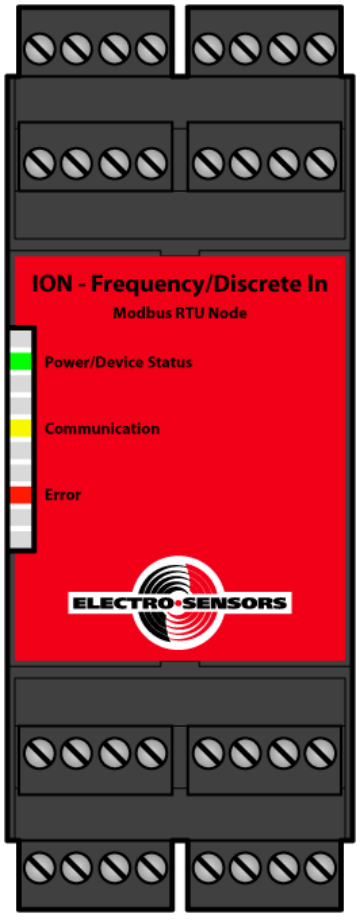
ION – Frequency/Discrete-Input

Modbus RTU Node

USERS MANUAL



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Contents

Note: Read through page 5 (at least). The remainder is a reference to use as needed.

1 Description

ION Frequency/Discrete-In is a DIN-rail mount, signal frequency and discrete-binary state acquisition device with a low-latency Modbus RTU slave interface. While optimized for measuring rotating shaft speeds using pulse-frequency-output sensors, it has the flexibility and features to measure pulse/square-wave frequencies from any source and provide them in any units.
12 dual-purpose inputs acquire signal frequencies or discrete-binary (high/low, closed/open) states in any combination.
6 pluggable terminal blocks each provide protected sensor power and 2 sensor/signal inputs. Shaft-speed/signal-frequency or discrete-binary state from each input are continuously and independently acquired for access over Modbus.

Terminal blocks (see Figure 1)

Sensor/signal connection terminals are organized into 6 pluggable 4-terminal blocks (TB1 … TB6), each with:

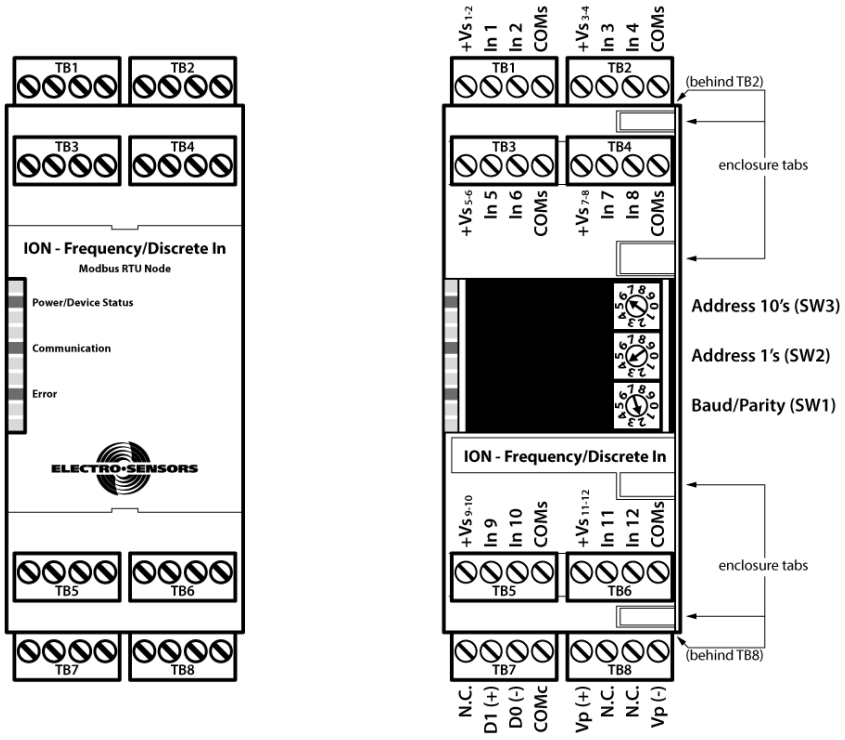
+Vs terminal	sensor 24Vdc power output
2 In terminals	signal inputs (In 1 … In 12)
COMs terminal	sensor/signal input common

Modbus RTU (2-wire) RS485 terminals are located on the pluggable 4-terminal block TB7:

1 unused terminal (N.C.)	
D1 (+) terminal	Modbus RTU D1 (EIA/TIA-485 B)
D0 (-) terminal	Modbus RTU D0 (EIA/TIA-485 A)
COMc terminal	Modbus RTU Common (EIA/TIA-485 C)

24Vdc power terminals are located on the pluggable 4-terminal block TB8:

Vp(+) terminal	ION 24Vdc power in (wire to isolated single 24Vdc power supply, +V/red terminal)
2 unused terminals (N.C.)	
Vp(-) terminal	ION power common (wire to isolated single 24Vdc power supply, –V/black/common terminal)



(front cover on) **(front cover off)**

Figure 1

2 Installation

Attaching to DIN rail

Orient the ION vertically with the LED lens on the left and the rotary switches (located behind the removable front cover) on the right (see Figure 1).
Slide the rear bottom groove onto the DIN rail bottom edge (the rear clip springs should engage behind the DIN rail bottom edge).
While pushing up on the ION (compressing the rear clip springs), tilt the ION back until the rear top groove clears the DIN rail top edge and snaps into place.

