Active Microstrip Antenna for Mobile Communication

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Abstract: This paper describe analysis active microstrip antenna with low noise amplifier at 900 MHz for mobile communication. The microstrip patch antenna is integrated with low noise amplifier on a permittivity 4.5 (Epoxy – FR4) and thickness of substrate 1.6 mm. Low noise amplifier is designed by using GaAs FETs. The analysis characteristics of antenna include return loss, input impedance, vswr, radiation pattarn, bandwidth and gain of antenna. Mesurement gain of antenna is shown 19.2435 dBi.

Keywords: active microstrip antenna, gain of antenna, mobile communication

1. INTRODUCTION

Active microstrip antennas are antennas incorporating one or more passive solid-state devices and circuits to amplify or generate new RF frequencies. Typical active microstrip antennas have focused primarily on a single function such as detection, amplification, or oscilation. However, more complicated functions require combinations of several devices and/or MMICs. In this fashion all possible RF component functions can be localized within the antenna structure to provide the smallest possible subsystem. The smallest possible subsystem, however, is not without its share of problems. Due to strong coupling between the fields of the circuit and the radiator, there is considerable degradation of both the component and antenna performance. If a single substrate is used, its properties cannot be separately optimized for the circuit or the antenna. The combination of antennas and circuit on a single substrate often forces a significant trade-off in the overall performance. Solid-state devices and MICs may also require direct current (DC) biasing lines near the antenna which can disturb currents flowing on the radiating surfaces. Sumilarly, the antenna may have to be modified to accommodate these devices which often degrade radiation characteristics.

Amplifiacation is one of the most basic and prevalent microwave circuit functions. Early microwave amplifiers used klystron or traveling-wave tubes, or two-terminal solid-state devices such as tunnel or varactor diodes. But due to the dramatic improvements in transistors (FETs) silicon bipolar transistors, heterojunction bipolar transistors (HBTs), and high electron mobilith transistors (HEMTs). Microwave transistor amplifiers are rugged, low cost, reliable, and can be used at frequency to 100 GHz in a wide variety of application requiring low-noise figure, broad bandwidth, and medium power capacity.

Microwave transistors are used as amplifiers, oscillators, switches, phase shifters, mixers, and active filters. Most of these applications use either silicon bipolar transistors or GaAs field effect transistors (FETs). Silicon bipolar device technology is very mature and inexpensive compared to GaAs transistor technology. Bipolar transistors are capable of higher gain and can operate at much lower Frequency, but GaAs Fets generally have better noise figures and can operate at much higher frequencies. Present silicon bipolar transistors are limited to applications below about 10 GHz, but GaAs FETs have been used at frequencies in excess of 100 GHz.

When low noise amplification is required, matching is done to reduce the device noise to its lowest possible value. The input matching circuit must then present the impedance that provides the smallest noise figure. Additionally, the transistor amplifier must be stable; in other word, it must not oscillate at any frequency. This condition must be satisfied with all the loads that might be connects to the amplifier.

In this paper propose active microstrip antenna which rectangular patch antenna is integrated with GaAs FETs low noise amplifier. Design GaAs FETs low noise amplifiers are analyzed. Futhermore, experimental results of active microstrip antenna are analyzed.

2. ANTENNA STRUCTURE

The microstrip patch antenna is integrated with low noise amplifier on a permittivity 4.5 (Epoxy – FR4) and thickness of substrate 1.6 mm. The active microstrip antenna is designed at 900 MHz for mobile communication. Fig 1. show the circuit of GaAS FETs low noise amplifier that is designed by using MGA 85563.

