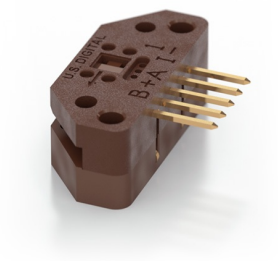
## EM1_WEB Features



- Encoder module for measuring linear or rotary movement
- Two-channel quadrature with optional index channel
- 21 Rotary Resolutions from 32 to 2,500 CPR (128 to 10,000 PPR)
- 9 Linear Resolutions from 120 to 500 LPI (x1 quadrature decoding)
- Sink/source 8 mA outputs
- Internal decoupling capacitor for enhanced noise immunity
- Single 5 VDC supply
- Improved replacement for HEDS-9000 Series

## EM1 Product Description

The EM1 is a transmissive optical encoder module designed to measure rotary or linear motion when paired together with an encoder disk or linear strip. The EM1 consists of a lensed LED source and a monolithic detector IC enclosed in a small polymer package. The EM1 uses phased array detector technology, allowing for a wider gap tolerance and reliable performance even with some disk contamination.

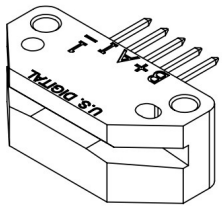
The EM1 encoder module provides digital A & B quadrature outputs with an optional index channel. Each EM1 module is resolution-specific and is matched to the resolution of an encoder disk or linear strip. The EM1 module supports 21 different resolutions. The EM1 operates with a single 5V supply and provides single-ended outputs capable of sinking and sourcing 8mA. An internal 0.1 µF decoupling capacitor provides enhanced noise immunity.

For open collector and higher voltage applications, add the PC3 *(https://www.usdigital.com/products/accessories/interfaces/cable-drivers/pc3/)* cable driver, or for differential cable driver outputs, add the PC4 *(https://www.usdigital.com/products/accessories/interfaces/cable-drivers/pc4/)* cable driver.

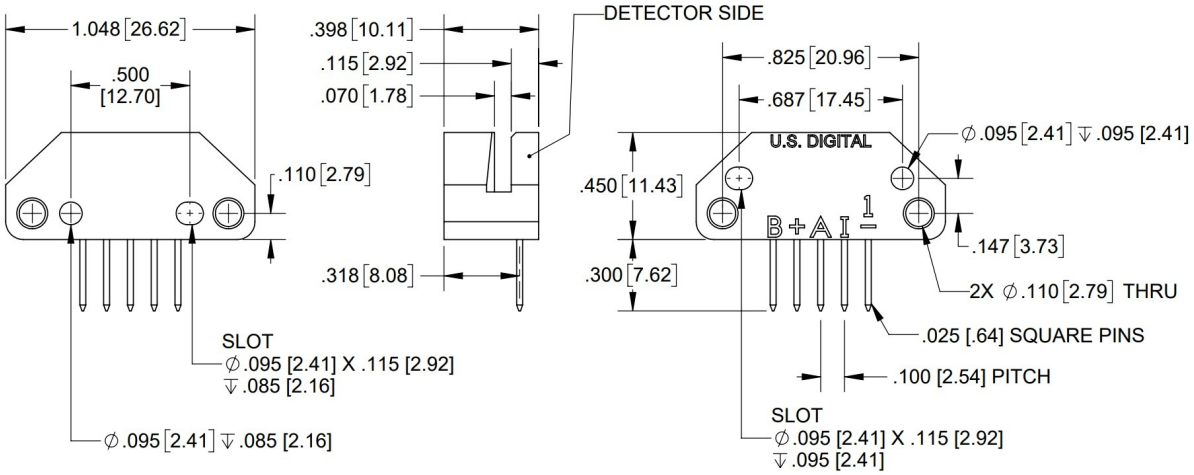
Accessories such as encoder disks, linear strips, mating connectors and cables are also available.

