

User Guide

Programmable Attenuators



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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' programmable attenuators: RUDAT and ZVVA series (USB & RS232), and RCDAT series (USB & Ethernet).

For information on Mini-Circuits' programmable attenuators see: <https://www.minicircuits.com/app/AN49-011.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 Programmable Attenuators

2.1. Introduction

Mini-Circuits has developed a series of programmable attenuators with powerful software support and a range of control options to suit any application:

- USB - All models support the USB Human Interface Device (HID) class for plug & play operation.
- Ethernet - RCDAT models support HTTP & Telnet communication over an IP network, with SSH available on some models for secure communication.
- RS232 - RUDAT & ZVVA models include a D-Sub interface for compatibility with RS232 control systems.
- SPI - RUDAT-13G models include additional support for 3-wire SPI communication.
- TTL - RCDAT-18G-63 includes a TTL control interface for high-speed parallel control.
- Daisy-chain control - Some models include Mini-Circuits' unique dynamic daisy-chain feature, allowing multiple units to be connected together and controlled via a single USB or Ethernet connection.

Refer to *section 2.4* for details of specific models.

2.2. Key Features

The programmable attenuators come in different variations with:

- Wide frequency ranges, from 9 kHz and up to 67 GHz
- Fine attenuation resolutions, as low as 0.05 dB
- Wide attenuation ranges, up to 120 dB

The attenuators are light, compact and can be powered from the USB bus or external power supply, increasing system flexibility.

These models are “plug & play” devices which require no drivers for any of the supported interfaces. The attenuators can be controlled via the supplied GUI software or with most common lab test software the user can set remotely any attenuation level in range almost instantly. Using the RCDAT’s models Ethernet control it is possible to control the models from almost any computer, or even a smartphone, with a network connection from anywhere in the world.

For additional details, performance data and graphs, outline drawing, ordering information and environmental specifications, see our catalog at: <https://www.minicircuits.com/WebStore/RF-Programmable-Step-Attenuators.html>

2.3. Intended Applications

Mini-Circuits programmable attenuators are intended for indoor use in:

- Lab and test equipment setups for both manual and automated measurements.
- Control systems.
- Production test equipment.

The attenuators 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	Atten. range (dB)	Attenuation resolution (dB)	Max input power (dBm)	Control protocols
RCDAT-3000-63W2	50 MHz – 3 GHz	63	1	+33	USB, HTTP, Telnet
RCDAT-4000-120	1 MHz – 4 GHz	120	0.25	+20	USB, HTTP, Telnet
RCDAT-6000-30	1 MHz – 6 GHz	30	0.25	+20	USB, HTTP, Telnet
RCDAT-6000-60	1 MHz – 6 GHz	60	0.25	+20	USB, HTTP, Telnet
RCDAT-6000-90	1 MHz – 6 GHz	90	0.25	+20	USB, HTTP, Telnet
RCDAT-6000-110	1 MHz – 6 GHz	110	0.25	+20	USB, HTTP, Telnet
RCDAT-6G-120H	200 MHz – 6 GHz	120	0.05	+23	USB, HTTP, Telnet, SSH
RCDAT-8G-120H	200 MHz – 8 GHz	120	0.05	+23	USB, HTTP, Telnet, SSH
RCDAT-8000-30	1 MHz – 8 GHz	30	0.25	+28	USB, HTTP, Telnet
RCDAT-8000-60	1 MHz – 8 GHz	60	0.25	+28	USB, HTTP, Telnet
RCDAT-8000-90	1 MHz – 8 GHz	90	0.25	+28	USB, HTTP, Telnet
RCDAT-18G-63	100 MHz – 18 GHz	63	0.25	+24	USB, HTTP, Telnet, RS232, TTL
RCDAT-30G-30	100 MHz – 30 GHz	30	0.5	+24	USB, HTTP, Telnet, Daisy-chain
RCDAT-40G-30	100 MHz – 40 GHz	30	0.5	+24	USB, HTTP, Telnet, Daisy-chain
RCDAT-50G-30	100 MHz – 50 GHz	30	0.5	+24	USB, HTTP, Telnet, Daisy-chain
RUDAT-4000-120	1 MHz – 4 GHz	120	0.25	+20	USB, RS232
RUDAT-6000-30	1 MHz – 6 GHz	30	0.25	+20	USB, RS232
RUDAT-6000-60	1 MHz – 6 GHz	60	0.25	+20	USB, RS232
RUDAT-6000-90	1 MHz – 6 GHz	90	0.25	+20	USB, RS232
RUDAT-6000-110	1 MHz – 6 GHz	110	0.25	+20	USB, RS232
RUDAT-13G-60	10 MHz – 13 GHz	60	0.5	+23	USB, RS232, SPI
RUDAT-13G-90	10 MHz – 13 GHz	90	0.5	+23	USB, RS232, SPI
eDAT-67G-30	10 MHz – 67 GHz	31.5	0.5	+26	USB, Daisy-chain
eDAT-67G-60	10 MHz – 67 GHz	63	0.5	+26	USB, Daisy-chain
ZVVA-3000*	20 MHz – 3 GHz	25	0.1	+23	USB, RS232

* This model is not recommended for new designs. Available while supplies last.

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

For setup and control instructions for the different control protocols see *chapter 4*.

2.5. Environmental Specifications

Mini-Circuits' programmable attenuators 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 programmable attenuators have been tested in the following operating systems:

- 32-bit systems: Windows 7 or later.
- 64-bit systems: Windows 7 or later (GUI & API); Linux.

The attenuators will work with almost any software environment that supports ActiveX or .Net, including Python, C#, LabVIEW, MatLab and more. Please contact us for support.

Refer to the [programming manual](#) for more information on attenuator programming.

2.7. Conformity

Mini-Circuits' programmable attenuators conform to the following international standards:

Standard	Meaning
CE	Meets the requirements of the following applicable European directives and carries the CE marking accordingly: <ul style="list-style-type: none">• 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: <ul style="list-style-type: none">• 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.
RS232	The RUDAT series meets all requirements for RS232 standard.
TCP/IP	The RCDAT 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 RCDAT series supports all requirements for communicating with the Hypertext Transfer Protocol (HTTP) as defined in RFC 1945.
Telnet	The RCDAT series supports all requirements for communicating with the Telnet protocol, as defined in RFC 854.
SSH	The RCDAT 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

The programmable attenuators are supplied with a control cable:

- 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)

The following optional accessories are available (see [models' datasheet](#) for details):

- Ethernet cable: RJ45 (Male) to RJ45 (Male) Cat 5E cable
- RS232 & TTL cable: 15 pin D-sub (Female) to Pig-tail (bare wires)
- RS232 cable: 9 pin D-sub (Male) to 9 pin D-sub (Female)
- USB extension cable: USB type A (Male) to USB type A (Female)
- Daisy-chain cable: Digital snap fit (Male-Male) cable assembly connectors
- AC/DC power adapter suitable for a wide selection of wall sockets
- Mounting bracket
- The full software package including GUI, API DLL files and programming instructions, can be downloaded from <https://www.minicircuits.com/softwaredownload/patt.html>

2.9. Service and Calibration

The programmable attenuators do not require any periodic service or calibration.

The only user-performed service possible for attenuator modules 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' programmable attenuators 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 attenuator modules:

Caution:

- Do not input to the device signals of greater power than the attenuator 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.

2.11. Functional Block Diagram

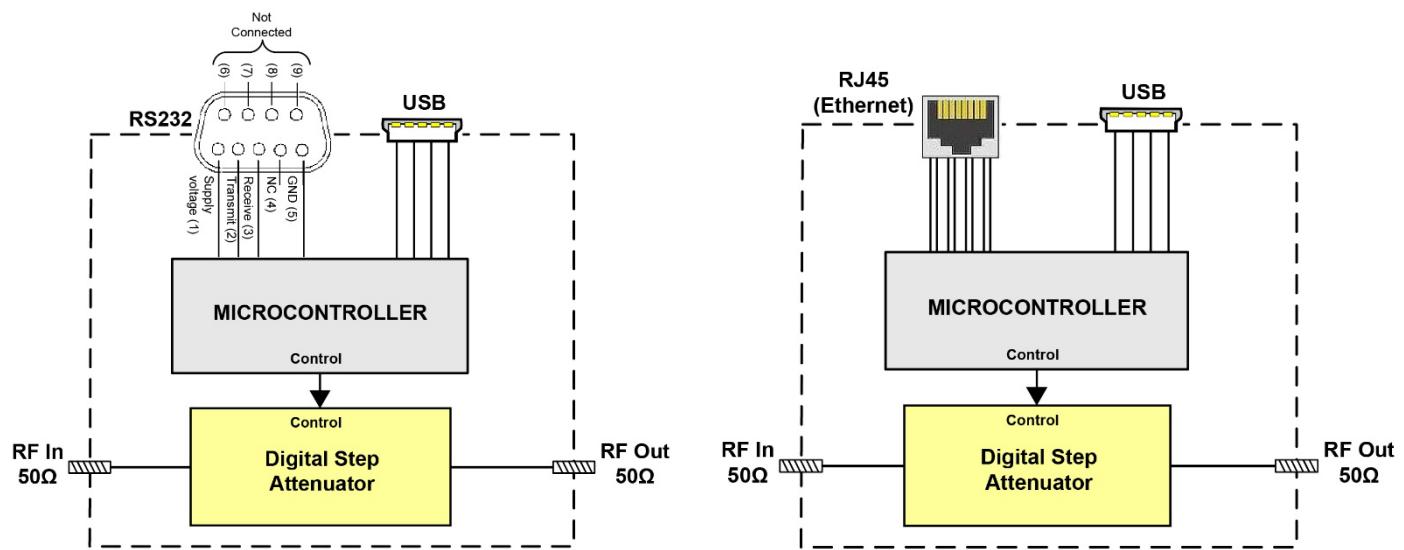


Figure 2.11a: Functional block diagrams RUDAT (left) and RCDAT (right)

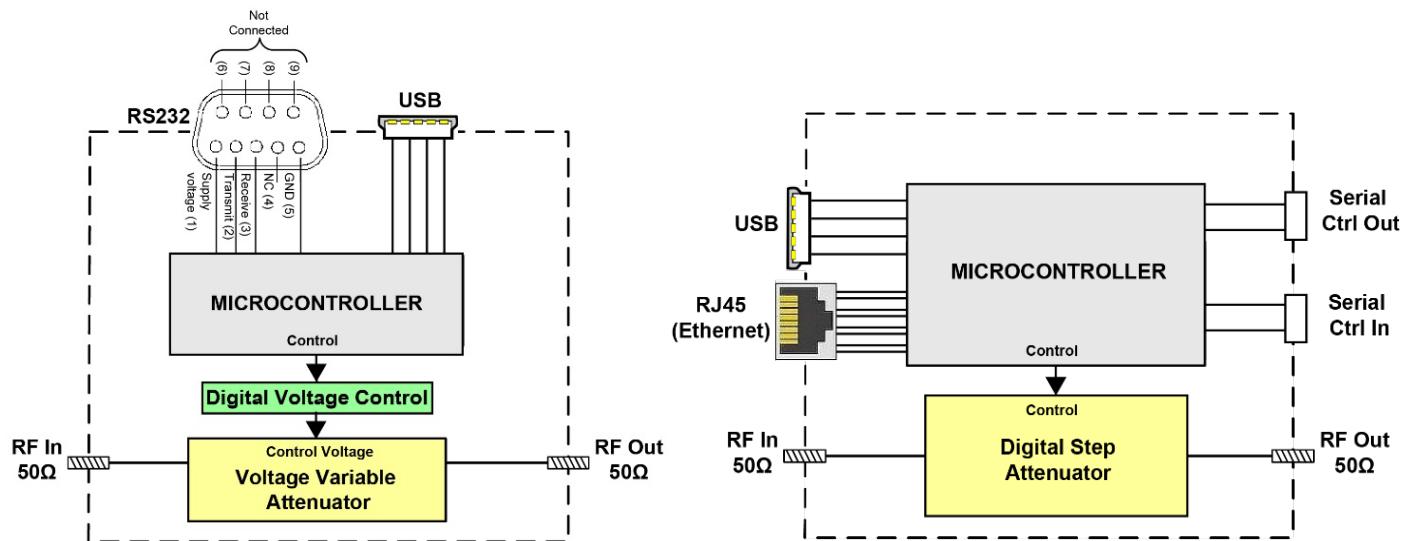


Figure 2.11b: Functional block diagram for ZVVA (left) and RCDAT with daisy-chain (right)

