User Guide
DAT2014
DAT2015
DAT2016

GENERAL DESCRIPTION

All the data shared by a remote module communicating with the Modbus RTU / Modbus ASCII protocol are mapped in tables, where a specific address is associated with each data.
Each data can be of two types:
- "REGISTER", made up of 2 bytes (16-bit word), can be associated with analogue inputs or outputs, variables, set-points, etc...
- "COIL", consisting of 1 single bit, can be associated with digital inputs, digital outputs or logic states.

A register can also contain the image (mirror) of several coils, for example the 16 digital inputs of a device can be read or written individually as bits, addressing the coil related to each input, or they can be read or written as a single port by addressing the associated register, where each bit corresponds to a coil.
In the Modbus protocol, registers and coils are divided into the following address banks:

0xxxx and 1xxxx = Coils (bits)
3xxxx and 4xxxx = Registers (word)

To use the register and coil reading and/or writing functions, refer to the tables in this manual.
It is possible to access the internal registers of the module by direct Modbus RTU / Modbus ASCII command.
The module configuration can be performed through the master unit (PLC, SCADA, etc…) or, more simply, through the *"Modbus_3000_10000"* configuration software which can be downloaded from the website *www.datexel.it* in the *"Software & Drivers"* section.
For correct installation of the device, refer to the product data-sheet which can be downloaded from the website *www.datexel.it*
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SUPPORTED MODBUS FUNCTIONS

Modbus Function Code	Modbus Function	(*) Maximum Reading/Writing
01	Read Coil Status	16 coils
02	Read Input Status	16 coils
03	Read Holding Register	16 registers
04	Read Input Register	16 registers
05	Write Single Coil	1 coil
06	Write Single Register	1 register
15 (0x0F)	Write Multiple Coils	16 coils
16 (0x10)	Write Multiple Registers	16 registers

(*) The maximum number of registers that can be written or read using the Modbus functions is in relation to the registers/coils in the *"Modbus Register Mapping"* and *"Coils Mapping"* tables. If registers that are not present in the tables are read or written, the device generates an exception message.

REGISTERS STRUCTURE

The internal registers of Modbus devices are mainly represented in two formats: ***Unsigned Integer*** or ***Signed Integer***. In the signed registers (Signed Integer), the most significant bit represents the sign of the contained value therefore the values represented are between ±32767 while in the unsigned ones (Unsigned Integer) the values represented are between 0 and 65535. Therefore, in the case where Signed Integer registers are read and the value is greater than 32767, it is necessary subtract 65536 from the read value to obtain the true signed value.
The registers have the following 16-bit structure (WORD):

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Descr	MSB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	LSB
Byte	HB (1 byte)								LB (1 byte)							

Legend:
MSB → Most Significant Bit
LSB → Least Significant Bit
HB → High Byte
LB → Low Byte

MODBUS REGISTERS MAPPING

Modbus Register (base 1)	Modbus Register (base 0)	Description	Register Type/Format	Access	Storage
40001	0	Test		R/W	RAM
40002	1	Firmware[0]	-	RO	FW
40003	2	Firmware[1]	-	RO	FW
40004	3	Module Name[0]	-	R/W	EEPROM
40005	4	Module Name[1]	-	R/W	EEPROM
40006	5	Communication	16-bit, Unsigned	R/W	EEPROM
40007	6	Address / Node	16-bit, Unsigned	R/W	EEPROM
40008	7	Delay RX/TX	16-bit, Unsigned	R/W	EEPROM
40009	8	Watchdog Timer	16-bit, Unsigned	R/W	EEPROM
40010	9	System Flags	16-bit, Unsigned	R/W	RAM/EEPROM
40011	10	Input Type ch 0 / ch 1	16-bit, Unsigned	R/W	EEPROM
40012	11	Temperature Scale (°C,°F, K) ch 0 / ch 1	16-bit, Unsigned	R/W	EEPROM
40013	12	Offset CJC ch 0	16-bit, Signed	R/W	EEPROM
40014	13	Offset CJC ch 1	16-bit, Signed	R/W	EEPROM
40015	14	CJC Measure ch 0	16-bit, Signed	R/W	RAM
40016	15	CJC Measure ch 1	16-bit, Signed	R/W	RAM
40017	16	Input measure ch 0	16-bit, Signed	R/W	RAM
40018	17	Input measure ch 1	16-bit, Signed	R/W	RAM
40019	18	Input Offset ch 0	16-bit, Signed	R/W	EEPROM
40020	19	Input Offset ch 1	16-bit, Signed	R/W	EEPROM

