# 35AT-4Bxx16 Series

## 39 Bits Battery Backup Multi-Turn Absolute Encoder

## Introduction

35AT-4Bxx16 series encoder is a 39-bit high-resolution optical absolute encoder from Nemicon, which offers 23-bit single turn and 16-bit multi-turn counts. The 35AT-4Bxx16 series encoder is a house encoder consisting of a patterned disk, a light source, and photosensitive elements to translate the mechanical motion into electrical signal.

The 35AT-4Bxx16 series encoder has a built in communication protocol which is supported by a full-duplex or half-duplex line transmissions driver, offering good noise immunity for a robust transmission data rate of up to 2.5Mbps in harsh industrial applications. As the product is intended for industrial applications, ESD protection circuitry has been designed-in to achieve a Class 3 ESD immunity per  IEC -61000-4-2 standard .

The 35AT-4Bxx16 series is also compliant with IP40 per IEC 60529 standard. The optical encoder is sensitive to contaminants such as dust, oil, grease & others. To ensure the optimal performance, the encoder enclosure should always be IP50 or better to protect the encoder system from external contamination.

The key advantage of the 35AT-4Bxx16 series is a multi-turn tracking that employs battery backup technology. Its gearless multi-turn counting method eliminates the gear wear-out or acoustics noise issues that are encountered in conventional geared multi-turn encoders.



## Operating Theory

Structure-wise, the encoder contains two main functional blocks: the single-turn optical engine block and the battery backup multi-turn counter block.  The single-turn engine comprises a high-performance optical detector ASIC which is accompanied by high-precision amplifiers circuitry, coupled with a special multi-track code disk that rotates between the LED emitter and detector ICs.

On multi-turn side, the multi-turn counting is enabled by utilizing a battery backup counter technology. During battery mode (encoder operates in main power "OFF" state), the battery backup circuitry will periodically power up the LED emitter and enables the photo sensor to scan the code disk multi-turn tracks for detection of shaft rotation.  In order to prolong the battery life, extra effort has been put into the design of the detector ASIC to ensure a minimum current consumption during battery mode operation. Therefore, no miscounts occur even in the absence of external power supply.
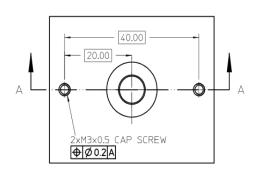
## Applications

- Robotics
- Factory automation
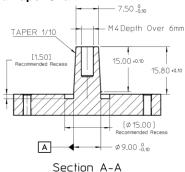- CNC machine tool

Nemicon encoders are not recommended for use in safety critical applications. E.g. ABS braking systems, power steering, life support systems and critical care medical equipment. Please contact Nemicon sales representative if more clarification is needed.
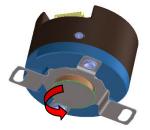
# Mounting Requirement and Guideline

## Standard Hollow Taper Shaft (Φ9-Φ7.5mm; 1:10)

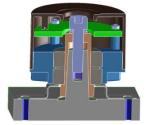**Figure 1 Recommended shaft and mounting holes for Standard Taper Shaft.**



1.  Dimensions are in millimeters
2.  3rd angle projection
3.  Unless otherwise specified, all tolerances are within ±0.5 mm
4.  Recommended to have a recess on motor mounting surface to prevent encoder shaft interference with motor base.



**Step 1:**

Remove the sticker from bottom shaft carefully. Do not poke or damage the sticker as it will create contamination to encoder.



**Step 2:**

Slide encoder taper shaft over motor shaft until the taper shaft of encoder is fully touching on the motor shaft.
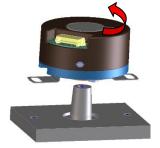


**Step 3:**

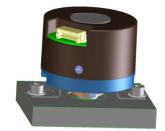Fasten the M4 socket head cap screw on top to the encoder shaft. Recommended tightening torque: 1.5 Nm
Seal the housing opening hole immediately by using the provided polyester film sticker. Make sure the hole is fully covered by the sticker for dust protection.
**Remark:** To remove the encoder from motor shaft, use an M5x40mm screw to eject encoder shaft from motor shaft.
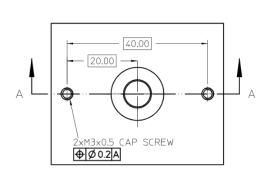


**Step 4:**

If necessary, perform a minor adjustment on the encoder orientation (M3 slot allows +/-5 degrees rotation). This is followed by fastening both the M3 coupling mounting screws.
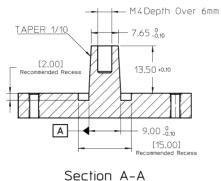Recommend to use spring washer and flat washer. Apply screw thread lock fluid to better secure the coupling plate, e.g. Threebond 1401.
Recommended tightening torque:  1Nm with M3 socket head cap screw.

