MAQ®20

Industrial Data Acquisition and Control System

MA1058

MAQ20-DIOH
Hardware User Manual



DATAFORTH®

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MAQ20-DIOH Hardware User Manual
MA1058 Rev. A – September 2015
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Errata Sheets

Refer to the Technical Support area of Dataforth's website (www.dataforth.com) for any errata information on this product.

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1.0 System Features

The MAQ20 Data Acquisition System encompasses more than 25 years of design excellence in the process control industry. It is a family of high performance, DIN rail mounted, programmable, multi-channel, industrially rugged signal conditioning I/O and communications modules.

Instrument Class Performance

- ±0.035% Accuracy
- Industry leading ±0.3C CJC Accuracy over full operating temperature range
- Ultra low Zero and Span Tempco
- Over-range on one channel does not affect other channels
- 1500Vrms Channel-to-Bus Isolation
- 240Vrms Continuous Field I/O Protection
- ANSI/IEEE C37.90.1 Transient Protection
- Ventilated Communications and I/O Modules
- Industrial Operating Temperature of -40°C to +85°C
- Wide Range 7-34VDC Power
- CE Compliant, UL/CUL Listing and ATEX Compliance pending

Industry Leading Functionality

- The system is a Modbus Server and can be operated remotely with no local PC
- Up to 4GB of logged data can be transferred via FTP during real-time acquisition
- Up to 24 I/O modules, or 384 channels, per system, per 19” rack width
- Per-channel configurable for range, alarms, and other functions
- Backbone mounts within DIN rail and distributes power and communications
- System firmware automatically registers the installation and removal of I/O modules
- I/O modules can be mounted remotely from the Communications Module
- Equal load sharing power supply modules allow for system expansion
- Hot Swappable I/O modules with Field-side pluggable terminal blocks on most models
- Sophisticated package enables high density mounting in 3U increments
- DIN Rail can be mounted on a continuous flat panel or plate

Distributed Processing Enables Even More Functionality

- Output modules are programmable for user-defined waveforms
- Discrete I/O modules have seven high level functions:
  - Pulse Counter
  - Frequency Counter
  - Waveform Measurement
  - Time Between Events
  - Frequency Generator
  - PWM Generator
  - One-Shot Pulse Generator

Multiple Software Options

- Free Configuration Software
- Intuitive Graphical Control Software
  - ReDAQ Shape Graphical HMI Design & Runtime Solution
  - IPEmotion Muli-Vendor and Multi-Language Solution
  - Programming examples and LabVIEW VIs
  - OPC Server

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2.0 System Description and Documentation

A MAQ20 Data Acquisition System must have as a minimum a Communications Module, a Backbone, and one I/O Module. Examples include:

MAQ20-COMx Communications Module with Ethernet, USB and RS-232 or RS-485 Interface

MAQ20-DIOx Discrete Input / Output Module

MAQ20-xTC Type x Thermocouple Input Module

MAQ20-mVxN, -VxN Voltage Input Module

MAQ20-IxN Process Current Input Module

MAQ20-IO, -VO Process Current Output and Process Voltage Output Module

MAQ20-BKPLx x Channel System Backbone

Refer to www.dataforth.com/maq20.aspx for a complete listing of available modules and accessories.

System power is connected to the Communications Module, which in turn powers the I/O modules. For systems with power supply requirements exceeding what the Communications Module can provide, the MAQ20-PWR3 Power Supply module is used to provide additional power. When a MAQ20 I/O module is inserted into a system, module registration occurs automatically, data acquisition starts, and data is stored locally in the module. The system is based on a Modbus compatible memory map for easy access to acquired data, configuration settings and alarm limits. Information is stored in consistent locations in module memory for ease of use and system design.

MAQ20 modules are designed for installation in Class I, Division 2 hazardous locations and have a high level of immunity to environmental noise commonly present in heavy industrial environments.

The MAQ20-DIOH module has 4 isolated discrete input channels and 4 isolated discrete output channels. Input channels interface to 90-280 VAC/VDC signals and output channels control 24-280 VAC signals at up to 3Arms current. The output channels switch AC loads only. Discrete output channels have user configurable default output states which are set upon power up or module reset. In addition to performing standard discrete I/O, the channels can be configured to perform two Special Functions: Event Counter and Time Between Events. Two Special Functions can run simultaneously. High, Low, High-High and Low-Low alarms provide essential monitoring and warning functions to ensure optimum process flow and fail-safe applications. Field I/O connections are made through a pluggable terminal block.

Input-to-Bus isolation is a robust 1500Vrms and Channel-to-Channel isolation is 300Vrms. Each individual channel has continuous overload and reverse connection protection in the case of inadvertent wiring errors.

For details on hardware installation, configuration, and system operation, refer to the manuals and software available for download from www.dataforth.com/maq20_download.aspx This includes, but is not limited to:

MA1036 MAQ20 Quick Start Guide
MA1040 MAQ20 Communications Module Hardware User Manual
MA1041 MAQ20 milliVolt, Volt and Current Input Module Hardware User Manual
MA1037 MAQ20 Configuration Software Tool User Manual
MA1038 MAQ20 ReDAQ Shape for MAQ20 User Manual

MAQ20-940/-941 ReDAQ Shape Software for MAQ20 – Developer Version/User Version
MAQ20-945 MAQ20 Configuration Software Tool
MAQ20-951/952 IPEMotion Software for MAQ20

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3.0 Unpacking

Each MAQ20 Data Acquisition System component is shipped in electro-static discharge (ESD) protective packaging. Use appropriate ESD protection measures while unpacking. Check visually for physical damage. If physical damage is noted, file a claim with the shipping carrier.

4.0 Module Dimensions and I/O Connections

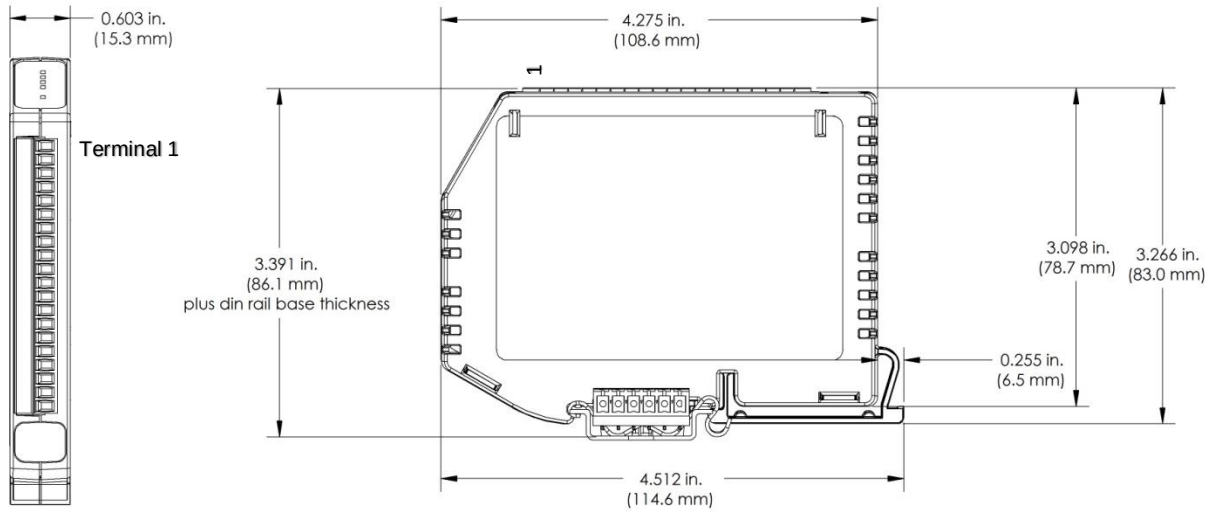


Figure 1: Module Dimensions

Table 1: I/O Terminal Block Connections

TERMINAL BLOCK POSITION (TOP TO BOTTOM)	MAQ20-DIOH FIELD CONNECTIONS	SPECIAL FUNCTION ASSIGNMENT	ALARM OUTPUT ASSIGNMENT
1	DO CH0 +OUT	Sec. 12.0, Table 4	Sec 14.0, Table 5
2	DO CH0 -OUT		
3	DO CH1 +OUT	Sec. 12.0, Table 4	Sec 14.0, Table 5
4	DO CH1 -OUT		
5	DO CH2 +OUT	Sec. 12.0, Table 4	Sec 14.0, Table 5
6	DO CH2 -OUT		
7	DO CH3 +OUT	Sec. 12.0, Table 4	Sec 14.0, Table 5
8	DO CH3 -OUT		
9	NC		
10	NC		
11	NC	Sec. 12.0, Table 4	
12	NC		
13	DI CH0 +IN	Sec. 12.0, Table 4	
14	DI CH0 -IN		
15	DI CH1 +IN	Sec. 12.0, Table 4	
16	DI CH1 -IN		
17	DI CH2 +IN	Sec. 12.0, Table 4	
18	DI CH2 -IN		
19	DI CH3 +IN	Sec. 12.0, Table 4	
20	DI CH3 -IN		

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5.0 Installation

The MAQ20 I/O module package has been designed for easy insertion into and removal from a system and can mate with DIN rails mounted flush on continuous panels or plates.

To install a module:

1. Orient the module with the field connector facing out.
2. Align the angled surface on the top rear corner with panel or plate the DIN rail is mounted to.
3. Slide the module down to capture the DIN rail with the hook on the module.
4. Rotate the module and snap in place

To remove a module, reverse the steps in the installation process. If space is available, the clip at the bottom of the module can be squeezed by hand to release. For tight installations, insert a flat blade screwdriver into the recess in the clip (5), place the shaft of the screwdriver against the curved part of the clip and gently pry the clip to release (6) as shown in Figure 2 below.

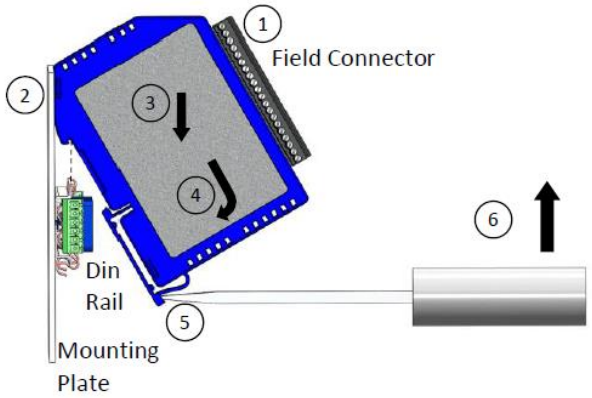


Figure 2: Installation and Removal

Multiple rows of MAQ20 modules can be mounted at a 3U vertical spacing interval. Backbones can be combined to add I/O modules to a system. A system is only allowed to have one MAQ20-COMx module. Some possible configurations in a 19" rack are shown in Figure 3 below.

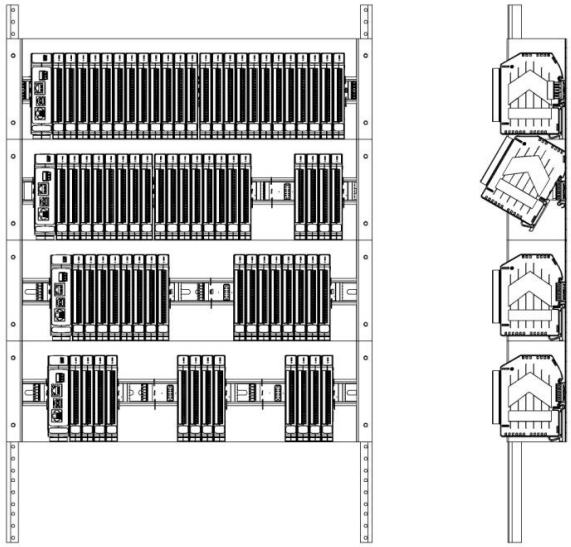


Figure 3: Possible System Configurations

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6.0 Building a System

An automated I/O module registration process reduces system setup to three basic steps:

STANDARD SETUP PROCESS

1.) Install a MAQ20-BKPLx backbone in a DIN rail then insert a MAQ20-COMx module in the left-most position and apply power.

2.) Install any MAQ20 I/O Module in any vacant local or remote backbone position. Observe that the green Power LED is on and communications activity is seen on the TX and RX LEDs. Allow 1 second for registration. This module has now been assigned Registration Number 1.

    Label and connect field wiring to the I/O Module. If desired, record module physical position in the system.

3.) Repeat Step 2 for all remaining MAQ20 I/O modules in the system. Subsequent modules installed are assigned Registration Number 2, 3, etc. The Registration Number sequence matches the physical sequence of module installation.

