

PI2010

Intelligent Communicating Power Transducer



Communications Manual

(Including Register Definitions)

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Introduction

The PI2010 is what is known as, a 'blind' instrument. That is, it has no data display screen and relies on serial communications to make the data available to the user. The PI2010 has a 2-wire RS485 communications interface allowing computer access to all of the instruments monitored and derived values.

With a network connection, the data can be made available to anyone with a suitably configured PC anywhere on that network, and with an internet port, this data can be accessed world-wide.

Description

This manual describes the Modbus RTU communications functions implemented within the PI2010 instrument. The data transfer uses binary encoded data – each transmitted character contains 8 data bits.

For a more detailed description of the Modbus protocol, please refer to the Modicon 'Modbus' Protocol Reference Guide (PI-MBUS-300 Rev. J).

Each Modbus register contains a 16 bit integer value transmitted as 2 x 8-bit characters. Decimal points, where used, are implied.

Certain accumulation registers are defined as double registers – 32-bit values – and are transmitted as 4 x 8-bit characters.

Supported Function Codes

For simplicity, only the following Modbus functions are supported:-

Code	Function
03	Read holding register
06	Preset single holding register

Block mode data transfer – Modbus function code 3

Modbus supports block mode read. Rather than explicitly reading each register individually, the PI2010 allows up to 50 consecutive registers to be read in a single transaction.

However, a single parameter read is possible – with a block length of 1.

Writing Data – Modbus function code 6

Unlike the Modbus read function, data writes can only be performed one register at a time. Only certain parameters are available for write access. These are described in the register descriptions later in this document.

Transaction function 3: read 'n' holding registers.

Read back contents of 1 to 'n' holding registers.

Request

Slave address	Function	Register address		Number of registers		CRC 16	
1	3	msb	lsb	msb	lsb	msb	lsb

Where:

- Slave Address 8 bit (1 byte) unique instrument address in the range 1 to 247 (01H to F7H)
- Function code = 3 (03H).
- Register address 16 bit (2 byte) address of first holding register to be read.
- Number of registers 16 bit (2 byte) number of holding registers to be read.
- CRC 16 16 bit (2 byte) message checksum.

Transaction function 6: preset single holding register.

Write a new value into the required holding register.

Request

Slave address	Function	Register address		Preset data		CRC 16	
1	6	msb	lsb	msb	lsb	msb	lsb

Where:

- Slave Address 8 bit (1 byte) unique instrument address in the range 1 to 247 (01H to F7H)
- Function code = 6 (06H).
- Register address 16 bit (2 byte) address of first holding register to be written.
- Preset data 16 bit (2 byte) preset data to be written to the addressed holding register
- CRC 16 16 bit (2 byte) message checksum.

Instrument Register Allocation

This section describes the register allocation of the PI2010 instrument.

Although all registers described here exist and are readable, not all of the registers will contain valid data as the content of any specific register will depend on the instrument configuration.

The register allocation has been divided up into 3 sections – each section contains specific types of data.

Section	Register (Dec)		Word Count	Byte Count	Description
	First	End			
1	0 (0)	1F (31)	32	64	Measured and Derived Data (read only).
2	21 (33)	28 (40)	4	16	Energy Accumulators (32 bit – read only)
3	300 (768)	309 (777)	10	20	Configuration and Commissioning Parameters (read/write).
4	330 (816)	335 (821)	6	12	Analogue Retransmission Configuration Parameters (read/write)

Notes:

Voltage inputs (registers 0, 1, 8, 9, 16, 17, and 25)

The voltage input registers return the actual voltage level measured at the terminals in volts to 2 decimal places. Input range 0.00 V to 600.00. If a voltage transformer is used, this reading must be multiplied by the voltage transformation ratio, PT, to give the actual voltage value.

$$\text{Actual voltage} = \text{voltage register} \times \text{PT ratio} \times 0.01 \text{ volts}$$

Current inputs (registers 2, 10, 18 and 26)

The current input registers return the actual current level measured at the terminals in milliamps to 1 decimal place. Input range 0.0 mA to 6000.0 mA. If a current transformer is used (recommended), this reading must be multiplied by the current transformation ratio, CT, to give the actual current value.

$$\text{Actual current} = \text{current register} \times \text{CT ratio} \times 0.1 \text{ mAmps}$$

Power inputs (registers 4, 6, 7, 12, 14, 15, 20, 22, 23, 28, 30 and 31)

The power input registers return the actual power levels calculated from the normalized voltage and current values measured at the terminals in amps and volts. To arrive at the true power value, the register value must be multiplied by the voltage and current transformation ratios.

$$\text{Actual power} = \text{power register} \times \text{CT ratio} \times \text{PT ratio} \times \text{constant}$$

Where : constant = 0.4 for active (W) and reactive (VAr) power levels.
 constant = 0.2 for apparent (VA) power levels.

