Contents

Purpose
• the purpose of this training module is to familiarize you with rotary encoders and to show the benefits of the AMT102 & 103

Objectives
• understand what makes the AMT102 & 103 revolutionary
• explain the different components that make up the AMT102 & 103 and how they are assembled
• illustrate why the 16 programmable resolutions offer incredible flexibility

Content
• 28 pages

Learning time
• 15 minutes
What is an encoder?
Types of rotary encoders

**mechanical**  Very low cost, low resolution encoders that generate output code by making and breaking a circuit. Most often used as panel controls such as the volume on a car radio.

**optical**  Low to high cost, low to high resolution encoders that generate output code using infrared light and phototransistor. The most common type of encoder available, optical encoders are used as panel controls in precision applications and built into electronic devices to control motion.

**magnetic**  Medium to high cost, medium resolution encoders that generate output code by detecting changes in magnetic flux fields. Most often used in adverse environments. Resistant to most airborne contaminants.
Types of rotary encoders

**fiber optic** High cost, medium to high resolution encoders that generate output code using a laser and phototransistor most often used in explosion-proof applications where extremely flammable gasses are present.

**capacitive** Low cost, low to high resolution encoders that generate output code through detecting changes in capacitance using a high frequency reference signal. Capacitive encoders are relatively new compared to the other types listed. The technology has been used for years in digital calipers and has proven to be highly reliable and accurate.
How an optical encoder functions
How an optical encoder functions

Channel I

Channel A

Channel B

+5V  0V

+5V  0V

+5V  0V
Quadrature decoding

quadrature decoding circuit for obtaining count up/down signals.
Encoders provide directional information

**CHANNEL A LEADS CHANNEL B**

In this example, Channel A leads B, i.e., Channel A outputs a signal before Channel B. This indicates the shaft is rotating counter-clockwise.

**CHANNEL B LEADS CHANNEL A**

In this example, Channel B leads A. This indicates the shaft is rotating counter-clockwise.
Encoders provide speed information

Encoders can detect speed when the number of output pulses is counted in a specified time span. The time element is typically provided by an internal oscillator or clock. The number of pulses in one revolution must also be known.

The equation for calculating speed is:

$$ S = \frac{C}{PPR} \times \frac{t}{60} $$

Where "S" is speed in rpm, "C" is the number of pulses counted in a "t" time interval. If 60 pulses were counted in 10 seconds from a 360PPR encoder, the speed can be calculated:

$$ S = \frac{60}{360} \div \frac{10}{60} = 0.1666 \div 0.1666 = 1 \text{ rpm} $$

All of the counting, timing and calculations can be done electronically in real time and used to monitor or control speed.
Encoders provide distance information

Encoders can detect distance traveled based on the number of pulses counted. In most applications, rotary motion is converted to linear travel by mechanical components like pulleys, drive gears and friction wheels.

In this illustration of a cutting table, if the diameter of the friction wheel and the PPR of the encoder are known, linear travel can be calculated:

\[ C = \frac{L}{\pi \times D} \times \text{PPR} \]

Where \( C \) = encoder pulse count, \( L \) = desired cut length in inches, \( D \) = friction wheel diameter in inches, and \( \text{PPR} \) = total pulses per one revolution of the encoder. For a desired cut length of 12", assuming the friction wheel diameter is 8" and encoder PPR of 2,000:

\[ C = \frac{12}{3.142 \times 8} \times 2000 = 955 \]

Pulse count to achieve desired linear travel can be calculated in a similar fashion for devices that use ball screws, gears or pulleys to convert rotary motion to linear travel.
Where are encoders used?

- Exercise equipment
- Sound equipment
- Aircraft
- Automobiles
- Cameras
- Satellites
- Printers
- Machine tools
- Conveyors
- Industrial robots
- Medical devices
- Toys
Common example

Encoder in a mouse

Inside a mouse there are three encoders – one mechanical encoder and two optical encoders.

Notice the sets of slotted discs, phototransistors and IR LEDs, one for horizontal motion, the other for vertical motion.

As the trackball moves it turns the disc shafts.
Typical optical encoder configuration

From the illustration you can see that optical encoder construction is fairly complex. Alignment of optical components must be precise in resolutions above 300 CPR. Alignment becomes even more critical in resolutions above 1000 CPR. For this reason ball bearings must be staked in a rigid housing to assure little or no radial shaft movement or ‘wobble.’
AMT capacitive encoding
No optical disk

One of the main benefits of the AMT102 & 103 is the absence of a glass optical disk.

This greatly simplifies assembly because the AMT disc is not fragile like a glass optical disc. The benefit of this is reduction in assembly time and cost.
16 resolutions in one encoder

The AMT's dip switch enables setting the AMT to any one of 16 different selectable resolutions.

Starting at 48 PPR and reaching 2048 PPR, the AMT's selectable resolution settings make it ideal for use in many different applications.

<table>
<thead>
<tr>
<th>resolutions (PPR)</th>
<th>48</th>
<th>96</th>
<th>100</th>
<th>125</th>
</tr>
</thead>
<tbody>
<tr>
<td>196</td>
<td>200</td>
<td>250</td>
<td>256</td>
<td></td>
</tr>
<tr>
<td>384</td>
<td>400</td>
<td>500</td>
<td>512</td>
<td></td>
</tr>
<tr>
<td>800</td>
<td>1000</td>
<td>1024</td>
<td>2048</td>
<td></td>
</tr>
</tbody>
</table>

16 resolutions available via the dip switch
Top cover

The top cover of the AMT102 & 103 houses the circuitry that detects the motor shaft rotation. These top covers are metal, adding durability.

