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Implementation of direct current to direct current converter exploiting power amplifier

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ABSTRACT

In the last years, RF power amplifiers are taking advantage of the switched dc-dc converters to use them in several architectures that may improve the efficiency of the amplifier, keeping good linearity. In this study a DC-DC power converter design suitable for high-frequency applications by using a class E power amplifier (Inverter), instead of using small battery values choosing Radio Frequency (RF) values and getting high efficiency of output voltage and a maximum of current and voltage values between 0-9 mW of power input in rectifier, the class E power amplifier designed by using GaN HEMT device and the power added efficiency of 64% after getting optimization of matching network and the gain is 14.4 dBm.

1. Introduction

Wireless communication using high-frequency batteries for laptop, mobile, and cellular Wi-Max is used mostly for delivering power wirelessly. The wireless system of high-frequency power converter gets damaged due to heat dissipation in the system by choosing the proper switching frequency can achieve the good efficiency. Consuming the high frequency and efficiency of the portable device with maximum output and gain is achieved. The process of power converters converts the current from DC-DC converter using the inverter and then the rectifier both are matched by the matching network and the process of an inverter is converting direct current to the alternating current and the current flows in a reverse direction and the process of rectifier is alternating current to the direct current and the flows in direct way.

The process of a power amplifier is considered as the inverter and is shunt capacitance is placed to maintain the high input power and maintains the efficiency and the power is added. The converter of CMOS technology (Suetsugu and Kazimierczuk, 2008) and the capacitor is used for reducing the power dissipation (Lee et al., 2010) the biasing part mentions the resistor at the gate used to reduce the power loss (Brama et al., 2008) the shunt capacitance is used to satisfy the condition of zero voltage and zero current and zero derivative switching for zero switching, low noise purpose (Deen et al., 2007) the reactance component used to realization of the dual broadband component in the rectifier and achieves the maximum of power current (Garcia et al., 2012) matching network in transmission line using microstrip lines for measuring the current values of developing the determinations used (Garcia et al., 2013) converts the power from RF power to DC power in the rectifier and determining the diode with high switching speed (Chuang et al., 2015) vs. is the switch voltage, Cj0 is the drain-to-source capacitance at vs equal to 0 and Vbi is the built-in potential of the MOSFET (Rivas et al., 2011) the rectifier process achieving developing the value of power and current voltage and input power is 0-9 mW is used.

2. Materials and methods

2.1. Power converter design

Class E power amplifier: The power amplifier classified as many depends upon the efficiency, drain, voltage, operating point, frequency, and sine wave rotation. The process of choosing class E power amplifier because of their efficiency it achieves 100% theoretically and practically achieves up to 60-75% and the range of output voltage depends upon the device or transistor and the device is MOSFET, so, that, the process is done by RF3931 transistor is used and by calculating the analysis design of power amplifier (Fig. 1). The power amplifier generally for the inverter design and the matching network matches the function of the matches the inverter and the rectifier, the rectifier with the filters can develop

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the function of the devices easily and the switching frequency control is used to determine the function of on and off stage and then the resonant in multistage of tuning the device depends upon the voltage values and the measurements of the sine wave generation using the general device testing by using the four steps.

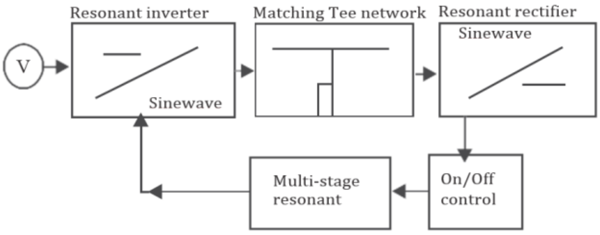

Fig. 1: Overall design of power converter using power amplifier (inverter) and switching control is used to maintain the power converter range the V is Voltage input given for the inverse

2.2. Design and simulation

DC load-line analysis: The DC load-line analysis the operating and Q-point of the transistor and from the DC load-line measuring voltage and current values by using that reducing the power consumption, three different regions in operating point active region, the transistor or device in active state and the locus point of the device is operating region, secondly saturation region, generally saturation have maximum voltage and minimum or zero current values, finally cutoff region have maximum current value and minimum or zero voltage value or vice versa of saturation region. The process of operation and Q point are calculated using the graph.

