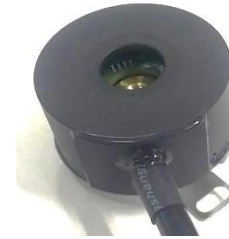# 35AT-4B2516 Series

Battery Backup Multi-Turn Absolute Encoder

Introduction

35AT-4Bxx16 series encoder is a high-resolution optical absolute encoder from Nemicon, which offers up to 25-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 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 the standard 2.5Mbps in harsh industrial applications. Higher transmission rates of 5Mbps or 10Mbps are now also available. 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 compatible to the IP40 protection per IEC 60529 standard. The optical encoder is sensitive to contaminants such as dust, oil, grease & others. To ensure the optimal performance, the final motor 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

CAUTION   This product is not specifically designed or manufactured for use in any specific application. Customers are solely responsible for determining the suitability of this product for its intended application and solely liable for all loss, damage, expense, or liability in connection with such use. Please contact Nemicon sales representative if more clarification is needed.

Recommended Motor Mounting Requirement and Guideline

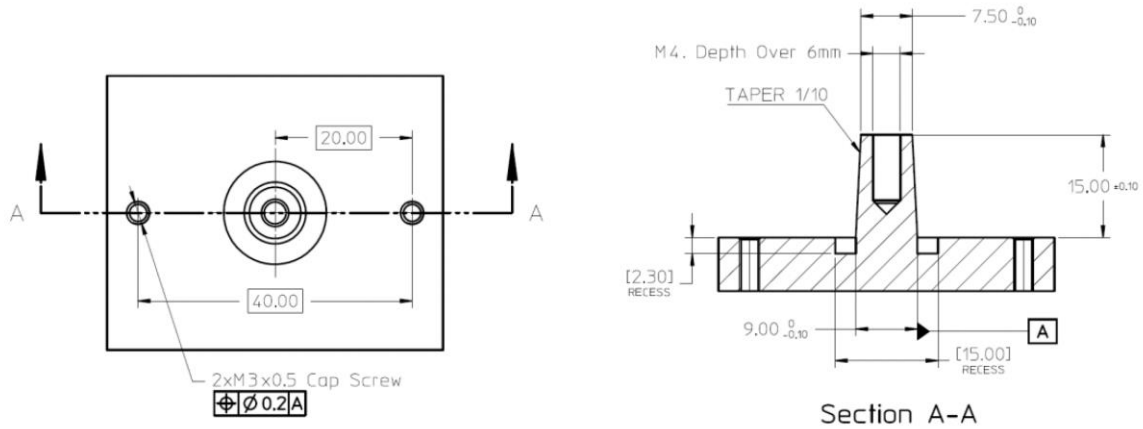## Standard Hollow Taper Shaft Option (Φ9-Φ7.5mm; 1:10)

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

NOTE

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.

Recommended Encoder Assembly Steps – Taper Shaft Options

Step 1:

Assemble the supplied flexible coupling plate with the two pieces of M2.6 x 5 screws (property class 4.6).

Recommended tightening torque 4 +/- 0.2 kgf.cm.

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.

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

Step 3:

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. Recommended tightening torque with socket head cap screw:

9 +/- 1 kgf.cm (property class 8.8 screw) or
4.8 +/- 0.2 kgf.cm (property class 4.6 screw)

Recommend to use spring washer and flat washer. Apply screw thread lock fluid to better secure the coupling plate, e.g. Threebond 1401.

Step 4:

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

18 +/- 2 kgf.cm (property class 8.8 screw) or
10 +/- 0.2 kgf.cm (property class 4.6 screw)

