User Guide

USB, RS232, SPI & Ethernet
Programmable Attenuators

RS232 & USB control,
Single channel (RUDAT)

Ethernet & USB control,
Single channel (RCDAT)

RS232, USB & SPI control,
Single channel (RUDAT-13G)

RS232, &USB control,
Single channel (ZVVA)

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Chapter 1 – General Information

1.1 *Scope of the User Guide*

This User Guide provides general introduction, installation instructions and operating information for Mini-Circuits USB & RS232 programmable attenuators (RUDAT & ZVVA series) and USB & Ethernet programmable attenuators (RCDAT series).
For information on multi-channel programmable attenuators see AN-49-011.

1.2 *Warranty*

See Mini-Circuits website http://www.minicircuits.com/support/ordering.html for warranty information.

1.3 *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 (no danger to users).**

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.**

1.4 *General safety precautions*

There are no general safety precautions for using Mini-Circuits programmable attenuators.

1.5 *Introduction*

Mini-Circuits has developed three series of programmable attenuators:

- The RUDAT and ZVVA series, which can be controlled via standard USB or RS232 ports (some also support SPI), with the ZVVA providing 0dB glitch
- The RCDAT series, which can be controlled via standard USB or Ethernet-TCP/IP (Telnet or HTTP protocols), and some of which allow connecting multiple units in series(daisy chain) via Mini-Circuits unique dynamic addressing function to control them all from a single network or USB port.

The programmable attenuators come in different variations with (see section 1.8.2 for details):

- Wide frequency ranges, from 1MHz and up to 50GHz
- Fine attenuation resolutions, as low as 0.05 dB
- Wide attenuation ranges, up to 120 dB

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

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

1.6 *Service and Calibration*

None of the programmable attenuator models require any periodic service or calibration. The only user service possible for the models is external cleaning of the case and connectors as needed. Do not use any detergents or spray cleaning solutions to clean the attenuators. To clean the connectors use an alcohol solution, and to clean the case a soft, damp cloth.

1.7 *Contact Information*

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For regional offices and tech support see http://www.minicircuits.com/contact/offices.html

1.8 *Technical Description*

1.8.1 **Features of Mini-Circuits Programmable Attenuators**

- Wide attenuation range (model dependent, see section 1.8.2)
- Wide frequency range (model dependent, see section 1.8.2)
- Fine attenuation resolution (as low as 0.05 dB, see section 1.8.2)
- Multiple control options
- Easy installation and operation
- Plug & Play devices, no driver installation required
- ActiveX COM object and .Net class library for use with other software: C++, C#, CVI®, Delphi®, LabVIEW® 8 or newer, MATLAB® 7 or newer, Python, Agilent VEE®, Visual Basic®, Visual Studio® 6 or newer, and more (see AN-49-001 for full details)
- User friendly Graphical User Interface for any Windows® 32 or 64 bit computer. Command line support for Linux® computers.
- Mounting bracket (optional)

1.8.2 Model Selection Guide

Model Name	Frequency Range (MHz)	Attenuation Range (dB)	Attenuation Resolution (dB)	Max Input Power (dBm)	Control Protocols
RCDAT-3000-63W2	50 – 3,000	63	1	33	USB, HTTP & Telnet
RCDAT-4000-120	1 – 4,000	120	0.25	20	USB, HTTP & Telnet
RCDAT-6000-30	1 – 6,000	30	0.25	20	USB, HTTP & Telnet
RCDAT-6000-60	1 – 6,000	60	0.25	20	USB, HTTP & Telnet
RCDAT-6000-90	1 – 6,000	90	0.25	20	USB, HTTP & Telnet
RCDAT-6000-110	1 – 6,000	110	0.25	20	USB, HTTP & Telnet
RCDAT-6G-120H	200 – 6,000	120	0.05	23	USB, HTTP & Telnet
RCDAT-8G-120H	200 – 8,000	120	0.05	23	USB, HTTP & Telnet
RCDAT-8000-30	1 – 8,000	30	0.25	28	USB, HTTP & Telnet
RCDAT-8000-60	1 – 8,000	60	0.25	28	USB, HTTP & Telnet
RCDAT-8000-90	1 – 8,000	90	0.25	28	USB, HTTP & Telnet
RCDAT-30G-30	100 – 30,000	30	0.5	24	USB, HTTP & Telnet, Dynamic Addressing*
RCDAT-40G-30	100 – 40,000	30	0.5	24	USB, HTTP & Telnet, Dynamic Addressing*
RCDAT-50G-30	100 – 50,000	30	0.5	24	USB, HTTP & Telnet, Dynamic Addressing*
RUDAT-4000-120	1 – 4,000	120	0.25	20	USB & RS232
RUDAT-6000-30	1 – 6,000	30	0.25	20	USB & RS232
RUDAT-6000-60	1 – 6,000	60	0.25	20	USB & RS232
RUDAT-6000-90	1 – 6,000	90	0.25	20	USB & RS232
RUDAT-6000-110	1 – 6,000	110	0.25	20	USB & RS232
RUDAT-13G-60	10 – 13,000	60	0.5	23	USB, RS232 & SPI
RUDAT-13G-90	10 – 13,000	90	0.5	23	USB, RS232 & SPI
ZVVA-3000	20 – 3,000	25	0.1	23	USB & RS232

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

*See section 3.6 for details on dynamic addressing.

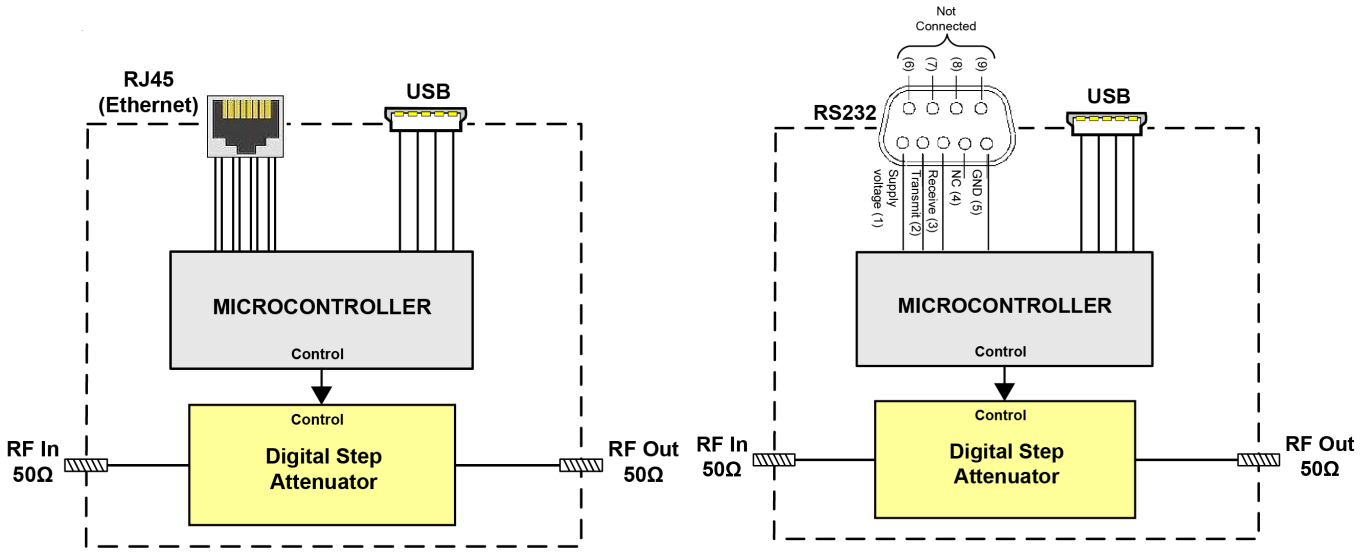


Figure 1.8.2a *RUDAT & RCDAT functional block diagrams*

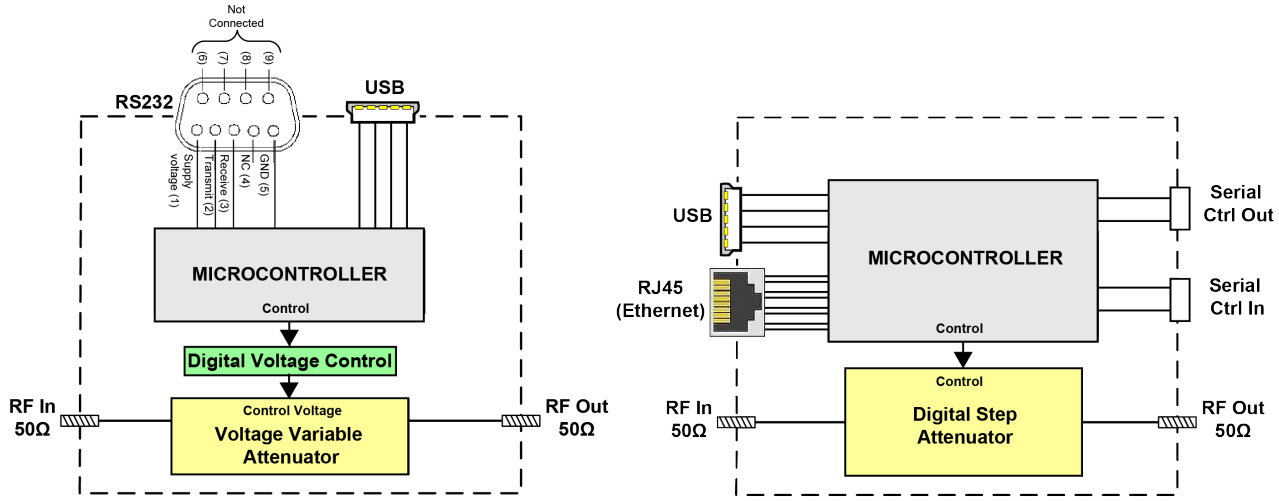


Figure 1.8.2b *ZVVA & RCDAT with dynamic addressing functional block diagram*

1.8.3 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 models can be used by anyone familiar with the basics of electronic measurements or electronic control systems.

1.8.4 Supported Software Environments

Mini-Circuits programmable attenuators have been tested in the following operating systems:
32 bit systems: Windows 10, Windows 8, Windows 7, Windows Vista, Windows XP, Windows 98 and Linux.
64 bit systems: Windows 10, Windows 8, Windows 7, Windows Vista and Linux
The attenuators will work with almost any software environment that supports ActiveX or .Net including: C++, C#, CVI®, Delphi®, LabVIEW® 8 or newer, MATLAB® 7 or newer, Python, Agilent VEE®, Visual Basic®, AutoIT, Visual Studio® 6 or newer, and more (see AN-49-001 for full details).

