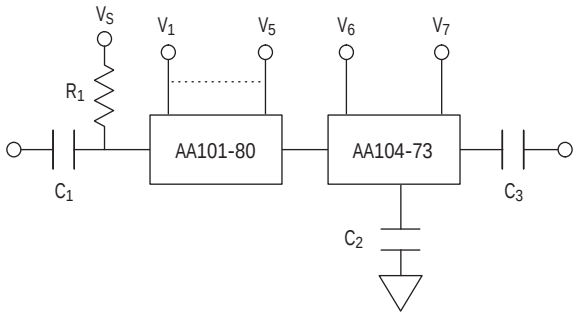
APPLICATION NOTE

APN2014: 6 Bit 63 dB RF Digital Attenuator Solution 500–2000 MHz

High dynamic range systems often require an attenuator with a very wide attenuation range. It is possible to achieve 63 dB attenuation range by cascading two low cost digital attenuators, AA101-80 and AA104-73. It is effectively impossible to achieve such high attenuation range with a single package device.

AA101-80 is a 5-bit attenuator with a 1 dB least significant bit (LSB). Full-scale attenuation for this attenuator is 31 dB. AA104-73 is a 1-bit digital attenuator that produces 32 dB attenuation. When these two attenuators are cascaded on a standard FR4 printed circuit board, 63 dB total attenuation range with 1 dB step size is produced within the frequency range 500 MHz to 2 GHz.



R_1: 10 kΩ
C_1, C_3: 47 pF
C_2: 12 pF

Figure 1. Block Diagram, 6 Bit Attenuator, 900 MHz

The AA104-73 offers unique design flexibility in a miniature SOT-6 package. This part may be tuned for different center frequencies by changing capacitors C_2 and C_3 (Table 1). Once the proper capacitance value is chosen for the desired frequency, the attenuation will cover a 150–200 MHz bandwidth. Performance for various values of capacitance is shown in the AA104-73 data sheet.

The AA101-80 is a broadband device. Its attenuation will be flat over the frequency range from 500 MHz to 2.5 GHz.

The cascade of AA104-73 and AA101-80 will exhibit a tuned response. See data plots (Figure 3). The example shown is for an operation at 900 MHz. This solution works with supply and control voltages of 3 to 5 V. The AA101-80 requires five lines of control and the AA104-73 requires two lines of complementary positive voltage, for a total of seven control lines. The truth table is shown in Table 2.

RF Frequency (MHz)	Bypass Capacitor Value C_2 (pF)
900	12
1700	3.3
1800	2.7
1900	2.5

Table 1. Typical Capacitance for Desired RF Frequency

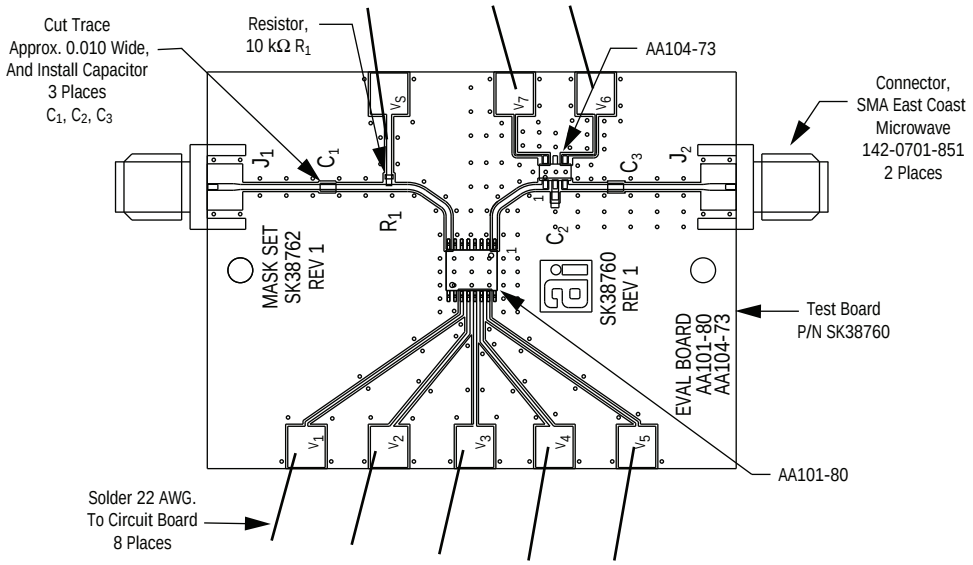
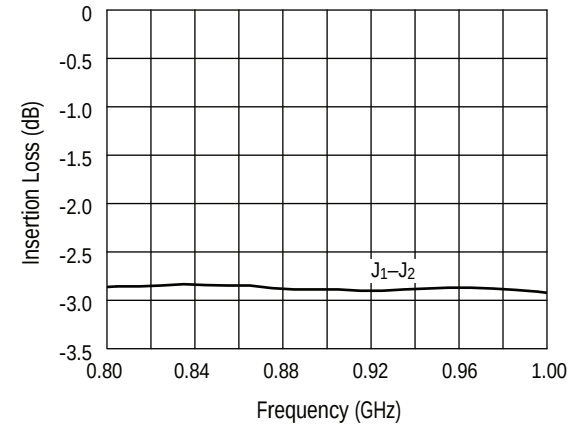
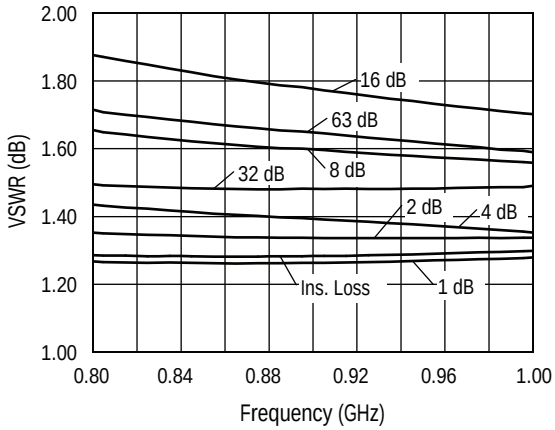


