MAQ®20

Industrial Data Acquisition and Control System

MA1042

MAQ20-VO MAQ20-IO
Hardware User Manual

DATAFORTH®

MAQ20-VO/-IO Hardware User Manual
MA1042 Rev. B – March 2024

ISO9001:2015-Registered QMS

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About Dataforth Corporation

"Our passion at Dataforth Corporation is designing, manufacturing, and marketing the best possible signal conditioning, data acquisition, and data communication products. Our mission is to set new standards of product quality, performance, and customer service." Dataforth Corporation, with more than a quarter century of experience, is the worldwide leader in Instrument Class® Industrial Electronics – rugged, high performance signal conditioning, data acquisition, and data communication products that play a vital role in maintaining the integrity of industrial automation, data acquisition, and quality assurance systems. Our products directly connect to most industrial sensors and protect valuable measurement and control signals and equipment from the dangerous and degrading effects of noise, transient power surges, internal ground loops, and other hazards present in industrial environments.

Dataforth spans the globe with more than 50 International Distributors and US Representative Companies. Our customers benefit from a team of over 130 salespeople highly trained in the application of precision products for industrial markets. In addition, we have a team of application engineers in our Tucson factory ready to solve any in-depth application questions. Upon receipt of an RFQ or order, our Customer Service Department provides fast one-day delivery information turnaround. We maintain an ample inventory that allows small quantity orders to be shipped from stock.

Dataforth operates under an ISO9001:2015 quality management system.

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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:

- 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 output module and current output module offer 8 isolated process voltage or process current outputs. All channels are individually configurable for range and output to match the most demanding applications. High-level per-channel isolation gives the module unmatched ruggedness and flexibility while default outputs provide essential functionality for fail-safe systems. User defined waveform outputs allow application specific sophisticated, autonomous control. Field output connections are made through a pluggable terminal block which simplifies wiring during system setup and reconfiguration. Four positions are provided for the termination of wiring shields.

Input-to-Bus isolation is a robust 1500Vrms and Channel-to-Channel isolation is 300Vrms. In addition, each channel is protected up to 40Vrms continuous overload in the case of inadvertent wiring errors.

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 Input Connections

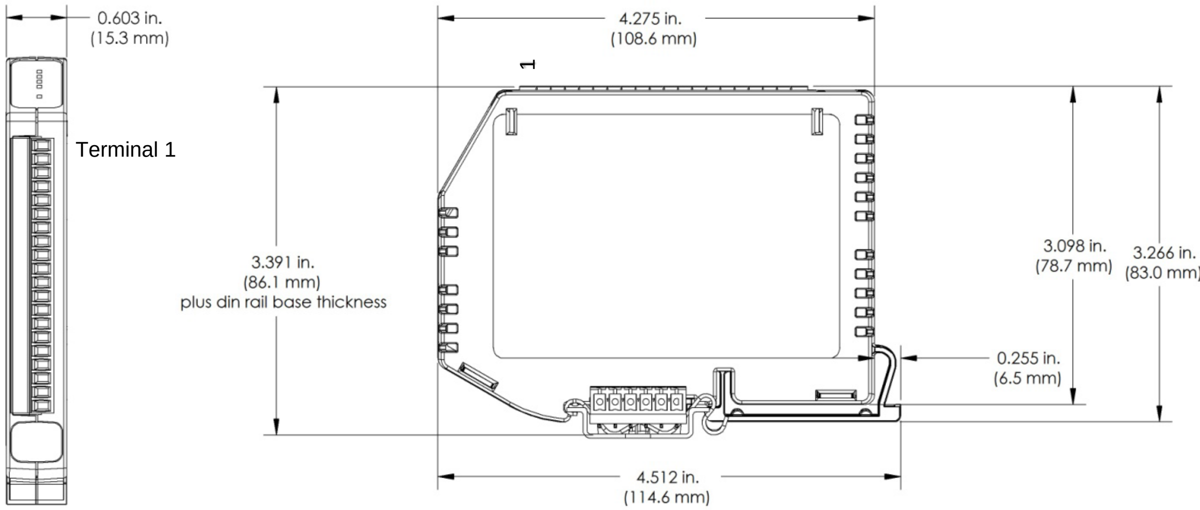


Figure 1: Module Dimensions

Table 1: Output Terminal Block Connections

TERMINAL BLOCK POSITION (TOP TO BOTTOM)	MAQ20-VO OUTPUT CONNECTIONS	MAQ20-IO OUTPUT CONNECTIONS
1	CH0 +OUT	CH0 +OUT
2	CH0 -OUT	CH0 -OUT
3	CH1 +OUT	CH1 +OUT
4	CH1 -OUT	CH1 -OUT
5	SHIELD	SHIELD
6	CH2 +OUT	CH2 +OUT
7	CH2 -OUT	CH2 -OUT
8	CH3 +OUT	CH3 +OUT
9	CH3 -OUT	CH3 -OUT
10	SHIELD	SHIELD
11	CH4 +OUT	CH4 +OUT
12	CH4 -OUT	CH4 -OUT
13	CH5 +OUT	CH5 +OUT
14	CH5 -OUT	CH5 -OUT
15	SHIELD	SHIELD
16	CH6 +OUT	CH6 +OUT
17	CH6 -OUT	CH6 -OUT
18	CH7 +OUT	CH7 +OUT
19	CH7 -OUT	CH7 -OUT
20	SHIELD	SHIELD

The shield terminals are connected to the Field Side common and are isolated from the Bus. If shield drain to system ground is required, this connection must be made external to the module.

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).

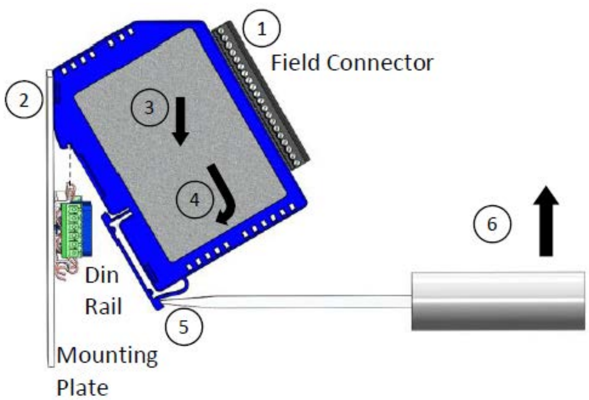


Figure 2: Installation and Removal

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.

