

DI-900MB Series Modbus/RS485 Network I/O Modules

Model DI-942MB
Dual Frequency or Pulse Counting Input Module

User's Manual

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Units within the warranty period returned for repair, test, and recalibration are serviced at no charge in accordance with the terms of the warranty policy. The Customer pays all transportation and other charges to the factory.

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Please be sure all returns are shipped with the following information included:

1. "Returned Material Authorization," RMA number, clearly shown on each package. Please call DATAQ Instruments, Inc., at 330-668-1444 to obtain your RMA number.
2. Your company Name with Billing and Shipping Addresses.
3. A complete description of your problem, or re-calibration data.
4. The contact person at your company, with their telephone and facsimile numbers.
5. Non-Warranty returns additionally need your Purchase Order Number.

Please pack your returned instruments in their original shipping cartons, or in equivalent strong protective shipping cartons.

Service and Repair Assistance

This module contains solid-state components and requires no maintenance, except for periodic cleaning and transmitter configuration parameter (zero, full-scale, setpoint, deadband, etc) verification. Since Surface Mount Technology (SMT) boards are generally difficult to repair, it is highly recommended that a non-functioning module be returned to DATAQ Instruments Inc., for repair. The board can be damaged unless special SMT repair and service tools are used. Further, DATAQ Instruments, Inc., has automated test equipment that thoroughly checks and calibrates the performance of each module. Please contact DATAQ Instruments, Inc., for complete details on how to obtain service parts and repair.

CAUTION: Risk of Electric Shock - More than one disconnect switch may be required to de-energize the equipment before servicing.

Preliminary Service Procedure

Before beginning repair, be sure that all installation and configuration procedures have been followed. Make sure that the correct baud rate is selected for the RS232-to-RS485 converter employed. The unit routinely performs internal diagnostics following power-up or reset. During this period, the green "Run" LED flashes.

If the diagnostics complete successfully, the "Run" LED will stop flashing after two seconds and remain ON. This indicates that the unit is operating normally. If the "Run" LED continues to flash, then this is indicative of a problem. In this case, use the Modbus Configuration Software to reconfigure the module and this will usually cure the problem. If the diagnostics continue to indicate a problem (a continuously flashing green LED), or if other evidence points to a problem with the unit, an effective and convenient fault diagnosis method is to exchange the questionable module with a known good unit. DATAQ Instruments' Application Engineers can provide further technical assistance if required. When needed, complete repair services are available from DATAQ Instruments, Inc.

Safety Summary



Means "Caution, refer to this manual for additional information."

IMPORTANT SAFETY CONSIDERATIONS

It is very important for the user to consider the possible adverse effects of power, wiring, component, sensor, or software failures in designing any type of control or monitoring system. This is especially important where economic property loss or human life is involved. It is important that the user employ satisfactory overall system design. It is agreed between the Buyer and DATAQ Instruments, Inc., that this is the Buyer's responsibility.

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1. Introduction

These instructions cover the hardware functionality of the DI-942MB module.

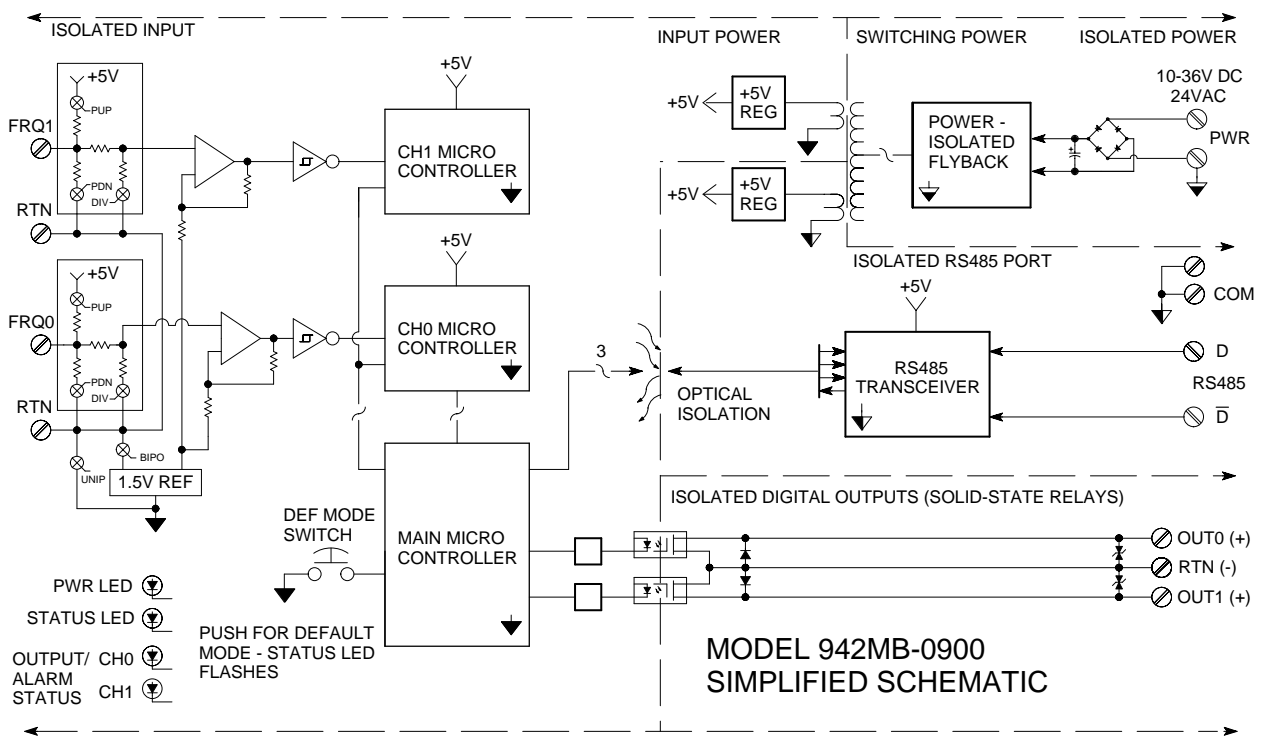
How it Works

These transmitters use a comparator and logic gate to convert the input signal into a digital pulse stream. The comparator provides the threshold and hysteresis, while the logic gate will “square” the wave-shape. Separate microcontrollers sample the input pulse streams and track the number of internal clock cycles to determine the period of the input signal and its frequency. Two methods of determining frequency are used according to the input range.

For the 0-50KHz range, the microcontroller counts the number of input cycles over a gated time period from 0.1 to 1.0s (Gate Time) and calculates the relative period and frequency. Thus, the longest Gate Time is 1 second for this range making 1Hz the slowest possible frequency that can be measured. For this range, input frequencies below 1Hz will read as 0Hz.

For the 0-100Hz and 0-1KHz ranges, the microcontroller measures the period of a signal by counting a specified number of cycles while using the internal clock to track the total time. The total time divided by the number of cycles determines the period. The lowest measurable frequency for these ranges is 0.5Hz, but with a slow input frequency and a high number of cycles, the time to detect a loss of signal may be high. In this case, a specified cutoff frequency is used and any frequency below the cutoff will read as 0Hz.

The microcontroller will compute the input frequency and complete the transfer equation according to the input type and its embedded function. The microcontroller also compares the signal value to the limit value for the alarm function and completes all necessary alarm functionality according to its embedded program. I/O lines of the microcontroller will switch the solid-state relays ON/OFF, as required. The UART of the microcontroller sends/receives its I/O signals to the network via an optically isolated RS485 transceiver. Embedded configuration and calibration parameters are stored in non-volatile memory integrated within the controller. New module functionality can be downloaded from a host computer running the Modbus Configuration Software, or other compatible Modbus software via the network interface. Refer to the simplified schematic that follows to gain a better understanding of the circuit.



Key Features

- **Easy Setup With Windows® Configuration Software** - You don't have to be a programmer to quickly setup and operate this module.
- **RS485/Modbus Network Interface** - Highly immune to noise and can operate over long distances. Allows many modules to network together.
- **High-Speed Data Rates** - RS485 up to 115K baud.
- **Nonvolatile Reprogrammable Memory** - Allows the functionality of this device to be reliably reprogrammed thousands of times.
- **Fully Isolated** - The inputs, outputs, network, and power are all isolated from each other for safety and increased noise immunity.
- **Wide-Band Frequency Inputs With Event Counter** - Two channels of frequency in 3 ranges from 0Hz to 50KHz, plus event counter.
- **High Voltage Inputs** - Signal amplitudes up to 140VAC, or 200V peak.
- **Flexible Interface Supports Many Input Types** - Programmable pull-up and pull-down resistors provide support for a variety of input types.
- **Supports Bipolar or Unipolar Input Signals** - Variable input bias for both zero crossing and non-zero crossing periodic signals. The voltage threshold and relative hysteresis are also user-selectable.
- **Plug-In Terminal Blocks & DIN-Rail Mount** - Make mounting, removal, and replacement easy.
- **Event Counter Alarm Function** - Counts pulses on the positive or negative edge, upward, in the range 0-65535. Counter may latch at a high limit and turn the high alarm output ON, or pulse the alarm output and reset itself to 0 after reaching the high limit. Counter(s) may be reset remotely.
- **Input Filtering** - Inputs include hysteresis, over-sampling (frequency inputs), debounce (event counter), and deadband (alarms).
- **Dual Discrete SSR or Alarm Outputs** - High voltage/current solid-state switches provide for direct or alarm control of external devices, with both failsafe and non-failsafe modes.
- **Self-Diagnostics & Built-In Watchdog** - For easy maintenance and troubleshooting. Includes a hardware watchdog timer built into the microcontroller that causes it to initiate a self reset if the controller ever "locks up" or fails to return from an operation in a timely manner.
- **Wide-Range DC-Power or 24VAC Power** - Non polarized and diode-coupled for use with redundant supplies, and/or battery back-up.
- **I/O Watchdog Timer** - For periods up to 65534 seconds (18.2 hours). Timer will timeout if an I/O channel read or write operation does not occur for the configured time period. Outputs may also be automatically set to user-defined states following timeout.
- **Hardened For Harsh Environments** - For protection from RFI, EMI, ESD, EFT, & surges. Has low radiated emissions per CE requirements.
- **Wide Ambient Operation** - Reliable over a wide temperature range.
- **LED Indicators** - A green LED indicates power. A yellow status LED indicates over-range, default communication mode, and watchdog timeout. Another yellow output LED indicates the On/Off output state.
- **Push-Button Default Communication Mode** - Can set the module to a default set of communication parameters for baud rate, module address, and parity if its internal settings are unknown.
- **Alarm Function With Variable High and Low Limits Plus Deadband** - Includes optional failsafe or non-failsafe alarm outputs.

2. Specifications

General

The Model DI-942MB is a DC-powered, or 24VAC powered, transmitter which conditions two channels of Frequency or Event Counter inputs, and provides an isolated RS485/Modbus network interface, plus two solid-state outputs. The outputs may operate as independent ON/OFF switches, or as limit alarm controls. Isolation is supplied between inputs, the network, power, and the outputs. This network transmitter is DIN-rail mounted.

The unit is configured, calibrated, and controlled with a Windows® Configuration Program, or any software that adheres to the Modbus command/response format for supported commands. Non-volatile reprogrammable memory in the module stores calibration and configuration information. A push button on the module allows communication with a module when its address, baud rate, and parity settings are unknown.

Model Number Definition

DI-942MB-0900: Input transmitters are color coded with a white label. The prefix “900” denotes the Series 900. The “MB” suffix denotes ModBus. The four digit suffix of this model number represents the following options, respectively: 0 = No Options; 9 = Output: RS485/Modbus; 0 = Enclosure: DIN rail mount; 0 = Approvals: CE marked, UL Listed, and cUL Listed

Default Factory Configuration:

PARAMETER	CONFIGURATION
Module Address	247
Baud Rate	9600bps
Parity	None
Response Delay	0 (No Delay)
Watchdog Timer	0 (Disabled)
Output Timeout States	Both ON (Timer Disabled)
Input Range (Each Input)	Frequency, 0-50KHz
Samples	1 (No Input Averaging)
Threshold/Hysteresis	Bipolar 0V \pm 25mV Hysteresis
Event Debounce	5ms
Event Edge	Rising
Event Count Termination	Auto-Reset
Input Resistor	None (Not Connected)
0-50KHz Gate Time	1.0 seconds
Number of Cycles	8 cycles
Cutoff Frequency	0.5Hz
Limits (Each Input)	Alarm Outputs Disabled
High Limit (Each Input)	50KHz (High Endpoint)
Low Limit (Each Input)	1Hz (Low Endpoint)
Deadband (Each Input)	500Hz

Inputs

Frequency: Select 0 to 100.00Hz, 1000.0Hz, or 50KHz. Unit accepts unipolar or bipolar (zero crossing) input signals. Frequency is accurately measured to a minimum of 1Hz (50KHz range), or 0.5Hz (100Hz & 1KHz ranges). Un-measurable frequencies below 1Hz (or 0.5Hz) are indicated as 0Hz. The Status LED will flash if input frequency is un-measurable (below 1Hz), or if the signal amplitude is too low for detection.

Pulse/Event Counter: Upward 0 to 65535, up to 100Hz (debounce = 0), unipolar or bipolar input pulses.

Unipolar Signal Configuration

Threshold/Hysteresis: Select 1.5V/±25mV or 5.0V/±83mV, typical.

Amplitude: 0 to 3V minimum, 200V peak.

Bipolar (Zero-Crossing) Signal Configuration

Threshold/Hysteresis: Select 0.01V/±25mV or 0.03V/±83mV, typical.

Amplitude: 0-20KHz ±50mV minimum with ±25mV hysteresis, or ±150mV minimum with ±83mV hysteresis, to ±200V peak maximum;

20K-50KHz: ±100mV minimum with ±25mV hysteresis, or ±200mV minimum with ±83mV hysteresis, to ±200V peak maximum.

Minimum Pulse Width: Frequency-10us; Event Counter-5ms (5ms ON + 5ms OFF = 10ms period or 100Hz).

Overvoltage Protection: Bipolar Transient Voltage Suppression (TVS).

Resolution: The effective resolution is generally better than the display resolution indicated in the Table below. The sampling mechanism used for the 100Hz & 1000Hz ranges will result in decreased internal resolution with increased frequency. As the input frequency approaches the upper end of the 100Hz & 1000Hz ranges (higher number of cycles), the reduced internal resolution can approach twice the display resolution noted below for these ranges, increasing error.

<u>Input Range</u>	<u>Display Resolution</u>
0 to 100.00Hz	0.01Hz
0 to 1000.0Hz	0.1Hz
0 to 50000Hz	1Hz
0 to 65535 Pulses	1 Pulse

Input & Alarm Accuracy: See Table below. Internal timing is crystal-based for best accuracy, temperature stability, and minimum long term drift. Note the sampling mechanism used for the 100Hz and 1000Hz ranges will result in decreased resolution near the upper end of the range, decreasing the effective accuracy in this region.

Input Range	Accuracy at 25°C	Accuracy (-25 to 70°C)
0 to 100.00Hz	±0.02Hz (f ≤ 50Hz)±0.04Hz (f > 50Hz)	±0.04Hz (f ≤ 50Hz)±0.06Hz (f > 50Hz)
0 to 1000.0Hz	±0.2Hz (f ≤ 500Hz)±0.4Hz (f > 500Hz)	±0.4Hz (f ≤ 500Hz)±0.6Hz (f > 500Hz)
0 to 50000Hz	±10Hz	±15Hz
0 to 65535 Pulses	±1 pulse	±1 pulse

Input Impedance: 36KΩ typical.

Input Response Time/ Input Filter Bandwidth: -3dB at 35KHz, typical. See Input Acquisition and Output Response times for more information.

Input Acquisition Time (Frequency Inputs):	Varies from 100ms to 1 second with input frequency for 0-50KHz range. For 0-1KHz & 0-100Hz ranges, acquisition time is a function of the number of Cycles and the input frequency. For example, a 2Hz signal with Cycles set to 8 will take 4 seconds to acquire (8 Cycles / 2 cycles/second).
Input Pull-Up/Pull-Down (Internal):	Select 2.7K Ω input pull-up to +5V, a 1K Ω input pull-down to RTN, or none to disconnect the internal resistor. WARNING: Do not exceed 11V with internal pullup or pulldown resistors enabled, or damage to the circuit will result. Limit internal pullup/pulldown resistor power to less than 0.125W. Disable the internal pull resistors with AC voltages.
Input Debounce (Event Counter Only):	Set from 0 (disabled) to 1 second in 5ms increments. Set appropriately with respect to input signal bandwidth and characteristics.
Input Averaging (0-100Hz & 0-1KHz inputs only):	Specify the number of wave cycles to sample while tracking total time to determine the input period. Increasing Cycles will increase the response time.
Noise Rejection (Common Mode):	80dB @ 60Hz, typical.
Reference Test Conditions:	25°C ambient; 24VDC power.

