Tecfluid s.a.
Instrumentation for fluids

Communication protocols for MX4B and MX4H converters

Instructions manual

R-MI-MX4COM Rev.: 0 English version

PREFACE

Thank you for choosing the MX4 converter from Tecfluid S.A.

This instruction manual allows the connection, commissioning and operation of the MX4 converter with HART or Modbus communications option. It is recommended to read it before using the equipment.

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MODBUS

1 INTRODUCTION

Modbus is a communication protocol commonly used to connect industrial electronic devices. It is based in a master-slave architecture.

Protocol Modbus RTU uses a compact binary representation of the data and ends its frames with a cyclic redundancy check code.

2 MODBUS DATA MODEL

Modbus bases its data model in four tables with differentiated characteristics.

Discrete Inputs: Read only bits. This type of data can be read by a master device. They are not implemented in Tecfluid Modbus protocol devices.

Coils: Read write bits. These data can be read or written by a master device. They are not implemented in Tecfluid Modbus protocol devices.

Input Registers: 16 bits read only data. This type of data can be read by a master device.

Holding Registers: 16 bits read write data. These data can be read or written by a master device.

3 MODBUS FUNCTIONS

Modbus functions allow access to a device in order to read or modify the value of some of its data. The Tecfluid devices support the following functions:

3.1 Function “Read Input Registers” 0x04h

Gets the value of the "Input Registers" of one or more consecutive addresses of the selected device.

3.2 Function “Read Holding Registers” 0x03h

Gets the value of the "Holding Registers" of one or more consecutive addresses of the selected device.

3.3 Function “Write Single Register” 0x06h

Writes the value of a "Holding register" to the address of the selected device.

3.4 Function “Write Multiple Registers” 0x10h

Writes the value of the "Holding Registers" to several consecutive addresses of the selected device.

4 MODBUS IN MX4B CONVERTER

4.1 Data access

The data that can be accessed in a MX4B converter and their format are the following:

Data	Format	Type
Flow rate	Floating point IEEE 754 32 bits	Read only
Total	Floating point IEEE 754 32 bits	Read write
Analog output 4 mA value	Floating point IEEE 754 32 bits	Read write
Analog output 20 mA value	Floating point IEEE 754 32 bits	Read write
Integration filter	Integer 16 bits	Read write
Status	Integer 16 bits	Read only

4.2 Register addresses

The addresses for the different data are the following:

Input Registers (Read only)

Access (Hex)	Data	Type
0x2000	Flow rate MSB	Floating point
0x2001	Flow rate LSB	Floating point
0x2002	Reserved	---

Holding Registers (Read write)

Address (Hex)	Data	Type
0x3000	Totalizer MSB	Floating point
0x3001	Totalizer LSB	Floating point
0x3002	Flow rate 4 mA MSB	Floating point
0x3003	Flow rate 4 mA LSB	Floating point
0x3004	Flow rate 20 mA MSB	Floating point
0x3005	Flow rate 20 mA LSB	Floating point
0x3006	Totalizer units	Integer
0x3007	Flow rate units	Integer
0x3008	Filter	Integer
0x3009	Status	Integer
0x300A	Reserved	---
0x300B	Reserved	---
0x300C	Reserved	---

5 DEVICE DATA ACCESS

NOTE: The floating point data use two registers. It is recommended to access them with an unique message instead of two consecutive readings or writings.

When using the writing function "Write Single Register" to write a data in floating point, it is imperative to write the lower address first and then the upper one. If done in reverse order generates the error "INVALID DATA VALUE" and the value is not programmed into the device until the two registers that compose the data have been completed.

5.1 Flow rate

Description: Instantaneous flow rate of the converter.

The flow rate data contains the numeric value of the instantaneous flow rate corresponding to flow rate units programmed into the device. Variable is a floating point 32-bit IEEE 754. To access this data on the device is necessary to access two 16-bit registers.

The address 0x2000h corresponds to the most significant 16 bits and address 0x2001h to the least significant 16 bits.

Supported functions:	Read Input Registers. (0x04)		
Addresses:	0x2000	16 bit	Flow rate MSB
	0x2001	16 bit	Flow rate LSB

5.2 Total

Description: Totalizer value.

The Total data contains the numerical value of the cumulative total corresponding to the units programmed into the device. Variable is a floating point IEEE 754 32 Bits. To access this data on the device is necessary to access two 16-bit registers.

