MSCS

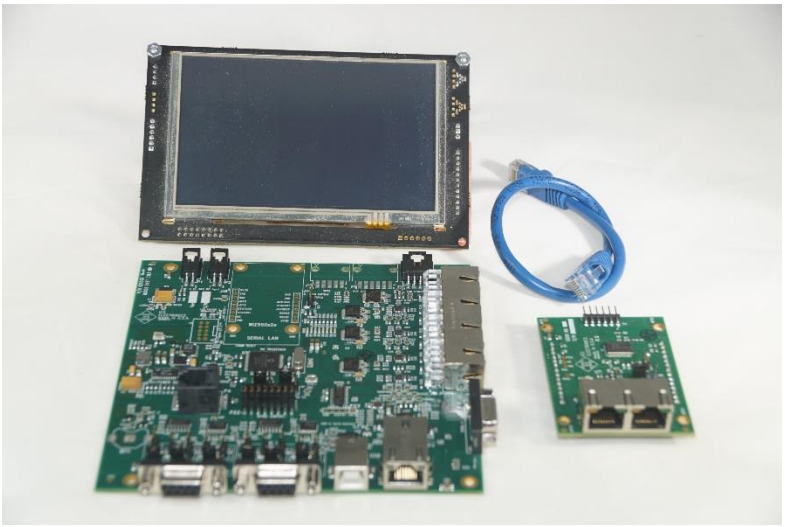
MODULAR SWITCH CONTROL SYSTEM

Control RF Switch Matrixes up to 100x100 and other devices with a Color Touchscreen panel, Ethernet, USB, or Serial using SCPI or MODBUS commands

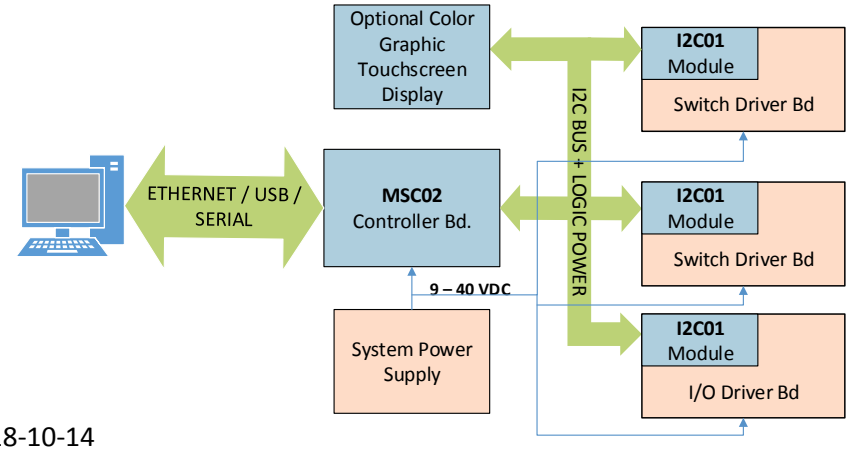
Description

The Modular Control System is designed to minimize NRE and RE in OEM control systems for RF switches and other devices. The modular design using standard Ethernet cables for interconnection significantly reduces the amount of chassis wiring in a typical system. Common approaches with standard parallel I/O boards result in large bundles of wires routed through the chassis increasing complexity and production costs. The OEM can quickly configure a control system using proven off the shelf boards and modules. Our engineering staff will assist in the configuration of your system thus freeing up your staff to concentrate on the overall system.

The Modular Control System consists of a MSC02 Modular System Controller



MSC02 Modular Controller Board, I2C01 I²C Module and an Optional 5" Color Touchscreen Display



MSC02 & I2C01 MODULAR SWITCH CONTROL SYSTEM

- **Scalable OEM control system**
  Control and monitor RF switches, attenuators, relays, LEDs, synthesizers, RF power sensors, fans and other analog, digital or mechanical devices.
- **Configure Large Matrixes**
  Using standard commands.
- **Minimize NRE**
  Create custom systems with off-the-shelf boards, design your own I/O boards using standard interface modules or have us create custom boards.
- **Inter-board control is by the Industry standard I²C bus**
  Capable of controlling hundreds of devices.
- **Minimize chassis wiring**
  All interfaces are connected with standard Ethernet cables.
- **Minimize power supplies**
  Power everything from a single voltage power supply.
- **Multiple Control Options**
  Ethernet, USB, or serial RS-232, RS-422 or RS-485.
- **Standard control protocols**
  IEEE-488.2 & SCPI commands or MODBUS RTU.
- **Optional full color graphic touchscreen display.**
  Supports 5" and 7", 800 x 480 pixel models.

