KμDA
Kaman's Micro Digital Advantage

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KAMAN

Contents

Part I: Welcome

Introduction

Kaman Instrumentation, for 30 years the world leader in high-precision inductive position measuring systems, now offers KµDA (Kaman's Micro Digital Advantage), an easy to use, high-performance digital measurement system. Set-up is quick; you can calibrate the system yourself with only six keystrokes on the front panel.

KµDA is also extremely flexible, built with the future and your changing needs in mind. KµDA's performance is easily upgradeable via embedded software. This means when your requirements change, Kaman can provide you with software to implement the necessary changes in KµDA. In addition, if you need to change sensors to accommodate a different measuring range, all adjustments to KµDA can be handled through software. There is no need to send the system back to Kaman.

Features Summary / Advantages

- Out of the box measurements, set-up is quick
- 3 Point push-button calibration, easy-to-use
- Simple Windows based commands
- Change of sensors without changing electronics
- Single or dual channel configuration
- 3 User configurable switches
- 3 Analog voltage *and* current outputs
- User adjustable output voltage range
- 2 LED Bargraphs
- RS232 interface
- Fast sampling, up to 10,000 / second
- Small electronics footprint for tight spaces
- Powerful new signal conditioning and error correction
- Active temperature compensation
- Kaman's unmatched precision, reliability, and service
- Standard Sensors with moderate temperature (200 $^\bullet$C) capability

KµDA System Options

- Power Supply
- Micrometer calibration fixture
- Ceramic spacers
- Special factory calibration
- Special custom software functionality
- Single channel to dual channel upgrade
- Wide selection of sensors

Part II: Setting up the System

What is Included with your KµDA System

- KµDA Electronics
- KµDA Sensors (one or two)
- KµDA Hardware Manual
- KµDA View Manual and Software disk (3 1/2")

Cautions and Safeguards

- To protect against risk of electrical shock, do not place the system module in water.
- Do not operate with a damaged power cord.
- Do not let power cords or sensor cables touch hot surfaces.
- The KµDA power supply should be OFF when connecting or disconnecting it from KµDA.
- Unplug all power supplies before attempting to make any hardware modifications.
- Do not expose system components to excessive heat or moisture.

KµDA Electrical Connections

KµDA Electrical Connections Diagram

RS 232 Connector
(as viewed)

Gnd   TX232
RX232

5 4 3 2 1

9 8 7 6

Power Supply Connector
(as viewed)

+5V   Gnd
+12V   -12V

Gnd

KAMAN
Instrumentation

Keys Off   Error   Power

Calibrate
Run

Set Minimum
User Function 1

Set Mid Point
User Function 2

Set Maximum
User Function 3

Sensor 1   Min   Max
Select / Zero

Sensor 2   Min   Max
Select / Zero

KµDA

Sensor 1   Sensor 2

Terminal Block Connector
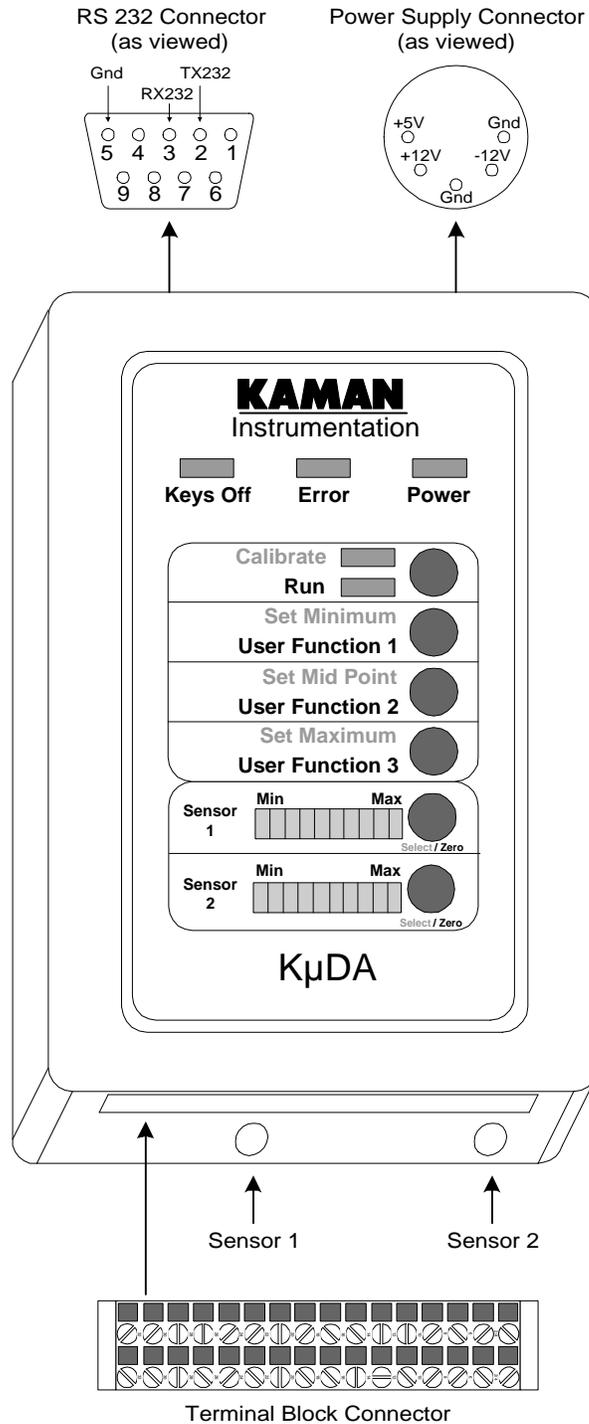
Figure 1: KµDA Electrical Connections

Connecting the Power Supply

The KµDA electronics uses a standard 5 pin DIN connector to bring +5 VDC and ±12 VDC into the electronics. Alternatively, the connections may be made via the terminal block.
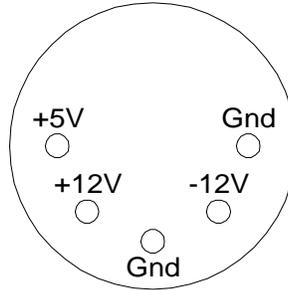
Figure 2: Power Supply DIN Connector (as viewed)

NOTE: All grounds are connected internally

An optional power supply is available from Kaman Instrumentation, but other power supplies may be used if the following requirements are met. For best performance, a power supply with low output noise and good regulation should be used.

Connector Pin name	Function
+5V	Power supply input voltage, + 5.0 ± 10 % @ 1.7 amps max.
+12V	Power supply input voltage, + 12.0 ± 10 % @ 0.35 amps max.
-12V	Power supply input voltage, - 12.0 ± 10 % @ 0.35 amps max.

WARNING:

Connecting power to any other than the specified pins may cause damage to KµDA and/or power source.

Power supply voltages in excess of the rating may damage KµDA.

