**N33MA-M42 Series**

# 42-bit Full Magnetic Energy Harvesting Multi-Turn Absolute Encoder Module

## Preliminary Datasheet

**Encoder Part Numbers**

N33 M A – M 42 ＊ – ＊ ＊ – 00 E

- RoHS compliant
- Specification No.: Standard type
- Operating Voltage:
  - 5: 5V±10%
  - 7: 7 to 12.5V
- Hub screw:
  - 3: M3 pitch0.5
  - 4: M4 pitch0.7
- Protocol:
  - B: Biss-C(10MHz)
  - S: SSI(1MHz)
  - K: RS485 Half-duplex(2.5MHz)
- Resolution:
  - 42: 42bits(Single:18bit Multi:24bit)
- M: Multi Turn
- A: Absolute
- M: Moduler type

## 1. Introduction

### 1.1 Description

M33MA-M42 series encoder is an absolute magnetic encoder, which offers 18-bit single-turn (ST) and 24-bit multi-turn (MT) counts, hence a combined 42-bit high resolution encoder. Design of the encoder features state of the art Energy Harvesting Multi-turn technology. To improve system integrity and simplicity, a single magnetic solution is responsible for both ST and MT positions generation.

The key advantage of N33MA-M42 series encoder is the patented energy-harvesting technology for revolution tracking. This technology converts rotating magnetic field into electrical energy, which powers the revolution tracking circuit. The beauty of Energy Harvesting technology is that the same amount of energy is generated independent of encoder rotation speed and direction. The generated energy is sufficient to power up the multi-turn counter circuitry. Therefore, no loss of revolution count even in the absence of external power supply. On the other hand, when comparing to battery backed up multi-turn counting, this technology does not require periodic maintenance of the battery backup components and the down time associated with it.

N33MA-M42 series encoder has a built in communication protocol, which is supported by a full-duplex or half-duplex line transmissions drive, offering good noise immunity for more robust transmission of data up to 10Mbps in harsh industrial applications. Being a magnetic technology-based encoder, it is robust against contamination such as dust and finger print on the sensing element. As a result, it requires less stringent control in production handling and harsh environment.

### 1.2 Operating Theory

N33MA-M42 series encoder contains two major blocks, which are MT revolution tracking block and ST absolute position block. Both MT and ST blocks are based on magnetic technology. The MT block employs energy harvesting technology whilst the ST block implements magnetic sensor for absolution position generation.

When encoder is powered up, encoder absolute position is generated by synchronizing the MT revolution count to the ST absolute positon; and henceforth tracked by the ST absolute position.

### 1.2 Features

- Patented Energy Harvesting technology
- Total 42-bit resolution with 18-bit single-turn and 24-bit multi-turn
- Overall encoder outer diameter Ø33 mm and maximum height of 20 mm
- Built-in communication protocol (option): SSI (2MHz), BiSS C (10MHz) & RS-485 half-duplex (2.5, 5.0, 10MHz)
- Built-in temperature sensor
- Operating temperature range -40°C to 115°C.

### 1.3 Benefits

- No battery or capacitor required for position detection during power failure
- Immediate position detection on power up
- Cost effective solution
- Robust environment

### 1.4 Applications

- Small motors and linear Actuator
- Robotic automation and Engineering
- Drone
- Test and Measurement Equipment

**Note:** The encoder is not recommended for use in life critical applications, e.g. ABS braking systems, power steering, life support and critical care systems and medical equipment. Please contact sales representative if more clarification is needed.

## 2. Product Specifications

**Table 1. Absolute Maximum Rating**

Note: Exposure to absolute maximum rating conditions for extended periods may affect reliability.

| Parameters | Symbol | Min | typ | Max | Unit | Remark |
|---|---|---|---|---|---|---|
| Supply Voltage | $V_{DD}$ | -0.3 | | 15 | V | |
| Operating temperature | $T_J$ | -40 | | 115 | ˚C | |
| Storage temperature | $T_s$ | -40 | | 115 | ˚C | |
| Permissible Speed | - | - | - | 12,000 | rpm | Note (1) |

