June 2023

High Power Balanced Amplifier Combiner

Qorvo US, Inc.

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HIGH POWER BALANCED AMPLIFIER COMBINER ON THIN SUBSTRATES

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I. INTRODUCTION

Lange couplers used in balanced amplifiers on thin GaN substrates have narrow metal traces. The narrow metal traces limit the max power that can be combined (using only Metal1). Using stacked metals have limitations due to trace width variations over process and min spacing for stacked metal. Peak RF voltage on output of Lange is ≈50V @ 30W Pout for a 50 ohms design. The isolation resistor on the Lange needs to be large to handle VSWR mismatches on output of the balanced amplifier. Large thin film resistors on thin substrates have a large capacitance at higher frequencies. A 50 ohms TaN resistor that can handle 22.5W needs to be at least 300x300um. This size resistor has <-10dB IRL at 30GHz.

This paper proposes changing the Lange from a 50ohm impedance to a 25 ohm impedance. Changing the Lange from 50 ohms to 25ohms and adding a 25ohm to 50 ohm Trifilar transformer on the output will allow for much higher power balanced amplifiers on thin substates like 50um GaN. The topology could also be used on other substrate materials like Alumina to make the trace widths larger so that you can work at higher frequency and power levels.

II. DISCUSSION

Figure 1(a) illustrates a circuit schematic of standard 50ohm back to back Lange couplers. Figure 1(b) illustrates the voltage and waveforms of the standard 50 ohm back to back Lange couplers.

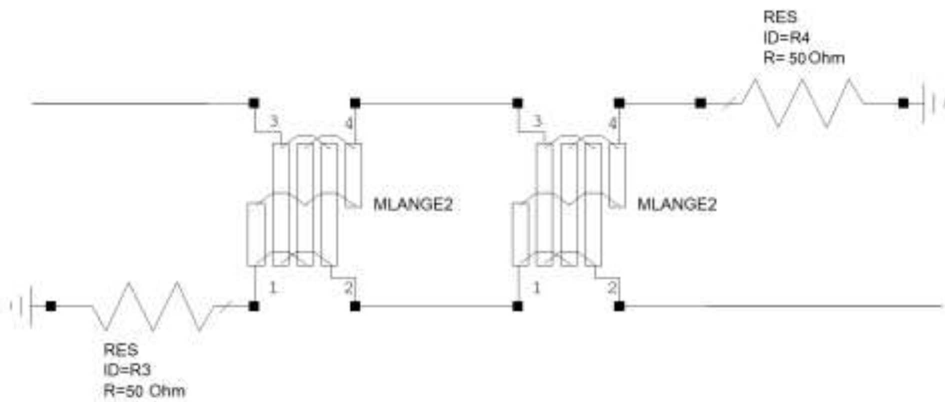

Figure 1(a)