The graph in Fig. 2 represents the voltage versus current values for measuring the power consumption, the process of DC load-line analysis for the measuring the device power consumption and the equations of the graph represent the operating point of the device from Fig. 2, increasing the drain voltage VDS it decreases the drain current IDS and increases the gate voltage VGS and automatically decreases the power consumption of the device.

Bias and stability: The second step in the design of a power amplifier is bias and stability, every transistor satisfies the condition of stability has two types stability measurement and stability factor, and biasing is used to reduce the error and represent the flow of current in the resistors if the condition of stability is not satisfied then the transistor is oscillator or negative resistor and the process of stability is to maintain the stable conditions of device and achieve the good stability in it.

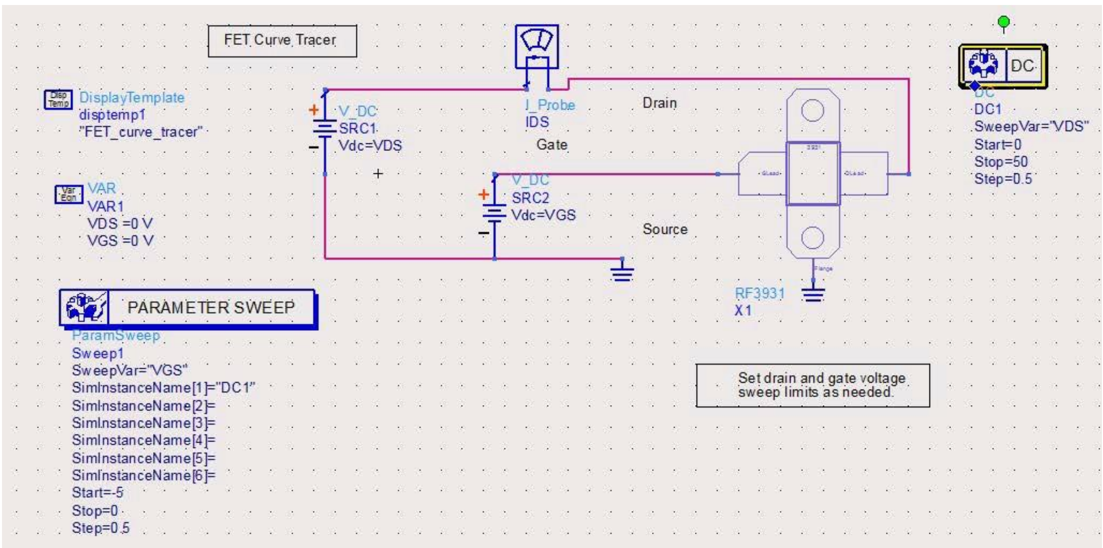

Fig. 2: Schematic of DC load-line of RF3931 to find the power consumption value of the overall device

Fig. 3 the device with a bias network is a symbol of a large circuit and the bias network achieves the gate, source, drain, and the drain part have a resistor to reduce the power losses in the device and the gate part have inductor to achieve high stability to maintain in the state of stability and biasing and the bias used for the current flow of the device and the development of the stability conditions (Figs. 4 and 5).

The stability factor and stability measurements are inbuilt the equations of the stability factor is measuring the k factor values and the input and output reflection coefficient and the insertion loss and coupling loss are determined the stability factor should be >1 and the stability measurements should be <1 and then the stability condition of the device is satisfied.

