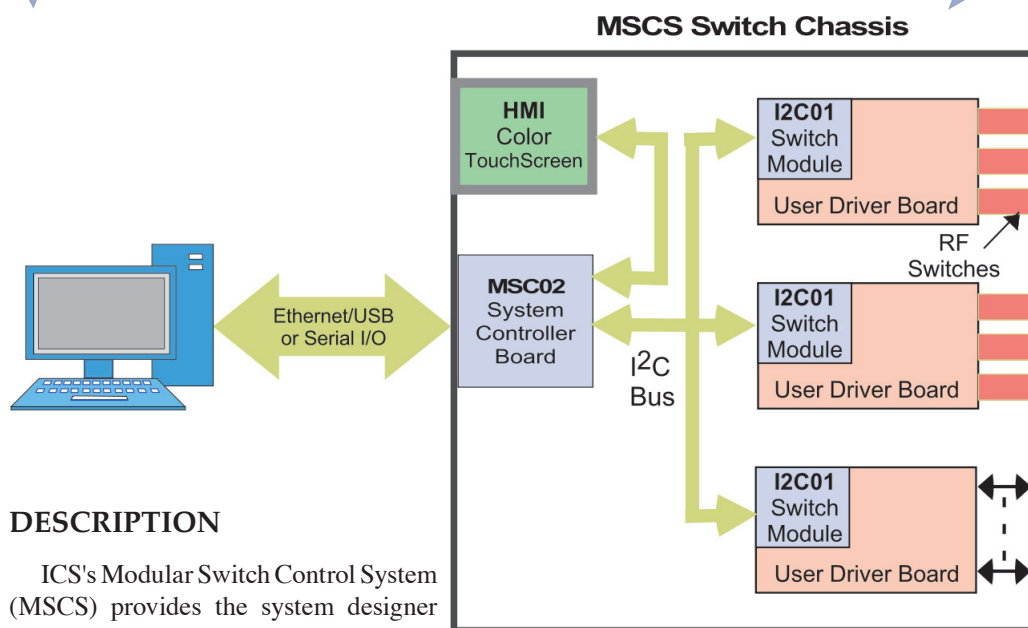


# MODULAR SWITCH CONTROL SYSTEM

## MSCS

### Expandable switch control system.



MSCS Chassis Block Diagram

### DESCRIPTION

ICS's Modular Switch Control System (MSCS) provides the system designer with quick way to assemble any size or type switching system. The basis of the system is a Controller Board that provides the external interfaces and sends commands to Switch Modules via internal I<sup>2</sup>C buses. The Switch Modules plug onto the user's Driver boards which can hold relays, drive RF switches, attenuators or provide digital I/O lines. Short CAT5 cables connect the Switch Modules together and also connect to an optional color HMI touch panel display that can be mounted on the front panel.

ICS's Modular Switch Control System (MSCS) can be used to put together an almost unlimited size system, from small matrixes to systems with multiple chassis and hundreds of switches. Applications include relay and RF switches, attenuators, digital I/O and electronic loads. The daisy-chained CAT5 cables provide a very neat, almost empty look to the chassis while saving assembly labor. Bulky flat-ribbon cables and costly wire bundles are virtually eliminated.

### Background

ICS has been supplying GPIB, Ethernet and Serial to Parallel boards with custom firmware to switch system manufacturers for decades. Over time, ICS developed a library of routines for switching systems that let the users configure mutli-pole switches, switch feedback lines, run contact counters, control attenuators, and drive front panel displays.

However, expanding switch systems in a parallel fashion by adding more I/O lines ran into messy wiring issues, consumed more space and generated more RFI. Using expander boards to expand the system size had definite size steps that

did not fit all customers. Customers had to make their own driver connector boards often using messy decoding schemes.

ICS's new Modular Switch Control System overcomes these problems with an easily scalable solution that lets a user get his desired system size with minimal engineering. The MSCS solution utilizes ICS's switching routines, neatly solves the interconnect issues, reduces fabrication cost and gives the user an incremental way of building an any size smart switching system.

### System Description

ICS's Modular Switch Control System has two major components. First is the Modular System Control Board that interfaces with the outside world and second are the satellite Switch Modules. The Modular System Control Board (MSC02) contains the control processor, Ethernet, USB and serial interfaces, the I<sup>2</sup>C interfaces and the power regulator. The MSC02 board can be controlled by 10/100 MHz Ethernet, over a USB bus, or by RS-232C, RS-422 or RS-485 serial signals. The three buffered I<sup>2</sup>C bus ports drive the Switch Modules and an optional front panel HMI touch screen.

