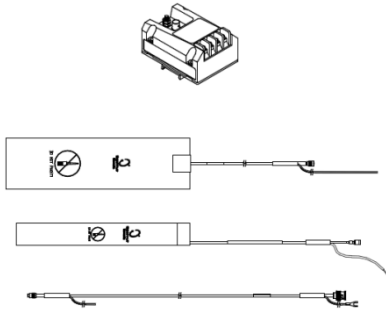


# 4000 Series Air Gap Sensor System

Bently Nevada\* Asset Condition Monitoring



## Description

Bently Nevada's air gap monitoring system provides monitoring and diagnostic capability for all new and existing hydro generators and motor/generators. Air gap monitoring is fully integrated with the 3500/System 1\* platform and utilizes the 3500/46M Hydro Monitor. While the 4000 Series Air Gap 50 mm Sensor System targets applications requiring large machines, the 4000 Series Air Gap 20 mm Sensor System addresses small to medium machines.

## Criticality

Air gap is a measure of the distance between rotor and stator in a hydroelectric generator. Monitoring of air gap is critically important because both the stator and the rotor on large hydroelectric machines can be quite flexible and their shape and location are affected by operating centrifugal, thermal, and magnetic forces. Off-center or out-of-round conditions will at least reduce operating efficiency and, in more severe cases, can lead to damage from magnetically induced heating or a rotor-to-stator rub.

## Measuring Air Gap

Air gap monitoring utilizes multiple specially designed capacitive proximity probes that are mounted on the inner bore of the generator stator in one or more planes. Measurements are made from the stator bore to each rotor pole as the rotor turns. Minimum air gap dimension and location along with rotor shape are directly measured during unit operation. Stator shape is calculated utilizing the multiple air gap probes. The air gap monitoring system provides operations and maintenance personnel with early warning of impending problems with shape and concentricity of the generator rotor and stator.

## Typical Benefits

Air gap dimensions along with rotor and stator shape cannot be effectively measured with the generator out of service because of the combined effects of centrifugal, thermal, and magnetic forces. Early detection of air gap anomalies will facilitate condition-based maintenance by allowing the user time to plan for repairs before scheduled outages. Long term trending of gap and shapes can be correlated with operating conditions and used in operational and rehabilitation planning. Knowing the rotor and stator shapes and minimum air gap dimensions will provide the operator with the information needed to remove a machine from service before serious damage like that from a rotor stator rub occurs.



## Proximity Probe and Extension Cable

The 4000 series air gap probe is designed for maximum survivability in the harshest hydro generator environment. It can continually operate and maintain its accuracy in temperatures up to +125 °C (+257 °F). The probe can also continually operate and maintain its accuracy in the 1.5 Tesla magnetic field often experienced between the rotor pole and the stator. ClickLoc\* connectors come standard on both the probe and extension cable to prevent loosening of the connectors.

### Proximito\* Sensor

The 4000 series Air Gap Proximito Sensor is based upon our best selling 3300 XL Proximito Sensor technology. The Proximito Sensor uses a DIN rail connection to ease installation and to minimize the number of cumbersome screws required when working around the hydro generator. The grounding stud on the Proximito Sensor features a safety thread in order to ensure the locking nut does not inadvertently fall off during the installation of the ground wire on the extension cable.

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## Specifications

Unless otherwise noted, the following specifications are for a 4000 Series Air Gap Proximito Sensor, extension cable, and probe between 0 °C and +50 °C (+32 °F to +122 °F), with a +24 Vdc power supply, and a 10kΩ load.

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### Electrical

#### Proximito Sensor Input:

Accepts one non-contacting 4000 Series Capacitive Probe and Extension Cable.

#### Power:

Requires +23.25 Vdc to +24.75 Vdc at 85 mA maximum consumption.

#### Supply Sensitivity:

Less than 2 mV change in output voltage per volt change in input voltage.

#### Output Resistance:

50 Ω ± 5%.

#### Extension Cable capacitance:

75.5 pF/m (23.0 pF/ft) typical.

#### Field Wiring:

0.2 to 1.5 mm<sup>2</sup> (16 to 24 AWG).

Recommend using two-conductor shielded cable. Recommended maximum length of 305 metres (1000 feet) between the 4000 Series Proximito Sensor and the monitor.

**Linear Range:**

## 20 mm System

18.3 mm (720 mils). Linear range begins at approximately 2 mm (80 mils) from the face of the probe and is from 2 to 20.3 mm (80 to 800 mils) (approximately +1 to +10 Vdc).

## 50 mm System

45.7 mm (1800 mils). Linear range begins at approximately 5.1 mm (200 mils) from the face of the probe and is from 5.1 to 50.8 mm (200 to 2000 mils) (approximately +1 to +10 Vdc).

**Average Scale Factor (ASF):**

## 20 mm System

0.50 mV/ $\mu$ m (12.5 mV/mil), nominal

## 50 mm System

0.20 mV/ $\mu$ m (5.0 mV/mil), nominal

**Deviation from a straight line:**

## 20 mm System

Less than  $\pm 1.02$  mm ( $\pm 40$  mils) with system between 0 °C and +50 °C (+32 °F and +122 °F).

## 50 mm System

Less than  $\pm 2.54$  mm ( $\pm 100$  mils) with system between 0 °C and +50 °C (+32 °F and +122 °F).

**Frequency Response:**

0 to 2.0 kHz: +0, -3 dB typical with up to 305 metres (1000 feet) of field wiring.

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**Compliance & Certifications****EMC**

European Community Directives:

EMC Directive 2004/108/EC

Standards:

EN 61000-6-2

EN 61000-6-4

*For other approvals or certifications available on this product, refer to the Country and Regional Approvals Standard 323773.*

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**Mechanical****Probe Material:**

FR4 type material.

**Probe & Extension Cable Material:**

75  $\Omega$  triaxial, fluoroethylene propylene (FEP) cable.

**Proximator Sensor Material:**

Aluminum.

**Tensile Strength (maximum rated):**

312 N (70 pounds) probe lead to probe. 89 N (20 pounds) at probe lead to extension cable connectors.

**Connector Material:**

Gold-plated brass and gold-plated beryllium copper.

**Connector-to-connector torque:**

*Recommended Torque:*

Finger tight.

*Maximum Torque:*

0.565 N•m (5 lbf•in).

**Minimum Bend Radius:**

25.4 mm (1.0 in).

**System Mass (typical):**

*Probe:*

Approximately 140 g (0.3 lbs).

*Extension Cable:*

Approximately 320 g (0.7 lbs).

*Proximator Sensor:*

Approximately 380 g (0.8 lbs).

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**Environmental Limits**

**Probe Temperature Range:**

*Operating Temperature:*

0 to +125 °C (+32 to +257 °F).

*Storage Temperature:*

-35 to +125 °C (-31 to +257 °F).

**Extension Cable Temperature Range:**

*Operating Temperature:*

0 to +125 °C (+32 to +257 °F).

*Storage Temperature:*

-35 to +125 °C (-31 to +257 °F).

**Proximator Sensor Temperature Range:**

*Operating Temperature:*

0 to +70 °C (+32 to +158 °F).

*Storage Temperature:*

-35 to +85 °C (-31 to +185 °F).

**Relative Humidity**

Less than a 5% change in average scale factor when tested in 93% humidity in accordance with IEC standard 60068-2-78 for up to 56 days.

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**Patents**

Components or procedures described in one or more of the following patents apply to this product: 6,989,679; 7,084,643.

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## Ordering Information

For a detailed listing of country and product specific approvals, refer to the *Approvals Quick Reference Guide* (document 108M1756) located at the following website: [www.GEmeasurement.com](http://www.GEmeasurement.com).

