

Integrated, Single-Step, 10dB Attenuator for Power Control Applications

Introduction

Wireless communication is continuing to expand into all areas of the business, government, and consumer sectors. New markets are opening around the world for products that will meet specialized requirements. To build such products, designers rely on having access to ever more sophisticated and integrated devices.

Basic Types of Integrated Attenuators and their Advantages

One particular type of device that has not seen a great deal of development is the surface mount, integrated attenuator. They are useful in reducing the power level of RF signals by a specific amount. There are two general classes - step and variable. Step attenuators allow one or more discrete levels of attenuation and are set by one or more control inputs. The variable class allows a specific value of attenuation to be selected from an overall range via an analog control voltage. They are more flexible than step attenuators as they allow any amount of attenuation to be set but the cost is greater circuit complexity. In both types, when no attenuation is selected, the attenuation is just the insertion loss of the device. The simplest type, and the focus of this article, is the single-step attenuator which needs only one control input.

Integrated attenuators offer several advantages over solutions using other types of devices. They are small, consume very little power, and can handle reasonable input power levels. Their small size makes them very attractive when trying to preserve or reduce printed circuit board space. Being designed with field effect transistor (FET) technology, they can function while drawing very low levels of current. Other approaches to providing the same function would include the use of discrete semiconductors, PIN diodes, or resistive networks in combination with active, discrete switches or relays. Each of these alternatives has drawbacks in cost, size, or performance when compared with the integrated solution.

Attenuator Design

An integrated attenuator is internally composed of a resistive attenuator network, in either a 'pi' or 'T' configuration, and active switches for signal routing. Figure 1 shows an equivalent circuit for a 'pi' attenuator along with the standard equations for first-order calculation of the resistor values. One example of this kind of component is the RF2421 from RF Micro Devices. It is a

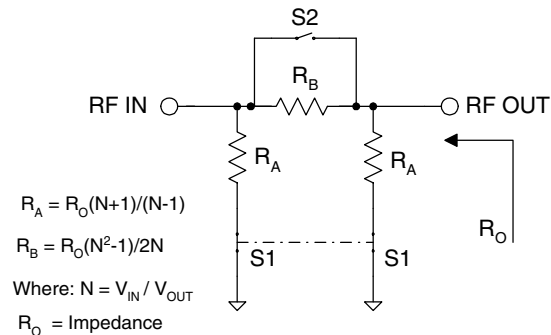


Figure 1. Single-Step Attenuator Equivalent Circuit

monolithic, GaAs MESFET, switched attenuator in an SOP-8 style package. It has a digitally controlled, single-step, typical attenuation of 10dB. The supply voltage range is 2.7V to 6V DC and no negative supply voltages are required. The current consumption is less than 1uA with no attenuation and is typically less than 500uA in the attenuation mode.

The input and output of the device have a low voltage standing wave ratio (VSWR) 50Ω match (Fig. 2) and the RF output can drive up to +16dBm. It has 1dB typical insertion loss over the specified 500 to 3,000MHz operating frequency range and good flatness in any 50MHz band (Fig. 3). The resistors are nickel chromium and provide excellent temperature stability. The RF ports are reversible, i.e., the input signal can be applied to either port. The attenuation control pin has an internal pull-down resistor which causes the attenuator to be turned off when it is not connected.

Typical Applications

Typical uses for this type of part include local oscillator, IF and RF level control throughout communications, measurement, and control circuits. Due to its flat, wide-band response, it has little effect on phase and group delay and thus introduces minimal distortion. One radio designer required a way to reduce the output of the receive mixer in a CDMA base station prior to the IF amplifier. He found the RF2421 to be an ideal solution. Also, to provide one step of transmit level control with little degradation of the noise figure (NF), it could be used in a CDMA handset transmit chain between the upconverter and the bandpass filter (Fig. 4). Since the device is purely passive, it produces no additive noise and the NF is, essentially, the insertion loss.