The address 0x3000h corresponds to the most significant 16 bits and address 0x3001h to the least significant 16 bits.

Supported functions:	Read Holding Registers. (0x03h)		
	Write Single Register. (0x06h)		
	Write Multiple Registers. (0x10h)		
Addresses:	0x3000h	16 bit	Total MSB
	0x3001h	16 bit	Total LSB

5.3 Flow rate 4 mA

Description: Flow rate beginning of scale of analog output.

Flow rate 4 mA contains the numerical value of the flow rate corresponding to the beginning of the scale of the analog output (4 mA) in the flow rate units programmed into the device.

Variable is a floating point 32-bit IEEE 754. To access this data on the device is necessary to access two 16-bit registers.

The address 0x3002h corresponds to the most significant 16 bits and address 0x3003h to the least significant 16 bits.

Supported functions:	Read Holding Registers. (0x03h)		
	Write Single Register. (0x06h)		
	Write Multiple Registers. (0x10h)		
Addresses:	0x3002h	16 bit	4 mA MSB
	0x3003h	16 bit	4 mA LSB

5.4 Flow rate 20 mA

Description: Flow rate end of scale of analog output.

Flow rate 20 mA contains the numerical value of the flow rate corresponding to the end of the scale of the analog output (20 mA) in the flow rate units programmed into the device.

Variable is a floating point 32-bit IEEE 754. To access this data on the device is necessary to access two 16-bit registers.

Address 0x3004h corresponds to the most significant 16 bits and address 0x3005h to the least significant 16 bits.

Supported functions:	Read Holding Registers. (0x03h)		
	Write Single Register. (0x06h)		
	Write Multiple Registers. (0x10h)		
Addresses:	0x3004h	16 bit	20 mA MSB
	0x3005h	16 bit	20 mA LSB

5.5 Totalizer units

Description: Contains the code corresponding to the totalizer units of the converter. It is a 16 bits integer data type (see totalizer code table).

Supported functions:	Read Holding Registers. (0x03h)		
	Write Single Register. (0x06h)		
	Write Multiple Registers. (0x10h)		
Address:	0x3006h	16 bit	Totalizer units

Units	Data (Hex)
US gal.	0x0001
UK gal.	0x0002
l	0x0003
m^3	0x0004

Totalizer code table

5.6 Flow rate units

Description: Contains the code corresponding to the flow rate units of the converter. It is a 16 bits integer data type (see flow rate code table).

Supported functions:	Read Holding Registers. (0x03h)		
	Write Single Register. (0x06h)		
	Write Multiple Registers. (0x10h)		
Address:	0x3007h	16 bit	Flow rate units

Units	Data (Hex)
US Gal/h	0x0001
US Gal/min	0x0002
US Gal/s	0x0003
Gal/h	0x0004
Gal/min	0x0005
Gal/s	0x0006
l/h	0x0007
l/min	0x0008
l/s	0x0009
m^3/h	0x000A
m^3/min	0x000B
m^3/s	0x000C

Flow rate code table

5.7 Filter

Description: Contains the integration time value between 0 and 40 s.

Supported functions: Read Holding Registers. (0x03h)
Write Single Register. (0x06h)
Write Multiple Registers. (0x10h)

Address: 0x3008h 16 bit Filter

5.8 Status

Description: Contain the status bits of the converter.

Supported functions: Read Holding Registers. (0x03h)

Address: 0x3009h 16 bit

Bit	Status
0	Empty pipe
1	Coil cable disconnected
2	Status relay 1
3	Status relay 2
4 .. 15	Reserved

Note: Bits 3-0 can not be modified. They are read only.

6 EXAMPLES

NOTE: In all examples, where said CRC refers to “Cyclic redundancy check”, that is an error detecting code sent at the end of each frame.

Example 1: Flow rate reading

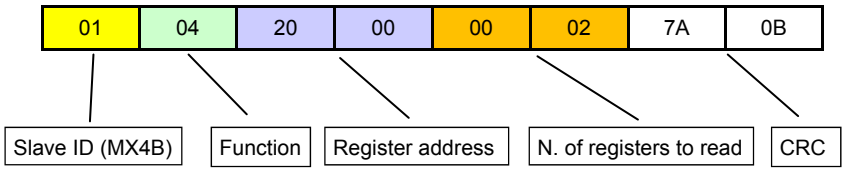
Master requests the slave number 0x01 (MX4B converter) a flow rate.

