ModMAG®
M-Series® | Electromagnetic Flow Meters

# Electromagnetic Flow Meters

## M1000 Modbus Map


Badger Meter

MAG-UM-03381-EN-02 (February 2021)

# Installation Manual

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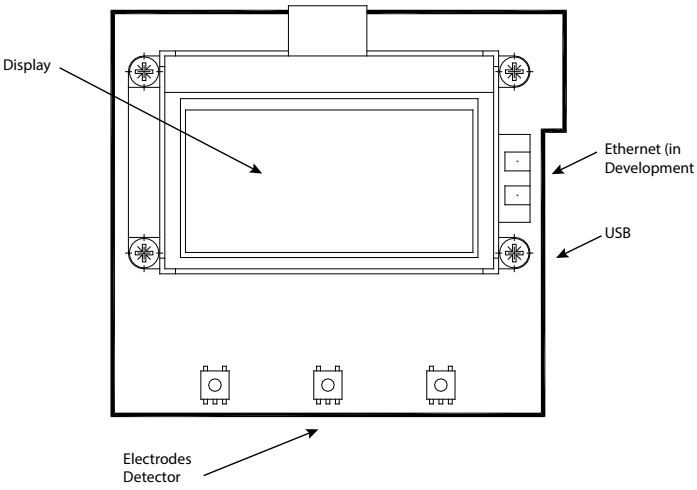
# SCOPE OF THIS MANUAL

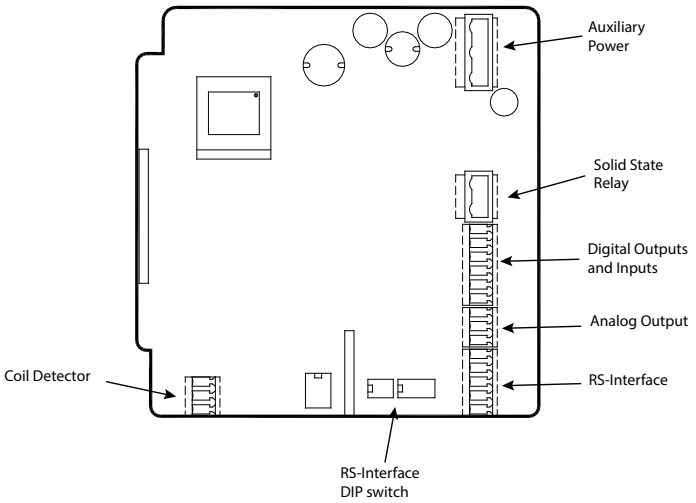
This manual is designed to instruct on how to set up the M1000 Flow Meter for Modbus communications.

# OVERVIEW

The M1000 supports Modbus RTU communications. Physical layers are: RS-232, RS-422, RS-485, USB CDC, and Ethernet (if assembled).

## Wiring




### Wiring diagram for RS232, RS422, and RS485

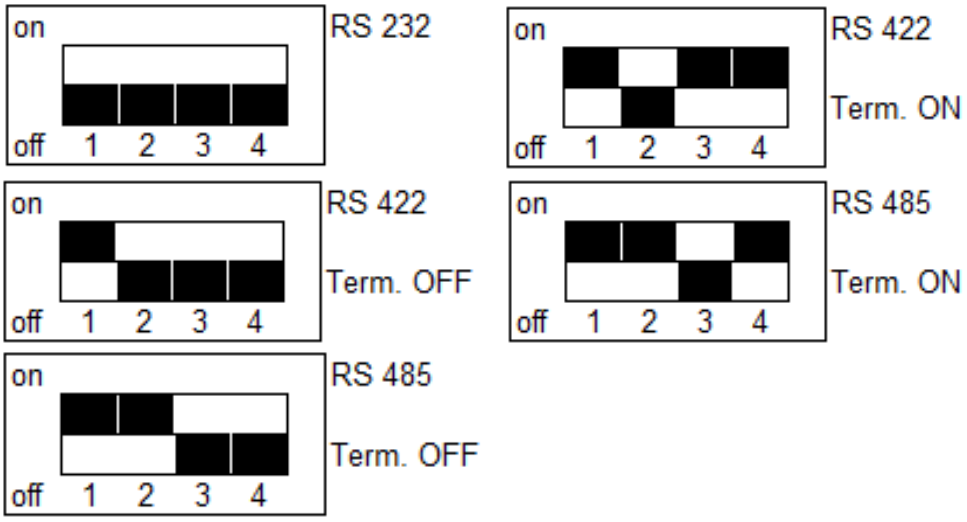
**M1000** **External Device**

| | RS | | |
|---|---|---|---|
| | 422 | 232 | 485 |
| A | A | RxD | |
| B | B | | |
| Z | Z | TxD | B |
| Y | Y | | A |
| GND | GND | | |

### Interface Mode Selection and Termination of the Bus

RS232, RS485 and RS422 with Modbus® RTU.

