Low Current Amplifier Module with Integrated Filtering for the n258 5G mmWave Band

The use of mmWave frequency bands for 5G facilitates very high data rate wireless communications. One the bands defined for mmWave 5G-NR networks is n258, which covers 24.25GHz to 27.5GHz using Time Division Duplex (TDD). This white paper describes a low-current amplifier module with integrated filtering that addresses this band. It comprises two commercially available low current SMT amplifiers (CMX90B702 from CML Micro) and a printed band defining filter realised on a low-cost laminate PCB.

Introduction

The amplifier/filter module architecture is shown in Figure 1. The amplifiers have an operating band of 23 - 29.5GHz, and the filter defines the band of the module to cover the n258 5G band of 24.25GHz to 27.5GHz. The resulting module offers ~30dB of gain with a sharp band-pass response over the n258 5G band with a maximum total supply current of 20mA (from a +3V to +5V Vdd supply).

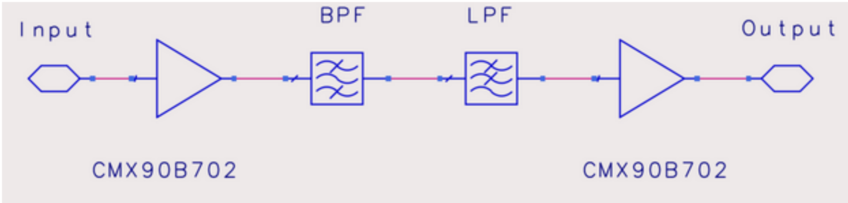

Figure 1: Simplified Schematic for the n258 5G mmWave Module

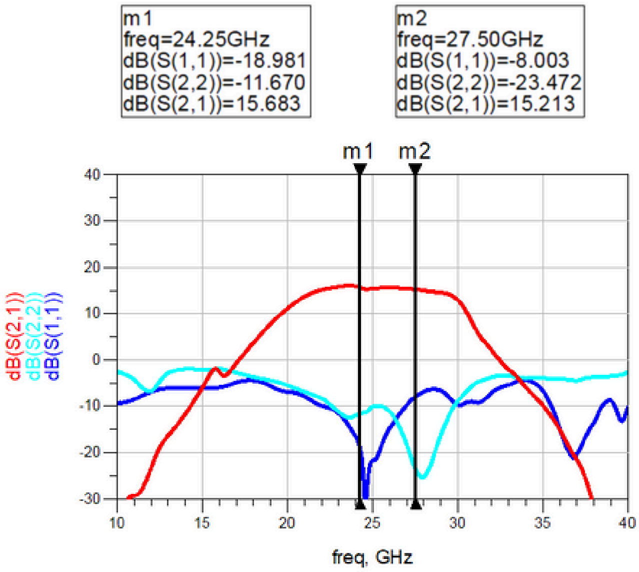

Figure 2: Measured S-parameters of the CMX90B702 Amplifier Biased at +5V/10mA

Low-current SMT Amplifier

The amplifier component used in the module is the CMX90B702 from CML Micro. It adopts an innovative current sharing design approach to allow operation from a supply current of just 10mA. It provides ~ 15dB across 23 - 29.5GHz from a single positive supply voltage (+3V to +5V Vdd). It is housed in a compact 3mm x 3mm 16-pin QFN plastic package providing low cost in high volume manufacture.

The small-signal measured performance of one of the CMX90B702 amplifiers biased at +5V and 10mA current as shown in Figure 2. The operating band is clearly much broader than the n258 band, as illustrated by the two markers.

Design of the Printed Filter

The band-pass filter used 5 coupled sections to produce a 4th order filter response. This can be realised on a low-cost PCB material, 8 mil. Rogers RO4003C is used in the simulations presented below. A schematic is shown in Figure 3.