Figure 2. Assembly Test Board

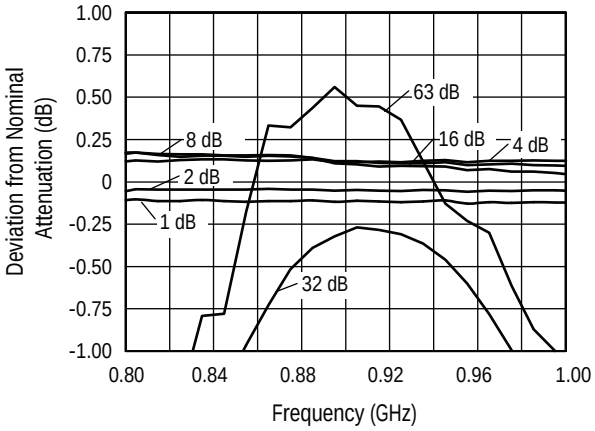
Typical Performance Data (0, 5 V) 900 MHz



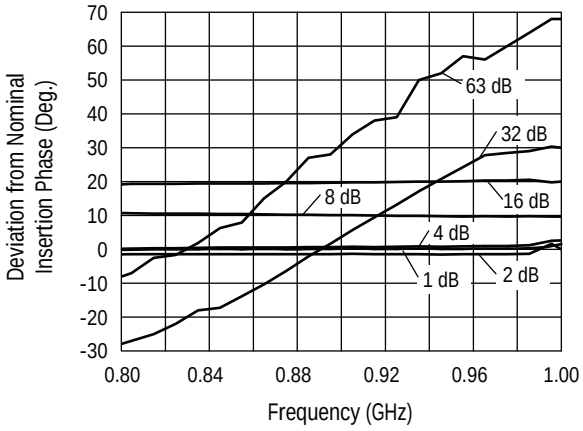
Insertion Loss vs. Frequency



VSWR vs. Frequency



Attenuation Accuracy



Attenuation Phase Accuracy

Figure 3

16 dB	8 dB	4 dB	2 dB	1 dB	32 dB		Attenuation State
V_1	V_2	V_3	V_4	V_5	V_6	V_7	
V_{High}	V_{High}	V_{High}	V_{High}	V_{High}	V_{High}	0	Insertion Loss
V_{High}	V_{High}	V_{High}	V_{High}	0	V_{High}	0	1 dB
V_{High}	V_{High}	V_{High}	0	V_{High}	V_{High}	0	2 dB
V_{High}	V_{High}	0	V_{High}	V_{High}	V_{High}	0	4 dB
V_{High}	0	V_{High}	V_{High}	V_{High}	V_{High}	0	8 dB
0	V_{High}	V_{High}	V_{High}	V_{High}	V_{High}	0	16 dB
V_{High}	V_{High}	V_{High}	V_{High}	V_{High}	0	V_{High}	32 dB
0	0	0	0	0	0	V_{High}	63 dB

V_{High} = +3 to +5 V (V_S = V_{High} ± 0.2 V).

Table 2. Truth Table