COILS MAPPING

Modbus Coil (base 1)	Modbus Coil (base 0)	Description	Register Type/Format	Access	Storage
00001	0	Input Break Status ch 0	1-bit	RO	RAM
00002	1	Input Break Status ch 1	1-bit	RO	RAM
00009	8	Watchdog Enable	1-bit	R/W	EEPROM
00010	9	Watchdog Event	1-bit	R/W	RAM
00011	10	Power-Up Event	1-bit	R/W	RAM
00012 (*)	11	Enable Internal CJC ch 0	1-bit	R/W	EEPROM
00013 (*)	12	Enable Internal CJC ch 1	1-bit	R/W	EEPROM

NOTES:

1. The registers and coils marked in the 'Access' column with the wording RO are read only registers.
2. The registers and coils marked in the 'Access' column with the wording R/W are read and write registers (Read / Write).
3. The registers and coils marked in the 'Storage' column with the wording EEPROM reside in the non-volatile memory therefore they retain their value permanently even in the event of a power failure.
   Note: these registers / coils must not be written continuously because the EEPROM could be irreparably damaged.
4. The bank 0xxxx is the mirror of the bank 1xxxx, as the bank 3xxxx is the mirror of the bank 4xxxx, so for example the first register can be addressed indifferently as 30002 (with function 04) or 40002 (with function 03).
5. FW → fixed by firmware. The value is defined in the firmware.
   EEPROM → the value is stored in a non-volatile memory permanently (see note 3).
   RAM → the value is stored in a volatile memory. In the absence of power supply, the stored value is cleared.

MODBUS REGISTERS DESCRIPTION

40001: TEST
Reserved

40002 / 40003: FIRMWARE VERSION
Field of 2 read only registers that contains the firmware identifier provided by the manufactured. The value changes in function of the device.
DAT2014: Firmware version K100
DAT2015: Firmware version K200
DAT2016: Firmware version K300

40004 / 40005: DEVICE NAME
Field of 2 read/write registers (4 bytes or 4 ASCII characters) available for the user. It contains the name of the device or an abbreviation that identifies its function inside the plant. Each one of the 4 bytes could be written by values from 0 to 255, ASCII characters included.
The default value of this field contains the identifier of the device expressed in ASCII characters. The value changes in function of the device.
DAT2014: "2014"
DAT2015: "2015"
DAT2016: "2016"

40006: COMMUNICATION
If the user wants to set the communication parameters by PC, it is necessary to set the bits of this register referring to the table below in order to configure baud-rate, stop bit, parity and mode.
- Default of manufacturer: 38400 bps, mode RTU, parity NONE, stop bit 1

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Descr	-	-	-	-	-	-	-	-	-	M	P1	P0	N	B2	B1	B0

Modbus Protocol	M
ASCII	0
RTU	1

MODBUS RTU			
Stop bit	Parity	P1	P0
1	None	0	0
1	Even	0	1
1	Odd	1	0
2	None	1	1

N° bit	N
7 bit	0
8 bit	1

MODBUS ASCII			
Stop bit	Parity	P1	P0
1	Mark (*)	0	0
1	Even	0	1
1	Odd	1	0
1	Space	1	1

Baud Rate	B2	B1	B0
2400	0	0	1
4800	0	1	0
9600	0	1	1
19200	1	0	0
38400	1	0	1
57600	1	1	0
115200	1	1	1

NOTES:

- The number of bits is ignored, as in ASCII mode it is fixed to 7 and in RTU mode it is fixed to 8.
- In RTU mode and ASCII mode, the number of "Stop bits" is fixed in relation to the parity configuration chosen
- (*) In ASCII mode, the "Mark" parity configuration with 1 stop bit is equivalent to the "No Parity" (None) configuration with 2 stop bit

40007: ADDRESS
Contains the MODBUS address of the device; the values allowed are from 1 to 254 decimal as address 255 is used for broadcast function.
Each node connected to the same line has a unique address.
- Default value: 01

40008: DELAY RX/TX
Indicates the value of the delay time between the reception of a query and the transmission of the response, expressed as milliseconds.
- Default value: 01(1 ms.)