Additionally the HTTP and Telnet protocols can operate from almost any computer, or even a mobile device/smartphone with a network connection.
For more information see programming handbook on our website.

1.8.5 Included Accessories and Options

1.8.5.1 **All models** are supplied with

- 2.6 ft (0.8m) USB cable (Type A to Type Mini-B)

1.8.5.2 **The following additional accessories are also available:**

- Mounting bracket
- 6.9 ft (2m) USB cable (Type A to Type Mini-B)
- 6 ft (1.8m) RS232 cable (9 Pin D-Sub Male-Female)
- 3 ft (0.9m) RS232 & SPI cable (9 Pin D-Sub Male-Pigtail)
- 5 ft (1.5 m) Ethernet cable: RJ45(Male) to RJ45(Male) Cat 5E cable
- AC/DC power adapter suitable for a wide selection of wall sockets
- 1.5 ft (0.5m) Interconnect data cable for daisy chain dynamic addressing.
- 5 ft (1.5m) Interconnect data cable for daisy chain dynamic addressing.

1.8.6 Conformity

Mini-Circuits series of programmable attenuators conform to all requirements for the following international standards:

RoHS – The models comply with EU directive for Restriction of Hazardous Substances for 6 substances.

USB 2.0 – The models meet the specifications of the Universal Serial Bus Ver. 2.0 communication standard as described by USB-IF.

USB HID – The models meet the requirements for Universal Serial Bus Human Interface Devices according to USB-IF's Device Class Definition for Human Interface Devices firmware rev. 1.11

RUDAT series models also comply with:

RS232 – The RUDAT series models meet all requirements for RS232 standard.

RCDAT series models also comply with:

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 models' support all requirements for communicating with the Hypertext Transfer Protocol (HTTP) as defined in RFC 1945.

Telnet – The RCDAT series models' support all requirements for communicating with the Telnet protocol, as defined in RFC 854

SSH – RCDAT models which specify SSH control also support the requirements for SSH protocol, as defined by RFCs 4250-4253, 4419, 5647, 5656 and 6668.

Chapter 2 – Installation and Setup

2.1 *Software setup*

System requirements for the programmable attenuator models are a computer (Pentium II or better) with the following support depending on the control method used:

RS232 control	SPI	USB control	Ethernet control
Serial COM port	3-wire I/O control at LVTTL	USB HID	Network connection

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

To run the GUI program a Windows operating system for either 32 or 64 bits is required as well.
No additional requirements for using units in daisy chain configuration

If you have had any problems installing the software, we're here to help.
Try following these complete step-by-step instructions. If you still experience problems, give us a call at Mini-Circuits Worldwide Technical support. It's (718) 934-4500 or e-mail apps@minicircuits.com for North America or go to minicircuits.com/contact/worldwide_tech_support.html for other regional numbers and addresses.

2.1.1 ***First,*** save all work in progress and close any other programs that may be running.

2.1.2 ***Next,*** download the full CD software from https://www.minicircuits.com/softwaredownload/RUDAT_CD.zip. Unzip the downloaded files to a suitable folder on your computer, then open the file folder you created and double-click the "Install" icon.

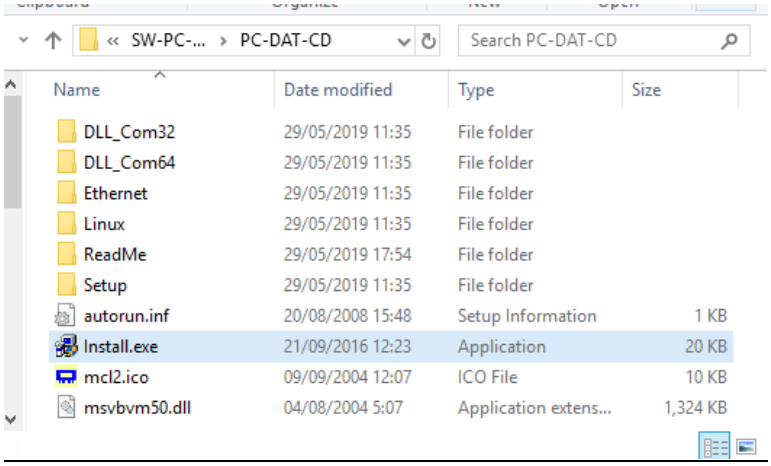


Figure 2.1.2 *CD file listing window*

2.1.3 ***Alternatively,*** you may wish to just download and open without saving the setup files, from https://www.minicircuits.com/softwaredownload/RUDAT_Setup.zip . Then double click on the setup.exe icon.

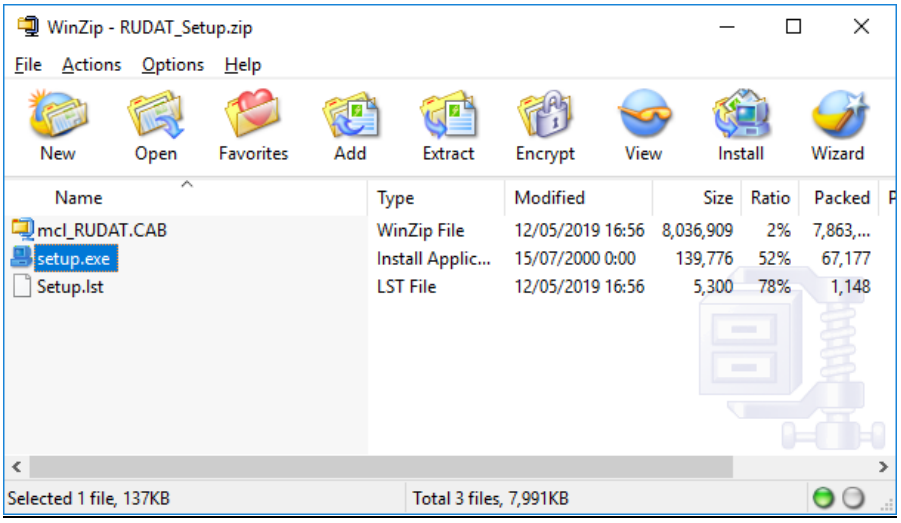


Figure 2.1.3 *Setup file listing window*

2.2 *Installation*

2.2.1 ***The installer window*** should now appear. Click the “Install Now” button (if you downloaded only the setup files skip to 2.2.2).

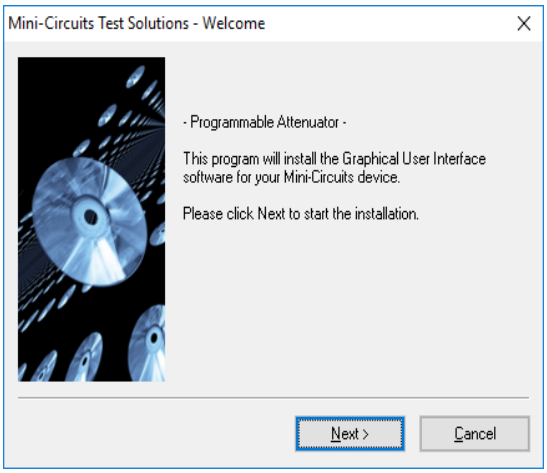


Figure 2.2.1 *Installation window*

2.2.2 ***The license agreement*** should now appear. To proceed, click “Yes to accept the agreement.

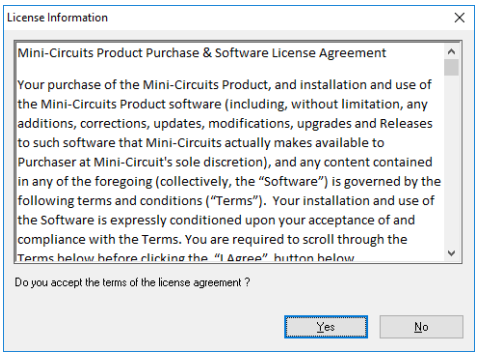


Figure 2.2.2 *License agreement*

2.2.3 ***The installation program will install (will take a few seconds)***. Click the “Exit” button to close the installer.

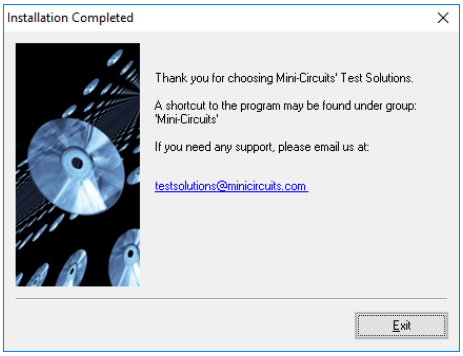


Figure 2.2.3 *Installation program window*

2.2.4 ***The programmable attenuator program will be in*** C:\Program Files (x86)\Mini-Circuits\ProgrammableAttenuator with links on the desktop and in the Start menu under Mini-Ciruits -> ProgrammableAttenuator.

2.3 *Attenuator physical setup*

CAUTION

The maximum allowed RF input for programmable attenuators models is reduced at low frequencies. Check the individual model datasheet and do not exceed the specified limits.

2.3.1 *USB Control (All models)*

-Connect USB cable between the attenuator's USB port and the computer's USB port.
-Note the attenuator's USB indicator lights up.
-Connect attenuator input and output SMA ports to your system.

