

Mini-Circuits®

Digital Step Attenuators

Precision TTL-controlled step attenuators, accurate over 10 to 1000 MHz and -55° to $+100^{\circ}$ C, are available from Mini-Circuits in hermetically-sealed TO-8 cases and SMA connectorized packages. In each package style, five models are offered, each with three internal discrete attenuators switchable to provide eight discrete and accurate levels up to 35 dB. Models can be cascaded to provide increased attenuation because of the excellent input/output return loss of each model; the final value of attenuation will equal the sum of the attenuations of the individual models. The accuracy of these step attenuators is comparable to precision fixed attenuators. Attenuation values are flat over the full frequency range and the full -55° to $+100^{\circ}$ C temperature range.

Three TTL lines are provided, one to correspond with each step of attenuation. To achieve 6-bit attenuation, merely cascade two models. Each step is switched on or off by a TTL signal, with the difference in insertion loss between the on and off state being the step attenuation. The 50 ohm TOAT- and ZFAT-series perform with 6 μ sec switching speed and can handle power levels up to +10 dBm above a few hundred MHz, and 0 dBm at 10 MHz.

Modern Definition of Terms

digital attenuator/electronic step attenuator

an attenuator whose attenuation can be varied by digital control signals. As digital signals have finite states, a digitally controlled attenuator has a corresponding number of finite attenuation states.

thru loss

insertion loss of the step-attenuation in "000" state of the digital control signal.

primary attenuation step

Mini-Circuits' step attenuators have 3 digital control lines. When one of the signals is in the "high" state and the other two are in the "low" state, one step of the attenuator is activated, which is called a primary attenuation step.

step accuracy

is the deviation of the actual attenuation step from the specified value over the specified frequency range.

rise time

time required for the attenuator to change from 10% to 90% of its final value when one of the steps is switched on. The digital control signal should have a much lower rise time (approximately 1/10 of the attenuator) to make a good measurement.

delay time

is the time difference between 50% of the TTL signal to 90% of the final attenuation step value when the attenuator is turned "ON" or 10% of the step value when it is turned "OFF."

maximum attenuation

the sum total of the primary attenuation steps. It is the maximum achievable step attenuation.

Most Often Asked Questions About Digital Step Attenuators

Q. Suppose I don't work at less than the specified 1dB compression of a step attenuator, what are the consequences?

A. Should you exceed the specified compression, typically given at 0dBm input, harmonics will be generated which may affect system operation. Also, when you measure the fundamental for attenuation, an error will appear because some of the fundamental's power has been transferred to the harmonic products.

Q. What is meant by the "zero" value of a step attenuator?

A. Step attenuators are referenced to the minimum insertion loss of the switch. If the switch in its "zero" position has an insertion loss of 3dB at 10MHz, it might be 3.5dB at 1GHz. All attenuation values are given relative to this "zero" reference.

Q. Why do Mini-Circuits' ads on TTL controlled step attenuators emphasize the word "precision"?

A. Most step attenuators on the market have a relatively wide variation of attenuation over the specified frequency band; for example, a 3dB step could be off by as much as 1dB so that attenuation is anywhere from 2 to 4dB. With Mini-Circuits' step attenuators, the difference would be 0.3dB or less. The same situation occurs for temperature variation.

Further, when switching internal resistors to increase attenuation from say 3dB to 6dB, the sum may be off by as much as 2dB if return loss within the unit is poor. With Mini-Circuits' precision step attenuators, designed with 24dB return loss, the sum will be within 0.6dB of nominal.

Q. What makes Mini-Circuits' step attenuators so precise?

A. Along with the 24dB return loss criterion, extremely short lead lengths, resistors trimmed with high accuracy, and switches with low parasitics yield precision performance.

Q. What happens when step attenuators are cascaded?

A. Attenuation will be arithmetically additive provided return loss of each unit is extremely good, 20dB or better. Otherwise, the sum may be other than the total of the units. Mini-circuits' attenuators can be cascaded without loss of accuracy.

Q. How fast is attenuation switched from one value to another?

A. TTL switching from one value to another is specified by delay time, and is 6 μ s max. Delay is defined as the time to achieve 90% of the resulting RF amplitude change.

Q. If I exceed the maximum input level, will I burn out the step attenuator?

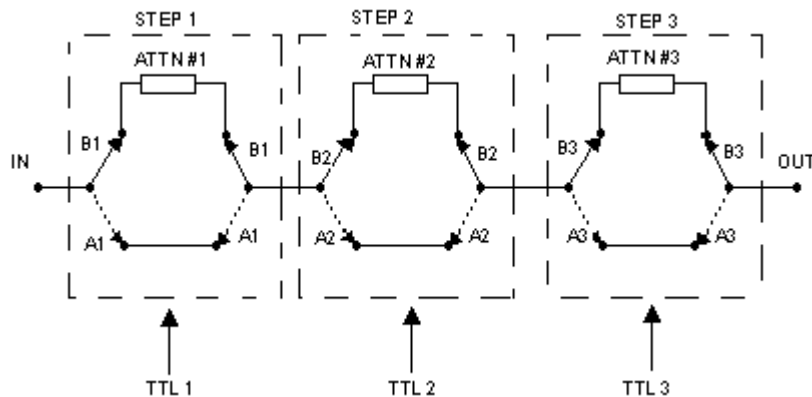
A. It's not recommended, but you can exceed the input power rating by 10dB without damage. The penalty would be the presence of distortion products and a decrease in attenuation accuracy.

Q. What is the consequence of feeding pulses with excessive peak voltage into a step attenuator?

A. Excessive voltage peaks will widen the pulse width.

Q. Please sketch the configuration of a typical TTL-controlled step attenuator.

A.



Each of the three steps is configured with two single-pole, double-throw switches and a fixed attenuator; see figure. Step 1 is shown with B1 and B1' contacting Attn #1, Step 2 with B2 and B2' contacting Attn #2, and Step 3 with B3 and B3' contacting Attn #3. Thus, all steps are connected to their individual attenuators and are in cascade to provide maximum attenuation.

Q. What are the TTL requirements for proper operation and how much latitude is allowable?

A. For MCL attenuators, TTL "0" corresponds to 0 to 0.8V and TTL "1" corresponds to 2 to 5V.

Q. Must the TTL input be 50-ohms? What if it is 75-ohms?

A. TTL interfaces are defined in terms of voltages and currents, rather than impedance.