Mode can be configured by DIP switches. Each terminal can be switched ON or OFF.




# REGISTERS

## Register Name

Register Name, when applicable, describes the parameter so it can be associated within the display menu items. Please note, not all registers can be modified directly by the menu manager. Some registers are not accessible via the menu manager.

## Register Security

Register Security identifies the security level required for the register to be reprogrammed. This feature does not prevent reading of the register. Registers listed with ADMIN, SERVICE or USER security levels are unprotected if no PIN is set for the meter. There are several different levels of security:

- **READ-ONLY** – Only the flow meter firmware can update the register
- **FACTORY** – Registers can only be written by the factory
- **ADMIN** – Register requires administrator level access
- **SERVICE** – Register requires service level access
- **USER** – Register requires user level access

All registers can be protected by enabling security on the flow meter. Once the flow meter is secured, all registers are write-protected unless remote privilege is granted. All read accesses to registers are still accepted when the flow meter is secured. Obtaining remote privilege for write operations requires a sequence of Modbus actions to take place. The remote login process is encrypted to protect the login PINs.

1. Read the random value register (Address 0x012B).
2. Perform necessary calculations (contact Badger Meter for details).
3. Write the remote login register (Address 0x012F).

A support application has been written to perform this process and is embedded within the main application software used to access the flow meter.

## Register Address

Register Address defines the physical address that is required to be transmitted over the Modbus RTU serial link. Some third-party applications require the use of logical addressing when communicating over Modbus. The logical address determines the Modbus function code that is transmitted over the serial link.

Logical address range 4xxxx is supported. Logical address range 4xxxx issues the Read Holding Register function code 0x03. All logical addresses start at index 1 (example, 40001).

For example, suppose the application requires logical addressing and is targeting to access the "Flow Rate [User Units]" register. The physical address for this register is 0xF1 or 241d. This register can be read from logical address 40242. The logical address is calculated by adding the physical address to the logical start address (40001).

40001 + 241 = 40242 (Issues function code 0x03 – Read Holding Register)

## Register Type

Register Type identifies the number of registers the parameter requires. Each register is 16 bits. Supported Register Types include:

| Register type | Description | Number of Modbus registers |
|---|---|---|
| HEXADECIMAL[x] | Unsigned Character (16 bits) | x |
| UCHAR8[x] | Unsigned Character Array | x/2 |
| UINT16 | Unsigned Integer (16 bits) | 1 |
| UINT64 | Unsigned Integer (64 bits) | 4 |
| UINT32 | Unsigned Integer (32 bits) | 2 |
| FLOAT32 | Floating Point (32 bits) | 2 |

For FLOAT32 register types, these registers make use of IEEE-754 floating point standard. For example, 1.0 is transmitted as 0x3F800000. Modbus serial link transmits the most significant byte first, 0x3F, followed by 0x80, 0x00, 0x00.

## Support Function Codes

Following table identifies the Modbus function codes (commands) available to access the register. Supported Modbus function codes include:

| Modbus function code | Description |
|---|---|
| 0x03 | Read holding register |
| 0x10 | Write multiple registers |

## IMPORTANT

*Write function codes update only the working register located in volatile memory. Any sequence of writes must be followed by a write of value 0x01 to the "Command Action Request Register", address 0x0125. Otherwise changes will be lost if the flow meter is power cycled or reset.*

*It is not possible with read function code 0x03 to read blocks of registers. Read multiple registers in one transmission is not allowed.*

