MR430 Series
ZapFREE® Fiber Optic
Absolute Encoder System
Instruction Manual

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Revision History

Revision	Date	Notes
A	8-March-2018	Initial Release
A1	21-June-2018	Product release
A2	11-July-2018	Added MR431 sensor diagrams
A3	17-Aug-2018	Added System Loss Budget to MR430 Controller specifications
A4	18-Sept-2018	Correction to Digital Output Load in Section 3.14
A5	3-Apr-2019	Added Functionality for Auxiliary Function see section 3.15 and 4.5 Modbus Commands, Register 0x208. Deleted Fax Numbers Updated documentation supplied per product shipment
B	8 July 2020	Changed to Photon Control

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1. Product Description

1.1 Position Sensor Background

Position sensors are typically used to provide an absolute position from a mechanical moving device to a controller unit. The position information is either used to measure a position or to close the servo loop for an automatic positioning system. The key characteristics of an absolute position sensor are:

- Range
- Accuracy
- Resolution
- Time response of the actual position

1.2 Fiber Optic Position Sensor

The MR430 series fiber optic position sensor system is an innovative all-optical design immune to any electro-magnetic interference such as lightning, radiation, magnetic fields and other harsh environmental conditions. The fiber optic aspect of the sensor also makes it perfectly suited for sensing position at high voltage power lines, within high magnetic fields (MRI) or explosive atmospheres. This innovative product measures absolute angular position from 0° to 360° with 13-bit resolution and distances up to 100 feet.

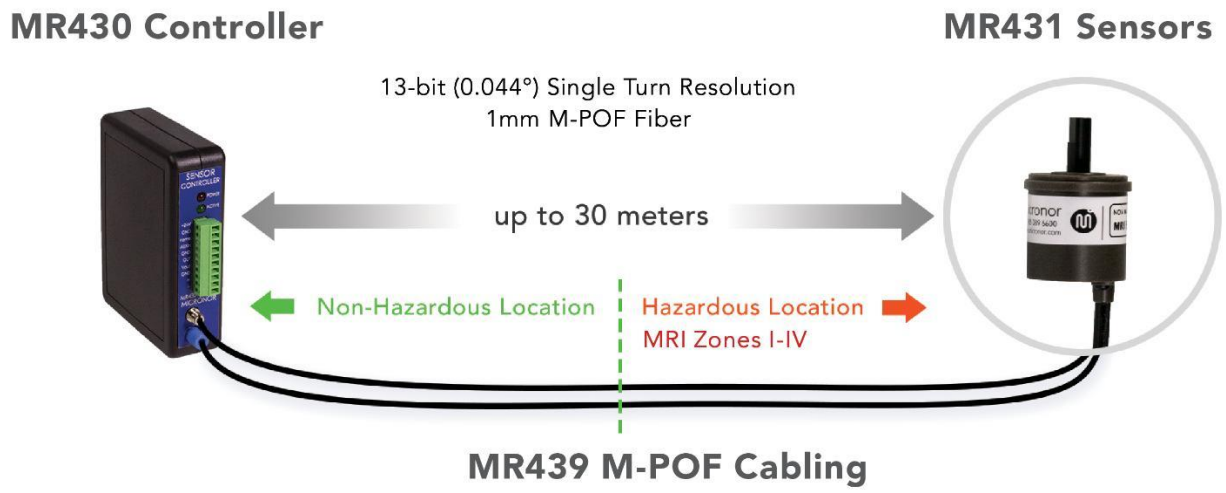


Figure 1. Micronor MR430 Fiber Optic Position Sensor System

The sensor utilizes Plastic Optical Fiber for sensing the exact position of the sensor disk. There are two fibers, the Transmit fiber sends a short light pulse of light at a wavelength of 645nm to the sensor. A unique code on the sensing disk impresses the code image to the receiving imaging fiber. The controller analyzes the code impressed on the Receiving fiber and determines the exact position. Since the sensor is electrically passive, it can be deployed in EMI/RFI intense environment without being disturbed by such interference.

The position signal is measured and updated at a rate of 1.2 kHz. The controller provides a host of interface capabilities, including: scalable analog voltage and current outputs, digital SSI (Serial Synchronous Interface) output, USB, and a Modbus compatible serial interface.

1.3 Features

- Absolute Angular Position with 13-bit (8192) Resolution
- Multi-turn tracking to 12-bits (4096 turns)
- Immune to Electrical Interference
- Zero Emitted Electrical Radiation
- MRI Safe Sensor, Non-Metallic
- Transmission without Interference up to 30m (100 feet)
- Utilizes 1mm diameter POF fibers
- Multiple interfaces built-in into one unit
    - SSI Interface
    - Modbus RTU via RS422/RS485 serial interface.
    - USB Interface
    - Two Scalable Analog Position Outputs (±10V and 4-20mA)
    - One Programmable Digital Set-Point
- User settable Zero Position
- External Zero Position input.
- Powers from +18V DC to +28VDC
- Low Energy consumption, < 1.5 Watts
- ZapView® Setup Software
- Small form factor Sensor (size 11)
- Ex classified "Inherently Safe, Simple Mechanical Device", i.e. sensor can be installed in all manner of hazardous location or combustible atmosphere – mines, gas, vapors or dust.

2. Initial Preparation

2.1 Unpacking and Inspection

The unit was carefully inspected mechanically and electrically before shipment. When received, the shipping carton should contain the following items listed below. Account for and inspect each item before the carton is discarded. In the event of a damaged instrument, write or call your nearest PHOTON CONTROL office in the U.S. A. Please retain the shipping container in case reshipment is required for any reason.

2.2 Damage in Shipment

If you receive a damaged instrument you should:

1. Report the damage to your shipper immediately.
2. Inform PHOTON CONTROL
3. Save all shipping cartons.

Failure to follow this procedure may affect your claim for compensation.

2.3 Standard Contents

MR430-1 SSI Controller Module:

- MR430-1 Controller Module
- Detachable Phoenix Terminal connector plugged into unit.
- MR232-3 USB Cable (one per shipment)
- Application Note AN128 Where to download Product Documentation and Application Software (one copy per shipment)

MR431 Sensor:

- MR431 Sensor Device
- Test Protocol Sheet
- Application Note AN120 Fiber Optic Cable Care (one copy per shipment)
- Application Note AN128 Where to download Product Documentation and Application Software (paper copy, one per shipment)

MR439-PXX Sensor Cable:

- MR439-PXX Sensor cable per specified length
- Application Note AN120 Fiber Optic Cable Care (one copy per shipment)
- Application Note AN128 Where to download Product Documentation and Application Software (one copy per shipment)

Available accessories (must be ordered separately):

- MR431A - set of 3, non-metallic synchro clamps and screws
- MR430-99-01 (J2) Breakout Cable for connection to SSI and RS485 interfaces
- MR498 cable assemblies (for extended links)
- MR498 inline mating adapters for use with MR498 extension assemblies

3. Installation and Operation

3.1 Mounting the Sensor Unit

The MR431 sensor unit is a Size 11 standard servo mount configuration with Ø6mm shaft. Figure 2 illustrates 3 methods of mounting the sensor. Detailed mounting instructions and dimensions can be found in the MR431 Reference Drawing in Section 9.2.

a) Synchro clamps (set of 3x clamps and screw available as Micronor P/N MR431-1101)
b) Flat washers
c) Face mount

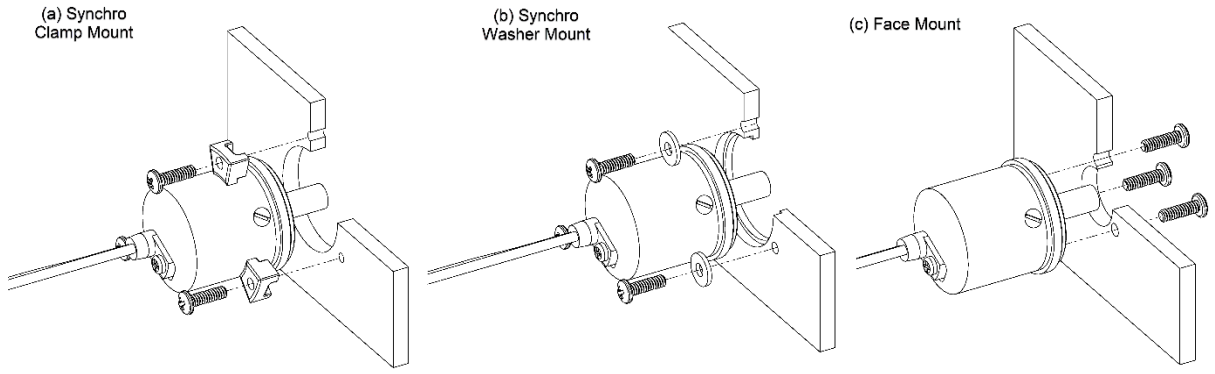
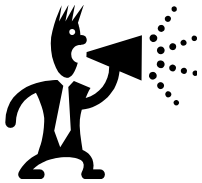


Figure 2. Three Methods of Mounting MR431 Sensor – (a) Synchro Mount with Clamps, (b) Synchro Mount with Flat Washers, and (c) Face Mount.



IMPORTANT NOTES
The sensor requires secure installation to meet published specifications.
No excessive force or load should be applied while installing.
The sensor should be mounted to a flat surface or bracket.
A flexible shaft coupling should be used when mounting to an external motor shaft.

3.2 Mounting the Controller Unit

The controller unit mounts on standard 35mm DIN rail, or it can be screw mounted to a wall or cabinet.

- For DIN rail mounting, insert clip to the unit and then clip onto DIN rail by bending the clip tabs toward of the enclosure.
- When screw mounting, remove clip from enclosure and use screws to affix clip to the wall and then clip enclosure onto the plastic clip. Both mounting schemes are shown below.

IMPORTANT:

- The optical power emitted by the Controller is classified both Eye-Safe (Class 1) and Inherently Safe (Ex op is).
- By design, the optoelectronic Controller must be installed in a non-hazardous, Safe Area.

