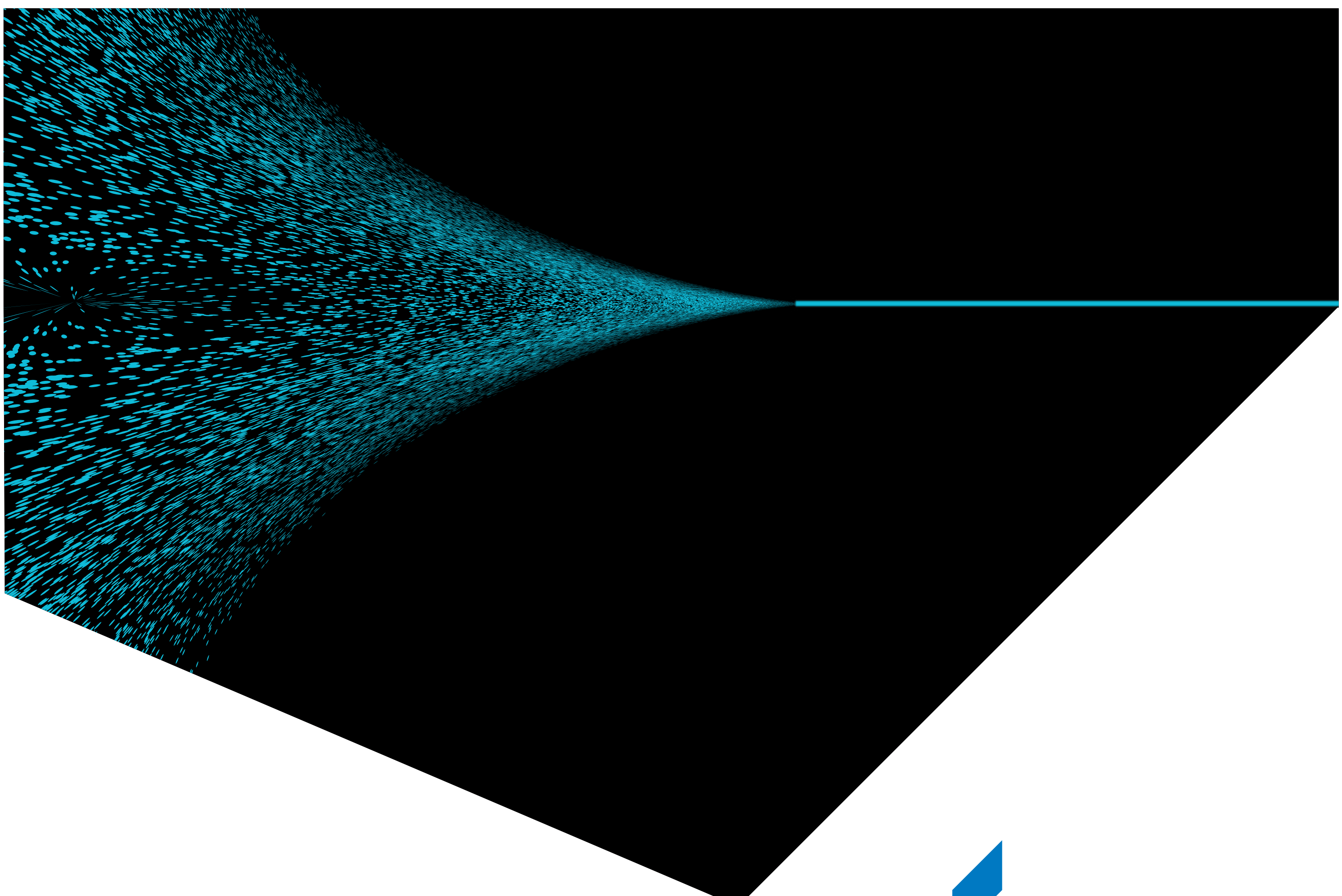
TECH BRIEF

Realizing the SWaP-C Benefits of Designing with Positive Gain Slope MMIC Amplifiers



Custom MMIC

INTRODUCTION

Modern wideband microwave systems often require a flat overall gain response with respect to frequency. Achieving this performance can be difficult, however, since most wideband microwave components exhibit a negative gain slope as the frequency increases. In this technical brief we discuss a means of achieving a flat system response using distributed amplifier MMICs which exhibit positive gain slope characteristics.

