MAQ®20

Industrial Data Acquisition and Control System

MA1043

MAQ20-DIOL Hardware User Manual

DATAFORTH®

MAQ20-DIOL Hardware User Manual
MA1043 Rev. C – March 2024

ISO9001:2015-Registered QMS

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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.

1.0 System Features

The MAQ®20 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 ±0.3°C 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 Power Supply Range of 7-34VDC
- CE Compliant
- UL/cUL (Class I, Div 2, Groups A, B, C, D) Compliant, file E232858
- 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
  - ReDAQ Shape Graphical HMI Design & Runtime Solution
- Intuitive Graphical Control Software
  - ReDAQ Shape Graphical HMI Design & Runtime Solution
  - Phyton API
  - OPC Server
  - Programming examples and LabVIEW Vis

2.0 System Description and Documentation

A MAQ®20 Data Acquisition System must have as a minimum a Communications Module, a Backbone, and one I/O Module. Examples include but are not limited to:

- 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 https://www.dataforth.com/maq20 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 MAQ®20 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 from module to module for ease of use and system design.

MAQ®20 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 MAQ®20 voltage and current input modules offer 8 or 16 input channels. All channels are individually configurable for range, alarm limits, and averaging to match the most demanding applications. High, Low, High-High and Low-Low alarms provide essential monitoring and warning functions to ensure optimum process flow and fail-safe applications. Hardware low-pass filtering in each channel provides rejection of 50 and 60 Hz line frequencies. Field I/O connections are made through a pluggable terminal block with 4 positions provided for the termination of wiring shields.

Input-to-Bus isolation is a robust 1500Vrms and each individual channel is protected up to 240Vrms continuous overload in the case of inadvertent wiring errors. Overloaded channels do not adversely affect other channels in the module which preserves data integrity.

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

MA1036 MAQ®20 Quick Start Guide

MA1040 MAQ®20 Communications Module Hardware User Manual

MA1041 MAQ®20 milliVolt, Volt, and Current Input Module Hardware User Manual

MA1037 MAQ®20 Configuration Software Tool User Manual

MA1038 MAQ®20 ReDAQ Shape for MAQ®20 User Manual

MAQ20-940 ReDAQ Shape Software for MAQ®20 – Developer Version

MAQ20-941 ReDAQ Shape Software for MAQ®20 – User Version

MAQ20-945 MAQ®20 Configuration Software Tool

MAQ20-952 IPEMotion Software for MAQ®20

3.0 Unpacking

Each MAQ®20 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

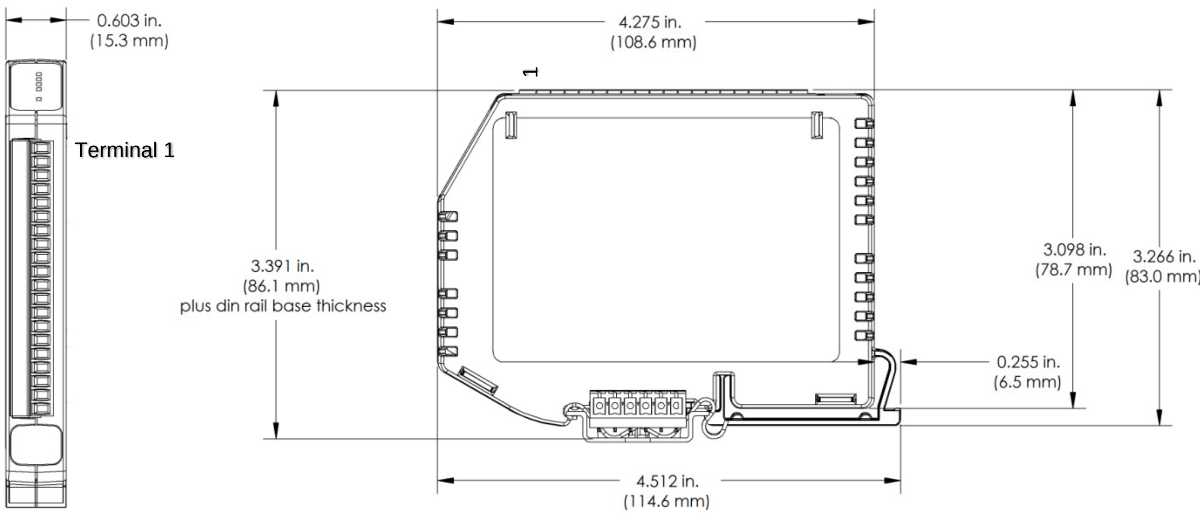

Figure 1: Module Dimensions

Table 1: I/O Terminal Block Connections

TERMINAL BLOCK POSITION (TOP TO BOTTOM)	MAQ20-DIOL 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	DO CH4 +OUT		
10	DO CH4 -OUT		
11	DI CH0 +IN	Sec. 12.0, Table 4	
12	DI CH0 -IN		
13	DI CH1 +IN	Sec. 12.0, Table 4	
14	DI CH1 -IN		
15	DI CH2 +IN	Sec. 12.0, Table 4	
16	DI CH2 -IN		
17	DI CH3 +IN	Sec. 12.0, Table 4	
18	DI CH3 -IN		
19	DI CH4 +IN		
20	DI CH4 -IN		

5.0 Installation

The MAQ®20 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.

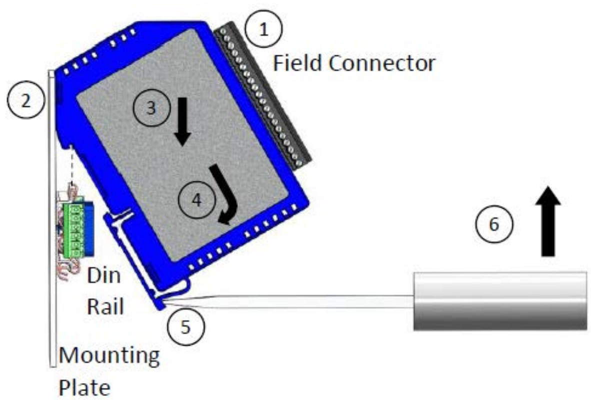

Figure 2: Installation and Removal

Multiple rows of MAQ®20 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.

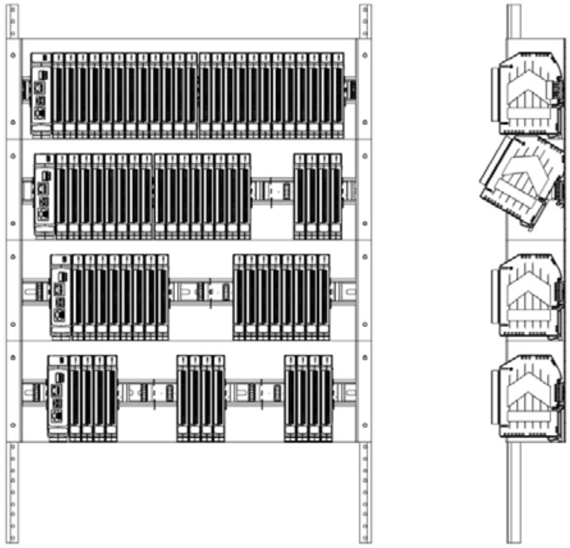

Figure 3: Possible System Configurations

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 MAQ®20 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 MAQ®20 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 MAQ®20 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

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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 MAQ®20 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 MAQ®20 and MAQ20-945 - MAQ®20 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.

7.0 Maintaining a System

The MAQ20-COMx Communications Module periodically scans the system and will detect if a MAQ®20 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 MAQ®20 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 MAQ®20 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 MAQ®20 I/O modules in the system requiring maintenance.

ALTERNATE MAINTENANCE PROCESS

1.) With the 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 MAQ®20 and MAQ20-945 - MAQ®20 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.

8.0 Expanding a System

The MAQ20-COMx Communications Module periodically scans the system and will detect if a MAQ®20 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 MAQ®20 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 MAQ®20 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 MAQ®20 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 <u>not associated with the physical position on the backbone</u>. 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 MAQ®20 and MAQ20-945 - MAQ®20 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.

9.0 MAQ®20 I/O Module Registration

The MAQ®20 Data Acquisition System uses an automated registration process which periodically scans the system and will detect when MAQ®20 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 MAQ®20 and MAQ20-945 - MAQ®20 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.

The Address Map for the MAQ20-DIOL 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-DIOL 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	10	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 DI4 to DI0 and DO4 to DO0 = 1011011000. 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 – DO4 Inverted Logic 0 = switch closed 1 = switch open DI0 – DI4 Inverted Logic 0 = input > threshold 1 = input < threshold	INT16
1010	R	1	DIO States, Decimal Equivalent	Example: 728 (the decimal equivalent of the binary number above. MSB to LSB 1011011000). Default = 1023	0 to 1023	INT16

Example: A MAQ20-DIOL 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-DIOL module with s/n 1234567-89 has an address offset of 2000 * 4 = 8000

Write to the DO channels DO0 – DO4 at addresses 8000 + 1000 to 1004 = 9000 to 9004
Read from the DI channels DI0 – DI4 at addresses 8000 + 1005 to 1009 = 9005 to 9009

The MAQ20-940 - ReDAQ Shape Software for MAQ®20 and MAQ20-945 - MAQ®20 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.