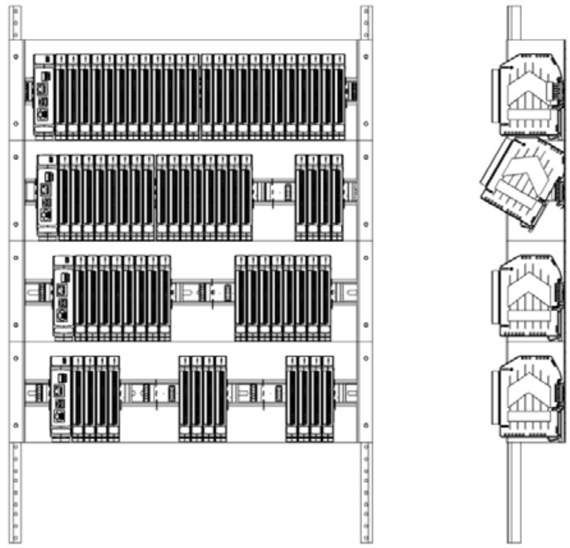


Figure 3: Possible System Configurations

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.

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

4.) 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

5.) 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.

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

NOTES:

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

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

MAQ20-940 - ReDAQ Shape Software for 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 <u>not associated with the physical position on the backbone</u>. 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 Maps for the MAQ20-VO and MAQ20-IO modules are found at the end of this manual. An excerpt from the MAQ20-VO Address Map is shown below. Channel Data is stored starting at address 1000.

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 - 1699: Module Data						
Start Address	**R/W**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
1000	R/W	8	Channel Data	Data for each of the 8 channels	-4096 to +4095	INT16

Example: A MAQ20-VO module with serial number 1234567-89 is installed in a system and has been assigned a Registration Number of 6. Write a data value of 2200 counts to Channels 0-7.

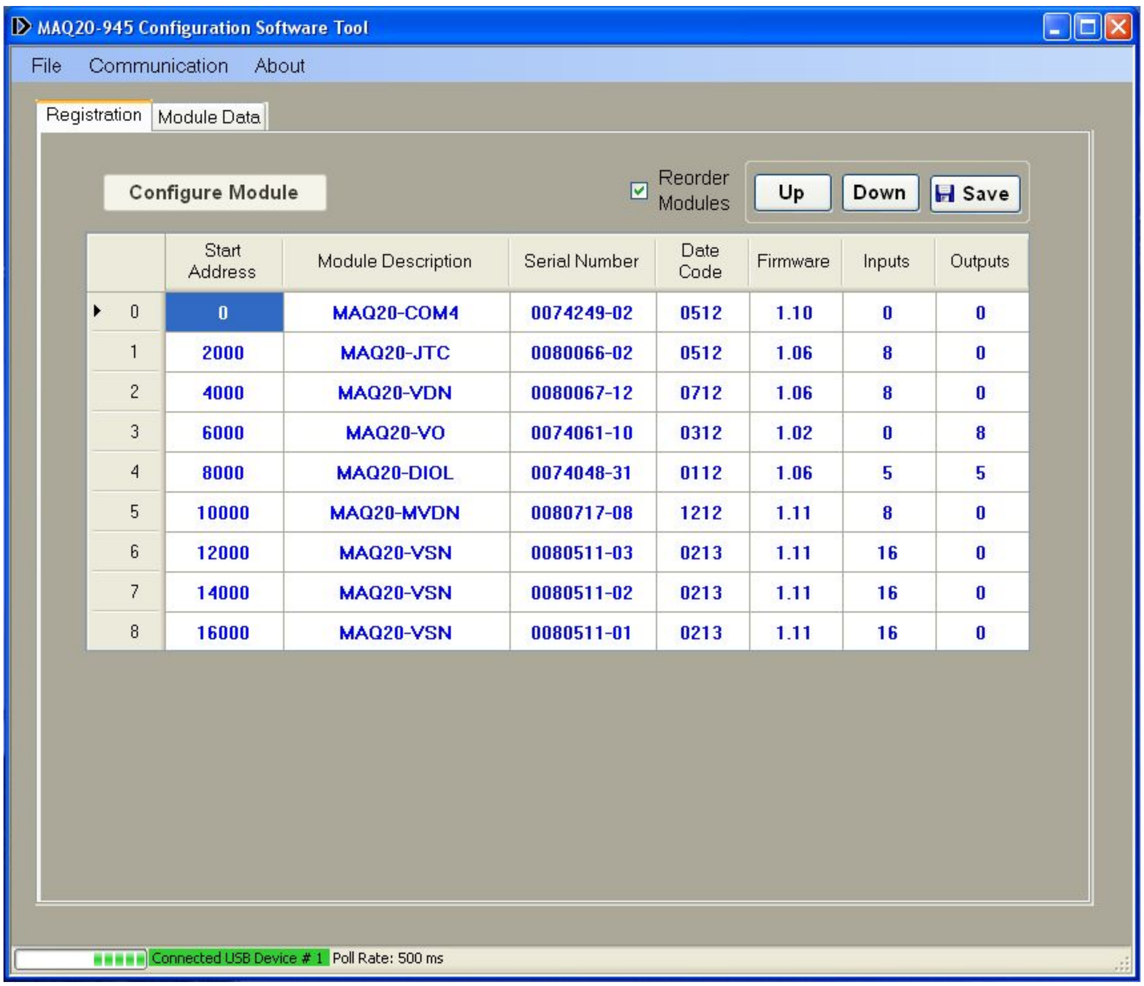
The MAQ20-VO module with s/n 1234567-89 has an address offset of 2000 * 6 = 12000

Write to register addresses 12000 + 1000 to 1007 = 12000 to 12007 a data value of 2200 to set the respective output voltage to Channels 0-7.

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.



	Start Address	Module Description	Serial Number	Date Code	Firmware	Inputs	Outputs
0	0	MAQ20-COM4	0074249-02	0512	1.10	0	0
1	2000	MAQ20-JTC	0080066-02	0512	1.06	8	0
2	4000	MAQ20-VDN	0080067-12	0712	1.06	8	0
3	6000	MAQ20-VO	0074061-10	0312	1.02	0	8
4	8000	MAQ20-DIOL	0074048-31	0112	1.06	5	5
5	10000	MAQ20-MVDN	0080717-08	1212	1.11	8	0
6	12000	MAQ20-VSN	0080511-03	0213	1.11	16	0
7	14000	MAQ20-VSN	0080511-02	0213	1.11	16	0
8	16000	MAQ20-VSN	0080511-01	0213	1.11	16	0

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.