## Mechanical Drawings

## **EM1** Transmissive Optical Encoder Module




RELEASE DATE: 02/07/2022

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UNITS: INCHES [MM]
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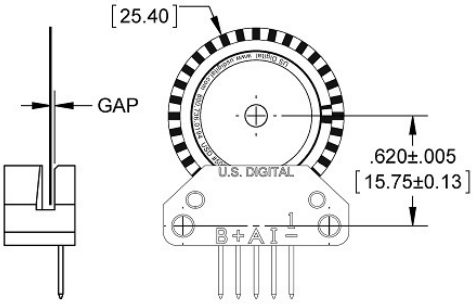
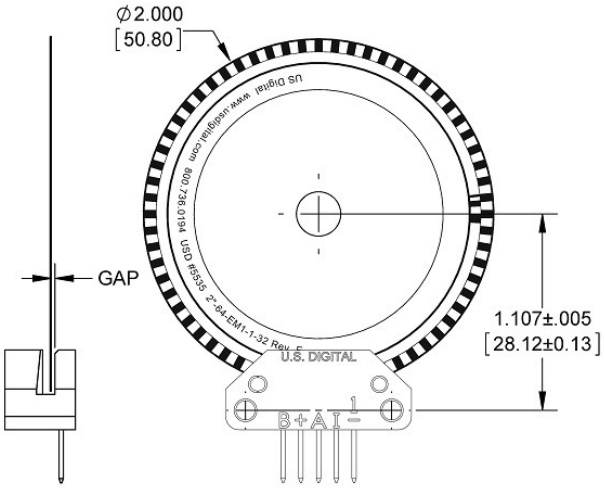
**EM1** Transmissive Optical Encoder Module
Disk Alignment

RELEASE DATE: 04/06/2015

1" DISK




2" DISK




RECOMMENDED DISK GAP: $.020^{+.005}_{-.010}$ $[0.51^{+0.13}_{-0.25}]$
(.020±.005 [0.51±0.13] FOR 32 CPR 1" DISKS OR 64 CPR 2" DISKS)

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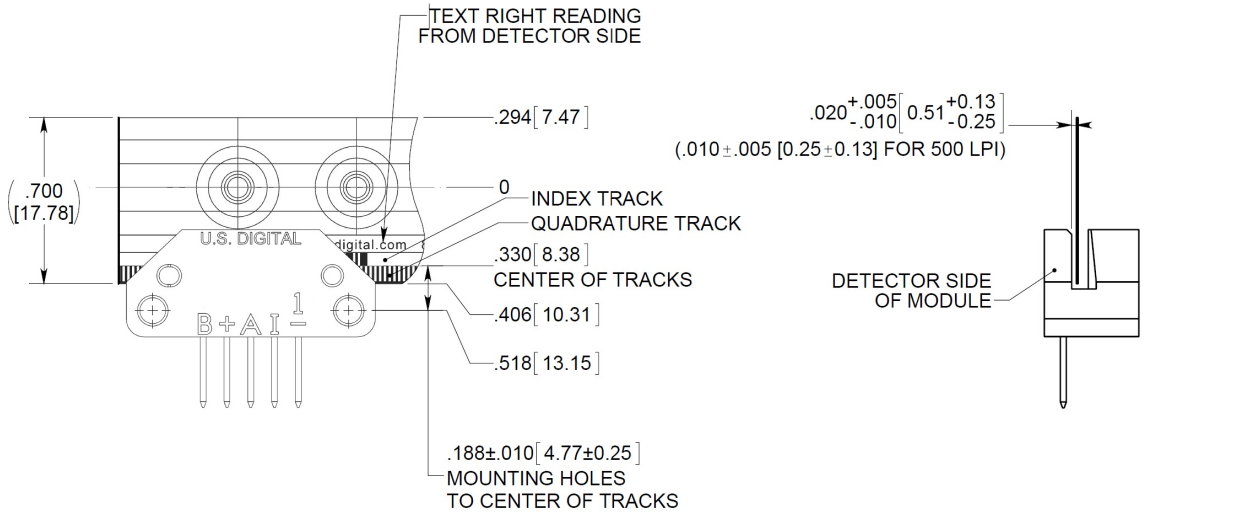
**EM1** Transmissive Optical Encoder Module
Linear Strip Alignment