Detaching from DIN rail

Push the ION up (compressing the rear clip springs) until the rear top groove can tilt free from the DIN rail top edge,
tilt the ION top slightly forward enough to free it. Do not tilt too much (the rear clip springs can break).
Now lower the ION to free it from the DIN rail bottom edge.

3 Quick-start instructions

Set the slave address and baud/parity switches (Figure 1)
Three rotary switches immediately behind the removable front cover configure the Modbus communications.
Remove the front cover by prying it free at the indented pry points (re-attach after switches are set).
Set the slave Address switches to a unique address within your Modbus network (1 … 99; do not set to 0).

Slave address = 10*(Address 10's) + (Address 1's)

Set the Baud/Parity switch to the same baud rate and parity/stop-bit setting as the other devices on your Modbus network.

Baud/Parity switch

Setting	Baud rate	Parity / Stop-bits
0	9.6k	None / 2
1	19.2k	None / 2
2	38.4k	None / 2
3	57.6k	None / 2
4	115.2k	None / 2
5	9.6k	Even / 1
6	19.2k	Even / 1
7	38.4k	Even / 1
8	57.6k	Even / 1
9	115.2k	Even / 1

Table 1

Example (Figure 1): Slave address = 64, Baud/Parity/Stop-bits = 38.4k/None/2.

Wire 2-wire Modbus RTU network to TB7 (Figure 1)
Wire the D1(+), D0(-) and COMc (Modbus Common) terminals to your Modbus RTU network.

Wire 24Vdc power to TB8 (Figure 1)
Wire the Vp(+), Vp(-) terminals to the (+) and (-) output terminals of an isolated single 24Vdc power supply. Switch the power ON.
Your ION is now ready to communicate with your Modbus RTU Master device.
Test-read some ION registers (e.g. Holding Register 40001 p.6) to verify Modbus communication.

Wire sensors, switches and signal sources to inputs (Figure 1, Figure 2)
Wire each sensor, switch or signal source to In, +Vs and COMs terminals (as needed) within the same terminal block (Fig 2).

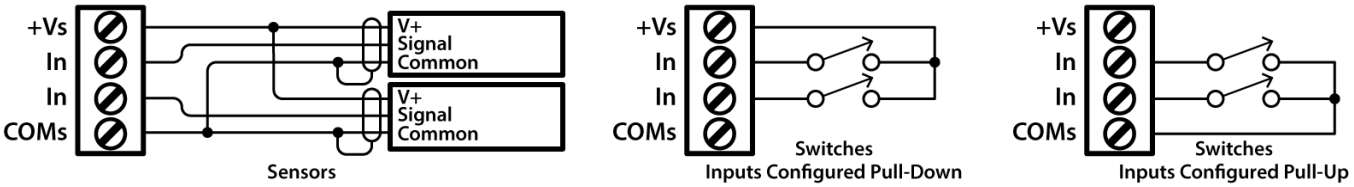


Figure 2

All inputs are factory configured with Pull-Up termination. To configure inputs Pull-Up, Pull-Down or Hi-Z, in any combination, see Input termination p.11.

Read shaft speeds and discrete signal states
Read input speed measurements (16 or 32 bit) from their Input Registers (Speeds, discrete states and other read-only data p. 7, p. 8).
Inputs used for shaft speed may require changing one or more set-up parameter values from their factory-defaults.
Each input PPR parameter value (sensor pulses per pulser revolution) must match that of the corresponding pulser + sensor.
The factory-default input PPR parameter values (PPR = 8) work for Electro Sensors 255 pulser discs with Hall-Effect sensors.
The factory-default input Units and Mode parameter values set the measured speed units to rpm.
The factory-default input RPM_{min}, RPM_{max} and Mode parameter values work for the majority of applications.
See Internal organization \ Input set-up parameters p. 5 for a description of the set-up parameters and speed/frequency measurement options.

Read input discrete states from Input Register 30213.
(Internal organization \ Input discrete states p. 5., Speeds, discrete states and other read-only data \Discrete states p. 7.)
With factory-default Mode setting (Mode = 10), Low inputs (≤ 1.0V) are binary state 1, High inputs (≥ 2.5V) are binary state 0.

