User Guide

Solid-State Switch Modules

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1 - General Information

1.1. User-Guide Scope

This user guide provides general introduction, installation instructions and operating information for Mini-Circuits' high-isolation (H-series) solid-state switch modules.

For information on Mini-Circuits' USB/Ethernet mechanical switches see: https://www.minicircuits.com/app/AN49-002.pdf

For information on USB-SP4T-63 solid-state switch see: https://www.minicircuits.com/app/AN49-009.pdf

1.2. Support Contacts

We are here to support you every step of the way. For technical support and assistance, please contact us at the email address below or refer to our website for your local support:

- testsolutions@minicircuits.com
- https://www.minicircuits.com/contact/worldwide_tech_support.html

1.3. Warranty & RMA Returns

Mini-Circuits provides a limited time warranty with all products. Please contact your account manager or refer to our website for full details: https://www.minicircuits.com/support/ordering.html

If you have any questions or concerns with your product, please contact us in the first instance through testsolutions@minicircuits.com. Our team will work with you promptly to understand and resolve any issues. As a software-controlled instrument, it is usually possible to resolve issues remotely without requiring the unit to be returned to the factory.

In the event that a return to the factory is necessary, Mini-Circuits will provide an RMA number and full return instructions.

1.4. End of Life

Please contact testsolutions@minicircuits.com to review environmentally friendly end of life disposal options.

1.5. Definitions

Note:

- A note advises on important information you may need to ensure proper operation of the equipment.
- There is no risk to either the equipment or the user.

Caution:

- A caution advises about a condition or procedure which can cause damage to the equipment.
- There is no danger to the user.

Warning:

- A warning alerts to a possible risk to the user and steps to avoid it.
- Do NOT proceed until you are sure you understand the warning.

2 - About Mini-Circuits Solid-State Switch Modules

2.1. Introduction

Mini-Circuits has developed a series of solid-state USB/Ethernet RF switch modules in rugged, low-profile cases. Switch models are available for a broad range of applications in frequencies from DC to 67 GHz, configurations from SPDT up to SP16T, and multiple switches integrated within a single package. These models have been designed to combine the fast-switching speeds and bullet-proof reliability of solid-state switches, with the exceptional isolation performance typically reserved only for mechanical switches.

The daisy-chain control interface with "dynamic addressing" simplifies control integration, allowing multiple switches of various types to be combined. Simply connect the devices via the serial interfaces and power on, and the whole chain of up to 25 compatible switches can be controlled independently through a single USB and software interface.

The switches can be controlled via the supplied GUI or with most common lab test software using the supplied API DLLs. In addition, Mini-Circuits provides the command codes for direct USB control (see programming manual for details). TTL and I^2C control interfaces are available for some switch models.

2.2. Key Features

- Absorptive solid-state switches
- Wide frequency ranges
- High-speed switch transitions
- High reliability (no moving parts to wear out)
- High isolation
- High power handling (model dependent)
- Programmable with timed switching sequences
- USB HID (Human Interface Device) for "plug & play" operation (no driver installation required)
- Remote control via Ethernet protocols
- User-friendly graphical user interface (GUI) for Windows
- API DLL for Windows and direct USB programming support for Linux (see programming manual for details)
- DC can be supplied via the USB or serial control connectors (model dependent)

For additional details, performance data and graphs, outline drawing, ordering information and environmental specifications, see our catalog at: https://www.minicircuits.com/WebStore/RF-Solid-State-Compact-Switch.html

2.3. Intended Applications

Mini-Circuits solid-state high-isolation switches are intended for indoor use in:

- Lab and test equipment setups for both manual and automated measurements.
- Control systems.
- Automated switching of signal paths in a complex system.

The switch modules can be used by anyone familiar with the basics of electronics measurements or electronic control systems.

2.4. Model Selection Guide

Model name	Frequency range	Conn. type	Switch type	No. of switches	Max PWR (dBm)	Daisy chain?	Control protocols
U2C-1SP2T-63VH	10 MHz - 6 GHz	SMA	SPDT	1	+33	No	USB, I^2C, SPI
USB-1SP16T-83H	1 MHz – 8 GHz	SMA	SP16T	1	+30	Yes [3]	USB, Daisy-chain, TTL
USB-2SP2T-DCH	DC [1] – 8 GHz	SMA	SPDT	2	+35	Yes [2]	USB, Daisy-chain
U2C-1SP4T-852H	2 MHz – 8.5 GHz	SMA	SP4T	1	+30	No	USB, I^2C
USB-1SP8T-852H	10 MHz – 8.5 GHz	SMA	SP8T	1	+30	Yes	USB, Daisy-chain
USB-2SP4T-852H	10 MHz – 8.5 GHz	SMA	SP4T	2	+30	Yes	USB, Daisy-chain
USB-4SP2T-852H	10 MHz – 8.5 GHz	SMA	SPDT	4	+30	Yes	USB, Daisy-chain
USB-1SP2T-183	100 MHz – 18 GHz	2.92 mm	SPDT	1	+24	Yes	USB, Daisy-chain
USB-1SP4T-183	100 MHz – 18 GHz	2.92 mm	SP4T	1	+24	Yes	USB, Daisy-chain
USB-1SP8T-183	100 MHz – 18 GHz	2.92 mm	SP8T	1	+24	Yes	USB, Daisy-chain
USB-1SP8T-183SP	100 MHz – 18 GHz	SMP	SP8T	1	+24	Yes	USB, Daisy-chain
USB-1SP2T-34	100 MHz – 30 GHz	2.92 mm	SPDT	1	+24	Yes	USB, Daisy-chain
USB-1SP4T-34	100 MHz – 30 GHz	2.92 mm	SP4T	1	+24	Yes	USB, Daisy-chain
USB-1SP8T-34	100 MHz – 30 GHz	2.92 mm	SP8T	1	+24	Yes	USB, Daisy-chain
USB-1SP2T-A44	100 MHz – 43.5 GHz	2.92 mm	SPDT	1	+24	Yes	USB, Daisy-chain
eSB-1SP2T-A673	100 MHz – 67 GHz	1.85 mm	SPDT	1	+26	Yes	USB, Daisy-chain
eSB-1SP4T-A673	100 MHz – 67 GHz	1.85 mm	SP4T	1	+26	Yes	USB, Daisy-chain
RCS-1SP2T-A673	100 MHz – 67 GHz	1.85 mm	SPDT	1	+26	Yes	USB, Daisy-chain, Ethernet
USB-1SP2T-673	100 MHz – 67 GHz	1.85 mm	SPDT	1	+27	Yes	USB, Daisy-chain

1. True DC; passes DC current up to 60 mA.
2. From S/N 1201004xxxx and up.
3. From S/N 1210101xxxx and up.

For detailed model performance, data and graphs, outline drawing, ordering information and environmental specifications click on the model part number.

2.5. Environmental Specifications

Mini-Circuits' solid-state switch models are intended for operation in office, laboratory, or production test environments. Do not use in any condition which exceeds the published environmental specifications.

Condition	Specification
Operating temperature	0°C to +50°C
Humidity	5% to 85% RH (non-condensing)
Altitude	Up to 2000 m (6560 ft)
Pollution degree	2 - Normally only non-conductive pollution occurs (per IEC 61010)

2.6. Supported Software Environments

Mini-Circuits' solid-state switches have been tested in the following operating systems:

- 32-bit systems: Windows 7 or later.
- 64-bit systems: Windows 7 or later; Linux.

Custom automation programs can be created in most modern programming environments, including Python, C#, LabVIEW, MatLab and more.

Refer to the programming manual for more information on solid-state switch programming.

2.7. Conformity

Mini-Circuits' solid-state switches conform to the following international standards:

Standard	Meaning
CE	Meets the requirements of the following applicable European directives and carries the CE marking accordingly: • Low Voltage – Directive 2014/35 • Electromagnetic Compatibility – Directive 2014/30/EU • Restriction of the Use of certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) – Directive 2015/863
UKCA	Meets the requirements of the following applicable UK directives and carries the UKCA marking accordingly: • Electrical Equipment (Safety) Regulations 2016 • Electromagnetic Compatibility Regulations 2016 • The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012
FCC	This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation.
USB 2.0	The model meets the specifications of the Universal Serial Bus version 2.0 communication standard as described by USB-IF.
USB HID	The model meets the requirements for Universal Serial Bus Human Interface Devices according to USB-IF's Device Class Definition for Human Interface Devices firmware revision 1.11.
I^2C	The **U2C** series meet the requirements for an I^2C slave device as defined in revision 6 of the I^2C bus specification and user manual.
TCP/IP	The **RCS** series models' Ethernet communication complies with the specifications of the Transmission Control Protocol (TCP) and Internet Protocol (IP) as defined in RFC 791 and RFC 793.
HTTP	The **RCS** series supports all requirements for communicating with the Hypertext Transfer Protocol (HTTP) as defined in RFC 1945**.**
Telnet	The **RCS** series supports all requirements for communicating with the Telnet protocol, as defined in RFC 854.
SSH	The **RCS** models which specify SSH control, support the requirements for SSH protocol as defined by RFCs 4250-4253, 4419, 5647, 5656 and 6668.