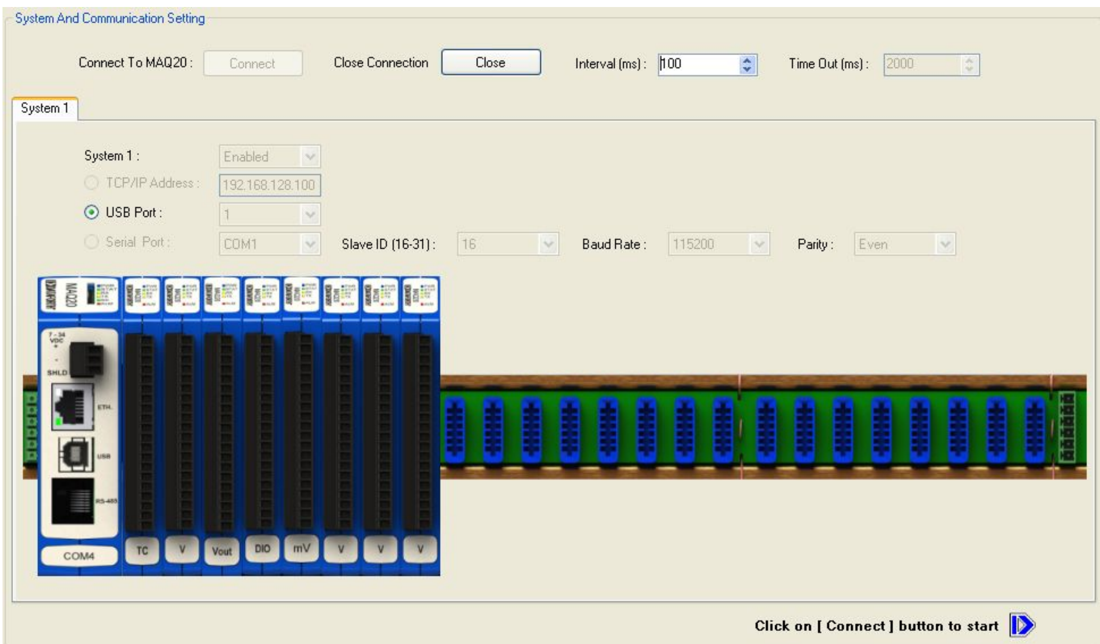


Figure 5: MAQ20-940 ReDAQ Shape for MAQ®20 Main Configuration Screen

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

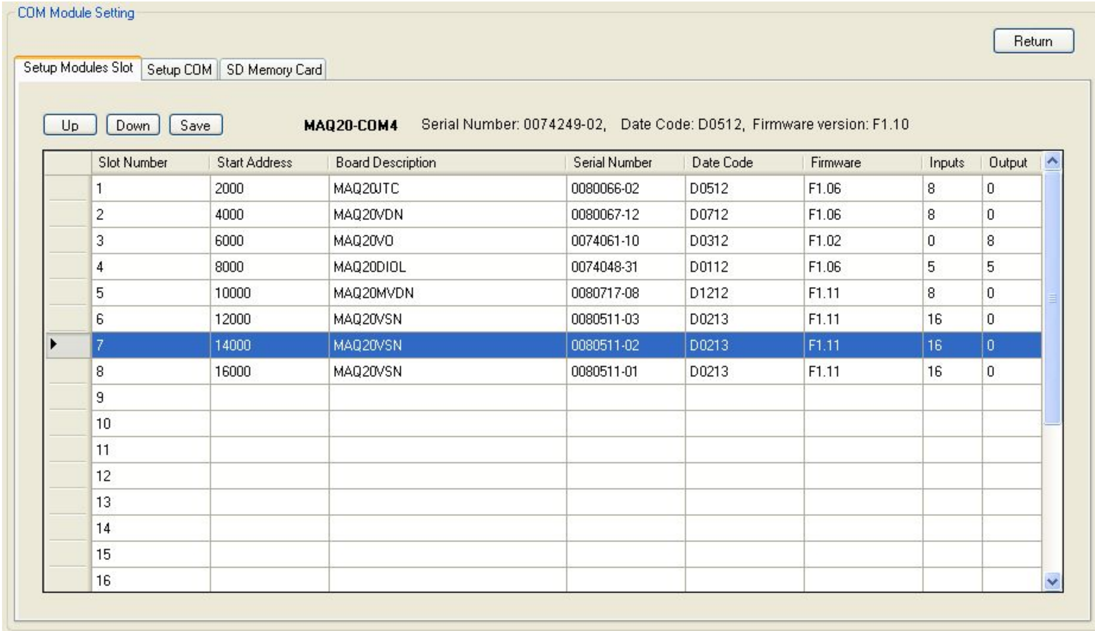


Figure 6: Module Registration using MAQ20-940 ReDAQ Shape for MAQ20

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 Range Selection

The MAQ20-VO module has six user selectable output ranges, and the MAQ20-IO module has two selectable output ranges. Output ranges are selectable on a per-channel basis. Over-range and Under-range up to 5% beyond the standard output values for MAQ20-VO and up to 9% beyond the standard output values for MAQ20-IO can be set. The published accuracy is guaranteed over the standard output ranges. The Range Tables following the Address Maps for each module at the end of this manual show the output ranges for each module and the counts to output mapping. The Range Table for the MAQ20-VO module is shown below for reference.

Range	Standard Output Voltage	Equivalent Counts	Over/Under Range	Equivalent Counts	Volts per Count
0	-10V to +10V (Default)	98 to 3998	-10.5V to +10.5V	0 to 4095	$5.128*10^{-3}$
1	-5V to +5V	1073 to 3023	-5.25V to +5.25V	1024 to 3072	$5.128*10^{-3}$
2	-2.5V to +2.5V	1561 to 2536	-2.625V to +2.625V	1536 to 2560	$5.128*10^{-3}$
3	0 to +10V	2048 to 3998	0 to +10.5V	2048 to 4095	$5.128*10^{-3}$
4	0 to +5V	2048 to 3023	0 to +5.25V	2048 to 3072	$5.128*10^{-3}$
5	0 to +2.5V	2048 to 2536	0 to +2.625V	2048 to 2560	$5.128*10^{-3}$

The Address Maps for the MAQ20-VO and MAQ20-IO modules are found at the end of this manual. An excerpt from the MAQ20-VO Address Map is shown below. Output Range is stored starting at address 100 and Channel Data is stored starting at address 1000.

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	**R/W**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
100	R/W	8	Output Range	Range for each of 8 channels	See Table 4	INT16

Address Range 1000 - 1699: Module Data						
Start Address	**R/W**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
1000	R/W	8	Channel Data	Data for each of 8 channels Default = 2048	See Table 4	INT16

To change the output range, write the appropriate range code to address 100 + 2000 * R.

Once a range selection 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.

Channels in a module are always enabled. Non-used channels should be configured to have an output that is appropriate for the application.

Example: **A MAQ20-VO module with serial number 1234567-89 is installed in a system and has been assigned a Registration Number of 2. Set channels 0 and 1 to output signals from -5V to +5V with an initial value of +3.0V and channels 4 and 5 to output signals from 0 to +2.5V with an initial value of +1.0V. Assume channels 2, 3, 6 and 7 are not used and set their output to 0V.**

The MAQ20-VO module with s/n 1234567-89 has an address offset of 2000 * 2 = 4000

The default module configuration is for channels to have an output range of -10V to +10V. The table shows that Range 1 is -10V to +10V out and Range 5 is 0V to +2.5V out. Range information is also stored in registers at addresses 1700 – 1820 for user read back if desired.

