

Abstract:

With the abundance of data and voice traffic being transmitted across standard cable and wireless pathways and the ever increasing linearity requirements of CATV amplifiers, there is a great need for amplification that optimizes gain, VSWR, efficiency and linearity. This application note demonstrates how to use two NGA-486 amplifiers in a push-pull configuration with better than +65 dBm IP2 performance across the 50-860 MHz band. A lower cost push-pull option, the SGA-6289, is presented with better than +60 dBm IP2 from 50-860 MHz.

Introduction:

Inherent in push-pull amplifiers is the distinct cancellation of second order harmonics and intermodulation products. The low cost of RFMD amplifiers, coupled with their excellent linearity, makes them an easy choice for use in these high linearity CATV applications. A summary of performance of the NGA-486 and SGA-6289 push-pull amplifiers is shown in Table 1 and Figures 1 and 2 below. All measurements in this Application Note were taken in a 75 Ohm system.

Summary Table	Measured Performance in Push-Pull Configuration	
	NGA-486	SGA-6289
Parameter		
IP2 (dBm)	70	62
IP3 (dBm)	38	36
P1dB (dBm)	20	20
Gain (dB)	13.5	13.5
Input Return Loss (dB)	15	18
Output Return Loss (dB)	15	15

Table 1: Typical Performance Summary of Push-Pull Configured Amplifiers

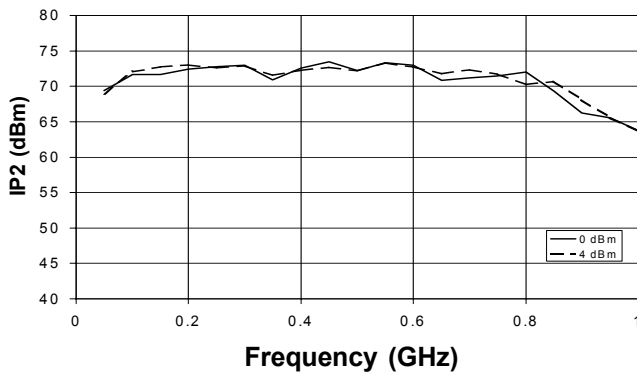


Figure 1: NGA-486 Second Order Intercept vs. Pout/Tone Push-Pull, 1 MHz Spacing

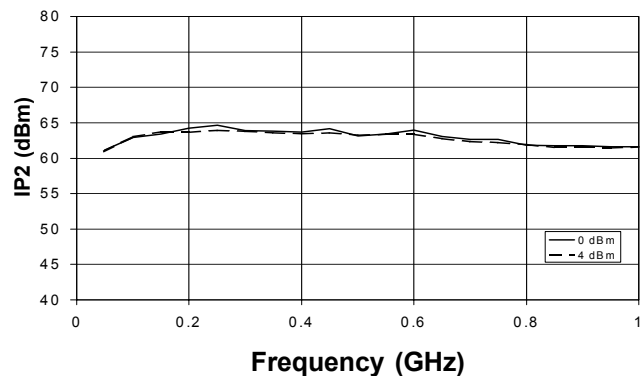


Figure 2: SGA-6289 Second Order Intercept vs. Pout/Tone Push-Pull, 1 MHz Spacing

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Measurement Results for InGaP HBT NGA-486.

The NGA-486 was tested for IP2 performance in both single ended and push-pull configurations. One device was measured in the single ended configuration and two in the push-pull configuration. The push-pull devices have excellent IP2 performance, well exceeding typical CATV specification requirements of +60 dBm over the entire cable band. The basic amplifier building block for the push-pull configuration is shown in Figures 3 and 4. The push-pull configuration is shown in Figures 5 and 6.