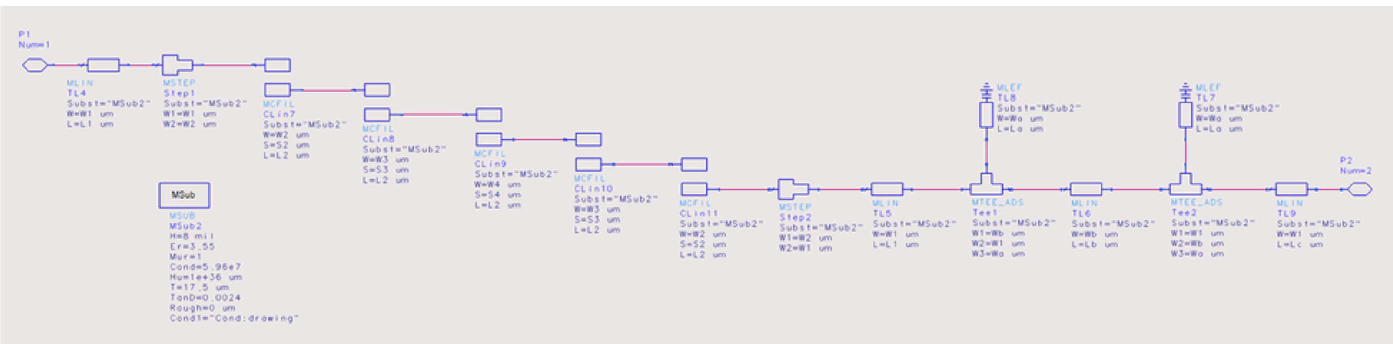

Figure 3: Coupled Line Band-pass Filter Schematic

The simulated performance of the above BPF is presented in Figure 4. It can be seen that the insertion loss across the n258 band is a flat 1.3dB, and out of band roll-off is quite sharp. A re-entrant pass-band response can also be observed at twice the fundamental pass-band frequency. This re-entrance is an inherent feature of this style of printed filter but can be easily suppressed with the addition of a simple printed low-pass filter (LPF).

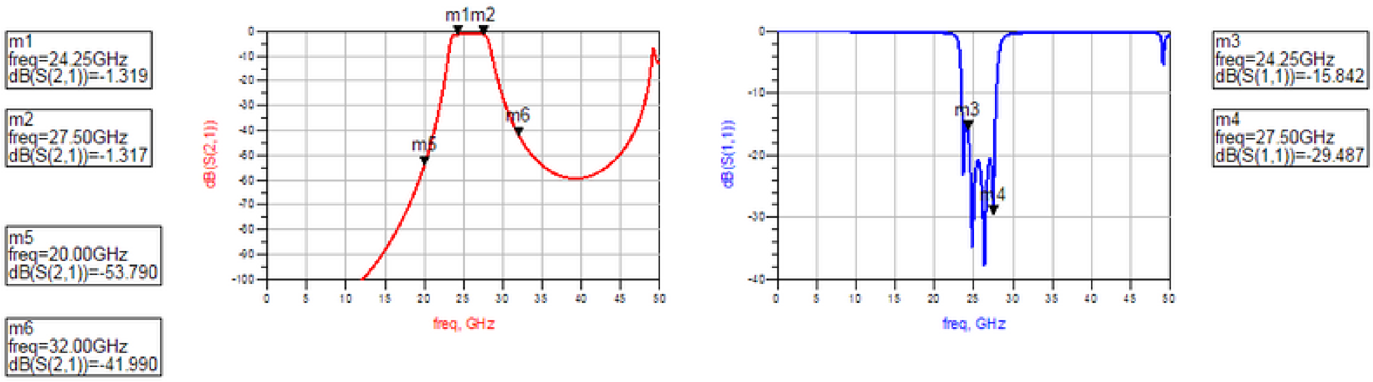

Figure 4: Schematic Simulation of the Coupled Line BPF

The implementation of the simple low-pass filter in cascade with the BPF is detailed in the updated schematic shown in Figure 5. The LPF comprises of two shunt open-circuit (capacitive) stubs (with end-effects included) and a series inductive transmission line in between them. The simulated performance of the above BP/LP filter combination is shown in blue in Figure 6, superimposed on the previous BPF only simulation, shown in red. The suppression of the re-entrancy of the BPF alone can be clearly seen.