1.) Write to register address 4000 + 100 = 4100 a data value of 1 to set Ch 0 output range to ±10V
2.) Write to register address 4000 + 101 = 4101 a data value of 1 to set Ch 1 output range to ±10V
3.) Write to register address 4000 + 104 = 4104 a data value of 5 to set Ch 4 output range to 0 to 2.5V
4.) Write to register address 4000 + 105 = 4105 a data value of 5 to set Ch 5 output range to 0 to 2.5V

If the output from Channels 0 and 1 is to be +3.0V, the corresponding count value is:

$$\text{Ch0, Ch1:} \ +3\text{V} * \frac{(3023 \text{ counts} - 1073 \text{ counts})}{\left(5\text{V} - (-5\text{V})\right)} + 2048 \text{ counts} = 2633 \text{ counts}$$

If the output from Channels 0 and 1 is to be +1.0V, the corresponding count value is:

$$\text{Ch4, Ch5:} \ +1\text{V} * \frac{(2536 \text{ counts} - 2048 \text{ counts})}{(2.5\text{V} - 0\text{V})} + 2048 \text{ counts} = 2243 \text{ counts}$$

If the output from Channels 2, 3, 6 and 7 is to be 0V, the corresponding count value is:

$$\text{Ch0, Ch1:} \ +0\text{V} * \frac{(3998 \text{ counts} - 98 \text{ counts})}{(10\text{V} - 10\text{V})} + 2048 \text{ counts} = 2048 \text{ counts}$$

5.) Write to register address 4000 + 1000 = 5000 a count value of 2633 to output +3.0V
6.) Write to register address 4000 + 1001 = 5001 a count value of 2633 to output +3.0V
7.) Write to register address 4000 + 1004 = 5004 a count value of 2243 to output +1.0V
8.) Write to register address 4000 + 1005 = 5005 a count value of 2243 to output +1.0V
9.) Write to register address 4000 + 1002 = 5002 a count value of 2048 to output 0V
10.) Write to register address 4000 + 1003 = 5003 a count value of 2048 to output 0V
11.) Write to register address 4000 + 1006 = 5006 a count value of 2048 to output 0V
12.) Write to register address 4000 + 1007 = 5007 a count value of 2048 to output 0V

11.0 Setting Default Outputs

The eight isolated output channels in the MAQ20-VO and MAQ20-IO 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 Maps for the MAQ20-VO and MAQ20-IO modules are found at the end of this manual. An excerpt from the MAQ20-VO Address Map is shown below. Default Output values are stored starting at address 110.

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	**R/W**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
100	R/W	8	Output Range	Range for each of 8 channels	See Table 4	INT16
110	R/W	8	Default Output	Default Output for each channel	See Table 4	INT16

Example: **A MAQ20-VO module with serial number 1234567-89 is installed in a system and has been assigned a Registration Number of 4. Assume all channels are set to the default output range of -10V to +10V. Set the Default Output value for channels 0 and 1 to +5V and the Default Output value for channels 4 and 5 to -5V.**

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

The corresponding count value for Channels 0 and 1 is:

$$\text{Ch0, Ch1:}\ +5\text{V} * \frac{(3998\ \text{counts} - 98\ \text{counts})}{(10\text{V} - (-10\text{V}))} + 2048\ \text{counts} = 3023\ \text{counts}$$

The corresponding count value for Channels 4 and 5 is:

$$\text{Ch4, Ch5:}\ -5\text{V} * \frac{(3998\ \text{counts} - 98\ \text{counts})}{(10\text{V} - (-10\text{V}))} + 2048\ \text{counts} = 1073\ \text{counts}$$

Write to register address 8000 + 110 = 8110 a count value of 3023 to set Ch 0 Default Output = +5V
Write to register address 8000 + 111 = 8111 a count value of 3023 to set Ch 1 Default Output = +5V
Write to register address 8000 + 114 = 8114 a count value of 1073 to set Ch 4 Default Output = -5V
Write to register address 8000 + 115 = 8115 a count value of 1073 to set Ch 5 Default Output = -5V

12.0 Output Burst Mode

The eight isolated output channels in the MAQ20-VO and MAQ20-IO module can be individually configured to output data streams or waveforms defined by a set of user-entered data. Each channel has allocated space in volatile and non-volatile memory to store 100 data points which define a data stream or waveform to be output from that channel. The number of sequential channels from Channel 0 to Channel n with Burst Mode active is selected by writing to a register. The interval between data points written to the output channels is specified by the Refresh Rate with values ranging from 10ms to 65,535ms. Individual channels can have different output data streams, but all channels use the same Refresh Rate. Data can be output in a single sequence or continuously looped. When writing to memory, channel data which is outside channel range limits will be ignored. If a write or read operation exceeds the 100 point per channel boundary, the operation wraps around to data point 0 and overwrites or reads the data there. When Burst Mode is started, channels with Burst Mode active will have channel data read from memory starting at data point 0 and continuously output sequentially until Burst Mode is stopped or a termination data point is read. Once an output data stream or waveform has been stopped, the channel output remains at the last output value.

Each of the eight output channels have 10 registers that are used to write data to and read data from the 100 data point memory space allocated for each channel. A write to or read from the 10 Channel n Burst Data registers allows the user to transfer up to 10 data values at a time to or from the channel allocated memory space. After each write or read operation the Burst Data Pointer is automatically incremented by the number of data points written or read such that subsequent write or read operations to or from that channel will continue where the last write or read operation stopped. Write or read operations occur sequentially in increasing order starting at the data point specified by the Burst Data Pointer. Each channel has its own data pointer. Sequential data to be stored in memory must be entered into the 10 Burst Data transfer registers in the same sequential order starting at the Channel n Burst Data Start Address. When data is initially entered, it is stored in volatile memory and will be lost upon power cycle, reset, or brownout conditions. Data is stored to non-volatile EEPROM memory by writing to a register.

MAQ20-940 ReDAQ Shape Software for MAQ®20 and MAQ20-945 MAQ®20 Configuration Software Tool both allow Output Burst Mode data entry by loading a file to simplify the operation for long data streams.

To use Output Burst Mode, store data stream or waveform data in memory, set the output data Refresh Rate, choose the number of channels with Burst Mode active, then start and stop Burst Mode with the control register. When Burst Mode is stopped, the Burst Data Pointer is reset to 0.

The Address Maps for the MAQ20-VO and MAQ20-IO modules are found at the end of this manual. An excerpt from the MAQ20-VO Address Map is shown below. Output Burst Mode settings are stored at addresses 600 to 699.

