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Digital Phase Converter

Modbus Protocol

INTUITIVELY ENGINEERED

Modbus Physical Connections and Requirements

The Modbus adapter board uses a 2-Wire configuration. Any shielded cat5/RJ45 cable can be used. The adapter has 2 Modbus terminals J2 and J3. J3 is an optional terminal that can be populated to daisy-chain PTs on the same Modbus network. These terminals have the same pinouts, so J3(Modbus Out) can directly connect to J2(Modbus In) on another PT.

2-Wire

- If the PLC/Modbus Master has 4-Wire Modbus, then the positive data lines need to be shorted together, and the negative lines need to be shorted together. The positive data lines might be labeled TX+/RX+, TXD1/RXD1, D1, D+, etc. The negative data lines might be labeled TX-/RX-, TXD0/RXD0, D0, D-, etc. The PLC/Modbus Master device will also need to supply its own 5V to power the Modbus network.

Network Topology

- For short Modbus networks, the network may be daisy-chained using the J2 MODBUS IN and J3 MODBUS OUT terminals. For longer networks (100+ meters), it may be necessary to use a more conventional bus and tap topology to mitigate line reflections.

Termination

- A 120-ohm termination resistor must be inserted between the D+ and D- lines on the PLC/Modbus Master side. The last PT in the Modbus network (or the other end of the bus) also needs a termination resistor. Setting DIP Switch 3 (TERM) to ON will pull in the termination resistor on the adapter board.

Line Biasing

- Line biasing may be needed to prevent noise from triggering messages when the data lines are not driven. The PLC/Modbus Master may already have line biasing, but the PT adapter board has 2 DIP Switches to bias the network if necessary. Setting DIP Switch 1 (Bias+) and DIP Switch 2 (Bias-) ON will engage the 620-ohm line biasing resistors. Only one device on a network can have bias resistors engaged.

RJ45 Pinout for both J2 and J3 terminals:

1. NC
2. NC
3. NC
4. D+
5. D-
6. NC
7. 5V
8. COM

Programming PT Modbus Parameters

Modbus Slave ID, Data Rate, Parity, and Stop Bits are available for programming.

Before programing, save/write down the current DIP Switch configuration.

To access the Modbus Config programming, set DIP Switches 1, 2, 3, and 4 to ON, and DIP Switch 5 to OFF. DIP Switches 9 and 10 will decide which parameter to program, with DIP Switches 6, 7, and 8 deciding the value. When the PT has booted up, it will show a screen displaying what parameter it programmed, and what value it was programmed with. The DIP switch combinations to program the Modbus parameters are given below.

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Default values are configured for the PT's automated test procedure.

Here are the defaults for the PT:

- Slave ID: 6
- Data Rate: 38400
- Parity: Even
- Stop Bits: 1

NOTE: 'X' means it can be On or Off.

DIP 9 OFF, DIP 10 OFF = Slave ID

DIP 6	DIP 7	DIP 8	SLAVE ID
OFF	OFF	OFF	1
OFF	OFF	ON	2
OFF	ON	OFF	3
OFF	ON	ON	4
ON	OFF	OFF	5
ON	OFF	ON	6
ON	ON	OFF	7
ON	ON	ON	8

DIP 9 OFF, DIP 10 ON = Data Rate

DIP 6	DIP 7	DIP 8	DATA RATE
OFF	OFF	OFF	4800
OFF	OFF	ON	9600
OFF	ON	OFF	19200
OFF	ON	ON	38400
ON	X	X	57600

DIP 9 ON, DIP 10 OFF = Parity

DIP 6	DIP 7	DIP 8	PARITY
X	OFF	OFF	NONE
X	OFF	ON	ODD
X	ON	X	EVEN

DIP 9 ON, DIP 10 ON = Stop Bits

DIP 6	DIP 7	DIP 8	STOP BITS
X	X	OFF	1
X	X	ON	2

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Modbus Message Structure

The following function codes are implemented in the PT Modbus:

- Read Holding Registers (0x03)
- Read Input Registers (0x04)
- Write Single Register (0x06)

To simplify the Modbus application, only Input and Holding registers are implemented. Input registers are Read Only, and Holding registers are Read/Write. Any binary value in these registers will be represented as 1 (On, True), and 0 (Off, False). Certain parameters may have a multiplier applied to them, e.g., I1/I3 Current have a 10x multiplier: 123 = 12.3A.

Each request will have a Register Address field. This must be the index of the register (e.g., register 40001 is index 0, 40002 is index 1, etc). A maximum of 10 registers can be requested in a single message.

Here is the message structure for Read Holding Register (0x03) and Read Input Register (0x04):

- Slave ID (1 byte)
- Function Code (1 byte)
- Register Address [Hi:Lo] (2 bytes)
- Number of Registers [Hi:Lo] (2 bytes) (Max of 10 registers)
- CRC [Lo:Hi] (2 bytes)

Here is the response given for Read Holding Register (0x03) and Read Input Register (0x04):

- Slave ID (1 byte)
- Function Code (1 byte)
- Data Byte Count (1 byte) (Max of 20 bytes)
- Data 0 [Hi:Lo] (2 bytes)
- ...
- Data (n-1) [Hi:Lo] (2 bytes)
- CRC [Lo:Hi] (2 bytes)

Here is the message structure for Write Single Register (0x06):

- Slave ID (1 byte)
- Function Code (1 byte)
- Register Address [Hi:Lo] (2 bytes)
- Data [Hi:Lo] (2 bytes)
- CRC [Lo:Hi] (2 bytes)

Here is the response given for Write Single Register (0x06):

- Slave ID (1 byte)
- Function Code (1 byte)
- Register Address [Hi:Lo] (2 bytes)
- Data [Hi:Lo] (2 bytes)
- CRC [Lo:Hi] (2 bytes)

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Modbus Error Handling

- In case of a CRC Error, the received message is ignored, and a CRC Error counter is incremented.
- If an invalid function code is requested, an exception message is given, with an Illegal Function (0x01) error code.
- If the number of registers is invalid, an exception message is given, with an Illegal Data Address (0x02) error code.
- If an invalid/reserved register is accessed, or number of registers isn't correct, an exception message is given, with an Illegal Data Value (0x03) error code.
- If a written value is out of range of that parameter, the message is accepted, but the value is ignored, and the parameter remains unchanged.