2.8. Accessories and Options

Solid-state switch models are come with a single control cable (model dependent):

- 3.3 ft (1.0 m) USB cable: USB type A (Male) to USB type Mini-B (Male)
- 3.3 ft (1.0 m) USB cable: USB type A (Male) to USB type C (Male)

Additional ordering options are available (see models' datasheet for details):

- 6.6 ft (2.0 m) USB cable: USB type A (Male) to USB type Mini-B (Male)
- 3.3 ft (1.0 m) USB cable: USB type C (Male) to USB type C (Male)
- 5.0 ft (1.5 m) Ethernet cable: RJ45 (Male) to RJ45 (Male) Cat 5E cable
- 6.0 ft (1.8 m) TTL cable: 9 pin D-sub (Male) to 9 pin D-sub (Female)
- 3.3 ft (1.0 m) I^2C cable: 9 pin D-sub (Male) to Pig-tail (bare wires)
- 3.0 ft (0.9 m) I^2C & SPI cable: DF11 (plug) to Pig-tail (bare wires)
- 1.5 ft (0.5 m) Daisy-chain cable: Digital snap fit (Male-Male) cable assembly connectors
- 5.0 ft (1.5 m) Daisy-chain cable: Digital snap fit (Male-Male) cable assembly connectors
- 5V AC/DC power adapter suitable for a wide selection of wall sockets
- Mounting bracket

2.9. Service and Calibration

The solid-state switch models do not require any periodic service or calibration.

The only user-performed service possible for switch models is external cleaning of the case and connectors as needed. Do not use any detergents or spray cleaning solutions. The case can be cleaned with a soft, slightly dampened cloth and the connectors with an alcohol solution. Do not allow any liquid ingress into the case or connectors.

2.10. Safety & Precautions

Mini-Circuits' solid-state switch models contain no user serviceable parts and should not be opened. Discontinue use and contact Mini-Circuits in the event of visible damage to any parts.

Please observe the following safety precautions at all times when using Mini-Circuits USB switch modules:

Caution:

- Do not attempt to switch signals of greater power than the switch is rated for in its datasheet.
- Safe power input degrades below specified frequency range. Do not input signals below the specified frequency range.

Warning:

- Properly ground all equipment to reduce the risk of accidental electrical shock.

3 - Software Setup

3.1. System Requirements

The minimum requirements for installation of the "Mini-Circuits Solid-State Switch" software package and API on the host PC are:

- Microsoft Windows 7 or later (32- or 64-bit).
- Intel i3 or equivalent (recommended).

Control method	Required support
USB control	USB HID
Ethernet control	Network connection

For control of supported switches using SPI, I^2C or TTL, a controller capable of supplying the necessary logic levels and sequences is required, as defined on the respective datasheets. No software support is provided for these methods.

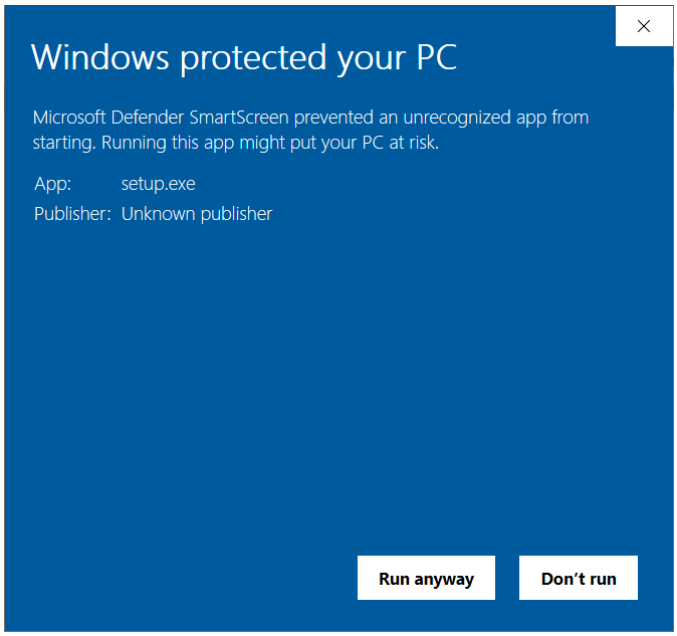
3.2. Software Downloads & Resources

The full Solid-State Switch software package (including GUI, API, and documentation) is available for download from:

- https://www.minicircuits.com/softwaredownload/solidstate.html

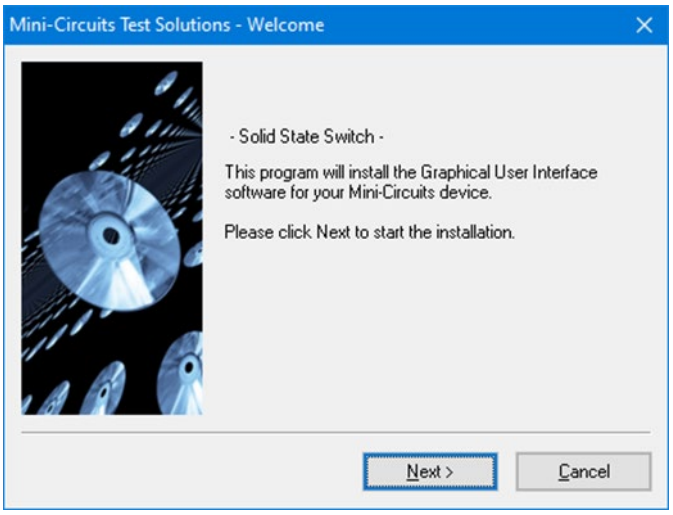
3.3. Software Installation

- Save all work in progress and close any other programs that may be running.
- Download the "GUI Setup Package" software from the Mini-Circuits website.
- Extract the downloaded zip file and begin the installation process and double-click the **Setup.exe** icon.
- If Microsoft Defender SmartScreen provides a warning about an unrecognized app, select **More Info** and then **Run Anyway**.

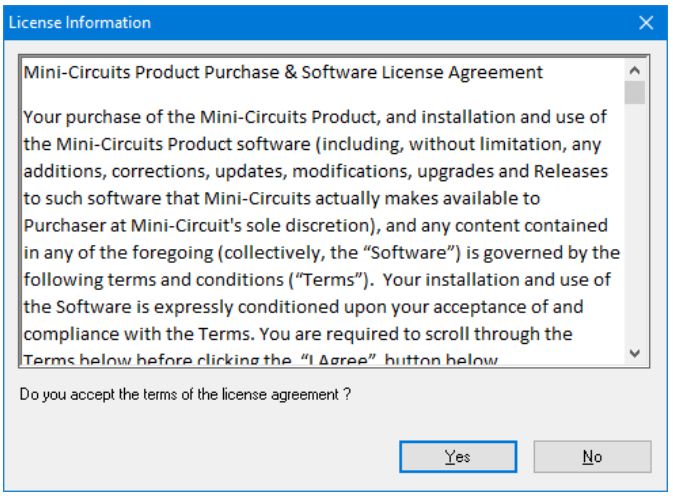


- If prompted by Windows User Account Control, enter user credentials for an account allowing software installation.

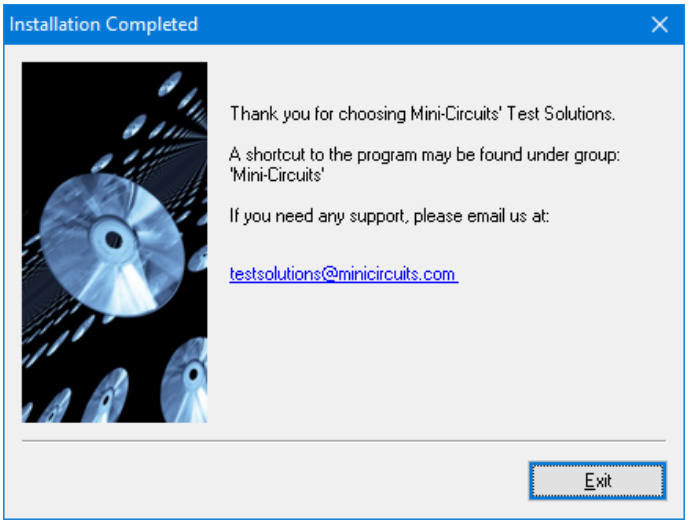
- Click **Next** to begin the installation.



- Click **Yes** to accept the license agreement.



- Click **Exit** on the final window confirming that installation completed successfully.



In the event of any issues with installation, please contact testsolutions@minicircuits.com for support.

4 - Hardware Setup

4.1. USB Control

Connect the switch to the computer using the provided USB cable or equivalent one, and then connect the required RF connections.

Caution:
- Note the maximum input power rating in the datasheet and the conditions specified for it.
- Exceeding these values may damage the switch.

4.2. Ethernet Control (RCS series)

- Connect the unit to power source via a USB cable.
- Connect a standard network cable between the unit's RJ45 socket and the network port.
- Ensure the network indicators on the unit's RJ45 socket light up after a few seconds.
- Connect the unit's input and output RF ports to your system.

4.3. TTL Control (USB-1SP16T-83H only)

The USB-1SP16T-83H TTL control interface consists of 5 unlatched parallel control bits that select the desired switch state (see model datasheet for truth table). The parallel control does not have any latch and thus will respond immediately to any change.

Connecting the switch to USB control and establishing USB communication will disable the TTL control until the switch is reset by disconnecting and then reconnecting power.

All TTL controls are connected with internal pull-down resistors, so the default state of the switch is in "disconnected" state.

The TTL interface is input only and does not provide feedback on switch state.

4.3.1. TTL Setup Instructions

- Connect the control lines (5 bits) to a suitable I/O controller.
- Connect 5V power either using a power adaptor such as USB-AC/DC-5+ connected to the USB port, or by supplying power to pin #1 of the D-Sub connector.

4.4. I²C Control (U2C series)

I²C is a short-range synchronous communication protocol for simple 2-wire communication with slave devices using clock (SCL) and data (SDA) connections. The U2C models also include 3 address pins (A0, A1 and A2), allowing up to 8 switches to be controlled independently from a single master with shared SDA and SCL connections.

All I²C pins are connected to an internal pullup resistor so will float to logic '1' when disconnected. This sets a default address of 111 for all units (decimal 7). Addresses from 0 to 7 can be set by externally grounding the relevant address pins (A0, A1 and A2).

