



MODBUS for Photon analyser

manual v.1.0
2019-03

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1. Basic connection data

Photon analyser uses MODBUS TCP standard, with 502 default port. Port number is fixed and cannot be changed.

2. MODBUS TCP vs MODBUS RTU

Modbus works based on master-slave relation between devices connected in the network, with one master device and all others working as slaves. Master is the only device that can ask questions, while all slaves can only answer. Photon works in slave mode.

Modbus TCP is a MODBUS RTU message transmitted with a TCP/IP wrapper and sent over a network instead of serial lines.

MODBUS TCP message differs from MODBUS RTU message: it does not have a SlaveID since it uses an IP Address instead; it also does not need CRC, as this is handled by TCP protocol. Detailed description on MODBUS TCP implementation can be found in this manual:

http://www.modbus.org/docs/Modbus_Messaging_Implementation_Guide_V1_0b.pdf

Example of Modbus RTU request for the content of analogue output holding registers # 40108 to 40110 from the slave device with address 17:

11 03 006B 0003 7687

11: The SlaveID Address (17 = 11 hex)

03: The Function Code (read Analog Output Holding Registers)

006B: The Data Address of the first register requested. (40108-40001 = 107 =6B hex)

0003: The total number of registers requested. (read 3 registers 40108 to 40110)

7687: The CRC (cyclic redundancy check) for error checking.

In Modbus TCP, neither SlaveID nor CRC are necessary, therefore the same request, but in MODBUS TCP (before TCP encapsulation), is **03 006B 0003**

3. MODBUS MAP

3.1. Read coil status (function code FC=01)

Example: **01 0013 0025** – this command is requesting the ON/OFF status of discrete coils # 20 to 56

01: The Function Code 1 (read Coil Status)

0013: The Data Address of the first coil to read.

(**0013** hex = 19 , + 1 offset = coil #20)

0025: The total number of coils requested. (**25** hex = 37, inputs 20 to 56)

Offset	Coil	Address Offset + Coil	Description
1	0	1	Storage of measurement session 0 = storage disabled 1 = storage enabled To start / stop storing the results please see 3.5

3.2. Read input status (FC=02)

Example: **02 00C4 0016** – this command is requesting the ON/OFF status of discrete inputs # 10197 to 10218

02: The Function Code 2 (read Input Status)

00C4: The Data Address of the first input to read.

(**00C4** hex = 19, + 1 offset = coil #20)

0016: The total number of inputs requested. (**16** hex = 22, inputs 197 to 218)

Offset	Coil	Address Offset + Coil	Description
10001	0	10001	PGD-100 dryer 0 = not connected 1 = connected
10001	1	10002	MaNOX analyser 0 = not connected 1 = connected
10001	2	10003	Martel printer 0 = not connected 1 = connected
10001	3	10004	GOOJ printer 0 = not connected 1 = connected

10001	5	10006	2 nd stage gas cooler in PGD-100	0 = installed 1 = not installed
10001	6	10007	1 st stage gas cooler in PGD-100	0 = Peltier module 1 = Nafion® module
10001	7÷24	10008÷25	VACANT	For future use
10001	25	10026	NoErrors	0 = no errors 1 = any of the below errors exists
10001	26	10027	WarmInterrupt	1 = warmup phase was interrupted (shortened)
10001	27	10028	SensSetChng	1 = sensors set was changed
10001	28	10029	PhotonTgasErr	1 = error of T _{gas} sensor in analyser
10001	29	10030	DryerTgasErr	1 = error of T _{gas} sensor in gas dryer
10001	30	10031	PhotonTambErr	1 = error of T _{amb} sensor in analyser
10001	31	10032	DryerTambErr	1 = error of T _{amb} sensor in gas dryer
10001	32	10033	FlowErr	1 = incorrect gas flow
10001	33	10034	NoZeroing	1 = sensors requires ventilation and zeroing
10001	34	10035	CriticalNoZeroing	1 = sensors MUST be ventilated and zeroed
10001	35	10036	SensZeroingFailure	1 = it was not possible to zero gas sensors
10001	36	10037	CPUErr	1 = no communication with CPU
10001	37	10038	FlowErr2	1 = flow is too low
10001	38	10039	FlowErr3	1 = gas outlet is blocked
10001	39	10040	PS2Error	1 = communication with PS2 keyboard was lost
10001	40	10041	NoSensMulti	1 = SensMulti module was not found
10001	41	10042	MultipleSensMulti	1 = more than one SensMulti module was found
10001	42	10043	SensorLost	1 = one of the IR sensor is missing

10001	43	10044	ModuleCRCErr	1 = CRC checksum error
10001	44	10045	NoExcludesFile	For madur internal use
10001	45	10046	BothPumps	1 = no pump is working (nor in gas dryer nor in Photon)
10001	46	10047	NoMaNOxZeroingFailure	1 = zeroing in MaNox analyser was unsuccessful
10001	47	10048	NoMaNOxCriticalZeroingFailure	1 = zeroing of MaNox was not confirmed (no reply from MaNox)

3.3. Read holding registers (FC=03)

Example: **03 006B 0003** – this command is requesting the content of analogue output holding registers # 40108 to 40110

03: The Function Code 3 (read analogue output holding registers)

006B: The Data Address of the first register requested.