Slave ID: 0x01

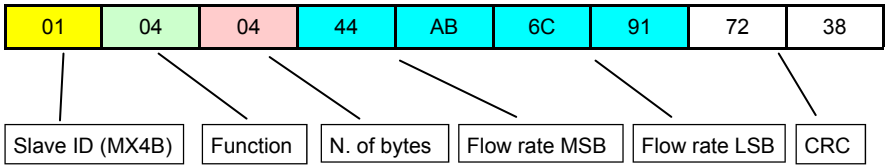
Function: 0x04 (Read input registers)

Initial address: 0x2000

Number of registers to read: 2



The slave responds after more than 3.5 characters, indicating its identification, the requested function code, the number of data bytes to be sent, data and the CRC.



The flow rate received is the floating point 32 bits data 0x44AB6C91 = **1371,31**

Example 2: Totalizer reading

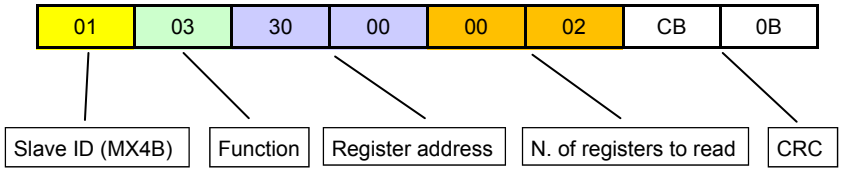
Master requests the slave number 0x01 (MX4B converter) the totalizer value.

Slave ID: 0x01

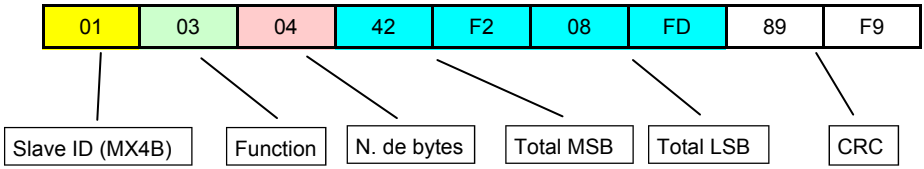
Function: 0x03 (Read holding registers)

Initial address: 0x3000

Number of registers to read: 2



The slave responds after more than 3.5 characters, indicating its identification, the requested function code, the number of data bytes to be sent, data and the CRC.



The totalizer value is the floating point data 0x42F208FD = **121,017555**

Exemple 3. Writing the Flow rate value for 20 mA

Master requests slave number 0x01 (MX4B converter) to write the contents corresponding to Flow rate 20 mA. The value to write is 1400.

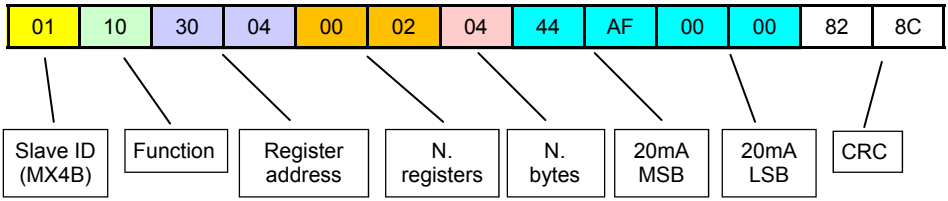
Slave ID: 0x01

Function: 0x10 (Write multiple registers)

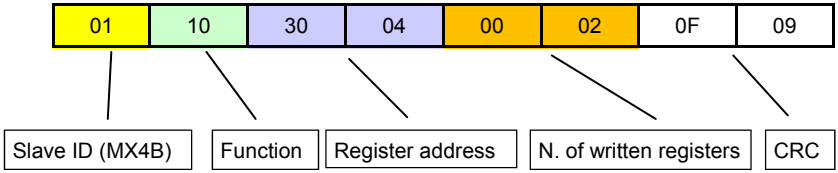
Initial address: 0x3004

Number of registers to write: 2

Data to write: 1400 = 0x44AF0000



The slave responds after more than 3.5 characters, indicating its identification, the requested function code, the register address, the number of registers, the number of written data bytes, data and the CRC.



Example 4. Writing totalizer units.