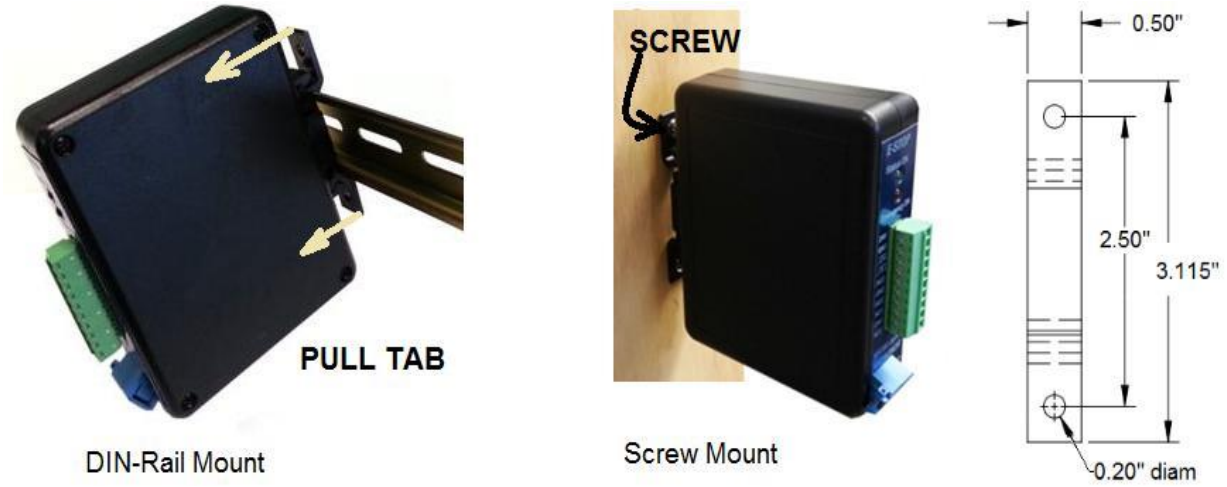
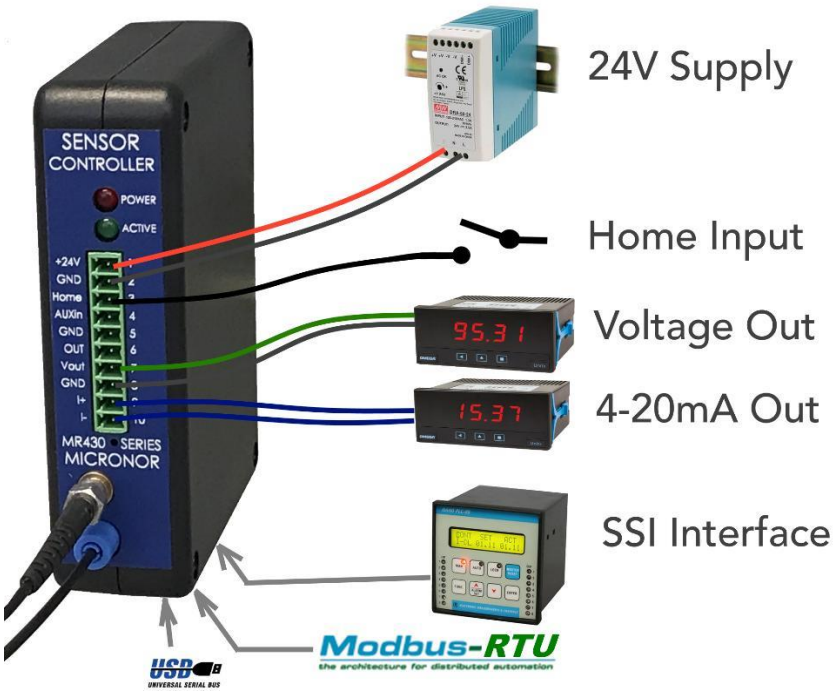


Figure 3. Mounting MR430 Controller on DIN Rail



The Sensor Controller requires 24V DC and consumes approximately 60mA.

A number of interface options exist:

Voltage and current outputs are scalable using the ZapView® software.

The 4-20mA current output is isolated and requires an external voltage source.

The Homing input requires a 18V to 24V logic or switch signal.

Figure 4. Connections to the MR430-1 Controller

The SSI interface usually connects to a PLC, servo drive unit or other position indicator. The SSI allows for clock speeds of up to 250kHz and block read-out speeds up to 10kHz. Signals are available on connector J3 which is shared with the Modbus interface signals.

The Modbus/RTU interface is available at connector J3. Controller units are slave devices and the device address is programmable via this interface or the USB interface. Standard Baud rate is 57,600, 1 Stop Bit, No Parity. The default Common Device Address is 235.

The USB interface is a serial FTDI Virtual Communications Port (VCP) serial emulator. It operates exactly the same way and the protocol must be Modbus/RTU. Whenever the USB is connected and active, the Modbus/Interface is disabled.

Electrical Connections to the Sensor Controller (J1)		
1	+24V	Power Supply, 65mA typical
2	GND	
3	Home	24V signal will set position to pre-defined value. (normally 0)
4	AUXin	24V signal. Reserved for future use.
5	GND	
6	Set Point Out	5V Logic, goes Hi if a user-defined set point is reached.
7	Voltage Position Out	-10V to +10V, user defined scale based on position
8	GND	
9	I (+)	4-20mA isolated current loop, user defined scale based on position, user must provide a voltage source.
10	I (-)	
Detachable Screw Terminal accepts 14 to 30AWG wires Mating Terminal Connector: Phoenix P/N 1803659 (one supplied with unit)		

3.3 USB (J2) and RS485/SSI Interface Connections (J3)

Connector J2 provides the USB interface with Type B connection.
Connector J3 provides both RS485 and SSI interfaces.

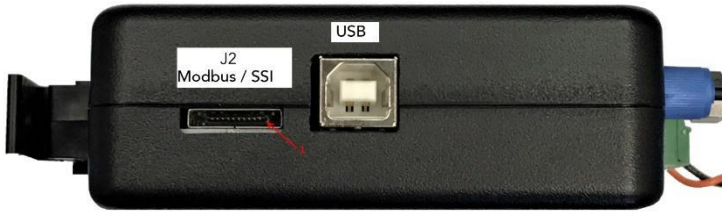


Figure 5. Location of RS485/Modbus RTU, SSI and USB Connections

RS485 Via J2		SSI Via J2	(Optional) MR430-99-01 Wire Color Code
Pin	Function	Function	Color
1	+5V	+5V	Brown
2	RS422 – RCV- (input)		Red
3	RS422 – RCV+(input)		Orange
4	RS422 – TX- (output)		Yellow
5	RS422 – TX+(output)		Green
6	GND	GND	Blue
7		SSI-CLK-	Purple
8		SSI-CLK+	Grey
9		SSI-DAT-	White
10		SSI-DAT+	Black
NOTE: Pin 1 (+5V Power) can be used to power an RS232 to RS485 converter module.			

Figure 6. J3-Connector Pin Assignments

Default Baud rate is: 57600, 8 bit data, 1stop bit, no parity bit

Connector Plug: Hirose P/N 3240-10P-C(50)
Digikey P/N H11343-ND
Mouser P/N 798-324010PC50

Recommended Cable:
Tensility International P/N 30-00534
Digikey P/N T1355-5-ND

Micronor P/N MR430-99-01 (available separately) is a pre-assembled pigtail assembly with 1m pigtail

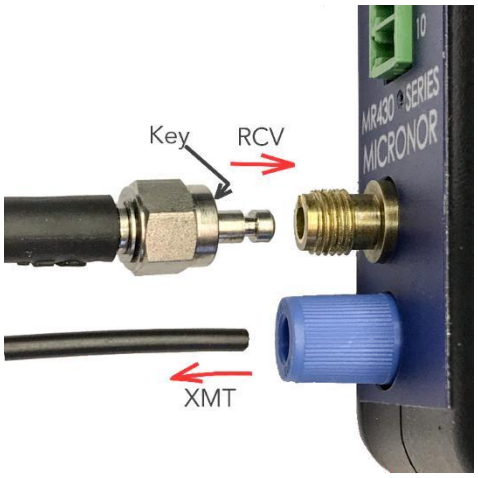
Figure 7. Plug for J3 Connector

3.4 Optical Connection

The system uses two POF fibers:

a.) Transmit fiber is a standard 1mm POF fiber. On controller this fiber connects straight into the blue LED transmitter receptacle. Push fiber all the way to the stop and then gently lock the blue collar nut.

b.) Receive fiber is a plastic optical imaging fiber (POIF). On the controller the end is terminated and has a high quality polished finish. (do not scratch). The fiber is terminated into an SMA connector with a key. Locate the key and insert connector all the way and hand tighten the SMA hex nut.



On the sensor end, the two POF fibers terminate into a special purpose connector. This connector end is polished and must be protected from scratches and contamination. This connector is a service connector only, and it should be disconnected only when mounting or servicing the sensor.
When sensor is disconnected cover sensor opening with a tape.

3.5 Blink Status and Error Codes

Status information is provided by a blinking PWR LED.

See Section 5 for more details regarding status and error codes.

Blinks	Code Description
Steady ON	System is ok. Shaft position within measuring range
1	Outside Range for Turn-Restore
2	Bad position signal. -> Sensor may need to be “paired” to the controller box
3	No optical signal, i.e. Fiber disconnected
4	System Problem

The blinking LED status may be cleared by a momentary push on the Home/Reset button located below the J1 connector.

When the MR430 controller indicates an Error Blink Status, it is advisable to use the ZapView®430 software to troubleshoot the problem. If not already installed on your computer, the current version of the software can be downloaded from www.micronor.com.

3.6 System Start-Up Without PC Computer

It is recommended to use a PC (laptop) computer when making the MR430 Position Sensing System operational. PHOTON CONTROL provides the ZapView® software for setting parameters and performing diagnostics of the system. Checking the system after installation with ZapView® provides assurance that the installation is complete and the system functions perfectly.

There may be instances where no PC is available. Installations that use only the analog or SSI outputs, do not require specific programming on-site, especially if the MR430 controller was pre-configured for the customer's application at the factory - or the customer is using the default settings.

Install the sensor as described above, connect the fiber optic lines, and apply 24V to the MR430 controller. Rotate the sensor through at least one full revolution. If the power LED remains ON steady state, it means that all tests internal were completed successfully and the system is ready to go.

All that is left to do is to set the Home (Zero) position. Bring the system to the desired Home position, and activate the recessed Home button located below J1, as shown in the figure below.

Note: In case of an error, the LED power light will blink a specific error code. The first press of the Home button will acknowledge the error signal. The second press will secure the Home position. (Pressing the switch twice will always Home the unit.)

Figure 8. Location of Recessed Home Button

3.7 Functional System Overview

The MR430 system consists of an all optical, non-electrical, passive sensor (MR431) which is connected to the MR430 Controller via a duplex POF and POIF fiber assembly.

The MR430 Controller constantly interrogates the sensor by sending a short optical pulse to the sensor. The sensor impresses a code corresponding to the actual shaft position on to the imaging fiber. The MR430 controller receives this optical image and through computational algorithms determines the absolute shaft position. The system is a "Single Turn Absolute" position sensor. However, the controller provides mechanism which enables the system to function quasi multi-turn position sensor.

Figure 9 provides a block diagram of the MR430 system and its user interfaces. The single-turn resolution is 13 bits and there is also a 12-bit turn counter which keeps track of the full turns of the sensor while the unit is powered up and the sensor is connected with the fiber optic link. Absolute single-turn position (13 bits) and turn counter (12 bits) combine to provide a 25-bit position signal. The user has the option to mask the turn counter and thus limit the output to match the physical setup. If the sensor is only used to measure a range over , let's say, 5 turns then the user may limit the turn counter to 3bits providing a range of maximum 8 turns until the output wraps around back to zero. Using the example above, the readout would be limited to 16bits (0 to 65,535) to cover the position range of (3 turns times 8192 resolution per turn) 24,575 counts

As the block diagram shows, the position signal is routed to all the various output interfaces built into the unit and position information is available simultaneously.

