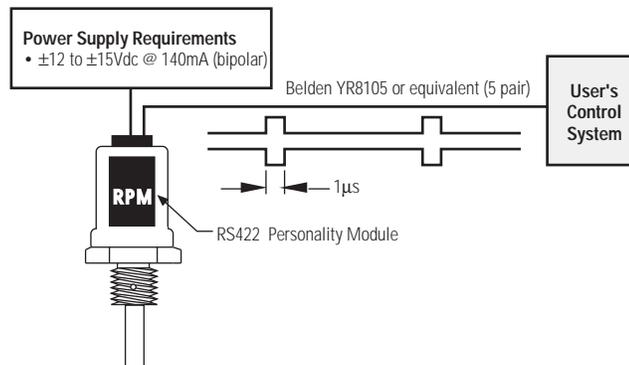
## 4. Digital System Configurations

The typical digital system configurations are shown in Figures 4-1, 4-2, and 4-3. Figure 4-1 is a “full” digital system. A full digital system includes a Temposonics II LDT with an integrated Digital Personality Module (DPM) and a Digital Counter Card and supplies either a Binary Coded Decimal (BCD) or Natural Binary output. When ordered as a scaled system, the components are matched and factory calibrated and will provide an exact, discrete resolution.

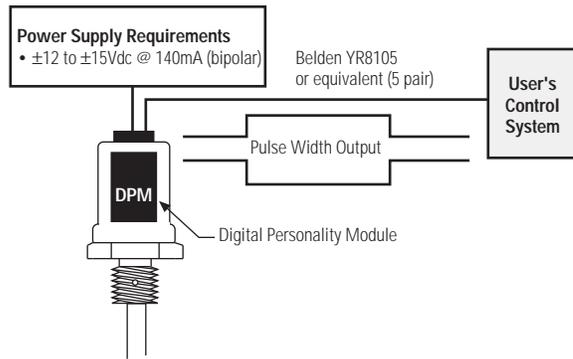
Figures 4-2 and 4-3 illustrate other system configurations which use the output from either the Digital Personality Module (DPM) or the RS422 Personality Module (RPM) as direct input into a control system. The DPM provides a pulse duration output and the RPM provides an RS422 interface.



**Figure 4-1**  
**Digital System Configuration with DPM, LDT and Digital Counter Card**



**Figure 4-2**  
**Temposonics II Digital System Configuration with RS422 Personality Module**



**Figure 4-3**  
**Half Digital System Configuration**  
**with an LDT and a DPM**

#### 4.1 Specifications/Digital System Components (Temposonics II with TCS Counter Card)

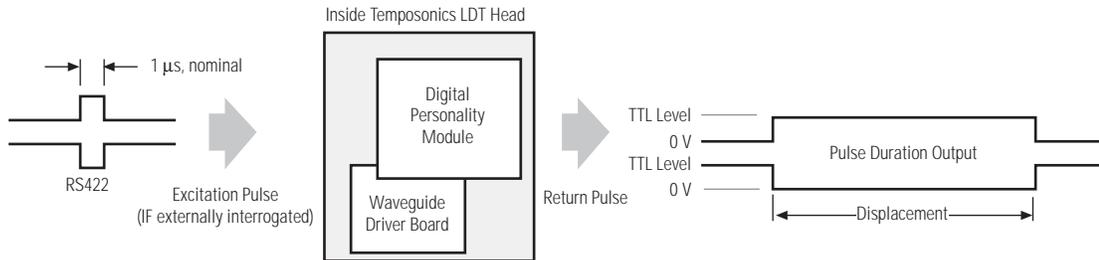
<i>Parameter</i>	<i>Specification</i>
<b>Digital Counter Card</b>	
<i>Power Requirements</i>	
Voltage:	+5 Vdc
Current:	800 mA
<i>Output</i>	
	TTL Compatible, nominal 0 & 5 Vdc, parallel, true high. Source Current: 0.8 A Sink Current: 16 mA (up to 18 bits natural binary, 4 1/4 digit BCD; up to 22 bits binary and 6 digit BCD can be achieved with a second counter card)
<i>Mounting Distance</i>	300 ft. maximum from Digital Personality Module (DPM)
<b>Digital Personality Module</b>	
<i>Recirculations</i>	Selectable from 1 to 127
<i>Interrogation</i>	Internal External (1 to 4μs pulse)
<i>Power Requirements</i>	
Voltage:	± 15 Vdc
Current:	50 mA
<i>Temperature Requirements</i>	
Storage:	- 40°F to 180°F (- 40°C to 83°C)
Operating:	- 40°F to 180°F (- 40°C to 83°C)
<b>RS422 Personality Module</b>	
<i>Interrogation</i>	External
<i>Power Requirements</i>	
Voltage:	± 15 Vdc
Current:	40 mA
<i>Temperature Requirements</i>	
Storage:	- 40°F to 180°F (- 40°C to 83°C)
Operating:	- 40°F to 180°F (- 40°C to 83°C)
<b>Temposonics II Power Supply</b>	
<i>Power Supply Requirements</i>	±15 Vdc at 175 mA maximum, 25 mA minimum [current draw varies with magnet position, maximum draw occurs when the magnet is 2 inches (50.8 mm) from the flange and the minimum update time is being utilized]

## 4.2 Digital Personality Module (DPM)

The Digital Personality Module (DPM) replaces the functions provided by the digital interface box. The DPM, which is roughly the size of a US postage stamp, is installed directly into the transducer head and provides electronics for pulse shaping, digital recirculations, auto interrogation, and cable interfacing.

**NOTE:**

*Call MTS Sensors Division when replacing a Digital Interface Box with an integrated Digital Personality Module (DPM)*



**Figure 4-4**  
**Excitation Pulse**

The waveguide driver board detects a logic level excitation pulse from the DPM. If the device is externally interrogated, an RS422 excitation pulse is fed from an external control system.

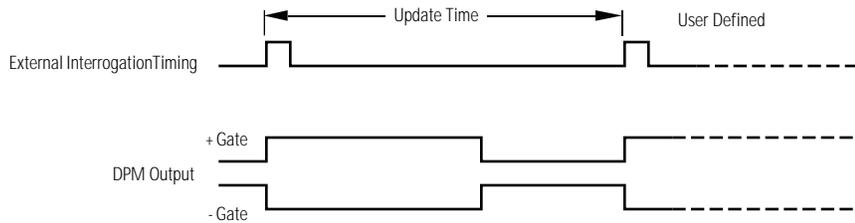
The Temposonics linear displacement measurement systems are available with either synchronous or asynchronous options. These options are available by the configuration of three miniature rotary switches (SW1, SW2 and SW3).

### 4.2.1 Synchronous (External Interrogating) Mode

In synchronous operation, an interrogation pulse is supplied to the linear displacement transducer from an external counter module. After supplying the pulse, the counter module waits until the recirculation electronics return a termination pulse, and then ends the cycle. The time between the interrogation and termination pulses is proportional to the distance between the transducer head assembly and the movable magnet.

In this synchronous mode, SW1 and SW2 are set to the hexadecimal value of the desired number of recirculations plus 80 (i.e. 81 to FF hex or 129 to 255). SW1 is the least significant digit and SW2 is the most significant digit. Permissible settings are 81 to FF corresponding to 1 to 127 recirculations.

SW3 is ignored in this mode.



**Figure 4-5**  
**Timing for Two Circulations**

#### 4.2.2 Asynchronous (Internal Interrogating) Mode

In asynchronous operation the transducer interrogates itself. The DPM uses a fixed interrogation frequency. Switches SW1 and SW2, located on the DPM board, are set to the hexadecimal value of the desired number of recirculations. Permissible settings are 01 to 7F corresponding to 1 to 127 recirculations.

The update rate in this mode is determined by the following formula:

$$U = (N + 1) * (SW3 + 1) * .2 \text{ ms}$$

Where:

U = Update rate in ms

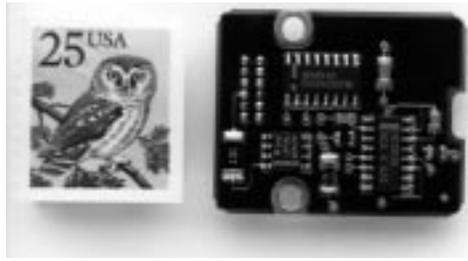
N = # of recirculations selected on SW1 and SW2 (1 to 127)

SW3 = Setting of SW3 (0 to 15)

Refer to the Addendum in the back of this manual for DPM programming procedures.

#### 4.2.3 Operation During Loss of Signal

It is the responsibility of the Digital Counter Card to detect a loss of signal in the system (such as when the magnet is removed from the rod). The DPM supports this mode by supporting a restart mode if the Digital Counter Card negates its interrogation cycle before the end of a data acquisition cycle.

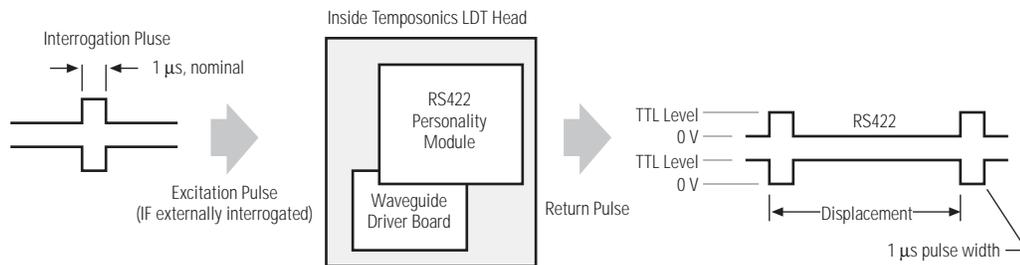


**Figure 4-6**  
**RS422 Personality Module (RPM)**

### 4.3 RS422 Personality Module (RPM)

The RS422 Personality Module (RPM) is an alternate integrated circuit module. The RPM is also the size of a US postage stamp and is installed directly into the transducer head to provide the circuitry required to produce an RS422 start/stop output. This signal is then transmitted to a digital counter card or various other devices. The RPM must be interrogated by an external source.