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### 4000 Series Capacitive Proximity Probes

400102 Air Gap 50 mm Sensor

400202 Air Gap 20 mm Sensor

#### Product Number-AXX

A: Cable Length Option  
0 1 Standard, 18 inches

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### 4000 Series Air Gap Proximitors

400100 Air Gap 50 mm Proximitors

#### Product Number-AXXX-BXX

A: Cable Length Option  
1 0 0 10.0 metres (33 feet) system length

B: Linear Range Option  
0 2 50 mm (2 inches)

400200 Air Gap 20 mm Proximitors

#### Product Number-AXXX-BXX

A: Cable Length Option  
1 0 0 10.0 metres (33 feet) system length

B: Linear Range Option  
0 2 20 mm (0.8 inches)

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### 4000 Series Extension Cable

400130 Air Gap 50mm Extension Cable

400230 Air Gap 20mm Extension Cable

#### Product Number-AXXX

A: Cable Length Option  
1 0 0 10.0 metres (33 feet) system length

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## Accessories

167684-01

Air Gap Transducer System Operation Manual.

02200627

+24 Vdc Power Supply.  
Typically 2 sensor systems will be powered by 1 power supply in each Proximitors Housing. The power supply is capable of running 4 sensor systems.

330181

3300 XL Proximitors Housing. Suggested configuration is 330181-01-00-01-00-00; a housing with DIN mount hardware, no conduit fitting, standard 2.34 mm (0.092 in) gland plate thickness, no terminal blocks, and no approvals. Typically 2 sensor systems and 1 power supply will be located in each housing. The housing is capable of holding 1 power supply and 4 Proximitors Sensors.

02173006

Bulk Cable (specify length in feet) 1.0 mm<sup>2</sup> (18 AWG), 2-conductor, twisted, shielded cable used for the PROX OUT signal on the Air Gap Proximitors Sensor terminal strip.

168448-01

Air Gap Verification Kit.

173873

7-inch PEEK® cable ties suitable for hydro generator environments, bag of 50

# Graphs and Figures

Unless otherwise specified, dimensions are in mm (inches).