Power factor inputs (registers 5, 13 and 21)

The power factor input registers return the actual power factor value measured to 4 decimal places. Input range is -1.0 to +1.0.

Frequency (register 27)

The measured frequency input register returns the frequency in Hz to 2 decimal places of accuracy. The actual value MUST be scaled to give a true value. Multiply the reading by 1.06813 will give the true frequency value..

1. Basic Measured Values (Read Only)

No.	Address		Data Type	Description	Scaling	Units
	Hex	Decimal				
1	000	0	Unsigned	Phase 1 Voltage (Value x PT Ratio x 0.01)		V/100
2	001	1	Unsigned	Line Voltage (L3 – L1) (Value x PT Ratio x 0.01)		V/100
3	002	2	Unsigned	Phase 1 Current (Value x CT Ratio x 0.0001)		mA/10
4	003	3				
5	004	4	Signed	Phase 1 Active Power +/- (Value x CT x PT x 0.4)		W
6	005	5	Signed	Phase 1 Power Factor (Cos Φ): +L / -C (Value x 0.0001)		-
7	006	6	Signed	Phase 1 Reactive Power +/- (Value x CT x PT x 0.4)		VAr
8	007	7	Signed	Phase 1 Apparent Power +/- (Value x CT x PT x 0.2)		VA
9	008	8	Unsigned	Phase 2 Voltage (Value x PT Ratio x 0.01)		V/100
10	009	9	Unsigned	Line Voltage (L1 – L2) (Value x PT Ratio x 0.01)		V/100
11	00A	10	Unsigned	Phase 2 Current (Value x CT Ratio x 0.0001)		mA/10
12	00B	11				
13	00C	12	Signed	Phase 2 Active Power +/- (Value x CT x PT x 0.4)		W
14	00D	13	Signed	Phase 2 Power Factor (Cos Φ): +L / -C (Value x 0.0001)		-
15	00E	14	Signed	Phase 2 Reactive Power +/- (Value x CT x PT x 0.4)		VAr
16	00F	15	Signed	Phase 2 Apparent Power +/- (Value x CT x PT x 0.2)		VA
17	010	16	Unsigned	Phase 3 Voltage (Value x PT Ratio x 0.01)		V/100
18	011	17	Unsigned	Line Voltage (L2 – L3) (Value x PT Ratio x 0.01)		V/100
19	012	18	Unsigned	Phase 3 Current (Value x CT Ratio x 0.0001)		mA/10
20	013	19				
21	014	20	Signed	Phase 3 Active Power +/- (Value x CT x PT x 0.4)		W
22	015	21	Signed	Phase 3 Power Factor (Cos Φ): +L / -C (Value x 0.0001)		-
23	016	22	Signed	Phase 3 Reactive Power +/- (Value x CT x PT x 0.4)		VAr
24	017	23	Signed	Phase 3 Apparent Power +/- (Value x CT x PT x 0.2)		VA
25	018	24				
26	019	25	Unsigned	Average Phase Voltage (Value x PT Ratio x 0.01)		V/100
27	01A	26	Unsigned	Average Phase Current (Value x CT Ratio x 0.0001)		mA/10
28	01B	27	Unsigned	Frequency (Value x 0.00106813)		Hz/100
29	01C	28	Signed	Total Active Power (Value x CT x PT x 0.4)		W
30	01D	29	Signed	Total Power Factor (Value x 0.0001)		-
31	01E	30	Signed	Total Reactive Power (Value x CT x PT x 0.4)		VAr
32	01F	31	Signed	Total Apparent Power (Value x CT x PT x 0.2)		VA

All above data is 16 bit

Unsigned data has an absolute range of 0 to 65,536

Signed data has an absolute range of -32,768 to +32,767

Warning:

Attempts to write to registers 0 through 16 (00H to 10H) will modify the instrument configuration as they overlay the configuration registers 768 through 784 (300H to 310H).