Connecting the Sensors

KµDA electronics and sensors utilize SMA type coaxial connectors: female on the electronics, male on the sensor cable. Connect Sensor 1 to the connector labeled "SENSOR 1" and Sensor 2 to the connector labeled "SENSOR 2". To connect the sensor to the electronics, simply thread the male connector onto the female connector, located at one end of the electronics enclosure. (Use care not to cross thread or over torque the connections).

> Since the sensor and its cable are electrical components of the calibrated system, it is important to match each sensor to its proper connection. Connecting a sensor to the wrong input will cause severe degradation in performance!

Connecting RS232

KµDA supports digital communications via RS232 through a female DB9 connector. It functions as a Data Circuit-terminating Equipment (DCE) device, receiving data on pin 3 and transmitting data on pin 2. This pinout is required to hook directly to the serial port on most PC-compatible computers. An optional DB9 male to DB25 female adapter is available for compatibility with computers using the DB25 interface.

KµDA uses no hardware handshaking - only the transmit, receive, and ground pins are used for communications. If possible, you should disable hardware handshaking at your computer or terminal. If your computer or terminal interface requires hardware handshaking, it may be necessary to connect the DTR (pin 4 on DTE connector) with DSR (pin 6 on DTE connector) and / or the CTS (pin 8 on DTE connector) with RTS (pin 7 on DTE connector) at your computer or terminal.

RS 232 Connector (as viewed)
DCE Equipment

Gnd   TX232
        RX232

5   4   3   2   1
    9   8   7   6
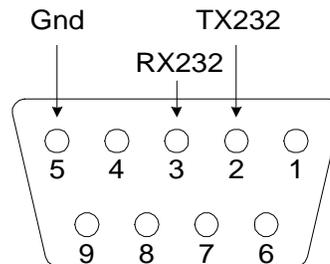
Terminal Block Connector

KµDA's terminal block is used to interface to the analog and digital outputs. It can also be used as a redundant method of connecting power and serial I/O communications (RS232 or RS485).
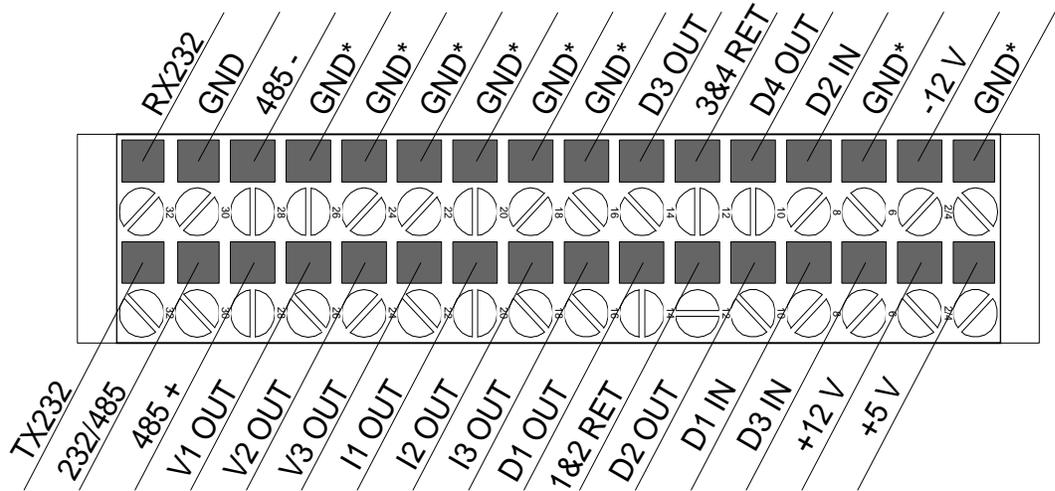
Figure 3: Terminal Block Pinout

*NOTE: All connections labeled "GND" are connected internally. For optimum performance, use the closest ground connection to the signal input or output.

Terminal Block Pin Summary

| Pin name (top)	Function			Function		Pin name (bottom)
c32	RX232:	RS232 receive line		TX232:	RS232 transmit line	a32
c30	GND:	Use for RS232 and RS485.		232/485:	Serial I/O select: Ground - RS485 is active Open or high - RS232 is active	a30
c28	485-:	RS485 Negative logic input/output		485+:	RS485 Positive logic input/output	a28
c26	GND	Use for V1 OUT.		V1 OUT:	Voltage output # 1	a26
c24	GND	Use for V2 OUT.		V2 OUT:	Voltage output # 2	a24
c22	GND	Use for V3 OUT.		V3 OUT:	Voltage output # 3	a22
c20	GND	Use for I1 OUT.		I1 OUT:	Current output # 1	a20
c18	GND	Use for I2 OUT.		I2 OUT:	Current output # 2	a18
c16	GND:	Use for I3 OUT.		I3 OUT:	Current output # 3	a16
c14	D3 OUT:	Optically isolated open collector output #3		D1 OUT:	Optically isolated open collector output #1	a14
c12	3&4 RET:	Signal return for optically isolated outputs 3 & 4		1&2 RET:	Signal return for optically isolated outputs 1 & 2	a12
c10	D4 OUT:	Optically isolated open collector output #4		D2 OUT:	Optically isolated open collector output #2	a10
c8	D2 IN:	Discrete digital input # 2, CMOS logic levels		D1 IN:	Discrete digital input # 1, CMOS logic levels	a8
c6	GND:	Use for D1 IN - D3 IN.		D3 IN:	Discrete digital input # 3, CMOS logic levels	a6
c4	-12 V:	Power supply input voltage, - 12.0 ± 10 % @ 0.35 amps max.		+12 V:	Power supply input voltage, + 12.0 ± 10 % @ 0.35 amps max.	a4
c2	Pwr Sply Gnd:	Use for Power Supply connections.		+5 V:	Power supply input voltage, + 5.0 ± 10 % @ 1.7 amps max.	a2

KµDA Signal Descriptions

Serial I/O

RX232 and **TX232** are the standard receive and transmit lines, respectively for RS232. They are electrically in parallel with the signals on the 9 pin RS232, offering an alternative means of wiring up a serial I/O connection.

232/485 is the connection for enabling either RS232 or RS485. If the connection is left open or pulled up to + 5 V, RS232 will be enabled. If the connection is tied to GND, RS485 will be enabled.

485 + and 485 - are the standard positive and negative logic signals, respectively for RS485.

Voltage Outputs

V1 OUT, V2 OUT, and V3 OUT are the voltage outputs from KµDA. V1 OUT voltage is a measure of the position of Sensor 1 with respect to its target. V2 OUT voltage is a measure of the position of Sensor 2 with respect to its target. V3 OUT voltage is a measure the value of a function computed inside KµDA. For example, in thickness application, V3 OUT voltage is a measure of the thickness of the target. See "Part VI: Thickness Measurements" on page 31 for a description of how KµDA can be used to make thickness measurements.

KµDA's output voltage range as the target moves from the minimum to the maximum calibrated positions is adjustable over a wide range of values.

The output voltage when the sensor is at the minimum calibrated distance from the target is adjustable from -10 V to 0 V.

The output voltage when the sensor is at the maximum calibrated distance from the target is adjustable from 0 V to +10 V.