3. Results and discussion

Loadpull analysis: Loadpull analysis can achieve maximum output power and gain of the device, the gain is high when the source power gets increased and loadpull analysis is used to measure the input matching and the output matching device using the smith chart. The smith chart shows that three different values in different blocks from the first block resulting in the load at the maximum gain and the power can be measured and the smith chart denoting the gain value, secondly, the load at the maximum power-added efficiency is measured by using that the output matching network can be measured, finally the load can select the marker and result in the power added efficiency values and maximum efficiency, the gain can be determined (Fig. 6).

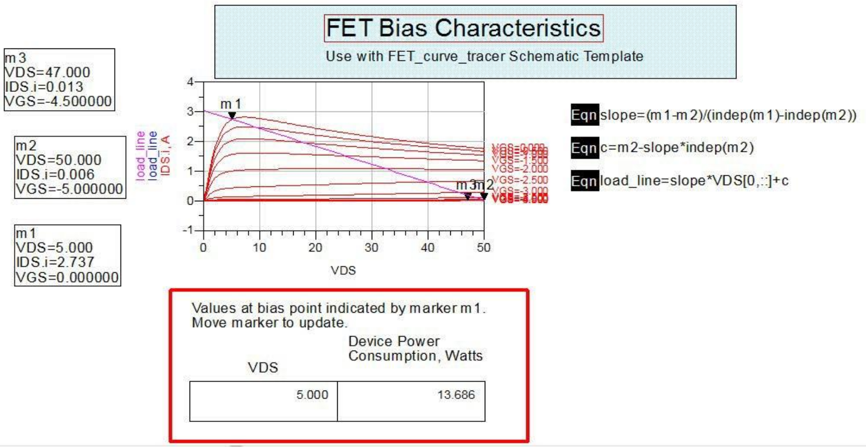

Fig. 3: Results of current vs voltage of device and power consumption values for the three different regions

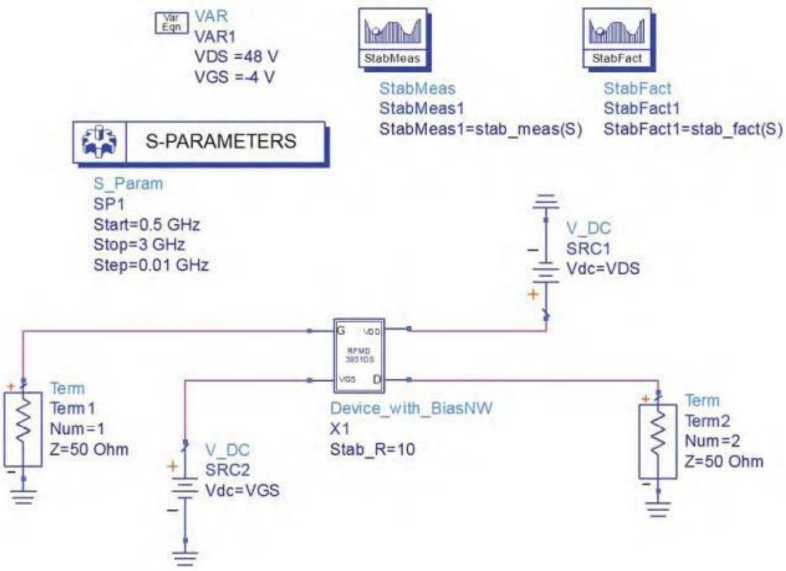

Fig. 4: Bias and stability conditions

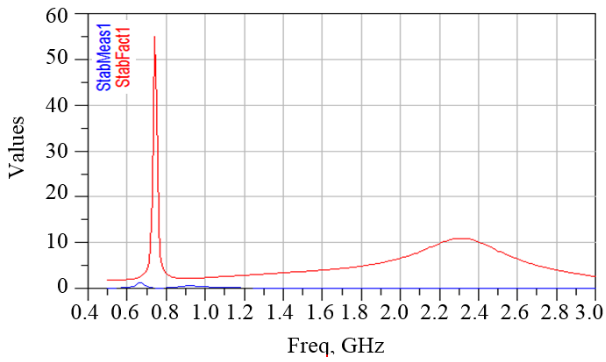

Fig. 5: RF3931 two stability conditions for stability measurements and stability factor

The one tone loadpull analysis has output power and power-added efficiency of each fundamental harmonic and the harmonic balance remains, the bias network device is used and the voltage bias is -4-48 V and the power availability is 34, the bias one connected to the ground and the bias two connected to the drain load with no DC values, VDS in bias two and achieving the high gain values in Fig. 7.

