PCB PIEZOTRONICS
AN AMPHENOL COMPANY

ENDEVCO Model - Modular 6DoF Sensor

Modular 6DoF Sensor using Endevco 7330, 773A and 776

Installation and Operation Manual

For assistance with the operation of this product,
Contact PCB Piezotronics, Inc.

Toll-free: 716-684-0001
24-hour SensorLine: 716-684-0001
Fax: 716-684-0987
Email: Info@pcb.com
Web: www.pcb.com

SAFETY CONSIDERATIONS

Model 7330, 773A and 776 are declared to fully comply with EU Council Directives:

Low Voltage Directive, 2014/35/EU - Compliant
EMC Directive, 2014/30/EU - Compliant
RoHS Directive, 2011/65/EU and 2015/863 (RoHS 3)- Compliant

The Products listed above are manufactured by PCB Piezotronics, Inc. and are declared to comply with the noted Product Safety and Environmental Standards when installed and operated in accordance with the Manufacturer's instructions provided. The product is declared to comply by design, testing and 3rd party evaluation (when necessary). The certification program management, product safety testing, EMC testing and evaluations were provided by PCB Piezotronics, Inc. or an outsourced 3rd Party Provider. RoHS compliance declared by evaluation of product and materials used and exemptions granted to test instruments. The products are eligible to bear and display the CE mark.

This manual contains information and warnings that must be followed to ensure safety of personnel and the safe operation of the product.

Warnings:

Switch off all power to equipment before connecting or disconnecting the product. Failure to do so may cause damage to the product.

Any adjustment, maintenance or repair, other than detailed within this manual, must be carried out by trained service personnel.

If it is suspected that the correct operation of the equipment is threatened, impaired or otherwise, it must be made safe and free from further operation until the threat has been removed.

1.0 Table of Contents

1.0	Table of Contents	2
2.0	Introduction	3
3.0	Materials Required	4
4.0	Pre-installation Check	5
5.0	6DoF Stacked Mounting	6
5.1.	Assembly Sequence	6
5.2.	Mounting Surface	6
5.3.	Screw Mount of 6DoF Module	6
5.4.	Adhesive Mount of 6DoF Module	7
5.5.	Cable	9
6.0	Electrical Precautions	9
6.1.	Excitation Voltage	9
6.2.	Signal Conditioning	10
6.3.	Grounding	10
7.0	Recalibration	10
8.0	Questions	11

2.0 Introduction

6DoF (Six Degrees of Freedom) measurement is the comprehensive process of tracking an object's complete movement in 3D space - three linear movements (X,Y and Z) and three rotational movements (pitch, yaw, and roll). 6DoF measurement is vital for achieving high-precision spatial awareness and enabling machines to interact naturally with the environments. This capability is fundamental to applications in automotive safety testing, aerospace testing and other testing in harsh shock and vibration environments requiring accurate measurement of a combination of linear and angular motions.

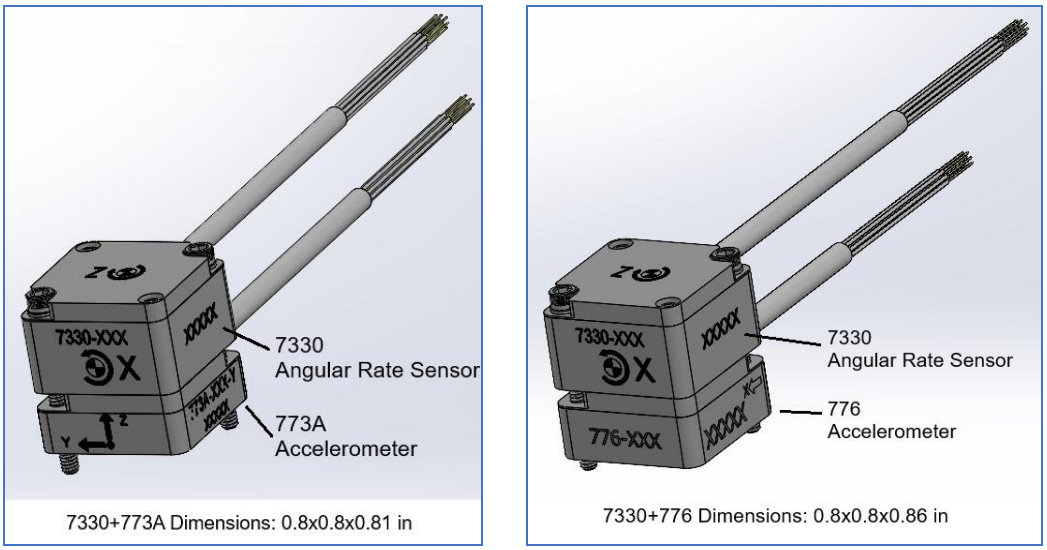
6DoF measurement can be achieved using either an integrated, all-in-one 6DoF sensor (e.g. Endevco Model 7360A) or a modular approach by stack mounting Endevco Models 7330, 773A and 776, depending on the application's specific needs for space, flexibility, and performance.

