

# DIT-5200L

## Non-Contact Displacement Differential Measuring System User's Manual

This apparatus, when installed and operated per the manufacturer's recommendations, conforms with the protection requirements of EC Council Directive 89/336/EEC on the approximation of the laws of the member states relating to Electromagnetic Compatibility. Refer to the DIT-5200L Declaration of Conformity or contact Kaman Precision Products for details.



# Table of Contents

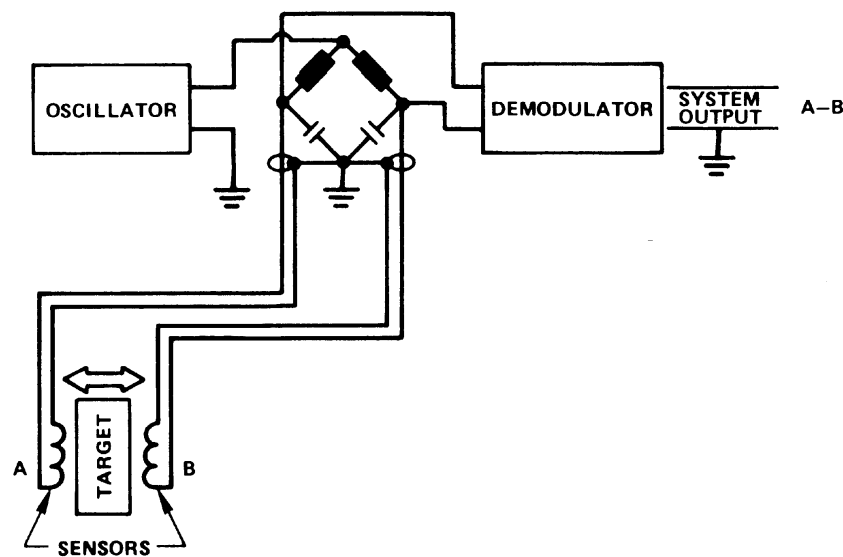
PART 1 - INTRODUCTION.....	3
PART 2 – CONNECTING THE DIT-5200L.....	4
2.1 What’s Included .....	4
2.2 Cautions and Safeguards.....	4
2.3 Pin out and Connector Assignments .....	4
PART 3 – APPLICATION INFORMATION .....	6
3.1 Fixturing .....	6
3.2 Sensor Mounting and Installation.....	7
3.3 Electrical Nulling Procedure.....	7
3.4 Optimizing Performance .....	8
3.5 Factors That May Degrade Performance .....	8
3.6 Target Characteristics.....	9
PART 4 – CALIBRATION .....	11
PART 5 – GENERAL SPECIFICATIONS & TYPICAL PERFORMANCE.....	12
PART 6 - TROUBLESHOOTING .....	15
APPENDIX A DIT-5200L SENSOR DIMENSIONS .....	16
APPENDIX B DIT-5200L ENCLOSURE DIMENSIONS .....	17
APPENDIX C TERMINOLOGY.....	18

## PART 1 - INTRODUCTION

The DIT-5200L Non-Contact Displacement Measuring System is an advance in precision measurement technology. It provides exceptional resolution, repeatability, and nulling accuracy for detecting the aligned / centered position of a conductive target relative to a pair of non-contacting sensors.

The DIT-5200L is identical in form to Kaman's previous DIT-5200 product. Enhancements have resulted in lower noise (better resolution) and CE Marking.

The DIT-5200L uses advanced inductive measurement technology to detect the aligned or centered position of a conductive target. For differential measurement applications, two precisely matched sensors per channel are positioned on opposite sides or ends of a target. In this sensor-to-target relationship, as the target moves away from one sensor, it moves toward the other sensor an equal amount. Output is differential and bipolar. Electrically matched sensors on opposing legs of the same bridge provide exceptional thermal stability



**Figure 1 DIT-5200L Circuit**

The DIT-5200L signal conditioning electronics is packaged in a die cast aluminum box with MCX style sensor connections. The Input/Output (I/O) is on a 9 pin mini-D connector. The input power connections are reverse voltage protected.

The electronics can also be supplied as a bare PCB for installation inside the user's enclosure. Custom configurations can also be designed for OEM application requirements. The DIT5200L is CE Marked when purchased in the original enclosure. To maintain the CE Marking, a ferrite bead (supplied) must be installed over the input power wires only on the I/O cable.

