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Attenuators Program 0.25-dB Steps to 120 dB

Covering frequency ranges from 1 to 4000 MHz and 1 to 6000 MHz, these programmable step attenuators are fast, accurate, and command as much as 120-dB attenuation.

Attenuation is an important electrical characteristic for a wide range of applications, from communications networks to measurement systems. Attenuators come in many shapes and sizes, ranging from tiny fixed components to large instruments. As a practical compromise in size—but not in performance—a pair of new programmable attenuators from Mini-Circuits operate over broad bandwidths as wide as 1 to 6000 MHz, with 110-dB or more precisely controlled attenuation that is adjustable in fine 0.25-dB steps.

These programmable attenuators are noteworthy for maintaining consistent attenuation with high accuracy across their 4- and 6-GHz frequency ranges and wide temperature ranges. They are well suited for controlling signal levels where needed, such as for testing or for protecting other components [e.g., low-noise amplifiers (LNAs) in receivers] from overload damage.

Model RCDAT-4000-120 *(Fig. 1)* features programmable 0-to-120-dB attenuation in 0.25-dB steps across a frequency range of 1 to 4000 MHz. In contrast, model RUDAT-6000-110 *(Fig. 2)* boasts programmable 0-to-110-dB attenuation in 0.25-dB steps across a frequency range of 1 to 6000 MHz. The attenuators differ somewhat with their control interfaces: The RCDAT-4000-120 provides Universal Serial Bus (USB) and RJ45 Ethernet ports, while the RUDAT-6000-110 includes USB and RS-232C ports.

Both attenuators are well-equipped for taming the attenuation levels in communications and automatic-test-equipment (ATE) systems—and even in manual test setups, where the flexibility in amplitude control and speed protects the measurements and test gear.

1. Model RCDAT-4000-120 is a programmable attenuator with 0-to-120-dB attenuation in 0.25-dB steps from 1 to 4000 MHz.

2. Model RUDAT-6000-110 is a programmable step attenuator with 0-to-110-dB attenuation in 0.25-dB steps from 1 to 6000 MHz.

The model RCDAT-4000-120 includes a dedicated microcontroller, broadband monolithic digital step attenuator (DSA), control ports, and input and output connectors, all packed into a compact housing measuring just 2.5 × 3.0 × 0.85 in. The DSA supports bidirectional operation with its SMA female signal connectors, which allows either connector to serve as an input or output port.

This attenuator commands a range of attenuation from 0 to 120 dB in 0.25-dB steps from 1 to 4 GHz, but also offers the fast switching speed essential for production-line testing and the high levels of accuracy needed for trusted testing. Model RCDAT-4000-120 can change attenuation states with high-speed switching speed of typically 650 ns, while also settling to new attenuation settings with remarkable stability and accuracy.

The attenuation accuracy for this DSA is typically ±0.5 dB or better across the full attenuation range, even at the highest attenuation settings and frequencies. The attenuation accuracy is consistent across the full attenuation range *(Table 1)* and with frequency.

Attenuation accuracy is quite impressive across all attenuation settings and frequencies. For example, from 1 to 4000 MHz and for attenuation settings from 0.25 to 10.00 dB, the attenuation accuracy is typically ±0.15 dB. The attenuation accuracy is a worst case of ±0.70 dB for attenuation settings from 90.25 to 120.00 from 1 to 2000 MHz; this level of accuracy improves to typically ±0.35 dB for this same range of attenuation settings for frequencies from 2000 to 4000 MHz.

The typical attenuation accuracy is ±0.55 dB for attenuation settings from 10.25 to 40.00 dB from 1 to 2000 MHz, and ±0.50

TABLE 1: THE MODEL RCDAT-4000-120 ATTENUATION ACCURACY AT A GLANCE

Frequency range (MHz)	Attenuation setting (dB)	Attenuation accuracy (dB)
1 to 2000	0.25 to 10.00	±0.15
1 to 2000	10.25 to 40.00	±0.55
1 to 2000	40.25 to 90.00	±0.50
1 to 2000	90.25 to 120.00	±0.35
2000 to 4000	0.25 to 10.00	±0.15
2000 to 4000	10.25 to 40.00	±0.50
2000 to 4000	40.25 to 90.00	±0.25
2000 to 4000	90.25 to 120.00	±0.35

dB for attenuation settings of 40.25 to 90.00 dB from 1 to 2000 MHz. Across the upper half of the frequency range, attenuation accuracy is typically ±0.50 dB for attenuation settings of 10.25 to 40.00 dB from 2000 to 4000 MHz, ±0.25 dB for attenuation settings of 40.25 to 90.00 dB from 2000 to 4000 MHz, and ±0.35 dB for settings of 90.25 to 120.00 dB from 2000 to 4000 MHz.