Digital Outputs (SSR's)

To control higher voltages and/or currents, or for controlling AC, an interposing relay may be used. Refer to Optional Wiring.

Output Channels:	Two Solid-State Relays (SSR), Form A (SPST-NO). Outputs share a common return at the RTN terminals.
Output Control:	Discrete on/off control, alarm control, or watchdog timeout control. Alarm control of output state has a higher priority than direct control, while watchdog timeout control has the highest priority when enabled. Disable the alarm outputs if direct control is required. Outputs are turned OFF following a software or power-on reset. Note: When the outputs are used to control interposing relays for switching AC & DC devices of higher voltage & current, the coil ratings for the interposing relay shall not exceed 24V DC, 100mA.
Output "OFF" Voltage Range:	0 to +48V DC.
Output "OFF" Leakage Current:	1uA typical at 48VDC.
Output "ON" Current Range (each output):	0 to 1A DC (to 40°C).
Output Deration:	Derate "ON" current above 40°C at 10mA per °C.
Output "ON" Resistance:	0.4 Ω Maximum.
Output "ON" Voltage:	0.4V DC Maximum at 1A DC.
Output Response Time:	5ms typical, from receipt of force coil command to switch transfer. Effective time will vary with output load.

Enclosure and Physical

Dimensions:	1.05 inches wide, 4.68 inches tall, 4.35 inches deep. Refer to the Drawing "Mounting and Dimensions" on page 9.
DIN Rail Mount:	Type EN50022; "T" rail (35mm).

Connectors: Removable plug-in type terminal blocks rated for 15A/300V; AWG #12-24 stranded or solid copper wire.

Case Material: Self-extinguishing NYLON type 6.6 polyamide thermoplastic UL94 V-2, color beige; general purpose NEMA Type 1 enclosure.

Printed Circuit Boards: Military grade FR-4 epoxy glass.

Shipping Weight: 1 pound (0.45 Kg) packed.

Agency Approvals

Approvals: CE marked (EMC Directive 89/336/EEC); UL Listed (UL3121 - First Edition, UL1604); cUL Listed (Canada Standard C22.2, No. 1010.1 -92); Hazardous Locations (Class 1; Division 2; Groups A, B, C, and D).

Environmental

Operating Temperature: -25°C to +70°C (-13°F to +158°F).

Storage Temperature: -40°C to +85°C (-40°F to +185°F).

Relative Humidity: 5 to 95%, non-condensing.

Power Requirements: Non-polarized 12-36V DC SELV (Safety Extra Low Voltage), or 22-26 VAC. See table for current.

Supply	DI-942MB Current Draw
10V	124mA Typical, 135mA Maximum
12V	100mA Typical, 110mA Maximum
15V	80mA Typical, 90mA Maximum
24V	52mA Typical, 60mA Maximum
36V	38mA Typical, 45mA Maximum
24VAC	94mArms Typical, 100mArms Maximum

Power Supply Effect:

DC Volts: $\leq \pm 0.001\%$ of output span change per volt for rated variation.

60/120 Hz Ripple: $\leq \pm 0.01\%$ of output span per volt peak-to-peak of power supply ripple.

Isolation: Inputs, network, power, and outputs, are isolated from each other for common-mode voltages up to 250VAC, or 354V DC off DC power ground, on a continuous basis (will withstand 1500VAC dielectric strength test for one minute without breakdown). Complies with test requirements of ANSI/ISA-82.01-1988 for voltage rating specified.

Note: Input and output channel pairs are not isolated channel-to-channel

Installation Category: Designed to operate in an installation in a Pollution Degree 2 environment with an installation category (Over-voltage Category) II rating.

Electromagnetic Interference Immunity (EMI): Measurement and alarm shift is less than $\pm 0.25\%$ of input span for interference from switching solenoids, commutator motors, and drill motors.

Electromagnetic Compatibility (EMC)

Minimum Immunity Per European Norm EN50082-1:	<p>Electrostatic Discharge (ESD) Immunity: 4KV direct contact and 8KV air-discharge to the enclosure port per EN61000-4-2.</p> <p>Radiated Field Immunity (RFI): 3V/M, 80 to 1000MHz AM and 900MHz keyed carrier, per EN61000-4-3 and ENV50204.</p> <p>Electrical Fast Transient Immunity (EFT): 0.5KV to power and signal I/O per EN61000-4-4.</p> <p>Conducted RF Immunity (CRFI): 3Vrms, 150KHz to 80MHz, per EN61000-4-6.</p> <p>Surge Immunity: 0.5KV per EN61000-4-5.</p>
Emissions Per European Norm EN50081-1:	<p>Radiated Frequency Emissions: 30 to 1000MHz per EN55022 Class B.</p>

Communication Interface

Interface Standard:	3-wire RS-485, half-duplex (D, D-bar, and Common).
Command/Response Protocol:	Standard Modbus RTU protocol as defined under “Modicon Modbus Reference Guide” PI-MBUS-300 Rev J (reference www.public.modicon.com).
Baud Rate:	Can be programmed for 2400, 4800, 9600 (Default Mode rate), 14400, 19200, 28800, 38400, 57600, 76800, or 115200 bits per second.
Parity:	Odd, Even, or None.
Stop Bits:	One for Even or Odd parity, two for no parity. Module will work with 1 or two stop bits with no parity.
Response Delay:	0 to 65500 ticks (1 tick = 1.085us). The minimum communication delay the module waits before sending a reply to the host. As a minimum, it must be set greater than the inherent delay already present to be effective. Some signal converters or host/software systems will not accept an immediate response from a slave without added delay.
Module Address:	0 to 247 (01H-F7H). Default Mode address is 247 (F7H).
Network Capacity:	Multi-drop up to 31 modules, plus a host, without a repeater. Up to 247 modules total if a repeater is used for every 31 nodes plus a host computer.
Communication Distance:	Up to 4000 feet without a repeater.
Default Communication Mode:	Sets communication address to 247, baud rate to 9600bps, and no parity. Used to communicate with a module when its internal address, baud rate, and parity settings are unknown. Enter this mode by pressing the DFT push-button until the yellow ST LED flashes. Exit this mode by resetting the module or by pressing the DFT button until the Status LED stops flashing. Programmed settings for address, baud rate, and parity take effect outside of Default Mode.
I/O Watchdog Timer:	Set for periods up to 65534 seconds (18.2 hours). Timeout is indicated by a rapidly flashing ST status LED, a set bit in the Module Status Register, and optionally via defined digital output timeout states. The timer is reinitiated via a read or write to any input/output channel. Note that clearing a timeout will not automatically restore the outputs to their initial state-outputs have to be driven manually or under alarm control. Another watchdog timer is built into the microcontroller that causes it to initiate a self reset if it ever fails to return from an operation or “locks up.”

Supported Modbus Commands: Per Modbus/RTU standard for Modbus Functions below (Reference refers to the register addresses the function operates on):

Code	Function	Reference
01 (01H)	Read Coil (Output) Status	0xxxx
03 (03H)	Read Holding Registers	4xxxx
04 (04H)	Read Input Registers	3xxxx
05 (05H)	Force Single Coil (Output)	0xxxx
06 (06H)	Preset Single Register	4xxxx
15 (0FH)	Force Multiple Coils (Outputs)	0xxxx
16 (10H)	Preset Multiple Registers	4xxxx
17 (11H)	Report Slave ID	Hidden
08 (08H)	Reset Slave	Hidden

Controls and Indicators

Module Push Button (See Dwg. Default (DFT) - Push to engage or disengage the default communication mode. under “Controls” on page 9 For Default mode sets baud rate to 9600bps, module address to 247, and no parity. Location): Status LED flashes in default mode. A module will leave the default mode following a software or power-on reset.

LED Indicators: Run (Green) - Constant ON indicates power applied and unit OK. Flashing ON/OFF indicates unit is performing diagnostics (first two seconds following power-up), or has failed diagnostics (after a few seconds).

Status (Yellow) - Indicates Default Mode (slow flash), Watchdog Timeout (rapid flash), and input over-range (constant ON).

Output (Yellow, One Per Output) - ON if output relay is ON (closed).

Important: Over-range indication may mask timeout and default mode indication.

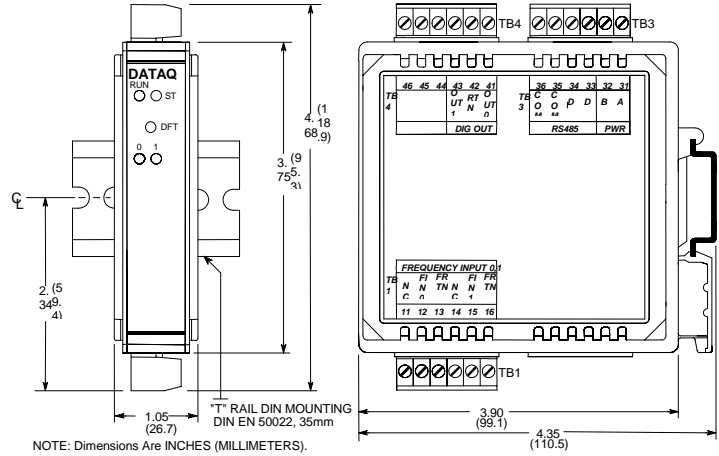
3. Getting Started

Mounting and Dimensions

Unit mounts to "T" type DIN rails (35mm, type EN50022).

Units may be mounted side-by-side on 1-inch centers.

WARNING: IEC Safety Standards may require that this device be mounted within an approved metal enclosure or sub-system, particularly for applications with exposure to voltages greater than or equal to 75VDC or 50VAC.



Controls

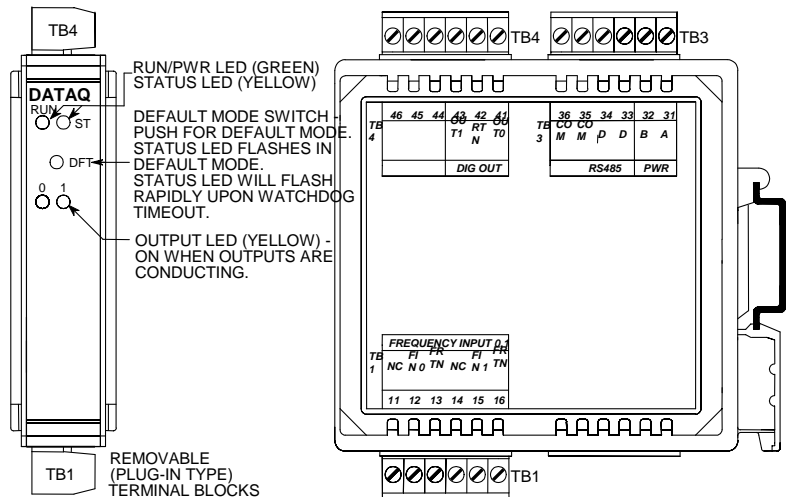
Green Run LED will stay ON if power is on and unit is OK and will blink if unit fails.

Yellow ST LED will blink slowly if module is in Default Mode.

This LED will blink quickly for a watchdog timeout and will stay ON if any channel is open or over-range.

Yellow Output LED's will turn ON if output switch is closed.

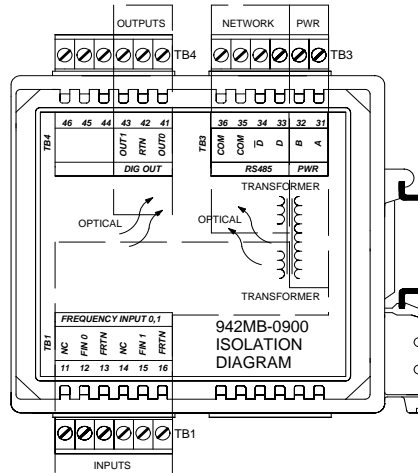
Push the DFT button to place module in Default Mode (ST LED will blink). This sets unit to 9600 baud, address 247, and no parity.



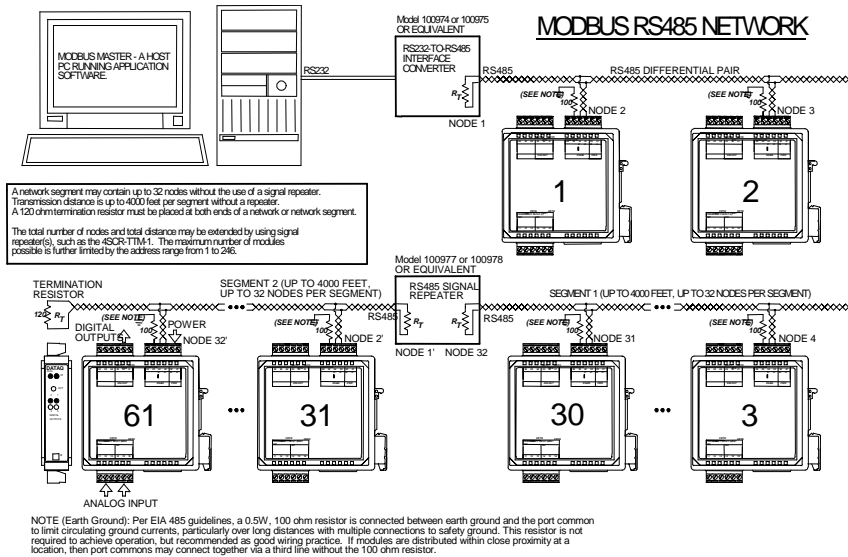
Isolation Barriers

Dashed Lines denote isolation barriers.

The inputs, outputs, network, and power circuits are isolated from each other for safety and noise immunity.



Connections

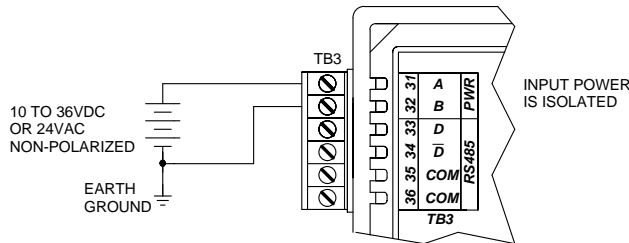


Example Modbus System Connections.

Power

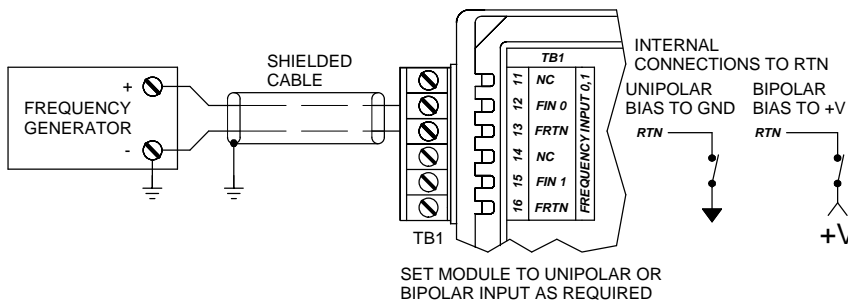
Connect 12-36V DC or 24VAC to the non-polarized power terminals labeled A & B. For supply connections, use No. 14 AWG wires rated for at least 75°C. CAUTION: Do not exceed 36VDC peak power voltage.

<u>Voltage</u>	<u>Current</u>
10VDC	135mA
12VDC	110mA
15VDC	90mA
24VDC	60mA
36VDC	45mA
24VAC	100mArms



Input Connections

Connect Frequency or Pulse signal to the input terminals FIN & FRTN. Refer to the examples below for connections to other types of inputs.



Connection to a standard frequency generator.

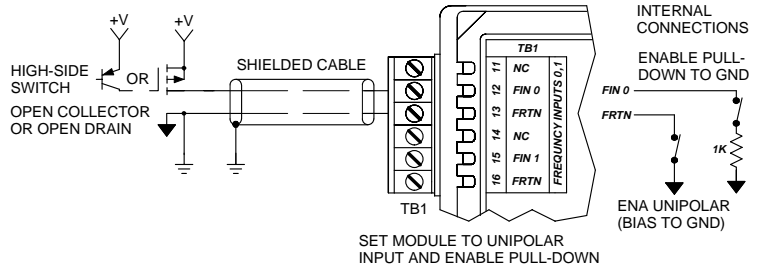
To prevent measurement error, limit maximum input frequency to less than 110% of full-scale.

Limit signal amplitude to $\pm 200V$ peak (disconnect internal pullup/pulldown connections above 11V).

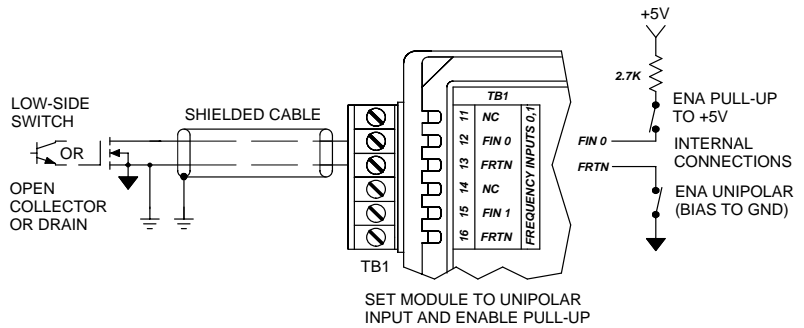
CAUTION: Do not connect internal pull-up or pull-down resistors for voltages greater than 11V peak, or damage to the circuit may result.

