

## 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 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 and 12-bit resolutions. While the accuracy is the same for both encoders, the 12-bit version provides 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 no torque added option 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 ball bearing version uses miniature precision ball bearings that are suitable for high speed and ultra low torque applications. The shaft diameter for ball bearing version 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.



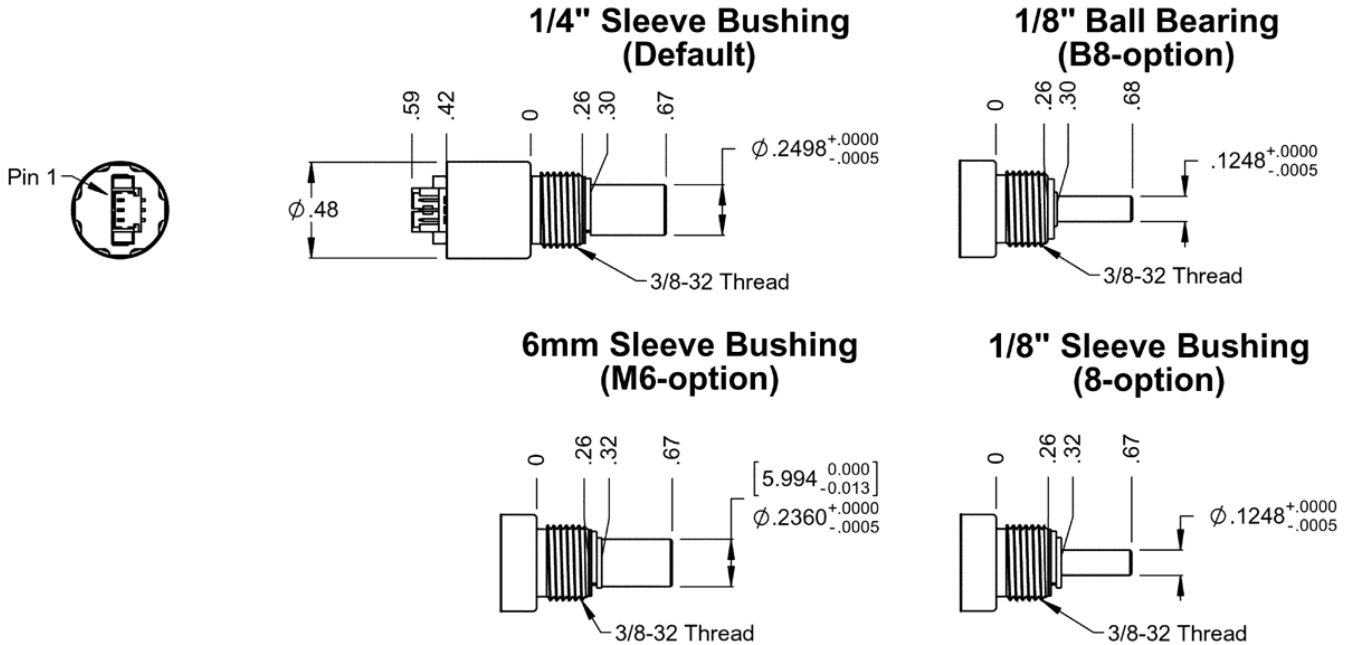
## Features

- ▶ Patent pending
- ▶ Miniature size (0.48" diameter)
- ▶ Non-contacting magnetic single chip sensing technology
- ▶ -40C to 125C. operating temperature range
- ▶ 10-bit Analog output - 2.6 kHz sampling rate
- ▶ 10-bit PWM output - 1024 positions per revolution, 1 kHz
- ▶ 12-bit PWM output - 4096 positions per revolution, 250 Hz

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 Mechanical Drawing



 Mechanical

Specification	Sleeve Bushing	Ball Bearing
Moment of Inertia	$4.1 \times 10^{-6}$ oz-in-s <sup>2</sup>	$4.1 \times 10^{-6}$ oz-in-s <sup>2</sup>
Angular Accuracy	<0.5 deg. @ 25C	<0.5 deg. @ 25C
Angular Accuracy Over Temperature	<0.9 deg. @ -40 to 125C	<0.9 deg. @ -40 to 125C
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	20G. 5Hz to 2kHz	20G. 5Hz to 2kHz
Shaft Torque	0.5 ± 0.2 in. oz. (D - torque option) 0.3 in. oz. max. (N - torque option)	0.05 in. oz. max.
Shaft Loading	2 lbs. max. dynamic* 20 lbs. max. static	1 lb. max.
Bearing Life	-	$(40/P)^3$ = 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.

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

### Environmental

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

### Mounting

Parameter	Dimension
Hole Diameter	0.375" +0.005 / -0.0
Panel Thickness	0.125" max.
Panel Nut Max. Torque	20 in.-lbs.

### Materials

Parameter	Dimension
Shaft	Stainless
Bushing	Brass

### Magnetic Field Crosstalk

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.

### Electrical

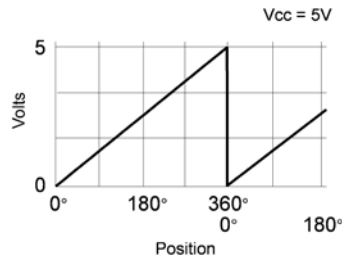
Parameter	Min.	Typ.	Max.	Units
Power Supply	4.5	5.0	5.5	Volts
Supply Current	-	16	20	mA

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Parameter	Min.	Typ.	Max.	Units
Power-up Time	-	-	50	mS

### Analog 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 impedance should be  $\geq 4.7k\Omega$  and less than 100pF. The graphs below show the typical output levels for various output loads when powered by a 5V supply.