Of course, the RCDAT-4000-120 suffers some insertion loss of its own, as measured at its 0-dB attenuation setting as a function of frequency. The insertion loss is typically 6.5 dB from 1 to 2000 MHz and 9.0 dB from 2000 to 4000. The isolation between input and output ports with power on is typically 134 dB from 1 to 4000 MHz. Across that same frequency range, the programmable attenuator offers excellent linearity, as measured by its high input third-order intercept point (IIP3) of typically +53 dBm at a 0-dB attenuation setting.

The attenuator is closely matched to 50 Ω, with low VSWR of typically 1.30:1 for attenuation settings of 0 to 40 dB from 1 to 500 MHz and VSWR of typically 1.05:1 for attenuation settings of 40.25 to 120.00 dB from 1 to 500 MHz. For higher frequencies, the VSWR is typically 1.10:1 for attenuation settings from 0 to 20 dB for frequencies from 500 to 4000 MHz and typically 1.05:1 for attenuation settings from 20.25 to 120.00 dB from 500 to 4000 MHz.

Controlling the model RCDAT-4000-120 programmable step attenuator is a simple matter, since each attenuator is supplied with easy-to-install, user-friendly graphical-user-interface (GUI) software for a PC or laptop computer. The GUI software is written with API objects for Microsoft Windows operating environments, and complete programming instructions for 32- and 64-b Windows and Linux operating systems. The software provides clear, straightforward user screens whether under USB or Ethernet control, allowing users to set attenuation, sweep speeds and modes, and even hop modes.

For those in need of higher-frequency operation with slightly less attenuation, the model RUDAT-6000-110 programs 0.25-dB steps across an attenuation range of 0 to 110 dB and a frequency range of 1 to 6000 MHz. It measures a compact 2.0 × 3.0 × 0.6 in. with female SMA input and output connectors.

TABLE 2: THE MODEL RUDAT-6000-110 ATTENUATION ACCURACY AT A GLANCE

Frequency range (MHz)	Attenuation setting (dB)	Attenuation accuracy (dB)
1 to 2000	0.25 to 10.00	±0.15
1 to 2000	10.25 to 40.00	±0.55
1 to 2000	40.25 to 90.00	±0.50
1 to 2000	90.25 to 110.00	±0.70
2000 to 4000	0.25 to 10.00	±0.15
2000 to 4000	10.25 to 40.00	±0.50
2000 to 4000	40.25 to 90.00	±0.25
2000 to 4000	90.25 to 110.00	±0.35
4000 to 6000	0.25 to 10.00	±0.10
4000 to 6000	10.25 to 40.00	±0.40
4000 to 6000	40.25 to 90.00	±0.60
4000 to 6000	90.25 to 110.00	±0.80

Like its lower-frequency counterpart, this programmable attenuator provides very good attenuation accuracy of typically ±0.45 dB across its wide frequency and attenuation ranges *(Table 2)*. Moreover, it features high-speed switching of attenuation settings, allowing for efficient and effective production testing.

Also like the lower-frequency attenuator, model RUDAT-6000-110 exhibits low VSWR across its wide frequency range. From 1 to 500 MHz, the VSWR is typically 1.30:1 for attenuation settings from 0 to 20 dB and 1.05:1 for attenuation settings from 20.25 to 110.0 dB. From 500 to 4000 MHz, the VSWR is typically 1.10:1 for attenuation settings from 0 to 20 dB and 1.05:1 for attenuation settings from 20.25 to 110.0 dB. From 4000 to 6000 MHz, the VSWR is typically 1.30:1 for attenuation settings from 0 to 20 dB and 1.15:1 for attenuation settings from 20.25 to 110.00 dB.

Model RUDAT-6000-110 is a true Plug & Play device, with no drivers required, and is supplied with operating software on a CD. It has some insertion loss, measured as the loss at a 0-dB attenuation setting, at typically 6.5 dB from 1 to 2000 MHz, 9.0 dB from 2000 to 4000 MHz, and 9.5 dB from 4000 to 6000 MHz. It exhibits typical input-output isolation of 124 dB from 1 to 6000 MHz, and achieves excellent linearity, with input IIP3 of typically +53 dBm from 1 to 3000 MHz and +51 dBm from 3000 to 6000 MHz, as measured with a 0-dB attenuation setting and +10-dBm test-signal input power.

These compact programmable attenuators are useful for a wide range of purposes, from communications systems to manual measurements and ATE applications. Both attenuators feature good electrostatic-discharge (ESD) tolerance for use in a wide range of systems and environments. mw

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