Appendix A - Three-phase Terminology

Basic Terms And Definitions

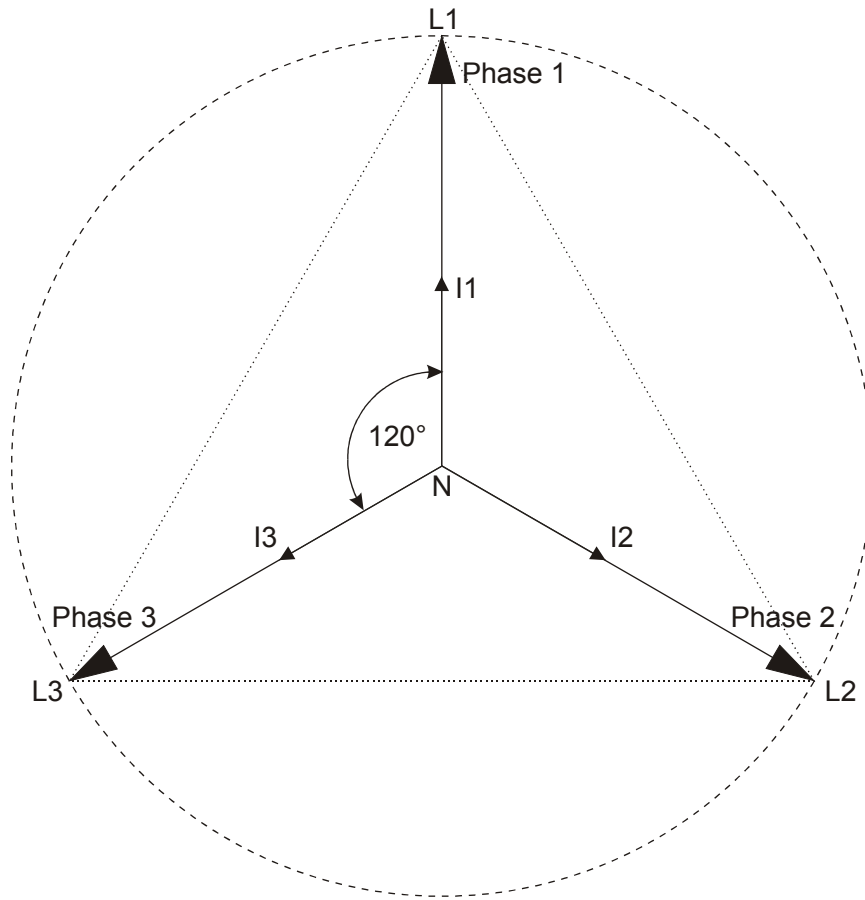


Figure 1 – Phase Diagram

	Current	UK	European	USA	European (2)
Phase 1	I1	Red	L1 (Brown)	A	R
Phase 2	I2	Yellow	L2 (Black)	B	S
Phase 3	I3	Blue	L3 (Grey)	C	T
Neutral		Black	N (Blue)		
Earth	Yellow/green	Yellow/green	Yellow/green	Yellow/green	Yellow/green

Pentagon Instruments will use the European standard for identifying phase – L1, L2 and L3.