The boards are swaged into the casing to make assembly even easier. The dip switch can also be accessed here.
AMT is smaller

Because it has no optical disk, the AMT is smaller than competing optical encoders.

Dimensions (mm):

<table>
<thead>
<tr>
<th></th>
<th>length</th>
<th>width</th>
<th>height</th>
</tr>
</thead>
<tbody>
<tr>
<td>competitor</td>
<td>46.50</td>
<td>31.00</td>
<td>16.26</td>
</tr>
<tr>
<td>AMT102</td>
<td>43.39</td>
<td>28.77</td>
<td>9.00</td>
</tr>
<tr>
<td>AMT103</td>
<td>34.20</td>
<td>28.60</td>
<td>9.00</td>
</tr>
</tbody>
</table>

The AMT102 & 103 are smaller in every dimension, allowing them to fit into tighter spaces.
The AMT is rugged

**Dust & Dirt** The AMT, being an ASIC driven product, is not affected by dust and dirt build-up. This results in much more rugged, reliable performance.

**Temperature** The AMT’s ASIC technology is less sensitive than an optical disk to heat and cold, offering reliable operation between a wider temperature range.

**Vibration** The AMT encoder’s ASIC-based construction is far less susceptible to vibration than the glass disk of an optical encoder.

**LED burn-out** The AMT, on the other hand, avoids this issue thanks to the use of a semiconductor instead of an LED.
Simple assembly

Assembly of the AMT102 & 103 requires minimal time and effort.

With just a few durable pieces, it snaps together in seconds without risk of damaging a glass optical disk or other fragile components.

The AMT102 has a straight output connector and the AMT103 has a right angle output connector.
Ideal for direct motor mounting

The AMT Series can be used on any rotating shaft, however, it is ideal for mounting directly to motors:

- mounting patterns for hundreds AC & DC motors
- 9 shaft diameter options
- extremely low mass reduces potential backlash
- small size fits in tight spaces

<table>
<thead>
<tr>
<th>hole pattern (mm/in)</th>
<th># of holes</th>
<th>hole size</th>
<th>available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø16/0.63</td>
<td>2</td>
<td>M1.6</td>
<td>AMT102/103</td>
</tr>
<tr>
<td>Ø19.05/0.75</td>
<td>2</td>
<td>#4</td>
<td>AMT102/103</td>
</tr>
<tr>
<td>Ø20/0.787</td>
<td>2</td>
<td>M1.6 or M2</td>
<td>AMT102/103</td>
</tr>
<tr>
<td>Ø20.9/0.823</td>
<td>3</td>
<td>M1.6 or M2</td>
<td>AMT102/103</td>
</tr>
<tr>
<td>Ø22/0.866</td>
<td>3</td>
<td>M1.6 or M2</td>
<td>AMT102/103</td>
</tr>
<tr>
<td>Ø25.4/1.0</td>
<td>4</td>
<td>M1.6 or M2</td>
<td>AMT102/103</td>
</tr>
<tr>
<td>Ø32.43/1.277</td>
<td>2</td>
<td>#4</td>
<td>AMT102</td>
</tr>
<tr>
<td>Ø46.025/1.812</td>
<td>2</td>
<td>#4</td>
<td>AMT102</td>
</tr>
<tr>
<td>0.62&quot; x 0.825&quot;</td>
<td>2</td>
<td>#4</td>
<td>AMT102</td>
</tr>
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</table>

shaft bushings

<table>
<thead>
<tr>
<th>Ø2 mm</th>
<th>Ø3 mm</th>
<th>Ø1/8 in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø4 mm</td>
<td>Ø3/8 in.</td>
<td>Ø5 mm</td>
</tr>
<tr>
<td>Ø6 mm</td>
<td>Ø1/4 in.</td>
<td>Ø8 mm</td>
</tr>
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</table>
AMT102 & 103

click on the illustration below to view a short assembly video
Simplify inventory with AMT102-V & 103-V

The AMT102-V & 103-V were designed to be flexible enough to handle many different applications, reducing inventory to only two encoder models. AMT102-V and AMT103-V includes:

- 9 shaft adaptors
- standard and wide base for the AMT102
- tools for simple assembly

In addition to all of this, custom versions are available. Both models are RoHS compliant.
Shaft adapter and sleeves

Using the shaft adapter and the 9 color-coded sleeves, both the AMT102-V & AMT103-V can be adapted to 9 different motor shaft sizes.

This is done by snapping one of the sleeves into the shaft adapter.

Sleeve diameters (mm):

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2.00</td>
<td>3.00</td>
<td>3.17</td>
</tr>
<tr>
<td>4.00</td>
<td>4.76</td>
<td>5.00</td>
</tr>
<tr>
<td>6.00</td>
<td>6.35</td>
<td>8.00</td>
</tr>
</tbody>
</table>
Base

The bases for the AMT102-V & 103-V offer 16 different mounting options.

**AMT102-V** = 9 different mounting options

**AMT103-V** = 7 different mounting options

Along with the standard base, the AMT102-V also comes with a wide base to accommodate more motor options. This accounts for the additional mounting options for the AMT102-V.
Tools

The AMT102-V & AMT103-V come with two tools that are necessary for correct assembly.

**Tool A** is a wrench-like tool used as a spacer between the motor and the encoder.

**Tool B** is used to center the AMT's components on the motor shaft and ensure that the components are flush.
Output options

The standard output for both the AMT102 & AMT103 is TTL voltage (see fig. 1).

Line-driver output (fig. 2) is available through the use of a line-driver cable that converts the TTL output.

The line-driver output is recommended for environments with significant electrical noise or when the distance between the AMT and the receiving circuit exceeds 30 feet.
For more information visit www.amtencoder.com or call 1.800.275.4899