## PART 2 – CONNECTING THE DIT-5200L

### 2.1 What's Included

- DIT-5200L Signal Conditioning Electronics
- 2 or 4 sensors (Typically 15N or 20N)
- 18" Input/Output Cable

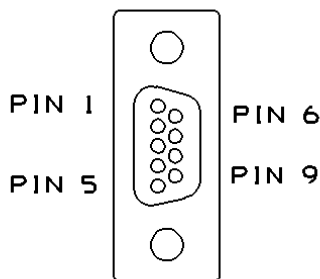
### 2.2 Cautions and Safeguards

The sensor faces may be damaged if allowed to strike the target or other hard surface. Protective plastic caps should remain in place until the sensors are ready for installation.

The maximum input voltage to the DIT-5200L is  $\pm 15.5V$ , exceeding this input voltage will cause damage to the DIT-5200L.

### 2.3 Pin out and Connector Assignments

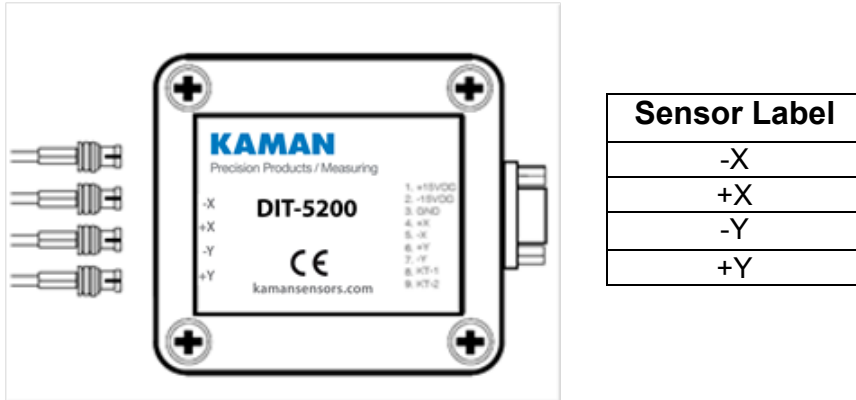
The DIT-5200L I/O connections are via an ITT Cannon model MDM-9SL2P connector on the enclosure. A mating connector with 18 inch leads is provided as part of the system. Connection information is detailed below.



Pin	Color	Function
1	Black	+15V @ 40 mA (typical).
2	Brown	-15V @ 40 mA (typical)
3	Red	Power Supply Common
4	Orange	+X Output
5	Yellow	-X (Gnd)
6	Green	+Y Output
7	Blue	-Y(Gnd)
8	Violet	N/C
9	Gray	N/C

Figure 2 I/O Connector

Sensor connections are the same for both the enclosure style and the OEM DIT-5200L. On the OEM DIT-5200L orient the box so the I/O connector is on the right and the sensor connections are on the left.



**Figure 3 Sensor Connections**

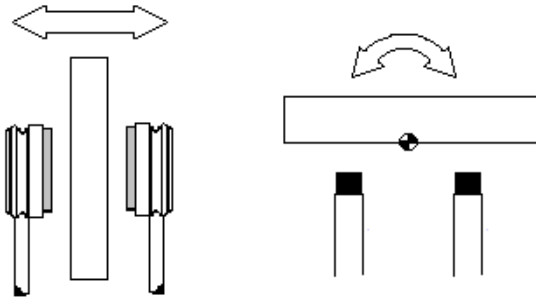
The output on the channel will become more positive with movement toward the positive (+) sensor. The output on the channel will become more negative with movement toward the negative (-) sensor.

On single channel systems only the Axis 1 (X channel) is used.

The system is set up with the sensors as marked. Sensors are supplied as matched pairs for optimum performance. Swapping sensors will result in degraded performance without factory recalibration.

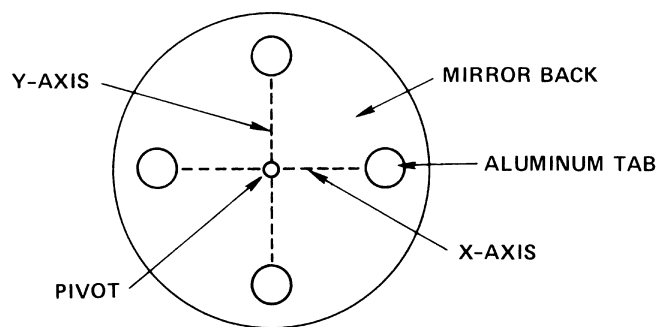
## PART 3 – APPLICATION INFORMATION

For differential measurement applications, the two electronically matched sensors are positioned on opposite sides or ends of the target. The sensor to target relationship is such that as the target moves away from one sensor, it moves toward the other an equal amount.



