

# MA3

# Miniature Absolute Magnetic Shaft Encoder

## Description:

The **MA3** is a miniature rotary absolute shaft encoder that reports the shaft position over 360° with no stops or gaps. The **MA3** is available with an analog or a pulse width modulated (PWM) digital output.

Analog output (**MA3-A**) provides an analog voltage that is proportional to the absolute shaft position. Analog output is only available in 10-bit resolution.

PWM output provides a pulse width duty cycle that is proportional to the absolute shaft position. PWM output is available in 10-bit (**MA3-P**) and 12-bit (**MA3-P12**) resolutions. The accuracy is the same for both resolutions, even though the 12-bit version offers higher resolution.

Three shaft torque versions are available. The standard torque version has a sleeve bushing lubricated with a viscous motion control gel to provide torque and feel that is ideal for front panel human interface applications.

The **NT**-option (no torque added) has a sleeve bushing and a low viscosity lubricant (that does not intentionally add torque) for low RPM applications where a small amount of torque is acceptable.

The **B8**-option (ball bearing option) has a ball bearing rather than a sleeve bushing for high speed, free spinning, and zero torque applications. The **B8**-option is recommended when a pulley, gear, or friction wheel drives the shaft. This eliminates the wear that would otherwise result from the side load even at slow speeds. The shaft diameter for **B8**-option is 1/8" rather than 1/4".

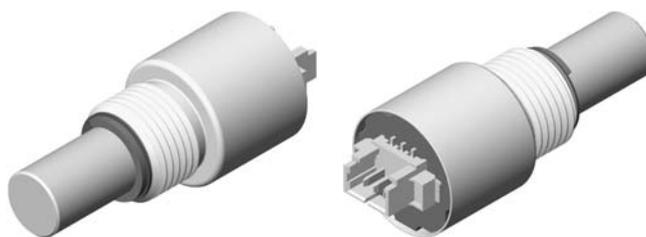
Connecting to the **MA3** is simple. The 3-pin high retention snap-in 1.25mm pitch polarized connector provides for +5V, output, and ground. Note that the **MA3** has a 3-pin connector and is smaller than its predecessor, the **MA2** which has a 4-pin connector.

## Features:

- > Patent pending
- > Low cost
- > Miniature size (0.48" diameter)
- > Non-contacting magnetic single chip sensing technology
- > -40 to 125°C. operating temperature range
- > 10-bit Analog output - 2.6 kHz sampling rate (**MA3-A**)
- > 10-bit PWM output - 1024 positions per revolution, 1 kHz (**MA3-P**)
- > 12-bit PWM output - 4096 positions per revolution, 250 Hz (**MA3-P12**)
- > RoHS compliant
- > US Digital warrants its products against defects in materials and workmanship for two years. See complete warranty for details.

## Applications:

- > Front panel control
- > Camera pan-tilt position sensor
- > Rotary valve position sensor
- > Rotary air duct valve position sensor
- > Studio lighting position feedback
- > Office equipment



## MA2 / MA3 Comparison:

US Digital continually seeks to improve our products by making them smaller, faster, more accurate, and lower cost. We found a way to make the **MA2** even smaller by changing the connector from 4-pins to 3-pins. This new product became the **MA3** and only has a diameter of 0.48". This next generation **MA3** product is highly recommended for all new designs and applications.

Feature	MA2	MA3
Size	0.62" dia.	0.48" dia.
Weight	0.56 oz.	0.46 oz.
Connector	4-pin	3-pin
Price		No Difference in Price

## Magnetic Field Crosstalk to Neighboring Encoders:

The **MA3** absolute encoder contains a small internal magnet, mounted on the end of the shaft that generates a weak magnetic field extending outside the housing of each encoder. If two **MA3** units are to be installed closer than 1 inch apart (measured between the center of both shafts), a magnetic shield, such as a small steel plate should be installed in between to prevent one encoder from causing small changes in reported position through magnetic field cross-talk.