The I²C functionality is limited to setting or reading switch states. Control sequences are sent to the switch in several bytes on the data connection, enclosed by a start and stop signal, and clocked at up to 400 kHz. The switch will acknowledge each byte received with a single "ACK" bit (logic 1) on the same data connection.

To send a command to the switch 3 bytes will be sent:

- Control byte (**1010**$A_2A_1A_0$**R/W**)
  Where:
  1010 = Control code for U2C models
  $A_2A_1A_0$ = 3-bit address for the switch module
  R/W = Read / write select bit ('0' to write or '1' to read)

  Example:
  Control code = **1010**
  Address = 4 (decimal) = **100** (binary)
  R/W = **0** (write to switch)
  Control byte = **1010**1000

- Switch selector byte – Currently all U2C models contain only a single switch so this byte is always 00000001.
- Switch state byte (00000XYZ) – The switch state, represented by a binary string according to the individual model's truth table in the model datasheet.

4.4.1. I²C Setup Instructions

- Determine the TTL addresses that you wish to set for each switch module (refer to the model datasheets for details).
- Specify the address within the control cable by connecting the relevant lines to DC ground for logic '0' or leaving them disconnected / floating for logic '1'.
- Connect the control cable to the I²C master device.
- Power to the switch can be provided either via the I²C port (see model datasheet for details) or via the USB port through a USB device or a power adaptor such as USB-AC/DC-5+.

4.5. SPI Control (U2C-1SP2T-63VH only)

The serial interface requires a full byte to be sent to each unit, although only the two LSB (least significant bits) affect the state of the switch. The control byte is loaded in a serial-in, parallel-out shift register buffered by a transparent latch.

It is controlled by three-wire SPI protocol using Data, Clock, and Latch Enable (LE) and an additional Blank for added noise immunity and increased flexibility in controlling the units. While Blank is at logic 1 the SPI interface is enabled, when Blank drops to logic 0 the unit will not respond to SPI control.

All signal voltages are compatible with TTL and LVTTL. The Data and Clock inputs allow data to be serially entered into the shift register, a process that is independent of the state of the LE input. The dual input and output SPI ports allow up to 30 units to be connected in a "Daisy-chain" configuration, all controlled by a single controller.

The LE input controls the latch. When LE is '1', the latch is transparent, and the contents of the serial shift register control the switch. When LE is brought to '0', data in the shift register is latched.

Blank is used to lock the current state of the switch regardless of LE state or shift register, while allowing the LE to pass to other switches in the chain. If Blank is at logic 1 the switch will respond to LE normally, when Blank is at logic '0' the switch will not respond to LE. If Blank is not required, it can be kept constantly at logic '1'.

The shift register should be loaded while LE is held at '0' to prevent the switch state from changing as data is entered, and Blank at '1' to allow the unit to respond to the SPI interface. After LE is raised to '1' to enable the switch changing, Blank should be held at '0' to prevent noise being received as SPI control signals. If multiple units are connected in series, data for all units should be entered before raising the LE to prevent switches assuming unanticipated states, and Blank kept at '1' until setting of all switches has been completed. Thus, for example, if three units are connected in daisy-chain all 6 bits of control should be entered before raising the LE.

The LE input should then be toggled to logic '1' and brought to logic '0' again, latching the new data, then Blank brought to logic '0' as well. The timing for this operation is defined in the model datasheet.

4.5.1. SPI Setup Instructions

- Connect in series all the units you wish to control in the SPI daisy-chain (maximum 30 units).
- Connect the first unit to a suitable controller and 24V power supply.

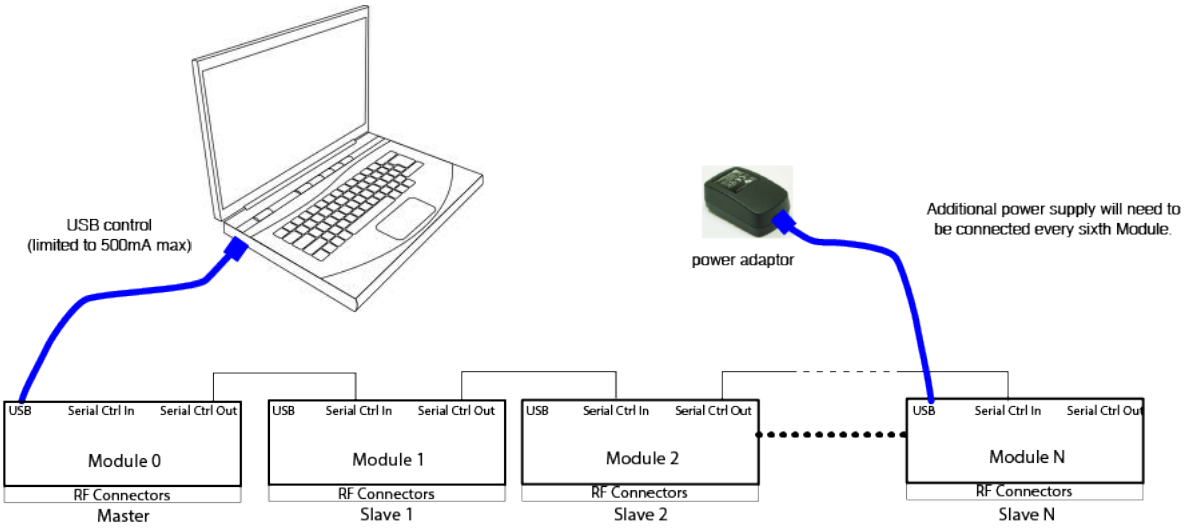
Caution:

- Be careful not to connect the 24V power to the I^2C port as this could damage the unit.

4.6. Daisy-Chain Control

Some models include Mini-Circuits' novel dynamic addressing daisy-chaining interface which allows multiple switches to be connected together into a master/slave chain, with independent control of each switch through the single USB or Ethernet connection of the master unit (see section 2.4 for models supporting this function).

The serial master/slave bus allows connecting modules of different types to the same daisy-chain as long as they all support Mini-Circuits' dynamic addressing setup. To add a new module, simply connect it to the daisy-chain and refresh the address listing – no need to reset any of the existing modules or assign addresses manually.



Modules will have their addresses assigned automatically when the USB connection from the PC to Master is established, or when a refresh address command is issued. The module connected to the computer USB port will be assigned address 0 (master), and subsequent modules connected through it will get incrementing addresses, starting from 1 to N. All control will be through the master module (address 0) which is the only one communicating with the PC.

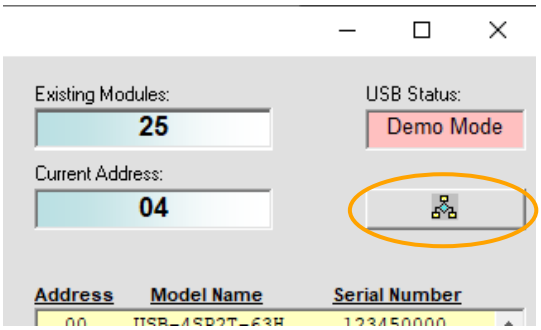
Note:

- It is possible to connect up to 99 units in a single setup as long as power considerations are taken into account. Refer to model datasheets for number of units tested in series of a given model.

4.6.1. Daisy-Chain Setup Instructions

Digital & DC connections for daisy chain control can be done in any order so long as addresses are refreshed once all units and power supplies are connected.

- Arrange the required switch modules on the work surface in the order that they are to be addressed.
- Use the serial control cables (CBL-1.5FT-MMD+, CBL-5FT-MMD+, or equivalent) to connect the units together in the daisy-chain, from Serial CTRL Out of the first unit, to Serial CTRL In of the second, and so forth.
- Note the DC current draw of each switch in the daisy-chain from the published datasheets.
- Starting from the first switch in the daisy-chain, sum the DC current draw of each switch to confirm whether the total exceeds the maximum pass-through current (500 mA), or the maximum available from the USB supply (if lower).
- If required, connect an additional 5V DC power supply to the USB port of one of the daisy-chained modules, to keep the DC consumption of the previous group beneath the specified limit.
- Repeat the check from this module forward and add additional power supplies as necessary.
- Finally, connect the USB cable from the first switch to the control PC and the complete chain will power up and automatically assign address (from 00 to NN).
- To add additional units to the daisy chain, repeat step 6 from the last unit connected to a power supply, then connect the additional units with serial control cables. When done, click on the **network reconnect** button in the GUI (shown below)



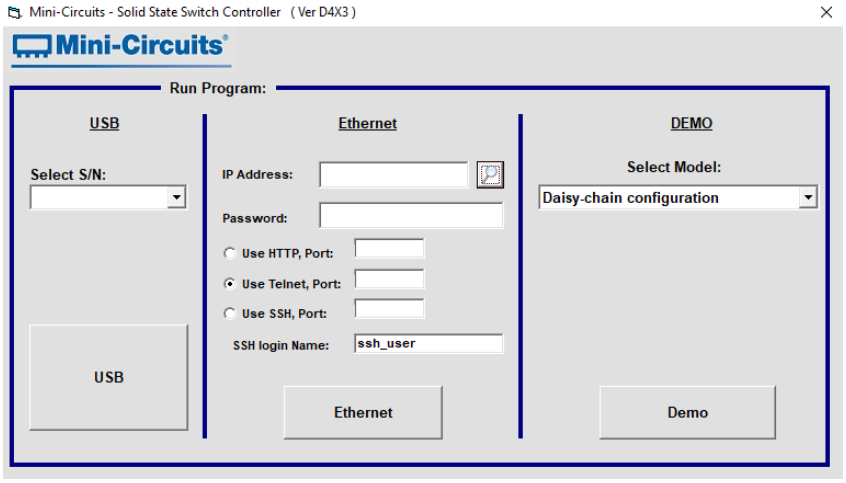
5 - Using Mini-Circuits' GUI

All solid-state switch models are supplied along with API programming objects (DLL files) to allow easy control by most common lab test software (see programming manual for details) and with a Windows GUI program to control the model manually.