This adjustment feature allows the user to match output voltage to engineering units or to the input range of a control system or A/D converter.

Consult the KµDA View software manual for details on how to adjust the output voltage range.

KµDA's V1 OUT, V2 OUT, and V3 OUT voltage outputs can optionally be filtered by a first order digital filter. Consult the KµDA View software manual for details on how to enable and adjust the digital filter.

Current Outputs

I1 OUT, I2 OUT, and I3 OUT are the current outputs from KµDA. I1 OUT is a measure of the position of Sensor 1 with respect to its target. I2 OUT is a measure of the position of Sensor 2 with respect to its target. I3 OUT is a measure the value of a function computed inside KµDA. For example, in thickness application, I3 OUT is a measure of the thickness of the target.

The current outputs are slaved to the voltage outputs. To use the current outputs over the standard 4 to 20 mA range, the output voltage range must be set to $\pm$ 10 V. Consult the KµDA View software manual for details on how to adjust the output voltage range.

Since KµDA's I1 OUT, I2 OUT, and I3 OUT current outputs are slaved to the voltage outputs, they can optionally be filtered by a first order digital filter. Consult the KµDA View software manual for details on how to enable and adjust the digital filter.

Optoisolated Digital Outputs

D1 OUT, D2 OUT, D3 OUT, and D4 OUT are optoisolated open collector digital outputs from KµDA. They can be used as limit outputs to provide a signal when any of the measurements for Sensor 1, Sensor 2, or special function are exceeded. Using KµDA View, the following parameters can be adjusted:

- the source of the limit checking - Sensor 1, Sensor 2, or special function

- the threshold level

- active state can be defined as high or low

- Hysteresis on the thresholds

Consult the KµDA View software manual for details on how these adjustments are defined.

Digital Inputs

D1 IN, D2 IN, and D3 IN are digital inputs to KµDA. There are pullup resistors on each of these inputs. As a standard definition, bringing the D1 IN, D2 IN, and D3 IN inputs to ground (via a remote switch, for example) performs the same function as depressing the User Function 1, User Function 2, and User Function 3 switches on the front panel.

Since the action of the switches is under software control, custom functions can also be defined and controlled.

Power Supply Connections

-12 V, +12 V, and + 5 V are power supply inputs. They are electrically in parallel with the standard 5 pin DIN connections, offering an alternative means of providing power to KµDA.

Sensor Mounting and Fixturing

Shielded and Unshielded Sensors

The specified linear measuring range for a sensor is directly proportional to the diameter of the sensor coil. Changes in oscillator frequency or power delivered to the sensor coil have little effect on the measuring range. For a given sensor coil diameter, shielded sensors have a smaller measuring range than unshielded sensors. This is because the sensor's field will "couple" with the shield, in effect limiting the amount of field available for interacting with the target, as illustrated below.

TARGET

UNSHIELDED SENSOR

TARGET

SHIELDED SENSOR
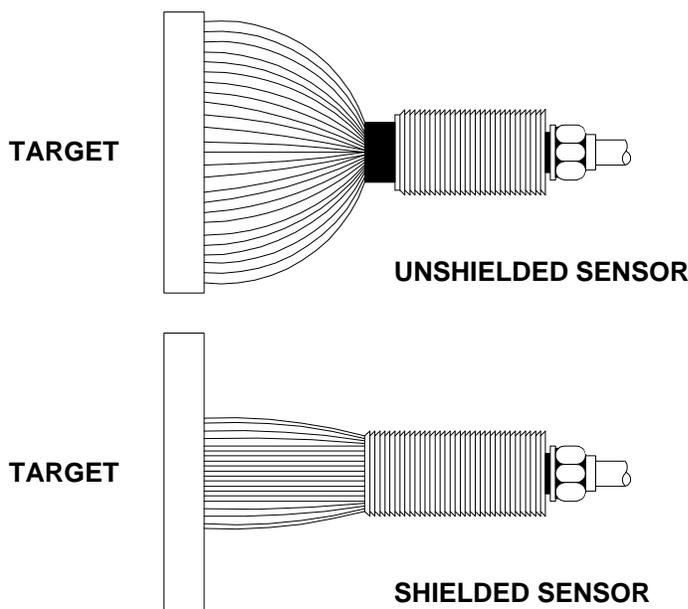
Fixturing for Sensor Mounting

Sensor mounting is critical to the operation and accuracy of the measuring system. One very basic consideration is the stability of the calibration and measurement fixtures. If either one is not stable through changing environmental conditions such as dimensional changes due to temperature or vibration of the mount relative to the target, errors will result. A change in position of the sensor and fixture of 0.00001" (10 micro inch) where 0.001" of accuracy is required is negligible. The sensor fixturing must be capable of maintaining the accuracy required by your application. Mounting techniques will vary depending upon whether you have a shielded or unshielded sensor. Using the temperature compensation feature, you can compensate for fixture drift to some degree *as long as it is linear and repeatable with temperature*.

Any stable mounting configuration is acceptable when it is in a non-conductive fixture. This will not affect system performance,

as the sensor cannot "see" a non-conductive material. If you mount the sensor in a conductive fixture, it can interact with the fixture and change system calibration. Shielded sensors will interact with a conductive fixture less than an unshielded sensor. If you locate a sensor in a conductive fixture, calibrate the channel with the sensor in place, or in a simulated fixture that duplicates the actual loading effects of your application fixture.

Whenever you calibrate a channel using a simulated fixture, install the sensor in the application fixture exactly as it was in the simulated one. When moving from the simulated fixture to the application fixture, deviations such as a change in loading, a different mechanical position, or a dissimilar mount will change the calibration of the channel to some degree. For maximum accuracy, it's best to calibrate a channel with the sensor in the application fixture.

Give consideration to the proximity of conductive materials not related to the fixturing that may pass within the "viewing" area of the sensor. The figure below illustrates the general rule for viewing area for shielded and unshielded sensors. For an unshielded sensor, mount it at a distance equivalent to 2.5 to 3 times the sensor's diameter away from conductive material, and 1.5 to 2 times the sensor's diameter for a shielded sensor. These materials in the viewing area act as a target and may affect calibration and the measuring range. For this reason, *any other conductive material in the viewing area must be absolutely dimensionally stable with reference to the sensor coil.*

**SENSOR
VIEWING
AREA**

**SHIELDED SENSOR
1.5 TO 2X DIAMETER**

**UNSHIELDED SENSOR
2.5 TO 3X DIAMETER**
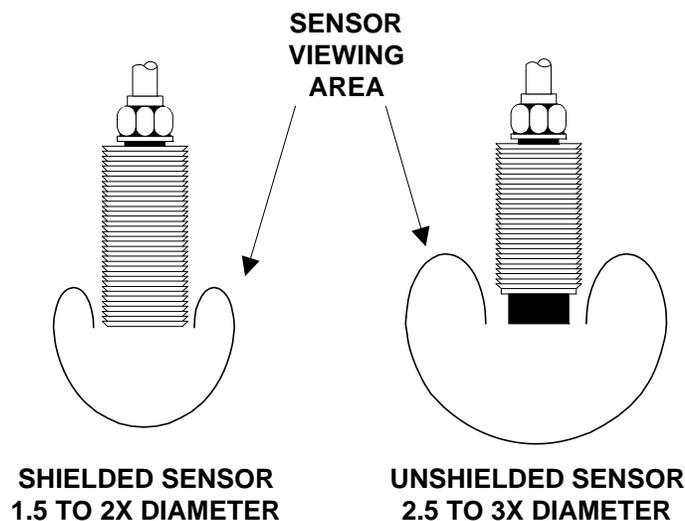
Surface Mounting Sensors:

Surface mounting a sensor will not affect its calibration, assuming there are no conductive parts other than the target in close proximity to the sensor face. When surface mounting in a

conductive fixture, the distance considerations are as given below. This is highly dependent on the type of sensor housing. Metal housings require less distance.