For low-side transistor switches, use the on board pull-up resistor. For high-side transistor switches, use the on board pull-down resistor.

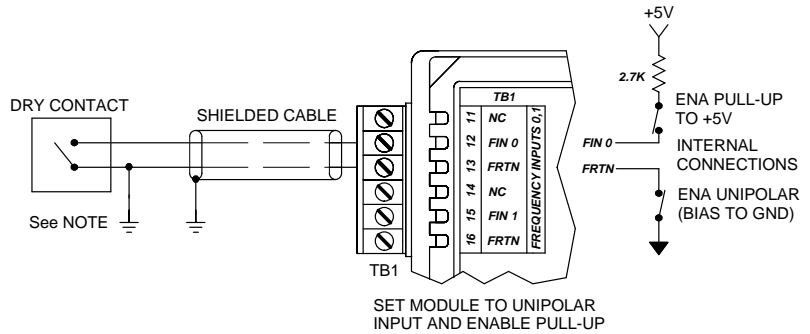
Connection to Low-Side switches.



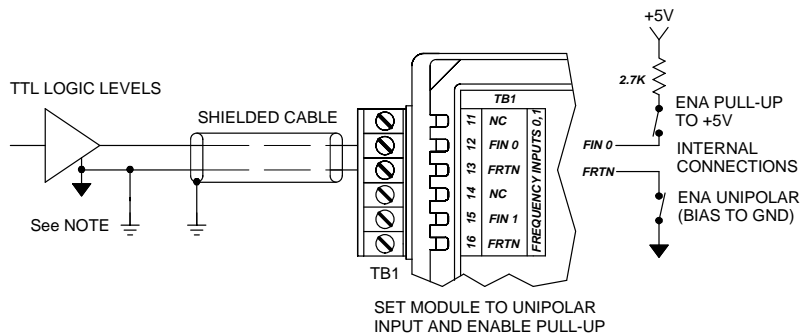
Connection to High-Side switches.

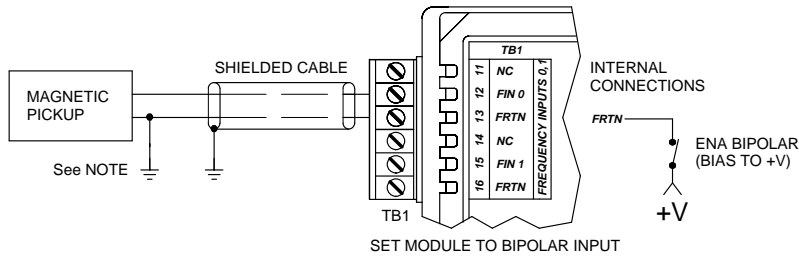


Connection to Dry Contact Relays.



Connection to TTL logic signals.

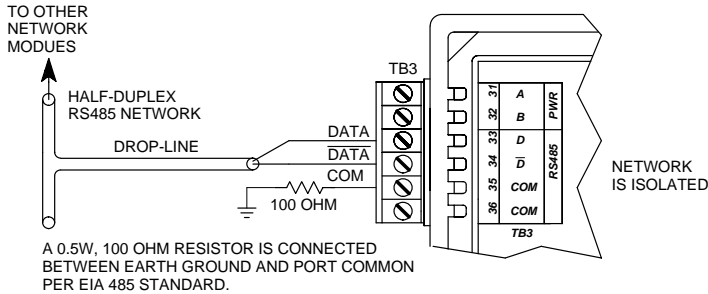




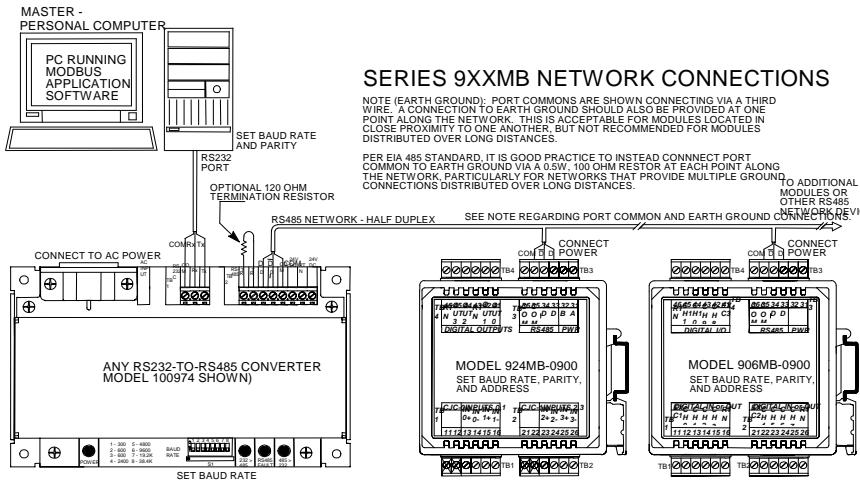
Connection to Magnetic pickups.

Network

Connect the RS485 terminals to your network. Differential data lines may use twisted pair. The 100 ohm resistor shown between port common and earth ground may be eliminated for modules in close proximity to one another.



Port common COM should connect to earth ground at each node. A 100 ohm resistor is shown connected between earth ground and port common per EIA 485 standard to limit circulating currents. This resistor is not required for operation, but is good wiring practice.



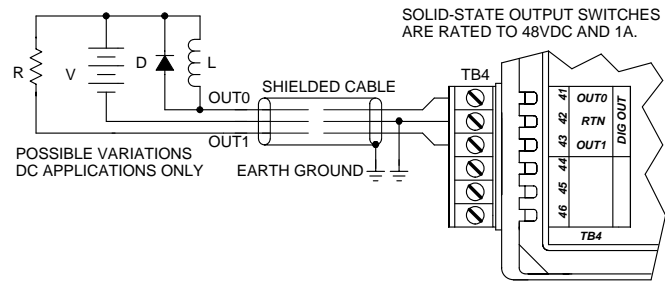
Refer to this drawing as an example of connections to an RS485 signal converter and network.

The Model 100974 signal converter is shown here.

Output

Outputs turn OFF (open) following a software or power-on reset of the module. Optionally, outputs may be sent to a defined state following a watchdog timer time-out.

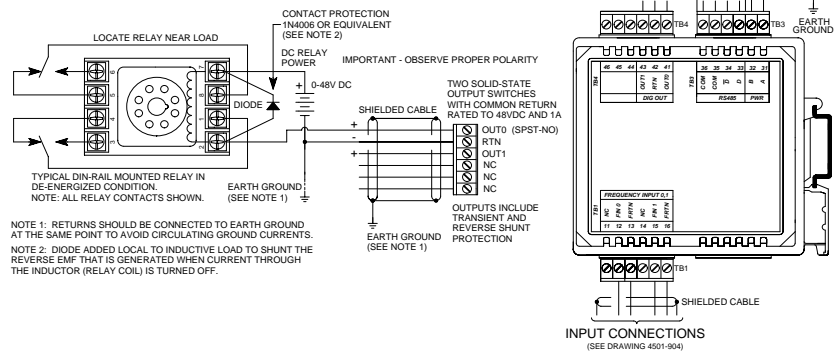
Connect solid-state output switches.



IMPORTANT - Add Protection With Inductive Loads: Outputs already include internal reverse-bias shunt diodes to help protect the switch from damage due to the reverse-bias voltages generated when switching inductive loads. You should add external protection near the inductive load to prevent these transients from being sent along the connection wires. Place a diode (1N4006 or equivalent) across an inductive load with the cathode to (+) and the anode to (-) as shown above.

Refer to this drawing if you need to increase switching capacity with another relay.

INTERPOSING RELAY CONNECTIONS MODEL 942MB-0900



Earth Ground

Warning: To comply with safety and performance standards, use shielded cable and connect earth ground as noted. Failure to use good wiring and grounding practices may be unsafe and hurt performance.

Connect Earth Ground as indicated in the example drawings above.

The plastic module housing itself does not require earth ground.

The ground connections noted in the drawings are recommended for best results and may be needed to meet EMC specifications. If sensors are already grounded, use caution and avoid making additional ground connections which could create ground loops.

4. Register Map

Modbus registers are organized into reference types identified by the leading number of the reference address:

Reference	Description
0xxxx	Read/Write Discrete Outputs or Coils. A 0x reference address is used to drive output data to a digital output channel.
1xxxx	Read Discrete Inputs. The ON/OFF status of a 1x reference address is controlled by the corresponding digital input channel.
3xxxx	Read Input Registers. A 3x reference register contains a 16-bit number received from an external source-e.g. an analog signal.
4xxxx	Read/Write Output or Holding Registers. A 4x register is used to store 16-bits of numerical data (binary or decimal), or to send the data from the CPU to an output channel.

Notes:

The “x” following the leading character represents a four-digit address location in user data memory. The leading character is generally implied by the function code and omitted from the address specifier for a given function. The leading character also identifies the I/O data type.

The following Modbus functions operate on register map registers to monitor, configure, and control module I/O:

CODE	FUNCTION	REFERENCE
01 (01H)	Read Coil (Output) Status	0xxxx
03 (03H)	Read Holding Registers	4xxxx
04 (04H)	Read Input Registers	3xxxx
05 (05H)	Force Single Coil (Output)	0xxxx
06 (06H)	Preset Single Register	4xxxx
08 (08H)	Reset Slave	Hidden
15 (0FH)	Force Multiple Coils (Outputs)	0xxxx
16 (10H)	Preset Multiple Registers	4xxxx
17 (11H)	Report Slave ID	Hidden

All I/O values are accessed via the 16-bit Input Registers or 16-bit Holding Registers given in the Register Map. Input registers contain information that is read-only. For example, the current input value read from a channel, or the states of a group of digital inputs. Holding registers contain read/write information that may be configuration data or output data. For example, the high limit value of an alarm function operating at an input, or an output value for an output channel.

The following table outlines the register map for the Model DI-942MB network I/O module. You will find it helpful to refer to this map as you review the Modbus function descriptions later.

Ref	Addr.	Description	Data Type/Format
Coil Registers (0x References, Read/Write)			
00001 Thru 00004	0-3 (0000- 0003)	Control & monitor the On/Off status of Discrete Outputs 0 & 1	Discrete Output Value. Addresses a specific bit of a 16-bit word that controls/ monitors the ON/OFF status for the output. Bits 15-2: 0, Not Used. Bits 1,0: A set bit (1) means the corresponding output is ON (closed). A clear bit (0) means the corresponding output is OFF (open). Bit position corresponds to the output channel number-output 0 uses bit 0 of the 16-bit word at address 0, output 1 uses bit 1 of the 16-bit word at address 1, etc.) Additionally, any unused bit is set to 0.
<p>IMPORTANT: Disable the corresponding limit if you wish to control the state of an output directly by writing to these registers, as limit alarm control will take precedence over direct control.</p> <p>After reset, these registers read 0 (outputs OFF) and these registers are not maintained in EEPROM.</p> <p>Note that with respect to mapping, the LSB of the word maps to the lowest numbered channel of a group and channel numbers increase sequentially as you move towards the MSB. Unused bits are set to zero.</p>			
Input Registers (3x References, Read-Only)			
30001	0(0000)	Module Status Report	Bit 15: Flash Checksum; 1 = Error, 0 = No Error Bit 14: Zero Bit 13: Default Mode Flag; 1 = Default Mode Indication; 0 = Not In Default Mode Bits 12-4: Zero Bit 3: I/O Watchdog Fault; 1 = Watchdog Timeout; 0 = No Timeout Bit 2: Limit Detect Flag; 1 = Global Limit Exceeded; 0 = No Limit Exceeded Bits 1,0: Zero
30002	1(0001)	Current Input Range Register (Both Inputs)	Bits 15-2: Zero Bits 1,0: Input Range 00 = 0 = 0-50000Hz 01 = 1 = 0-1000Hz 10 = 2 = 0-100Hz 11 = 3 = Event Counter
30003	2(0002)	Current Input Threshold/ Hysteresis Register (Both Inputs)	Bits 15-2: Zero Bits 1,0: Inp Thresh (Hysteresis) 00 = 0 = Bipolar 0.0V (± 25 mV) 01 = 1 = Bipolar 0.0V (± 83 mV) 10 = 2 = Unipolar 1.5V (± 25 mV) 11 = 3 = Unipolar 5.0V (± 83 mV)
30004	3(0003)	Current Input Resistor (Both Inputs)	Bits 15-2: Zero Bits 1,0: Input Resistor: 00 = 0 = Pullup to 5V 01 = 1 = PullDown RTN 10 = 2 = None - Floating 11 = 3 = Reserved

Ref	Addr.	Description	Data Type/Format
30005	4(0004)	Current Gate Time (seconds) for 0-50KHz Range (Both Inputs, 0-50KHz Frequency Inputs Only)	Bits 15-4: Zero Bits 3,2,1,0: Gate Time 0000 = 0 = Not Used 0001 = 1 = 0.1s 0010 = 2 = 0.2s 0011 = 3 = 0.3s 0100 = 4 = 0.4s 0101 = 5 = 0.5s 0110 = 6 = 0.6s 0111 = 7 = 0.7s 1000 = 8 = 0.8s 1001 = 9 = 0.9s 1010 = 10 = 1.0s
The 0-50KHz range uses a gated period of this time to count the number of input wave cycles in order to determine the input period and frequency. The maximum Gate Time provides the greatest resolution, while the minimum Gate Time provides the quickest measurement.			
30006	5(0005)	Number of Cycles for Period Measurement (Both Inputs, 0-100Hz & 0-1KHz Frequency Inputs Only)	Bits 15-8: Zero Bits 7-0: A 8-bit count from 1-255 representing the number of cycles per period for encoders. The measurement will represent an average of this number of cycles. This is useful in minimizing jitter when monitoring an encoder output with varying cycle widths in a single period (revolution).
The 0-100Hz & 0-1KHz ranges will count this many wave cycles and the elapsed time to determine the average period before updating the frequency.			
30007	6(0006)	Event Counter Debounce Time (Both Inputs, Event Count Only)	Bits 15-8: Zero Bits 7-0: An 8-bit count from 0-255 that represents a debounce delay time multiple of 5 milliseconds to be applied to event counter inputs (0-1.275 seconds in 5ms increments possible).
This is the amount of time the event counter input will wait after logging an event before allowing another event.			
30008	7(0007)	Event Counter Trigger Edge (Both Inputs, Event Count Only)	Bits 15-1: Zero Bit 0: Event Trigger Edge 0 = 0 = Rising Edge 1 = 1 = Falling Edge Specifies which edge of the pulse will trigger an event count.
30009	8(0008)	Acquire Count Enable and Event Count Termination (Both Inputs, Event Count Only)	Bit 15: Acquire Count; 0 = No (Default); 1 = Yes (Enabled) Bits 14-1: Zero Bit 0: Count Terminate; 0 = Auto-Reset (Default); 1 = Latching
30010	9(0009)	Cutoff Frequency (Both Inputs, 0-100Hz & 0-1KHz Ranges Only) Default=5 (0.5Hz)	Bits 15-1: Cutoff Frequency, 0 to 10000 representing Hertz/10. Value is 0-10000 which is 0.0-1000.0 with 0.1Hz resolution. For the 0-100Hz and 0-1KHz ranges, input frequencies below the cutoff will read as 0Hz.
30011	10(000A)	CH 0 Input Value	Count - 16-bit Unsigned, 0-65535 Hz or 0-65535 Counts. Not Applicable To Event Counters unless Acquire Count is enabled.