The surface mount components of the RPM reduce moment of inertia and enhance shock and vibration resistance of the module. The simplicity of design makes the module rugged and reliable.



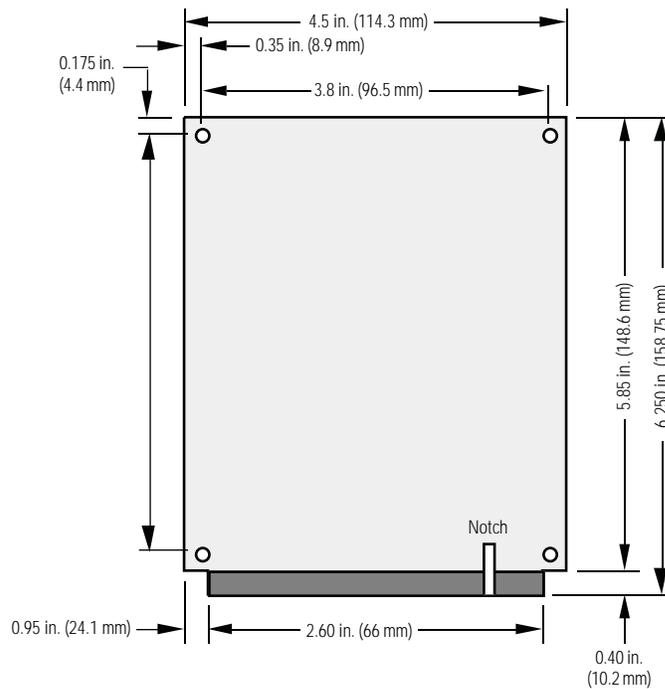
**Figure 4-7**  
**The RPM Start/Stop Signal**

#### 4.4 Digital Counter Card

The digital counter card measures the on-time of the DPM pulse duration signal. This is accomplished by using a crystal oscillator with frequency selected to provide the desired resolution (counts per inch). A 27-28 MHz crystal is typically used.

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.

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 4-8**  
**TCS Digital Counter Card**

#### **4.4.1 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 in 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, DPM, 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 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 DPMs with the same number of recirculations does not affect the output reading.

An unscaled system is provided upon request. An unscaled system may require calibration 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 0.00002 inches per count (approximately). Similarly, an unscaled BCD output may have a scale factor of 1.002 inches per inch of reading. This does not effect resolution but will vary the counts at any particular point on the stroke. Interchanging system components which do not have the same serial number will also result in an unscaled output.

#### **4.4.2 Spare Parts and Inventory Considerations**

The zero can be set on the counter card using DIP switches. An externally interrogated DPM or a counter card can be used as a common spare. However, a system calibration should be performed after any system component change.

## 5. Digital System Adjustments

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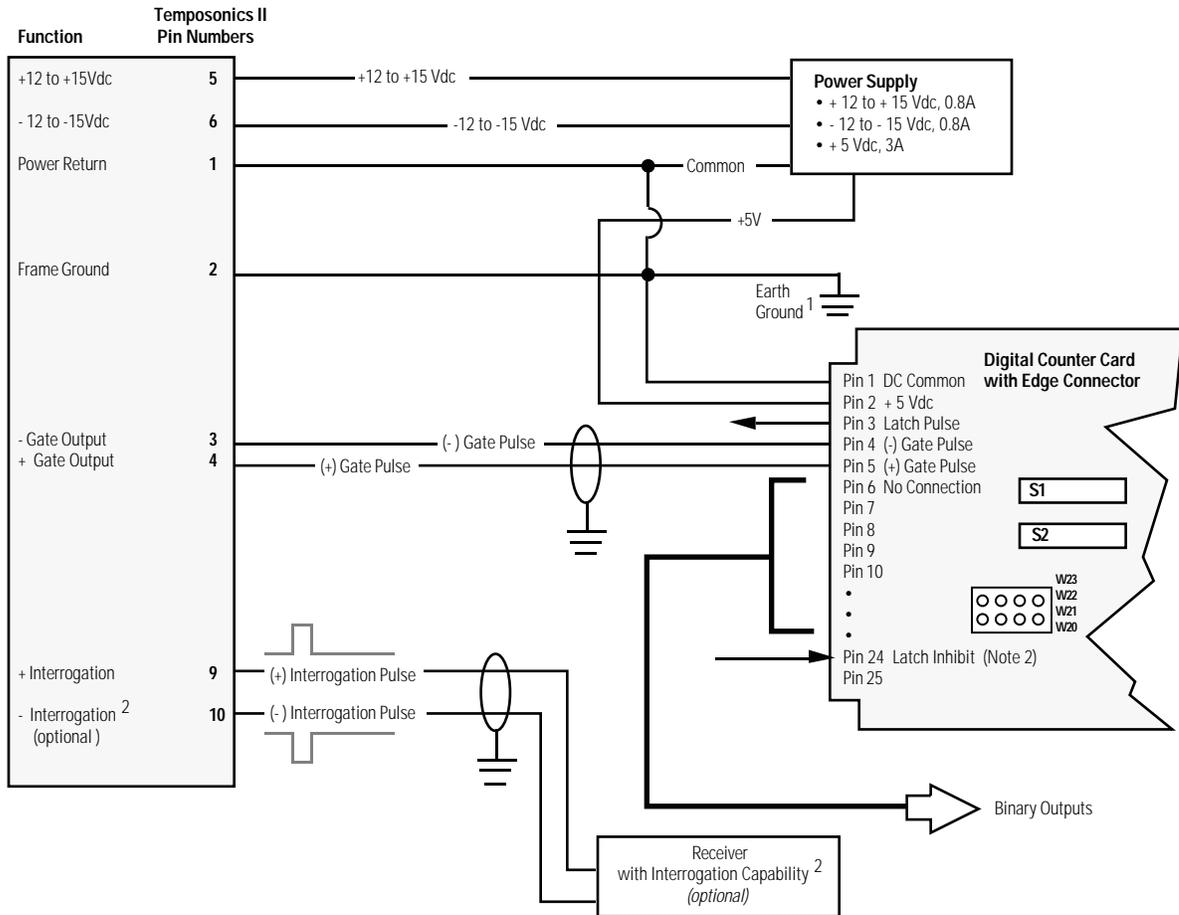
The Temposonics measurement systems do not require service or re-calibration under normal use. The systems' sensing elements are non-contacting and the components are solid state. Performance will not degrade, or drift over time.

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

## 6. Electronic Connections

### 6.1 General

Figure 6-1 (below) illustrates the interconnections of a typical digital system comprised of a Temposonics II transducer, an integrated Digital Personality Module (DPM) and a Digital Counter Card.



**Figure 6-1**  
**Typical Digital System Connections**

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

**NOTE:**  
*The following recommendations are supplied for "full digital" systems, which include a Temposonics Digital Counter Card. For systems which use a digital counting device in the receiver computer, the counter card is not supplied. Use the following procedures in conjunction with the receiver device manufacturer's recommendations.*

**6.2 Transducer Connections**

The cable from the transducer has 10 conductors (5 pair Belden YR8105 or equivalent). Standard available lengths are 5, 15, and 25 feet. (Consult MTS Sensors Division for custom lengths.) It is recommended to keep the transducer cable as short as possible to avoid possible noise or temperature effects on accuracy.

Table 6A (below) identifies the cable leads from the Temposonics II transducer. Note the three version indicated in the table: Neuter Temposonics II, Temposonics II with an integrated Digital Personality Module (DPM), and a Temposonics II with an integrated RS422 Personality Module (RPM).

**Table 6A Temposonics II Transducer Connections**

Pin No.	Temposonics II Integrated or Extension Cable <i>(see Note 1,2)</i>		Temposonics II Configurations:		
	<i>(Striped Leads)</i>	<i>(Solid Leads)</i>	Neuter	DPM Option	RPM Option
1	White/Blue Stripe	White	DC Ground	DC Ground	DC Ground
2	Blue/White Stripe	Brown	Frame	Frame	Frame
3	White/Orange Stripe	Gray	-	(-) Gate	(-) Start/Stop Pulse
4	Orange/White Stripe	Pink	-	(+) Gate	(+) Start/Stop Pulse
5	White/Green Stripe	Red	VCC	VCC	VCC
6	Green/White Stripe	Blue	VEE	VEE	VEE
7	White/Brown Stripe	Black	Not Used	Not Used	Not Used
8	Brown/White Stripe	Violet	Not Used	Not Used	Not Used
9	White/Gray Stripe	Yellow	(+) Interrogation (Note 3)	(+) Interrogation (Notes 4, 5)	(+) Interrogation (Note 5)
10	Gray/White Stripe	Green	(-) Interrogation (Note 3)	(-) Interrogation (Notes 4, 5)	(-) Interrogation (Note 5)

- Notes:**
1. Verify if the cable has striped or solid color leads and make connections accordingly.
  2. Cable : Belden YR8105 or equivalent
  3. **IMPORTANT:** Connect the unused interrogation lead to ground.
  4. Connect both positive and negative interrogation leads to ground when using a DPM programmed for internal interrogation.
  5. When using external interrogation, connect both the positive and negative interrogation leads to provide differential interrogation.