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 600 - 999: Burst Mode Settings						
Start Address	**Read/ Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
600	R/W	1	Burst Mode Control	1 = Start Burst 0 = Stop Burst	0 or 1	INT16
601	R/W	1	Refresh Rate	milliseconds up to 2^{16}	10 to 65535	INT16
602	R/W	1	Number of Channels with Burst Active	Number of sequential channels starting with Ch 0. i.e. 3 = Ch 0, Ch1, Ch 2 active.	1 to 8	INT16
609	W	1	Save to EEPROM	0 = Refresh Rate, Number of channels with burst active	0	INT16
610	R/W	8	Burst Data Pointer	Data pointer for each channel	0 to 99	INT16
619	W	1	Save to EEPROM	Save Burst Data to EEPROM, 0 = Channel 0, 7 = Channel 7	0 to 7	INT16
620	R/W	10	Channel 0 Burst Data	Store up to 100 data points per channel in memory. When Burst Mode is active, data is output sequentially to active channels at the specified refresh rate in a single sequence or continuously looped. Write or read up to 10 data points at a time to or from a channel allocated memory space by first setting the Burst Data Pointer and then writing the data points to the Start Address for the channel (i.e. address 620 for Channel 0). Save data to EEPROM by writing a 0 to register 619.	0 to 4098. 0 to 4095 is valid output data. Writing 4097 will stop a channel Burst Output. Writing 4098 will continuously loop a channel Burst Output. Default = 2048.	INT16
630	R/W	10	Channel 1 Burst Data			
640	R/W	10	Channel 2 Burst Data			
650	R/W	10	Channel 3 Burst Data			
660	R/W	10	Channel 4 Burst Data			
670	R/W	10	Channel 5 Burst Data			
680	R/W	10	Channel 6 Burst Data			
690	R/W	10	Channel 7 Burst Data			

Example: A MAQ20-VO module with serial number 1234567-89 is installed in a system and has been assigned a Registration Number of 3. The output channels have been set to the default range of -10V to +10V. Configure Channel 0 to continuously output the decreasing and increasing values +10V, +8V, +6V, +4V, +2V, 0V, -2V, -4V, -6V, -8V, 10V at a 500ms rate. Configure Channel 1 to output -5V for 6 seconds, +5V for 6 seconds, and then stop. Leave channels 2 through 7 available for standard output.

The MAQ20-VO module with s/n 1234567-89 has an address offset of 2000 * 3 = 6000.

First the waveform data must be written to memory. The corresponding count values are:

Channel 0:

$$+10V * \frac{(3998 \text{ counts} - 98 \text{ counts})}{(10V - (-10V))} + 2048 \text{ counts} = 3998 \text{ counts}$$
$$+8V * \frac{(3998 \text{ counts} - 98 \text{ counts})}{(10V - (-10V))} + 2048 \text{ counts} = 3608 \text{ counts}$$
$$+6V * \frac{(3998 \text{ counts} - 98 \text{ counts})}{(10V - (-10V))} + 2048 \text{ counts} = 3218 \text{ counts}$$
$$+4V * \frac{(3998 \text{ counts} - 98 \text{ counts})}{(10V - (-10V))} + 2048 \text{ counts} = 2828 \text{ counts}$$
$$+2V * \frac{(3998 \text{ counts} - 98 \text{ counts})}{(10V - (-10V))} + 2048 \text{ counts} = 2438 \text{ counts}$$
$$0V * \frac{(3998 \text{ counts} - 98 \text{ counts})}{(10V - (-10V))} + 2048 \text{ counts} = 2048 \text{ counts}$$
$$-2V * \frac{(3998 \text{ counts} - 98 \text{ counts})}{(10V - (-10V))} + 2048 \text{ counts} = 1658 \text{ counts}$$
$$-4V * \frac{(3998 \text{ counts} - 98 \text{ counts})}{(10V - (-10V))} + 2048 \text{ counts} = 1268 \text{ counts}$$
$$-6V * \frac{(3998 \text{ counts} - 98 \text{ counts})}{(10V - (-10V))} + 2048 \text{ counts} = 878 \text{ counts}$$
$$-8V * \frac{(3998 \text{ counts} - 98 \text{ counts})}{(10V - (-10V))} + 2048 \text{ counts} = 488 \text{ counts}$$
$$-10V * \frac{(3998 \text{ counts} - 98 \text{ counts})}{(10V - (-10V))} + 2048 \text{ counts} = 98 \text{ counts}$$

Channel 1:

$$-5V * \frac{(3998 \text{ counts} - 98 \text{ counts})}{(10V - (-10V))} + 2048 \text{ counts} = 1073 \text{ counts}$$
$$+5V * \frac{(3998 \text{ counts} - 98 \text{ counts})}{(10V - (-10V))} + 2048 \text{ counts} = 3023 \text{ counts}$$

To set up the 11-point waveform for Channel 0:

1.) Write to register address 6000 + 620 = 6620 a data value of 3998 to set Ch 0 data point 0
2.) Write to register address 6000 + 621 = 6621 a data value of 3608 to set Ch 0 data point 1
3.) Write to register address 6000 + 622 = 6622 a data value of 3218 to set Ch 0 data point 2
4.) Write to register address 6000 + 623 = 6623 a data value of 2828 to set Ch 0 data point 3
5.) Write to register address 6000 + 624 = 6624 a data value of 2438 to set Ch 0 data point 4
6.) Write to register address 6000 + 625 = 6625 a data value of 2048 to set Ch 0 data point 5
7.) Write to register address 6000 + 626 = 6626 a data value of 1658 to set Ch 0 data point 6
8.) Write to register address 6000 + 627 = 6627 a data value of 1268 to set Ch 0 data point 7
9.) Write to register address 6000 + 628 = 6628 a data value of 878 to set Ch 0 data point 8
10.) Write to register address 6000 + 629 = 6629 a data value of 488 to set Ch 0 data point 9

These writings can occur individually or in a block write.

The Burst Data Pointer will now be set to 10.

11.) Write to register address 6000 + 620 = 6620 a data value of 98 to set Ch 0 data point 10
12.) Write to register address 6000 + 621 = 6621 a data value of 4098 to loop the 11-point data stream and output it continuously
13.) Write to register address 6000 + 619 = 6619 a data value of 0 to save Ch 0 data points to EEPROM

To set up the waveform for Channel 1, 13 data points (0-12) are required for a 6 second duration:

1.) Write to register address 6000 + 630 = 6630 a data value of 1073 to set Ch 1 data point 0.

2.) Repeat this writing to register addresses 6631 to 6639 to set Ch 1 data points 1 through 9.

This covers the first 4.5 seconds of output.

These writings can occur individually or in a block write.

The Burst Data Pointer will now be set to 10.

1.) Write to register address 6000 + 630 = 6630 a data value of 1073 to set Ch 1 data point 10.
2.) Write to register address 6000 + 631 = 6631 a data value of 1073 to set Ch 1 data point 11.
3.) Write to register address 6000 + 632 = 6632 a data value of 1073 to set Ch 1 data point 12.