MODULAR SYSTEM CONTROLS

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Board and as many I2C01 Modules with I/O boards as needed. The modules are connected to the System Controller Board by I²C serial buses using standard Ethernet cables. Modules have two parallel connectors so they can be "daisy chained" on the buses. Each Module can be expanded up to 512 I/O lines on the users I/O board.

RF Switching Systems

In a RF switching system, one 6-position switch may require up to 14 wires if it has indicator contacts, this quickly multiplies into large numbers of wires and associated labor costs for chassis wiring. With this modular system, the RF switches can be plugged directly into switch driver backplane style boards which eliminates all of the wiring. This also allows for a modular chassis construction. Additional boards can control relays to switch RF sources or radios to prevent hot switching. Boards using the same controller modules for front panel switches and indicators, analog I/O, fan control, and general purpose I/O are simple to implement. These I/O boards can be designed as simple low cost 2-layer boards and off-the-shelf I²C controller modules.

I²C Bus

The industry standard Inter-Integrated Circuit (I²C) bus is ideal for this application. The I²C bus is widely used both on circuit boards and for interconnects such as in common HDMI video cables. Combined with the excellent noise rejection of low cost standard CAT-5 or CAT-6 cable, the noise immunity of the system is greatly improved. In addition to being a standard off-the-shelf commodity, CAT-5/6 cable incorporates twisted pairs to reduce noise coupling and shielded versions are available if required. The I²C bus is fully buffered with clock and data lines using the twisted pairs. In addition to the standard data signals, the bus has been expanded to provide an interrupt line back to the controller and 5V DC for the module's logic power. These buses can be extended to additional chassis for large systems. Using 7-bit addressing each of the 3 buses can control up to 112 separate I2C01 Modules or other I²C devices.

Configuration & Control

The Modular System can be controlled by an optional local color touchscreen display or remote controlled and configured by a computer using Standard Commands for Programmable Instruments (SCPI) and IEEE 488.2 commands. MODBUS RTU commands can also be used for control.

Optional 800 x 480 color touchscreen display for intuitive front panel control

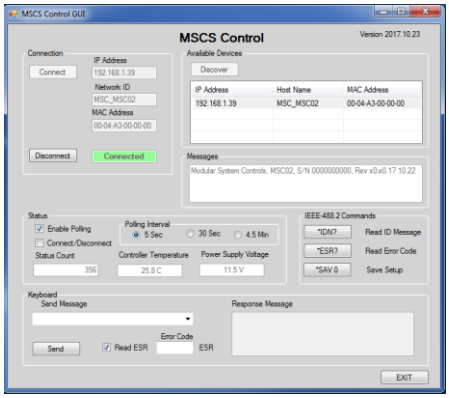
Using the standard firmware, devices such as switches, relays and I/O are assigned to modules during the configuration process. Once this is done, the devices are referred to by a number which is independent of the module. This allows the system programmer and operator to control devices without needing to know which module they are connected to. For example, switches 1 through 16 might be controlled by module 1 and switches 17 through 32 might be controlled by module 2. In this case the operator or programmer can just select a position for switches 1, 2, 20 and 27 without specifying a module.

Modules can also be assigned a name to simplify the configuration process. At power on the system checks all of assigned modules and if a touchscreen display is connected, reports their status on the boot up screen.

Control Interfaces

The Modular Control System can be interfaced to a computer by Ethernet, USB, Serial RS-232, RS-422 or RS-485.

The sample Ethernet control C# program shown below using the TCP/Telnet protocol is available with source code. This program also includes code for UDP discovery.