# Short Hollow Taper Shaft Option (Φ9-Φ7.65mm; 1:10)

**Figure 2 Recommended shaft and mounting holes for Short Taper Shaft**



Section A-A
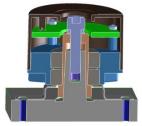
1. Dimensions are in millimeters
2. 3rd angle projection
3. Unless otherwise specified, all tolerances are within ±0.5 mm
4. Recommended to have a recess on motor mounting surface to prevent encoder shaft interference with motor base.





**Step 1:**

Remove the sticker from bottom shaft carefully. Do not poke or damage the sticker as it will create contamination to encoder.

**Step 2:**

Slide encoder taper shaft over motor shaft until the taper shaft of encoder is fully touching on the motor shaft.
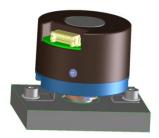




**Step 3:**

Fasten the M4 socket head cap screw on top to the encoder shaft. Recommended tightening torque: 1.5 Nm

Seal the housing opening hole immediately by using the provided polyester film sticker. Make sure the hole is fully covered by sticker as dust protection.

**Remark:** To remove the encoder from motor shaft, use an M5x40mm screw to eject encoder shaft from motor shaft.

**Step 4:**

If necessary, perform a minor adjustment on the encoder orientation (M3 slot allows +/-5 degrees rotation). Follow by fastening both the M3 coupling mounting screws.
Recommend to use spring washer and flat washer. Apply screw thread lock fluid to better secure the coupling plate, e.g. Threebond 1401.
Recommended tightening torque: 1Nm with M3 socket head cap screw.

# Hollow Blind Shaft Option (Φ8mm)

**Figure 3 Recommended shaft and mounting holes for Hollow Blind Shaft**



1.  Dimensions are in millimeters
2.  3rd angle projection
3.  Unless otherwise specified, all tolerances are within ±0.5 mm
4.  Recommended to have a recess on motor mounting surface to prevent encoder shaft interference with motor base.



**Step 1:**

Slide encoder hollow shaft into motor shaft until the coupling plate is touching the motor base.

Remarks: Do not remove or damage the sticker as it will create contamination to encoder. Make sure the housing opening hole is fully covered by the provided polyester film sticker as dust protection.

**Step 2:**

Fasten the M3X3 set-screw on the right, followed by the set-screw on the left.

Recommend to apply screw thread lock fluid to better secure the set-screws, e.g. Threebond 1401.

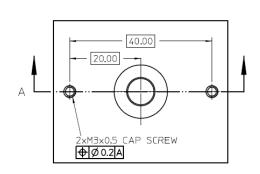Recommended tightening torque: 0.35Nm with 45H steel cup point M3 set screw.

**Step 3:**

If necessary, perform a minor adjustment on the encoder orientation (M3 slot allows +/-5 degrees rotation). Follow by fast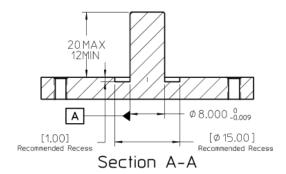ening both the M3 coupling mounting screws. Recommend to use spring washer and flat washer. Apply screw thread lock fluid to better secure the coupling plate, e.g. Threebond 1401.

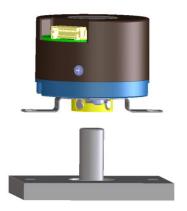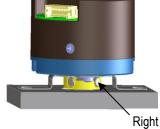Recommended tightening torque:  1Nm with M3 socket head cap screw.

# Battery Mode Operation

## Recommended External Battery

**Figure 4 Recommended product of external battery**



**Product name** = Toshiba ER6V/3.6V ER6VP
**Manufacturer part number** = ER6VP
**Brand** = Toshiba Ultra Lithium
**Nominal voltage** = 3.6V
**Nominal capacity** = 2000mAh
**Operating temperature range** = -55 ~ +85°C
**Size** = AA

**CAUTION**

1. Multi-turn data position is maintained with battery power during battery mode. Battery replacement process will cause data lost, therefore it is required to reset the multi-turn counter after every battery change.
2. Battery life calculation depends on user application condition, please consult factory if assistance is needed.