Ref	Addr.	Description	Data Type/Format
30012	11(000B)	CH 0 Status Value	Bits 15-4: Zero Bit 3: High Limit Flag; 1 = High Limit Exceeded; 0 = Below High Limit Bit 2: Low Limit Flag (Not For Event Counters); 1 = Low Limit Exceeded; 0 = Above Low Limit Bits 1,0: Range Flag; 00 = In Range; 01 = Overrange; 10 = Under Range; 11 = Not Defined
30013	12(000C)	CH 1 Input Value	Format Same As Ch 0
30014	13(000D)	CH 1 Status Value	Format Same As Ch 0
30015	14(000E)	CH 0 Raw Value	Untrimmed Value Read From Sampling Micro 0
30016	15(000F)	CH 1 Raw Value	Untrimmed Value Read From Sampling Micro 1
Holding Registers (4x References, Read/Write)			
Note: Changes to Holding Registers take effect following the next software or power-on reset of the module, except where noted otherwise.			
40001	0(0000)	Slave Address Default=247	1-247
40002	1(0001)	Baud Rate Default=2; 9600bps	0 = 2400bps 1 = 4800bps 2 = 9600bps 3 = 14400bps 4 = 19200bps 5 = 28800bps 6 = 38400bps 7 = 57600bps 8 = 76800bps 9 = 115200bps
40003	2(0002)	Parity Default=0, None	0 = None 1 = Odd Parity 2 = Even Parity
40004	3(0003)	I/O Watchdog Time Default=0, Disabled	Set from 1-65534 sec. Set to 65535 (FFFFH) or 0 (0000H) to disable the watchdog timer (default).
Watchdog timeout control takes precedence over alarm and direct control of the output relay.			
40005	4(0004)	Output Channel Timeout State Default=65535/disable	The two lower order bits of this 16-bit register define the state the output channels will be sent to following watchdog timeout. Bit 0 is for channel 0, and bit 1 for channel 1. Write 65535 (FFFFH) to this register to leave outputs unchanged following a timeout (this is the default value).
40006	5(0005)	Response Delay Time (Turnaround Delay) Default=0, No Delay	Can be set from 0 to 65500 ticks (1 tick = 1.085us). This is the additional delay the module will wait before responding to a host message. TIP: Increase this time if you are having communication problems or a high amount of error messages.
40007	6(0006)	Range Configuration (Both Inputs) Default=0,0=50KHz	Bits 15-2: Zero Bits 1,0: Input Type/ Range 00 = 0 = 0-50000Hz 01 = 1 = 0-1000Hz 10 = 2 = 0-100Hz 11 = 3 = Event Counter

Ref	Addr.	Description	Data Type/Format
40008	7(0007)	Threshold/ Hysteresis Configuration (Both Inputs) Default=0, Bipolar 0.0V±25mV	Bits 15-2: Zero Bits 1,0: Input Thresh/Hysteresis 00=0=Bipolar 0V, ±25mV 01=1=Bipolar 0V, ±83mV 10=2=Unipolar 1.5V, ±25mV 11=3=Unipolar 5.0V, ±83mV
40009	8(0008)	Input Resistor Configuration (Both Inputs) Default=0, Pull-up to 5V	Bits 15-2: Zero Bits 1,0: Input Resistor: 00 = 0 = 2.7KΩ Pull-Up to 5V 01 = 1 = 1KΩ Pull-Down to RTN 10 = 2 = None - Floating 11 = 3 = Reserved
WARNING: Do not enable internal pullup/pulldown resistor for voltages above 11V, or damage to the unit may result.			
40010	9(0009)	0-50KHz Range Gate Time in Seconds (Both Inputs, 0-50KHz Frequency Inputs Only) Default=0, 1.0 Second	Bits 15-4: Zero Bits 3,2,1,0: Gate Time 0000 = 0 = 1.0s 0001 = 1 = 0.1s 0010 = 2 = 0.2s 0011 = 3 = 0.3s 0100 = 4 = 0.4s 0101 = 5 = 0.5s 0110 = 6 = 0.6s 0111 = 7 = 0.7s 1000 = 8 = 0.8s 1001 = 9 = 0.9s
The 0-50KHz range uses a gated period of this time to count the input wave cycles in order to determine the input period and frequency. A 1.0s Gate Time will provide the greatest resolution, while a 0.1s Gate Time will give the quickest measurement.			
40011	10(000A)	Number of Cycles for Period Measurement (Both Inputs, 0-100Hz, 0-1KHz Ranges Only) Default=8	Bits 15-8: Zero Bits 7-0: An 8-bit count from 1-255 that is the number of cycles per period for encoders. Your measurement will represent an average period of this number of cycles. This is useful in minimizing jitter when monitoring an encoder output with varying cycle widths in a single period (revolution).
The 0-100Hz & 0-1KHz ranges will count this number of wave cycles and the elapsed time to measure the period before updating frequency.			
40012	11(000B)	Event Counter Debounce Time (Both Inputs, Event Counter Only) Default=0, No Debounce.	Bits 15-10: Zero Bits 9-0: An 8-bit count from 0-255 that represents a debounce time multiple of 5 milliseconds to be applied to event counter inputs (0-1.275 seconds in 5ms increments possible).
This is the time the event counter will wait after logging an event before allowing another event.			
40013	12(000C)	Event Counter Trigger Edge (Both Inputs, Event Counter Only) Default=0, Rising Edge	Bits 15-1: Zero Bit 0: Event Trigger Edge 0 = 0 = Rising Edge 1 = 1 = Falling Edge Specifies which edge of the pulse will trigger an event count.

Ref	Addr.	Description	Data Type/Format
40014	13(000D)	Acquire Count Enable and Event Count Termination (Both Inputs, Event Counter Only) Default=0, Auto-Reset	Bit 15: Acquire Count; 0 = No (Default); 1 = Yes/enable Bits 14-1: Zero Bit 0: Terminate Count Action; 0 = Auto-Reset; 1 = Latching Specifies if the count total will reset to 0 upon reaching the setpoint, or latch at the setpoint. Auto-Reset will reset counter to 0 upon reaching the high limit and pulse the alarm output for about 100ms (alarm LED will turn on briefly and alarm output will go to the alarm state momentarily). Latching will make the counter latch at the limit value until the even counter is reset. The alarm will also remain latched (and the corresponding alarm output if enabled) until the event counter is reset.
IMPORTANT: If you choose to also acquire the running count rather than just relying on the high limit, then you do so at the expense of possibly missing events during the time it takes to report the count. Disabling the acquire count function will help maintain an accurate event count.			
40015	14(000E)	Cutoff Frequency (Both Inputs, 0-100Hz & 0-1KHz Ranges Only) Default=5 (0.5Hz)	Bits 15-1: Cutoff Frequency, 0 to 10000 representing Hertz/10. Value is 0-10000 which is 0.0-1000.0 with 0.1Hz resolution. For the 0-100Hz and 0-1KHz ranges, input frequencies below the cutoff will read as 0Hz.
Raising the Cutoff Frequency will reduce the detection time for under-range frequencies.			
40016	15(000F)	Event Counter Reset (Both inputs, Event Counters Only) Default=0, No Reset	Bits 15-2: Zero Bit 0,1: Counter Reset 00 = 0 = Do Not Reset 01 = 1 = Reset CH0 Ctr 10 = 2 = Reset CH1 Ctr 11 = 3 = Reset Both Ctr Specifies which event counter is to be cleared, CH0 and/or CH1. This value is not stored and a read of this register will always return 0. This register is not maintained in EEPROM.
40017	16(0010)	CH0 High Limit Default=50KHz or Counter Limit Default=65535	Count -16-bit Unsigned, 0-65535
40018	17(0011)	CH0 Low Limit Default=1Hz (Not for Event Counters)	Count - 16-bit Unsigned, 0-65535
40019	18(0012)	CH0 Deadband Default=500HZ (Not for Event Counters)	Count -16-bit Unsigned, 0-65535
40020	19(0013)	CH0 Alarm Output State & Alarm Output Enable Default=0, Disabled	Bits 15-3: Zero Bit 2: Alarm Out State; 0 = Failsafe (OFF); 1 = Non-Failsafe (ON) Bit 1: High Limit Output Enable; 1 = Hi Output Enabled; 0 = Hi Output Disabled Bit 0: Low Limit Output Enable (Not for Event Counters); 1 = Lo Output Enabled; 0 = Lo Output Disabled.
The High Alarm Output is auto-enabled for event counters with Auto-Reset Termination. This output is non-fail-safe only for event counters.			

Ref	Addr.	Description	Data Type/Format
40021	20(0014)	CH1 High Limit Default=50000Hz or 65535 (Events)	Count - 16-bit Unsigned, 0-65535
40022	21(0015)	CH1 Low Limit Default=1Hz	Count -16-bit Unsigned, 0-65535, Does not apply to Event Counters
40023	22(0016)	CH1 Deadband Default=500HZ	Count -16-bit Unsigned, 0-65535, Does not apply to Event Counters
40024	23(0017)	CH1 Alarm Output State & Alarm Output Enable Default=0, Disabled	Bits 15-3: Zero Bit 2: Alarm Out State; 0 = Failsafe (OFF); 1 = Non-Failsafe (ON) Bit 1: High Limit Output Enable; 1 = Hi Output Enabled; 0 = Hi Output Disabled Bit 0: Low Limit Output Enable (Not for Event Counters); 1 = Lo Output Enabled; 0 = Lo Output Disabled
The High Alarm Output is auto-enabled for event counters with Auto-Reset Termination. This output is non-fail-safe only for event counters.			
40025	24(0018)	Calibration Access And Alternate Method of Module Reset	Writing 24106 (5E2AH) here immediately removes write protection from the calibration registers that follow. All other values apply write protection to the calibration registers (except 41429). Writing 41429 (A1D5H) to this register will cause an immediate module reset. This is provided as an alternate method of Reset for software that does not support the Reset Slave (08) command.
This register is not maintained in EEPROM. After a reset, this register reads 0 (write protection enabled and no reset).			
40026	25(0019)	CH0 50KHz Cal High Value	Count - 16-bit Unsigned,0-65535 Hz
40027	26(001A)	CH0 1KHz Cal High Value	Count - 16-bit Unsigned, 0-65535 Hz
40028	27(001B)	CH0 100Hz Cal High Value	Count - 16-bit Unsigned, 0-65535 Hz
40029	28(001C)	CH1 50KHz Cal High Value	Count - 16-bit Unsigned, 0-65535 Hz
40030	29(001D)	CH1 1KHz Cal High Value	Count - 16-bit Unsigned, 0-65535 Hz
40031	30(001E)	CH1 100Hz Cal High Value	Count - 16-bit Unsigned, 0-65535 Hz
40032	31(001F)	0-50KHz Input Range High Val.	Ideal Count - 16-bit Unsigned, 0-65535 Hz
40033	32(0020)	0-1KHz Input Range High Val.	Ideal Count - 16-bit Unsigned, 0-65535 Hz
40034	33(0021)	0-100Hz Input Range High Val.	Ideal Count - 16-bit Unsigned, 0-65535 Hz

Notes (Register Map):

- Note that the Report Slave ID and Reset Slave functions do not operate on Register Map locations. An alternate method of reset is provided if your software does not support the Reset Slave function (see Register 40025).
- Configuration data stored in holding registers (4xxx reference addresses) is maintained in EEPROM, unless otherwise noted. Changes to these registers do not take effect until the next software or power-on reset of the module, except for Calibration Access & Reset Register 40025 which takes effect immediately.
- Frequency input values are represented via 16-bit unsigned integer values with a possible range of 0 to 65535Hz. Default limit values are set to the Frequency input range endpoints: 1Hz (0-50KHz) or 0.5Hz (0-100, 0-1KHz) for the Low Limit, and 100Hz, 1KHz, or 50KHz for the High Limit, according to the range selected. Default deadband is set to 1% (1Hz, 10Hz, or 500Hz according to range selected). Limit checking is always active.

4. **IMPORTANT:** Access to calibration registers 40026 through 40034 is not normally required and writes to these registers should be avoided to prevent module miscalibration.

Data Types

I/O values for this model are represented by the following simple data types for temperature, percentage, and discrete on/off

Summary Of Data Types Used By DI-900MB Modules

Data Types	Description
Count Value	A 16-bit signed integer value representing an A/D count, a DAC count, time value, or frequency with a range of -32768 to +32767.
Count Value	A 16-bit unsigned integer value representing an A/D count, a DAC count, time value, or frequency with a range of 0 to 65535.
Percentage	A 16-bit signed integer value with resolution of 0.005%/lsb. ± 20000 is used to represent $\pm 100\%$. For example, -100%, 0% and +100% are represented by decimal values -20000, 0, and 20000, respectively. The full range is -163.84% (-32768 decimal) to +163.835% (+32767 decimal).
Temperature	A 16-bit signed integer value with resolution of 0.1°C/lsb. For example, a value of 12059 is equivalent to 1205.9°C, a value of -187 equals -18.7°C. The maximum possible temperature range is -3276.8°C to +3276.7°C.
Discrete	A discrete value is generally indicated by a single bit of a 16-bit word. The bit number/position typically corresponds to the discrete channel number for this model. Unless otherwise defined for outputs, a 1 bit means the corresponding output is closed or ON, a 0 bit means the output is open or OFF. For inputs, a value of 1 means the input is in its high state (usually $\gg 0V$), while a value of 0 specifies the input is in its low state (near 0V).

5. An Introduction to Modbus

The following information describes the operation of Modbus as it relates to Series DI-900MB I/O modules. For more detailed information on Modbus, you may also refer to the “Modicon Modbus Reference Guide”, PI-MBUS-300 Rev J, available via download from www.public.modicon.com.

The Modbus protocol provides an industry standard method that Modbus devices use for parsing messages. This protocol was developed by Modicon, Incorporated, for industrial automation systems and Modicon programmable controllers.

Modbus devices communicate using a master-slave technique in which only one device (the master) can initiate transactions (called queries). The other devices (slaves) respond by supplying the requested data to the master, or by taking the action requested in the query. A slave is any peripheral device (I/O transducer, valve, network drive, or other measuring device) which processes information and sends its output to the master using Modbus. Series DI-900MB I/O Modules are slave devices, while a typical master device is a host computer running appropriate application software.

Masters can address individual slaves, or can initiate a broadcast message to all slaves. Slaves return a response to all queries addressed to them individually, but do not respond to broadcast queries.

A master’s query consists of a slave address (or broadcast address), a function code defining the requested action, any required data, and an error checking field. A slave’s response consists of fields confirming the action taken, any data to be returned, and an error checking field. Note that the query and response both include a device address, plus a function code, plus applicable data, and an error checking field. If no error occurs, the slave’s response contains the data requested. If an error occurs in the query received, or if the slave is unable to perform the action requested, the slave will return an exception message as its response (see Modbus Exceptions). The error check field of the message frame allows the master to confirm that the contents of the message are valid. Additionally, parity checking is also applied to each transmitted character in its data frame.

Modbus Serial Transmission Modes

ASCII Mode (American Standard Code for Information Interchange)

In the ASCII Transmission Mode (American Standard Code for Information Interchange), each character byte in a message is sent as 2 ASCII characters. This mode allows time intervals of up to a second between characters during transmission without generating errors. The format of each byte in ASCII mode is outlined as follows:

ASCII Mode Byte Format

Coding System	Hexadecimal of ASCII characters 0-9, and A-F. One hexadecimal character contained in each ASCII character (7 bits) of the message.
Bits Per Byte	1 start bit + 7 data bits, lsb sent first + 1bit for even/odd parity or no bit for no parity + 1 stop bit if parity is used or 2 stop bits with no parity.
Error Check Field	Longitudinal Redundancy Check (LRC)

Keep in mind that in ASCII Mode, it takes two data words (two 7-bit characters) to transfer an equivalent 8-bit byte in RTU Mode. That is, each 4-bit nibble of the 8-bit RTU byte requires one ASCII character (7 bits). One RTU Byte is essentially two bytes in ASCII Mode. For example, the value 6AH is sent as one 8-bit byte in RTU mode (0110 1010), but two bytes in ASCII Mode, one for ASCII “6” (“6” = 36H = 011 0110), one for ASCII “A” (“A” = 41H = 100 0001). This makes the ASCII Mode less efficient and less favored than RTU Mode for most applications. DI-900MB modules do not use the ASCII Mode of transmission, they use the RTU Mode described below.

Remote Terminal Unit (RTU) Mode

In RTU (Remote Terminal Unit) Mode, each 8-bit message byte contains two 4-bit hexadecimal characters, and the message is transmitted in a continuous stream. The greater effective character density increases throughput over ASCII mode at the same baud rate. The format for each byte in RTU mode is outlined as follows:

RTU Mode Byte Format

Coding System	8-bit binary, hexadecimal 0-9, A-F, two hexadecimal characters in each 8-bit field of the message.
Bits Per Byte	1 start bit + 8 data bits, lsb sent first + 1bit for even/odd parity or no bit for no parity + 1 stop bit if parity is used or 2 stop bits with no parity.
Error Check Field	Cyclical Redundancy Check (CRC)

Series DI-900MB modules utilize the widely accepted Modbus network protocol in the more efficient RTU (Remote Terminal Unit) serial transmission mode.

Modbus Message Framing

A Modbus message is placed in a message frame by the transmitting device. Do not confuse the message frame with the data frame of a single byte (RTU Mode) or 7-bit character (ASCII Mode). A message frame is used to mark the beginning and ending point of a message allowing the receiving device to determine which device is being addressed and to know when the message is completed. It also allows partial messages to be detected and errors flagged as a result. Each word of this message (including the frame) is also placed in a data frame that appends a start bit, stop bit, and parity bit. In ASCII mode, the word size is 7 bits, while in RTU mode, the word size is 8 bits. Thus, every 8 bits of an RTU message is effectively 11 bits when accounting for the start, stop, and parity bits of the data frame (with one exception—see note below).

Note: Some Modbus software will misinterpret “no parity” as equivalent to “no bit transmitted”. According to the Modbus standard, no parity will add an additional stop bit (maintaining an 11 bit data frame in RTU mode). To prevent potential incompatibilities, DI-900MB modules are designed to accept messages with no parity and 1 or 2 stop bits.