The ENDEVCO Model 7330 is a tri-axial angular rate sensor that features three angular rate sensors packaged in a compact enclosure. This tri-axial angular rate sensor is designed specifically for automotive safety testing and other system designs in harsh shock and vibration environments requiring accurate measurement of angular velocity. The 7330 sensor features various full angular rate ranges including ±100/500/1500/6000/8000/12000/18000 deg/sec, and provides full scale voltage output of ±2Vp.

The ENDEVCO Model 773A is a tri-axial low g DC Accelerometer that utilizes unique variable capacitance microsensors, and is designed for measurement of relatively low level accelerations in automotive ride quality, motorsports and high speed rail applications where measurement of whole body motion immediately after the accelerometer is subjected to a shock motion and in the presence of severe vibrational inputs is required. The Accelerometer features various full scale g ranges including ±8g, ±15g, ±50g, ±100g and ±200g.

The ENDEVCO Model 776 is a tri-axial 2000g DC Accelerometer for high amplitude acceleration, vibration, and shock applications. The Model 776 uses a unique micro-machined, piezoresistive sensor with gas damping to attenuate resonant amplitudes, and mechanical stops to reduce breakage under overload conditions. The accelerometer features a four-active arm bridge circuit, with a nominal full-scale output of 600mV at 10 Vdc excitation for the -2000g unit.

Model 7330, 773A and 776 can be used individually for triaxial angular rate or acceleration measurement of the object, or they can be stacked together using 1pc 7330 and 1pc 773A or 776 to form 6DoF module for the measurement of three axes of angular rate and three axes of linear acceleration, as shown in Figure 1 (a) and (b). The stacked 7330+773A/776 structure provides a flexible mix & match of angular rate and acceleration measurement ranges for comprehensive linear and angular rate motion detection of the target object.



(a) (b)

Figure 1. (a) Modular 6DoF of 7330 and 773A.
(b) Modular 6DoF of 7330 and 776.

When configuring the stacked 6DoF module, use 773A for low-g measurements below 200g, as its variable capacitance sensors provide the high precision required for automotive ride quality and whole-body motion. Use 776 for high-g applications below 2000g, which utilizes damped piezoresistive technology to accurately capture extreme shock and vibration while minimizing zero shift.

This manual outlines the stacked mounting procedures of using 7330, 773A and 776 towards the modular 6DoF applications. Prior to installation, follow standard instrumentation protocols, including electrical inspections, secure mounting, and system recalibration.

3.0 Materials Required

The materials and tools used for the stacked mounting of 7330 with 773A/776 include:

(1) Allen wrench for #2-56 screws - Endevco P/N EDVEHM178 (1pc)
(2) #2-56 x 7/8 inch Socket Head Cap Screws - Endevco P/N 100-18920-70 (2pc)
(3) Size #2, Flat Washers - Endevco P/N EDVEHW200 (2pc)
(4) Adaptor Plate for Adhesive Mounting – Endevco P/N 7973 (1pc, optional)

Items 1-3 above are used for screw mounting of the stacked 7330+773A/776 6DoF module, and are supplied in the 7330 shipping container.

The Adaptor Plate 7973 in item 4 is an optional accessory for adhesive mounting of the stacked 7330+773A/776 6DoF module. It's made of hard anodized aluminum and is available per separate request.