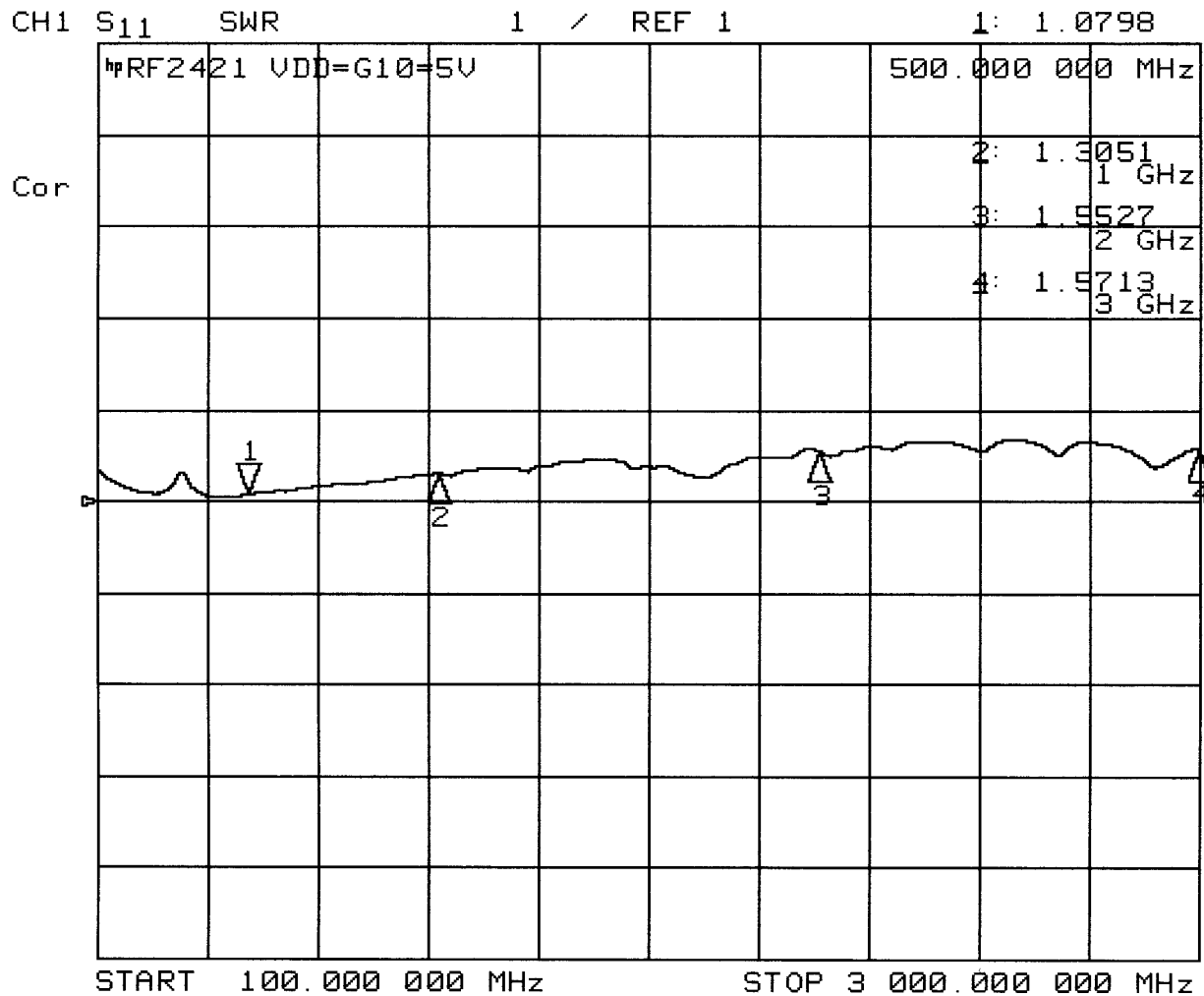


Fig. 2. RF2421 VSWR over Frequency

Even in the attenuation mode, the effect on noise figure would be minimal since the attenuator's noise figure would be the third term in the cascade NF equation.

In PCS systems, the base stations may be fed from multiple picocells that are physically separated from it by up to a hundred feet or more of coaxial cable. The signal levels coming into the base station will vary depending on the cable length and individual transponder power. It is desirable to keep the signals at a uniform level at the base station, and to do so, it may be necessary to attenuate the stronger signals. Again, a step attenuator can be easily dropped in to perform this function.

The upper end of a receiver's dynamic range is determined by the largest signal it can handle without being overdriven and producing unacceptable levels of distortion caused by nonlinearity. Switching in an attenuator

before a low noise amplifier (LNA) in the presence of strong, in-band signals allows reception by preventing them from overdriving the receiver front end. This effectively shifts the dynamic range upward by the amount of the attenuation. For this application, it is important that the third-order intercept point (IP3) performance of the attenuator in the off-attenuation mode is better than that of the LNA so it does not worsen the receiver's linearity.