ALTERNATE SETUP PROCESS

1.) Do not apply power. Install a MAQ20-BKPLx backbone in a DIN rail then insert a MAQ20-COMx module in the left-most position and install all required MAQ20 I/O modules in any vacant local or remote backbone position. Label and connect field wiring to the I/O Module and if desired record physical position in the system.

2.) Apply system power and observe that each module has the green Power LED on and communications activity is seen on the TX and RX LEDs. Allow 5 seconds for full system registration. All modules have now been assigned Registration Numbers, but in a random sequence not associated with the physical position on the backbone.

NOTES:

Once the registration process is complete, Registration Numbers are permanent as long as I/O modules are not removed from or added to a system. When system power is cycled or the system is reset, I/O module Registration Numbers will always remain the same.

I/O modules in a system are identified in general by their model number (MAQ20-VDN, MAQ20-JTC, etc.) and uniquely by their Serial Number printed on the side label (i.e. 1234567-89). When I/O modules are installed in the system, only a general identifier is visible on the front of the module (V, I, TCPL, etc.). Wire tags or additional labeling applied to the module terminal block may be used for visible unique identification in an installed system.

MAQ20-940 - ReDAQ Shape Software for MAQ20 automatically assigns tag names to each input and output channel. These can be changed by the customer to associate channels with input wiring or parameters measured and controlled.

The system does not identify I/O modules by physical position on a backbone, only by registration sequence. MAQ20-940 - ReDAQ Shape Software for MAQ20 and MAQ20-945 - MAQ20 Configuration Software Tool provided by Dataforth show a graphical representation of a system based on registration sequence and not by physical position. Tools within each software package allow the user to reassign Registration Numbers thereby making graphical representations match physical location for a single, local backbone. For further details, see Section 9.0.

Module Detect: A write to the Module Detect Register at I/O module address 98 plus the module offset based on Registration Number will blink the STAT LED on the top angled surface of the module at a 5Hz rate for 5 seconds so the module location in a system can be visually identified.

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7.0 Maintaining a System

The MAQ20-COMx Communications Module periodically scans the system and will detect if a MAQ20 I/O module has been removed from the system or has lost communications. When this happens the module Registration Number will be released and available for reassignment.

Standard system maintenance involves a simple three step process:

STANDARD MAINTENANCE PROCESS

1.) Turn system power on and observe communications activity on the I/O modules.

2.) CASE 1: I/O module is suspected faulty and is to be replaced with the same model number

Remove a single MAQ20 I/O module from any local or remote backbone position. Replace the module with another of the same model number. This module can be installed in any vacant local or remote backbone position. Observe that the green Power LED is on and communications activity is seen on the TX and RX LEDs. Allow 1 second for registration. This module now has the same Registration Number as the one removed.

CASE 2: I/O module is to be replaced with another having a different model number

Remove a single MAQ20 I/O module from any local or remote backbone position. Replace the module with another having a different model number. This module can be installed in any vacant local or remote backbone position. Observe that the green Power LED is on and that there is communications activity on the TX and RX LEDs. Allow 1 second for registration. This module now has the same Registration Number as the one removed.

Label and connect input/output wiring to the I/O module and if desired record physical position in the system.

3.) Repeat Step 2 for any remaining MAQ20 I/O modules in the system requiring maintenance.

ALTERNATE MAINTENANCE PROCESS

1.) With system power off, remove any I/O modules which are to be replaced. Replace the modules with others of the same or different model numbers. Modules can be installed in any vacant local or remote backbone position.

Label and connect input/output wiring to the I/O module and if desired record physical position in the system.

2.) Apply system power and observe that each module has the green Power LED on and communications activity is seen on the TX and RX LEDs. Allow 5 seconds for full system registration. Replaced modules have now been assigned the Registration Numbers of those removed, but in a random sequence not associated with the physical position on the backbone. Modules which were not replaced retain their assigned Registration Numbers.

NOTES:

Once the registration process is complete, Registration Numbers are permanent as long as I/O modules are not removed from or added to a system. When system power is cycled or the system is reset, I/O module Registration Numbers will always remain the same. Tools within MAQ20-940 - ReDAQ Shape Software for MAQ20 and MAQ20-945 - MAQ20 Configuration Software Tool allow the user to reassign Registration Numbers. For further details, see Section 9.0.

Module Detect: A write to the Module Detect Register at I/O module address 98 plus the module offset based on Registration Number will blink the STAT LED on the top angled surface of the module at a 5Hz rate for 5 seconds so the module location in a system can be visually identified.

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8.0 Expanding a System

The MAQ20-COMx Communications Module periodically scans the system and will detect if a MAQ20 I/O module has been added. When this happens the next available sequential Registration Number is assigned to the module.

Standard system expansion involves a simple three step process:

STANDARD EXPANSION PROCESS

1.) Turn system power on and observe communications activity on the I/O modules.

2.) Add a single MAQ20 I/O module in any local or remote backbone position. Observe that the green Power LED is on and communications activity is seen on the TX and RX LEDs. Allow 1 second for registration. This module has now been assigned the next available sequential Registration Number.

    Label and connect input/output wiring to the I/O module and if desired record physical position in the system.

3.) Repeat Step 2 for all remaining MAQ20 I/O modules to be added to the system. Subsequent modules installed are assigned the next sequential Registration Number.

ALTERNATE EXPANSION PROCESS

1.) With system power off, install all additional MAQ20 I/O modules in any vacant local or remote backbone positions. Label and connect field wiring to the I/O module and if desired record physical position in the system. Do not apply power.

2.) Apply system power and observe that each module has the green Power LED on and communications activity is seen on the TX and RX LEDs. Allow 5 seconds for full system registration. Added modules have now been assigned the next available sequential Registration Numbers, but in a random sequence not associated with the physical position on the backbone. Modules previously installed and registered in the system retain their assigned Registration Numbers.

NOTES:

Once the registration process is complete Registration Numbers are permanent as long as I/O modules are not removed from or added to a system. When system power is cycled or the system is reset, I/O module Registration Numbers will always remain the same. Tools within MAQ20-940 - ReDAQ Shape Software for MAQ20 and MAQ20-945 - MAQ20 Configuration Software Tool allow the user to reassign Registration Numbers. For further details, see Section 9.0.

Module Detect: A write to the Module Detect Register at I/O module address 98 plus the module offset based on Registration Number will blink the STAT LED on the top angled surface of the module at a 5Hz rate for 5 seconds so the module location in a system can be visually identified.

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9.0 MAQ20 I/O Module Registration

The MAQ20 Data Acquisition System uses an automated registration process which periodically scans the system and will detect when MAQ20 I/O modules are added and removed. Modules are assigned a sequential Registration Number based on the order in which they are detected. This order can be forced to occur in a given sequence by adding modules one at a time or it can be allowed to happen randomly. For further details, see Sections 6.0, 7.0 and 8.0.

The system does not identify I/O modules by physical position on a backbone, only by registration sequence. MAQ20-940 - ReDAQ Shape Software for MAQ20 and MAQ20-945 - MAQ20 Configuration Software Tool provided by Dataforth show a graphical representation of a system based on registration sequence and not by physical position. Tools within each software package allow the user to reassign Registration Numbers thereby making graphical representations match physical location for a single, local backbone.

Module Detect: A write to the Module Detect Register at I/O module address 98 plus the module offset based on Registration Number will blink the STAT LED on the top angled surface of the module at a 5Hz rate for 5 seconds so the module location in a system can be visually identified.

Each module is assigned an address space of 2000 addresses based on the Registration Number and starting at address 2000. I/O module with Registration Number 1 is assigned address space 2000 – 3999, I/O module with Registration Number 2 is assigned address space 4000 – 5999 and so on. The starting address for the module is very important because this is the offset address that must be added to the addresses listed in the I/O module address map to know where data for that module is located within the system level address map. The MAQ20-COMx Communication Module is always assigned a Registration Number of 0.

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The Address Map for the MAQ20-DIOH module is found at the end of this manual. An excerpt from the Address Map is shown below. Channel Data is stored starting at address 1000.

NOTE:

THE MAQ20-DIOH MODULE USES INVERTED LOGIC. LOGIC 0 READ FROM A DISCRETE INPUT CHANNEL INDICATES THAT THE SIGNAL ON THE INPUTS IS ABOVE THE THRESHOLD AND LOGIC 1 INDICATES THAT THE SIGNAL IS BELOW THE THRESHOLD.

WRITING A 0 TO A DISCRETE OUTPUT CHANNEL CLOSES THE SOLID STATE SWITCH AND WRITING A 1 OPENS THE SWITCH.

NOTE: When a module is registered in a system, addresses are offset by 2000 * R, where R is the Registration Number.

Address Range 1000 - 1299 : Module Data and Special Function Selection						
Start Address	**Read/Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
1000	R/W	8	DIO States, Binary Representation Inverted Logic Addr 1000 = LSB, Addr 1009 = MSB	Example: Starting at address 1009 and decreasing to address 1000, MSB to LSB, x then DI3 to DI0 and x then DO3 to DO0 = x0110x1000, where x = 0, register not used. Data written to an input channel will be ignored. Data written to an output channel committed to a Special Function returns an error. Default = 1 for all channels.	DO0 - DO3 Inverted Logic 0 = Switch Closed 1 = Switch Open DI0 - DI3 Inverted Logic 0 = Input > Threshold 1 = Input < Threshold	INT16
1010	R	1	DIO States, Decimal Equivalent	Example: 200 (the decimal equivalent of the binary number above. MSB to LSB 0011001000). Default = 495	0 to 255	INT16

Example: A MAQ20-DIOH module with serial number 1234567-89 is installed in a system and has been assigned a Registration Number of 4. Write data to the discrete output channels and read data from the discrete input channels.

The MAQ20-DIOH module with s/n 1234567-89 has an address offset of 2000 * 4 = 8000

Write to the DO channels DO0 – DO3 at addresses 8000 + 1000 to 1003 = 9000 to 9003
Read from the DI channels DI0 – DI3 at addresses 8000 + 1005 to 1008 = 9005 to 9008

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The MAQ20-940 - ReDAQ Shape Software for MAQ20 and MAQ20-945 - MAQ20 Configuration Software Tool both have a utility which allows the user to reassign Registration Numbers to I/O Modules in a system. This can be used to rearrange the way I/O modules are displayed in the software if the Alternate Registration Processes have been used instead of the Standard Registration Processes. These are both described in Sections 6.0, 7.0 and 8.0.

Graphical representations of a system in the ReDAQ Shape and Configuration Software Tool display I/O modules sequentially in the order they were registered. The display does not represent physical position and will not show vacant positions between I/O modules. The ReDAQ Shape graphic shows a 24 position backbone regardless of the backbone or combination of backbones used in a system.

When using the Configuration Software Tool, the registration sequence is presented on the main screen as shown in Figure 4.

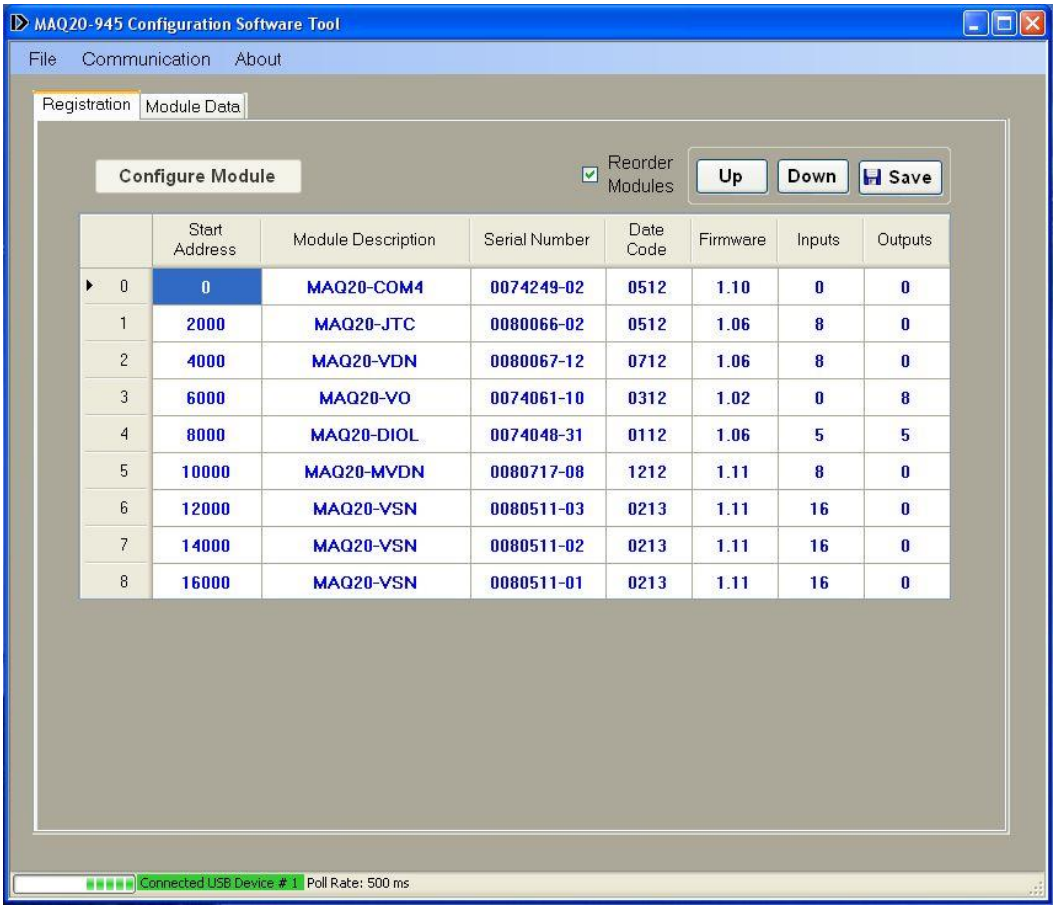


Figure 4: Module Registration using MAQ20-945 Configuration Software Tool

Registration Numbers are listed in the left column. To change the Registration Number of an I/O module, click the box with the Registration Number in the left column, select the 'Reorder Modules' box, then use the Up and Down buttons to move the module within the sequence. The system automatically reassigns the I/O modules above and below the one moved. Repeat for other modules if desired. The MAQ20-COMx module always has Registration Number 0 and cannot be moved. Press 'Save' to save the configuration. The new registration sequence is permanent as long as I/O modules are not removed from or added to a system.