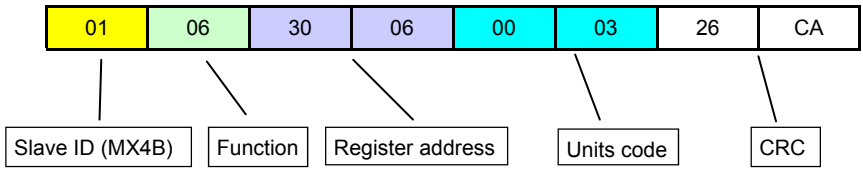
Master requests slave number 0x01 (MX4B converter) to write the corresponding code to totalizer units. The value to write is 0x03 (liters).

Slave ID: 0x01

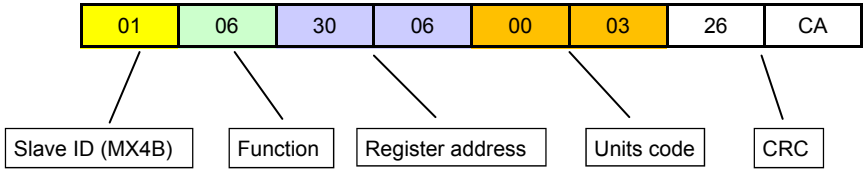
Function: 0x06 (Write Single register)

Initial address: 0x3006

Data to write: 3 = 0x0003



The slave responds after more than 3.5 characters, indicating its identification, the requested function code, the register address, written data and the CRC.



Example 5. Read flow rate units

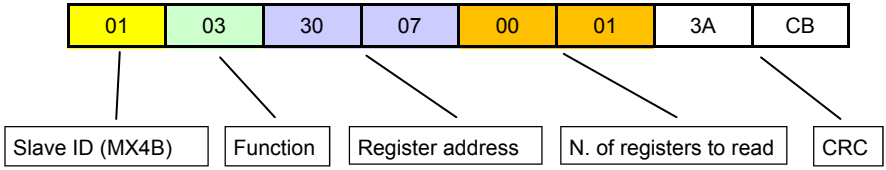
Master requests slave number 0x01 (MX4B converter) to read the corresponding code to flow rate units.

Slave ID: 0x01

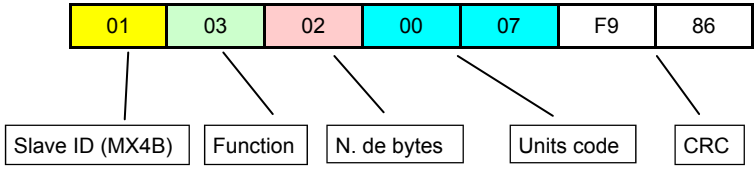
Function: 0x03 (Read Holding registers)

Initial address: 0x3007

Number of registers to read: 1



The slave responds after more than 3.5 characters, indicating its identification, the requested function code, the number data bytes, read data and the CRC.



The received code in the example is 0x0007 that corresponds to **l/h**.

7 ELECTRICAL CONNECTION

For the electrical connection, the MX4 converter has two terminal strips. To help in the wiring of the equipment, the description of the terminals is marked on a label in the rear cover of the device.

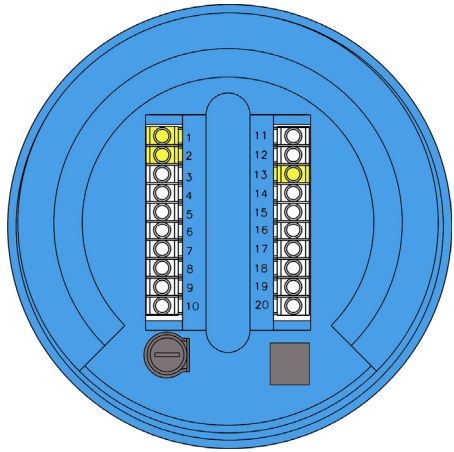
For the electrical connection it is recommended to use multiple conductor cables with individual cable sections in the order of 0.25 to 0.5 mm^2.

Before starting the installation, check that the cable glands are the right size for the cables to be used. This will guarantee the instrument will stay watertight. The cable glands used are for cables with outside diameters between 3.5 mm and 10 mm.