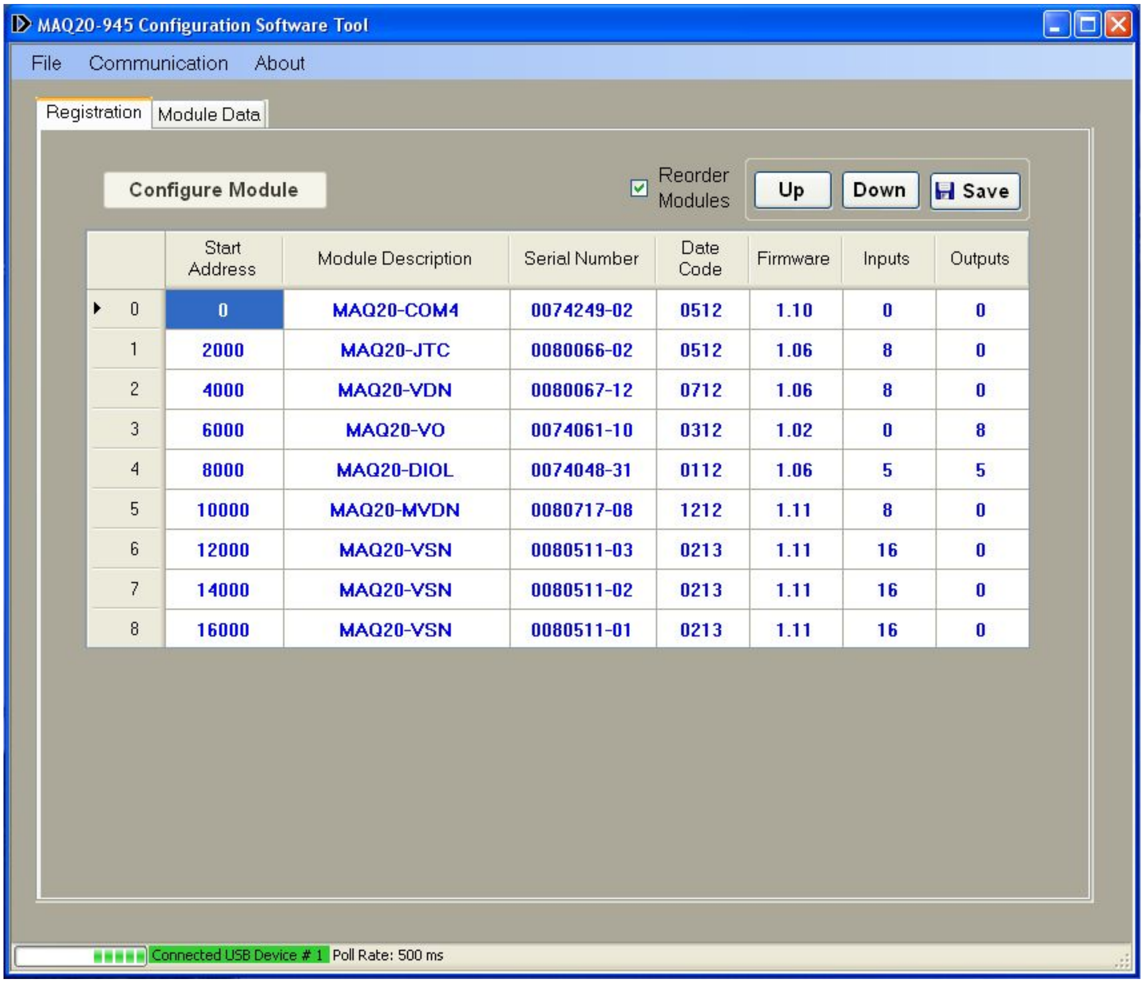


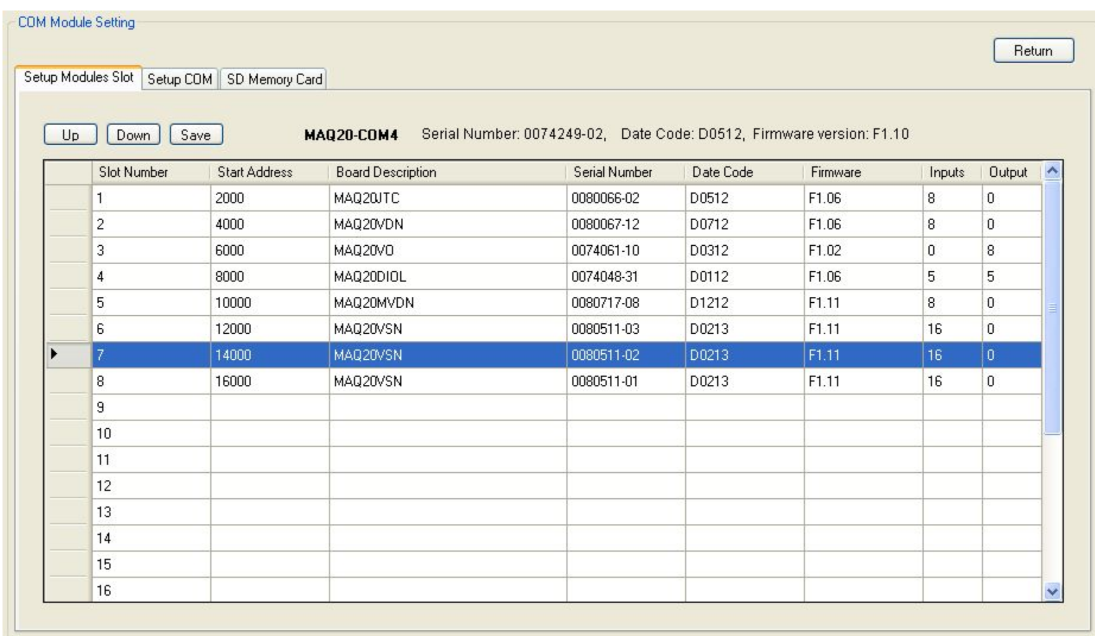
Figure 4: Module Registration using MAQ20-945 Configuration Software Tool

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.

ReDAQ Shape Software for MAQ®20 presents a graphical representation of the system on the Acquire panel as shown in Figure 5.

Figure 5: MAQ20-940 ReDAQ Shape for MAQ®20 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	MAQ20JTC	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.

10.0 Reading Discrete Input Channels and Writing Discrete Output Channels

The MAQ20-DIOL module has 5 isolated discrete input channels and 5 isolated discrete output channels. Input channels interface to 3-60VDC signals and output channels control 3-60VDC signals at up to 3A current. Channel-to-Channel isolation is 300Vrms. Each individual channel has continuous overload and reverse connection protection in the case of inadvertent wiring errors.

Signals applied to discrete input channels are detected as high when over 1.6V and low when below 1.6V. Discrete output channels have a solid-state switch. They do not output logic signals directly and must be connected to an external source. The basic circuit topology is shown in Figure 7 below.

NOTE:

THE MAQ20-DIOL 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.

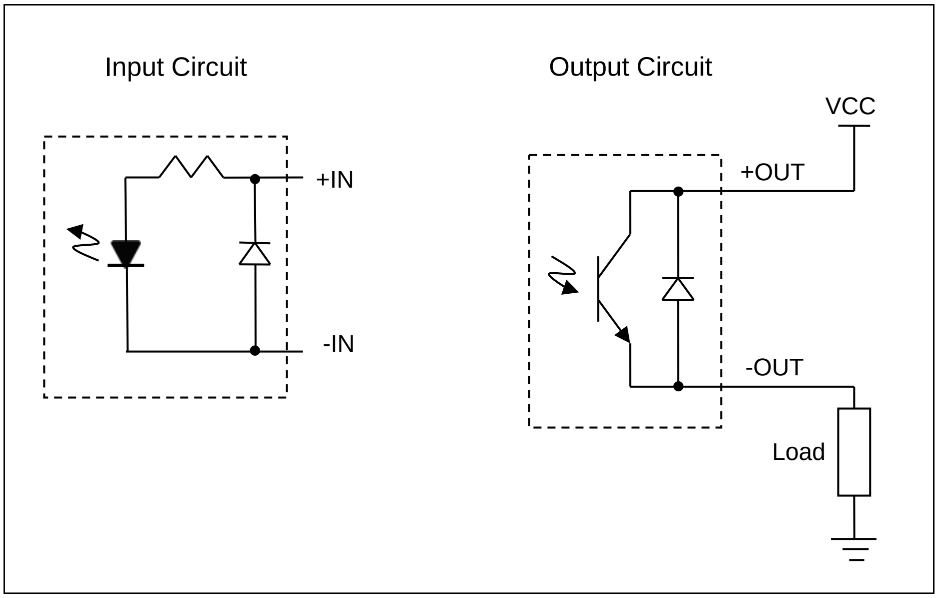


Figure 7: Discrete Input and Discrete Output Circuit Topology

The Address Map for the MAQ20-DIOL 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	10	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	10	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 DI4 to DI0 and DO4 to DO0 = 1011011000. 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 – DO4 Inverted Logic 0 = switch closed 1 = switch open DI0 – DI4 Inverted Logic 0 = input > threshold 1 = input < threshold	INT16
1010	R	1	DIO States, Decimal Equivalent	Example: 728 (the decimal equivalent of the binary number above. MSB to LSB 1011011000). Default = 1023	0 to 1023	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.

Once a channel configuration is made 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.

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	DO4	0 = switch closed, 1 = switch open	
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	DI4	0 = input > threshold, 1 = input < threshold	MSB
1010	All DO & DI	Decimal equivalent of 10-digit value	

Example: A MAQ20-DIOL 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, 3 and 4. Assume the channel data in registers 1000 to 1009 is 0001101101.

The MAQ20-DIOL 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 1009 = 9005 to 9009 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
Read from register address 8000 + 1009 = 9009 the data from Channel DI4, 1 = below threshold

The resulting bit pattern at register addresses 9000 to 9009 presented LSB to MSB is 0001101101.

Read from register address 8000 + 1010 = 9010 the decimal equivalent of the discrete IO states. Using the data above, a value of 728 is read which equates to 1011011000. MSB to LSB, this is the same as the data in registers 9000 to 9009.

11.0 Setting Default Outputs

The five discrete output channels in the MAQ20-DIOL 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-DIOL 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	10	Channel Configuration	Input or Output	1 = Input 2 = Output	INT16
110	R/W	5	Default Output Configuration	Discrete Output Default State. Default = 1 for all channels.	DO0 - DO4 0 = Switch Closed 1 = Switch Open	INT16
190	W	1	Save to EEPROM	0 = Saves Channel Configuration, Default Out	0	INT16

NOTE:

THE MAQ20-DIOL 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-DIOL 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, 3 and 4 to switch closed.