SCPI Commands

System and Module control and configuration is accomplished by using SCPI commands. The commands are independent of the interface in use, so control software can be designed to support multiple interfaces with the same commands. Configuration commands include serial parameters, network parameters, I2C01 Module addresses, switch or relay configuration, matrix configuration, PATH configuration and touchscreen display address.

SCPI control commands are provided for control of switches, relays, attenuators, byte oriented parallel I/O and bit oriented I/O. Both latching (pulsed) and non-latching switches and relays are supported.

MODBUS

RF switches, relays, attenuators, synthesizers, I/O ports and other devices can be controlled via MODBUS RTU serial. Switches, relays, I/O and other devices are controlled and monitored via MODBUS registers.

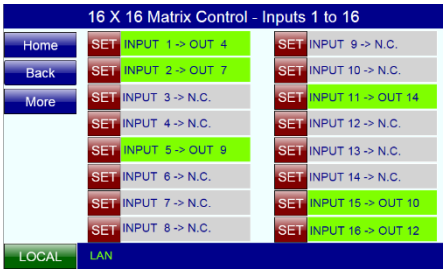
For detailed information on MODBUS register assignments and usage, contact the factory.

Color Touchscreen Display

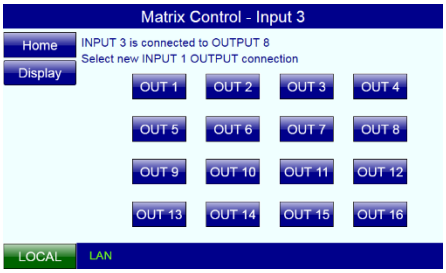
The optional color touchscreen display is connected to the MSC02 Controller

board via one of the I²C buses. It also receives its power from the bus cable. The standard firmware supports a 5" or 7" diagonal display with 800 x 480 pixel resolution and full color. The display contains an integrated piezo speaker to provide audio feedback to the operator. Other sizes of displays can be supported on special order. The touchscreen eliminates the need for most front panel controls and indicators, again greatly simplifying the system design and wiring.

The touchscreen control is via a system of menus with different screens available for each control function. Pushing the Matrix button on the Home screen shown above will bring up the Matrix Status screen shown below.



This screen displays the current connection status of a switch matrix with a button next to each input for selecting the matrix path. When a matrix input button is pushed the screen shown below will be displayed to allow the selection of a new output connection for that input.

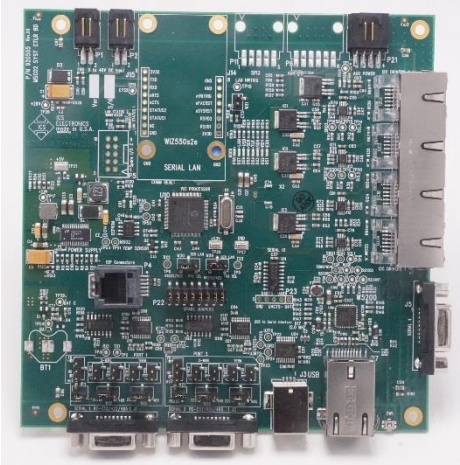


The desired output connection number is then entered and the display returns to the Matrix Status screen. System status information or any error messages are displayed on the blue bar at the bottom of the screen.

Other control functions are performed in a similar manner. Custom display programming is also available to create custom OEM products.

MSC02 Control Board

The Modular System Control Board pictured below is the heart of the system. It is a small 5.5" x 5.5" board designed to stack with other interface boards. The board contains the main control processor, serial interfaces, and connectors for the optional modules, power regulator and the I²C interfaces.

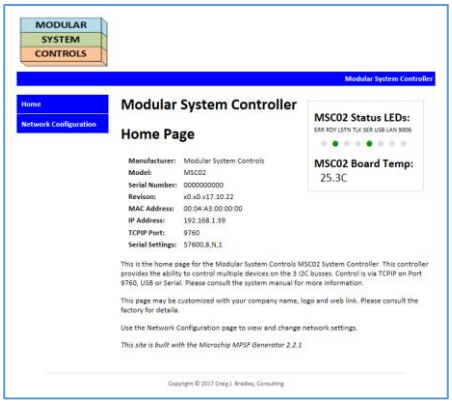


I/O Interfaces

The standard system can be controlled by Ethernet, USB or serial ports.