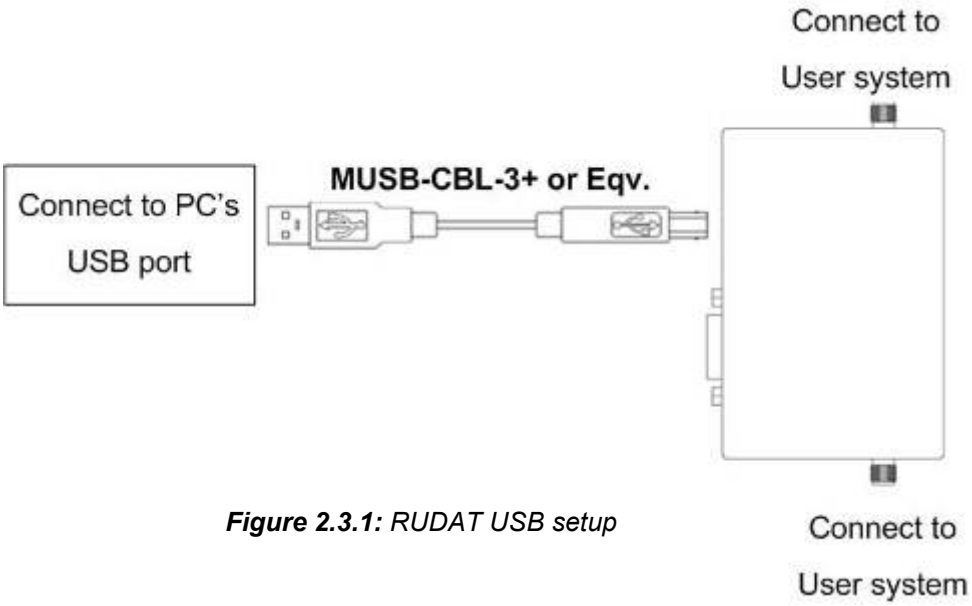


Figure 2.3.1: *RUDAT USB setup*

2.3.2 *RS232 Control (RUDAT & ZVVA) with power via USB*

-Connect D-Sub9 cable between attenuator unit D-Sub port and computer serial port.
-Connect plug suited for available wall socket to the provided power adaptor and plug in the power adaptor (if a USB bus is available it can be used instead of the power supply).
-Connect USB cable between supplied power adaptor and attenuator USB port.
-Note the Indicator lights up.
-Connect attenuator input and output SMA ports to your system.

Note: 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.

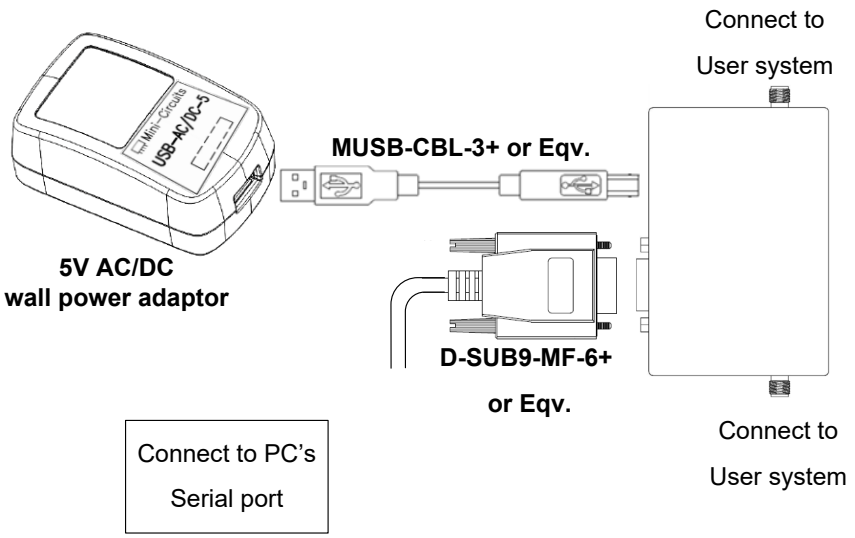


Figure 2.3.2: *RUDAT RS232 setup option1*

2.3.3 *RS232 Control (RUDAT & ZVVA) with power via D-Sub Pin#1*

This option is supported in the following units:

Model P/N	Serial Number
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 models	All serial Numbers

This option requires the use of an RS232 port wired to supply +5V_{DC} at Pin#1
-Connect D-Sub9 cable between attenuator unit D-Sub port and custom RS232 port.
-Note the Indicator lights up.
-Connect attenuator input and output SMA ports to your system.

Note: 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.

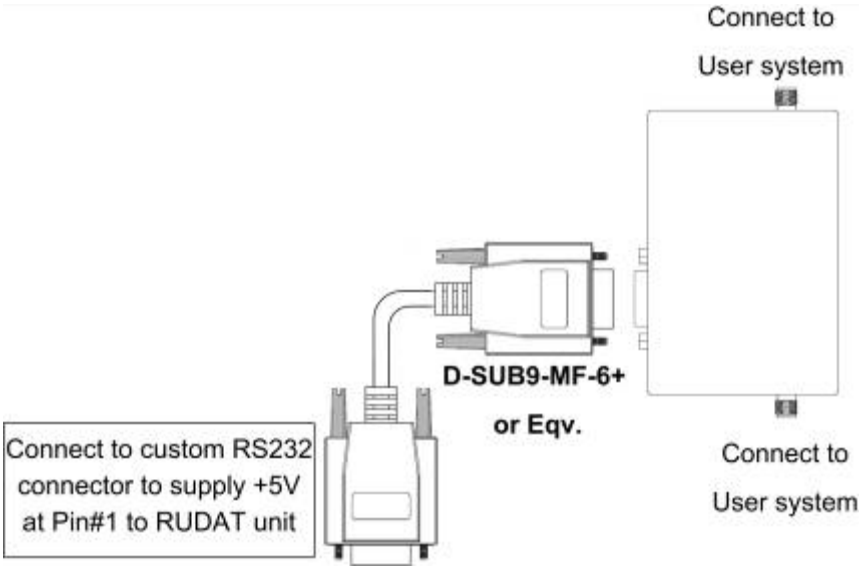


Figure 2.3.3: *RUDAT RS232 setup option 2*

2.3.4 *Ethernet Control (RCDAT)*

-Connect plug suited for available wall socket to the provided power adaptor and plug in the power adaptor (if a USB port is available it can be used instead of the AC mains power adapter).
-Connect USB cable between supplied power adaptor and RCDAT USB port.
-Note the USB indicator lights up.
-Connect a standard network cable between RCDAT unit RJ45 socket and network port.
-Note the network indicators on the RJ45 socket of the RCDAT unit light up after a few seconds.
-Connect RCDAT input and output SMA ports to your system.

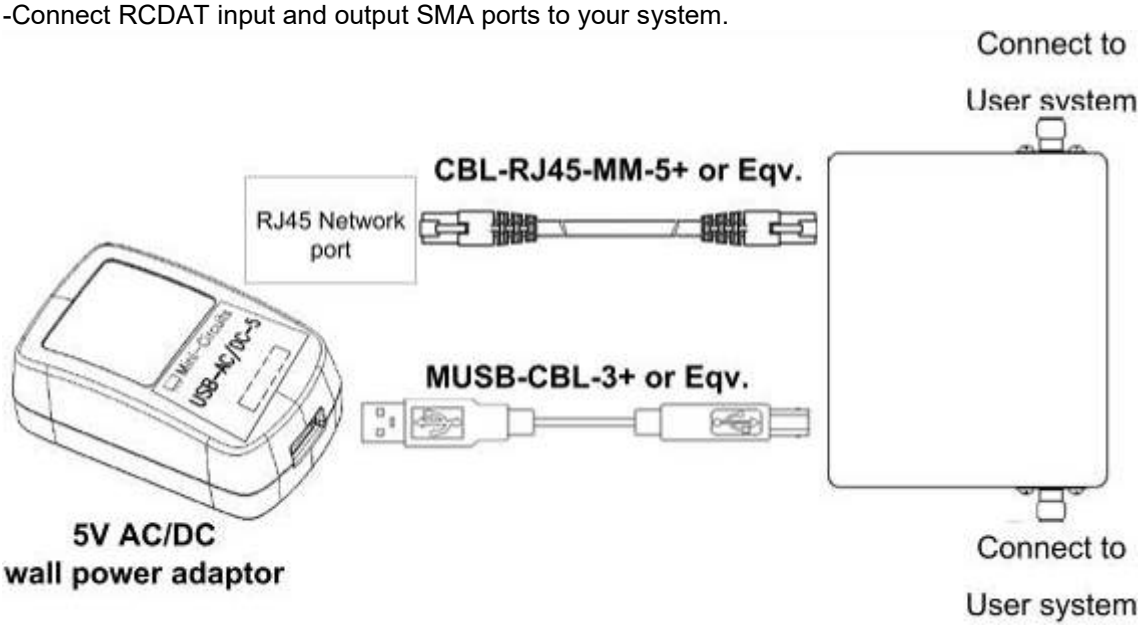


Figure 2.3.4: *RCDAT Ethernet setup*

2.3.5 *SPI Control (RUDAT-13G-xx)*

- Connect the SPI Clock, Data and Latch Enable pins (See pinout 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.

Notes: 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 control allows the device's attenuation to be set using a simple serial data sequence of LVTTL logic levels, without the need for a PC and minimal control hardware or software. The SPI voltage levels and timing instructions are covered in the model's datasheet. This 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

Parameter	Conditions		Min.	Typ.	Max.	Units
Voltage levels	Logic High Voltage	Input	2.1	–	3.3	V
	Logic Low Voltage	Input	0	–	0.8	
Control Current	Per Pin		–	–	1	mA
Clock Frequency	–		–	–	10	MHz

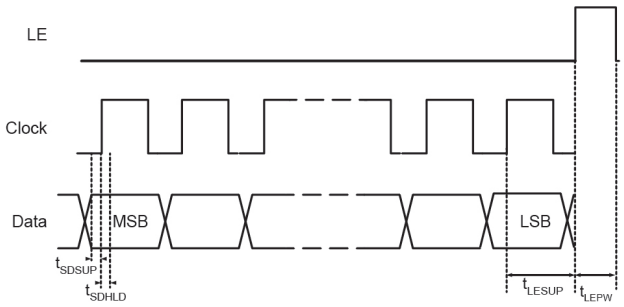
The SPI control uses an 8-bit serial in, parallel-out shift register buffered by a transparent latch with Data, Clock, and Latch Enable (LE) voltages compatible with LVTTL. The Data and Clock inputs allow data to be serially entered into the shift register, a process that is independent of the state of the LE input. The Value entered should be desired attenuation x 2, so for example to set attenuation level of 45.5 dB you will enter 91 decimal which is 0101 1011 in Binary.

Pin Number	Function
1	+5 V_{DC}
2	RS232 Transmit
3	RS232 Receive
4	Not Connected
5	GND
6	Factory Use
7	SPI LE
8	SPI Clock
9	SPI Data

The LE input controls the latch. When LE is HIGH, the latch is transparent and the contents of the serial shift register control the switch. 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 below

SPI timing diagram



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

2.3.6 *Daisy Chain configuration*

Some Mini-Circuits' models include our novel dynamic addressing daisy-chaining interface which allows multiple attenuators to be connected together into a Master / Slave chain, with independent control of each attenuator channel through the single USB or Ethernet connection of the master unit.