The MAQ20-DIOL 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
Write to register address 8000 + 104 = 8104 a data value of 0 to set DO4 default state to closed

12.0 Special Function Description and Configuration

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

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

Function	Discrete Channel Inputs	Discrete Channel Outputs
Pulse / Frequency Counter	Signal, Trigger	
Pulse / Frequency Counter with Debounce	Signal, Trigger	Debounced Signal
Waveform Measurement	Signal	
Time Between Events	Signal 1, Signal 2	
Frequency Generator		Signal
Pulse Width Modulation (PWM)		Signal 1, Signal 2
One-Shot Generator	Trigger	Signal

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 except PWM have a single set of inputs and/or outputs. Each instance of the PWM function can have two outputs, therefore a single module can have four PWM outputs if the function is run on both timers.

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	Pulse / Frequency Counter	Input	Input Signal	DI0	DI2
		Input	External Enable	DI1	DI3
2	Pulse / Frequency Counter w/Debounce	Input	Input Signal	DI0	DI2
		Output	Debounced Version of Input Signal	DO0	DO2
3	Waveform Measurement	Input	Input Signal	DI0	DI2
4	Time Between Events	Input	Input Signal 1	DI0	DI2
		Input	Input Signal 2	DI1	DI3
5	Frequency Generator	Output	Output Signal	DO0	DO2
6	PWM Generator	Output	Output Signal 1	DO0	DO2
		Output	Output Signal 2	DO1	DO3
7	One-Shot Pulse Generator	Output	Output Signal	DO0	DO2
		Input	Trigger	DI0	DI2

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.

The Address Map for the MAQ20-DIOL 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 Section 12.0 for details. Default = 0	0 = None (Default) 1 = Pulse/Freq Counter 2 = Pulse/Freq Counter w/ Debounce 3 = Waveform Measurement 4 = Time Between Events 5 = Frequency Generator 6 = PWM Generator 7 = One-Shot Pulse Generator	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 Section 12.0 for details. Default = 0	0 = None (Default) 1 = Pulse/Freq Counter 2 = Pulse/Freq Counter w/ Debounce 3 = Waveform Measurement 4 = Time Between Events 5 = Frequency Generator 6 = PWM Generator 7 = One-Shot Pulse Generator	INT16

Special Function 1: Pulse / Frequency 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 = Pulse / Frequency Counter	1	INT16

Special Function 3: Waveform Measurement						
***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	3 = Waveform Measurement	3	INT16

Example: A MAQ20-DIOL 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 Pulse / Frequency Counter and Waveform Measurement Special Functions.

The MAQ20-DIOL 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 Pulse / Frequency 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 3 to set the Waveform Measurement Special Function to operate on Timer 1. Connect the input signal to be measured to channel DI2.

12.1 Special Function 1: Pulse / Frequency Counter

The Pulse 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. Pulses on the input are cumulatively counted to an upper limit of 10,000,000. Input levels over 1.6V are detected as high and input levels below 1.6V are low. The MAQ20-DIOL module uses inverted logic so inputs over the threshold are reported as logic 0 and inputs below the threshold are reported as logic 1. Edge triggering can be set to positive or negative. If pulses per revolution is specified, RPM can be measured to an upper limit of 65,535. Counting is enabled or disabled by arming or disarming the function. Optionally, counting can 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. Pulse count is reset by writing a register.

In Figure 8 below, an active high external enable is used for pulse counting. Counting begins after the enable line goes high. If input signal positive edge trigger is selected, 3 pulses will be counted and if input signal negative edge trigger is selected 4 pulses will be counted.

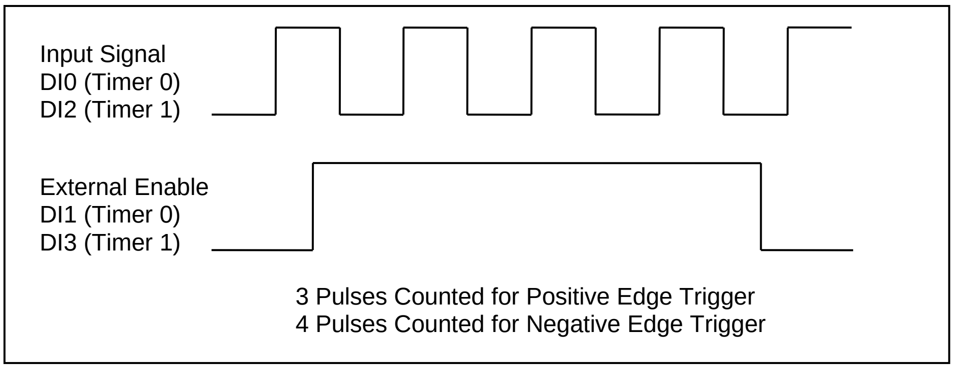


Figure 8: Pulse Counter Operation Using External Enable

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. Reference Section 14.0 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.

The Frequency 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. Frequency is measured from 0 Hz to an upper limit of 10,000 Hz. Input signals can have any waveshape but must cross through 1.6V to be detected as high or low. Edge triggering can be set to positive or negative. Frequency measurement is enabled or disabled by arming or disarming the function. Optionally, measurement can 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.

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. Reference Section 14.0 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.

12.2 Special Function 2: Pulse / Frequency Counter with Debounce

The Pulse Counter with Debounce 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. Pulses on the input are cumulatively counted to an upper limit of 10,000,000. Input levels over 1.6V are detected as high and input levels below 1.6V are low. The MAQ20-DIOL module uses inverted logic so inputs over the threshold are reported as logic 0 and inputs below the threshold are reported as logic 1. Minimum Low Time and Minimum High Time for valid pulses are specified in increments of 100µs. These can be used to prevent false triggering from invalid signals. A debounced version of the input signal is provided on discrete output channel DO0 if Timer 0 is used to implement the function or discrete output channel DO2 if Timer 1 is used to implement the function. This output can be enabled or disabled by writing to a register. Edge triggering can be set to positive or negative. Counting is enabled or disabled by arming or disarming the function. Pulse count is reset by writing to a register.

High Low or High-High Low-Low alarms can be configured for this function and dedicated discrete output channels can be set when High-High Low- Low alarm conditions are reached. Reference Section 14.0 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.

Figure 9 below shows function operation for positive edge triggering. When input signal pulses have a high time longer than the user specified Minimum High Time, the debounced signal transitions high and when input signal pulses have a low time longer than the user specified Minimum Low Time, the debounced signal transitions low.

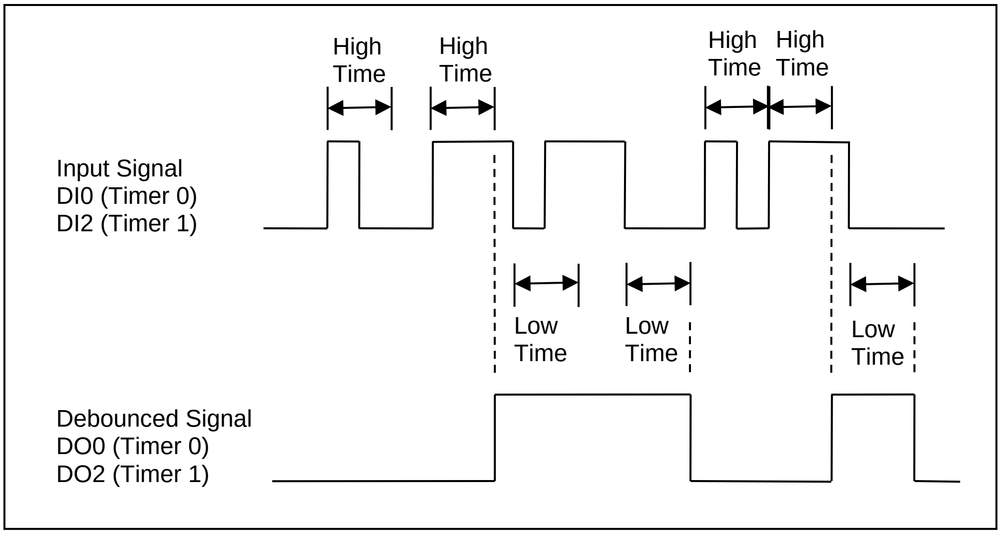


Figure 9: Pulse Counter with Debounce Operation

The Frequency Counter with Debounce 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. Frequency is measured from 0 Hz to an upper limit of 3,000 Hz. Input signals can have any waveshape but must cross through 1.6V to be detected as high or low. Minimum Low Time interval and High Time interval for valid pulses are specified in increments of 100µs. These can be used to prevent false triggering from invalid signals. A debounced version of the input signal is provided on discrete output channel DO0 if Timer 0 is used to implement the function or discrete output channel DO2 if Timer 1 is used to implement the function. This output can be enabled or disabled by writing to a register. Edge triggering can be set to positive or negative. Frequency measurement is enabled or disabled by arming or disarming the function.

High Low or High-High Low-Low alarms can be configured for this function and dedicated discrete output channels can be set when High-High Low-Low alarm conditions are reached. Reference Section 14.0 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.

12.3 Special Function 3: Waveform Measurement

The Waveform Measurement function can measure many waveform characteristics including frequency, pulse width, period, duty cycle, and number of events. The maximum frequency which can be measured is 500Hz for 1% accurate duty cycle reporting or 10kHz if greater than 1% duty cycle accuracy is acceptable. The maximum number of events which can be counted is 10 million and the timebase used for measurements can be selected as seconds, milliseconds or microseconds. Figure 10 shows two of the basic parameters that will be stored in registers.