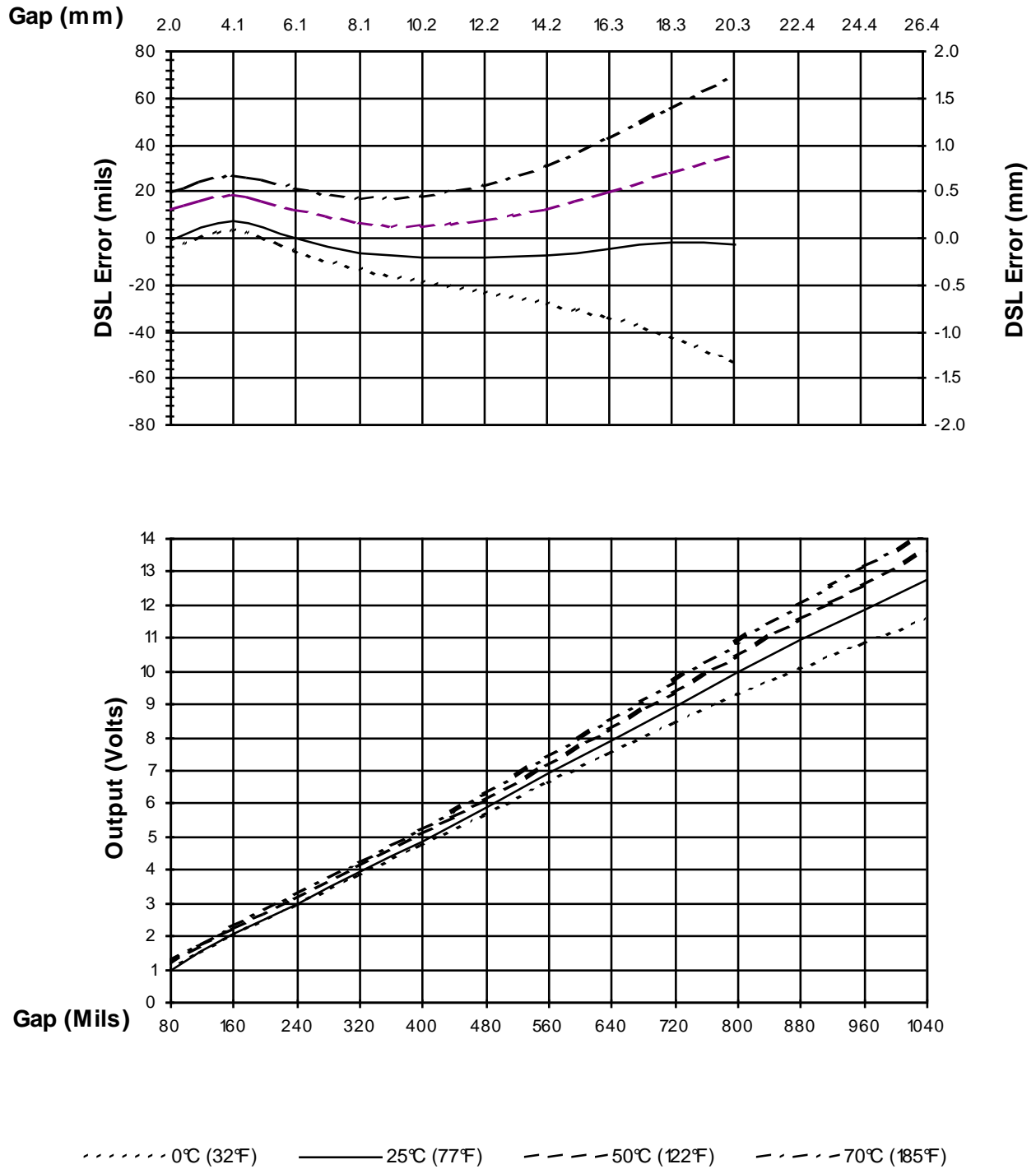


Figure 1: Typical Air Gap 20 mm Proximator Sensor Over Temperature

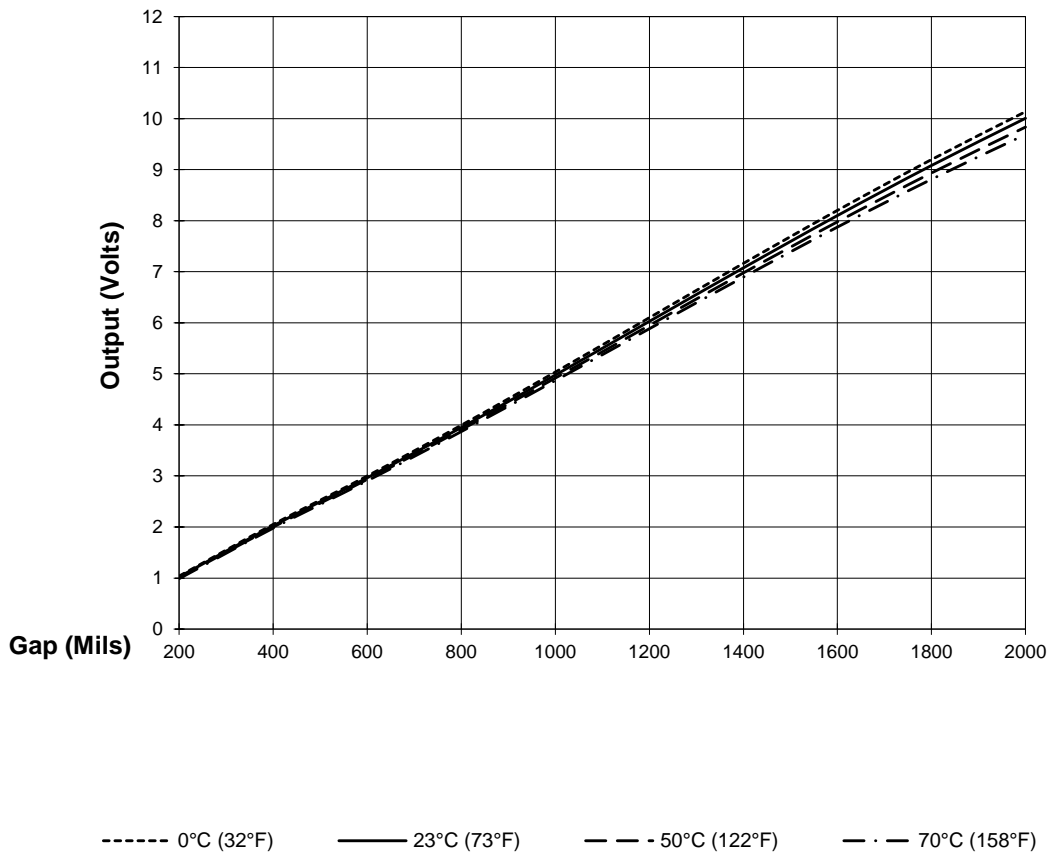
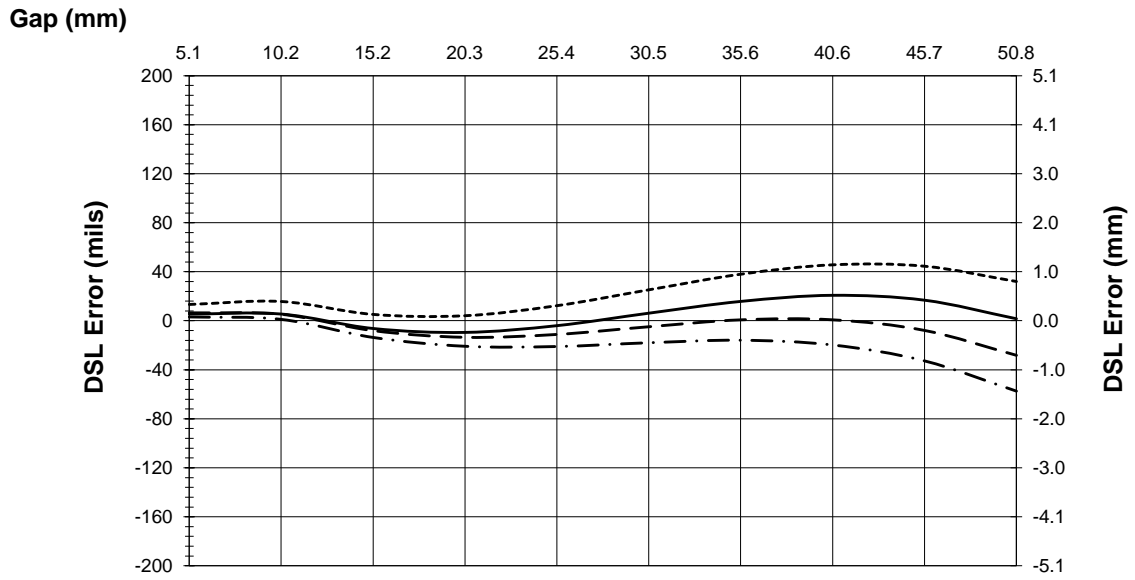
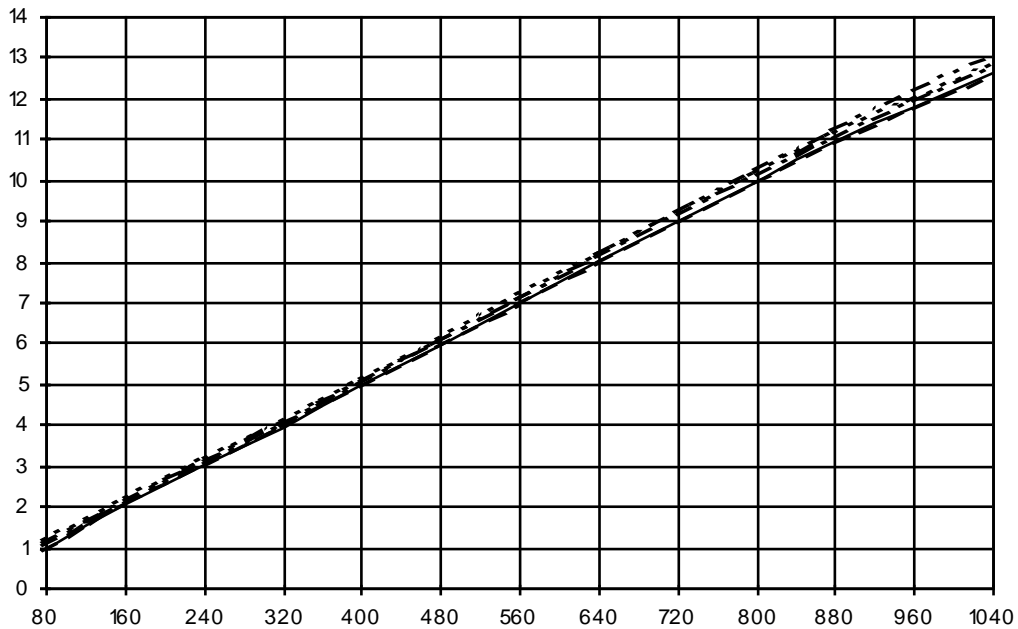
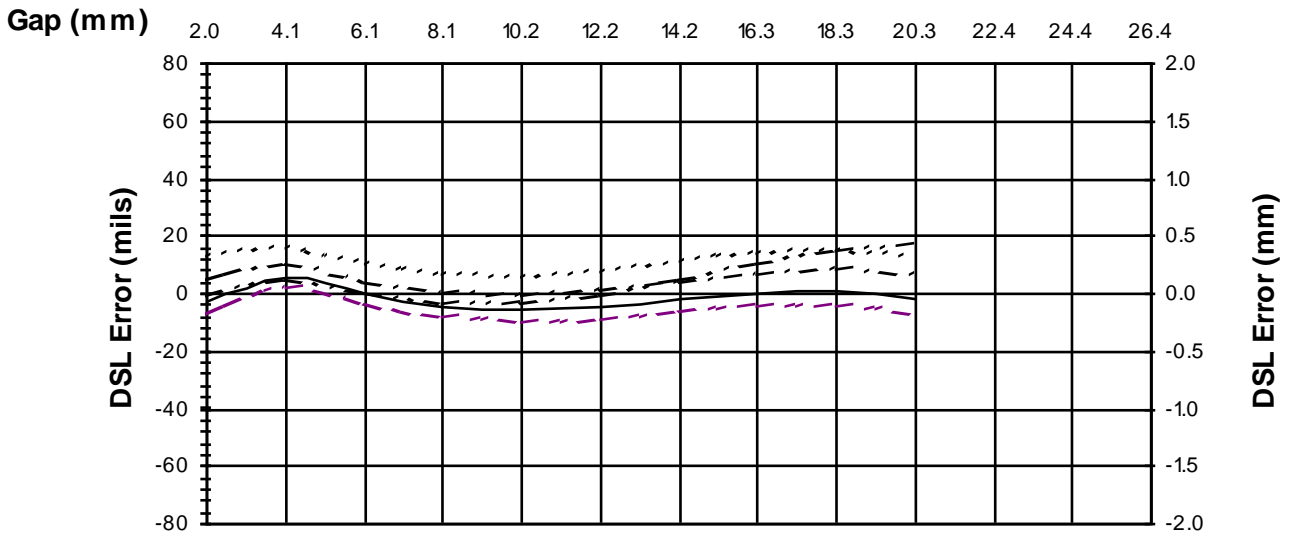