## Mechanical Specifications:

Specification	Sleeve Bushing (Default, 8-option, M6-option)	Ball Bearing (B8-option)
Moment of Inertia	4.1x10 <sup>-6</sup> oz-in-s <sup>2</sup>	4.1x10 <sup>-6</sup> oz-in-s <sup>2</sup>
Accuracy	<±0.5° @ 25°C	<±0.5° @ 25°C
Over Temp.	<±0.9° @ -40 to 125°C	<±0.9° @ -40 to 125°C
Shaft Speed	100 RPM max. continuous	15,000 RPM max. continuous
Acceleration	10,000 rad/sec <sup>2</sup>	250,000 rad/sec <sup>2</sup>
Vibration	20 g. 5 to 2KHz	20 g. 5 to 2KHz
Shaft Torque	0.5 ±0.2 in. oz. 0.3 in. oz. max. ( <b>NT</b> -option)	0.05 in. oz. max.
Shaft Loading	2 lbs. max. dynamic* 20 lbs. max. static	1 lb. max.
Bearing Life	-	(40/P) <sup>3</sup> = life in millions of revs. where P = radial load in pounds
Weight	0.46 oz.	0.37 oz.
Shaft Runout	0.0015 T.I.R. max.	0.0015 T.I.R. max.

\* When a pulley, gear, or friction wheel drives the shaft, the Ball Bearing option is recommended instead of the Sleeve Bushing.

## Electrical Specifications:

- > Specifications apply over entire operating temp. range.
  - > Typical values are specified at Vcc=+5V and 25°C.
- | Parameter      | Min. | Typ. | Max. | Units |
|----------------|------|------|------|-------|
| Power Supply   | 4.5  | 5.0  | 5.5  | Volts |
| Supply Current | -    | 16   | 20   | mA    |
| Power-up Time  | -    | -    | 50   | mS    |

## Materials:

Parameter	Dimension
Shaft	Stainless
Bushing	Brass

## Environmental Specifications:

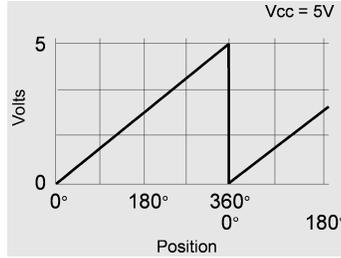
Parameter	Dimension
Operating Temperature	-40 to +125°C
Storage Temperature	-55 to +125°C
ESD	2 kV minimum
Humidity Non-condensing	5 to 85%



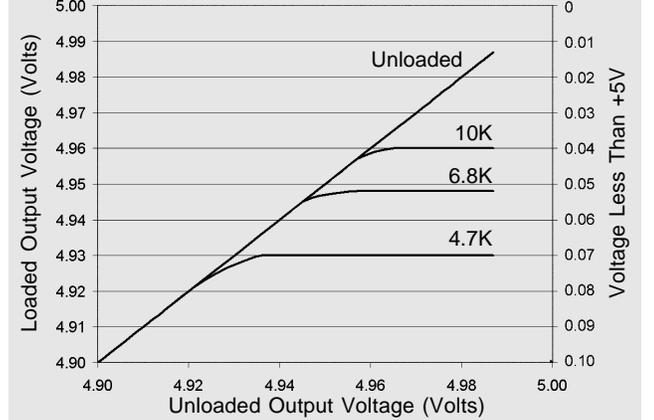
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## Analog (MA3-A) Output Operation:

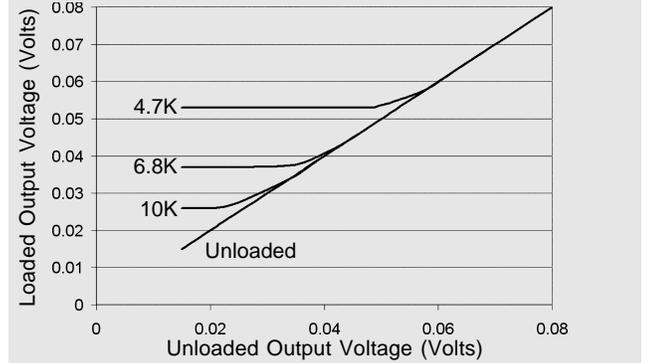
Analog output is only available in 10-bit resolution. The analog output voltage is ratiometric to the power supply voltage and will typically swing within 15 millivolts of the power supply rails with no output load. This non-linearity near the rails increases with increasing output loads. For this reason, the output load resistance should be  $\geq 4.7k\Omega$ s and less than 100pf. The analog output transition noise is equal to 0.06° RMS. The graphs to the right show the typical output levels for various output loads when powered by a 5V supply.