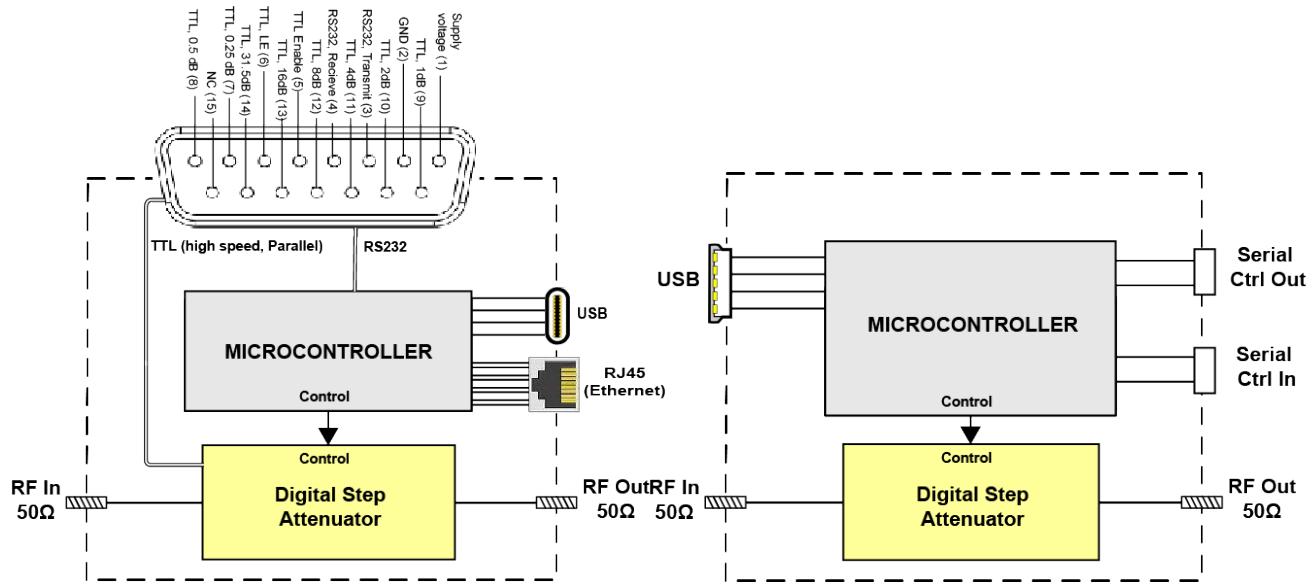


Figure 2.11c: Functional block diagram for RCDAT-18G-xx (left) and RUDAT with daisy-chain (right)

3. Software Setup

3.1. System Requirements

The minimum requirements for the installation of the Mini-Circuits programmable attenuator software package and API on the host PC are:

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

When using the supplied power adaptor, a power source of 110-220V_{AC} (with a socket matching one of the two pin plugs provided) is also needed.

Control method	Required support
RS232 control	Serial COM port
USB control	USB HID
Ethernet control	Network connection

3.2. Software Downloads & Resources

The full programmable attenuator software package (including GUI, API and documentation) is available for download from: <https://www.minicircuits.com/softwaredownload/patt.html>

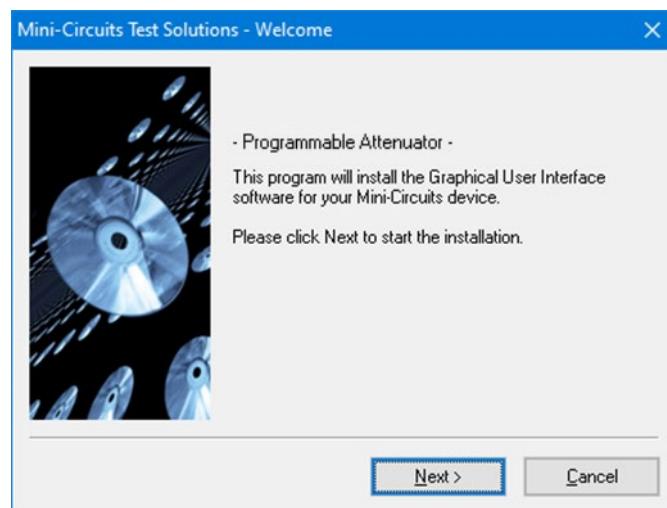
3.3. Software Installation

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

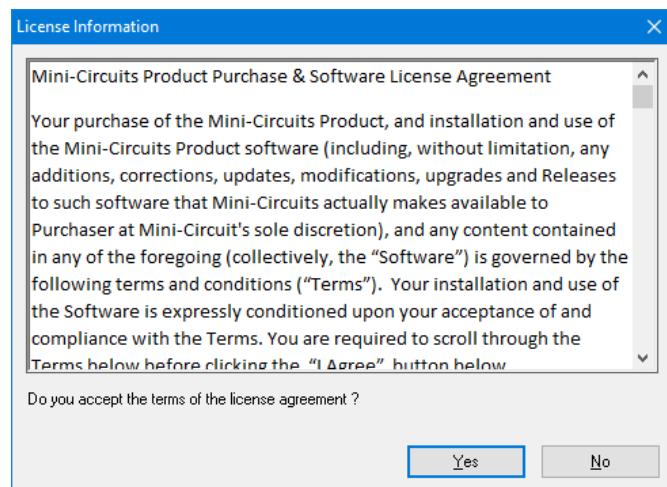


5. If prompted by Windows User Account Control, enter user credentials for an account allowing software installation.

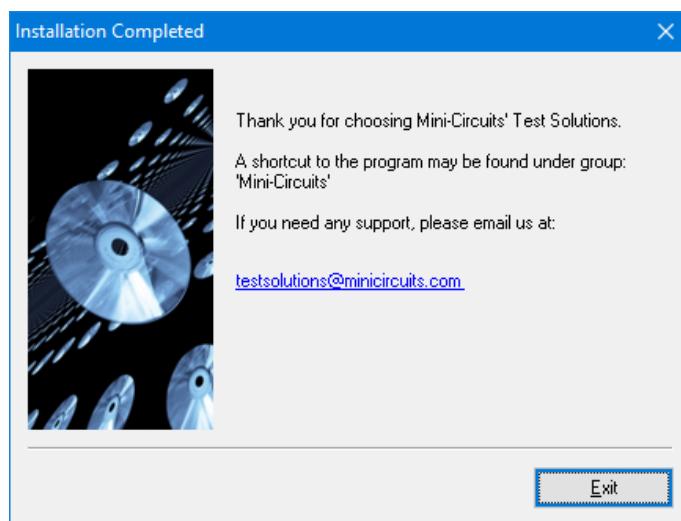
6. Click **Next** to begin the installation.



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



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

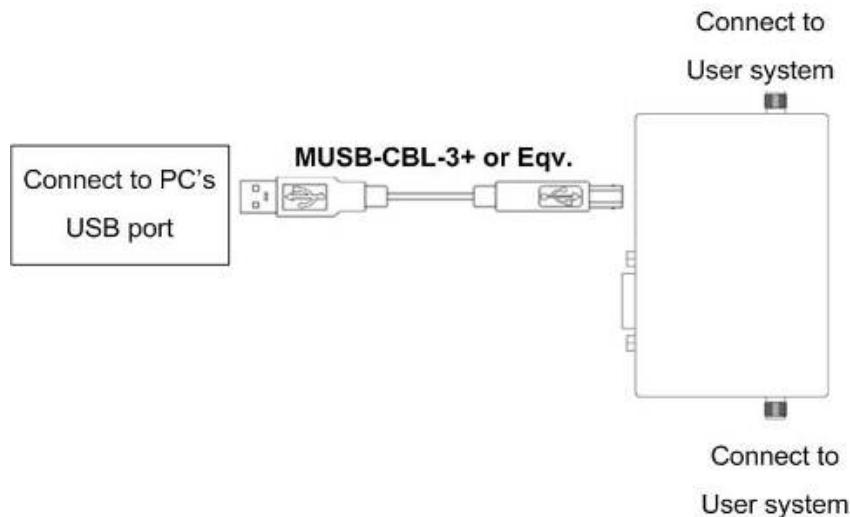


In the event of any issues with installation, please contact testsolutions@minicircuits.com for support.

4. Hardware Setup

4.1. USB Control (All models)

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

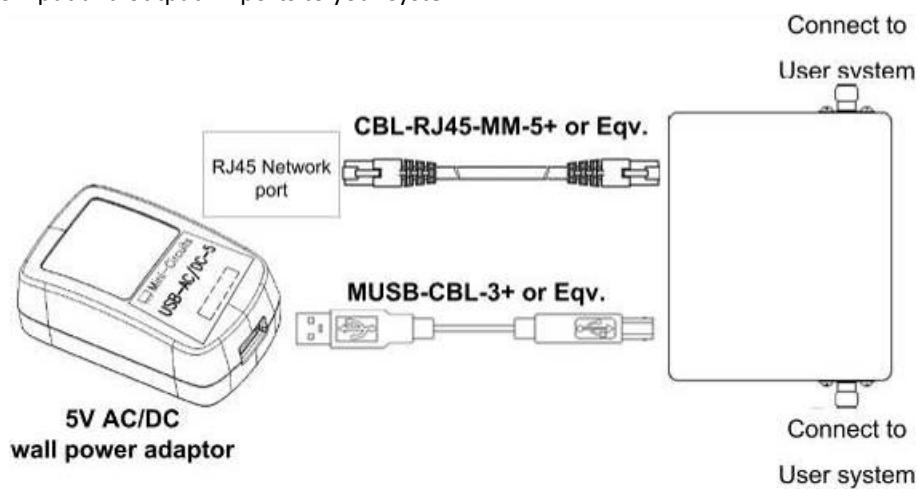


Caution:

- The maximum allowed RF input for programmable attenuator models is reduced at low frequencies.
- Exceeding these values may damage the attenuator. Check the individual model datasheet and do not exceed the specified limits.

4.2. Ethernet Control (RCDAT models)

- Connect unit to power source via USB cable or the provided power adaptor.
- 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.



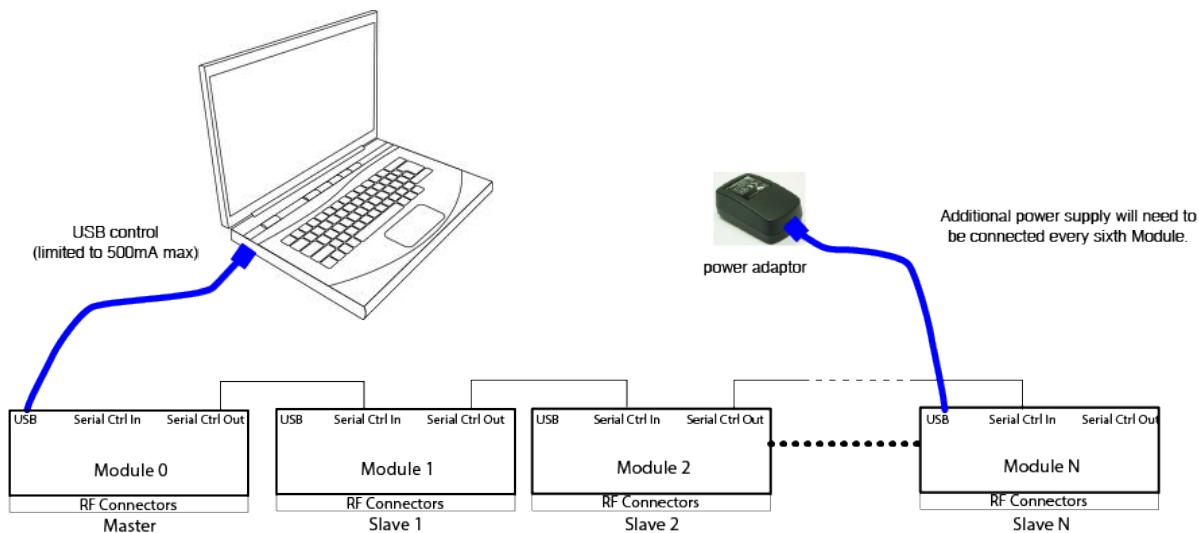
Note:

- For RCDAT-18G-xx models, the 5V DC supply can also be applied to pin #1 of the D-sub instead of the USB connector.