Currently models supporting this function are RCDAT-30G-30 and RCDAT-40G-30

-Connect the unit you wish to use as master to USB or Ethernet control (See **sections 2.3.1** & **2.3.4**).

–Connect CBL-1.5FT-MMD+, CBL-5FT-MMD+ or equivalent cable from serial out port of master unit to serial in port of first slave unit.

–Connect CBL-1.5FT-MMD+, CBL-5FT-MMD+ or equivalent cable from serial out port of first slave unit to serial in port of second slave unit.

–If total power consumption from all RCDAT units exceeds power available from supply connected to master unit connect additional supplies to the USB ports of slave units as needed (connecting a power supply to the USB port of a slave unit will automatically cut off power draw via the serial control port).

Note: Before connecting slave units it is recommended to disable Ethernet control (see section 3.3.5) of the slave units to reduce power consumption.

Chapter 3 – Using Mini-Circuits GUI

All attenuator models are supplied along with API programming objects (DLL files) to allow easy control by most common lab test software (See attenuator programming manual for details) and with a Windows GUI program to set the attenuation level manually.

To start the program go to the Start menu and select All Programs>Mini-Circuits>ProgrammableAttenuator. The "Mini-Circuits Programmable Attenuator" icon should be waiting there for you. Click on it and get started!

3.1 *Starting the GUI program*

3.1.1 ***When started the GUI will*** show the control selection screen allowing you to choose RS232, USB, HTTP, or Telnet control.

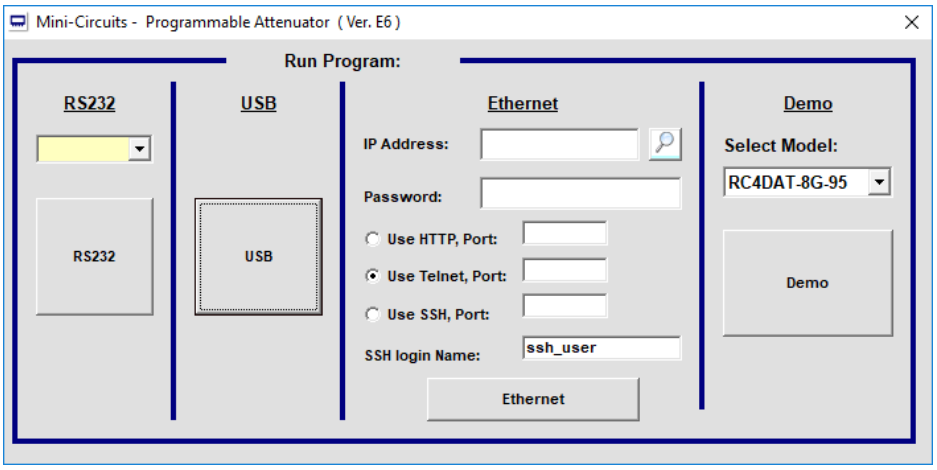


Figure 3.1.1: *Startup Screen*

3.1.2 ***To start a RUDAT or ZVVA unit in RS232 control*** select the COM port the unit is connected to from the drop box in the left section and click on the RS232 button. If no unit is found at the COM port selected an alert will pop up advising no unit is connected. Click "Yes" to proceed anyway, or "No" to return to startup screen. If you get this alert when unit is connected check the power and data connections to the attenuator and verify you selected the correct COM port.

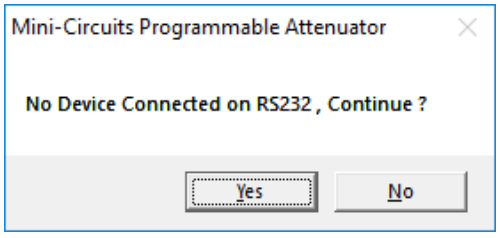


Figure 3.1.2: *No unit in RS232 alert*

3.1.3 ***To start a programmable attenuator unit in USB control*** click on the USB button in the center. If no unit is connected to USB an alert will pop up. Click "OK" to return to startup screen. If you get this alert with the unit connected to USB check the attenuators USB indicator.

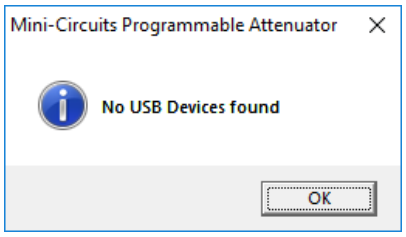


Figure 3.1.3: *No USB device alert*

3.1.4 ***If multiple units are connected via USB***, the unit selection screen will appear with a list of serial numbers and model names for connected units. Select the unit you wish to start with and click "OK", or click "Cancel" to exit the program. The program can handle up to 24 units connected simultaneously. If only one unit is connected via USB, the program will go directly to the attenuator control screen.

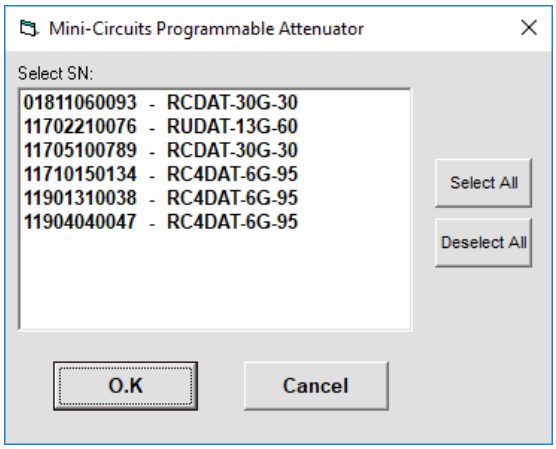


Figure 3.1.4: *Unit selection screen*

3.1.5 ***To start an RCDAT unit with Ethernet control,*** either enter the IP address of the unit (If using HTTP with a port other than 80 or telnet with port other than 23, port will also be needed) of the unit in the "IP address" field 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 3.3** or the programming manual for details.

3.1.6 ***After clicking on the search icon*** The IP search will pop up with a list of attenuators IP addresses found and their HTTP ports on the left side of the screen, and full details of each unit on the right. Mark the IP address you wish to use and click select. The search window will close and the IP address will be entered in the IP address field of the startup screen automatically.

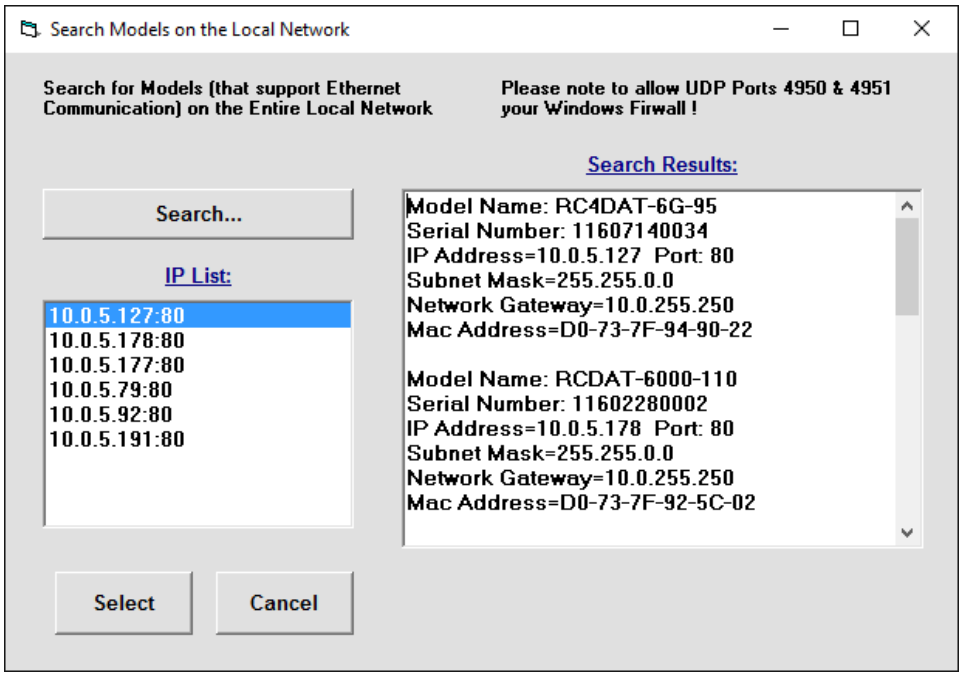


Figure 3.1.6: *Ethernet IP search window*

Notes:

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

3.1.7 ***After entering the IP address*** enter your password if you set one (see **section 3.2**), select the communication protocol you wish to use (HTTP, Telnet, or SSH) and click start, the Attenuation control screen will open.

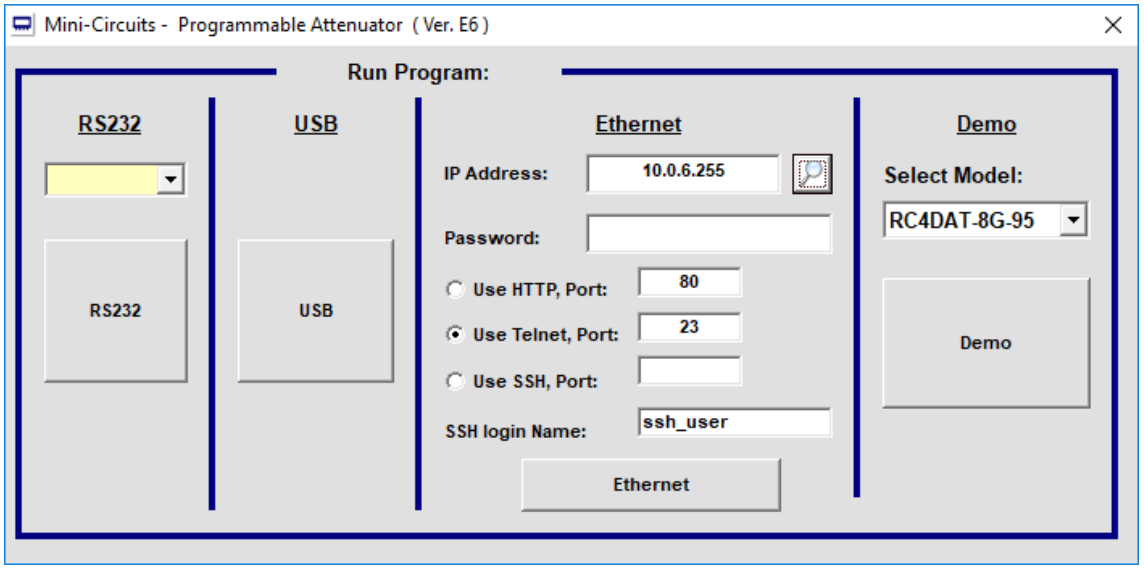


Figure 3.1.7: *Ethernet startup screen*

3.1.8 ***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 CD software (see section 2.1.2), in the Ethernet directory.