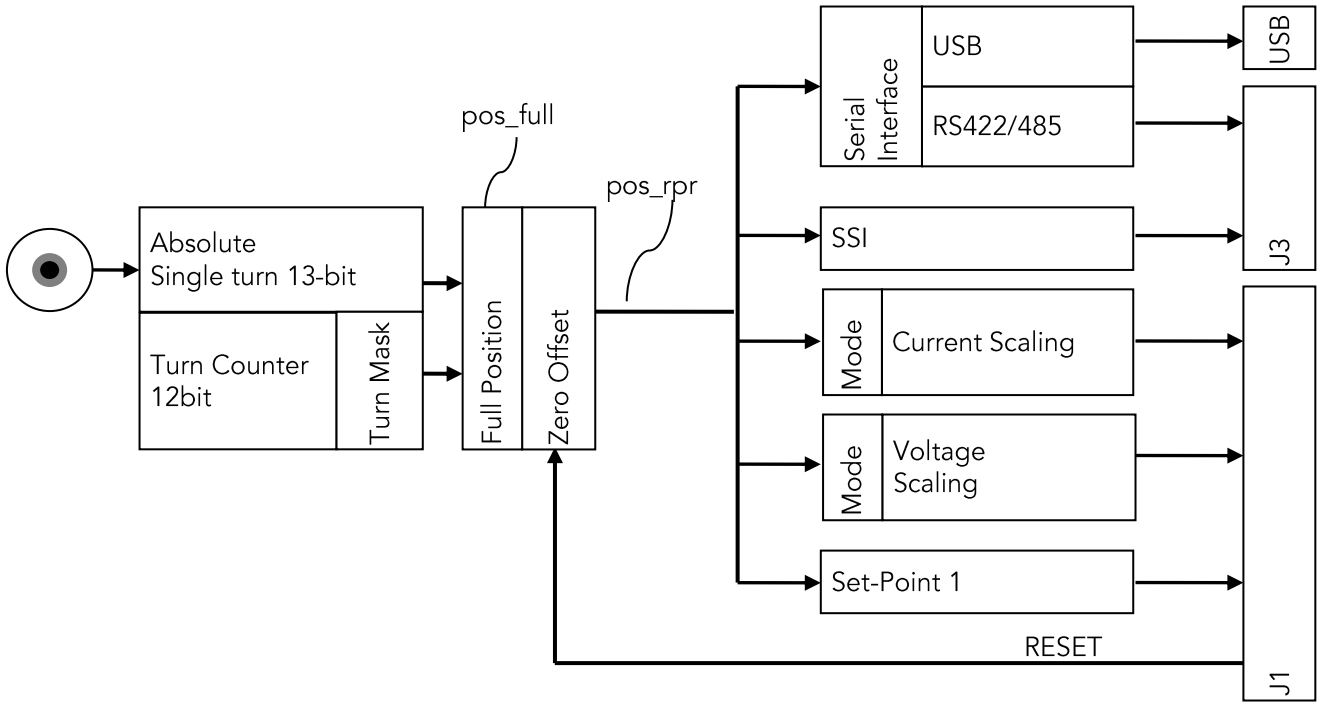


Figure 9. Block Diagram of MR430 System

The Serial Interface conforms to the Modbus/RTU standard and is the main communications interface, ify specifically for setup and configuration purposes. To simplify setup with a PC, a USB interface is also provided.

The SSI interface (available at J3 on the bottom of the unit) is often used to interface with PLC controllers and other automation equipment. This output toggles out fixed 25 bits and derives its information after the turn-mask. Therefore maximum read-out values are restricted to what the turn-mask is configured to. By definition, the SSI outputs only positive values. When the sensor rotates counter clockwise through zero, the reading will go from 0 to the maximum possible readout value defined by the turn counter. If, for example, the turn counter is set to 1, that means the maximum readout is $2^{(13+1)}$-1 = 16,383. The output reads 2,1,0, 16,383.

The Current Output is a fully isolated 4-20mA loop powered output. It has three programmable operating modes plus scaling over the full range of 25 bits. Digital to analog output resolution is 13 bits.

The Voltage Output provides voltage from -10V to +10V. It has four programmable operating modes plus scaling over the full range of 25 bits. Digital to analog resolution is 12 bits plus sign.

One digital Set-Point output provides a Limit Switch-like behavior. This output can be programmed to turn ON or OFF at a specific position with the full 25-bit range available. This output is a 5V logic level.

One external input is provided to Set the programmable Home position (usually zero). When this input goes Hi, the position is set to the user programmable home position.

There is an Auxiliary input available for special custom functionality uses. Contact PHOTON CONTROL sales if a special input function is required.

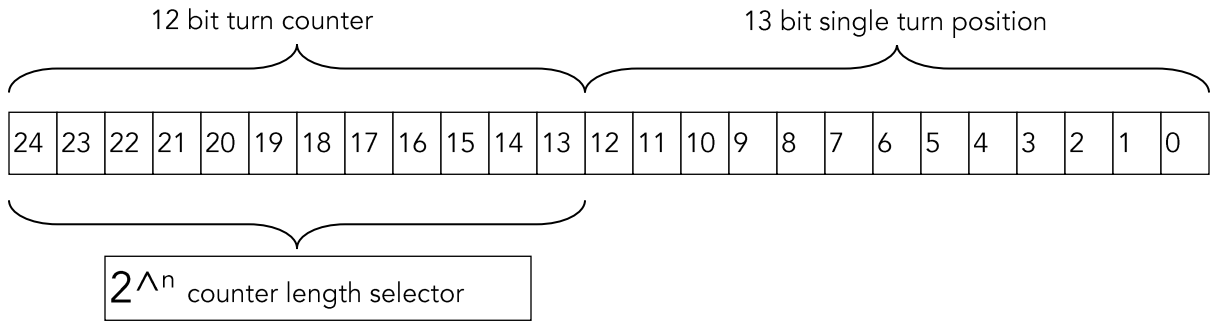
ZERO (HOME) Button Functionality

The ZERO or Homing button is located just below J1 connector.

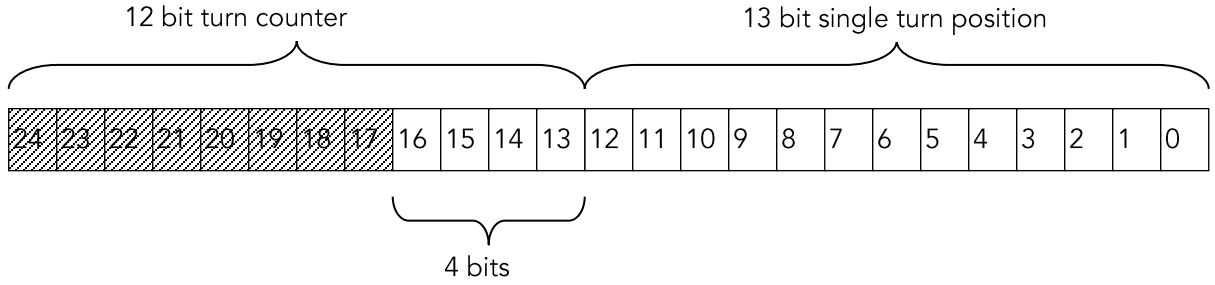
- Manual Sensor and Controller Pairing (see Section 3.6)
- Set Current Position to '0' or "HOME" location (see Section 3.6)
- Clear Error LED Codes (see Section 3.6)

3.8 Turn-Counter and Turn-Counter Size

The MR430 controller keeps track of the turns using a 12bit counter. The 12 bit counter is combined with the 13 bits of single-turn position information for a total of 25 bit position information. That arrangement allows for up to 4096 turns with a resolution of 13 bits is a maximum position range of 33,554,432. Most real world applications do not require this kind of measurement range. Therefore the user may want to limit the number of turns that the sensor keeps track of. The size of the turn counter is controlled by the user programmable 'Turn Counter" variable. This number defines how many bits deep the turn counter is counting until it rolls over back to zero. Please note there are no negative position numbers, all position number are positive.



Example:
The application needs to measure a position over 12.4 turns. The next binary number is at 16 and therefore the turn counter should be programmed to count to at least 16 turns. For this to take effect set the turn counter variable to 4, because 2^4 equals 16. Only the first 4 bits of the turn counter are now activated.



3.9 Multi-Turn Operation

The MR430 controller accurately counts each turn while the system is powered and the remote sensor is connected. Under these conditions multi-turn operation is possible.

If remote sensor is disconnected and the sensor position is moved past the zero point, then the turn counter is no longer synchronized with the actual position. Similarly, if the power to the controller is lost, then the sensor can no longer keep track of turns.

However, for a quasi multi-turn operation, the MR430 saves the last position, including the turns count, just as the electrical power is removed from the unit. Often the application is such that when power is lost, no further movement of the sensor is possible. Under these circumstances, the user may elect to have the MR430 controller restore the turns upon power-on. To safeguard against erroneous position restoration, the MR430 controller compares the new start-up single-turn position with the position saved at power down. If that comparison falls within a user defined range then the turn counter is restored. Together with the absolute single-turn position the actual multi-turn absolute position is retained in case of a power outage.

Note: User must decide if a quasi-Multi-Turn operation is feasible and appropriate.

3.10 Battery Backup for Multi-Turn Operation

The quasi multi-turn operation as described in the previous section is not fail-safe. A better method is to use a Battery backup and keep the unit powered up even over prolonged power outages. The low power consumption of only 60mA makes this feasible.

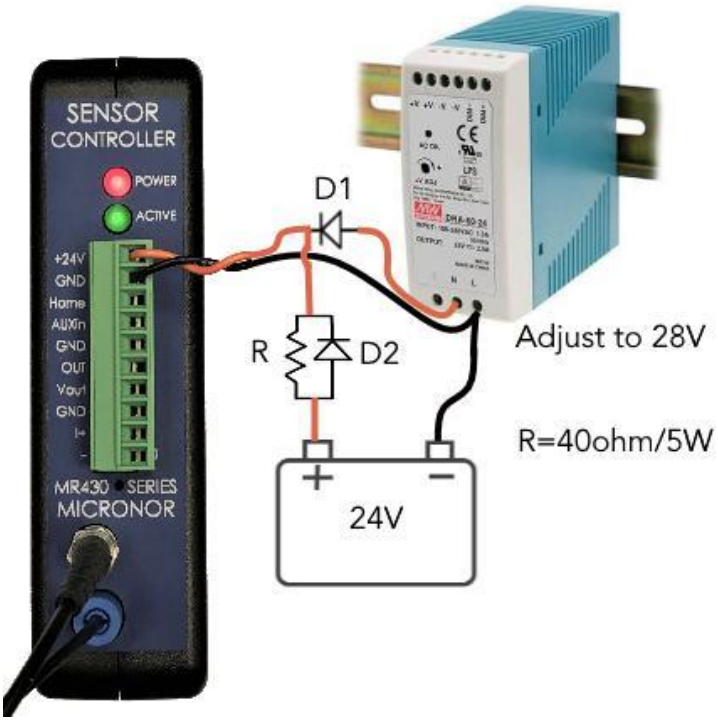
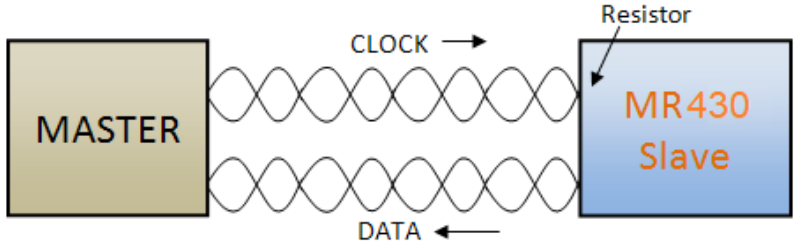


Figure 10. Suggested Battery Backup Circuit

3.11 SSI Interface



Clock -	J3-7
Clock +	J3-8
Data -	J3-9
Data +	J3-10

Figure 11. SSI Interface Connector – J3 (10 pin).