**Figure 4 Sensor/Target Relationship**

Standard systems come with two measurement axes (four sensors; two per axis) and can therefore be fixtured a number of ways to provide precise x-y alignment. The figure below illustrates target configuration for x-y alignment of an image stabilization mirror for an electro-optical application.



**Figure 5 Sensor Position on a Stabilization Mirror**

### 3.1 Fixturing

The user provides fixturing for the DIT-5200L electronics and sensors. The following information establishes fixturing requirements for optimum system performance. Both the sensor *and* target fixturing must be structurally sound and repeatable

## 3.2 Sensor Mounting and Installation

The sensors must be securely clamped. A collet type fixture is the best. It is best to clamp the fixture as close to the sensor face as possible (without causing additional loading on the sensor) – this is to minimize expansion differences between the two sensor housings. To insure that the fixturing does not load the sensor and cause performance errors you should have any metal parts approximately 3 sensor diameters away from the tip.

The target must not strike the sensor face. The sensor should have a null gap and measuring range specified on the calibration record. As an example a 15N sensor may have a null gap of 15 mils (0.015" / 0.381mm) and a range of  $\pm 10$  mils ( $\pm 0.010$ " /  $\pm 0.254$  mm). The difference between the null gap and measuring range is the offset distance for the sensors. In this example the offset would be  $15 - 10 = 5$  mils for an offset. The offset is the closest distance the sensor gets to the target during normal operation. This offset is necessary both to optimize performance and to keep the target from contacting and possibly damaging the coils in the sensor face.

Install the sensors so that only the target interacts with the sensor's field. No conductive material other than the target should be present within the sensor's field. Because the sensor field radiates in all directions, excessive back loading can also be a problem.

## 3.3 Electrical Nulling Procedure

**NOTE: This procedure could result in one sensor having a less than specified NULL.**

Although both sensors may appear to be positioned mechanically, this can cause a cumulative error. By electrically positioning the second sensor using the system output, the error is minimized.

The sensor coil is mounted at the face of both sensors. For purposes of mechanical nulling, measure distance from the sensor face. (Use care not to damage the sensor coil)

1. Sensor position relative to the target is critical. Make sure the target is in the null position. Install the first sensor of a pair (start with X-) in the application fixture. Using a dimensional standard, precisely locate the sensor at the null gap. Secure the sensor and recheck its position.
2. Now install the second sensor of the pair (X+) in the fixture and position it to within a few mils (10's of microns) of the required null gap. Connect the Power/Signal line and apply power to the system. The system must be energized for a minimum of 30 minutes for best results. Use the output from the system as a guide in the final positioning of this sensor (electrical nulling). Slowly move the second sensor toward or away from the target as necessary until the system output reads 0VDC (typically  $\pm 10$ mV). Secure the sensor and recheck that the output is 0VDC. This output indicates the sensor is positioned correctly.
3. Repeat steps 1 and 2 for sensor Y- and Y+.

The system is now ready for use.

## 3.4 Optimizing Performance

There are several things to be aware of when using the DIT-5200L in order to optimize the performance of the system.

- Insure that there are no ‘incidental targets’ – i.e. targets that the sensor may see that are not to be measured.
- Insure that the sensor is not tilted with respect to the target as this will cause additional non-linearity.
- Make sure that the system is set up with the proper null gap – electrical nulling of the second sensor in a pair is best.
- Insure you are using the specified calibration material (aluminum is the standard).
- Make certain that you are using stable fixturing and mounting of the sensors.
- Ensure the target is 3 sensor diameters in size and is thick enough to prevent penetration of the magnetic field. (reference section 3.6 on **Targets**)
- The system will perform the best if both sensors are in a similar thermal environment – avoid temperature differentials between the sensor pairs.