Ethernet

The Ethernet interface supports TCP/Telnet control, UDP discovery and a HTML web server for web browser control and network configuration. The HTML home page is shown below.



Serial Interfaces

The MSC02 board has 3 serial interfaces, two are capable of single ended RS-232 or differential RS-422 (RS-485) signals. There are on-board jumpers for selecting the desired driver, 2-wire or 4-wire connections and a termination network. One serial interface is RS-232 only with DTR and CTS handshaking signals.

USB

The USB interface is a USB 2.0 to serial interface compatible with MS Windows drivers. A virtual COM port is installed on the computer and any program that supports serial COM ports can be used to control the system.

I²C Interfaces

The MSC02 board has 3 separate fully buffered I²C interface buses. Bus 1 has 2 separately buffered RJ-45 connectors for larger systems. Bus 2 and Bus 3 each have one connector. Bus 3 is typically used for the optional touchscreen display. However the display can be configured for any bus.

SCPI Commands

The MSC02 board supports SCPI commands for control and configuration. Many of the commonly used control commands have a 2-character short form alternative to simplify commands and save space in programmable path buffers.

Switches and relays can be controlled by a simple SCPI command, ***ROUTe:SWITch*** or ***RS*** for the short form. This command would set switch 1 to position 5:

ROUT:SWIT 1, 5

A group or list of switches can also be controlled by the same command using the standard SCPI Channel List command syntax. Switches 1 and 2 would set to position 1 and switches 3 and 4 to position 3 with this command format:

RS (@1, 2, 3, 4), (@1, 1, 2, 2)

Switches can be combined to form switching matrixes. For example four 4-position input switches can be connected to four 4-position output switches to

form a 4x4 blocking switching matrix. This matrix can be configured with standard commands and then be controlled by specifying the path with X-Y commands. The command ***ROUTe:MATRIX 3,*** would connect input 3 to output 2.

Up 4 switches can be configured in each switch matrix path using SCPI commands. Sequences of SCPI commands can also be preprogrammed using named PATH buffers and executed with the command ***ROUTe:PATH pathname.***

Step attenuators are supported and controlled with the ***POWer:ATTenuation*** command. They can be configured with an attenuation value for each step and then set by specifying the attenuator number and desired value. The command ***POW:ATT 2, 13*** would set attenuator 2 to 13 dB.

Byte output is supported with the command ***SOURce:DIGital:DATA:PORT*** or **BO** for short. The following command would set port 2 to the value 10: ***BO 2, 10***

Byte input is supported with the command ***SENSE:DIGital:DATA:PORT?*** or ***BI?*** for short. The following command would read back the value of port 2. ***BI? 2***

Bit oriented I/O is supported by the commands ***ROUTe:CLOSe*** and ***ROUTe:OPEN*** to set or clear bits and ***SENSe:BIT?*** to read the status of a bit. I/O ports are bi-directional and one port can be a mixture of input and output bits. The following command would set bit 3 in byte 4:
ROUT:CLOS 4, 3

Power Supply

The MSC02 Modular System Control Board is powered from the system power supply (9 to 40V DC) and it has a switching regulator to provide additional 5V power for the I2C01 Modules, the optional front panel touchscreen display module and AUX power for other system boards. There are two power input connectors wired in parallel to allow "daisy chaining" power to other boards. The power input is protected from reverse polarity and all voltages are monitored by the microcontroller.

I2C01 Module

The I2C01 Module pictured below is a small business card size 2" x 2.65" daughter board which plugs onto an I/O board with standard 0.1" center header pins.

The module contains the two I²C RJ-45 connectors, buffers and the microcontroller which handles the I²C interface protocol, command parsing and control for switches, attenuators and parallel I/O. The micro-controller contains EEPROM non-volatile memory which is used to store configuration data and contact closure counts. The module also has a voltage regulator to provide 3.3V logic power from the 5V power supplied by the bus cable.