RELEASE DATE: 04/07/2015

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# Specifications

## COMPATIBLE 1" & 2" DISKS

| 1" DISKS | | | | |
|---|---|---|---|---|
| **CPR** | **MODULE Non-Index** | **1" DISK Non-Index** | **MODULE Index** | **1" DISK Index** |
| 32 | EM1-1-32-N | DISK-1-32-*-NE | | |
| 50 | EM1-1-50-N | DISK-1-50-*-NE | EM1-1-50-I | DISK-1-50-*-IE |
| 96 | EM1-1-100-N | DISK-1-96-*-NE | EM1-1-100-I | DISK-1-96-*-IE |
| 100 | EM1-1-100-N | DISK-1-100-*-NE | EM1-1-100-I | DISK-1-100-*-IE |
| 120 | EM1-1-100-N | DISK-1-120-*-NE | | |
| 192 | EM1-1-200-N | DISK-1-192-*-NE | EM1-1-200-I | DISK-1-192-*-IE |

| | | | | |
|---|---|---|---|---|
| 200 | EM1-1-200-N | DISK-1-200-*-NE | EM1-1-200-I | DISK-1-200-*-IE |
| 250 | EM1-1-250-N | DISK-1-250-*-NE | EM1-1-250-I | DISK-1-250-*-IE |
| 256 | EM1-1-250-N | DISK-1-256-*-NE | EM1-1-250-I | DISK-1-256-*-IE |
| 360 | EM1-1-360-N | DISK-1-360-*-NE | EM1-1-360-I | DISK-1-360-*-IE |
| 400 | EM1-1-400-N | DISK-1-400-*-NE | EM1-1-400-I | DISK-1-400-*-IE |
| 500 | EM1-1-500-N | DISK-1-500-*-NE | EM1-1-500-I | DISK-1-500-*-IE |
| 512 | EM1-1-512-N | DISK-1-512-*-NE | EM1-1-512-I | DISK-1-512-*-IE |
| 540 | EM1-1-540-N | DISK-1-540-*-NE | EM1-1-540-I | DISK-1-540-*-IE |
| 720 | EM1-1-720-N | DISK-1-720-*-NE | EM1-1-720-I | DISK-1-720-*-IE |
| 800 | EM1-1-800-N | DISK-1-800-*-NE | EM1-1-800-I | DISK-1-800-*-IE |
| 900 | EM1-1-900-N | DISK-1-900-*-NE | EM1-1-900-I | DISK-1-900-*-IE |
| 1000 | EM1-1-1000-N | DISK-1-1000-*-NE | EM1-1-1000-I | DISK-1-1000-*-IE |
| 1024 | EM1-1-1024-N | DISK-1-1024-*-NE | EM1-1-1024-I | DISK-1-1024-*-IE |
| 1250 | EM1-1-1250-N | DISK-1-1250-*-NE | EM1-1-1250-I | DISK-1-1250-*-IE |
| | *Represents the bore size | | | |