4 Definitions

pulser	A shaft-mounted sensor target (disc or wrap) with embedded permanent magnets or ferrous slugs. Depending on the type, pulse-frequency-output shaft-speed sensors output one signal-pulse per N/S magnet pair, one signal-pulse per magnet or one signal-pulse per ferrous slug.
rpm	(pulser shaft) revolutions per minute
f	Signal-pulse/square-wave frequency in Hz (pulses/s) units
Speed, speed	Measured signal-pulse/square-wave frequency, in any units (Hz, rpm, other) or data format

5 Internal organization

12 free-running, autonomous, identically-capable and individually-configurable inputs each acquire speed or discrete state.
1 Modbus RTU slave interface provides access to all input set-up parameters, speeds and discrete states.

Input speeds (signal frequency measurements)
Each input has 2 measured speeds calculated from the signal frequency (f) per its Mode-selected speed formula (see Mode below).
16-bit Speed is type unsigned integer.
32-bit Speed is type floating-point or unsigned long integer per the Mode setting (see Mode below).
Speeds are implemented in read-only Modbus Input Registers. See p.7, p.8.

Input discrete states (binary signal/switch state)
Each input has a 1-bit binary discrete state indicating the input voltage level (High or Low) with Mode-selected polarity (non-inverting or inverting, see Mode below).
In1 … 12 discrete states are grouped into Input Register 30213 as shown. See Speeds, discrete states and other read-only data p.7.

Input Register 30213

Discrete states	0	0	0	0	In12	In11	In10	In9	In8	In7	In6	In5	In4	In3	In2	In1
Bit position:	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Note: Input signal frequencies $f \geq f_{min}$ disable discrete state functionality by forcing the discrete state to 0.
To use an input for discrete state, set its RPM_{min} and PPR sufficiently high to ensure functionality.
RPM_{min} = 100 and PPR = 60 (f_{min} = 10 Hz) is more than adequate for most discrete signal switching rates.

Input set-up parameters
Each input has 5 set-up parameters. All are implemented in read/writable, non-volatile Modbus Holding Registers (4XXXX) p.6, 7.

Parameter	Description	What it does	Data type
RPM_{min}	Minimum rpm (0.1 rpm resolution)	defines f_{min}(in Hz) = RPM_{min}*PPR/600	16-bit (unsigned) integer
RPM_{max}	Maximum rpm (0.1 rpm resolution)	defines f_{max}(in Hz) = RPM_{max}*PPR/600	16-bit (unsigned) integer
	RPM_{min}, RPM_{max} are in 0.1 rpm units (e.g. 2000 represents 200.0 rpm).		
PPR	Sensor pulses per one pulser revolution	f to rpm conversion, pulser correction	16-bit (unsigned) integer
Mode	Selects the Speed formula and 32-bit Speed data type (see below)		16-bit (unsigned) integer
	Selects discrete state polarity for L/H input	0/1 or 1/0 (see below)	
Units	Speed user-units/rpm (Mode 0, 10)	allows non-rpm Speed units (see below)	32-bit floating-point

Mode value	Speed formula	Speed numeric range ($f = f_{min} \rightarrow f_{max}$)	32-bit Speed data type
0, 10	f*(60/PPR)*(Units)	($f_{min} \rightarrow f_{max}$)*(60/PPR)*Units	floating-point
1, 11	f	$f_{min} \rightarrow f_{max}$	floating-point
2, 12	$65535*(f - f_{min})/(f_{max} - f_{min})$	0 … 65535	unsigned long integer
3, 13	$65535*f/f_{max}$	$65535*f_{min}/f_{max}$ … 65535	unsigned long integer
All values:	Speed = 0 for $f < f_{min}$		
Note:	Use 32-bit Speed to avoid 16-bit limitations under the following circumstances:		
	Modes 0, 10:	if f*(60/PPR)*Units > 65535 is possible	
	Modes 2, 12 and 3, 13:	if $f > f_{max}$ is possible	

Mode value	Discrete state polarity	Disc. state (input Low)	Disc. state (input High)
0 … 3	Non-inverting	0	1
10 … 13	Inverting	1	0

Note: Input speed and discrete-state functionality are exclusive:
When $f > f_{min}$, speed is non-zero and discrete-state functionality is disabled (state is 0 regardless of input level).
When $f \leq f_{min}$, speed is 0 and discrete-state functionality is active (state is 0 or 1 per the input level and Mode).

For more set-up parameter discussion, see Input set-up parameters (a second look) p.10.

6 **Non-volatile set-up parameters** - Modbus Holding Registers (4XXXX)

Modbus Holding Registers are addressable, read/writeable 16-bit values.
The ION non-volatile set-up parameters are implemented in Modbus Holding Registers.
All ION Modbus Holding Registers are non-volatile (retain their last written value through power OFF → ON cycles).

