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Product	E2

Title	E2 Modbus RTU Control & register Mapping

Summary	This document gives information on Modbus RTU for Otpidrive E2

Optidrive E2 drives support Modbus RTU communications, allowing a network of drives to be controlled and monitored by any Modbus RTU capable PLC or control system. The Optidrive E2 is always a Slave to an external Modbus RTU Master. This document describes the registers and functions available.

Modbus RTU Protocol Specification

Protocol	Modbus RTU
Error check	CRC
Baud rate	9600bps, 19200bps, 38400bps, 57600bps, 115200bps (default)
Data format	1 start bit, 8 data bits, 1 stop bit, no parity
Physical signal	RS 485 (2-wire)
User Interface	RJ45

Modbus Telegram Structure

The following Modbus Commands are supported
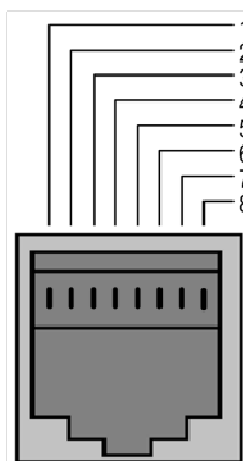- 03 Read Holding Registers
- 06 Write Single Holding Register

The telegram structure is as follows:-

Command 03 – Read Holding Registers					
Master Telegram		**Length**	**Slave Response**		**Length**
Slave address	1	Byte	Slave Address	1	Byte
Function Code (03)	1	Byte	Function Code (03)	1	Byte
1st Register Address	2	Bytes	Data Length	1	Byte
No. of Registers	2	Bytes	1st Register	2	Bytes
CRC Checksum	2	Bytes	2nd Register	2	Bytes
			Etc.		
			CRC Checksum	2	Bytes

Command 06 – Write Single Holding Register					
Master Telegram		**Length**	**Slave Response**		**Length**
Slave address	1	Byte	Slave Address	1	Byte
Function Code (06)	1	Byte	Function Code (06)	1	Byte
Register Address	2	Bytes	Register Address	2	Bytes
Value	2	Bytes	Register Value	2	Bytes
CRC Checksum	2	Bytes	CRC Checksum	2	Bytes

RJ45 Connection Pin configuration

1	No connection
2	No connection
3	0V
4	Optibus/Remote Keypad/PC Connection -
5	Optibus/Remote Keypad/PC Connection +
6	+24V Remote Keypad Power Supply
7	RS485 – Modbus RTU
8	RS 485 + Modbus RTU
Data format is fixed at: 1 Start bit, 8 Data bits, 1 Stop bit, No parity Baud rate & Address set in P-36	

Typical Modbus RTU Configuration
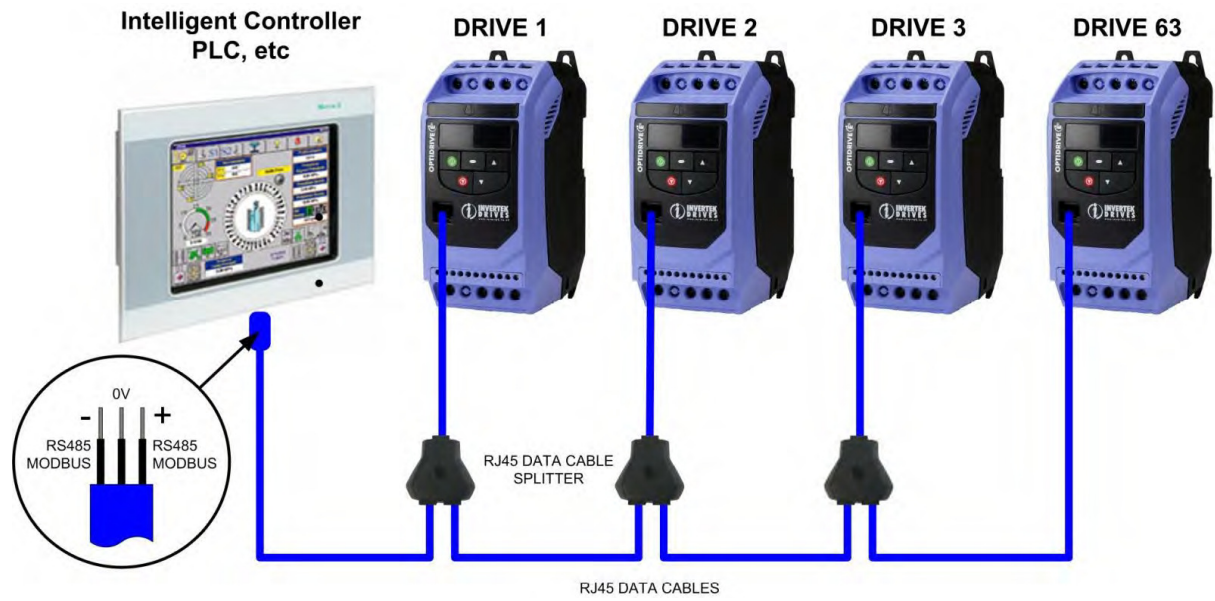
Memory Map
Control and status registers
Note : All registers are Holding Registers