## 3.5 Factors That May Degrade Performance

### Unequal Loading

This refers to an unequal amount of conductive material within the field of one sensor as opposed to the other sensor in the pair (the sensor’s field is approximately three times its diameter). Unequal loading causes asymmetrical output from the sensors which induces non-linearity in the system output. Ideally, no conductive material other than the target should be in the sensor’s field. Some loading may be acceptable if it is equal and the sensors are calibrated in place. Even then, sensor loading may cause non-linearity. If unable to calibrate, then loading is too great.

### Unequal Displacement

For targets using pivot point mount, the system should “see” equal displacement: i.e., the pivot point of the target is perfectly centered between the sensors. If the pivot point is a fraction of a centimeter off, it can introduce non-linearity into the system.

- The pivot point must be on a common line between the centerline of a pair of sensors.
- The axis of tilt must be a perpendicular bisector of a line between the centerlines of a sensor pair.
- The pivot point must be positioned on the target so as not to introduce a translation error. This error, a function of angle, is caused by slight changes in the effective null gap as the target moves about the pivot. This results in non-linearity.



- The pivot point must not move or change with time.

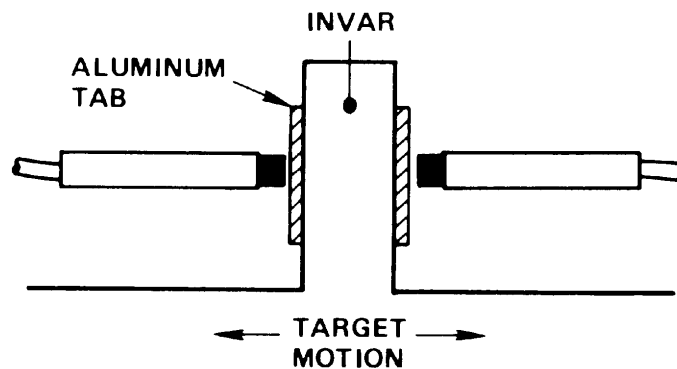
## 3.6 Target Characteristics

### Target Material

Aluminum is the preferred target material for the DIT-5200L. Aluminum targets may be mounted on materials with more stable temperature characteristics such as Invar or other substrates as long as the target thickness guidelines are observed. Invar is an excellent target substrate as it has a very low expansion coefficient with temperature. The figure below shows aluminum tabs (which give optimal performance from the DIT-5200L) mounted on and Invar fixture.

Iron, nickel, and many of their alloys (ferro-magnetic targets) can be used with the DIT-5200L. Performance to these materials may not meet standard performance specifications.

Refer to the DIT-5200L data sheet for performance specifications to aluminum.



**Figure 6 Attachment of Aluminum Targets**

If the system was purchased for use with a target material other than aluminum, it has been pre-calibrated (with pre-selected component values) at the factory using that specific material. Changing the target material will require re-calibration and/or cause the DIT-5200L to malfunction.

The effect of target material is due to the resistivity and mainly affects the sensitivity of the system. Expect about twice as much noise and drift on a system set up for a stainless steel target as compared to one set up for aluminum.

### Target Thickness

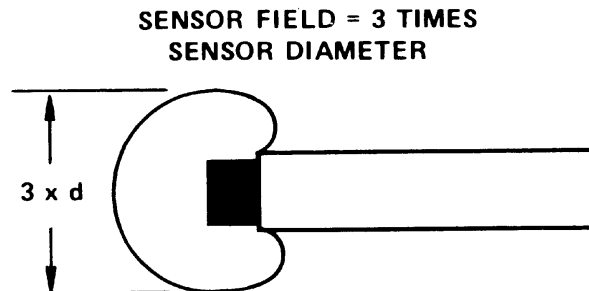
The RF field produced by the sensor is maximum on the target surface, but it also penetrates below the surface. The depth of penetration depends on the target material used. For example, the RF field will penetrate aluminum 0.018". To avoid variations caused by temperature changes of the target, use the recommended minimum target thickness in the table below:

Material	Thickness, mils (mm)
Gold and Copper	13 ( 0.33 )
Beryllium	17 ( 0.43 )
Aluminum	18 ( 0.45 )
Brass	23 ( 0.58 )
300 Series Stainless Steel	71 ( 1.8 )
Inconel	95 ( 2.4 )

In applications where the sensors oppose each other with the target between them, the minimum thickness should be at least double those listed above to prevent sensor interaction

### Target Size

The minimum target size must be  $1\frac{1}{2}$  to 2 times the sensor diameter. It is preferred that the target size be 3 times the sensor diameter for optimum performance.