2.5 TO 3 X
SENSOR
DIAMETER

SENSOR
DIAMETER

UNSHIELDED

0.25 TO 0.5 X
SENSOR
DIAMETER

SENSOR
DIAMETER
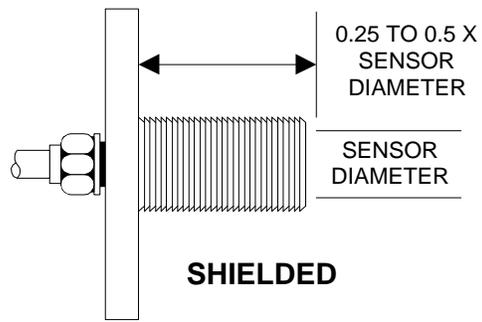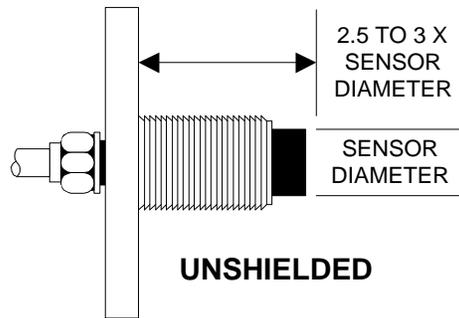
SHIELDED

Flush Mounting Sensors:

If it is necessary to mount any shielded or unshielded sensor in a conductive fixture as illustrated below, calibrate the system in place, or in a simulated fixture. You may find the loading effects of the conductive fixture on the sensor to be so severe that you may not be able to calibrate the system. At best, be prepared to accept degraded performance in measuring range, stability, and resolution of the system. It is possible to reduce the loading effects of the fixture by removing conductive material from the area around the sensor's tip. The amount of material removed depends upon sensor type.

**1.5 TO 2 X
SENSOR DIAMETER**

FULL SHIELD

**0.25 TO 0.5 X
SENSOR DIAMETER**

**2.5 TO 3 X
SENSOR DIAMETER**

PARTIAL SHIELD

**1.5 to 2 X
SENSOR DIAMETER**

**SENSOR
DIAMETER**

**NOT
RECOMMENDED**
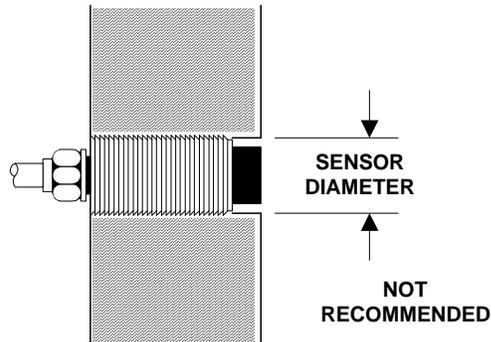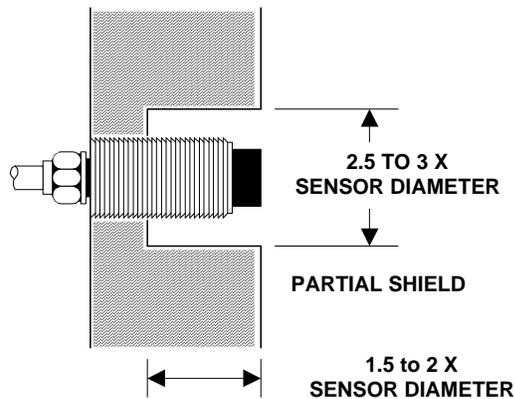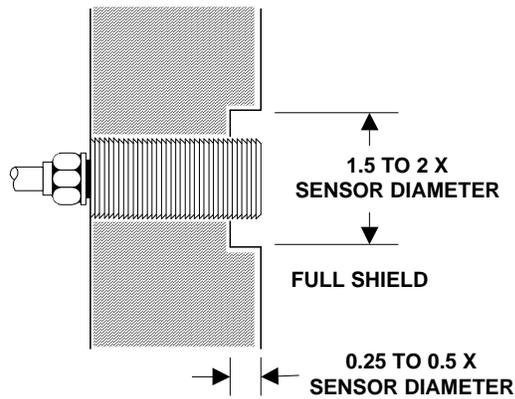
A potential disadvantage in using the technique shown is that the cut-out area may serve as a collection point for refuse, metal filings, cutting oils, coolant, etc. It may also disrupt gaseous or liquid flow patterns in the measurement area. You can effectively solve this problem by backfilling the area with a non-conductive material such as silicon rubber or epoxy.

Targets: Material, Size and Thickness

Material Type:

The target material must be conductive. Non-magnetic targets, such as aluminum, copper, and to a lesser extent, 300 series stainless steel, offer greater stability and linearity than magnetic targets. The system can be optimized to work with either a magnetic or non-magnetic target. This is highly dependent upon sensor diameter. In general, larger sensors work better against magnetic targets.

Target Size:

The size of your target relative to the sensor should be a minimum of 1.5 to 2 times the diameter of a shielded sensor, and 2.5 to 3 times the diameter of an unshielded sensor. Targets larger than the recommended size will have no effect on system performance. A target that is 3 times the diameter of an unshielded sensor will "look" the same as one that is 300 times its diameter.

Using targets smaller than the recommended size will result in some degradation of system performance, specifically in linearity and long term stability. Smaller targets also result in the measurement becoming dependent upon the horizontal as well as the vertical position of the target. Insure that there is minimal lateral movement of the target when using smaller targets.

Target Thickness:

The density of the field produced by the sensor is greatest at the surface of a target, although there is penetration beyond this point. The extent of the penetration is a function of the resistivity and permeability of the target as well as the carrier frequency used in the measuring system. Temperature will also contribute to field penetration to the extent that it affects resistivity and permeability. In general, highly resistive targets will allow for deeper penetration of the field. The lower the carrier frequency, the deeper the penetration will be.

Field penetration becomes a concern only when the target material is too thin to capture all of the field. This penetration or "shine through" reduces the strength of interaction between the target and sensor, ultimately reducing linearity, resolution, and long term stability of the measuring system.

Non-magnetic target materials are preferred when possible. Thickness of 0.4mm (0.020") is generally more than adequate.

