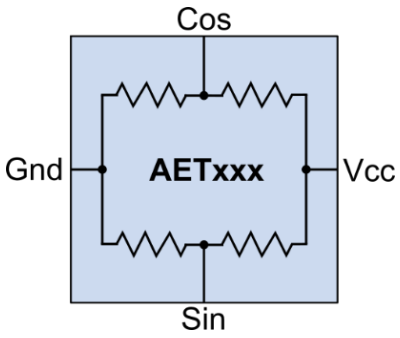
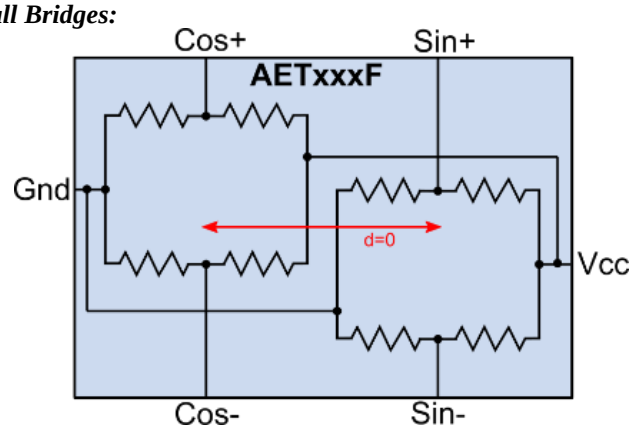
AET-Series TMR Off-Axis Rotational and Linear Sensors

Block Diagram

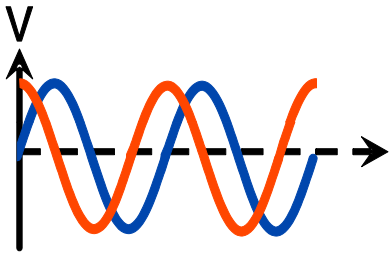
Half-bridges:



Full Bridges:



Outputs



AET-Series operation

Features

- Wide airgap
- Low hysteresis
- Excellent linearity, low distortion
- Large analog peak-to-peak signal
- Operating frequency to 350 kHz
- High 150°C operating temperature

Applications

- Linear and rotational encoders
- Motion, speed, and position sensing
- Closed-loop servo systems
- Motor feedback encoders

Description

NVE's AET-Series sensor elements are versatile, wide-airgap sensors typically used with multipole ring magnets, both radial and face poles, and magnetic linear scale. Standard spacing sensors can detect pole pitches from 0.5 mm to 5 mm. The sensors are Wheatstone bridges comprised of tunneling magnetoresistance (TMR) elements. Both full-bridge and half-bridge versions are available.

The AETxxxF full-bridge sensors offer excellent noise immunity and large differential output signals, and they fully cancel common-mode interference fields.

AETxxx half-bridge sensors combine high performance with a half-bridge outputs interface, ideal for simplicity and miniaturization. They can be influenced by common-mode magnetic fields above 1 millitesla.

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Absolute Maximum Ratings

AET-Series TMR Encoder Sensors			
Parameter	**Min.**	**Max.**	**Units**
Supply voltage	-7	7	Volts
Storage temperature	−65	170	°C
ESD (Human Body Model)		2000	Volts
Applied magnetic field		Unlimited	mT

Operating Specifications

Parameter	**Symbol**	**Min.**	**Typ.**	**Max.**	**Units**
Operating temperature	T_{min}; T_{max}	−50		150	°C
Supply voltage	V_{CC}	0		5.5	V
Resistance • AET500-02E • AETxxxF-00E		 30 1	 50 5	 70 8	kΩ
Offset voltage	V_O	−20		+20	mV/V
Nonlinearity			1	2	%
Hysteresis			0.5	1	%
Magnetic linear range		±10	±20		mT
Saturation of TMR sensor elements		±30			mT
Single resistor sensitivity	ΔR/mT	0.8	1	1.2	%/mT
Maximum output					
• AETxxx			200	300	mVpp/V
• AETxxxF (normal mode)			400	600	
• AETxxxF (double pitch mode)			300	450	
Temperature coefficient of device resistance	TCR		-0.08		%/°C
Temperature coefficient of output	TCO	-0.1	0	0.1	%/°C
Operating frequency	f_{MAX}		350		kHz

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Magnetic Pitch and Pole Pitch

The AET-Series are linear sensors designed for detecting multipole magnets for off-axis rotational or linear scale applications. The TMR sensor elements are bipolar, meaning they detect both north and south magnetic fields. This gives the sensors large output signals, but it also effectively doubles the "magnetic pitch" from the sensor's point of view. This concept is shown in Figure 1 below.