# M1000 MEMORY MAP BY REGISTER ADDRESS

| Register Address | Register Name | | Register Type | Security | Stored in Non-volatile Memory |
|---|---|---|---|---|---|
| 0x0000 | Product code | 4 : M1000R | UINT16 | Read-Only | |
| 0x0001 | HW name | | UCHAR8[16] | Read-Only | |
| 0x0009 | FW name | | UCHAR8[32] | Read-Only | |
| 0x0019 | Application version | | UCHAR8[20] | Read-Only | |
| 0x0023 | Compile date | | UCHAR8[32] | Read-Only | |
| 0x0033 | Compile time | | UCHAR8[32] | Read-Only | |
| 0x0043 | Identification number | | UCHAR8[10] | Factory | Yes |
| 0x0048 | OTP boot checksum | | UCHAR8[6] | Read-Only | |
| 0x004B | Flash OS checksum | | UCHAR8[6] | Read-Only | |
| 0x006F | Detector Diameter | 1: 6mm -1/8inch<br>2: 8mm -1/4inch<br>3: 10mm -3/8inch<br>4: 15mm -1/2inch<br>5: 20mm -3/4inch<br>6: 25mm -1inch<br>7: 32mm -1 1/4inch<br>8: 40mm -1 1/2inch<br>9 : 50mm -2inch<br>10 : 65mm -2 1/2inch<br>11 : 80mm -3inch<br>12 : 100mm -4inch<br>13 : 125mm -5inch<br>14 : 150mm -6inch<br>15 : 200mm -8inch<br>16 : 250mm -10inch<br>17 : 300mm -12inch<br>18 : 350mm -14inch<br>19 : 400mm -16inch<br>20 : 450mm -18inch<br>21 : 500mm -20inch<br>22 : 550mm -22inch<br>23 : 600mm -24inch<br>24 : 700mm -28inch<br>25 : 750mm -30inch<br>26 : 800mm -32inch<br>27 : 900mm -36inch<br>28 : 1000mm -40inch<br>29 : 1050mm -42inch<br>30 : 1200mm -48inch<br>31 : 1400mm -54inch<br>32 : 1600mm -64inch<br>33 : 1800mm -72inch<br>34 : 2000 mm -80 inch | UINT16 | Factory | Yes |
| 0x0071 | Detector factor | | FLOAT32 | Factory | Yes |
| 0x0075 | Detector offset [m/s] | | FLOAT32 | Factory | Yes |
| 0x0079 | Amplifier factor | | FLOAT32 | Factory | Yes |
| 0x007D | Detector current [mA] | | FLOAT32 | Factory | Yes |
| 0x0081 | Power line frequency [Hz] | 0 : 50Hz<br>1 : 60Hz | UINT16 | User | Yes |

| Register Address | Register Name | | Register Type | Security | Stored in Non-volatile Memory |
|---|---|---|---|---|---|
| 0x0082 | Excitation frequency | 1 : 3.125/3.75 Hz<br>2 : 6.25/7.5 Hz<br>3 : 12.5/15 Hz<br>4 : 2.083/2.5 Hz<br>5 : 1.042/1.25 Hz<br>6 : 0.833/0.833 Hz | UINT16 | Service | Yes |
| 0x0083 | Flow unit | 0 : LPS-liter/sec<br>1 : LPM-liter/min<br>2 : LPH-liter/hour<br>3 : M3S-cu.meter/sec<br>4 : M3M-cu.meter/min<br>5 : M3H-cu.meter/hour<br>6 : F3S-cu.ft./sec<br>7 : F3M-cu.ft./min<br>8 : F3H-cu.ft./hour<br>9 : GPS-gal./sec<br>10 : GPM-gal./min<br>11 : GPH-gal./hour<br>12 : MGD-mega gal/day<br>13 : IGS-UKG/sec<br>14 : IGM-UKG/min<br>15 : IGH-UKG/hour<br>17 : OPM-oz./min<br>18 : BPM-barrel/min | UINT16 | User | Yes |
| 0x0084 | Totalizer unit | 0 : L-liters<br>1 : HL-hectoliters<br>2 : $M^3$-cubic meters<br>3 : $Ft^3$-cu. feet<br>4 : USG-US gallons<br>5 : MG-mega gallons<br>6 : MG-mega gallons<br>8 : Oz.-fl. ounces<br>9 : Aft-acre feet<br>10 : bbl-barrel | UINT16 | User | Yes |
| 0x0086 | Full scale velocity [m/s] | | FLOAT32 | Factory | Yes |
| 0x008E | Low flow cutoff [%] | | FLOAT32 | Admin | Yes |
| 0x0090 | Full scale flow [User Units] | | FLOAT32 | Factory | Yes |
| 0x0092 | Flow direction | 0 : UniDirectional<br>1 : BiDirectional | UINT16 | Factory | Yes |
| 0x0094 | Digital Input: function | 0 : None<br>1 : Remote reset<br>2 : Positive zero return<br>3 : Batch reset<br>4 : ADE | UINT16 | Service | Yes |
| 0x0095 | Analog output range | 1 : 4 -20 mA<br>2 : 0 -20 mA<br>3 : 0 -10 mA<br>4 : 2 -10 mA | UINT16 | Service | Yes |
| 0x00A3 | Output #1: Mode | 0 : Normally open<br>1 : Normally closed | UINT16 | Service | Yes |