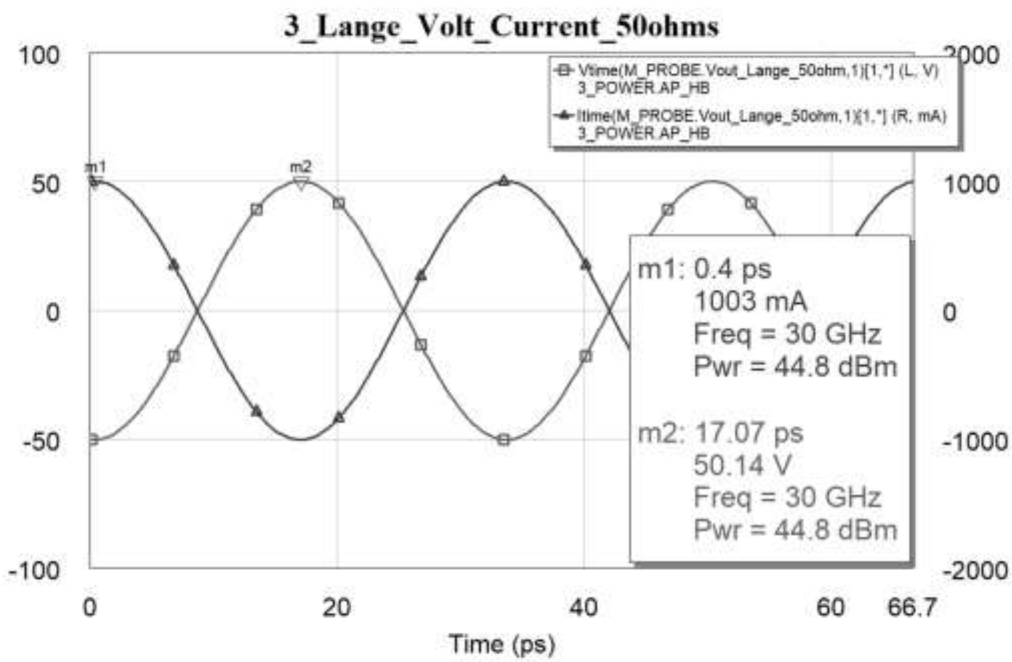

Figure 1(b)

Figure 2(a) illustrates a circuit schematic of 25ohm back to back Lange transformer. Figure 2(b) illustrates the voltage and waveforms of the 25ohm back to back Lange transformer.

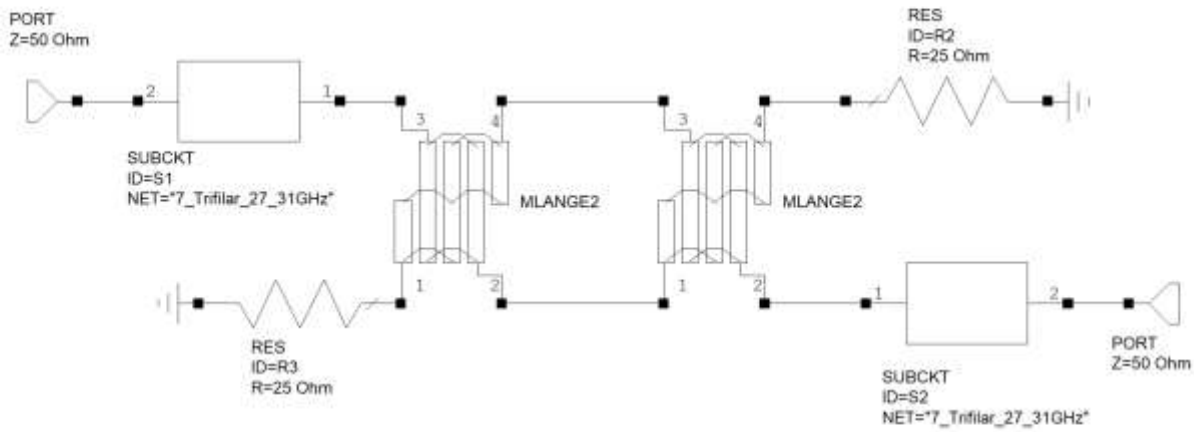

Figure 2(a)