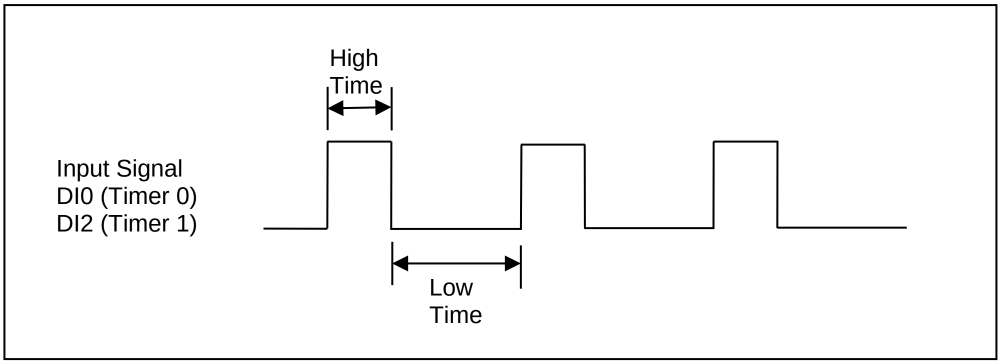


Figure 10: Waveform Measurement Parameters

This 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. Input levels over 1.6V are detected as high and input levels below 1.6V are low. The MAQ20-DIOL module uses inverted logic so inputs over the threshold are reported as logic 0 and inputs below the threshold are reported as logic 1. Edge triggering can be set to positive or negative. Waveform measurement is enabled or disabled by arming or disarming the function. The number of events to measure can be specified and measured waveform parameters are reset by writing corresponding registers. The timebase is selected based on the waveform to be measured in order to obtain the best measurement resolution and performance. The average weight for low and high pulse times can be set as applications require. Pulse high time and low time are stored as current, average, min and max values. Waveform 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. Events to Measure can be set from 1 to 10 million or can be set to 0 to measure waveforms continuously.

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. Reference Section 14.0 for details on using alarms. If the special function is disabled by writing a number other than 3 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.

12.4 Special Function 4: Time Between Events

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. Other parameters measured are the frequency of the specified event pair occurrence (inverse of the time between events), and the number of times the specified event pair occurred. The maximum frequency which can be measured is 10kHz, the maximum event pair occurrences which can be counted is 10 million and the timebase used for measurements can be selected as seconds, milliseconds or microseconds.

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 11 below, Input Channel 1 has been set to positive edge triggering and Input Channel 2 has also been set to positive edge triggering. When Channel 2 is high, Event 1 occurs when Channel 1 transitions high. Event 2 occurs after Channel 2 has transitioned low and then transitions high.

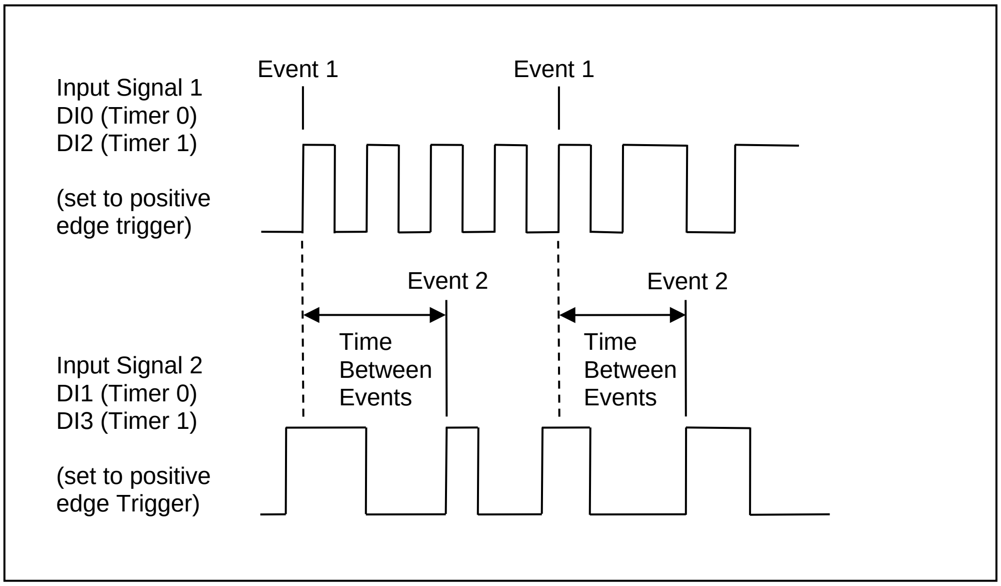


Figure 11: Time Between Events Operation

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 1.6V are detected as high and input levels below 1.6V are low. The MAQ20-DIOL module uses inverted logic so inputs over the threshold are reported as logic 0 and inputs below the threshold are reported as logic 1. Edge triggering for each event can be set to positive or negative. Time between events measurement is enabled or disabled by arming or disarming the function. 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 is computed continuously up to the limit set in the Events to Measure register using the specified average weight and are stored in registers. Events to Measure can be set from 1 to 10 million or can be set to 0 to measure waveforms continuously.

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. Reference Section 14.0 for details on using alarms. If the special function is disabled by writing a number other than 4 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.

12.5 Special Function 5: Frequency Generator

The Frequency Generator function uses discrete output channel DO0 if Timer 0 is used to implement the function or discrete output channel DO2 if Timer 1 is used to implement the function. A square wave output is generated on the respective discrete output channel. Waveform frequency is set by writing to a register. Minimum frequency is 0Hz and maximum frequency is 700Hz for 1% error or 10kHz for 14% error. The output is enabled or disabled by arming or disarming the function. Figure 12 shows a typical waveform and output channels used to implement the function.

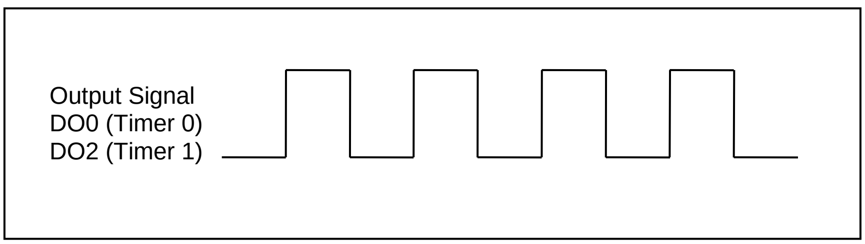


Figure 12: Time Between Events Operation

If the special function is disabled by writing a number other than 5 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.

12.6 Special Function 6: Pulse Width Modulation Generator

The Pulse Width Modulation Generator function uses discrete output channels DO0 and DO1 if Timer 0 is used to implement the function or discrete output channels DO2 and DO3 if Timer 1 is used to implement the function. One or two output signals can be generated for each implementation of the function. If two signals are generated using a given Timer, both will have the same period, but duty cycle for each can be independently controlled. Output DO0 for Timer 0 implementation or output DO2 for Timer 1 implementation are automatically enabled when the function is configured. Output DO1 for Timer 0 implementation or output DO3 for Timer 1 implementation are enabled or disabled by writing to a register. All PWM outputs are enabled or disabled by arming or disarming the function. The period and each output low time are set by writing to a register. Minimum period is 200µs and minimum low time is 100µs. The timebase is selected as seconds, milliseconds or microseconds based on the waveform to be generated in order to obtain the best resolution and performance. The example shown in Figure 13 below shows the use of both Timers, each used to generate two PWM signals.

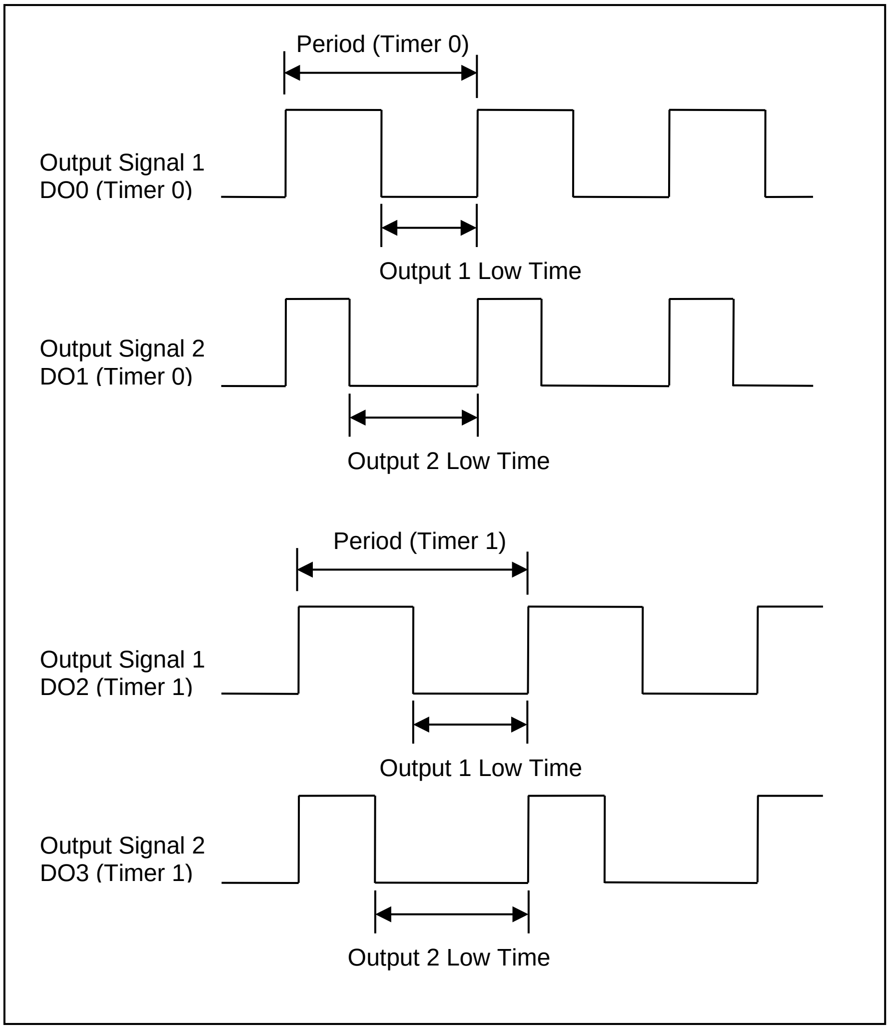


Figure 13: PWM Generator Configured to Output Four Separate Signals

If the special function is disabled by writing a number other than 6 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.