16-bit (unsigned integer) non-volatile setup parameters

Input	Set-up Parameter	Holding Register	Units / Resolution	Allowed values	Factory-default value	User value
1	RPM_{min}	40001	0.1 rpm	1 … 65535	10 (1.0 rpm)	
1	RPM_{max}	40002	0.1 rpm	1 … 65535	65535 (6,553.5 rpm)	
1	PPR	40003	1 (pulse)	1 … 100	8	
1	Mode	40004	1	0 … 3, 10 … 13	10	
2	RPM_{min}	40005	0.1 rpm	1 … 65535	10 (1.0 rpm)	
2	RPM_{max}	40006	0.1 rpm	1 … 65535	65535 (6,553.5 rpm)	
2	PPR	40007	1 (pulse)	1 … 100	8	
2	Mode	40008	1	0 … 3, 10 … 13	10	
3	RPM_{min}	40009	0.1 rpm	1 … 65535	10 (1.0 rpm)	
3	RPM_{max}	40010	0.1 rpm	1 … 65535	65535 (6,553.5 rpm)	
3	PPR	40011	1 (pulse)	1 … 100	8	
3	Mode	40012	1	0 … 3, 10 … 13	10	
4	RPM_{min}	40013	0.1 rpm	1 … 65535	10 (1.0 rpm)	
4	RPM_{max}	40014	0.1 rpm	1 … 65535	65535 (6,553.5 rpm)	
4	PPR	40015	1 (pulse)	1 … 100	8	
4	Mode	40016	1	0 … 3, 10 … 13	10	
5	RPM_{min}	40017	0.1 rpm	1 … 65535	10 (1.0 rpm)	
5	RPM_{max}	40018	0.1 rpm	1 … 65535	65535 (6,553.5 rpm)	
5	PPR	40019	1 (pulse)	1 … 100	8	
5	Mode	40020	1	0 … 3, 10 … 13	10	
6	RPM_{min}	40021	0.1 rpm	1 … 65535	10 (1.0 rpm)	
6	RPM_{max}	40022	0.1 rpm	1 … 65535	65535 (6,553.5 rpm)	
6	PPR	40023	1 (pulse)	1 … 100	8	
6	Mode	40024	1	0 … 3, 10 … 13	10	
7	RPM_{min}	40025	0.1 rpm	1 … 65535	10 (1.0 rpm)	
7	RPM_{max}	40026	0.1 rpm	1 … 65535	65535 (6,553.5 rpm)	
7	PPR	40027	1 (pulse)	1 … 100	8	
7	Mode	40028	1	0 … 3, 10 … 13	10	
8	RPM_{min}	40029	0.1 rpm	1 … 65535	10 (1.0 rpm)	
8	RPM_{max}	40030	0.1 rpm	1 … 65535	65535 (6,553.5 rpm)	
8	PPR	40031	1 (pulse)	1 … 100	8	
8	Mode	40032	1	0 … 3, 10 … 13	10	
9	RPM_{min}	40033	0.1 rpm	1 … 65535	10 (1.0 rpm)	
9	RPM_{max}	40034	0.1 rpm	1 … 65535	65535 (6,553.5 rpm)	
9	PPR	40035	1 (pulse)	1 … 100	8	
9	Mode	40036	1	0 … 3, 10 … 13	10	
10	RPM_{min}	40037	0.1 rpm	1 … 65535	10 (1.0 rpm)	
10	RPM_{max}	40038	0.1 rpm	1 … 65535	65535 (6,553.5 rpm)	
10	PPR	40039	1 (pulse)	1 … 100	8	
10	Mode	40040	1	0 … 3, 10 … 13	10	
11	RPM_{min}	40041	0.1 rpm	1 … 65535	10 (1.0 rpm)	
11	RPM_{max}	40042	0.1 rpm	1 … 65535	65535 (6,553.5 rpm)	
11	PPR	40043	1 (pulse)	1 … 100	8	
11	Mode	40044	1	0 … 3, 10 … 13	10	
12	RPM_{min}	40045	0.1 rpm	1 … 65535	10 (1.0 rpm)	
12	RPM_{max}	40046	0.1 rpm	1 … 65535	65535 (6,553.5 rpm)	
12	PPR	40047	1 (pulse)	1 … 100	8	
12	Mode	40048	1	0 … 3, 10 … 13	10	

6 **Non-volatile set-up parameters** - Modbus Holding Registers (4XXXX) **- continued**

32-bit (floating-point) non-volatile setup parameters

Input	Set-up Parameter	Holding Registers	Notes	Allowed values	Factory-default value	User value
1	Units	40101 (H) 40102 (L)	units/rpm	any > 0	1.0 (rpm units)	
2	Units	40103 (H) 40104 (L)	units/rpm	any > 0	1.0 (rpm units)	
3	Units	40105 (H) 40106 (L)	units/rpm	any > 0	1.0 (rpm units)	
4	Units	40107 (H) 40108 (L)	units/rpm	any > 0	1.0 (rpm units)	
5	Units	40109 (H) 40110 (L)	units/rpm	any > 0	1.0 (rpm units)	
6	Units	40111 (H) 40112 (L)	units/rpm	any > 0	1.0 (rpm units)	
7	Units	40113 (H) 40114 (L)	units/rpm	any > 0	1.0 (rpm units)	
8	Units	40115 (H) 40116 (L)	units/rpm	any > 0	1.0 (rpm units)	
9	Units	40117 (H) 40118 (L)	units/rpm	any > 0	1.0 (rpm units)	
10	Units	40119 (H) 40120 (L)	units/rpm	any > 0	1.0 (rpm units)	
11	Units	40121 (H) 40122 (L)	units/rpm	any > 0	1.0 (rpm units)	
12	Units	40123 (H) 40124 (L)	units/rpm	any > 0	1.0 (rpm units)	

7 **Speeds, discrete states and other read-only data** - Modbus Input Registers (3XXXX)

Modbus Input Registers are addressable, read-only 16-bit values.
All ION read-only data, including input speed measurements and discrete states, are implemented in Modbus Input Registers.

