Installation and Instruction Manual

TEMPOSONICS™ BRAND
LINEAR DISPLACEMENT
TRANSUDER SYSTEM
WITH ANALOG OUTPUT

919-677-0100

STROKE 1"
LENGTH

ATTN: REVI NTS

MTS SYSTEMS CORPORATION
Tempsonics™ Brand
Linear Displacement Transducer System with Analog Output
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Section I
Introduction

The Tempsonics™ brand Linear Displacement Transducer measurement system (with analog output) precisely senses the position of an external magnet to measure displacements with high resolution. The system measures the time interval between an interrogating pulse and a return pulse. The interrogating pulse is transmitted through the transducer waveguide and the return pulse is generated by a permanent magnet representing the displacement to be measured. The system includes a linear displacement transducer (LDT), a magnet, and the electronics necessary to generate the interrogating pulse, sense the return pulse and develop an analog output signal.

Figure 1-1. Linear Displacement Transducer System

1.1 Functional Description

The LDT assembly and the analog electronics are matched according to the stroke and selected options to meet the application requirements. The analog electronics assembly generates interrogating pulses at a frequency determined by the maximum displacement of the LDT assembly to allow sufficient time for the return pulse to be sensed.
The analog electronics assembly sends the interrogating pulse to the LDT assembly and starts the leading edge of the pulse-width modulation signal as shown in Figure 1-2. The pulse is conducted in a wire threaded through a magnetostrictive tube called a waveguide. The waveguide is mounted under tension in a non-magnetic stainless steel rod. A permanent magnet is positioned along the stainless steel tube and mounted to the device from which displacement is to be measured. Refer to Figure 1-2.

The interaction of the magnetic field of the interrogating pulse and the magnetic field of the external permanent magnet cause a twist in the waveguide. The twist (or torsional strain pulse) is transmitted along the waveguide. The torsional strain pulse is dampened at the end of the waveguide and sensed in the transducer head. Two magnetic strain sensitive tapes are attached to the waveguide and coupled to sensing coils in the transducer head. The torsional strain pulse from the waveguide causes a small vibration of the tapes relative to the magnetic field of the sensing coils. This induces a voltage in the coils which is amplified and conditioned in the transducer head assembly then it is sent back to the analog electronics box as the return pulse.

Figure 1-2. Waveguide Interaction
Refer to Figure 1-3. The returning pulse triggers the trailing edge of the pulse-width modulated signal. The pulse-width modulated signal is filtered to produce an average dc voltage which is the analog output signal. The amplitude of the average dc voltage (typically 0 to 10 Vdc) represents the distance the permanent magnet is from the null position. The pulse-width modulated signal is also available as an output. Further processing of the averaged dc voltage can produce a 4-20 mA and other available signals.

![Diagram of signals](image)

- **time base for max displacement cycle**
- **Pulse sent to LDT**
- **Pulse returned from LDT**
- **Pulse-width modulated output**
- **10 V**
- **Average dc output**

**Figure 1-3. Analog Electronics Box Signals**

### 1.2 Options

The linear displacement transducer measurement system is configured to meet the application requirements. The following are selections for system configurations:

- Several analog output selections including:
  - 0 to +10 Vdc output corresponding to null and full-scale (standard output).
  - Other output voltages may be ordered such as 0 to 5 Vdc or 0 to -10 Vdc.
  - Current outputs are available such as 4 to 20 mA, grounded or ungrounded.
  - Reverse outputs interchange the null and full-scale voltage levels.
  - An additional velocity output of ±10 Vdc is available.
  - Digital outputs are available using alternate electronics (consult Temposorics).
- Environmental protection options.
- Intrinsically safe designs for hazardous environments.
- Low ripple filtering to reduce AC ripple on the analog output signal.
- High noise rejection circuitry to reduce transient noise due to electromagnetic interference from other equipment.
- Single wire designs for die casting applications.

1.3 Specifications

Table 1–1 lists the specifications for the Temposonics brand Linear Displacement Transducer system with analog output.