Register Number	Parameter Number	Upper byte	Lower Byte	Format	Min	Max	Command	Type	Scaling
1*	-	Control Word		WORD	0	15	03,06	R/W	See Below
2*	-	Frequency Setpoint		S16	0	5000	03,06	R/W	1dp, e.g. 100 = 10.0Hz
3*	-	Reserved		-	-	-	03,06	R/W	
4*	-	Modbus ramp control time		U16	0	60000	03,06	R/W	2dp, e.g. 500 = 5.00s
5	-	Reserved		-	-	-	03	R	
6*	-	Error code	Drive status	-	-	-	03	R	See Below
7*	-	Output Frequency		S16	0	5000	03	R	1dp, e.g. 100 = 10.0Hz
8*	-	Motor Current		U16	0	-	03	R	1dp, e.g. 100 = 10.0A
9*	-	Reserved		-	-	-	03	R	
10	-	Reserved		-	-	-	03	R	
11	P00-04	Digital Input Status		WORD	0000	1111	03	R	See Below
12	P00-20	Rating ID		U16	-	-	03	R	Internal Value
13	P00-20	Power rating		U16	-	-	03	R	2dp, e.g. 37 = 0.37kW / HP
14	P00-20	Voltage rating		U16	-	-	03	R	Supply Voltage
15	P00-18	IO processor software version		U16	-	-	03	R	2dp, e.g. 103 = 1.03
16	P00-18	Motor control processor software version		U16	-	-	03	R	2dp, e.g. 103 = 1.03
17	P00-20	Drive type		U16	-	-	03	R	Internal Code
18	-	Reserved		-	-	-	03	R	
19	-	Reserved		-	-	-	03	R	
20	P00-01	Analog 1 input result		U16	0	1000	03	R	1dp, e.g. 500 = 50.0%
21	P00-02	Analog 2 input result		U16	0	1000	03	R	1dp, e.g. 500 = 50.0%
22	P00-03	Speed reference value		S16	0	5000	03	R	1dp, e.g. 500 = 50.0Hz
23	P00-08	DC bus voltages		U16	0	1000	03	R	600 = 600 Volts
24	P00-09	Drive temperature		S16	-10	150	03	R	50 = 50°C
25 to 30	-	Reserved		-	-	-	03	R	

* When using the external fieldbus gateways (Profibus, DeviceNet, Ethernet) these registers are available

Format

WORD = WORD Format, functions assigned to individual bits
S16 = Signed 16 Bit Integer
U16 = Unsigned 16 bit Integer

Control and Status Register Descriptions:

Read and write registers

Register 1: Drive command

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
High Byte								Low Byte							

Bit 0: Run/Stop command: Set to 1 to enable the drive. Set to 0 to stop the drive.
Bit 1: Fast stop request. Set to 1 to enable drive to stop with 2nd deceleration ramp.
Bit 2: Reset request. Set to 1 in order to reset the drive if drive is under trip condition.
User must clear this bit when drive is under normal condition to prevent un-expected reset.
Bit 3: Coast stop request. Set to 1 to issue a coast stop command.
For normal operation, Bit 3 has the highest priority, bit 0 has the lowest priority (bit 3>bit 1>bit 0).
For example if user set command as 0x0009, drive will do a coast stop rather than run. For normal run/start, just set this register to 1.
Note that stat/stop(bit 0), fast stop(bit 1) and coast stop(bit 3) only works if P-31= 0 or 1. Otherwise, start/stop function is controlled by drive control terminals. Reset function(bit 2) works all the time as long as drive is operated under Modbus control mode (P-12=3 or 4).