**Recommended Operating Conditions**

**Table 2. Electrical Specification Over $T_{amb}$ = 25°C**

| Parameters | Conditions | Min | Typ | Max | Unit | Remark |
|---|---|---|---|---|---|---|
| Supply Voltage | - | 4.5 | - | 5.5 | V | N33MA-M42-x5x |
| | | 7 | - | 12.5 | V | N33MA-M42-x7x |
| Supply Current | Without load | - | 55 | 65 | mA | N33MA-M42-x5x |
| | | - | 45 | 55 | mA | N33MA-M42-x7x |
| System Accuracy | With electrical correction(2) | - | ±0.087 | - | deg | |

**Table 3. Mechanical Specifications**

| Parameters | Conditions | Min | Typ | Max | Unit | Remark |
|---|---|---|---|---|---|---|
| Max axial shaft play | - | - | - | ±0.2 | mm | |
| Max radial shaft play | - | - | - | ±0.05 | mm | |
| Vibration | Per IEC 60068-2-6 | - | - | 10G; 10~2000Hz | - | |
| Shock | Per IEC 60068-2-27 | - | - | 6ms; Half Sine; 200G | - | |

**Table 4. Environmental Specifications**

| Parameters | Conditions | Min | Typ | Max | Units | Remark |
|---|---|---|---|---|---|---|
| Relative Air Humidity (Non-Condensing) | $T_{amb}$ = 60˚C | - | 90 | - | RH% | |
| Electrostatic Discharge (Module level) | Per IEC 61000-4-2 | - | - | ±4 | kV | |

**Table 5. Internal Temperature Sensor Specifications**

| Parameters | Conditions | Min | Typ | Max | Units | Remark |
|---|---|---|---|---|---|---|
| Resolution | | - | 1 | - | ºC | |
| Accuracy of evaluation circuit | 25ºC to 115ºC | -5 | - | 5 | ºC | |
| | -40ºC to 25ºC | -7 | - | 7 | ºC | |
| Temperature range(3) (4) | | -40 | - | 125 | ºC | Note (3) (4) |
| Calculation Time | | - | - | 100 | ms | |

**Table 6. Encoder Specifications**

| Parameter | Remarks |
|---|---|
| Single turn Resolution | Single-turn 18 bits (262143 counts) |
| Multi-turn Resolution | Multi-turn 24 bits (16777216 counts) |
| Counting Direction | Increase with counter-clockwise (CCW) motor shaft rotation, view from encoder top |
| Initialization Time | 500ms |

Note:

(1) Encoder works reliably up till this permissible speed.
(2) Under recommended magnetic shielding enclosure and calibration at ambient 25°C. Any wear and tear condition that might affect total indicated runout of motor shaft will cause encoder accuracy drift.
(3) Temperature error alarm setting = 115°C . Temperature readout is 2nd complement value.
(4) Temperature sensor is not available for SSI version product.
(5) Exposure to absolute maximum rating conditions for extended periods may affect reliability; and stress greater than the absolute maximum rating may cause permanent damage to the device.

## 3. Protocol Specifications

### 3.1 SSI Specifications

**Table 7. SSI Interface**

| Interface | Circuit | Remark |
|---|---|---|
| Shift Clock (SCLK) | Receiver (P/N: ISL3283E) | |
| Data Output (DAT) | Transmitter (P/N: ISL3295E) | |

**Table 8. SSI Timing Characteristics**

| Parameters | Symbol | Conditions | Min | Typ | Max | Unit | Remark |
|---|---|---|---|---|---|---|---|
| Clock frequency | $f_{CLK}$ | - | 100 | - | 2000 | kHz | |
| Clock duty | $DUT_{CLK}$ | - | - | 50 | - | % | |
| Monoflop time | $t_m$ | - | - | - | 20 | µs | |
| Pause time | $t_p$ | - | 21 | | - | µs | |