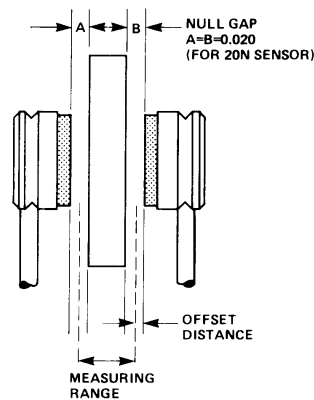
**Figure 7 Sensor Field Size**

Additional recommendations and guidelines can be found in Kaman's [Inductive Technology Handbook](#). The latest copy of this reference guide is located on our website.

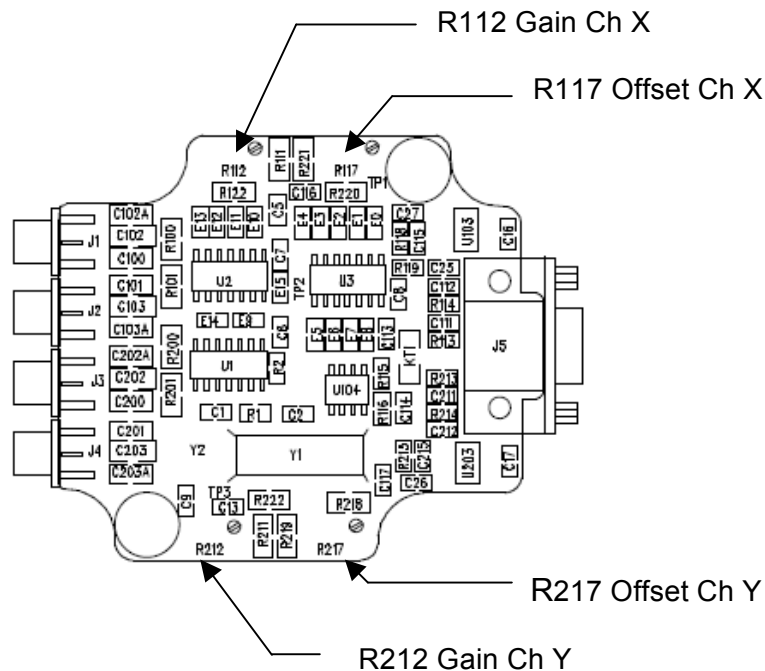
## PART 4 – CALIBRATION

The DIT-5200L systems are shipped from the factory pre-calibrated for a user specified measuring range, sensitivity, and target material. They do not normally require calibration or re-calibration. Potentiometer locations for the OEM and enclosure version are the same relative to the sensor and I/O connector positions.

The system must be positioned to the null gap by first adjusting one sensor to the null gap and adjusting the opposing sensor for a zero volt output. Reference section 3.2.



**Figure 8 Sensor Positioning for Calibration**



**Figure 9 Potentiometer Locations**

**Note:** Offset (zero) potentiometers R117 and R217 are not normally installed and are not included in this calibration sequence.

**For the purpose of this example, the desired Output is  $\pm 10.000$  Vdc, a span of 20.000 Vdc**

1. Position the target at (-) FS (Negative full scale)
2. Adjust the Gain control for the measuring channel being calibrated to the (-) full scale voltage  $\pm 0.005$ mV (unless otherwise specified) i.e.  $- 10.000$  Vdc
3. Position the target at (+) FS (Positive full scale)
4. Compare the actual output voltage to the desired output voltage and calculate the difference  
i.e. Actual output is  $+ 9.500$  Vdc; Desired output is  $+ 10.000$  Vdc; Difference is  $.500$  Vdc
5. Adjust the Gain control for the measuring channel being calibrated to bring the output voltage up or down by half of the difference noted in Step 4.  
i.e. Actual output is  $+ 9.500$ ;  $\frac{1}{2}$  Difference of Step 4 is  $.250$ ; Adjust output up to  $9.750$ .  
  
Note: Since the gain is being increased to bring the  $+ 9.500$  to  $9.750$ , the value of the (-) FS will also increase.
6. Check balance between (-) FS (Negative Full Scale) and (+) FS (Positive Full Scale).  
i.e. Actual Outputs:  $- 10.250$  ( $.250$  high) and  $+ 9.750$  ( $.250$  low); Output Span:  $-10.250 + 9.750 = 20.000$  Vdc
7. Slight adjustments can be made to the Gain control if necessary to improve the balance.

