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To design flat scattering parameters at 434 MHz frequency region by using AWRP

M. Duman[1,a]

[1] Duzce University, Faculty of Technology, Electrical Electronics Engineering, Duzce, Turkey.

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Abstract

In this study, an Ultra High Frequency (UHF) flat gain power amplifier which has 434 MHz centre frequency and 12 MHz bandwidth frequency is designed. The main purpose of the work is to design and obtain flat scattering parameters and the other figure of merit at these frequency values. Approximately 4 MHz flatness from 432 MHz to 436 MHz at gain characteristics has been obtained by using Microwave Office AWRP (Applied Wave Research Program) supported by National Instruments. Limitation borders have been put to the graph and other optimization techniques are used on the program so that the gain graph becomes flat along 4 MHz at the peak side. Efficiency and linearity are also examined but the flatness is the main object for this project.

Keywords: flatting bandwidth; gain characteristics; scattering parameters.

1. Introduction

In the design of active circuits; scattering parameters (S) are extremely important [1-3]. The gain, efficiency, reciprocity, stability, linearity and impedance matching can be changed with S parameters [2, 4, 5]. It is not quite possible for each concept to be maximum at the same time. For example, increasing the gain of the circuit can lead to a decrease in efficiency. Finding the optimum value will give a better result [6-8]. While all these studies are carried out; in active circuits, especially in power amplifier circuits, it is important that the gain graph should be flat [2, 5, 9] at the desired frequency.

In this study, the power amplifier circuit between 432 MHz and 436 MHz frequencies, especially the central frequency of 434 MHz, S_{21} parameter, in other words; gain graph was studied to make the design flat along the working area. The difference in this work is that after the designed power amplifier is integrated with the other components in the modem layer, the modem layer will form the satellite structure with other layers such as power layer and transponder layer [2, 10].

2. Materials and methods

The SGA-9289(z) medium power discrete Si-Ge transistor [11] is used to design the power amplifier on MicroWave Office Applied Wave Research Program (MWOAWRP). The S parameters of the transistor have to be got from the manufacturer. After that, circuit elements such as capacitance, inductance, RF choke are set to provide desired level of gain, efficiency, reciprocity, stability, linearity and impedance matching (figure of merit) for the power amplifier. The materials are placed on a composite material plate which is a type of FR4.

The limitation, optimization and tuning tools of The MWOAWRP will be used to make the 12 MHz bandwidth area quite flat. In order to keep the other parameters in the desired range, the flattened bandwidth frequency region should be around 4 MHz. Otherwise, one of the figure of merit can go beyond the boundary.

2.1. Limitation tool

In desired operating frequencies; parameters such as flat gain graph, linearity and efficient operation; the limiting technique that is in the program is used. This technique is called the "Limitation Tool" and can be used to place borders on any section on the chart. The MWOAWRP attempts to place the graph within the

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[a] Corresponding author; mehmetduman@duzce.edu.tr

borders. For example, if the gain value is limited from 19 dB to 21 dB as in Figure 1, the borders are set to these values and the graph tries to place between these two values. It is 20.1 dB gain in here.

There are two more borders on the left and right sides in Figure 1. These borders help the power amplifier circuit to get bandpass filter properties. In this way, except for the operating frequency, power boost will not be made and efficiency of the circuit will be increased. In addition, the gain graph takes the form of a chimney at the operation frequency 434 MHz.