The Switch Modules (I2C01) are small daughterboards which mount on the user's Driver boards and bring a high degree of intelligence down to the Driver board level. They handles the I<sup>2</sup>C interface protocol, command parsing and control outputs for switches, attenuators and parallel I/O. Contact closure counts and setup is saved in the Switch Module.

- **Scalable Control System**  
*System is a Control Board plus distributed Switch Modules on user's switch driver or I/O boards.*
- **Multiple Interfaces**  
*Control Board provides USB, Ethernet, and Serial I/O. Optional GPIB and VXI-11.*
- **Smart Switch Modules**  
*Add intelligence to simple switch driver or I/O boards.*
- **HMI Touchscreen Panel**  
*Control Board supports a HMI touchscreen display for local control and display*
- **Save on Design Cost**  
*Off the shelf boards and smart firmware eliminate much of the system design cost.*
- **Low Assembly Cost**  
*Inexpensive CAT5 cables quickly connect the whole system together and eliminate time consuming wiring. Only one power supply per chassis.*
- **East Customization**  
*User set IDN message, switch, attenuator and I/O configuration. Optional HMI panel layouts.*

 **RoHS Compliant**



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## APPLICATIONS

The user's Driver board is where the system becomes physically customized to the user's chassis and application. The Driver board is a simple, two-layer PC board that holds the relay drivers, I/O chips, relays, attenuators and/or connectors needed to complete the user's system. Many RF switches have built-in connectors for their driver inputs so the Driver board can be designed to physically mate with them, eliminating additional wiring. An example of this construction is shown in the chassis on the right. Other switches have pigtail connectors that can plug onto the board. ICS provides design information and support that minimizes the user's design effort.

During system configuration, information about each switch, attenuator, digital I/O line and other devices is downloaded to the Controller board which distributes it to the appropriate Switch Module. The configuration is saved so the system knows how to respond to future switch, attenuator or digital I/O commands.

### Modular System Control Board

The Modular System Control Board (MSC02) is a 5.5" x 5.5" board that can be mounted up against the rear panel or anywhere in the chassis. Rear panel mounting is recommended so the end user will have easy access to the Ethernet reset button and to eliminate additional cables. This also gives the end user access to the Ethernet, USB and Serial interfaces.

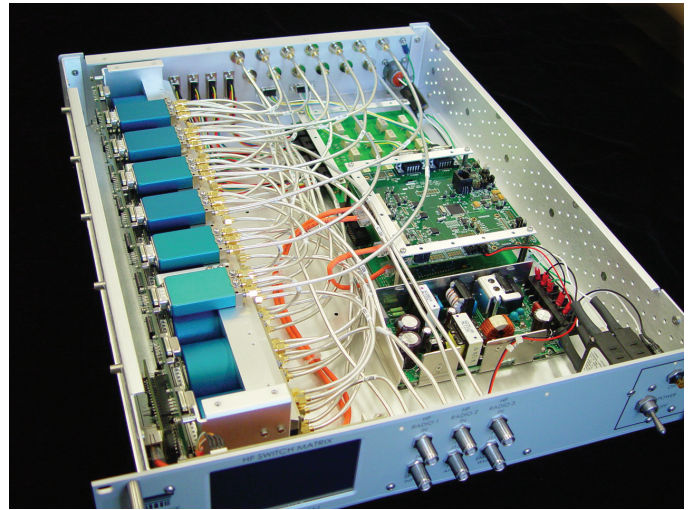
The MSC02 has three buffered I<sup>2</sup>C bus connectors. One is normally reserved for driving a HMI color touchscreen that is normally mounted on the front panel of the chassis. The HMI touchscreen has proven itself as a very effective way to manually control the chassis and to display setup information such as network IP address, firmware revision etc. The touchscreen panel can show contact closures, signal routing, attenuator settings etc. The remaining two I<sup>2</sup>C interfaces are used to drive the I2C01 Switch Modules and even such diverse items as a Frequency Synthesizer.