The Configuration Software Tool does not have a user interface specific to the MAQ20-DIOH, but it can be used to set up module registration and to read from and write to the module Modbus registers.

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ReDAQ Shape Software for MAQ20 presents a graphical representation of the system on the Acquire panel as shown in Figure 5.

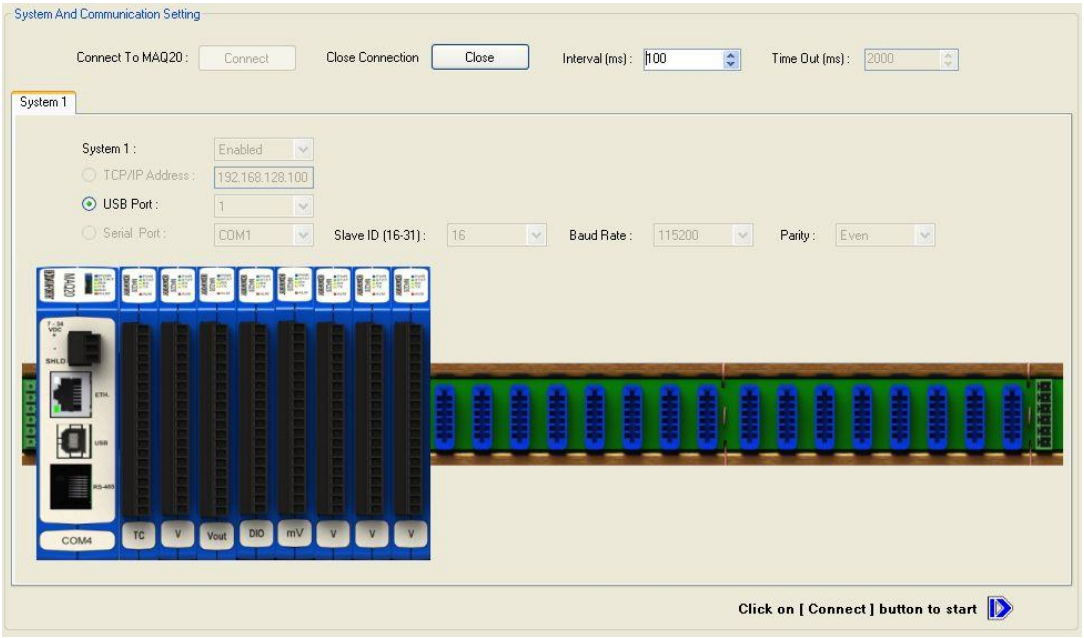
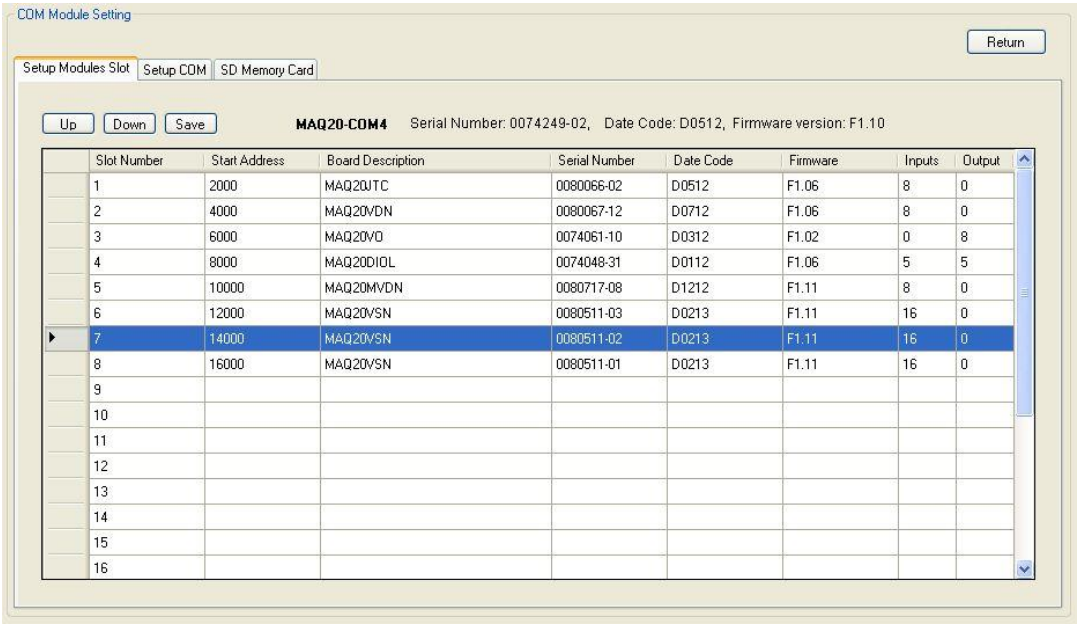


Figure 5: MAQ20-940 ReDAQ Shape for MAQ20 Main Configuration Screen

To view the registration sequence, double-click on the MAQ20-COMx graphic as shown in Figure 6.



Slot Number	Start Address	Board Description	Serial Number	Date Code	Firmware	Inputs	Output
1	2000	MAQ20UTC	0080066-02	D0512	F1.06	8	0
2	4000	MAQ20VDN	0080067-12	D0712	F1.06	8	0
3	6000	MAQ20VO	0074061-10	D0312	F1.02	0	8
4	8000	MAQ20DIOL	0074048-31	D0112	F1.06	5	5
5	10000	MAQ20MVDN	0080717-08	D1212	F1.11	8	0
6	12000	MAQ20VSN	0080511-03	D0213	F1.11	16	0
7	14000	MAQ20VSN	0080511-02	D0213	F1.11	16	0
8	16000	MAQ20VSN	0080511-01	D0213	F1.11	16	0
9							
10							
11							
12							
13							
14							
15							
16							

Figure 6: Module Registration using MAQ20-940 ReDAQ Shape for MAQ20

Registration Numbers are listed in the left column. To change the Registration Number of an I/O module, click the box in the left column next to the Registration Number, then use the Up and Down buttons to move the module within the sequence. The system automatically reassigns the I/O modules above and below the one moved. Repeat for other modules if desired. The MAQ20-COMx module always has Registration Number 0 and cannot be moved. Press 'Save' to save the new configuration. The new registration sequence is permanent as long as I/O modules are not removed from or added to a system.

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10.0 Reading Discrete Input Channels and Writing Discrete Output Channels

The MAQ20-DIOH module has 4 isolated discrete input channels and 4 isolated discrete output channels. Input channels interface to 90-280VAC/VDC signals and output channels control 24-280VAC signals at up to 3Arms current. Channel-to-Channel isolation is 300Vrms. Each individual channel has continuous overload protection in the case of inadvertent wiring errors.

Signals applied to discrete input channels are bridge rectified and detected as high when over 60VAC or 75VDC or low when below 60VAC or 70VDC. Discrete output channels use a TRIAC for switching and will only switch when the controlled AC signal crosses through zero. The basic circuit topology is shown in Figure 7 below.

NOTE:

THE MAQ20-DIOH MODULE USES INVERTED LOGIC. LOGIC 0 READ FROM A DISCRETE INPUT CHANNEL INDICATES THAT THE SIGNAL ON THE INPUTS IS ABOVE THE THRESHOLD AND LOGIC 1 INDICATES THAT THE SIGNAL IS BELOW THE THRESHOLD.

WRITING A 0 TO A DISCRETE OUTPUT CHANNEL CLOSES THE SOLID STATE SWITCH AND WRITING A 1 OPENS THE SWITCH.

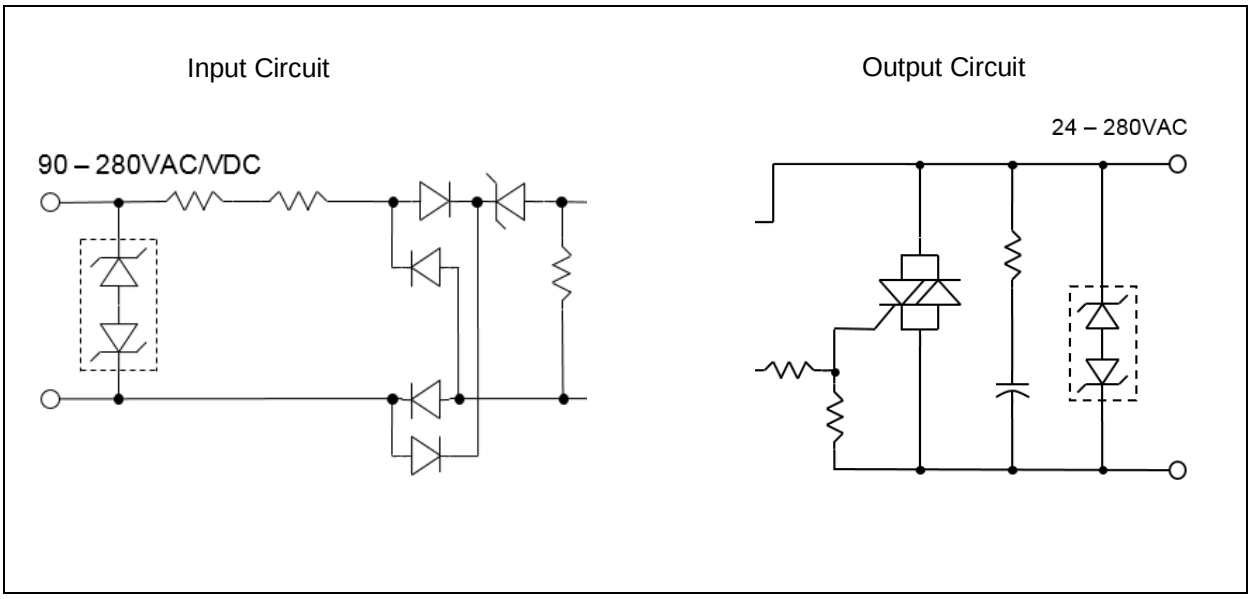


Figure 7: Discrete Input Circuit and Discrete Output Circuit Topology

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The Address Map for the MAQ20-DIOH module is found at the end of this manual. An excerpt from the Address Map is shown below.

NOTE: When a module is registered in a system, addresses are offset by 2000 * R, where R is the Registration Number. Refer to Section 9.0 for further details on Registration Number.

Address Range 100 - 499 : Module Configuration						
Start Address	**Read/Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
100	R	8	Channel Configuration	Input or Output	1 = Input 2 = Output	INT16

Address Range 1000 - 1299 : Module Data and Special Function Selection						
Start Address	**Read/Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
1000	R/W	8	DIO States, Binary Representation Inverted Logic Addr 1000 = LSB, Addr 1009 = MSB	Example: Starting at address 1009 and decreasing to address 1000, MSB to LSB, x then DI3 to DI0 and x then DO3 to DO0 = x0110x1000, where x = 0, register not used. Data written to an input channel will be ignored. Data written to an output channel committed to a Special Function returns an error. Default = 1 for all channels.	DO0 - DO3 Inverted Logic 0 = Switch Closed 1 = Switch Open DI0 - DI3 Inverted Logic 0 = Input > Threshold 1 = Input < Threshold	INT16
1010	R	1	DIO States, Decimal Equivalent	Example: 200 (the decimal equivalent of the binary number above. MSB to LSB 0011001000). Default = 495	0 to 255	INT16

Channel configuration is stored in a series of 10 registers starting at reference address 100. Discrete output and discrete input channels in the module are fixed and cannot be changed. This data can be read if desired for host software detection of module channel configuration.