The SSI interface is configured as Slave and the Master must supply the clock. The clock maybe in the range from 25kHz to 250kHz. The user should also set the MR430 with the appropriate clock rate. This will allow the MR430 to provide correct timing for repeat read' mode on the SSI bus. If not sure how to set the SSI baud rate leave it at the lowest setting of 25k baud, this setting will work fine in most applications. Reading position packets at higher than 4 kHz is not recommended as the update rate of the MR430 is 1.2kHz. Reading at higher intervals will not add more information.

Termination Resistor

For long link length and high clock rate it may be necessary to terminate the Clock line at the MR430 in order to avoid reflective signal interference. The user must install that resistor external to the MR430. (For OEM customers please consult PHOTON CONTROL as this resistor may be added inside the controller)

SSI Single Transmission

The diagram in below illustrates a single data transmission using SSI protocol:

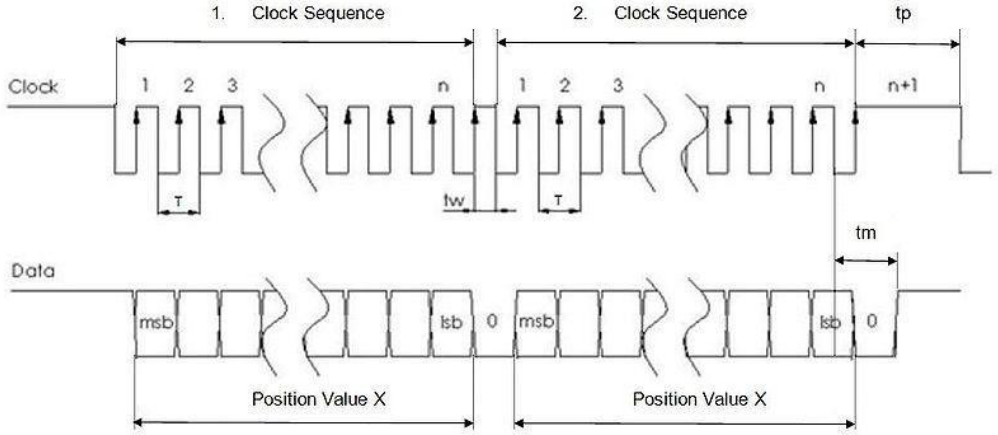


Figure 12. SSI Single Transmission Timing

The SSI is initially in the idle mode, where both the data and clock line are high. The transmission mode is evoked when the master initiates a train of clock pulses. Once, the slave receives the beginning of the clock signal (1), it automatically freezes its current data. With the first rising edge (2) of the clock sequence, the MSB of the sensor's value is transmitted and with consequent rising edges, the bits are sequentially transmitted to the output. After the transmission of complete data word (3) (i.e. LSB is transmitted), and an additional rising edge of the clock sets the clock line to go HIGH. The data line is set to low and remains there for a period of time, tm, to recognize the transfer timeout. If a clock signal (data-output request) is received within the time, tm, the same data as before will be transmitted again (multiple transmission). The slave starts updating its value and the data line is set to HIGH (idle mode), if there are no clock pulses within time, tm. This marks the end of single transmission of the data word. Once the slave receives a clock signal at a time, tp ≥ tm, then the updated position value is frozen and the transmission of the value begins as described earlier.

To set this timeout, use ZapView® software and select page: 'SSI Interface"

MODBUS commands:

Address	Register	Description
0x138	0x139	Baud Rate SSI

3.12 Voltage Output

The analog output voltage is derived from the position signal and maybe freely scaled by the user. There are four distinct modes:

Mode 0:	OFF, voltage is always 0
Mode 1:	Single-turn 0V to +10V
Mode 2:	Scalable 0V to +10V
Mode 3:	Scalable -10V to +10V

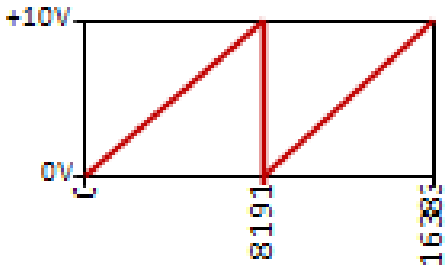


Figure 13. Mode 1 Voltage Output

MODE 1 automatically sets the Scale to 8192. It outputs 0V when position is 0 and +10V when position is 8191. Output wraps around back to 0V when one turn completes. This wrap around occurs regardless of the Turn Mask setting.

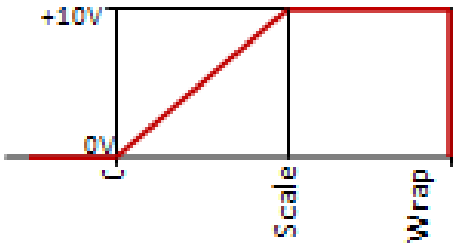


Figure 14. Mode 2 Voltage Output

MODE 2 lets the user program the output voltage based on a scale value. The output is 0 when the position is 0 and will reach +10V when the position reaches the scale value. The full 25-bit range is available for scaling.
When setting this mode up the user should also take into account what should happen when the position reaches maximum or minimum values. The MR430 system determines the wrap-around point based on the available position range, which is based on the turn mask setting n. The $Count_{max}$ is then 2^n

$$P_w = \frac{(Count_{max} - Scale)}{2} + Scale$$

The wrap point P_w is determined based on the formula above. Essentially, it is the midpoint between the unused range.

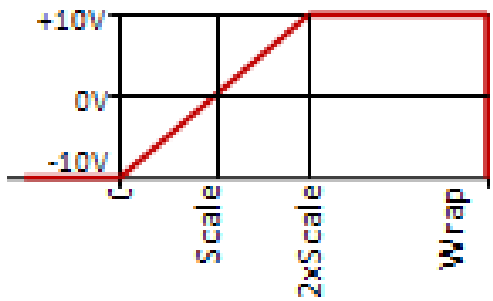


Figure 15. Mode 3 Voltage Output

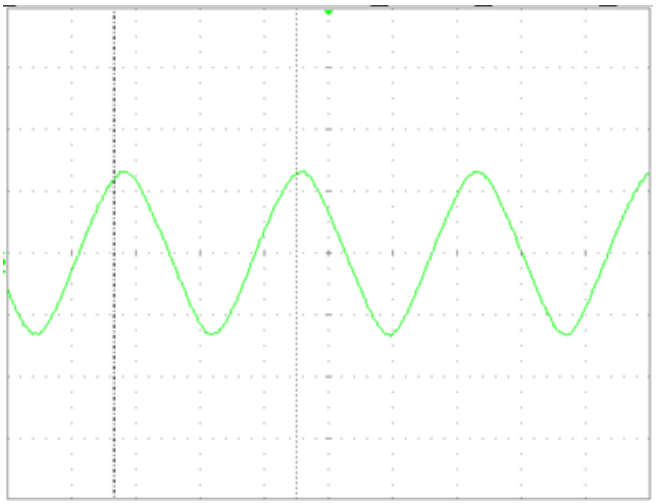
MODE 3 is very similar to mode 2 but it makes use of the negative output voltage capability of the MR430. The output voltage follows the position output with 0 position being -10V and when the Scale value is reached the output is 0V and with position twice the scale value the output is +10V. Mode 3 is ideal when the voltage should swing positive or negative around a predetermined home position. In that case the Reset Value of the MR430 should be set to the same value as the scale. When the sensor is in the home position, it is then equal to the scale value and the voltage output will be 0V. When the sensor turns CCW, the voltage will start going negative, and, vice versa, when the sensor turns CW the voltage will go positive.

As in mode 2 the system also determines a wraparound point based on the turn counter setting.

$$P_W = \frac{Count_{max}}{2} + Scale$$

The Wrap point Pw is in the middle of the unused range of the senor. The maximum position range is determined by the Turn Counter setting.

Output Frequency
The voltage output follows the position in real time with a delay of approximately 800us from when the actual position was reached. The update rate of the D/A converter is 850us.



V: 2V/DIV
H: 50ms/DIV

Analog Output while input shaft is being oscillated with an amplitude of ±45° at a frequency of 7Hz.
Ω = 44.3r/s

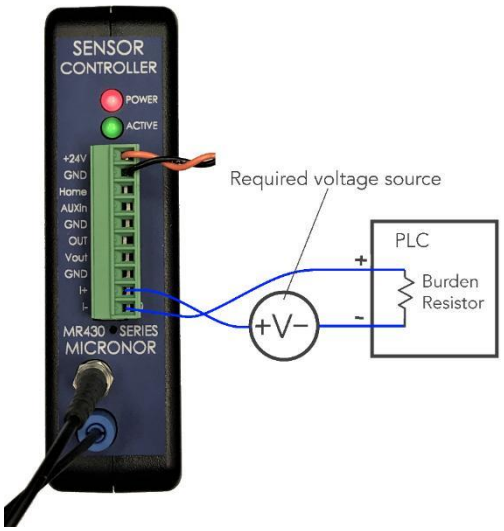
Figure 16. Analog Output With An Oscillating Shaft Input

In ZapView®, select page: **'Voltage Output"**

MODBUS commands:

Address	Register	Description
0x200	0x201	Voltage Mode
0x201	0x202	Voltage Scale

3.13 Isolated Current Output (4-20mA)



The isolated current output is derived from the position signal and may be freely scaled by the user. Since the output is isolated from the rest of the circuitry, it must be loop powered:

There are three selectable output modes:

Mode 0: OFF, current is less then 300uA
Mode 1: Single-turn 4mA to 20mA
Mode 2: Scalable 4mA to 20mA

Figure 17. Isolated 4-20mA Connection

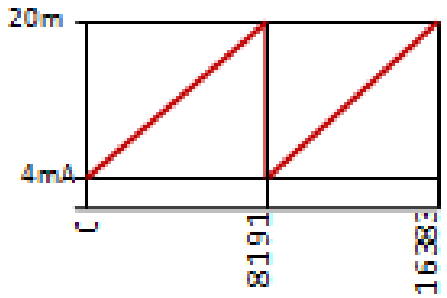


Figure 18. Mode 1 Current Output

MODE 1 automatically sets the Scale to 8192. It outputs 4mA when position is 0 and 20mA when position is 8191. Output wraps around back to 4mA when position changes from 8191 to 0 at the completion of one turn. This wrap around occurs regardless of the Turn Mask setting.

Figure 19. Mode 2 Current Output

MODE 2 The user programmable scale defines the position where 20mA output current is reached. The full 25-bit range is available for scaling. When setting this mode, the user should also take into account what should happen when the position reaches maximum or minimum values. The wrap-around point is based on the available position range, which is based on the turn mask setting n. The $Count_{max}$ is then 2^n

$$P_w = \frac{(Count_{max} - Scale)}{2} + Scale$$

The wrap point P_w is determined based on the formula above. It is the midpoint between the un-used range.