The I2C01 Module's interface to the I/O board is accomplished by a standard SPI serial bus. The SPI bus consists of a clock line, data out, data in, 4-enable lines and 2-interrupt lines. The standard I2C01 firmware is designed to control Microchip MCP23S17 16-bit I/O Expanders. These chips have 3 addressing inputs which allows up to 8 chips to be addressed with each enable line.

The I2C01 Module has 4 enable lines which allows up to 32 I/O expanders to be controlled by one module. The I/O expanders each have 16 I/O pins with can be individually configured as inputs or outputs resulting in up to 512 I/O lines per board. The outputs are capable of directly driving LEDs, TTL input switches, relay or switch coil drivers or any other TTL compatible circuit. When configured as inputs, each line can also have a pull up resistor enabled if desired. To drive switch coils or relays directly, a low cost Darlington driver array with protection diodes can be added. The module also contains a voltage divider for monitoring a coil voltage from the interface board and an input for temperature measurement from a low cost device on the interface board.

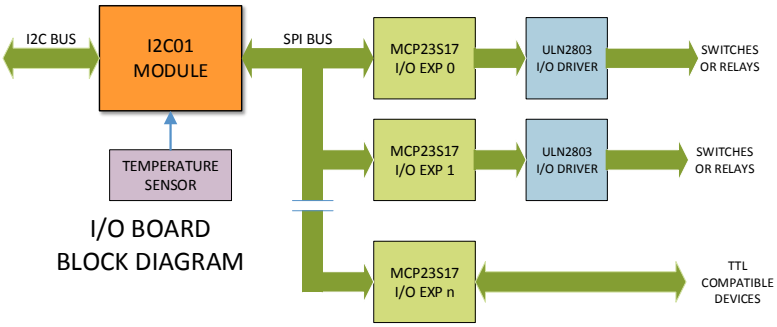
The I2C01 Module can control any mix of switches, relays, attenuators or lamps. Standard predefined switch types include one-of-n controlled (a control line for each position) multiple position switches with up to 8 positions, with or without indicator contacts, latching switches with a clear line, attenuators (latching and non-latching) and binary encoded switches. Custom switch types can be defined with simple SCPI configuration commands.

Byte and Bit oriented commands are provided for general purpose I/O control. The I2C01 Modules each have two RJ-45 connectors for daisy chaining of modules and other interfaces.

The I2C01 modules all contain the same standard firmware and they are configured via SCPI commands from the controller board.

A reference design schematic is available to allow OEMs to design their own I/O boards or we can design custom boards per OEM specifications.

In addition a prototype board will be available for evaluation.



I/O BOARD BLOCK DIAGRAM

I/O and Switch Driver Boards

As the microcontroller is on the I2C01 module, interface boards can be simple 2-sided boards which significantly reduces the cost. For a switch driver board, the I/O expanders and any necessary coil driver circuitry can be placed on the board near the switch connectors to reduce the length of the traces to the connectors simplifying the board layout.

The board can be designed as a backplane to plug directly onto a sub-assembly of switches. As each switch manufacturer uses different connector types and pin connections which can vary with the model of the switch, it is likely that most switch controller boards will need to be custom layouts to fit the mechanical requirements of the OEM's system. As the design is scalable, circuit design and firmware will not need to be changed to support different numbers and types of switches.

An example 72-channel board is shown below, which supports nine Charter Engineering, Inc. H3-H6 series 3 to 6-position TTL input switches and nine Charter Engineering, Inc. B series 2-position TTL input switches all with indicator contact read-back (144 I/O lines). The top board in the picture shows the component side of the board with the 9 I/O expander chips and the I^2C module installed on the right. The bottom board shows the connectors which plug directly onto the switch assembly eliminating all switch wiring. The board has two power input connectors (up right corner of bottom board) to allow daisy chaining of the system power. Coil voltage and board temperature are monitored and reported to the system controller.