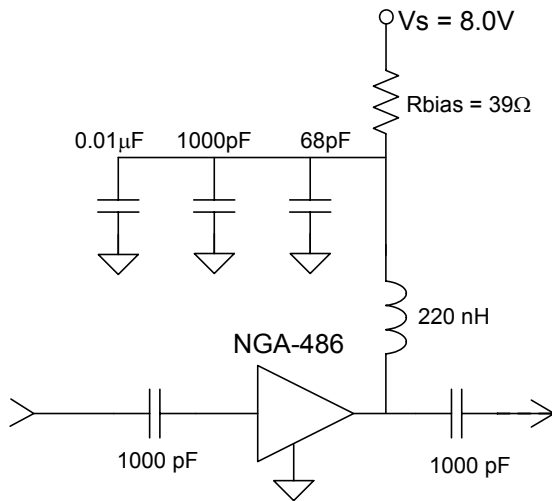


Figure 3: NGA-486 Singled Ended Schematic

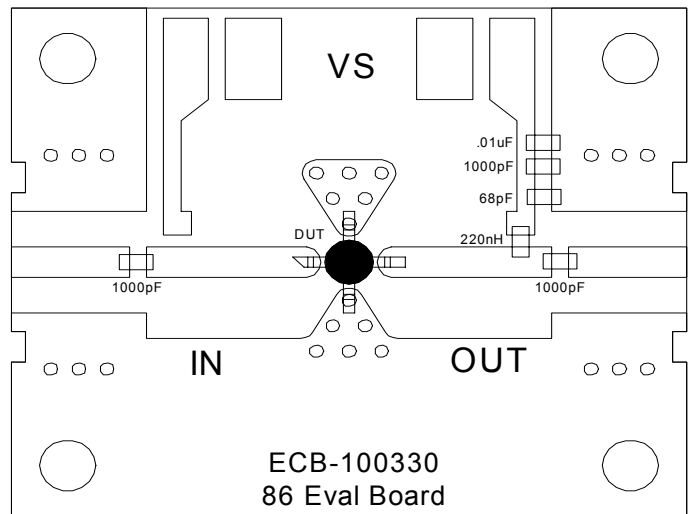


Figure 4: NGA-486 Singled Ended PCB Layout

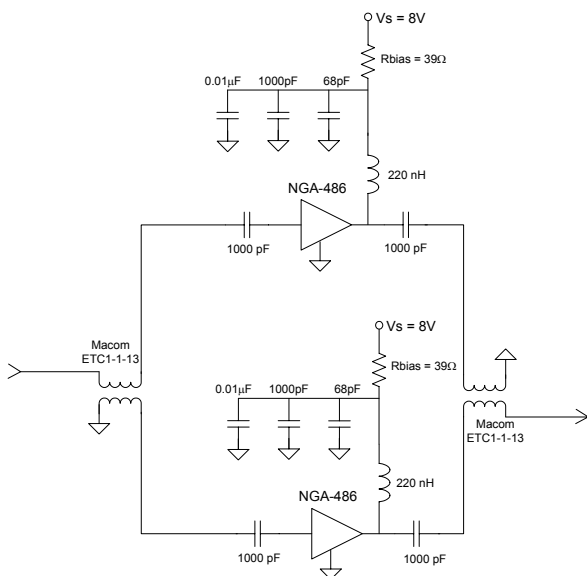


Figure 5: NGA-486 Push-Pull Schematic

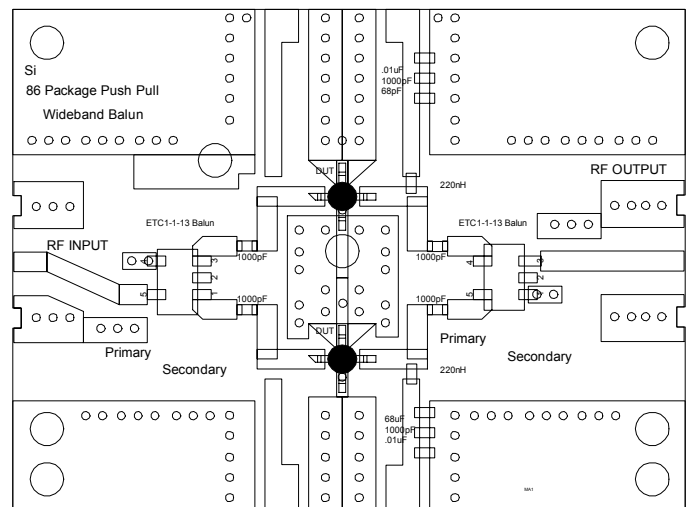


Figure 6: NGA-486 Push-Pull PCB Layout

Tables 2 and 3 illustrate IP2 performance of the NGA-486 at 5 frequency pairings. Two spacings yield a 54 MHz tone and and three spacings yield an 860 MHz tone. These tables represent the performance of one single-ended and one push-pull amplifier across the 50-860 MHz CATV band. This shows that the IP2 performance of the push-pull configuration is much improved over that of the single ended devices.

