



# **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.



# 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.	Тур.	Max.	Units	
Operating temperature	T <sub>min</sub> ; T <sub>max</sub>	-50		150	°C	
Supply voltage	V <sub>cc</sub>	0		5.5	V	
Resistance						
• AETxxx		30	50	70	kΩ	
• AETxxxF		1	5	8		
Offset voltage	Vo	-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	$\Delta R/mT$	0.8	1	1.4	%/mT	
Maximum output						
• AETxxx			200	300	mVnn/V	
• AETxxxF			400	600	mvpp/v	
Temperature coefficient of device resistance	TCR		-0.08		%/°C	
Temperature coefficient of output	TCO	-0.1	0	0.1	%/°C	
Operating frequency	f <sub>MAX</sub>		350		kHz	



# 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.



Pole pitch =  $\frac{2\pi R}{\text{number of poles}}$ 

Figure 3. Multipole ring magnet with face poles



# Customized AET-Series for Nonstandard Magnetic Pitch

Each AET-Series sensor is optimized for a single magnetic pitch. Available parts are listed in Table 1:

AET-Series TMR Sensors				
Part No.	<b>Bridge Configuration</b>	Pole Pitch	Package	Package Marking Code
AET500-02E	Half	5 mm	SOIC8	AET500
AET050F-00E	Full	0.5 mm	MSOP8	FTDe
AET075F-00E	Full	0.75 mm	MSOP8	FTCe
AET100F-00E	Full	1 mm	MSOP8	FTBe
AET120F-00E	Full	1.2 mm	MSOP8	FTEe

### Table 1. Standard AET-series with pole pitch requirement.

Customized AET-series can be manufactured for any pole pitch from 0.25 to 10 mm. Please contact <u>sensor-apps@nve.com</u> to discuss custom tooling for your application.



# 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 4. 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 5 and 6.



Figure 5. A dual op amp circuit with a gain of 2.5 boosts the 300 mVpp/V AETxxx outputs to near full-scale.





Figure 6. A dual op amp circuit with a gain of 1.3 boosts the 600 mVpp/V AETxxx outputs to near full-scale.



# AETxxx Pinout (top view)





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)





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+	Sing bridge differential output		
3	SIN-	Sine bridge differential output		
7	COS+	Cosing bridge differential output		
6	COS-	Cosine bridge differential output		

\*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.



# Part Numbering

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



### Available Parts

AET-Series TMR Sensors				
Part No.	<b>Bridge Configuration</b>	Pole Pitch	Package	Package Marking Code
AET500-02E	Half	5 mm	SOIC8	AET500
AET050F-00E	Full	0.5 mm	MSOP8	FTDe
AET075F-00E	Full	0.75 mm	MSOP8	FTCe
AET100F-00E	Full	1 mm	MSOP8	FTBe
AET120F-00E	Full	1.2 mm	MSOP8	FTEe



### **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)







RoH

SOIC8 (-02 suffix)

Dimensions in inches (mm); scale = approx. 5X



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



# **AET-Series TMR Encoder Sensors**

# **Revision History**

# **SB-00-118-G** March 2024

SB-00-118-F

October 2022

# Change

- Increased maximum sensitivity to 1.4%/mT
- Removed "double-pitch mode" recommendations
- Added custom element spacing information

### Change

- Increased typical magnetic linear range
- Added min and max sensitivity specifications
- Added die position drawing to package drawings

# Change

Lowered resistance specification

# Change

• Corrected pinout table

# Change

• Updated application circuits

# Change

• Added evaluation, demo kits, and magnets; updated AET500 resistance spec.

# Change

• Initial datasheet release.

# SB-00-118-E

August 2021

SB-00-118-D September 2020

SB-00-118-C September 2020

# SB-00-118-B September 2020

**SB-00-118-A** September 2020



# **AET-Series TMR Encoder Sensors**

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