For good conductors such as aluminum, system performance tends to be independent of target thickness. To avoid potential problems and maximize system performance, use the recommended thickness as shown in the following table. These recommendations are approximate and can vary depending upon sensor size, range, target temperature, etc. Depending on the application, it is possible to get usable information at lesser thicknesses.

Material	Recommended Minimum Thickness in inches
Silver and Copper	.018
Gold and Aluminum	.018
Magnesium, Brass, Bronze, Lead	.048
300 Series Stainless Steel	.090
Inconel	.090

Part III: Getting Started

Quick Start Procedure using KµDA

1. Mount the Sensors.

2. Connect the Sensors to KµDA.

3. Connect to the desired outputs on the terminal block (See the sections titled "Terminal Block Connector" on page 7, "Terminal Block Pin Summary" on page 8, and "KµDA Signal Descriptions" on page 9 for detailed information o the terminal block).

4. Connect the Power Supply to KµDA (See the section "Connecting the Power Supply" on page 5" for power supply connector pinouts).

5. KµDA will go through a power up self test sequence to verify functionality of your system. This will be evident to you by the flashing LEDs.

6. After the self test is complete, KµDA automatically begins taking measurements. The LED bargraph gives an indication of the target to sensor distance.

7. Note: For high precision, stable measurements, allow approximately 1 hour warm up time.

Keypad and Display

Keypad and Display Diagram

KµDA's Front Panel LEDs can be very helpful in quickly identifying the operational status of KµDA. The LED Bargraphs give an approximate indication of displacement.
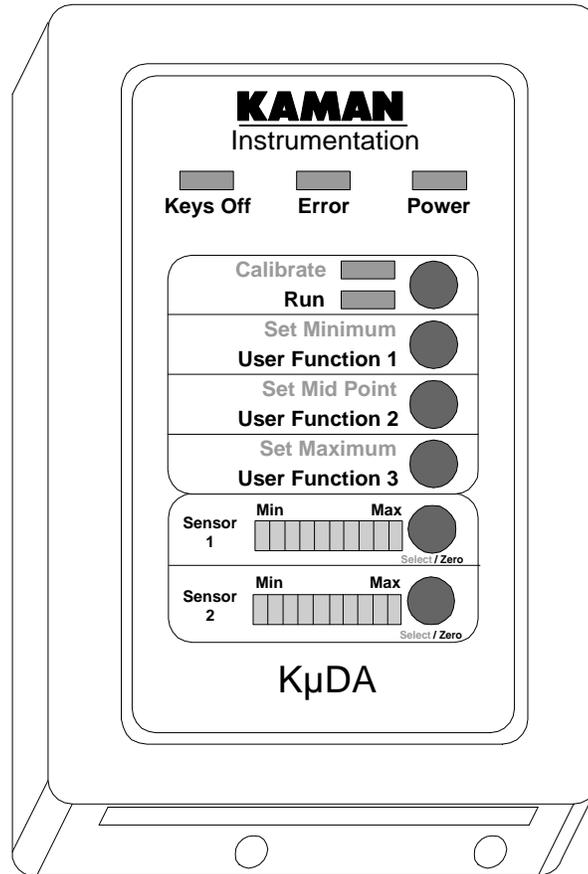

Figure 4: KµDA Keypad and Display

Front Panel LEDs

Keys Off LED

When this LED is ON, the front panel keypad is disabled. This allows the system to be installed in an area where the user may be concerned that a calibration or setting may be accidentally modified.

Consult the KμDA View software manual for details on how to enable or disable the front keypad.

Error LED

This LED is ON whenever KμDA detects an error. KμDA then displays an error code to point to the type of failure. The error code is a 2-digit number formed by counting the number of nonblinking LEDs in the Sensor 1 and Sensor 2 bargraphs. The number of nonblinking LEDs in the Sensor 1 position forms the 10's digit and the number of nonblinking LEDs in the Sensor 2 position forms the 1's digit.

Some of the conditions which can cause an error are:

- Self test detection of hardware fault
- Improper calibration
- Sensors not detected on Measuring Channels

Consult the KμDA View software manual for the complete list of possible error codes.

Power LED

This LED is ON whenever +5 V power is applied to KμDA. It does not imply power on the +12 V or -12 V inputs or that the +5 V power is within specifications.

Calibrate LED

This LED is used to indicate that KμDA is in the process of receiving a new calibration. Position measurements are suspended during calibration.

Run LED

Run LED is the normal mode of operation: This LED is used to signify that KμDA is in the mode of taking position measurements.

LED Bargraphs

The LED Bargraphs consist of a 10 segment display. The first segment is turned ON to indicate to the user that the sensor to target distance is less than the minimum calibrated position. Whenever this LED segment is ON, it flashes as a warning to the user.

The last segment is turned ON to indicate to the user that the target-to-sensor distance is greater than the maximum calibrated position. Whenever this LED segment is ON, it flashes as a warning to the user.

The middle 8 LED segments give a visual indication of the position of the sensor relative to the target. As the target-to-

sensor distance increases, additional LEDs are turned ON, giving the user a "thermometer" code indication of the target-to-sensor distance.

Note: The LED Bargraphs are not intended as a calibrated output. They are intended as a convenience to the user, allowing for a quick and easy means of verifying functionality and approximating target-to-sensor distance.

Front Panel Switches

Calibrate / Run Switch

This switch is used to toggle KµDA between the Calibrate and Run modes of operation. The corresponding LED signals the current mode of operation.

Set Minimum / User Function 1 Switch

This is a dual purpose switch. It's function is determined by whether the Calibrate or Run LED in ON.

If the Calibrate LED is ON, KµDA is in Calibrate mode. This switch is used to signal KµDA that the target is at the Minimum distance from the sensor (see "Part IV: Calibration" on page 23).

If the Run LED is ON, KµDA is in Run mode. This switch is then used to initiate a custom function or action within KµDA. Consult the KµDA View software manual for options on the functionality of the switch.

Set Mid Point / User Function 2 Switch

This is a dual purpose switch. It's function is determined by whether the Calibrate or Run LED in ON.

If the Calibrate LED is ON, KµDA is in Calibrate mode. This switch is used to signal KµDA that the target is at the Mid Point distance from the sensor (see "Part IV: Calibration" on page 23).

If the Run LED is ON, KµDA is in Run mode. This switch is then used to initiate a custom function or action within KµDA. Consult the KµDA View software manual for options on the functionality of the switch.

Set Maximum / User Function 3 Switch

This is a dual purpose switch. It's function is determined by whether the Calibrate or Run LED in ON.

If the Calibrate LED is ON, KµDA is in Calibrate mode. This switch is used to signal KµDA that the target is at the Maximum distance from the sensor (see "Part IV: Calibration" on page 23).

If the Run LED is ON, KµDA is in Run mode. This switch is then used to initiate a custom function or action within KµDA. Consult the KµDA View software manual for options on the functionality of the switch.

Select / Zero Switch

These switches are used to select the channel being calibrated when the Calibrate/Run switch is in the calibrate mode. See the section on Calibration for more details. When the Calibrate/Run switch is in the Run mode, these switches zero the channel output.