The structure of the data frame depends on the transmission mode (ASCII or RTU). Note that on some other network types and on Modbus Plus, the network protocol handles the framing of messages and uses start and end delimiters specific to the network.

ASCII Mode Message Frames

ASCII Mode messages start with a colon character “:” (ASCII 3AH) and end with a carriage return-line feed pair of characters (CRLF, ASCII 0DH & 0AH). The only allowable characters for all other fields are hexadecimal 0-9 & A-F. Recall that it only takes 7 significant bits to represent an ASCII character. Likewise, the Modbus ASCII Mode data ‘byte’ or character is only 7 bits long.

Allowable Ascii Mode Characters			
ASCII	HEX	ASCII	HEX
0	30H	:	3AH
1	31H	CR	0DH
2	32H	LF	0AH
3	33H	A	41H
4	34H	B	42H
5	35H	C	43H
6	36H	D	44H
7	37H	E	45H
8	38H	F	46H
9	39H		

Note: For ASCII Mode transmission, each character requires 7 data bits. Thus, each character is 10 bits when accounting for the start bit, parity bit, and stop bit of the data frame.

In ASCII Mode, all network devices continuously monitor the network for the ‘start of message’ colon (:) character. When it is received, every network device decodes the next field to determine if it is the addressed device. Intervals of up to one second may occur between message characters and if this interval is more than one second, the receiving device will assume that an error has occurred and the message is ignored (the device resumes looking for the another start of message colon character).

ASCII Mode Message Frame

Start	Addr.	Function	Data	LRC	End
1 char (colon)	2 char	2 char	N char	2 char	2 char (CRLF)
3A	X X	X X	x1...xN	X X	0D 0A

Note that each character noted above requires an ASCII code for 0-9 & A-F, and this requires 7 bits, plus 3 bits for the start bit, parity bit, and stop bit of the data frame. For example, even though the LRC is an 8 bit value, it effectively requires that 2 bytes be transmitted (two 7-bit bytes) in ASCII mode, one for each digit.

Note that some controllers may terminate the ASCII message after the LRC field with no CR LF attached (an interval of at least 1 second replaces the CR LF pair in this case).

Series DI-900MB modules do not support ASCII Mode of transmission and use the more efficient RTU Mode described below.

RTU Mode Message Frames

RTU mode messages start with a silent interval of at least 3.5 character times implemented as a multiple of character times at the baud rate being used on the network (indicated as t1t2t3t4 below). The first field transmitted is the device address. The allowable characters transmitted for all fields are hexadecimal values 0-9, A-F.

A networked device continuously monitors the network, including the silent intervals, and when the first field is received (the address) after a silent interval of at least 3.5 character times, the device decodes it to determine if it is the addressed device. Following the last character transmitted, a similar silent interval of 3.5 character times marks the end of the message and a new message can begin after this interval. A typical message frame is shown below.

Character-Time: the time it takes to transmit one character at the chosen baud rate. In RTU mode, there are 11 bits per character and this would be 11 bit-times. For example, at 9600 baud, 1 character-time is 11 bit times or 11bits/char* 1/9600bits/sec = 1146us/char..

RTU Message Frame

Start	Addr.	Function	Data	CRC	End
t1t2t3t4	8 bits	8 bits	nx8 bits	16 bits	t1t2t3t4

The entire message must be transmitted as a continuous stream. If a silent interval of more than 1.5 character times occurs before completion of the frame (not a continuous stream), the receiving device flushes the incomplete message and assumes the next byte will be the address field of a new message.

In similar fashion, if a new message begins earlier than 3.5 character times following a previous message, the receiving device assumes it is a continuation of the previous message. This will generate an error, as the value in the final CRC field will not be valid for the combined messages.

How Characters Are Transmitted Serially

When messages are transmitted on Modbus serial networks, each character or byte is sent in the order of Least Significant Bit (LSB) to Most Significant Bit (MSB) as outlined below (left to right):

RTU Character Framing (No Parity)

Start	0	1	2	3	4	5	6	7	Stop	Stop
-------	---	---	---	---	---	---	---	---	------	------

RTU Character Framing (With Parity)

Start	0	1	2	3	4	5	6	7	Parity	Stop
-------	---	---	---	---	---	---	---	---	--------	------

Note that an additional stop bit is transmitted to fill out the character frame for no parity. This is clearly defined in the Modbus standard, but often violated in industry. That is, some programmer’s interpret “No Parity” as “No Bit”, and fail to realize that the absence of parity is equivalent to adding another stop bit. DI-900MB modules were designed to accept messages with no parity and 1 or 2 stop bits so that this will not be an issue.

The character frame for ASCII Mode transmission is identical to RTU Mode, except that ASCII Mode uses only 7 data bits, versus 8 bits for RTU mode as shown above.

Modbus Addresses

The master device addresses a specific slave device by placing the 8-bit slave address in the address field of the message (RTU Mode). The address field of the message frame contains two characters (in ASCII mode), or 8 binary bits (in RTU Mode). Valid addresses are from 1-247. When the slave responds, it places its own address in this field of its response to let the master know which slave is responding. Address 0 is reserved for the broadcast address, which all slave devices on a network recognize. Some functions do not support the broadcast address. A slave device does not issue a response to a broadcast message.

All data addresses in Modbus messages are referenced to 0, with the first occurrence of a data item addressed as item number zero. Further, a function code field already specifies which register group it operates on (i.e. 0x, 1x, 3x, or 4x reference addresses). For example, holding register 40001 is addressed as register 0000 in the data address field of the message. The function code that operates on this register specifies a “holding register” operation and the “4xxxx” reference group is implied. Thus, holding register 40108 is actually addressed as register 006BH (107 decimal).

Modbus Functions

The function code field of the message frame will contain two characters (in ASCII mode), or 8 binary bits (in RTU Mode) that tell the slave what kind of action to take. Valid function codes are from 1-255, but not all codes will apply to a module and some codes are reserved for future use. The following table highlights the subset of standard Modbus functions supported by the DI-900MB modules (the reference register addresses that the function operates on are also indicated):

The functions below are used to access the registers outlined in the register map of the module for sending and receiving data. The Report Slave ID and Reset Slave commands do not operate on register map registers.

Code	Function	Reference
01 (01H)	Read Coil (Output) Status	0xxxx
02 (02H)	Read Input Status	1xxxx
03 (03H)	Read Holding Registers	4xxxx
04 (04H)	Read Input Registers	3xxxx
05 (05H)	Force Single Coil (Output)	0xxxx
06 (06H)	Preset Single Register	4xxxx
08 (08H)	Reset Slave	Hidden
15 (0FH)	Force Multiple Coils (Outputs)	0xxxx
16 (10H)	Preset Multiple Registers	4xxxx
17 (11H)	Report Slave ID	Hidden

When the slave device responds to the master, it uses the function code field to indicate either a normal (error-free) response, or that some kind of error has occurred (an exception response).

A normal response simply echoes the original function code of the query, while an exception response returns a code that is equivalent to the original function code with its most significant bit (msb) set to logic 1. For example, the Read Holding Registers command has the function code 0000 0011 (03H).

If the slave device takes the requested action without error, it returns the same code in its response. However, if an exception occurs, it returns 1000 0011 (83H) in the function code field and appends a unique code in the data field of the response message that tells the master device what kind of error occurred, or the reason for the exception (see Modbus Exceptions).

The master's application program must handle the exception response. It may choose to post subsequent retries of the original message, it may try sending a diagnostic query, or it may simply notify the operator of the exception error.

The following paragraphs describe some of the Modbus functions supported by the DI-900MB modules. To gain a better understanding of Modbus, please refer to 4. Register Map as you review this material.

Read Coil Status (01)

This command will read the ON/OFF status of discrete outputs or coils (0x reference addresses) in the slave. For DI-900MB modules, its response is equivalent to reading the on/off status of solid-state output relays or switches. Broadcast transmission is not supported.

The Read Coil Status query specifies the starting coil (output channel) and quantity of coils to be read. Coils correspond to the discrete solid-state relays of this transmitter and are addressed starting from 0 (up to 4 coils addressed as 0-3 for this model). The Read Coil Status in the response message is packed as one coil or channel per bit of the data field. For DI-900MB modules, the output status is indicated as 1 for ON (conducting current), and 0 for OFF (not conducting). The LSB of the first data byte corresponds to the status of the coil addressed in the query. The other coils follow sequentially, moving toward the high order end of the byte. Since this example has only 4 outputs, the remaining bits of the data byte will be set to zero toward the unused high order end of the byte.

Read Coil Status Example Query

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	1 (01)
Starting Address High Order	0 (00)
Starting Address Low Order	0 (00)
Number Of Points High Order	0 (00)
Number Of Points Low Order	4 (04)
Error Check (LRC or CRC)	--

Read Coil Status Example Response

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	1 (01)
Byte Count	1 (01)
Data (Coils 3-0)	10 (0A)
Error Check (LRC or CRC)	--

This example reads the output channel status of coils 0-3 at slave device 247.

Note that the leading character of the 0x reference address is implied by the function code and omitted from the address specified. In this example, the first address is 00001, referenced via 0000H, and corresponding to coil 0.

To summarize, the status of coils 3-0 is shown as the byte value 0A hex, or 00001010 binary. Coil 3 is the fifth bit from the left of this byte, and coil 0 is the LSB. The four remaining bits (toward the high-order end) are zero. Reading left to right, the output status of coils 3..0 is ON-OFF-ONOFF.

Bin	0	0	0	0	1	0	1	0
Hex	0				A			
Coil	NA	NA	NA	NA	3	2	1	0

Read Holding Registers (03)

Reads the binary contents of holding registers (4x reference addresses) in the slave device. Broadcast transmission is not supported.

The Read Holding Registers query specifies the starting register and quantity of registers to be read. Note that registers are addressed starting at 0 (registers 1-16 addressed as 0-15). The Read Holding Registers response message is packed as two bytes per register, with the binary contents rightjustified in each byte. For each register, the first byte contains the high order bits and the second byte the low order bits.

Read Holding Register Example Query

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	3 (03)
Starting Address High Order	0 (00)
Starting Address Low Order	5 (05)
Number Of Points High Order	0 (00)
Number Of Points Low Order	3 (03)
Error Check (LRC in ASCII mode)	--

Read Holding Register Example Response

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	3 (03)
Byte Count	6 (06)
Data High (Register 40006)	(3A)
Data Low (Register 40006)	75%=15000 (98)
Data High (Register 40007)	(13)
Data Low (Register 40007)	25%=5000 (88)
Data High (Register 40008)	(00)
Data Low (Register 40008)	1%=200 (C8)
Error Check (LRC in ASCII mode)	--

This example reads holding registers 40006...40008 (Channel 0 high limit value, low limit value, & deadband value) at slave device 247.

To summarize our example, the contents of register 40006 (2 bytes) is the channel 0 high limit of 75% (15000=3A98H). The contents of register 40007 (2 bytes) is the channel 0 low limit of 25% (5000=1388H). The contents of register 40008 is the channel 0 deadband value (2 bytes) of 1% (200=00C8H).

Read Input Registers (04)

This command will read the binary contents of input registers (3x reference addresses) in the slave device. Broadcast transmission is not supported.

The Read Input Registers query specifies the starting register and quantity of registers to be read. Note that registers are addressed starting at 0. That is, registers 1-16 are addressed as 0-15. The Read Input Registers response message is packed as two bytes per register, with the binary contents right-justified in each byte. For each register, the first byte contains the high order bits and the second byte the low order bits.

Read Input Register Example Query

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	4 (04)
Starting Address High Order	0 (00)
Starting Address Low Order	2 (02)
Number Of Points High Order	0 (00)
Number Of Points Low Order	2 (02)
Error Check (LRC in ASCII mode)	--

Read Input Register Example Response

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	4 (04)
Byte Count	4 (04)
Data High (Register 30003)	(3E)
Data Low (Register 30003)	80%=16000 (80)
Data High (Register 30004)	(00)
Data Low (Register 30004)	136 (88)
Error Check (LRC in ASCII mode)	--

To summarize our example, the contents of register 30003 (2 bytes) is the channel 1 input value of 80% (16000=3E80H). The contents of register 30004 (2 bytes) is the channel 0 status flags of 136 (0088H)—i.e. flagging high limit exceeded.

Force Single Coil (05)

Forces a single coil/output (0x reference address) ON or OFF. With broadcast transmission (address 0), it forces the same coil in all networked slaves.

The Force Single Coil query specifies the coil reference address to be forced, and the state to force it to. The ON/OFF state is indicated via a constant in the query data field. A value of FF00H forces the coil to be turned ON (i.e. the corresponding solid-state relay is turned ON or closed), and 0000H forces the coil to be turned OFF (i.e. the solid-state output relay is turned OFF or opened). All other values are invalid and will not affect the coil.

Coils are referenced starting at 0—up to 4 coils are addressed as 0-3 for our example and this corresponds to the discrete output channel number. The following example forces discrete output 3 ON at slave device 247.

Force Single Coil Example Query

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	5 (05)
Coil Address High Order	0 (00)
Coil Address Low Order	3 (03)
Force Data High Order	255 (FF)
Force Data Low Order	0 (00)
Error Check (LRC in ASCII mode)	--

Force Single Coil Example Response

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	5 (05)
Coil Address High Order	0 (00)
Coil Address Low Order	3 (03)
Force Data High Order	255 (FF)
Force Data Low Order	0 (00)
Error Check (LRC in ASCII mode)	--

The Force Single Coil response message is simply an echo (copy) of the query as shown above, but returned after executing the force coil command. No response is returned to broadcast queries from a master device.

Preset Single Register (06)

This command will preset a single holding register (4x reference addresses) to a specific value. Broadcast transmission is supported by this command and will act to preset the same register in all networked slaves.

The Preset Single Register query specifies the register reference address to be preset, and the preset value. Note that registers are addressed starting at 0--registers 1-16 are addressed as 0-15. The Preset Single Registers response message is an echo of the query, returned after the register contents have been preset.

Preset Holding Register Example Query

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	6 (06)
Register Address High Order	0 (00)
Register Address Low Order	1 (01)
Preset Data High Order	0 (00)
Preset Data Low Order	2 (02)
Error Check (LRC in ASCII mode)	--

Preset Holding Register Example Response

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	6 (06)
Register Address High Order	0 (00)
Register Address Low Order	1 (01)
Preset Data High Order	0 (00)
Preset Data Low Order	2 (02)
Error Check (LRC in ASCII mode)	--

This example writes a baud rate of 9600bps to holding register 40002 (Baud Rate) at slave device 247. The response message is simply an echo (copy) of the query as shown above, but is returned after the register contents have been preset. No response is returned to broadcast queries from a master device.

Force Multiple Coils (15)

Simultaneously forces a sequence of coils (0x reference addresses) either ON or OFF. Broadcast transmission is supported by this command and will act to force the same block of coils in all networked slaves.

The Force Multiple Coils query specifies the starting coil reference address to be forced, the number of coils, and the force data to be written in ascending order. The ON/OFF states are specified by the contents in the query data field. A logic 1 in a bit position of this field requests that the coil turn ON, while a logic 0 requests that the corresponding coil be turned OFF.

Unused bits in a data byte should be set to zero. Note that coils are referenced starting at 0—up to 4 coils are addressed as 0-3 for this example and this also corresponds to the discrete output channel number. This example forces outputs 1 & 3 OFF, and 0 & 2 ON for coils 0-3 at slave device 247.

Force Multiple Coils Example Query

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	15 (0F)
Coil Address High Order	0 (00)
Coil Address Low Order	0 (00)
Number Of Coils High Order	0 (00)
Number Of Coils Low Order	4 (04)
Byte Count	01
Force Data High (First Byte)	5 (05)
Error Check (LRC or CRC)	--

Note that the leading character of the 0x reference address is implied by the function code and omitted from the address specified. In this example, the first address is 00001 corresponding to coil 0 and referenced via 0000H. Thus, in this example the data byte transmitted will address coils 3..0, with the least significant bit addressing the lowest coil in this set as follows (note that the four unused upper bits of the data byte are set to zero):

Bin	0	0	0	0	0	1	0	1
Hex	0				5			
Coil	NA	NA	NA	NA	3	2	1	0

Force Multiple Coils Example Response

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	15 (0F)
Coil Address High Order	0 (00)
Coil Address Low Order	0 (00)
Number Of Coils High Order	0 (00)
Number Of Coils Low Order	(04)
Error Check (LRC or CRC)	--

The Force Multiple Coils normal response message returns the slave address, function code, starting address, and the number of coils forced, after executing the force instruction. Note that it does not return the byte count or force value. No response is returned to broadcast queries from a master device.

Preset Multiple Registers (16)

Presets a block of holding registers (4x reference addresses) to specific values. Broadcast transmission is supported by this command and will act to preset the same block of registers in all networked slaves.

The Preset Multiple Registers query specifies the starting register reference address, the number of registers, and the data to be written in ascending order. Note that registers are addressed starting at 0--registers 1-16 are addressed as 0-15.