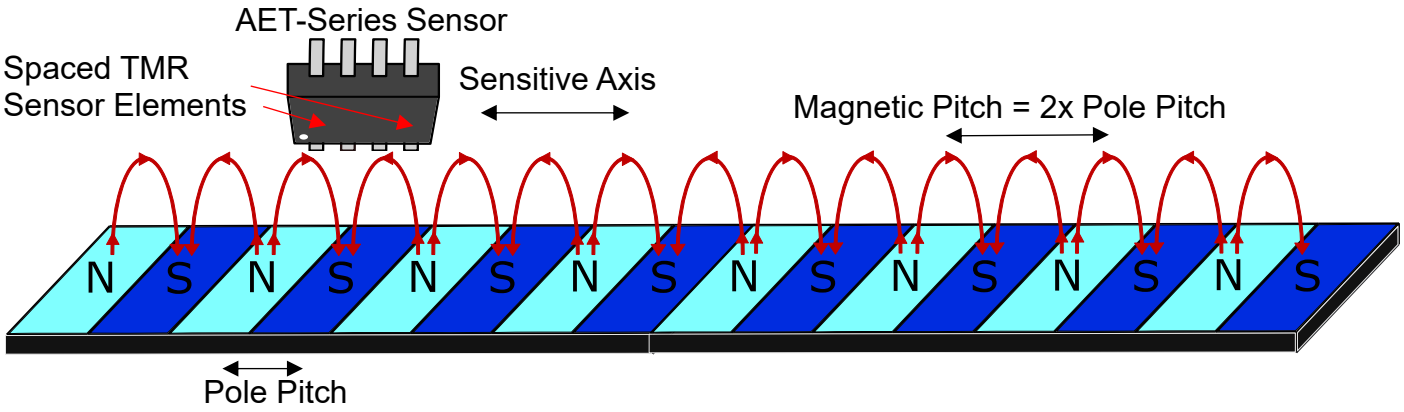

Figure 1: Pole pitch (north to south) vs. magnetic pitch (north to north) on a magnetic linear scale

AET-Series sensors are named based on the north-south "pole pitch" they are optimized to detect. The sensor's sine and cosine outputs are periodic with the "magnetic pitch." As an example, to detect a magnetic strip with "pole pitch" (specified by the manufacturer) of 1 mm, choose AET100F-00E. The sensor provides sine and cosine output signals, with a full cycle occurring every 2 mm.

Other common configurations for the AET-Series are illustrated below, where the same comments about "pole pitch" and "magnetic pitch" apply. The sensor output amplitude scales approximately linearly with airgap, reaching the maximum value when the sensor face is at the magnet face. The outputs scale ratiometrically with the supply voltage.

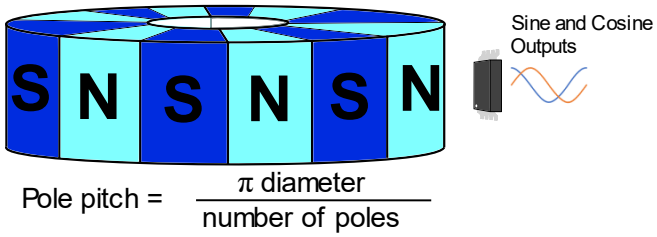

Figure 2: Multipole ring magnet with radial poles.

