

SENSOR DATA SHEET

# SMU-9000

Noncontact  
position  
measuring systems  
specifically for  
OEM applications



**KAMAN**  
PRECISION PRODUCTS

# SMU-9000

## FEATURES

- > Extremely high resolution, to 1Å
- > Signal-to-noise ratio: 1 PPM
- > Precision of 0.1% of full scale, using computer correction.
- > Small size for efficient system integration: 2 channels ~ 5.5 cubic inches (91 cc)
- > Flexible packaging and performance
- > Single channel or balanced differential operation, and two or three channel models
- > Wide range of sensor options
- > Low power consumption: less than 40 mW per channel.

## OVERVIEW

Kaman's SMU-9000 system uses proven inductive (eddy current) technology to measure position without contacting the target. It is ideal for applications requiring high resolution, including precision machining and grinding, spindle axial runout, mirror alignment, optical stage positioning, metrology measurements, and others.

The SMU-9000 system is based on Kaman's proprietary Pulse Width Modulated electronics, incorporating the latest surface-mount components with printed circuit board designs. Combined with our proven eddy current sensors recognized worldwide for high reliability and outstanding

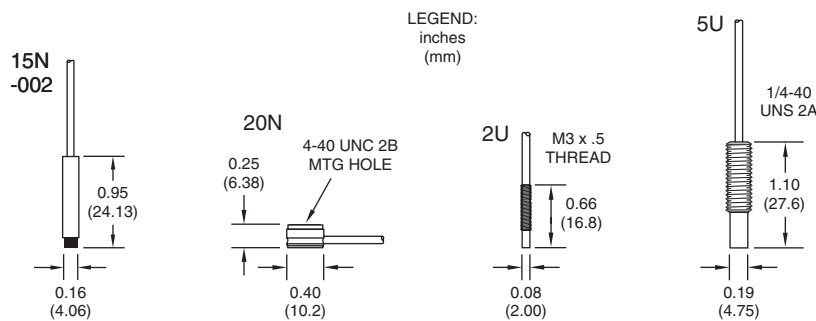
quality, we provide a simple, small, stable, highly-reliable measurement tool.

The SMU-9000 is versatile enough to meet the most demanding of OEM performance and packaging requirements. Chances are, Kaman has already designed a system to measure in places worse than what you have in mind. The SMU system brings the right combination of position sensing performance and packaging elements together at the right price for the OEM.

We offer a wide range of sensors with integral cable and signal conditioning electronics. Four standard sensors and their dimensions and ranges are presented below. Other sensors are available. For best performance, the system must be calibrated with actual target material.

Measuring ranges in excess of 50% of sensor diameter are feasible, with trade-offs in linearity and resolution. Kaman designed this system to offer flexibility in making these trade-offs while optimizing resolution, repeatability, thermal stability, linearity, packaging, and price for your application. In general, systems with the best linearity will not yield the best thermal stability; systems set up for the best thermal stability will be less linear. As a rule, a sensor set up for a measuring range equal to about 10% of its diameter against a nonmagnetic target will be linear to 1% with thermal stability of 0.05% full scale output (FSO)/°C.

## RECOMMENDED SMU-9000 SENSORS



## TYPICAL MEASURING RANGE

<b>15N:</b>	35 mils (0.9mm)
<b>20N:</b>	75 mils (1.9mm)
<b>2U:</b>	20 mils (0.5mm)
<b>5U:</b>	50 mils (1.3mm)

## OTHER KAMAN SENSORS TO CONSIDER:

3U1, 6U1, 9U, 12U, 26U, 38U, 51U

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At this range, if optimal linearity is needed, the system can be adjusted to provide nonlinearity of less than 1% while the temperature stability decreases (temperature coefficient = 0.05% FSO/°C). Likewise, if temperature is the more critical parameter, at this range the temperature coefficient can be as low as 0.01% FSO/°C with nonlinearity increasing to ±3% typically. Fifth order polynomial curve fit linearity coefficients can be provided for use in customer processors to achieve linearity performance of ~0.01% FS.