Figure 2: Typical Air Gap 50 mm Proximito Sensor Over Temperature

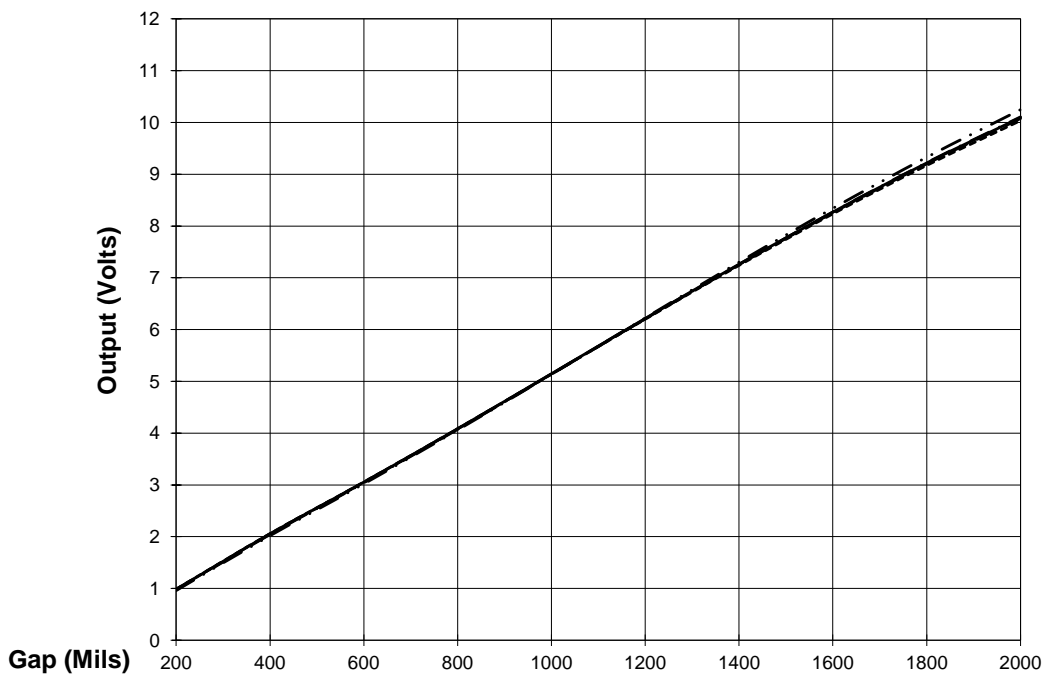
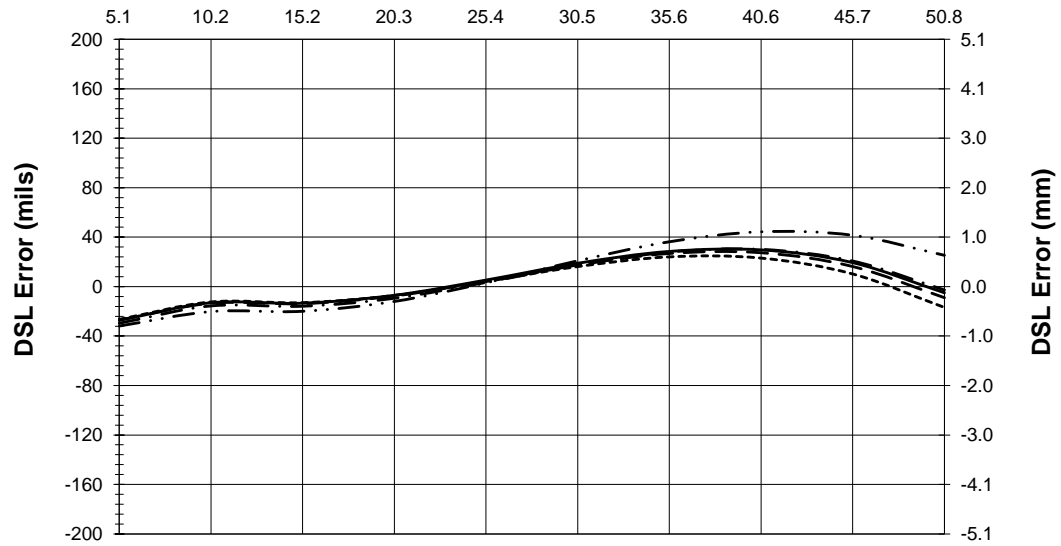


..... 0°C (32°F)                      ——— 25°C (77°F)                      - - - - 50°C (122°F)  
 - - - - 85°C (185°F)                      - · - · - 125°C (257°F)

Figure 3: Typical Air Gap 20 mm Probe Over Temperature

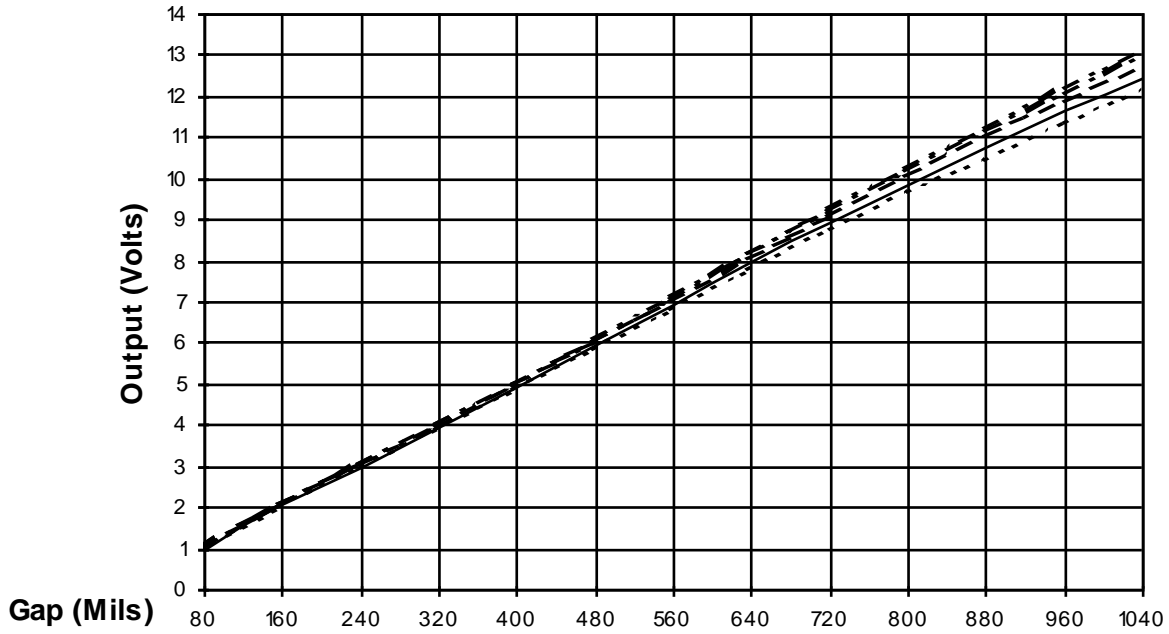
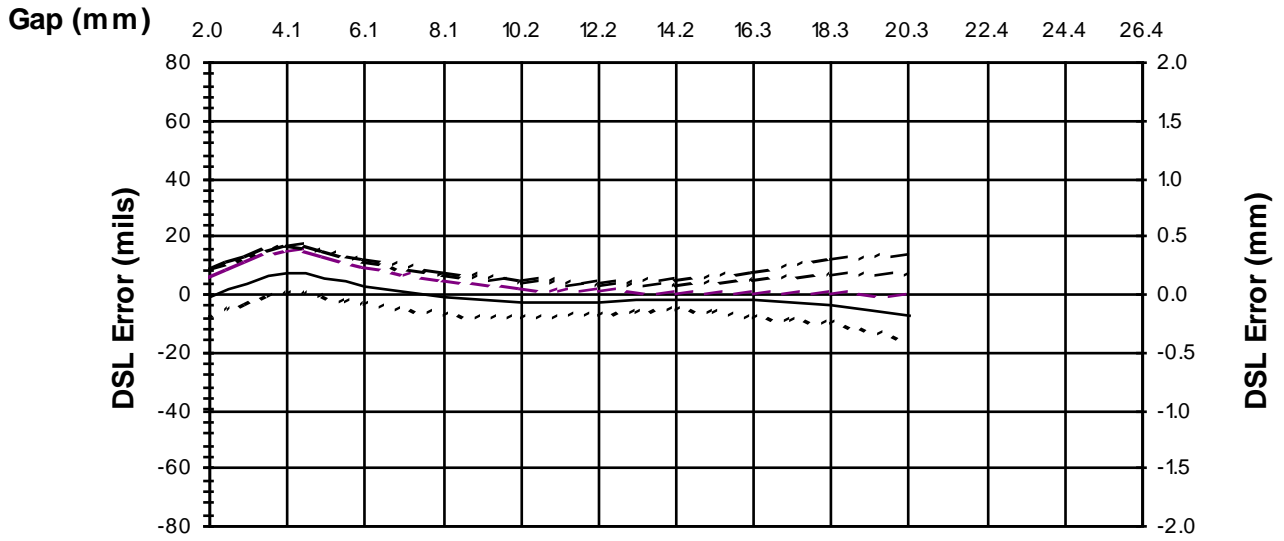