Using KµDA View to Customize Your System

KµDA View is a software program that runs on a Windows™ PC compatible computer. It allows you to acquire and analyze data as well as customize your KµDA system. Some examples of data analysis include:

- Poll for data at periodic intervals

- Draw charts with a variety of statistical processing on the data

- View the KµDA configuration

- Communicate with KµDA in a "dumb terminal" mode to access low level functions

Some examples of system customization that can be performed include:

- Adjustment of output voltage ranges.

- Setting of Digital Output Limits.

- Adjustment of A/D sample rate.

To use KµDA View, connect KµDA to your computer via the RS232 connection. Start the KµDA View software that was included with your system.

Consult the KµDA View software manual for more details.

Part IV: Calibration

Dimensional Standard

The reason for calibration is to verify that the system output relates to some known physical displacement -- a reference or dimensional standard with a known degree of accuracy. Choose a dimensional standard with the understanding that the accuracy of the calibration, and thus the measurement, is directly related to the accuracy of the standard.

An optional micrometer fixture is available from Kaman Instrumentation for use as a dimensional standard repeatable to within 100 microinches (.0001"). It has a provision for rigidly mounting the sensor, along with a non-rotating spindle and attached target. You can use this same calibration fixture to accommodate other user provided targets.

Note: Whenever making a measurement using a micrometer, always go past the measurement, turning counter-clockwise, then approach the measurement in a clockwise direction. Failure to do so will result in measurement errors caused by backlash in the micrometer head.

In the case of large sensors and in some applications with small ones, the use of non-conductive precision spacers such as phenolic or ceramic can be an acceptable alternative. Ceramic spacers are available from Kaman Instrumentation, ranging in size from .025" (.635 mm) to 1.000" (25.4 mm).

Measurement Band

Sensor Range vs. Calibration Range

The system outputs (analog voltage, analog current, or digital voltage) will saturate at the ends of the calibrated span. This means that if you calibrate a sensor over a subset of its possible full range, the outputs will saturate once the displacement exceeds the *calibrated* range.

Figure 5: Displacement Output Voltage vs. Calibration Range

The sensor installed in your system has a specified linear measuring range that defines certain system performance characteristics such as linearity, resolution, and long term stability. Prior to calibrating the system, determine the measurement band that will best suit your measurement application. If you need greater range, you should consider using a larger sensor.

3-Point Calibration

If your system needs calibration, you can do it yourself, following the simple instructions below for a 3-point calibration. It is only necessary to position the sensor at three distinct positions relative to the target: the minimum (sometimes known as the offset position), the maximum, and the midpoint between the minimum and maximum. KµDA interpolates and linearizes the data between these 3 data points.

This 3 point calibration can be accomplished in a few easy steps.

Note: Allow approximately 1 hour warm up time for high precision applications.

1. Press the "Calibrate / Run" switch to select the calibrate mode. The LED corresponding to the selected mode will turn on.

2. Select the Sensor (1 or 2) that you want to calibrate by pressing the appropriate "Select / Zero" switch. The right most segment of the LED bar graph display corresponding to the selected channel will flash.

3. Position the sensor at the maximum position and press the "Set Maximum / User Function 3" switch.

4. Position the sensor at the minimum position and press the "Set Minimum / User Function 1" switch.

5. Position the sensor at the mid point position and press the "Set Mid Point / User Function 2" switch.

6. Press the "Calibrate / Run" switch.

7. The LED bar graph will show a rotating light pattern to indicate that KµDA is calibrating itself to provide an output that is linear with displacement. When the LED bar graph stops its rotating light pattern, the "Run" LED will light and KµDA is now in full operation.
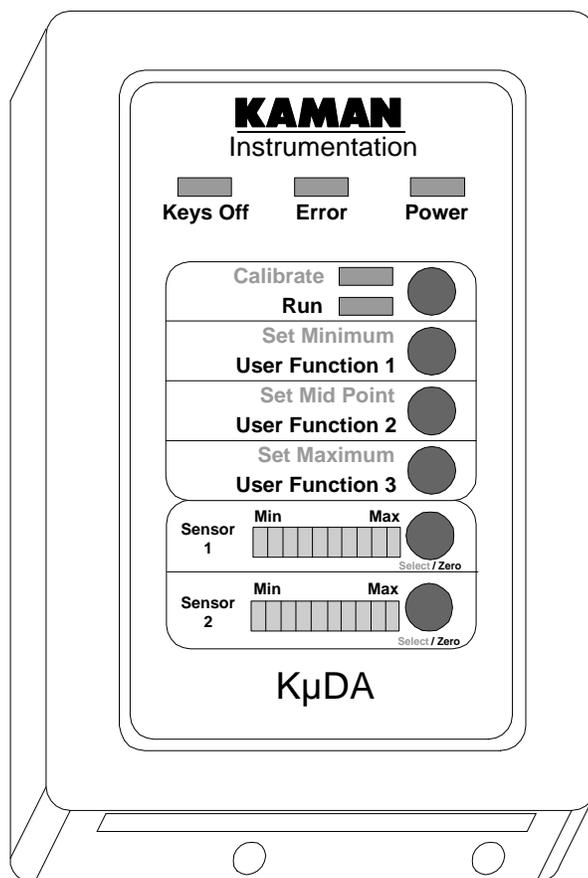
Figure 6: KµDA Front Panel

# Simultaneous 3-Point Calibration for Thickness Measurements

Although the KµDA sensors can be independently calibrated as two measurement channels for thickness applications, this is not the best procedure. When independently calibrated as the two channels, it is possible for the linearity errors in both channels to be added together, effectively doubling the linearity errors in the thickness measurement.

KµDA was designed to allow for potential cancellation of some linearity errors when both channels are calibrated simultaneously. Although this procedure appears more complex, the total number of steps is about the same as independently calibrating two channels.

The key to the enhancement of the simultaneous calibration is to ensure that when Sensor 1 is at its maximum displacement, Sensor 2 is at its minimum displacement. When Sensor 1 is at its minimum displacement, Sensor 2 is at its maximum displacement. Similarly, the same displacement point is used for the midpoint of both Sensor 1 and Sensor 2.

Here are the steps to follow:

1. Position the target at the Sensor 1 minimum position / Sensor 2 maximum position.

Target at Sensor 1 minimum /
Sensor 2 maximum position
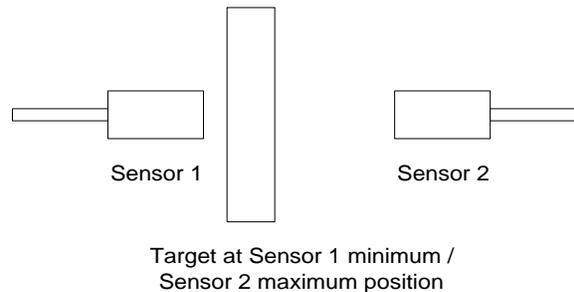
2. Press the "Calibrate / Run" switch.