**2" DISKS**

| CPR | MODULE Non-Index | 2" DISK Non-Index | MODULE Index | 2" DISK Index |
|---|---|---|---|---|
| 64 | EM1-1-32-N | DISK-2-64-*-NE | | |
| 100 | EM1-1-50-N | DISK-2-100-*-NE | EM1-1-50-I | DISK-2-100-*-IE |
| 200 | EM1-1-100-N | DISK-2-200-*-NE | EM1-1-100-I | DISK-2-200-*-IE |
| 400 | EM1-1-200-N | DISK-2-400-*-NE | EM1-1-200-I | DISK-2-400-*-IE |
| 500 | EM1-2-500-N | DISK-2-500-*-NE | EM1-2-500-I | DISK-2-500-*-IE |
| 512 | EM1-2-500-N | DISK-2-512-*-NE | EM1-2-500-I | DISK-2-512-*-IE |
| 800 | EM1-1-400-N | DISK-2-800-*-NE | EM1-1-400-I | DISK-2-800-*-IE |
| 1000 | EM1-2-1000-N | DISK-2-1000-*-NE | EM1-2-1000-I | DISK-2-1000-*-IE |
| 1024 | EM1-2-1024-N | DISK-2-1024-*-NE | EM1-2-1024-I | DISK-2-1024-*-IE |
| 1800 | EM1-2-1800-N | DISK-2-1800-*-NE | EM1-2-1800-I | DISK-2-1800-*-IE |
| 2000 | EM1-2-2000-N | DISK-2-2000-*-NE | EM1-2-2000-I | DISK-2-2000-*-IE |
| 2048 | EM1-2-2048-N | DISK-2-2048-*-NE | EM1-2-2048-I | DISK-2-2048-*-IE |
| 2500 | EM1-2-2500-N | DISK-2-2500-*-NE | EM1-2-2500-I | DISK-2-2500-*-IE |
| | *Represents the bore size | | | |

## COMPATIBLE 1" & 2" HUBDISKS

| 1" HUBDISKS | | | | |
|---|---|---|---|---|
| **CPR** | **MODULE Non-Index** | **1" HUBDISK Non-Index** | **MODULE Index** | **1" HUBDISK Index** |
| 32 | EM1-1-32-N | HUBDISK-1-32-*-NE | | |
| 50 | EM1-1-50-N | HUBDISK-1-50-*-NE | EM1-1-50-I | HUBDISK-1-50-*-IE |
| 96 | EM1-1-100-N | HUBDISK-1-96-*-NE | EM1-1-100-I | HUBDISK-1-96-*-IE |
| 100 | EM1-1-100-N | HUBDISK-1-100-*-NE | EM1-1-100-I | HUBDISK-1-100-*-IE |
| 120 | EM1-1-100-N | HUBDISK-1-120-*-NE | | |
| 192 | EM1-1-200-N | HUBDISK-1-192-*-NE | EM1-1-200-I | HUBDISK-1-192-*-IE |
| 200 | EM1-1-200-N | HUBDISK-1-200-*-NE | EM1-1-200-I | HUBDISK-1-200-*-IE |
| 250 | EM1-1-250-N | HUBDISK-1-250-*-NE | EM1-1-250-I | HUBDISK-1-250-*-IE |
| 256 | EM1-1-250-N | HUBDISK-1-256-*-NE | EM1-1-250-I | HUBDISK-1-256-*-IE |
| 360 | EM1-1-360-N | HUBDISK-1-360-*-NE | EM1-1-360-I | HUBDISK-1-360-*-IE |
| 400 | EM1-1-400-N | HUBDISK-1-400-*-NE | EM1-1-400-I | HUBDISK-1-400-*-IE |
| 500 | EM1-1-500-N | HUBDISK-1-500-*-NE | EM1-1-500-I | HUBDISK-1-500-*-IE |
| 512 | EM1-1-512-N | HUBDISK-1-512-*-NE | EM1-1-512-I | HUBDISK-1-512-*-IE |
| 540 | EM1-1-540-N | HUBDISK-1-540-*-NE | EM1-1-540-I | HUBDISK-1-540-*-IE |
| 720 | EM1-1-720-N | HUBDISK-1-720-*-NE | EM1-1-720-I | HUBDISK-1-720-*-IE |
| 800 | EM1-1-800-N | HUBDISK-1-800-*-NE | EM1-1-800-I | HUBDISK-1-800-*-IE |
| 900 | EM1-1-900-N | HUBDISK-1-900-*-NE | EM1-1-900-I | HUBDISK-1-900-*-IE |
| 1000 | EM1-1-1000-N | HUBDISK-1-1000-*-NE | EM1-1-1000-I | HUBDISK-1-1000-*-IE |
| 1024 | EM1-1-1024-N | HUBDISK-1-1024-*-NE | EM1-1-1024-I | HUBDISK-1-1024-*-IE |
| 1250 | EM1-1-1250-N | HUBDISK-1-1250-*-NE | EM1-1-1250-I | HUBDISK-1-1250-*-IE |
| | *Represents the bore size | | | |