Discrete input channels are read and discrete output channels are written using a series of 10 registers starting at reference address 1000. In addition, the decimal equivalent of the 10-digit value representing channel states can be read from a single register at reference address 1010. Registers 1009 and 1004 are not used and contain a value of 0 that cannot be changed.

Once a channel configuration is setup it can be saved to EEPROM. Standard Reset does not affect the setting in volatile memory. Reset-to-Default will clear the setting in volatile memory and reset the ranges to the default values. Settings stored to EEPROM are not affected by Standard Reset or Reset-to-Default. Module power cycle will restore range settings from EEPROM.

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Channel Data and operation is summarized in Table 2.

Table 2: Discrete I/O Channel Data Storage in Registers

Address	Channel	Data	
1000	DO0	0 = switch closed, 1 = switch open	LSB
1001	DO1	0 = switch closed, 1 = switch open	
1002	DO2	0 = switch closed, 1 = switch open	
1003	DO3	0 = switch closed, 1 = switch open	
1004	Not Used	0	
1005	DI0	0 = input > threshold, 1 = input < threshold	
1006	DI1	0 = input > threshold, 1 = input < threshold	
1007	DI2	0 = input > threshold, 1 = input < threshold	
1008	DI3	0 = input > threshold, 1 = input < threshold	
1009	Not Used	0	MSB
1010	All DO & DI	Decimal equivalent of 10-digit value	

Example: A MAQ20-DIOH module with serial number 1234567-89 is installed in a system and has been assigned a Registration Number of 4. Set Discrete Output Channels 0, 1 and 2 to switch closed and read the state of Discrete Input Channels 0, 1, 2, and 3. Assume the channel data in registers 1000 to 1009 is 0001001100.

The MAQ20-DIOH module with s/n 1234567-89 has an address offset of 2000 * 4 = 8000

Write to register address 8000 + 1000 = 9000 a data value of 0 to close channel DO0
Write to register address 8000 + 1001 = 9001 a data value of 0 to close channel DO1
Write to register address 8000 + 1002 = 9002 a data value of 0 to close channel DO2

Read from register addresses 8000 + 1005 to 1008 = 9005 to 9008 the Current Data from the Discrete Input Channels.

Read from register address 8000 + 1005 = 9005 the data from Channel DI0, 0 = above threshold
Read from register address 8000 + 1006 = 9006 the data from Channel DI1, 1 = below threshold
Read from register address 8000 + 1007 = 9007 the data from Channel DI2, 1 = below threshold
Read from register address 8000 + 1008 = 9008 the data from Channel DI3, 0 = above threshold

The resulting bit pattern at register addresses 9000 to 9009 presented LSB to MSB is 0001001100.

Read from register address 8000 + 1010 = 9010 the decimal equivalent of the discrete IO states. Using the data above, a value of 200 is read which equates to 0011001000. MSB to LSB, this is the same as the data in registers 9000 to 9009.

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11.0 Setting Default Outputs

The four discrete output channels in the MAQ20-DIOH module have user configurable default output values which are set upon power cycle and when a Reset-to-Default command is issued. These are used to put a system or application in a known safe state at startup or under non-standard operating conditions.

The Address Map for the MAQ20-DIOH module is found at the end of this manual. An excerpt from the Address Map is shown below.

NOTE: When a module is registered in a system, addresses are offset by 2000 * R, where R is the Registration Number. Refer to Section 9.0 for further details on Registration Number.

Address Range 100 - 499 : Module Configuration						
Start Address	**Read/Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
100	R	8	Channel Configuration	Input or Output	1 = Input 2 = Output	INT16
110	R/W	4	Default Output Configuration	Discrete Output Default State. Default = 1 for all channels.	DO0 - DO3 0 = Switch Closed 1 = Switch Open	INT16
190	W	1	Save to EEPROM	0 = Saves Channel Configuration, Default Out	0	INT16

NOTE:

THE MAQ20-DIOH MODULE USES INVERTED LOGIC. LOGIC 0 READ FROM A DISCRETE INPUT CHANNEL INDICATES THAT THE SIGNAL ON THE INPUTS IS ABOVE THE THRESHOLD AND LOGIC 1 INDICATES THAT THE SIGNAL IS BELOW THE THRESHOLD.

WRITING A 0 TO A DISCRETE OUTPUT CHANNEL CLOSES THE SOLID STATE SWITCH AND WRITING A 1 OPENS THE SWITCH.

Example: A MAQ20-DIOH module with serial number 1234567-89 is installed in a system and has been assigned a Registration Number of 4. Set the Default Output Value for Discrete Output Channels 0 and 1 to switch open and for Channels 2 and 3 to switch closed.

The MAQ20-DIOH module with s/n 1234567-89 has an address offset of 2000 * 4 = 8000

Write to register address 8000 + 100 = 8100 a data value of 1 to set DO0 default state to open
Write to register address 8000 + 101 = 8101 a data value of 1 to set DO1 default state to open
Write to register address 8000 + 102 = 8102 a data value of 0 to set DO2 default state to closed
Write to register address 8000 + 103 = 8103 a data value of 0 to set DO3 default state to closed

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12.0 Special Function Description and Configuration (Preliminary)

In addition to performing standard discrete I/O, the MAQ20-DIOH module can be configured to perform two Special Functions listed in Table 3.

Table 3: Discrete I/O Channel Usage for Special Function I/O

Function	Discrete Channel Inputs	Discrete Channel Outputs
Event Counter	Signal, Trigger	None
Time Between Events	Signal 1, Signal 2	None

The module has two timers, referred to as Timer 0 and Timer 1, which are used for these functions. Each timer can run one function which means two of the same or two separate Special Functions can run simultaneously on the module. All functions have a single set of inputs.

Each timer uses specific discrete input and discrete output channels to implement the Special Functions. These are fixed and cannot be changed by the user. Channels which are not committed to a Special Function can be used for standard discrete I/O. If a Special Function is enabled and data is written to a discrete output committed to that function, an error will be returned.

Depending on which timer is used to implement a given Special Function, discrete I/O channels are assigned to Special Functions as shown in Table 4.

Table 4: Discrete I/O Channel Assignments for Special Function I/O

Special Function Number	Special Function Description	Channel Type	Channel Function	Channel Assignment for Special Functions using Timer 0	Channel Assignment for Special Functions using Timer 1
1	Event Counter	Input	Input Signal	DI0	DI2
		Input	External Enable	DI1	DI3
2	Time Between Events	Input	Input Signal 1	DI0	DI2
		Input	Input Signal 2	DI1	DI3

Special Functions are specified and configured using a series of registers starting at reference address 1100 for Timer 0 and reference address 1200 for Timer 1. Each Special Function has a different set of information stored in these registers. To set and configure a Special Function, write the appropriate code to reference address 1100 or 1200, then write the appropriate information to reference addresses 1101 through 1190 for functions implemented on Timer 0 or 1201 through 1290 for functions implemented on Timer 1 as shown in the Address Map. The sections in the Address Map for each Special Function show registers with Start Addresses of 0 to 90. These are offset addresses starting at reference address 1100 if the Special Function uses Timer 0 or reference address 1200 if the Special Function uses Timer 1.

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The Address Map for the MAQ20-DIOH module is found at the end of this manual. Excerpts from the Address Map are shown below.

NOTE: When a module is registered in a system, addresses are offset by 2000 * R, where R is the Registration Number. Refer to Section 9.0 for further details on Registration Number.

Address Range 1000 - 1299 : Module Data and Special Function Selection						
Start Address	**Read/Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
1100		100	Timer 0 Configuration and Start Address for Special Function registers.	Select Special Function. See Address Maps below for register contents starting at address 1100 specific to each Special Function selected. *Special Functions using Timer 0 use channels DI0, DI1, DO0, DO1. See Table 4 for details. Default = 0	0 = None (Default) 1 = Event Counter 2 = Time Between Events	INT16
1200		100	Timer 1 Configuration and Start Address for Special Function registers.	Select Special Function. See Address Maps below for register contents starting at address 1200 specific to each Special Function selected. *Special Functions using Timer 1 use channels DI2, DI3, DO2, DO3. See Table 4 for details. Default = 0	0 = None (Default) 1 = Event Counter 2 = Time Between Events	INT16

Special Function 1: Event Counter *Start Addresses below are offset from address 1100 for Special Functions using Timer 0 or address 1200 for Special Functions using Timer 1.						
Start Address offset from 1100 or 1200	**Read/Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
0	R/W	1	Function	1 = Event Counter	1	INT16

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Special Function 2: Time Between Events						
***Start Addresses below are offset from address 1100 for Special Functions using Timer 0 or address 1200 for Special Functions using Timer 1.**						
Start Address offset from 1100 or 1200	**Read/Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
0	R/W	1	Function	2 = Time between Events	2	INT16

Example: A MAQ20-DIOH module with serial number 1234567-89 is installed in a system and has been assigned a Registration Number of 4. Configure the module to have Event Counter and Time Between Events Special Functions.

The MAQ20-DIOH module with s/n 1234567-89 has an address offset of 2000 * 4 = 8000

Write to register address 8000 + 1100 = 9100 a data value of 1 to set the Event Counter Special Function to operate on Timer 0. Connect the input signal to be measured to channel DI0 and if an external trigger is to be used, connect it to channel DI1.

Write to register address 8000 + 1200 = 9200 a data value of 2 to set the Time Between Events Special Function to operate on Timer 1. Connect input signal 1 to channel DI2 and input signal 2 to channel DI3.

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12.1 Special Function 1: Event Counter (Preliminary)

The Event Counter function measures the number of times a specified event occurs. The minimum time between events which can be measured is 150ms, the maximum event occurrences which can be counted is 10,000,000 and the timebase used for measurements can be selected as seconds or milliseconds.

The Event Counter function uses discrete input channel DI0 if Timer 0 is used to implement the function or discrete input channel DI2 if Timer 1 is used to implement the function. Transitions on the input are cumulatively counted to an upper limit of 10,000,000. Input levels over 60VAC or 75VDC are detected as high and input levels below 60VAC or 75VDC are low.

The MAQ20-DIOH module uses inverted logic so DC or AC inputs over the threshold are reported as logic 0 and DC or AC inputs below the threshold are reported as logic 1. Edge triggering can be set to positive or negative which represents rising or falling edges for a DC input signal or presence versus no presence for an AC signal.

Counting is enabled or disabled by writing to a register. Counting can also be controlled using an external signal applied to discrete input channel DI1 if Timer 0 is used to implement the function or discrete input channel DI3 if Timer 1 is used to implement the function. The external enable can be configured as either active low or active high. Event count is reset by writing a register.

The timebase is selected based on the waveforms to be measured in order to obtain the best measurement resolution and performance.

In Figure 8 below, an active high external enable is used for event counting. Counting begins after the enable line goes high. If the rectified input signal trigger is set to positive edge to detect no DC or AC signal present, 3 events will be counted and if the rectified input signal trigger is set to negative edge to detect DC or AC signal presence, 4 events will be counted.

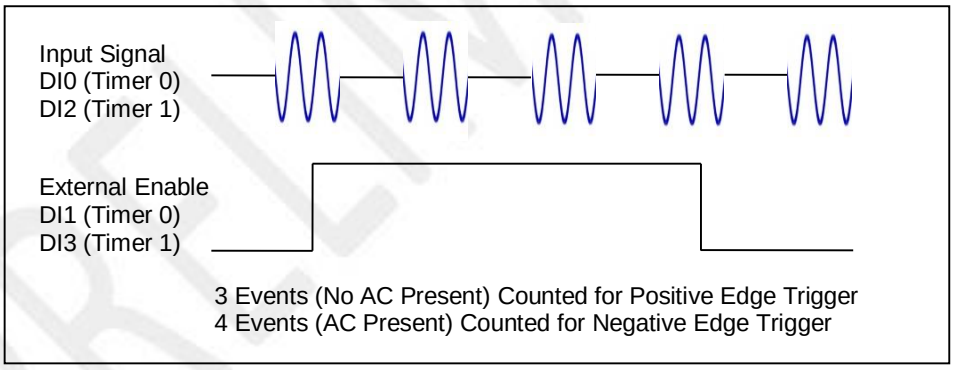


Figure 8: Event Counter Operation Using External Enable

High Low or High-High Low-Low alarms can be configured for this function and dedicated discrete output channels can be set when alarm conditions are reached. Alarms pertain to event counts. Refer to Section 13.0 for details on using alarms. If the special function is disabled by writing a number other than 1 to the register at reference address 1100 or 1200, all function configuration parameters remain resident in memory. Special function configuration parameters are stored in EEPROM by writing to a register. Power cycle or Standard Reset returns configuration parameters to the last values stored in EEPROM. Reset-to-Default returns configuration parameters to factory default values.