Modbus Input Registers 30001 … 30048, 30101 … 30124

See Speeds, discrete states and other read-only data \ Special-purpose registers \ Active set-up parameter values p.9

16-bit speeds, discrete states, etc.

Input	Use	Input Register	16-bit Data type	Speed formula / data format	Notes
1	Speed	30201	unsigned int	per Mode	see Input set-up parameters \ Speed formula p.5
2	Speed	30202	unsigned int	per Mode	see Input set-up parameters \ Speed formula p.5
3	Speed	30203	unsigned int	per Mode	see Input set-up parameters \ Speed formula p.5
4	Speed	30204	unsigned int	per Mode	see Input set-up parameters \ Speed formula p.5
5	Speed	30205	unsigned int	per Mode	see Input set-up parameters \ Speed formula p.5
6	Speed	30206	unsigned int	per Mode	see Input set-up parameters \ Speed formula p.5
7	Speed	30207	unsigned int	per Mode	see Input set-up parameters \ Speed formula p.5
8	Speed	30208	unsigned int	per Mode	see Input set-up parameters \ Speed formula p.5
9	Speed	30209	unsigned int	per Mode	see Input set-up parameters \ Speed formula p.5
10	Speed	30210	unsigned int	per Mode	see Input set-up parameters \ Speed formula p.5
11	Speed	30211	unsigned int	per Mode	see Input set-up parameters \ Speed formula p.5
12	Speed	30212	unsigned int	per Mode	see Input set-up parameters \ Speed formula p.5
1…12	Disc states	30213	binary	polarity per Mode	see Internal organization \ Input discrete states p.5
--	Rot. switches	30214	binary	BCD (x4)	see Special-purpose reg's \ Rotary switch settings p.9
--	Firmware	30215	binary	BCD (x4)	see Special-purpose registers \ Firmware codes p.9
--	Diagnostics	30216	--	0	t.b.d. (reserved)

7 **Speeds, discrete states and other read-only data** - Modbus Input Registers (3XXXX) - **continued**

32-bit speeds

Input	Use	Register	Data type	Speed formula	Notes
1	Speed	30301 (H) 30302 (L)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
2	Speed	30303 (H) 30304 (L)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
3	Speed	30305 (H) 30306 (L)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
4	Speed	30307 (H) 30308 (L)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
5	Speed	30309 (H) 30310 (L)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
6	Speed	30311 (H) 30312 (L)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
7	Speed	30313 (H) 30314 (L)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
8	Speed	30315 (H) 30316 (L)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
9	Speed	30317 (H) 30318 (L)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
10	Speed	30319 (H) 30320 (L)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
11	Speed	30321 (H) 30322 (L)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
12	Speed	30323 (H) 30324 (L)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5

32-bit speeds (16-bit H, L halves reversed)

Input	Use	Register	Data type	Speed formula	Notes
1	Speed	30401 (L) 30402 (H)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
2	Speed	30403 (L) 30404 (H)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
3	Speed	30405 (L) 30406 (H)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
4	Speed	30407 (L) 30408 (H)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
5	Speed	30409 (L) 30410 (H)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
6	Speed	30411 (L) 30412 (H)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
7	Speed	30413 (L) 30414 (H)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
8	Speed	30415 (L) 30416 (H)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
9	Speed	30417 (L) 30418 (H)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
10	Speed	30419 (L) 30420 (H)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
11	Speed	30421 (L) 30422 (H)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5
12	Speed	30423 (L) 30424 (H)	per Mode	per Mode	see Input set-up parameters \ Speed formula p.5

7 Speeds, discrete states and other read-only data - Modbus Input Registers (3XXXX) - **continued**

Special-purpose registers

Rotary switch settings

The rotary switch settings can be read from Input Register 30214.
Each switch setting is expressed in 4-bit BCD.

Input Register	30214															
Rotary switches	SW4				SW3				SW2				SW1			
Bit position:	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

SW4 (internal)	non-volatile set-up parameter over-ride (see SW4 operation below).	
SW3	Address 10's	(Figure 1, Set Rotary Switches)
SW2	Address 1's	(Figure 1, Set Rotary Switches)
SW1	Baud/Parity/Stop-bits	(Figure 1, Set Rotary Switches, Table 1)

Firmware (versions, revisions)

The firmware versions and revisions can be read from Input Register 30215.
Each version and revision is expressed in 4-bit BCD.