(**006B** hex = 107, + 40001 offset = input #40108)

0003: The total number of registers requested. (read 3 registers 40108 to 40110)

Offset	Coil	Address Offset + Coil	Description
40001	0	40001	Sensors' zeroing 0 = zeroing successful 3 = zeroing still in progress 4 = zeroing failed (with critical error) 5 = zeroing complete (with error)

3.4. Read input registers (FC=04)

Input registers holds results measured by analyser, calculated results, value of current and voltage of analogue outputs, other.

Example: 04 0008 0001

04: The Function Code 4 (read analogue input registers)

0008: The Data Address of the first register requested.

(0008 hex = 8 , + 30001 offset = input register #30009)

0001: The total number of registers requested. (read 1 register)

Offset	Register	Addr. Offset + Register		Description
30001	0	30001	Measurement block 1 – result	Each result, calculated value, etc, consists of two consecutive registers: one contains result, the other contains unit and decimal point information. Measurement blocks are described in chapter 3.5
30001	1	30002	Measurement block 1 – unit + DP	LSB – DP (decimal point) MSB – unit (unit codes are described in chapter 3.7)
PGD-100 gas dryer settings:				
30001	9976	39977	Gas pump efficiency	PWM 16 bits (0..65535) - 0÷100% (0% = pump off, 100% = pump max)
30001	9977	39978	Type of ambient temperature sensor	0 = PT500 1 = KTY
30001	9978	39977	Type of gas temperature sensor	0 = thermocouple type K 1 = thermocouple type E 2 = thermocouple type S 3 = thermocouple type J
30001	9979	39980	Thermocouple reference temperature (cold junction)	0,1°C + 8000H 0000H = result error FFFFH = no result
30001	9980	39981	Ambient temperature	0,1°C + 8000H 0000H = result error FFFFH = no result

30001	9981	39982	Gas temperature - Thermocouple measuring temperature (hot junction)	0,1°C + 8000H 0000H = result error FFFFH = no result
30001	9982	39983	2 nd Cooler target temperature	0,1°C + 8000H 0FFFFH = OFF
30001	9983	39984	1 st Cooler target temperature	0,1°C + 8000H 0FFFFH = OFF
30001	9984	39985	Heated filter target temperature	0..200 0FFH = OFF 0FEH = filter not installed
30001	9985	39986	Heated hose target temperature	0..200 0FFH = OFF
30001	9986	39987	Peristaltic pump PWM setting	0..16
30001	9987	39988	Gas pump PWM setting	16 bit (0..65535 → 0..100%)
30001	9988	39989	2 nd Cooler temperature	0,01°C + 8000H 0000H = result error FFFFH = no result
30001	9989	39990	1 st Cooler temperature	0,01°C + 8000H 0000H = result error FFFFH = no result
30001	9990	39991	Heated filter temperature	0,1°C + 8000H 0000H = result error FFFFH = no result
30001	9991	39992	Heated hose temperature	0,1°C + 8000H 0000H = result error FFFFH = no result
30001	9992	39993	Gas dryer report (4 th line in display)	

30001	9993	39994	Gas dryer status	Dryer's simplified status: 0 = ready 1 = warming / cooling 2 = ventilation 3 = error
30001	9994	39995	Firmware version	Firmware version
30001	9995	39996	Vacant	
30001	9996	39997	Measurement blocks	Quantity of measurement blocks in analyser
30001	9997	39998	Fuels	LSB = amount of fuels in analyser MSB = number of selected fuel
30001	9998	39999	Work mode	0 = idle (start of analyser) 1 = continuous 2 = cyclic 3 = delayed cyclic 4 = timetable 5 = XL 6 = 3x XL 7 = n-point 8 = emergency mode 9 = warming up

3.5. Force single coil (FC=05)

Example: **05 00AC FF00** – this command is writing the contents of discrete coil # 173 to ON

05: The Function Code 5 (force single coil)

00AC: The Data Address of coil.