Now the first 6 seconds of data have been entered.

1.) Write to register address 6000 + 633 = 6633 a data value of 3023 to set Ch 1 data point 13.
2.) Repeat this write to register addresses 6634 to 6639 to set Ch 1 data points 14 through 19.

This covers the next 3 seconds of output.

These writings can occur individually or in a block write.

The Burst Data Pointer will now be set to 20.

1.) Write to register addresses 6630 to 6635 a data value of 3023 to set Ch 1 data points 20 through 25.

This covers the last 3 seconds of output.

1.) Write to register address 6000 + 636 = 6636 a data value of 4097 to stop the output.

2.) Write to register address 6000 + 619 = 6619 a data value of 1 to save Ch 1 data points to EEPROM.

3.) Write to register address 6000 + 601 = 6601 a data value of 500 to set the Refresh Rate to 500ms.

4.) Write to register address 6000 + 602 = 6602 a data value of 2 to set Ch 0 and Ch 1 with Output Burst Mode Active.

5.) Write to register address 6000 + 609 = 6609 a data value of 0 to save Refresh Rate and Number of Channels with Burst Active to EEPROM.

Waveform data points have now been entered, burst mode parameters have been configured, and all data has been stored to non-volatile memory.

1.) Write to register address 6000 + 600 = 6600 a data value of 1 to start Output Burst Mode. Stored data points will be read from memory and written to Channel 0 and Channel 1.

    Channel 0 output will run continuously. Channel 1 output will run for 12 seconds and then remain at the last data value written.

2.) Write to register address 6000 + 600 = 6600 a data value of 0 to stop Output Burst Mode. Channel 0 output will remain at the last data value written before the stop command was issued.

    Channel 1 output will remain at the last data value written before the stop data value was read.

13.0 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 2 shows what parameters are affected for each reset.

Table 2: Parameters Affected by Standard Reset and Reset-to-Default

RESET TYPE	PARAMETERS
Standard Reset	Resets Channel Data to Default Value Stops Output Burst Mode Resets Output Burst Data to Default Value Clears all Status and Diagnostic registers
Reset-to-Default	All parameters listed under Standard Reset, plus: Resets Output Ranges to Default Value Resets Default Outputs to Default Value Resets Output Burst Active Channels to 0 Resets Refresh Rate to 10ms Resets Burst Data Pointer to 0

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 and 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.

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14.0 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-VDN, MAQ20-JTC, 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 (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. 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 is monitored and made available to the user. Registers at addresses 1900 – 1910 hold this information.

15.0 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 7: 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 the 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 off of 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.

16.0 Specifications

MAQ®20 VOLTAGE AND CURRENT OUTPUT MODULES Typical at T_A = +25°C and +24V system power

Model Number	**Description**
MAQ20-VO	8-Isolated Channel Voltage Output 0-2.5V, 0-5V, 0-10V, ±2.5V, ±5V, ±10V (Default ±10V)
MAQ20-IO	8-Isolated Channel Current Output 0-20mA, 4-20mA (Default 0-20mA)
Per Channel Setup	Individually configurable for range, default output, waveform
MAQ20-VO	
Output Drive (Max Load)	10mA (1000Ω @ 10V)
Over-range	10.5V
MAQ20-IO	
Compliance	15V
Load Range	0-600Ω
Over-range	21.5mA
Current Limit	26mA
Output Protection	
Continuous	40Vrms max
Transient	ANSI/IEEE C37.90.1
CMV	
Channel-to-Bus	1500Vrms, 1 min
Channel-to-Channel	300Vrms
Transient	ANSI/IEEE C37.90.1
CMR	75dB @ 50/60 Hz
Accuracy(1)	±0.040% span
Linearity / Conformity	±0.030% span
Resolution	0.024% span
Stability	
Zero	±25ppm/C
Span	±35ppm/C
Bandwidth	100Hz
Update Rate	1600 Ch/s
Power Supply Current	450mA @ no-load, 650mA @ full-load
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) Includes linearity, hysteresis, and repeatability.

17.0 MAQ20-VO Address Map and Range Table

Tables in this section outline the MAQ20-VO and MAQ20-IO 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 3: MAQ20-VO Address Map

Address Range 0 - 99: Module Information						
Start Address	**R/W**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
0	R	15	Device Description	MAQ20-VO	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	0 Input Channels	0	ASCII
41	R	1	Output Channels	8 Output Channels	8	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/W	8	Output Range	Range for each of 8 channels	See Table 4	INT16
110	R/W	8	Default Output	Default Output for each channel	See Table 4	INT16
119	W	1	Save to EEPROM	0 = Range, 1 = Default Out	0 or 1	INT16

Table 3: MAQ20-VO Address Map

Address Range 600 - 999: Burst Mode Settings						
Start Address	**Read/ Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
600	R/W	1	Burst Mode Control	1 = Start Burst 0 = Stop Burst	0 or 1	INT16
601	R/W	1	Refresh Rate	milliseconds up to 2^{16}	10 to 65535	INT16
602	R/W	1	Number of Channels with Burst Active	Number of sequential channels starting with Ch 0. i.e. 3 = Ch 0, Ch1, Ch 2 active.	1 to 8	INT16
609	W	1	Save to EEPROM	0 = Refresh Rate, Number of channels with burst active	0	INT16
610	R/W	8	Burst Data Pointer	Data pointer for each channel	0 to 99	INT16
619	W	1	Save to EEPROM	Save Burst Data to EEPROM, 0 = Channel 0, 7 = Channel 7	0 to 7	INT16
620	R/W	10	Channel 0 Burst Data	Store up to 100 data points per channel in memory. When Burst Mode is active, data is output sequentially to active channels at the specified refresh rate in a single sequence or continuously looped. Write or read up to 10 data points at a time to or from a channel allocated memory space by first setting the Burst Data Pointer and then writing the data points to the Start Address for the channel (i.e. address 620 for Channel 0). Save data to EEPROM by writing a 0 to register 619.	0 to 4098. 0 to 4095 is valid output data. Writing 4097 will stop a channel Burst Output. Writing 4098 will continuously loop a channel Burst Output. Default = 2048.	INT16
630	R/W	10	Channel 1 Burst Data			
640	R/W	10	Channel 2 Burst Data			
650	R/W	10	Channel 3 Burst Data			
660	R/W	10	Channel 4 Burst Data			
670	R/W	10	Channel 5 Burst Data			
680	R/W	10	Channel 6 Burst Data			
690	R/W	10	Channel 7 Burst Data			

Address Range 1000 - 1699: Module Data						
Start Address	**Read/ Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
1000	R/W	8	Channel Data	Data for each of 8 channels Default = 2048	See Table 4	INT16