4.3. Daisy-Chain Control

Some models include Mini-Circuits' novel dynamic addressing daisy-chaining interface which allows multiple modules to be connected together into a master/slave chain, with independent control of each module through the single USB 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.
- It is recommended to disable the Ethernet function (see *section 5.3*) of the slave units before connecting them in series to reduce power consumption.

4.3.1. Setup Instructions

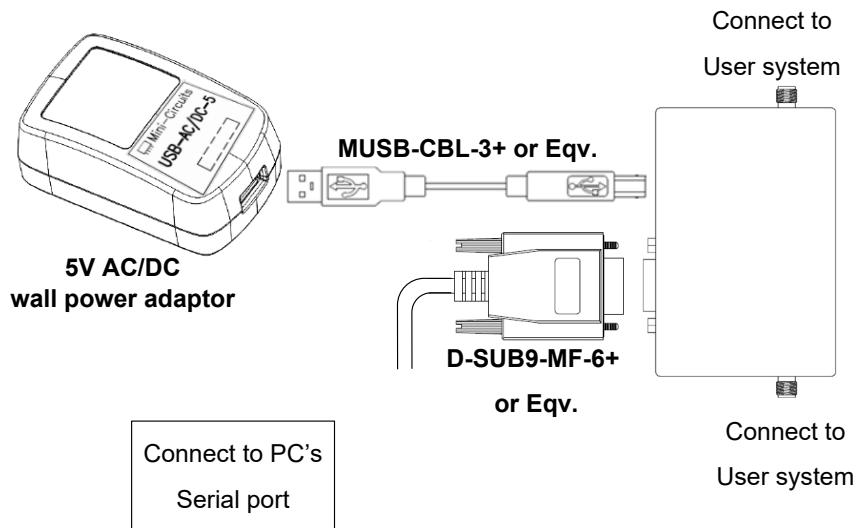
Digital & DC connections for daisy-chain control can be done in any order so long as addresses are refreshed once all units and power supplies are connected.

1. Arrange the required modules on the work surface in the order they are to be addressed.
2. 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.
3. Note the DC current draw of each module in the daisy-chain from the published datasheets.
4. Starting from the first module in the daisy-chain, sum the DC current draw of each module to confirm whether the total exceeds the maximum pass-through current (500 mA), or the maximum available from the USB supply (if lower).
5. 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.
6. Repeat the check from this module forward and add additional power supplies as necessary.
7. Finally, connect the USB cable from the first module to the control PC and the complete chain will power up and automatically assign address (from 00 to nn).
8. To add additional units to the daisy chain just repeat step 6 from the last unit connected to a power supply then connect the additional units with serial control cables and click on the address refresh button in the GUI (below the list of units connected).

4.4. RS232 Control (with power via USB)

4.4.1. Setup Instructions

- Connect unit to power source via USB cable or the provided power adaptor.
- Connect a D-Sub cable between the unit's D-Sub port and computer's serial port.
- Connect the unit's input and output RF ports to your system.



Note:

- See individual model data sheet for specific model pinout.
- For RUDAT-13G-xxx verify pins 7-9 in the D-Sub connector are not connected to any active signal as this may disrupt proper operation.
- For RCDAT-18G-xx verify pin 5 is not connected to any active signal as this may disrupt proper operation. See section 4.8 for details on using Trigger.

4.5. RS232 Control (with power via D-Sub)

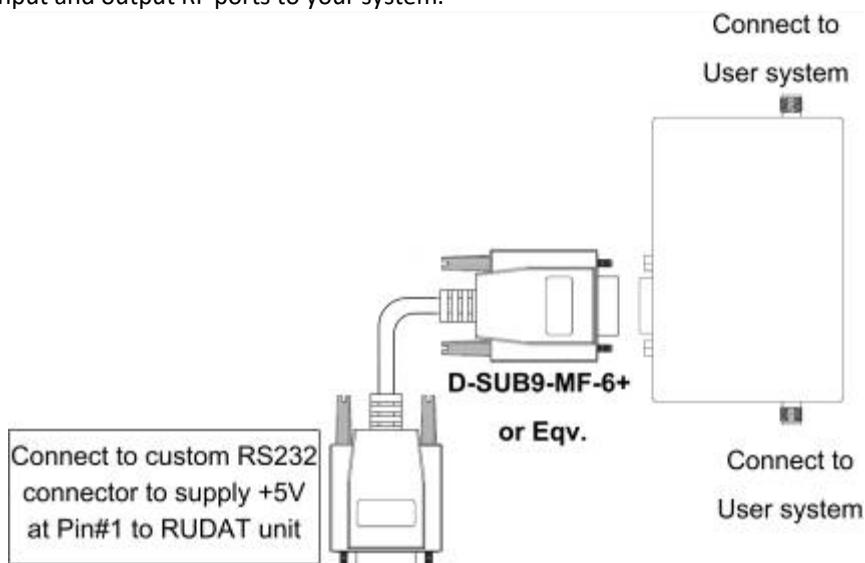
This option requires the use of an RS232 port wired to supply +5V_{DC} at Pin #1.

It is supported in the following units:

Model P/N	Serial number
RCDAT-18G-63	All serial numbers
RUDAT-6000-30	11405010010 and greater
RUDAT-6000-60	11407150001 and greater
RUDAT-6000-90	11403230000 and greater
Other RUDAT models	All serial numbers
ZVVA-3000	All serial numbers

4.5.1. Setup Instructions

- Connect unit to power source via USB cable or the provided power adaptor.
- Connect a control cable between the unit's D-sub connector and the controller, wired according to the pin-out table in the datasheet.
- Connect the unit's input and output RF ports to your system.



4.6. SPI Control (RUDAT-13G-xx models)

4.6.1. SPI Communication

SPI control allows the device's attenuation to be set using a simple serial data sequence of LVTTL logic levels. It is a synchronous communication method designed for minimal control systems (no need for a PC), and as such, it is not possible to query any of the attenuator's parameters in this mode of operation.

SPI uses an 8-bit serial in, parallel-out shift register buffered by a transparent latch with Data, Clock, and Latch Enable (LE) voltages compatible with 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 Value entered should be desired attenuation x2 -- for example, to set an attenuation level of 45.5 dB the user will enter 91 decimal which is 0101 1011 in binary.

The LE input controls the latch. When LE is high, the latch is transparent and the contents of the serial shift register control the module. When LE is brought LOW, data in the shift register is latched.

The shift register should be loaded while LE is held low to prevent the attenuation state from changing as data is entered. The LE input should then be toggled high and brought low again, latching the new data. The timing for this operation is defined by the "SPI Timing" diagram and "SPI Interface AC Characteristics" table.

Note:

- SPI voltage levels and timing instructions are covered in the models' datasheets.
- SPI is a synchronous communication method designed for minimal control systems and thus, it is not possible to query any of the attenuator's parameters in this mode of operation.
- As SPI and RS232 control share the same plug, when using SPI control it is recommended to keep pins #2 & #3 disconnected to avoid problems with proper operation.

SPI Interface AC Characteristics				
Symbol	Parameter	Min	Max	Units
f_{clk}	Serial data clock frequency		10	MHz
t_{clkH}	Serial clock High time	5		ns
t_{clkL}	Serial clock Low time	5		ns
t_{LESUP}	LE setup time after last clock falling edge	30		ns
t_{LEPW}	LE minimum pulse width	20		ns
t_{SDSUP}	Serial data set-up time before clock rising edge	5		ns
t_{SDHLD}	Serial data hold time after clock falling edge	5		ns

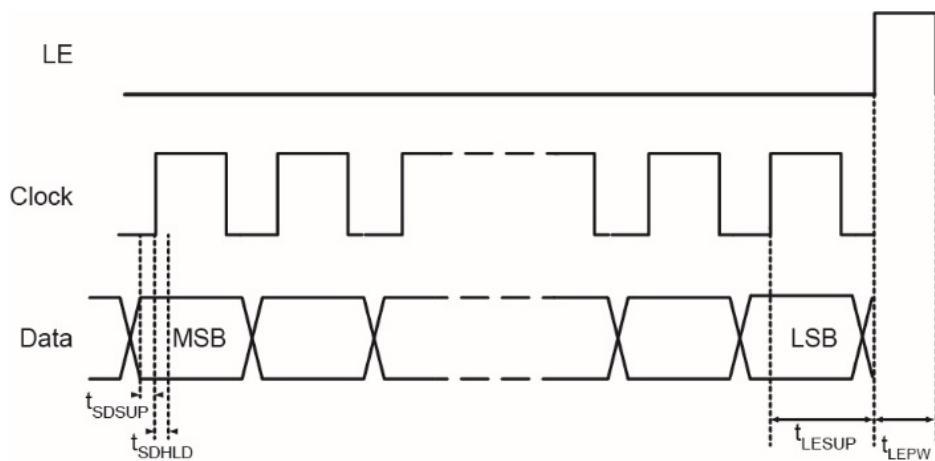


Figure 4.6.1: SPI timing diagram

4.6.2. Setup Instructions

- Connect the SPI Clock, Data and Latch Enable pins (see pinout table below) to your I/O control device.
- Connect power as for RS232 control.
- Note the indicator lights up.
- Connect RUDAT input and output SMA ports to your system.

Parameter	Conditions	Min	Typ	Max	Units	Pin #	Function
Voltage Levels	Logic High (Input)	2.1	-	3.3	V	1	+5 V _{DC}
Voltage Levels	Logic Low (Input)	0	-	0.8	V	2	RS232
Control Current	Per Pin	-	-	1	mA	3	Transmit
Clock Frequency	-	-	-	10	MHz	4	RS232 Receive
						5	Not Connected
						6	GND
						7	Factory Use
						8	SPI LE
						9	SPI Clock
							SPI Data

4.7. TTL Control (RCDAT-18G-xx models)

4.7.1. TTL Communication

TTL control allows direct parallel control of the RCDAT attenuation state, bypassing the micro-controller for high-speed response (120 nsec typical response).

The TTL controls use 8 control bits buffered by a transparent latch to select the attenuation state. All TTL controls except the TTL Enable are connected through an internal 10 kΩ pull-up resistor to 3.3V, which sets the default state of the buffer to Max attenuation state with the latch set to “transparent”, allowing any signal on the attenuation control bits to translate immediately to a change in the attenuation state. When LE is held at logic low the buffer is latched and the RCDAT will maintain the same attenuation state regardless of the input.

The parallel interface timing requirements are defined by the “TTL Timing” diagram and “Parallel TTL Interface AC Characteristics” table.

Parallel TTL Interface AC Characteristics				
Symbol	Parameter	Min	Max	Units
t_{SETUP}	TTL Enable setup time - used only to start the TTL control and afterwards not needed.	10	–	μs
t_{PS}	LE Setup time - time from when controls C0.25 - C31.5 are set to LE rising edge.	2	–	ns
t_{LE}	LE pulse width	10	–	ns
t_{HLD}	Hold time - the controls C0.25 - C31.5 need to remain stable after the LE rising edge	10	–	ns

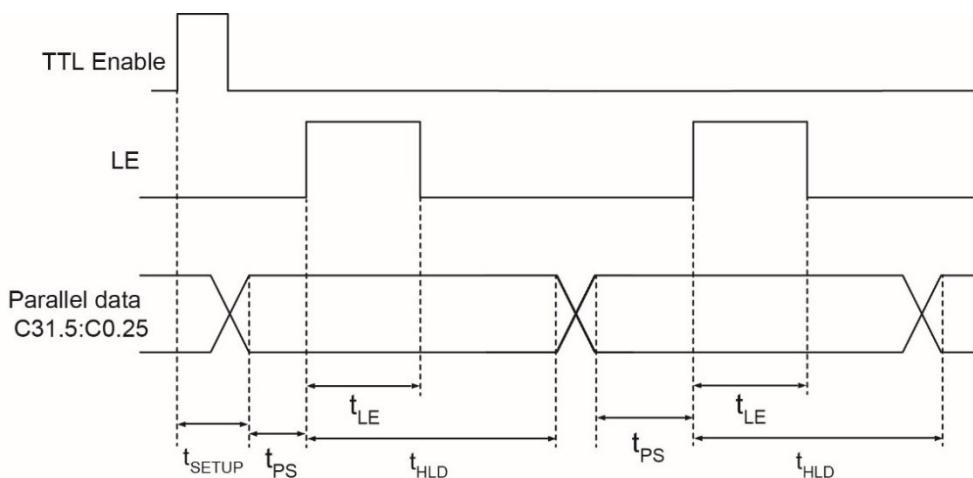


Figure 4.7.1: TTL timing diagram

For latched parallel programming the Latch Enable (LE) should be held low while changing attenuation state control values, then pulses high-to-low to latch new attenuation state into device.