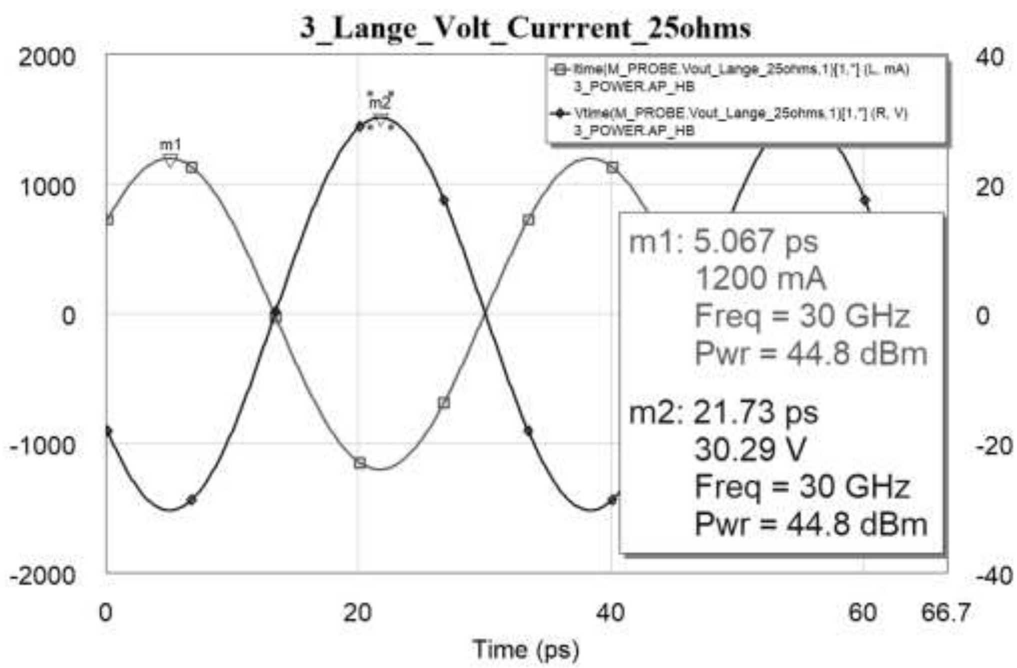

Figure 2(b)

Figures 3(a)(b) comprise graphs that show the frequency response of a trace width and spacing of 6µm of M1 for a 50 ohm standard Lange coupler on a 50um GaN substrate.

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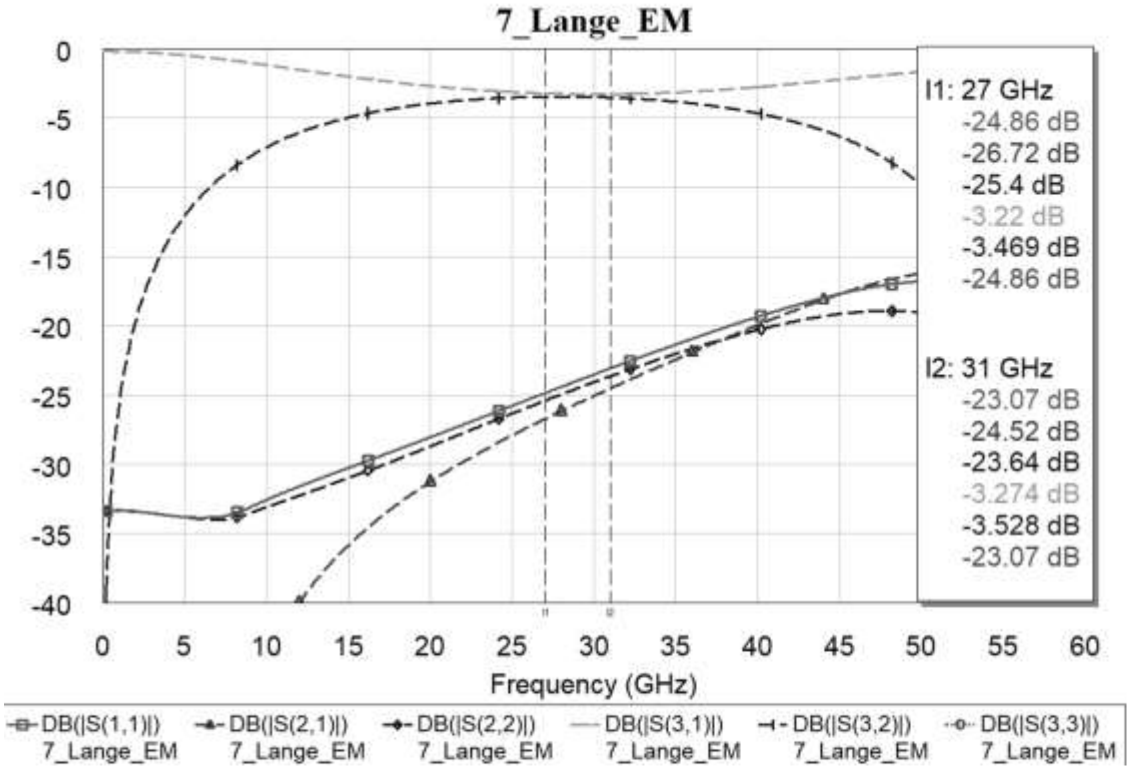