Figure 1 shows a typical wideband distributed amplifier response. As a standalone component its negative gain slope of approximately 3 dB is not a limiting factor. Unfortunately for designers of wideband microwave systems, a single amplifier rarely meets the overall system requirements. A wideband system will typically incorporate multiple amplifiers, passive elements and transmission lines in the signal chain. This cascade of elements with a negative gain slope versus frequency can quickly become a serious problem for the designer.

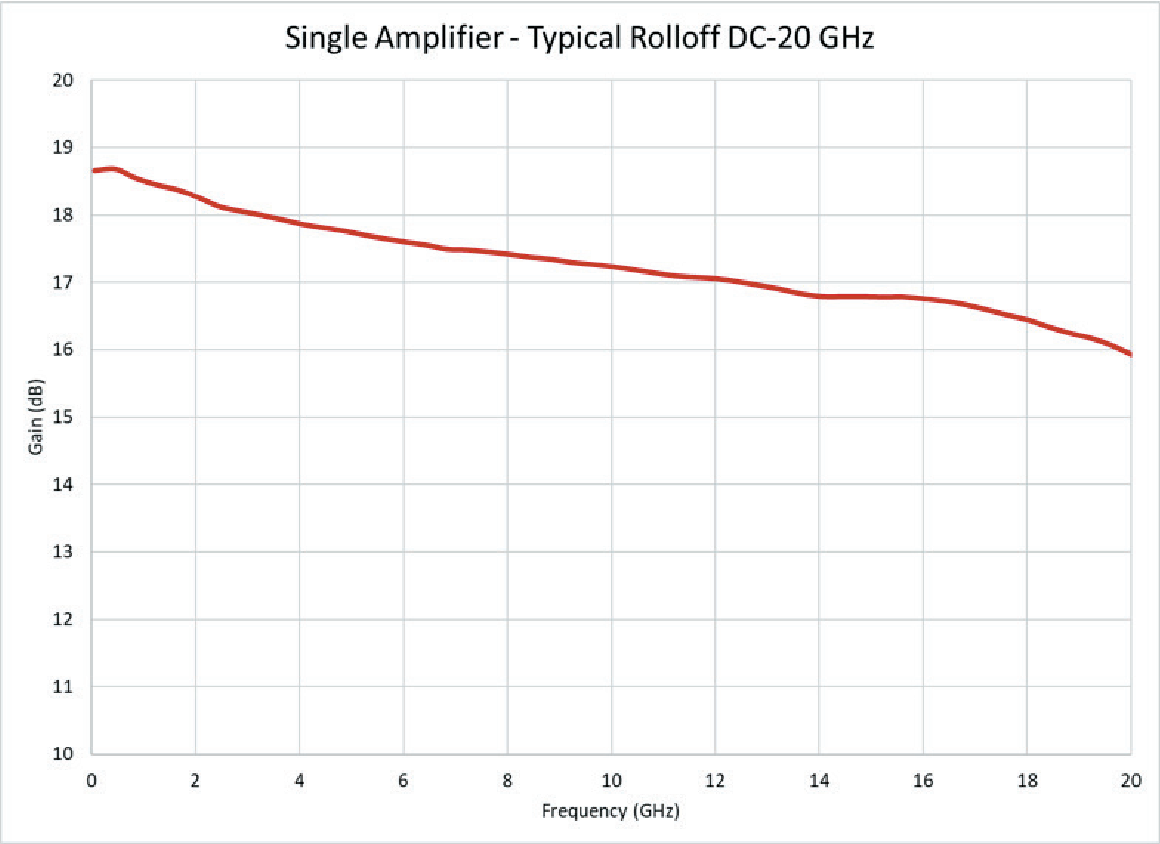


FIGURE 1.
Frequency response of a typical distributed amplifier

Figure 2 shows the frequency response of five typical microwave amplifiers in cascade with passive components and transmission lines, and demonstrates that while a single amplifier only had a gain delta versus frequency of 3 dB peak to peak, this cascaded lineup has a gain delta of greater than 20 dB from DC to 20 GHz.

Traditional Methods for Flattening out the Gain

The most common solution to this problem is to add passive equalization to flatten the response across the frequency band. While this technique can solve the problem of flatness, it can also introduce three major concerns.

1. The first is the need for additional components that will increase the size and cost of the overall system. This is true whether building a discrete equalizer using resistors, inductors and capacitors, or buying an off-the-shelf die or surface-mount equalizer.

2. The second concern is the additional loss these components will add, which will undoubtedly have a negative impact on system sensitivity and noise.