Register 2: speed reference setup
This register holds the speed reference value with one decimal place (200 = 20.0Hz). The maximum speed reference value is limited by P-01.

Register 4: Acc/Dec ramp setup
This register specifies the drive acceleration and deceleration ramp time. The same value is applied simultaneously to the acceleration and deceleration ramp times. This register is only active when P-12 = 4.

Read only registers

Register 6: Drive status and error code
High byte gives drive error code. (Valid when drive tripped, see appendix for details)
Low byte gives drive status (0: drive stopped, 1: drive running, 2: drive tipped)

Register 7: Motor speed information
This register gives motor speed information. The data is in Hz and with one decimal place (i.e. 234 = 23.4Hz)

Register 8: Motor current
This register gives motor current information. The data is in Amp with one decimal place (i.e. 87 = 8.7A)

Register 11: Digital input status
The value in this register represents the drive terminal digital input status (Digital input 1 to 4). Lowest bit indicates digital input 1 status.

Register 12: Rating ID
This register gives the following information:
Drive size, drive type, Power units and Power value decimal places
Register value (16 bits HEX format):

X	X	X	X	h		
			Power Units	0	kW	
				1	HP	
		Drive Type		4	E2	
	Power Decimal Places			0	No Decimal Places	
				1	One Decimal Place	
				2	Two Decimal Places	
Drive Frame Size				1	Frame Size 1	
				2	Frame Size 2	
				3	Frame Size 3	

NOTE : Power decimal places is used for register 13 (Power rating). For example, if we have value x1x0h in register 12 and value 15 in register 13, this gives the drive power as 1.5KW. If we have value x0x0h in register 12 and same value 15 in register 13, this gives drive power as 15KW. Or if we have x1x1h in register 12 and 5 in register 13, then the drive power rating is 0.5HP. If we have x0x1h in register 12 and 5 in register 13, this gives drive power rating as 5HP.

Register 13: Power rating
Combined with the value in register 12, this gives the drive power rating information

Register 14: Voltage level
This register gives the rated input voltage for the drive.
i.e. 230 : 230V 400: 400V 460: 460V

Register 15: Software version
This register contains the drive software version info. Value includes two decimal places.
i.e. 103 means version 1.03

Parameter registers

All user adjustable parameters within the drive are accessible by Modbus, and can be Read or Written to. For further information regarding the parameter functions and specific settings, please refer to the User Guide.

Register	Parameter	Description	Format	Min	Max	Data format
129	01	Max speed limit	U16	0	5*P-09	Internal value (3000 = 50.0Hz)
130	02	Min speed limit	U16	0	P-01	Internal value (3000 = 50.0Hz)
131	03	Accel ramp time	U16	0	60000	2dp, e.g. 300=3.00s
132	04	Decel ramp time	U16	0	60000	2dp, e.g. 300=3.00s
133	05	Stop mode select	U16	0	2	0: Ramp to stop 1: Coast to stop 2: Ramp to stop
134	06	Energy save	U16	0	1	0: Disabled 1: Enabled
135	07	Motor rated voltage	U16	0	250 500	135
136	08	Motor rated current	U16	0	Drive Rating Dependent	1dp, e.g. 100 = 10.0A
137	09	Motor rated frequency	U16	25	500	Data unit is in Hz
138	10	Motor rated speed	U16	0	30000	Maximum value equals to the sync speed of a typical 2-pole motor
139	11	Boost voltage value	U16	0	Size 1 - 0 to 200 Size 2 - 0 to 150 Size 3 - 0 to 100	1dp, e.g. 100 = 10.0%
140	12	Control mode	U16	0	6	0: Terminal Control 1: Keypad forward only 2: Keypad forward and reverse 3: Modbus control mode 4: Modbus control with ramp control 5 : PID control 6 : PID control with analog speed sum
141	13	Trip log	U16	See Appendix for Details		
142	14	Access code	U16	0	9999	
143	15	Digital input function	U16	0	12	See user guide for function details
144	16	Analog input format	U16	0	6	0: 0…10V 1: b 0…10V 2: 0…20mA 3: t 4…20mA 4: r 4…20mA 5: t 20…4mA 6: r 20…4mA
145	17	Effective switching frequency	U16	0	5 (Drive Rating Dependent)	0 = 4KHz 1 = 8KHz 2 = 12Khz 3 =16KHz 4 = 24KHz 5 = 32KHz
146	18	Relay output function	U16	0	7	See user guide for function details
147	19	Digital output limit	U16	0	1000	100 = 10.0%
148	20	Preset speed 1	U16	-P-01	P-01	Internal value (3000 = 50.0Hz)
149	21	Preset speed 2	U16	-P-01	P-01	Internal value (3000 = 50.0Hz)
150	22	Preset speed 3	U16	-P-01	P-01	Internal value (3000 = 50.0Hz)
151	23	Preset speed 4	U16	-P-01	P-01	Internal value (3000 = 50.0Hz)
152	24	2nd deceleration ramp	U16	0	2500	250 = 2.50s
153	25	Analog output function	U16	0	9	See user guide for function details
154	26	Skip frequency	U16	0	P-01	Internal value (3000 = 50.0Hz)
155	27	Skip freq band	U16	0	P-01	Internal value (3000 = 50.0Hz)
156	28	V/F adjust voltage	U16	0	P-07	100 = 100V
157	29	V/F adjust frequency	U16	0	P-09	50 = 50Hz