# Cable Output Assignment

| Wire | Color | Description |
|------|-------|-------------|
| 1 | Red | VCC, Encoder Supply |
| 2 | Black | GND, Ground |
| 3 | Brown/Black | GND (External Battery) |
| 4 | Brown | BATPWR(External Battery) |
| 5 | White | Data + |
| 6 | White/Black | Data - |
| 7 | Cable Shield Strand | Cable Shield, Connect to Chassis |

# Recommended I/O Connection

1. It is strongly recommended to provide encoder power supply, Vcc within 4.5V ~ 5.5V. Typical value is 5V.

2. For best noise immunity, it is recommended to use twisted-pairs shielded cable for connection to controller (servo driver).

3. It is recommended to connect encoder chassis and cable shield to frame ground (FG) in application for enhanced noise immunity in harsh operating condition.

4. To prevent undesirable signal reflections, the termination resistor is needed. Termination resistor, *220ohm 1/4W is recommended but may depends on the characteristic impedance of cable used.

## Half-duplex Transceiver (RS-485 Half-Duplex Protocol)

**Figure 5 Circuit diagram of half-duplex transceiver**

# Interface Protocol – RS-485 Half-Duplex

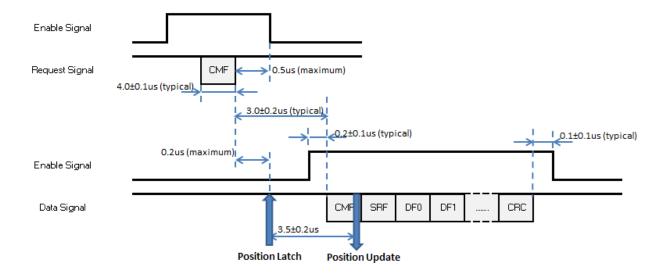| Interface | Circuit |
|---|---|
| RS-485 Serial Data (DATA +) | Transceiver (P/N: ISL8485E) |
| RS-485 Serial Data (DATA -) | Transceiver (P/N: ISL8485E) |

## Timing Characteristic

| Parameter | Min | Typ. | Max | Units |
|---|---|---|---|---|
| Communication Baud Rate | | | 2.5 | MHz |
| Frame length | | 10 | | Bit/Frame |

## Position Read Frame

**Figure 6 Timing Characteristics of Enable, Request and Data Signals**

# EEPROM Read/Write Frame

**Figure 7 Timing Characteristics of Enable, Request and Data Signals**



# Register Communication and Assignment

Please refer to 35AT-4Bxx16-Kxxx software specification document for details information.

## Memory Map (Non-Volatile Memory)

There are a total of 5 register banks of user areas (register bank 0 to register bank 4) that are accessible by users. The memory data are kept in a non-volatile memory.

| Bank | Address | Remarks |
|---|---|---|
| 0 | 00h~7Eh | User Area |
| Bank Selection | 7Fh | |
| 1 | 00h~7Eh | |
| Bank Selection | 7Fh | |
| 2 | 00h~7Eh | |
| Bank Selection | 7Fh | |
| 3 | 00h~7Eh | |
| Bank Selection | 7Fh | |
| 4 | 00h~7Eh | |
| Bank Selection | 7Fh | |