| Register Address | Register Name | | Register Type | Security | Stored in Non-volatile Memory |
|---|---|---|---|---|---|
| 0x00A4 | Output #1: Function | 0 : Off<br>1 : Flow Alarm<br>2 : Empty Pipe Alarm<br>3 : Error Alarm<br>4 : Pulse Forward<br>6 : Pulse Reverse<br>8 : Preset Batch Output<br>9 : Direction<br>10 : Verification Test<br>11 : Ade<br>12 : Loopback | UINT16 | Service | Yes |
| 0x00B0 | Output #2: Mode | 0 : Normally Open<br>1 : Normally Closed | UINT16 | Service | Yes |
| 0x00B1 | Output #2: Function | 0 : Off<br>1 : Flow Alarm<br>2 : Empty Pipe Alarm<br>3 : Error Alarm<br>4 : Pulse Forward<br>6 : Pulse Reverse<br>9 : Direction<br>10 : Verification Test<br>12 : Loopback | UINT16 | Service | Yes |
| 0x00E9 | Flow velocity [M/S] | | FLOAT32 | Read-Only | |
| 0x00ED | Flow rate [M3/S] | | FLOAT32 | Read-Only | |
| 0x00F1 | Flow rate [User Units] | | FLOAT32 | Read-Only | |
| 0x010B | Scale factor [%] | | FLOAT32 | Service | Yes |
| 0x0114 | Menu Language Setting | 0 : English<br>1 : German<br>2 : Czech<br>3 : Spanish<br>4 : French<br>5 : Russian<br>6 : Italian | UINT16 | User | Yes |
| 0x0115 | Analog input measure value | | FLOAT32 | Read-Only | |
| 0x0119 | Analog input measure counter | | UINT16 | Read-Only | |
| 0x011A | Empty pipe actual resistance [Ohms] | | FLOAT32 | Read-Only | |
| 0x0124 | Empty pipe mode | 0 : Off<br>1 : On | UINT16 | Admin | Yes |
| 0x0125 | Command action request | | UINT16 | Admin | |
| 0x0126 | Analog output calibration point A [mA] | | FLOAT32 | Factory | Yes |
| 0x0128 | Analog output calibration point B [mA] | | FLOAT32 | Factory | Yes |

| Register Address | Register Name | | Register Type | Security | Stored in Non-volatile Memory |
|---|---|---|---|---|---|
| 0x012A | Flow simulation | 0 : 0.0%<br>10 : + 10.0%<br>20 : + 20.0%<br>30 : + 30.0%<br>40 : + 40.0%<br>50 : + 50.0%<br>60 : + 60.0%<br>70 : + 70.0%<br>80 : + 80.0%<br>90 : + 90.0%<br>100 : +100.0%<br>65408 : Off<br>65436 : -100.0%<br>65446 : -90.0%<br>65456 : -80.0%<br>65466 : -70.0%<br>65476 : -60.0%<br>65486 : -50.0%<br>65496 : -40.0%<br>65506 : -30.0%<br>65516 : -20.0%<br>65526 : -10.0% | UINT16 | Service | |
| 0x012B | Random value | | UINT32 | Read-Only | |
| 0x012E | Alarm mode | 0 : Meter error has no influence on analog output<br>1 : Meter error drives output 2 mA below min<br>2 : Meter error drives output 2 mA beyond max | UINT16 | Service | Yes |
| 0x0155 | Digital input: Status | | UINT16 | Read-Only | |
| 0x0201 | Empty pipe counter | | UINT16 | Read-Only | |
| 0x0202 | Pulse: PulsesPerM3 | | FLOAT32 | Service | Yes |
| 0x0204 | Pulse: width | | UINT16 | Service | Yes |
| 0x0205 | Out low | | UINT16 | Service | Yes |
| 0x0206 | Out high | | UINT16 | Service | Yes |
| 0x0207 | Totalizer T1Plus | | FLOAT32 | Read-Only | |
| 0x0209 | Totalizer T1Minus | | FLOAT32 | Read-Only | |
| 0x020B | Totalizer T1BiDir | | FLOAT32 | Read-Only | |
| 0x020D | Totalizer T2Plus | | FLOAT32 | Read-Only | |
| 0x020F | Totalizer T2Minus | | FLOAT32 | Read-Only | |
| 0x0211 | Totalizer T2BiDir | | FLOAT32 | Read-Only | |
| 0x0216 | Totalizer ActualUnit T1Plus | | FLOAT32 | Read-Only | |
| 0x0218 | Totalizer ActualUnit T1Minus | | FLOAT32 | Read-Only | |
| 0x021A | Totalizer ActualUnit T1BiDir | | FLOAT32 | Read-Only | |
| 0x021C | Totalizer ActualUnit T2Plus | | FLOAT32 | Read-Only | |
| 0x021E | Totalizer ActualUnit T2Minus | | FLOAT32 | Read-Only | |
| 0x0220 | Totalizer ActualUnit T2BiDir | | FLOAT32 | Read-Only | |