This example writes a new slave address of 200, a baud rate of 28800bps, and sets parity to even, by writing to holding registers 40001 through 40003 at slave device 247 (changes to slave address, baud rate, and parity will take effect following the next software or power-on reset).

Preset Multiple Registers Example Query

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	16 (10)
Starting Register High Order	0 (00)
Starting Register Low Order	0 (00)
Number Of Registers High Order	0 (00)
Number Of Registers Low Order	3 (03)
Preset Data High (First Register)	0 (00)
Preset Data Low (First Register)	200 (C8)
Preset Data High (Second Reg)	0 (00)
Preset Data Low (Second Reg)	5 (05)
Preset Data High (Third Reg)	0 (00)
Preset Data Low (Third Reg)	2 (02)
Error Check (LRC or CRC)	--

Preset Multiple Registers Example Response

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	16 (10)
Starting Register High Order	0 (00)
Starting Register Low Order	0 (00)
Number Of Registers High Order	0 (00)
Number Of Registers Low Order	3 (03)
Error Check (LRC or CRC)	--

The Preset Multiple Registers normal response message returns the slave address, function code, starting register reference, and the number of registers preset, after the register contents have been preset. Note that it does not echo the preset values. No response is returned to broadcast queries from a master device.

Report Slave ID (17)

This command returns the model, serial, and firmware number for the slave device, the status of the Run indicator, and any other information specific to the device. This command does not address Register Map registers and broadcast transmission is not supported.

Report Slave ID Example Query

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	17 (11)
Error Check (LRC in ASCII mode)	--

Report Slave ID Example Response

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	17 (11)
Byte Count	26 (1A)

Slave Model ID	0 (00H) = 924MB-0900 1 (01H) = 913MB-0900 2 (02H) = 914MB-0900 3 (03H) = 917MB-0900 4 (04H) = 918MB-0900 5 (05H) = 901MB-0900 6 (06H) = 902MB-0900 7 (07H) = 903MB-0900 8 (08H) = 904MB-0900 9 (09H) = 905MB-0900 10 (0AH) = 906MB-0900 11 (0BH) = 932MB-0900 12 (0CH) = 934MB-0900 13 (0DH) = 942MB-0900
Run Indicator Status (ON)	255 (FF)
Firmware ASCII Data String (Data Field)	“ACROMAG, 9300-043A, 942MB-0900,” (41 43 52 4F 4D 41 47 2C 39 33 30 30 2D 30 34 33 41 2C 39 34 32 4D 42 2D 30 39 30 30 2CH)
Serial Number ASCII String (Unique Per Module)	Six Numbers + Revision “123456A” (31 32 33 34 35 36 41H)
CRC Error Check	--

Reset Slave (08)

This command is used to trigger a reset of the module and its effect is equivalent to a power-on reset of the module. Note that with respect to DI-900MB modules, changes to baud rate, slave address, and parity are initiated following reset.

The Reset Slave command uses sub-function 01 (Restart Communications) of the standard Modbus Diagnostics Command (08) to accomplish a reset and does not operate on a register map location. Broadcast transmission is not supported. Allow a few seconds following reset to re-initiate communication with a module.

The Reset Slave query simply sends the slave address, function code, sub-function code, and data (data is ignored and simply echoed back), with error check (CRC) as shown here.

Reset Slave Example Query

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	08 (08)
Sub-Function High Order Byte	0 (00)
Sub-Function Low Order Byte	1 (01)
Data Field High-Order Byte	0 (00)
Data Field Low Order Byte	0 (00)
Error Check (LRC in ASCII mode)	--

Reset Slave Example Response (Sent Prior To Reset)

Field Name	Example Value (Hex)
Slave Address	247 (F7)
Function Code	08 (08)
Sub-Function High Order Byte	0 (00)
Sub-Function Low Order Byte	1 (01)
Data Field High-Order Byte	0 (00)
Data Field Low Order Byte	0 (00)
Error Check (LRC in ASCII mode)	--

A Reset Slave response is simply an echoed acknowledge that is returned just before the reset is executed.

DI-900MB modules provide an alternate method of reset via a write to the Module Reset Register (See 4. Register Map) for Modbus software that does not support the Reset Slave function.

Modbus Data Field

The data field provides the slave with any additional information required by the slave to complete the action specified by the function code. The data is formed from a multiple of character bytes (a pair of ASCII characters in ASCII Mode), or a multiple of two hex digits in RTU mode, in range 00H-FFH. The data field typically includes register addresses, count values, and written data. For some messages, this field may not exist (has zero length), as not all messages require data.

If no error occurs, the data field of a response from a slave will return the requested data. If an error occurs, the data field returns an exception code (see Modbus Exceptions) that the master's application software can use to determine the next action to take.

Supported Data Types

All I/O values are accessed via 16-bit Input Registers or 16-bit Holding Registers (see 4. Register Map). Input registers contain information that is read-only. For example, the current input value read from a channel, or the states of a group of digital inputs. Holding registers contain read/write information that may be configuration data or output data. For example, the high limit value of an alarm function operating at an input, or an output value for an output channel.

I/O values of DI-900MB modules are represented by the following simple data types for temperature, percentage, and discrete on/off.

Summary Of Data Types Used By DI-900MB Modules

Data Types	Description
Count Value	A 16-bit signed integer value representing an A/D count, a DAC count, time value, or frequency with a range of -32768 to $+32767$.
Count Value	A 16-bit unsigned integer value representing an A/D count, a DAC count, time value, or frequency with a range of 0 to 65535.
Percentage	A 16-bit signed integer value with resolution of 0.005%/lsb. ± 20000 is used to represent $\pm 100\%$. For example, -100% , 0% and $+100\%$ are represented by decimal values -20000 , 0 , and 20000 , respectively. The full range is -163.84% (-32768 decimal) to $+163.835\%$ ($+32767$ decimal).
Temperature	A 16-bit signed integer value with resolution of $0.1^{\circ}\text{C}/\text{lsb}$. For example, a value of 12059 is equivalent to 1205.9°C , a value of -187 equals -18.7°C . The maximum possible temperature range is -3276.8°C to $+3276.7^{\circ}\text{C}$.
Discrete	A discrete value is generally indicated by a single bit of a 16-bit word. The bit number/position typically corresponds to the discrete channel number for this model. Unless otherwise defined for outputs, a 1 bit means the corresponding output is closed or ON, a 0 bit means the output is open or OFF. For inputs, a value of 1 means the input is in its high state (usually $\gg 0\text{V}$), while a value of 0 specifies the input is in its low state (near 0V).

Modbus Error Checking

Modbus networks employ two methods of error checking: parity checking of the data character frame (even, odd, or no parity), and frame checking within the message frame (Cyclical Redundancy Check in RTU Mode, or Longitudinal Redundancy Check in ASCII Mode).

Parity Checking

A Modbus device can be configured for even or odd parity, or for no parity checking. This determines how the parity bit of the character's data frame is set.

If even or odd parity checking is selected, the number of 1 bits in the data portion of each character frame is counted. Each character in RTU mode contains 8 bits. The parity bit will then be set to a 0 or a 1, to result in an even (even parity), or odd (odd parity) total number of 1 bits.

For example, if an RTU character frame contains the following eight data bits: 1100 0011, then since the total number of 1 bits is 4 (already an even number), the frame's parity bit will be 0 if even parity is selected. If odd parity is used, then the parity bit will be set to 1, making the total number of bits an odd number (five).

When a message is transmitted, the parity bit is calculated and applied to the data frame of each character transmitted (every 7 bits in ASCII Mode, or every 8 bits in RTU Mode). The receiving device counts the quantity of 1 bits in the data portion of the frame and sets an error flag if the count differs from that received. As such, parity checking can only detect an error if an odd number of bits are picked up or dropped off from a character frame during transmission. For example, if odd parity is employed and two 1 bits are dropped from a character, the result is still an odd count of 1 bits and no parity error is detected. Note that all devices on a Modbus network must use the same parity. If no parity checking is selected, then no parity bit is transmitted and no parity check is made. However, an additional stop bit is transmitted to fill out the character frame for the no parity selection.

LRC Longitudinal Redundancy Check (ASCII Mode Only)

In the ASCII transmission mode, the character frame includes an LRC field as the last field preceding the CRLF characters. This field contains two ASCII characters that represent the result of a longitudinal redundancy calculation for all the fields except the starting colon character and ending CR LF pair of characters.

The LRC field contains an 8-bit binary value that is calculated by the transmitting device and appended to the outgoing message. The receiving device also calculates an LRC value upon receipt of the message and compares its calculation to value the sent to it. If the two values are different, an error is generated.

The LRC value is calculated by first adding the successive 8-bit bytes of the message and discarding the carry bits to produce an 8-bit result (do not include the starting colon character or the ending CR LF characters). Then take the two's complement of this 8-bit result by subtracting it from FFH (one's complement), and adding 1 to get the two's complement. The 8-bit value that results (2 ASCII characters) is then transmitted in the message with the high-order character first, followed by the low-order character. For example, if the 8-bit LRC value is A1H (1010 0001), the LRC High character is A and this precedes the LRC low character of 1 in the data frame just prior to the CR LF characters.

DI-900MB modules do not support the ASCII mode and do not use LRC error checking. These modules use the more efficient RTU mode and employ CRC error checking as described below.

CRC Error Checking (RTU Mode Only)

RTU Mode message frames include an error checking method that is based on a Cyclical Redundancy Check (CRC). The error checking field of a message frame contains a 16-bit value (two 8-bit bytes) that contain the result of a Cyclical Redundancy Check (CRC) calculation performed on the message contents.

The CRC value is calculated by the transmitting device and appended to the message as the last field in the message—the low order byte is appended first, followed by the high-order byte. Thus, the CRC high-order byte is the last byte to be sent in a message. The receiving device calculates a CRC during receipt of a message and compares the calculated value to that received in the CRC field. If the two values differ, an error will result.

The CRC is started by first preloading the 16-bit CRC register to all 1's. Successive 8-bit bytes of the message (only the 8-data bits in each character--no start, stop, or parity bits) are applied to the current contents of the register, and each 8-bit character is exclusive OR'ed with the register contents. The exclusive OR result is shifted in the direction of the least significant bit (lsb) of the CRC, with a zero placed into the most significant bit (msb). The lsb is then extracted and examined, if the lsb is a 1, the register is exclusive OR'ed with a preset fixed value. If the lsb is a 0, no exclusive OR takes place.

This process is repeated until 8 shifts have been performed. After the last (eighth) shift, the next 8-bit byte is exclusive OR'ed with the register's current contents, and the process repeats itself for 8 more shifts as described above. The final contents of the CRC register after all the message bytes have been applied is the CRC value.

Modbus Exceptions

If an unsupported function code is sent to a module, then the exception code 01 (Illegal Function) will be returned in the data field of the response message. If a holding register is written with an invalid value, then exception code 03 (Illegal Data Value) will be returned in the response message.

Modbus Exception Codes

Code	Exception	Description
01	Illegal Function	The function code received in the query is not allowed or invalid.
02	Illegal Data Address	The data address received in the query is not an allowable address for the slave or is invalid.
03	Illegal Data Value	A value contained in the query data field is not an allowable value for the slave or is invalid.
04	Slave Device Failure	An unrecoverable error occurred while the slave was attempting to perform the requested action.
05	Acknowledge	The slave has accepted the request and is processing it, but a long duration of time is required to do so. This response is returned to prevent a timeout error from occurring in the master.
06	Slave Device Busy	The slave is engaged in processing a long-duration program command. The master should retransmit the message later when the slave is free.
07	Negative Acknowledge	The slave cannot perform the program function received in the query. This code is returned for an unsuccessful programming request using function code 13 or 14 (code not supported by this model). The master should request diagnostic information from the slave.
08	Memory Parity Error	The slave attempted to read extended memory, but detected a parity error in memory. The master can retry the request, but service may be required at the slave device.

In a normal response, the slave echoes the function code of the original query in the function field of the response. All function codes have their most-significant bit (msb) set to 0 (their values are below 80H). In an exception response, the slave sets the msb of the function code to 1 in the returned response (i.e. exactly 80H higher than normal) and returns the exception code in the data field. This is used by the master's application to recognize an exception response and to direct an examination of the data field for the applicable exception code.

6. Configuration Terms and Definitions

Each module has already been calibrated and has a default factory configuration as noted in 2. Specifications. Your application will likely differ from the default configuration and the module will need to be reconfigured. The easiest way to reconfigure your module is to use the Configuration Software provided to program and control the module parameters and operating modes. You may also configure this module by issuing the appropriate ModBus functions to Register Map registers, as required by your application.

Below is a subset of standard Modbus functions that are supported by this module along with the reference register addresses that the function operates on. Use these functions to access these registers as outlined in the Register Map for sending and retrieving data. Any software that supports the Modbus RTU command/response protocol may also be used.

CODE	MODBUS FUNCTION	REFERENCE
01 (01H)	Read Coil (Output) Status	0xxxx
03 (03H)	Read Holding Registers	4xxxx
04 (04H)	Read Input Registers	3xxxx
05 (05H)	Force Single Coil (Output)	0xxxx
06 (06H)	Preset Single Register	4xxxx
08 (08H)	Reset Slave	Hidden
15 (0FH)	Force Multiple Coils (Outputs)	0xxxx
16 (10H)	Preset Multiple Registers	4xxxx
17 (11H)	Report Slave ID	Hidden

The following parameters and controls are supported by Model DI-942MB.

Slave Communication

Report Slave Identification: This command returns the model number, run on/off status, serial number, and firmware number.

Reset Slave: This command resets the module (equivalent to a power-on reset). A reset can also be done by a write to the Calibration Access & Reset Register (see Memory Map register 40025) for use with Modbus software that does not support the Reset Slave command.

Slave Address: Select from 1 to 247 (01H-F7H). Address 247 is the default communication mode address.

Baud Rate: Select 2400, 4800, 9600 (default), 14400, 19200, 28800, 38400, 57600, 76800, or 115200 bits per second.

Parity: Select Even, Odd, or No Parity error checking. DI-900MB modules will accept no parity with 1 or 2 stop bits.

Response Delay: Select 0 to 65500 ticks (1 tick = 1.085us) for the additional delay a module is to wait before it sends its reply to the host. Some signal converters or host/software systems will not accept a message response immediately after sending the message without added delay.

TIP: Try increasing this delay if you cannot communicate with the module or have many errors.

Module Status: This register tracks alarm status, I/O watchdog timeout, and internal flash memory checksum error status.

I/O Watchdog Timer & Output Reset: A watchdog fault flag (bit 0 of the Module Status register) will be set if any of output channels have not been written to over the specified time period, or if any of the I/O channels have not been read over the same period. In addition, a timeout will cause the ST status LED to blink rapidly. Use the Watchdog Time Register to select a period from 1 to 65534 seconds (up to 18.2 hours). A time of 65535 (FFFFH) or 0 (0000H) will disable the timer. Use the Timeout State Register to set the states the outputs go to upon timeout (the two lower order bits of this register define the timeout states of each output channel). Writing 65535 (FFFFH) to this register will leave the outputs unchanged upon timeout. Watchdog output state control takes precedence over alarm and direct control.

Input Configuration

Range/Type: Choose 0-100Hz, 0-1KHz, 0-50KHz, or Event Counter, for both inputs together.

Threshold (Bipolar/Unipolar): Choose bipolar (zero crossing), or unipolar (non-zero crossing) thresholds.

Resistor (Pullup/Pulldown/None): Enable/disable an internal input pullup (2.7KΩ to 5V), or pulldown (1KΩ to input RTN), to connect to the input.

Gate Time (0.1 to 1.0s, 0-50KHz Range Only): A gated period of this time is used to count the number of input wave cycles in order to determine the period and frequency for this range.

Cycles (1-255, 0-100Hz & 0-1KHz Ranges Only): This is the number of cycles that are counted while tracking the total time to determine the average input period before updating the frequency. This is useful for applications that make use of encoders with irregular cycle widths in one period (revolution). The measurement is a running average of this many cycles which helps to minimize jitter in these applications. Note the response time will be increased by the factor selected.

Cutoff Frequency (0-100Hz & 0-1KHz Inputs Only): Input frequencies below cutoff read as 0Hz. Cutoff is used to minimize the time to detect a loss of signal with slow frequencies and a high number of cycles. Values slightly above cutoff may be intermittently reported as 0 due to 10ms of uncertainty. You can approximate the cutoff time within $\pm 10\text{ms}$ via the expression: $\text{Cutoff Time} = (\text{Cycles} + 1) / \text{Cutoff Frequency}$.

<p>TIP: You can examine the channel's Raw Value register to determine if an input is 0Hz due to a broken lead (exactly 0), or because the input is below the cutoff frequency (greater than 0).</p>
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Calibration (Frequency Input Only): The configuration software can be used to calibrate the high endpoint of the frequency ranges. Optionally, you may use the Preset Register Functions and your own software to write appropriate data to the calibration registers to achieve calibration.