12.7 Special Function 7: One-Shot Pulse Generator

The One-Shot Pulse Generator function uses discrete output channel DO0 if Timer 0 is used to implement the function or discrete output channel DO2 if Timer 1 is used to implement the function. The output is enabled or disabled by arming or disarming the function. Minimum pulse width is 100µs and is set by writing to a register. Pulse polarity can be selected as positive or negative with settable pulse width high or low respectively. The timebase is selected as seconds, milliseconds or microseconds based on the waveform to be generated in order to obtain the best resolution and performance.

Pulses generated are cumulatively counted to an upper limit of 10,000,000. This count is reset by writing to a register. A pulse count limit can be set which disarms the function after the limit is reached. Pulse generation is triggered through software by writing to a register or by using an external signal applied to 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. External signal edge triggering can be set to positive or negative. Pre-delay before the pulse is generated and post-delay after the pulse is generated both have a minimum value of 100µs and are set by writing to respective registers.

In Figure 14 below, a discrete input channel is used to trigger the one-shot pulse. After the discrete input channel trigger is detected, the specified pre-delay period is counted before the output signal is generated. After the pulse is generated with the specified pulse width, the specified post-delay period is counted before the function will accept another discrete input channel trigger.

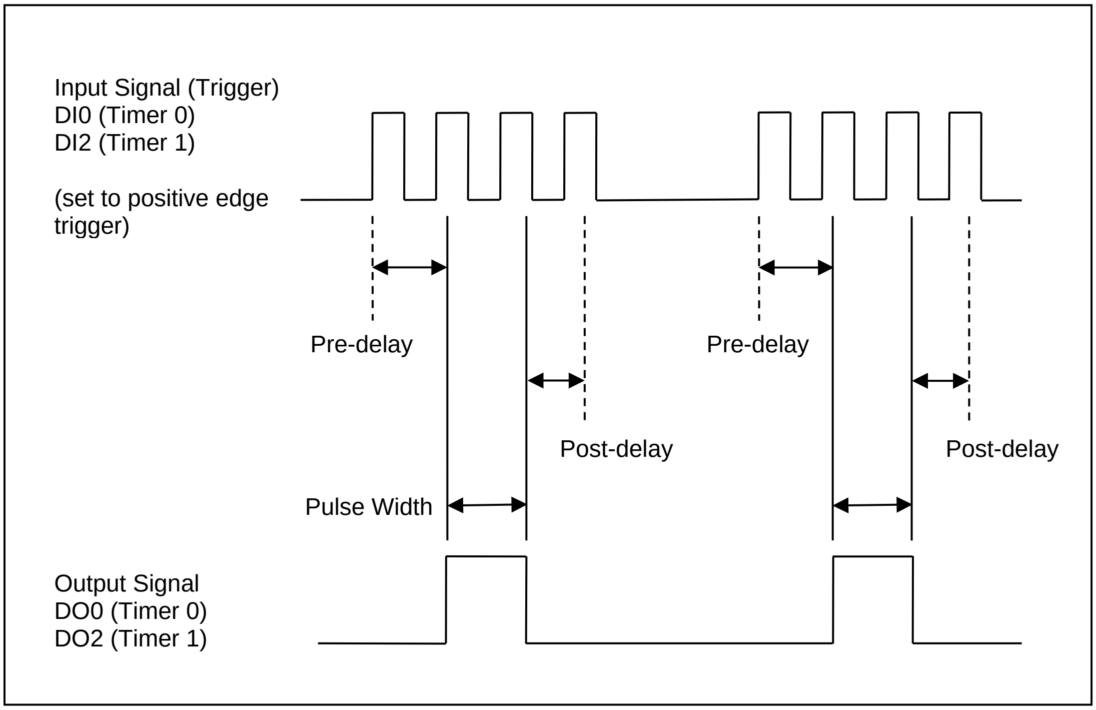


Figure 14: One-Shot Pulse Generator with Discrete Input Channel External Trigger

If the special function is disabled by writing a number other than 7 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.

13.0 Alarm Functions

The powerful alarm functions in the MAQ®20 Data Acquisition System provide essential monitoring and warnings to ensure optimum process flow and fail-safe applications. Alarms have the following parameters which can be configured:

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.

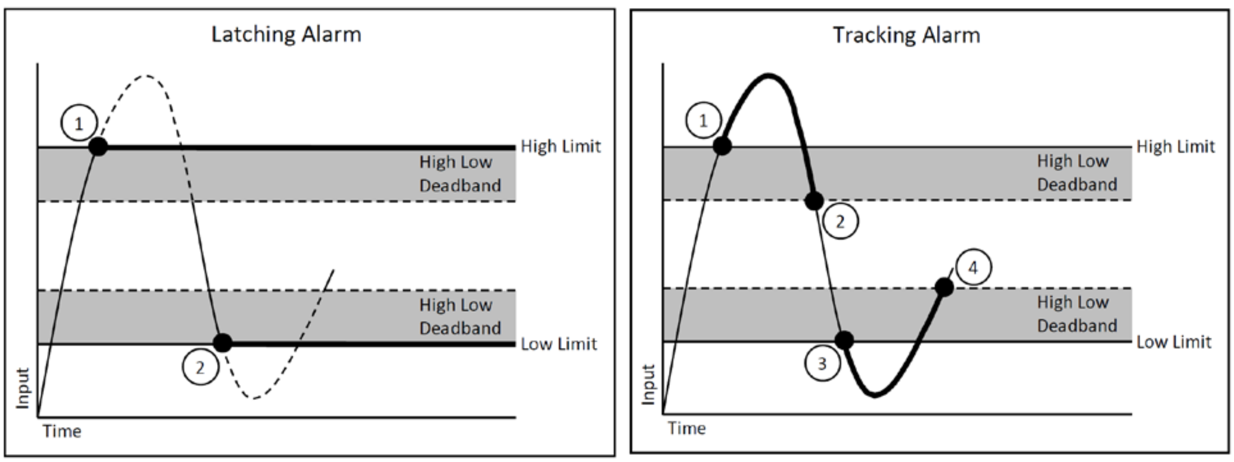
Low-Low Limit

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

High-High Low-Low Deadband

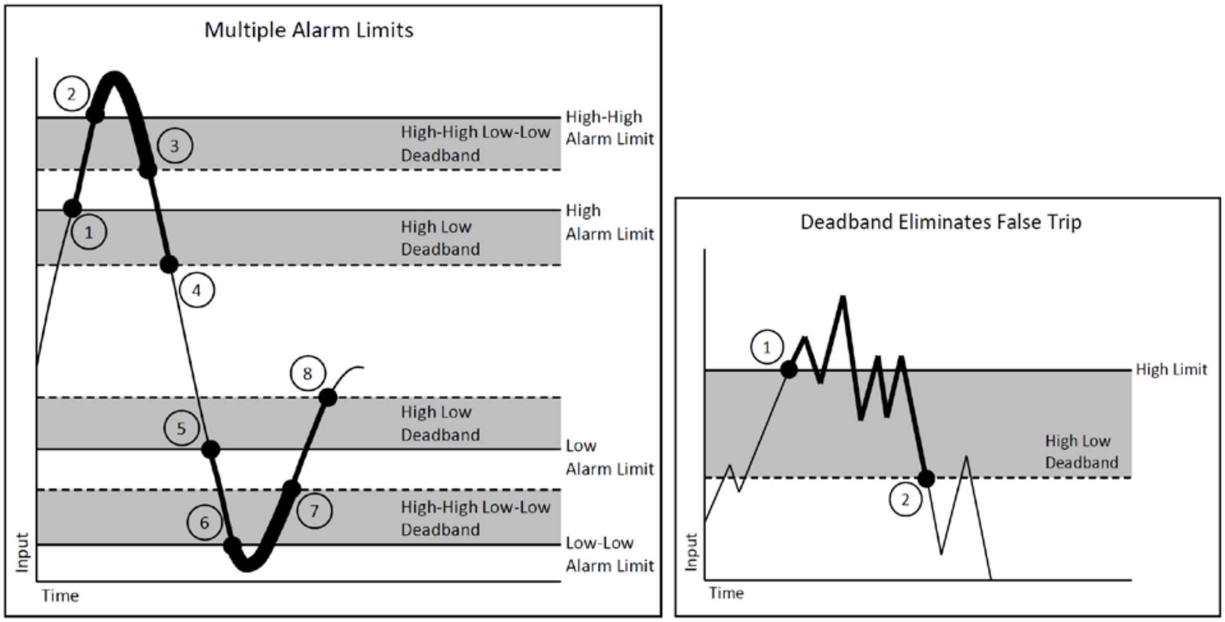
Used for the High-High and/or Low-Low limits to prevent false tripping or alarm chatter for noisy signals. Deadband is the region less than the High-High limit or greater than the Low-Low limit, measured in counts, which the signal must traverse through before the alarm is reset after being tripped.

See Figure 15 below for graphical representations of alarm parameters and functionality.



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 15: Alarm Parameters and Functionality

14.0 Setting and Monitoring Alarms

Alarms can be set for four of the Special Functions; Pulse / Frequency Counter, Pulse / Frequency Counter with Debounce, Waveform Measurement, 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.

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-DIOL 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
Pulse / Frequency 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.
Pulse / Frequency Counter w/Debounce	High Low. Alarm **cannot** be mapped to DO0. High-High Low-Low. Alarm can be mapped to DO1.	High Low. Alarm **cannot** be mapped to DO2. High-High Low-Low. Alarm can be mapped to DO3.
Waveform Measurement	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.