5.1. Getting Started

To start the program, use the **Start** menu or navigate to the location the "Mini-Circuits Solid-State Switch Controller" software was installed in and run the program.

Once running, the user will be required to pick one of the available control modes: USB, HTTP, Telnet, or SSH control.



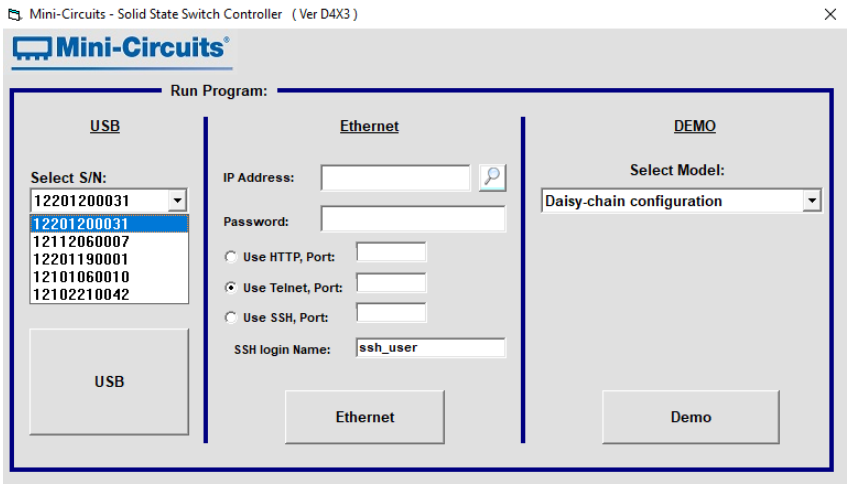
In addition to the control modes, the user can try the demo mode:

- Select a model from the drop-down menu to learn and experiment with its GUI without connecting said model.
- The "Daisy-chain configuration" presents the GUI for a set of multiple switch models connected using the daisy-chain feature.

5.1.1. USB Control

Clicking the **USB** button in the startup screen will start the unit in USB control. In case the program does not detect a unit connected to the PC via USB or if there are no connected units then an alert will pop-up. If the alert persists even when a unit is connected, then check the unit's USB LED indicator or the USB cable's integrity.

If multiple units are connected to the PC via USB, select the desired unit's serial number from the list in the drop-down menu.



5.1.2. Ethernet Control

To use Ethernet control with a supporting unit, either enter its IP address on the startup screen (ports for HTTP/Telnet/SSH would also be required if using non-default ports) or click on the **search icon** next to it to find all Mini-Circuits switch models connected to the network.

Note:

- When connecting to the unit with Ethernet control for the first time you may need to connect using default IP address or change the factory default Ethernet configuration to match your network configuration. See *section 5.4* or the programming manual for details.

After clicking on the **search icon,** the IP search will pop up with a list of switch models' IP addresses and their assigned ports on the left side of the screen, and full details of each unit on the right. Click the IP address of the desired unit and press **Select**. The search window will close and the IP address, along with the related assigned ports, will be entered in the IP address field of the startup screen automatically.

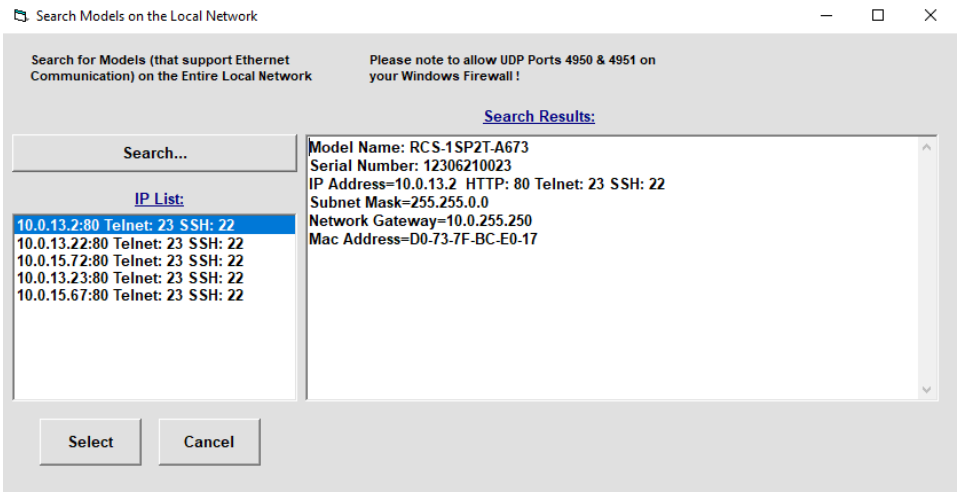


Figure 5.1.2a: *Ethernet IP search window*

Note:

- To refresh the list of found units click on the **Search…** button.
- The search function uses ports UDP 4950 and UDP 4951 for communication. Ensure your firewall allows access to them.

Once the IP address has been entered, input the password if one has been set (see *section 5.4*). Proceed to select the desired communication protocol (HTTP, Telnet, or SSH) and click on the **Ethernet** button to begin.

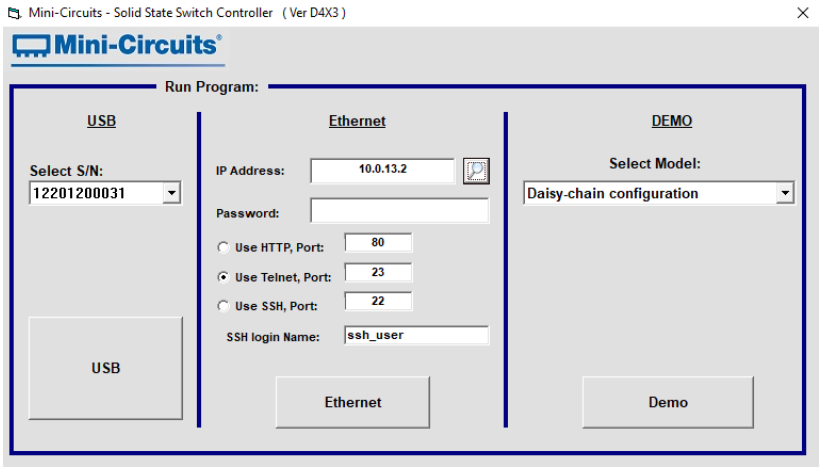


***Figure 5.1.2b: S**tartup screen with Ethernet fields filled-in*

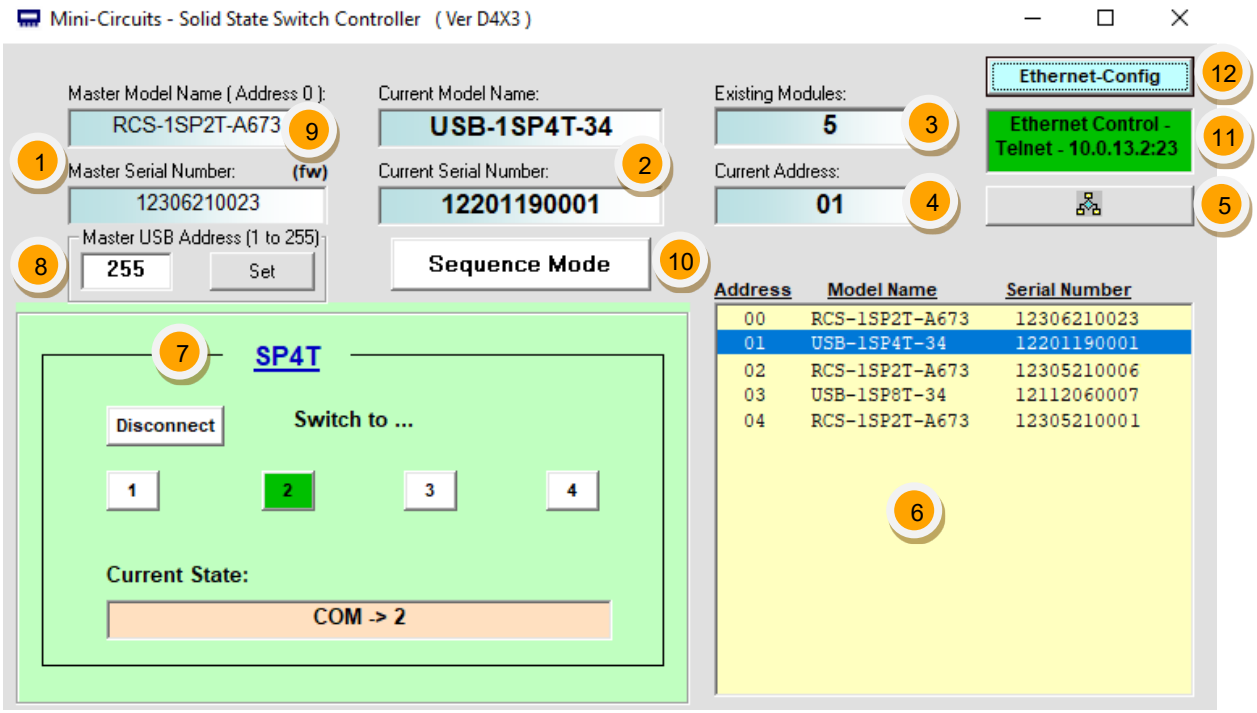
Telnet or HTTP text commands can also be used to control the module. This can be achieved in one of the ways below:

- Type the command in the address field of your internet browser.
- Implement a Get/Post HTTP function in your selected application (for HTTP).
- Establish a Telnet connection.

A full list of the possible commands and queries is available in Mini-Circuits Programming handbook, and in a text file on the downloaded software, in the Ethernet directory.

5.2. Main Screen Operation

Once the control method has been selected, the main screen of the GUI program will appear.