To connect the cables, peel the outside insulation to free the inner cables. It is recommended to put a terminal at the ends of the wires to avoid loose ends. Pass the cables through the cable glands and screw down in the corresponding positions of the terminal strip. Once the wiring is finished make sure that the cables are well gripped by the cable glands to maintain the degree of protection.

Incorrect installation of the cable gland or inadequate cable placement can cause irreparable damage to the converter.

The recommended cable is a three wire cable with a shield. These cables should have a characteristic impedance of 120 Ω.



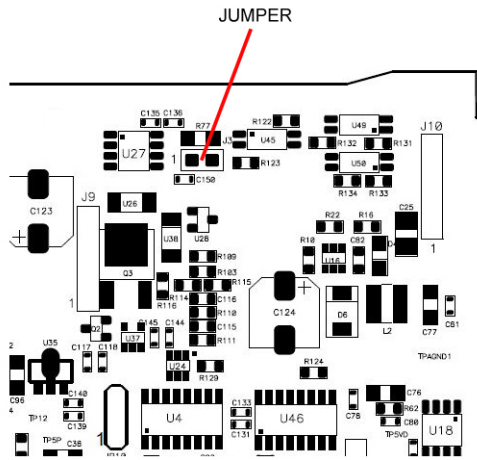
Terminal	
1	B
2	A
13	GND

It is recommended that the shield is connected to ground only in one of its ends.

The cable connection between the MX4B converter and a Master is the following:

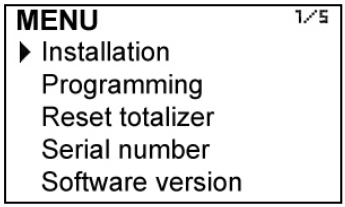
MX4B Converter	Master
Terminal A	A/D-
Terminal B	B/D+
GND	G/Reference

In some cases in which several devices are connected in a line it is necessary to incorporate an impedance at the end. If the converter MX4B is the last device of the line, the impedance can be set by placing a jumper in the position shown in the figure below.



8 CONVERTER PROGRAMMING

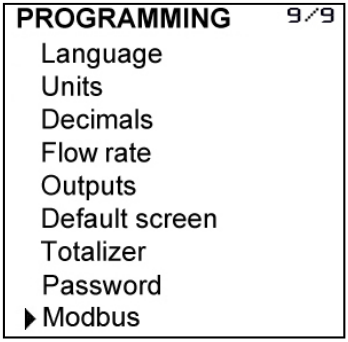
Turn on the converter and press (Enter)  to go to the main menu. The following screen appears:



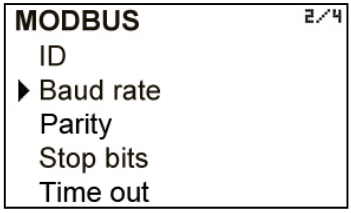
With the keys (Down / Left) and (Up), select Programming, and then validate with the key (Enter).

To access the programming of the converter, you must enter the password. At first access, the default password is 0123. For more details about the password, see the instructions manual of the instrument (R-MI-FIMX4 or R-MI-FAMX4).

Once the password is entered, the first screen allows to choose between the different programming options.



Go to the Modbus option and press (Enter). It appears the screen that allows to program the communication parameters.

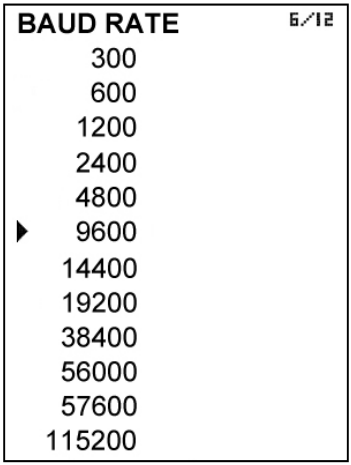


8.1 Slave address

In this screen the slave address can be assigned to the converter. This address must be unique, that is, no other slave devices in the bus can have the same number.

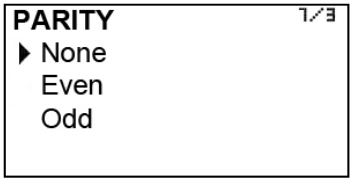
8.2 Baud rate

It determines the data transmission speed. All the devices in the bus have to be configured with the same baud rate.



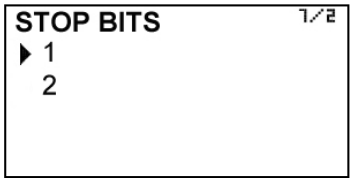
8.3 Parity

It is used to detect communication errors. All the devices in the bus have to be configured with the same parity .