3.2 *Operating the attenuator with the GUI program*

Once you've selected the control method to use, the main screen of the GUI program will appear.

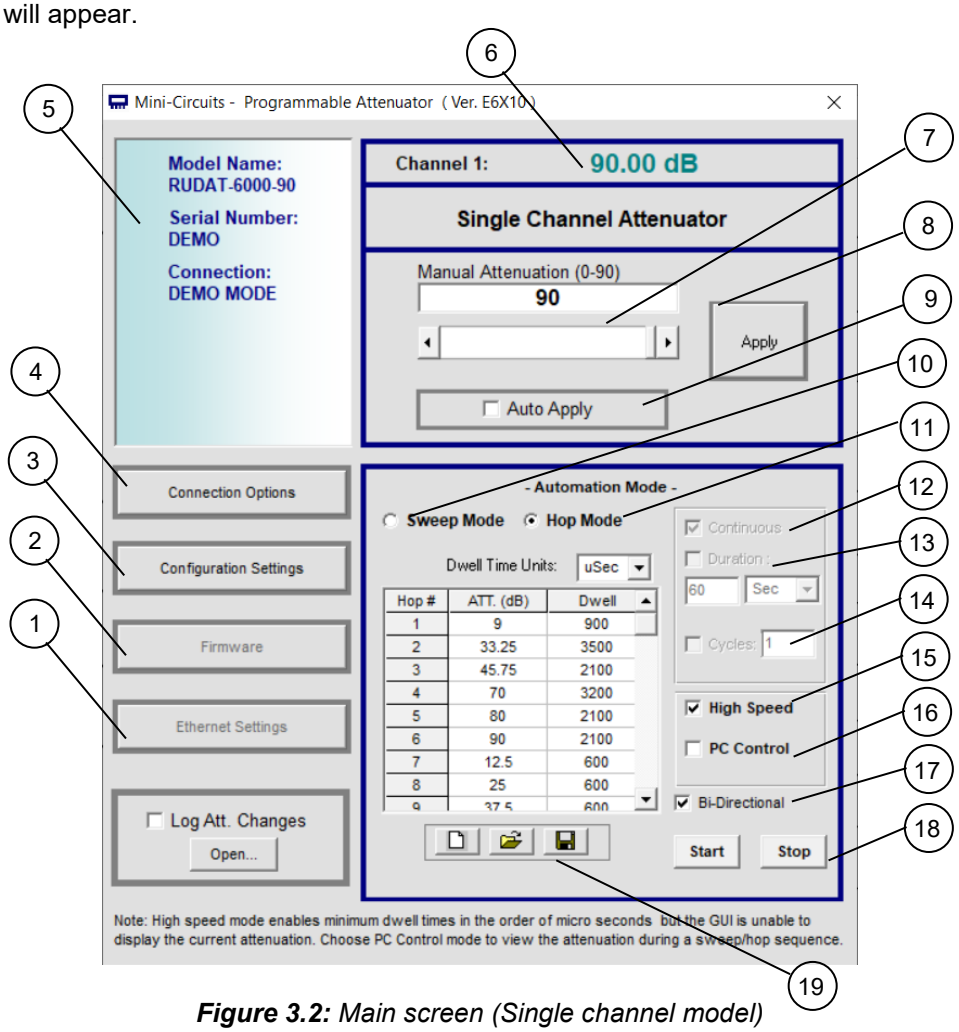


Figure 3.2: *Main screen (Single channel model)*

3.2.1 *Manual mode* ***functions***

#	Name	Descriptions
1	Ethernet Config	Opens a Ethernet configuration window (See **section 3.3** 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 0** 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.

3.2.2 *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 **section 3.5.2** for details
16	PC control	Default setting. Sweep and Hop instructions are sent individually to the unit See **section 3.5.1** 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	Icons	In Hop mode allows clearing all current settings, opening a file of saved settings or saving current settings. Not available in Sweep mode.

3.2.3 *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 (in red the current date YYMMDD and in blue the current time 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.

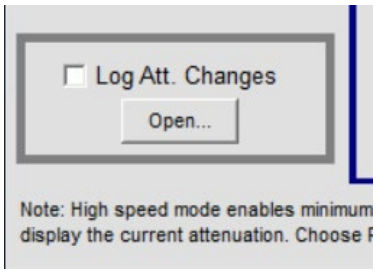


Figure 3.3.1: *Option to generate an attenuation change-log file*

3.2.4 *Configuration Settings*

Clicking on 'configuration Settings' opens a popup window which allows the user to set the following parameters:

- Device Address -
  - Set the device's USB address in the 1 – 255 range (factory default 255)
- Power Up State -
  - For 30, 60 or 90 dB models, Firmware A4 or newer required
  - 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.

Notes:

1. 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
2. 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.

- Manual attenuation Step size -
  - Gross tune is the step size for each click on scroll bar.
  - Fine Tune is the step size for the arrows

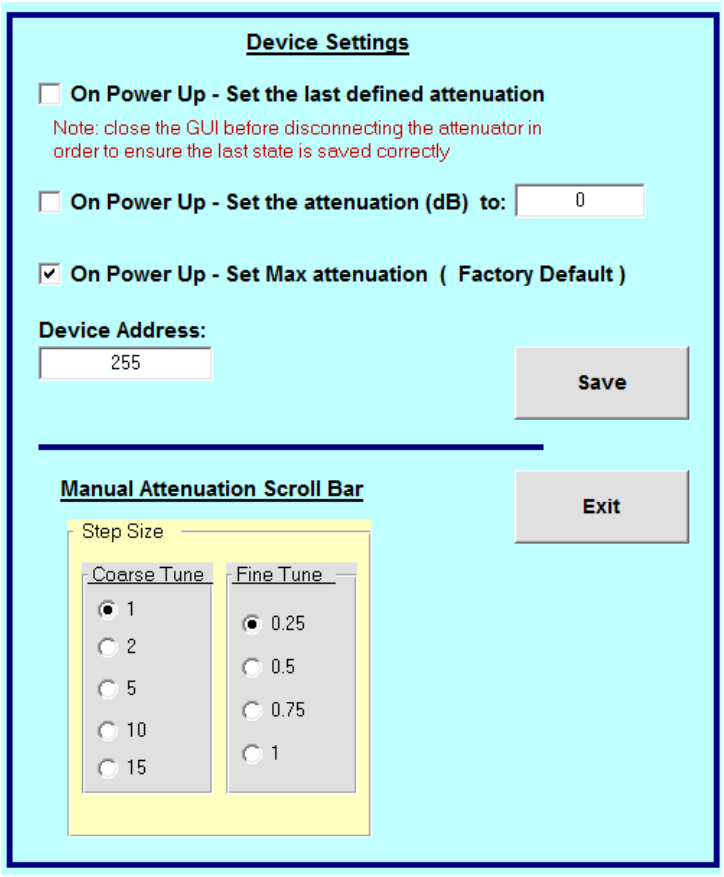


Figure 0: *Configuration Settings screen*

3.3 *Ethernet Configuration (RCDAT)*

3.3.1 *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.

3.3.2 *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 3.3.7**), connect to the attenuator using the 169.254.10.10 default IP and proceed to set the new configuration as needed.

Notes:

- This feature is available to models from certain firmware revisions. Refer to **table 3.3.2** to confirm what revision is required for your unit.

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

Table 3.3.2: *Required firmware revision "Link-Local" IP address*

3.3.3 *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.

3.3.4 ***Default factory settings*** for RCDAT models are Dynamic IP (DHCP) using port 80 for HTTP or port 23 for Telnet (see **Figure 3.3.6**). To change these settings, click on the Ethernet Settings button In the GUI (see **section 3.3.4**), or use Mini-Circuits Ethernet configuration tool (see **section 3.3.7**).

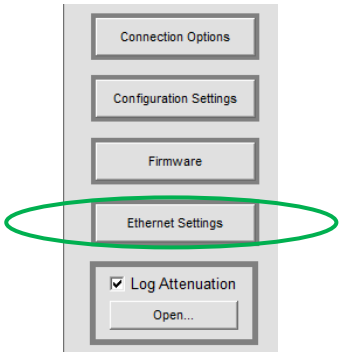


Figure 3.3.4: *Ethernet settings button*

3.3.5 ***The Ethernet Settings screen*** will open showing the current configuration. **Figure 3.3.6** 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 3.1.5**.

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

Notes:

- In units with older firmware revisions (see **table 3.3.2**) 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.

3.3.6 *Ethernet settings descriptions:*

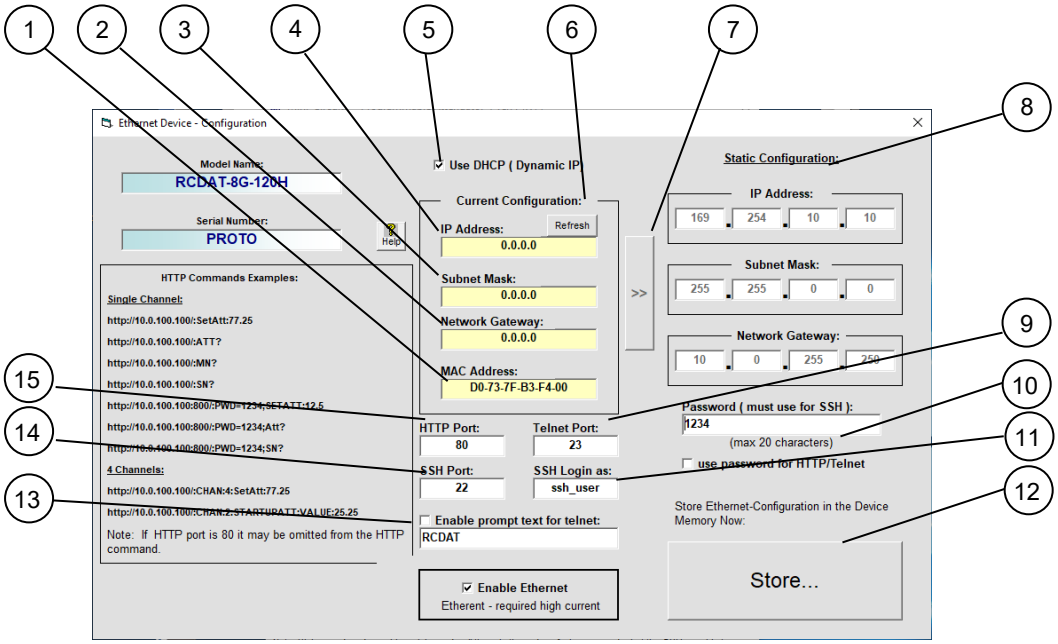


Figure 3.3.6: *Ethernet Settings screen (showing factory default state)*

#	Name	Description
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.

3.3.7 *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 3.3.2** for firmware requirements)
https://www.minicircuits.com/softwaredownload/MCL_PTE_Ethernet_Config.html
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, entered the updated information in the relevant fields in step 2, and click 'Set New Configuration' and you're done.