Table 3: MAQ20-VO Address Map

Address Range 1700 - 1899: Output Ranges						
Start Address	**Read/ Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
1700	**R**	**1**	**Range Count**	**Number of ranges supported**	**1 to 6**	**INT16**
1710	**R**	**1**	**Range 0**	**Engineering -fs.**	**-32,767 to 32,768**	**INT16**
1711	R	1	Range 0	Future Use	-32,767 to 32,768	INT16
1712	R	1	Range 0	Engineering +fs	-32,767 to 32,768	INT16
1713	R	1	Range 0	Future Use	-32,767 to 32,768	INT16
1714	R	1	Range 0	+fs & -fs multiplier Factor 10^X	-32,767 to 32,768	INT16
1715	R	1	Range 0	Engineering Units ("C", "V", etc.)	A to Z	ASCII
1716	R	1	Range 0	Engineering Units ("C", "V", etc.)	A to Z	ASCII
1717	R	1	Range 0	Future Use	-32,767 to 32,768	INT16
1718	R	1	Range 0	Count Value of -fs.	-32,767 to 32,768	INT16
1719	R	1	Range 0	Future Use	-32,767 to 32,768	INT16
1720	R	1	Range 0	Count Value of +fs.	-32,767 to 32,768	INT16
1730	**R**	**1**	**Range 1**	**Engineering -fs.**	**-32,767 to 32,768**	**INT16**
1731	R	1	Range 1	Future Use	-32,767 to 32,768	INT16
1732	R	1	Range 1	Engineering +fs	-32,767 to 32,768	INT16
1733	R	1	Range 1	Future Use	-32,767 to 32,768	INT16
1734	R	1	Range 1	+fs & -fs multiplier Factor 10^X	-32,767 to 32,768	INT16
1735	R	1	Range 1	Engineering Units ("C", "V", etc.)	A to Z	ASCII
1736	R	1	Range 1	Engineering Units ("C", "V", etc.)	A to Z	ASCII
1737	R	1	Range 1	Future Use	-32,767 to 32,768	INT16
1738	R	1	Range 1	Count Value of -fs.	-32,767 to 32,768	INT16
1739	R	1	Range 1	Future Use	-32,767 to 32,768	INT16
1740	R	1	Range 1	Count Value of +fs.	-32,767 to 32,768	INT16

Table 3: MAQ20-VO Address Map

Address Range 1700 - 1899: Output Ranges						
Start Address	**Read/ Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
1750	**R**	**1**	**Range 2**	**Engineering -fs.**	**-32,767 to 32,768**	**INT16**
1751	R	1	Range 2	Future Use	-32,767 to 32,768	INT16
1752	R	1	Range 2	Engineering +fs	-32,767 to 32,768	INT16
1753	R	1	Range 2	Future Use	-32,767 to 32,768	INT16
1754	R	1	Range 2	+fs & -fs multiplier Factor 10^X	-32,767 to 32,768	INT16
1755	R	1	Range 2	Engineering Units ("C", "V", etc.)	A to Z	ASCII
1756	R	1	Range 2	Engineering Units ("C", "V", etc.)	A to Z	ASCII
1757	R	1	Range 2	Future Use	-32,767 to 32,768	INT16
1758	R	1	Range 2	Count Value of -fs.	-32,767 to 32,768	INT16
1759	R	1	Range 2	Future Use	-32,767 to 32,768	INT16
1760	R	1	Range 2	Count Value of +fs.	-32,767 to 32,768	INT16
1770	**R**	**1**	**Range 3**	**Engineering -fs.**	**-32,767 to 32,768**	**INT16**
1771	R	1	Range 3	Future Use	-32,767 to 32,768	INT16
1772	R	1	Range 3	Engineering +fs	-32,767 to 32,768	INT16
1773	R	1	Range 3	Future Use	-32,767 to 32,768	INT16
1774	R	1	Range 3	+fs & -fs multiplier Factor 10^X	-32,767 to 32,768	INT16
1775	R	1	Range 3	Engineering Units ("C", "V", etc.)	A to Z	ASCII
1776	R	1	Range 3	Engineering Units ("C", "V", etc.)	A to Z	ASCII
1777	R	1	Range 3	Future Use	-32,767 to 32,768	INT16
1778	R	1	Range 3	Count Value of -fs.	-32,767 to 32,768	INT16
1779	R	1	Range 3	Future Use	-32,767 to 32,768	INT16
1780	R	1	Range 3	Count Value of +fs.	-32,767 to 32,768	INT16

Table 3: MAQ20-VO Address Map

Address Range 1700 - 1899: Output Ranges						
Start Address	**Read/ Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
1790	**R**	**1**	**Range 4**	**Engineering -fs.**	**-32,767 to 32,768**	**INT16**
1791	R	1	Range 4	Future Use	-32,767 to 32,768	INT16
1792	R	1	Range 4	Engineering +fs	-32,767 to 32,768	INT16
1793	R	1	Range 4	Future Use	-32,767 to 32,768	INT16
1794	R	1	Range 4	+fs & -fs multiplier Factor 10^X	-32,767 to 32,768	INT16
1795	R	1	Range 4	Engineering Units ("C", "V", etc.)	A to Z	ASCII
1796	R	1	Range 4	Engineering Units ("C", "V", etc.)	A to Z	ASCII
1797	R	1	Range 4	Future Use	-32,767 to 32,768	INT16
1798	R	1	Range 4	Count Value of -fs.	-32,767 to 32,768	INT16
1799	R	1	Range 4	Future Use	-32,767 to 32,768	INT16
1800	R	1	Range 4	Count Value of +fs.	-32,767 to 32,768	INT16
1810	**R**	**1**	**Range 5**	**Engineering -fs.**	**-32,767 to 32,768**	**INT16**
1811	R	1	Range 5	Future Use	-32,767 to 32,768	INT16
1812	R	1	Range 5	Engineering +fs	-32,767 to 32,768	INT16
1813	R	1	Range 5	Future Use	-32,767 to 32,768	INT16
1814	R	1	Range 5	+fs & -fs multiplier Factor 10^X	-32,767 to 32,768	INT16
1815	R	1	Range 5	Engineering Units ("C", "V", etc.)	A to Z	ASCII
1816	R	1	Range 5	Engineering Units ("C", "V", etc.)	A to Z	ASCII
1817	R	1	Range 5	Future Use	-32,767 to 32,768	INT16
1818	R	1	Range 5	Count Value of -fs.	-32,767 to 32,768	INT16
1819	R	1	Range 5	Future Use	-32,767 to 32,768	INT16
1820	R	1	Range 5	Count Value of +fs.	-32,767 to 32,768	INT16

Table 3: MAQ20-VO Address Map

Address Range 1900 - 1999: Status Registers						
Start Address	**Read/ Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
1900	R/W	1	Watchdog Flag	1 = Watchdog Reset, 0 = Normal	0 or 1	INT16
1901	R/W	1	Brownout Flag	1 = Brownout Reset, 0 = Normal	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
1905	R/W	1	DAC Error	Increments when a Write to DAC fails	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