Use Table 6B (below) when:

1. Replacing an original Temposonics transducer (connected to a Digital Interface Box) with a Temposonics II transducer.
2. Replacing an original Temposonics transducer and a Digital Interface Box with a Temposonics II transducer and integrated Digital Personality Module (DPM)

**Table 6B Temposonics II Retrofit Wiring Connections**

(For direct replacement of Original Temposonics transducer using an existing DIB)

Temposonics II Cable Color Code (see Note 1,2)				DIB Connections	
Pin No.	Wire Color (Striped Leads)	Wire Color (Solid Leads)	Functional Description	J2 Pin Connections	Retrofit connections to R3 connector (P/N 370160, See Note 7)
1	White/Blue Stripe	White	DC Ground	J2 Pin B	A
2	Blue/White Stripe	Brown	Frame (Note 3)	J2 Pin B	J
3	White/Orange Stripe	Gray	Not Used	Not Used	K
4	Orange/White Stripe	Pink	Not Used	Not Used	G
5	White/Green Stripe	Red	VCC	J2 Pin F (Pin A if stroke length exceeds 200 in.)	H
6	Green/White Stripe	Blue	VEE	J2 Pin D	B
7	White/Brown Stripe	Black	Amp Return (Gnd.)	J2 Pin B	Not Used
8	Brown/White Stripe	Violet	Amp Output (Return pulse)	J2 Pin C	Not Used
9	White/Gray Stripe	Yellow	+ Interrogation (Note 4, 6)	J2 Pin E	E
10	Gray/White Stripe	Green	- Interrogation (Note 5, 6)	J2 Pin B	D

**Notes:**

1. Verify if the cable has striped or solid color leads and make connections accordingly.
2. Cable : Belden YR8105 or equivalent
3. Frame ground is isolated from circuit ground inside the transducer head.
4. For retrofitting DIBs with strokes greater than 12 inches (+ interrogation)
5. For retrofitting DIBs with strike lengths less than 12 inches (- interrogation)
6. **IMPORTANT:** Connect the unused interrogation lead to ground.
7. Connections to existing mating connector when replacing a Digital Interface Box with a Temposonics II LDT with a DPM
8. Shield: Connect Extension cable shield at J2 Pin B

Table 6C (below) identifies the cable leads of an original Temposonics transducer.

**Table 6C Original Temposonics I Transducer Cable**

Signal/Function	Wire Color Code
+ 15 Vdc	Green or Gray
DC Ground	Black
Return Pulse from LDT	Orange or Brown
- 15 Vdc	Blue
Interrogation Pulse	White
+ 12 Vdc	Red

Table 6D (below) identifies the terminations to make with the positive and negative interrogation lines (Pin 9 and 10) depending on the Temposonics II configuration being used in your application. It is important to note that when using a “neuter” version Temposonics II, DO NOT connect both the positive and negative interrogation leads at the same time — the unused lead must be tied to ground.

**Table 6D Temposonics II Interrogation Configurations**

<i>Transducer Pin No.</i>	<i>Functional Description</i>	<i>Personality Module Interrogation Mode</i>
9	(+) Interrogation	Neuter Temposonics II, Temposonics II w/RPM
10	(-) Interrogation	or Temposonics II w/DPM (external interrogation, See Note)
9	(+) Interrogation	Neuter Temposonics II (positive interrogation), Temposonics II w/RPM
10	DC Common	or Temposonics II w/DPM (external positive interrogation)
9	DC Common	Neuter Temposonics II (negative interrogation), Temposonics II w/RPM
10	(-) Interrogation	or Temposonics II w/DPM (external negative interrogation)
9	DC Common	Temposonics II w/DPM (internal interrogation)
10	DC Common	Temposonics II w/APM (all modes)

**Note:**

1. It is recommended that both the positive and negative interrogation leads be connected when using a Temposonics II with a DPM (external interrogation ONLY). This will provide a differential interrogation signal which is preferred over a single ended interrogation.

### 6.3 Digital Counter Card Connections

See Appendix A of this manual for an in-depth explanation on how to specify systems with digital output.

Tables 6E, 6F, and 6G show the counter card output connection tables. In order to select the proper table, the following order variables must be known.

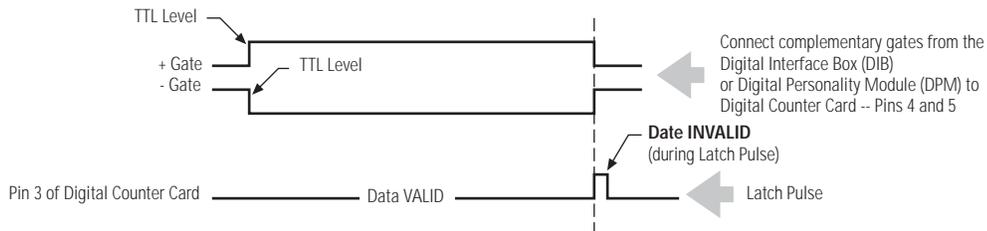
Stroke:	_____	inches (mm)
Resolution:	_____	inches (mm)
Recirculation:	_____	(1 - 127)
Output Format:	_____	BCD or Natural Binary
Output:	_____	Latch Pulse (standard: 1µs, optional: 12 µs)
Input:	_____	Latch Inhibit (Standard)

**NOTE:**

*The latch pulse is offered on Pin 3 and the latch inhibit is offered on Pin 24, but can be switched via jumpers on the board.*

**6.3.1 Latch Pulse**

The latch pulse is a nominal 1 $\mu$ s wide pulse that is used as a “data valid” signal. Data is invalid when the signal is high. Data is valid and can be read when the signal is low. The standard latch pulse can be “gated” with a read type pulse generated at the receiver device. The user performs the gating logic external of the counter card. The latch pulse is available on pin 3 of the digital counter card. (An optional 12 $\mu$ s wide latch pulse is available if the 1 $\mu$ s pulse is too fast.)



**Figure 6-2**  
**Latch Pulse**

**6.3.2 Protocol**

The recommended protocol for assuring that valid count data is received from the counter card is as follows:

- Poll the data-valid output for a logic 1, indicating that data is currently invalid, but will soon be valid.
- Poll the same output for a logic 0, indicating that new, valid count data is present at the outputs of the counter card.
- Bring the latch-inhibit input of the counter card low. This prevents the outputs of the counter card from changing.
- When ready, accept the data into the user control system processing
- After sampling, bring the latch-inhibit input high.

If this protocol is followed, data presented to the user control system from the input module will be valid count data, and the effects of electrical noise and signal transitions will be minimized.

**6.3.3 Latch Inhibit Input**

The latch inhibit input is available on the digital counter card to “freeze” the binary output signal. The users’ receiver provides an inhibit signal to pin 24 on the counter card. The signal must be a low TTL level to inhibit downloading of the updated displacement information into the output registers; the receiver is then provided unchanging data.

## 6.4 Counter Cards - Natural Binary Output

Table 6E is based upon a counter card with  $\pm 1$  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 versus stroke are as follows:

<i>Resolution</i>	<i>Circulations</i>	<i>Stroke Length</i>
0.000125	32	Up to 32 inches
0.00025	16	Up to 65 inches
0.0005	8	Up to 131 inches
0.001	4	Up to 262 inches
0.002	2	Up to 300 inches
0.004	1	Up to 300 inches

**Table 6E Counter Card Output ( $\pm 1$ )**

Pin No.	Bit Weight	Decimal Value	Bit	Maximum Counts vs. Number of Bits
10	LSB <sup>1</sup>		$2^0$	1 = 1 bit
9			$2^1$	3 = 2 bits
8			$2^2$	7 = 3 bits
7			$2^3$	15 = 4 bits
14			$2^4$	31 = 5 bits
13			$2^5$	63 = 6 bits
12			$2^6$	127 = 7 bits
11			$2^7$	255 = 8 bits
18			$2^8$	511 = 9 bits
17			$2^9$	1023 = 10 bits
16			$2^{10}$	2047 = 11 bits
15			$2^{11}$	4095 = 12 bits
20			$2^{12}$	8191 = 13 bits
21			$2^{13}$	16,383 = 14 bits
22			$2^{14}$	32,767 = 15 bits
19			$2^{15}$	65,535 = 16 bits
23			$2^{16}$	131,071 = 17 bits
25	MSB <sup>2</sup>		$2^{17}$	262,143 = 18 bits

### NOTES:

1. LSB = Least Significant Bit

2. MSB = Most Significant Bit. MSB is determined by dividing the stroke length by the resolution and comparing to the maximum count.

**For Example:** 25 in./0.001 = 25,000; this requires a maximum count of 32,767, thus yielding an MSB at Pin 22.

**NOTE:**

*When using more than 18 bits Natural Binary or 17 bits BCD, a second counter card is required.*

Table 6F is based upon a counter card with  $\pm 2$  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 versus stroke are as follows:

<i>Resolution</i>	<i>Circulations</i>	<i>Stroke Length</i>
0.000125	64	Up to 16 inches
0.00025	32	Up to 32 inches
0.0005	16	Up to 65 inches
0.001	8	Up to 131 inches
0.002	4	Up to 262 inches
0.004	2	Up to 300 inches
0.008	1	Up to 300 inches

**Table 6F Counter Card Output ( $\pm 2$ )**

<b>Pin No.</b>	<b>Bit Weight</b>	<b>Decimal Value</b>	<b>Bit</b>	<b>Maximum Counts vs. Number of Bits</b>
9	LSB <sup>1</sup>		$2^0$	1 = 1 bit
8			$2^1$	3 = 2 bits
7			$2^2$	7 = 3 bits
14			$2^3$	15 = 4 bits
13			$2^4$	31 = 5 bits
12			$2^5$	63 = 6 bits
11			$2^6$	127 = 7 bits
18			$2^7$	255 = 8 bits
17			$2^8$	511 = 9 bits
16			$2^9$	1023 = 10 bits
15			$2^{10}$	2047 = 11 bits
20			$2^{11}$	4095 = 12 bits
21			$2^{12}$	8191 = 13 bits
22			$2^{13}$	16,383 = 14 bits
19			$2^{14}$	32,767 = 15 bits
23			$2^{15}$	65,535 = 16 bits
15	MSB <sup>2</sup>		$2^{16}$	131,071 = 17 bits

**NOTES:**

1. LSB = Least Significant Bit

2. MSB = Most Significant Bit. MSB is determined by dividing the stroke length by the resolution and comparing to the maximum count.