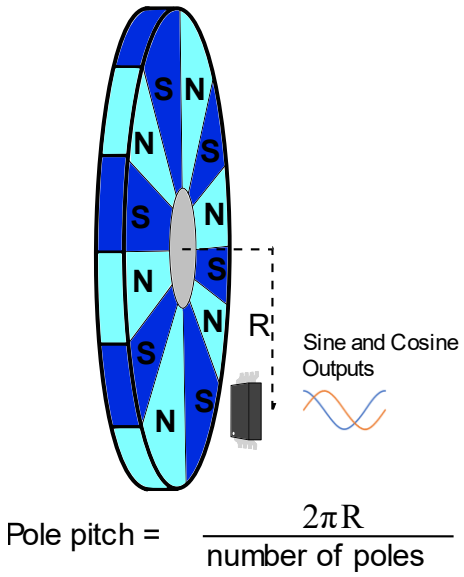

Figure 3: Multipole ring magnet with face poles

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AETxxxF Normal Mode and Double Pitch Mode

AETxxxF full bridge sensors can be used in two distinct modes of operation: normal mode and double pitch mode. Double pitch mode optimizes an AETxxxF sensor to measure twice as large a pole pitch as its normal mode. To use double pitch mode, the output signals are rearranged, swapping Sin+ and Cos-. For example, an AET100F-00E sensor is optimized for a 1 mm pole pitch in the normal mode and a 2 mm pole pitch in the double pitch mode connection. Figure 4 illustrates the concept.

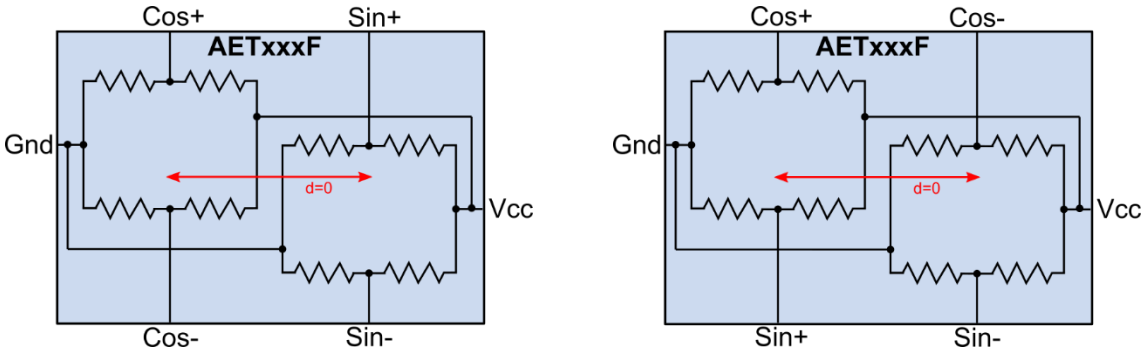

Figure 4: (left) Normal mode and (right) double pitch mode.

Double pitch mode will decrease the maximum output signal by 25% due to the modified effective TMR resistor arrangement, but all other performance characteristics, including common-mode field rejection, are preserved.

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Illustrative Application Circuits

Direct Microcontroller Interface

Large output signal and low output impedance allow the AETxxx or AETxxxF to be interfaced directly to a standard microcontroller or ADC. Incremental position information can be obtained with an arctangent function.