# Alarm Description

| Error Flags | Detection Mode | Description | Reset Method |
|---|---|---|---|
| Over Speed Error | Battery mode | To detect over speed and wrong multi-turn counting during Battery mode. The error flag is latched and will be transmitted once encoder enter normal mode.<br><br>1: Shaft rotation speed > 6000 rpm and wrong multi-turn count detected<br><br>0: Condition 1) Shaft rotation speed < 6000 rpm or,<br>   Condition 2) Shaft rotation speed > 6000 rpm but no wrong multi-turn count detected.<br><br>This error flag are Not defined if speed > 14000 rpm. | Perform all error clear |
| Single-turn Counting Error | Normal mode | To check integrity of single-turn position data calculation.<br><br>1: Error detected in single-turn position counting.<br><br>0: No Error detected. | Cycle power encoder |
| Counter Overflow Error | Battery mode | To indicate multi-turn counter overflow condition. (Refer to Figure 13). The error flag is latched and will be transmitted out once encoder entering normal mode.<br><br>1: Multi turn counter overflowed.<br><br>0: Multi turn counter Not overflowed. | Perform MT counter reset and all error clear |
| Multi-turn Counting Error | Normal mode | To check integrity of multi turn position data counting. The error flag is latched.<br><br>1: Error detected in multi turn position counting<br><br>0: No Error detected | Perform MT counter reset and all error clear |
| Battery Supply Error | Battery mode | To check backup battery supply low voltage condition. The error flag is latched and will be transmitted out once encoder entering normal mode.<br><br>1: Battery voltage is lower than 2.9 ±0.25V<br><br>0: Battery voltage is higher than 2.9 ±0.25V | Perform all error clear |
| Battery Supply Alarm | Normal mode | To check backup battery supply low voltage condition. The error flag will be automatically cleared once the battery voltage return to normal value.<br><br>1: Battery voltage is lower than 3.1 ±0.1V<br><br>0: battery voltage is higher than 3.1 ±0.1V | Error flag automatically clear once battery voltage return to normal |
| LedErr Error | Normal mode | To indicate if LED current is out of operating range.<br>1: LED out of operating range.<br>0: LED within operating range. | Cycle power encoder |
| LisErr Error | Normal mode | To check integrity of ADC Sin and Cos signals by means of Lissajous specifications.<br>1: Lissajous out of specification.<br>0: Lissajous within specification. | Cycle power encoder |

# Trouble Shooting Guide

| No. | Description | Potential Causes | Counter Measure |
|-----|-------------|------------------|-----------------|
| 1 | No output | Encoder power supply too low | Check if Vcc versus ground potential is within 4.5~5.5V |
| | | Poor connectivity between encoder connector to customer connector | Check encoder connector and customer connector connectivity |
| | | Wrong wire connection assignment | Check connector wire connection assignment |
| | | Detector IC faulty/shorted | Perform power cycle. If problem still exist, please consult factory. |
| | | Transceiver faulty/shorted | |
| 2 | Encoder high current consumption (>200mA at 25˚C) | LED faulty/ shorted | |
| | | Detector IC faulty/shorted | |
| | | Transceiver faulty/shorted | |
| 3 | Single-turn Counting Error triggered | Single-turn block faulty | |
| 4 | Multi-turn Counting Error triggered | Multi-turn block faulty | |
| 5 | LedErr triggered | LED faulty | |
| 6 | LisErr triggered | LED faulty | |
| | | Codewheel issue | |
| | | Single-turn block faulty | |
| 7 | Over Speed triggered | Speed > 6000 rpm | Check motor speed and make sure it is <6000rpm |
| 8 | Multi-turn Counter Overflow triggered | Out of the range of -32767 and +32768 | Perform multi-turn data reset request |
| 9 | Battery Supply Error triggered | Battery voltage is less than 2.9 +/-0.25V | Check battery voltage |
| | | Battery installation issue | Check battery installation condition (e.g. polarity is correct) |
| | | Battery low/damage | Replace battery |
| 10 | Battery Supply Alarm triggered | Battery voltage is less than 3.1 +/-0.1V | Check battery voltage |
| | | Battery low/damage | Replace battery |

# Dos and Don'ts

## Do

1. Ensure clean environment during installation. Provide adequate protection from dust and moisture when use in harsh environment.

2. Ensure encoder housing opening hole is fully covered with sticker to avoid any contamination to encoder.

3. Ensure encoder power supply is within 5V +/- 10%.

4. Replace batteries with the recommended size and type.

5. Ensure pin configuration is per datasheet.

6. Observe all ESD precaution when performing installation or handling the encoder.

7. Ensure to use recommend screw type as per mounting guideline in order to avoid generating any brass debris, which will create contamination to encoder.

## Don't

1. Do not overload transceiver by using wrong termination resistor.

2. Do not hammer encoder shaft into motor shaft during installation.

3. Do not deform coupling plate during installation.

4. Do not reverse the power source polarity for both encoder main power and battery power.

5. Do not operate encoder under extreme temperature over time.

6. Do not poke or damage the encoder sticker.

For detail specification of this encoder, refer to the 35AT-4Bxx16 Series datasheet.