The Address Map for the MAQ20-DIOL module is found at the end of this manual. Excerpts from the Address Map are shown below. Alarm parameters are stored in registers at offset addresses 3 and 35 to 45 starting at reference address 1100 if the Special Function uses Timer 0 or reference address 1200 if the Special Function uses Timer 1.

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.

Special Function 1: Pulse / Frequency 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**
3	R	1	Alarm Status	0 = No Alarm 1 = High Low Alarm 2 = High-High Low-Low Alarm	0 to 2	INT16
35	R/W	1	Alarm Configuration	Set Alarms for Pulse Count, Frequency, RPM	See Section 14.0	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	0 to 65,535	INT16
45	R/W	1	Alarm High-High Low-Low Deadband	0 to 65,535	0 to 65,535	INT16

Special Function 3: Waveform Measurement						
***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**
3	R	1	Alarm Status	0 = No Alarm 1 = High Low Alarm 2 = High-High Low-Low Alarm	0 to 2	INT16
35	R/W	1	Alarm Configuration	Set Alarms for Events Measured, Frequency, Positive Pulse Width	See Section 14.0	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	0 to 65,535	INT16
45	R/W	1	Alarm High-High Low-Low Deadband	0 to 65,535	0 to 65,535	INT16

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. 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 on the next page details how this code is constructed.

Table 6: Building the Alarm Configuration Value

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

Parameter to Monitor	Code
Pulse Count / Events Measured	1000
Frequency	2000
RPM	3000
Positive Pulse Width	4000
Time Between Events	5000

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Alarm Type	Code
Tracking	100
Latching	200

\+

Alarm Limit	Code
Low	10
High	20
High Low	30
Low Low-Low	40
High High-High	50
All	60

\+

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

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.

Example: A MAQ20-DIOL module with serial number 1234567-89 is installed in a system and has been assigned a Registration Number of 4. Configure the module for Pulse Counter (Special Function 1) on Timer 0. Set a Tracking Alarm on the Pulse Counter function to monitor pulses counted with a High limit of 100 pulses and a High-High limit of 200 pulses. When the High limit is reached, close discrete output channel 0 and when the High-High limit is reached, close discrete output channel 1. Also configure the module for Waveform Measurement (Special Function 3) on Timer 1. Set a Tracking Alarm on the Waveform Measurement function to monitor frequency with a Low limit of 500Hz, a High limit of 800Hz and a Deadband of 25Hz. When the frequency falls below the Low limit, open discrete output channel 2 and when the frequency exceeds the High limit, open discrete output channel 2.

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

Pulse Counter Alarm Configuration & Monitoring:

Write to register address 8000 + 1100 = 9100 a data value of 1 to set the Pulse / Frequency Counter Special Function to operate on Timer 0.

The Alarm Configuration Value for the Pulse Counter function is 1000 + 100 + 50 + 4 = 1154. Write this value to the Alarm Configuration register at address 8000 + 1100 + 35 = 8135.

To set the Pulse Counter Alarm High limit, write to register address 8000 + 1100 + 39 = 9139 a data value of 100. Note that this value is written to the register at address 39 because this limit is a 32-bit number which is stored in 2 registers.

When this limit is reached, a value of 0 will be written to discrete output channel 0 which will close the solid-state switch and the red LED on the module will be lit. This channel should have been previously set to a value of 1 or have a default output value of 1 so the state change can be detected.

Read register address 8000 + 1100 + 3 = 7103 to view the status of the High Alarm.

To set the Pulse Counter Alarm High-High limit, write to register address 8000 + 1100 + 37 = 9137 a data value of 200. Note that this value is written to the register at address 37 because this limit is a 32-bit number which is stored in 2 registers.

When this limit is reached, a value of 0 will be written to discrete output channel 1 which will close the solid-state switch and the red LED on the module will be lit. This channel should have been previously set to a value of 1 or have a default output value of 1 so the state change can be detected.

Read register address 8000 + 1100 + 3 = 9103 to view the status of the High-High Alarm.

Waveform Frequency Alarm Configuration & Monitoring:

Write to register address 8000 + 1200 = 9200 a data value of 3 to set the Waveform Measurement Special Function to operate on Timer 1.

The Alarm Configuration Value for the Waveform Measurement function is 2000 + 100 + 30 + 8 = 2138. Write this value to the Alarm Configuration register at address 8000 + 1200 + 35 = 9235.

To set the Waveform Measurement Deadband, write to register address 8000 + 1200 + 44 = 9244 a data value of 25. This value will be used for both Low and High limits.

To set the Waveform Measurement Low limit, write to register address 8000 + 1200 + 41 = 9241 a data value of 500. Note that this value is written to the register at address 41 because this limit is a 32-bit number which is stored in 2 registers.

When this limit is reached, a value of 1 will be written to discrete output channel 2 which will open the solid-state switch and the red LED on the module will be lit. This channel should have been previously set to a value of 0 or have a default output value of 0 so the state change can be detected.

Read register address 8000 + 1200 + 3 = 9203 to view the status of the Low Alarm.

To set the Waveform Measurement High limit, write to register address 8000 + 1200 + 39 = 9239 a data value of 800. Note that this value is written to the register at address 39 because this limit is a 32-bit number which is stored in 2 registers.

When this limit is reached, a value of 1 will be written to discrete output channel 2 which will open the solid-state switch and the red LED on the module will be lit. This channel should have been previously set to a value of 0 or have a default output value of 0 so the state change can be detected.

Read register address 8000 + 1200 + 3 = 9203 to view the status of the High Alarm.

15.0 Reset Functions

Two types of firmware reset are supported in the MAQ®20 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 Discrete Input Channel states to 1 (Input < Threshold) 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 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 MAQ®20 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

MAQ®20 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.

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-DIOL, 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 (DIOL, V, TC, 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 visible 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. Registers at addresses 1900 – 1910 hold this information.

17.0 LED Indicators

A set of 5 LEDs on the top panel of the MAQ®20 I/O modules indicate module power, operation, communication, and alarm status.

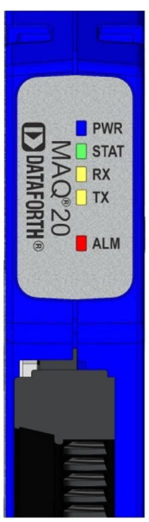

Figure 16: MAQ®20 Faceplate

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

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 MAQ®20 I/O module and/or MAQ20-COMx module to verify proper insertion into Backbone.
- Remove and reinstall MAQ®20 I/O module into another backbone position.
- If a Backbone extension cable is used, ensure that the connections are made correctly.

18.0 Specifications

MAQ®20 DISCRETE INPUT/OUTPUT MODULE Typical at Ta = +25°C and +24VDC system power

Model Number	Description
MAQ20-DIOL	5 Isolated Channel Discrete Input, 3-60 VDC 5 Isolated Channel Discrete Output, 3-60 VDC
MAQ20-DIOH (PRELIMINARY)	4 Isolated Channel Discrete Input, 90-280 VAC/VDC 4 Isolated Channel Discrete Output, 24-280 VAC
Per Channel Setup	Individually configurable for default output, special function
Input Protection	
Continuous, -DIOL	70VDC max, Reverse Polarity Protected
Continuous, -DIOH	350VAC/VDC max
Transient	ANSI/IEEE C37.90.1
Output Protection	
Continuous, -DIOL	70VDC max, Reverse Polarity Protected
Continuous, -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
Switching Characteristics	
MAQ20-DIOL	
Input Channel Turn-On / Turn-Off Time	25µs / 55µs
Output Channel Turn-On / Turn-Off Time	20µs / 40µs
MAQ20-DIOH	
Input Channel Turn-On / Turn-Off Time	20ms / 30ms (VAC), 1ms / 1ms (VDC)
Output Channel Response Time	0.5 Cycle
I/O Special Functions	
Pulse/Frequency Counter	Freq to 10kHz, Count to 10M, RPM to 65k
Pulse/Frequency Counter w/ De-Bounce	Freq to 3kHz, Count to 10M
Waveform Measurement	Freq to 500Hz(1), # Periods, Pulse Width, Period, Duty Cycle
Time Between Events	Min, Max, Avg, Selectable Timebase
Frequency Generator	Up to 700Hz @ 1% error, 10kHz @ 14% error
PWM Generator	200µs min period, Selectable Timebase
One-Shot Pulse Generator	100µs min, Programmable Pre- and Post-Delay
Scan/Update Rate	3500 Ch/s
Alarms	High / High-High / Low / Low-Low
Power Supply Current	30mA
Dimensions (h)(w)(d)	4.51” x 0.60” x 3.26” (114.6mm x 15.3mm x 82.8mm)
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 UL/cUL (Class I, Div 2, Groups A, B, C, D) file E232858 ATEX Pending

(1) Refer to Section 12.3 for details

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 power requirements, but channel density and the compact module enclosure limit the ability to dissipate power. When the MAQ20-DIOL module is installed in a system with adjacent MAQ®20 I/O modules which also dissipate significant power, power dissipation is further limited. When possible, a MAQ20-DIOL 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.

MAQ20-DIOL derating over temperature given load and signal parameters is shown in Figure 16, Figure 17, Figure 18, and Table 8 below. All data reflects worst case operating condition with the MAQ20-DIOL module installed in a backbone and no adjacent MAQ®20 I/O modules. Special Function ratings are for a single implementation of the function. Further derating is required if adjacent modules dissipating maximum power are present, if the system is installed in a location with minimal ventilation, or if multiple instances of a Special Function are used. Contact the factory for details in these situations.

