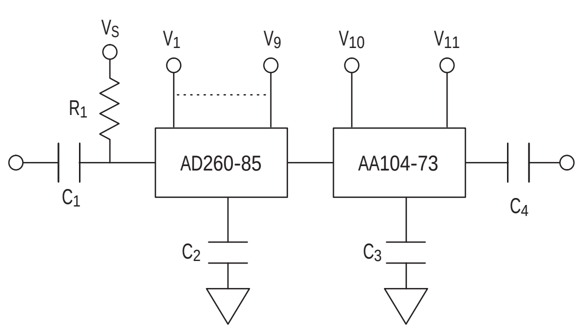
APPLICATION NOTE

APN2013: 6 Bit 63 dB IF Digital Attenuator Solution 1–500 MHz

High dynamic range systems often require an attenuator with a very large attenuation range. It is possible to achieve 63 dB attenuation range by cascading two low cost Skyworks digital attenuators, AA260-85 and AA104-73. It is effectively impossible to achieve such high attenuation range with a single package device.

AA260-85 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 1 MHz to 500 MHz.

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



R_1: 10 kΩ
C_1, C_2, C_4: 680 pF
C_3: 220 pF

Figure 1. Block Diagram, 6 Bit Attenuator, 242 MHz

The AA260-85 is a broadband device. Its attenuation is flat over the frequency range from 300 kHz to 2 GHz.

The cascade of AA104-73 and AA260-85 exhibits a tuned response. See data plots (Figure 3). The example shown is for operation at 242 MHz. This solution works with supply and control voltages of 3 to 5 V. The AA260-85 requires nine lines of complementary control voltages (two control lines per bit, only one control line for the LSB) and the AA104-73 requires two lines of complementary positive voltage, for a total of 11 control lines. The truth table is shown in Table 2.

AA260-85 operates with negative control voltage. The attenuator may be operated with positive control voltage by “floating” the device with DC block capacitors in the signal path (C_1 and C_4) and in the ground connections (C_2).

IF Frequency (MHz)	Bypass Capacitor Value C_2, C_3 (pF)
450	250, 82
242	680, 220
131	3000, 1000
70	4700, 1500

Table 1. Typical Bypass Capacitor for a Given IF

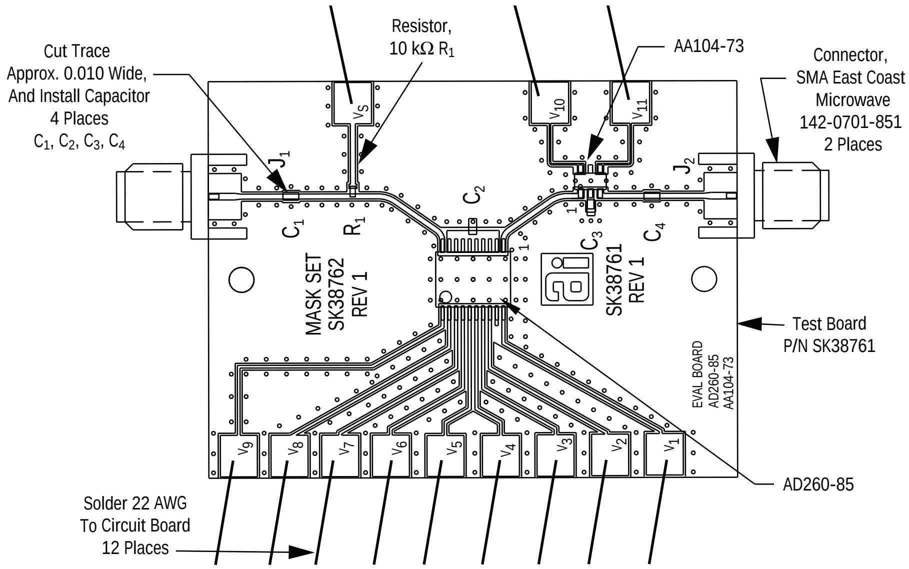
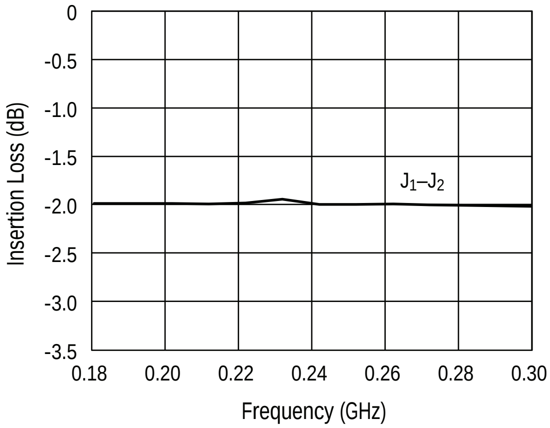
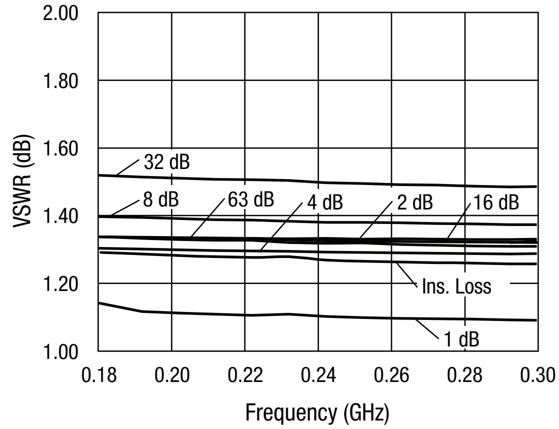