3. Finally, these components require careful selection and analysis as they will also affect the power handling and linearity of the overall system.

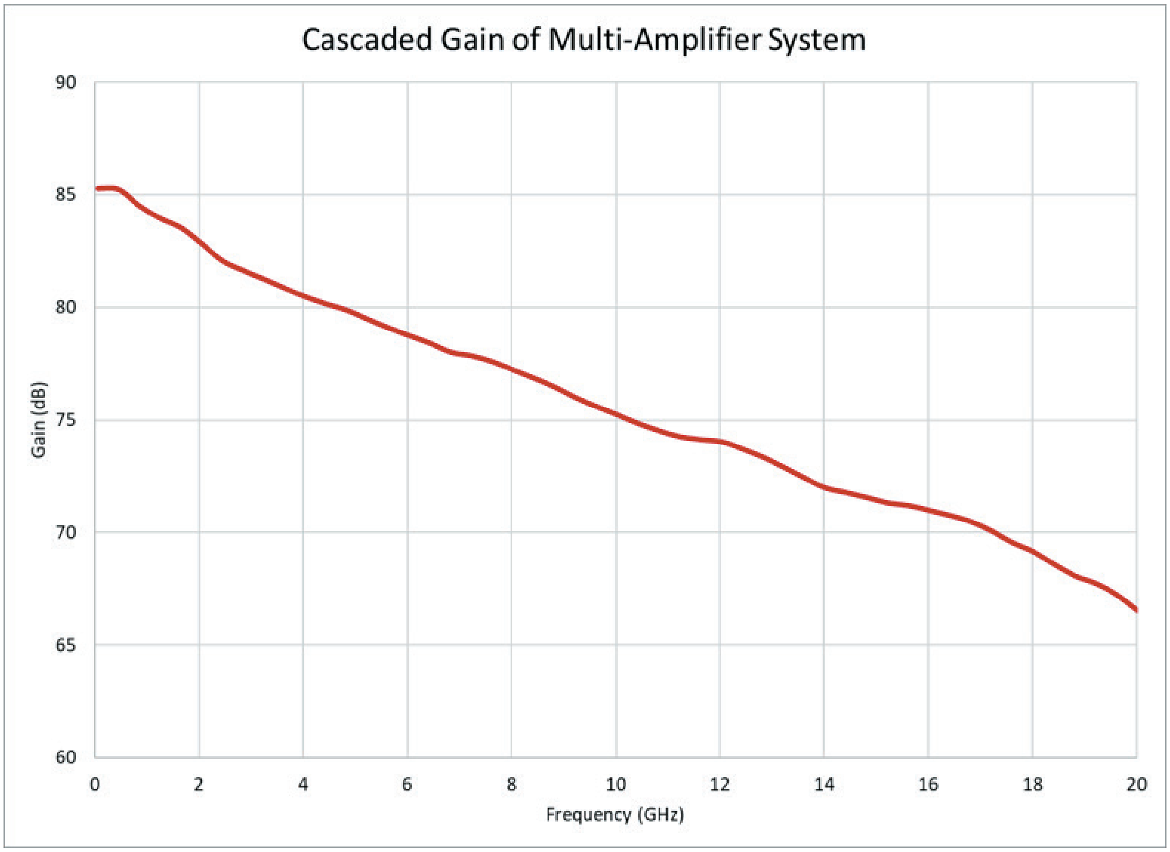


FIGURE 2.
Frequency response of a typical wideband lineup

Figure 3 shows the frequency response of the system once equalizers have been added to flatten the response. The equalizers selected were commercial off-the-shelf equalizers available in die form with less than 0.1 dB of loss at 20 GHz. Since each equalizer contributes roughly 3.5 dB of equalization over the band from DC to 20 GHz, five equalizers were used to balance the negative gain slope of the five amplifiers and the added passive components. This added up to 20 dB of loss at the low end of the frequency range while minimizing the impact at high frequency.

While this approach does provide a flat gain response versus frequency, it is not ideal due to the additional unwanted loss and other system concerns previously discussed.

Utilizing the Natural Behavior of a MMIC with Positive Gain Slope

As a more elegant solution to this problem, wideband microwave system designers should consider using positive gain slope distributed amplifier MMICs, which effectively create the necessary equalization in each stage without the need for additional components. As one example, consider the positive gain slope of Custom MMIC's CMD192.