Gap (mm)



----- 0°C (32°F)    ——— 23°C (73°F)    - - - 50°C (122°F)    - · - 85°C (185°F)    - · · - 125°C (257°F)

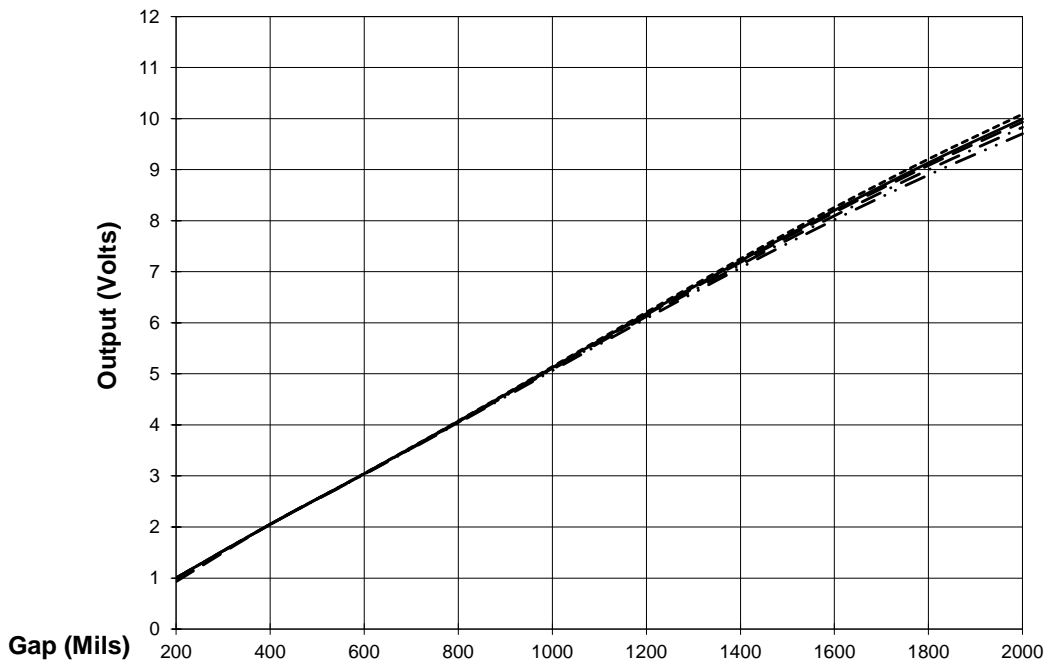
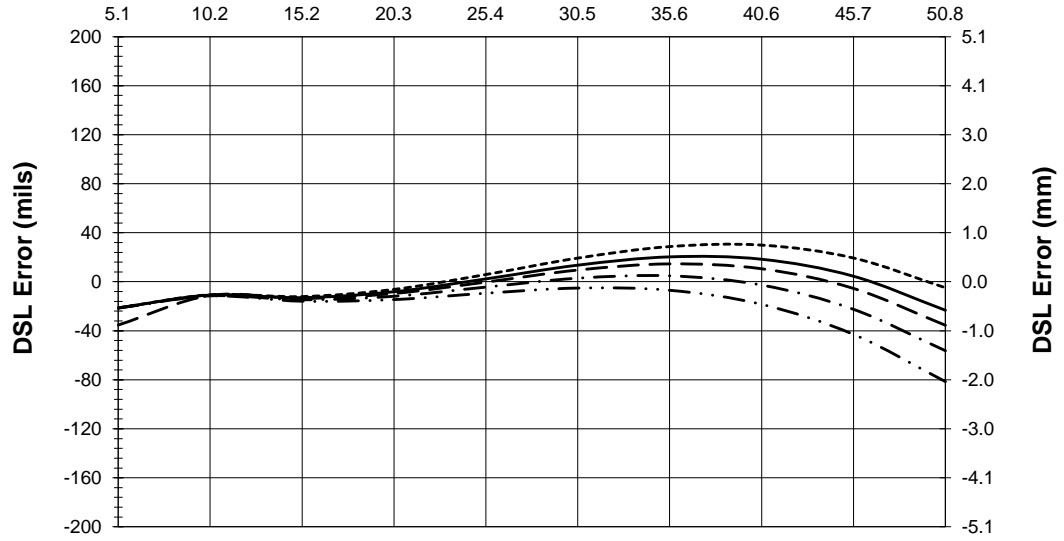
Figure 4: Typical Air Gap 50 mm Probe Over Temperature



..... 0°C (32°F)                      ——— 25°C (77°F)                      - - - - 50°C (122°F)  
 - - - - 85°C (185°F)                      - · - · - 125°C (257°F)

Figure 5: Typical Air Gap 20 mm Cable Over Temperature

Gap (mm)



----- 0°C (32°F)    ——— 23°C (73°F)    - - - 50°C (122°F)    - · - 85°C (185°F)    - · · - 125°C (257°F)