For direct parallel programming, the Latch Enable (LE) line should be pulled high. Changing attenuation state control values will change device state to new attenuation. Direct mode is ideal for manual control of the device.

Pin #	Function
1	+5 V _{DC} (Optional)
2	GND
3	Not Connected
4	Not Connected
5	TTL Enable
6	LE
7	0.25 dB
8	0.5 dB
9	1.0 dB
10	2.0 dB
11	4.0 dB
12	8.0 dB
13	16.0 dB
14	31.5 dB
15	Not Connected

4.7.2. Setup Instructions

To start working with TTL, the user needs to raise momentarily TTL Enable to logic high. The internal micro-controller will go to sleep mode, disabling other control options (USB, Ethernet, and RS232) and enabling the parallel TTL until power is cycled.

Parameter	Conditions		Min	Typ	Max	Units
Voltage Levels	Logic High (Input)		2.2	-	5	V
	Logic Low (Input)		0	-	0.6	
Control Current	$V_{CTRL} = 0 \text{ V}$	Per Pin	-400	-	-	μA
	$V_{CTRL} = 3.3 \text{ V}$		0	-	40	
	$V_{CTRL} = 5.0 \text{ V}$		-	-	300	

4.8. Trigger In (RCDAT-18G-xx models)

In USB, RS232 or Ethernet control the LE control bit can be used as trigger by holding it at logic low until you are ready to implement the command. As long as the LE is held at logic low the DSA state will remain unchanged regardless of commands sent. Once the trigger is set to logic high the latest attenuation command will be implemented. Lowering it again to logic low will keep the attenuation at that state until the next trigger is received.

This allows synchronizing the change of attenuation level with outside processes and eliminates the need to wait for communication delays caused by USB, Ethernet or RS232 communication speeds.

To improve response time the trigger bypasses the RCDAT's micro-controller, thus queries sent to the RCDAT while the trigger is held low will return responses indicating the attenuation state has been changed, but the actual attenuation state will remain unchanged.

Note:

- The "SETATT" command to set a new attenuation value is the only command supported by the trigger function. Sending any other command while the trigger is held low may lead to unexpected results.

5. Using Mini-Circuits' GUI

Both API programming objects (DLL files) for easy control by most common lab test software, and a Windows GUI program for manual control are available from Mini-Circuits website for all programmable attenuator models. See <https://www.minicircuits.com/softwaredownload/patt.html>

5.1. Getting Started

To start the GUI program, use the Start menu or navigate to the location the Mini-Circuits Programmable Attenuator software was installed in and run the program.

Once running, the user will be required to pick one of the available control modes: RS232, USB, HTTP, Telnet, or SSH control.

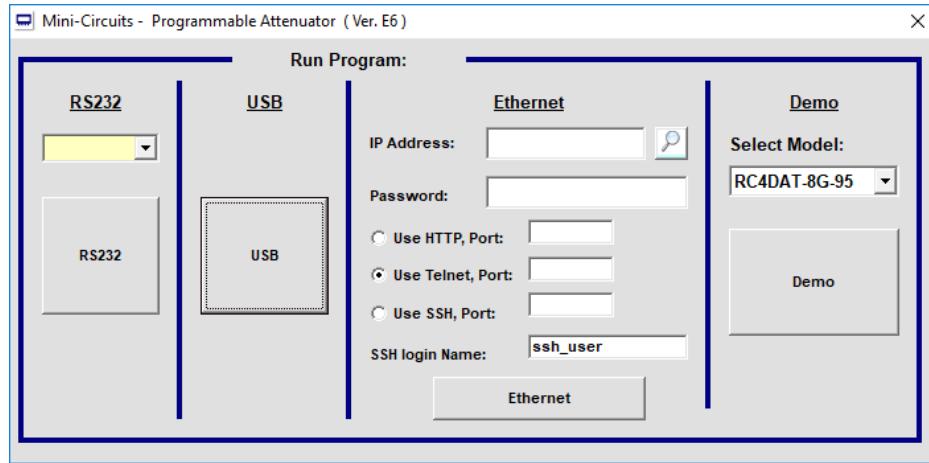


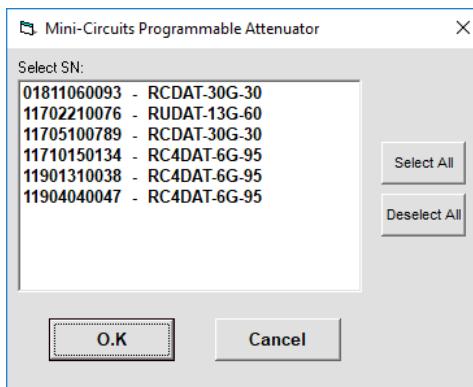
Figure 5.1: Startup screen

In addition to the control modes, the user can try the demo mode – pick one of the available models from the drop-down menu to learn about the GUI and experiment with the model's operation without a unit connected.

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 (non-daisy-chain link), the unit selection screen will appear with a list of the connected models' serial numbers and model names.



Note:

- The program can handle up to 24 units connected simultaneously.

5.1.2. RS232 Control

Use the drop-down menu to select the COM port the unit is connected to and click on the **RS232** button.

If no unit is found at the selected COM port an alert will pop-up advising of the matter. Click **Yes** to proceed anyway or **No** to return to the startup screen. If the alert persists when a unit is connected, then check the power and data connections to the attenuator and verify the correct COM port was selected.

5.1.3. 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 be also required if using non-default ports) or click on the **search icon** next to it to find all Mini-Circuits attenuators 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 5.3](#) or the [programming manual](#) for details.

After clicking on the **search icon**, the IP search will pop up with a list of attenuators' IP addresses and their HTTP 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.

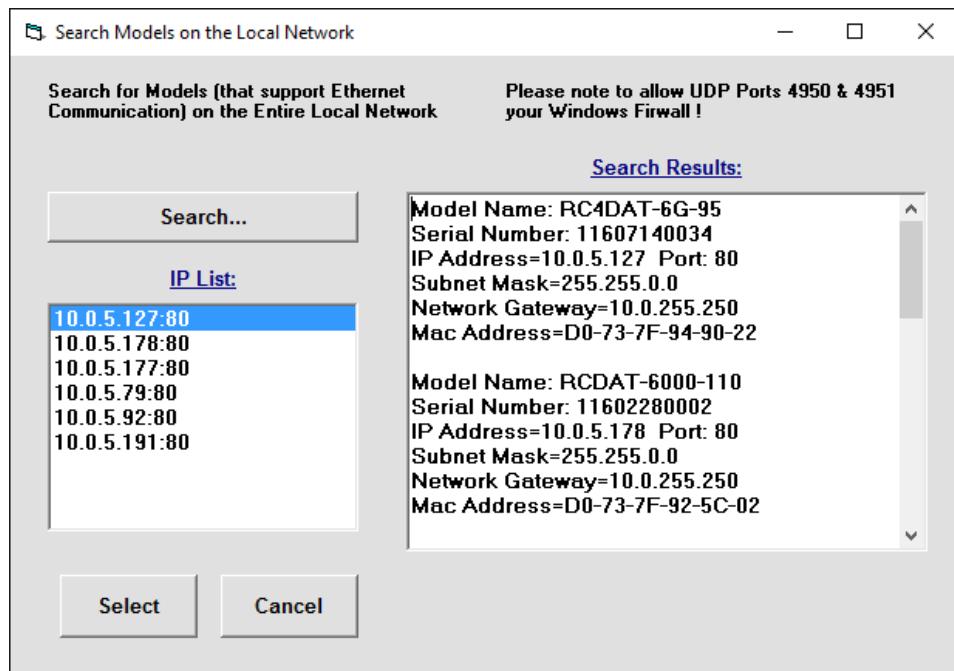


Figure 5.1.3a: Ethernet IP search window

Note:

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

After the IP address has been entered, input the password if one has been set (see *section 5.3*). Proceed to select the communication protocol you wish to use (HTTP, Telnet, or SSH) and click on the **Ethernet** button to begin.

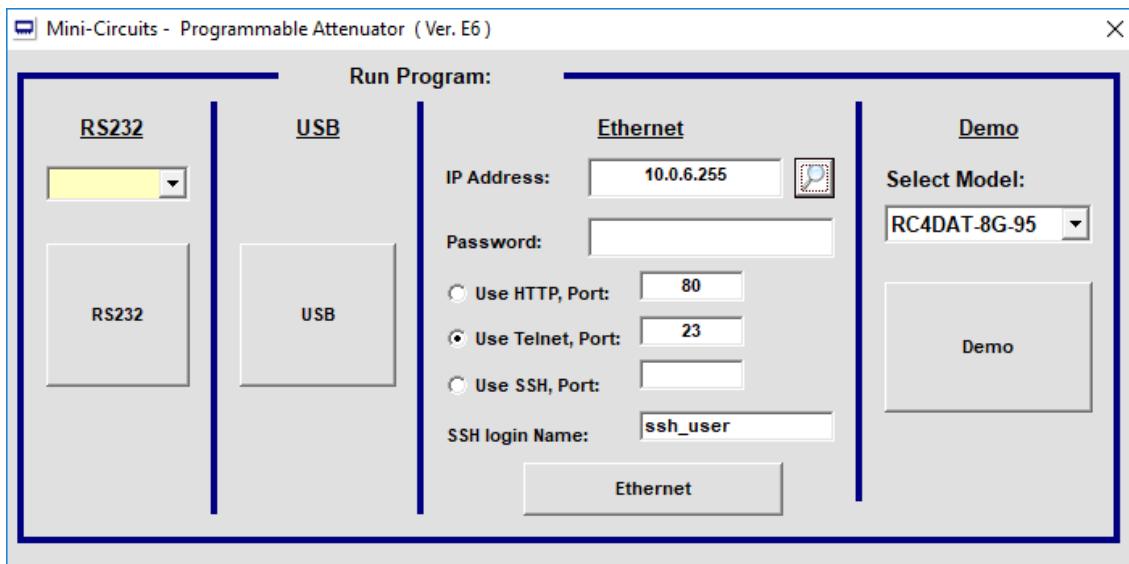


Figure 5.1.3b: Startup screen with Ethernet fields filled

Telnet or HTTP text commands can also be used to control the attenuator. Just type the command in the address field of your internet browser or implement a Get/Post HTTP function in your selected application (for HTTP), or 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 (see *section 3.3*), in the Ethernet directory.