3. Press Sensor 1 "Select / Zero" switch.

4. Press the "Set Minimum / User Function 1" switch.

5. Press Sensor 2 "Select / Zero" switch.

6. Press the "Set Maximum / User Function 3" switch.

7. Position the target at the Sensor 1 midpoint position / Sensor 2 midpoint position.

Target at Sensor 1 midpoint /
Sensor 2 midpoint position
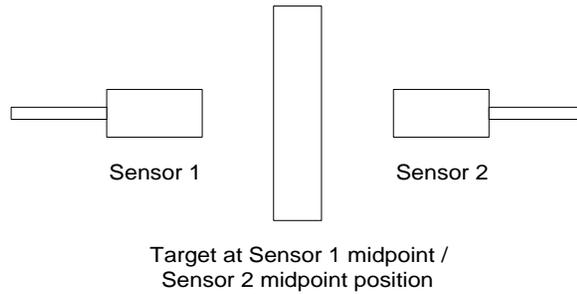
8. Press the "Set Mid Point / User Function 2" switch.

9. Press Sensor 1 "Select / Zero" switch.

10. Press the "Set Mid Point / User Function 2" switch.

11. Position the target at the Sensor 1 maximum position / Sensor 2 minimum position.

Target at Sensor 1 maximum /
Sensor 2 minimum position
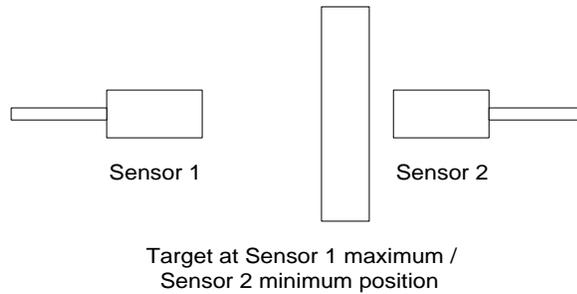
12. Press the "Set Maximum / User Function 3" switch.

13. Press Sensor 2 "Select / Zero" switch.

14. Press the "Set Minimum / User Function 1" switch.

15. Press the "Calibrate / Run" switch.

The LED bar graph will show a rotating light pattern to indicate that KμDA is calibrating itself to provide an output that is linear with displacement. When the LED bar graph stops its rotating light pattern, the "Run" LED will light and KμDA is now in full operation.

21-Point Calibration

For enhanced performance over the standard 3 point calibration, particularly with regards to linearity, it is sometimes necessary to calibrate KμDA by using additional reference data points. KμDA supports an enhanced calibration using 21 known reference data points. These data points are at the minimum position, maximum position, and at 5% increments in the range. KμDA then interpolates the position between these 21 data points.

Consult the KμDA View software manual for details on how to perform a 21 point calibration.

Part V: Temperature Compensation

Active Temperature Compensation:

One of the most powerful features of KμDA is its ability to do active temperature compensation on the sensor. This can generally reduce any temperature errors to an insignificant level. As well as compensating for any inherent temperature coefficients in the sensor and cable, it can compensate for fixturing that may change with temperature. The best compensation will result if the system is compensated in an environment similar to the actual application. One of the powerful benefits of this compensation is the fact that it compensates for any scale factor shifts, as well as offset shifts due to temperature. In order to compensate, you must be able to position the sensor to two displacements within the measuring range (preferably about 10-15 % and 85-90 % of the calibrated span). The temperature of what is to be compensated must change enough for the system to capture an adequate temperature coefficient - generally a 5º C change is sufficient, but you may get a better compensation with larger temperature changes if the sensor is going to be used over longer ranges. If the sensor cable will be in the changing temperature environment, it must be included in that environment when compensating as well.

Limitations on Temperature Compensation:

The system compensates for both scale factor and offset shifts with temperature. It will not compensate for any non-linear changes due to temperature. If the best possible performance is desired, you will need to use stable fixturing so the system isn't trying to compensate for large changes due to temperature (which will add undesirable noise to the system output). Fixturing such as that shown in the following figure is recommended. Be careful not to load the sensor unnecessarily with the metal of the fixture. KμDA View must be used to set up temperature compensation parameters, but is not required beyond setup.

Ceramic Spacer Stack — Standoffs — Measurement Gap — Aluminum Target — Ceramic Spacer Stack — Aluminum Holder — Nuts — Sensor — Sensor Cable
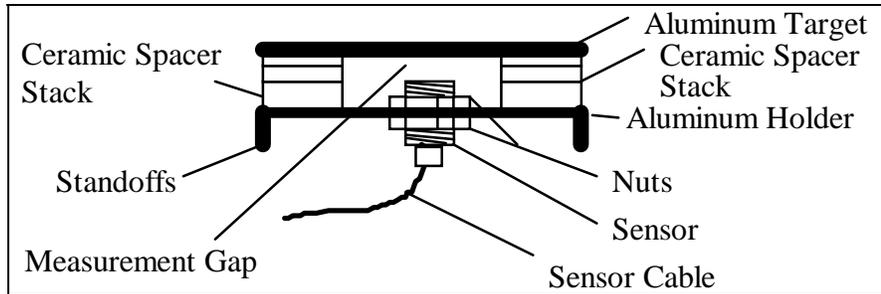
Temperature Compensating the Sensor:

In order to acquire the compensation values, you will need to be able to go to two different temperatures, at each of two different displacements. The displacements should be stable relative to the sensor reference point. If the fixture is moving in a repeatable way, you will need to calibrate for fixture movement. A bad calibration will result from a fixture which moves in a non-repeatable way or from calibrating without taking fixture movement into account. Consult the KμDA View manual for details on how to set up and perform active temperature compensation.

Cable considerations in Temperature Compensation:

The cable is inherently a part of the sensor network and must be considered during temperature compensation. The percentage of the cable which will share the sensor environment must be included in the compensation environment.

Part VI: Thickness Measurements

Thickness measurement setup

Consider the following diagram of a typical thickness measuring application.
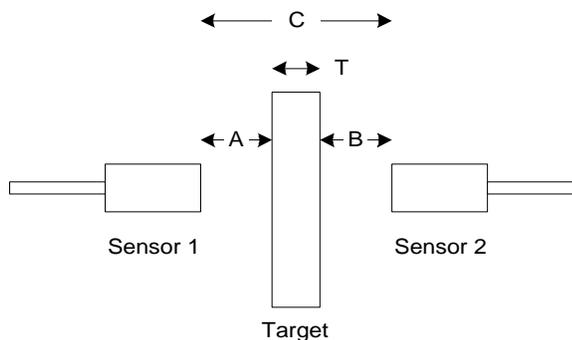
From the diagram it can be seen that the following mathematical relationships exist between the dimensions:

$C = A + T + B$

$T = C - (A + B)$

How KµDA Calculates Thickness Measurements

The software internal to KµDA has been designed so that thickness measurements are easy to set up and verify. It is not even necessary to precisely position the sensors!

Using KµDA View software and a target of known thickness (known as the Reference Target), thickness measurements can easily be accomplished.