The Modular System Control Board has a power regulator that accepts any available voltage from 9 to 40 volts DC. The MSC02 uses spare wires in the CAT5 cables to supply 5 volt regulated power to the Switch Modules and to the HMI Touchscreen.

### Switch Modules

The I2C01 Switch Modules are a small 2" x 2.65" daughter boards which plug onto a user's Driver board with standard 0.1" center header pins. The Switch Module contains the I<sup>2</sup>C RJ-45 connectors, buffers and the high-speed micro-controller which handles the I<sup>2</sup>C interface protocol, command parsing and control for switches, attenuators and parallel I/O. The Switch Module's micro-controller contains nonvolatile memory which is used to store local configuration data for controlling the user's Driver board and optional contact closure counts. A regulator on the Switch Module reduces the 5 volt power on the I<sup>2</sup>C bus down to 3.3 volts for the micro-processor and driver chips.

The I2C01 Switch Module's interface to the user's Driver board is a SPI serial bus with clock, data out, data in, enable lines and interrupt lines. The I2C01's standard firmware is designed to control up to 16 Microchip MCP23S17 16-bit I/O Expanders for a total of 256



**Chassis with minimal MSCS System control wiring**  
Photo courtesy of Renaissance Electronics



**MSC02 System Controller Board with Ethernet, USB and Serial interfaces.**



**Small I2C01 Switch Module showing the dual I<sup>2</sup>C bus connectors**



APPLICATIONS

lines. Each line can source 3 mA or sink 8 mA. The lines can be individually configured as inputs or outputs and can directly drive LEDs, TTL input switches, relay or switch coil drivers or any other TTL compatible circuit. When configured as inputs, each line can also be enabled with an internal pull-up resistor for sensing contact closures or open lines. A low cost Darlington driver array with protection diodes is recommended to drive switch coils, relays or other heavy loads.

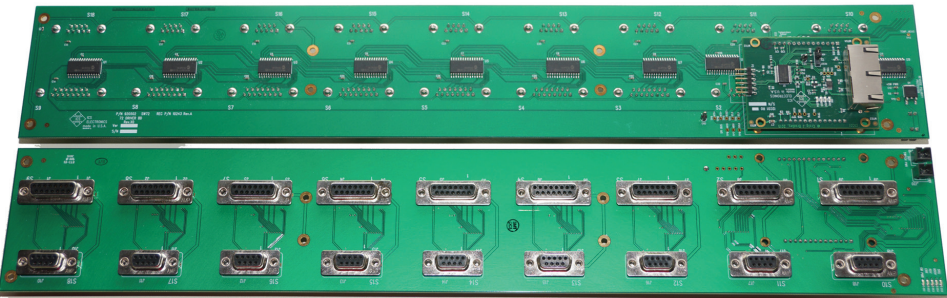
The Switch Module also contains a voltage divider for monitoring a coil voltage from the Driver board and an input for sensing temperature on the Driver board. The Switch Module's firmware can be configured to check switch indicator lines, digital inputs etc and alert on command complete, switching error or input signal change. Contact counters can count switch or individual position actuations.

User Driver Boards

The user's Driver boards can be designed for a wide variety of uses and the user can have several different boards designs in a chassis. The boards can hold relays, connect to RF Switches, have digital input/output lines, attenuators, connectors or any mix the user needs to meet his design goals. The Driver board assumes the physical shape to fit his chassis with the appropriate mounting points. The user has to bring power to the board for switching the relays, RF switches and attenuators. Power for the Microchip MCP23S17 16-bit I/O Expanders is supplied by the I2C01 switch Modules.

Because the micro-controller and high speed logic is on the plug-in Switch Module, the user's Driver boards can be simple 2-sided boards which reduces their design and fabrication costs. The SPI bus from the Switch Module to the 16-bit I/O Expanders does not require a ground plane nor does it have special impedance design restraints. The high voltage for driving the relays is kept on the user's Driver boards, preventing accidental damage to the rest of the system. ICS supplies reference design information for designing the Driver boards.

An example Driver board is shown below. It has 72 channels that support nine 6-position TTL input switches and nine 2-position TTL input switches all with indicator contact read-backs. The top board shows the component side of the board with the 9 I/O expander chips and the I2C01 module installed on the right. The bottom board in the picture shows the connectors which plug directly onto the RF switches eliminating all switch wiring.