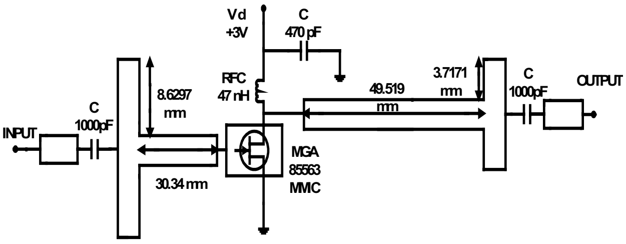

Fig 1. Circuit of GaAs FETs low noise amplifier

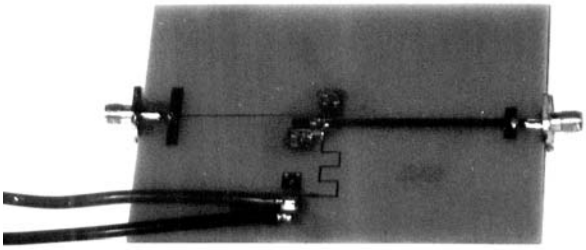

Fig 2. GaAs FETs low noise amplifier

Fig 2. show the GaAS FETs low noise amplifier that is done to reduce noise figure to its lowest possible value and increasing gain to its highest possiible value at 900 MHz.

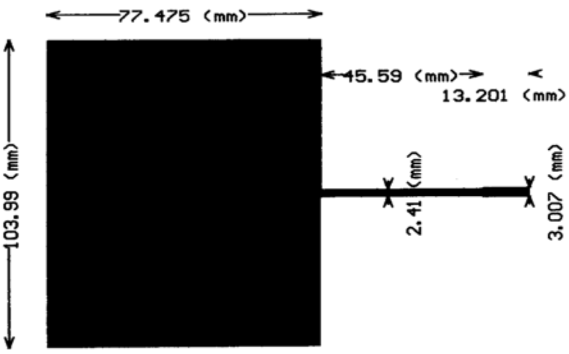

Fig 3. Structure of microstrip patch antenna

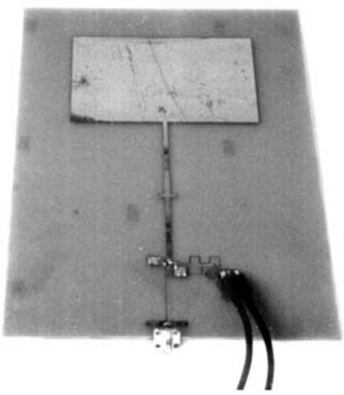

Fig 4. Microstrip patch antenna is integrated with GaAs FETs low noise amplifier

Fig 3. shows microstrip patch antenna that can be calculated by

$$W = \frac{C}{2F_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \qquad (1)$$

$$L = \frac{C}{2F_r\sqrt{\varepsilon_{reff}}} - 2\Delta L \qquad (2)$$

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2} \qquad (3)$$

$$\Delta L = 0.412\, h \frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)} \qquad (4)$$

where W is width of patch
L is length of patch
h is thickness of substrate
ε_{reff} is effective dielectric constant

By studying the given design, The patch element antenna dimensions control the resonant frequency. For matching impedance of the antenna is design by using quarter wavelength tranformer. Hence, the dimensions of patch antenna is 103.99 × 77.475 mm., length and width of microstrip line for quarter wavelength tranformer 45.59 mm. with 2.41mm. respectively.

Fig 4. shows Microstrip patch antenna is integrated with GaAs FETs low noise amplifier is designed for matching at 900 MHz