Register	Parameter	Description	Format	Min	Max	Data format
158	30	Start mode select	U16	0	6	0: Edgr-r 1: Auto_0 2…6: Auto_1 to Auto_5
159	31	Keypad restart mode	U16	0	3	See user guide for details
160	32	DC injection enable	U16	0	250	250= 25.0s
161	33	Spin start enable	U16	0	1	
162	34	Brake circuit enable	U16	0	2	See user guide for function details
163	35	Analog input scaling	U16	0	5000	100 = 10%
164	36	Drive address (Low byte)	0	63	Drive comms address	Drive address (Low byte)
		Baudrate select	1	6	1 = Optibus fixed baudrate 2 = 9K6 3 = 19K2 4 = 38K4 5 = 57K6 6 = 115K2	Baudrate select
		Trip time setup	0	8	See user guide for more information	Trip time setup
165	37	Access code definition	U16	0	9999	
166	38	Parameter lock	U16	0	1	0: Unlock 1: Locked
167	39	Analog input offset	U16	-5000	5000	1dp, e.g. 300=30.0%
168	40	Display scaling factor	U16	0	6000	3dp, e.g.100 = 0.100
169	41	User PI P gain	U16	1	300	1dp, e.g. 10 = 1.0
170	42	User PI I time constant	U16	0	300	1dp, e.g. 10 = 1.0s
171	43	User PI mode select	U16	0	1	See user guide for more information
172	44	User PI reference select	U16	0	1	See user guide for more information
173	45	User PI digital reference	U16	0	1000	1dp, e.g. 100 =10.0%
174	46	User PI feedback select	U16	0	3	See user guide for more information
175	47	2nd an input format	U16	0	5	0: 0…10V 1: 0…20mA 2: t 4…20mA 3: r 4…20mA 4: t 20…4mA 5: r 20…4mA

Parameter Registers – Additional Information

Register 164 – Communications Configuration

This Register entry contains multiple data entries, as follows :

High Byte								Low Byte							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Trip Configuration				Baud Rate				Drive Address							

Drive Address : Integer 1 to 63
Baud Rate : Settings as follows :
1 = Optibus fixed baudrate
2 = 9K6
3 = 19K2
4 = 38K4
5 = 57K6
6 = 115K2
Trip Time Setup : Settings as follows :
0 = Comms Loss Trip Disabled
1 = 30ms Watchdog, Trip on Comms Loss
2 = 300ms Watchdog, Trip on Comms Loss
3 = 1000ms Watchdog, Trip on Comms Loss
4 = 3000ms Watchdog, Trip on Comms Loss
5 = 30ms Watchdog, Ramp To Stop on Comms Loss
6 = 300ms Watchdog, Ramp To Stop on Comms Loss
7 = 1000ms Watchdog, Ramp To Stop on Comms Loss
8 = 3000ms Watchdog, Ramp To Stop on Comms Loss

Modbus Exception Response Telegrams
Under some circumstances, the drive may reply with an Exception Response (error) in response to a request telegram sent from the network master, for example where the master tries to read a register which does not exist. Exception Responses which can be generated by the drive are listed below:-

Exception Code 1: Invalid Request
Returned under the following conditions
- Network Master sends an unsupported Modbus command (e.g. Read Coils).
- Run command issued to drive whilst the drive is not set for Modbus Control Mode (e.g. P1-12 <>4).
- Run command issued to drives whilst the drive is not enabled (e.g. Digital Input 1 is open).
- Run command issued to drive whilst the drive is in a tripped condition.