Event Counter Debounce Time (0-255 x5ms): Select a time factor from 0 to 255 (multiple of 5 milliseconds). Debounce is used to eliminate false counts due to mechanical contact bounce. Be sure to set this time appropriately with respect to your count rate (bandwidth).

Event Counter Trigger-Edge (Rising/Falling): Select the rising edge (positive), or falling edge (negative) of the input pulse to trigger a count.

Event Counter Termination (Auto-Reset, or Latch): An auto-reset counter will count up to the limit, then reset to 0 and resume counting while simultaneously pulsing the output ON for 100-200ms. A latching counter will count up to the limit, latch there, and turn the output ON. The event counter remains latched until it is reset. Note the high limit output must be enabled for the output to turn ON, or you will have no indication of the limit being reached (unless you also choose to acquire the count). Counter can be reset to zero using the Event Counter Reset Register, or via Reset Event Counter of the Configuration Software.

Event Counter Acquire Count (Yes or No): If you acquire count, the running count will be reported every 100ms. This can cause the sampling processor to miss events during the time it reports its count (decreasing accuracy), so consider its use carefully when exact counts are required. Otherwise, you can rely on the high limit alarm to let you know where the count is and this provides best accuracy.

Event Counter Reset: Causes one or both event counters at channel 0 and channel 1 to reset their counts to zero.

Output Configuration

Output State: The coil registers (0x references) may be read via the Read Coil (01) command to determine the current state of the outputs. The output state is also indicated by a yellow status LED at the front of the module (ON when switch is closed). The Force Single Coil (05) and Force Multiple Coil (15) commands may be used to directly control the output state via the coil registers. The outputs may also be set under alarm control, or via watchdog timeout.

IMPORTANT: Alarm limits take precedence over direct control and must be disabled if direct control is desired. Watchdog timeout control has the highest priority if enabled.

Alarm Configuration

Alarm Output State & Output Enable: Use the Alarm Output State and Alarm Output Enable Register to make the corresponding output act as an alarm output and to select failsafe or non-failsafe activation. A failsafe alarm will turn OFF in alarm (same state with power off). A non-failsafe alarm will turn ON in alarm. Alarm limit checking is always active for the module, but assignment of an alarm output is optional via this control. Event counter high limit outputs are non-failsafe only.

High Limit Value/Event Counter Setpoint: Use the channel High Limit Value Register to write a high limit value with the same units as the input (Hz for Frequency, Counts for Event Counters). Limit values must be within the full input range (see 2. Specifications). The corresponding digital output will transfer to the alarm state when the high limit value is exceeded and remains at that state until the input signal has retreated below the limit, plus any deadband.

Low Limit Value (Not for Event Counters): Use the channel Low Limit Value Register to write a low limit value with the same units as the input (Hz for Frequency, Counts for Event Counters). The corresponding digital output will transfer to the alarm state when the low limit value is exceeded and remains at that state until the input signal has retreated above the low limit, plus any deadband.

Deadband Value (Not for Event Counters): Use the channel Deadband Value Register to assign deadband to limit checking. Use the same units as the input (Hz for Frequency, Counts for Event Counters) choose a value within the full input range. Deadband is the amount the input signal has to return into the “normal” operating range before the output will turn OFF. Deadband is normally used to eliminate false trips or alarm “chatter” caused by input fluctuations near the alarm point.

IMPORTANT: Noise or jitter on the input signal has the effect of reducing an instrument's deadband and may cause output chatter. This can reduce the life of any mechanical relay controlled via the output. To prevent this, increase the deadband.

Alarm Output Indication: The yellow output LED can provide visual status indication of when the corresponding channel is in alarm. This LED is ON when the output switch is closed. Thus, this LED will turn ON for a non-failsafe alarm, and OFF for a failsafe alarm.

Software Alarm Indication: The Module Status Register will indicate if any inputs are in alarm. The Channel Status Register will indicate if a specific input is in alarm.

7. Module Software Configuration

The software for this product is supplied on CD-ROM and included as part of the Series DI-900MB Software Interface Package (Order Model 100969). **IMPORTANT:** Before continuing with installation, be sure to exit any other Windows programs that may be running.

Installation Instructions

1. Insert the DI-900MB Resource CD into your CD-ROM drive. **IMPORTANT:** Before continuing with installation, be sure to exit any other Windows programs that may be running.
2. The Window's AutoRun feature should start the CD and the installation software will run.
3. Select the option "Install DI-900MB Configuration Software" and click on OK.
4. The Welcome Dialog Box appears. Click on Next to continue with the installation or Cancel to abort.
5. Fill out your user information in the appropriate text boxes and click on Next.
6. The Choose Destination dialog box allows you to specify the program files' destination directory. To keep the default (C:\Program Files\Series900MB) click on Next, to change the destination click on the Browse button, select a destination, then click on Next.
7. The Select Program Folder allows you to designate the program folder. To keep the default (Series900MB), click on Next, to choose a different folder, make a selection from the list then click on Next.
8. The Start Copying Files dialog box shows the current settings and allows you to change them by using the Back button. To change settings, click on the Back button until you reach the setting you would like to change, change that setting, and click on the Next button until you get back to the Start Copying Files dialog box. To keep the current settings and install the software, click on the Next button.
9. Setup is complete. Click Finish to exit the Dataq installation program and return to Windows.
10. To run the configuration software, go to the Start Menu and click on Programs > Series900MB > Series900MB Configuration (this is the default - if you did not keep the default settings choose the program folder and directory you had specified during installation).

In addition to configuring all features of the module, the Configuration Software includes these additional features:

- Allows a configuration to be uploaded or downloaded to/from the module via the RS485 interface.
- Polls the module & allows polling to be turned on or off.
- Monitors the input frequency or event count.
- Monitors/controls the discrete output signal states.
- Reads the contents of the Module Status Register.
- Provides controls to reset one or both event counters.
- Provides controls to reset a module.
- Provides controls to separately recalibrate each input frequency range (high endpoint).
- Allows optional user documentation fields to be saved to a module file on the PC.
- Allows a module's complete configuration to be printed in an easy to read, one or two page format, including user documentation.

The following section will walk you through the software. You should have a module connected in order to access all pages of this software. Using the Configuration software is the easiest method of setting up your module.

Starting the Program

Click on the Series DI-900MB program icon to boot the Configuration Program and the screen at right will be displayed.

Click on the “Settings-Serial Communications...” pull-down menu (or press Ctrl-E) to set the COM port, baud rate, parity, and slave address that the host computer will use to communicate with the module.

Set the host **Communication Port** the module is connected to (COM1-COM4), or type in a COM port from COM1 to COM99.

Set the host **Baud Rate** for communication with the module.

Set the host **Parity** to Odd, Even, or No Parity error checking.

Set the **Slave Address** the host is to use to talk to the module.

Use **File-New** to create a new configuration file.

Use **File-Open** to open an existing configuration file.

Use **File-Save** to save the current configuration file to disk.

Use **File-Save As** to save the current configuration file to a new file name.

Use **File-Print** to get a printout of the currently loaded configuration file.

Use **File-Print Preview** to preview a printout of the current configuration.

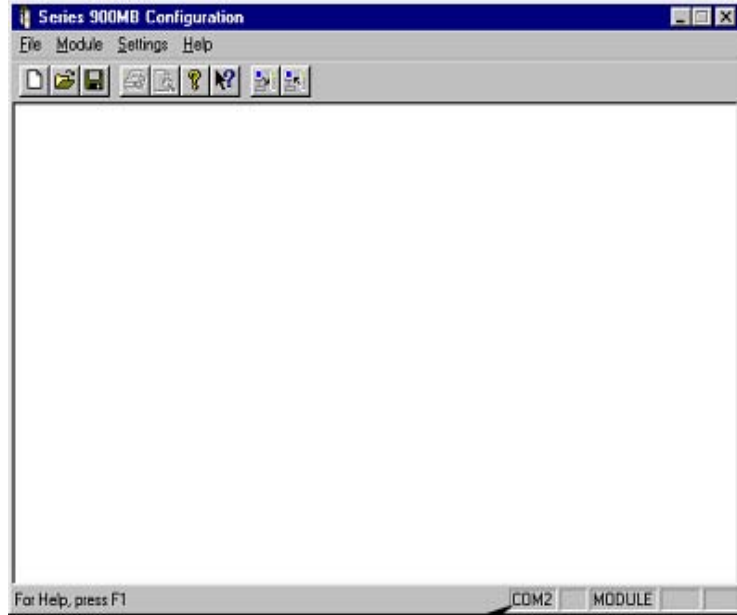
Use **File-Print Setup** to select a printer and font style.

Use **Module-Upload Configuration** to upload the module's current configuration and calibration (recommended).

Use **Module-Download Configuration** to write the currently loaded configuration to the module.

Use **Help** to obtain information about using this software or configuring transmitters. Note that context sensitive help (h?) is also available for help on a specific field or topic. Simply click on the [h?] button, then click on the field or topic of interest to obtain help on that subject. You may also click the right mouse button to copy or print the help screen while it is being displayed.

Note: Uploading first is recommended as it will automatically detect the correct model connected and load the property sheets for that model.



The host COM port setting is indicated in the first box of the lower right-hand corner. MODULE is indicated in the third box if a connected module is detected by the software. The fourth and fifth boxes indicate NUM for Num lock and CAP for Caps lock, respectively.



You can check this box to automatically change host settings to match new module settings following download.

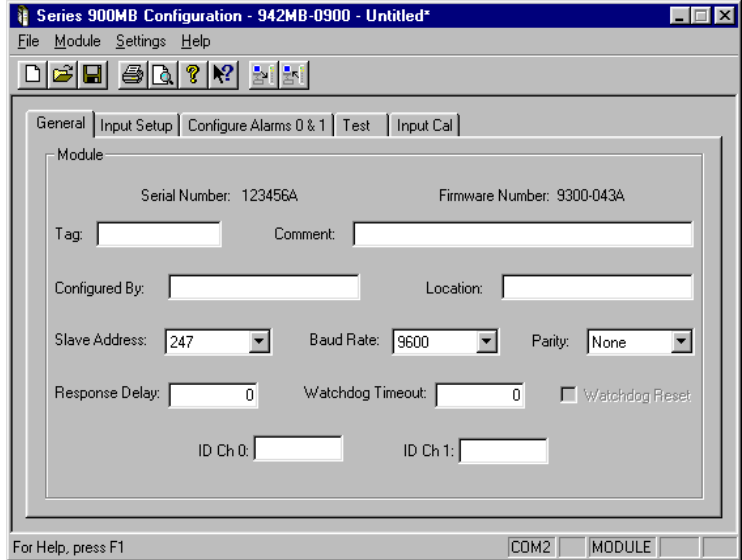
Creating a Configuration File

This screen is displayed once you choose to create, open, or upload a file. The model number is indicated at the top of the screen along with the current file name.

Optional documentation: Enter a “Tag:” (15 characters), “Comment:” (31 characters), “Configured By:” (15 characters), “Location:” (25 characters), “ID Channel:” (15 characters). This info is not stored within the module.

Use the scroll bars of the following fields to make a selection. Your selection will take effect following the next download.

Note: Address, baud rate, & parity selections take effect following a configuration download, but do not alter the settings used by the host software which is configured separately via the **Settings** pull-down menu.



Set “**Slave Address**” from 1 to 247.

Set “**Baud Rate**” (2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600, 76800, or 115200 bits per second).

Set “**Parity**” to Odd, Even, or No Parity error checking.

If you already checked the “Update Communications settings at download” box of the Settings pull-down menu, the host software will change its own settings to match the new module settings that take effect after download in an effort to maintain communication with the module.

Some host software or signal converters may require a communications turnaround delay to work properly. Set “**Response Delay**” from 0 to 65500 ticks (1 tick=1.085us) if required. This will add delay between message receipt by the module and its response to the host. Since a fixed amount of delay is already present, you will have to specify a comparable amount of response delay to measure any affect.

You can enable the I/O Watchdog Timer by setting “**Watchdog Timeout:**” from 1 to 65534 seconds (0 or 65535 will disable timer). A timeout will occur if no I/O data transfer occurs within this time period. You may optionally click the “**Watchdog Reset**” check box to also send the digital outputs to their reset states upon watchdog timeout (Reset States are set separately via the Configure Alarms screen).

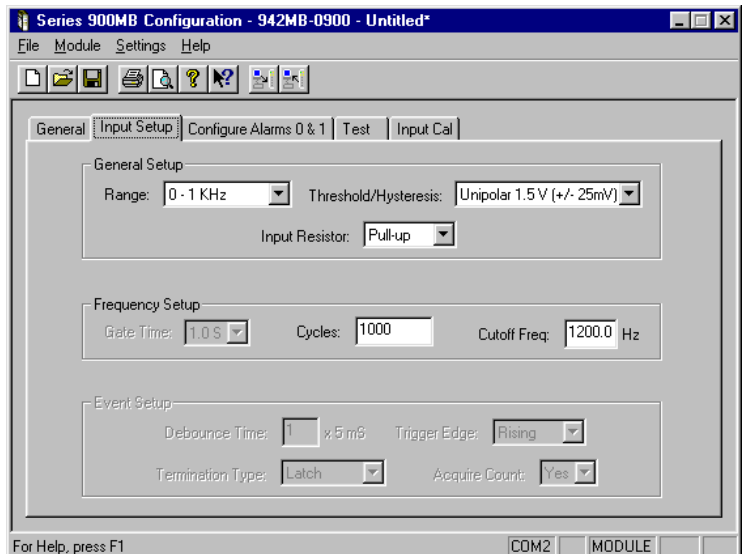
Input Setup

Click the Input Setup tab to display the screen shown above. Input Setup is used to specify parameters for the frequency or event counter inputs (parameters apply to both inputs together).

General Setup

Use the field scroll bars to select parameters as follows:

For “**Range:**”, pick 0-50KHz, 0-1KHz, 0-100Hz, or Event Counter.



For “**Threshold/Hysteresis:**”, pick Bipolar 0.0V ($\pm 25\text{mV}$), Bipolar 0.0V ($\pm 83\text{mV}$), Unipolar 1.5V ($\pm 25\text{mV}$), or Unipolar 5.0V ($\pm 83\text{mV}$).

For “**Input Resistor**”, select an input pull-up to the internal +5V supply, an input pull-down to RTN, or none to leave the input pull resistors disconnected.

Thresh/Hysteresis Selection:

Sine Waves (Zero Crossing): Set Bipolar 0.0V ($\pm 25\text{mV}$).

Square Waves (Logic Level): Set Unipolar 1.5V ($\pm 25\text{mV}$).

Frequency Setup

Use the “**Gate Time:**” scroll bar to select a time period from 0.1s to 1.0s in 0.1s increments. This is the fixed time over which a number of input cycles is counted in order to calculate the period & frequency for the 0-50KHz range only.

Enter an integer from 1-255 into the “**Cycles:**” field to set the number of cycles to sample for the 0-1KHz and 0-100Hz ranges only. The total time to acquire this many cycles is used to calculate the period and frequency for the 0-100Hz and 0-1KHz ranges.

Enter a “**Cutoff Freq:**” into this field to set the minimum measurable frequency for the 0-100Hz and 0-1KHz ranges only. Frequencies below 0.5Hz (default), or below the specified cutoff frequency, will read as 0Hz. Specify a cutoff frequency to minimize the time to detect a loss of signal for a large number of cycles at low frequencies.

Event Setup (Event Counter Only)

In the “**Debounce Time:**” field, enter an increment multiple of 5ms from 1-200. This is the amount of time the module will wait following an event before it will allow another event to occur. Your maximum count rate will be reduced with increased debounce time.

Use the “**Trigger Edge:**” scroll bar to select the rising (positive-going) edge, or falling (negative-going) edge, of the input pulse that will trigger an event count.

Use the “**Termination Type:**” scroll bar to select Auto-Reset, or Latch for the event counter. Auto-Reset will turn the alarm output ON for 100-200ms and reset the counter back to 0 when the limit value has been reached. Latch will turn the output ON upon reaching the limit and stop counting events, until the event counter is reset.

Note: The corresponding High limit must be separately enabled to control the associated digital output.

Use the “**Acquire Count:**” scroll bar to select No (default), or Yes. Normally, the event counter uses a high limit and alarm output to indicate it has reached a defined count limit and this keeps accurate count. Choosing “Yes” will cause the sampling controller to also send the running count to the main micro every 100ms for display purposes, rather than just relying on the high limit to report where the count is. However, choosing “Yes” can cause the sampling controller to miss events during the time it’s reporting the count and this can decrease count accuracy. This field is set to “No” (off) by default and its use must be carefully considered where exact counts are required.

CAUTION: Selecting “Yes” to periodically acquire the event count may cause the event counter (the sampling controller) to miss events for the time it takes to report its count to the main processor. You have the option of reporting the running count, but at the possible expense of count accuracy. Keep this in mind for critical counting applications.

The next section covers Alarm Configuration.