Note: two pieces of 5/8'' long #2-56 Socket Head Cap Screws are provided in the 7330 shipping container as accessories for standalone installation of the 7330 model as well. All necessary installation accessories for models 773A or 776 are included separately within their respective shipping containers.

4.0 Pre-installation Check

Before stacking the 7330 angular rate sensor with the 773A or 776 accelerometers, perform a pre-installation check to confirm all sensing axes are operational.

For model 7330 and 773A, a basic Output Voltage test can be conducted with minimal test equipment on each sensor. Place each sensor on the flat surface of a vibration-free table top, apply excitation voltage to sensor (see data sheet of each model for proper wiring hook-up) and measure the output with a voltage meter on each of the X/Y/Z outputs, verify sensor output per nominal values shown in Table 1 and 2. Allow the sensor to warm-up for one minute before the output voltage measurement.

Excitation Voltage	5-16V
+OUT with respect to GND	2.3V ~ 2.6V
+OUT with respect to –OUT	± 100mV

Table 1. Nominal Output Voltage for each axis of 7330.

Excitation Voltage	5V (-R), 7-36V (-U)
VREF with respect to GND	2500V ± 75mV
VOUT at 0g with respect to VREF	± 75mV

Table 2. Nominal Output Voltage for each axis of 773A.

For model 776, a resistance check is a quick way to verify the sensor is functional. Place 776 sensor on the flat surface of a vibration-free table top, measure the input and output resistances across different pairs of leads shown in Table 3 by a multi-meter. Perform the resistance measurement on all three X/Y/Z axes and compare to the nominal values in Table 3.

Input Resistance (between +EXC and -EXC)	6500 ± 2500 Ohm
Output Resistance (between +OUT and -OUT)	6500 ± 2500 Ohm

Table 3. Nominal Resistance for each axis of 776.

If the pre-installation check does not give a proper reading within the nominal values, which indicates a possible malfunction, and the reason for the erroneous reading cannot be found, please contact sales@endevco.com for troubleshooting or return of the sensor.

5.0 6DoF Stacked Mounting

To mount the 7330 and 773A or 776 sensors for 6DoF applications, the stacked module may be secured to the substrate using either screws or adhesive. Follow the specific assembly sequence and utilize the tools and techniques listed in Section 3.0 to ensure optimal measurement performance

5.1. Assembly Sequence

To ensure optimal mechanical coupling between the accelerometer and the measurement surface, always stack the 7330 triaxial angular rate sensor on top of the 773A or 776 triaxial accelerometer. While stacking the 7330 underneath would not affect its own performance, it may degrade the accelerometer's performance by causing unexpected resonance modes in the frequency response.

5.2. Mounting Surface

Ensure the mounting surface is clean and free of burrs. Prepare the mounting surface of substrate with two #2-56 tapped holes, at least 0.25 inch deep and spaced 0.85 inches apart to align with the 7330 mounting holes. For optimal performance, the contact area for the accelerometer base should have a 32 micro-inch RMS surface finish and a flatness tolerance of 0.0001 inches.

To minimize acceleration measurement errors, ensure the sensing axes and the two mounting holes are drilled perfectly perpendicular (within ±1°) to the mounting surface. For optimal accelerometer performance, position the mounting holes as close to the target object as possible; however, the hole placement is less critical for angular rate measurements, which can be located either centrally or near the edge of the mounting surface of the rotational substrate.

5.3. Screw Mount of 6DoF Module

To screw mount the 7330+773A/776 6DoF Module to the mounting surface, use the 2pc supplied #2 washers (p/n EDVEHW200), 2pc mounting screws (EDVEHM178, 2-56 x 7/8’’) and Allen wrench (EDVEHM178) as shown in Figure 2 (a) and (b).