Figure 6: Typical Air Gap 50 mm Cable Over Temperature

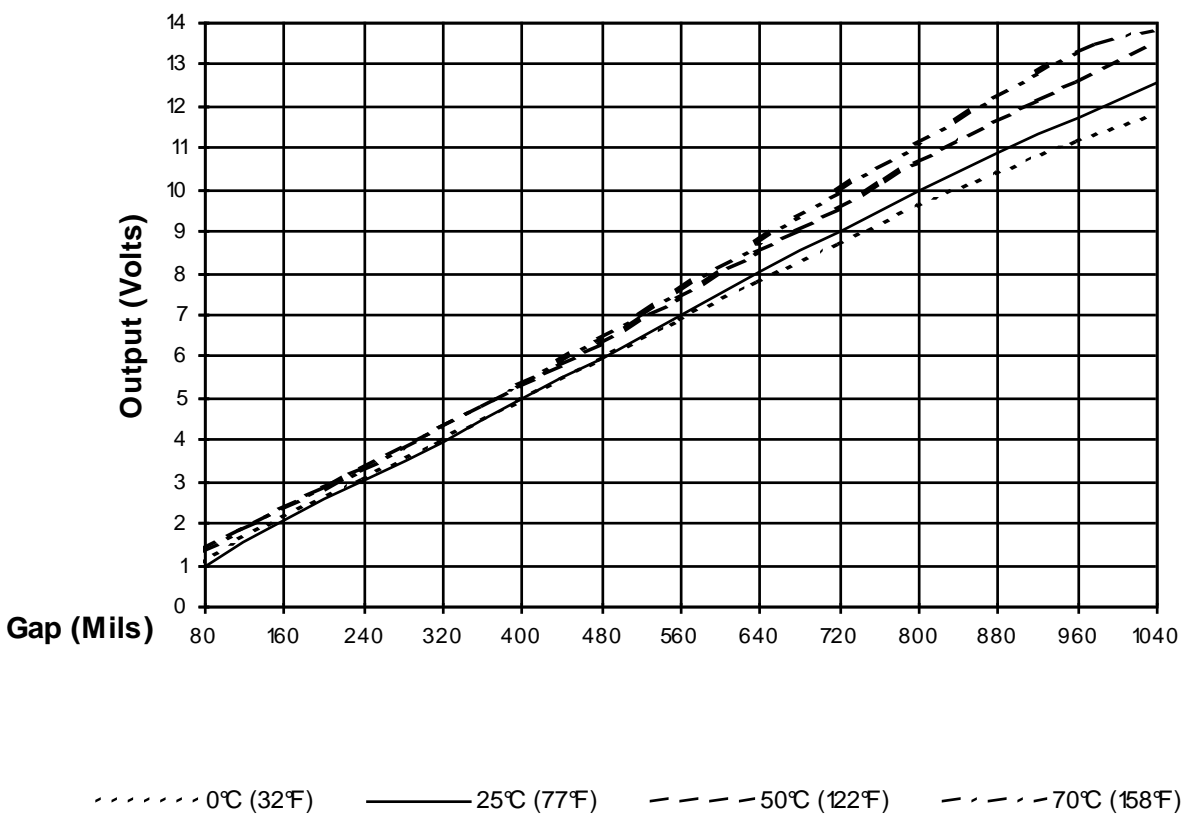
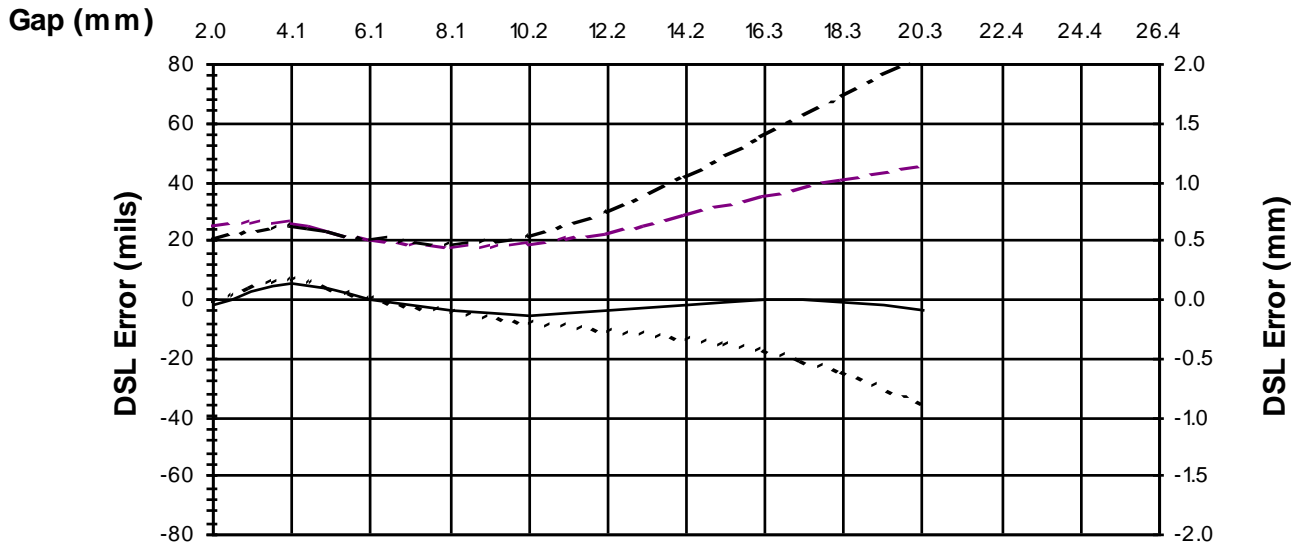
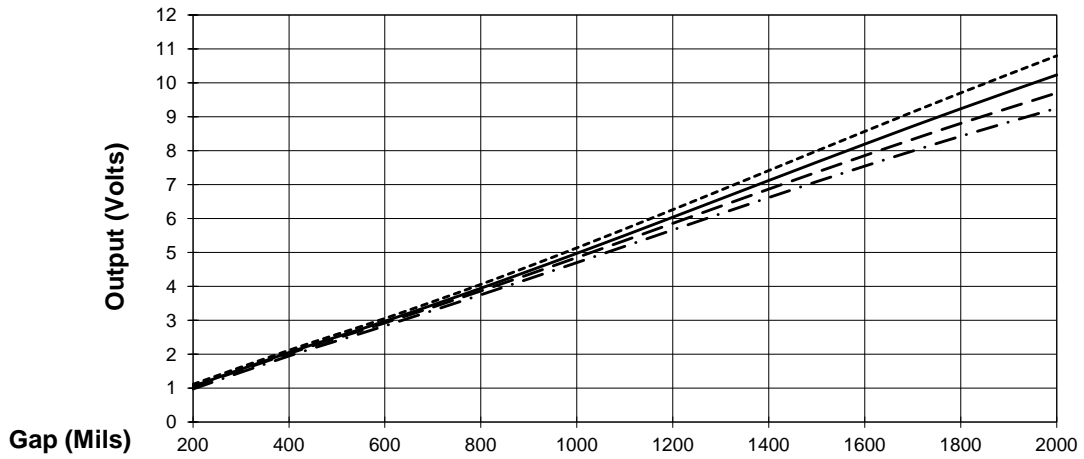
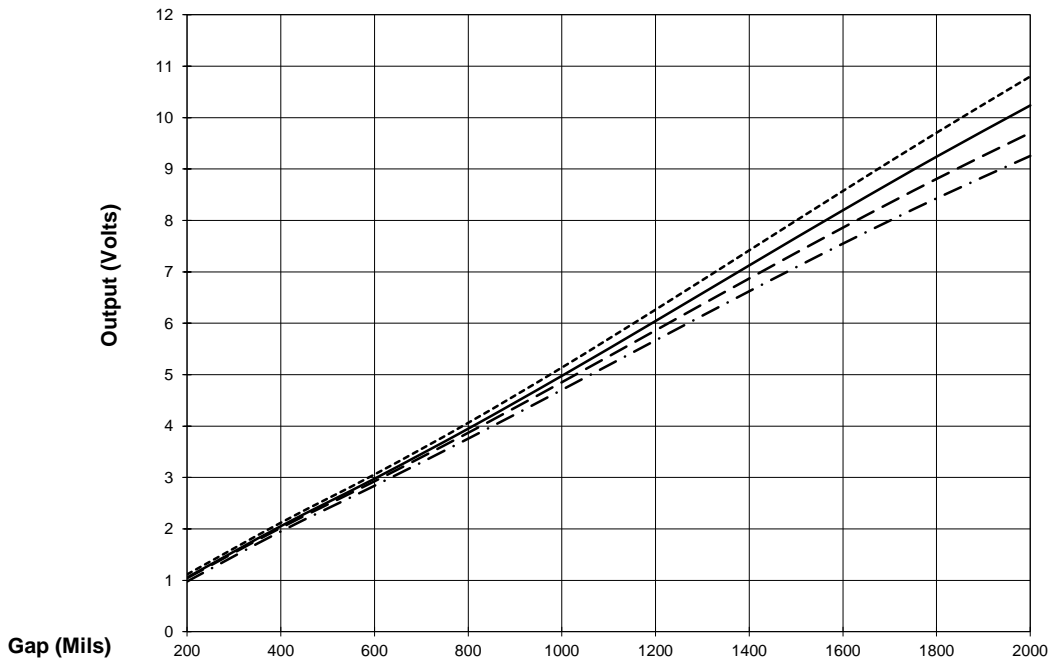


Figure 7: Typical Air Gap 20 mm Sensor System Over Temperature



----- 0°C (32°F)      ——— 23°C (73°F)      - - - -50°C (122°F)      - · - · 70°C (158°F)



----- 0°C (32°F)      ——— 23°C (73°F)      - - - -50°C (122°F)      - · - · 70°C (158°F)