Exception Code 2: Invalid Modbus register
Returned under the following conditions
- Network Master attempts to read or write a register that does not exist within the drive.

Exception Code 3: Register Value Out of Range
Returned under the following conditions
- Network Master attempts to write a holding register with a value outside the range of the register

Exception Code 6: Drive Busy
Returned under the following conditions
- Drive busy due to internal data transfer. The Network Master should re-send the message after a delay

Dataflow example:
Read data from register 6:

Request: [01]	[03]	[00] [05]	[00] [01]	[94] [0B]
(Drive Addr)	(Command)	(Reg start addr)	(No. of Registers)	(Checksum)

Reply: [01]	[03]	[02] [00]	[00]	[B8] [44]
(Drive Addr)	(Command)	(No of data bytes)	(Data)	(Checksum)

Note: The actual start address of register 6 is 5. All data in [ ] is in 8bits Hex format.

Write start command to the register 1 (suppose P-12 = 3, P-15 =0 and digital input 1 is closed):

Request: [01]	[06]	[00] [00]	[00] [01]	[48] [0A]
(Drive Addr)	(Command)	(Reg addr)	(Data value)	(Checksum)
Reply: [01]	[06]	[00] [00]	[00] [01]	[48] [0A]
(Drive Addr)	(Command)	(Reg addr)	(Data value)	(Checksum)

Note: The actual address of register 1 on the data link is 0. All data in [ ] is in 8bits Hex format.
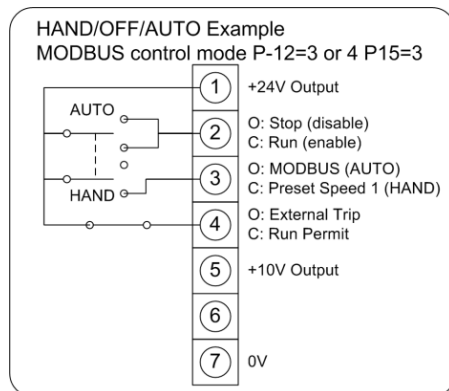
Reply can be error message depending on drive parameter settings and digital input status.

Analog and Digital Input Configurations when in MODBUS control mode (P12 = 3 or 4)
By changing the value in P-15 adjusts the functionality of the control terminals as below:
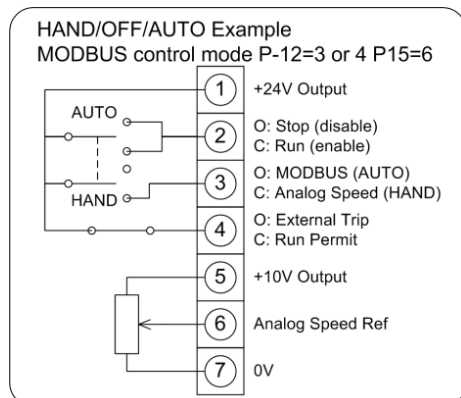
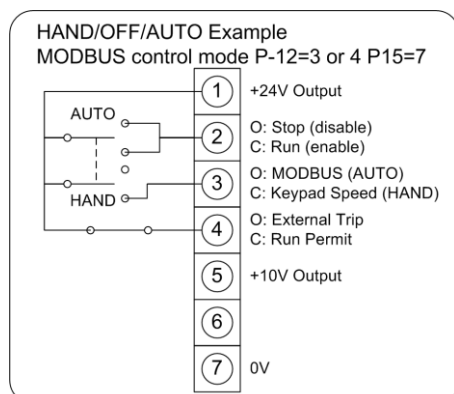| P-15	Digital input 1 (T2)	Digital input 2 (T3)	Digital input 3 (T4)	Analog input (T6)	Comments
0..2, 4..5, 8..12	Open: Stop (disable) Closed: Run (enable)	No effect	No effect	No effect	Run and stop commands given via the RS485 link and Digital input 1 must be closed for the drive to run.
3 [1)]	Open: Stop (disable) Closed: Run (enable)	Open : Master speed ref Closed : Preset speed 1	External trip input : Open: Trip, Closed: Run	No effect	Connect external thermistor type PT100 or similar to digital input 3
6 [1)]	Open: Stop (disable) Closed: Run (enable)	Open : Master speed ref Closed : Analog input	External trip input : Open: Trip, Closed: Run	Analog input reference	Master Speed Ref - start and stop controlled via RS485. Keypad Speed Ref - drive auto runs if digital input 1 closed, depending on P-31 setting
7 [1)]	Open: Stop (disable) Closed: Run (enable)	Open : Master speed ref Closed : keypad speed ref	External trip input : Open: Trip, Closed: Run	No effect	