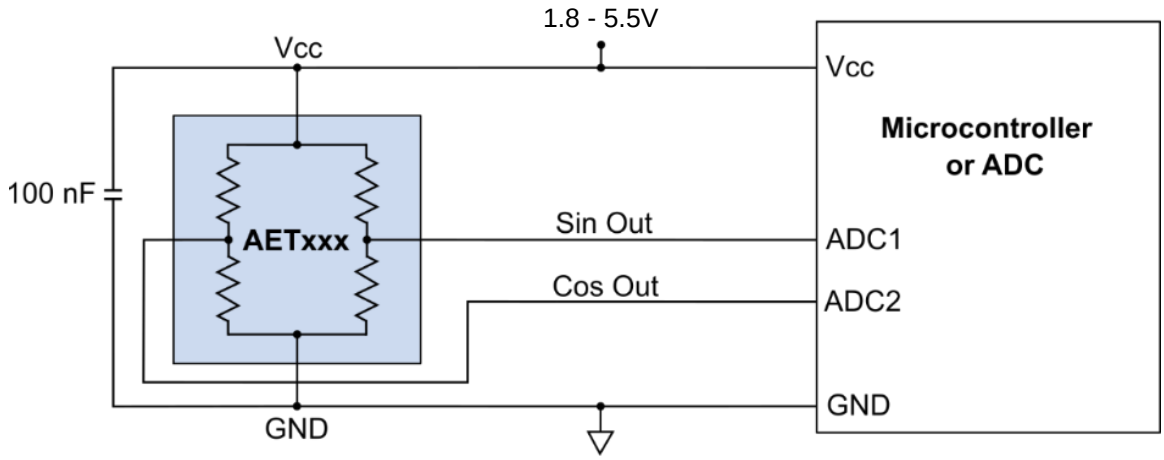

Figure 5. An AETxxx or AETxxxF can be interfaced to an ADC or microcontroller directly, without any external components.

Full-Scale Outputs

While AET-Series Sensors typically don't need buffering or amplification, they can be interfaced to low-cost op amps, as shown in Figures 6 and 7.

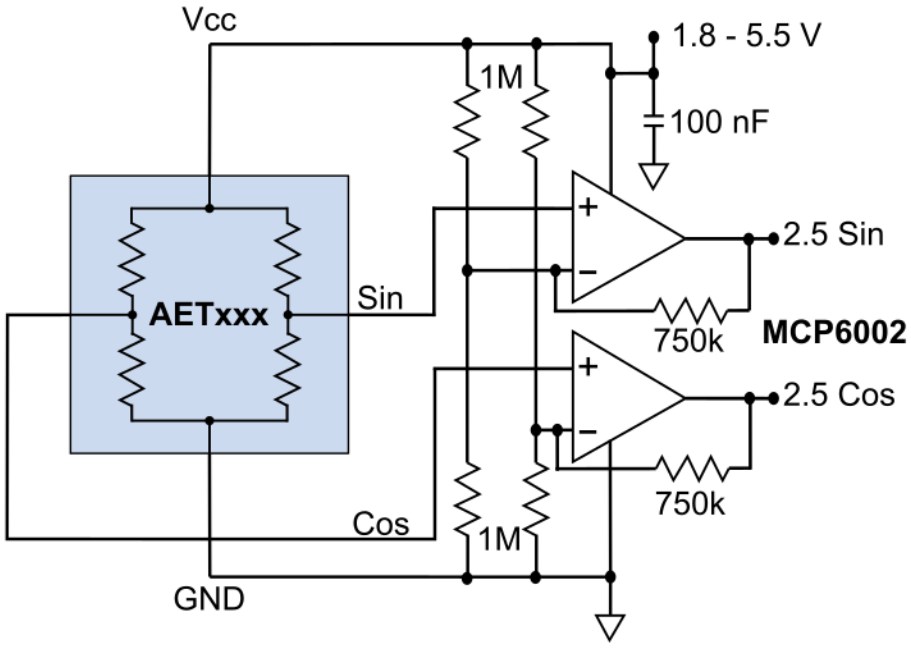

Figure 6. A dual op amp circuit with a gain of 2.5 boosts the 300 mVpp/V AETxxx outputs to near full-scale.