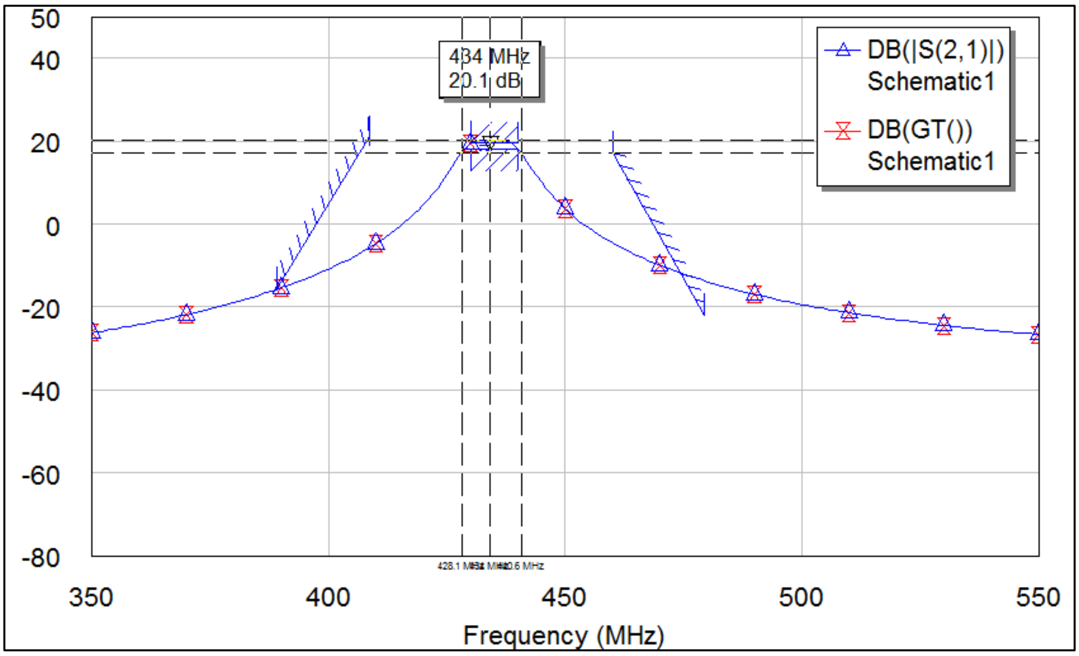

Figure 1. Gain graph for the power amplifier [dB] versus frequency [MHz].

2.2. Optimization and tuning tool

The "Optimization Tool" is used when selecting some discrete elements in the power amplifier circuit design which need to be changed in MWOAWRP. By means of this tool, the selected discrete elements colours shift to red and the program can change the value of these discrete elements between the given limited values. Even if the new value of the discrete element remains between the limited values, it can be difficult or even impossible to find and buy the element (capacitance, inductance) in the market. In such cases; the element in the market that has the closest value can be selected instead of the element calculated with the "Optimization Tool" in the program. As a result; when the calculated value is changed to the nearest value in the market, the figure of merit and S parameters can also vary. However, these parameters are desired to be set by the optimization tool again and again.

In this case, the "Tuning Tool" can be used. By means of this tool, the values of other discrete elements in the circuit can be changed one by one. With this application, it is aimed to provide the desired parameter values on the graphs of the power amplifier or the other active circuits. However, it should be noted that the discrete element with fine adjustment have to be able to be found and bought in the market when this change is made.

In Figure 2, capacitor C1 is rounded from 43.8 pF to 44 pF; the capacitor C2 is drawn from 16.2 pF to 15 pF. These changes are made by controlling the other values which are calculated by the program. The graphics created by the program are also checked while making fine adjustments. In spite of these changes made on the capacities; if the graphs are not within the desired limited range, inductances can be changed too. Because inductances can be produced easier in the laboratory by some methods such as winding method.

3. Results and discussion

The MWOAWRP is one of the program to design active circuits. It also provides fine adjustment and optimization techniques to the user. If the flatness, efficiency and linearity are important for the circuits as A class power amplifiers and if the power amplifier is used in the satellite structure which repairment is extremely difficult after sent to the space, the circuit of amplifier have to be complete, unproblematic and perfect. While performing all these steps, attention should be paid not to affect other parameters.

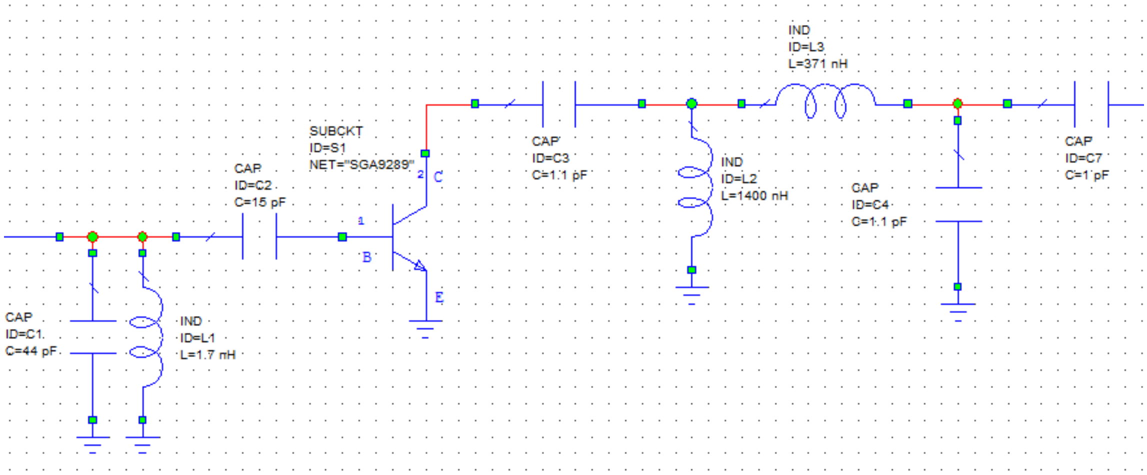

Figure 1. Transistor section of the power amplifier circuit.

4. Conclusion

At the end; in this study, the methods of obtaining a straight gain graph (S_{21} parameter) are given in detail with examples of optimization, tuning and limitation tools which are in the MWOAWRP. Also, how to increase the level of efficiency by these methods is given. The power amplifier for this work is A class so it has to be linear amplifier. The circuit is designed according to these criteria. The other figure of merit can be calculated, changed, fine adjusted and set by using program tools too. After all, the circuit which has 20.1 dB gain, 12 MHz bandwidth, 4 MHz flat bandwidth and 434 MHz operating frequency is ready to be integrated to the modem layer to form the satellite structure.

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