(**00AC** hex = 172, + 1 offset = coil #173)

FF00: The status to write (**FF00** = ON, **0000** = OFF)

Offset	Coil	Address Offset + Coil	Description
1	0	1	Store measurement session
			FF = start measurements storage 00 = stop measurements storage To read status of measurement storage – please see 3.1

3.6. Preset single register (FC=06)

Example: **06 0001 0003** – this command is writing the contents of analogue output holding register # 40002

06: The Function Code 6 (preset single register)

0001: The Data Address of the register

(**0001** hex = 1, + 40001 offset = register #40002)

0003: The value to write

Offset	Coil	Address Offset + Coil	Description
40001	0	40001	Sensors' zeroing
			1 = perform zeroing with ventilation 2 = perform zeroing without ventilation

Measurement blocks

Block number	Address Offset + Register		Description
0	30001	O ₂	volume concentration
	30002		LSB – DP MSB – unit
1	30003	CO ₂	volume concentration
	30004		LSB – DP MSB – unit
2	30005	CH ₄	volume concentration
3	30007	CO high	volume concentration (high range sensor)
4	30009	H ₂ high	volume concentration (high range sensor)
5	30011	CO	volume concentration
6	30013	NO	volume concentration
7	30015	SO ₂	volume concentration
8	30017	H ₂ S	volume concentration
9	30019	H ₂	volume concentration
10	30021	NO ₂	volume concentration
11	30023	N ₂ O	volume concentration
12	30025	CO ₂ low	volume concentration (low range sensor)
13	30027	CH ₄ low	volume concentration (low range sensor)
14	30029	P _{dif}	Differential pressure measured with Photon's +/- gas ports
15	30031	P _{abs}	Atmospheric pressure
16	30033	T _{amb}	Ambient temperature (measured with sensor's type selected in analyser's menu)
17	30035	T _{gas}	Gas temperature (measured with sensor's type selected in analyser's menu)

menu)			
18	30037	T_1	Temperature measured with #1 optional SensTemp module
19	30039	T_2	Temperature measured with #2 optional SensTemp module
20	30041	T_3	Temperature measured with #3 optional SensTemp module
21	30043	T_4	Temperature measured with #4 optional SensTemp module
22	30045	T_5	Temperature measured with #5 optional SensTemp module
23	30047	T_6	Temperature measured with #6 optional SensTemp module
24	30049	T_{int}	Analyser's internal temperature
25	30051	T_{air}	Air temperature (measured at fan of the top part of analyser)
26	30053	$T_{compPhoton}$	Thermocouple reference temperature (cold junction) – measured with sensor connected to Photon's PROBE connector
27	30055	$T_{compDryer}$	Thermocouple reference temperature (cold junction) – measured with sensor connected to PGD-100 PROBE connector
28	30057	$T_{ambPhoton}$	Ambient temperature measured with sensor connected to Photon's T_{AMB} connector
29	30059	$T_{ambDryer}$	Ambient temperature measured with sensor connected to PGD-100 T_{AMB} connector
30	30061	$T_{gasPhoton}$	Gas temperature (thermocouple measuring temperature – hot junction) measured with sensor connected to Photon's PROBE connector
31	30063	$T_{gasDryer}$	Gas temperature (thermocouple measuring temperature – hot junction) measured with sensor connected to PGD-100 PROBE connector
32	30065	P_{flow}	Pressure measured with Photon's Pflow sensor
33	30067	GasFlow1	Flow through analyser measured in main gas channel
34	30069	GasFlow2	Flow through analyser measured in auxiliary gas channel
35	30071	$T_{HoseDryer}$	Heated hose temperature

36	30073	T _{FilterDryer}	Heated filter temperature
37	30075	T _{Cooler1Dryer}	Cooler 1 temperature
38	30077	T _{Cooler2Dryer}	Cooler 2 temperature
39	30079	PressGas	Overpressure in gas channel
40	30081	Iout ₁	Current at analogue output (optional SensAnaOut module)
41	30083	Iout ₂	Current at analogue output (optional SensAnaOut module)
42	30085	Iout ₃	Current at analogue output (optional SensAnaOut module)
43	30087	Iout ₄	Current at analogue output (optional SensAnaOut module)
44	30089	Iout ₅	Current at analogue output (optional SensAnaOut module)
45	30091	Iout ₆	Current at analogue output (optional SensAnaOut module)
46	30093	Iout ₇	Current at analogue output (optional SensAnaOut module)
47	30095	Iout ₈	Current at analogue output (optional SensAnaOut module)
48	30097	Uout ₁	Voltage at analogue output (optional SensAnaOut module)
49	30099	Uout ₂	Voltage at analogue output (optional SensAnaOut module)
50	30101	Uout ₃	Voltage at analogue output (optional SensAnaOut module)
51	30103	Uout ₄	Voltage at analogue output (optional SensAnaOut module)
52	30105	Uout ₅	Voltage at analogue output (optional SensAnaOut module)
53	30107	Uout ₆	Voltage at analogue output (optional SensAnaOut module)
54	30109	Uout ₇	Voltage at analogue output (optional SensAnaOut module)
55	30111	Uout ₈	Voltage at analogue output (optional SensAnaOut module)
56	30113	C _x H _y	volume concentration
57	30115	NO _x	volume concentration
58	30117	CO _{mas}	mass concentration