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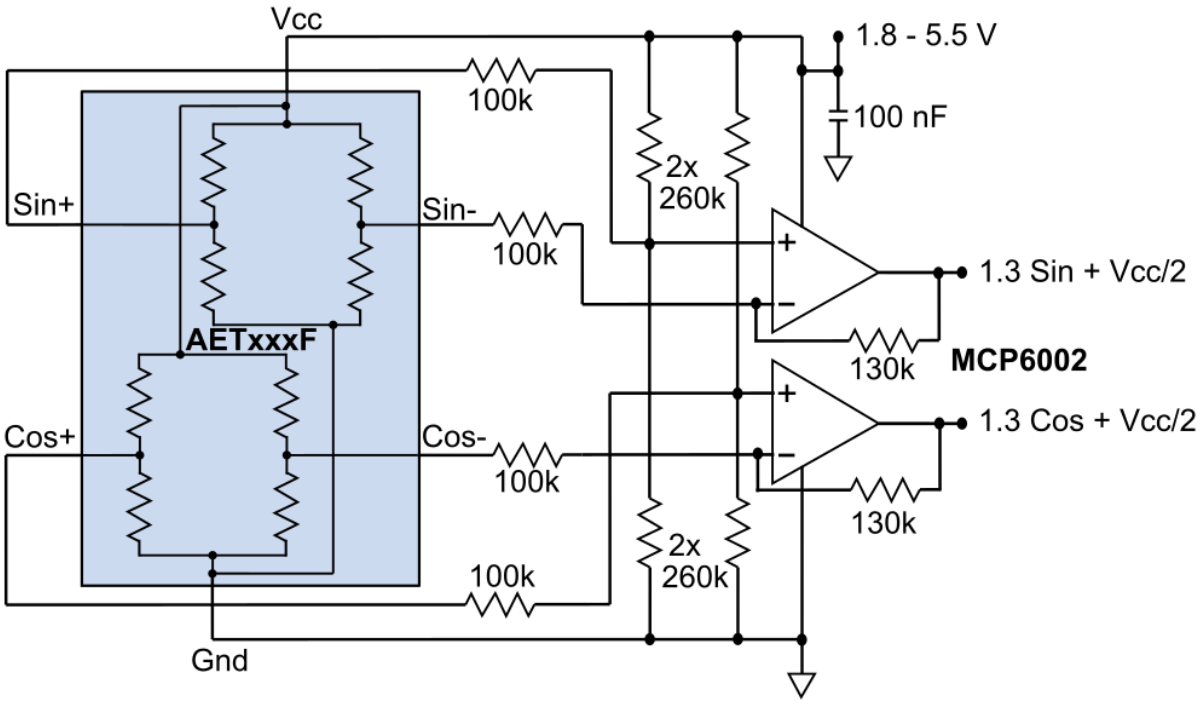


Figure 7. A dual op amp circuit with a gain of 1.3 boosts the 600 mVpp/V AETxxx outputs to near full-scale.

AETxxxF Double-Pitch Mode

Figure 8 shows the AETxxxF in double-pitch mode. Compared to Figure 7, the Sin+ and Cos- outputs are interchanged.

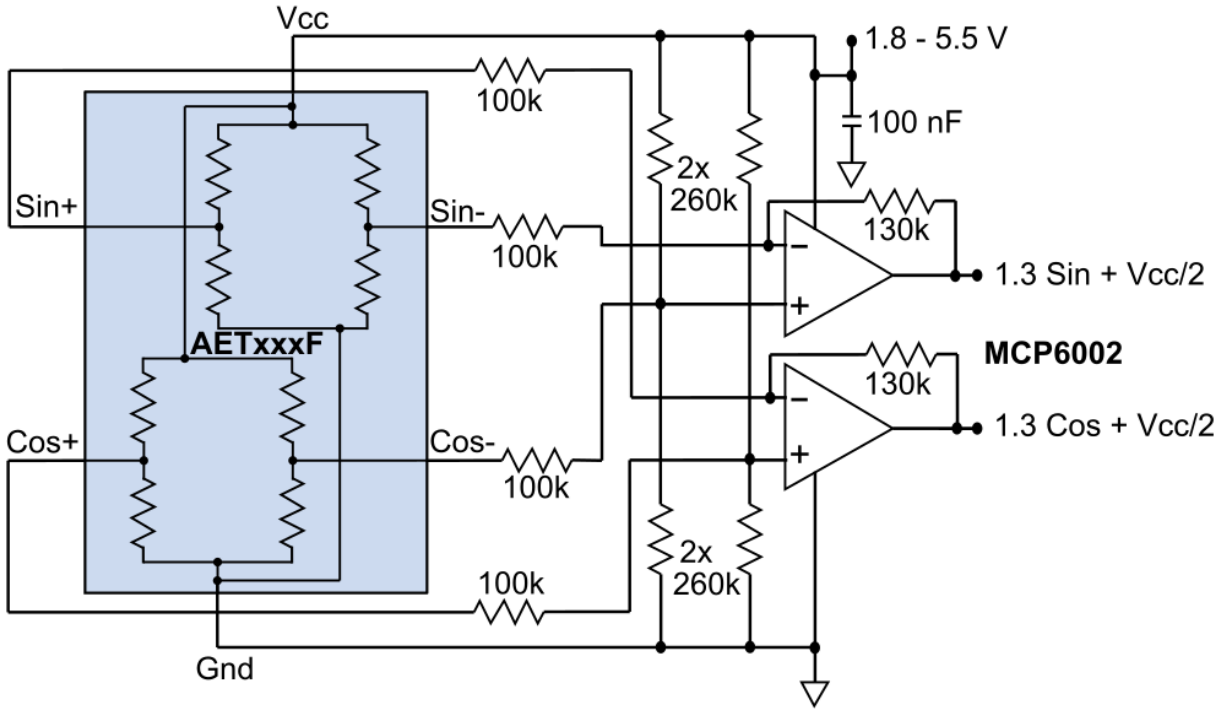
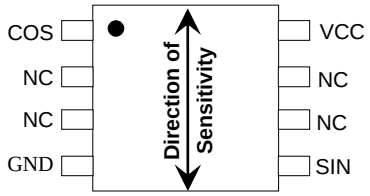