## PART 5 – GENERAL SPECIFICATIONS & TYPICAL PERFORMANCE

<b>Parameter</b>	<b>Value</b>	<b>Units</b>	<b>Comments</b>
Target Material	Aluminum is preferred		Most conductive materials can be considered
Null Gap	See Data Sheet		Range and sensor dependant. See Data Sheet.
Range	See Data Sheet		See Data Sheet
Output Voltage	±10	Volts	Typical
Non-Linearity	<0.5	%FSO	Typical
Resolution at Null (p-p at 1kHz BW)	<0.004	%FSO	Typical
Resolution at FSO (p-p @ 1kHz BW)	<0.015	%FSO	Typical
TempCo at Null	<0.005	%FSO/°C	Typical
TempCo at FSO	<0.02	%FSO/°C	Typical
Power Dissipation at 15N Sensor Head	< 0.5	mW/sensor	Typical
Power Dissipation at 20N Sensor Head	< 2	mW/sensor	Typical
Power Dissipation (Electronics)	<1.35	Watts	
Frequency Response	0 - 20	kHz	
Input Voltage	±15	Volts	
Output Impedance	<1	Ohm	
Weight	<8	oz	Enclosure Version (Typical)

### Operating Temperature

- Electronics: +32to +140°F (0C to +60°C)
- Sensors: -62°F to +220°F (-52°C to +105°C)
- Cryogenic 20N Sensor: +4°K to +220°F (+105°C)

### Storage Temperature Range

- Electronics: -26°F to +180°F (-32°C to +82°C)
- Sensors: -62°F to +220°F (-52°C to +105°C)
- Cryogenic 20N Sensor: +4°K to +220°F (+105°C)

## Sensor/Range Specific Performance

Range, ± mil	Range ± mm	Null, mil	Null, mm	15N	20N	Typical Non-Linearity, %FR	Max. Non-Linearity, %FR	Typical Sensor TempCO, %FR/°C	Equivalent RMS Input Noise, %FR/√Hz @ FR	Equivalent RMS Input Noise, %FR/√Hz @ Null
10	0.25	15	0.40	x		0.15%	0.30%	0.02%	2E-5%	2E-5%
10	0.25	20	0.50		x	0.10%	0.20%	0.02%	2E-5%	2E-5%
20	0.50	25	0.65	x		0.25%	0.50%	0.03%	2E-5%	2E-5%
20	0.50	40	1.0		x	0.15%	0.30%	0.02%	2E-5%	2E-5%
35	0.90	40	1.0	x		0.50%	1.00%	0.03%	2E-5%	1E-5%
50	1.25	60	1.5		x	0.25%	0.50%	0.03%	2E-5%	1E-5%
75	1.90	85	2.2		x	0.50%	1.00%	0.03%	1.5E-5%	1E-5%

**Note:** Full Range (FR) is considered as twice the ± Range

### Calculating Effective Resolution

To calculate the effective resolution, take the Equivalent RMS Input Noise and multiply it by the square root of the measurement bandwidth. Peak-to-peak noise is normally 6.6 times higher than the RMS noise assuming gaussian (randomly distributed) noise.

**For Example,** to calculate the worst case noise of a 15N system with a ± 0.5 mm (± 500 micron) range at a 20 kHz bandwidth:

**Step 1)** Calculate the full range of the system:

$$\text{FR (Full Range)} = 2 \times 500 \text{ microns} = 1,000 \text{ microns}$$

**Step 2)** Calculate the Equivalent RMS Input Noise in measurement units by multiplying by the Full Range (don't forget to divide by 100 to take into account the percent).

$$\text{Resolution at Full Scale is } 2\text{E-5}\% \text{FR}/\sqrt{\text{Hz}} \times 1,000 \text{ microns} / 100 = 2\text{E-4} \text{ microns}/\sqrt{\text{Hz}}$$

**Step 3)** Multiply by the square root of the measurement bandwidth to calculate the effective resolution.

$$\text{Effective RMS Resolution @ 20kHz} = 2\text{E-5}\% \text{FR}/\sqrt{\text{Hz}} \times 1,000 \text{ microns} \times \sqrt{20 \text{ kHz}} = 0.028 \text{ microns}$$

**Step 4)** To approximate the peak-to-peak resolution multiply by 6.6

$$\text{Effective peak-to-peak resolution @ 20 kHz} = 0.028 \times 6.6 = 0.185 \text{ microns}$$

**Note:** Output filtering on the DIT-5200L is set to 20 kHz. External filtering is assumed when calculating resolutions at lower bandwidths.