In ZapView®, select page: 'Current Output"

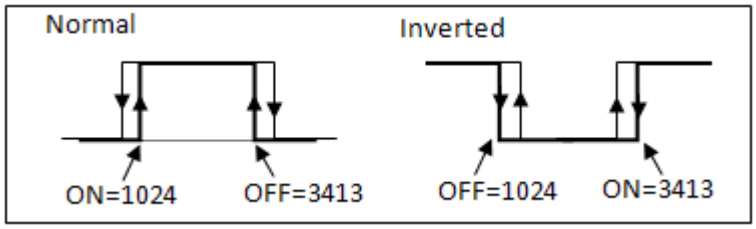
MODBUS commands:

Address	Register	Description
0x204	0x205	Current Mode
0x205	0x206	Current Scale

3.14 Digital Set Point

There is one user programmable digital set point. The set point, once programmed, may be used as limit switch. The output can drive a load of 5mA with 5V output.

The full multi-turn range of 25 bits is available for the set-point limits. The switching point has a fixed defined hysteresis of 5 counts (~0.22º). This hysteresis prevents undesired chatter on the output.



To program, simply define the point in position counts where the output should turn ON (Set_Point_ON) and then define the point where the output should turn OFF again.

Should the output be inverted; reverse the position points of the two entries and the output will switch at the same position but with the reversed sign.

In ZapView®, select page 'Set Points"

MODBUS commands:

Address	Register	Description
0x230	0x231	Set Point 1 On
0x232	0x233	Set Point 1 Off

3.15 Auxiliary Functions

Applicable to firmware Version 1.3.20 and higher.

Auxiliary Functions are implemented into the firmware for OEM users. A specific auxiliary function is enabled by setting the corresponding bit of register 0x208.

bit	Aux Function Description
0	Debounces homing input pin. If 0 Edge triggered, if 1 debounced ~100ms.
1	Forces turn counter to 1 when auxiliary hardware input (J1-4) is pulled high.
2	--
3	--

Bit 1 Function forces the turn counter to 1 (readings > 8191) when Aux Input is pulled high. In a multi turn system this function can be used to force (or home) the absolute position to the second turn of the system.
When the sensor is started up it will provide exact position within one turn. In order to make the system fail safe, an external limit switch which is sensing when the mechanical system is on the second turn is connected to the Aux input and will force the sensor to read out absolute position (> 8191).
Note: Turn counter (reg 0x136) must be set to 1 or higher.

4. Serial Communication – Modbus

Integration with a PLC or other host computer within an automation system is via the Modbus compatible serial interface. Obviously the main purpose is to query the MR430 controller for position information which is accomplished by reading Register 0x001. In most cases, it is recommended to also include the status information registers 0x000 with the position register 0x001 for the same read request.

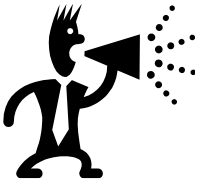
In addition to the position register the MR430 provides a host of auxiliary functions and parameter settings that the user may choose to utilize. All the functions and parameter settings maybe programmed by the PLC during system initialization. An alternate way is to pre-configure the MR430 using the PHOTON CONTROL provided ZapView® software and permanently store all the parameters in the EEPROM. Specifically, an individual configuration of the MR430 controller is required when a specific Modbus address need to be preset before connecting the controller to the Modbus.

To access these functions and to familiarize yourself with the functionality of the MR430 controller we recommend to use ZapView® software, which is supplied with the unit. To run ZapView®, you must have a Personal Computer available with a USB interface. If a USB interface is not available then a serial interface plus the Micronor RS232-to-RS422/RS485 converter cable model MRS232-1 (must be purchased separately) maybe used.

4.1 USB-Serial Emulator

The MR430, being Modbus compatible, must communicate via a serial interface, thus the USB interface utilizes the Future Technology Devices International (FTDI) interface chip www.ftdichip.com. This chip communicates via USB, but within the PC emulates a serial COM port. When ZapView® is installed, the appropriate FTDI driver is installed on the PC. The conversion from USB to Serial is essential to keeping the communications protocol Modbus compatible.

Even when communicating via USB the MR430 controller uses the actual baud rate and bus address settings. The baud rate of the PC's COMx port must therefore be set to match the baud rate of the MR430 controller.



DEFAULTS
The default bus address of the MR430 controller is 235.
The default and recommended baud rate is 57,600 baud, 8bits, 1 Stop, No Parity

4.2 Serial Interface Specification

- RS-422/RS485 Duplex addressable bus interface
- Baud rate programmable: 9,600 / 19,200 / 38,400 / 57,200 or 11,5200 baud
- 1 Start Bit
- 8 Data Bits
- 1 Stop Bit
- no parity

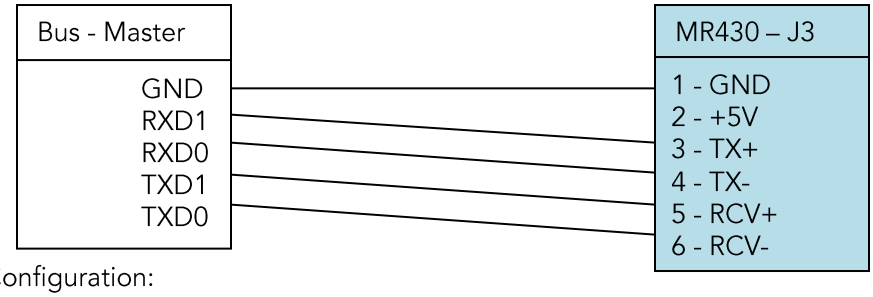
Factory Standard Modbus Address is set to 235 (Hexadecimal 0xEB)l.

When not using a USB interface, the optional MR232-1 Interface cable may be connected directly to a PC Computer via standard RS232 and DB9 connector. In that case the maximum baud rate is 57,600. The MR232-1 Interface cable converts the RS232 signals to the RS485 compatible signals of the MR430.

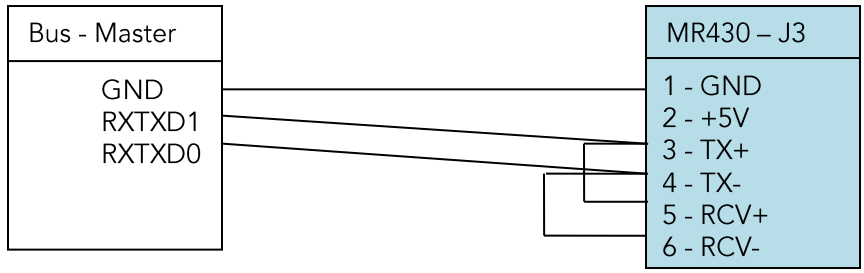
4.3 Physical Connection for Modbus operation

BUS Master	Wire	Slave		MR430 Connector -J3
TXD0	→	RXD0	A	RCV- (6)
TXD1	→	RXD1	B	RCV+ (5)
RXD1	←	TXD0	A	TX- (4)
RXD0	←	TXD1	B	TX+ (3)
GND		GND		GND (1)

Four Wire Configuration:



Two Wire Configuration:



4.4 Serial Bus Termination Resistor

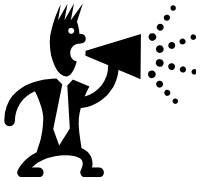
The Serial Interface of the RS485 interface internally "open", it does not have a termination resistor inside. The user must add this resistor externally if so required.

Since this is a fiber optic sensing system, it is expected that the Controller is always located nearby or within the same control closet where the position signal is required. Long electrical link lengths should thus be avoided.

4.5 MODBUS Communications Protocol

The communications protocol follows the Modbus RTU (binary) protocol. A number of commands allow for configuring the operational parameters of the MR430 while other commands are specifically meant for diagnostics used during setup, maintenance and troubleshooting. The status and position readout registers are intentionally arranged in sequence for a quick readout while system is in operation mode. The format for the commands and responses in general follow the MODBUS RTU specification, with the exception that not all registers maybe combined within one readout sequence. See table below for allowable register combination.

➔ MODBUS information can be obtained at: www.Modbus.com



What Is ZapView®430 Setup Software?

PHOTON CONTROL provides ZapView®, a user friendly setup program free of charge along with the purchase of the MR430 system. ZapView® runs on Windows 10 and requires Microsoft .net Framework 4.0 to be on the machine.
Please refer to section x.xx for detailed information.

➔ Unless you plan to connect the MR430 to your own PLC or computer equipment for real-time data retrieval, there is no need to become familiar with the Communications protocol described herein.

Framing
Message frames are separated by a silent interval of at least 3.5 character times. If a silent interval of more than 1.5 character times occurs between two characters of the message frame, the message frame is considered incomplete and is discarded.
A 16bit LRC/CRC Frame Check follows the message.

Device Address Selection:

The MR430 comes pre-configured with Device address 235
The MR430 always listens to address 235 (Broadcast Address). To re-program the device address, send desired new address via command FC10 to register 0x104 via the broadcast address (235) and then send the appropriate "STORE EEPROM" command via FC52 register. Upon executing this procedure, the unit will listen to the newly assigned Device Address and the Broadcast address 235.
In a bus system do NOT use the Broad cast Address 235.

➔ In ZapView®, select tab page "System Info" and enter the desired new bus address and hit <enter> key. When the red "Save to EEPROM" button pops up push this button and the new address is stored in the MR430 controller.

➔ REGISTER NUMBERS VS. METER ADDRESSES

In this instruction manual all register are referred to by their address i.e. starting at 0.
Some Master devices (e.g., Modicon) require that the desired Register Number and not the Register Address be entered. The Register Number is 1 higher than the Register Address. For entry to these devices, add 1 to the Register Address shown in the tables below. The Register Address shown will then be output from these devices.

FUNCTION FC03 – Read Holding Registers
FUNCTION FC10 – Write Holding Registers

Holding registers FC03 are used for reading the position and all other parameters
These Registers can be written using Function FC10 using identical address offset

Register Address	Register Number	Name	# regs	Range	Description
0x000	0x001	System Status	1	n/a	Returns the system status. num register = 1 : reads status only num register = 3 : reads status & position num register = 4 : reads status & position & angle num register = 5 : reads status & position & angle & amplitude
0x001	0x002	Get Position	2	n/a	Returns position count as a 32 bit integer
0x003	0x004	Get Angle	1	n/a	Returns position angle in 1/100 of degrees (0..36000)
0x005	0x006	Get Last Position	2	n/a	Returns the very last position when unit was shut down. Used when determining if the turn counter restore is feasible.
0x040	0x041	Get Error Counts	24	n/a	Returns 24 registers with the total number of errors for each error class.
0x100	0x101	Set New Position	2	0..MaxCount	The value is used as the new position readout. The MR430 automatically calculates a position offset.
0x102	0x103	Get Position Offset	2	n/a	Position offset used to adjust for desired position readout.
0x104	0x105	Device Address	1	1 – 254	Sets the MR310 serial address for commands. Note that the address 4 cannot be used. A FC06 command to save EEPROM must be issued following this command.
0x105	0x106	Operating Mode	1	0..3	Used to setting MR430 in calibration, or troubleshooting mode. Normal Operating is 0. Debug mode is 1. Pairing Operation is 2.