Often, when considered early in the design cycle, these trade-offs are easily managed through the proper choice of measuring range, sensor size, and target material. With computer modeling, we can provide you with a specification unique to your application. At the same time, we provide preliminary drawings of the sensor and electronics, as well as mounting provisions, operating and storage temperatures, and other parameters.

Custom packaging and sensor designs are also available. These include signal conditioning electronics integral to the sensor for three-wire operation (+6 to +30 Vdc, common, and signal out). The minimum package size for integral sensors is 15 mm x 45 mm. Smaller sensors will require signal conditioning electronics separate from the sensor itself. Multiple channels, synchronized and on a single PC board, are also available.

While the SMU-9000 was designed to be customized, Kaman does offer standard sensors and packaging. Many applications do not require customizing, while others benefit from a proof of concept measurement study. In either case, an off-the-shelf part will help to speed delivery time. Standard sensors and specifications are shown on *page 2*.

## APPLICATION SUCCESS STORIES

### AIRCRAFT MANUFACTURING: DYNAMIC RIVET HEIGHT INSPECTION

The small 2U sensor provides the needed range and fits the limited space available in this dynamic inspection system that measures rivet height and uniformity. Nonlinearity is not important in this application due to computer correction.

**Part number:** Custom system.

**Sensor:** 2U, 3 channels.

**Target material:** Aluminum.

**Offset:** 0.5 mm.

**Range:** 0.5 mm.

**Nonlinearity:** ±10% FSO.

**Resolution:**

*Static:* <math>5 \times 10^{-9}</math> meter.

*Dynamic:* <math>5.0 \times 10^{-9}</math> meter/root Hz.

**Power supply requirements:**

*Input voltage:* +7.5 to +30 Vdc.

*Input current:* 15 mA per channel.



**Sensitivity:** 10 V/mm.

**Frequency response:** Static to 10 kHz (-3 dB).

**Cable length:** 2 meters, RG-178.

**Output, full range:**

*Analog:* 0 to 5 Vdc.

*Impedance:* 100 W.

**Temperature coefficient:**

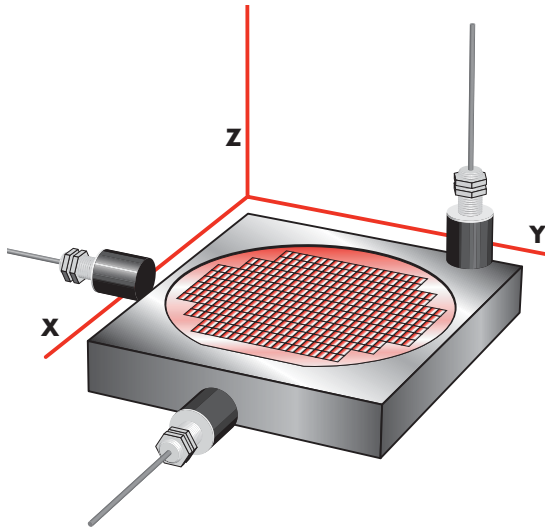
<math>0.5</math> mm/°C (10.0 μinch/°F).

# SENSOR DATA SHEET

## SMU-9000

### APPLICATION SUCCESS STORIES

#### HIGH-PRECISION 3-CHANNEL PHOTOLITHOGRAPHY STAGE POSITION



This system is designed to be an integral part of the latest generation of photolithography equipment. Feedback from Kaman's sensors allow for extremely precise 3-axis positioning of the stage.

**Part number:** 854562-001.

**Sensor:** 16U, 3 channel system.

**Target material:** Aluminum.

**Offset:** 0.5 mm.

**Range:** 1.6 mm.

**Nonlinearity:**

$\pm 7.0\%$ ;  $\pm 0.1\%$  using 5th order polynomial.

**Resolution:** *Static:*  $< 25 \times 10^{-9}$  meter.

*Dynamic:*  $< 2.5 \times 10^{-9}$  meter/root Hz.