59	30119	CO _{rel}	relative mass concentration
60	30121	CO _u	undiluted volume concentration
61	30123	NO _{mas}	mass concentration
62	30125	NO _{rel}	relative mass concentration
63	30127	NO _u	undiluted volume concentration
64	30129	NO _{2mas}	mass concentration
65	30131	NO _{2rel}	relative mass concentration
66	30133	NO _{2u}	undiluted volume concentration
67	30135	SO _{2mas}	mass concentration
68	30137	SO _{2rel}	relative mass concentration
69	30139	SO _{2u}	undiluted volume concentration
70	30141	H _{2S} _{mas}	mass concentration
71	30143	H _{2S} _{rel}	relative mass concentration
72	30145	H _{2S} _u	undiluted volume concentration
73	30147	H _{2mas}	mass concentration
74	30149	H _{2rel}	relative mass concentration
75	30151	H _{2u}	undiluted volume concentration
76	30153	N _{2O} _{mas}	mass concentration
77	30155	N _{2O} _{rel}	relative mass concentration
78	30157	N _{2O} _u	undiluted volume concentration
79	30159	CO _{2low} _{mas}	mass concentration
80	30161	CO _{2low} _{rel}	relative mass concentration
81	30163	CO _{2low} _u	undiluted volume concentration

82	30165	CH ₄ low _{mas}	mass concentration
83	30167	CH ₄ low _{rel}	relative mass concentration
84	30169	CH ₄ low _u	undiluted volume concentration
85	30171	NO _x mas	mass concentration
86	30173	NO _x rel	relative mass concentration
87	30175	NO _x u	undiluted volume concentration
88	30177	Flow	Gas flow velocity (measured indirectly with differential pressure sensor and pitot tube)
89	30179	SL	Stack loss
90	30181	SCO	Loss by incomplete combustion
91	30183	ETA	Combustion efficiency
92	30185	ETA ₁	Corrected (incomplete combustion lost) combustion efficiency
93	30187	Lambda	excess air coefficient
94	30189	EAF	excess air factor (according to EPA methods)
95	30191	Toxic index	$\frac{CO}{CO_2}$ ratio
96	30193	Dew point	Measured gas dew point temperature
97	30195	Gas density	Combustion gas density (indirect parameter when calculating dew point)
98	30197	Calculated CO ₂	volume concentration of carbon dioxide, calculated based on oxygen volume concentration and parameters of selected fuel. Valid only for measurements of combustion processes
115	30231	NH ₃	volume concentration
116	30233	NH ₃ mas	mass concentration
117	30235	NH ₃ rel	relative mass concentration

118	30237	NH _{3u}	undiluted volume concentration
119	30239	VOC	volume concentration
120	30241	HCl	volume concentration
121	30243	HCl _{mas}	mass concentration
122	30245	HCl _{rel}	relative mass concentration
123	30247	HCl _u	undiluted volume concentration
124	30249	VOC _{mas}	mass concentration
125	30251	VOC _{rel}	relative mass concentration
126	30253	VOC _u	undiluted volume concentration
127	30255	HHV	Higher calorific value
128	30257	LHV	Lower calorific value
129	30259	C ₃ H ₈	volume concentration
130	30261	C ₃ H _{8mas}	mass concentration
131	30263	C ₃ H _{8rel}	relative mass concentration
132	30265	C ₃ H _{8u}	undiluted volume concentration

3.7. Units

Code	Unit		Code	Unit
0	ppm		16	g/m ³
1	%		17	l/h
2	°C		18	mmHg
3	°F		19	inHg
4	mg/m ³		20	psi
5	g/GJ		21	K
6	hPa		22	kPa
7	Pa		23	MJ/kg
8	mmH ₂ O		24	S
9	inH ₂ O		25	m ³
10	m/s		26	litre
11	mV		27	MJ/m ³
12	V		28	kg
13	mA		29	m (meter)
14	A		30	min
15	no unit			