					Do not put unit in any of these modes without first consulting the user manual. Be familiar with what these functions before using.
0x106	0x107	Get Temperature	1	n/a	n/a for model MR430
0x130	0x131	Scan Start	1	1 – 200	Factory use only – do NOT write to it. Determines the start of the disk code reading
0x132	0x133	Voltage Offset	1	-128 – 127	Factory use only – do NOT write to it. Hardware calibration value for voltage output
0x133	0x134	Voltage Gain Pos	1	-128 – 127	Factory use only – do NOT write to it. Hardware calibration value for voltage output
0x134	0x135	Voltage Gain Neg	1	--128 – 127	Factory use only – do NOT write to it. Hardware calibration value for voltage output
0x135	0x136	Current Gain	1	-128 – 127	Factory use only – do NOT write to it. Hardware calibration value for current output
0x136	0x137	Turn Counter	1	0 - 11	Depth of Turn Counter in binary increments (2^n) User sets this value depending how far the turn counter should count until resetting to 0 again Example: n = 3: Maximum Position readout is: 8 revolutions with 8192 per revolution. Therefore maximum position readout will be 65,536.
0x137	0x138	Resolution of Readout	1	13 | 14	Sets the internal readout resolution. 13 bit is fully compatible with electrical encoders. 14 bit provides a resolution of 13950 per revolution. (not full binary 14-bit resolution)
0x138	0x139	Baud Rate SSI	1	25 – 250	Defines the SSI Baud Rate. This value should be set by the user and it should match the clock frequency of the SSI master reading the position output.
0x139	0x13A	Baud Rate Serial Communications	1	0 – 3	Sets the Baud Rate for Serial Communications on the MODBUS. 0 = 9,600 1 = 19,200 2= 38,400 3 = 57,600 4 = 115,200
0x13A	0x13B	Optical Amplitude Report	1	0 to 1023	Read-Only reports signal strength Should be in the range of 300 to 600 for normal operation.
0x13B	0x13C	Pairing Progress	1		Returns the currently executing calibration step. Read Only, only active during the pairing process.

0x13C	0x13D	Reserved			
0x13D	0x13E	Reserved			
0x13E	0x13F	SSI_Mode SPI Mode	1	0..3	0 = Position, 1=Angle in 1/100° B0 = CKP; B1=CKE
0x13F	0x140	Setpoint Output	1	0..1	Sets or Reset Output (J1-6)
0x140	0x141	Input Port	1	0..7	Reads hardware port status B0=SW1, B1=Home, B2=Aux Input
0x141	0x142	Sensor Cal. value	1	-20 to +20	This value is automatically set when sensor pairing. Do not change.
0x142	0x143	Reserved			
0x200	0x201	Voltage Mode	1	0 - 3	Defines the output mode for the voltage output. 0 = OFF no Position Output 1 = Single Turn 0 to 10V 2 = Multi Turn 0 to 10V 3 = Multi Turn -10V to +10V
0x201	0x202	Voltage Scale	2	0 – MaxCount	Establishes the scale used for the voltage output. Regardless of Voltage Mode setting 10V refers to the scale value. When the position count reaches the scale value the output is 10V.
0x204	0x205	Current Mode	1	0 – 2	Defines the output mode for the current output. 0 = OFF current is < 300uA. 1 = Single Turn 4 to 20mA 2 = Multi Turn 4 to 20mA
0x205	0x206	Current Scale	2	0 – MaxCount	Establishes the scale used for the isolated current output. Regardless of current Mode setting 16mA refers to the scale value. When position count reaches the scale value then the output is 16mA plus 4mA bias for a total of 20mA.
0x208	0x209	Reset Mode	1	0 – 15	Defines how the hardware input resets the internal counter. 0 = Edge Triggered, resets the counter at the first rising edge 1 = Debounced Trigger when state changes from 0 to 1 after 60ms debounce time. (used for switch or relay input) - Bit 1, 2, 3..n are used to enable auxiliary functions. If the corresponding bit is set then the auxiliary function is activated. These functions are being embedded in the firmware as customers require them.
0x209	0x20A	Preset Value	2	0 - MaxCount	Counter will be preset to this value when the Zero push button is pressed or when hardware input is activated. (See Reset Mode)
0x20B	0x20C	Turn Direction	1	0 - 1	Defines output results based on turning direction of the sensor 0 = when CW outputs are positive reading.

					1 = when CCW then outputs are positive reading
0x20C	0x20D	Power Up Mode	1	0 – 1	Defines if controller should attempt to restore the turn counter after power-up. 0 = do not restore turn counter. 1 = attempt to restore turn counter. When within the restore range then restore full position, otherwise indicate an error.
0x230	0x231	Set Point 1 On	2	0 - MaxCount	Lower threshold for digital limit switch output 1
0x232	0x233	Set Point 1 Off	2	0 - MaxCount	Upper threshold for digital limit switch output 1
0x234	0x235	Set Point 2 On	2	0 - MaxCount	n/a for MR430
0x236	0x237	Set Point 2 Off	2	0 - MaxCount	n/a for MR430
0x237	0x238	Restore Range	1	0 - 4095	Defines the range within the automatic turn counter restore will be considered valid.
0x300	0x301	Ref Voltage	1	n/a	Internal Reference voltage of 2.5V Updated only at Power ON
0x301	0x302	5 Volt Supply	1	n/a	Internal Supply Voltage 5V Updated only at Power ON
0x302	0x303	12 Volt Supply	1	n/a	Internal Supply Voltage 12V Updated only at Power ON
0x303	0x304	24V Power Supply	1	n/a	External applied Voltage 24V nominal Updated only at Power ON
0x304	0x305	n/a	1	n/a	
0x305	0x306	n/a		n/a	
0x306	0x307	n/a		n/a	
0x307	0x308	n/a		n/a	
0x330	0x331	DAC 1, Chan 1	1		Internal Digital to Analog Converter Value Positive Voltage Output
0x331	0x332	DAC 1, Chan 2	1		Internal Digital to Analog Converter Value Negative Voltage Output
0x332	0x333	DAC 1, Chan 3	1		Internal Digital to Analog Converter Value CCD Bias voltage
0x333	0x334	DAC 1, Chan 4	1		Internal Digital to Analog Converter Value Optical source bias Voltage
0x334	0x335	Reserved			
0x339	0x33A	Optical Pulse Time	1	0..65	Factory use only! Determines the Optical Pulse Strength for Sensor interrogation.
0x400	0x401	Device Name	4	n/a	Returns the ASCII string equivalent as device name (MR430)
0x404	0x405	Version	4	n/a	Returns the ASCII string equivalent of the software version form MM.mm.bb
0x408	0x409	Serial Number	2	n/a	Returns the serial number of the device.

Note: MaxCount = 2^25-1 => 33,554,431

FUNCTION FC05 – Write Single Coil

Single Coil commands are used to trigger an action.

Register Address	Register Number	Name	Description
0x001	0x002	Device Reset	Same as a Power OFF and Power ON cycle.
0x002	0x003	Save to EEPROM	Save current parameters to EEPROM. A time delay of approximately 20ms should be allowed before sending any other command.
0x003	0x003	Restore From EEPROM	Restore all configuration parameters from EEPROM. Same as a Power Up.
0x004	0x004	Restore Factory Default	Restores Factory Defaults. The MR430 stores a factory default for each user parameter. These values maybe restored using this command. Factory calibration values and pairing data are not affected.
0x004	0x005	Clear Status	Clears the status register. If another error is pending then the status register will reflect that new value in queue.
0x005	0x006	Clear Error Count Table	Resets error table counters to 0. Same as in power up.

MODBUS Message Format

The following is a brief overview of the detailed byte by byte messaging of the Modbus protocol. Please consult the Modbus standards for detailed information.

DA = Device Address
FC = Function Code
RA = Register Address
NR = Number to Read
NB = Number of bytes

DD = Data to read
WW = Data to write
SF = Sub Function
EC = Error Code

CRCL = CRC Byte low
CRCH = CRC byte high
DD* = Number of bytes requested or being sent

FC	Action	Sync 3.5b	Byte Number										
			1	2	3	4	5	6	7	8	9	10	11
01 01	request response	pause	DA DA	FC FC	RA NR								
03 03	request response	pause	DA DA	FC FC	RA NB	RA DD*	NR DD*	NR CRL	CRL CRH	CRH			
04 04	request response	pause	DA DA	FC FC	RA NR								
05 05	request response	pause	DA DA	FC FC	RA RA								
08 08	request response	pause	DA DA	FC FC	SF SF								
23 23	request response	pause	DA DA	FC FC	RA NR	RA							
			DA DA	FC FC									

5. MR430 - Error Handling and Troubleshooting

5.1 Explanation of Status and Error Handling

The MR430 incorporates a sophisticated integrity monitoring, error and failure reporting system. There are four Error Groups:

1. EEPROM
   At start-up the EEPROM checksum and EEPROM data integrity are checked.

2. Power Supply Voltages
   At start-up the applied power supply voltage (24V) and internal voltages are checked. If they fall outside the required value, errors are logged and reported. These voltages are evaluated once at system power-up. Subsequent voltage changes will not be evaluated.

3. Sensor Read Error
   - Low optical power
   - Position read error
   - Restore Value out of Range

4. Communication Errors
   Communication errors are flagged by the underlying Modbus drivers. However, Modbus standard does not specify a data integrity test. This is where the MR430 allows the user to query the Status byte after each transmission to verify if the provided data was within the appropriate range etc.

5.2 Explanation of Status and Error Indication

When an error occurs the System Status Word is set with the associated Error Code (Register 0x00). When more than one error at the time occurs then the error code is stacked up in order of its priority.

Each Error has an associated error counter. The user may request all error registers for examination through a request to Register 0x040. MODBUS Function Register 0x40, Reads all 24 Error Registers Sequentially