40009: WATCHDOG TIMER
Contains the value of WatchDog timer , expressed of intervals of 0.5 seconds. If the WatchDog is enabled and the device doesn't receive command for the time set in this register , the WatchDog Alarm will be activated (refer to section "Procedures").
- Default value: 10 (5 sec.)

40010: SYSTEM FLAGS

This register contains the mirror of the Coils table: each bit of the register corresponds to a coil in according to the table below.
It is possible to use this register to read or write all the coils at the same time without having to implement the specific coil write/read functions (01-02-15).

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Coil (*)	-	-	-	-	-	-	01	00	-	-	-	12	11	10	09	08
Descr							Break Status Ch 1	Break Status Ch 0				CJC Enable Ch 1	CJC Enable Ch 0	PUP Event	WDT Event	WDT Enable

NOTE: (*) Coils based 0

WATCHDOG ALARM Enable (WDT Enable)
Enables the Watchdog alarm. If the alarm is enabled and the device doesn't receive commands for a time higher than the one specified in register 40009, the Watchdog Alarm will be activated (refer to section “Procedures”).
0 = Watchdog disabled.
1 = Watchdog enabled.

WATCHDOG ALARM Event (WDT Event)
Indicates the state of the Watchdog Alarm. If the alarm is enabled and the device doesn't receive commands for a time higher than the one specified in register 40009, this bit is forced to 1. To erase the alarm set this bit to 0. If the bit is forced to 1 by a command of the Master unit, a Watchdog event will be simulated and consequently an alarm condition will be created.
0 = Normal condition
1 = Alarm condition

POWER-UP Event (PUP Event)
This bit is forced to 1 each time the device is powered-on in order to indicated that the device has been switched-off or a reset is occurred. By the set of this bit to 0 and check its state it is possible to monitor if a reset of the device is occurred.
0 = reset occurred
1 = reset not occurred

COLD JUNCTION COMPENSATION Enable channel 0 (CJC Enable Ch 0) – FOR THERMOCOUPLE INPUTS DAT2016 ONLY.
COLD JUNCTION COMPENSATION Enable channel 1 (CJC Enable Ch 1) – FOR THERMOCOUPLE INPUTS DAT2016 ONLY.
They are active for DAT2016 only and enable the cold junction compensation for Thermocouple inputs. If the flags are enabled, the device carries out cold junction compensation using the temperature sensors inside it, returning the temperature values already compensated. If the flag are disabled, the temperatures returned are the absolute one, ie with the reference junction at 0°C.
0 = Internal CJC disabled
1 = Internal CJC enabled

BREAK STATUS Ch 0 – FOR DAT2014 AND DAT2016 ONLY.
BREAK STATUS Ch 1 – FOR DAT2014 AND DAT2016 ONLY.
When a sensor connected to a channel is on break condition (sensor interrupted, cables not connected or over-temperature), the coil associated to the channel is forced to 1.
It is possible to use this register to read and write at the same time all the bits without to implement the specific functions of read and write of coils (01-02-05).

40011: INPUT TYPE / CHANNEL ENABLING

Contains the configuration of the sensor type connected to each input. The value of the input type for channel 0 is contained in the LSB byte, the value of the input type for channel 1 is contained in the MSB byte.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Descr	Input type channel 1								Input type channel 0							

Input values for DAT2014

Input Type	Value (Hex)	Value (Dec)
Res 3000 Ω	10	16
Res 500 Ω	11	17
Pt100	12	18
Ni100	13	19
Pt1000	14	20
Ni1000	15	21

Input values for DAT2015

Input Type	Value (Hex)	Value (Dec)
Volt	04	4
mA	05	5

Input values for DAT2016

Input Type	Value (Hex)	Value (Dec)
90 mV	01	1
200 mV	02	2
800 mV	03	3

Input Type	Value (Hex)	Value (Dec)
Tc J	07	7
Tc K	08	8
Tc R	09	9
Tc S	0A	10
Tc T	0B	11
Tc B	0C	12
Tc E	0D	13
Tc N	0E	14

40012: TEMPERATURE SCALE

In this register it is possible to set for displaying the measurement.
This option is valid only for the device DAT2014 if the selected input is a RTD or for the device DAT2016 if the selected input is a Thermocouple (Tc).
The temperature scale for channel 0 is contained in the LSB byte, the temperature scale for channel 1 is contained in the MSB byte.