**Sensitivity:** 12.5 V/mm.

**Power supply requirements:**

*Input voltage:*  $\pm 15$  Vdc.

*Input current:* 15 mA per channel.

**Frequency response:** Static to 10 kHz (-3 dB).

**Cable length:** 1.0 meter.

**Output, full range:** Analog:  $\pm 10.0$  Vdc.

**Temperature coefficient:**

$< 2$  mm/ $^{\circ}$ C (40  $\mu$ inch/ $^{\circ}$ F).

**Enclosure:** Die cast metal.

3.2 in x 2.8 in x 2.3 in, gray enamel paint.

#### HIGH-PRECISION 1-CHANNEL PHOTOLITHOGRAPHY STAGE POSITION

Kaman's single-channel system provides feedback for positioning the optical head in a photolithography process. High resolution and extremely good repeatability are critical in this application.

**Part number:** 853834-001.

**Sensor:** 15N, 1 channel.

**Target material:** Aluminum.

**Offset:** 0.25 mm.

**Range:** 25 mm.

**Nonlinearity:**  $\pm 1\%$  FSO.

**Resolution:** *Static:*  $< 25 \times 10^{-11}$  meter.

*Dynamic:*  $< 2.5 \times 10^{-11}$  meter/root Hz.

**Sensitivity:** 0.4 V/mm.

**Power supply requirements:**

*Input voltage:* +12 to +30 Vdc.

*Input current:* 15 mA per channel.

**Frequency response:** Static to 10 kHz (-3 dB).

**Cable length:** 0.5 meter, RG-178.

**Output, full range:** Analog: 0 to 10 Vdc.

*Impedance:* 100 W.

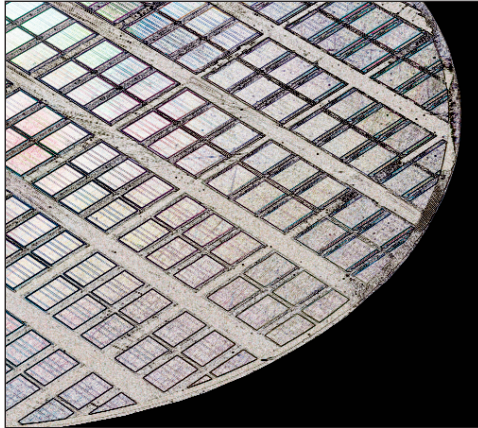
**Temperature coefficient:**

$< 0.5$  mm/ $^{\circ}$ C (10.0 minch/ $^{\circ}$ F).

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**SMU-9000**

APPLICATION SUCCESS STORIES

SEMICONDUCTOR WAFER  
AND MASK (RETICLE) INSPECTION



*In this setting, Kaman's system provides position feedback to bring the subject (wafer or mask) into initial focus prior to inspection. Then, an optical system performs the final focus. High resolution and repeatability are critical.*

**Part number:** 853834-004  
**Sensor:** 15N, 1 channel.  
**Target material:** Aluminum.  
**Offset:** 0.625 mm.  
**Range:**  $\pm 0.25$  mm.  
**Nonlinearity:**  $\pm 1\%$  FSO using 5th order polynomial.  
**Resolution:** *Static:*  $< 5 \times 10^{-9}$  meter.  
*Dynamic:*  $< 0.5 \times 10^{-9}$  meter/root Hz.  
**Sensitivity:** 10 V/mm.  
**Power supply requirements:**  
*Input voltage:* +6 to +30 Vdc.  
*Input current:* 15 mA per channel.  
**Frequency response:** Static to 10 kHz (-3 dB).  
**Cable length:** 0.5 meter RG-178.  
**Output, full range:** *Analog:*  $\pm 2.5$  Vdc.  
*Impedance:* 100 $\Omega$ .  
**Temperature coefficient:**  $< 0.25$  mm/ $^{\circ}$ C (5.0  $\mu$ inch/ $^{\circ}$ F).