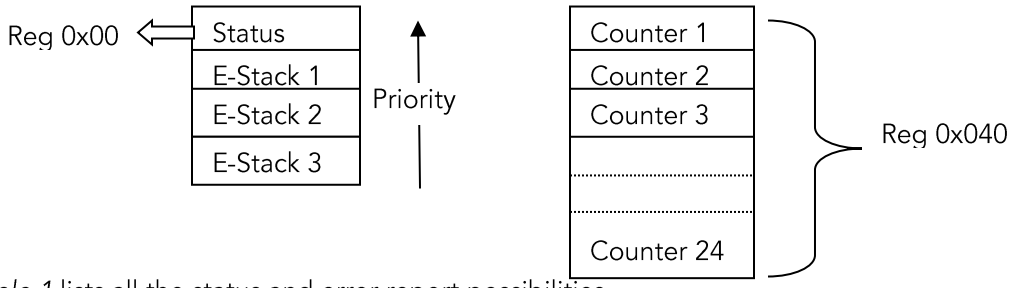
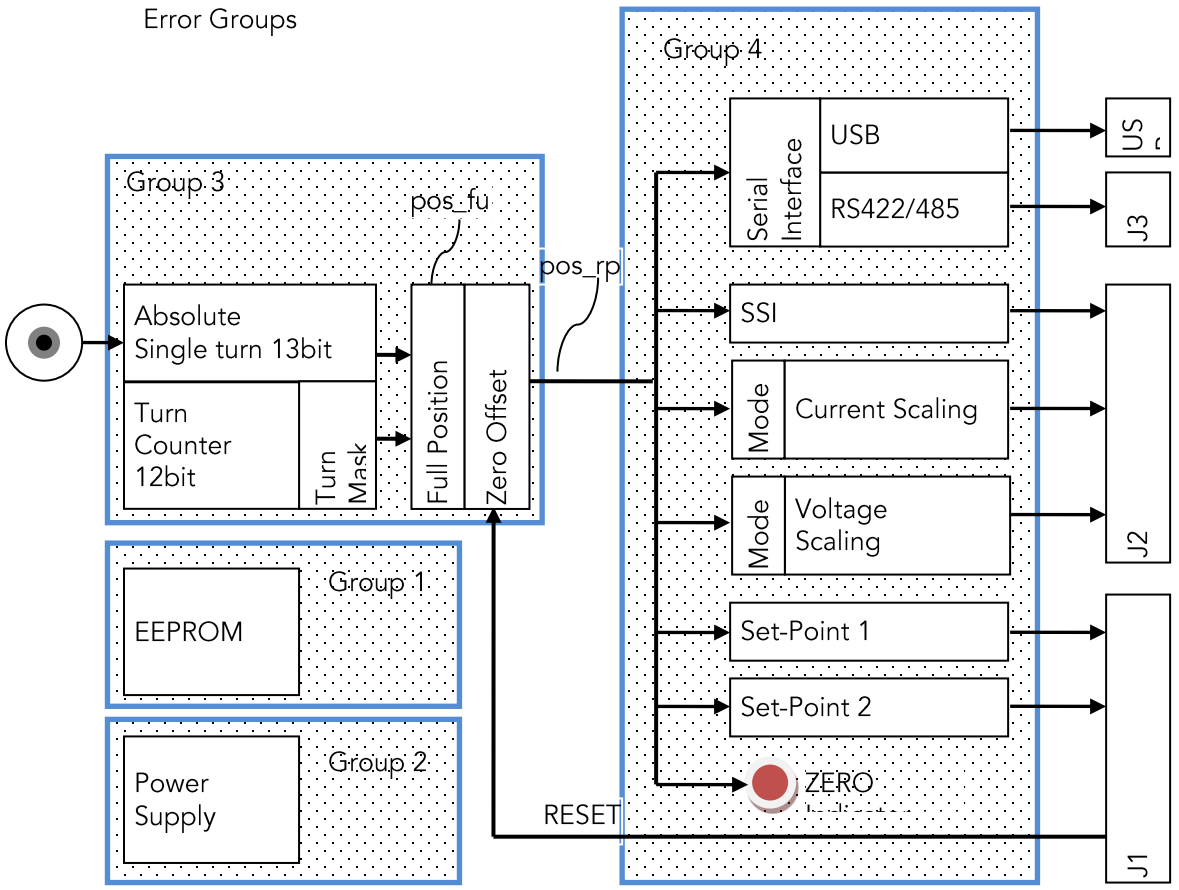


Table 1 lists all the status and error report possibilities.



All errors get logged but may not necessarily provide visual indication. The user should take necessary action based on the severity level of the reported status/error.

3 = System will no longer work without a remedy.
2 = Important, problem should be fixed but system may still be partially operational
1 = Benign, system keeps on working fine

After examination the user may clear the Error Indication by issuing the Function Call FC5 to coil number 5. This will clear the indicated error in the Status byte. If there are more errors stacked up, then the next highest priority will be displayed.

While there is an error Indication The Zero push button will also clear a pending error indication. The user must be careful to only push the button once and wait and check if the error indication. Because once the error is cleared the button will assume it's normal function as a Zero Point switch.

Some errors are cleared as soon as normal operation is established. For instance when the sensor is disconnected or a high loss in the optical connection occurs then an error is reported and the PWR LED will blink. However, when the optical connection is re-established then the error will clear itself without user interaction.

Some errors are not sufficient cause of a problem and therefore they are logged and indicated by a short blink on the PWR LED and then will clear themselves. For instance, if the 24V power supply deviates by

more, than ±10% such an error is indicated but since the MR430 works flawlessly in the range of 15V to 30V there is no cause for further error indication.

Table 1. Table of Error Codes

Hardware Related Status Indication EEPROM					
#	Description	S	Remedy	How Cleared	Announced
257	EEPROM INIT EEprom is not initialized not initialized. This occurs only on first factory power up of new system or when a badly corrupt EEPROM is detected	3	Firmware automatically re-initializes the EEPROM. User must remove Power and apply power again Restore factory values. All parameters are lost.	Recycle Power	Blink 5x + code
258	EEPROM Checksum checksum failure both banks	3	Both data banks indicate a bad checksum. User should read all parameters and verify proper settings and then save parameters again using PHOTON CONTROL Zappy software.	software or recycle Power	Blink 5x + code
259	EEPROM Checksum Low Bank checksum failure low bank	1	One set of data in EEPROM shows a bad checksum. Firmware automatically corrects the error.	n/a	n/a
260	EEPROM Checksum High Bank checksum failure low bank	1	One set of data in EEPROM shows a bad checksum. Firmware automatically corrects the error.	n/a	n/a
261	EEPROM Bad Value One or more parameter values are out of range in both data banks.	3	User should use Zappy to read and examine the data and restore the corrupted value.	Timed Clear	Blink 5x + code

Voltages					
#	Description	S	Remedy	How Cleared	Announced
513	Bad Hardware No Clock Signal from CPLD Bad I2C Bus on internal components	3	Recycle Power If persist repair	next startup	blink 5x
514	BAD Firmware Firmware is corrupted	3	Recycle Power If persist repair	next startup	blink 5x
515	Voltage Reference Internal reference voltage is out of tolerance	3	Recycle Power If persist repair	next startup	Blink 4x + Code
516	Voltage 5V Internal 5V out of tolerance	3	Recycle Power If persist repair	next startup self-clear when restored	Blink 4x + Code

517	Voltage 12V Internal 12V out of tolerance	2	Recycle Power If persist repair	Timed self-clear or self-clear when restored	Blink 4x + Code
518	Voltage 24V Low User applied 24V is of +/-10% tolerance (measured on AN4)	1	Apply proper voltage. It's ok to operate unit anywhere from +15V to +30V	self-clear	Blink 2x + Code
519	Voltage 24V too Low User applied 24V input less then 14V	3	Apply proper voltage.		Blink 2x + code

Position Sensor Failures					
#	Description	S	Remedy	How Cleared	Announced
769	Sensor Not Paired System detected that the sensor is not paired to the Controller. For best performance a sensor should be paired to the controller. This test is performed at power ON.	2	User should use ZAPPY software and follow the procedure 'Pairing Sensor"	Push-button will clear this error. FC5 #5	Blink 3x + code
770	Sensor Disconnect Detect low optical power	3	Check Fiber Optic connection to the sensor. Initiate a new Sensor pairing.	self-clear when restored.	Blink 3x + code
771	Sensor Read Error Single Read Error. The sensor makes a position measurement every 850µs. This error indicates that an invalid position reading has occurred. (binary code on the disk allows for error checking).	1	This error may occur when the encoder is rotated faster than 2500rpm; insufficient optical power; sensor is not paired with controller.	self-clear examine error counter for a history of this error.	None
772	Sensor 65000 Read Error >1 in 65000 System keeps an statistical track how often this error occurs. See appendix A	2	If this occurs the installation should be checked for optical connection. Or perhaps the system rotates the sensor too fast.	self-clear examine error counter for a history of this error.	Blink 3x once
773	Sensor 1024 Read Error >1 in 1024 System keeps an statistical track how often this error occurs. See appendix A	3	If this occurs the installation should be checked for optical connection. Or perhaps the system rotates the sensor too fast.	self-clear examine error counter for a history of this error.	Blink 3x Until cleared
774	Sensor Turn Restore The position of the sensor at last power down differs from the position at power-ON.	1	This indication is important when using the sensor as a multi-turn position sensor. The user should now	Clear by FC5 coil 5	Blink 3x

	➔ The sensor has moved outside the 'Restore' value while power was off.		determine if the stored position can be restored or if the system needs to be homed. See also Restore range Command R		

Communication Failures					
#	Description	S	Remedy	How Cleared	Announced
1025	CMD Unknown Function A non-valid or non-implemented Modbus function was sent to the controller	1	Check your software for correct function calls.	self-clear after one blink	Blink 1x once
1026	CMD Unknown Register A non-implemented register address was addressed	1	Check your software for correct register addressing. See user manual with address table.	self-clear after one blink	Blink 1x once
1027	CMD Wrong Register Count The register count in your command did not match the length of requested register.	1	Check your software for correct register addressing. See user manual with address table. ***Note:*** This controller does not allow to read across multiple registers.	self-clear after one blink	Blink 1x once
1028	CMD Wrong Device Addr. The device address sent was not matching the address of this unit.	1	The MR430 controller has on fixed address at 235. If you are not sure what the address is talk to the unit at 235 and reset your desired bus address.	self-clear after one blink	Blink 1x once
1029	CMD Wrong Value The data value was outside the permissible range for this parameter.	1	Consult the user instruction for the permissible parameter values allowed in each register.	self-clear after one blink	Blink 1x once
1030	CMD Checksum Modbus Packet Checksum was invalid.	1	Resend the packet.	self-clear after one blink	Blink 1x once

5.3 Reading the Error Counters

The entire packet of all 24 error counters may be read by issuing MODBUS command to Register 0x040 with a register count of 24. The sequence of registers is according to the error number in Table 1 in ascending order.

Each register is a 16-bit word. If the most significant bit is set to a logical one, this indicates that there is an active error residing in the Status stack.

The remaining 15 bits indicate the number of errors that occurred since power was applied to the unit.

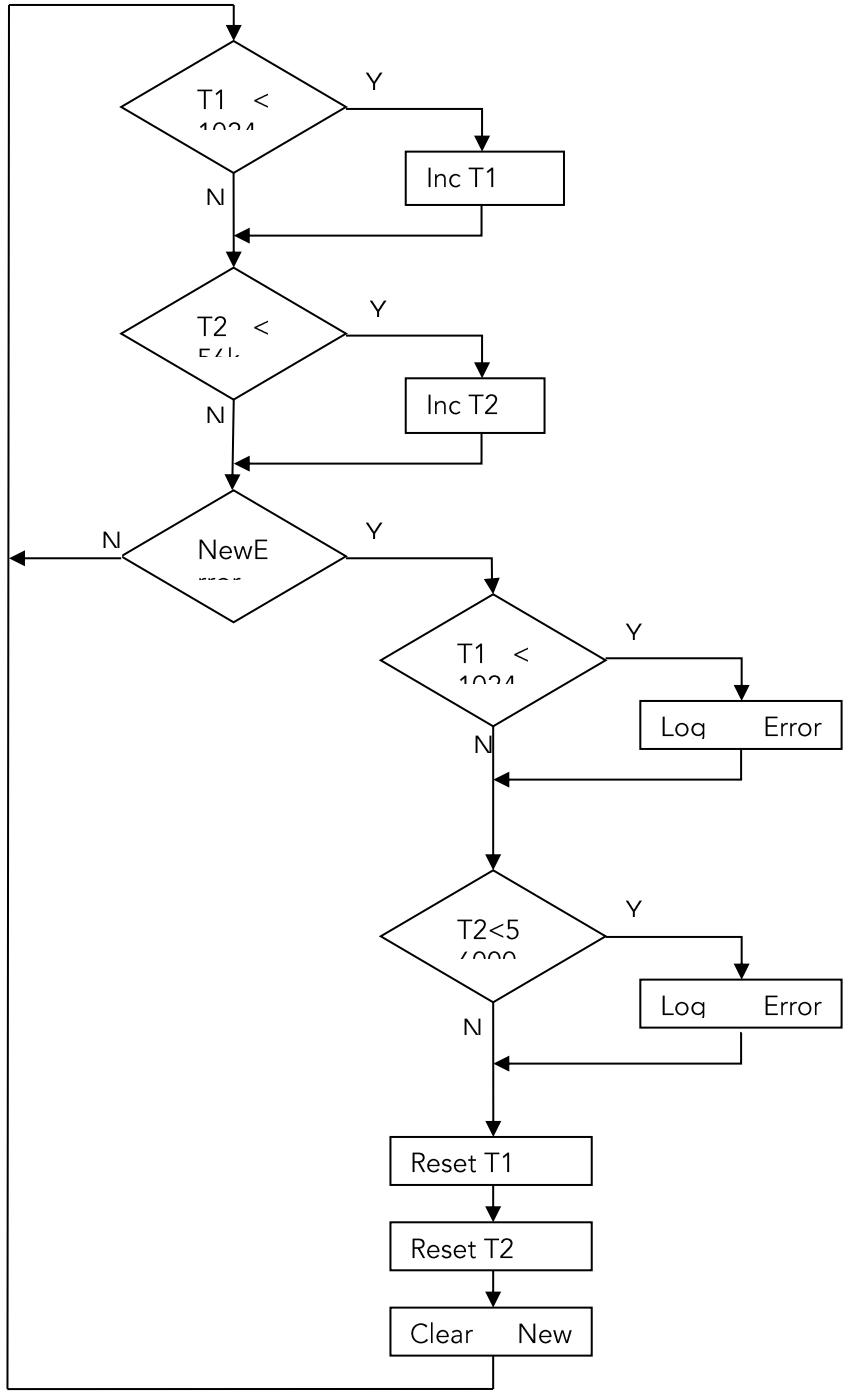
The user may clear all error counters by issuing Function Call FC5 coil #6.