The input matching value and output matching the value of the impedance matching are matched by the loadpull analysis design and at the load, power added efficiency maximum gain of 10.059 dBm and at the load, gain input using that the output matching network can be measured, finally, the load can select the marker and resulting in the power added efficiency values and maximum efficiency, the gain can be determined (Fig. 6).

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The input matching value and output matching the value of the impedance matching are matched by the loadpull analysis design and at the load power added efficiency maximum gain of 10.059 dBm and at the load gain input matching gives the maximum 14.3 dBm and at the load selected by marker m1 determines the gain at maximum high output power.

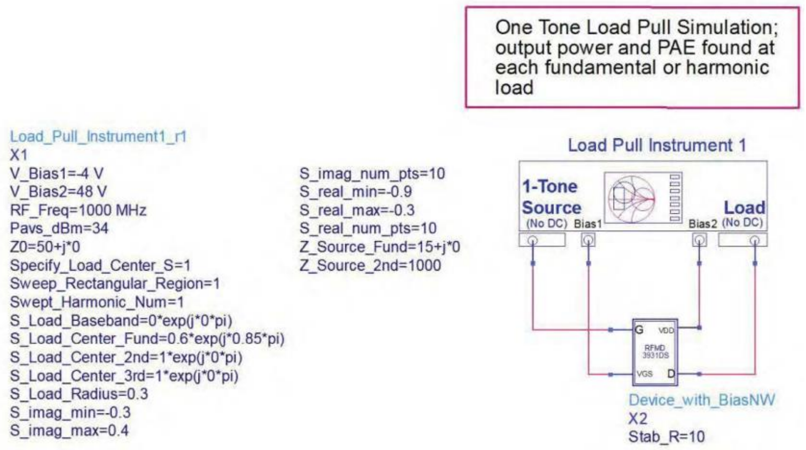

Fig. 6: Improving the gain value

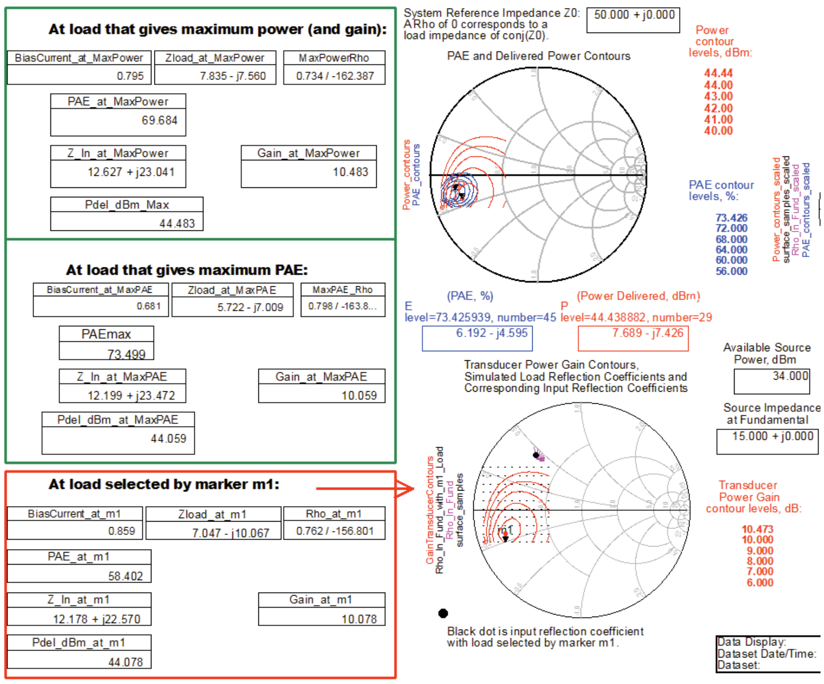

Fig. 7: High gain value with maximum source power

Impedance matching: Finally, the impedance matching can match the device by using the input matching and output matching of loadpull analysis value, and then the process of impedance matching is used to measure the high output voltage values and maximum power-added