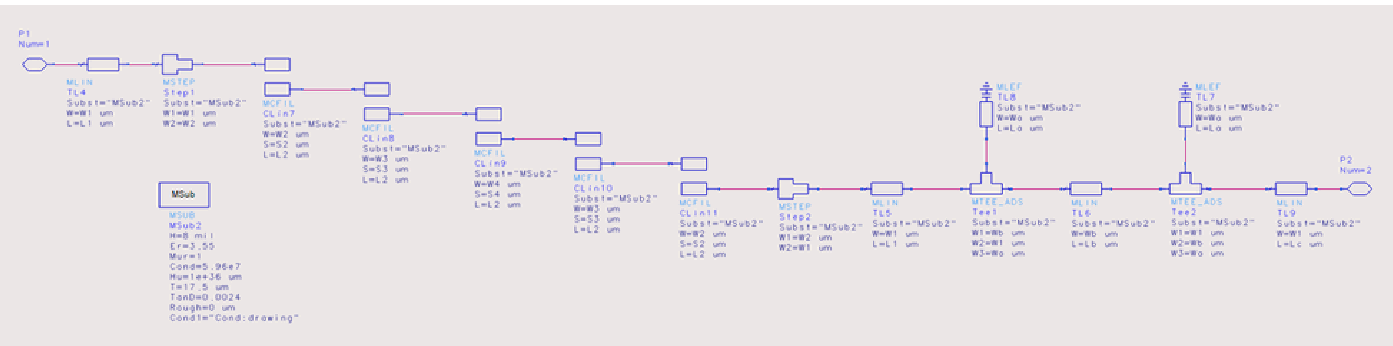

Figure 5: Schematic of the Coupled Line Band-pass Filter with Low-pass Filter Added

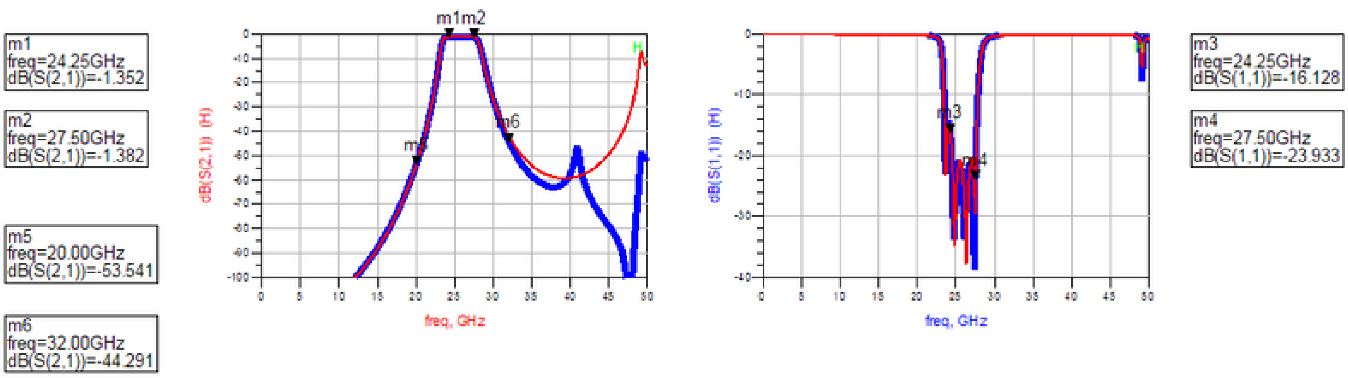

Figure 6: Schematic simulation of the BP/LP Filter Combination (Blue Traces) Compared to the BPF Alone (Red Traces)

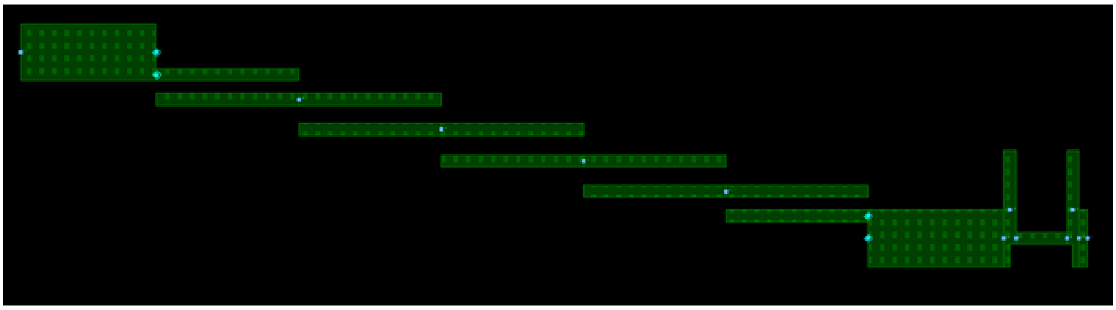

Figure 7: PCB Layout of the BP/LP Filter Combination

A practical layout of the BP/LP filter combination on an 0.008” thick (8 mil) Rogers RO4003C substrate is shown in Figure 7. This was EM simulated and adjusted for optimum performance. The EM simulated performance of the final layout is presented in Figure 8.