Table 4: MAQ20-VO Range Table

Range	Standard Output Voltage	Equivalent Counts	Over/Under Range	Equivalent Counts	Volts per Count
0	-10V to +10V (Default)	98 to 3998	-10.5V to +10.5V	0 to 4095	$5.128*10^{-3}$
1	-5V to +5V	1073 to 3023	-5.25V to +5.25V	1024 to 3072	$5.128*10^{-3}$
2	-2.5V to +2.5V	1561 to 2536	-2.625V to +2.625V	1536 to 2560	$5.128*10^{-3}$
3	0 to +10V	2048 to 3998	0 to +10.5V	2048 to 4095	$5.128*10^{-3}$
4	0 to +5V	2048 to 3023	0 to +5.25V	2048 to 3072	$5.128*10^{-3}$
5	0 to +2.5V	2048 to 2536	0 to +2.625V	2048 to 2560	$5.128*10^{-3}$

18.0 MAQ20-IO Address Map

Tables in this section outline the MAQ20-VSN 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 5: MAQ20-IO 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-IO	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	0 Input Channels	0	ASCII
41	R	1	Output Channels	8 Output Channels	8	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/W	8	Output Range	Range for each of 8 channels	See Table 6	INT16
110	R/W	8	Default Output	Default Output for each channel	See Table 6	INT16
119	W	1	Save to EEPROM	0 = Range, 1 = Default Output	0 or 1	INT16

Table 5: MAQ20-IO Address Map

Address Range 600 - 999: Burst Mode Settings						
Start Address	**Read/ Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
600	R/W	1	Burst Mode Control	1 = Start Burst 0 = Stop Burst	0 or 1	INT16
601	R/W	1	Refresh Rate	milliseconds up to 2^{16}	10 to 65535	INT16
602	R/W	1	Number of Channels with Burst Active	Number of sequential channels starting with Ch 0. i.e. 3 = Ch 0, Ch1, Ch 2 active.	1 to 8	INT16
609	W	1	Save to EEPROM	0 = Refresh Rate, Number of channels with burst active	0	INT16
610	R/W	8	Burst Data Pointer	Data pointer for each channel	0 to 99	INT16
619	W	1	Save to EEPROM	Save Burst Data to EEPROM, 0 = Channel 0, 7 = Channel 7	0 to 7	INT16
620	R/W	10	Channel 0 Burst Data	Store up to 100 data points per channel in memory. When Burst Mode is active, data is output sequentially to active channels at the specified refresh rate in a single sequence or continuously looped. Write or read up to 10 data points at a time to or from a channel allocated memory space by first setting the Burst Data Pointer and then writing the data points to the Start Address for the channel (i.e. address 620 for Channel 0). Save data to EEPROM by writing a 0 to register 619.	0 to 4098. 0 to 4095 is valid output data. Writing 4097 will stop a channel Burst Output. Writing 4098 will continuously loop a channel Burst Output. Default = 667.	INT16
630	R/W	10	Channel 1 Burst Data			
640	R/W	10	Channel 2 Burst Data			
650	R/W	10	Channel 3 Burst Data			
660	R/W	10	Channel 4 Burst Data			
670	R/W	10	Channel 5 Burst Data			
680	R/W	10	Channel 6 Burst Data			
690	R/W	10	Channel 7 Burst Data			

Address Range 1000 - 1699: Module Data						
Start Address	**Read/ Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
1000	R/W	8	Channel Data	Data for each of the 8 channels Default = 0	See Table 6	INT16

Table 5: MAQ20-IO Address Map

Address Range 1700 - 1899: Output Ranges						
Start Address	**Read/ Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
1700	**R**	**1**	**Range Count**	**Number of ranges supported**	**1 to 2**	**INT16**
1710	**R**	**1**	**Range 0**	**Engineering -fs.**	**-32,767 to 32,768**	**INT16**
1711	R	1	Range 0	Future Use	-32,767 to 32,768	INT16
1712	R	1	Range 0	Engineering +fs	-32,767 to 32,768	INT16
1713	R	1	Range 0	Future Use	-32,767 to 32,768	INT16
1714	R	1	Range 0	+fs & -fs multiplier Factor 10^X	-32,767 to 32,768	INT16
1715	R	1	Range 0	Engineering Units ("C", "V", etc.)	A to Z	ASCII
1716	R	1	Range 0	Engineering Units ("C", "V", etc.)	A to Z	ASCII
1717	R	1	Range 0	Future Use	-32,767 to 32,768	INT16
1718	R	1	Range 0	Count Value of -fs.	-32,767 to 32,768	INT16
1719	R	1	Range 0	Future Use	-32,767 to 32,768	INT16
1720	R	1	Range 0	Count Value of +fs.	-32,767 to 32,768	INT16
1730	**R**	**1**	**Range 1**	**Engineering -fs.**	**-32,767 to 32,768**	**INT16**
1731	R	1	Range 1	Future Use	-32,767 to 32,768	INT16
1732	R	1	Range 1	Engineering +fs	-32,767 to 32,768	INT16
1733	R	1	Range 1	Future Use	-32,767 to 32,768	INT16
1734	R	1	Range 1	+fs & -fs multiplier Factor 10^X	-32,767 to 32,768	INT16
1735	R	1	Range 1	Engineering Units ("C", "V", etc.)	A to Z	ASCII
1736	R	1	Range 1	Engineering Units ("C", "V", etc.)	A to Z	ASCII
1737	R	1	Range 1	Future Use	-32,767 to 32,768	INT16
1738	R	1	Range 1	Count Value of -fs.	-32,767 to 32,768	INT16
1739	R	1	Range 1	Future Use	-32,767 to 32,768	INT16
1740	R	1	Range 1	Count Value of +fs.	-32,767 to 32,768	INT16

Table 5: MAQ20-IO Address Map

Address Range 1900 - 1999: Status Registers						
Start Address	**Read/ Write**	**Number of Registers**	**Contents**	**Description**	**Data Range**	**Data type**
1900	R/W	1	Watchdog Flag	1 = Watchdog Reset, 0 = Normal	0 or 1	INT16
1901	R/W	1	BrownOut Flag	1 = BrownOut Reset, 0 = Normal	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
1905	R/W	1	DAC Error	Increments when a Write to DAC fails	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

Table 6: MAQ20-IO Range Table

Range	Standard Output Current	Equivalent Counts	Over/Under Range	Equivalent Counts	Amps per Count
0	0 to 20mA (Default)	0 to 3809	0 to 21.5mA	0 to 4095	$5.25*10^{-6}$
1	4 to 20mA	762 to 3809	3.5 to 21.5mA	667 to 4095	$5.25*10^{-6}$

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