Figure 8. Double-pitch mode with an AETxxxF. The dual op amp circuit with a gain of 1.3 boosts the 450 mVpp/V AETxxx double-pitch mode outputs to near full-scale.

AETxxx Pinout (top view)

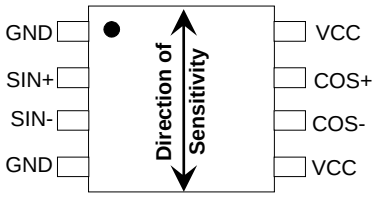
SOIC8
(-02E suffix)



SOIC8	Symbol	Description
8	VCC	Bridge power supply
4	GND	Bridge ground
1	COS	Cosine half-bridge output
5	SIN	Sine half-bridge output
2,3,6,7	NC	Leave floating

AETxxxF Pinout (top view)

MSOP8 / SOIC8
(-00E / -02E suffix)



Pin MSOP8 / SOIC8	Symbol	Description
5	VCC	Bridge power supply*
8	VCC	Bridge power supply*
1	GND	Bridge ground*
4	GND	Bridge ground*
2	SIN+**	Sine bridge differential output
3	SIN-	
7	COS+	Cosine bridge differential output
6	COS-**	

*Pin 5 and pin 8 should both have an external connection to VCC, and Pin 1 and Pin 4 should both have an external connection to GND.

**Swap COS- and SIN+ connections for AETxxxF double pitch mode.

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Part Numbering

The following example shows the AET-Series part-numbering system:

Base Part
AET = TMR Encoder Sensor Element

Pole Pitch
050 = 0.50 mm
075 = 0.75 mm
100 = 1.00 mm
120 = 1.20 mm
500 = 5.00 mm

Full or Half Bridges
F = Full
blank = Half

Package Type
00E = 3 x 3 mm MSOP8 (RoHS)
02E = 4 x 5 mm SOIC8 (RoHS)

Available Parts

AET-Series TMR Sensors					
Part No.	**Half or Full Bridges**	**Pole Pitch (normal mode)**	**Pole Pitch (double pitch mode)**	**Package**	**Package Marking Code**
AET500-02E	Half	5 mm	N/A	SOIC8	AET500
AET050F-00E	Full	0.5 mm	1 mm	MSOP8	FTDe
AET075F-00E	Full	0.75 mm	1.5 mm	MSOP8	FTCe
AET100F-00E	Full	1 mm	2 mm	MSOP8	FTBe
AET120F-00E	Full	1.2 mm	2.4 mm	MSOP8	FTEe