| 2" HUBDISKS | | | | |
|---|---|---|---|---|
| **CPR** | **MODULE Non-Index** | **2" HUBDISK Non-Index** | **MODULE Index** | **2" HUBDISK Index** |
| 64 | EM1-1-32-N | HUBDISK-2-64-*-NE | | |
| 100 | EM1-1-50-N | HUBDISK-2-100-*-NE | EM1-1-50-I | HUBDISK-2-100-*-IE |
| 200 | EM1-1-100-N | HUBDISK-2-200-*-NE | EM1-1-100-I | HUBDISK-2-200-*-IE |
| 400 | EM1-1-200-N | HUBDISK-2-400-*-NE | EM1-1-200-I | HUBDISK-2-400-*-IE |

| | | | | |
|---|---|---|---|---|
| 500 | EM1-2-500-N | HUBDISK-2-500-*-NE | EM1-2-500-I | HUBDISK-2-500-*-IE |
| 512 | EM1-2-500-N | HUBDISK-2-512-*-NE | EM1-2-500-I | HUBDISK-2-512-*-IE |
| 800 | EM1-1-400-N | HUBDISK-2-800-*-NE | EM1-1-400-I | HUBDISK-2-800-*-IE |
| 1000 | EM1-2-1000-N | HUBDISK-2-1000-*-NE | EM1-2-1000-I | HUBDISK-2-1000-*-IE |
| 1024 | EM1-2-1024-N | HUBDISK-2-1024-*-NE | EM1-2-1024-I | HUBDISK-2-1024-*-IE |
| 1800 | EM1-2-1800-N | HUBDISK-2-1800-*-NE | EM1-2-1800-I | HUBDISK-2-1800-*-IE |
| 2000 | EM1-2-2000-N | HUBDISK-2-2000-*-NE | EM1-2-2000-I | HUBDISK-2-2000-*-IE |
| 2048 | EM1-2-2048-N | HUBDISK-2-2048-*-NE | EM1-2-2048-I | HUBDISK-2-2048-*-IE |
| 2500 | EM1-2-2500-N | HUBDISK-2-2500-*-NE | EM1-2-2500-I | HUBDISK-2-2500-*-IE |
| | *Represents the bore size | | | |

## COMPATIBLE LINEAR STRIPS

| LPI | MODULE Non-Index | Linear Strip Non-Index | MODULE Index | Linear Strip Index |
|---|---|---|---|---|
| 120 | EM1-0-120-N | LIN-120-*-N | EM1-0-120-I | LIN-120-*-# |
| 127 | EM1-0-127-N | LIN-127-*-N | EM1-0-127-I | LIN-127-*-# |
| 150 | EM1-0-150-N | LIN-150-*-N | EM1-0-150-I | LIN-150-*-# |
| 180 | EM1-0-180-N | LIN-180-*-N | EM1-0-180-I | LIN-180-*-# |
| 200 | EM1-0-200-N | LIN-200-*-N | EM1-0-200-I | LIN-200-*-# |
| 250 | EM1-0-250-N | LIN-250-*-N | EM1-0-250-I | LIN-250-*-# |
| 300 | EM1-0-300-N | LIN-300-*-N | EM1-0-300-I | LIN-300-*-# |
| 360 | EM1-0-360-N | LIN-360-*-N | EM1-0-360-I | LIN-360-*-# |
| 500 | EM1-0-500-N | LIN-500-*-N | EM1-0-500-I | LIN-500-*-# |
| | * Represents length of Linear Strip | | * Represents length of Linear Strip<br># Represents location of Index | |