Input Register	30215															
Firmware	Main Version				Main Revision				FDC Version				FDC Revision			
Bit position:	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Diagnostics (reserved)

Input Register	30216															
Diagnostics	<RESERVED>															
Bit position:	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Active set-up parameter values

The Holding Register set-up parameters can be over-ridden by special switch selected settings (see SW4 operation below).
The set-up parameters which are in effect (Holding Registers or SW4 selected) are the active set-up parameters.
The active set-up parameter values can be read at any time from Input Registers 30001 … 30048 and 30101 … 30124.
Input Registers 30001 … 30048 correspond to the same 16-bit setup parameters as Holding Registers 40001 … 40048 (p.6).
Input Registers 30101 … 30124 correspond to the same 32-bit setup parameters as Holding Registers 40101 … 40124 (p.7).
When SW4 is set to 0, these Input Registers return the corresponding Holding Register values.
When SW4 is set 1 … 9, these Input Registers return the SW4-selected set-up parameter values (see Table 2 below).

8 SW4 operation

Over-riding the Holding Register set-up parameters

SW4 (internal rotary switch) allows over-riding the Holding Register set-up parameters with the values of Table 2.
SW4 setting determines the source of the active setup parameter values:

SW4 = 0:	the active setup parameter values are the Holding Register values. This is the factory default setting.
SW4 = 1 … 9:	the active setup parameter values are SW4-selected values per Table 2.
	All 12 inputs have the same 5 (Table 2) set-up parameter values.
	Only PPR differs from the factory-default Holding Register values.

SW4	Input i active RPM_{min}	Input i active RPM_{max}	Input i active PPR	Input i active Mode	Input i active Units
0	HR 40001 + 4*(i - 1)	HR 40002 + 4*(i - 1)	HR 40003 + 4*(i - 1)	HR 40004 + 4*(i - 1)	HR 40101/2 + 2*(i – 1)
1	10 (1.0 rpm)	65,535 (6,553.5 rpm)	1	10	1.0 (rpm units)
2	10 (1.0 rpm)	65,535 (6,553.5 rpm)	2	10	1.0 (rpm units)
3	10 (1.0 rpm)	65,535 (6,553.5 rpm)	4	10	1.0 (rpm units)
4	10 (1.0 rpm)	65,535 (6,553.5 rpm)	6	10	1.0 (rpm units)
5	10 (1.0 rpm)	65,535 (6,553.5 rpm)	8	10	1.0 (rpm units)
6	10 (1.0 rpm)	65,535 (6,553.5 rpm)	10	10	1.0 (rpm units)
7	10 (1.0 rpm)	65,535 (6,553.5 rpm)	12	10	1.0 (rpm units)
8	10 (1.0 rpm)	65,535 (6,553.5 rpm)	16	10	1.0 (rpm units)
9	10 (1.0 rpm)	65,535 (6,553.5 rpm)	60	10	1.0 (rpm units)

Table 2

8 SW4 operation - continued

Changing the SW4 setting

Remove the front cover. SW4 is located 2 ½ inches behind the other 3 rotary switches. Do not touch any other internal components/pins when changing the SW4 setting. Use a small plastic (or other insulated-shaft) straight-blade screwdriver.

9 Input set-up parameters (a second look) – also see Internal organization \ Input set-up parameters p.5

RPM_{min} (minimum measureable shaft rpm)
Defines f_{min}(in Hz) = RPM_{min}*PPR/600. Speed = 0 for $f \le f_{min}$ (all Modes).
Defines the stopped-shaft detection time (from f = 0 to speed = 0): T_{stop} (in seconds) = $1/f_{min} = 600/(RPM_{min}*PPR)$
Note: Increasing RPM_{min} decreases the stopped shaft detection time.
Note: RPM_{min} is in 0.1 rpm* units (e.g. write 10 for 1.0 rpm).

RPM_{max}
Defines f_{max}(in Hz) = RPM_{max}*PPR/600.
f_{max} defines the maximum measurable 16-bit speed for Modes 2, 12, 3 and 13 (see Mode below).
f_{max} is not used in Modes 0, 10, 1 and 11 (see the Mode-selected speed formulas below).
Note: Speed from signal frequencies $f > f_{max}$ can be measured using 32-bit Speed (all modes).
See Internal organization\Input setup parameters\Mode (Mode value note) p.5.
Note: RPM_{max} is in 0.1 rpm* units (e.g. write 65535 for 6553.5 rpm).

*RPM_{min} and RPM_{max} are the only items whose numeric and represented values are different (e.g. 1 represents 0.1 rpm).
The numeric and represented values of all other settings and speeds are the same (e.g. PPR = 8 represents 8 pulses per revolution).

PPR (pulser + sensor pulses per revolution)
Defines $f_{min} = RPM_{min}*PPR/600$ and $f_{max} = RPM_{max}*PPR/600$, configures pulser correction. To measure shaft speed using a pulser and sensor, set the input PPR to the number of sensor signal-pulses per one pulser/shaft revolution. Doing so properly configures pulser correction, preventing all speed variations and errors caused by pulser strength and spacing variations (all modes).