efficiency, the impedance matching can calculate by using the two steps, one is normal impedance matching and the other thing is optimizing the impedance matching and achieve high power-added efficiency and output voltage in dBm, the impedance matching shows the high power-added efficiency for the transistor in Fig. 8. The impedance matching is used to match the device and the power added efficiency and output voltage (Fig. 9). Without the goal and optimization achieves only minimum power-added efficiency and output power of41.003 (dBm) at the frequency of 1 GHz and the process of the matching impedance matches the device and the loadpull analysis values.

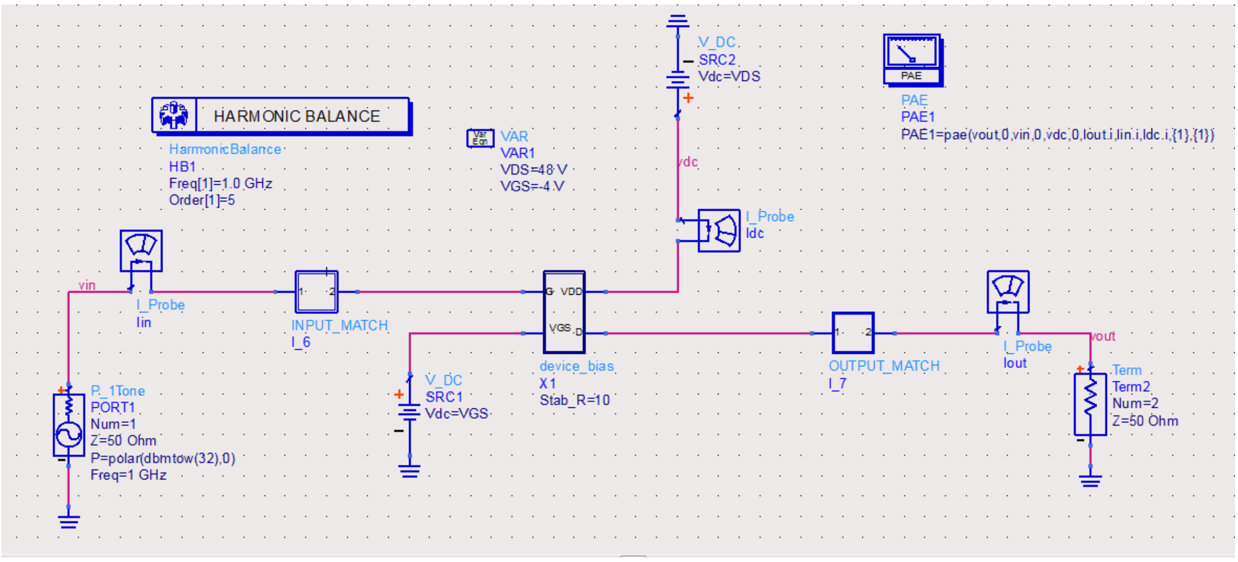

Fig. 8: Matching the input and output device

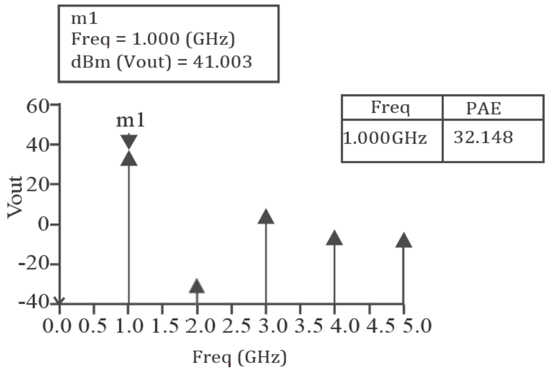

Fig. 9: Impedance matching before optimization

The process of optimization achieves maximum power-added efficiency they goals, one for the maximum output voltage and another for maximizing the power added efficiency and the process achieves only by tuning the variables for the achievements and then the development of processing the s parameters and the maximum output voltage of the device is 44.5 dBm and the power added efficiency is 64% is achieved (Fig. 10).