72-channel user IO Board with I2C01 Switch Module

Smart Switch Control Firmware

The heart of the Modular Switch Control System is the firm-ware which gives the user great control over the operation of the switching system. First, regardless of the interface used (Ethernet, USB or Serial), the system is IEEE-488.2 compliant to the extent allowed by the selected interface. This gives the user a set of in-dustry common commands and behaviors that fit with all modern test systems. Second the firmware uses SCPI<sup>1</sup> standard (Standard Commands for Programmable Instruments) for all setup and control commands. Many of these commands also have a 2-character short form alternative to save space in the path command buffers or when manually controlling the system.

Switch Modules, RF switches, relays and attenuators are defined by the ASSign root command. Switch assignments let the user specify the switch number, type, number of poles, control coding, optional pulse width, switch readback lines and enable a counter for switch actuations. Attenuator assignments let the user specify the attenuator number, control coding, max attenuation, optional pulse width and enable a counter. Their positions and values are then controlled by the following SCPI commands:

```
ROUTe:SWITCh 1, 5           or RS 1,5
POWER:ATTenuator 2, 13
```

Byte output, byte input, bit input and bit set/clear commands are all part of the MSC02 parser and can be used to directly set, reset or read I/O lines. All configuration settings are saved in nonvolatile memory.

The MSCS firmware includes a PATH command that lets a user control several elements or I/O lines at a time. Paths are saved with meaningful eight character ASCII names. Path assignments can be any sequence of switches, attenuators, I/O lines etc. the user desires. The Path is called with the simple:

```
ROUTe:PATH PumpOn           or RP PumpOn
```

The MSCS firmware includes a unique Matrix command that allows direct and simple control of 2 to 8 level switch matrixes with up to eight switches in a path. The command simply speci-fies that Input X connects to Output Y. The Matrix is defined by the ASSign:MATrix:PATH command and the configuration is saved in nonvolatile memory. This example connects Input 2 to Output 3:

```
ROUTe:MATRIX 2,3           or RM 2,3
```

Design Assistance

The MSCS concept is extremely flexible and capable of operation in virtually any switching system. The MSCs firmware and the HMI screens and webpages can be cus-tomized for your system. ICS's engineers will show you how you can best take advantage of its capability and to generate a reliable and low cost switching system.

Notes: 1. SCPI commands are a root and branch structure where the command branches out to set or query a variable.

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HMI Displays

The MSCS supports the Matrix Orbital GTT50 and GTT70 color touchscreens which can be mounted on the front panel of the chassis. The screens let the user see or change the current settings and control switches, attenuators, and switch matrices.

On the Home screen, the user can select Setup which lets him change the Serial COM port settings, Ethernet network settings, display brightness and calibrate the display. The Home screen also lets the user select one of the three control categories.

Control is granted to the front panel when the user selects Local by touching the Local button. The MSCS normally stays in local until the user puts it back in Remote. The remote computer can query the system at any time and can override the Local selection and regain control of the system.

The two Matrix screens in the Cascaded picture (upper right) show how the typical switching screens work. The first Matrix screen shows the overall status of the Switch Matrix and what inputs are connected to which outputs. To add a connection, touch an input button and its associated Control Screen is displayed. Select an output to manually make the connection and then go back to the main Matrix screen. The Matrix, Switches and Attenuator screens are automatically sized when the system is configured without any additional effort on the user's part. e.g. A configured 4 x 6 matrix will be displayed as a 4 x 6 matrix.