As a gain control element at the input of an amplification stage, the step attenuator would offer the added benefit of reducing the VSWR by reducing the return loss. In many cases, only one or two dB of additional isolation is needed to improve amplifier instability or to help isolate a poorly matched load from a source. When the attenuator is active, it is actually a pad since it has the same input and output characteristic impedance. It presents itself to the signal as a lossy trans-

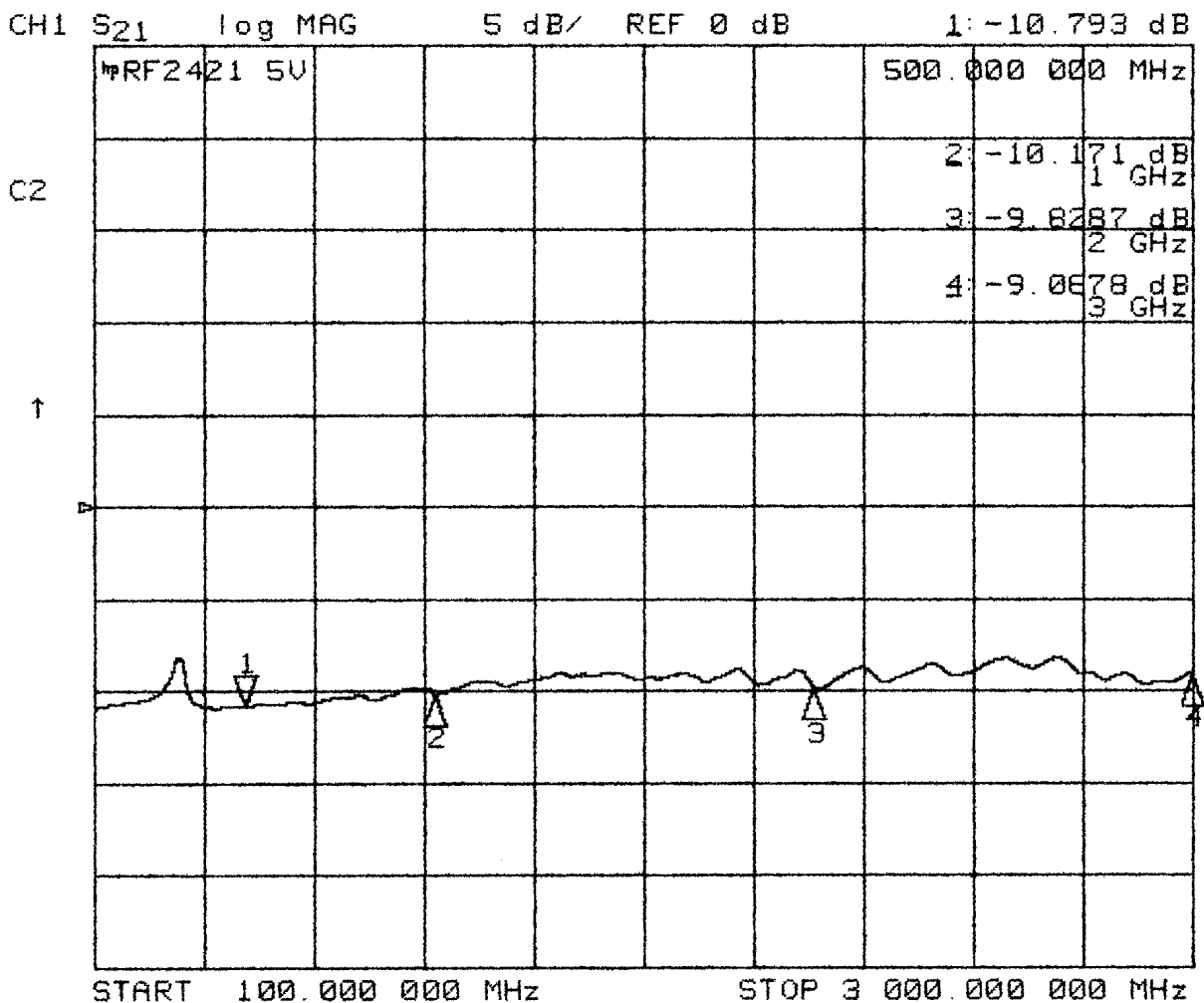


Figure 3. RF2421 Frequency Response

mission line having zero path length and, therefore, no delay. A 10dB pad would decrease a 2:1 VSWR to about 1.07:1.

Conclusion

The RF2421 Single Step 10dB Integrated Attenuator is an extremely versatile component allowing radio designers to improve system performance by appropriately setting RF signal levels through their systems.

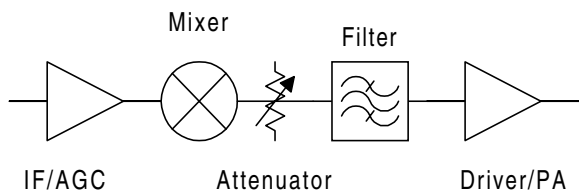


Figure 4. CDMA Handset Transmit Application

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**TECHNICAL NOTES
AND ARTICLES**