**Table 9. SSI Data Field**

| MT[23:0] | ST[17:0] | Status[0] | Alarm[0] |
|---|---|---|---|

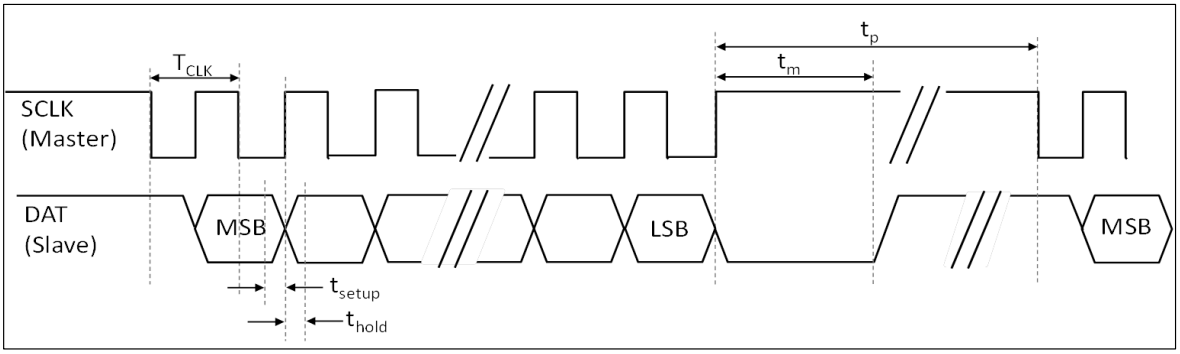



Figure 1. SSI Interface Timing Diagram

**SSI Command list**

| Command | Signal |
|---|---|
| 42-bit Position Zero Reset | 100ms Hi-Lo-Hi Pulse to SPI_DIN pin |

### 3.2 BiSS C Specifications

**Table 10. BiSS C Interface**

| Interface | Circuit | Remark |
|---|---|---|
| Serial Clock (MA) | Receiver (P/N: ISL3283E) | |
| Serial Data Output (SLO) | Transmitter (P/N: ISL3295E) | |

**Table 11. BiSS C Timing Characteristics**

| Parameters | Symbol | Conditions | Min | Typ | Max | Unit | Remark |
|---|---|---|---|---|---|---|---|
| MA frequency | $f_{MA}$ | - | 0.08 | - | 10 | MHz | |
| MA duty | $DUT_{CLK}$ | - | - | 50 | - | % | |
| Busy | $T_{busy}$ | - | - | - | 5 | µs | |
| Timeout | $t_{BiSS\text{-}timeout}$ | - | - | - | 5 | µs | |
| Frame to Frame | | - | - | - | 1 | us | |

**Table 12. BiSS C Data Field**

| MT[23:0] | ST[17:0] | Error[0] | Warning[0] | CRC[5:0] |
|---|---|---|---|---|

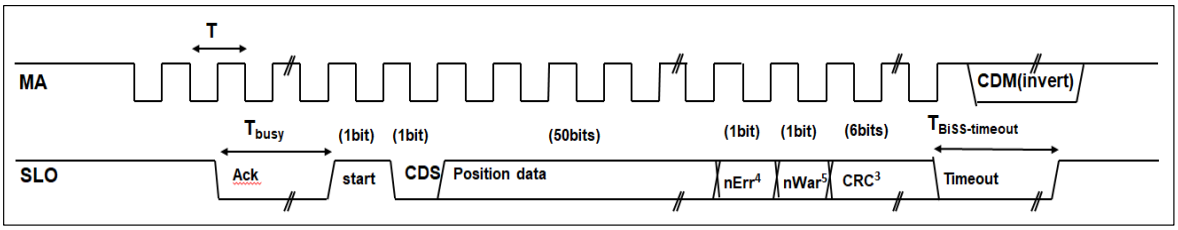



Figure 2. BiSS C Interface Timing Diagram

Note:
1. CRC Polynomial = Invert of ($X^6 + X^1 + X^0$).
2. nErr bit is active low. (Combine all the Error Status and reflect in nErr bit)
3. nWar bit is active low. (Combine all the Warning Status and reflect in nWar bit)

**BiSS C Command list**

| Command | Register |
|---|---|
| 8-bit Temperature Readout | Read address 0x75 |
| 42-bit Position Zero Reset | Write address 0x4A with data 0x03 |

**Register Communication and Assignment**
Please refer to BiSS C Interface Protocol Description Rev C6 document for detail information.
https://www.ichaus.de/upload/pdf/BiSS_C_protocol_C6en.pdf

