Proof of concept of mmWave high capacity backhaul: RF and antenna components

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***Abstract*—In the next generation of mobile network, 5G, mmwave (mmW) communication is considered one of the main disruptive technologies to increase data rates, improve spectrum efficiency and provide new frequency bands for wireless communication. New frequency bands require new radio frequency components and design of radio circuits operating at mmW frequencies is a challenging task. This paper provides simulation and measurement results of a commercial power amplifier, a Wilkinson divider and a distributed element 22 GHz high pass filter used in a proof of concept 5G mmW radio.**

I. INTRODUCTION

One of the technology drivers of the next generation of mobile networks (so-called 5G) is the communication at the high carrier millimeter wave (mmW) frequency bands such as Ka- and E-band [1]. The spectrum between 26.5 and 29.5 GHz is the band proposed for the Winter Olympics in Korea, of which 27.5 − 28.5 GHz is of particular interests for demonstrations [2]. A radio-unit capable of operating at the 28 GHz band is presented thoroughly in [3]. In this paper we study a power amplifier, a Wilkinson divider and a 22 GHz high pass filter which are used in the transceiver.

II. ANALYSED COMPONENTS

A block diagram of the proof of concept radio transceiver is shown in Fig. 1 [4] and the components, which are studied in the paper are marked to the diagram. All measured components include losses from SMPM connectors (surface mounted on the board), SMPM – 2.92 mm adapters and short microstrip lines.

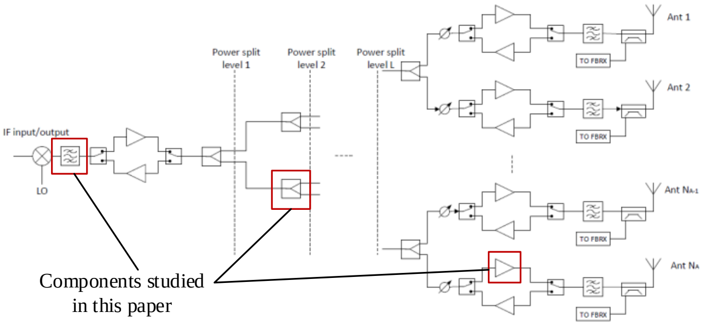

Fig. 1. Block diagram of the proof of concept transceiver

A. Power amplifier

The transceiver has a similar power amplifier in each transmission path. Available power amplifiers operating at 28 GHz frequency band are studied in [5] and TGA2595 from Qorvo [5] has been selected for the purpose. A data sheet of the power amplifier promises 23 dB small signal gain over the band of interest and we have measured similar values from application board. Small signal gain and reverse isolation of the component is shown in Fig. 2. A gain roll-off can be seen at frequencies higher than 30 GHz.

A constant wave (CW) input power sweep is shown in Fig. 3. The data sheet of the component states a saturated conducted power of 39.5 dBm and we have measured similar values at the band of interest. Measured values include losses of the connectors and adapters and de-embedding those would give a good match to the expected transmission power.

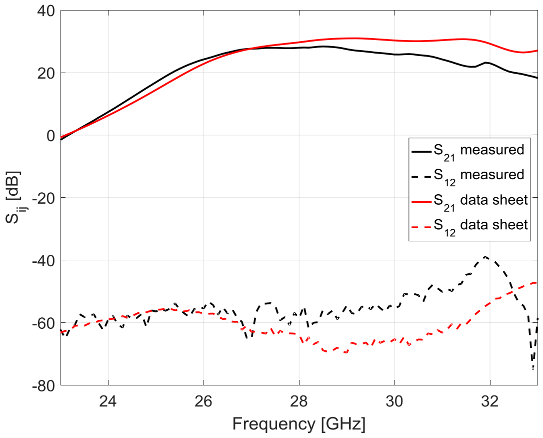

Fig. 2. Comparison of gain and isolation power amplifier from actual board measurements and from data sheets

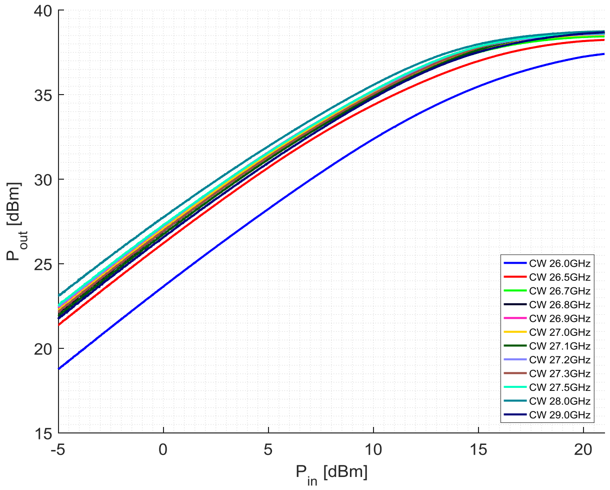

Fig. 3. Power level sweep of power amplifier at different frequencies

B. Wilkinson power divider

Wilkinson power divider is a three-port element which divides a common port power into two output ports. A typical configuration is that power is divided equally and the output power is attenuated with an insertion loss from the common port to the output port. A Wilkinson divider PD-0535SM from Marki Microwave [6] has been selected. The main motivation for this selection is the widths of the RF pins, which only require a small width transition to the 50 ohm microstrip line. It has 1.5 dB insertion loss from the common port to the output port and a frequency response of the component is shown in Fig. 4. Measured values from the actual board match to the S-parameter values from the manufacturer. Measured amplitude imbalance between the branches is 0.5 dB at 28 GHz frequency range, which is within the tolerance of the component.