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

Remarks: To remove the encoder from motor shaft, an M5 X 40mm screw is needed to eject encoder shaft from motor shaft.
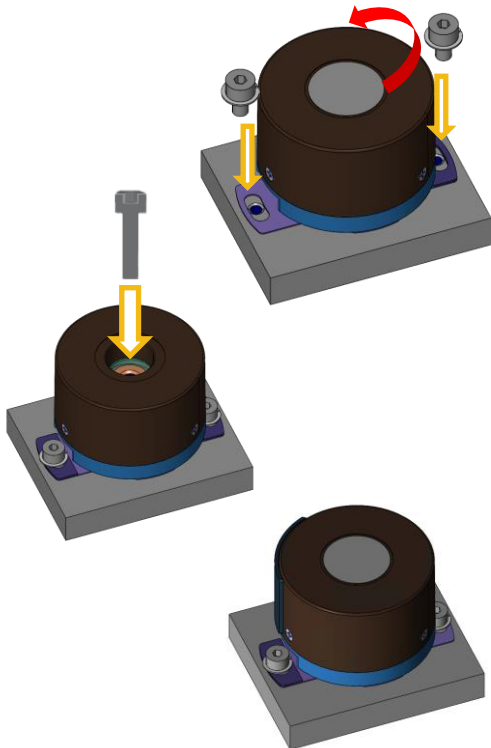
Battery Considerations

Table 1 Recommended External Battery

Product Name	Toshiba ER6V/3.6V ER6VP
Manufacturer Part Number	ER6VP
Brand Range	Toshiba Ultra Lithium
Nominal voltage	3.6V
Nominal capacity	2000mAh
Operating temperature range	-55 ~ +85˚C
Size	AA

Figure 2 Recommended external battery

WARNING

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 battery has been changed.

2) Battery life calculation depends on User application conditions, please consult factory if assistance is needed.

Cable Output Assignment

Table 2 Cable output definition

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.

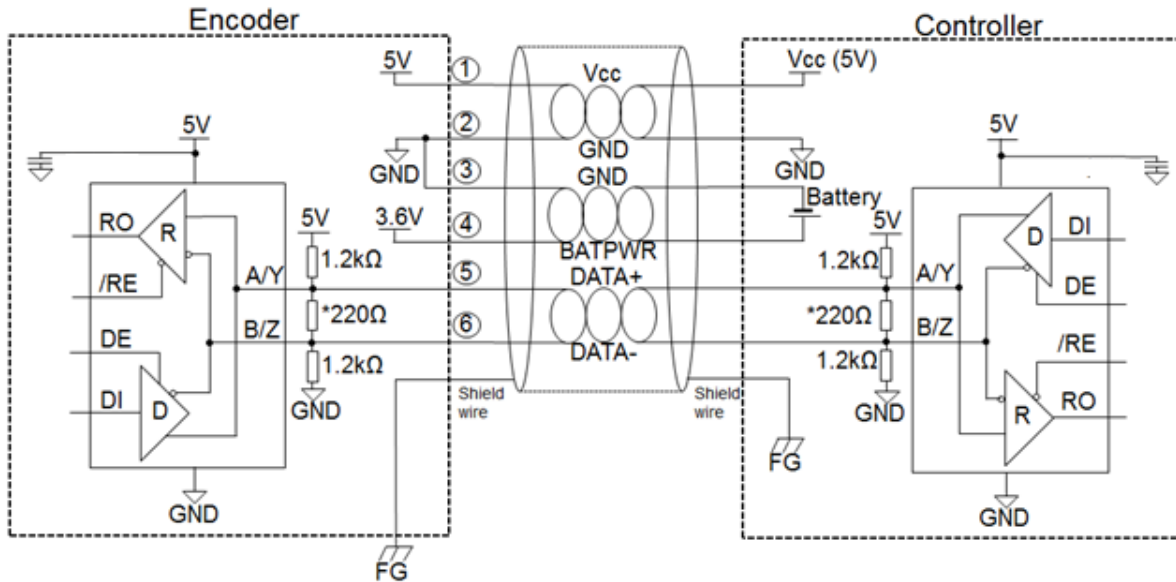# Half-duplex Transceiver (RS-485 half-duplex protocol):

Figure 3 Circuit diagram of half-duplex transceiver

Interface Protocol – RS-485 Half-Duplex

Table 3 Differential Line Transceiver

Interface	Recommended Circuit
RS-485 Serial Data (DATA +/DATA-)	Transceiver Part Number: ISL8485E for 2.5Mbps, up to 30m cable length.