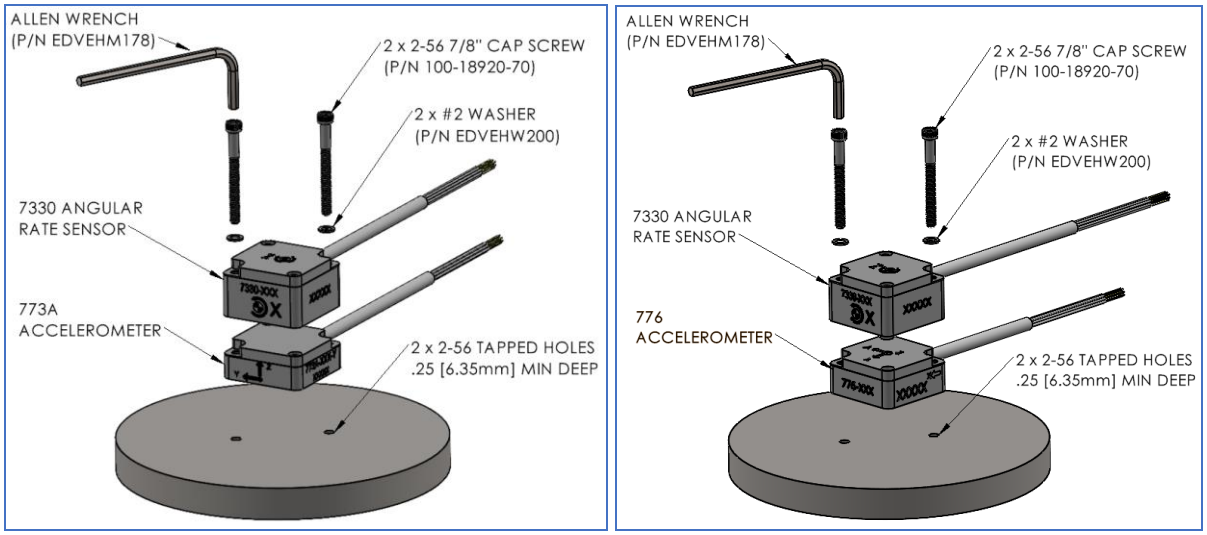
Remove the sensors and accessories from the shipping containers. Place the sensors on the mounting surface and align with the mounting holes.

The screw mount of the 7330+773A and 7330+776 modular 6DoF sensors on the mounting surface are illustrated in Figure 2 (a) and (b). Slide the washers over the screws. Install the screws with washers into the through holes of the 7330 angular rate sensor first and then to the through holes in the 773A/776 accelerometer. Make sure 7330 is always stacked on top of the 773A or 776 to ensure best mechanical coupling of the acceleration measurement. Use the supplied Allen wrench or a torque wrench, tighten the screws to 2 lbf-in (0.23 Nm). This is roughly equivalent to finger tight with the supplied wrench.

It’s recommended to re-torque the screws of the modular 6DoF after each high g vibration or shock test that may cause loose screws that degrades the high frequency performance of the accelerometer. A thread-locking compound is recommended to be applied to the screws in applications where re-torquing is not possible.

In case of high g shock applications using modular 6DoF of 7330 and 776, a thin layer of vacuum grease (e.g. Dow Corning High Vacuum Grease) can be applied between the accelerometer and the mounting surface to further enhance the mechanical transmissibility of the acceleration input.

To accommodate specific directional requirements, either the angular rate sensor or the accelerometer may be rotated 180° to align with the mounting holes. It is not necessary to align the cable exits of the angular rate sensor and the accelerometer; they may be positioned 180° apart. For correct orientation, refer to the arrow symbols on the 773A or 776 for positive X/Y/Z linear sensing directions and the rotational arrows on the 7330 for positive X/Y/Z rotational sensing directions.



(a) (b)

FIGURE 2. (a) Screw Mount of 7330+773A 6DoF module.
(b) Screw Mount of 7330+776 6DoF module