Single Ended			IM (dBc) 0 dBm/tone	IM (dBc) 4 dBm/tone	IP2 (dBm) 0 dBm/tone	IP2 (dBm) 4 dBm/tone
Freq. Pairs (MHz)	IM2 Freq.					
553.25	499.25	54	56.2	51.5	56.2	55.5
865.25	811.25	54	52.9	48.2	52.9	52.2
427.25	433.25	860.5	56.3	52	56.3	56
327.25	533.25	860.5	55.1	51	55.1	55
227.25	633.25	860.5	54	50.2	54	54.2

Table 2: Single Ended NGA-486 IP2 Summary

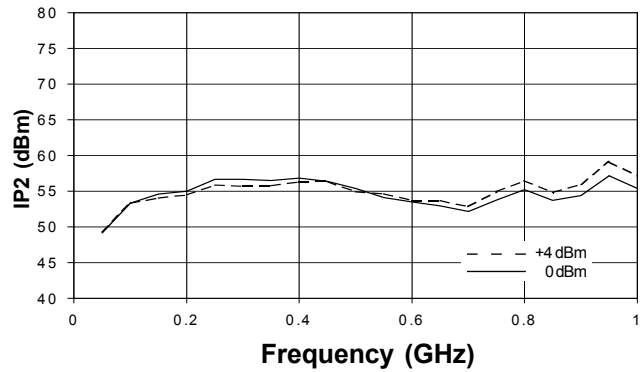


Figure 7: Single Ended NGA-486 IP2 vs. Pout/Tone Push-Pull, 1 MHz Spacing

Push-Pull			IM (dBc) 0 dBm/tone	IM (dBc) 4 dBm/tone	IP2 (dBm) 0 dBm/tone	IP2 (dBm) 4 dBm/tone
Freq. Pairs (MHz)	IM2 Freq.					
553.25	499.25	54	81.2	81.9	81.2	85.9
865.25	811.25	54	69.1	64.4	69.1	68.4
427.25	433.25	860.5	75.6	73.3	75.6	77.3
327.25	533.25	860.5	71.8	67.5	71.8	71.5
227.25	633.25	860.5	80.5	75.5	80.5	79.5

Table 3: Push-Pull NGA-486 IP2 Summary

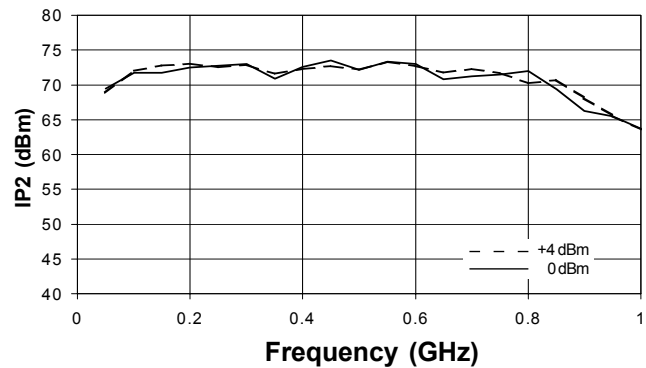


Figure 8: Push-Pull NGA-486 IP2 vs. Pout/Tone Push-Pull, 1 MHz Spacing

Figure 9 illustrates that there is a 2 dB improvement in P1dB when comparing a push-pull configuration to a single device. The high insertion loss of many wideband baluns prevents realization of the theoretical 3 dB P1dB advantage. The balun used for these measurements (MACOM ETC1-1-13) has between .35 dB and .9 dB insertion loss across the CATV band.

Figure 10 shows the excellent third order linearity performance of the push-pull amplifiers. Both push-pull amplifiers were tested at +6 dBm output power per tone (about 15 dB below the P1dB point).