Table 1–1. Temposonics LDT Specifications (with Analog Output)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Voltage</td>
<td>+15 Vdc (± 2%) @ 250 mA, with &lt;1% ripple&lt;br&gt;-15 Vdc (± 2%) @ 65 mA, with &lt;1% ripple</td>
</tr>
<tr>
<td>Displacement</td>
<td>up to 360 in. (9 m); longer displacements available</td>
</tr>
<tr>
<td>Nonlinearity</td>
<td>&lt; ± 0.05% full-scale, or min ± 0.002 in.&lt;br&gt;(± 2.5 x 10⁻³ cm)</td>
</tr>
<tr>
<td>Repeatability</td>
<td>± 0.001% of full-scale or 0.0001 inch (whichever is greater)</td>
</tr>
<tr>
<td>Frequency Response</td>
<td>response depends on length and type of filtering; 200 Hz to 50 Hz is typical for lengths&lt;br&gt;12 in. (30 cm) to 100 in. (254 cm) respectively; wider response is available</td>
</tr>
<tr>
<td>Transducer Temperature</td>
<td>10 ppm/°F (18 ppm/°C) for transducers 10 in. to&lt;br&gt;30 in. (25 cm to 76 cm); 5 ppm/°F (9 ppm/°C) for&lt;br&gt;transducers over 30 in. (76 cm)</td>
</tr>
<tr>
<td>Coefficient</td>
<td></td>
</tr>
<tr>
<td>Electronic Temperature</td>
<td>55 ppm/°F (81 ppm/°C); 30 ppm/°F&lt;br&gt;(54 ppm/°C)</td>
</tr>
<tr>
<td>Coefficient</td>
<td>optional</td>
</tr>
</tbody>
</table>
Table 1-1. Temposonics LDT Specifications (with Analog Output) (continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Temperature Transducer:</td>
<td>35°F to 150°F (2°C to 65°C) for strokes less than 12 inches; 35°F to 180°F (2°C to 82°C) for stroke more than 12 inches; wider temperature ranges available</td>
</tr>
<tr>
<td>Analog Electronics Box:</td>
<td>35°F to 150°F (2°C to 66°C)</td>
</tr>
<tr>
<td>Operating Pressure</td>
<td>transducer rating 3000 psi (21 MPa)</td>
</tr>
<tr>
<td>Output</td>
<td>0 to 10 Vdc and a TTL compatible, pulse-width modulated output are provided as standard; other voltages and 4 to 20 mA outputs are optional</td>
</tr>
<tr>
<td>Output Impedance</td>
<td>&lt;10 ohms</td>
</tr>
<tr>
<td>Velocity Output</td>
<td>±10 V; ±10 Vdc traveling away from the LDT head assembly, -10 Vdc traveling toward the LDT head assembly</td>
</tr>
</tbody>
</table>

Specifications are subject to change without notice.
Section II
Service

This section provides the adjustment procedures for the analog electronics box. The linear displacement transducer (LDT) assembly has no adjustments. All adjustments are performed in the electronics box. Periodic calibration checks may be desirable to compensate for environmental factors or mechanical wear of the movable device to which the permanent magnet is mounted. The following procedures assume the system is properly installed as described in Section III.

NOTE

The adjustment values specified in the following procedures depend on the system configuration. The adjustment tolerances of these procedures during field calibration are dependent on system requirements and available test equipment.

2.1 Null and Full-Scale Adjustments

The following procedure calibrates the null position and the full-scale position to the required output levels. If the following adjustments are inadequate, refer to Subsection 3.2 for possible mechanical adjustments. Refer to Figure 2-1 for the adjustment locations.

Figure 2-1. Electronic Box Adjustment Locations
NOTE

The following procedure assumes the standard full-scale 0 to 10 Vdc output is supplied. When other output signals are supplied, use the appropriate signal levels and/or test equipment for the following adjustments.

1. Determine a point in the system electronics to monitor the displacement signal (refer to Tables 3-1, 3-2 and 3-3). Connect a DVM to monitor the displacement signal.

2. Position the permanent magnet at the specified null position. The null position is specified when the LDT assembly is ordered (typically 2 inches from the transducer head).

3. Remove the rubber cap covering the null adjustment. Adjust the null control for a DVM reading of 0.000 Vdc. Replace the rubber cap.

4. Position the permanent magnet for full-scale displacement (typically 7 inches from the end of the LDT assembly).

5. Remove the rubber cap covering the displacement scale adjustment. Adjust the scale control for a DVM reading of +10.000 Vdc. Replace the rubber cap.

6. Repeat this procedure to check the null and full-scale settings; readjust as necessary.

7. Disconnect the DVM and check overall system operation.

2.2 Velocity Zero Adjustment

The velocity zero and scale adjustments are factory set and should not require readjustment. The velocity output signal represents a static displacement with 0 volts and the maximum velocity of a dynamic displacement with 10 volts. The direction of the displacement is indicated by the polarity of the velocity signal; a positive signal normally indicates the permanent magnet is moving away from the transducer head (unless otherwise specified). The following procedure provides the velocity zero adjustment; the velocity scale adjustment requires special equipment. The scale adjustment is difficult in the field without the precision equipment to exactly control the velocity.
1. Determine a point in the system electronics to monitor the transducer velocity signal (refer to Table 3-1). Connect a peak reading DVM (or oscilloscope) to monitor the velocity output.