## **PART 6 - TROUBLESHOOTING**

### **5.1 Insufficient Gain**

If attempting to recalibrate for a specific sensitivity, measuring range, or for a target different from factory calibration specifications, there may be insufficient gain control to do this. You may need to decrease the desired output in order to calibrate the system.

Another cause for insufficient gain could be excessive loading of the sensors by conductive material (other than the target) within the field of the sensors. The sensor's field is approximately three times its diameter.

### **5.2 Unable to Zero**

The DIT-5200L is an exceptionally stable measuring system. Long term drift is less than 2 micro-inches per month. If the unit does not work, this would most likely be discovered during the functional test. If you are unable to calibrate your system in no more than two iterations, the problem is most likely poor mechanical repeatability in the fixturing or actuating mechanisms. To determine this:

1. Do not make any adjustments to the calibration controls. (Record how much time the next step takes).
2. Do at least 12 to 15 iterations of moving the target from null to full range and back to null. Record the output at null each time. If successive readings of the output at null consistently vary with no clear trend (drift) in one direction or the other, the problem is mechanical repeatability.
3. Stabilize the target at null and record the output. Leave the target at null for the same length of time it took to accomplish step two and monitor the output.
4. If the output remains constant, this confirms the problem is mechanical repeatability.

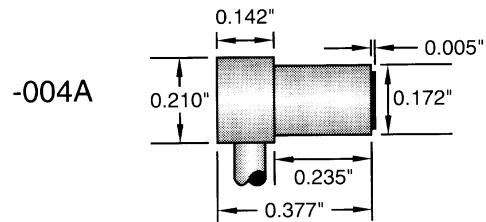
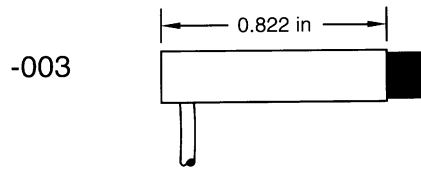
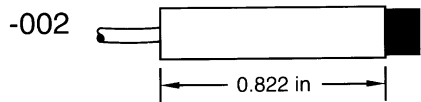
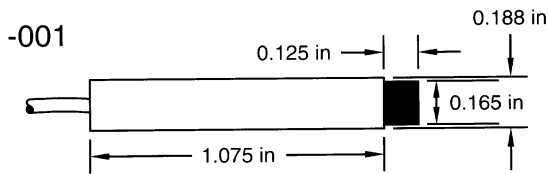
If the output drifts, the problem could be drift in the fixturing, drift in the target positioning servos, or drift in the DIT-5200L.

If you can positively eliminate all other variables as the source of the problem, consult Kaman Precision Products.

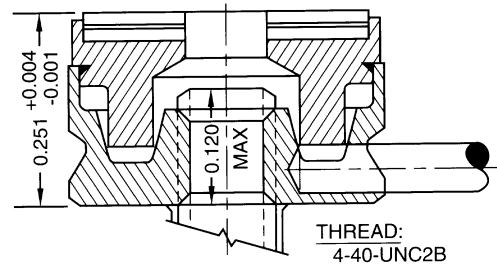
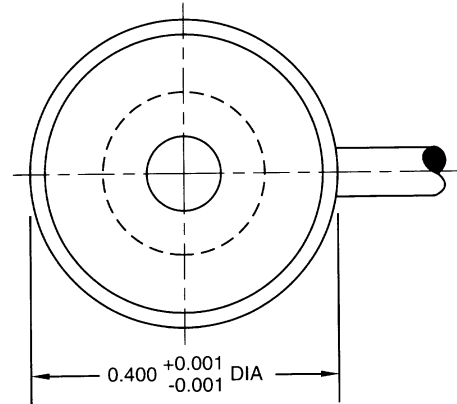
### **5.3 Poor Non-Linearity**

Poor non-linearity is typically the result of additional loading on the sensor or the sensor head being slightly tilted.