C. High pass filter after mixer

We have designed a high pass filter to an output of the mixer to attenuate unwanted local oscillator (LO) frequency leakage. The high pass filter has a pass band starting from 25 GHz and a rejection band has a 7 GHz wide dual notch response. The filter has been designed and simulated with 2.5D EM simulator and implemented with microstrip lines on the radio board. The shape of the designed filter is shown in Fig. 5. A good match between simulations and measurement results of the filter can be seen from the Fig. 6.

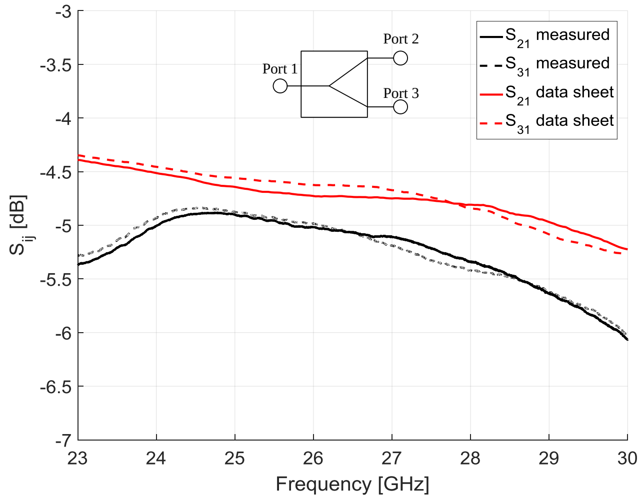

Fig. 4. Comparison of Wilkinson divider branches from actual board measurement and component data sheets

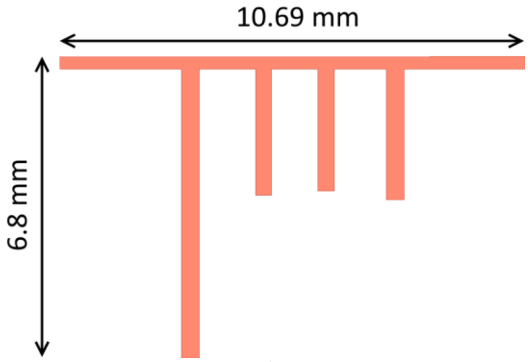

Fig. 5. Implemented 22 GHz high-pass filter

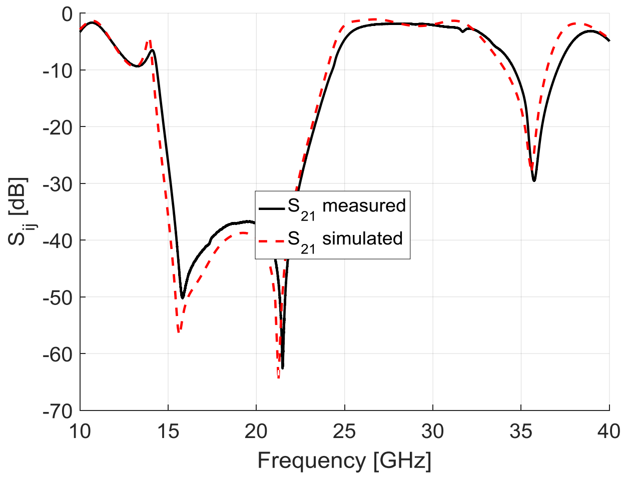

Fig. 6. Measurement and simulation results of high pass filter

III. CONCLUSIONS

Component measurement results of implemented proof of concept mmWave radio solution have good agreement with evaluation data from component manufacturers. Due to the lack of an SMPM calibration kit, the measurement reference plane was at the 2.92 mm end of the SMPM – 2.92 mm adapter.

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REFERENCES

[1] F. Boccardi, R. W. Heath, A. Lozano, T. L. Marzetta, and P. Popovski, “Five disruptive technology directions for 5G,” IEEE Communications Magazine, vol. 52, no. 2, pp. 74–80, Feb. 2014.

[2] World Radiocommunication Conference (WRC-15). International Telecommunications Union (ITU), “Studies on frequency-related matters for International Mobile Telecommunications identification including possible additional allocations to the mobile services on a primary basis in portion(s) of the frequency range between 24.25 and 86 GHz for the future development of International Mobile Telecommunications for 2020 and beyond,” Tech. Rep., 2015.

[3] M. Mueck et al. “5G CHAMPION - Rolling out 5G in 2018,” in IEEE Globecom Workshops, Dec. 2016, pp. 1–6.

[4] G. Destino et al. “System analysis and design of mmW mobile backhaul transceiver at 28 GHz,” in EuCNC 2017, Oulu, Finland, in press.

[5] Qorvo, ”27.5 – 31 GHz 9 W GaN Power Amplifier,” data sheet

[6] Marki Microwave, “Wilkinson Power Divider PD-0535SM,” data sheet