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Power Amplifier for E-band Wireless Link Using 0.1μm GaAs pHEMT

Minsoo Kang*, Bongsu Kim*, Kwangseon Kim*, Woojin Byun*,

*Electronics and Telecommunications Research Institute, Radio Technology Research Department, 161 Gajeong-dong, Yuseong-gu, Daejeon, 305-350, Korea

***Abstract* — We present the design and fabrication of Power amplifier(PA) for E-band wireless P2P (Point to Point) link using 0.1μm GaAs pHEMT process. PA has three stages topology and low impedance transmission line matching network was used for broadband matching. We obtained small signal gain of 18.1~21.9dB, P_{1dB} of >16dBm, and input/output return loss of <-6dB in PA at 71~83GHz. The size of PA is 2.8 x 1.1mm^2.**

I. INTRODUCTION

Recently, there has been a tremendous demand for high speed wireless communication due to explosive increases of smart phone and mobile internet. To support these data streams, more 3G/4G base station backhaul networks are needed. Wireless mobile backhaul link is a good solution to meet these demands. There are abundant frequency resources in E-band (71-76GHz, 81-86GHz) for wireless P2P link. Using these millimeter waves, the simple system providing mulit-Gbps data transmission can be easily realized with simple modulation such as OOK[1]. U.S. have allocated the frequencies, 71-76GHz, 81-86GHz, and 92-95GHz. Canada, Europe also have opened 10GHz of 71-76GHz and 81-86GHz for light license use and Korea also has opened these frequencies in 2009[2].

In this paper, we has reported the design and fabricated results of PA for wireless P2P link in 70/80GHz using 0.1μm GaAs pHEMT process. For broad band matching, low impedance transmission line was used in DA matching networks instead of 50 ohm transmission line.

II. DESIGN OF POWER AMPLIFIER

The power amplifier has been designed in a 0.1μm GaAs pHEMT process with 50μm wafer thickness, a cutoff frequency of $f_T \approx$ 120GHz, and maximum oscillation frequency of f_{max} > 200GHz. The process is consisted of three metal layers with a thick 3.5μm thick top metal layer as low loss transmission lines such as microstrip lines, couplers, and inductor lines. The gate-drain breakdown voltages of the transistor BV_{gdr} is typically -6.0V and pinch-off voltage V_{po} is typically -0.6V.

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To operate the transistor as amplifier, matching network is needed. There are three methods for matching network such as lumped LC, distributed transmission line, and mixed methodology. In this paper, we used distributed transmission lines for matching network. Typically, distributed transmission line method has a poor characteristic in view of wideband matching than lumped L,C matching method. But if low impedance line is used in some matching points, more broadband matching characteristic can be achieved. In figure 1, the S-parameters (S_{21}) of three different matching networks are shown. To compare matching method in broadband matching characteristic, single transistor was considered at center frequency of 78.5GHz. And simultaneous conjugate input/ output matchings of transistor have done for maximum available gain. The simulation result shows that 1dB gain bandwidth of low impedance transmission line is similar to lumped L,C matching network and 25% broader than 50 ohm transmission line matching network.

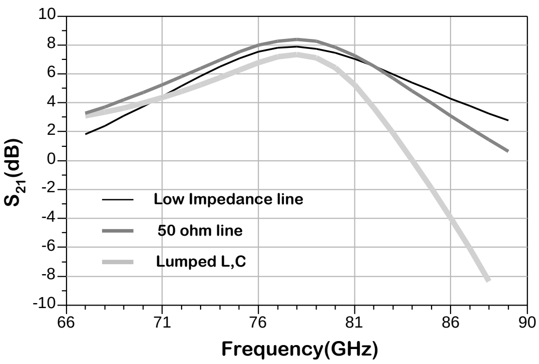

Figure 1. The simulation results of S-parameters(S_{21}) due to matching methods

The power amplifier is composed of three stage amplifiers. Figure 2 shows the schematic of three stage power amplifier. For matching network, distributed transmission line method was used. To obtain broadband matching characteristic, low impedance transmission line was used at input matching networks of each transistor. In input matching network of first stage, open stub was used for gain flatness and stability. In multistage amplifier, the bias line can be operated as feedback route and it could make the amplifier unstable. To avoid this