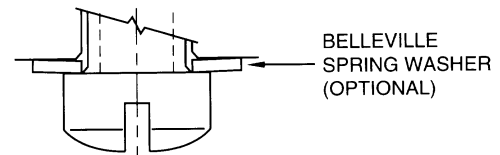
## APPENDIX A DIT-5200L SENSOR DIMENSIONS



-004B total length = 0.506"



3X ACTUAL SIZE

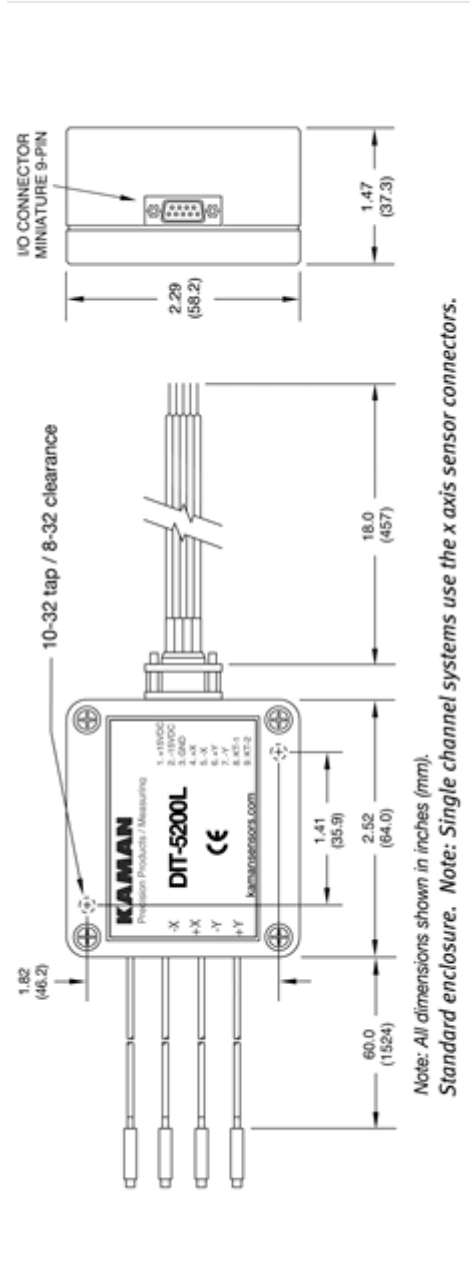


**15N Sensor Versions**

**20N Sensor**



## APPENDIX B DIT-5200L ENCLOSURE



## DIMENSIONS

## APPENDIX C TERMINOLOGY

### Null Gap

The point at which a target is equidistant from each sensor of a differential pair. The system output at null = 0VDC. The actual gap is measured from the sensor face to the corresponding target face and includes a required offset (null gap = offset plus maximum measuring range).

### Offset

The minimum distance between the sensor face and the target. Offset is necessary to both prevent the target from striking the sensor face and to optimize performance (offset = null gap minus max range).

### Measuring Range

The full range of target motion over which the various specifications such as resolution, linearity, and sensitivity can be met. The differential sensor arrangement yields a bipolar output and measuring range is expressed as + and – value either side of the null position (measuring range = null gap minus the offset).

### Sensitivity (scale/gage factor)

Output voltage per unit of displacement. Usually expressed as millivolts per mil (0.001”) or per millimeter.

### Linearity (or non-linearity)

The maximum deviation of any point of a calibrated system’s output from a best fit Least Squares straight line. Expressed in actual units, e.g., micro-inches or as a percentage of the full range (the full scale output times 2).

### Equivalent RMS Input Noise

A figure of merit used to quantify the noise contributed by a system component. It incorporates into a single value, several factors that influence a noise specification such as signal-to-noise ratio, noise floor, and system bandwidth. Given a measuring systems sensitivity/scale factor and the level of “white” noise in the system, Equivalent RMS Input Noise can be expressed using actual measurement units.

### Effective Resolution

An application dependent value determined by multiplying the Equivalent RMS Input Noise specification by the square root of the measurement bandwidth.

Example: an application with a 100 Hz bandwidth using a DIT-5200 with an Equivalent RMS Input Noise level of 0.2nm/  $\sqrt{\text{Hz}}$  results in a system with an effective resolution of 0.2nm/  $\sqrt{\text{Hz}}$  x  $\sqrt{100 \text{ Hz}}$  or 2nm.