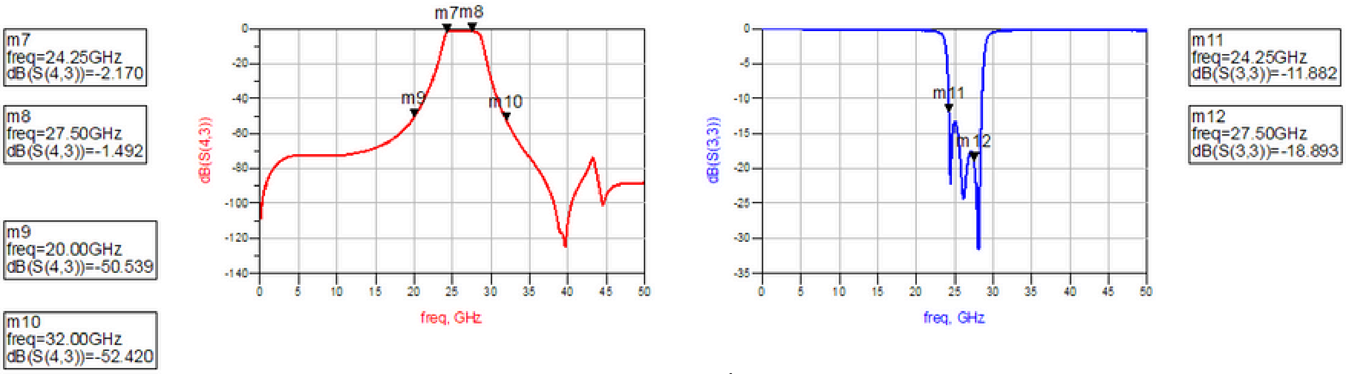

Figure 8: EM simulation of the BP/LP Filter Combination

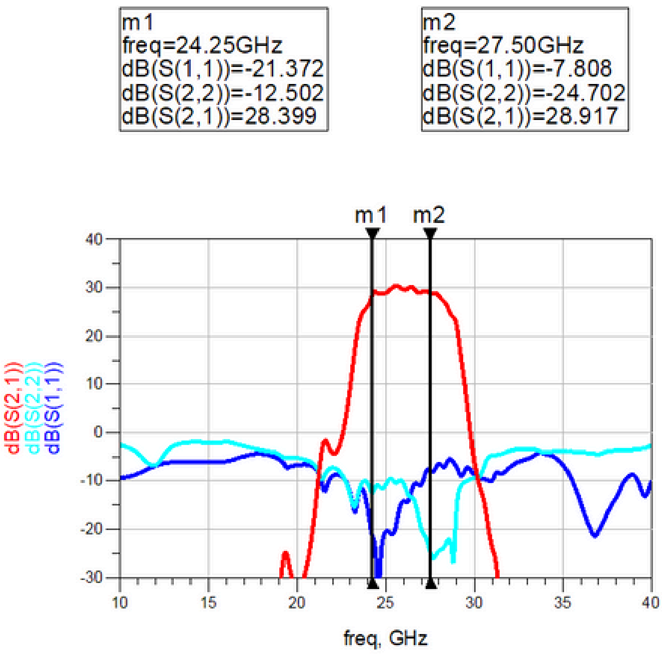

Figure 9: Simulated S-parameters of the n258 module, with the two amplifiers biased at +5V/10mA (each)

Simulated Performance of the Complete Amplifier/Filter Module

A small-signal simulation of the complete amplifier/filter module depicted in Figure 1 is presented in Figure 9. The gain outside of the n258 band is greatly suppressed.

The CMX90B702 amplifier components can also operate from a +3V supply, with a slightly lower current consumption of around 9mA per device. The simulated performance of the module with both amplifiers biased at +3V is shown in Figure 10.

A photograph of the readily available evaluation board for the CML CMX90B702 low-current amplifier (part number EV90B702) is shown in Figure 11.

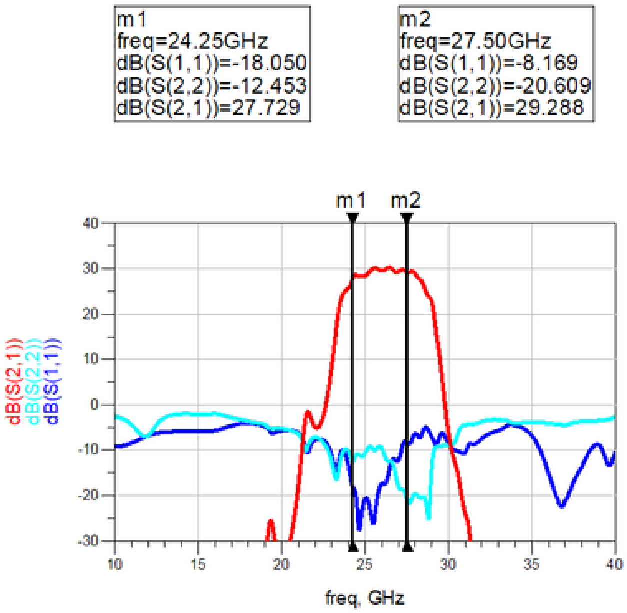

Figure 10: Simulated S-parameters of the n258 Module, with the two amplifiers biased at +3V/9mA (each)