Figure 3(a)

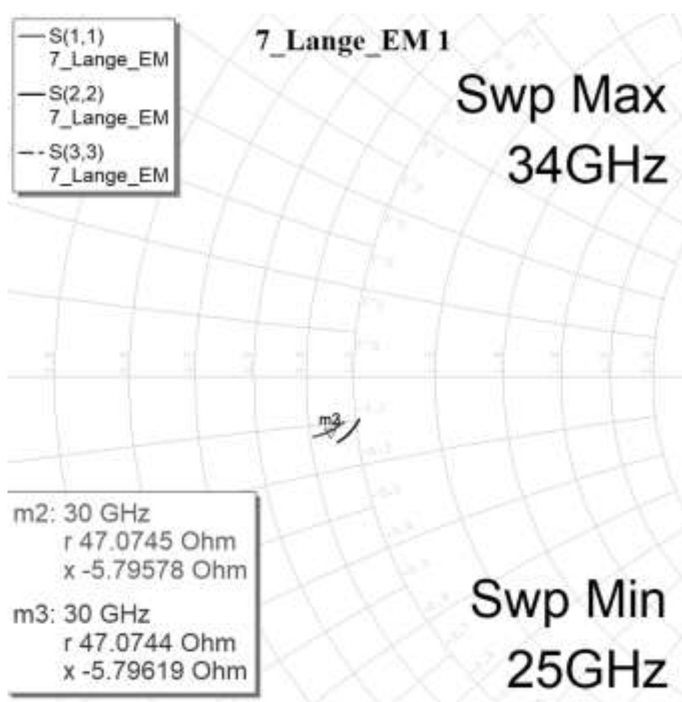

Figure 3(b)

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Figures 4(a)(b) comprises graphs that show the frequency response of a resistor of 150µm width for a 50 ohm resistor on a 50µm GaN substrate. A 150µm x 150µm x 0.25W resistor yields approximately 5.6W in Pdiss power handling.

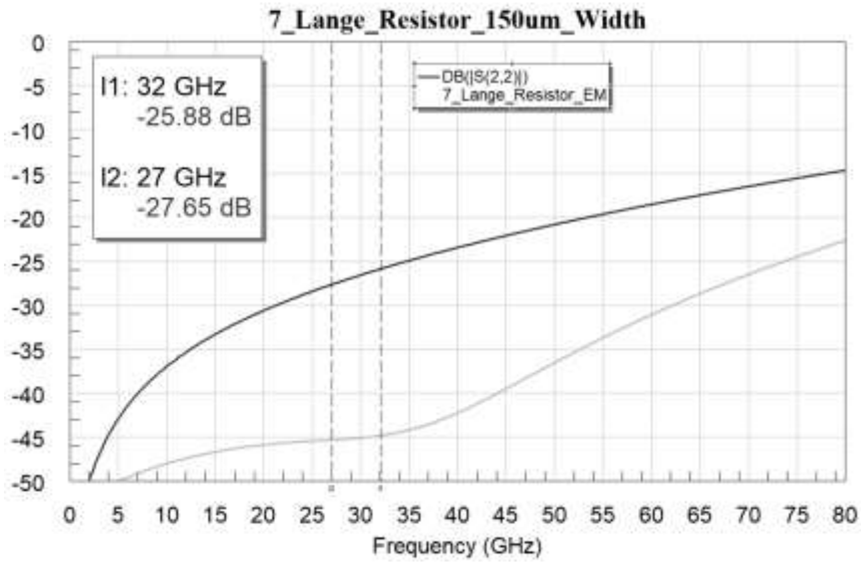

Figure 4(a)