Output Voltage vs. Output Load w/ Pulldown Resistors to GND



Output Voltage vs. Output Load w/ Pullup Resistors to +5V



Parameter	Min.	Typ.	Max.	Units
Position Sampling Rate	2.35	2.61	2.87	kHz
Propagation Delay	-	-	384	μS
Analog Output Voltage Maximum	-	4.987	-	Volts*
Analog Output Voltage Minimum	-	0.015	-	Volts*
Output Short Circuit Sink Current	-	32	50	mA**
Output Short Circuit Source Current	-	36	66	mA**
Output Noise	160	220	490	μVrms
Output Transition Noise	-	0.06	-	Degrees RMS***

\* With no output load. See graphs to the right.

\*\* Continuous short to +5V or ground will not damage the MA3.

\*\*\* Transition noise is defined as the jitter in the transition between two adjacent position steps.

## PWM (MA3-P, MA3-P12) Output Operation:

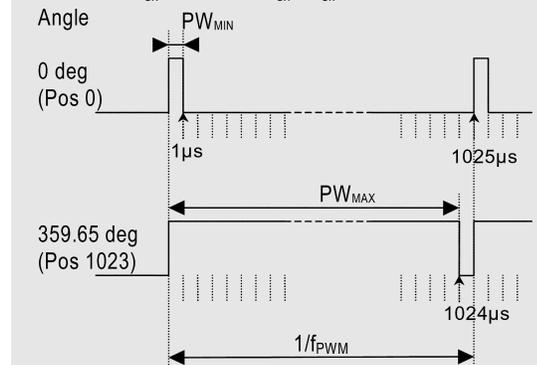
The magnetic sensor chip in the MA3 has an on-chip RC oscillator which is factory trimmed to  $\pm 5\%$  accuracy at room temperature ( $\pm 10\%$  over full temperature range). This tolerance influences the sampling rate and the pulse width of the PWM output. If only the PWM pulse width  $t_{on}$  is used to measure the angle, the resulting value also has this timing tolerance. However, this tolerance can be cancelled by measuring both  $t_{on}$  and  $t_{off}$  and calculating the angle from the duty cycle. Accuracy including non-linearity is within  $\pm 0.5^\circ$  at 25°C, but may increase to  $\pm 0.9^\circ$  at high temperatures.

Parameter	Min.	Typ.	Max.	Units
PWM Frequency (-40° to 125°C)				
10-bit	0.878	0.976	1.074	kHz
12-bit	220	244	268	Hz
Minimum Pulse Width				
10-bit	0.95	1.00	1.05	μS
12-bit	0.95	1.00	1.05	μS
Maximum Pulse Width				
10-bit	973	1024	1075	μS
12-bit	3891	4096	4301	μS
Internal Sampling Rate				
10-bit	9.38	10.42	11.46	kHz
12-bit	2.35	2.61	2.87	kHz
Propagation Delay				
10-bit	-	-	48	μS
12-bit	-	-	384	μS
High Level Output Voltage ( $V_{OH}$ : @4mA Source)	$V_{CC} - 0.5$	-	-	V*
Low Level Output Voltage ( $V_{OL}$ : @4mA Sink)	-	-	0.4	V*

\* Continuous short to +5V or ground will not damage the MA3.

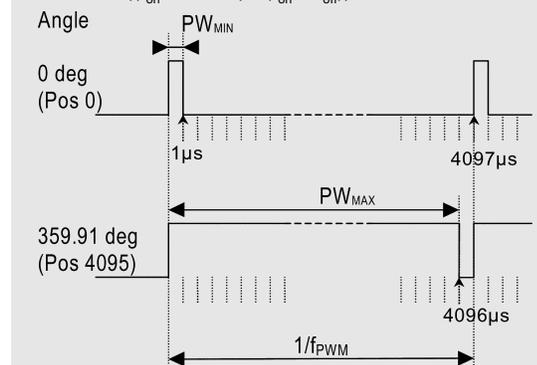
### 10-bit PWM:

$$\text{Position} = ((t_{on} \times 1025) / (t_{on} + t_{off})) - 1$$



### 12-bit PWM:

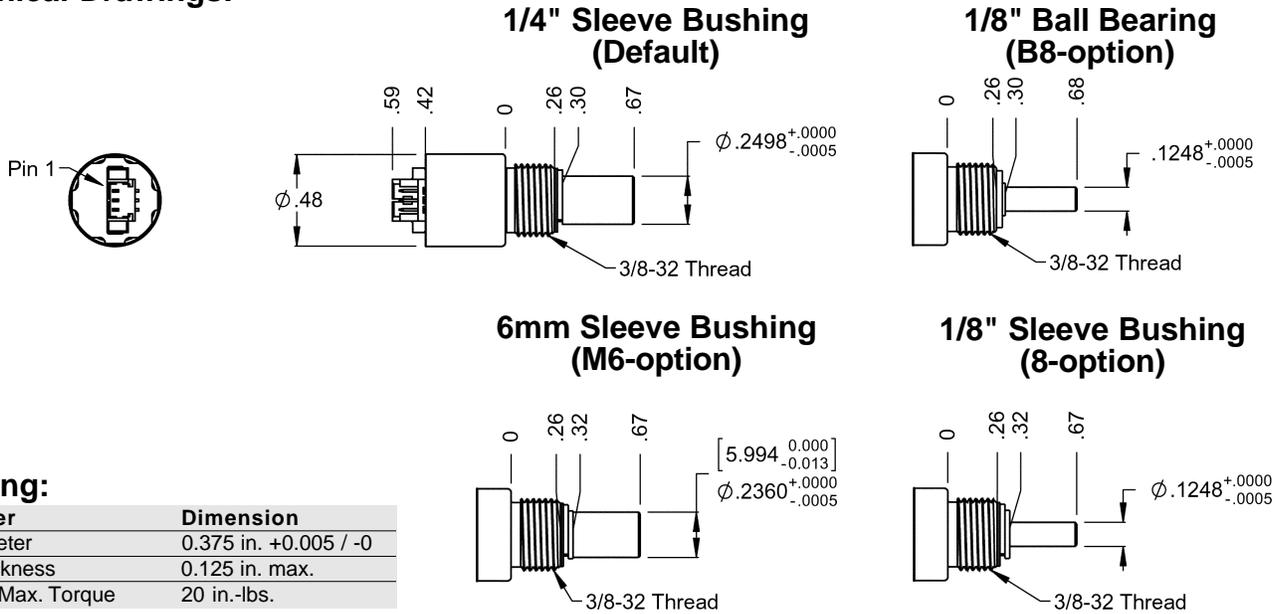
$$\text{Position} = ((t_{on} \times 4097) / (t_{on} + t_{off})) - 1$$



# MA3

# Miniature Absolute Magnetic Shaft Encoder

## Mechanical Drawings:



## Mounting:

Parameter	Dimension
Hole Diameter	0.375 in. +0.005 / -0
Panel Thickness	0.125 in. max.
Panel Nut Max. Torque	20 in.-lbs.

## Compatible Cables & Connectors:

3-pin Micro:	
CON-MIC3	Connector
CA-8703-1FT	Connector on one end with 3 12 in. wires
CA-8704-6FT	Connector on one end of a 6 ft. round cable

**Attention:**

- > Specify cable length when ordering.
- > Custom cable lengths are available. See the **Cables / Connectors** data sheet for more information.

**Connector Notes:**

- > Connector built into encoder: Molex# 53398-0371.
- > Mating connector housing: Molex# 51021-0300.
- > Mating connector individual crimp-on pins: Molex# 50079-8100.
- > To install connector pins, a special crimp tool is needed: Molex# 50079

## MA3-A (Analog Output):

Pin	Name	Description
1	5	+5VDC power
2	A	Analog output
3	G	Ground

## MA3-P, MA3-P12 (PWM Output):

Pin	Name	Description
1	5	+5VDC power
2	A	PWM output
3	G	Ground

## Ordering Information:

**10-bit:**  
 \$29.00 / 1  
 \$26.10 / 10  
 \$23.49 / 50  
 \$21.00 / 100

**12-bit:**  
 \$34.00 / 1  
 \$30.54 / 10  
 \$27.48 / 50  
 \$24.57 / 100

**Cost Modifiers:**

- > Add \$6 for **B8**-option.
- > Add \$5 for **M6**-option.

**Includes:**

- > 1 washer and 1 nut per encoder.

### Example Part#:

- > MA3-A-B8
- > MA3-P12-M6NT
- > MA3-A-8

### Part #:

**MA3** -

**Output:**  
**A** = 10-bit analog.  
**P** = 10-bit PWM.  
**P12** = 12-bit PWM.

**Options:** (specify in order shown)  
**Blank** (default) = 1/4" dia. sleeve bushing (standard torque).  
**M6** = 6mm dia. sleeve bushing (standard torque).  
**8** = 1/8" dia. sleeve bushing (standard torque).  
**B8** = 1/8" dia. ball bearing (free spinning).  
**NT** = Replaces standard torque with no torque added.

**Notes:**  
 \* Not available with **NT**-option (no torque added).

Technical Data, Rev. 03.29.07, March 2007  
 All information subject to change without notice.