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12.2 Special Function 2: Time Between Events (Preliminary)

The Time Between Events function measures the time between a specified event on one discrete input channel and another specified event on a second discrete input channel. The number of times the specified event pair occurred is also measured. The minimum time between events which can be measured is 150ms, the maximum event pair occurrences which can be counted is 10,000,000 and the timebase used for measurements can be selected as seconds or milliseconds.

This function uses discrete input channel DI0 for Input Signal 1 and DI1 for Input Signal 2 if Timer 0 is used to implement the function or discrete input channel DI2 for Input Signal 1 and DI3 for Input Signal 2 if Timer 1 is used to implement the function. Input levels over 60VAC or 75VDC are detected as high and input levels below 60VAC or 75VDC are low.

The MAQ20-DIOH module uses inverted logic so DC or AC inputs over the threshold are reported as logic 0 and DC or AC inputs below the threshold are reported as logic 1. Edge triggering can be set to positive or negative which represents rising or falling edges for a DC input signal or presence versus no presence for an AC signal.

Time between events measurement is enabled or disabled by writing to a register. The timebase is selected based on the waveforms to be measured in order to obtain the best measurement resolution and performance. The average weight for time between event measurements can be set as applications require. The measured time between events is stored as current, average, min and max values. Measured parameters are reset by writing to corresponding registers. Time between events parameters are computed continuously up to the limit set in the Events to Measure register using the specified average weight and are stored in registers. The number of events to measure can be set from 1 to 10 million, after which counting will stop, or the number can be set to 0 to measure waveforms continuously.

Timing starts when the second channel is in its specified triggered state and the first channel transitions to its specified triggered state. Timing stops after the second channel transitions opposite its specified triggered state and then again transitions to its specified triggered state. In the example shown in Figure 9 below, Input Channel 1 has been set to negative edge triggering to detect the presence of a DC or AC signal and Input Channel 2 has also been set to negative edge triggering. When Input Channel 2 has a DC or AC signal present, Event 1 occurs when Input Channel 1 has a DC or AC signal present. Event 2 occurs after Input Signal 2 has transitioned low and then transitions high, representing DC or AC signal off followed by DC or AC signal present.

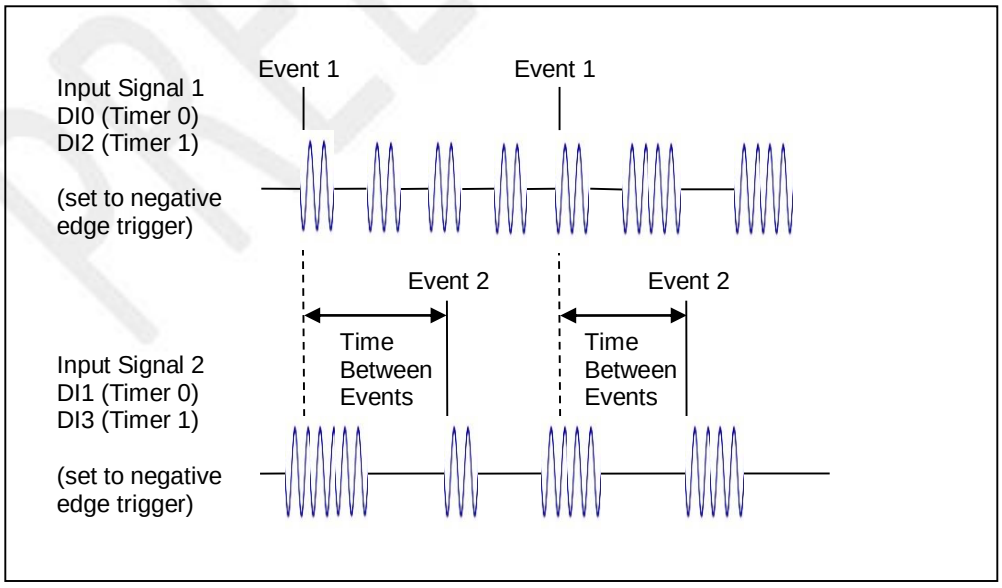


Figure 9: Time Between Events Operation

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High Low or High-High Low-Low alarms can be configured for this function and dedicated discrete output channels can be set when alarm conditions are reached. Refer to Section 13.0 for details on using alarms. If the special function is disabled by writing a number other than 2 to the register at reference address 1100 or 1200, all function configuration parameters remain resident in memory. Special function configuration parameters are stored in EEPROM by writing to a register. Power cycle or Standard Reset returns configuration parameters to the last values stored in EEPROM. Reset-to-Default returns configuration parameters to factory default values.

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13.0 Alarm Functions (Preliminary)

Alarms in the MAQ20-DIOH module are only allowed on the two special functions. For the Event Counter alarms apply to the count and for Time Between Events, alarms apply to the time between events and the event pair count. Alarms have the following parameters which can be set to meet application requirements.

Alarm Enable

Enables the Alarm on a given channel provided that the Alarm Configuration Register has a valid configuration. Set the bit corresponding to the given channel to a 1 to enable the alarm. If the Alarm Configuration register for the given channel does not have a valid value, the write will be ignored and the Alarm Enable bit will remain 0. Write a 0 to the bit corresponding to the given channel to disable the alarm and clear any alarms that have tripped.

Alarm Configuration

Selects Tracking or Latching alarms for a given channel and selects which limits trip the alarm - High, Low, High-High or Low-Low. There is a register for each channel. The value written to this register is the sum of the codes for the Alarm Type and Alarm Limits. Refer to Section 14.0 for the specific codes. If an invalid value is written to this register, the value will be ignored and the last valid value that the register contained will be kept. If a 0 is written to the register, the Alarm Enable register for the channel will be set to 0 and alarms that the channel has tripped will be cleared.

Tracking alarms follow the value of the input signal and reset automatically when the signal comes back into the valid range specified by the limit and deadband. Latching alarms trip when the signal exceeds the alarm condition and remain set until reset by the user.

High Limit

Sets the value for the High limit in counts. Alarm status is stored in a register.

Low Limit

Sets the value for the Low limit in counts. Alarm status is stored in a register.

High Low Deadband

Used for the High and/or Low limits to prevent false tripping or alarm chatter for noisy signals. Deadband is the region less than the High limit or greater than the Low limit, measured in counts, which the signal must traverse through before the alarm is reset after being tripped.

High-High Limit

Sets the value for the High-High limit in counts. Alarm status is stored in a register.

Low-Low Limit

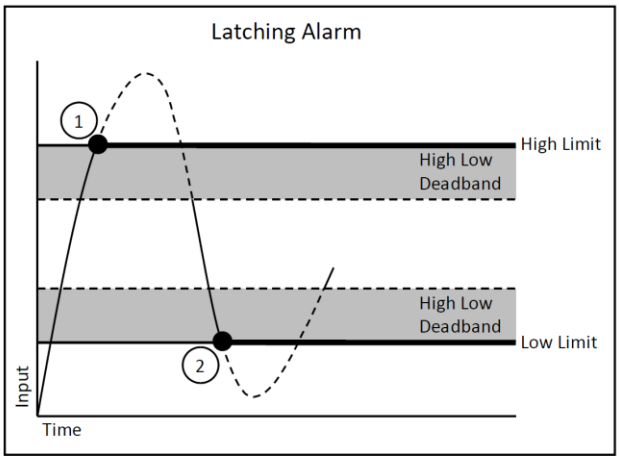
Sets the value for the Low-Low limit in counts. Alarm status is stored in a register.

High-High Low-Low Deadband

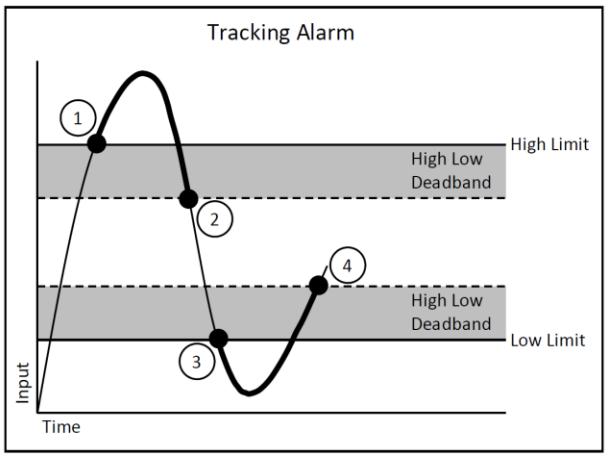
Used for the High-High and/or Low-Low limits to prevent false tripping or alarm chatter for noisy signals. Deadband is the region less than the High-High limit or greater than the Low-Low limit, measured in counts, which the signal must traverse through before the alarm is reset after being tripped.

See Figure 10 below for graphical representations of alarm parameters and functionality keeping in mind that the parameters being monitored for alarms are event count, time between events, and event pair count.

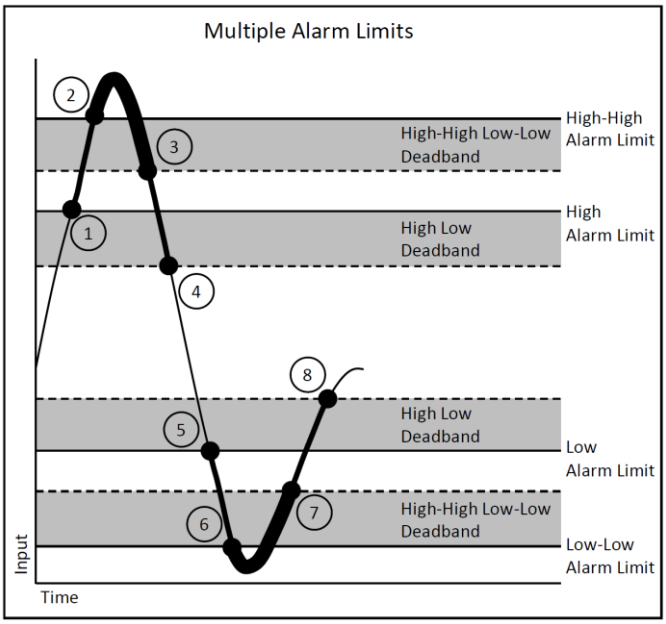
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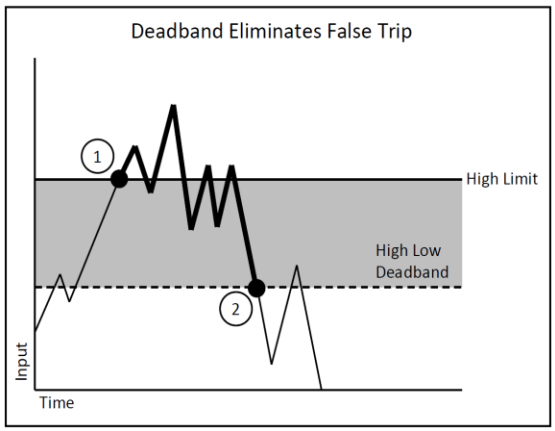
1. High Alarm Tripped
2. Low Alarm Tripped



1. High Alarm Tripped
2. High Alarm Reset
3. Low Alarm Tripped
4. Low Alarm Reset



1. High Alarm Trip
2. High-High Alarm Trip
3. High-High Alarm Reset
4. High Alarm Reset
5. Low Alarm trip
6. Low-Low Alarm Trip
7. Low-Low Alarm Reset
8. Low Alarm Reset



1. High Alarm Trip
2. High Alarm Reset

Figure 10: Alarm Parameters and Functionality

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14.0 Setting and Monitoring Alarms (Preliminary)

Alarms can be set for the two Special Functions; Event Counter and Time Between Events. Two types of alarms for each of the functions are possible; High Low and High-High Low-Low. Alarms are not available for standard discrete I/O.

For the Event Counter, alarms apply to the count and for Time Between Events, alarms apply to the time between events and the event pair count.

When an alarm condition occurs, the appropriate register is written to show alarm status. This register can then be monitored by the host software for alarm detection. In addition, the MAQ20-DIOH module has the ability to map alarm events to discrete output channels that are not associated with Special Functions. These discrete output channels will then be set to a user defined state when the alarm condition is met.