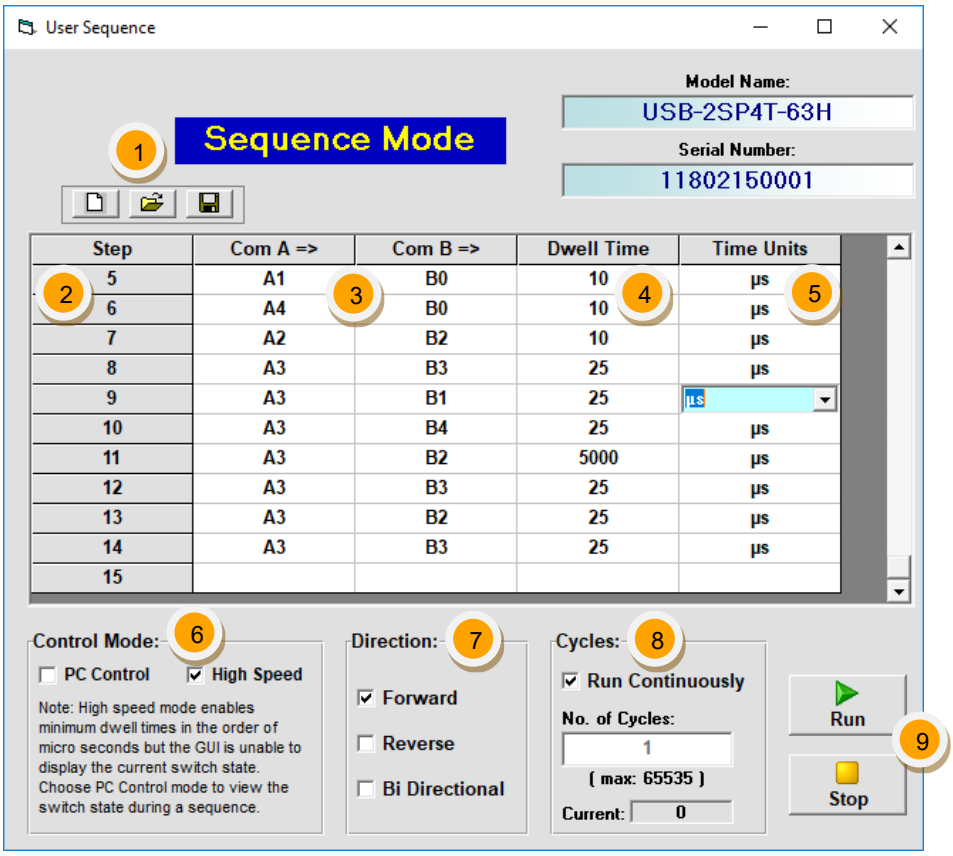
#	Name	Description
1	Master unit	Part number and Serial number of the Master unit (the unit connected to the PC).
2	Current unit	Part number and Serial number of the selected unit in the daisy-chain list. It will be the same as the master unit if only a single unit is connected.
3	Existing Modules	The total number of daisy-chained units.
4	Unit address	Displays the daisy chain list order (address) of the selected unit.
5	Network reconnect	Refreshes the list of daisy-chained units.
6	Daisy-chain unit list	Lists all the daisy-chained units connected to the PC. List order follows the physical connection order.
7	Switch State Control	Allows users to control the switch's state. Section display changes according to the *selected* switch.
8	Master USB address	Set a specific USB address to the master unit (1 to 255). Allows switch's operation by referring to that address instead of their serial number.
9	(fw)	Opens the firmware status check and upgrade window (see *section 5.5*).
10	Sequence Mode	Opens sequence mode window to set sequence of timed states (see *section 5.3*).
11	Control method	Displays the control method status chosen to operate the switch unit.
12	Ethernet configuration	Opens the dedicated Ethernet configuration screen (see *section 5.4.5*).

5.3. Sequence Mode

The GUI supports a sequence mode which allows the user to program a timed sequence of switch states.

5.3.1. Sequence Setup

Click the **Sequence Mode** button on the main screen to access the sequence setup window.



- To delete a line, click on the relevant step number and press the **Delete** button on your keyboard.
- To run only a single step, double-click on the number of that step.

- Configure the required switching sequence, referring to the table below:

#	Name	Description
1	Save \ Recall	Allow clearing the current sequence to start a new one, opening a previously saved sequence or saving the current sequence.
2	Step	The sequence steps. It is possible to configure up to 100 steps in a sequence.
3	Com	The port to which the Com port connects in any given step. In models with multiple switches, one column for each switch, all columns need to be filled.
4	Dwell time	The time the switch will hold at each step (must be an integer value). When operating in high-speed mode, note that some models have an additional processing delay of a few microseconds, which should be subtracted from the desired value to get accurate timing (see 0 for details).
5	Time units	The time units of the dwell time set in each step. The time units can be set independently for each step to seconds, milliseconds or microseconds (in high-speed mode).
6	Control mode	Select between PC control (each command is sent individually from the PC and status can be monitored) or high-speed mode (the entire sequence is sent in a single block of commands and triggered with an execute command – allows for faster and more precise timing but status cannot be monitored from the PC).
7	Direction	The direction of the sequence. Forward is the sequence as shown, reverse will run the sequence from last step to first and bi-directional will run the sequence from first step to last, then from last step to first.
8	Cycles	Number of cycles to run, can be set from 1 to 65535. If “Run continuously” is selected the sequence will keep repeating until stopped.
9	Run / Stop	Start/stop running the sequence with the current settings.

5.3.2. High-Speed Mode

High-speed mode is only available from certain firmware revision in each model. This mode allows the sequence to be programmed into the device's internal memory to be executed without additional USB communication delays at each step. The trade-off is that it is not possible to query the switch state during the process.

See below table of models with the earliest revision that supports high-speed mode. The typical processing delay for each model dictates the minimum dwell time that can be achieved:

Model name	Firmware revision	Processing delay	Typical switch transition time
U2C-1SP4T-63H	B9	No delay	0.2 µs
USB-1SP8T-63H	A5	10 µs	0.2 µs
USB-2SP4T-63H	A5	12 µs	5 µs
USB-4SP2T-63H	A5	25 µs	0.2 µs
U2C-1SP2T-63VH	B9	No delay	0.7 µs
USB-1SP16T-83H	A5	10 µs	5 µs
USB-2SP2T-DCH	A5	10 µs	10 µs
U2C-1SP4T-852H	All units	No delay	0.2 µs
USB-1SP8T-852H	All units	10 µs	0.2 µs
USB-2SP4T-852H	All units	12 µs	5 µs
USB-4SP2T-852H	All units	25 µs	0.2 µs
USB-1SP2T-183	All units	10 µs	5 ns
USB-1SP4T-183	All units	10 µs	10 ns
USB-1SP8T-183	All units	10 µs	25 ns
USB-1SP8T-183SP	All units	10 µs	25 ns
USB-1SP2T-34	All units	10 µs	5 ns
USB-1SP4T-34	All units	10 µs	10 ns
USB-1SP8T-34	All units	10 µs	25 ns
USB-1SP2T-A44	All units	12 µs	10 ns
eSB-1SP2T-A673	All units	No delay	0.6 µs
eSB-1SP4T-A673	All units	No delay	0.6 µs
RCS-1SP2T-A673	All units	No delay	0.6 µs
USB-1SP2T-673	All units	No delay	5 µs

5.3.3. Typical Transition Speed Plots

The below graphs show the typical transition time (10% / 90% signal amplitude) for selected models at different dwell times. This is the time during which the signal path is interrupted, and thus excludes communication and processing delays:

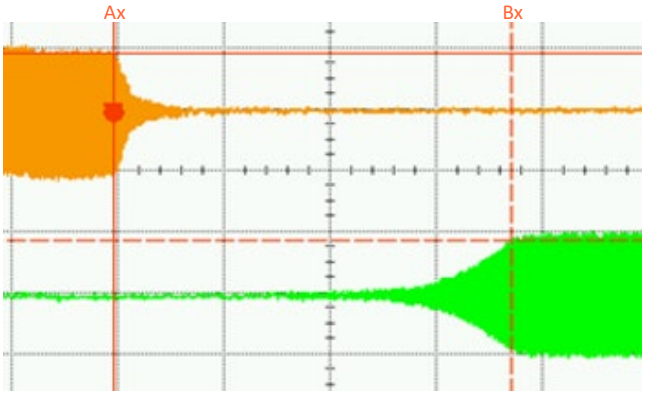


Figure 5.3.3.a: U2C-1SP2T-63VH with dwell time 5 µs

Ax =	614.308 µs
Bx =	614.683 µs
Δx =	375 ns

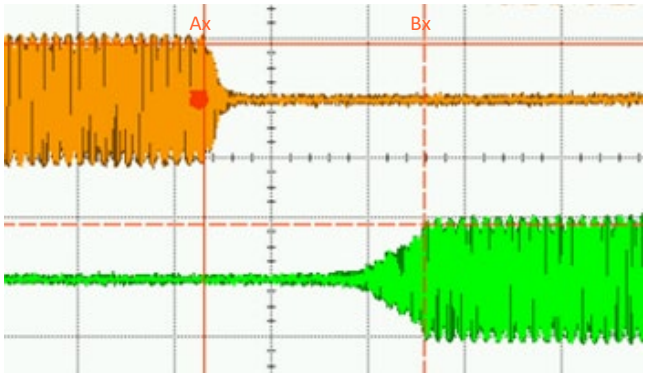


Figure 5.3.3.b: USB-1SP16T-83H Port 1-Port 16 with dwell time 15 µs

Ax =	609.676 µs
Bx =	614.221 µs
Δx =	4.545 µs

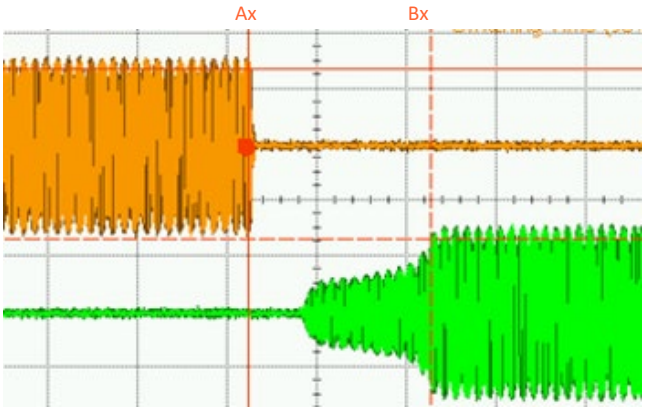


Figure 5.3.3.c: USB-2SP4T-63H Port1-Port4 with dwell time 15 µs

Ax =	625.747 µs
Bx =	629.820 µs
Δx =	4.073 µs

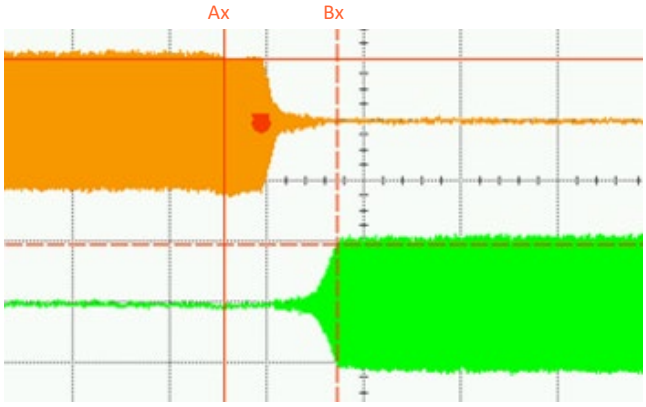


Figure 5.3.3.d: U2C-1SP4T-63H Port1-Port4 with dwell time 5 µs

Ax =	628.071 µs
Bx =	628.188 µs
Δx =	116 ns

The below graphs show the typical transition time (10% / 90% signal amplitude) for selected models at different dwell times. This is the time during which the signal path is interrupted, and thus excludes communication and processing delays:

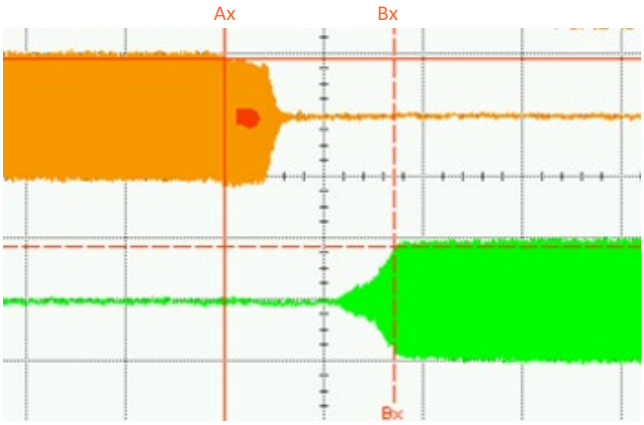


Figure 5.3.3.e: USB-1SP8T-63H Port1-Port8 with dwell time 25 µs

Ax =	634.592 µs
Bx =	634.763 µs
Δx =	171 ns

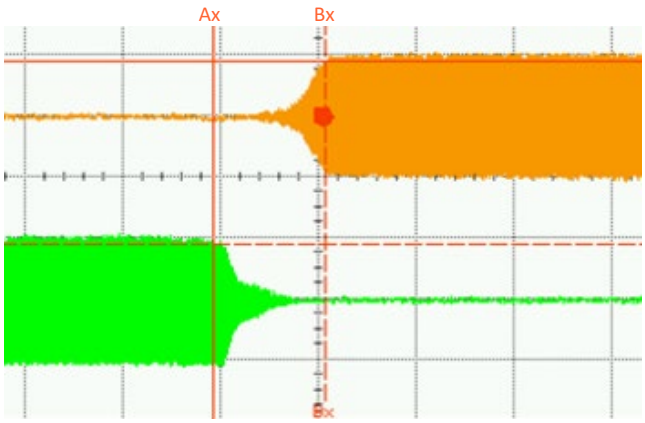


Figure 5.3.3.f: USB-1SP8T-63H Port1-Port2 with dwell time 25 µs

Ax =	642.124 µs
Bx =	642.239 µs
Δx =	115 ns

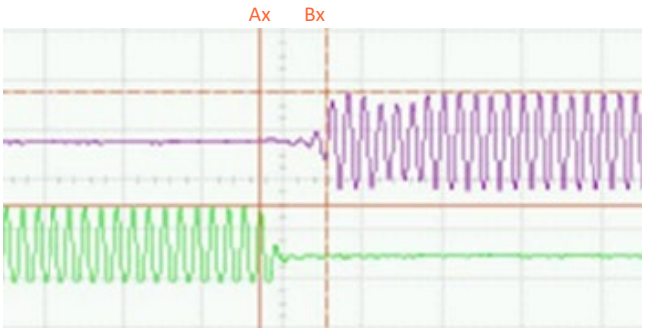


Figure 5.3.3.g: USB-1SP2T-A44 Port1-Port2 with dwell time 12 µs

Ax =	68.3163 µs
Bx =	68.3246 µs
Δx =	8.3 ns

5.4. Ethernet Configuration

Ethernet configuration is available only on Ethernet controlled models (such as the **RCS** switch series).

5.4.1. Default IP Configuration

Mini-Circuits' models ship from the factory with DHCP enabled by default so in most cases an IP address will be assigned automatically when the device is connected to the network. Once a valid IP address has been assigned and identified it can be re-configured via the Ethernet connection (for example, to set a static IP configuration) using our GUI, Ethernet configuration tool, or the programming API.

5.4.2. Default Static / "Link-Local" IP Address

A default "link-local" IP address will be assumed when DHCP is enabled if the device does not receive a valid response from a DHCP server. This also applies when a module with DHCP enabled is connected directly via an Ethernet cable to a PC (instead of via a network). The default static / link-local IP address for all Mini-Circuits devices with the relevant firmware is 169.254.10.10.

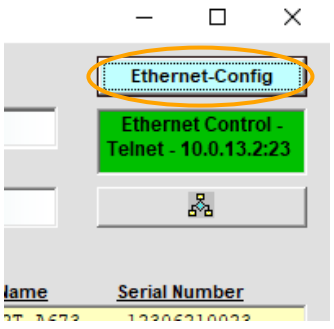
This can be used as a method to configure a specific static IP address for a new device straight out of the box, without resorting to a USB connection or even Mini-Circuits' GUI. Just connect the module directly to the PC, open the HTML Ethernet configuration tool (see *section 5.4.6*), connect to the module using the *169.254.10.10* default IP and proceed to set the new configuration as needed.

5.4.3. Recovery of IP Configuration via USB

If at any time an Ethernet connection cannot be established (for example, if the current IP address is not valid on the network) then the settings can always be reset by connecting to the device using USB and the GUI or programming API.

5.4.4. Default Factory Setting

Default factory settings for Ethernet models are Dynamic IP (DHCP) using port 80 for HTTP or port 23 for Telnet (see *Figure 5.4.5*). To change these settings, click on the **Ethernet-Config** button in the GUI, or use Mini-Circuits' Ethernet configuration tool (see *section 5.4.6*).



5.4.5. Ethernet Settings Screen

The Ethernet Settings screen will open showing the current configuration. *Figure 5.4.5* shows the factory default of the module.

If these settings are appropriate for your local network, then you do not need to access the setup before connecting the module to the network and can proceed to connecting it via Ethernet as described in *section 4.2*.

After making the changes you want, click on **Store** and the changes will be saved to the model's memory.

Note:

- It is not advised to set the HTTP, Telnet, and SSH ports to use the same port.