### 3.3 RS-485 Half-Duplex Specifications

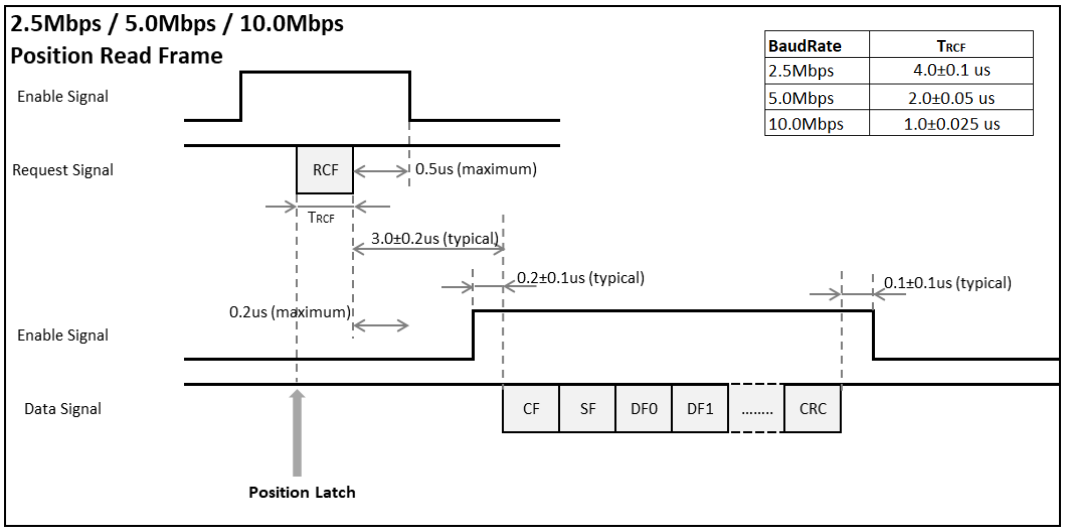
**Table 13. RS-485 half Duplex interface**

| Interface | Circuit | Remark |
|---|---|---|
| RS-485 Serial Data (DAT) | Receiver (P/N: ISL3283E) | |
| RS-485 Serial Data (DAT) | Transmitter (P/N: ISL3295E) | |

**Table 14. RS-485 Half-Duplex Timing Characteristic**

| Parameter | Condition | Min | Typ. | Max | Units | Remark |
|---|---|---|---|---|---|---|
| Communication Baud Rate | - | - | - | 10 | MHz | 2.5, 5.0, 10.0MHz |
| Frame length | - | - | 10 | - | Bit/Frame | |
| Jitter | - | - | - | 100 | ns | |

**Position Read Frame**




**EEPROM Read/Write Frame**

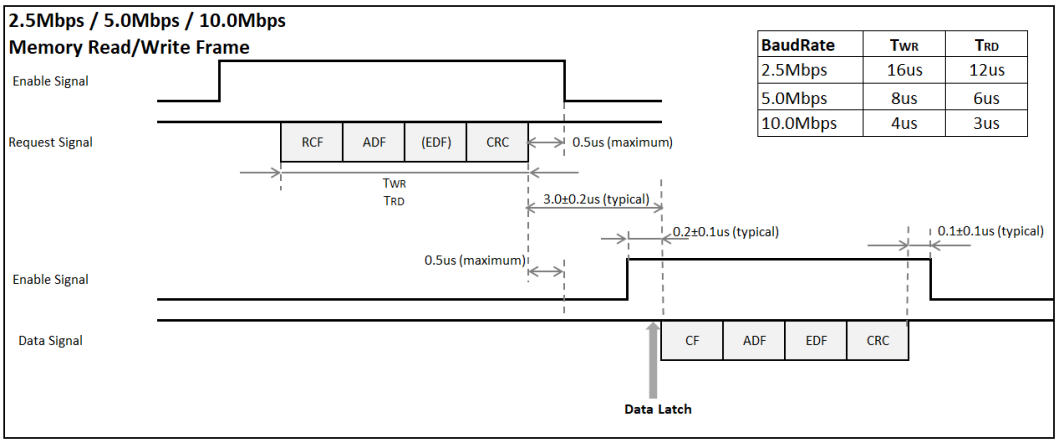



Figure 3. Timing Characteristics of Enable, Request and Data Signals

**Register Communication and Assignment**

Please refer to N33MA-42M software specification document for details information.