Table 4 Timing Characteristic

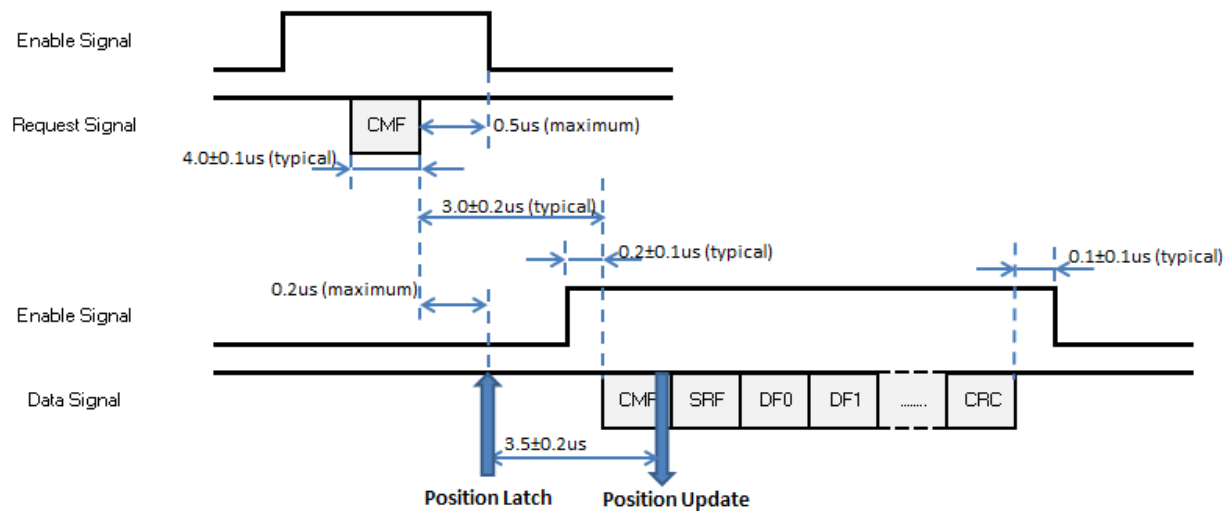| Parameter	Min	Typ.	Max	Units	Remarks
Communication Baud Rate		2.5	10	Mbps	Configurable to 2.5, 5.0, or 10Mbps
Frame length		10		Bit/Frame	

Position Read Frame

Figure 4 Timing Characteristics of Enable, Request and Data Signals based on 2.5Mbps
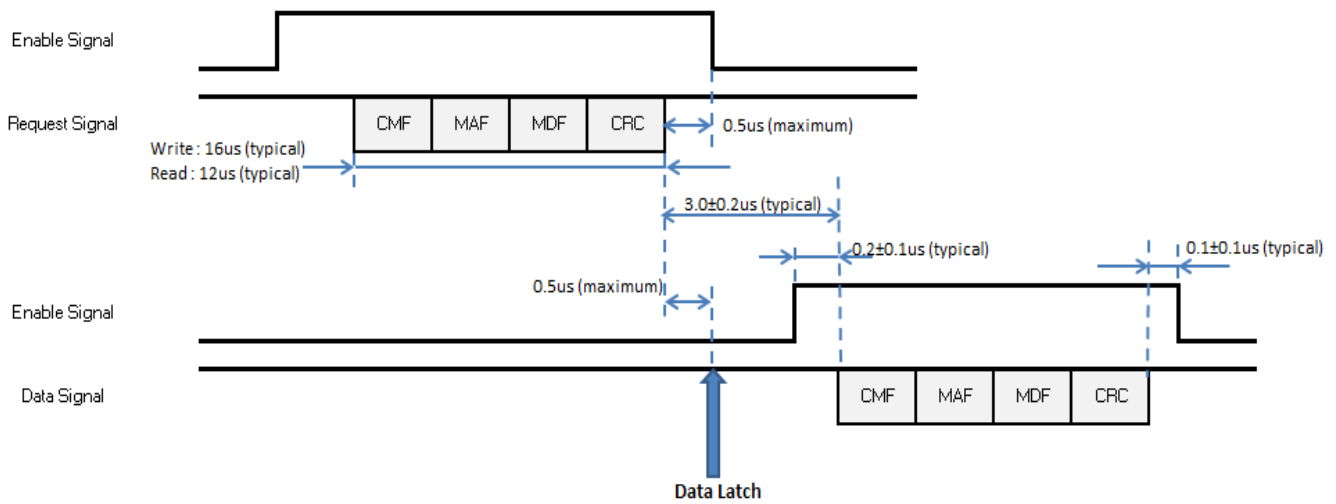
EEPROM Read/Write Frame