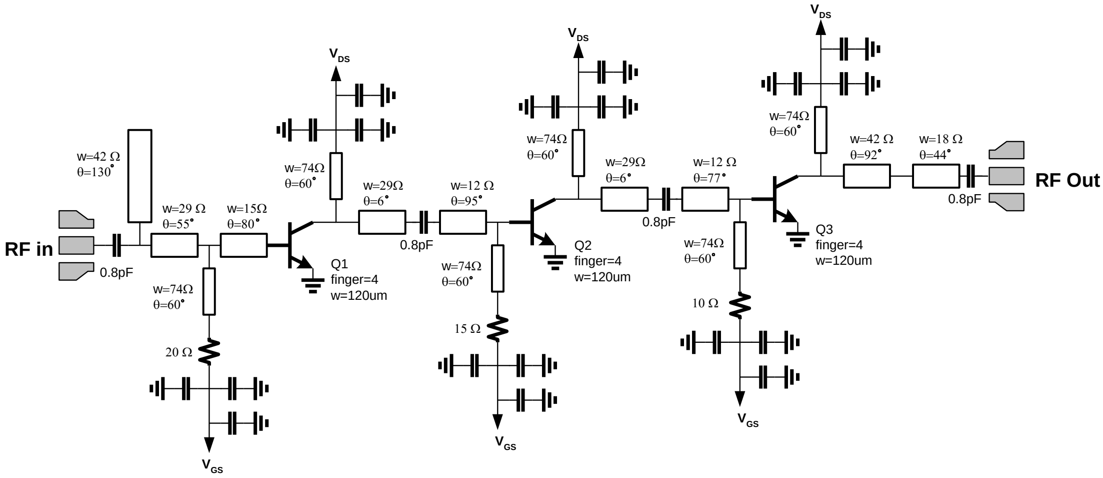

Figure 2. The schematic of three stage power amplifier

feedback route, lumped resistor was used in gate bias line. Although there is less current in gate bias line, the resistor affects the gain and P_{1dB} of amplifier. And the lower value of resistor was used at following transistors to reduce these effects.

III. Experimental Results

Figure 3 shows the fabricated power amplifier in 0.1μm GaAs pHEMT process. The chip size is 2.8 x $2.1mm^2$ including in/out RF pads and DC bias pads. The size of RF pads is 50 x $50μm^2$ and that of DC bias is 100 x $100μm^2$
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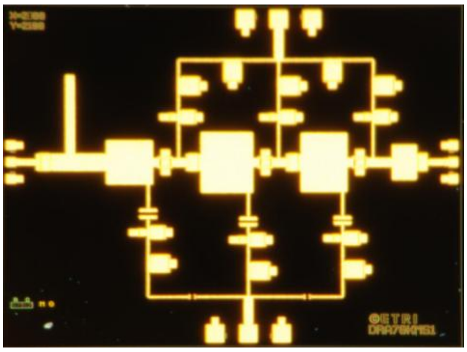

Figure 3. The die micrograph of the E-band power amplifier

The simulation(ADS Momentum) and measured S-parameters of power amplifier are shown in figure 4. The fabricated power amplifier exhibits a measured small signal gain(S_{21}) of 18.1~21.9dB, input reflection coefficient(S_{11}) of -6.0~-30dB, and output reflection coefficient(S_{22}) of -7.1~ -25dB for 71~83GHz. These measurements were found to be in good agreement with simulation results. The power amplifier has a 1dB compression power(P_{1dB}) of more than 16dBm at 71~83GHz as shown in figure 5. The DC bias condition was V_{DS} of 4.0V, I_D of 54mA. And the max power efficiency was 19% at P_{1dB} compression point.

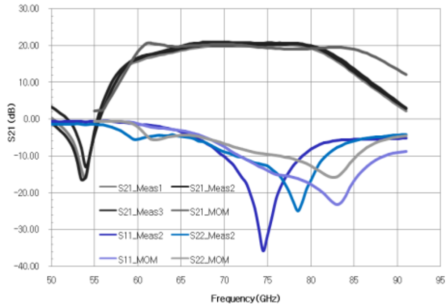

Figure 4. The simulation and measured results of PA

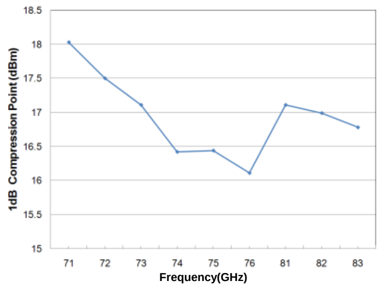

Figure 5. The measured P_{1dB} vs. frequency

IV. Conclusion

Power amplifier based on 0.1μm GaAs pHEMT process was designed and fabricated. Using low impedance transmission , wideband matching characteristic was obtained. The results of the fabricated power amplifier indicate the good performance in 70/80GHz E-band. Therefore this PA can is suitable for wireless E-band P2P system.

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