**Table 15. Connector Output Assignment**

| Pin No | SSI | BiSS C | RS485 half-duplex |
|---|---|---|---|
| 1 | GND | GND | GND |
| 2 | VDD | VDD | VDD |
| 3 | SCLK- | MA- | NC |
| 4 | SCLK+ | MA+ | NC |
| 5 | DAT- | SLO- | DATA- |
| 6 | DAT+ | SLO+ | DATA+ |
| 7 | SPI CLK | NC(1) | NC(1) |
| 8 | SPI DO | NC(1) | NC(1) |
| 9 | SPI DIN | NC(1) | NC(1) |
| 10 | GND | GND | GND |

Note (1) : Do not connect during operation

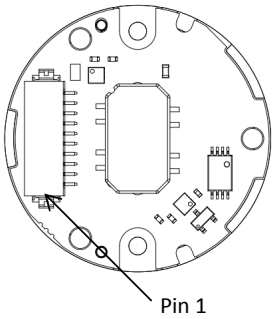
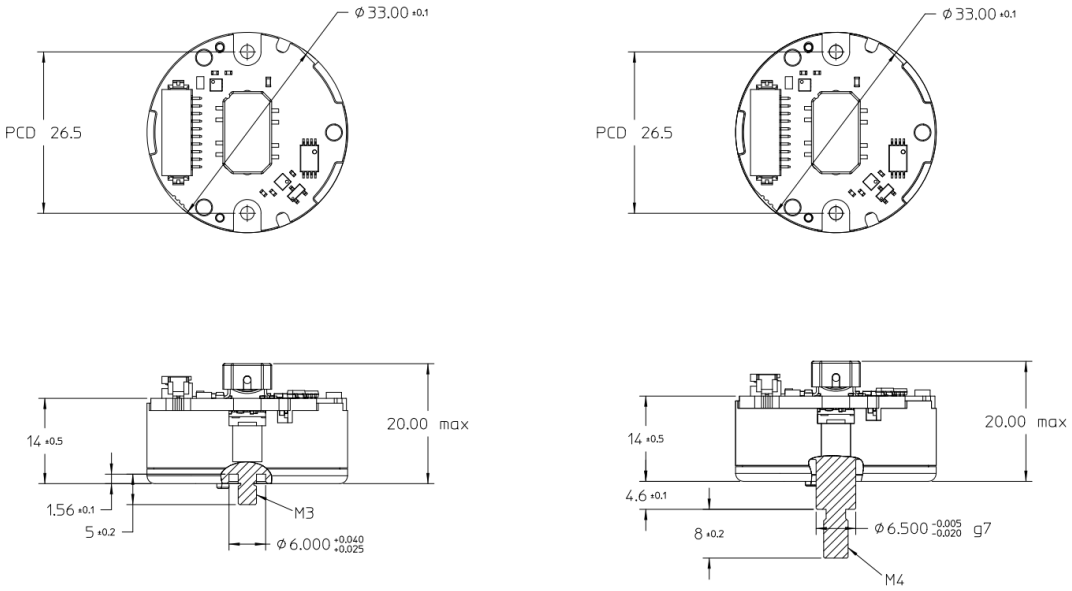



Figure 4. Pin 1 location viewed from encoder top

*Recommended mating connector:
Hirose Part No: DF13-10S-1.25C (CL No.536-0006-8)
Hirose (Terminal Pin for Wire 26~30AWG): DF13-2630SCF (CL No.536-0300-5)

## 4. Mechanical Dimensions




**M3 Hub Screw** **M4 Hub Screw**

Figure 5. Package dimensions

Note:
1. Dimensions are in millimeters
2. Unless otherwise specified, all tolerances are within ±0.5 mm
3. DO NOT USE FERRO-MAGNETIC SHAFT FOR THE MOTOR

## 5. Magnetic Shield Design Guidelines

In order to eliminate or minimize the influence of external magnetic field interference on encoder operation, use of shielding is mandatory. A recommended design of shielding made of 1.2mm mild steel (SPCC) is given in Figure 6.

Shield Requirement
Minimum Thickness: 1.2mm
Material: Ferromagnetic

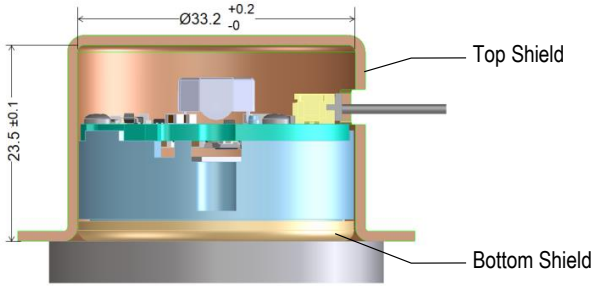



Figure 6. Recommended Magnetic Shield Design

Note:
1. External magnetic interference varies by the application and operating environment.
2. Proper study of external magnetic field and appropriate shield design is needed.
3. Consult factory for technical assistance.

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