**For Example:** 25 in./0.001 = 25,000; this requires a maximum count of 32,767, thus yielding an MSB at Pin 19.

Table 6G is based upon a counter card with [ $\div 4$ ] 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 versus stroke are as follows:

<i>Resolution</i>	<i>Circulations</i>	<i>Stroke Length</i>
0.000125	125	Up to 8 inches
0.00025	64	Up to 16 inches
0.0005	32	Up to 32 inches
0.001	16	Up to 65 inches
0.002	8	Up to 131 inches
0.004	4	Up to 262 inches
0.008	2	Up to 300 inches
0.016	1	Up to 300 inches

**Table 6G Counter Card Output ( $\div 4$ )**

Pin No.	Bit Weight	Decimal Value	Bit	Maximum Counts vs. Number of Bits
8	LSB <sup>1</sup>		$2^0$	1 = 1 bit
7			$2^1$	3 = 2 bits
14			$2^2$	7 = 3 bits
13			$2^3$	15 = 4 bits
12			$2^4$	31 = 5 bits
11			$2^5$	63 = 6 bits
18			$2^6$	127 = 7 bits
17			$2^7$	255 = 8 bits
16			$2^8$	511 = 9 bits
15			$2^9$	1023 = 10 bits
20			$2^{10}$	2047 = 11 bits
21			$2^{11}$	4095 = 12 bits
22			$2^{12}$	8191 = 13 bits
19			$2^{13}$	16,383 = 14 bits
23			$2^{14}$	32,767 = 15 bits
15	MSB <sup>2</sup>		$2^{15}$	65,535 = 16 bits

1. LSB = Least Significant Bit

2. MSB = Most Significant Bit. MSB is determined by dividing the stroke length by the resolution and comparing to the maximum count.

**For Example:** 25 in./0.001 = 25,000; this requires a maximum count of 32,767, thus yielding an MSB at Pin 15.

## 6.5 Counter Card - BCD Output

The Digital Counter Card can be provided with Binary Coded Decimal (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:

<i>Decimal No.</i>	<i>Binary No.</i>	<i>Decimal No.</i>	<i>Binary No.</i>
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:

<i>Decimal No.</i>	8	7	4	=	8.74
<i>Binary No.</i>	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 following 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 6H (below) lists the maximum stroke length versus number of significant bits for a resolution of 0.001 inch.

**Table 6H BCD Representations of Stroke**

<i>X</i> <i>(maximum stroke reading)</i>	<i>BCD Value of 'X'</i>	<i>Required Number of Bits</i>
7.999 (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*

\* A second Digital Counter Card is required for all values requiring 18 bits or more.

Table 6I (below) can be used to determine connections for Digital Counter Cards with BCD output.

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 on the following page.

**Table 6I BCD Output Connections**

1 Max. Reading	2 No. of Active Bits	3 Active Digits	4 Pin Connectors		5 Binary Weight	6 Digit	7 Check Appropriate Column Resolution		
			<i>Card A</i>	<i>Card B</i>			<i>other</i>		
			8		1	1			
			7		2	(LSD) <sup>1</sup>			
			14		4		0.000	0.001	0.01
		1	13		8		1		
			12		1	2			
			11		2				
			18		4		0.001	0.01	0.1
		2	17		8				
			16		1	3			
			15		2				
			20		4		0.01	0.1	1
999	12	3	21		8				
1999	13	3 1/4	22		1	4			
3999	14	3 1/2	19		2				
7999	15	3 3/4	23		4		0.1	1	10
9999	16	4	25		8				
19999	17	4 1/4	9 <sup>3</sup>	8	1	5			
39999	18	4 1/2		7	2				
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		11	2	(MSD) <sup>2</sup>			
799999	23	5 3/4		18	4		10	100	1000
999999	24	6		17	8				

**NOTES:**

1. LSD = Least Significant Digit
2. MSD = Most Significant Digit
3. Used ONLY with 4 1/4 digits. For 4 1/2 digits or more, a second Digital Counter Card is required (5th digit is on second card).

**Example:** Stroke = 200 in., Resolution = 0.001 in.

- Results:**
- Maximum Reading: 199.99 or 200 inches (See column 1)
  - Digits: 5 1/4 (1 is considered 1/4 digit)
  - Digital Counter Card Connections: Per column 4 (Pin Connections)
  - Least Significant Digit (LSD) Connections: Pins 8, 7, 14, 13 (Card A)
  - Most Significant Digit (MSD) Connections: Pin 12 (Card B)  
The next MSD connections are Pins 8, 7, 14, 13 on Card B, Pin 9 on Card A is NOT USED (see Note 3, below).

**Resolution:**

- 1/4 Digit, Pin 12 (Card B): 100
- 5th Digit: 10
- 4th Digit: 1
- 3rd Digit: 0.1
- 2nd Digit: 0.001
- 1st Digit: 0.001

**Example Table: BCD Output Connection Table**

1 Max. Reading	2 No. of Active Bits	3 Active Digits	4 Pin Connectors		5 Binary Weight	6 Digit	7 Check Appropriate Column Resolution		
			Card A	Card B			<i>other</i>		
			8		1	1			
			7		2	(LSD) <sup>1</sup>			
			14		4		0.000	<b>0.001</b>	0.01
		1	13		8				
			12		1	2			
			11		2				
			18		4		0.001	<b>0.01</b>	0.1
		2	17		8				
			16		1	3			
			15		2				
			20		4		0.01	<b>0.1</b>	1
999	12	3	21		8				
1999	13	3 1/4	22		1	4			
3999	14	3 1/2	19		2				
7999	15	3 3/4	23		4		0.1	<b>1</b>	10
9999	16	4	25		8				
19999	17	4 1/4	9 <sup>3</sup>	8	1	5			
39999	18	4 1/2		7	2				
79999	19	4 3/4		14	4		1	<b>10</b>	100
99999	20	5		13	8				
<b>199999</b>	21	<b>5 1/4</b>		<b>12</b>	1	6			
399999	22	5 1/2		11	2	(MSD) <sup>2</sup>			
799999	23	5 3/4		18	4		10	<b>100</b>	1000
999999	24	6		17	8				

**NOTES:**

1. LSD = Least Significant Digit
2. MSD = Most Significant Digit
3. Used ONLY with 4 1/4 digits. For 4 1/2 digits or more, a second Digital Counter Card is required (5th digit is on second card).

## 6.6 System Calibration

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There are no adjustments on the Digital Personality Module or on 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 re-settable DIP switches on the counter card. Generally, the system components do not show shift, age, or drift over time, and re-calibration is not necessary. However, calibration may be used to compensate for mechanical wear on external mechanical parts connected to the magnet or the transducer.

### 6.6.1 Re-zeroing the Digital Counter Card

On the 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 2.5 inches from the tip of the transducer rod.

There are three ways of changing the zero setting:

#### 1. 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.

Fabricate 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).

#### 2. Software Programming

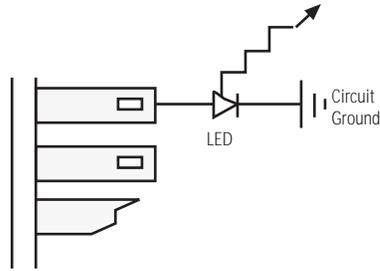
In some applications it is possible (and preferable) to maintain a zero offset in software at the receiver. This permits quick re-zeroing without adjusting the magnet or resetting the DIP switches.

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.

### 3. 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 7-1 for a typical connection). Figures 6-5 and 6-6 show DIP switches S1 and S2, along with tables for determining the switch settings.



**Figure 6-3**  
**Testing Counter Card Output**

#### a. Binary Output

Take the following steps (Refer to Figure 6-4, next page):

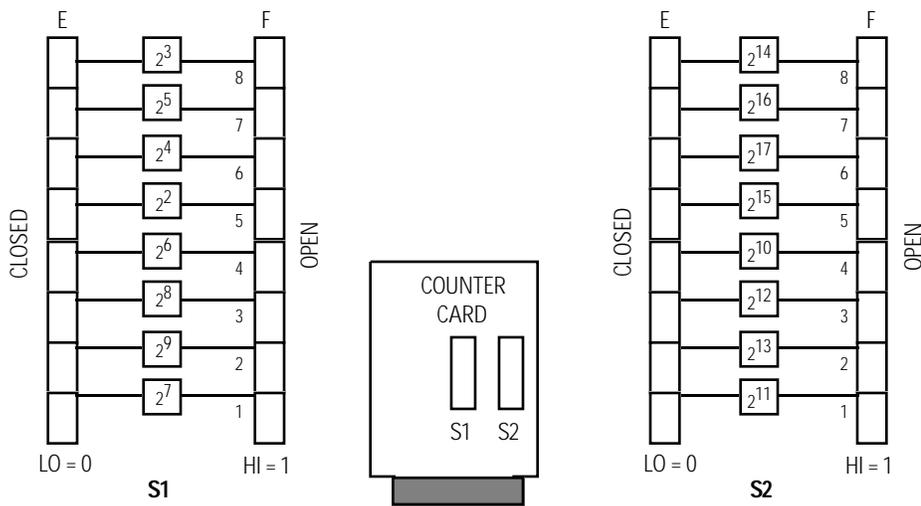
1. Before changing any DIP switch positions, record the factory-set positions for reference.
2. Move the magnet to the desired null position. Clamp it in place to prevent movement.
3. Reset all switch segments to the LO (closed) position, taking note of alignment marks on the board.
4. If a PLC or readout device indicates the equivalent counts, write this value in row A of the diagram in Figure 6-4. 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 in 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 F (open or HI). If the corresponding bit is 0, mark an X in column E (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.