Special Functions Alarm Functionality is summarized in Table 5.

Table 5: Special Function Alarm Functionality

Special Function	Available Alarms for Special Functions using Timer 0	Available Alarms for Special Functions using Timer 1
Event Counter	High Low. Alarm can be mapped to DO0. High-High Low-Low. Alarm can be mapped to DO1.	High Low. Alarm can be mapped to DO2. High-High Low-Low. Alarm can be mapped to DO3.
Time Between Events	High Low. Alarm can be mapped to DO0. High-High Low-Low. Alarm can be mapped to DO1.	High Low. Alarm can be mapped to DO2. High-High Low-Low. Alarm can be mapped to DO3.

Alarms are configured by writing a code to the register at address 2000 * R + 1100 + 35 for Special Functions using Timer 0 or address 2000 * R + 1200 + 35 for Special Functions using Timer 1, where R is the Registration Number. Alarm Status is stored in the register at address 2000 * R + 1100 + 3 for Special Functions using Timer 0 or address 2000 * R + 1200 + 3 for Special Functions using Timer 1. The code written to the Alarm Configuration register is the sum of numbers representing the parameter to monitor, alarm type, alarm limit, and desired alarm output. Table 6 details how this code is constructed.

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Table 6: Building the Alarm Configuration Value

Alarm Configuration Value = Parameter to Monitor + Alarm Type + Alarm Limit + Alarm Output

Parameter to Monitor	Code	+	Alarm Type	Code	+	Alarm Limit	Code	+
Event Counter	1000		Tracking	100		High Low	10	
Time Between Events	2000		Latching	200		High-High Low-Low	20	

Alarm Output				
High Low Alarm for Special Function on Timer 0	**High-High Low-Low Alarm for Special Function on Timer 0**	**High Low Alarm for Special Function on Timer 1**	**High-High Low-Low Alarm for Special Function on Timer 1**	**Code**
Register	Register	Register	Register	0
Register	DO1 Closed	Register	DO3 Closed	1
Register	DO1 Open	Register	DO3 Open	2
DO0 Closed	Register	DO2 Closed	Register	3
DO0 Closed	DO1 Closed	DO2 Closed	DO3 Closed	4
DO0 Closed	DO1 Open	DO2 Closed	DO3 Open	5
DO0 Open	Register	DO2 Open	Register	6
DO0 Open	DO1 Closed	DO2 Open	DO3 Closed	7
DO0 Open	DO1 Open	DO2 Open	DO3 Open	8

Alarm Configuration Example:
1115 = Events Measured, Tracking, High Low, High Low Output Default On & High-High Low-Low Output Default Off

If the Alarm Configuration Value = 0, the Alarm is Off (Disabled). The Alarm for a given channel cannot be turned On (Enabled) until a valid, non-zero value is written to the Alarm Configuration register.

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15.0 Reset Functions

Two types of firmware reset are supported in the MAQ20 I/O modules:

Standard Reset is used to put the module in a user-defined state. The parameters listed below will be set to the last state saved to EEPROM. Parameters stored in EEPROM are not affected.

Reset-to-Default reverts the module to the settings used at the factory during manufacture. It performs the standard reset actions plus resets most non-volatile parameters to default settings. Parameters stored in EEPROM are not affected.

Table 7 shows what parameters are affected for each reset.

Table 7: Parameters Affected by Standard Reset and Reset-to-Default

RESET TYPE	PARAMETERS
Standard Reset	Disables all Alarms Sets Discrete Output Channel states to user defined Default states Sets Special Function parameters to user defined values Resets Min, Max and Average registers to 0 Clears all Status and Diagnostic registers
Reset-to-Default	All parameters listed under Standard Reset, plus: Sets Discrete Output Channel states to 1 (switch open) Sets Discrete Output Channel Default states to 1 (switch open) Set Special Functions to 0 (No Special Function Selected) Sets Special Function parameters to factory default values Clears all Alarm Limits and Deadbands

Reset Registers
Writing a valid data value to the Reset Register will force the module to perform a specified reset. Write 0 to perform Standard Reset or write 255 to perform Reset-to-Default.

NOTE: The MAQ20 I/O modules send a response to the reset register write before carrying out the reset. This means the module will be unresponsive to commands for approximately 3 seconds.

Power-On-Reset (POR) and Brownout
MAQ20 I/O modules utilize a brown-out detect circuit and watchdog timer to ensure reliable and predictable operation under all conditions. Upon power cycle, brown-out detect or any extreme circumstance under which the watchdog timer expires, a Standard Reset is performed and parameters stored in EEPROM are loaded to the appropriate registers.

Configuration Stored in Local Memory
MAQ20 I/O modules are shipped with the factory default settings shown in the Address Map. Special Function configuration and Discrete Output Channel default output states are stored locally in EEPROM. Standard Reset and Reset-to-Default do not affect the contents EEPROM. To set EEPROM contents back to the factory configuration, first execute a Reset-to-Default operation, then save the Special Function and Discrete Output channel default output states to EEPROM.

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16.0 Module Identification and Status Registers

Module identification including model number, serial number, date code and firmware revision are stored in registers at addresses 0 – 41.

I/O modules in a system are identified in general by their model number (MAQ20-DIOH, MAQ20-VDN, etc.) and uniquely by their Serial Number printed on the side label (1234567-89). When I/O modules are installed in the system, only a general identifier is visible on the front of the module (DIOH, V, etc.). Wire tags or additional labeling applied to the module terminal block may be used for visible unique identification in an installed system. Additionally, the system has a utility to provide a visual indication of module response for identification. Any write to address 98 plus the offset based on the Registration Number will blink the STATUS LED on the top angled surface of the module at a 5Hz rate for 5 seconds.

For troubleshooting purposes, reset status, communications errors, and invalid data written to a module are monitored and made available to the user. Diagnostic registers at addresses 1900 – 1910 hold this information.

17.0 LED Indicators

A set of 5 LEDs on the top panel of the MAQ20 I/O modules indicate module power, operation, communication and alarm status.



LED Function and Troubleshooting Tips:

PWR
Normal operation: BLUE, solid lit

LED Off: Abnormal power situation
- Verify that a MAQ20-COMx is present in system
- Verify that the MAQ20-COMx module has 7-34VDC power connected and turned on
- Determine if the module is communicating by observing the TX and RX LEDs

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STAT
Normal operation: GREEN, 1 Hz blinking

Module Detect: A write to the Module Detect Register will force this LED to blink at 5Hz rate for 5 seconds so the module location in a system can be visually identified. Referring to the Address Map, this register is at address 98 offset from the module base address.

LED Constant On or Constant Off: Abnormal operation
- Remove and reinstall module to force a reset
- Remove and reinstall module into another backbone position
- Determine if the module is communicating by observing the TX and RX LEDs

RX, TX
Normal Operation – YELLOW, rapid blinking during communication with MAQ20-COMx module

LED Constant Off: Abnormal operation or no communications to MAQ20-COMx module
- Verify communications by sending a request for data. Note that the fast communications rate used on the system backbone will result in the LED appearing dim due to short blinking cycle
- Verify that the PWR and STAT LED indicate normal operation
- Verify that there is only one MAQ20-COMx module installed in the system

ALM
Normal operation: Off

Alarm Condition Detected: RED, solid lit.
- One or more alarms have been tripped.
- Read Alarm Registers based on Alarm Configuration to determine system status

The following troubleshooting tips can be used to further diagnose and fix system problems:

- Remove and reinstall MAQ20 I/O module and/or MAQ20-COMx module to verify proper insertion into Backbone
- Remove and reinstall MAQ20 I/O module into another backbone position
- If a Backbone extension cable is used, ensure that the connections are made correctly

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18.0 Specifications

MAQ20-DIOH DISCRETE INPUT/OUTPUT MODULE Typical at Ta = +25°C and +24V system power

Model Number, Input / Output	90 to 280 VAC/VDC Input 24 to 280 VAC Output
Number of Channels	4 Discrete Input, 4 Discrete Output
Per Channel Setup	Individually configurable for Default Out, Special Function
Switching Characteristics	
Input Channel Turn-On / Turn-Off Time (VAC)	15ms / 90ms
Input Channel Turn-On / Turn-Off Time (VDC)	1ms / 1ms
Output Channel Response Time	0.5 Cycle
Output Load (See Derating Chart Below)	
Ta = +25°C, (1 channel operating / 4 channels operating)	3Arms / 1.4Arms
Ta = +85°C, (1 channel operating / 4 channels operating)	1Arms / 0.3Arms
Input Protection (Discrete Input Channels)	
Continuous, MAQ20-DIOH	350VAC/VDC max
Transient	ANSI/IEEE C37.90.1
Output Protection (Discrete Output Channels)	
Continuous, MAQ20-DIOH	350VAC/VDC max
Transient	ANSI/IEEE C37.90.1
CMV	
Channel-to-Bus	1500Vrms, 1 min
Channel-to-Channel	300Vrms, 425VDC
Transient	ANSI/IEEE C37.90.1
I/O Special Functions	
Event Counter	Count to 10M, Selectable Timebase
Time Between Events	150ms min, Min, Max, Avg, Selectable Timebase
Scan/Update Rate	500 Ch/s
Alarms	High / High-High / Low / Low-Low
Power Supply Current	30mA
Dimensions (h)(w)(d)	3.27” x 4.51” x 0.60” (83.1mm x 114.6mm x 15.3mm)
Environmental	
Operating Temperature	-40°C to +85°C
Storage Temperature	-40°C to +85°C
Relative Humidity	0 to 95%, non-condensing
Emissions, EN61000-6-4	ISM Group 1
Radiated, Conducted	Class A
Immunity EN61000-6-2	ISM Group 1
RF	Performance A +/- 0.5% Span Error
ESD, EFT	Performance B
Certifications	Heavy Industrial CE, ATEX Pending
	UL/CUL Class I, Division 2, Groups A, B, C, D Pending

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18.1 Derating

Operating the discrete output channels at the maximum published ratings results in significant power dissipation. The robust internal circuits are designed to handle the published power requirements, however, channel density and the compact module enclosure limit the ability to dissipate power in certain system configurations. A MAQ20-DIOH module operated at maximum published ratings should be installed in a backbone slot next to I/O modules with low power dissipation or located in a slot without adjacent I/O modules. Figure 11 below shows module derating for a MAQ20-DIOH module installed in a backbone with adjacent slots vacant and one channel at maximum operating conditions. If the system is installed in a location with minimal or no ventilation, additional derating may be required. Contact the factory for installation details in these situations.

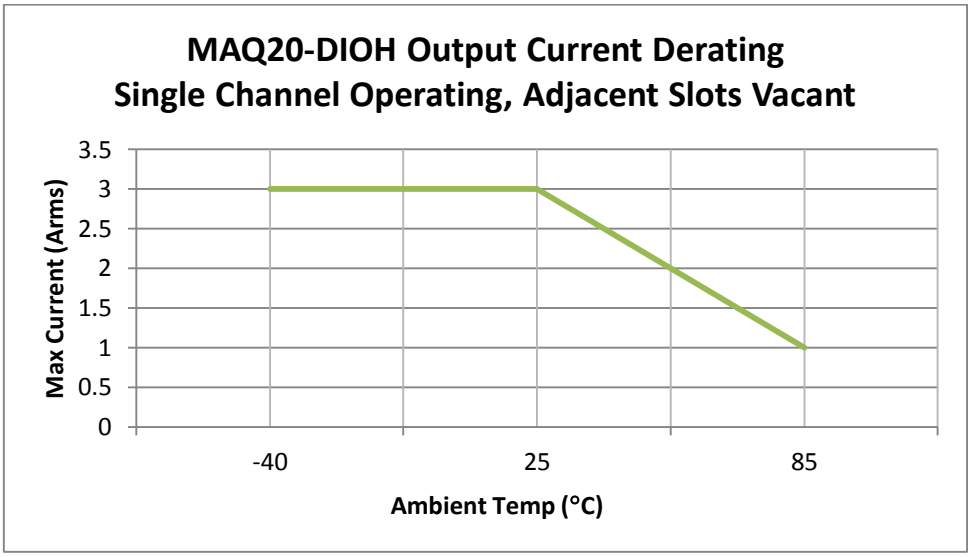


Figure 11: MAQ20-DIOH Derating with Single Channel Operating and Adjacent Slots Vacant

Derating can be expressed in watts using the rms value of the signal being switched and the on resistance of the output channel triac. See Figure 12 below.