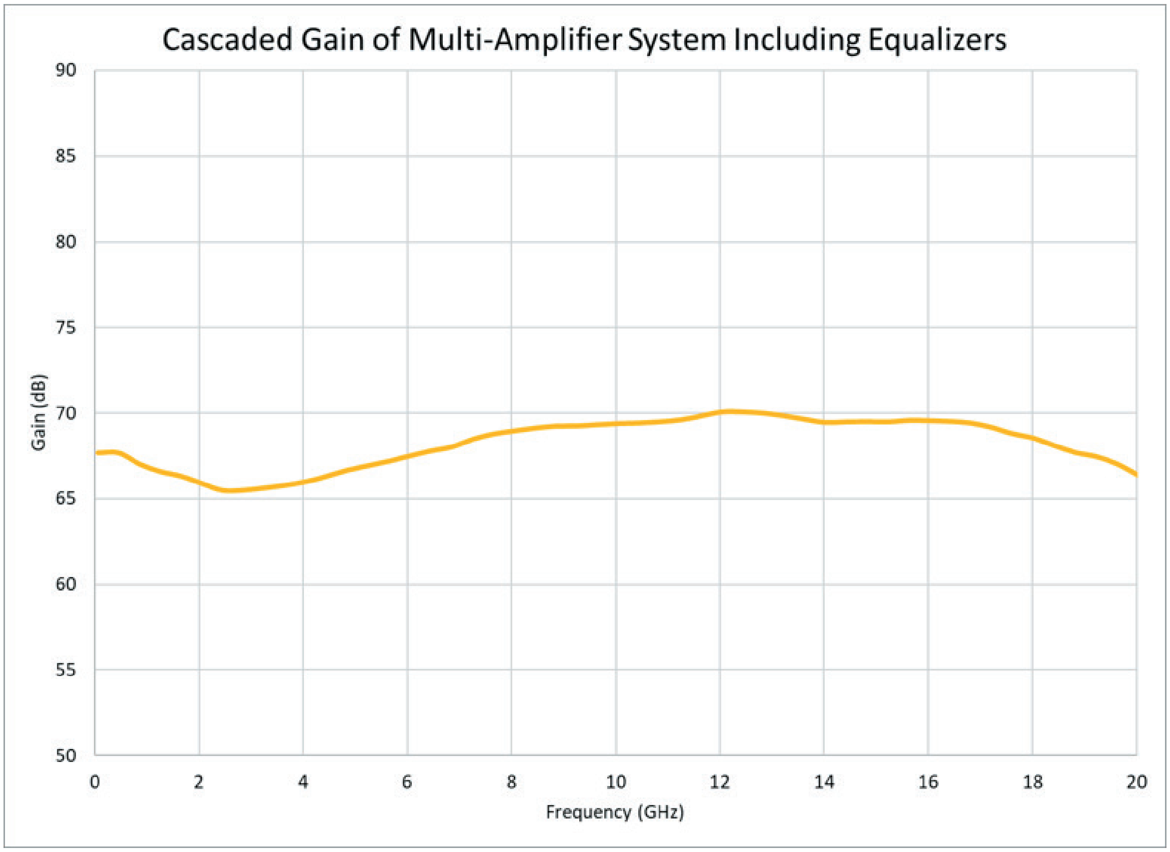


FIGURE 3.
Frequency response of a wideband lineup including equalizers

In *Figure 4*, we first compare the gain of a single CMD192 versus the typical distributed amplifier of *Figure 1*. The nominal gain of each amplifier is around 18 dB, however the typical distributed amplifier shows approximately 3 dB of negative gain slope across the band while the CMD192 exhibits a positive gain slope of greater than 1.5 dB across the same band, which results in a gain differential of greater than 3 dB at 20 GHz.

The benefit of this positive gain slope becomes apparent when the CMD192 is cascaded in a system.