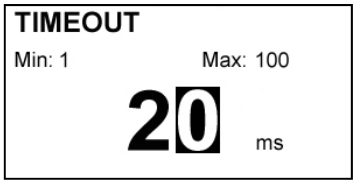
8.4 Stop bits

It allows to choose the number of stop bits. All the devices in the bus have to be configured with the same number of stop bits.



8.5 Timeout

It is the minimum time between frames. Default value is 20 ms. In this screen a different value can be programmed, taking into account that it must be at least the time corresponding to 3.5 characters. If a lower value is intended to be programmed, the converter will limit internally the timeout to that value.



Once the previous steps are done, a communication with a master can be established.

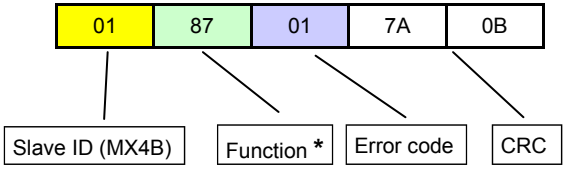
9 ERRORS

MX4B converter can report errors when transmitting or receiving processes.

The implemented errors in the converter are the following:

Error	Code (Hex)	Description
Function not implemented	0x01	The function requested by the master is not implemented by the MX4B converter
Wrong data address	0x02	The register intended to be accessed (read or write) is beyond the limits allowed by the converter
Wrong data value	0x03	The value contained in the data field is not allowed by the converter.

When any of these errors is detected, MX4B converter responds with a frame with the following structure:



* The function is the same as sent by the master, changing the first bit from 0 to 1.

In the example the function sent by the master was 07 and the converter responds with code 01 (function not implemented).

HART

1 INTRODUCTION

HART is a bi-directional communication protocol that provides data access between intelligent field instruments and host systems. A host system can be any software application from a handheld terminal to control plant processes, asset manager, safety or other system using any control platform.

HART protocol is based on a current loop, and has the peculiarity that provides two simultaneous communication channels, the analog signal of 4-20 mA and digital signal.

Signal 4 to 20 mA communicates the primary measured value (in the case of a field instrument) using the 4-20 mA current loop.

Additional device information can be transmitted by a digital signal superimposed on the analog signal.

MX4H Converter is a field instrument that meets the HART protocol revision 6.0.

This document specifies all the functions implemented MX4H regarding the protocol converter.

MX4H Converter is fully compatible with the **HART Server** software from HART Communication Foundation.

Tecfluid S.A. do not guarantee that the MX4H converter is compatible with the different servers on the market.

2 DEVICE IDENTIFICATION

Manufacturer:	Tecfluid S.A.
Model:	Converter MX4H
Manufacturer identification code:	204 (0xCC)
Device code:	141 (0x8D)
HART revision	6.0
Number of device variables:	2
Physical layer supported:	FSK
Device category:	Transmitter

3 DESCRIPTION OF LOOP CURRENT

There is one current loop.

The current output is related directly to the measured flow rate of the process input, which in turn is the primary variable (PV).

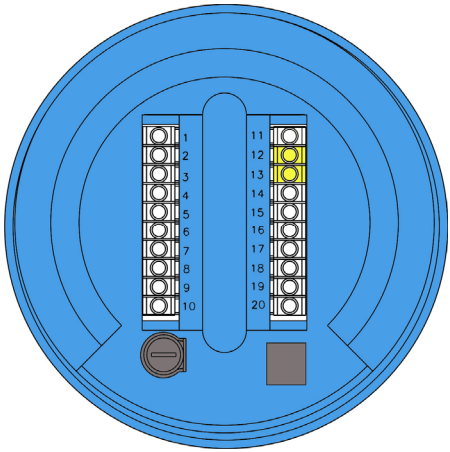
The output range is from 4 mA to 20 mA for full scale output.

The maximum current drawn is 20 mA at and above 100 % of full scale.

The Multi-Drop (loop disabled) current is 4 mA.

The receive impedance is Rx > 8,5 MΩ and Cx < 200 pF

3.1 Current loop connection



Terminal	
12	mA (+)
13	mA (-)

The mA output is galvanically isolated.