A 72-Channel Switch Driver Board. The component side (top) shows the expander chips and the I2C01 Module on the right. The connector side (bottom) shows the switch mating connectors.

72 Channel Board Specifications:

Supported Switches:

- 9 each, 3-6 position Charter Engineering H3-6 series with TTL inputs & indicators (latching or non-latching)
- 9 each, 2 position Charter Engineering B series with TTL inputs & indicators (latching or non-latching)

Input voltage:

- 12 to 28 VDC, blue status LED, voltage monitored and reported to the Controller Bd. via I^2C bus.
- Reverse voltage protection

Temperature:

- Board temperature in degrees C monitored and reported to Controller Bd. via I^2C bus.

Size:

- 19" x 3"

MSC02 Modular System Controller Board Specifications

Serial Interfaces

Two DE-9S female connectors with a full duplex serial interface supporting single ended 2-wire RS-232 or differential RS-422 (RS-485) signals. On-board jumpers select the desired driver, 2-wire or 4-wire RS-422 connections and a termination network.

RS-232	TxD, RxD
RS-422	Tx & Rx pairs

One DE-9S female connector with RS-232 only and handshaking signals.

RS-232	TxD, RxD, RTS, CTS

Serial Data Format

Baud Rates	300 to 115,200
Data Bits	7 or 8 bits
Parity	Even, odd or none
Stop Bits	1 or 2
Modes	Half duplex, RS-485, Addressed
Addresses	0 to 15

Ethernet Interface

The MSC02 Board has one Ethernet port that supports common TCP / Telnet connections and has a web server interface which provides HTML web pages for displaying status information and for configuration of the MSC02.

Connector	RJ45
Type	IEEE 802.3 compliant
Speeds	10BaseT (10 Mb/s) 100BaseT (100Mb/s)
Auto Negotiation	Full & Half Duplex 10 & 100 based
Auto MDI/MDIX	Supported
IP Address	Static or DHCP
TCP Port	23 (programmable)
UDP Discovery	Port 30303

USB Interface

USB support is a USB 2.0 compliant interface using a virtual com port installed on the control computer. This interface can be used with any application that supports serial communications. The connector is a standard USB Type B.

Measurements

Board temperature	0 to 60 C
Supply voltages:	Input, 5V, 3.3V

Command Sets

IEEE-488.2 Common Commands

*CLS, *ESE, *ESE?, *ESR?, *IDN?, *OPC, *OPC?, *PSC, *RST, *SAV, *SRE, *SRE?, *STB, *TST?, and *WAI

SCPI Commands

Conforms to the 1999.0 Specification. Consult the factory for a complete list of commands.

Configuration commands:

- Serial parameters
- Network parameters
- Switch & relay settings
- I/O port setup
- I2C01 Module configuration
- Touchscreen display select
- Switch Matrix configuration
- Attenuator step settings
- Command Paths

Control Commands:

- Switch/Relay control
- Attenuator control
- I/O port control
- Matrix control
- Path control

MODBUS RTU

MODUS Application Protocol Specification V1.1b3 and MODBUS over Serial Line Specification and Implementation Guide V1.02 will be supported on the Control serial interface for control. Configuration is via SCPI commands. On special order, consult factory.

MODBUS TCP/IP

Consult factory.

I^2C Interfaces

Shielded RJ45 connectors for 3 fully buffered buses. Bus one has 2 separately buffered connectors.

I^2C Signals

SCL	Twisted pair
SDA	Twisted pair
INT (SRQ)	Twisted pair
+5V	2-wires

I^2C Modes

I^2C mode	Master
Address Mode	7-bit
Addresses	112 per bus

Touchscreen Display

The standard MSC02 firmware supports an optional 5” or 7” full color TFT display with an integrated touchscreen. Support for other sizes is available on special order. Consult factory for mechanical details.

Display

Resolution: 800 x 480

Interface

I2C bus SCL & SDA

Power

+5V DC from I^2C bus cable

Audio

Integrated piezo speaker

Power Requirements

Input Voltage

+9 to +40 VDC

Power

1.2W - MSC02 only

4.5W - Typical with 5” touchscreen display and 3 I2C01 modules connected (~180 mA @ 24V).