READ/WRITE HEAD MANUFACTURING  
AND LAPPING PLATE POSITION



*Using three 2-channel single-ended systems balanced for differential operation, this head assembly manufacturer monitors the read/write head position relative to the lapping plate.*

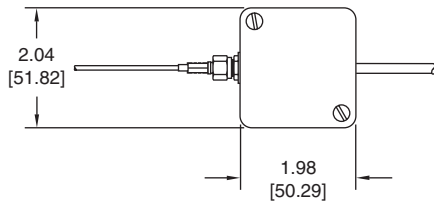
**Part number:** Custom system.  
**Sensor:** 20NEP, 2 channels.  
**Target material:** Aluminum.  
**Null gap:** 0.5 mm.  
**Range:**  $\pm 25$  mm.  
**Nonlinearity:**  $\pm 1\%$  FSO.  
**Resolution:** *Static:*  $< 5 \times 10^{-11}$  meter.  
*Dynamic:*  $< 5.0 \times 10^{-11}$  meter/root Hz.  
**Sensitivity:** 0.4 V/mm.  
**Power supply requirements:**  
*Input voltage:* +12 to +30 Vdc.  
*Input current:* 15 mA per channel.  
**Frequency response:** Static to 10 kHz (-3 dB).  
**Cable length:** 1.0 meter, RG-178.  
**Output, full range:** *Analog:* 0 to 10 Vdc.  
*Impedance:* 100 $\Omega$ .  
**Temperature coefficient:**  $< 0.25$  mm/ $^{\circ}$ C (5.0  $\mu$ inch/ $^{\circ}$ F).

SENSOR DATA SHEET  
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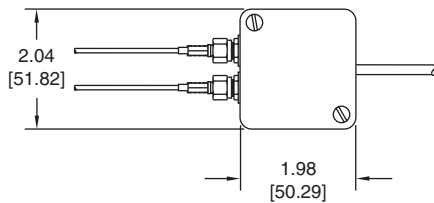
APPLICATION SUCCESS STORIES

- › Optical stage position measurement
- › Semiconductor and optics polishing and grinding
- › Semiconductor mask alignment stepper systems
- › Vapor deposition systems
- › Scanning electron microscope - vertical axis positioning
- › Atomic force microscopy - vertical axis positioning
- › Magnetic bearing suspension control
- › Fine positioning for parts grinding and precision machining
- › Aircraft rivet height inspection
- › Mirror steering
- › Material compression testing measurement
- › Mechanical structure creep detection and testing

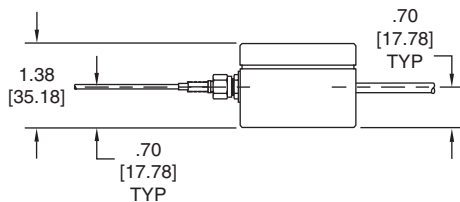
ELECTRONICS CONFIGURATIONS



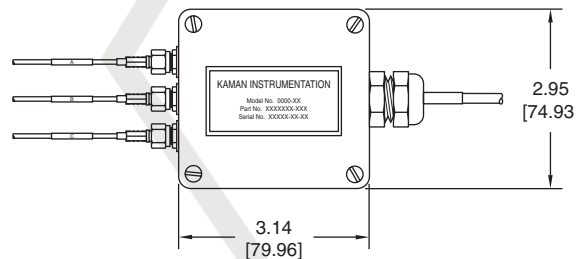
*Single-channel system. Top view.*



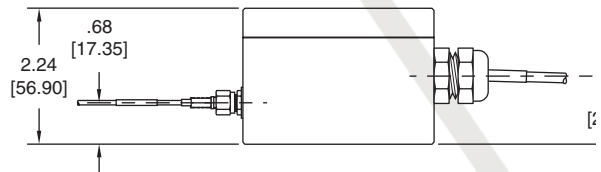
*Dual-channel system. Top view.*



*Single- and dual-channel systems. Side view.*



*Three-channel system. Top view.*



*Three-channel system. Side view.*

*Polycarbonate enclosure.  
 Die cast aluminum available.*