5.2. Operating the Attenuator

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

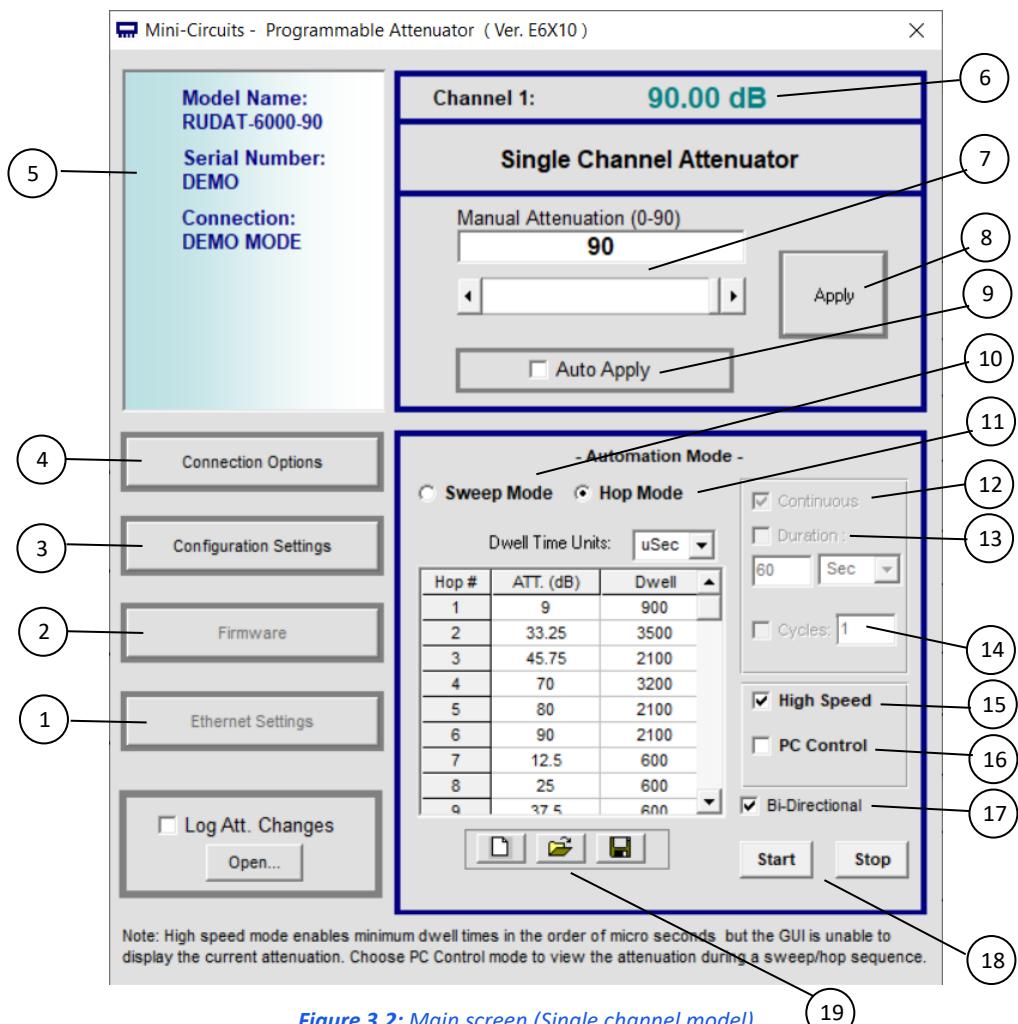


Figure 3.2: Main screen (Single channel model)

5.2.1. Manual Mode Functions

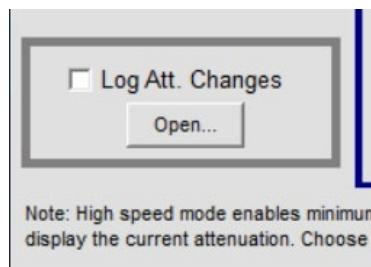
#	Name	Descriptions
1	Ethernet Settings	Opens the Ethernet configuration window (see section 5.3 for details)
2	Firmware	Opens the Firmware update window.
3	Configuration Settings	Opens a pop-up window allowing the user to specify attenuator state at power up (see section 5.2.4 for details) and set the step size used in the manual attenuation setting.
4	Connection Options	Returns to the startup screen
5	Model description	Field describing the model, this shows model part number, serial number and connection details.
6	Current Attenuation	The value the attenuator is currently set to.
7	Manual Attenuator	Attenuation value to be set. This can be changed by either typing a value or using the scroll bar and arrows to change the attenuation.
8	Apply	Applies the changes made to the attenuation setting.
9	Auto Apply	When this check box is selected every change in attenuation setting will be applied immediately, when it is not selected user must click 'Apply' to execute the changes.

5.2.2. Automatic Mode Functions

#	Name	Descriptions
10	Sweep Mode	When selected, allows setting an attenuation sweep with user defined start, stop, step and dwell time values.
11	Hop Mode	When selected, allows setting a table of user defined attenuation and dwell time which the attenuator will "hop" through.
12	Continuous	When selected, the attenuator will repeat the user defined sweep or hop until the Stop button is clicked.
13	Duration	When selected the attenuator will repeat the user defined sweep or hop sequence for the time specified (can be defined in milliseconds, seconds, minutes or hours).
14	No. of Cycles	When selected the attenuator will repeat the user defined sweep or hop sequence for the number of cycles specified.
15	High-speed	Enables high-speed Sweep and Hop functions. See <i>section 5.4.2</i> for details.
16	PC control	Default setting. Sweep and Hop instructions are sent individually to the unit. See <i>section 5.4.1</i> for details.
17	Bidirectional	When selected, the attenuator will sweep or hop through the user defined sequence, then repeat in the reverse direction (sweeping from stop to start or hopping from last to first point in the hop list).
18	Start \ Stop	Start and Stop the automatic run (Sweep or Hop) at the current attenuation setting.
19	Save \ Recall	Allow clearing the current sequence to start a new one, opening a previously saved sequence or saving the current sequence.

5.2.3. Log Attenuation Changes

It is possible to record all attenuation changes the unit undergoes by marking the “Log Att. Changes” option (located at the lower left corner of the GUI).



Upon checking the option, a pop-up will notify the user of the folder location the *txt* log file will be saved to “*C:\Users\Public\Mini-Circuits\ProgrammableAttenuator\Log*”. The log file name format will contain the current date and time, for example “**Log_191211153017**” (Red – Current date in format **YYMMDD**; Blue – Current time in format **HHMMSS**).

Once unchecked, the log file will be saved properly with all the attenuation changes in the aforementioned folder.

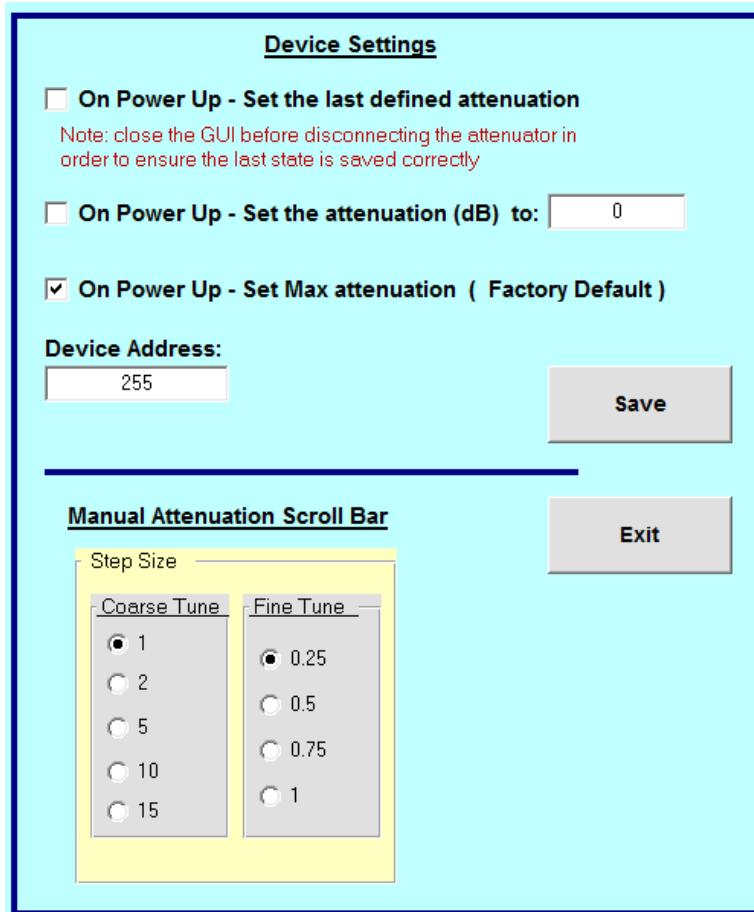
Note:

- Trying to open the file while a recording is on-going will pop-up a notification alert about the last attenuations possibly not being saved to the file.

5.2.4. Configuration Settings

Clicking on **Configuration Settings** opens a pop-up window which allows the user to set the following parameters:

- On Power Up State – The attenuator can be configured to power up with max attenuation setting (factory default), a user defined attenuation value, or the last attenuation value set (For 30/60/90 dB models, firmware A4 or newer is required).
- Device Address – Set the device's USB address in the 1 – 255 range (factory default 255).
- Manual Attenuation Scroll Bar – Coarse tune is the step size for each click on scroll bar; Fine Tune is the step size for the arrows.



Note:

- If the GUI is not shut down before the attenuator is disconnected the last attenuation state will not be saved and if “set last defined attenuation” was selected the attenuator will start up in max attenuation state.
- Shutting down and then starting up the GUI repeatedly in less than 3 minutes while “set last attenuation” is enabled may result in attenuator resetting to max attenuation state at power up due to last attenuation state not being recorded correctly.

5.3. Ethernet Configuration (RCDAT-models)

5.3.1. Default IP Configuration

Mini-Circuits' programmable attenuators 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.

5.3.2. 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 an attenuator 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 attenuator directly to the PC, open the HTML Ethernet configuration tool (see *section 5.3.7*), connect to the attenuator using the 169.254.10.10 default IP and proceed to set the new configuration as needed.

Consult the table below for which firmware revision is required for your unit to support this feature:

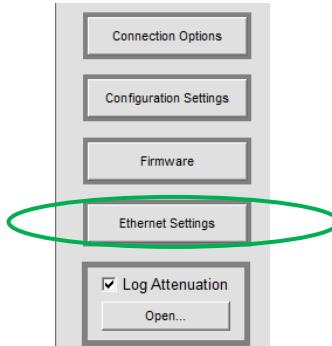
Model P/N	Firmware revision
RCDAT-xG-120H	H7 and newer
RCDAT-18G-xx	H9 and newer
All Other models	F1 and newer

5.3.3. 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.

5.3.4. Default Factory Setting

Default factory settings for RCDAT models are Dynamic IP (DHCP) using port 80 for HTTP or port 23 for Telnet (see *Figure 5.3.6*). To change these settings, click on the **Ethernet Settings** button in the GUI, or use Mini-Circuits' Ethernet configuration tool (see *section 5.3.7*).



5.3.5. Ethernet Setting Screen

The Ethernet Settings screen will open showing the current configuration. *Figure 5.3.6* shows the factory default of the programmable attenuators.

If these settings are appropriate for your local network, then you do not need to access the setup before connecting the attenuator to the network and can connect to the attenuator 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 attenuator's memory.

Note:

- In units with older firmware revisions (see *section 5.3.2*), if no DHCP server is available user will need to change Ethernet configuration via USB control to match their network setup.
- It is not advised to set the HTTP, Telnet, and SSH ports to use the same port.
- RCDAT-30G-30 & RCDAT-40G-30 have an additional setting, “Enable Ethernet”, which is active by default. It can be turned off while in USB control or as a ‘slave’ unit in daisy chain configuration to reduce the unit’s current consumption.