Parameter	Min.	Typ.	Max.	Units
Position Sampling Rate	2.35	2.61	2.87	kHz
Propagation Delay	-	-	384	?S
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	Vrms**
Output Transition Noise	-	0.06	-	Degrees RMS***

\* With no output load. See graphs below.

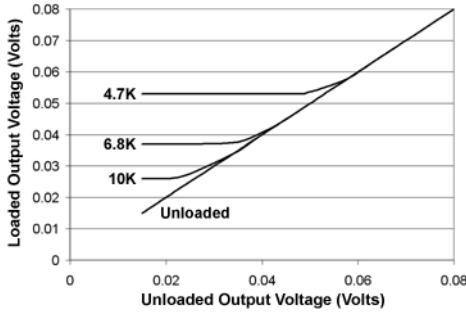
\*\* Continuous short to +5V or ground will not damage the MA3.

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

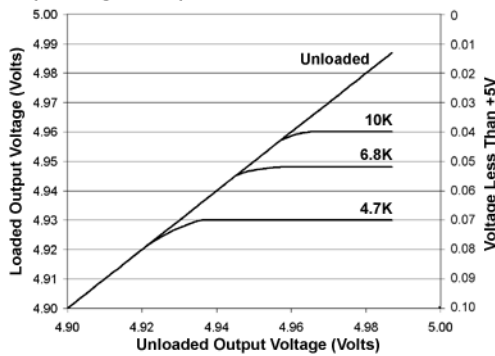
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Output Voltage vs. Output Load w/ Pullup Resistors to +5V



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



## PWM Output Operation

The magnetic sensor chip in the MA3 has an on-chip RC oscillator which is factory trimmed to 5% accuracy at room temperature (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. Angular accuracy including non-linearity is within 0.5 deg. at 25C, but may increase to 0.9 deg. at high temperatures.

Parameter	Min.	Typ.	Max.	Units
PWM Frequency (-40C to 125C)	0.878	0.976	1.074	kHz
10-bit	220	244	268	Hz
12-bit				
Minimum Pulse Width	0.95	1.00	1.05	?S
10-bit	0.95	1.00	1.05	?S
12-bit				
Maximum Pulse Width	973	1024	1075	?S
10-bit	3891	4096	4301	?S
12-bit				

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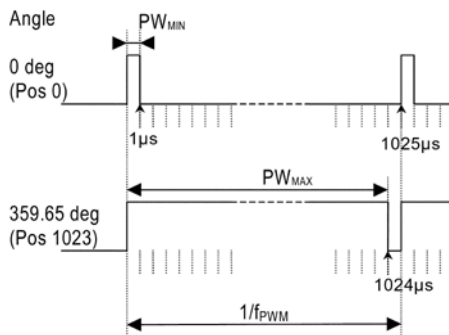
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Parameter	Min.	Typ.	Max.	Units
Internal Sampling Rate	9.38	10.42	11.46	kHz
10-bit	2.35	2.61	2.87	kHz
12-bit				
Propagation	-	-	48	?S
10-bit	-	-	384	?S
12-bit				
High Level Output Voltage (V OH: @4mA Source)	Vcc -0.5	-	-	V*
Low Level Output Voltage (V OL: @4mA Sink)	-	-	0.4	V*

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

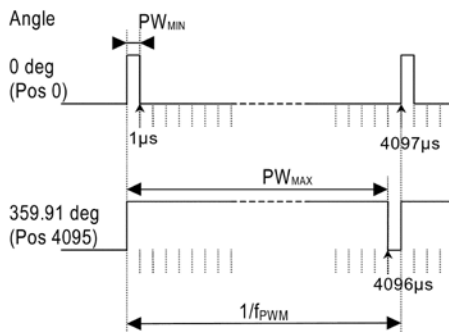
10-bit PWM:

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



12-bit PWM:

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



 Pin-outs

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**Analog Output (MA3-A):**

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

**PWM Output (MA3-P10, MA3-P12):**

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

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**Ordering Information**

MA3 -  -  -

**Interface**

A10 = 10-Bit Analog  
 P10 = 10-Bit PWM  
 P12 = 12-Bit PWM

**Shaft**

125 = 1/8" dia. sleeve bushing (standard torque)  
 236 = 6mm dia. sleeve bushing (standard torque)  
 250 = 1/4"

**Torque**

D = Default  
 B = 1/8" dia. ball bearing  
 N = Replaces standard torque with no torque added

**Rules**

▸ Torque must be something other than B when Shaft is 125

**Notes**

▸ Cables and connectors are not included and must be ordered separately.  
 ▸ US Digital warrants its products against defects in materials and workmanship for two years. See complete warranty for details.

**Pricing**

Quantity	Price
1	\$36.00
10	\$31.54
50	\$27.78
100	\$23.89

- Add 17% per unit for **Interface** of 12-Bit PWM
- Add \$1.00 per unit for **Shaft** of 6mm dia. sleeve bushing (standard torque)
- Add \$5.80 per unit for **Torque** of 1/8" dia. ball bearing

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