Matching circuit: The matching network for matching the class E power amplifier (inverter) and rectifier using a tee-matching network is two L-shaped RLC circuits are attached and resistor value in 50 ohm and the process of tee matching circuit network in microstrip lines and the width and length are measured by using the line calculation process and the development of microstrip can separate the lines to get proper matching and the inverter at the first and the rectifier at the end of the matching network (Fig. 11).

The process of matching the network matches the inverter and rectifier and the development of high frequency of DC-DC power converter values and the function of the matching network is used. The direct current to alternating current and then matches with the alternating current with the direct current input of the radio frequency is used for the high-frequency efficiency.

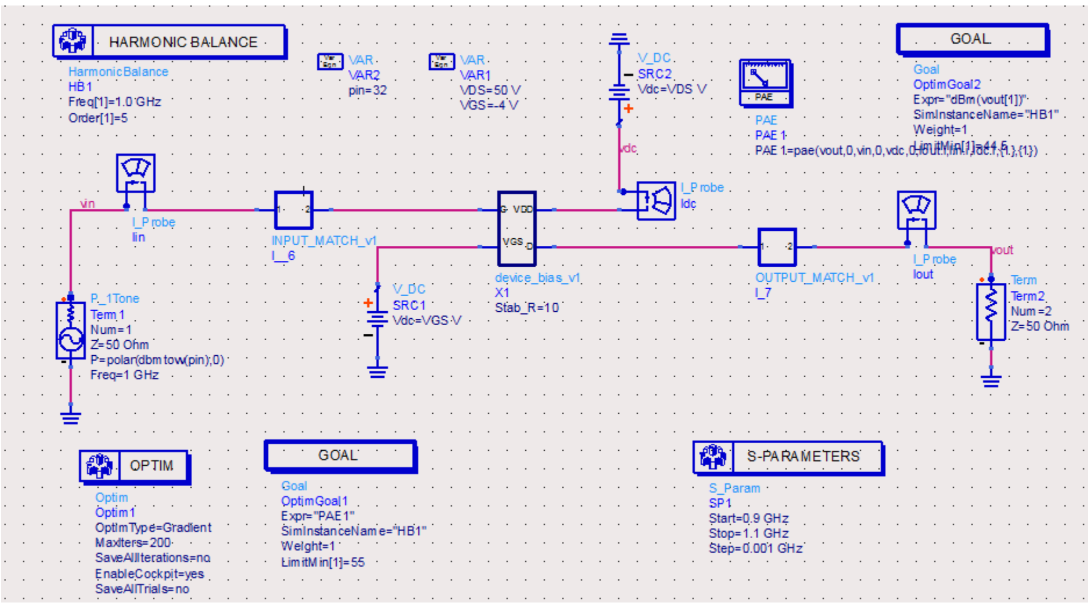

Fig. 10: Optimization and goals achieve maximum PAE

Rectifier: Generally rectifier is converting the alternating current to direct current and the current flows in direct direction only not in a reverse direction and the process of the rectifier has the diode of di_hp_HSMS2868-2000301 (Fig. 12).

The process of a high-frequency diode is used and the output voltage of the inverter and the rectifier are the same 44.6 dBm value is achieved and the then the process of the matching network and the rectifier diode part is attached and the condition is maximum amount of output voltage at the high-frequency value is determined. The function of the rectifier is alternating current to the direct current and the current flows in direct direction if moves in a reverse direction and then moves to the inverter is used is for the matching network can be developed and then function the rectifier value and the process is achieving the same of the inverter efficiency (Fig. 13).