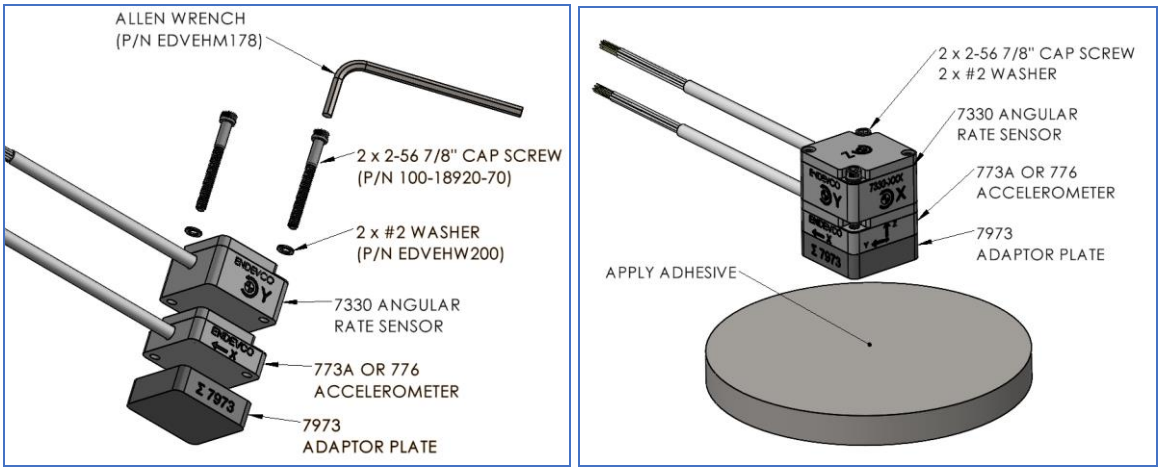
5.4. Adhesive Mount of 6DoF Module

For quick and easy installation on smooth, flat surfaces, the 7330 and 773A/776 6DoF module can be adhesively mounted using the 7973 adapter plate. This method is ideal for applications where mounting holes are unavailable or where drilling into the substrate is not feasible.

Figure 3 (a) illustrates the 6DoF module assembly for adhesive mounting. To assemble, slide the washers onto the screws, then pass the screws through the 7330 angular rate sensor, followed by the 773A/776 accelerometer, and then into the 7973 adapter plate. Always ensure the 7330 is stacked on top of the 773A or 776 to maintain optimal mechanical coupling for acceleration measurements. Using the provided wrench or a torque wrench, tighten the screws to 2 lbf-in (0.23 Nm), which is approximately equivalent to finger-tight. In case of high g shock applications using modular 6DoF of 7330 and 776, a thin layer of vacuum grease (e.g. Dow Corning High Vacuum Grease) can be applied between the accelerometer and the 7973 adaptor plate to further enhance the mechanical transmissibility of the acceleration input. Following each high-G vibration or shock test, re-torque all screws to specification when necessary. Alternatively, apply a thread-locking compound during assembly to maintain long-term fastener security.

Figure 3 (b) shows the adhesive installation of the 6DoF module with 7973 adaptor plate. Apply a thin, even layer of epoxy or super glue to the bottom of the 7973 plate or the mounting substrate using an oiler or a toothpick. Ensure the epoxy covers all contact surfaces of mounting surface and 7973 plate. While epoxy bonds exceptionally well to the hard-anodized surface of the 7973, thermal expansion mismatches can degrade the joint or warp the mounting surface. To mitigate this, a compliant adhesive like Dow Corning 3145 RTV or Loctite 430 is recommended to be used for adhesive mounting. During curing of the epoxy, ensure the 6DoF module remains perfectly flat on mounting surface to prevent measurement errors.

To remove the adhesively installed 6DoF module, apply a small amount of acetone or a compatible solvent to the adhesive layer with a cotton swab. Once the adhesive has softened, gently remove the sensor. If using tools (e.g. Wrench) for removal of the 6DoF module, apply force only on the 7973 adapter plate. Avoid applying excessive strain to the 7330, 773A, or 776 sensor bodies to prevent damage of the sensors.



(a) (b)

FIGURE 3. (a) Assembly of 7330+773A/776 6DoF module to adaptor plate 7973.
(b) Adhesive Mount of 7330+773A/776 6DoF module to substrate.

5.5. Cable

Models 7330, 773A, and 776 include integrated cables with pigtail terminations. To protect sensors from strain during rotation, vibration, or shock, secure the cables to the mounting surface within 2 to 3 inches (4 to 6 cm) of the unit using tape or cable ties. Alternatively, the sensor cables can be secured permanently to mounting surface by epoxy.
Route all sensor cabling away from power lines or other electronics cabling to minimize electrical noise interference. The cable should be coiled (with generous bend radius) or relaxed for proper strain relief between the sensor and the power supply/signal conditioner. Additionally, handle the 7330 integral cable with care, its soft jacket is susceptible to cuts and tears.