5.3.6. Ethernet Setting Descriptions

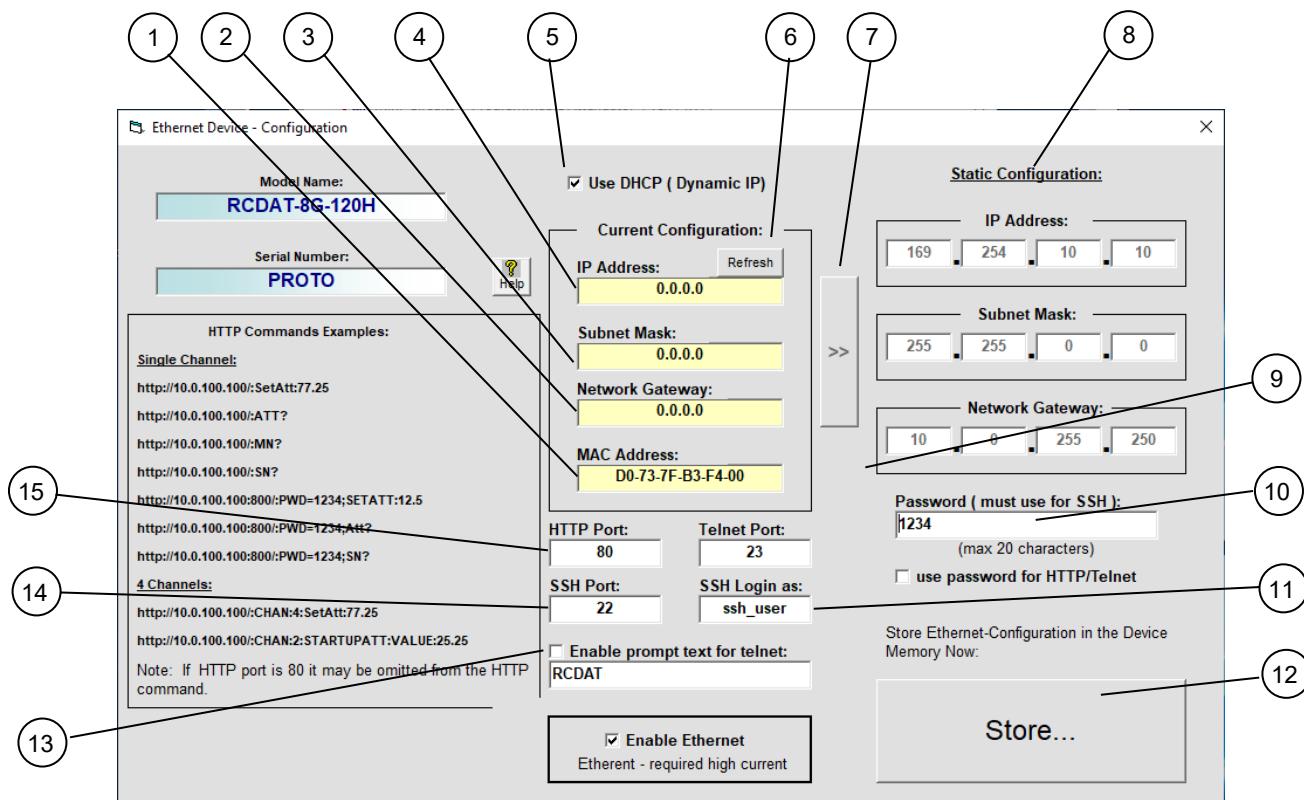


Figure 5.3.6: Ethernet Settings screen (showing factory default state)

#	Name	Descriptions
1	MAC Address	Media Access Control address – a unique, unchanging identifier for the attenuator unit.
2	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.
3	Subnet Mask	The network's subnet mask. When DHCP is selected this is assigned by the server and will change according to 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	Use DHCP	When selected the attenuator will query the server for appropriate parameters with no input from the user.
6	Refresh	Request IP address, gateway and subnet mask from server.
7	Copy state	Copies current state of dynamic IP to static IP, not available when DHCP is selected.
8	Static Configuration	When DHCP is not selected the user must specify the values below which will not be changed by the server.
9	Telnet Port	Specify the port to use for Telnet communication on the network (default 23).
10	Password	To restrict remote access to the attenuator in HTTP or Telnet mode, select "Use Password" and enter the desired password below (up to 20 characters). In SSH protocol Password is required at all times.
11	SSH login	Login ID for SSH protocol. Factory default is ssh_user
12	Store	After you've made all changes, you want to click on this button to save the settings.
13	Telnet Prompt	When enabled the prompt will appear in every response from the unit in Telnet protocol. To have the unit return its model number user prompt "MN", and to have it return its serial number use "SN"
14	SSH Port	Specify the port to use for SSH communication on the network (default 22).
15	HTTP Port	Specify the port to use for HTTP communication on the network (default 80). Note port address does not get assigned by the server when DHCP is selected.

5.3.7. 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 (see **table 5.3.2** for firmware requirements).

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 is 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.

file:///F:/LAB4WIN/00/MCL_PTE_Ethernet_Config(X1).HTML

MCL UViewer Login Login Page Arena > Log In Other Bookmarks Search

Mini-Circuits Test Solutions - Ethernet Configuration Tool (Ver. X1)

Step 1: Enter the current IP address and password for your device

1. Devices ship with DHCP enabled and no password set
2. If DHCP is not present the device will revert to default IP 169.254.10.10 and subnet mask 255.255.0.0

IP Address: 169.254.10.50:443 Password:

Read Current Configuration

Step 2: Enter the new IP configuration to set for your device

1. Please ensure a valid configuration is entered which will not clash with other devices on your network
2. To recover an invalid / incompatible IP configuration, connect by USB and use the provided GUI / API

Model Name:
Serial number:
DHCP Enabled
Static IP:
Subnet Mask:
Network Gateway:
HTTP Port:
Telnet Port:
Use Password
Password:

Set New Configuration

5.4. Sweep and Hop Functions

The GUI provides the ability to carry out an automated sequence of attenuations settings, either a sequential sweep from a start value to a stop value, with a fixed step size (increment or decrement) and dwell time, or an arbitrary "hop" sequence of attenuation and dwell time values.

5.4.1. PC Control Mode

This is the default mode, available on all programmable attenuator models. In this mode, the attenuation sweep or hop sequence is managed by the GUI so each attenuation value is sent to the attenuator one at a time, as needed. Since the GUI is managing the sequence it is always able to display the current attenuation state but each attenuation setting is subject to communication delays between the PC and attenuator. Communication delays vary by computer but in practice this dictates a minimum dwell time in the order of 3 ms or more for USB 3.0 connections, or longer with USB 1 or 2 connections (10 - 20 ms is not uncommon for older computers or slower connections).

5.4.2. High-speed Mode

In high-speed mode, the attenuation sweep parameters or list of attenuation hop values are loaded into the attenuator's internal memory. This initial configuration step, along with the Start and Stop commands from the GUI, are subject to the same communication delays as above but once executed the timing is controlled by the attenuator's internal reference and no further PC communication is required. This enables high speed attenuation sequences with dwell times as low as 600 μ s or 400 μ s (depending on model). Since the PC communication delays are significantly longer than this minimum dwell time, the GUI will not be able to display the current attenuation state in this mode until the sequence is stopped.

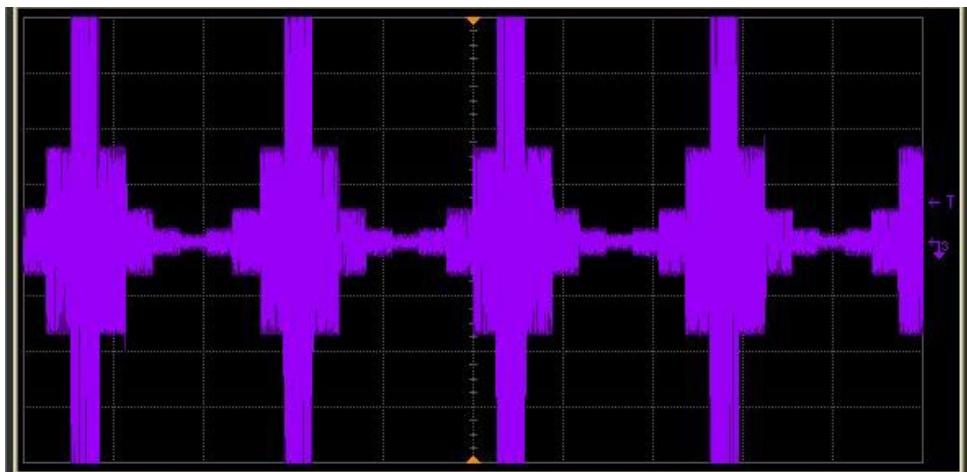


Figure 5.4.2: Plot of signal when sweeping attenuation 0 - 40dB in 10 dB steps (scale 2ms/div)

5.4.3. Attenuator Switching Time

Attenuator models are specified with typical switching times of 100 to 900 ns depending on the model, but even faster transitions can be observed in practice. Switching time in this instance is defined as the time during which the attenuator is transitioning from one attenuation level to the next. This short switching time means the RF signal path has an undefined attenuation state for as short a time as possible during changes in attenuation levels. Switching time is distinct from minimum dwell time during a sweep or hop sequence which is generally dictated by communication and control delays rather than RF switching characteristics.

Some typical switching time measurements applicable to the programmable attenuator series are presented below:

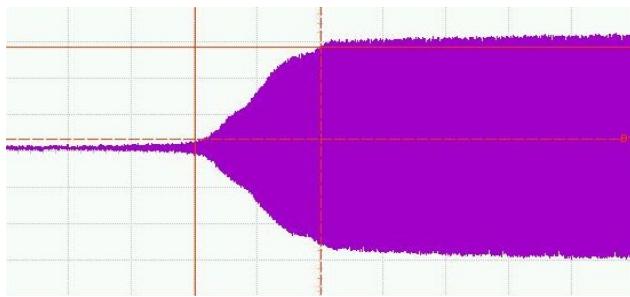


Figure 5.4.3a: Typ. Switching time from 120 to 0 dB (RCDAT-4000-120); 200 ns switching time achieved.

$\Delta x = 200.00$ ns
 $\Delta y = 127.00$ mV

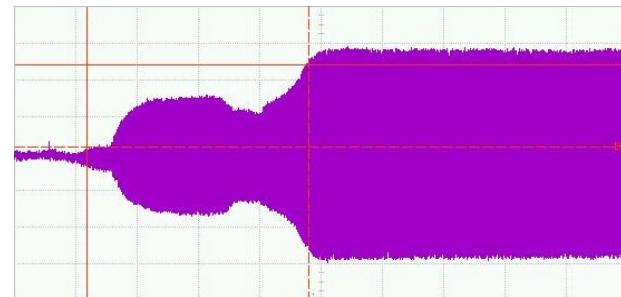


Figure 5.4.3b: Typ. Switching time from 45 to 15 dB (RCDAT-4000-120); 362 ns switching time achieved.

$\Delta x = 362.00$ ns
 $\Delta y = 22.44$ mV

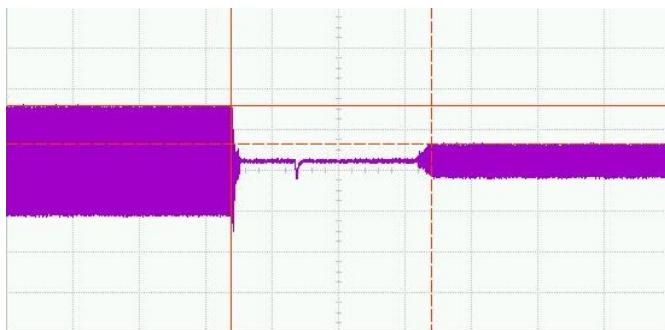


Figure 5.4.3c: Typ. Switching time from 10 to 0 dB (RUDAT-13G-90); 603 ns switching time achieved.

$\Delta x = 603.00$ ns
 $\Delta y = 100.00$ mV

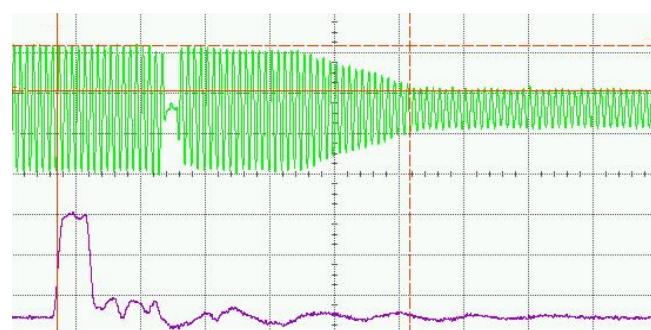


Figure 5.4.3d: Typ. Switching time from 5 to 15.75 dB (RCDAT-18G-63); 109 ns switching time achieved.

$\Delta x = 109.091$ ns
 $\Delta y = 110.300$ mV

5.5. Daisy-Chain Control with Dynamic Addressing

5.5.1. Master/Slave Connection with USB Control

In models with dynamic addressing support you can connect a number of units in series, allowing control of multiple attenuators from a single USB or Ethernet port, with each attenuator controlled independently. Dynamic addressing sets the addresses automatically in the order the attenuators are connected (no need to set addresses for each unit) with the master unit (unit connected directly to USB or Ethernet control) as address 0 and the slave units incrementing to the end of the chain.