Here is the message structure for an exception message:

- Slave ID (1 byte)
- Function Code (MSB is set to 1, e.g., 0x83, 0x84, 0x86) (1 byte)
- Exception Code (1 byte)
- CRC [Lo:Hi] (2 bytes)

Controlling the PT Through Modbus

The PT has a few programmable registers to allow controls through Modbus.

Modbus Control Select (40001)

- Selects between Aux Switch and Modbus controls
- Cannot change while the PT is actively outputting
- 0 = Only listen to Aux1 or Aux2 (Default)
- 1 = Aux1 or Aux2 must be closed AND Control State ON
- 2 = Aux1 or Aux2 must be closed OR Control State ON
- 3 = Only listen to Control State

Modbus Control State (40002)

- Controls the PT output depending on Modbus Control Select value.
- Setting is not saved between resets/power cycles.
- 0 = Off / No Output (Default)
- 1 = On / Output Active

Modbus CommLoss Select (40003)

- Selects what to do when communication loss occurs. A valid Modbus message must be sent and addressed to the PT to enable this feature.
- 0 = Nothing
- 1 = Clear Modbus Control State (State = 0) (Default)
- 2 = Fault (Creates a fault to store in fault log. Auto restarts after countdown)
- If Modbus Control Select is 2 (Aux1/Aux2 OR Control State), and CommLoss Select is 1, then the PT will still output if Aux1 or Aux2 are closed.

Modbus CommLoss Timeout (40004)

- How long it takes to trigger a communication loss event.
- Minimum: 1s
- Default: 5s
- Maximum: 30s

Modbus Fault Reset (40005)

- Can reset the PT if there is an active fault (System Status > 0)
- 0 = No Action
- 1 = Reset PT if there is a fault, ignored if there is no fault

PT Output Active (30013) can be read for the PT active switching.

- Can be read for the PT active switching

Contactor On (30015)

- Can be read for the output contactor closing

System Status (30017)

- Can be read for any faults present on the PT. Any value greater than 0 means there is an active fault, and the PT will not output

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Modbus Counter (Troubleshooting)

Counters are available to assist in network troubleshooting. Counters will increment up to 32,000 and then reset back to 0.

Counter: Modbus Messages (30021)

- Increases whenever the PT sees a message on the Modbus Network.

Counter: Slave Addressed Messages (30022)

- Increases whenever the PT sees a message addressed to itself.

Counter: CRC Errors (30023)

- Increases when a message addressed to the PT fails the CRC integrity check.

Counter: SCI Errors (30024)

- Increases when an error occurs in the SCI/UART communication.
- Framing Errors, Overrun Errors, Break Detect, or Parity Errors

Counter: Data Errors (30025)

- Increases when a Modbus exception occurs.
- Illegal Function, Illegal Data Address, or Illegal Data Value

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Modbus Registers

REGISTER	REGISTER NAME
30001	NTC Temp 1
30002	NTC Temp 2
30003	V12 Voltage
30004	V23 Voltage
30005	V31 Voltage
30006	Bus Voltage
30007	I1 Current
30008	I3 Current
30009	AUX 1 Setting
30010	AUX 2 Setting
30011	AUX 3 Setting
30012	AUX 4 Setting
30013	PT Output Active
30014	Fan On
30015	Contactor On
30016	Startup Delay Active
30017	System Status
30018	Model HP
30019	Model Input Voltage
30020	Model Output Voltage
30021	Counter: Modbus Messages
30022	Counter: Slave Addressed Messages
30023	Counter: CRC Errors
30024	Counter: SCI Errors
30025	Counter: Data Errors
40001	Modbus Control Select
40002	Modbus Control State
40003	Modbus CommLoss Select
40004	Modbus CommLoss Timeout
40005	Modbus Fault Reset
40006	Transformer Mode
40007	Elevator Mode
40008	Startup Delay Enable
40009	Startup Delay Time
40010	Infinite Restarts

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System Status Fault Codes

FAULT CODE	FAULT NAME
0	No Fault
1	IGBT3 Fault
2	IGBT Fault
3	OverTemp Fault
4	Bus Overvoltage
5	Unused
6	Unused
7	Unused
8	Low Input Voltage
9	Class 4 Overload
10	PLL Fault
11	Unused
12	Unused
13	Over Current Input
14	Temp Sense Fault
15	High Input Voltage
16	Output Overload
17	Unused
18	Unused
19	Bus Voltage Unbalance
20	Voltage Balance
21	Unused
22	Unused
23	Unused
24	IGBT2 Fault
25	Unused
26	Unused
27	Unused
28	Unused
29	Modbus CommLoss

References: https://www.modbus.org/docs/Modbus_over_serial_line_V1.pdf

https://modbus.org/docs/PI_MBUS_300.pdf

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