## ENVIRONMENTAL

| Parameter | Value | Units |
|---|---|---|
| Operating Temperature | -40 to 100 | C |
| Electrostatic Discharge, IEC 61000-4-2 | ± 4 | kV |
| Vibration (10Hz to 2kHz, sinusoidal) | 20 | G |
| Shock (6 milliseconds, half-sine) | 75 | G |

## OPERATING CONDITIONS

| PARAMETER | MIN. | MAX. | UNITS |
|---|---|---|---|
| A/B Output Frequency | 0 | 300 | kHz |
| Disk RPM | 0 | (18 x 10^6) / CPR | RPM |
| Linear Strip Speed | 0 | (3 x 10^5) / LPI | inches/sec. |
| Disk/Linear Strip Radial Position Tolerance | ±.005 | | inch |

## ELECTRICAL SPECIFICATIONS

- Specifications apply over the entire operating temperature range.
- Typical values are specified at Vcc = 5.0V and 25C.

| PARAMETER | MIN. | TYP. | MAX. | UNITS | CONDITIONS |
|---|---|---|---|---|---|
| Supply Voltage | 4.5 | 5.0 | 5.5 | V | Ripple < 100 mVpp |
| Supply Current, EM1-0- (linear strip) | | 27<br>54 | 33<br>65 | mA<br>mA | LPI < 300, no load<br>LPI ≥ 300, no load |
| Supply Current, EM1-1- (1" disk) | | 27<br>54 | 33<br>65 | mA<br>mA | CPR < 500, no load<br>CPR ≥ 500, no load |
| Supply Current, EM1-2- (2" disk) | | 27<br>54 | 33<br>65 | mA<br>mA | CPR < 1000, no load<br>CPR ≥ 1000, no load |
| Low-level Output | | <br>0.05 | 0.5 | V<br>V | $I_{OL}$ = 8mA max.<br>No load |
| High-level Output | 2.0 | <br>4.8 | | V<br>V | $I_{OH}$ = -8mA max.<br>No load |
| Output Current Per Channel | -8 | | 8 | mA | |
| Load Capacitance | | | 100 | pF | |
| Output Rise Time | | 110 | | nS | |
| Output Fall Time | | 100 | | nS | |