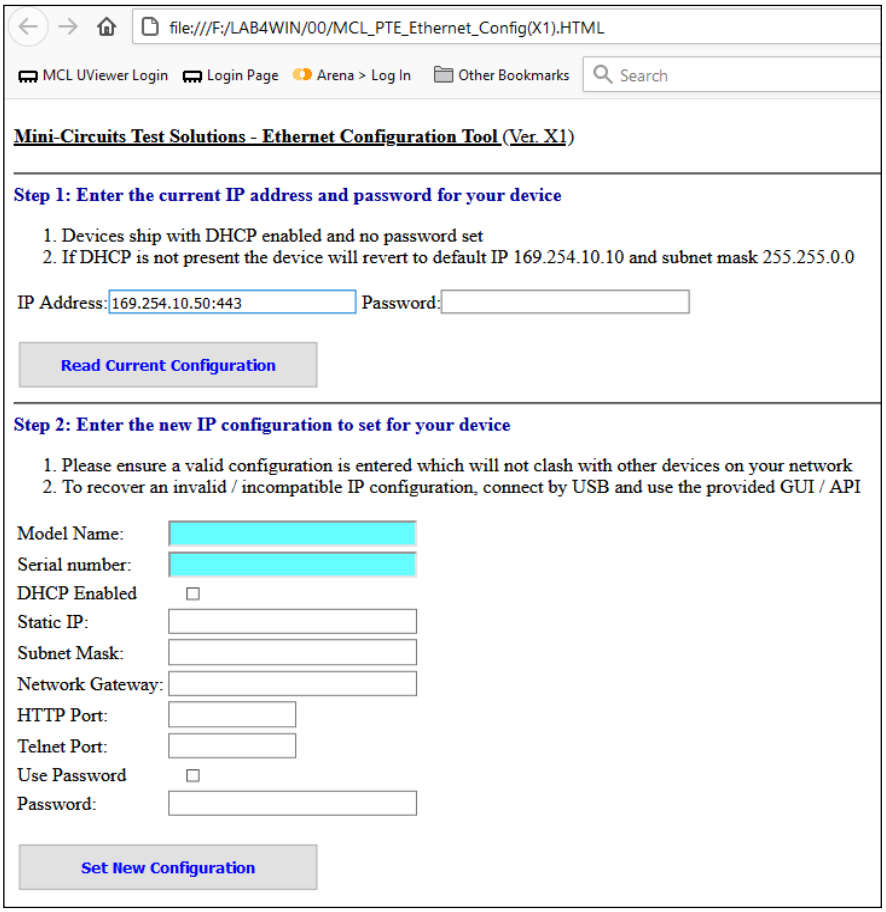


Figure 3.3.7: *Ethernet Configuration Tool*

3.4 *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.

3.4.1 *PC Control Mode (Sweep & Hop Sequences)*

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).

3.4.2 *High Speed Mode (Sweep & Hop Sequences)*

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 µs or 400 µs (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.

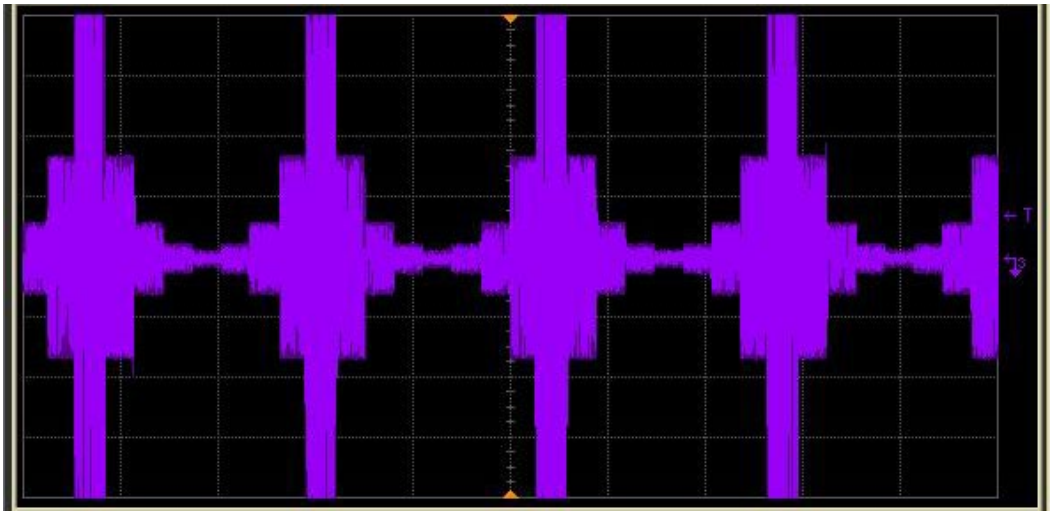


Figure 3.5: *Plot of signal when sweeping attenuation 0-40dB in 10 dB steps (scale 2ms/div)*

3.4.3 *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:

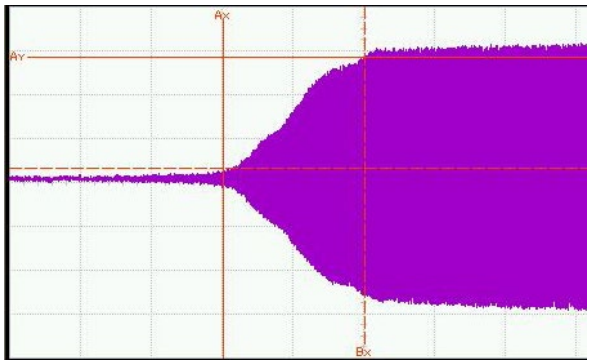


Figure 3.5.3a: Typ. Switching time from 120 to 0 dB(RCDAT-4000-120); 200 ns switching time

Ax = 711.998 µs	Ay = 143 mV
Bx = 712.198 µs	By = 16 mV
Δx = 200.000 ns	Δy = -127 mV

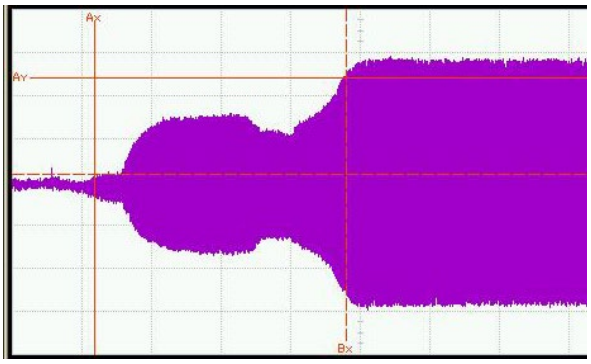


Figure 3.5.3b: Typ. Switching time from 45 to 15 dB(RCDAT-4000-120); 362 ns switching

Ax = 472.735 µs	Ay = 25.25 mV
Bx = 473.097 µs	By = 2.81 mV
Δx = 362.000 ns	Δy = -22.44 mV

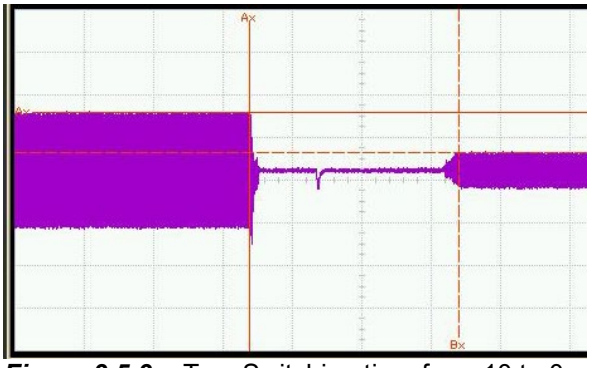


Figure 3.5.3c: Typ. Switching time from 10 to 0 dB(RUDAT-13G-90); 600 ns switching time

Ax = 174.907 µs	Ay = 140 mV
Bx = 175.510 µs	By = 46 mV
Δx = 603.000 ns	Δy = -100 mV

3.5 *Dynamic addressing*

3.5.1 ***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.

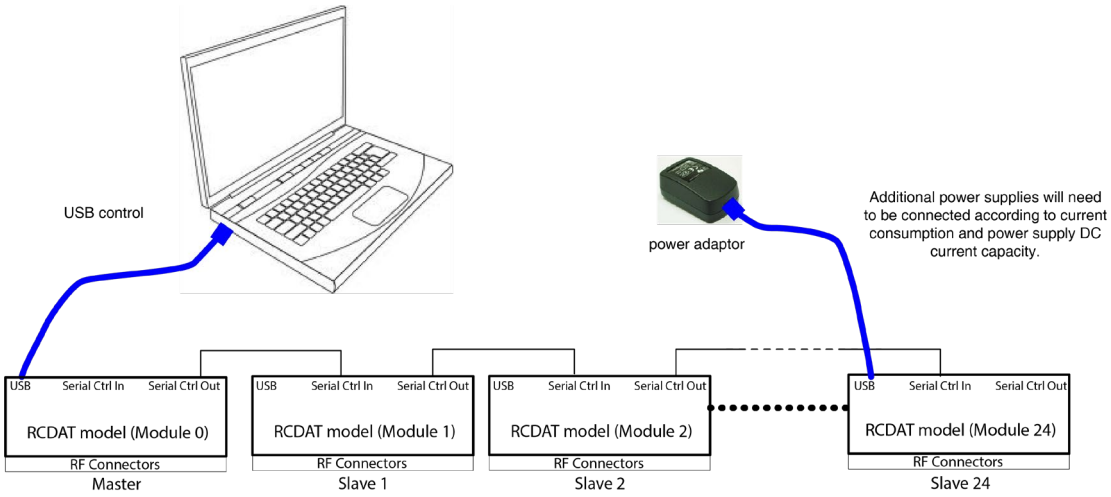


Figure 3.5.1: Master/Slave connection with USB control

3.5.2 ***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.