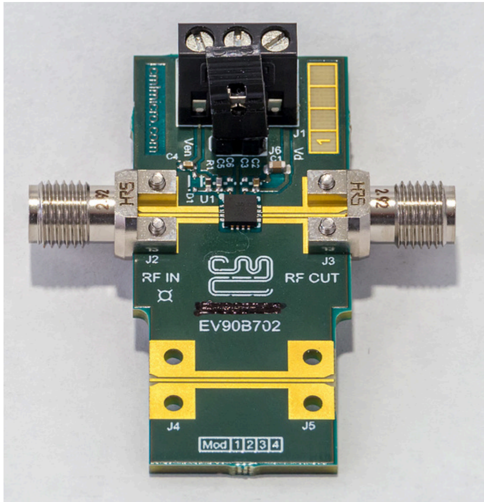

Figure 11: CMX90B702 Evaluation Board (EV90B702)

The proposed layout of the complete module, including all necessary bias/decoupling components for the amplifiers, is presented in Figure 12.

Conclusions

A high-gain, low-current mmWave amplifier lineup can be achieved using cost-effective commercially-available amplifiers from CML Micro. A PCB band-pass and low-pass filter combination achieves excellent out-of-band rejection such that the module is optimised for the n258 5G band of 24.25GHz to 27.5GHz.

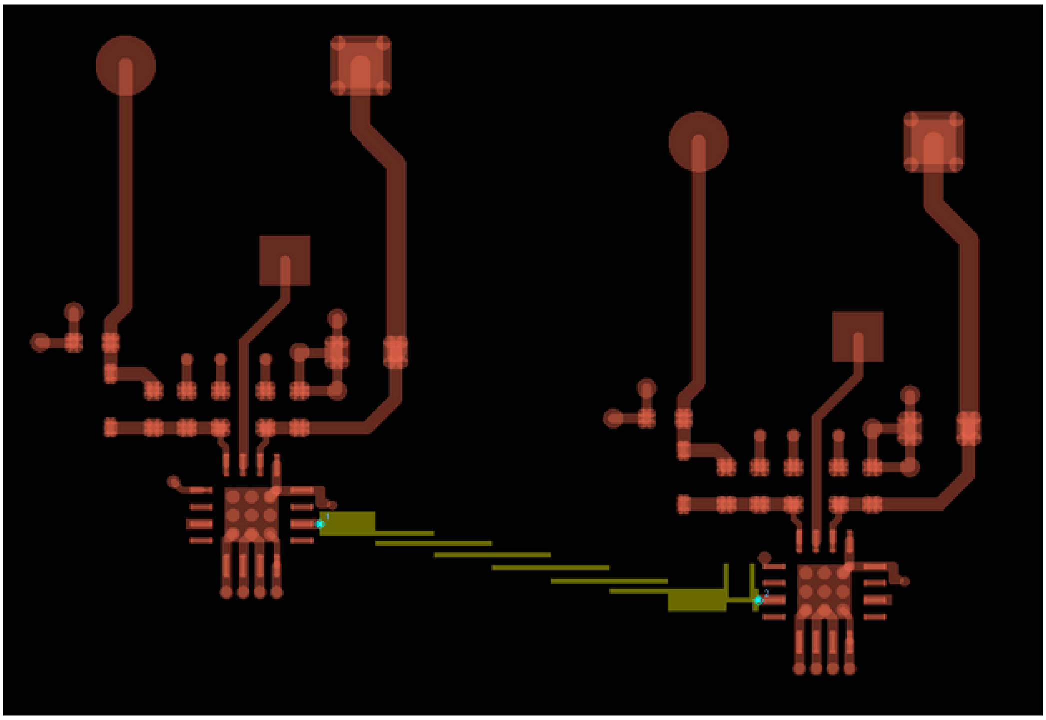

Figure 12: Proposed PCB Layout of the full n258 Module