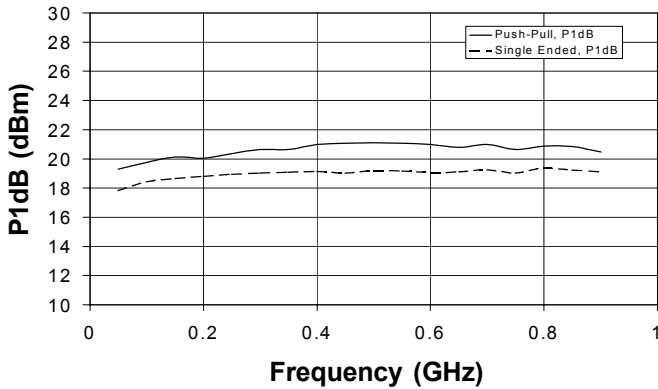


Figure 9: NGA-486 Push-Pull vs. Single Ended P1dB

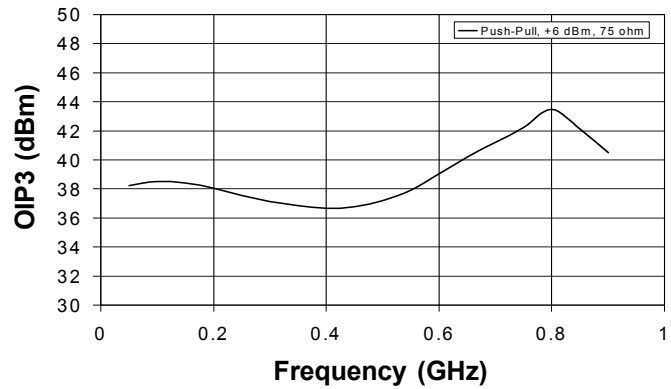


Figure 10: NGA-486 Push-Pull IP3 vs. Frequency

The Gain response of the NGA-486 push-pull amplifier is shown in Figure 11. Input and Output return loss of this amplifier is illustrated in Figure 12. Notice the wide bandwidth of the return loss of the amplifier configured this way.

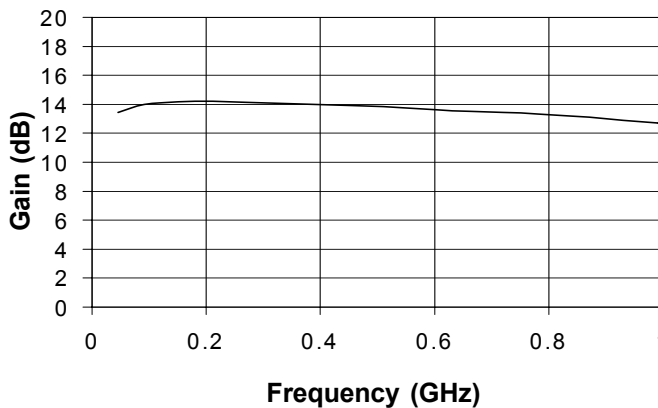


Figure 11: NGA-486 Push-Pull Gain vs. Frequency

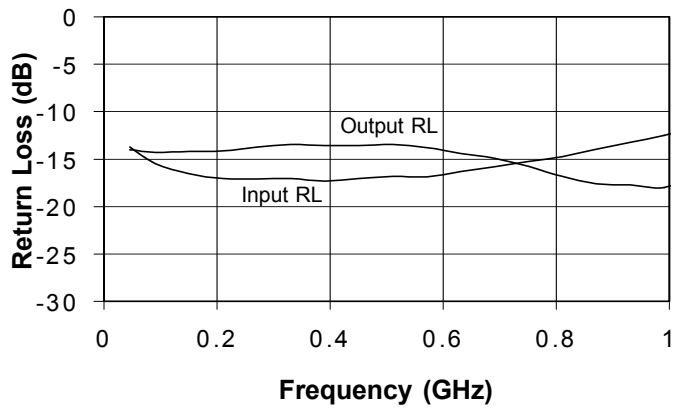


Figure 12: NGA-486 Push-Pull IRL and ORL vs. Frequency

Measured Data for SiGe HBT SGA-6289

The configurations of the SGA-6289 single ended amplifier is shown in Figures 13 and 14. The push-pull schematic and layout are shown in Figures 15 and 16.