# Edge Card Connector

Pin No.																		
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 <i>(If available)</i>																		
B. Reading in Binary <i>(From LEDs or Binary of 'A')</i>																		
C. Complement <i>(Complement of 'B')</i>																		



**Figure 6-4**  
**Setting DIP Switches (Binary System)**

## **b. BCD Output**

Take the following steps (Refer to Figure 6-5, next page):

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 6-5 (next page).

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.

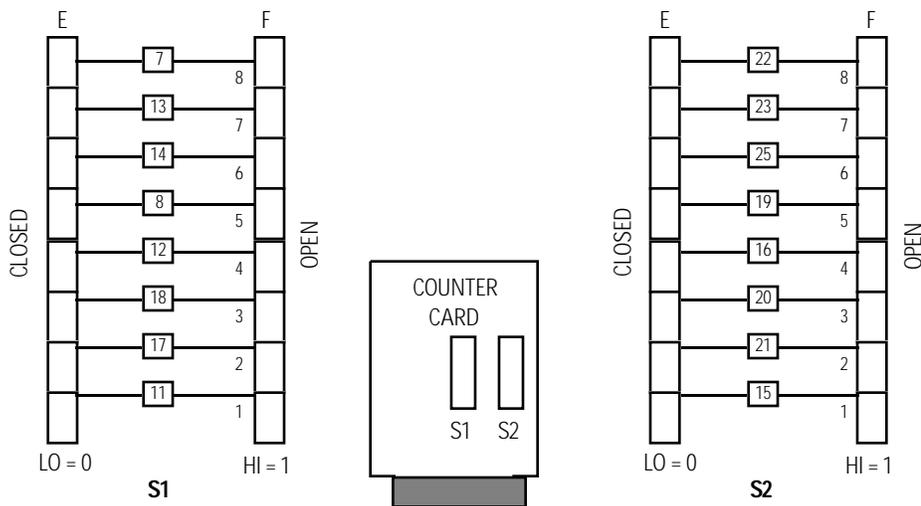
5. Subtract each digit in row B from 9, and record the result in row C.
6. Convert row C into BCD binary and record the result in row D.
7. Use the number from row C to mark the columns E and F. If the corresponding bit from C is 1, mark an X in column F (open or HI). If the corresponding bit is 0, mark an X in column E (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.

## Edge Card Connector

Digit	10 <sup>3</sup>				10 <sup>2</sup>				10 <sup>1</sup>				10 <sup>0</sup>				Not Used	
	2 <sup>3</sup>	2 <sup>2</sup>	2 <sup>1</sup>	2 <sup>0</sup>	2 <sup>3</sup>	2 <sup>2</sup>	2 <sup>1</sup>	2 <sup>0</sup>	2 <sup>3</sup>	2 <sup>2</sup>	2 <sup>1</sup>	2 <sup>0</sup>	2 <sup>3</sup>	2 <sup>2</sup>	2 <sup>1</sup>	2 <sup>0</sup>		
Pin No.	25	23	19	22	21	20	15	16	17	18	11	12	13	14	7	8	9	10
Bit																		
A. Reading in BCD <i>(from LEDs, if used)</i>																		
B. Reading in Decimal <i>(From BCD Indicator, if used)</i>																		
C. Complement <i>(Subtract B from 9)</i>																		
D. Converted to BCD <i>(Convert C to BCD)</i>																		

If a second Counter Card is provided (required for 5 or 6 digit BCD) use the following table in addition to the table above.

Digit	10 <sup>4</sup>			
Bit	2 <sup>3</sup>	2 <sup>2</sup>	2 <sup>1</sup>	2 <sup>0</sup>
Pin No.	13	14	7	8
A. Reading in BCD				
B. Reading in Decimal				
C. Complement				
D. Converted to BCD				



**Figure 6-5**  
**Setting DIP Switches (BCD System)**

### 6.6.2 Scaling 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 6.4.1, page 18 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,

$$\begin{array}{l} \text{Measurement} = 36.000 \text{ inches} \\ \text{Reading} = 35,420 \text{ counts (or 35.420 in BCD)} \\ \hline \text{Scale Factor} = 36 \div 35,420 = 0.0010163 \text{ inches per count} \\ \text{(35,420 counts per inch in BCD)} \end{array}$$

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  $\pm 0.05\%$  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 Appendix D for troubleshooting information.

## APPENDIX A How to Specify Systems with Digital Outputs

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### A.1 General

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To order a transducer with digital output, you must first determine the stroke length, the resolution, and the maximum acceptable update time for your application, and then select the appropriate options. Four sizing procedures are provided:

- I. Natural Binary Output, using the standard 27-28 MHz clock.
- II. Natural Binary Output, using non-standard clocks.
- III. BCD Output, using the standard 27-28 MHz clock.
- IV. BCD Output, using non-standard clocks.

Note that procedures I and III, based upon a 27-28 MHz counter card clock crystal, offer a scaled output with the standard shipping schedule. If the combinations of options available do not match the resolution or update needs of your application, MTS Sensors Division can (by special order) modify the clock crystal rate to improve resolution or shorten update time. Refer to procedures II and IV to select a non-standard counter card clock crystal.

### A.2 Natural Binary Output Selection

---

#### PROCEDURE I

##### System Sizing for Natural Binary Output (Scaled Output, 27-28 MHz Clock Crystal)

This procedure is for 95% of all applications, and provides a scaled output with best possible manufacturing lead time. (For applications requiring a shorter update time or a non-standard resolution, use procedure II.) From the stroke length, resolution, and maximum acceptable update time, we can determine the number of TTL level parallel bits supplied by the Digital Counter Card(s), the number of circulations required in the Digital Personality Module (or Digital Interface Box), and the actual update time using a standard 27 MHz clock crystal.

Take the following steps:

1. Divide the stroke length by the resolution. This number gives the minimum number of counts required. Use Table 1A to determine how many bits are required to accommodate this number.
2. Use Table 2A to determine how many circulations are required for the specified resolution.

**NOTE:**

*The following additional steps are recommended, to increase output stability:*

- a. Divide the required resolution by 2*
- b. Select the number of bits from Table 1A, using the new resolution.*
- c. Discard or do not connect to the least significant bit.*
- d. Do not exceed 18 bits (to avoid using an additional counter card.)*

3. Use the graph in Figure A-1 to determine the update time, based upon the stroke and circulations.

4. If the update time is unacceptable, adjust the resolution and circulations to lower the update time.

**You can make a note of the parameters as you go along:**

Number of bits required: \_\_\_\_\_  
 Resolution (R): \_\_\_\_\_  
 Circulations (N): \_\_\_\_\_  
 Update Time: \_\_\_\_\_ less than \_\_\_\_\_ ms.

**Table 1A Calculations for Required Binary Bits**

Binary Bits	Maximum Count	Maximum Stroke (in.), w/0.001 in. Resolution	Maximum Stroke (in.), w/0.0005 in. Resolution
14	16,383	16	8
15	32,767	32	16
16	65,535	65	32
17	131,071	131	65
18	262,143	262	131
19	524,287	524	262
20	1,048,575	-	-

**Table 2A Circulations vs. Resolutions**

Resolution	Circulations (N)
0.004	1
0.002	2
0.001	4
0.0005	8
0.00025	16
0.000125	32

**NOTE:**

Values in Table 2A are based on 27-28 MHz clock.

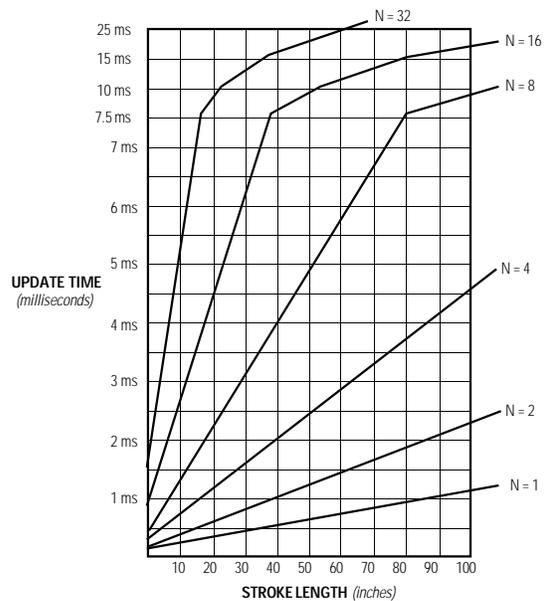
**Example 1**

**Given:**

- Stroke: 48 in.
  - Resolution: 0.001 in.
  - Maximum Update Time: 3 milliseconds
1.  $48 \div 0.001 = 48000$  counts. From Table 1A, this requires 16 bits.
  2. From Table A-2,  $N = 4$ .
  3. The graph (Figure A-1) indicates an update time of approximately 2.3 milliseconds (which is acceptable).
  4. Repeat Steps 1 to 3 for half the resolution (0.0005 in.), to provide increased stability for the 0.001 in. least significant bit. Notice that for 0.0005 in. resolution,  $N = 8$  and the update time exceeds the specified maximum of 3 ms. Therefore, specify  $N=4$  and 0.001 inch resolution.