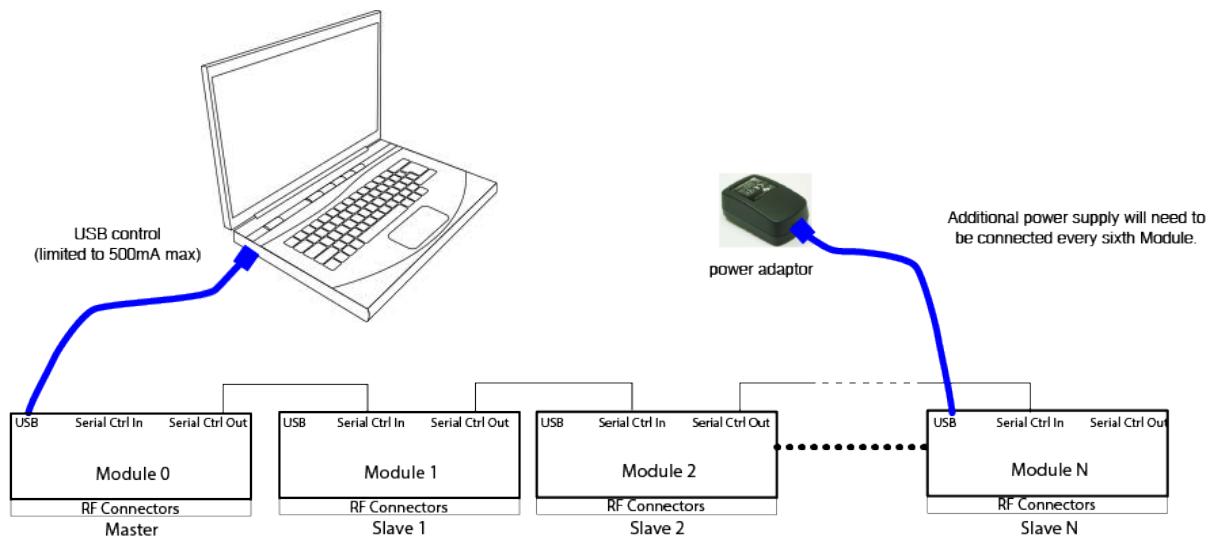


Figure 5.5.1: Master/Slave connection with USB control

The additional “Dynamic Address” panel on the right-hand side of the main control screen will appear if any slave units are detected when the GUI connection (USB or Ethernet) is initiated. This panel shows the number of units connected and their current attenuation settings. If any changes are subsequently made to the daisy-chain interconnections the **Refresh** button can be used to have the addresses checked and re-assign automatically to all units in the chain.

5.5.2. Dynamic Addressing Functions

The center control panel will apply the attenuation settings to whichever combination of attenuators is selected in the “Dynamic Address” panel.

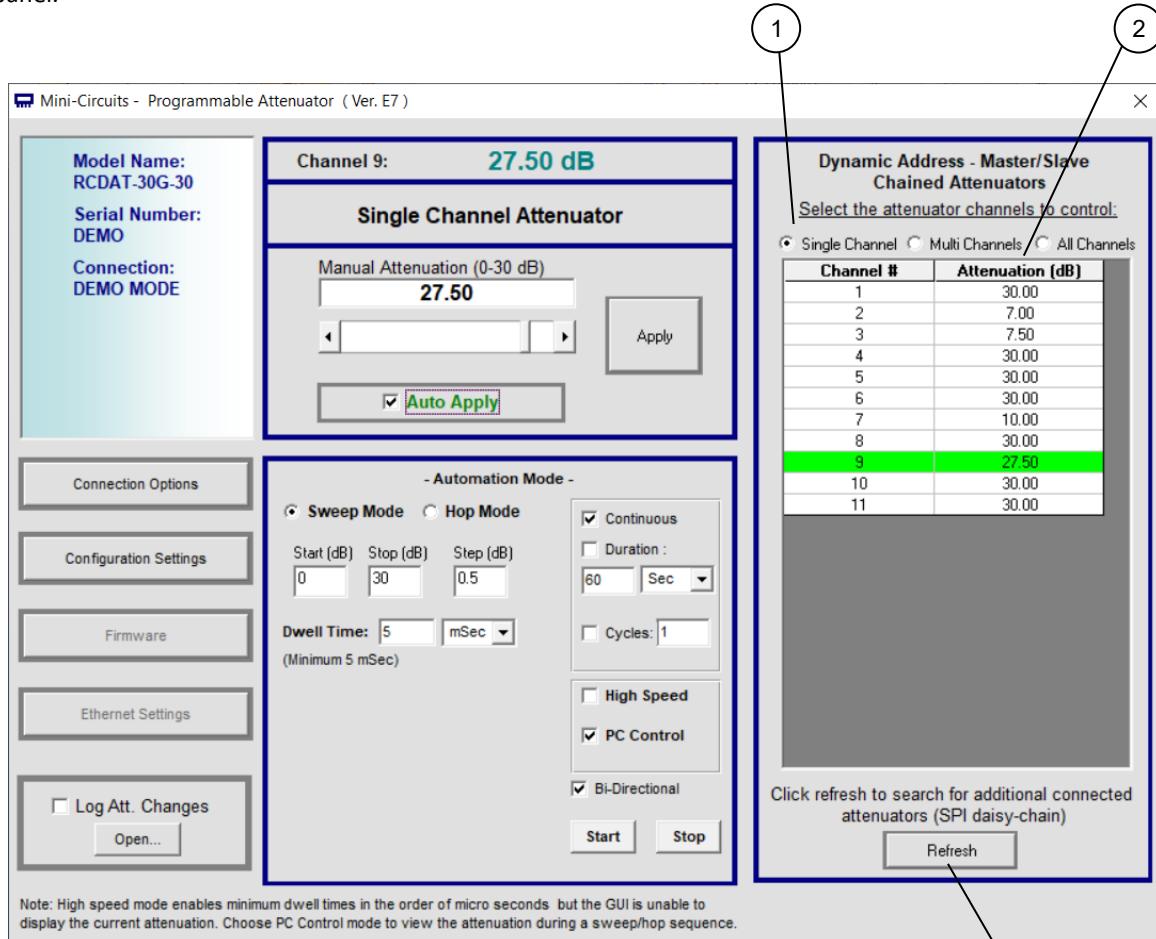


Figure 5.5.2: Main screen (with dynamic addressing)

#	Name	Descriptions
1	Select the attenuator channels to control	Select one of three options: Single channel – control one attenuator at a time. Multi channels – select a number of attenuators by clicking on them and send to them the same command (reset the selected channels by selecting ‘single channel’ then ‘multi channels’ again). All Channels – all connected attenuators will be selected.
2	Attenuation tables	Table showing current attenuation setting of all connected attenuators
3	Refresh	Refreshes the addresses for the dynamic addressing daisy chain. Click on this after connecting additional units, or changing the units connected.

5.5.3. Configuring Units with Dynamic Addressing

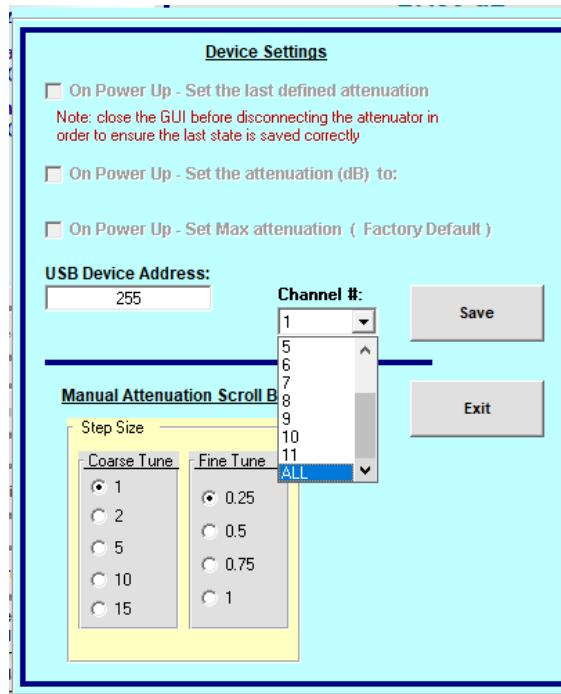


Figure 5.5.3: Configuration screen (with dynamic addressing)

Units connected in daisy-chain configuration can be configured just as when connected individually to the PC, just select the unit you wish to configure from the drop box, or select **ALL** to set the configuration of all units then configure the unit as described in section 5.2.4.

5.6. Multiple Attenuation Modes (RCDAT-40G-30)

In the RCDAT-40G-30 you will see below the connection type on the left side of the screen options for selecting between two attenuation modes. Mode 1 allows attenuation in 0-30 dB range, 1 dB steps, while mode 2 allows attenuation 0-29, 0.5 dB step. Switching between modes will reset the attenuation state to the max attenuation allowed in the mode.

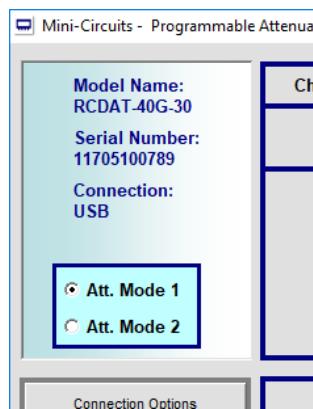


Figure 5.6: Attenuation modes

5.7. Pop-up Alerts

If you type an attenuation value the attenuator cannot meet – either too large a number, or resolution too fine for the attenuator model, an alert will pop up and the attenuation setting will not change. Click **OK** to dismiss the alert and enter a valid attenuation value.

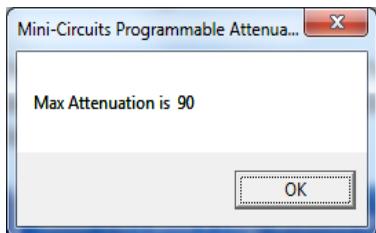


Figure 5.7a: Value too large for model



Figure 5.7b: Resolution too fine for model

If the attenuator is disconnected during operation, or experiences a problem with the power supply an alert will pop up. Click **OK** to close the program and check the power and data connections to the unit before restarting the program.

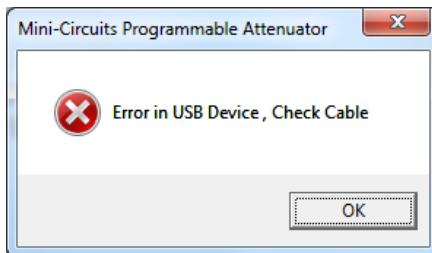


Figure 5.7c: data or power disconnected alert

Checking/Un-checking the Log Att. Changes option will pop-up an alert notifying the user of the location of the txt file log when enabling and disabling the logging operation. An alert will also pop-up if a user tries to open the log file mid recording. Clicking OK on either will dismiss the alert.



Figure 5.7d: Start/end of logging alert

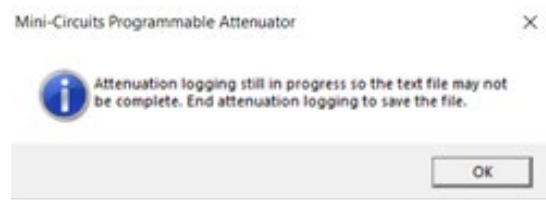


Figure 5.7e: Mid-recording alert

The programmable attenuator models can also be controlled automatically using most common lab test software and the provided DLL files, or your own custom programs. For more information on this see the Programming Guide available for download at <https://www.minicircuits.com/softwaredownload/patt.html>

5.8. Firmware Update

All 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 5.9* for details).