Ron = -Ta / 320°C + 1.2Ω for +25°C < Ta < +85°C

Ron = 1.2Ω for -40°C < Ta < +25°C

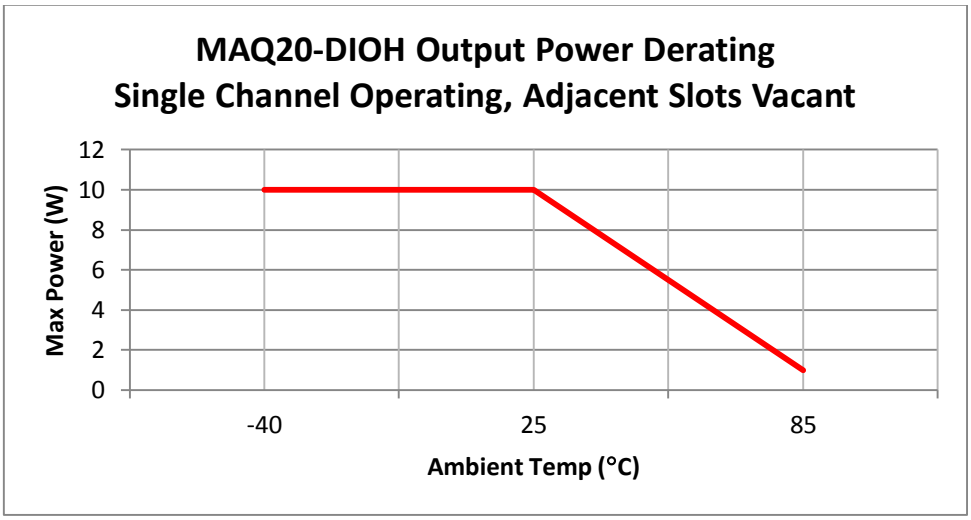


Figure 12: MAQ20-DIOH Derating with Single Channel Operating and Adjacent Slots Vacant

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When the MAQ20-DIOH module is installed in a system with adjacent MAQ20 I/O modules that dissipate significant power, module power dissipation is further limited. MAQ20-DIOH derating over temperature based on the number of channels operating is shown in Figure 13 and Figure 14 below. The data reflects maximum operating condition with the MAQ20-DIOH module installed in a backbone with MAQ20-DIOH modules in adjacent slots at maximum operating condition. If the system is installed in a location with minimal or no ventilation, additional derating may be required. Contact the factory for installation details in these situations.

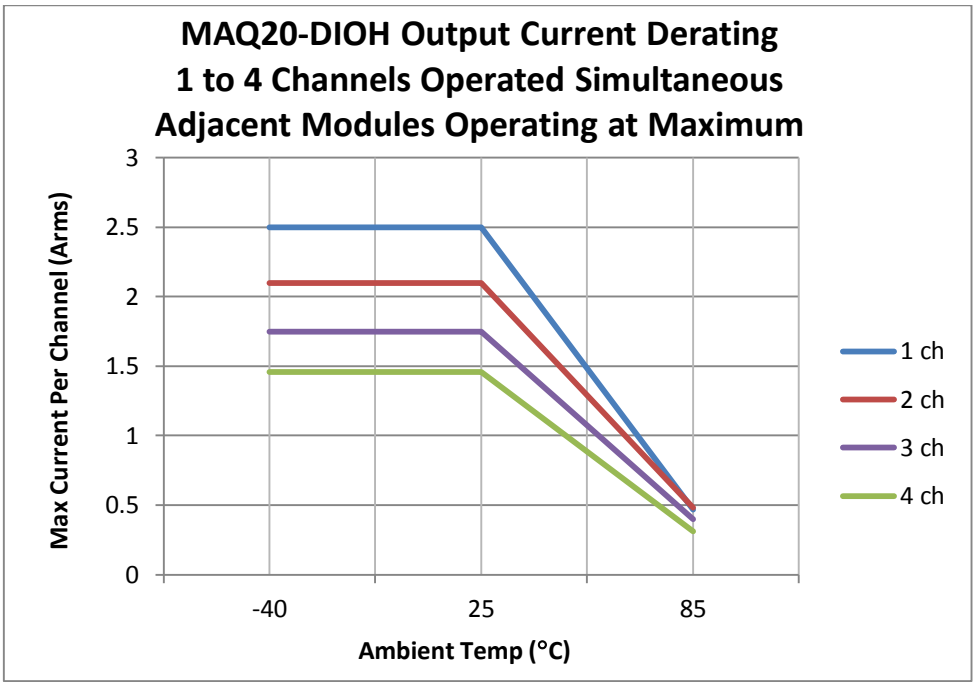


Figure 13: MAQ20-DIOH Derating, 1-4 Channels Operating, Adjacent Modules Operating At Maximum

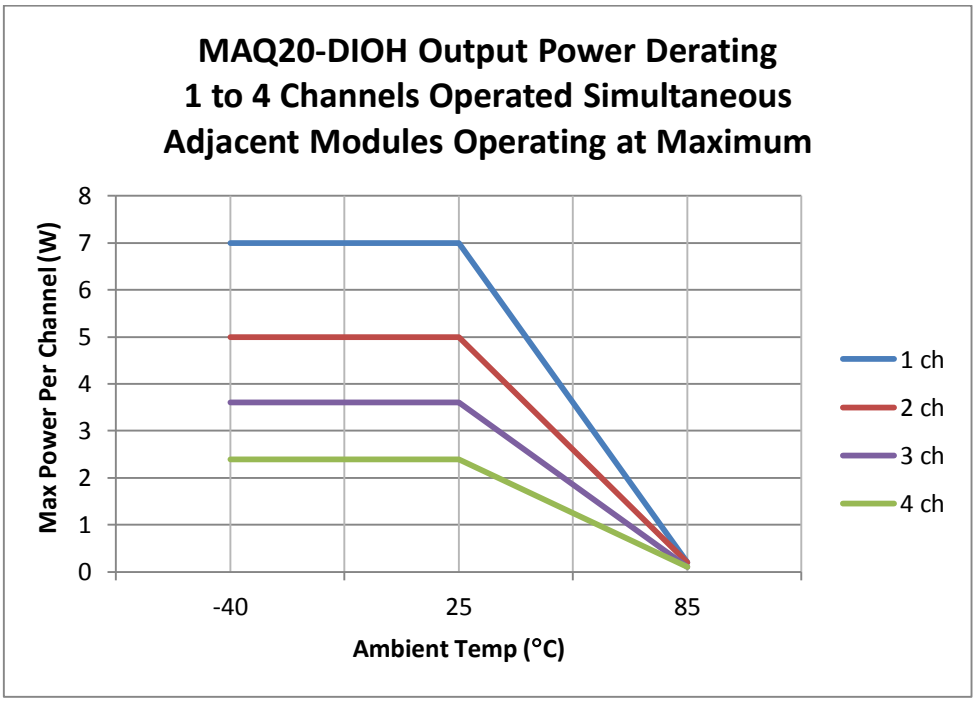


Figure 14: MAQ20-DIOH Derating, 1-4 Channels Operating, Adjacent Modules Operating At Maximum

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19.0 MAQ20-DIOH Address Map

The table in this section outlines the MAQ20-DIOH address space. Data in these registers contains all permanent and user settable information for module configuration, status, operation of all functions, data read/write, and data storage. Table columns list the following information:

Start Address: Start address for the specified quantity of addresses. The start address is offset by 2000 * R where R is the module Registration Number.

Read/Write: Indicates whether data at the address is Read, Write or both.

Number of Registers: The number of 16 bit registers reserved for the specified contents.

Contents: Parameter stored at the specified address.

Description: Details, examples, limits, and default values for the parameter stored at the specified address.

Data Range: Valid data read from or written to an address range. Data not in this range which is written to an address may return a Modus Exception 3, Illegal Data, or may be ignored.

Data Type: The type of data stored at the specified address.

ASCII 0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz, -, " "
INT16 16 bit integer value, 0 to 65535, unless otherwise indicated. Stored at a single address.
INT32 32 bit integer value, 0 to 4294967295, unless otherwise indicated. Stored at two 16 bit addresses. MSB is stored at address N, LSB is stored at address N+1.

Table 8: MAQ20-DIOH Address Map

NOTE: When a module is registered in a system, addresses are offset by 2000 * R, where R is the Registration Number. Refer to Section 9.0 for further details on Registration Number.

Address Range 0 - 99 : Module Information						
Start Address	**Read/Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
0	R	15	Device Description	MAQ20-DIOH	Characters, Numbers, "-" and Space	ASCII
19	R	11	Serial Number	S1234567-89	Characters, Numbers, "-" and Space	ASCII
30	R	5	Date Code	D0315 (week+year)	Characters, Numbers	ASCII
35	R	5	Firmware Rev	Fx.xx	Characters, Numbers and "."	ASCII
40	R	1	Input Channels	4 Input Channels	5	ASCII
41	R	1	Output Channels	4 Output Channels	5	ASCII
98	W	1	Module Detect	Any write will blink Status LED at 5Hz for 5 seconds	0 to 65,535	INT16
99	W	1	Reset Register	0 = Standard Reset 255 = Reset to Default	0, 255	INT16

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Address Range 100 - 499 : Module Configuration						
Start Address	**Read/Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
100	R	8	Channel Configuration	Input or Output	1 = Input 2 = Output	INT16
110	R/W	4	Default Output Configuration	Discrete Output Default State. Default = 1 for all channels.	DO0 - DO3 0 = Switch Closed 1 = Switch Open	INT16
190	W	1	Save to EEPROM	0 = Saves Channel Configuration, Default Out	0	INT16

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Address Range 1000 - 1299 : Module Data and Special Function Selection						
Start Address	**Read/Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
1000	R/W	8	DIO States, Binary Representation Inverted Logic Addr 1000 = LSB, Addr 1009 = MSB	Example: Starting at address 1009 and decreasing to address 1000, MSB to LSB, x then DI3 to DI0 and x then DO3 to DO0 = x0110x1000, where x = 0, register not used. Data written to an input channel will be ignored. Data written to an output channel committed to a Special Function returns an error. Default = 1 for all channels.	DO0 - DO3 Inverted Logic 0 = Switch Closed 1 = Switch Open DI0 - DI3 Inverted Logic 0 = Input > Threshold 1 = Input < Threshold	INT16
1010	R	1	DIO States, Decimal Equivalent	Example: 200 (the decimal equivalent of the binary number above. MSB to LSB 0011001000). Default = 495	0 to 255	INT16
1100		100	Timer 0 Configuration and Start Address for Special Function registers.	Select Special Function. See Address Maps below for register contents starting at address 1100 specific to each Special Function selected. *Special Functions using Timer 0 use channels DI0, DI1, DO0, DO1. See Table 4 for details. Default = 0	0 = None (Default) 1 = Event Counter 2 = Time Between Events	INT16
1200		100	Timer 1 Configuration and Start Address for Special Function registers.	Select Special Function. See Address Maps below for register contents starting at address 1200 specific to each Special Function selected. *Special Functions using Timer 1 use channels DI2, DI3, DO2, DO3. See Table 4 for details. Default = 0	0 = None (Default) 1 = Event Counter 2 = Time Between Events	INT16

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Special Function 0: None						
***Start Addresses below are offset from address 1100 for Special Functions using Timer 0 or address 1200 for Special Functions using Timer 1.**						
Start Address offset from 1100 or 1200	**Read/Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
0	R/W	1	Function	0 = No Special Function Selected	0	INT16

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Special Function 1: Event Counter						
*Start Addresses below are offset from address 1100 for Special Functions using Timer 0 or address 1200 for Special Functions using Timer 1.						
Start Address offset from 1100 or 1200	**Read/Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
0	R/W	1	Function	1 = Event Counter	1	INT16
1	R/W	1	Enable/ Disable	0 = Disable 1 = Enable	0 or 1	INT16
2	R	1	Function Status	0 = Function OK 12 = Tried to Arm Function without Function Selected 17 = Too Many Events	0 to 20 Only 0, 12 and 17 defined	INT16
3	R	1	Alarm Status	0 = No Alarm 1 = High Low Alarm 2 = High-High Low-Low Alarm	0 to 2	INT16
4	R/W	2	Event Count	A write to this address will reset the counter. MSB at Address 4, LSB at Address 5.	0 to 10 Million	INT32
10	R/W	1	Internal Trigger	0 = Negative Edge (Default) 1 = Positive Edge	0 or 1	INT16
11	R/W	1	External Enable	0 = Not Used (Default) 1 = Active Low 2 = Active High	0 to 2	INT16
12	R	1	External Enable Status	0 = Not Used (Default) 1 = Active Low 2 = Active High	0 to 2	INT16
16	R/W	1	Timebase	0 = seconds 1 = milliseconds (Default)	0 or 1	INT16
35	R/W	1	Alarm Configuration	Set Alarms for Event Count, Frequency, RPM. Default = 0	See Section 13.0	INT16
36	R/W	2	Alarm High-High Limit	0 to 10 Million. Default = 0. MSB at Address 36, LSB at Address 37.	0 to 10 Million	INT32
38	R/W	2	Alarm High Limit	0 to 10 Million. Default = 0. MSB at Address 38, LSB at Address 39.	0 to 10 Million	INT32
40	R/W	2	Alarm Low Limit	0 to 10 Million. Default = 0. MSB at Address 40, LSB at Address 41.	0 to 10 Million	INT32
42	R/W	2	Alarm Low-Low Limit	0 to 10 Million. Default = 0. MSB at Address 42, LSB at Address 43.	0 to 10 Million	INT32
44	R/W	1	Alarm High Low Deadband	0 to 65,535. Default = 0	0 to 65,535	INT16