Example Wiring

HAND/OFF/AUTO Example
MODBUS control mode P-12=3 or 4 P15=3

1. +24V Output
2. O: Stop (disable) / C: Run (enable)
3. O: MODBUS (AUTO) / C: Preset Speed 1 (HAND)
4. O: External Trip / C: Run Permit
5. +10V Output
6.
7. 0V

AUTO – MODBUS Speed
HAND – Preset Speed 1

HAND/OFF/AUTO Example
MODBUS control mode P-12=3 or 4 P15=6

1. +24V Output
2. O: Stop (disable) / C: Run (enable)
3. O: MODBUS (AUTO) / C: Analog Speed (HAND)
4. O: External Trip / C: Run Permit
5. +10V Output
6. Analog Speed Ref
7. 0V

AUTO – MODBUS Speed
HAND - Analog Speed ref (potentiometer)

HAND/OFF/AUTO Example
MODBUS control mode P-12=3 or 4 P15=7

1. +24V Output
2. O: Stop (disable) / C: Run (enable)
3. O: MODBUS (AUTO) / C: Keypad Speed (HAND)
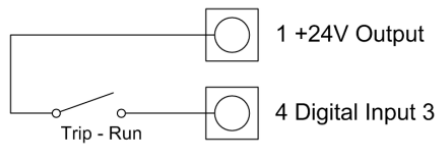4. O: External Trip / C: Run Permit
5. +10V Output
6.
7. 0V

AUTO – MODBUS Speed
HAND – Keypad Speed ref (UP & DOWN keys on drive)

Note 1:

Note: 1)
Motor Thermistor & E-Trip Connection

1 +24V Output

4 Digital Input 3

Trip - Run

Suitable for PTC Motor Thermistors of type PT100 or similar.

Trip Level set at 2.5 kΩ

Only operational using E-trip terminal function on Digital Input 1 or 2

Appendix A - Register Changes for E2 Single Phase Output Drives

The Optidrive E2 Single Phase Output drive has some registers that are different to the standard Optidrive E2. For this reason the Registers/Parameters are listed below:

Adr	Par	Description	Data range	Data format
134	06	Reserved		
148	20	Preset speed 1	0 to P-01	Internal value (3000 = 50.0Hz)
149	21	Preset speed 2	0 to P-01	Internal value (3000 = 50.0Hz)
150	22	Preset speed 3	0 to P-01	Internal value (3000 = 50.0Hz)
151	23	Preset speed 4	0 to P-01	Internal value (3000 = 50.0Hz)
160	32	Boost Frequency	0 to P09	50 = 50Hz
161	33	Boost Period Duration	0 to 150s	100 = 10.0 seconds

Drive Error Code	Drive Display Fault Code	Description
0x00	Stop	Drive healthy no fault present
0x01	OI-b	Brake channel over current
0x02	OL-br	Brake resistor overload
0x03	O-I	Over current on drive output.
0x04	It_trP	Motor Thermal Overload
0x05	PS-trP	Internal power stage fault
0x06	O_Volt	Over voltage on DC bus
0x07	U_Volt	Under voltage on DC bus
0x08	O-t	Heatsink over temperature
0x09	U-t	Under temperature
0x0A	P-dEF	Factory Default parameters have been loaded
0X0B	E-triP	External trip (on digital Input 3)
0X0C	SC-trP	Serial communications loss trip
0X0D		RESERVED
0X0E	P-LOSS	Input phase loss trip
0X0F	Spin-F	Spin start failed
0x10	Th-FLt	Faulty thermistor on heatsink.
0X11	dAtA-F	Internal memory fault.
0X12	4-20 F	Analog input current out of range (4-20mA)

Trip Log – Register 141
The last 4 drive error codes are stored in this register as follows :-

High Byte								Low Byte							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Last Prior Trip				Last Prior Trip				Last Prior Trip				Last Trip			