6.0 Electrical Precautions

6.1. Excitation Voltage

Model	Excitation Voltage	Current Draw (Tri-axial total)
7330	5V to 16V	18 mA max
773A	5V (-R), 7-36V (-U)	14 mA max
776	5V or 10V, 12V max	7.5 mA max

Table 4. Excitation Voltage and Max Current Draw of 7330, 773A and 776

Models 7330, 773A, and 776 require stable, clean and regulated DC excitation voltage for optimal performance. Refer to Table 4 for the specific excitation voltage and maximum current requirements for each model. Operating the sensors outside the specified excitation voltage values can cause permanent damage.

Each axis of the 6DoF module can be powered a dedicated power supply, or a single external DC power supply can provide excitation for all six axes of the 6DoF module. For instance, an 5V external voltage source is suitable for the six axes in 7330+773A-R or 7330+776 modules, while a 10V excitation can power the 7330+773A-U and 7330+776 combinations. (Refer to Signal Conditioning section for wiring single power supply to six axes of the 6DoF module.) The specifications (e.g. sensitivity, ZMO) of 7330 and 773A do not change with the excitation voltage. Model 776 specs are defined with 10V excitation and may differ from the specified values if a different voltage is used.

The six axes of 7330+773A module require a total of 32 mA max current draw from the external power supply, and 7330+776 needs total 25.5 mA max current. Please ensure there is sufficient current capacity from the power supply to operate the 6DoF module correctly.

6.2. Signal Conditioning

For 7330 and 776 in modular 6DoF, each sensing axis includes a four-wire configuration: EXC+, EXC- (GND), OUT+, and OUT-. The excitation voltage is applied across EXC+ and EXC- (GND) in each individual axis. All six sensing axes are electrically isolated from one another. For simplified wiring, the six EXC+ leads can be connected together to the positive terminal of a single excitation power source, and the six EXC- (GND) leads can be tied together to the negative terminal (signal return) of the power source. The differential output of 7330 and 776 is measured between OUT+ and OUT- using a voltmeter or DAQ system.

For Model 773A, the three sensing axes share the common EXC and GND pins. When integrating 7330 and 773A into 6DoF module, for simplified wiring the EXC wire of 773A can be tied to the three EXC wires of 7330, and the GND wire to the three EXC- (GND) wires of 7330. 773A can operate in differential output mode by measuring the voltage between the +OUT and VREF which results in a 0V bias, or it can operate in single-ended output mode by measuring the voltage between the +OUT and EXC- (GND) which results in a +2.5V bias.

To minimize noise interference, follow standard instrumentation practices by using shielded, twisted-pair cabling to connect the sensor signal leads to the measurement equipment.

PCB 483C28 8-channel signal conditioner can be used for power source and data acquisition with 7330 and 773A/776 6DoF module. When multi-channel signal conditioner is used, each channel supplies excitation to each axis of the 6DoF module individually, do not tie the power wires or GND wires of different axes together.

6.3. Grounding

The sensor case of the model 7330, 773A or 776 is not attached to the circuit ground, and the cable shield is not attached to the case or to circuit ground. The recommended grounding scheme is to ground the cable shield of the sensors at the power supply ground and to no other point to avoid ground loops.

7.0 Recalibration

Calibration of Sensitivity and Zero Measurand Output in 7330, 773A and 776 should be performed at 6 to 12 month intervals, depending on usage. Ordinarily, recalibration need be performed only at 12 month intervals if it is known that the sensors have not been used beyond

its rated specifications. If the sensor is used under severe environments, it may be desirable to use shorter calibration intervals.

Contact Endevco for local calibration facility information or return the sensors to Endevco for recalibration. Endevco maintains a recalibration service with A2LA traceability in the United States.

Dirty units may be wiped clean using a damp cloth and a solvent such as acetone.

8.0 Questions

If you have any questions regarding the use of this or any Endevco sensors, please contact sales@endevco.com or go to our website https://endevco.com/ for information of Endevco Application Engineering in North America and your local sales representatives.