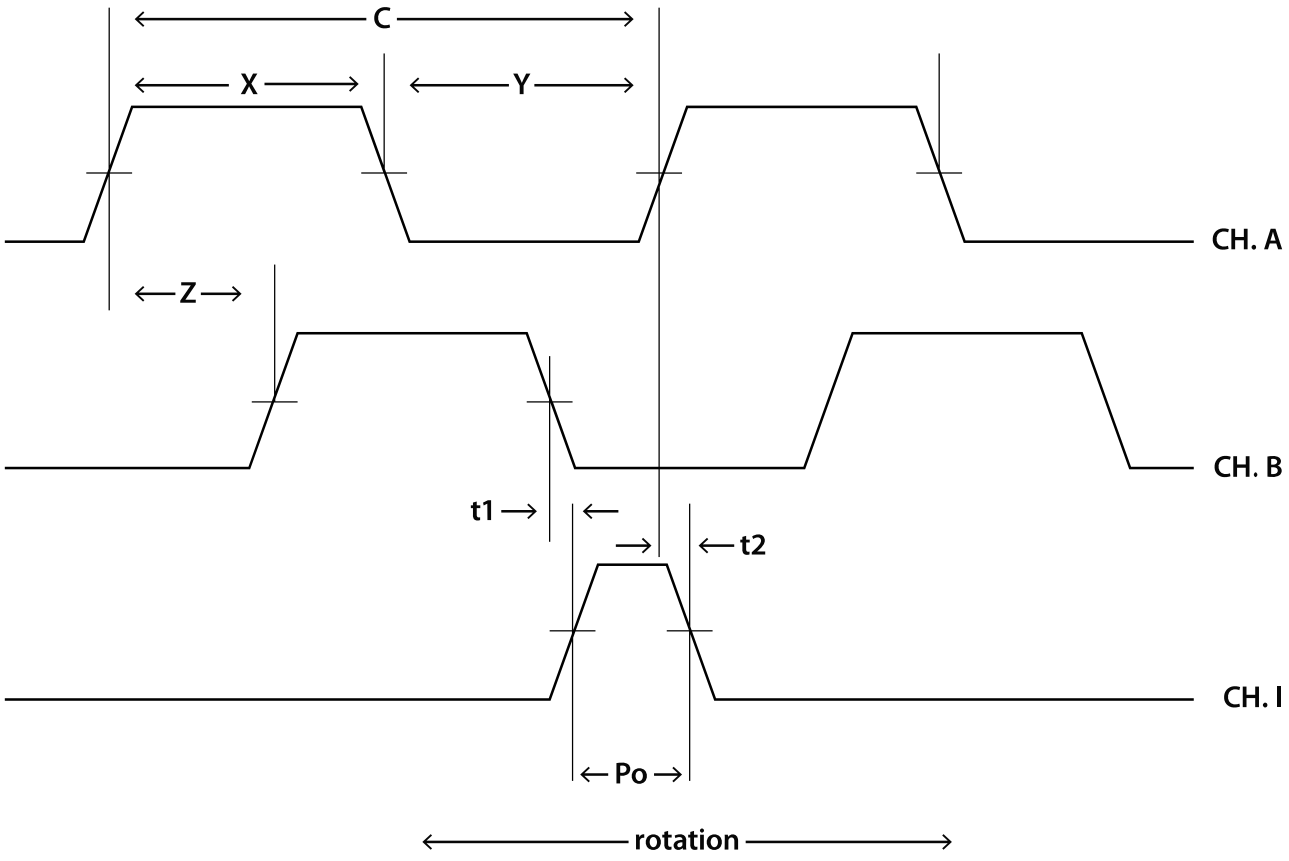
## TIMING CHARACTERISTICS

## ENCODING CHARACTERISTICS:

- Specifications apply over the entire operating temperature range.
- Values are for the worst error over full rotation.
- Refer to the timing diagram below.

| PARAMETER | SYMBOL | MIN. | TYP. | MAX. | UNITS |
|---|---|---|---|---|---|
| Symmetry | X, Y | 150 | 180 | 210 | °e *(https://www.usdigital.com/support/resources/glossary/#glossary_e)* |
| Quadrature | Z | 60 | 90 | 120 | °e *(https://www.usdigital.com/support/resources/glossary/#glossary_e)* |
| Index Pulse Width | Po | 40 | 90 | 120 | °e *(https://www.usdigital.com/support/resources/glossary/#glossary_e)* |
| Ch. I Rise After Ch. B or Ch. A Fall | t1 | 50 | 100 | 200 | ns |
| Ch. I Fall After Ch. B or Ch. A Rise | t2 | -10 | 15 | 25 | ns |

## TIMING DIAGRAM:




**CPR:** The number of Cycles (C) of the A or B outputs Per Revolution.

**Cycle Error:** An indication of cycle uniformity. The difference between an observed shaft angle which gives rise to one electrical cycle, and the nominal angular increment of 1/CPR of a revolution.

**Index (I):** The index output goes high once per revolution, coincident with the low states of channels A and B, nominally 1/4 of one cycle (90 °e).