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Special Function 1: Event Counter						
***Start Addresses below are offset from address 1100 for Special Functions using Timer 0 or address 1200 for Special Functions using Timer 1.**						
45	R/W	1	Alarm High-High Low-Low Deadband	0 to 65,535. Default = 0	0 to 65,535	INT16
90	W	1	Save Function Configuration	Write Saves to EEPROM	0	INT16

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Special Function 2: Time Between Events						
*Start Addresses below are offset from address 1100 for Special Functions using Timer 0 or address 1200 for Special Functions using Timer 1.						
Start Address offset from 1100 or 1200	**Read/Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
0	R/W	1	Function	2 = Time between Events	2	INT16
1	R/W	1	Enable/ Disable	0 = Disable 1 = Enable	0 or 1	INT16
2	R	1	Function Status	0 = Function OK 12 = Tried to Arm Function without Function Selected 17 = Too Many Events	0 to 20 Only 0, 12 and 17 defined	INT16
3	R	1	Alarm Status	0 = No Alarm 1 = High Low Alarm 2 = High-High Low-Low Alarm	0 to 2	INT16
4	R/W	2	Event Pairs Measured	A write to this address resets the counter. MSB at Address 4, LSB at Address 5.	0 to 10 Million	INT32
8	R	2	Time Between Events, current	A write to this address resets the counter. MSB at Address 8, LSB at Address 9.	0 to 10 Million	INT32
10	R/W	2	Time Between Events, max	A write to this address resets the counter. MSB at Address 10, LSB at Address 11.	0 to 10 Million	INT32
12	R/W	2	Time Between Events, min	A write to this address resets the counter. Default = 7280. MSB at Address 12, LSB at Address 13.	0 to 10 Million	INT32
14	R	2	Time Between Events, average	A write to this address resets the counter. MSB at Address 14, LSB at Address 15.	0 to 10 Million	INT32
16	R/W	1	Timebase	0 = seconds 1 = milliseconds (Default)	0 or 1	INT16
17	R/W	1	Event 1 Internal Trigger	0 = Negative Edge (Default) 1 = Positive Edge	0 or 1	INT16
18	R/W	1	Event 2 Internal Trigger	0 = Negative Edge (Default) 1 = Positive Edge	0 or 1	INT16

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Special Function 2: Time Between Events						
***Start Addresses below are offset from address 1100 for Special Functions using Timer 0 or address 1200 for Special Functions using Timer 1.**						
19	R/W	1	Average Weight	Used to calculate Average = Average + ((Sampled Value – Average) / Average Weight). Default = 4	0 to 65,535	INT16
20	R/W	2	Event Pairs to Measure	Number of events to measure. 0 = Unlimited. Default = 0. MSB at Address 20, LSB at Address 21.	0 to 10 Million	INT32
35	R/W	1	Alarm Configuration	Set Alarms for Events Measured, Time Between Events. Default = 0	See Section 13.0	INT16
36	R/W	2	Alarm High-High Limit	0 to 10 Million. Default = 0. MSB at Address 36, LSB at Address 37.	0 to 10 Million	INT32
38	R/W	2	Alarm High Limit	0 to 10 Million. Default = 0. MSB at Address 38, LSB at Address 39.	0 to 10 Million	INT32
40	R/W	2	Alarm Low Limit	0 to 10 Million. Default = 0. MSB at Address 40, LSB at Address 41.	0 to 10 Million	INT32
42	R/W	2	Alarm Low-Low Limit	0 to 10 Million. Default = 0. MSB at Address 42, LSB at Address 43.	0 to 10 Million	INT32
44	R/W	1	Alarm High Low Deadband	0 to 65,535. Default = 0	0 to 65,535	INT16
45	R/W	1	Alarm High-High Low-Low Deadband	0 to 65,535. Default = 0	0 to 65,535	INT16
90	W	1	Save Function Configuration	Write Saves to EEPROM	0	INT16

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Address Range 1900 - 1999 : Status Registers						
Start Address	**Read/ Write**	**Number of Registers**	**Type**	**Example**	**Range**	**Data type**
1900	R/W	1	Watchdog Reset	0 = Normal 1 = Watchdog Reset	0 or 1	INT16
1901	R/W	1	Brownout Flag	0 = Normal 1 = Brownout Reset	0 or 1	INT16
1902	R/W	1	I2C Error	I2C TX Error Counter	0 to 65,535	INT16
1903	R/W	1	I2C Error	I2C RX Error Counter	0 to 65,535	INT16
1906	R/W	1	Numeric Error	Increments when a value received is outside of the allowed range	0 to 65,535	INT16
1908	R/W	1	UART RX Error	UART RX Error Counter. Command Too Short	0 to 65,535	INT16
1909	R/W	1	UART RX Error	UART RX Error Counter. Command Too Long	0 to 65,535	INT16
1910	R/W	1	UART RX Error	UART RX Error Counter. Command received in invalid state	0 to 65,535	INT16

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i. for all software products including licensed programs, thirty (30) days from date of initial delivery;

ii. for all hardware products including complete systems, one (1) year from date of initial delivery;

iii. for all special products, sixty (60) days from date of initial delivery; and

further, all products warranted hereunder for which Dataforth has received timely notice of nonconformance must be returned FOB to Dataforth's plant in Tucson, Arizona USA within thirty (30) days after the expiration of the warranty periods set forth above.

The foregoing warranties shall not apply to any products which Dataforth determines have, by buyer or otherwise, been subjected to operating and/or environmental conditions in excess of the maximum value established therefore in the applicable specifications, or any products that have been the subject of mishandling, misuse, misapplication, neglect, improper testing, repair, alteration or damage. THE PROVISIONS OF THE FOREGOING WARRANTIES EXTEND TO BUYER ONLY AND NOT TO BUYER'S CUSTOMERS OR USERS OF BUYER'S PRODUCTS. THE DATAFORTH STANDARD WARRANTY IS IN LIEU OF ALL WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE OR USE AND ALL OTHER WARRANTIES WHETHER EXPRESS, IMPLIED OR STATUTORY, EXCEPT AS TO TITLE. THE DATAFORTH STANDARD WARRANTY MAY BE CHANGED BY DATAFORTH WITHOUT NOTICE.

b. **Buyer Indemnity**. Buyer agrees to indemnify and hold Dataforth harmless from and against any and all claims, damages and liabilities whatsoever asserted by any person, entity, industry organization, government, or governmental agency of any country resulting directly or indirectly (i) from any acts not authorized by Dataforth in writing or any statements regarding the products inconsistent with Dataforth's product documentation or standard warranty, or (ii) from any breach or threatened breach by buyer, or by any of its employees or agents, of any term, condition or provision of this Warranty or (iii) from any warranty, representation, covenant or obligation given by buyer to any third party and not expressly provided for in this Warranty or (iv) for any non-compliance (in any form) of the products with any necessary or mandatory applicable laws, regulations, procedures, government or industry policies or requirements related to the use, sale or importation of the products. Such indemnification shall include the payment of all reasonable attorneys' fees and other costs incurred by Dataforth in defending such claim.

c. **Limitation on Damages**.

(1) IN NO EVENT SHALL DATAFORTH, ITS SUPPLIERS, LICENSORS, SERVICE PROVIDERS, EMPLOYEES, AGENTS, OFFICERS, AND DIRECTORS BE LIABLE FOR INDIRECT, SPECIAL, INCIDENTAL, COVER, ECONOMIC, PUNITIVE, ACTUAL, EXEMPLARY, CONSEQUENTIAL OR OTHER DAMAGES OF ANY NATURE INCLUDING, WITHOUT LIMITATION, LOST PROFITS OR REVENUES, COSTS OF REPLACEMENT PRODUCTS, LOSS OR DAMAGE TO DATA ARISING OUT OF THE USE OR INABILITY TO USE ANY DATAFORTH PRODUCT.

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d. **Technical Assistance**. Dataforth 's Warranty as hereinabove set forth shall not be enlarged, diminished or affected by, and no obligation or liability shall arise or grow out of, Dataforth's rendering of technical advice, facilities or service in connection with buyer's order of the products furnished hereunder.

e. **Warranty Procedures**. Buyer shall notify Dataforth of any products which it believes to be defective during the applicable warranty period and which are covered by the Warranty set forth above. Buyer shall not return any products for any reason without the prior authorization of Dataforth and issuance of a Return Material Authorization ("RMA") number. After issuance of a RMA number, such products shall be promptly returned by buyer (and in no event later than thirty (30) days after the Warranty expiration date), transportation and insurance prepaid, to Dataforth's designated facility for examination and testing. Dataforth shall either repair or replace any such products found to be so defective and promptly return such products to buyer, transportation and insurance prepaid. Should Dataforth's examination and testing not disclose any defect covered by the foregoing Warranty, Dataforth shall so advise buyer and dispose of or return the products in accordance with buyer's instructions and at buyer's sole expense, and buyer shall reimburse Dataforth for testing expenses incurred at Dataforth's then current repair rates.

f. **Repair Warranty**. Dataforth warrants its repair work and/or replacement parts for a period of ninety (90) days from receipt by buyer of the repaired or replaced products or for the remainder of the warranty period for the initial delivery of such order as set forth in paragraph a above, whichever is greater.

g. **Critical Applications**. Certain applications using Dataforth's products may involve potential risks of death, personal injury, or severe property or environmental damage ("Critical Applications"). DATAFORTH'S PRODUCTS ARE NOT DESIGNED, INTENDED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT DEVICES OR SYSTEMS, SAFETY EQUIPMENT, NUCLEAR FACILITY APPLICATIONS OR OTHER CRITICAL APPLICATIONS WHERE MALFUNCTION OF THE PRODUCT CAN BE EXPECTED TO RESULT IN PERSONAL INJURY, DEATH OR SEVERE PROPERTY DAMAGE. BUYER USES OR SELLS SUCH PRODUCTS FOR USE IN SUCH CRITICAL APPLICATIONS AT BUYER'S OWN RISK AND AGREES TO DEFEND, INDEMNIFY AND HOLD HARMLESS DATAFORTH FROM ANY AND ALL DAMAGES, CLAIMS, PROCEEDINGS, SUITS OR EXPENSE RESULTING FROM SUCH USE.

h. **Static Sensitive**. Dataforth ships all product in anti-static packages. Dataforth's Warranty as hereinabove set forth shall not cover warranty repair, replacement, or refund on product or devices damaged by static due to buyer's failure to properly ground.

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Application Support

Dataforth provides timely, high-quality product support. Call 1**-800-444-7644 TOLL-FREE**.

Returns/Repair Policy

All warranty and repair requests should be directed to the Dataforth Customer Service Department at (520) 741-1404. If a product return is required, request a Return Material Authorization (RMA) number. You should be ready to provide the following information:

1. Complete product model number.
2. Product serial number.
3. Name, address, and telephone number of person returning product.
4. Special repair instructions.
5. Purchase order number for out-of-warranty repairs.

The product should be carefully packaged, making sure the RMA number appears on the outside of the package, and ship prepaid to:

Dataforth Corporation
6230 S. Country Club
Tucson, AZ 85706 USA

An RMA Request Form and instructions for processing are also found at www.dataforth.com.

The information provided herein is believed to be reliable; however, DATAFORTH assumes no responsibility for inaccuracies or omissions. DATAFORTH assumes no responsibility for the use of this information, and all use of such information shall be entirely at the user's own risk. Application information is intended as suggestions for possible use of the products and not as explicit performance in a specific application. Prices and specifications are subject to change without notice. No patent rights or licenses to any of the circuits described herein are implied or granted to any third party. DATAFORTH does not authorize or warrant any DATAFORTH product for use in life support devices and/or systems.

MAQ20-DIOH Hardware User Manual
MA1058 Rev. A – September 2015
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