KµDA must be calibrated and warmed up prior to this setup. Although it is best to use either the "Simultaneous 3-point Calibration" or the "21-Point Calibration" method, any calibrated KµDA will work. See the sections on calibration for more details.

The following steps represent an overview of how thickness measurements are set up. Consult the KµDA View manual for the detailed KµDA View instructions.

1. Using KµDA View, enable KµDA for thickness measurements.

2. Position the sensors with respect to the Reference Target such that they are at approximately the midpoint of their

calibrated measuring range. This can be verified by using the LED bargraphs on the KµDA display.

3. Using KµDA View, inform KµDA of the thickness of the Reference Target.

4. Inform KµDA that the Reference Target is in position. This is usually accomplished by pressing the User Function 1 switch on the keypad.

5. KµDA calculates the variable $C = A + T + B$.

6. KµDA stores the variable C for later use.

7. Remove the reference target and replace it with the targets to be measured.

8. KµDA calculates thickness using the equation:
$T = C - (A + B)$

The thickness output is available in KµDA View and as V3 OUT on the terminal block connection.

Part VII: Technology

Eddy Current Position Sensing Technology

Kaman Instrumentation's KµDA uses eddy current technology to determine the position of a conductive target relative to the system's sensor. AC current flowing through the sensor coil generates an electromagnetic field that radiates from the sensor. As a conductive target enters this field, this electromagnetic field induces a current flow in the target. The current flowing in the target produces a secondary and opposing electromagnetic field, reducing the intensity of the sensor coil's original field. The change in the sensor coil's field results in an impedance variation in the sensor coil.

Non-conductive materials intervening between the sensor and target have little or no effect on system output. As a result, environmental contaminants such as oil, dirt, humidity, electrical interference, and magnetic fields have virtually no effect on system performance.

KµDA Technology

KµDA Block Diagram

Keypad / Display
PCB

Switches

LED
Bargraphs

LEDs

Measuring Channel # 1
PCB

Analog Drive
Electronics

Analog Signal
Conditioning

Sensor
#1

Measuring Channel # 2
PCB (optional)

Analog Drive
Electronics

Analog Signal
Conditioning

Sensor
#2

Diagnostic
Electronics

Analog Mux
& A / D

Memory

Serial
I/O

RS 232
RS 485

µController

User
Programmable
Inputs (3)

General
Purpose
Outputs (4)

Output 1 Electronics

D/A

V out

I out

V out 1

I out 1

Output 2 Electronics

D/A

V out

I out

V out 2

I out 2

Output 3 Electronics

D/A

V out

I out

V out 3

I out 3

µController Electronics
PCB

The KµDA Electronics consists of the Display, Measuring Channel(s), and µController Printed Circuit Boards (PCBs).

The Measuring Channel PCB drives the sensor coil with the appropriate analog signal. When the impedance of the sensor coil changes as a function of target position, the response to the drive signal also varies. The Measuring Channel PCB converts the coil's response to a signal proportional to displacement. It also offsets and amplifies the signal to a level compatible with the A/D converter on the µController PCB.

The Display PCB functions as the interface to the user. It contains the LEDs that aid in quickly identifying the operational status of KµDA. Two LED Bargraphs give an approximate indication of the distance from the target to the sensor. The switches on the Display PCB are used to control 3 point calibration as well as activate custom functions in software.

The µController PCB is the "control center" of KµDA. It interfaces with the Keypad / Display PCB to provide feedback to the user as well as allow the user to initiate front panel operations such as 3-point calibrations and other custom functions. The µController PCB contains the Analog to Digital Converter that is used digitize the displacement measurements. It supports digital communication with external electronics via the Serial I/O (RS232 or RS485).

The µController PCB contains many functions that can be controlled with the KµDA View software. These include:

- Range and scaling of the analog voltage and current outputs.

- Analog to Digital Converter sample rate.

- Math functions, such as thickness.

- Digital Filtering.

- Limit thresholds.

- Active Temperature Compensation.

Consult the KµDA View manual for details on how these functions can be controlled.

Part VIII: Specifications

Measuring System Performance

See KµDA Data Sheet

Optoisolated Digital Output Current:

30 mA maximum

Operating Temperature:

Sensors:	2U:	- 55°C to 104°C
	Others:	- 55°C to 200°C
Electronics:		- 20°C to 50°C

Storage Temperature:

Sensors:	2U:	- 55°C to 104°C
	Others:	- 55°C to 200°C
Electronics:		- 20°C to 125°C

Power Supply Requirements:

+ 12 VDC:	0.35 Amps
- 12 VDC:	0.35 Amps
+ 5 VDC:	2.0 Amps

Physical Characteristics:

Size:	7.5" long x 4.75" wide x 2.0" high
Weight:	1.7 pounds

In our continuous efforts to improve this product, Kaman reserves the right to change specifications without notice.

Outline Drawing:

ACCEPTS 3/16"
MAX DIA SCREW

KAMAN
Instrumentation

Keys Off   Error   Power

Calibrate
Measure

Set Minimum
User Function 1

Set Mid Point
User Function 2

Set Maximum
User Function 3

Sensor 1   Min   Max   Select/Zero

Sensor 2   Min   Max   Select/Zero

KµDA

(7.52) (6.91)

(2.32)

(2.00)

(.085)

(4.64)

SENSOR 1   SENSOR 2

Part IX: Warranty

Kaman Instrumentation Products Standard Limited Warranty

Products of Kaman Instrumentation are warranted to be free from defects in materials and workmanship when installed and operated in accord with instructions outlined in the KµDA Hardware Manual.

Kaman Instrumentation's obligation under this warranty shall be limited to repair or replacement (at the discretion of Kaman Instrumentation) of the defective goods returned to Kaman's plant within one (1) year from date of shipment.

This warranty is valid except when the products have been subject to misuse, accident, negligent damage in transit or handling, or operation outside the conditions prescribed in the data sheet or instruction manual. This will be determined by Kaman Instrumentation personnel.

In no event shall Kaman be liable for incidental or consequential damages, including commercial loss, resulting from any article sold under this Agreement.

In the event Buyer fails to limit to Kaman's warranty set forth above, any express or implied warranty it may make with respect to any product of which any article sold thereunder is a component, Buyer shall indemnify and hold Kaman harmless from any and all liability, costs and expenses to which Kaman may be subjected as a result of Buyer's failure to so limit its express or implied warranties.

THIS WARRANTY IS EXCLUSIVE AND IS MADE IN LIEU OF ALL OTHER WARRANTIES; AND THOSE IMPLIED WARRANTIES, INCLUDING SPECIFICALLY THE WARRANTIES OR MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE HEREBY EXPRESSLY LIMITED TO ONE (1) YEAR DURATION.

NO MODIFICATION OR ALTERATION OF THE FOREGOING WARRANTY AND LIMITATION OR REMEDIES PROVISIONS SHALL BE VALID OR ENFORCEABLE UNLESS SET FORTH IN A WRITTEN AGREEMENT SIGNED BY KAMAN AND THE BUYER.

Kaman Instrumentation Warranty No. 7