Figure 2. Assembly Test Board

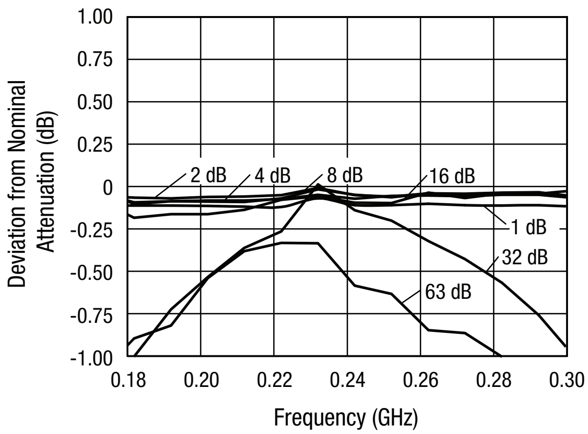
Typical Performance Data (0, 5 V) 242 MHz



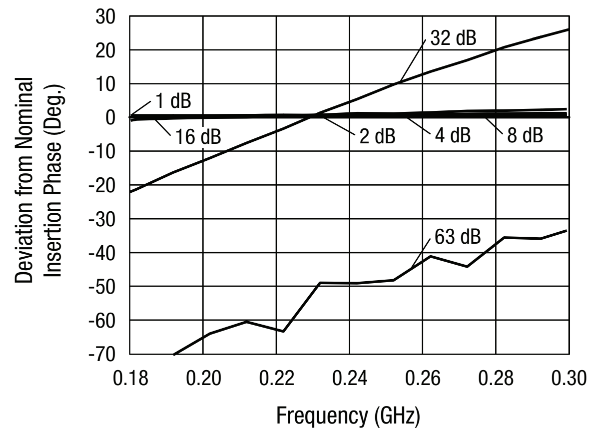
Insertion Loss vs. Frequency



VSWR vs. Frequency



Attenuation Accuracy



Attenuation Phase Accuracy

Figure 3

1 dB	2 dB		4 dB		8 dB		16 dB		32 dB		Atten. State
V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	
0	0	V_{High}	0	V_{High}	0	V_{High}	0	V_{High}	0	V_{High}	Ins. Loss
V_{High}	0	V_{High}	0	V_{High}	0	V_{High}	0	V_{High}	0	V_{High}	1 dB
0	V_{High}	0	0	V_{High}	0	V_{High}	0	V_{High}	0	V_{High}	2 dB
0	0	V_{High}	5	0	0	V_{High}	0	V_{High}	0	V_{High}	4 dB
0	0	V_{High}	0	V_{High}	V_{High}	0	0	V_{High}	0	V_{High}	8 dB
0	0	V_{High}	0	V_{High}	0	V_{High}	V_{High}	0	0	V_{High}	16 dB
0	0	V_{High}	0	V_{High}	0	V_{High}	0	V_{High}	V_{High}	0	32 dB
V_{High}	V_{High}	0	V_{High}	0	V_{High}	0	V_{High}	0	V_{High}	0	63 dB

V_{High} = +3 to +5 V ($V_S = V_{High} \pm 0.2$ V).

Table 2. Truth Table