Output Power Supply

Aux Power Out

I2C Bus Connectors

+5 VDC	1A continuous 1.25A surge

For powering an external interface boards and I^2C bus modules/boards.

Physical

Size, L x W x H

5.5 x 5.5 x 0.64 inches
No modules
5.5 x 5.5 x 1.15 inches
With Ethernet/serial module

Temperature

Operation -10C to +50C
Storage -40C to +85C
Humidity 0-90% RH non-condensing

Connectors

Serial	9-pin DE-9S
Ethernet	RJ45
USB	USB Type B
I2C	(4) RJ45
Power Inputs (2)	Molex 0015912025
SPI Bus	Molex 0015912055
AUX I/O	Molex 0015912065
AUX PWR OUT	Molex 0015912045

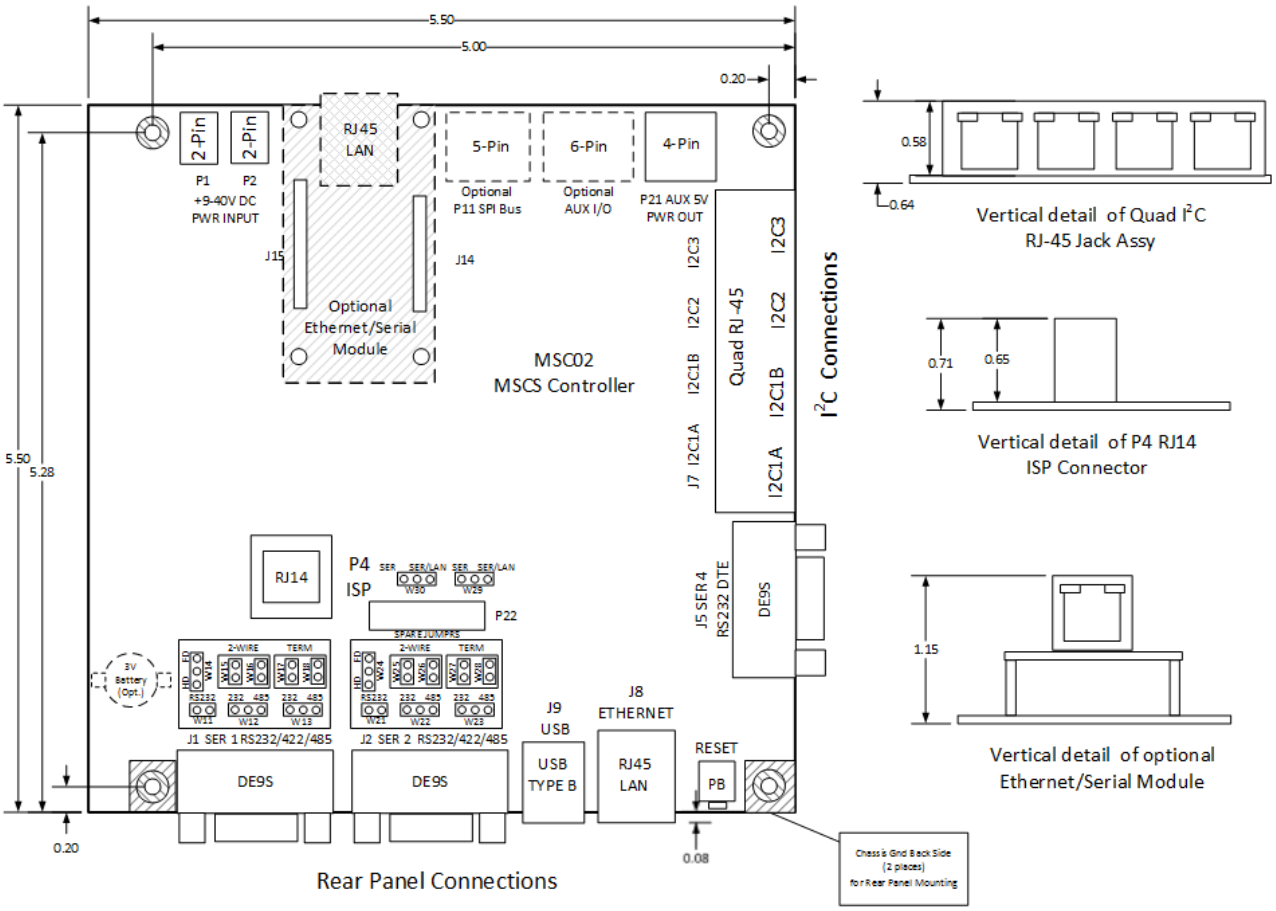
LED Indicators

PWR IN, 5V PWR, 3.3V PWR, AUX PWR, ERR, RDY, LSTN, TLK, USB, SER, LAN, 9006, I2C1, I2C2, I2C3

Certifications

Our assembly facility is ISO 9001 and ISO 13485 certified

All boards are RoHS certified



MSC02 Installation Drawing

I2C01 Module Specifications

I²C Interface

I²C Signals

SCL	Twisted pair w/ground
SDA	Twisted pair w/ground
INT (SRQ)	Twisted pair w/ground
+5V	2-wires

I²C Modes

I²C mode	Slave
Address Mode	7-bit
Addresses	1 per module

LED Indicators

RDY, ERR, ADDR, SRQ

Physical

Power

+5 VDC	From I²C bus cable

Size, L x W x H

2.0 x 2.65 x 1.0 inches