Figure 5 Timing Characteristics of Enable, Request and Data Signals (2.5Mbps)

Register Communication and Assignment

Please refer to 35AT-4B2516-Kxxx software specification document for details information.

Memory Map (Non-Volatile Memory)

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	
Bank Selection	7Fh	
1	00h~7Eh	
Bank Selection	7Fh	
2	00h~7Eh	User Area
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. 1: Shaft rotation speed > 6000 rpm and wrong multi-turn count detected 0: Condition 1) Shaft rotation speed < 6000 rpm or, Condition 2) Shaft rotation speed > 6000 rpm but no wrong multi-turn count detected. 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. 1: Error detected in single-turn position counting. 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. 1: Multi turn counter overflowed. 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. 1: Error detected in multi turn position counting 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. 1: Battery voltage is lower than 2.9 ±0.25V 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. 1: Battery voltage is lower than 3.1 ±0.1V 0: battery voltage is higher than 3.1 ±0.1V	Error flag automatically clear once battery voltage return to normal

Multi-turn Counter Overflow Flag Explanation
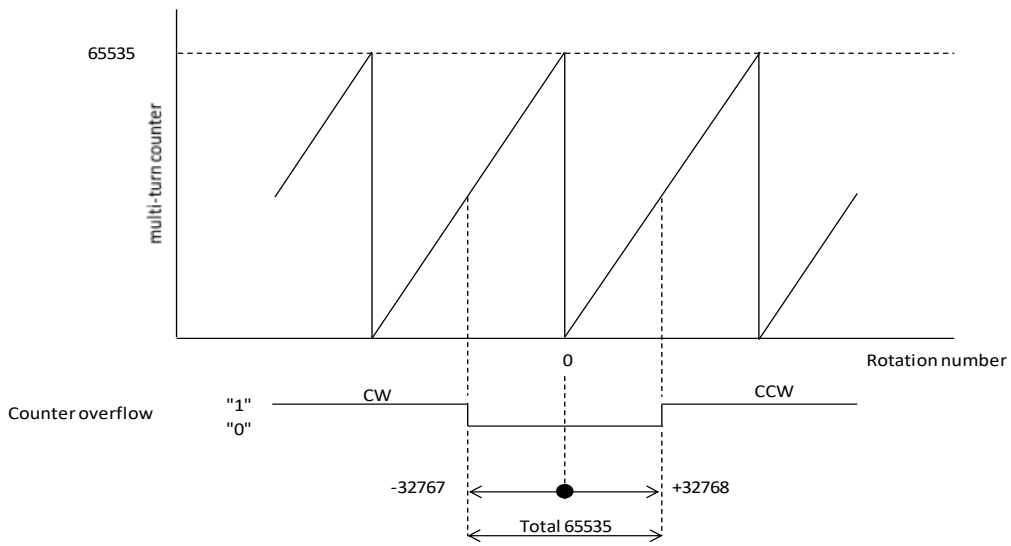
Figure 6 Relation between multi-turn counting and over flow flag

Trouble Shooting Guide

No.	Description	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	Over Speed triggered	speed > 6000 rpm	Check motor speed and make sure it is <6000rpm
6	Multi-turn Counter Overflow triggered	Out of the range of -32767 and +32768	Perform multi-turn data reset request
7	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
8	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%. Avoid sudden drop or surge in the power supply line, including upon power up.

4. Replace used battery with the recommended size and type.

5. Ensure cable output 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-4B2516 Series datasheet.