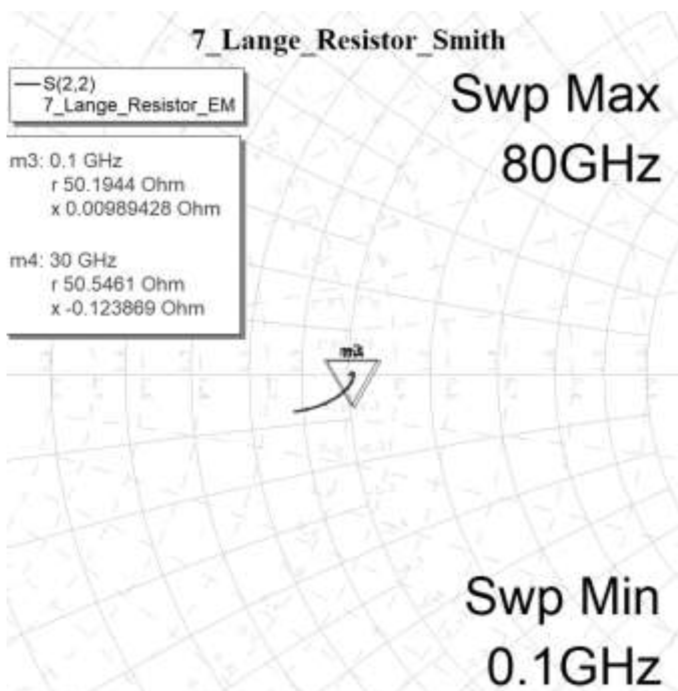

Figure 4(b)

Figures 5(a)(b) below comprise graphs that show the trace width and spacing for a 25ohm Lange with Trifilar combiner on a 50µm GaN substrate. In contrast with the 50ohm Lange coupler, the width is 26µm of M1. This yields a 4.4X increase in width for more RF power and current handling. The Trifilar has less than 0.1db loss from 27 to 32GHz for a total combiner loss of less than 0.4db.

Output matching of the PA's now only have to transform up to 25ohms. This simplifies matching, reduces loss in matching, and increases the bandwidth. In addition, isolation resistor length can be shortened (25ohm to 50ohm) for less capacitance. The width can be increased for more power handling with the same length. A schematic of a 25 ohm Lange with a Trifilar combiner is illustrated in Figure 6.