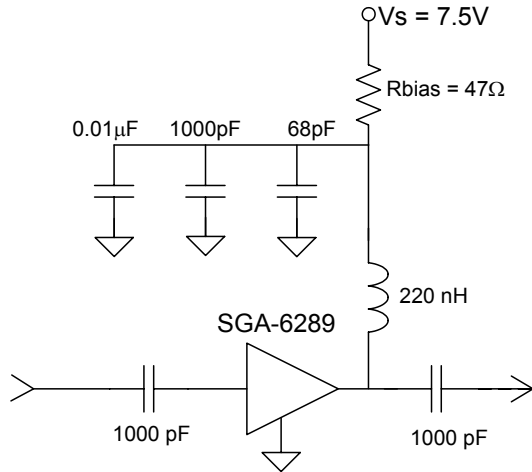


Figure 13: SGA-6289 Single Ended Schematic

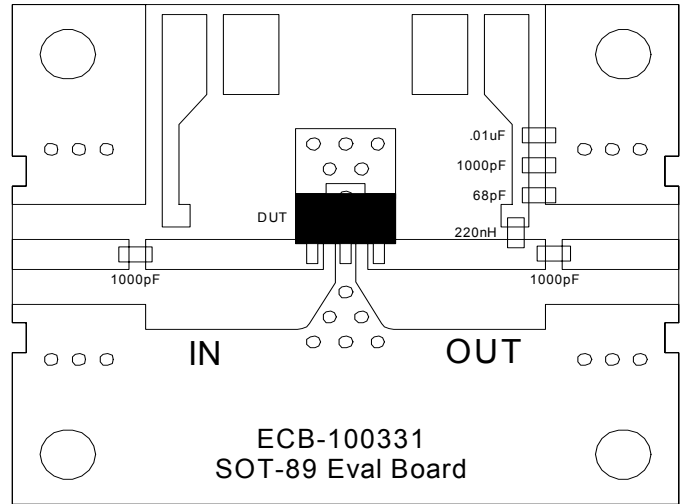


Figure 14: SGA-6289 Single Ended PCB Layout

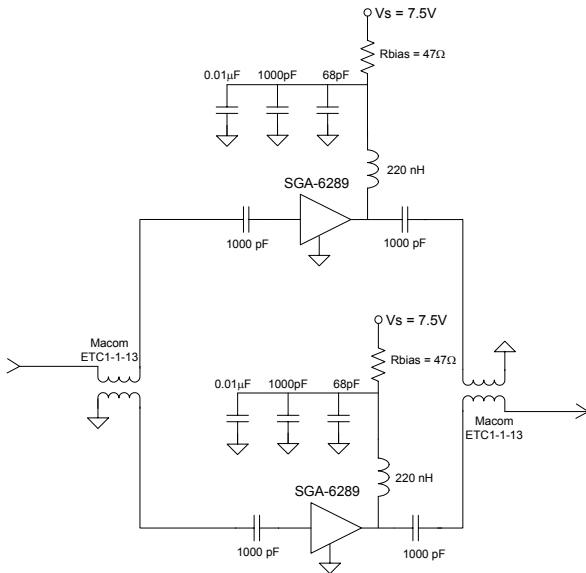


Figure 15: SGA-6289 Push-Pull Schematic

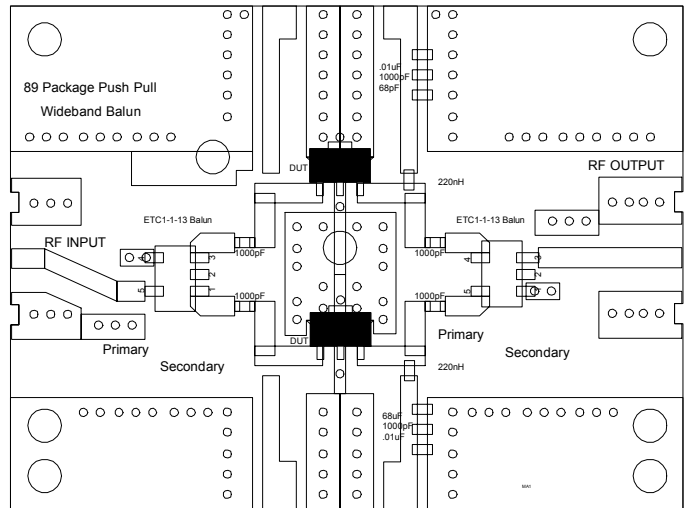


Figure 16: SGA-6289 Push-Pull PCB Layout

Push-Pull High IP2 Amplifiers

The SGA-6289 IP2 performance is shown in Tables 4 and 5 and Figures 17 and 18. The push-pull amplifier’s IP2 is greater than +60 dBm across the band. As mentioned before this device has the advantage of low bias current and excellent linearity at a very low price. Again, notice the significant IP2 advantage gained when the push-pull configuration is used.