5.8.1. Requirements

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

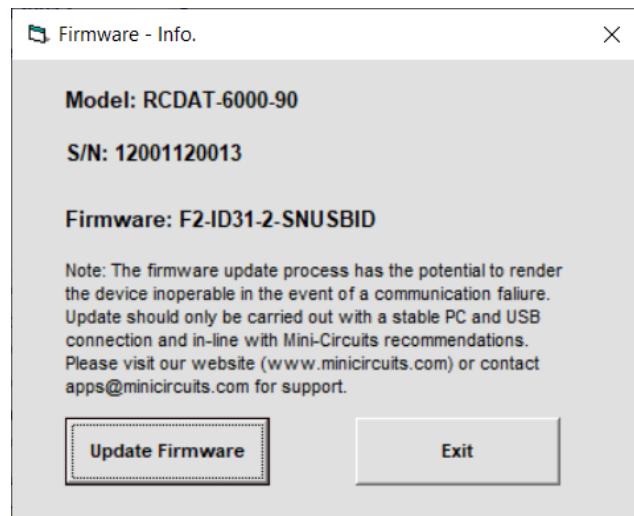
Before starting, consult the table below to check if your unit supports the firmware upgrade feature:

Model P/N	Serial number
RUDAT-4000-120	11510110020 and greater
RUDAT-6000-30	11505310041 and greater
RUDAT-6000-60	11506070001 and greater
RUDAT-6000-90	11505310001 and greater
RUDAT-6000-110	11510110020 and greater
All other models	All units

5.8.2. Process

The following firmware upgrade instructions apply to all programmable attenuators but there are some visual differences between models (highlighted below).

- Connect only the unit to be upgraded to the PC via USB (see *section 4.1*) and start Mini-Circuits' Programmable Attenuator GUI program.
- After selecting **USB** connection, click the **Firmware** button on the left side of the program.
- The “Firmware – Info” window will list the currently installed firmware revision. Choose **Update Firmware** to proceed or **Exit** to cancel the process.



- Navigate to the location of the upgrade file you received from Mini-Circuits' Test Solutions and choose it.

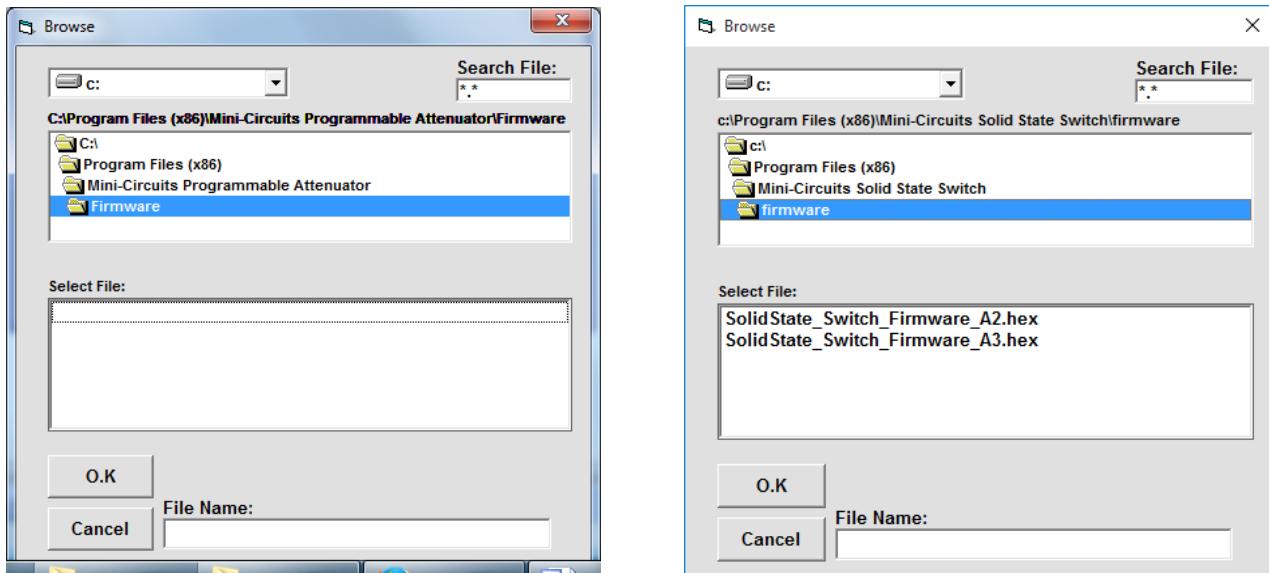


Figure 5.8.2a: Firmware - Browse Window

- The selected file should be now installed on the attenuator with the process taking up to a minute.

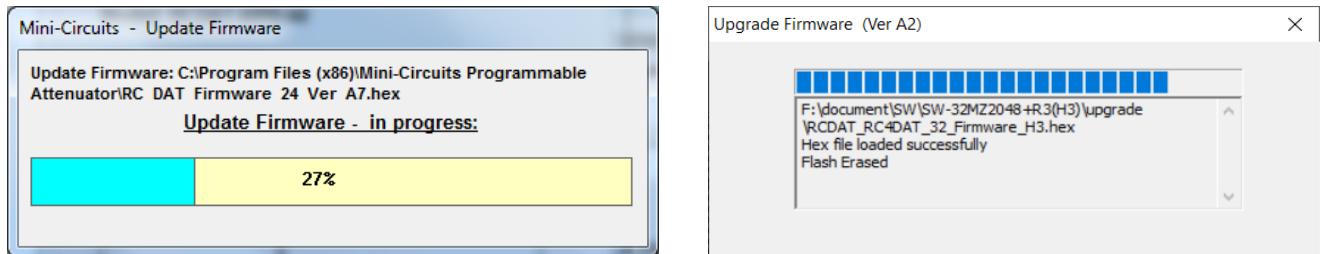


Figure 5.8.2b: Firmware - Progress Bar Window

Caution:



- Do not disconnect the attenuator or shut down the program while the firmware is being updated. Doing so may damage the attenuator.
- 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 normally.
- If the firmware upgrade was interrupted this can result in partial installation rendering the device inoperable. Refer to *section 5.9* to check if your unit supports the feature.

5.9. 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).

Consult the table below to check if your unit supports the firmware recovery feature:

Model P/N	Serial number
RCDAT-3000-63W2	11611200006 and greater
RCDAT-4000-120	11602250001 and greater
RCDAT-6000-30	11603270031 and greater
RCDAT-6000-60	11602280055 and greater
RCDAT-6000-90	11602180001 and greater
RCDAT-6000-110	11602280001 and greater
RCDAT-8000-30	11611130001 and greater
RUDAT-4000-120	11603310001 and greater
RUDAT-6000-30	11604070001 and greater
RUDAT-6000-60	11603060001 and greater
RUDAT-6000-90	11603100001 and greater
RUDAT-6000-110	11511010001 and greater
All other models	All units



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.

5.9.1. Recovery Steps (except RCDAT-xG-120H & RCDAT-18G-xx models)

Follow the below recovery steps for all models except RCDAT-xG-120H & RCDAT-18G-xx:

- Connect the unit to the PC via USB.
- Start Mini-Circuits' Programmable Attenuator 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 5.8.2* on how to proceed.

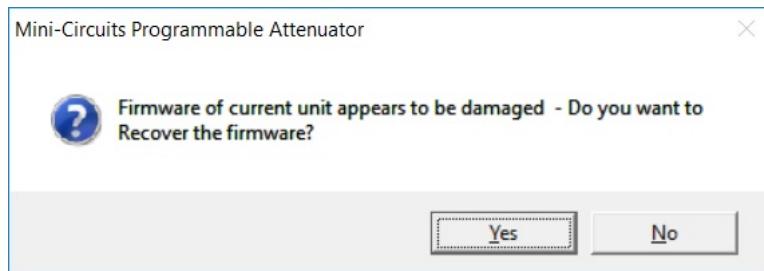


Figure 5.9.1: A corrupted firmware alert

5.9.2. Recovery Steps (RCDAT-xG-120H & RCDAT-18G-xx models)

Follow the below recovery steps for RCDAT-xG-120H or RCDAT-18G-xx models only:

- Connect the unit to the PC via USB.
- Navigate to the directory where the Programmable Attenuator 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.

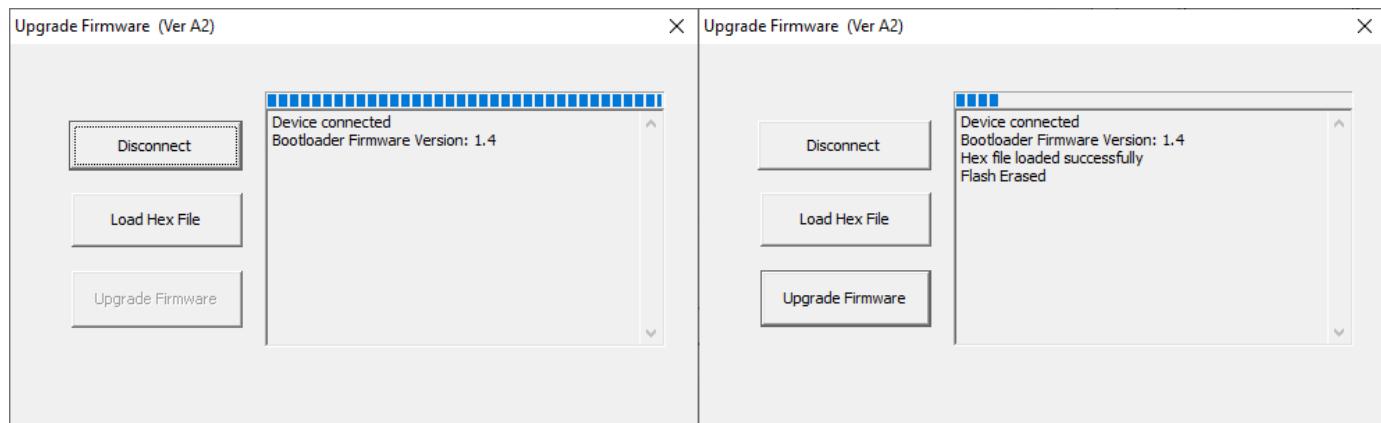


Figure 5.9.2: Left – Unit connection step; Right – Firmware upgrade step

6. Revision History

Revision OR (Mar 12, 2015):

- Initial release of the user guide.

Revision A (Jun 26, 2015):

- Updated user guide per CD Rev. C2 and Firmware Rev. B1, adding high-speed Sweep & Hop.
- Showed firmware upgrade support for RUDAT models.

Revision B (Aug 10, 2015):

- Rewrote Sweep & Hop section to add more detail to high-speed mode.
- Added section on attenuation switching time with plots showing examples.

Revision C (Oct 16, 2015):

- Added models: RCDAT-3000-63W2, and RCDAT-8000-30.
- Added caution note concerning multiple GUI sessions during firmware upgrade.

Revision D (Aug 07, 2016):

- Added RC4DAT model family and RUDAT-13G-90.
- Added SPI control section.
- Added multi-channel attenuators to sweep & hop, added third timing diagram
- Rewrote firmware upgrade to provide contact information for firmware upgrades.

Revision E (May 08, 2017):

- Added model: RUDAT-13G-60.
- Added Firmware recovery option.
- Moved multi-channel (RC4DAT) models to a separate user guide.

Revision F (Aug 06, 2017):

- Added model: ZVVA-3000.
- Expanded “SPI Control” section.

Revision G (Apr 30, 2018):

- Added model: RCDAT-30G-30.
- Added “Dynamic Addressing” section.
- Added optional accessory D-SUB9-MPT-3+.
- Clarified connection instructions for RUDAT-13G-xxx models in RS232 or SPI control.

Revision H (Jul 30, 2019):

- Added model: RCDAT-40G-30.
- Added Telnet prompt function.
- Updated installation process to show new version.

Revision J (Dec 11, 2019):

- Added model: RCDAT-6G-120H.
- Added explanation on new attenuation log function and a note on SSH login.

Revision K (Apr 22, 2021):

- Added model: RCDAT-8G-120H.
- Updated Ethernet configuration to show new factory default.
- Added explanation of Ethernet configuration tool.
- Updated “Firmware Upgrade” and “Firmware Recovery” sections.

Revision L (Aug 15, 2021):

- Added model: RCDAT-18G-63.
- Added “TTL Control” and “Trigger In” sections.
- Fixed a typo in URL of Ethernet configuration tool.

Revision M (Nov 10, 2022):

- Updated user-guide format: Re-written and restructured sections to support format update.
- Added models: UDAT-67G-30 and UDAT-67G-60.

Revision N (Jun 26, 2025):

- Removed models: UDAT-67G-30 and UDAT-67G-60.
- Added models: eDAT-67G-30 and eDAT-67G-60.

7. Contact

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