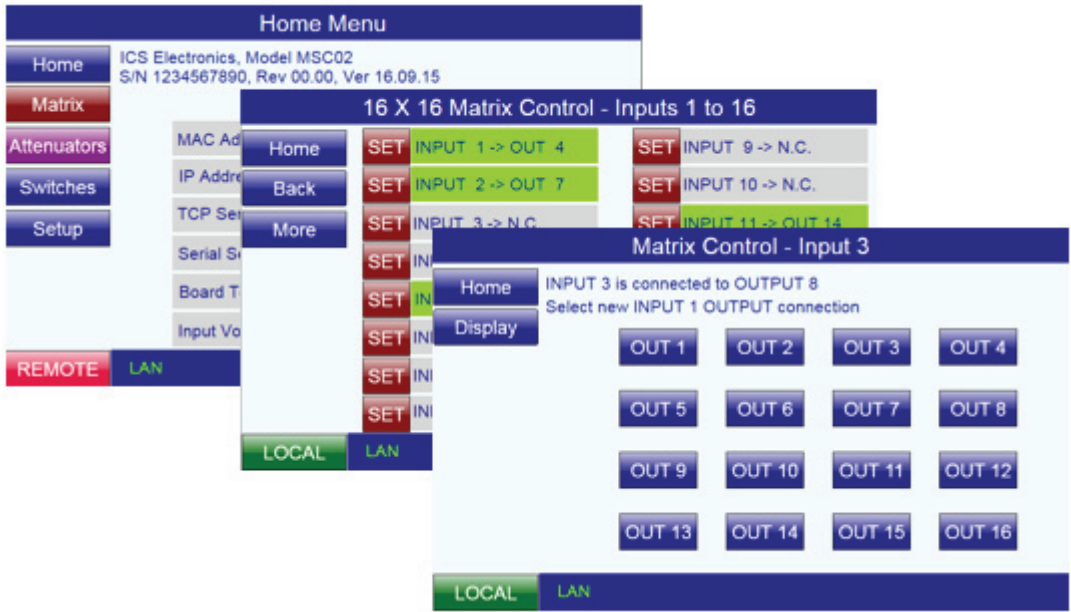
Touch Screen Setup

The Matrix Orbital Touchscreens have an internal flash memory which needs to be loaded before they can be used by the MSCS system. ICS provides a file of screens, button images and fonts that are downloaded by plugging the touchscreen into a USB port on a PC. The files are then copied onto the touchscreen memory.

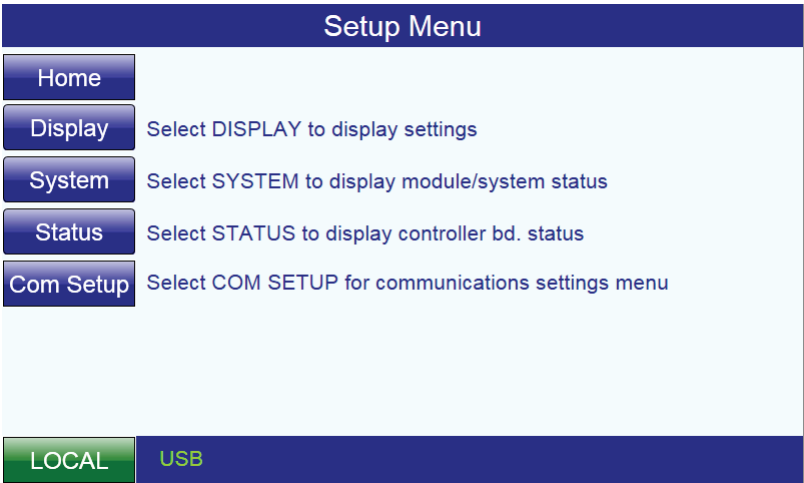
The touchscreen is connected to MSC02 Controller Board by its own I2C interface on Port 3. Control of the touchscreen is automatic by the MSCS firmware when the system is powered on. Without the touchscreen, the MSCS system stays in Remote.

Custom Screens

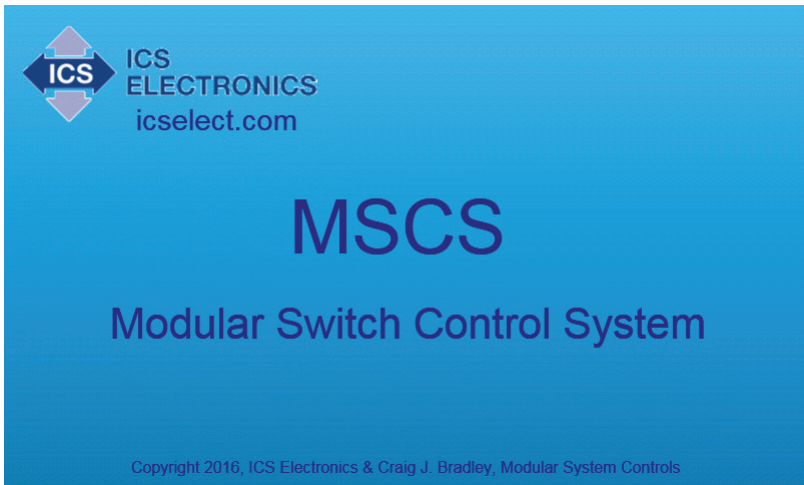
The standard MSCS System firmware and touchscreen displays are designed around switching systems but are easily adapted to other applications. The standard button graphics and fonts are provided at no charge to the MSCS user and can be customized for the user. The most obvious change is to put the OEM's company name and Logo on the screens. Another possible change is to change the name on a control button or to create another control category such as Digital I/O. ICS is willing to work with the MSCS user to generate additional touchscreen graphics and firmware changes for his application.