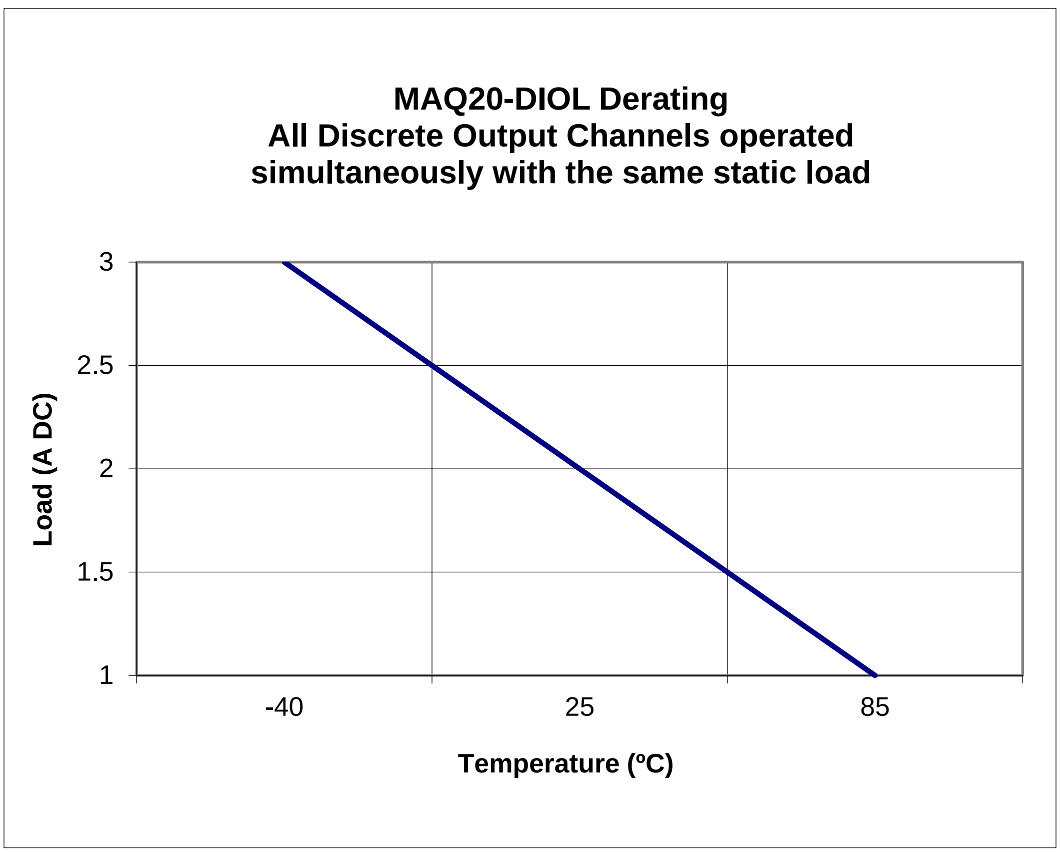

Figure 16: MAQ20-DIOL Derating for Static Loads

Table 8: MAQ20-DIOL Derating for Static Loads

Special Function	Maximum Ratings, 25ºC
Frequency Generator	900Hz @ 3A 1.8kHz @ 2A 4.9kHz @ 1A
PWM Generator	14% Duty Cycle @ 100µs Pulse, 3A 22% Duty Cycle @ 100µs Pulse, 2A 50% Duty Cycle @ 100µs Pulse, 1A

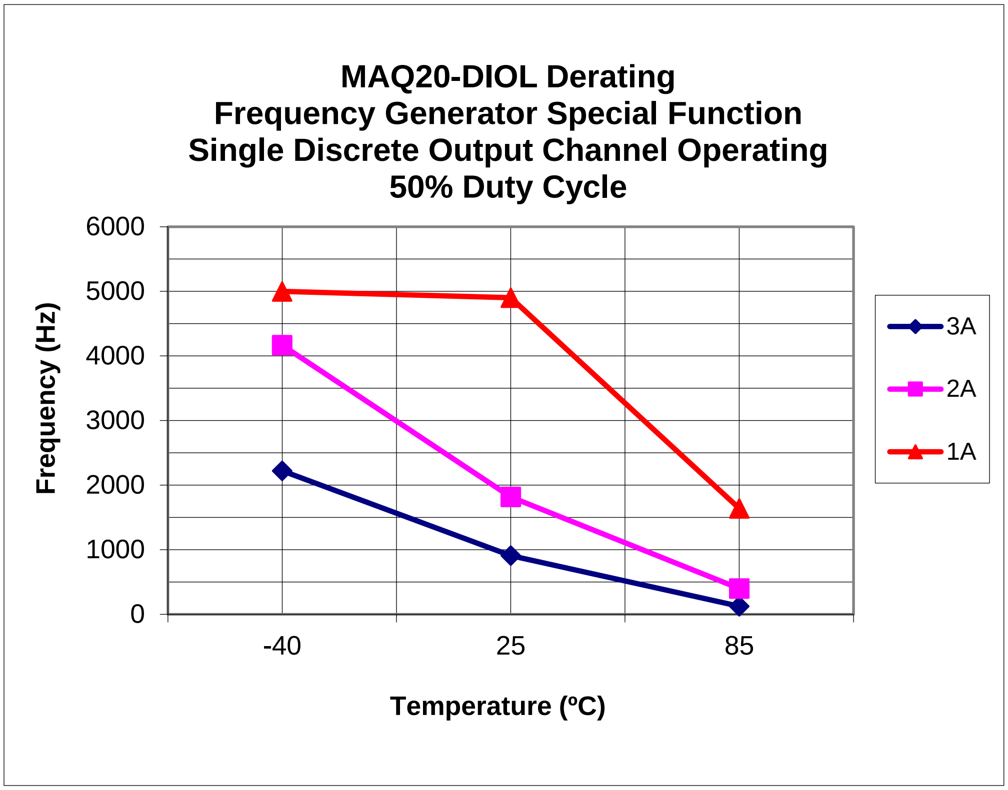

Figure 17: MAQ20-DIOL Derating for Single Channel Square Wave Output vs. Frequency

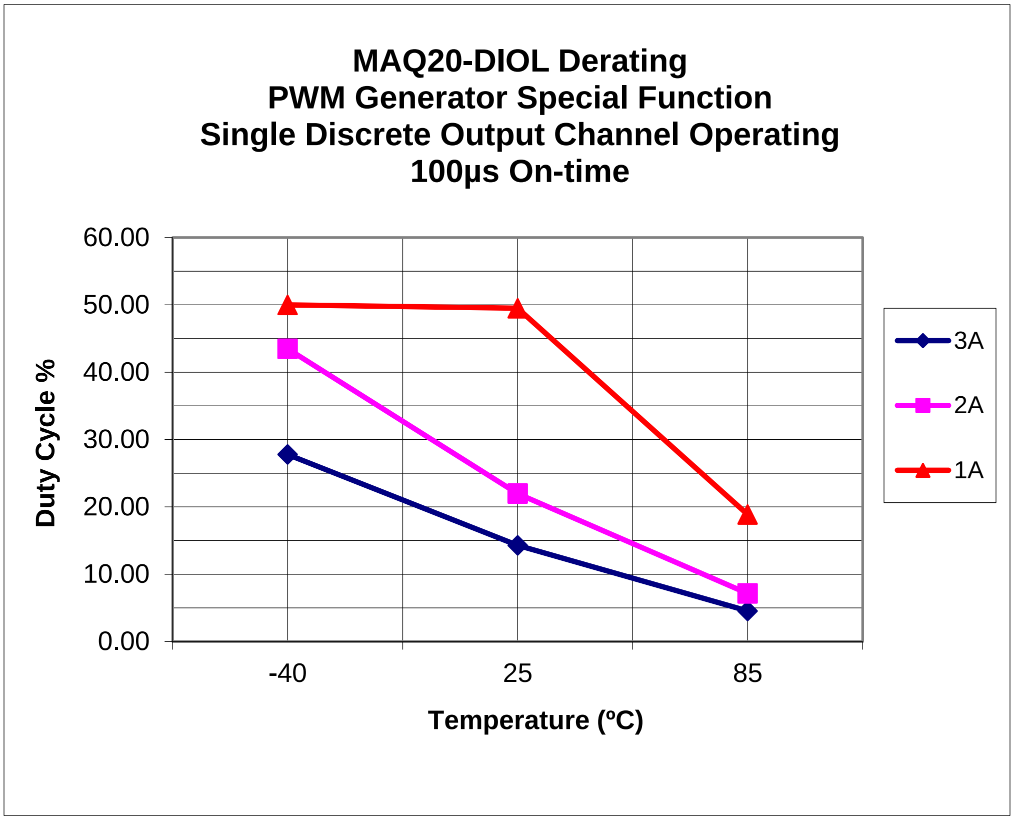

Figure 18: MAQ20-DIOL Derating for Single Channel Square Wave Output vs. Duty Cycle

19.0 MAQ20-DIOL Address Map

Tables in this section outline the MAQ20-DIOL 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.

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.