3.5.3 *Dynamic addressing functions:*

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

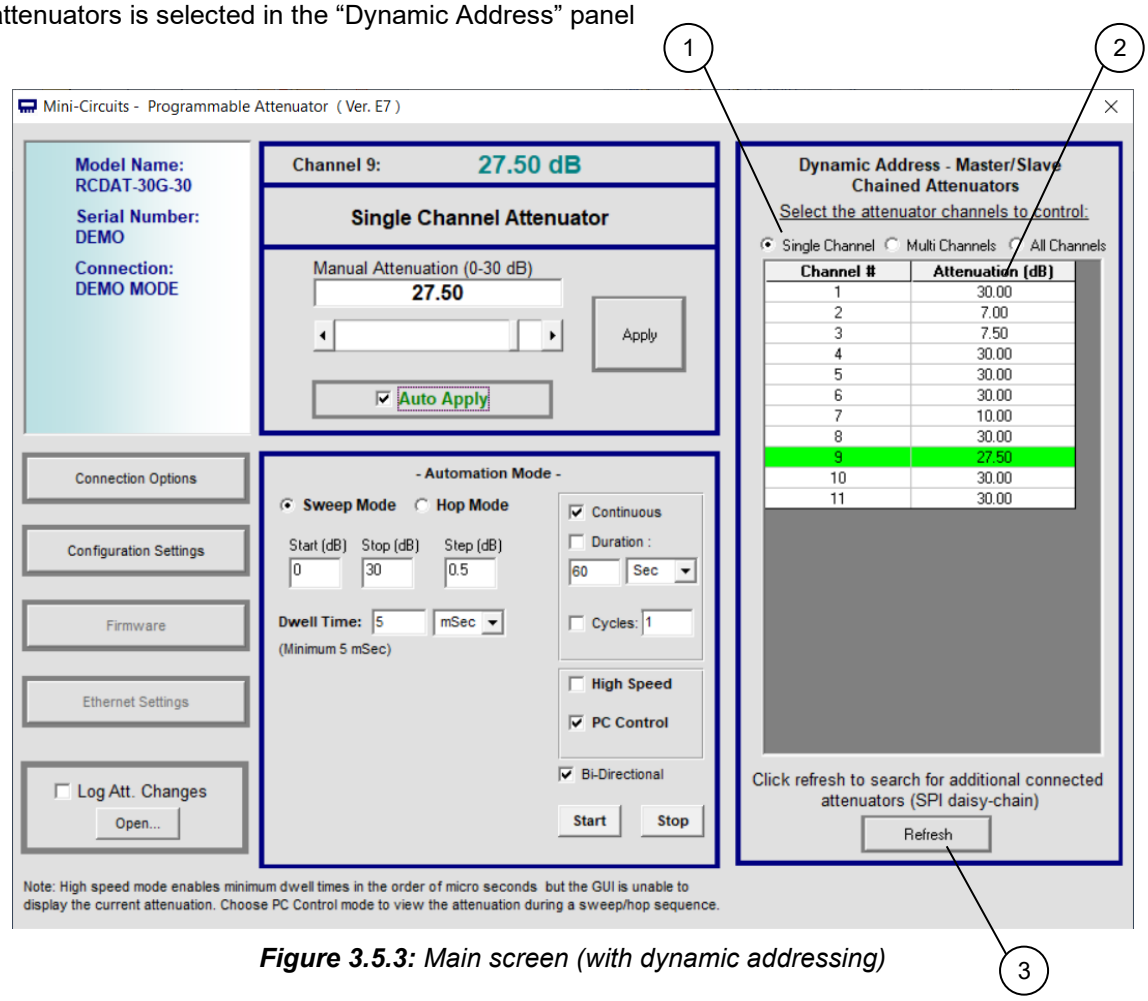


Figure 3.5.3: *Main screen (with dynamic addressing)*

#	Name	Description
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 .

3.5.4 *Configuring units with dynamic addressing*

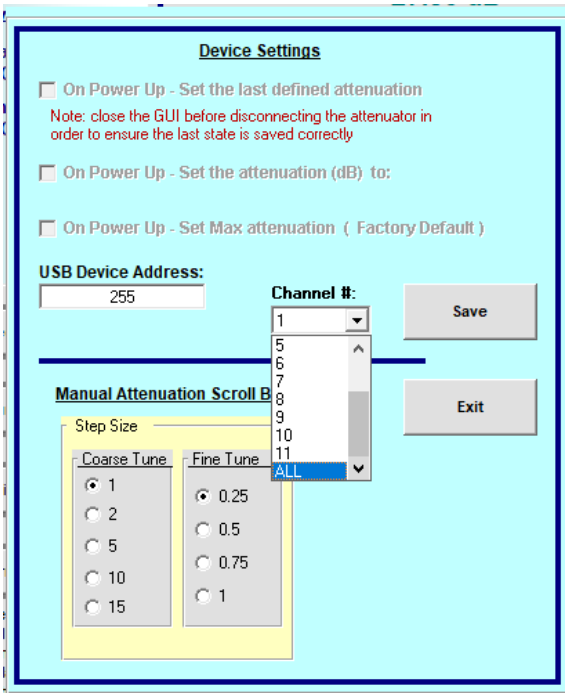


Figure 3.5.4: *Configuration screen (with dynamic addressing)*

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 0**

3.6 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.

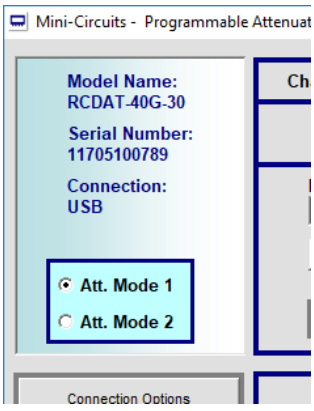


Figure 3.6: *Attenuation modes*

3.7 Alerts during operation of the Programmable Attenuator

3.7.1 ***If you type*** an attenuation value the attenuator cannot meet – either too large a number, or resolution to 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.

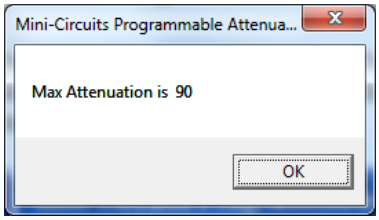


Figure 3.7.1a: *Value too large for model*

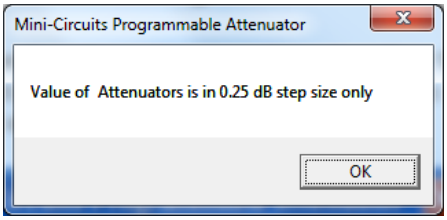


Figure 3.7.1b: *Resolution too fine for model*

3.7.2 ***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.

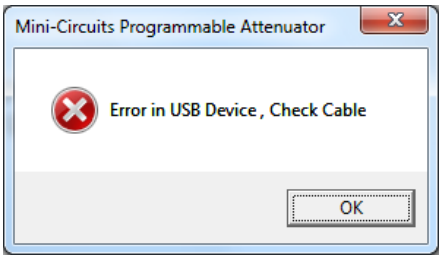


Figure 3.7.2: *data or power disconnected alert*

3.7.3 ***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.

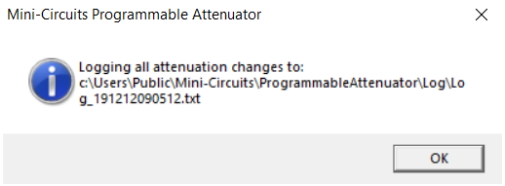


Figure 3.7.3a: *Start/end of logging alert*

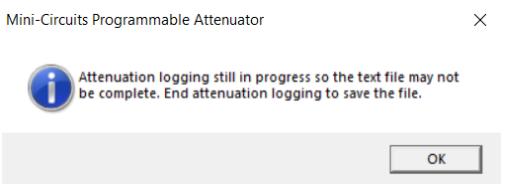


Figure 3.7.3b: *Mid-recording alert*

3.7.4 ***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

3.8 *Firmware update*

The firmware upgrade process requires a computer running a Windows operating system and with the latest Mini-Circuits GUI (Graphical User Interface) program installed for the model to be upgraded, and a suitable upgrade file for the unit.

3.8.1 *Model serial numbers which support firmware upgrade are:*

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

3.8.2 *All products 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.

3.8.3 *The upgrade is done using a provided .hex file and* the programmable attenuator GUI. The GUI must be started in USB control (See **section 3.1**) without any slave units connected to allow firmware upgrade. Click on the Firmware button on the left side of the screen.

Note: If the file name of the .Hex file is changed it will not be recognized as a valid firmware file.

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.
In newer units a recovery option is available to restore units rendered inoperable by an incorrect upgrade process. See section 3.8.9 for details.

3.8.4 *The following firmware upgrade instructions apply to* both current (RCDAT-xG-120H) and legacy controller (all other models) versions, but with some visual differences highlighted below.

3.8.5 ***The Firmware button will open the*** firmware info window (See **Fig. 3.8.5**). The 'Firmware' listed is the version of the firmware installed in your attenuator. Click on "Update Firmware" to select a new firmware version to install or click 'Exit' to close the firmware info window.

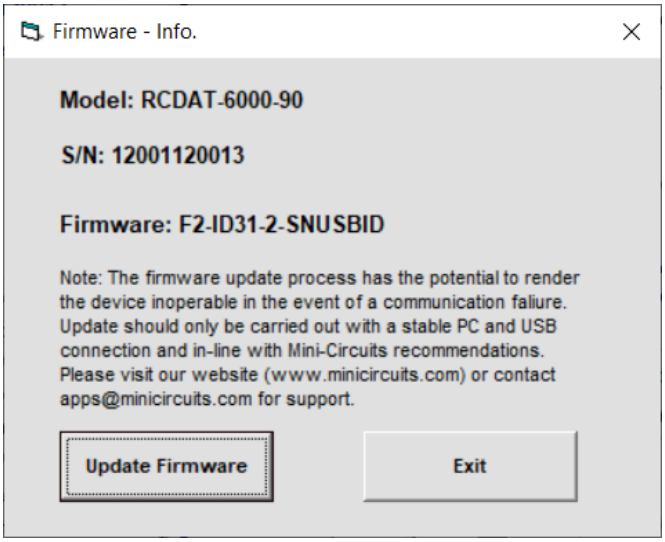


Figure 3.8.5: *Firmware - Information Window*

3.8.6 ***Clicking on 'Update firmware'*** will open a browse window for you to navigate to where you saved the upgrade file you received and run it.