2. Ensure the permanent magnet is not moving.

3. Remove the rubber cap covering the velocity zero adjustment. Adjust the velocity zero control for a reading of 0.000 Vdc. Replace the rubber cap.
Section III
Installation

This section describes general installation procedures for the 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 hydraulic cylinders and 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 analog electronics with a ruggedized box is suitable for environments exposed to moisture and vibrations.

- A transducer assembly with the intrinsically safe design is available for hazardous areas.

3.2 Mechanical Installation

The mechanical installation includes mounting the transducer, the analog 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 space (refer to Figure 3-1).

1. The transducer assembly is mounted to the selected location with 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 MS 28778-8 is recommended) in the special groove if a pressure or moisture seal is required.
3. 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 (i.e. iron, steel, etc) on the magnetic field of the permanent magnet, ensure the minimum spacing requirements are met as shown in Figure 3-2. Any nonmagnetic materials can be in direct contact with the permanent magnet.

**NOTE**

It is recommended to design a coupler with adjustments to mount the magnet to the measured member. This provides a mechanical null adjustment for the magnet should the electronic calibration be inadequate.
Figure 3-2. Magnetic Material Mounting Specifications

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.

4. 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. Additional supports should be made from non-ferrous materials and require open magnets (which allow the magnet to pass the extra supports).

5. Mount the analog electronics box in a location within reach of the LDT assembly cable. Standard systems allow the analog electronics box to be mounted within 50 feet of the LDT assembly. Systems with the optional cable driver allow the analog electronics box to be mounted within 100 feet of the LDT assembly. For cable lengths greater than 20 feet, use a high quality shielded cable such as Belden #9730 or equivalent.
3.3 Electronic Connections

Electronic connections are made at connectors J1 and J2. Connector J1 provides inputs for the user supplied power supply and outputs for the displacement, pulse modulated and optional velocity signals. Connector J2 provides the connections to the LDT assembly. This cable is typically supplied with the LDT assembly.

NOTE

The round cover on the LDT assembly is at circuit ground and should not be grounded.

1. Connect a ground wire from the analog electronics box to a central earth ground or to the power supply earth ground (if it is grounded). Only one earth ground should be used to prevent ground loops.

2. Connect the cable from the LDT assembly to J2 (6-pin connector) on the analog electronics assembly.

NOTE

Ensure the +15 volt power supply can provide 250 mA with less than 1% ripple. Ensure the -15 volt power supply can provide 65 mA with less than 1% ripple.

3. Ensure the receiver device input connections do not have voltage present.

CAUTION

The input to the system electronics should be a passive, resistive device to prevent damage to the analog electronics box circuitry.

4. Connect a cable between J1 (5-pin connector) of the analog electronics box and the receiver device input terminals and the power supply. A single cable or dual cables may be used for the power supply and the output signals. Perform the following procedure to construct the J1 cable assembly.

A. Refer to the following tables to determine the appropriate J1 connections.
Table 3-1. Voltage Output J1 Connections

<table>
<thead>
<tr>
<th>J1 pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>+15 Vdc</td>
</tr>
<tr>
<td>B</td>
<td>-15 Vdc</td>
</tr>
<tr>
<td>C</td>
<td>DC Ground</td>
</tr>
<tr>
<td>D</td>
<td>Displacement</td>
</tr>
<tr>
<td>E</td>
<td>Pulse-width modulated signal</td>
</tr>
</tbody>
</table>

1 Optional velocity signal replaces the pulse-width modulated signal.

Table 3-2. Ungrounded 4-20 mA Current Output J1 Connections

<table>
<thead>
<tr>
<th>J1 pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>+15 Vdc</td>
</tr>
<tr>
<td>B</td>
<td>-15 Vdc</td>
</tr>
<tr>
<td>C</td>
<td>DC Ground</td>
</tr>
<tr>
<td>D</td>
<td>+ Current Output (source)</td>
</tr>
<tr>
<td>E</td>
<td>- Current Output (return)</td>
</tr>
</tbody>
</table>

1 Do not ground or damage may result. Maximum load resistance: 400 Ω.

Table 3-3. Grounded 4-20 mA Current Output J1 Connections

<table>
<thead>
<tr>
<th>J1 pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>+15 Vdc</td>
</tr>
<tr>
<td>B</td>
<td>-15 Vdc</td>
</tr>
<tr>
<td>C</td>
<td>DC Common and -Current (return)</td>
</tr>
<tr>
<td>D</td>
<td>+ Current Output (source)</td>
</tr>
<tr>
<td>E</td>
<td>N.C.</td>
</tr>
</tbody>
</table>

1 Maximum load resistance: 500 Ω.
B. Solder the connections to the type MS 3106 A 14S-5S connector supplied with the analog electronics box. Ensure the solder connections are clean and free of excessive solder. Use heat-shrink over the solder connections to prevent the pins from shorting.