**Specify:**

Number of bits required: 16  
 Resolution: 0.001 in.  
 (Re)circulations: 4  
 Update Time: less than 3 ms



**Figure A-1**  
**Update Times (external interrogation)**

## PROCEDURE II

### System Sizing for Natural Binary Output (Special Clock Frequency)

Procedure I above is for 95% of all applications, and provides a scaled output with best possible manufacturing lead time. For applications requiring a shorter update time or a non-standard resolution, use the following procedure to determine an approximate crystal frequency, number of circulations, and update time. Note that systems requiring a special clock frequency can add 2-4 weeks to manufacturing time and slight additional cost.

The crystal frequency versus circulations for a given resolution is approximated by the following formula:

#### FORMULA:

$$f_c = (0.11 \times D) \div [R \text{ (inches)} \times N] \text{ or}$$

$$f_c = (2.8 \times D) \div [R \text{ (mm)} \times N]$$

#### where

$f_c$  = Counter Card clock frequency in MHz

(maximum 56 MHz)

R = Resolution (inches or millimeters)

N = Number of circulations

D = Counter Card divider (1, 2, or 4 only)

Take the following steps:

1. Divide the stroke length by the resolution. This number gives the minimum number of counts required. Use Table 1A to determine how many bits are required to accommodate this number.

#### NOTE:

*The following additional steps are preferred, to increase output stability:*

- a. Divide the required resolution by 2
- b. Select the number of bits from Table 1A, using the new resolution.
- c. Discard or do not connect to the least significant bit.
- d. Do not exceed 18 bits (to avoid using an additional counter card.)

2. Use the above formula to determine the clock frequency,  $f_c$ , assuming  $N=1$  and  $D = 1$ .
3. If the calculated frequency is greater than 40 MHz, divide by  $N = 2, 4, 8, 16, 32$ , etc., until you find a value for  $N$  which determines an  $f_c$  between 11 and 40 MHz.
4. Taking the  $N$  value from Step 3 and the given stroke, use the graph in Figure A-1 to determine the update time.
5. If the update time is unacceptable, select a lower  $N$  value which yields a clock frequency  $f_c$  of 56 MHz or less. Then recheck the update time.

**You can make a note of the parameters as you go along:**

Number of bits required: \_\_\_\_\_

Resolution (R): \_\_\_\_\_

Circulations (N): \_\_\_\_\_

Update Time: \_\_\_\_\_ less than \_\_\_\_\_ ms.

## Example 2

### Given

- Stroke: 48 in.
- Resolution: 0.0001 in.
- Maximum Update Time: 30 milliseconds

### Specify

Number of bits required: 18  
 Resolution (R): 0.0001 in.  
 (Re)circulations: 32  
 Update Time: less than 25 ms.  
 $f_c$ : 34 MHz

1.  $48 \div 0.0001 = 480,000$  counts. From Table A-1, this requires 19 bits.
2.  $f_c = 0.11/0.0001 = 1100$  MHz
3. Try  $N = 2$ , and divide  $f_c$  by  $N$ :  $1100/2 = 550$ . This is greater than 56 MHz
4. Try  $N = 4$ , and divide:  $1100/4 = 275$ . This is also greater than 56 MHz.
5. Try  $N = 8, 16$ , and 32. For  $N = 32$ , the clock crystal value is 34.4 MHz.
6. The graph in Figure A-1 indicates an update time of less than 25 milliseconds (which is acceptable).
7. Repeat Steps 1-6, using half the resolution, and note that the update time is unacceptable.

Note that this application can also be satisfied in some cases with 0.000125 inch resolution and a standard 27-28 MHz clock crystal.

## A.3 BCD Output Selection

### Notes on BCD Output

When specified, digital systems can provide BCD (Binary Coded Decimal) output. BCD code is a binary method of representing decimal numbers. In BCD notation, each decimal digit is converted into a four-bit binary number. The BCD code for a decimal number is a string of four-bit binary numbers, each representing one decimal digit. Only the following binary groups are used:

Decimal	Binary	Decimal	Binary
0	000	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:

<b>Decimal</b>	8	.	7	4	=	8.74
<b>BCD</b>	1000	.	0111	0110	=	1000.01110100

In many cases, the BCD code for a stroke length lies within a range of BCD numbers where some bits never change value. For example, 19.999 inches can be 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 always be zero. This means that the remaining 17 bits are sufficient to encode a stroke of 19.999 inches; that is, one counter card is sufficient. Table 3A lists the maximum stroke length versus number of significant bits (for a resolution of 0.001 inch). By moving the decimal point, the number of bits required for all other resolutions can be determined.

**Table 3A**  
**Maximum Stroke Length vs. Number of Significant Bits**

<b>X</b> <i>(maximum stroke reading)</i>	<b>BCD Value of 'X'</b>	<b>Required Number of Bits</b>
7.999 (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 *

\* A second Digital Counter Card is required for all values requiring 18 bits or more.

**PROCEDURE III**  
**System Sizing/BCD Output - "Standard" Resolutions (Using a 27-28 MHz Clock Crystal)**

A 27-28 MHz clock crystal can be used to generate 0.001 in. and 0.1 mm resolutions, satisfying the following resolution requirements: 0.1 in., 0.01 in., 0.001 in., 1 mm, and 0.1 mm. For other resolutions, use procedure IV.

Take the following steps to determine the number of bits, circulations, update time, and counter card divider:

1. Select the circulation number N from Table 4A, using the calculated values. Begin by using the values in the first column (for counter card divider D = 2).

**Table 4A**  
**Recirculation Values for Selected Resolution**

<b>Resolution (R)</b>	<b>Recirculations (N)</b>		<b>Remarks</b>
	<i>D = 2</i>	<i>D = 1</i>	
0.1 in.	N/A	N/A	Use 0.001 in. resolution and discard the two least significant digits.
0.01 in.	N/A	N/A	Use 0.001 in. resolution and discard the least significant digit.
0.001 in.	8	4	
1 mm	N/A	N/A	Use 0.1 mm resolution and discard the least significant digit.
0.1 mm	2	1	

2. Using the N value selected, look up the update time in the graph, Figure A-1. If this update time is acceptable, record the values for N, R, D, and update time, and go on to Step 3. If this update time is not acceptable, try Step 1 again, using the values for D = 1. The divider D = 2 is preferred, to prevent instability of the least significant digit (LSD). If one or more digits are discarded, however, D = 2 offers only marginal improvement over D = 1.
3. Use Table 3A to determine the number of BCD bits required to generate the given resolution.

**NOTE:**

*If the number of bits required is 18 or more (requiring two counter cards), and the desired resolution is 0.1 inch, 0.01 inch, or 1 mm, then consider the alternate procedure in Section IV.*

*You can make a note of the parameters as you go along:*

Number of bits required: \_\_\_\_\_  
Resolution (R): \_\_\_\_\_  
Circulations (N): \_\_\_\_\_  
Update Time: \_\_\_\_\_ less than \_\_\_\_\_ ms.

#### **PROCEDURE IV**

#### **System Sizing for BCD Output - Other Resolutions/Non-Standard Clock Crystal**

For 0.1 in., 0.0001 in., 0.01 mm, and 0.001 mm, a non-standard counter card clock crystal must be estimated using the following procedure.

**NOTE:**

*Procedure IV should be used only when absolutely necessary. Ordering a non-standard clock crystal will add approximately four weeks to normal manufacturing lead times. An additional nominal charge also applies. Procedure III above should be used whenever possible.*

The crystal frequency for a given resolution versus circulations is approximated by the following formula.

**FORMULA:**

$$f_c = (0.11 \times D) \div [R (\text{inches}) \times N]$$

*or*

$$f_c = (2.8 \times D) \div [R (\text{mm}) \times N]$$

**where**

$f_c$  = Counter Card clock frequency in MHz  
R = Resolution (inches or millimeters)  
N = Number of circulations  
D = Counter Card divider (1, 2, or 4 only)

Take the following steps:

1. Select an N (circulation) value using Table 5A for the resolutions shown. These pre-calculated values are normally sufficient. As an alternative, N values can be calculated using the formulas above. Begin by using the values from the first column (for counter card divider D = 4). If none are available under D = 4, then use values from the next column (D = 2).
2. Using the N selected, look up the update time in the graph, Figure A-1. If this update time is acceptable, record the values for N, R, D, and update time, and go on to Step 3. If this update time is not acceptable, use the formula above to calculate values for N and try Step 1 again, using the values for D = 2, then, if necessary, D = 1. The higher divider numbers are preferred, to prevent instability of the least significant digit (LSD). If one or more digits are discarded, however, D = 2 offers only marginal improvement over D = 1.
3. Use Table 3A to determine the number of BCD bits required to generate the given resolution.

**Table 5A**  
**Recirculation Values for Resolutions**

Resolution (R)	Recirculations (N)		Remarks
	<i>D = 2</i>	<i>D = 1</i>	
0.1 in.	N/A	N/A	Use 0.001 in. resolution and discard the two least significant digits.
0.01 in.	N/A	N/A	Use 0.001 in. resolution and discard the least significant digit.
0.001 in.	8	4	
1 mm	N/A	N/A	Use 0.1 mm resolution and discard the least significant digit.
0.1 mm	2	1	

***You can make a note of the parameters as you go along:***

Number of bits required: \_\_\_\_\_

Resolution (R): \_\_\_\_\_

Circulations (N): \_\_\_\_\_

Update Time: \_\_\_\_\_ less than \_\_\_\_\_ ms.