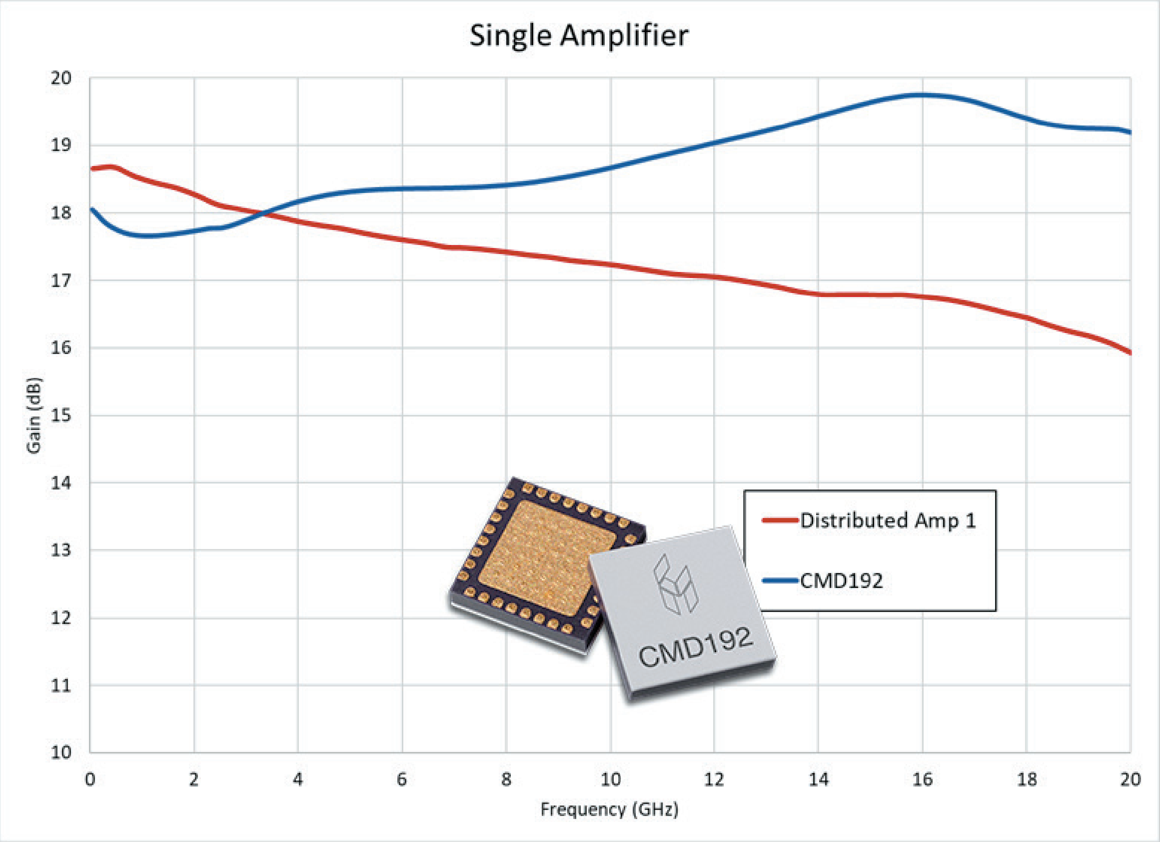


FIGURE 4.
CMD192 vs. a typical distributed amplifier

In *Figure 5*, we compare the overall gain of a few cascaded systems, including one comprised of five typical distributed amplifiers, one with five distributed amplifiers and equalization, one with five CMD192s and one with just four CMD192s. The solutions using CMD192s require no equalization, which results in approximately 15 dB more gain than the equivalent system built with the negative gain slope amplifier when using five stages. For this reason, an equivalent system can be created using only four CMD192s, further reducing the total component count. In either case, since no equalization is needed, the system complexity, cost and size of implementation are greatly reduced.