**LPI**: Lines Per Inch. The number of Cycles (C) of the A or B output per inch of linear strip movement.

**One Shaft Rotation:** 360 mechanical degrees.

**One Electrical Degree (°e):** 1/360th of one cycle.

**One Cycle (C):** 360 electrical degrees (°e). Each cycle can be decoded into 1 or 4 states, referred to as X1 or X4 resolution multiplication.

**PPR**: The number of resolvable Positions Per Revolution of the encoder disk with x4 quadrature decoding.

**Quadrature (Z):** The phase lag or lead between channels A and B in electrical degrees, nominally 90 °e.

**Symmetry:** A measure of the relationship between (X) and (Y) in electrical degrees, nominally 180°e.

### INSTALLATION TORQUE

| PARAMETER | TORQUE |
|---|---|
| Mounting Screws | 3.5-4 in-lbs |

### EM1 / HEDS COMPARISON

US Digital is the designer and manufacturer of the **EM1** transmissive optical encoder module. The design of the **EM1** provides electrical and mechanical compatibility with **HEDS-9000**, **HEDS-9100**, **HEDS-9200**, **HEDS-9040**, and **HEDS-9140** series modules.

The process of switching from the **HEDS** to the **EM1** module should not require any mechanical or electrical changes. Simply use the **EM1** and matching codewheel in place of the **HEDS** module and codewheel. The **EM1** has a built-in index channel available on most resolutions, for both rotary disks and linear strips. The **EM1** uses a US Digital designed codewheel with 2 tracks rather than 3 tracks for index versions. The **EM1** offers improved output drive capability and will source and sink 8mA at TTL levels.

Physically, the **EM1** has no external wire loops which can interfere when mounting. The connector pins are 0.051" shorter than **HEDS** modules, while still providing .30" insertion depth. US Digital's **EM1** offers custom resolutions.

### PIN-OUTS

| Pin | Description |
|---|---|
| 1 | Ground |
| 2 | Index |
| 3 | A channel |
| 4 | +5VDC power |
| 5 | B channel |

## Notes

- US Digital® warrants its products against defects in materials and workmanship for two years. See complete warranty *(https://www.usdigital.com/company/warranty)* for details.

## Configuration Options

| EM1_WEB | - | Type | - | Resolution | - | Index |
|---|---|---|---|---|---|---|
| | | 0 (*Linear Strip*) | | 120 LPI | | I (*Index*) |
| | | 1 (*1" Disk*) | | 127 LPI | | N (*Non-Index*) |
| | | 2 (*2" Disk*) | | 150 LPI | | |
| | | | | 180 LPI | | |
| | | | | 200 LPI | | |
| | | | | 250 LPI | | |
| | | | | 300 LPI | | |
| | | | | 360 LPI | | |
| | | | | 500 LPI | | |
| | | | | 32 CPR | | |
| | | | | 50 CPR | | |
| | | | | 64 CPR | | |
| | | | | 100 CPR | | |
| | | | | 100 CPR | | |
| | | | | 200 CPR | | |
| | | | | 200 CPR | | |
| | | | | 250 CPR | | |
| | | | | 360 CPR | | |
| | | | | 400 CPR | | |
| | | | | 400 CPR | | |
| | | | | 500 CPR | | |
| | | | | 500 CPR | | |
| | | | | 512 CPR | | |
| | | | | 540 CPR | | |
| | | | | 720 CPR | | |
| | | | | 800 CPR | | |
| | | | | 800 CPR | | |
| | | | | 900 CPR | | |
| | | | | 1000 CPR | | |
| | | | | 1024 CPR | | |
| | | | | 1250 CPR | | |
| | | | | 1000 CPR | | |
| | | | | 1024 CPR | | |
| | | | | 1800 CPR | | |
| | | | | 2000 CPR | | |
| | | | | 2048 CPR | | |
| | | | | 2500 CPR | | |

**PLEASE NOTE: This chart is for informational use only.** Certain product configuration combinations are not available. Visit the EM1_WEB product page *(https://www.usdigital.com/products/EM1_WEB)* for pricing and additional information.