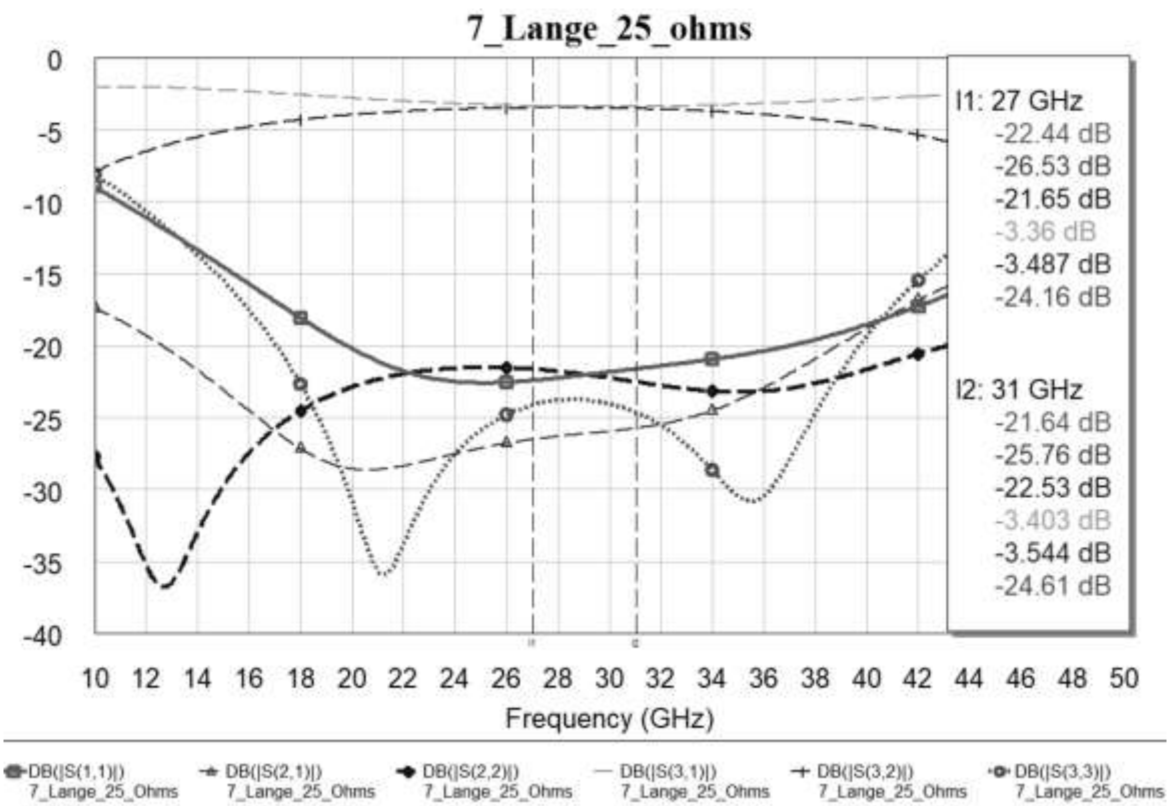

Figure 5(a)

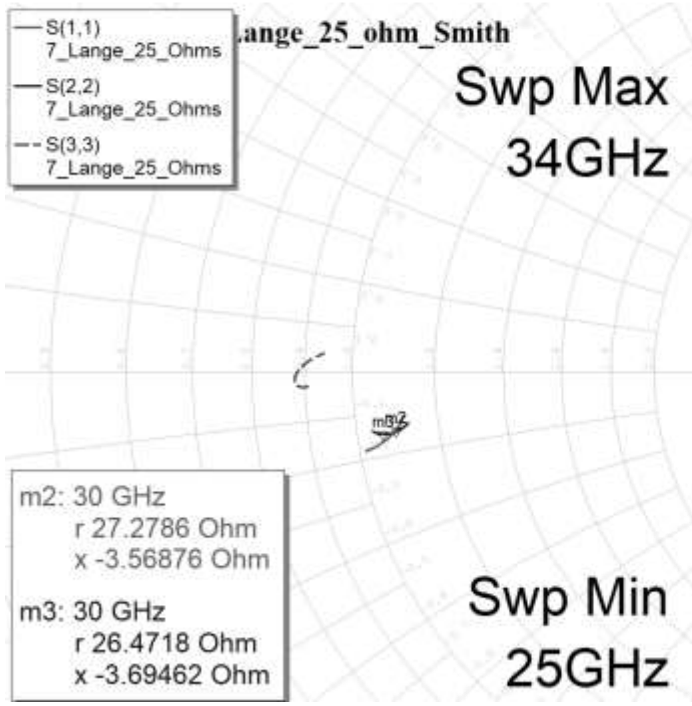

Figure 5(b)

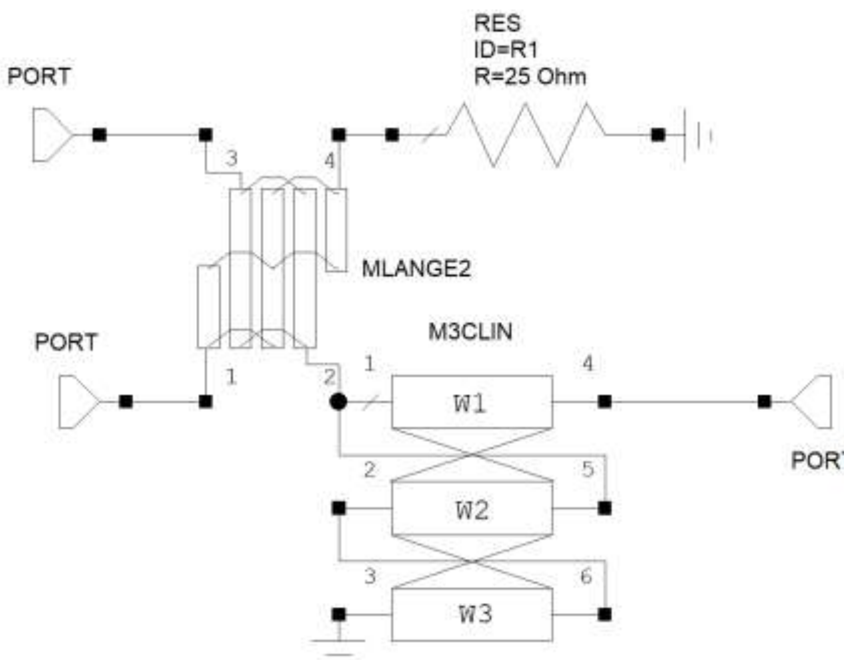

Figure 6

Figures 7(a)(b) below comprise graphs that illustrate the frequency response of a 300µm x 300µm Tan Resistor. A 300µm x 300µm x 0.25mW resistor yields approximately 22.5W Pdiss power handling.