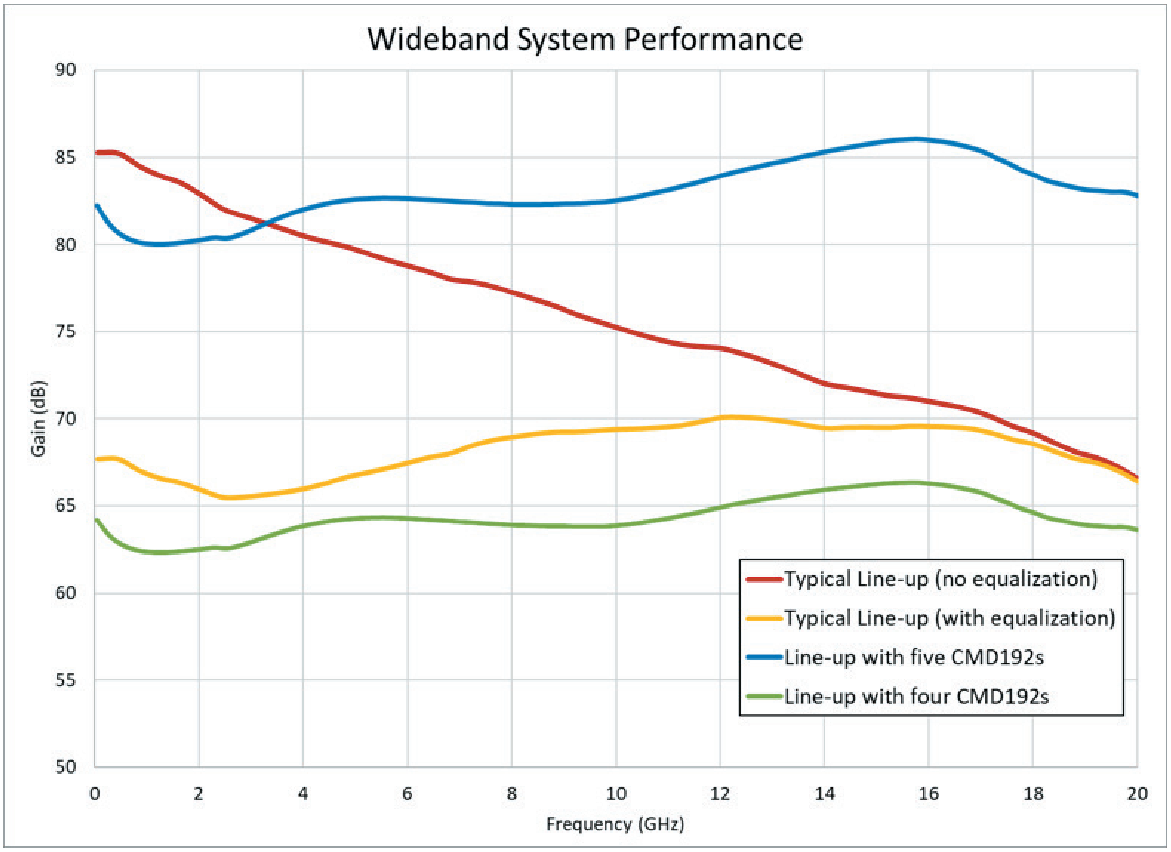
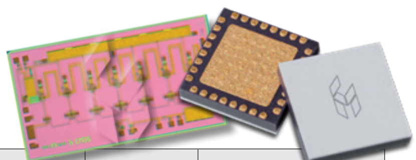


FIGURE 5.
Overall system performance including equalization

CONCLUSION

In this tech brief, we discussed the need for flat gain in wideband microwave systems. Typically, this performance is achieved using equalizers to cancel the effects of negative gain slope components, however, a more efficient solution utilizes positive gain slope amplifier MMICs that eliminate the need for equalization. This approach reduces the size, weight and cost of the system directly through elimination of a series of now unnecessary passive components. In addition, for systems that require multiple amplifier stages, the elimination of additional loss could reduce the total number of gain stages required. This will decrease a microwave system's power consumption in addition to reducing size, weight and cost, and help you achieve your SWaP-C goals.

See *Table 1* below for a list of Custom MMIC's positive gain slope amplifiers as well as a switch with positive gain slope that can also be used to eliminate an equalizer.



Part Number	Function	Frequency (GHz)	Gain (dB)	P1dB (dBm)	Bias (V)	Current (mA)	Package
CMD192/C5	Distributed Amp	DC-20	19	24.5	5-8/-1	200	Die / 5x5 mm
CMD240/P4	Distributed Amp	DC-22	15	19	5-8/-.65	80	Die / 4x4 mm
CMD241/P4	Distributed Amp	2-22	13.5	21	5-8/-.65	74	Die / 5x5 mm
CMD244	Distributed Amp	DC-24	18	25	5-8/-.65	185	Die
CMD246/C4	Low Phase Noise Amp	8-22	17	13	3-5/3	48	Die / 4x4 mm
CMD275P4	Low Phase Noise Amp	DC-26.5	16	18	5/3	74	4x4 mm
CMD195/C3	Switch (SPDT)	DC-20	-2	25	0/-5	0	Die / 3x3 mm

TABLE 1.
Positive gain slope components from Custom MMIC

Next Steps

Download our SWaP-C related Tech Brief "Simplify Amplifier Biasing Using Positive Bias pHEMT MMICs"

Visit our website for complete specifications and S-paramater data.

Custom MMIC strives to make success achievable through innovative MMIC design, thorough product specifications, and fast delivery of evaluation boards. Learn more at www.custommmic.com.