C. Identify the wires at the other end of the cable for connections to the power supply and the receiving device input terminals. Test the cable for shorts before connecting it to the J1 connector.

D. Complete the J1 cable connections at the power supply and the receiving device input terminals. Do not route the J1 cable near high voltage sources.

5. Apply power and check the displacement readings at the system electronics. If necessary, recalibrate the null and full-scale adjustments to nullify any offsets due to the mechanical installation (refer to Subsection 2.1).
Section IV
Troubleshooting

This section consists of troubleshooting procedures when operational problems are encountered. The following procedures are listed in order of frequency of occurrence and should be completed in order.

NOTE

The following procedures are for general troubleshooting purposes. Purchase of replacement components should not be determined solely on the following procedures. Consult Temposonics division of MTS Systems Corporation for recommendations before purchasing replacement components.

4.1 General

Ensure the magnet is positioned and moving properly along the LDT assembly. Trace all wiring from the J1 connector to ensure proper routing.

4.2 Power Supply Check

Perform the following procedure to check the power supply voltages.

1. Remove power and disconnect connector J1 to check open circuit power supply voltages (as described in steps 2 and 3).

   NOTE

   If voltage is not present in steps 2 and 3, a problem with wiring or the power supply is indicated.

2. Connect a DVM to pins A and C of cable connector J1. Apply power. The voltage should be +15 Vdc.

3. Connect the DVM to pins B and C of cable connector J1. The voltage should be -15 Vdc.

   NOTE

   A low voltage reading in steps 4 and 5 indicates a power supply with an inadequate rating or an excessive voltage drop in the cabling (i.e. improper wire sizes).
4. If the voltage readings are correct, check the power supply voltages under load (as described in steps 5 and 6).

5. Connect a 60 to 75 ohm resistor across pins A and C. The voltage across the resistor should be +14.7 Vdc (min).

6. Connect a 230 to 250 ohm resistor across pins B and C. The voltage across the resistor should be -14.7 Vdc (min).

4.3 Grounding

Trace all ground and power supply common connections. A single earth ground should be connected to the power supply common and the analog electronics box cover. If the analog electronics box is suspect, remove the mounting screws and place the box on insulating material (i.e. wood) then recheck the output readings.

4.4 Connections

Check the solder connections in the J1 cable. Ensure no cold solder joints are present. Perform a continuity check between the J1 connections to ensure no shorts are present.

4.5 LDT Signals

Disconnect connector J2 from the analog electronics box. Apply power and check the J2 readings per Table 4-1. If the J2 readings are proper, refer to step A. If the J2 readings are not proper, refer to step B.

<table>
<thead>
<tr>
<th>J2 pin #</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>+15 Vdc</td>
</tr>
<tr>
<td>B</td>
<td>Common</td>
</tr>
<tr>
<td>C</td>
<td>Pulse from LDT¹</td>
</tr>
<tr>
<td>D</td>
<td>-15 Vdc</td>
</tr>
<tr>
<td>E</td>
<td>Pulse to LDT²</td>
</tr>
<tr>
<td>F</td>
<td>+12 Vdc</td>
</tr>
</tbody>
</table>

¹ Signal will not be present with J2 disconnected.
² Typical signal is a 1 µs, 2-3 Vdc pulse @ 2-12 kHz (depending on stroke).
NOTE

Do not interchange transducers and analog electronics with differing model numbers without consulting Temposonics.

A. If a spare transducer of the same stroke and model number is available, connect the spare transducer to the analog electronics box and check the displacement readings at the system electronics.

B. If a spare analog electronics box of the same stroke model number is available, connect J1, J2 and the ground wire to the spare analog electronics box and check the displacement readings at the system electronics.
PRODUCT MANUAL
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MTS Job No. ______________ Date ______________

Manual Title __________________________________________

Manual Part Number __________________________
(See lower left corner of title page)

Product Model No. ______________ Product Serial No. __________

From: Company Name __________________________
   Mailing Address __________________________________________

Response Attention To: __________________________

COMMENTS:

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FOLD ON DOTTED LINES
MAIL TO ADDRESS ON BACK (DO NOT STAPLE)