Cascaded Home, Matrix Control and Matrix Output Select Screens



Setup Menu



Power turn-on Splash Screen

## SPECIFICATIONS

### Supported Standards

#### IEEE 488.2 Capabilities:

The MSC02 supports the following IEEE-488.2 Common Commands: \*CLS, \*ESE, \*ESE?, \*ESR?, \*IDN?, \*OPC, \*OPC?, \*PSC, \*RST, \*SAV, \*SRE, \*SRE?, \*STB, \*TST?, and \*WAI

#### SCPI

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

#### Configurable Parameters

Serial parameters  
Network parameters  
Switch & relay settings  
IDN Message & Company Identification  
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

### MSC02 System Control Board

MSC02 Board has four RJ45 connectors with three fully buffered buses. Bus one has 2 separately buffered connectors.

#### I<sup>2</sup>C Bus

SCL	Twisted pair
SDA	Twisted pair
INT (SRQ)	Twisted pair
+5V	For I2C01 modules
I <sup>2</sup> C Mode	Master
Address Mode	7-bit
Addresses	112 per bus
Switch Time	1.4 ms typical from receipt of a command to relay driver or digital output.

### I2C01 Switch Module

I2C01 module has two RJ45 connectors for daisy-chaining the I<sup>2</sup>C bus and has the following capabilities:

I <sup>2</sup> C Mode	Slave
I <sup>2</sup> C Addresses	7 bits [32 default]
I/O Expanders	Drives 1-16 Expanders
I/O Lines	256 lines
Devices	100 any combination of Switches, Attenuators or I/O lines.
Counters	100 (32-bit)

### Serial Interfaces

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

#### Serial Signals

RS-232	TxD, RxD
RS-422	Tx & Rx pairs
Baud Rates	300 to 115,200 [9600]
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

Ethernet	RJ45 on MSC02 board
Type	IEEE 802.3 compliant
Speeds	10BaseT (10 Mb/s) 100BaseT (100 Mb/s) Auto-MDIX
IP Address	Static or DHCP w/AutoIP
Factory setting	192.168.0.254 static
Interface name	any [gpi0]

#### Internal WebServer

The internal WebServer provides HTML web pages for displaying status information and for configuring the MSC02.

### USB Interface

USB support is a USB 2.0 compliant interface that uses Microsoft Virtual COM port driver.

### Touchscreen Display Support

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	Matrix Orbital
Resolution:	800 x 480
Interface	I <sup>2</sup> C bus with SCL & SDA signals
Power	+5V DC from I <sup>2</sup> C bus cable

### Physical

Size, L x W x H	5.5 x 5.5 x 1.15 inches (with Ethernet)
Weight	1.6 lbs. (0.73 kg.)
Construction	RoHS Compliant
Temperature	
Operation	-40C to +85C
Storage	-40C to +85C
Humidity	0-90% RH non-condensing
Shock/Vibration	Normal handling
Connectors	
Serial	9-pin, DE-9S
I <sup>2</sup> C	(4) RJ45
Power Inputs	(2) Molex 705550036
Aux Power Output	Molex 705430038

#### LED Indicators

PWR IN, 5V PWR, 3.3V PWR, AUX PWR, RDY, ERR, LSTN, TLK, I2C1, I2C2, I2C3,

#### Power Input

+9 to +40 VDC @ 5 VA (Typical)  
Load rating for MSC02 board with touchscreen display and 3 I2C01 modules.

#### Power Output

+5 VDC @ 500 mA  
For powering an optional interface board and for distribution on the I<sup>2</sup>C bus

### Included Accessories

Instruction Manual  
Reference Design data for user Driver Boards.

## ORDERING INFORMATION

MSC02 Controller Board with Ethernet, USB and Serial IO

I2C01 Switch Module

Part Number

MSC02

I2C01