Mode
Eight allowed mode values select the speed formula, 32-bit speed data type and discrete state polarity.
The mode value 1's digit selects the speed formula and 32-bit speed data type. The 10's digit selects the discrete state polarity.

Mode value	Speed formula, 32-bit speed data type, etc.
0, 10	**Speed = f*(60/PPR)*(Units)** When an input Units parameter is set to 1.0 (factory default), the corresponding input speed is in rpm units. To measure speed in non-rpm units, enter the desired units/rpm or units/rev conversion into the Units parameter (e.g. if a conveyor moves 0.42 ft per pulser revolution, set Units = 0.42 to measure speed in ft/min units). 16-bit speed rounds to the nearest whole number. 32-bit speed is type floating point.
1, 11	**Speed = f** Speed is the signal frequency in Hz (pulses/s) units. 16-bit speed rounds to the nearest Hz. 32-bit speed is type floating point.
2, 12	**Speed = $65535*(f - f_{min})/(f_{max} - f_{min})$** Speed is a unit-less frequency-to-digital-conversion with straight-line characteristic: 0 … 65535 for $f = f_{min} \rightarrow f_{max}$ (full 16-bit resolution). 32-bit speed is type unsigned long integer. Both speeds (16 and 32-bit) round to the nearest whole number.
3, 13	**Speed = $65535*f/f_{max}$** Speed is a unit-less frequency-to-digital-conversion with straight-line characteristic: 0 … 65535 for $f = 0 \rightarrow f_{max}$. However, like all other modes, speed = 0 for $f \le f_{min}$ (the non-zero codes up to $65535*f_{min}/f_{max}$ are missing). The measured speed ranges $65535*(f_{min}/f_{max})$ … 65535 for $f = f_{min} \rightarrow f_{max}$. 32-bit speed is type unsigned long integer. Both speeds (16 and 32-bit) round to the nearest whole number.

Mode value	Discrete state polarity	
0 … 3	**Non-inverting**	(binary state 0 for Low input, 1 for High input)
10 … 13	**Inverting**	(binary state 1 for Low input, 0 for High input)

Units
Defines measurement units for modes 0 and 10. See Mode (above) for details.

10 **Input termination** – pull-up, pull-down and Hi-Z

Each input is terminated per the position (or absence) of a shunt on a 3-pin header with pins labeled A, B and C.
12 headers, each labeled for an input (1 … 12), are grouped into 2 blocks (J7, J8) on the (internal) rotary switch pcb (Fig. 3 below).

Shunt position	Termination	Used for
A-B	Pull-up	NPN open-collector output not terminated elsewhere; COMs shorting switch (Figure 2 p.4)
B-C	Pull-down	PNP open-collector output not terminated elsewhere; +Vs shorting switch (Figure 2 p.4)
A, C (or none)	Hi-Z	NPN/PNP outputs terminated elsewhere; push-pull line-driver and logic outputs

Example (Fig 3): In1 … 4: Pull-up (A-B), In5 … 8: Hi-Z (A), In9 … 12: Pull-down (B-C)

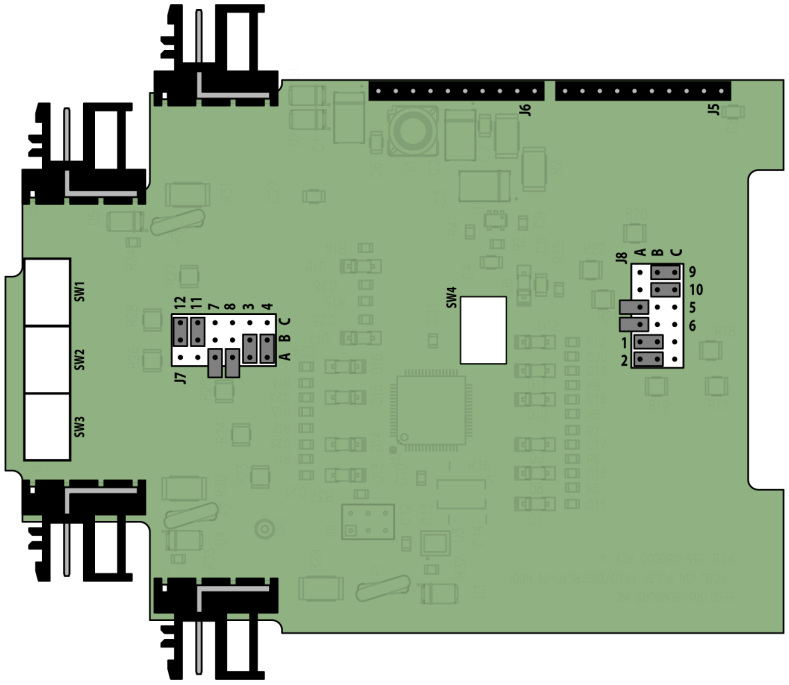


Figure 3 (rotary switch pcb)