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Descr	Temperature scale channel 1								Temperature scale channel 0							

The available temperature scales are:

Value	Unit of Degree	Description
0	°C	Celsius
1	°F	Fahrenheit
2	K	Kelvin

Note: In the case of Fahrenheit temperature scale, the maximum temperature value that can be displayed on the Input Value registers (40017, 40018) is 32000 (3200.0 ° F equivalent to 1760.0 ° C).

40013: OFFSET CJC CHANNEL 0 (FOR DAT2016 ONLY)
40014: OFFSET CJC CHANNEL 1 (FOR DAT2016 ONLY)
Value of calibration of the offset of the CJC measure for thermocouples for each channel of measure. The value is expressed as hundredths of °C, signed.

40015: MEASURE CJC CHANNEL 0 (FOR DAT2016 ONLY)
40016: MEASURE CJC CHANNEL 1 (FOR DAT2016 ONLY)
Contain the values of the temperature of CJC for thermocouples (one per channel, temperature of the terminals to which the Thermocouple is connected). The value is expressed as tenths of °C.

40017: INPUT VALUE CHANNEL 0
40018: INPUT VALUE CHANNEL 1
These registers contain the measure of the input channels converted in engineering unit.
The value expressed and the number of decimal digits depend on the input type as indicated in the tables below.

Values for DAT2014

Input Type	Decimals	Format
Pt100/Ni100	1	Tenth of °C
Pt1000/Ni1000	1	Tenth of °C
Res 3000 ohm	0	Ohm
Res 500 ohm	1	Tenth of Ohm

Values for DAT2015

Input Type	Decimals	Format
Volt	3	mV
mA	3	uA

Values for DAT2016

Input Type	Decimals	Format
90 mV	2	Hundredth of mV
200 mV	2	Hundredth of mV
800 mV	1	Tenth of mV
Thermocouple	1	Tenth of °C

40019: INPUT OFFSET CHANNEL 0
40020: INPUT OFFSET CHANNEL 1
Introduce an offset on the measurements. The values are expressed in the same format as the input register and, in the case of RTD or Tc, is independent of the type of temperature scale selected.

PROCEDURE

USE OF "INIT" FUNCTION

The "INIT" function allows you to set the device in the default configuration, regardless of the programming stored in EEprom.

The INIT forces: mode RTU, parity NONE, baud rate 9600, number of bit = 8, stop bit = 1, address 1

- Connect to the line RS485 only the device to configure.
- Connect the terminal 3 (INIT) to the terminal 2 (V-) .
- Power-on the device.

- Set the communication port with the following values:
  - Mode = Modbus RTU
  - baud-rate = 9600 bps
  - parity = None
  - n° bit = 8
  - bit di stop = 1
- the device will respond to the address 01 .
- Read or write the desired settings into the registers:
  - 40006: "Communication" to set the baud-rate.
  - 40007: "Address" to set the address of the device.
- Switch-off the device.
- Disconnect the terminal 3 (INIT) from the terminal 2 (V-) .
- Power-on the device.
- Set the communication port with the baud-rate configured in the register 40006.
- the device will respond to the address configured in the register 40007.

NOTE: the default configuration values are the following:
- Address: 01
- Baud-rate: 38400 bps
- Protocol: RTU
- Parity: None
- Stop bit: 1

WATCHDOG

The device has the Watchdog timer that, if enabled, activate an alarm each time that the communication between the device and the Master unit is not performed for a time higher that the one configured in to register 40009.
In alarm condition the coil "Watchdog Event" is forced to 1 and the led PW blinks one time per second.
To exit from the alarm condition, send a command to the device, reset the coil "Watchdog Event".The led PW stops to blink.