Table 9: MAQ20-DIOL Address Map

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-DIO	Characters, Numbers, "-" and Space	ASCII
19	R	11	Serial Number	S1234567-89	Characters, Numbers, "-" and Space	ASCII
30	R	5	Date Code	D1510	Characters, Numbers	ASCII
35	R	5	Firmware Rev	F1.00	Characters, Numbers and "."	ASCII
40	R	1	Input Channels	5 Input Channels	5	ASCII
41	R	1	Output Channels	5 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

Address Range 100 - 499: Module Configuration						
Start Address	**Read/ Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
100	R	10	Channel Configuration	Input or Output	1 = Input 2 = Output	INT16
110	R/W	5	Default Output Configuration	Discrete Output Default State. Default = 1 for all channels.	DO0 - DO4 0 = Switch Closed 1 = Switch Open	INT16
190	W	1	Save to EEPROM	0 = Saves Channel Configuration, Default Out	0	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	10	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 DI4 to DI0 and DO4 to DO0 = 1011011000. 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 – DO4 Inverted Logic 0 = switch closed 1 = switch open DI0 – DI4 Inverted Logic 0 = input > threshold 1 = input < threshold	INT16
1010	R	1	DIO States, Decimal Equivalent	Example: 728 (the decimal equivalent of the binary number above. MSB to LSB 1011011000). Default = 1023	0 to 1023	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 Section 12.0 for details. Default = 0	0 = None (Default) 1 = Pulse/Freq Counter 2 = Pulse/Freq Counter w/ Debounce 3 = Waveform Measurement 4 = Time Between Events 5 = Frequency Generator 6 = PWM Generator 7 = One-Shot Pulse Generator	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 Section 12.0 for details. Default = 0	0 = None (Default) 1 = Pulse/Freq Counter 2 = Pulse/Freq Counter w/ Debounce 3 = Waveform Measurement 4 = Time Between Events 5 = Frequency Generator 6 = PWM Generator 7 = One-Shot Pulse Generator	INT16

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

Special Function 1: Pulse / Frequency 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 = Pulse / Frequency Counter	1	INT16
1	R/W	1	Arm/Disarm	0 = disarmed/disarm 1 = armed/arm	0 or 1	INT16
2	R	1	Function Status	0 = Function OK 12 = Tried to Arm Function without Function Selected 17 = Too Many Pulses	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	Pulse Count	A write to this address will reset the counter. MSB at Address 4 LSB at Address 5	0 to 10 million	INT32
6	R	2	Frequency	0 to 10,000. Default = 0 MSB at Address 6 LSB at Address 7	0 to 10,000	INT32
8	R	1	RPM	0 to 65,535. Default = 0	0 to 65,535	INT16
9	R/W	1	Pulses Per Revolution	1 to 65,535. Default = 1	1 to 65,535	INT16
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
35	R/W	1	Alarm Configuration	Set Alarms for Pulse Count, Frequency, RPM. Default = 0	See Section 14.0	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

Special Function 1: Pulse / Frequency 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**
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

Special Function 2: Pulse / Frequency Counter w/Debounce						
***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 = Pulse / Frequency Counter w/ Debounce	2	INT16
1	R/W	1	Arm/Disarm	0 = disarmed/disarm 1 = armed/arm	0 or 1	INT16
2	R	1	Function Status	0 = Function OK 12 = Tried to Arm Function without Function Selected 17 = Too Many Pulses	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	Pulse Count	A write to this address will reset the counter. 0 to 10 million MSB at Address 4 LSB at Address 5	0 to 10 million	INT32
6	R	2	Frequency	0 to 3,000. Default = 0 MSB at Address 6 LSB at Address 7	0 to 3,000	INT32
8	R/W	1	Internal Trigger	0 = Negative Edge (Default) 1 = Positive Edge	0 or 1	INT16
9	R/W	1	Debounce Output Enable	0 = Disabled (Default) 1 = Enabled	0 or 1	INT16
10	R/W	1	Low Time (x 100us)	0 to 32,767. Default = 100	0 to 32,767	INT16
11	R/W	1	High Time (x 100us)	0 to 32,767. Default = 100	0 to 32,767	INT16
35	R/W	1	Alarm Configuration	Set Alarms for Pulse Count, Frequency. Default = 0	See Section 14.0	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

Special Function 2: Pulse / Frequency Counter w/Debounce						
*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**
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

Special Function 3: Waveform Measurement						
***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	3 = Waveform Measurement	3	INT16
1	R/W	1	Arm/Disarm	0 = disarmed/disarm 1 = armed/arm	0 or 1	INT16
2	R	1	Function Status	0 = Function OK 12 = Tried to Arm Function without Function Selected 17 = Too Many Pulses	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	Events Measured	A write to this address resets the counter. MSB at Address 4 LSB at Address 5	0 to 10 million	INT32
6	R	2	Frequency	0 to 10,000. Measured Duty Cycle accurate to f = 500Hz. Default = 0 MSB at Address 6 LSB at Address 7	0 to 10,000	INT32
8	R	1	Duty Cycle Combined	Duty cycle, fixed-point (8-bit integer, 8-bit fraction). Accurate to Waveform Frequency = 500Hz max. Default = 0	0 to 65,535	INT16
10	R	2	Period	A write to this address resets the counter. MSB at Address 10 LSB at Address 11	0 to 10 million	INT32
12	R	2	Low Time	A write to this address resets the counter. MSB at Address 12 LSB at Address 13	0 to 10 million	INT32
14	R	2	High Time	A write to this address resets the counter. MSB at Address 14 LSB at Address 15	0 to 10 million	INT32
16	R	2	Avg Low Time	A write to this address resets the counter. MSB at Address 16 LSB at Address 17	0 to 10 million	INT32

Special Function 3: Waveform Measurement						
***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**
18	R	2	Avg High Time	A write to this address resets the counter. MSB at Address 18 LSB at Address 19	0 to 10 million	INT32
20	R/W	2	Max Low Time	A write to this address resets the counter. MSB at Address 20 LSB at Address 21	0 to 10 million	INT32
22	R/W	2	Min Low Time	A write to this address resets the counter. MSB at Address 22 LSB at Address 23	0 to 10 million	INT32
24	R/W	2	Max High Time	A write to this address resets the counter. MSB at Address 24 LSB at Address 25	0 to 10 million	INT32
26	R/W	2	Min High Time	A write to this address resets the counter. MSB at Address 26 LSB at Address 27	0 to 10 million	INT32
30	R/W	1	Timebase	0 = seconds 1 = milliseconds (Default) 2 = microseconds	0 to 2	INT16
31	R/W	1	Internal Trigger	0 = Negative Edge (Default) 1 = Positive Edge	0 or 1	INT16
32	R/W	2	Events to Measure	Number of periods to measure. 0 = Unlimited. Default = 0 MSB at Address 32 LSB at Address 33	0 to 10 million	INT32
34	R/W	1	Average Weight	Used to calculate Average = Average + ((Sampled Value – Average) / Average Weight). Default = 4	0 to 65,535	INT16
35	R/W	1	Alarm Configuration	Set Alarms for Events Measured, Frequency, Positive Pulse Width. Default = 0	See Section 14.0	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

Special Function 3: Waveform Measurement						
***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**
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

Special Function 4: 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	4 = Time between Events	4	INT16
1	R/W	1	Arm/Disarm	0 = disarmed/disarm 1 = armed/arm	0 or 1	INT16
2	R	1	Function Status	0 = Function OK 12 = Tried to Arm Function without Function Selected 17 = Too Many Pulses	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	Number of Events	A write to this address resets the counter. MSB at Address 4 LSB at Address 5	0 to 10 million	INT32
6	R	2	Frequency	Up to 10,000. Default = 0. MSB at Address 6 LSB at Address 7	0 to 10,000	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) 2 = microseconds	0 to 2	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

Special Function 4: 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**
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	Events 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 14.0	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

Special Function 5: Frequency Generator						
***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	5 = Frequency Generator	5	INT16
1	R/W	1	Arm/Disarm	0 = disarmed/disarm 1 = armed/arm	0 or 1	INT16
4	R/W	2	Frequency	Desired frequency in Hz. 0 to 10,000. Default = 10. MSB at Address 4 LSB at Address 5	0 to 10,000	INT32
90	W		Save Function Configuration	Write Saves to EEPROM	0	INT16

Special Function 6: PWM Generator						
***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	6 = PWM Generator	6	INT16
1	R/W	1	Arm/Disarm	0 = disarmed/disarm 1 = armed/arm	0 or 1	INT16
3	R/W	1	Timebase	0 = seconds 1 = milliseconds (Default) 2 = microseconds	0 to 2	INT16
4	R/W	1	Output 2 Enable	0 = Output 2 disabled (Default) 1 = Output 2 enabled	0 or 1	INT16
6	R/W	2	Period	Length of period, in timebase units. 200us minimum. Default = 500. MSB at Address 6 LSB at Address 7	1 to 10 million	INT32
8	R/W	2	Output 1 Low Time	Length of low time on output 1, in timebase units. 100us minimum. Default = 250. MSB at Address 8 LSB at Address 9	1 to 10 million	INT32
10	R/W	2	Output 2 Low Time	Length of low time on output 2, in timebase units. 100us minimum. Default = 250. MSB at Address 10 LSB at Address 11	1 to 10 million	INT32
90	W		Save Function Configuration	Write Saves to EEPROM	0	INT16

Special Function 7: One-Shot Pulse Generator						
***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	7 = One-Shot Pulse Generator	7	INT16
1	R/W	1	Arm/Disarm	0 = disarmed/disarm 1 = armed/arm	0 or 1	INT16
3	R/W	1	Timebase	0 = seconds 1 = milliseconds (Default) 2 = microseconds	0 to 2	INT16
4	R/W	2	Pulse Count	# of pulses generated. A write will reset the counter. MSB at Address 4 LSB at Address 5	0 to 10 million	INT32
6	R/W	2	Pulse Count Limit	# pulses to generate before disarming, 0 = no limit. Default = 0. MSB at Address 6 LSB at Address 7	0 to 10 million	INT32
8	R/W	1	Output Pulse Polarity	0 = Positive (Default) 1 = Negative	0 or 1	INT16
9	R/W	1	Trigger	0 = Register Write (20) (Default) 1 = Negative Edge 2 = Positive Edge	0 to 2	INT16
10	R/W	2	Pulse Width	Using timebase. 100us min. Default = 500. MSB at Address 10 LSB at Address 11	1 to 10 million	INT32
12	R/W	2	Pre-delay	Using timebase. 100us min. Default = 100. MSB at Address 12 LSB at Address 13	1 to 10 million	INT32
14	R/W	2	Post-delay	Using timebase. 100us min. Default = 100. MSB at Address 14 LSB at Address 15	1 to 10 million	INT32
20	W	1	Software Trigger	A write here triggers the pulse	0	INT16
90	W	1	Save Function Configuration	Write Saves to EEPROM	0	INT16

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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