Single Ended			IM (dBc) 0 dBm/tone	IM (dBc) 4 dBm/tone	IP2 (dBm) 0 dBm/tone	IP2 (dBm) 4 dBm/tone
Freq. Pairs (MHz)	IM2 Freq.	IM2 Freq.				
553.25	499.25	54	48.4	44.5	48	48
865.25	811.25	54	47.6	43.7	47.6	47.7
427.25	433.25	860.5	48	44.1	48	48
327.25	533.25	860.5	47.3	43.5	47.3	47.5
227.25	633.25	860.5	47.6	43.6	47.6	47.6

Table 4: Single Ended SGA-6289 IP2 Summary

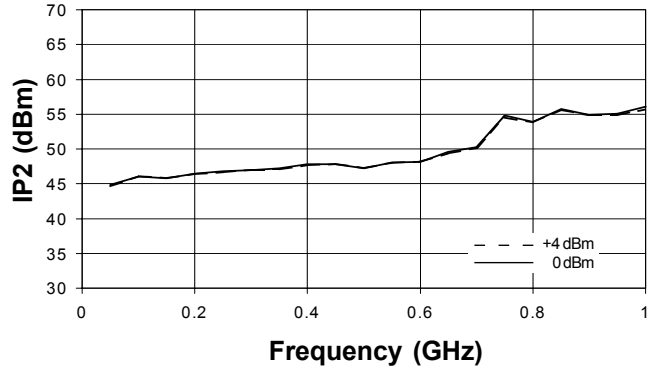


Figure 17: SGA-6289 IP2 vs. Pout/Tone Single Ended, 1 MHz Spacing

Push-Pull			IM (dBc) 0 dBm/tone	IM (dBc) 4 dBm/tone	IP2 (dBm) 0 dBm/tone	IP2 (dBm) 4 dBm/tone
Freq. Pairs (MHz)	IM2 Freq.	IM2 Freq.				
553.25	499.25	54	72.4	68.2	72.4	72.2
865.25	811.25	54	62.8	58.9	62.8	62.9
427.25	433.25	860.5	68.2	64	68.2	68
327.25	533.25	860.5	65.3	61.7	65.3	65.7
227.25	633.25	860.5	69.5	65.2	69.5	69.2

Table 5: Push-Pull SGA-6289 IP2 Summary

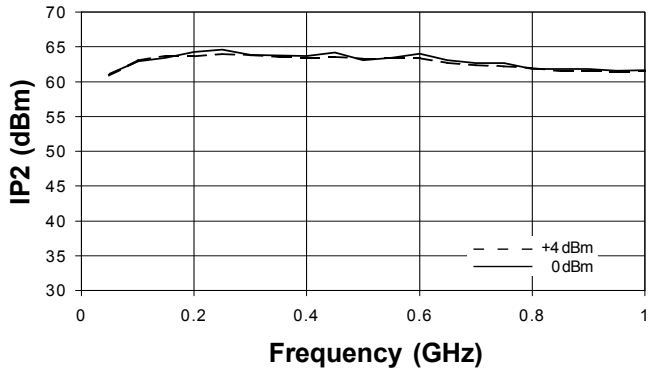


Figure 18: SGA-6289 IP2 vs. Pout/Tone Push-Pull, 1 MHz Spacing

Push-Pull High IP2 Amplifiers

Figure 19 compares the 1dB compression point of a push-pull and single ended amplifier. Figure 20 shows the excellent third order linearity performance of the push-pull amplifier at +6 dBm output power per tone (about 15 dB below the P1dB point).