**Figure 8: Typical Air Gap 50 mm Sensor System Over Temperature**

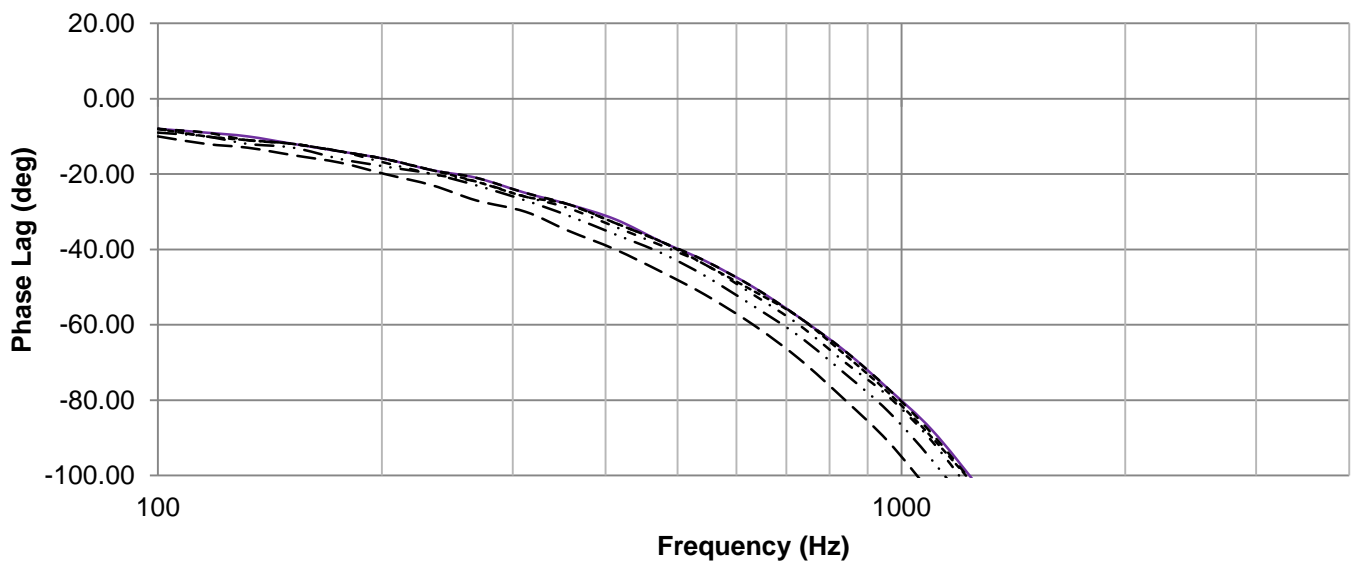
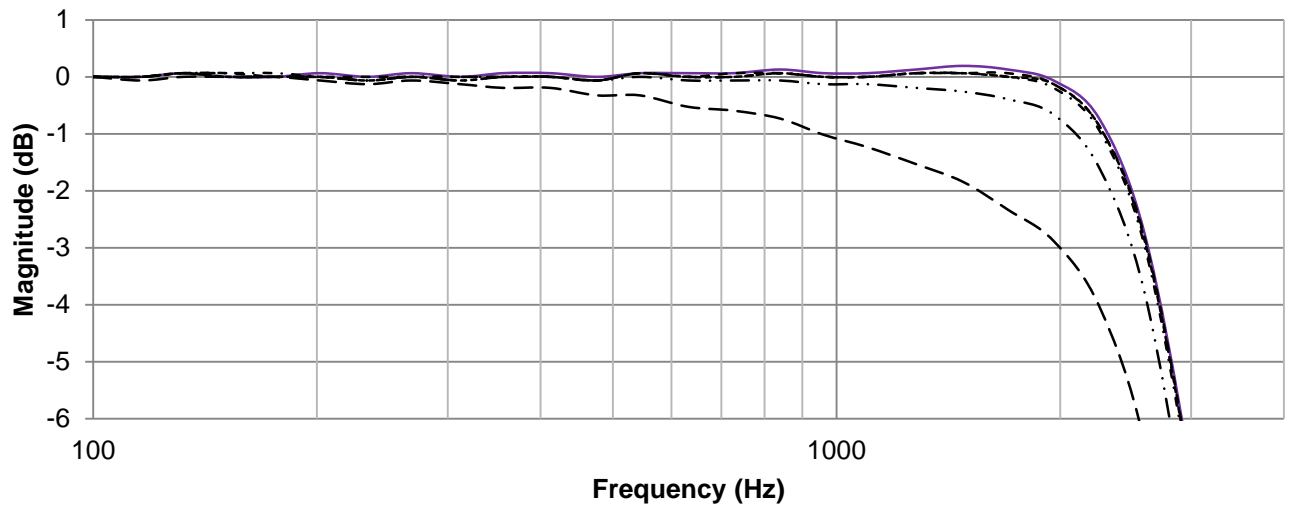