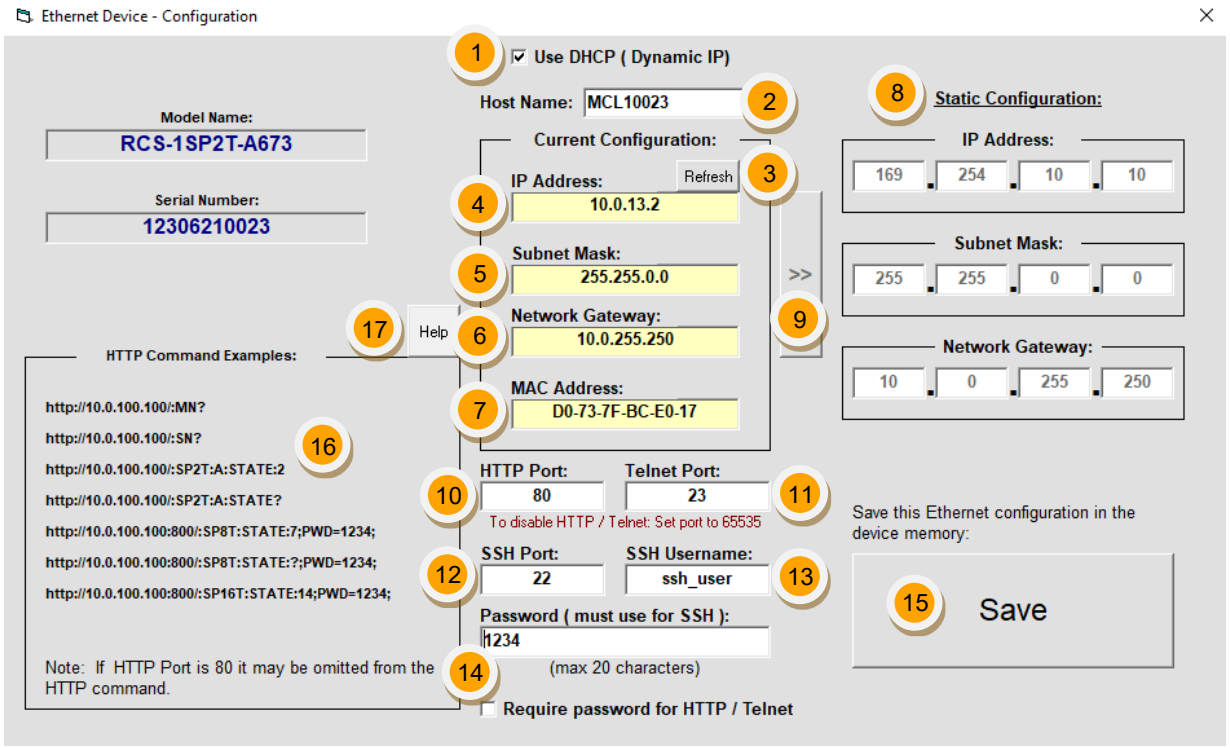


Figure 5.4.5: *Ethernet Settings screen (showing factory default state)*

#	Name	Descriptions
1	Use DHCP	When selected the attenuator will query the server for appropriate parameters with no input from the user.
2	Host Name	A unique name set by the user to be used instead of the IP address when connected to a network with a DHCP. The factory default name is “MCL[5 last digits of S/N]”.
3	Refresh	Request IP address, subnet mask and network gateway from the server.
4	IP Address	The IP address of the unit on the network. When DHCP is selected this is assigned by the server and will change according to the server.
5	Subnet Mask	The network's subnet mask. When DHCP is selected this is assigned by the server and will change according to the server.
6	Network gateway	IP address of the network gateway. When DHCP is selected this is assigned by the server and will change according to the server.
7	MAC Address	Media Access Control address – a unique, unchanging identifier for the attenuator unit.
8	Static Configuration	When DHCP is not selected the user must specify the values below which will not be changed by the server.
9	Copy state	Copies current state of dynamic IP to static IP (not available when DHCP is enabled).
10	HTTP Port	Specify the port to use for HTTP communication on the network (default 80). Note that port address does not get assigned by the server when DHCP is selected. To disable the HTTP protocol set the port to 65535.
11	Telnet Port	Specify the port to use for Telnet communication on the network (default 23). To disable the Telnet protocol set the port to 65535.
12	SSH Port	Specify the port to use for SSH communication on the network (default 22).
13	SSH Login	Login ID for SSH protocol. Factory default is “ssh_user”.
14	Password	To restrict remote access to the unit in HTTP or Telnet mode, check **Use Password** and enter the desired password (up to 20 characters). In SSH protocol, a password is required at all times.
15	Save	Saves the current Ethernet settings into the device’s memory.
16	HTTP command examples	A short list of useful HTTP commands. For more programming help, refer to the programming manual.
17	Help	Short helpful information on the window and how to use it.

5.4.6. Ethernet Configuration Tool

The Ethernet configuration can also be changed via Ethernet control. To make changing the Ethernet configuration easier for users operating in a non-Windows environment or otherwise can't use the provided GUI, Mini-Circuits created the Ethernet configuration tool.

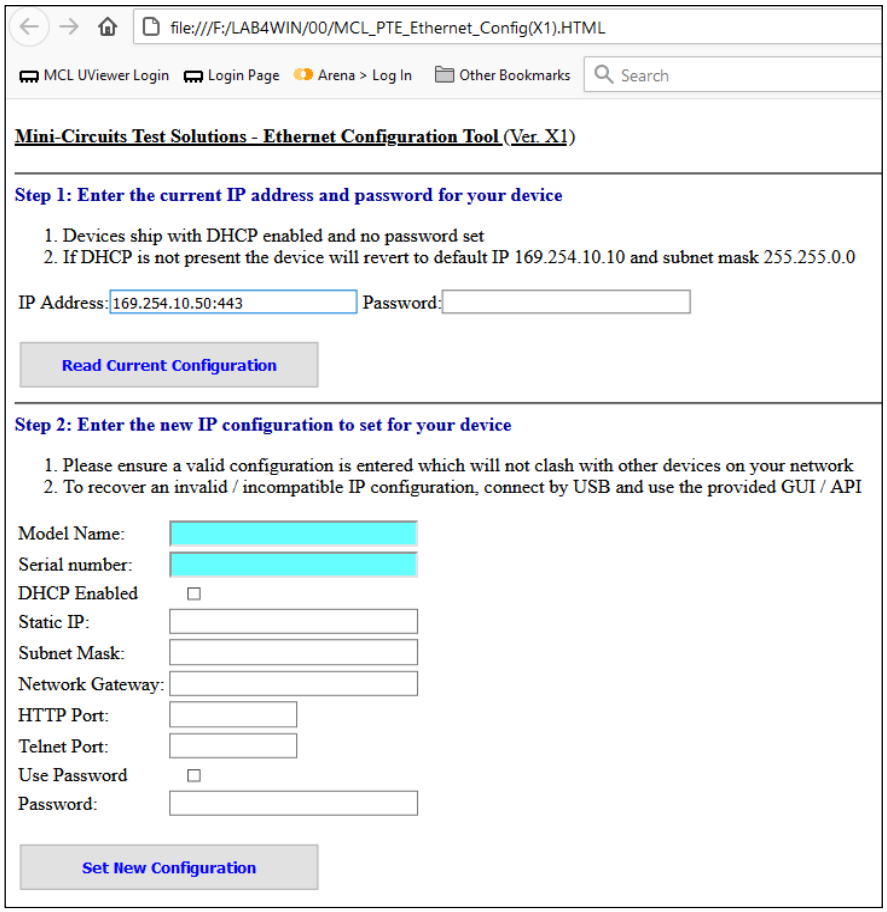
https://www.minicircuits.com/softwaredownload/MCL_PTE_Ethernet_Config.zip

Note:

- Javascript must be enabled in your browser to use the configuration tool.

To use the configuration tool:

- Type the IP address in the field in step 1 (if you assigned a password for the unit type it as well).
- If you set the device to some port other than 80, enter the port as well in the same field, then click **Read Current Configuration**.
- The fields in step 2 will be populated with the current state of the device. Enter the updated information in the relevant fields.
- Click **Set New Configuration** to end the process.



5.5. Firmware Update

All Mini-Circuits units are shipped with the latest available firmware and an update is usually not required. Mini-Circuits occasionally makes firmware update files available as a courtesy to add additional features or correct known issues.

Please contact testsolutions@minicircuits.com for details.

Caution:

- The firmware update process has the potential to render the device inoperable in the event of communication failure. Updates should only be carried out with a stable PC and USB connection, and in-line with Mini-Circuits' guidelines.
- A recovery option is available to restore units rendered inoperable by an incorrect upgrade process (see *section 5.6* for details).

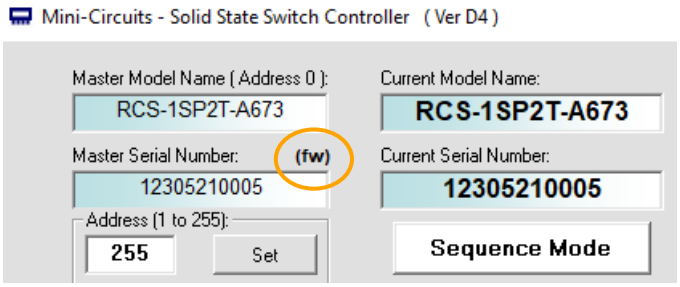
5.5.1. Requirements

To update a unit's firmware, a Windows computer with an installation of Mini-Circuits' Solid State Switch software is required. Additionally, a suitable firmware file provided by Mini-Circuits' Test Solutions department needs to be available on hand.

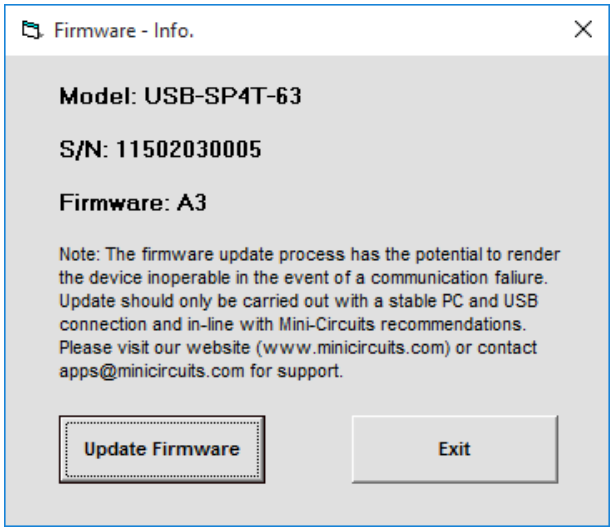
5.5.2. Process

To start the upgrade process, follow the below instructions carefully:

- Connect only the unit to be upgraded to the PC via USB (see *section 5.1.1*) and start Mini-Circuits' Solid State Switch GUI program.
- After selecting **USB** connection, click the **(fw)** indicator on the main screen (above the master unit's serial number display).



- The "Firmware – Info" window note the firmware revision currently installed on the unit. Chose **Update Firmware** to proceed or **Exit** to cancel the process.



- Navigate to the location of the firmware *.hex* file you received from Mini-Circuits' Test Solutions and chose it. The selected file should then be installed on the unit with the process taking up to a minute.