5.4 About Statistical Read Error Determination

The errors Sensor 1024 and Sensor 65000 are error rates that are measured by error occurrences within a time period. If more than one error occurs within the specified time period, then an error is logged. The time period is the number of samples times 850uS. 1024 x 850us = .87 seconds
65000 x 850us = 55 seconds.

Note: T1 and T2 are sample counters

The following algorithm is used to detect the errors:


T1 <
Y
Inc T1
N
T2 <
Y
Inc T2
N
NewE
N
Y
T1 <
Y
Log Error
N
T2<5
Y
Log Error
N
Reset T1
Reset T2
Clear New

5.5 Warranty Information

Warranty

PHOTON CONTROL USA INC. warrants this product to be free from defects in material and workmanship for a period of 1 (one) year from date of shipment. During the warranty period we will, at our option, either repair or replace any product that proves to be defective.

To exercise this warranty, write or call your local PHOTON CONTROL USA INC. representative, or contact PHOTON CONTROL USA INC. headquarters. You will be given prompt assistance and return instructions. Send the instrument, transportation prepaid, to the indicated service facility. Repairs will be made and the instrument returned transportation prepaid. Repaired products are warranted for the balance of the original warranty period, or at least 90 days.

Limitations of Warranty

This warranty does not apply to defects resulting from unauthorized modification or misuse of any product or part. This warranty also does not apply to Fiber Optic Connector interfaces, fuses or AC line cords. This warranty is in lieu of all other warranties, expressed or implied, including any implied warranty of merchantability of fitness for a particular use. PHOTON CONTROL USA INC. shall not be liable for any indirect, special or consequent damages.

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6. Specifications

6.1 MR430 Controller Specification

Position Measurement	
Single Turn Resolution	13 bits, 8192 counts, 0.044°
Turn Counter	Up to 12 bits (4096 turns)
Electrical Interfaces	
SSI	Up to 25 bits (13 bits ST + 12 bits Multi-Turn), Programmable baudrate 25 kHz – 250 kHz
RS485/Modbus RTU	57,600 Baud default.
USB	USB, Disables Modbus interface when used, Assigned Virtual Com Port
Current Output (I+/I-)	Isolated 4-20 mA (270V isolation maximum), Output scalable by user
Voltage Output (Vout)	-10 V to +10 V Load, Output scalable by user, Accuracy = ±0.25% Full Scale
Digital Output (OUT)	0-5V maximum, 5mA load, Programmable Set Point
Digital Input	+24V logic
Power Supply	+18 VDC to +28 VDC, 65 mA max. at 24 VDC NOTE: Power supply shall be current limited to 200mA.
Interface Update Rate	
Angular Speed	230 radians/second or 2200 RPM for accurate position reporting
Update Rate	1.17 kHz (850 µs)
Reporting Delay	SSI: Maximum 800 µs (time from actual position to SSI output) Analog Outputs: Maximum 1.0 ms
Optical Interface	**Class 1 Laser Safety**
Interface	Duplex, M-POF Assembly
System Loss Budget	23dB at 645nm
Maximum Optical Link Length	Up to 30 m (~100 ft) with MR431 Sensor Typical 2-way loss is 0.75dB/m
Explosive Atmospheres	**Inherently Safe, Optical Radiation**
EX Classification	Controller shall be installed in non-hazardous location only
IEC Ex	EPL Mb/Gb/Gc/Db/Dc
Environmental Performance	
Temperature/Humidity	Operating : -5° to +55°C (+23°F to +131°F) Storage: -25° to +65°C (-13F to +149°F) 25% to 95% RH (non-condensing)
Ingress Protection	IP40
Physical Attributes	
Housing Dimensions	114 W x 89 D x 32 mm H, includes 35mm DIN rail mount
Unit Weight	230 g (8.1 oz)

Specifications subject to change without notice

6.2 MR431 Sensor Specifications

Measurement Parameters	
Measurement Range	0° to 360° (continuous)
Resolution	13 bits (8192), 0.044°
Accuracy	0.5° max, 0.3° typical
Repeatability	±0.175°
Maximum RPM	500 RPM continuous, 2,200 RPM intermittent Note: 2200 RPM for <2 seconds duration, in stop motion allowed
Mechanical Performance	
Starting Torque	0.1 N*m
Max Shaft Load	500g at 5mm distance
Optical Interface	
Optical Interface	Duplex, POF and M-POF
Link Length	Up to 30 meters (100 ft) with MR430 Controller
Explosive Atmosphere	**Inherently Safe, Simple Mechanical Device**
EX Classification	Inherently safe, simple mechanical device when used with MR430-1 Controller
IEC Ex	EPL Mb/Gb/Gc/Db/Dc
MR Attributes	**ACR Guidance Document for Safe MR Practices**
MRI Usage Zones	MR431 Sensor and MR439 Cabling is designed for safe use in Zones I-IV
Materials	MRI Safe, Non-Metallic, Shaft/Body: Acetal
Environmental Performance	
Sensor Temperature	Operating: -5°C to +55°C (+23°F to +131°F), Storage: -40°C to +80°C (-40°F to +176°F)
Cable Temperature	Operation: -40°C to +60°C (-40°F to +140°F), Storage: -40°C to +60°C (-40°F to +140°F),
Humidity	0%-95% RH (non-condensing)
Ingress Protection	IP65
Physical Attributes	
Housing Dimension	Ø 25mm x 26mm x Ø6mm Shaft
Unit Weight	15g (0.53 oz.)

Specifications subject to change without notice

7. ZapView®-MR480 Software

PHOTON CONTROL provides ZapView®-MR480 for configuring MR430 Controller Module. ZapView® is used to pre-program MR430 parameters associated with the various Auxiliary Functions, such as programming the scale of the analog outputs, or it can be simply used to verify the proper operation of the position sensor system. The software also includes diagnostic and troubleshooting functions.

ZapView®-MR480 runs on Windows 10 with .NET Framework 4.0 installed.

For information on installing and using the software, please consult the separate ZapView®-MR480 Instruction Manual supplied with the MR430 Controller - or download the current version from the Micronor.com website.

8. MR430 Theory of Operation

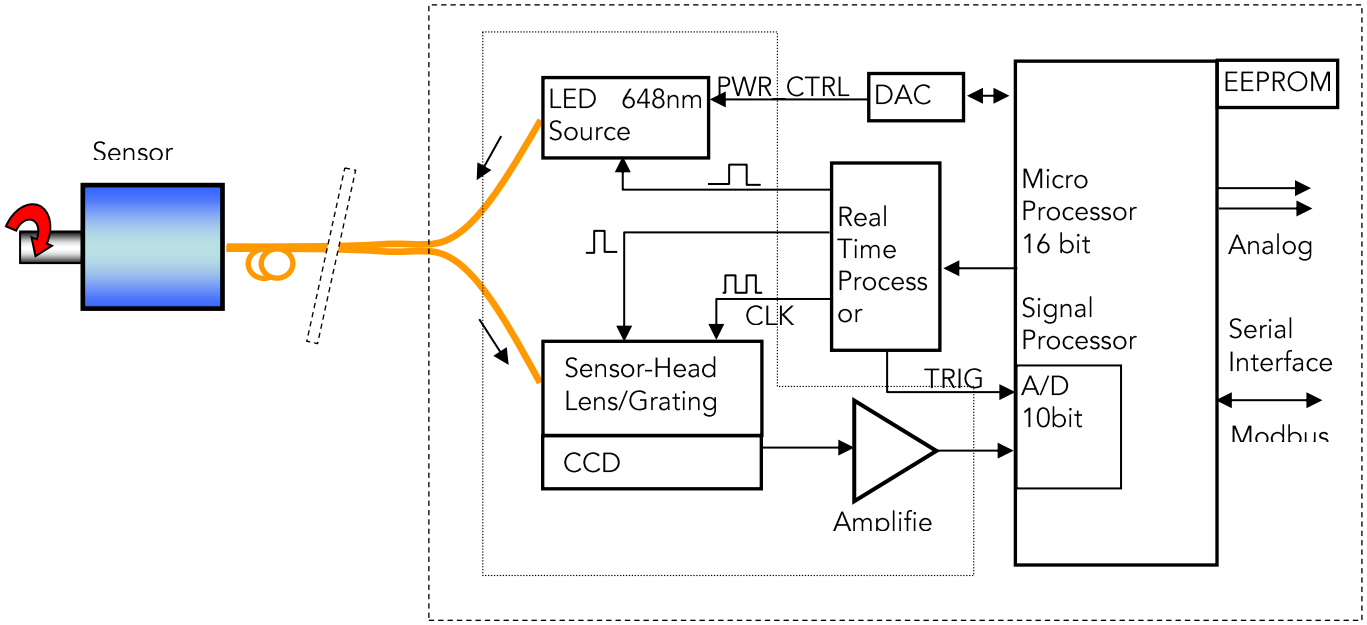

Figure 20. Block Diagram of the Fiber Optic Position Sensor System

The functional block diagram shows the two main components The Sensor is connected by a duplex fiber optic cable. The Transmit fiber guides an optical pulse from a red LED to the position sensor. A second Receive fiber returns the light with the embedded position information in the form of a specific unique light pattern impressed on to the imaging fiber.

The optical image of the returned light pattern is unique to any given position of the sensor. This light pattern is imaged to a linear CCD sensor which converts the optical pattern into an electrical representation of the position pattern. The firmware algorithm extracts the position information, converts the position into digital words, and exports the position information over the selected output interface - Modbus RTU or SSI interface (serial synchronous interface).

9. Mechanical Reference Drawings

These reference drawings can be found on the following pages.

9.1 MR430-1 Controller

9.2 MR431 Sensor

9.3 MR439 M-POF Cabling