Figure 9: Air Gap Frequency Response

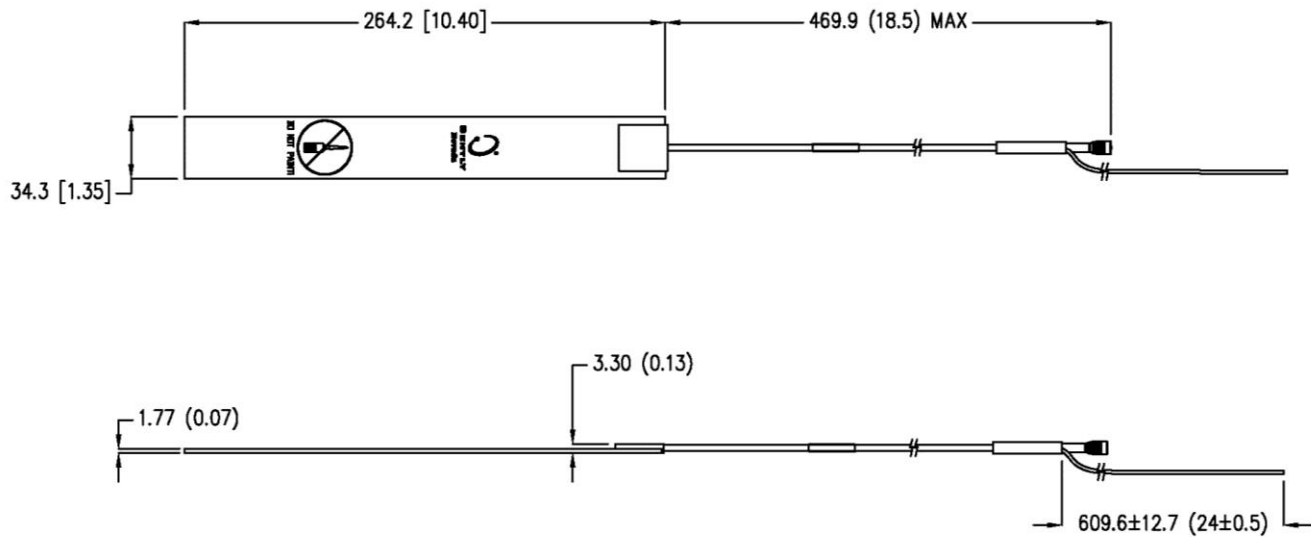


Figure 10: Air Gap 20 mm Probe

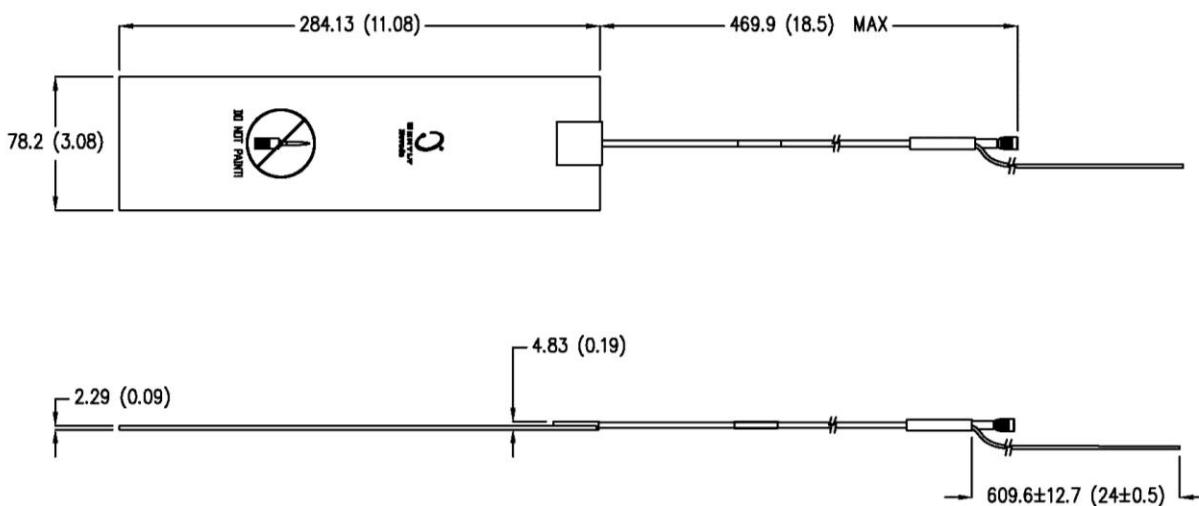


Figure 11: Air Gap 50 mm Probe

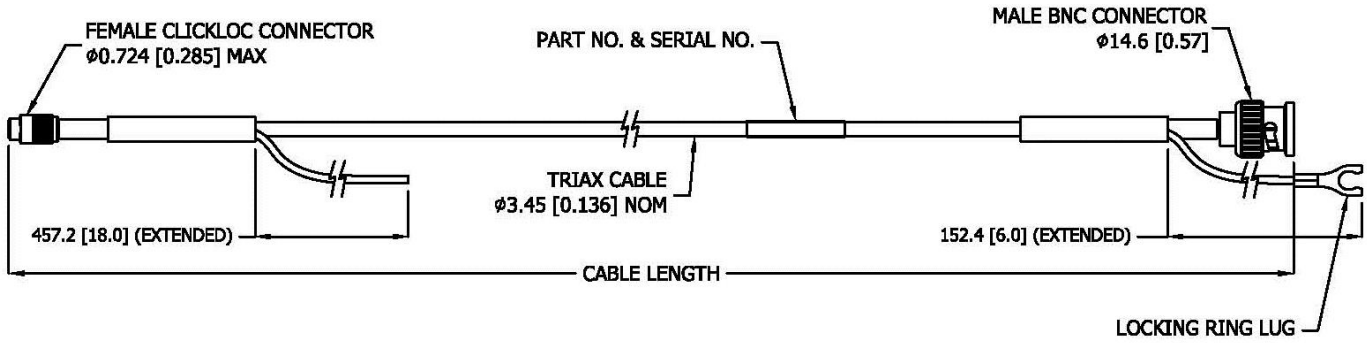


Figure 12: Air Gap 20 mm or 50mm Extension Cable

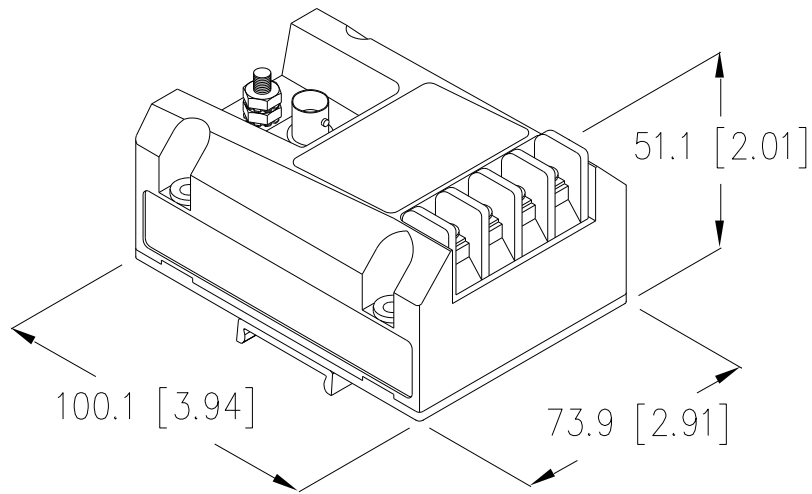


Figure 13: Air Gap 20mm or 50 mm Proximito Sensor



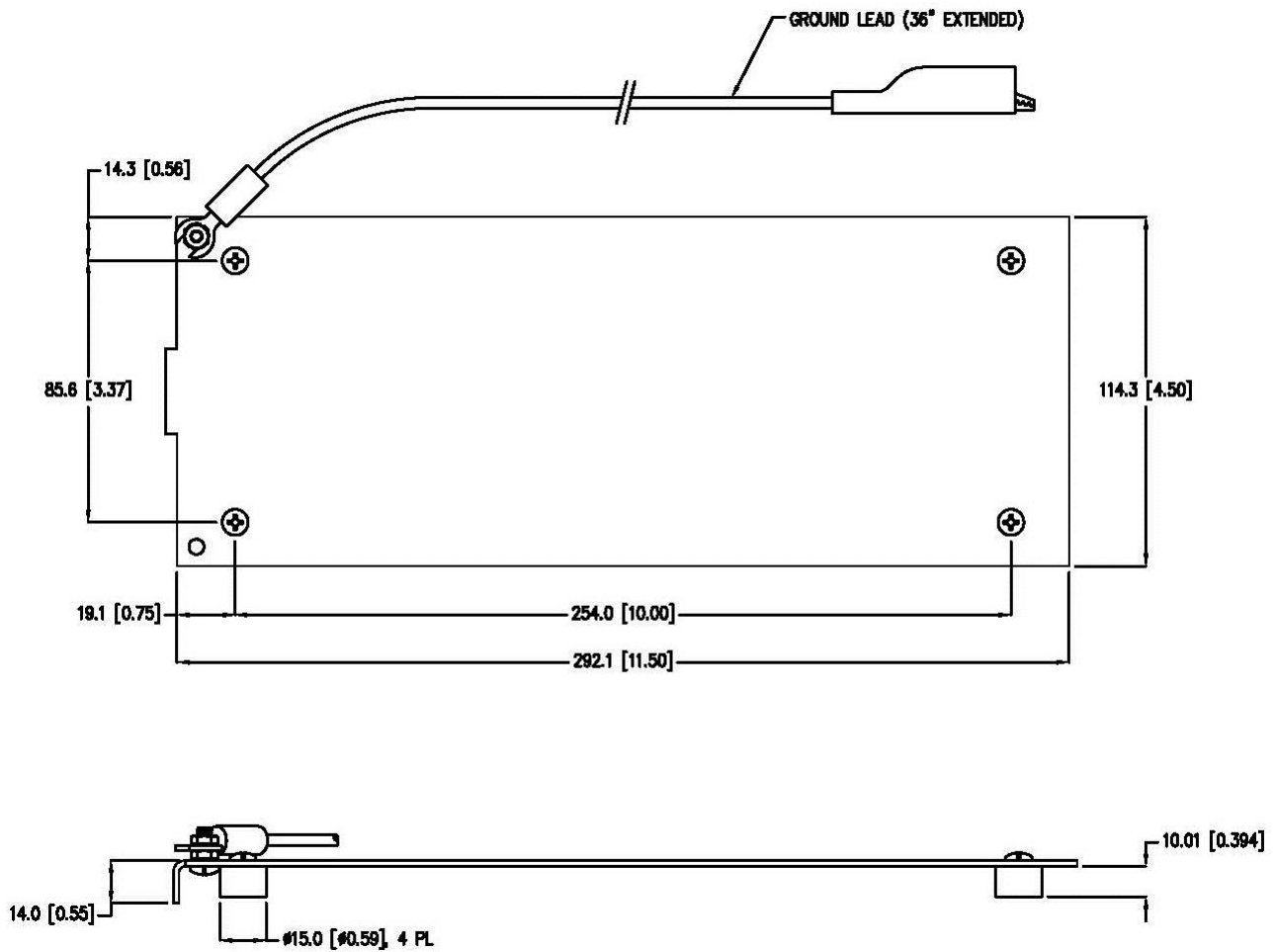


Figure 14: Air Gap Verification Fixture

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