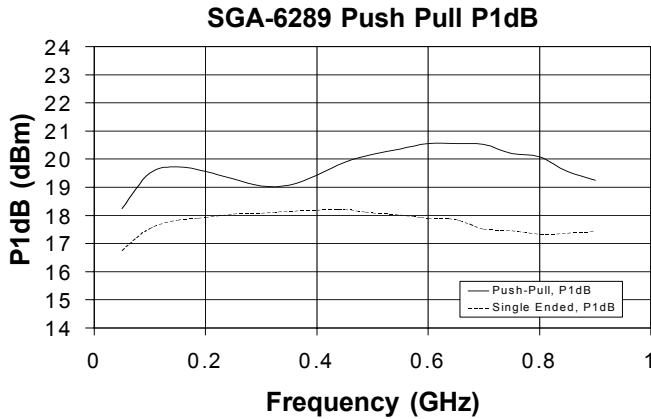


Figure 19: SGA-6289 Push-Pull vs. Single Ended P1dB

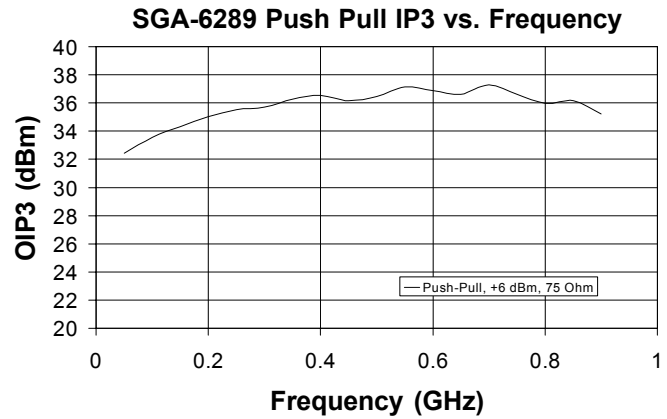


Figure 20: SGA-6289 Push-Pull IP3 vs. Frequency

The gain response of the SGA-6289 push-pull amplifier is shown in Figure 21, input and output return loss are shown in Figure 22. Notice the wide bandwidth of the return loss configured this way.

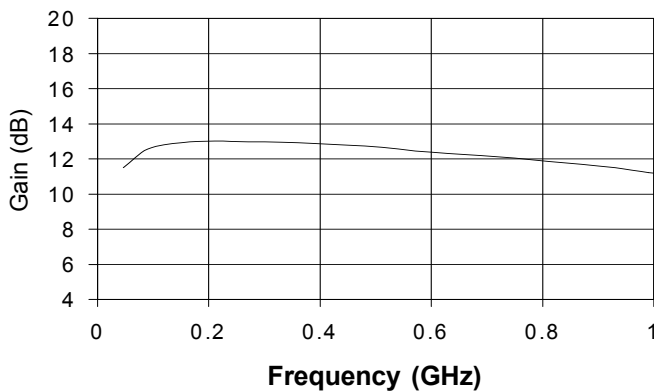


Figure 21: SGA-6289 Push-Pull Gain vs. Frequency

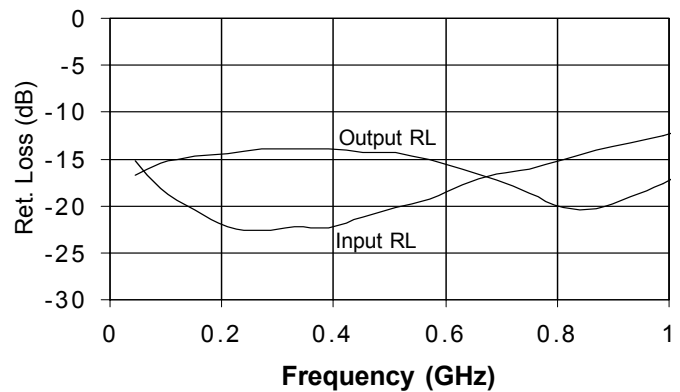


Figure 22: SGA-6289 Push-Pull IRL and ORL vs. Frequency

NGA-486 and SGA-6289 CSO, CTB and XMOD Measurement Results.

The CSO results for both SGA-6289 push-pull amplifiers were better than 75 dBc at the +25 and +34 dBmV output power level per tone as shown in Figures 23 and 24. The push-pull SGA-6289 far exceeded the -70 dBc requirement and the CSO was immeasurable at many of the channels. CTB was better than 68 dBc across the band and XMOD was better than 62 dBc across the band.

The power per tone was held constant for the devices at +25 and +34 dBmV into 75 ohms. 79 level channels were used for the measurements.

The NGA-486 CSO and CTB results were outstanding as illustrated in Figures 25 and 26. CSO was better than 80 dBc across the band and CTB and XMOD were better than 68 dBc across the band at +34 dBmV per channel for 79 channels.