| Register Address | Register Name | | Register Type | Security | Stored in Non-volatile Memory |
|---|---|---|---|---|---|
| 0x0222 | Pulse: Pulses Per ActualUnit | | FLOAT32 | Service | Yes |
| 0x0224 | Empty Pipe Treshold Resistance | | FLOAT32 | Admin | Yes |
| 0x0226 | Date Time | | DATETIME | Service | Yes |
| 0x0232 | Fault | | HEXADECIMAL | Read-Only | |
| 0x0233 | Port | | HEXADECIMAL | Read-Only | |
| 0x024A | Serial Interface | 0 : None<br>1 : Irda<br>2 : Serial<br>3 : M-Bus<br>4 : Hart<br>5 : RS 485 | UINT16 | Service | Yes |
| 0x025B | Internal Disk Size [byte] | | UINT64 | Read-Only | |
| 0x025F | Internal Disk Free Space [byte] | | UINT64 | Read-Only | |
| 0x0263 | Dataloger period | 1 : 1 Minute<br>15 : 15 Minutes<br>61 : 1 Hour<br>66 : 6 Hours<br>72 : 12 Hours<br>84 : 24 Hours | UINT16 | Service | Yes |
| 0x0265 | MBUS Manufacturer | | UINT16 | Factory | Yes |
| 0x0266 | MBUS product code | | UINT16 | Factory | Yes |
| 0x0267 | Filter median | | UINT16 | Service | Yes |
| 0x0268 | Filter moving average | | UINT16 | Service | Yes |
| 0x0269 | Filter display | | UINT16 | Service | Yes |
| 0x0270 | MBUS primary address | | UINT16 | Service | Yes |
| 0x0271 | ADE control | 0 : Off<br>1 : On | UINT16 | Service | Yes |
| 0x0272 | ADE protocol | 1 : Protocol v.1<br>2 : Protocol v.2<br>3 : Protocol v.3 | UINT16 | Service | Yes |
| 0x0273 | ADE Dial | 0 : 4 Dial<br>1 : 5 Dial<br>2 : 6 Dial<br>3 : 7 Dial<br>4 : 8 Dial<br>5 : 9 Dial | UINT16 | Service | Yes |
| 0x0274 | ADE Resolution | 1 : 10000<br>2 : 1000<br>3 : 100<br>4 : 10<br>5 : 1<br>6 : 0.1<br>7 : 0.01<br>8 : 0.001<br>9 : 0.0001 | UINT16 | Service | Yes |
| 0x0275 | Polarization voltage [v] | | FLOAT32 | Read-Only | |
| 0x0279 | Analog output K | | FLOAT32 | Read-Only | |
| 0x0281 | Analog output Q | | FLOAT32 | Read-Only | |
| | | 0 : M1000 mode<br>1 : M7600 mode | UINT16 | Service | Yes |

# TROUBLESHOOTING

Modbus transmissions can be rejected for various reasons:

- Write request received with an invalid value (out-of range value).
- Write request received to a secured meter.
- Invalid register address supplied in Modbus serial request.
- Invalid number of registers supplied in Modbus serial request (too many or too few).
- Invalid function code supplied in Modbus serial request.

The following error response codes are returned.

| **Error response code** | **Reason** |
|---|---|
| 0x01 – Illegal function code | Request received with invalid function code. |
| 0x02 – Illegal data address | Read/Write request received with invalid number of registers. |
| | Read/Write request received with address not supported. |
| | Write request received to a read-only register. |
| 0x04 – Device failure | Write request received with invalid value. |
| 0x21 | Write request received to a protected parameter (secured device). |

Modbus transmissions may not be responded to for various reasons:

- **Bad CRC** – Verify serial link is properly shielded.
- **Framing / Parity Errors** – Verify serial communication settings match for both the flow meter and application software.
- **Wrong port address** – Verify the flow meter is properly programmed with the correct node address.
- **Duplicate port addresses on serial link** – May cause collisions when multiple meters respond at the same time.
- **Wrong serial wiring** – verify wiring is appropriate.
- For RS485, lack of termination on end devices or lack of biasing by Modbus Master. Flow meter does not provide RS485 biasing. This is assumed to be accomplished by the Modbus Master.

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