NOTE: The analog output incorporates a protection against polarity inversion. Due to a second overvoltage protection, if a power supply voltage higher than 32 V is connected, the converter could be damaged.

In the case of a HART transmitter, an external resistor (R) must be included. Its minimum value will be 200 Ω, and the maximum value will depend on the current loop power supply.

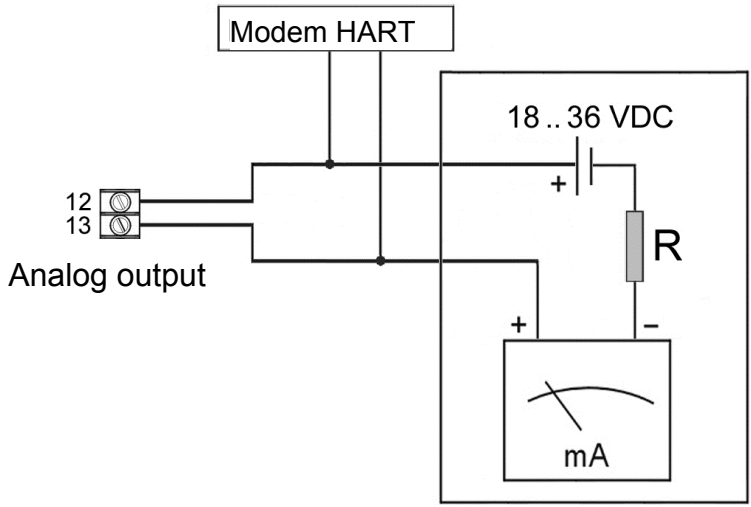
$$R(Ohm) = \frac{V - 12}{20 \cdot 10^{-3}}$$

Therefore, the minimum operating voltage will be V = 16 V.

$$200 = \frac{V - 12}{20 \cdot 10^{-3}}$$

This value is calculated without taking into account the resistance of the cable.

This resistance will depend on each cable type and length, and must be added to the load resistor to calculate the minimum operating voltage of the system.



Connection diagram

4 VARIABLES

4.1 Device variables

The MX4H converter has 2 device variables:

Number	Classification	Name	Units code
0	66	Flow rate	16, 17, 18, 19, 22, 24, 28, 30, 131, 136, 137, 138
1	68	Totalized volume	40, 41, 42, 43

4.2 Dynamic variables

There is only one dynamic variable in the device. This is the flow rate and it is associated to the loop current.

5 COMMANDS

5.1 Universal commands

All universal commands are available. Commands with some points to take into account are:

Command 3. It returns the “Primary variable” with 9 data bytes in the response.

Command 14. Returns the following frame:

“0x00, 0x00, 0x00, PV units code, 0x7F, 0xA0, 0x00, 0x00, 0x7F, 0xA0, 0x00, 0x00, 0x7F, 0xA0, 0x00, 0x00”

This frame indicates the master that the MX4H converter has not transducer information implemented.

Command 15. Returns PV units code in byte 2. Internally, Upper and Lower Range units are the same as Primary Variable units.

Command 18. It can return a response code 9 “Invalid Date Code”. The date code is filtered, “day” byte must be in the range from 1 to 31 both inclusive and “month” byte must be between 1 and 12 both inclusive.

Command 48. Returns 8 data bytes. Specific Device Status bytes are the following:

Byte	Bit	Meaning	Class	Field Device Status bits set
0	0x01	This bit is set when a configuration data error is detected on a cold start or reset of the device and the configuration data has been recovered from block 1 of data memory	Warning	0x10
	0x02	This bit is set when a configuration data error is detected on a cold start or reset of the device and the configuration data has been recovered from block 2 of data memory	Warning	0x10
	0x04	This bit is set when a configuration data error is detected on a cold start or reset of the device and the configuration data has been recovered from block 3 of data memory	Warning	0x10
	0x80	Default values have been loaded into memory	Error	0xE0

Bits not mentioned are not used and are always reset to “0”.

For byte 0, bits 0x01, 0x02 & 0x04 resets when command 48 is answered. Bit 0x80 is reset when all bits from byte 1 are 0.

Byte	Bit	Meaning	Class	Commands that can reset the bit	Field Device Status bits set
1	0x10	Lower range has not been configured	Warning	35	0x80
	0x20	Upper range has not been configured	Warning	35	0x80
	0x40	Flow rate (PV) units have not been configured	Warning	44	0x10

The three bits in byte 1 are set when a configuration data error is detected on a cold start or reset of the device. Each bit is reset when the corresponding data is accessed by a write command or manually by the operator.