**NOTE:**

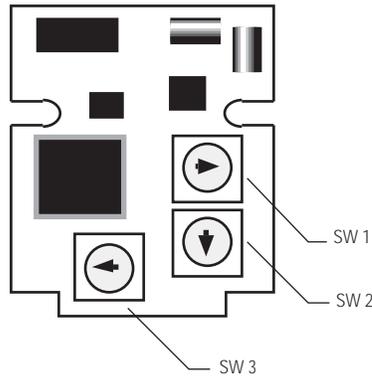
*DPM programming switches are pre-set at the factory. Only authorized OEMs are permitted to program this device. Call MTS before making any adjustments to the switches.*

*REMOVING THE TRANSDUCER COVER VOIDS THE WARRANTY.*

**WARNING!**

*The DPM is a static sensitive device and should be treated as such. MTS recommends that a static wrist strop be worn during installation and programming. Also, these procedures are to be conducted in a clean (dust and moisture-free) environment.*

*A small flat head screwdriver should be used to program the switches. See Figure B-1 for switch locations.*



**Figure B-1**  
**DPM Switch Locations**

**B.1 Setting Number of Recirculations**

SW1 and SW2 are programming switches that are used to set the number of recirculations (1 through 127). Refer to Table 2B (next page).

**NOTE:**

*The number of recirculations are specified by the customer at time of order. This number is based on resolution and frequency. You can use Table 1B to choose the number of recirculations based on resolution using a 27 - 28 MHz crystal.*

Hexadecimal numbers 01 to 7F (for internal interrogation) and 81 to FF (for external interrogation) are printed on the switches. Choose the desired number of recirculations from Table 2B and set SW1 and SW2 to the corresponding hexadecimal numbers.

**Table 1B**  
Resolution vs. Recirculations

Resolution	Recirculation
0.004	1
0.002	2
0.001	4
0.0005	8
0.00025	16
0.000125	32

*Values are calculated using a 27-28 MHz Crystal.*

**Table 2B**  
Recirculation Switch Settings

Internal Interrogation		Recirculations	External Interrogation	
SW 2	SW 1		SW 2	SW 1
0	1	<b>1</b>	8	1
0	2	<b>2</b>	8	2
0	4	<b>4</b>	8	4
0	8	<b>8</b>	8	8
1	0	<b>16</b>	9	0
2	0	<b>32</b>	A	0
4	0	<b>64</b>	C	0
7	F	<b>127</b>	F	F

## **B.2 Setting Update Time (Internal Interrogation)**

---

SW3 is the programming switch that is used to set the update time for internal interrogation.

**NOTE:**

*SW2 disables SW3 in external interrogation. That is, setting SW2 to any hexadecimal number past 7 will disable SW3. SW3 is pre-programmed for external interrogation from the factory.*

Update time is programmed with SW3 using hexadecimal numbers 0 - F. Refer to Table 3B (next page). To find the minimum required update time (Umin) use the following procedure:

**FORMULA #1:**

$$U(\min) = (2.5 + \text{NULL} + \text{STROKE}) \times .01086 \text{ ms/in.} \times N$$

**where**

NULL = Null length in inches

STROKE = Stroke length in inches (1 to 300 inches)

N = Number of recirculations

- 1) Select from Table 3B the switch setting for SW3 that yields the closest update time greater or equal to Umin.
- 2) Verify the exact update time of the transducer with the following formula:

**FORMULA #2:**

$$U = (N + 1) \times (\text{SW3} + 1) \times 0.2 \text{ ms}$$

**where**

N = Number of recirculations

SW3 = Switch setting in decimal

**B.3 Example:**

**Given**

- Null = 2 in.
- Stroke Length = 20 in.
- Resolution = 0.001 in.

**Solution**

- 1) From Table 1B, the corresponding resolution to number of recirculations is N = 4.
- 2) The *minimum* required update time using Formula #1 (previous page) is:  
$$U_{\min} = (2.5 + 2 + 20) \times .01086 \times 4 = \underline{1.064 \text{ ms}}$$
- 3) Table 3B shows that the closest update time greater or equal to Umin corresponding to N = 4 is 2.00 ms; therefore, SW3 = 1.
- 4) The exact update time using Formula #2 (previous page) is:

$$U = (4 + 1) \times (1 + 1) \times .2 \text{ ms} = \underline{2 \text{ ms}}$$

**Table 3B**

**SW 3 Setting Update Time as a Function of Stroke and Recirculation**

**(Internal Interrogation Only)**

Recirculations	SW3 Setting (according to stroke length in inches)								
	<i>1-32</i>	<i>32.1-65</i>	<i>65.1-102</i>	<i>102.1-135</i>	<i>135.1-175</i>	<i>175.1-215</i>	<i>215.1-250</i>	<i>250.1-290</i>	<i>290.1-300</i>
1	0	1	2	3	4	5	6	7	8
2	1	2	3	5	6	7	9	A	B
4	1	3	4	6	7	9	B	C	E
8	1	3	5	6	8	A	C	E	F
16	1	3	5	7	9	B	D	F	F
32	1	3	5	7	9	B	E	F	F
64	1	3	5	7	9	B	D	F	F
127	1	3	5	7	9	B	D	F	F

## APPENDIX C Modifications to the Digital Interface Box

### C.1 Modifying the Polarity of the Interrogation Pulse

Consult drawings 650110 and 250068 before performing the following procedure.

#### From INTERNAL to EXTERNAL interrogation

1. Remove the 4 cover screws from 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 socket (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).

#### From EXTERNAL to INTERNAL Interrogation

1. Remove the 4 cover screws from 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 resistor (or next highest available value) in R1 location. Use the following formula to determine the resistor value:

$$R1 (K\Omega) = [T(\text{msec}) \times 14.43] - 1$$

6. Install R2 (499Ω), C1 (0.1μF) and C13 (0.01μF) if R1 is not present.

### C.2 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 (re)circulations).
4. Install U3 (74161) for recirculations above 8.

Jumper (From 0 to X)	N (No. of circulations)
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.*

### C.3 Changing Polarity of Interrogation Signal

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.

**NOTE:**

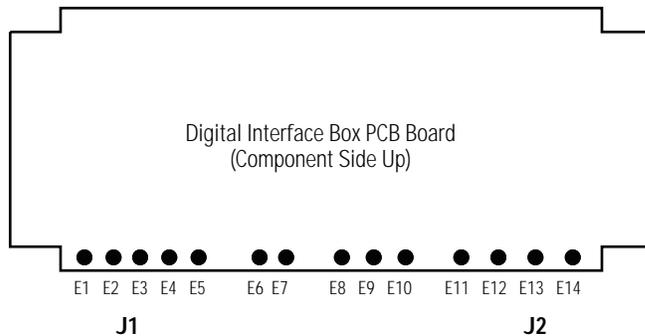
*The only transducers with a negative interrogation pulse are original Temposonics I transducers with stroke lengths of 12 inches or less (the serial number indicated on the transducer label ends with "N" to denote a negative interrogation pulse).*

**Temposonics II transducers can provide either a positive or a negative interrogation pulse.** The positive pulse is available on Pin 9 of the transducer connector (white/gray stripe or yellow wire of pigtail connection). The negative interrogation pulse is available on Pin 10 of the transducer connector (gray/white stripe or green wire of pigtail connection).

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 positive (+) or negative (-) pulse.

**Example:**

- Post E14 to J2 Pin-E is (+) polarity
- Post E13 to J2 Pin-E is (-) polarity



**Figure C-1**  
**Digital Interface Box - Posts E1 - E14**

## APPENDIX D Troubleshooting

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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 Sensors Division for recommendations before purchasing replacement system components.*

### D.1 General

---

If the output signal is erratic or unchanging, turn off power and recheck mechanical and electrical installation. Once all steps have been checked, continue with diagnostic test procedures to determine the cause of fault. The possible causes of faulty output are listed below in order of probability of occurrence, and should be checked in order.

1. Improper power supply/power connection
2. Mismatched system components\*
3. Ground loops/improper grounding\*
4. Improper wiring for counter card connections\*
5. Incorrect receiver device or software\*
6. Improper magnet mounting\*
7. EMI noise, affecting transducer, transducer cable, or counter card cable\*
8. Circuit fault within transducer
9. Circuit fault within counter card

\* 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

## D.2 Power Supply Check

---

**IMPORTANT NOTE:**

*This procedure is for checking the power supply voltage to the Digital Interface Box (DIB). The DIB is a discontinued product, but this procedure is included in this manual to support prior installations.*

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 at the interface box.

1. Remove power and disconnect J-1 10 pin connector from the Digital Interface Box (DIB). Also remove edge connector from counter card. Turn power on and check open circuit voltages at the connector pins of the Digital Interface Box' mating connector.
2. Pin H should read +15 Vdc with respect to Pin A.  
Pin B should read -15 Vdc with respect to Pin A.  
Pin C should read +5 Vdc with respect to Pin A.
3. Check power supply voltages under load by connecting a 150 ohm resistor (or similar 1.5 watt, 12-15 Vdc load\*) between pins H and A and read the voltage across the 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 A and B and read the voltage across the resistor. The voltage should read +4.75 Vdc minimum.