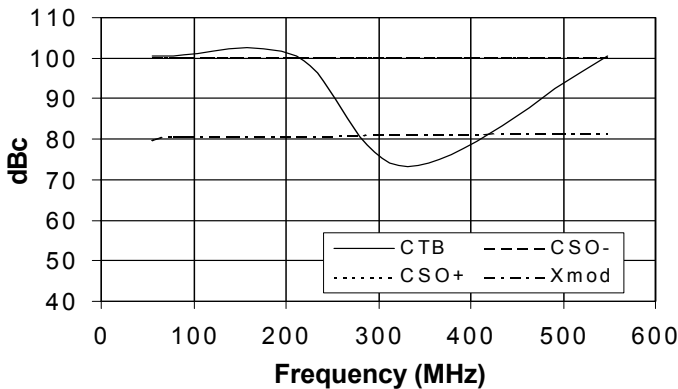


Figure 23: SGA-6289 Push-Pull CTB/CSO/XMOD 8V/150mA, 25 dBmV/Ch., 79 Ch., Flat

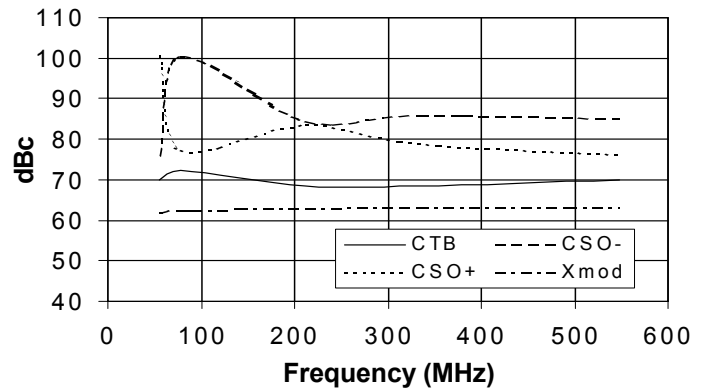


Figure 24: SGA-6289 Push-Pull CTB/CSO/XMOD 8V/150mA, 34 dBmV/Ch., 79 Ch., Flat

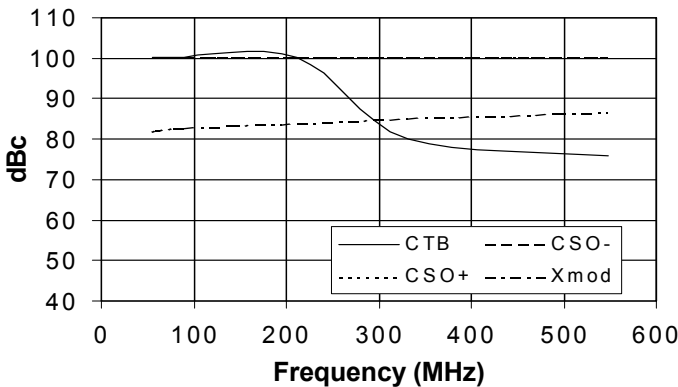


Figure 25: NGA-486 Push-Pull CTB/CSO/XMOD 8V/160mA, 25 dBmV/Ch., 79 Ch., Flat

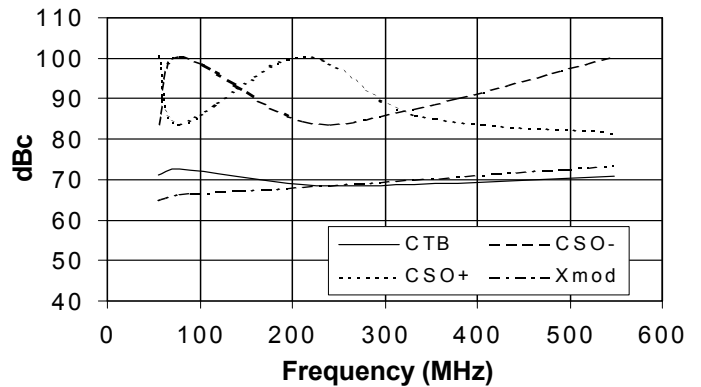


Figure 26: NGA-486 Push-Pull CTB/CSO/XMOD 8V/160mA, 34 dBmV/Ch., 79 Ch., Flat