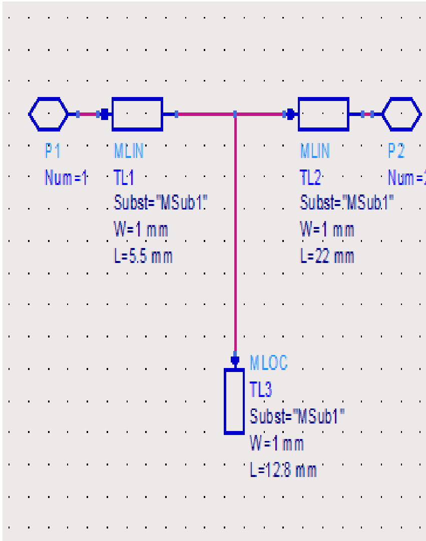

Fig. 11: Matching circuit for converting the inverter and rectifier

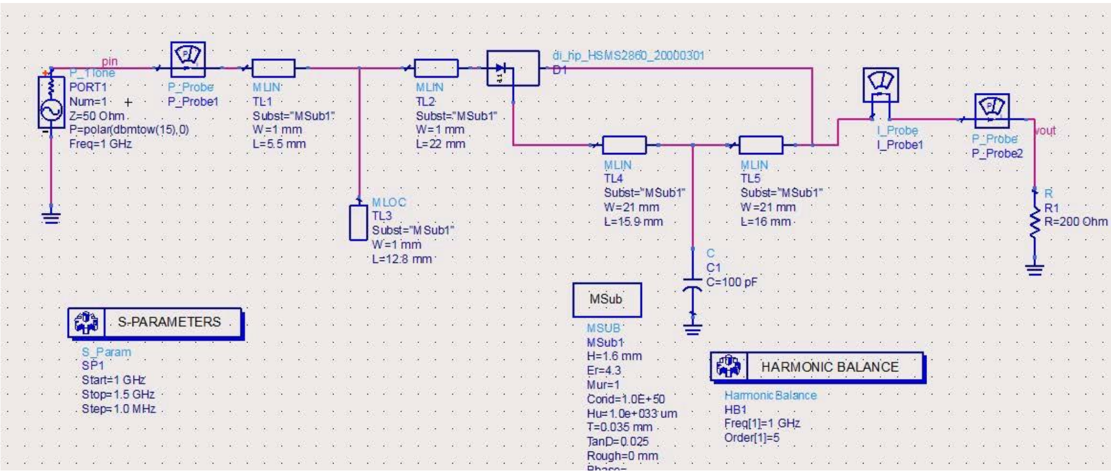

Fig. 12: High-frequency rectifier design

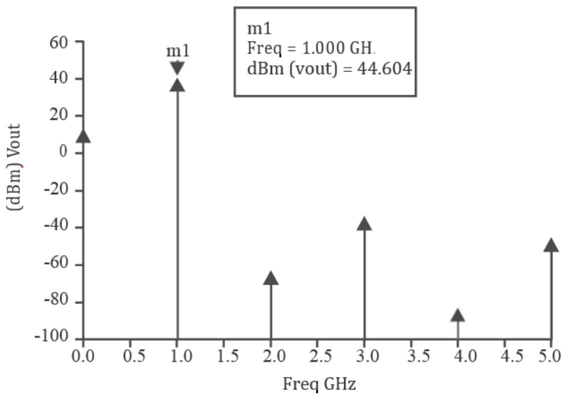

Fig. 13: Rectifier output voltage

The rectifier achieves the power level of 7.216 and the input power value id 0-9 mW and then the output power of the rectifier is 44.6 dBm is measured.

4. Conclusion

This study gives a broad view of the DC-DC power converter by using the class E power amplifier for high frequency application and gives the instead of normal battery values using radiofrequency value to achieve high output voltage value of 44.5 dBm at 1GHz frequency and the gain of the device is 14.4 dB and high power-added efficiency 64% designed using an ADS software tool.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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