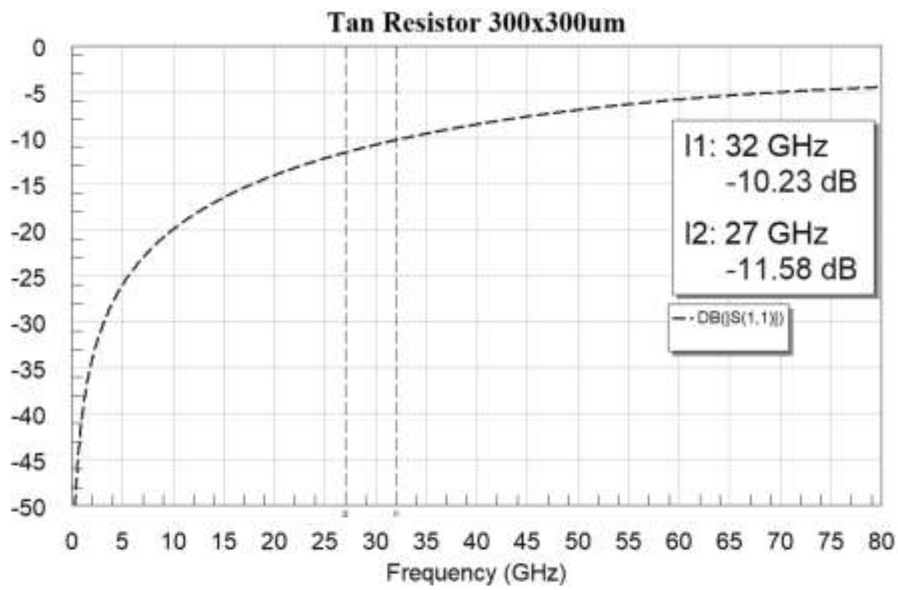

Figure 7(a)

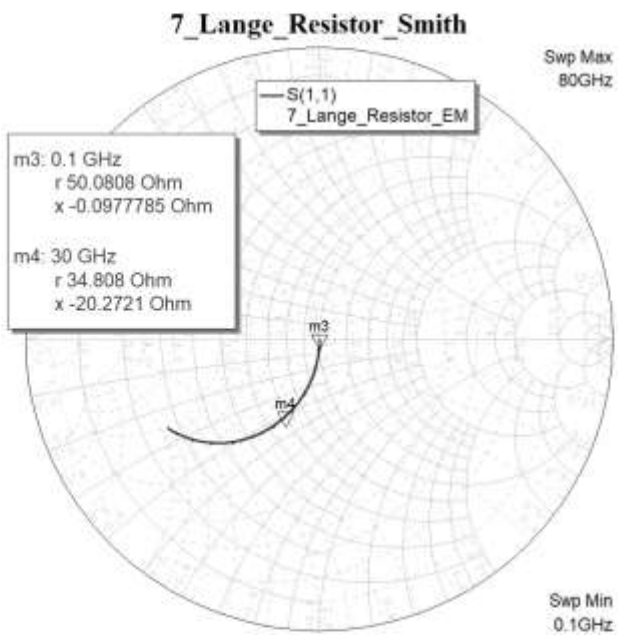

Figure 7(b)

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The solutions described in this paper provide a number of technical benefits. Benefits include:

- Increased power handling of the balanced amplifier.
- Decrease of peak RF voltage on the output of Lange coupler
- Increase width of metal traces of the Lange by 4.4X
- Increase bandwidth of the output match and reduce output matching loss.
- Reduced capacitance of Isolation resistor. A 25 ohm resistor area can be ½ that of a 50ohm resistor.