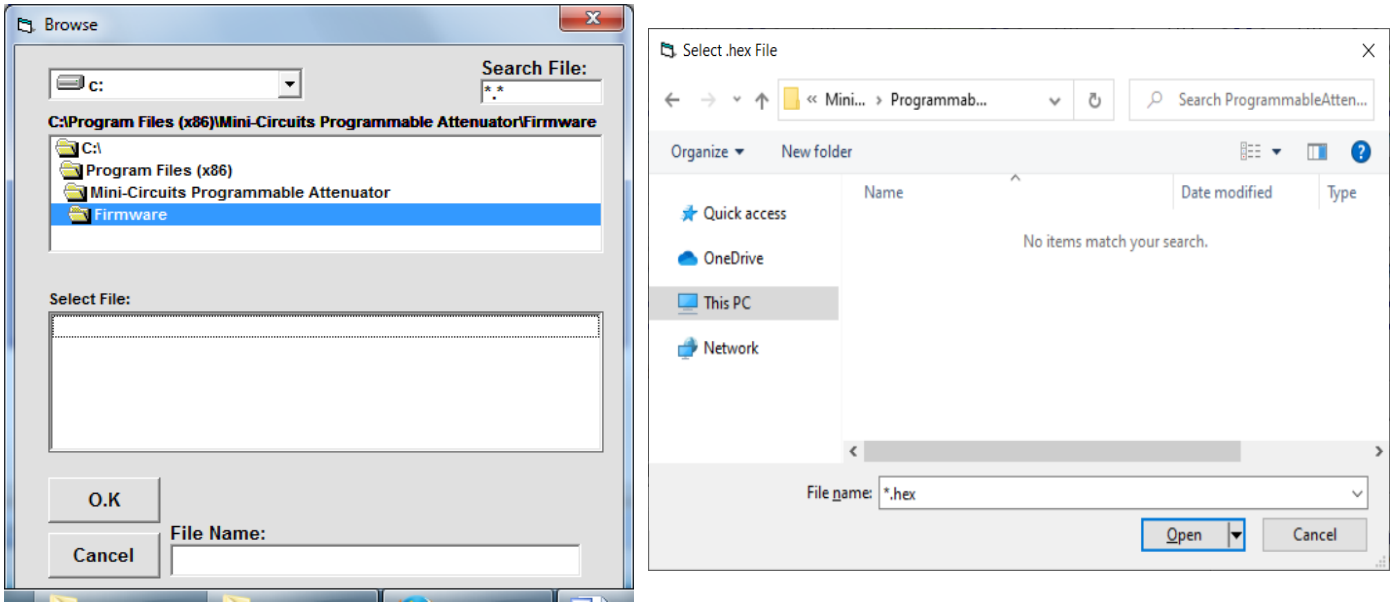


Figure 3.8.6 *Firmware - Browse Window (Legacy – left, Current – right)*

3.8.7 ***The selected file will be installed in the attenuator,*** the process will take up to a minute.

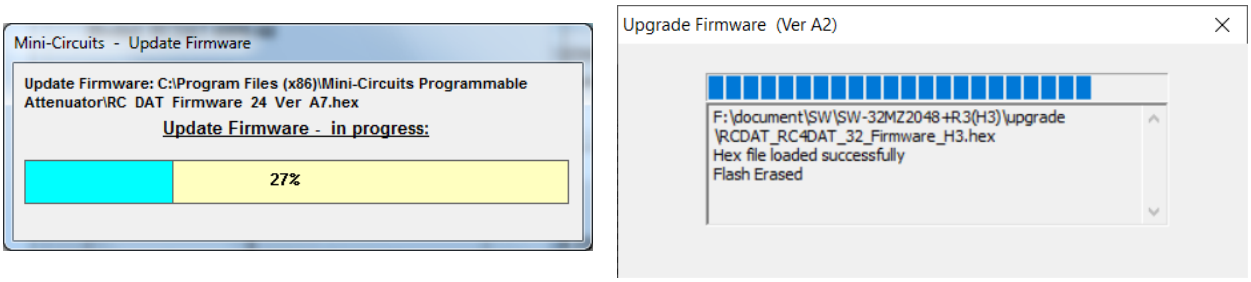


Figure 3.8.7: *Firmware - Progress Bar Window (Legacy – left, Current – right)*

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.

3.8.8 ***After the firmware has updated*** an alert will appear. Click 'OK' to shut down the Programmable Attenuator program and then restart it normally.

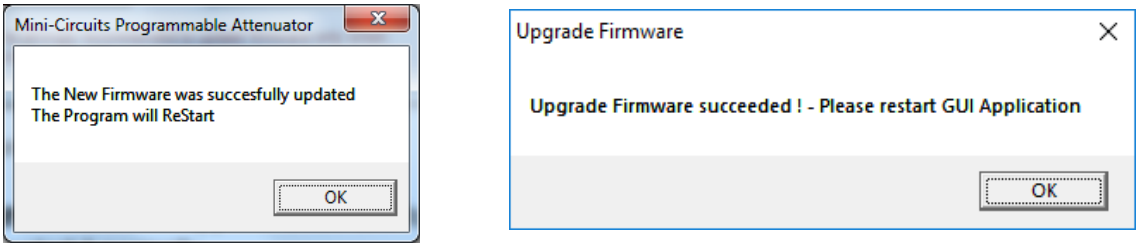


Figure 3.8.8: *Firmware - Successful Update (Legacy – left, Current – right)*

3.8.9 ***If the firmware upgrade was interrupted*** this can result in partial installation rendering the device inoperable. In newer units an additional recovery function was added. The recovery option is supported by the following S/N:

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

3.9 Firmware recovery

With newer units, if your device has corrupted firmware and is no longer accessible (for example due to an interrupted firmware upgrade), you can follow the below steps to recover. The table in ***section*** 3.8.9 summarizes which units support this feature.

Please contact testsolutions@minicircuits.com if you do not have the *.hex* firmware file.

3.9.1 ***For all models except RCDAT-xG-120H,*** open the GUI and attempt to establish a USB connection. An alert should appear (See **Fig *3.9.1)*** advising that the corrupted attenuator has been identified, click 'Yes' to proceed and refer to steps ***3.8.3*** - ***3.8.8*** above, or 'No' to cancel.

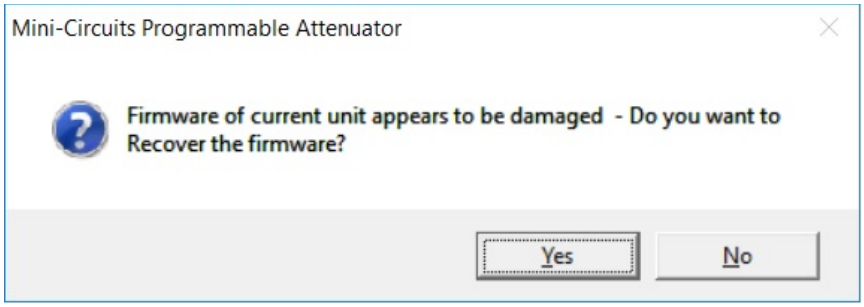


Figure 3.9.1 *Firmware – recovery option (Legacy)*

3.9.2 ***For RCDAT-xG-120H models,*** navigate to the directory where you installed the GUI and run "UpgradeFirmware.exe". In the new window click the "Connect/ Disconnect" button. After a connection has been made proceed to click on "Load Hex File" button for a browse window to open. Navigate to where you saved the upgrade file and select it, then click on "Upgrade Firmware".

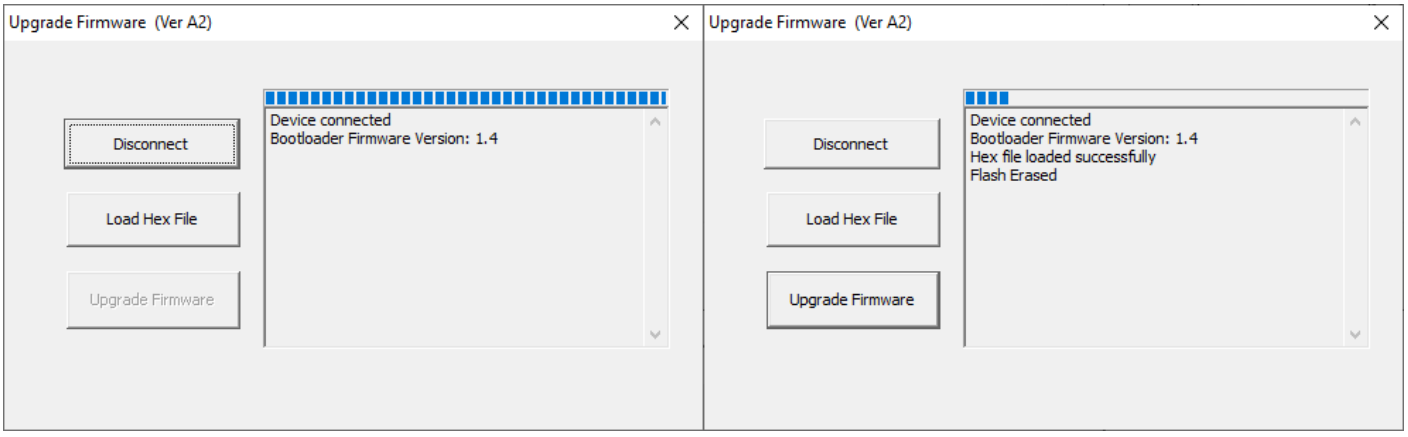


Figure 3.9.2 *Firmware Upgrade App. (Connection step – left, Upgrade step – right)*

Chapter 4 – 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-132G-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 RC4DAT models to 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-120.
- Added explanation on new attenuation log function and a note on SSH login.

Revision K (Apr 22, 2021):

- Added model RCDAT-8G-120.
- Updated Ethernet configuration to show new factory default.
- Added explanation of Ethernet configuration tool.
- Updated firmware upgrade and recovery sections.