Byte	Bit	Meaning	Class	Commands that can reset the bit	Field Device Status bits set
2	0x40	Polling Address has not been configured	Warning	6	0x10
	0x80	Tag has not been configured	Warning	18	0x10

In byte 2, bits 0x40 and 0x80 cannot be reset manually by the operator

Bytes 3, 4 & 5 of Device Specific Status are not used and all their bits will be reset “0”.

5.2 Common practice commands

Command implemented are the following:

Number	Command
33	Read Device Variables
34	Write Primary Variable Range Values
35	Write Primary variable Damping Values
38	Reset Configuration Changed flag
40	Enter/Exit Fixed Current Mode
44	Write Primary Variable Units
48	Read additional device status

6 BURST MODE

MX4H converter does not support Burst Mode.

7 OPERATING MODES

The converter MX4H implements fixed current mode.

To change to this mode Command 40 can be used.

The output current can be set to any fixed value between 4 mA and 20 mA.

By sending Command 40 to the MX4H with a value of “0” the fixed current mode will be exited.

This mode is automatically exited on a device reset or power up.

Current signalling can be disabled using Command 6. In this case the current output will be set to 4 mA.

Current signalling is normally disabled when the converter is part of a network coexisting with other instruments.

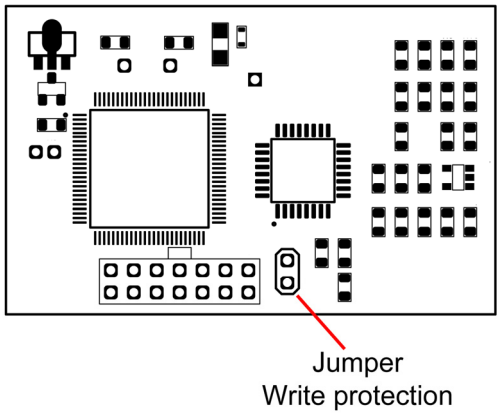
When current signalling is disabled using the “Loop Current Mode = 0” in Command 6, the only way in which current signalling can be enabled is through the use of Command 6 and setting “Loop Current Mode = 1”.

If there is a power up, current signalling keeps this operating mode.

8 WRITE PROTECTION

Write protection is provided, selected by an internal jumper.

When the jumper is present, all commands are accepted. When the jumper is absent, no write commands or local configuration changes are accepted.



Resume of the main communication characteristics:

Manufacturer, Model and Revision	Tecfluid S.A., converter MX4H, Rev. 0
Device type	Transmitter
HART revisión	6.0
Device Description available	No
Number and type of sensors	1, exterior
Number and type of actuators	0
Number and type of host side signals	1, 4 – 20 mA analog
Number of Device Variables	2
Number of Dynamic Variables	1
Mappable Dynamic Variables	No
Number of Common Practice Commands	7
Number of Device Specific Commands	0
Bits of Additional Device Status	9
Burst mode?	No
Write Protection?	Yes

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WARRANTY

Tecfluid S.A. guarantees all the products for a period of 24 months from their sale, against all faulty materials, manufacturing or performance. This warranty does not cover failures which might be imputed to misuse, use in an application different to that specified in the order, the result of service or modification carried out by personnel not authorized by Tecfluid S.A., wrong handling or accident.

This warranty is limited to cover the replacement or repair of the defective parts which have not damaged due to misuse, being excluded all responsibility due to any other damage or the effects of wear caused by the normal use of the devices.

Any consignment of devices for repair must observe a procedure which can be consulted in the website www.tecfluid.com, “After-Sales” section.

All materials sent to our factory must be correctly packaged, clean and completely exempt of any liquid, grease or toxic substances.

The devices sent for repair must enclose the corresponding form, which can be filled in via website from the same “After-Sales” section.

Warranty for repaired or replaced components applies 6 months from repair or replacement date. Anyway, the warranty period will last at least until the initial supply warranty period is over.

TRANSPORTATION

All consignments from the Buyer to the Seller´s installations for their credit, repair or replacement must always be done at freight cost paid unless previous agreement.

The Seller will not accept any responsibility for possible damages caused on the devices during transportation.