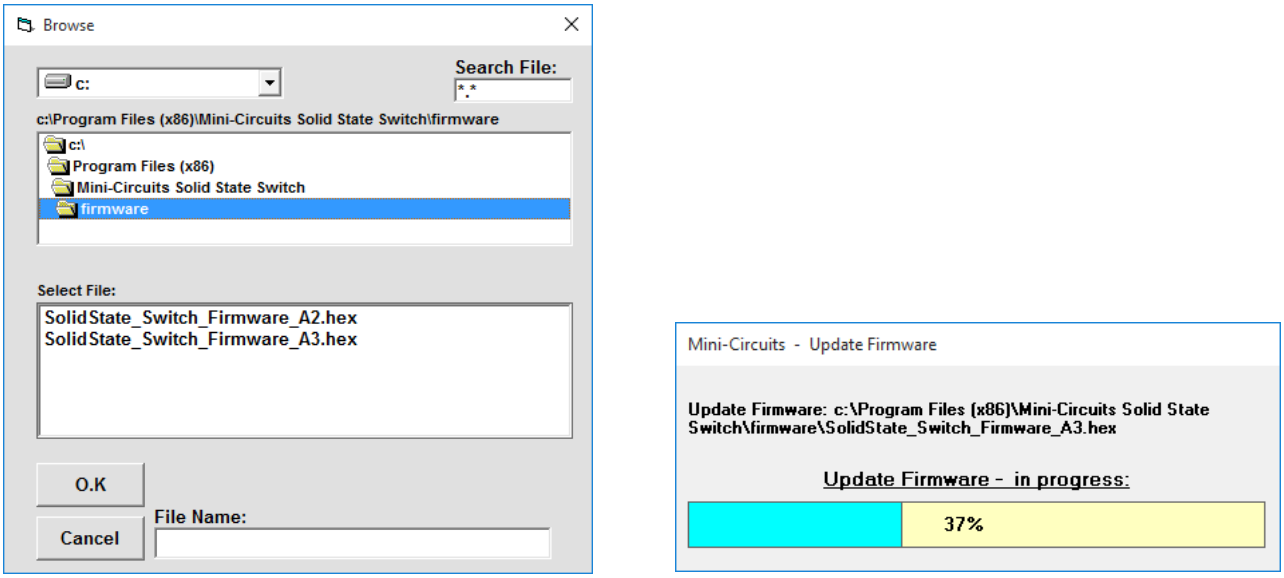


***Figure 5.5.2**: Left – Browse Window ; Right – Progress Bar Window (visuals may slightly differ than presented)*

Caution:

- Do not disconnect the unit or shut down the program while the firmware is being updated. Doing so may damage the unit.
- Attempting to start a second GUI session while the firmware is being updated may cause the firmware to be corrupted. It is therefore recommended not to attempt to start any additional GUI sessions until after the firmware upgrade has been completed.

- After the firmware has been updated a confirmation alert will appear. Click **OK** to shut down the program and restart it.
- If the firmware upgrade was interrupted this can result in partial installation rendering the device inoperable. Refer to *section 5.6* to use the firmware recovery function on your unit.

5.6. Firmware Recovery

Mini-Circuits models feature a firmware recovery option for cases where the unit's firmware has become corrupted rendering it no longer accessible (for example, due to an interrupted firmware upgrade).

Caution:
- Ensure you have the firmware file ready before attempting a recovery process.
- Contact testsolutions@minicircuits.com if you do not have the *.hex* firmware file.

5.6.1. Recovery Steps (non-RCS models)

Follow the below recovery steps for all non-RCS switch models:

- Connect the unit to the PC via USB.
- Start Mini-Circuits' Solid State Switch GUI program and allow it time to attempt and establish a connection with the unit.
- If the connection attempt has failed, an alert would appear advising the user of a corrupt firmware.
- Click **Yes** to proceed with the firmware recovery and refer to *section 5.5.2* on how to proceed.

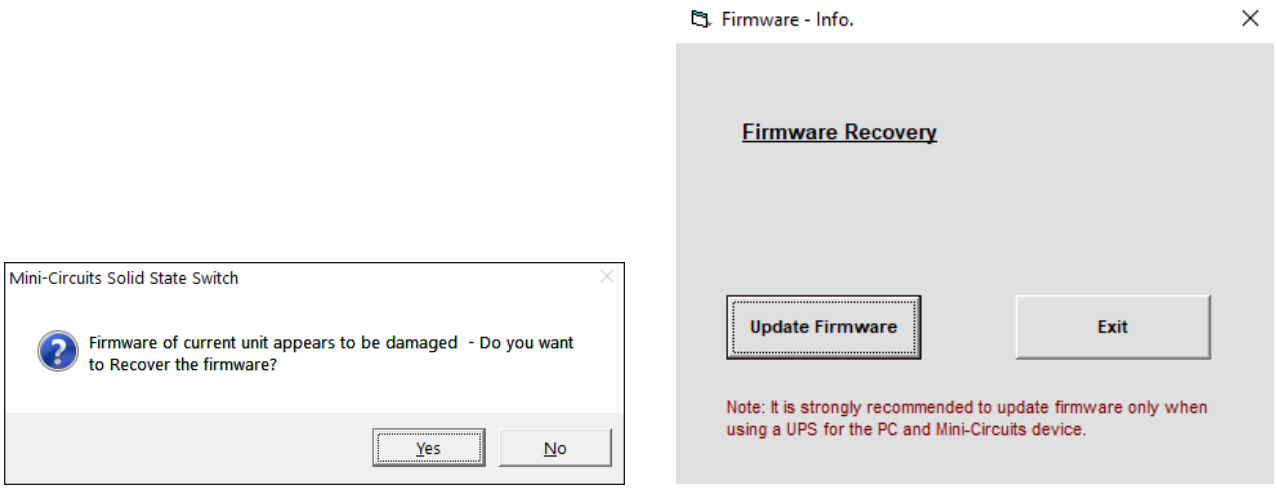


***Figure 5.6.1**: A corrupted firmware alert (left) and firmware recovery window (right)*

5.6.2. Recovery Steps (RCS Models)

Follow the below recovery steps for RCS series switch models only:

- Connect the unit to the PC via USB.
- Navigate to the directory where Mini-Circuits' Solid State Switch GUI has been installed.
- Locate and run the "UpgradeFirmware.exe" utility program.
- Click **Connect** / **Disconnect** and wait for the device to be connected.
- Click **Load Hex File** and navigate to the firmware's (file ending with *.hex*) location on your PC.
- Click **Upgrade Firmware** and wait for the program to finish.

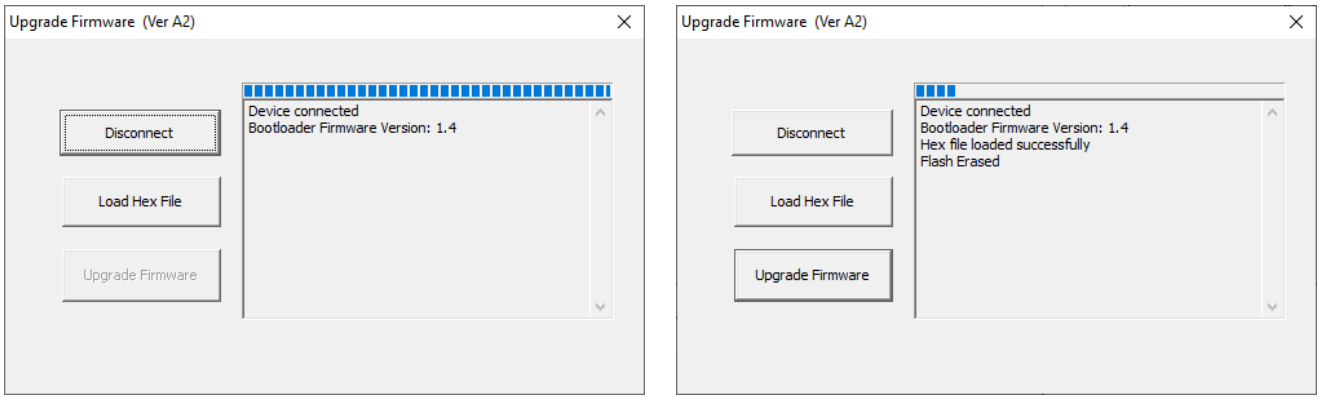


***Figure 5.6.2**: Left – Unit connection step; Right – Firmware upgrade step*

6 - Revision History

Revision OR (Aug 31, 2017):

- Initial revision of the user guide.

Revision A (Jun 05, 2018):

- Added models: USB-1SP16T-83H, U2C-1SP4T-63H, U2C-1SP2T-63VH.
- Added descriptions of SPI and TTL control methods.

Revision B (Jan 10, 2019):

- Added model: USB-2SP4T-63H.
- Added description of high-speed switching mode.
- Added switching time plots for various models.

Revision C (Feb 05, 2021):

- Added model: USB-1SP2T-A44.
- Added description of “Daisy-Chain” control method.

Revision D (Aug 15, 2021):

- Added models: USB-1SP2T-183, USB-1SP4T-183, USB-1SP8T-183.
- Added “Daisy-Chain Operation” in GUI section.

Revision E (Dec 21, 2021):

- Added models: USB-1SP2T-34, USB-1SP8T-34.

Revision F (Apr 28, 2022):

- Added model: USB-1SP2T-673.
- Updated MCL logo (front page) and document footer.

Revision G (Oct 25, 2022):

- Updated user-guide format: Re-written and restructured sections to support format update.
- Added model: USB-1SP8T-183SP.
- Updated “Model Selection Guide” table with RF connector type column.
- Updated “Conformity” section with CE, UKCA and FCC compliance notes.

Revision H (Aug 21, 2023):

- Added models: U2C-1SP2T-852H, USB-1SP8T-852H, USB-2SP4T-852H, USB-4SP2T-852H.
- Added models: eSB-1SP2T-A673, eSB-1SP4T-A673, RCS-1SP2T-A673.
- Added description of Ethernet control method.
- Expanded the “Firmware Update” and “Firmware Recovery” sections.

7 - Contact

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