Input	Jumper block	Factory shunt setting	Changed shunt setting	Notes
1	J8	A-B (pull-up)		
2	J8	A-B (pull-up)		
3	J7	A-B (pull-up)		
4	J7	A-B (pull-up)		
5	J8	A-B (pull-up)		
6	J8	A-B (pull-up)		
7	J7	A-B (pull-up)		
8	J7	A-B (pull-up)		
9	J8	A-B (pull-up)		
10	J8	A-B (pull-up)		
11	J7	A-B (pull-up)		
12	J7	A-B (pull-up)		

Table 3

Changing input termination (requires opening the enclosure)

Disconnect power and unplug all terminal block plugs. See Fig. 1 p.3. Detach from DIN rail (if attached). See Installation p.3.
Carefully pry/lift each of the 6 enclosure tabs (take care to not break them) enough to release the enclosure R-side panel. As you release each tab, flex and separate the R-side panel enough to keep the tab(s) released. See Fig 1 (front cover off) p.3.
Carefully remove the R-side panel. You will see the back side of the rotary switch pcb.
Carefully lift this pcb just enough to free it from the enclosure (be careful, it's connected to another pcb with short ribbon cables).
Turn it over (with ribbon cables acting as a hinge) so you can access the J7 and J8 header blocks.
Change input header shunt positions as needed and record your changes in the changed shunt setting column of Table 3 (above).
Check where the 2 ribbon cables mate with the 10-pin J5 and J6 pcb headers. If they have separated or lifted, re-seat them, pushing them all the way down onto the header pins, taking care to not misalign (no J5 or J6 header pins should be visible).
Carefully re-assemble the rotary switch pcb back into the enclosure and re-attach the R-side panel verifying all tabs and edges snap into place.

11 Specifications

Input frequency measurable range	0.001 → 10,000 Hz	
Shaft rpm measureable range	0.1 → 600,000/PPR rpm	
Speed measurement accuracy	% Error (max) = 0.0025 + f/25,000	(modes 0 and 10, 32-bit speed)
Speed acquisition rate	50 times/s (T = 20 mS)	(all inputs)
Discrete input response time	200 mS (changed input level must persist uninterrupted for 200 mS before state change)	
Signal inputs (In1 … In12)	TB1 … TB6 (Figure 1 p.3, Figure 2 p.4)	
V_{IL}(signal LOW)	0 → 1.0V	
V_{IH}(signal HIGH)	2.5V → 25V	
Termination	4.7kΩ pull-up (to $+V_S$), 4.7kΩ pull-down (to COMs) or Hi-Z (47kΩ) per internal jumpers - see Input termination p.11 Factory default: 4.7kΩ pull-up (all inputs)	
-3db frequency	15,400 Hz	
Sensor DC power outputs (+Vs)	TB1 … TB6 (Figure 1 p.3, Figure 2 p.4)	
V_o	Vp – 1V	
I_o	40mA (max source) Each +Vs output terminal is protected by an internal device that shuts off power when overloaded. To reset power to the terminal, disconnect all load from the +Vs terminal (or disconnect Vp), wait 60s then reconnect.	
RS485 serial port	TB7 (Figure 1 p.3)	
Isolation voltage	1kV (min)	
Differential output voltage	1.5V (min) @ 54Ω line impedance	
Configuration	2-wire RS485 (half-duplex)	
Baud/Parity/Stop-bits	Set with 1 rotary Baud/Parity switch (see Figure 1 p.3, Table 1 p.4)	
NOTE	Connect the TB7 terminals to a "2-wire" Modbus RTU network: D1(+), D0(-) and COMc terminals (see Terminal Blocks and Fig 1 p.3) Do not connect power (AC or DC) to TB7 terminals or the RS485 network.	
Modbus RTU slave		
Supported slave addresses	1 … 99	set with 2 rotary Address switches (see Figure 1 p.3)
Supported function codes	03	Read Holding Registers (4XXXX)
	04	Read Input Registers (3XXXX)
	06	Write Single Holding Register (4XXXX)
	16	Write Multiple Holding Registers (4XXXX)
Query → Response latency	1mS	(max) – master query message end to ION slave response message start
LED operation		
Power (green)	ON	ION is powered
Communication (yellow)	ON	ION polled by Modbus master at least once per second
Error (red)	ON	Internal fault
	Blink	Serial communications fault (illegal slave address or message length; CRC or character error)
24V DC Power in (V_p)	TB8 (Figure 1 p.3)	
V = Vp(+) - Vp(-)	24Vdc ±5% (do not connect AC power)	
I	85mA	Vs outputs no load
	325mA	Vs outputs fully loaded (40 mA each)
Operating temperature	-40 → +85°C (-40 → +185°F)	
Dimensions, weight	4.65 in (118 mm) H, 1.77 in (45 mm) W, 4.88 in (124 mm) D, 0.50 Lb (0.23 kg)	