Temperature

Operation	-10C to +50C
Storage	-40C to +85C
Humidity	0-90% RH non-condensing

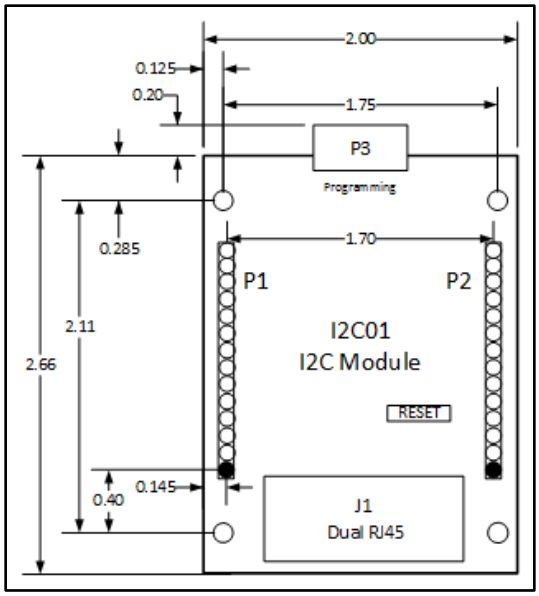
Connectors

I2C	(2) RJ45
Board Headers	(2)14-pin header pins on .1" centers

Module/Board Interface

Signals

+5V power	Power from I²C bus
+3.3V power	Regulated
Ground	Signal ground
CHASSIS GND	I²C bus shield
SPI SCLK	SPI clock
SPI MOSI	Master Out, Slave In data
SPI MISO	Master In, Slave Out data
SPI SEL1	Expander 0-7 Enable
SPI SEL2	Expander 8-15 Enable
SPI SEL3	Expander 16-23 Enable
SPI INTA-	Interrupt A
SPI INTB-	Interrupt B
RESET-	Circuit reset
SER TX	Serial Tx data or SPI SEL4 24-31 Enable
SER RX	Serial Rx data
ERR LED	Error LED
RDY LED	Ready LED
ADDR LED	Address LED
SRQ LED	SRQ on LED
TEMP MEAS	Temperature sensor input
SW VOLTAGE	Coil voltage sense input



I2C01 Installation Drawing

Note: Consult factory for detailed circuit board layout information

ORDERING INFORMATION

MODEL	DESCRIPTION	PART NUMBER
MSC02-01	Modular System Controller Board w/Ethernet & USB	
MSC02-SLAN	Serial to Ethernet Module	
MSC02-GTT50	5" Color Touchscreen Display Module	
MSC02-GTT70	7" Color Touchscreen Display Module	
I2C01	I2C Module	