Measured and Derived Values

Quantity	Symbol	Description / Definition / Derivation	Units
Phase 1 Voltage	V_1	True RMS voltage measured between L1 and neutral.	Volts
Phase 2 Voltage	V_2	True RMS voltage measured between L2 and neutral.	
Phase 3 Voltage	V_3	True RMS voltage measured between L3 and neutral.	
System (average) Phase Voltage	V	$= (V_1 + V_2 + V_3) / 3$	Volts
Line Voltage 1 – 2	U_{12}	True RMS voltage measured between L1 and L2.	Volts
Line Voltage 2 – 3	U_{23}	True RMS voltage measured between L2 and L3.	
Line Voltage 3 - 1	U_{31}	True RMS voltage measured between L3 and L1.	
System (average) Line Voltage	U	$= (U_{12} + U_{23} + U_{31}) / 3$	Volts
Phase 1 Current	I_1	True RMS current measured in L1.	Amps
Phase 2 Current	I_2	True RMS current measured in L2.	
Phase 3 Current	I_3	True RMS current measured in L3.	
System (average) Current	I	$= (I_1 + I_2 + I_3) / 3$	Amps
Frequency	f	Fundamental Frequency	Hz
Phase 1 Power Factor	$\cos \Phi_1$	Φ_1 is phase angle between V_1 and I_1 .	-
Phase 2 Power Factor	$\cos \Phi_2$	Φ_2 is phase angle between V_2 and I_2 .	
Phase 3 Power Factor	$\cos \Phi_3$	Φ_3 is phase angle between V_3 and I_3 .	
System (average) Power Factor	$\cos \Phi$	$= (\Phi_1 + \Phi_2 + \Phi_3) / 3$	-
Phase 1 Active Power	P_1	Phase 1 Active Power = $V_1 \times I_1 \times \cos \Phi_1$	Watts
Phase 2 Active Power	P_2	Phase 2 Active Power = $V_2 \times I_2 \times \cos \Phi_2$	
Phase 3 Active Power	P_3	Phase 3 Active Power = $V_3 \times I_3 \times \cos \Phi_3$	
System (average) Active Power	P	$= (P_1 + P_2 + P_3) / 3$	Watts
Phase 1 Reactive Power	Q_1	Phase 1 Reactive Power = $V_1 \times I_1 \times \sin \Phi_1$	VAr
Phase 2 Reactive Power	Q_2	Phase 2 Reactive Power = $V_2 \times I_2 \times \sin \Phi_2$	
Phase 3 Reactive Power	Q_3	Phase 3 Reactive Power = $V_3 \times I_3 \times \sin \Phi_3$	
System (average) Reactive Power	Q	$= (Q_1 + Q_2 + Q_3) / 3$	VAr
Phase 1 Apparent Power	S_1	Phase 1 Apparent Power = $V_1 \times I_1$	VA
Phase 2 Apparent Power	S_2	Phase 2 Apparent Power = $V_2 \times I_2$	
Phase 3 Apparent Power	S_3	Phase 3 Apparent Power = $V_3 \times I_3$	
System (average) Apparent Power	S	$= (S_1 + S_2 + S_3) / 3$	VA

Energy Values

Quantity	Symbol	Description / Definition / Derivation	Units
Total Active Energy	E	Active Energy consumption (+ve). Summation of active power against time: $E = \sum_0^{time} P$ Expressed as kW hours	kWh
Total Reactive Energy	E_r	Reactive Energy consumption (+ve). Summation of reactive power against time: $E_r = \sum_0^{time} Q$ Expressed as kVA hours	VArh
Positive Values indicate power consumption – e.g. electric motors Negative values indicate power generation – e.g. turbine generator			

Phase Angle

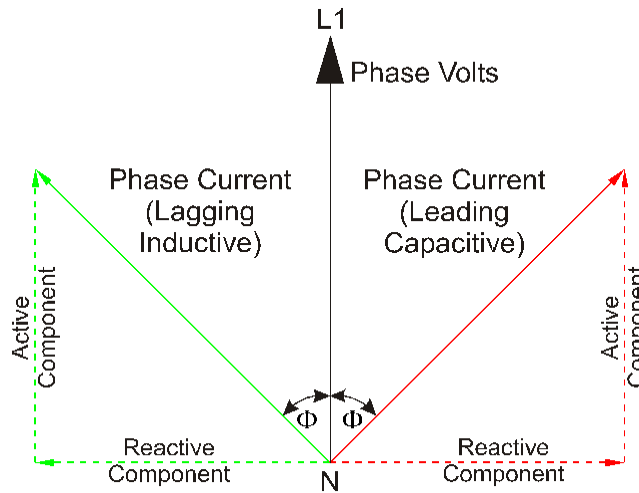


Figure 2 – Phase Angle

In Figure 1, the current vectors are shown in-line with the voltage vectors. This will be the case when the AC source encounters a resistive load. In this case, the active power will be the same as the apparent power ($\Phi = 0^\circ$ hence $\text{Cos } \Phi = 1$). Reactive power will be zero ($\text{Sin } \Phi = 0$).

Figure 2 shows the effect of a capacitive and inductive loading. The phase of the current will lag or lead the phase voltage. The phase angle between the voltage and current waveforms can vary between 90° lagging to 90° leading.

UK and European Agents:-

**Pentagon Instruments Ltd.
Unit 4 Wayside
Commerce Way
Lancing Business Park
Lancing
West Sussex
BN15 8SW**

**Tel. +44 (0) 1903 765225
Fax: +44 (0) 1903 765225**

www.pentagoninstruments.com