Alarm Configuration

Note: Limit checking is always active for this module. The default limits are the input range endpoints.

Limit Alarm (Each Input)

Hi/Lo Alm Output Enable: Click to check this box and enable the High and/or Low Limit alarm output for each input.

Note: Limit alarm control of the corresponding output takes priority over direct control when enabled.

High Limit/Event Counter Setpoint: Enter a high limit in Hertz (or events). The corresponding alarm output will go to its alarm state for an increasing input signal that equals or exceeds the high limit (if enabled).

Note: Be sure to enable the High Alarm Output for event counters, especially with Acquire Count set to “No.”

Low Limit (Not For Event Counters): Enter a low limit in Hertz. The corresponding alarm output will go to its alarm state for a decreasing input frequency that equals or goes below the low limit (if enabled).

Deadband (Not For Event Counters): Deadband is applied to both limit levels and determines the amount the input signal has to return into the “normal” operating range before the corresponding solid-state alarm relay will transfer out of the “alarm” state.

Note: Deadband is normally used to eliminate false trips or switch “chatter” caused by fluctuations of the input near the limit.

Alarm Mode (Each Input): Select Failsafe or Non-Failsafe alarm output action. A failsafe alarm output will turn OFF in alarm (the same state as the power-down state). A non-failsafe alarm output will turn ON in alarm. Alarm outputs must be separately enabled.

Alarm control of an output will take precedence over direct control when the High/Low Alarm Output Enable box is checked. Keep this in mind if you try to control the state of an alarm output directly, as the module will seek to maintain the correct output state each time it scans the input, relative to the alarm condition and alarm mode. This does not apply for input signals within the deadband region, where the output state can be controlled directly. However, direct control of an alarm output is not recommended.

There are three methods of detecting an alarm: the output status LED can be used to indicate a transfer to the alarm state, a global limit exceeded flag will be set in the Module Status Register, and a high and/or low limit flag will be set in the Channel Status Register.

Note: The test page of this software program will also report the alarm status for the module and at an input channel.

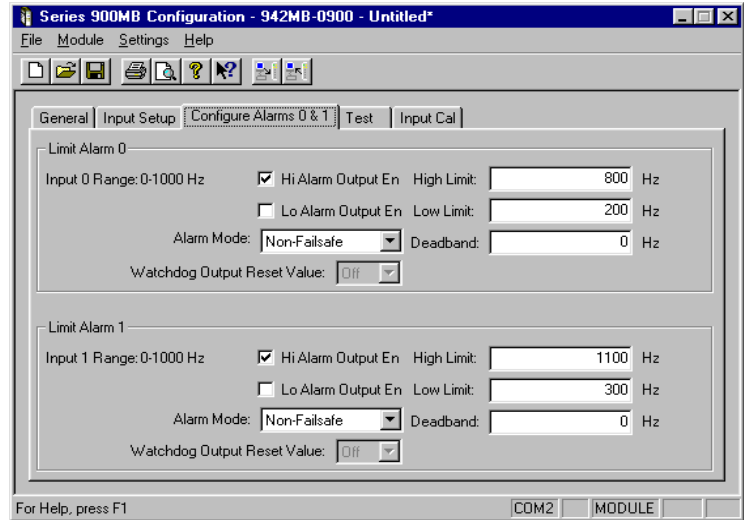
Watchdog Output Reset Value: This selection determines the state the output will be automatically toggled to following a watchdog timeout. Select “On” or “Off” as required. Watchdog timer control of the output will take precedence over alarm & direct control.

Writing Your Configuration

After making your General and Alarm Configuration selections, you must download the new settings as follows:

Select **Module-Download Configuration** to write your configuration to the module:

- Module**
- Upload Configuration
- Download Configuration



Note that you can select **Module-Upload Configuration** to retrieve the module's current alarm configuration/calibration, or to review and verify its configuration. Configuration data is stored in non-volatile memory within the module.

Printing Your Configuration

You can select **File-Print-Preview** to preview this document before printing. If you wish to document your transmitter configuration, then select **File-Print** to get a two page printout of all of your selected configuration parameters.

Saving Your Configuration

The currently loaded configuration file name is indicated at the top of the screen to the right of the model number.

You should select **File-Save As** to save your configuration file to disk and give it a new file name.

Use **File-Save** to save the current file without renaming it.

In the event that you lose a configuration file, you can always upload it from the module via **Module-Upload Configuration**.

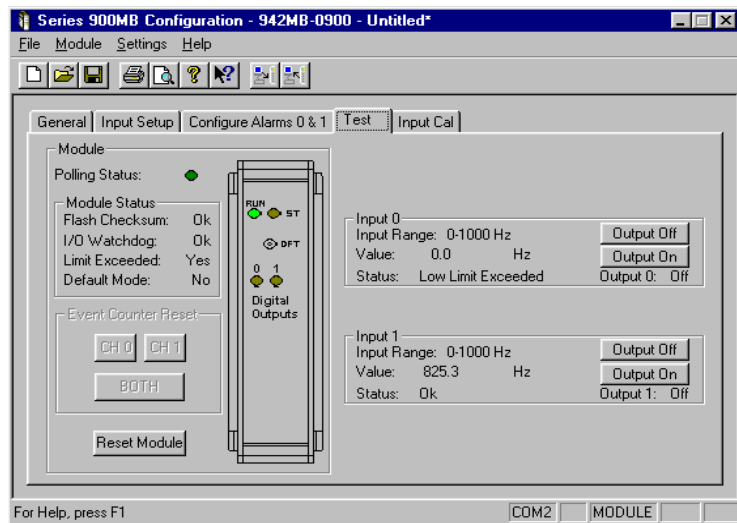
Now wasn't that easy! That's all there is to using the Configuration software to configure your module. The module is now ready for installation in the field.

The next section covers testing of your configuration. If you have made changes to any of the module configuration screens, be sure to download your changes to the module prior to invoking any of the active Test or Input Calibration pages.

Testing Your Module

Click the "Test" tab to display a screen similar to the one above. This screen allows you to actively interact with and poll the module, monitor the module status flags and I/O values, reset the module, and control and monitor the outputs.

CAUTION: Always download your changes to the module before invoking the active Test or Input Cal pages as selecting this page may change some of your software settings to match those obtained from polling the module.



The flashing green dot of "Polling Status" indicates the software is communicating with the module and polling its I/O. Polling is automatic when this screen is displayed and turns off if another screen is selected. The LED's of the graphic simulation will reflect actual module LED states.

For Event Counters, you can click the CH0, CH1, or BOTH Event Counter Reset buttons to reset event counters.

You can reset the module by clicking the "Reset" button (same effect as power-on reset).

Note: A module will exit the Default Mode following a reset.

For each input, the current selected input range, input value ("Value:"), and input status is indicated. Output states are also indicated. You may turn outputs On or Off by clicking the "Output On" and "Output Off" buttons (assuming they are not already enabled as alarm outputs).

Keep in mind that alarm control of an output has priority over direct control (if enabled) and will seek to maintain the correct output state relative to the input level each time the input is scanned.

Clearing a watchdog timeout by initiating I/O with a module that has timed out will not automatically return the digital outputs to their pre-timeout state. It simply returns control of the output state to the alarms, or to the operator via manual control. Watchdog timeout control of the output has the highest priority (if enabled), followed by alarms (if enabled). Manual control of the outputs has the lowest priority.

The next section covers calibration of your frequency inputs. Calibration has already been done at the factory and adjustment is not generally required. However, periodic re-calibration may be performed to correct for component aging, or as part of your company's maintenance requirements.

Input Calibration

CAUTION: Always download your changes to the module before invoking the active Test or Input Cal pages as selecting this page may change some of your software settings to match those obtained from polling the module.

IMPORTANT: Calibration of the input ranges has already been done at the factory. Recalibration is normally not required, except as necessary to correct for long term aging effects.

Module Input Calibration (Frequency Inputs Only)

Calibration is simplified using the controls of this software. Simply connect the high-endpoint frequency indicated, then click the “Calibrate” button.

We recommend a Gate Time setting of 1 second with 0-50KHz range and 8 Cycles with the 0-1KHZ or 0-100Hz ranges to improve measurement accuracy.

For best results, you will need a precision signal generator capable of producing the high calibration frequency indicated, and at least as accurate as the module itself. If calibration is attempted with equipment of poor accuracy, then recalibration may degrade performance, or possibly render a channel inoperable.

Module Input Calibration

- Click the Input Calibration tab to display the screen shown above.

Uploading first will help prevent miscalibration if the input range set at the module is different than that selected via this software.

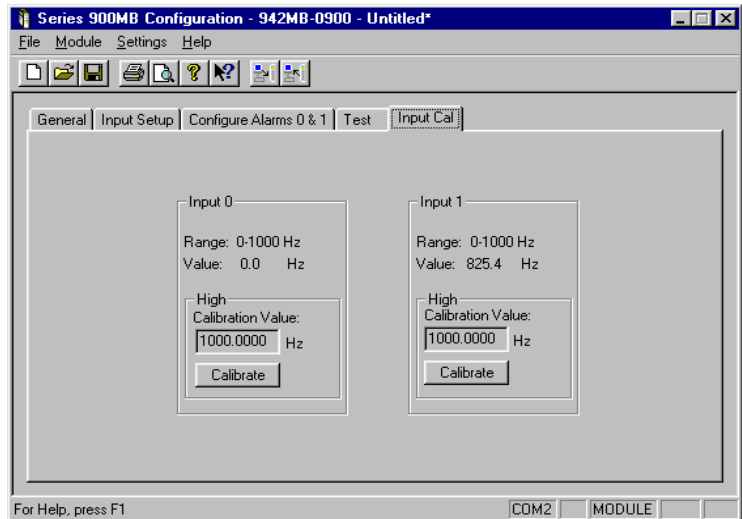
Note that **Module-Upload Configuration** will recall the module's current calibration. After uploading, the current active calibration values are indicated in the High Calibration Value field of each input. These correspond to the selected input range's upper endpoint signal.

- Observe proper polarity and wire your frequency generator to the input channel you wish to calibrate. Adjust this input frequency to the High Calibration value indicated.

You may wish to independently verify this frequency via a precision frequency counter.

- Note the measured frequency indicated in the Value field at the top of the screen. If the indicated value does not precisely match the High Calibration Value, then click the High “**Calibrate**” button to reset the High Calibration endpoint. After a moment, the value indicated at the top of the screen should closely match the High Calibration Value. If not, carefully repeat this procedure.

- Repeat steps 2-3 for the second input channel, as required.



8. Troubleshooting

The module routinely performs internal diagnostics following power-up or reset. During this period, the green “Run” LED will flash for a moment. If the diagnostics complete OK, the “Run” LED will stop flashing after a few seconds and remain ON. This indicates the unit is operating normally.

If your problem still exists after checking your wiring and reviewing the table below, or if other evidence points to another problem with the unit, an effective and convenient fault diagnosis method is to exchange the module with a known good unit. DATAQ Instruments’ Application Engineers can provide further technical assistance if required. Complete repair services are also available from DATAQ Instruments, Inc.

SYMPTOM	POSSIBLE CAUSE	POSSIBLE FIX
<i>Cannot communicate.</i>	Is power ON at the module and/or RS485 converter?	Check power. Is green RUN LED ON?
	Is baud rate correct?	Check baud rate settings at the host, module, and/or any RS485 signal converter or repeater.
	Is address correct?	Check address settings at the host and at the module.
	Is parity correct?	Check parity settings at the host and at the module.
	Additional response or turnaround delay time may required. Some host systems or signal converters require additional turnaround delay to work properly.	Try increasing the Response Delay Time at the module. Setting is found by experimentation and you must specify a time that is greater than the inherent time already present to notice a difference.
	Note: Some network converters or host/software systems cannot accept an immediate response from a slave device without additional delay inserted between message receipt and module response.	
	Have you tried the Default Communication Mode?	Press the DFT button until ST LED begins to blink. In this mode, the baud rate is 9600, the address is 247, and no parity is set.
<i>Continuous flashing green RUN LED.</i>	Internal firmware problem.	Return module to factory to restore firmware.
<i>Communication was lost while in the Default Mode.</i>	Has module been reset?	Module leaves the Default Mode if reset and internal baud, address, & parity settings take effect. Press DFT button until ST LED blinks to re-enter Default Mode.
<i>Input frequency is in error or input is inoperable.</i>	Miscalibration	Use the Configuration Software to recalibrate the input channel. Check your signal generator.
	Missing pullup or pulldown?	Review input resistor selection.
	Wrong threshold?	Review selection of polarity/threshold/hysteresis.

<i>Input frequency measurement indication is much lower than actual or 0Hz.</i>	Aliasing - Input signal is too fast to be sampled.	Limit maximum input frequency below 110% of nominal. The maximum measurable frequency of your unit is about 54.5KHz.
	Missing pullup or pulldown?	Review selection of input resistor.
	Wrong threshold?	Review selection of polarity/threshold/hysteresis.
<i>Event counter is missing events.</i>	Is Acquire Count enabled?	Count accuracy can be degraded if Acquire Count is set to Yes, as the sampling controller can miss events during the time it takes to report its running count. Disable Acquire Count and use the High Limit alarm to report count.
	Debounce Time is too long.	Reduce Debounce Time.
	Frequency of events is too fast.	With debounce time set to 0, the maximum count rate that can be obtained is about 200 samples per second. Reduce the frequency of events.
	Missing pullup or pulldown?	Review selection of input resistor.
	Wrong threshold?	Review selection of polarity/threshold/hysteresis.
<i>Yellow ST status LED remains ON.</i>	Indicates Over-range at an input.	Reduce input frequency.
<i>Yellow ST status LED blinks slowly.</i>	Indicates module is in Default Mode.	To exit Default Mode, You can press the DFT button, reset the module, or cycle power off/on to the module.
<i>Yellow ST status LED blinks rapidly.</i>	Indicates a watchdog timeout has occurred.	I/O communication with the module will clear a timeout.
<i>Yellow ST LED blinks in rapid bursts.</i>	Indicates both Default Mode and watchdog timeout.	See above.
<i>Cannot get unit to indicate Default Mode or Watchdog Timeout.</i>	Yellow ST LED is always ON.	This occurs if input frequency is over-range (between 100 and 110% of full-scale). Reduce input frequency until ST LED changes state.

9. Accessories

Series DI-900MB Software Interface Package (Model 100969)

The Software Interface Package combines the DI-900MB Configuration Software, RS-232 to RS-485 Serial Converter, Interface Cable, and Instructions, into a complete kit for interfacing with Series DI-900MB I/O Modules.

DI-900MB Configuration & Control Software

Series DI-900MB modules are configured with this user-friendly Windows 95/98[®] or NT[®] Configuration Program. Optionally, any software that supports the Modbus/RTU protocol may be used to configure and control Series DI-900MB modules, but the use of this software makes getting started easier. All module functions are programmable and downloadable to the modules via this software. The software also includes on-line help. Non-volatile memory provides program and configuration storage within the module.

RS-232 to RS-485 Serial Adapter

This device is a non-isolated, port-powered, signal converter for communication between the RS-232 serial port of a personal computer and the RS-485 network interface of Series DI-900MB I/O Modules. It is used in conjunction with the DI-900MB Configuration Software for simple reconfiguration, testing, and troubleshooting of Series DI-900MB I/O modules. As a port-powered device, it is not intended for driving fully loaded RS-485 networks over long distances, and does not have sufficient power to drive terminated networks. The adapter has DB-9F connectors at both ends and plugs directly into the common DB-9M serial port connector of most personal computers. The module is connected to the RS-485 side of this adapter via a separate interconnecting cable (see Interface Cable described below).

Interface Cable

This 3-wire cable is used to connect the RS-485 side of the Serial Adapter to the RS-485 network terminals of Series DI-900MB modules. This cable is 8 feet long and has a DE-9M connector on one end, and three stripped and tinned wires on the other end. The wires are labeled A, B, and C for connection to the module D, Dbar, and COM terminals, respectively.

Isolated Signal Converter (Models 100974 and 100975)

This unit provides an isolated interface between the host PC's RS-232 port and RS-485 Modbus network devices. Signal conversion is bidirectional with operation that is transparent to all devices. The RS-485 network supports up to 32 devices (including the Signal Converter) across 4000 foot distances. Installation of additional network devices or extending the distance requires the Network Repeater described below. Optional 115V AC Power (Model 100974) or 230V AC Power (Model 100975). Power cord included. The Model Number 100976 connects the PC's RS-232 port to the Isolated Signal Converter.

Isolated Network Repeater (Models 100977 and 100978)

This unit isolates and boosts RS-485 signals to extend communication distances or increase the number of devices on the network. Each Repeater permits the addition of a network branch with up to 32 devices (including the Network Repeater) and will transmit RS-485 signals another 4000 feet. Operation is transparent to all devices and no handshaking is required. Two terminal blocks are provided for 120 ohm resistors to terminate both ends of the network branch. Optional 115V AC Power (Model 100977) or 230V AC Power (Model 100978).



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