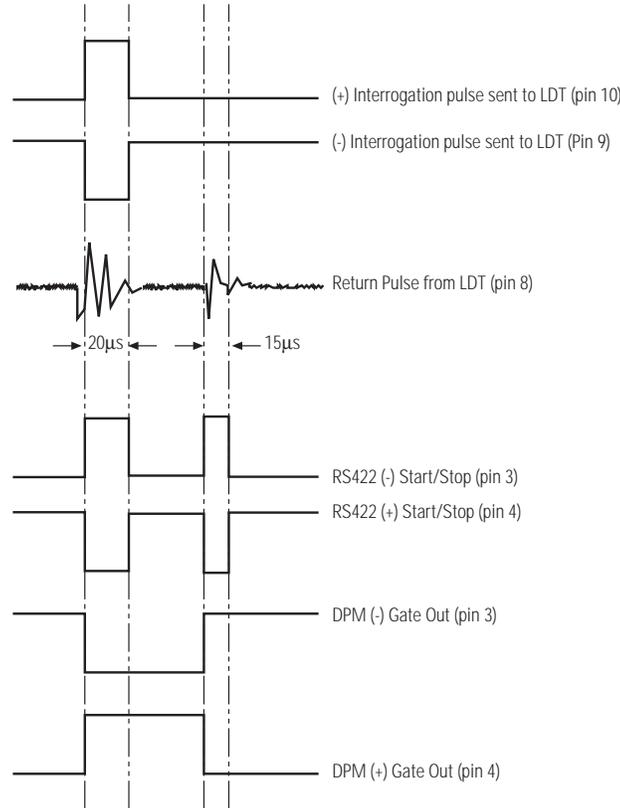
Perform the following procedure to check the power supply voltage and connections at the 5 volt power supply.

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.

### D.3 Temposonics II Digital System Signals

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**Figure D-1**  
**Digital System signals**

### D.4 Wiring Check

---

Improper wiring 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 transducer. Ensure that maximum cable length and type is observed.
3. Check system grounds. Figure D-3 shows a typical circuit diagram with the required and optional grounds. Ensure that circuit ground is made at only one location to avoid ground loops. If erratic or unstable output is encountered, recheck all earth grounds and cable grounds.
4. Disconnect transducer from the DIB while the power is off.
5. Connect the J1 connector to the DIB and restore power.
6. Check for the voltages listed below on the J2 (6-pin) connector on the DIB with respect to J2, pin-B (Ground).
  - A = +12 to +15 Vdc
  - D = -13 to -15 Vdc
  - F = +11.5 to +12 Vdc

7. Connect an oscilloscope to J2 pin-E with respect to J2 pin-B to see the 1 $\mu$ s, TTL, interrogation pulse (see Figure D-4). Transducers with stroke lengths  $\leq$  12 inches should have a negative signal and transducers with stroke lengths 13 inches or longer will have a positive signal.
8. Disconnect power and connect transducer back to the DIB and look for the same voltage and signal levels as in step 6 and 7 with the power restored.
9. Connect the oscilloscope to J2 pin-C with respect to J2 pin-B to see the transient return pulse along with the recirculations (see Figure D-5). If these signals are not present, go to the next step.
10. Disconnect power and isolate J2 pin-C (return pulse) from the DIB. Connect the oscilloscope to pin-C on the transducer side and restore the power. The signals should look like Figure D-5. If not, send the transducer to MTS Sensors for repair.

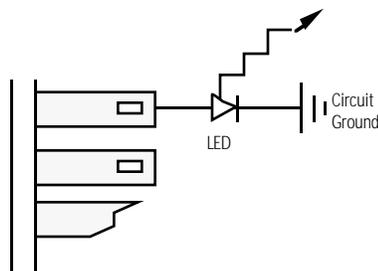
## D.5 Counter Card Digital Output Test Procedure

---

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 LEDs.

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 LEDs (rated for 3-5 Vdc, 50 mA maximum) between the binary output and power supply ground as shown in Figure 9-1. Select the bits (or digit) which will give a reading which is easily interpreted. (Four of the "middle" bits for natural binary; tenths or units place for BCD). The LEDs light when the bit is high. (Note that output voltage will drop under load - refer to a TTL data book for details.)
3. With the above test set-up procedure, some of the LEDs should light immediately. If no LEDs light, move the magnet through the stroke of the transducer and ensure that one or more LEDs light. If none respond, recheck the wiring of the LEDs and the power supply connections to the Digital Counter Card (Pins 1 and 2).



**Figure D-2**  
**Testing Counter Card Output**

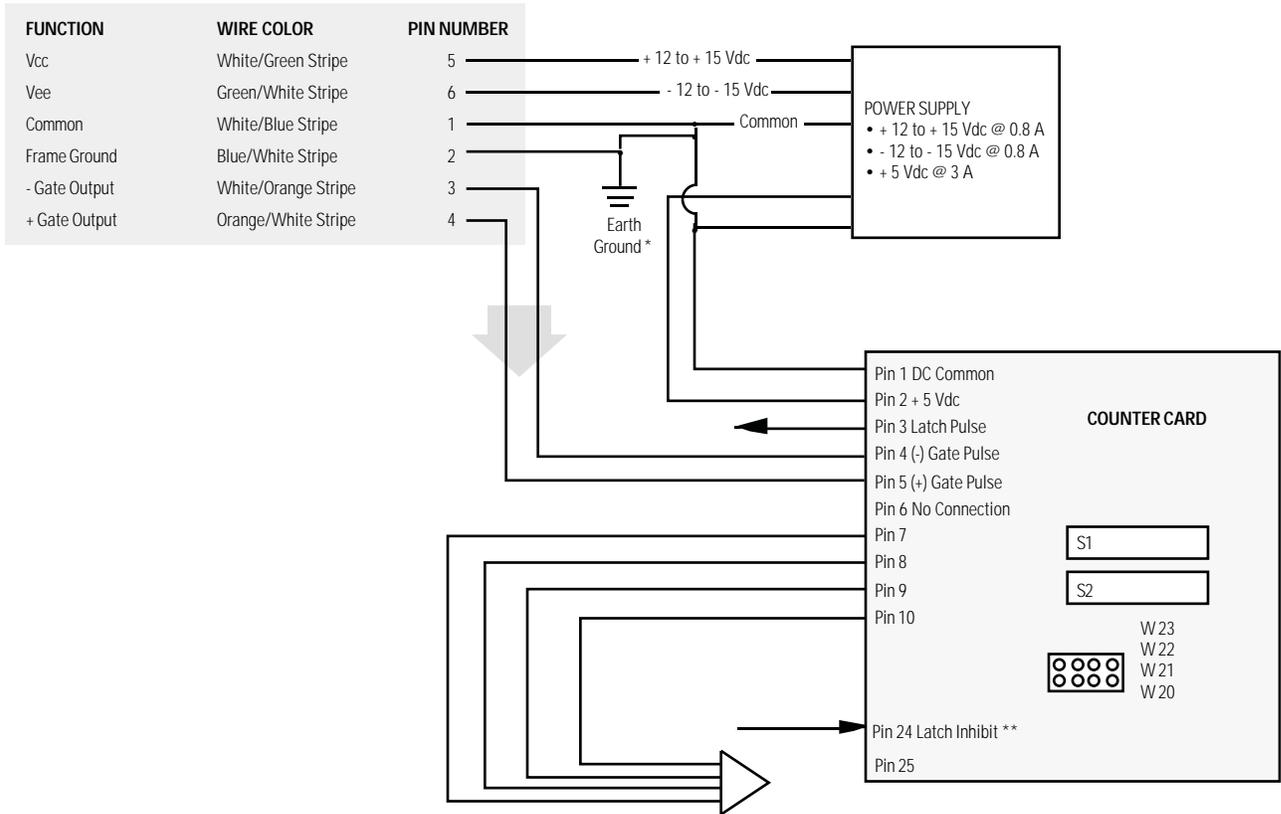
4. To check the Counter Card reading, move the magnet between two measured positions on the stroke, and record the LED readings, as "HI" or "LO". Take the complement of the readings, and calculate the decimal equivalent of the readings. Refer to Table 1D (next page).

Table 1D LED Test

Bit Number	LED	Complement (A)	Decimal Weight (B)	A x B
$2^0$			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	4.096
		Sum =	5.120	(inches of stroke)

Repeat the procedure for position 2, and compare the inches of stroke measured to the inches of stroke observed. A change in reading between 2 points on the stroke is a general indication of proper system operation.

Temposonics II Transducer Connections



NOTES:

\* It is common practice to apply earth ground to power supply terminals near power supply.

\*\* Jumpers W 20 and W 22 make P1 Pin 24 inhibit and P1 Pin 3 latch pulse  
 Jumpers W 21 and W 23 make P1 Pin 24 latch pulse and P1 Pin 3 inhibit.

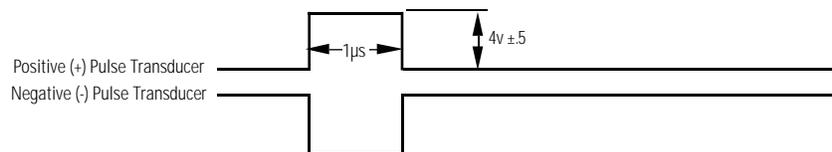
Figure D-3  
 Signal and Power Wiring, Digital Systems

**IMPORTANT NOTE:**

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

## D.5 Digital Interface Box (DIB)

1. Turn power OFF.
2. Disconnect transducer from DIB.
3. Turn power ON.
4. Check the following voltages on Pin-B (Gnd.) on J2 (6-pin) of the DIB.  
Pin A = +12 to +15 Vdc  
Pin D = -13.5 to -15 Vdc  
Pin F = +11.5 to +12 Vdc
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.



**Figure D-4**  
**Interrogation Signal**

5. Connect oscilloscope to Pin-C on the transducer cable. The return pulse and recirculations should be present. Go to Step 6 if these signals are present. Return 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:  $5\mu\text{s}$  (delay mode)



**Figure D-4**  
**(4) Recirculation Pulses**

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



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