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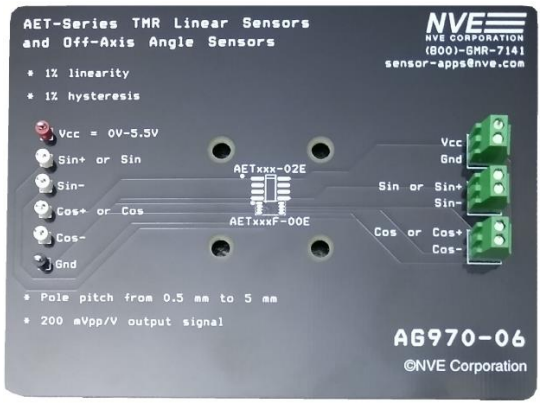
Evaluation Kits

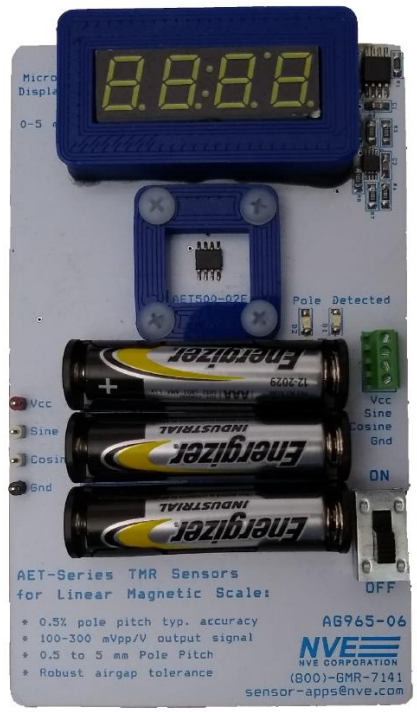
An evaluation kit is available for the AET-Series sensors. NVE also offers a linear magnetic scale demonstration featuring the AET500-02E sensor.



AG970-07E AET-Series Evaluation Kit

The AG970-07E Evaluation Kit helps with testing a variety of AET-Series sensors with linear magnetic scales. The kit includes:

- All five AET-Series parts (unsoldered in tubes)
- A 3 x 4-inch (76 x 101 mm) PCB with test points and screw terminals
- Detachable fixturing for linear magnetic tape (tape sold separately)

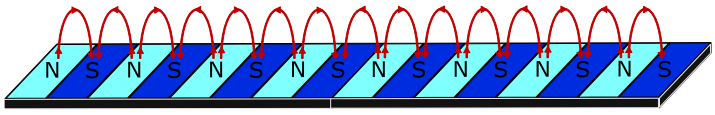


AG965-07E AET500 Micron Precision Demonstration

The AG965-07E demonstration kit showcases micron precision with an AET500-02E sensor. The kit includes:

- A 3 x 5-inch (76 x 127 mm) PCB
- An AET500-02E 5 mm pole-pitch sensor
- A four digit position display
- Part #12592 5mm pole pitch magnetic tape
- 3-D printed fixturing
- LEDs for pole detected
- Powered by three AAA batteries (included)

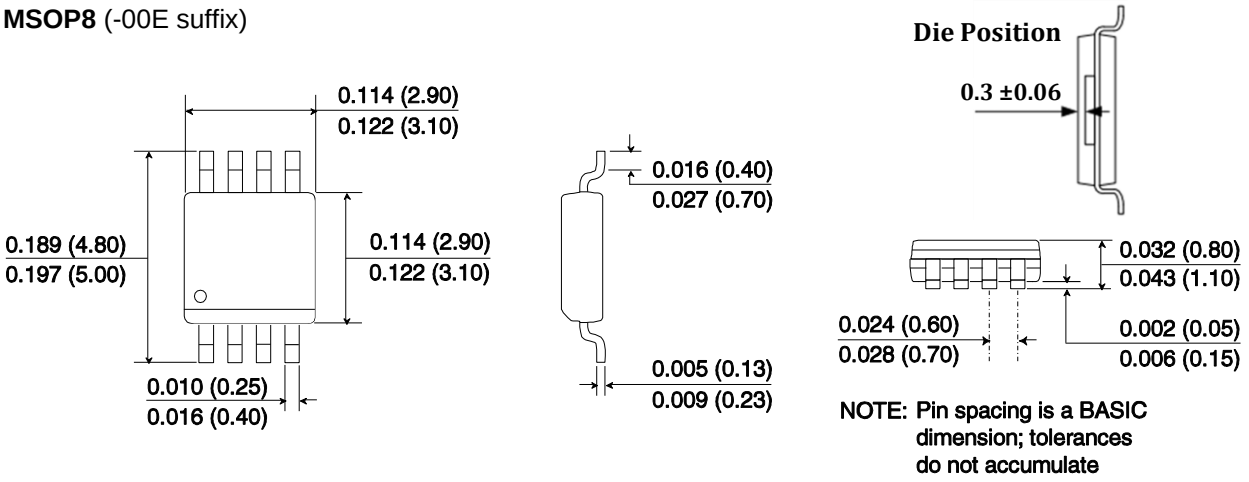
NVE also sells linear scale magnets that can be used with AET-Series sensors:



Part No.	Pole Pitch	Typical Flux Density @ Airgap
12589	0.5 mm	20 mT @ 0.2 mm
12590	1 mm	20 mT @ 0.4 mm
12591	2 mm	30 mT @ 0.7 mm
12592	5 mm	30 mT @ 1.4 mm

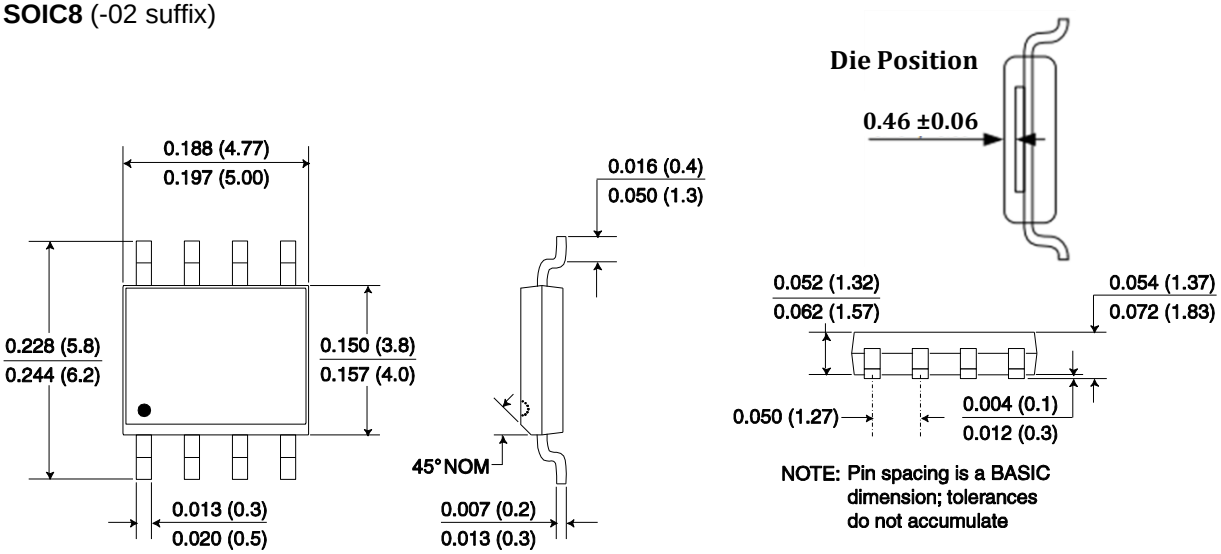
Package Drawings

MSOP8 (-00E suffix)



RoHS COMPLIANT

SOIC8 (-02 suffix)



RoHS COMPLIANT

All soldering profiles per JEDEC J-STD-020C, MSL 1.

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Revision History

SB-00-118-F October 2022	**Change** • Increased typical magnetic linear range • Added min and max sensitivity specifications • Added die position drawing to package drawings
SB-00-118-E August 2021	**Change** • Lowered resistance specification
SB-00-118-D September 2020	**Change** • Corrected pinout table
SB-00-118-C September 2020	**Change** • Updated application circuits
SB-00-118-B September 2020	**Change** • Added evaluation, demo kits, and magnets; updated AET500 resistance spec.
SB-00-118-A September 2020	**Change** • Initial datasheet release.

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