2. EXPERIMENTAL RESULTS

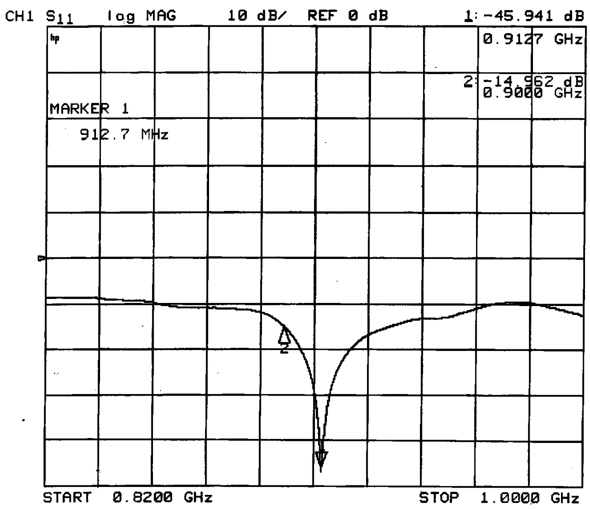

Fig 5. Return loss of active microstrip patch antenna

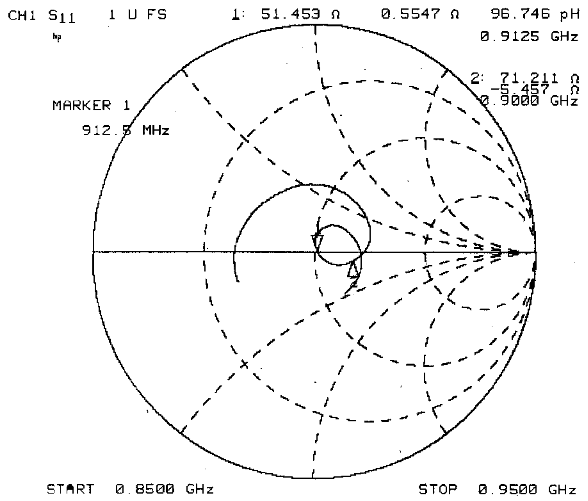

Fig 6. Input impedance of active microstrip patch antenna

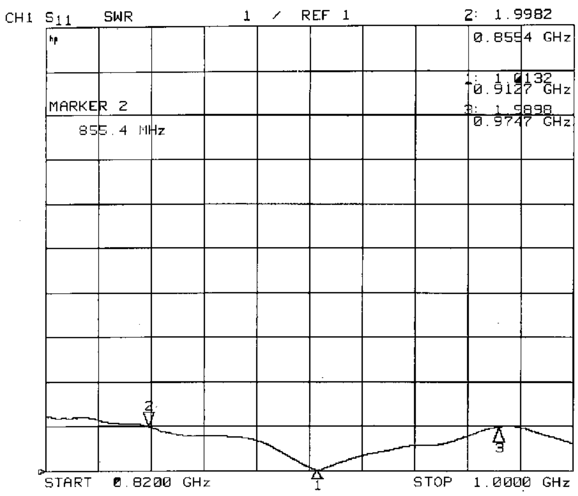

Fig 7. VSWR of active microstrip patch antenna

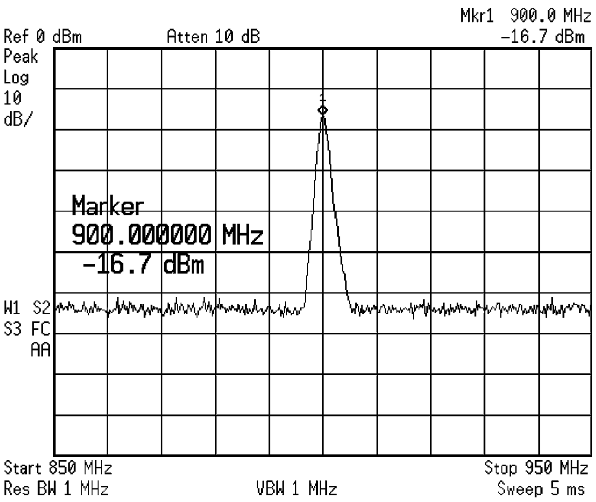

Fig 8. Power received using the signal under test of active microstrip patch antenna

The experimental results of antenna are shown in Fig 5. – Fig 8. The active microstrip antenna were designed to operate at 900 MHz for mobile communication. The return loss of antenna is shown in Fig 5., while Fig 6. shows the corresponding input impedance as real and imaginary parts. Fig 7. shows VSWR and bandwidth of antenna.

Fig 8. is shown power received using the signal under test of the active antenna. Gain of antenna can be calculated by

$$G_{Test}(dB) = P_{Test}(dB) + G_{Ref}(dB) - P_{Ref}(dB) \quad (5)$$

where G_{test} is Gain of antenna

P_{test} is Power received using the signal under test of antenna = -16.7 dbm

G_{ref} is Gain of reference antenna = 4 dB

P_{ref} is Power received using the signal under test of reference antenna = -31.65 dbm

Table 1. Experimetal results of antenna

Experimetal results	Resonance Frequency (912.7 GHz)
S_{11} (dB)	-45.941
VSWR	1.0132
Zin (ohm)	51.453+j0.5547
Bandwidth (%)	13.2
Gain (dB)	19.2435

Table 1 shows experimetal results of active microstrip patch antennn. The antenna is obtained for resonance frequency 912.7 GHz. The antenna shows good matching impedance, wide bandwidth and high gain.

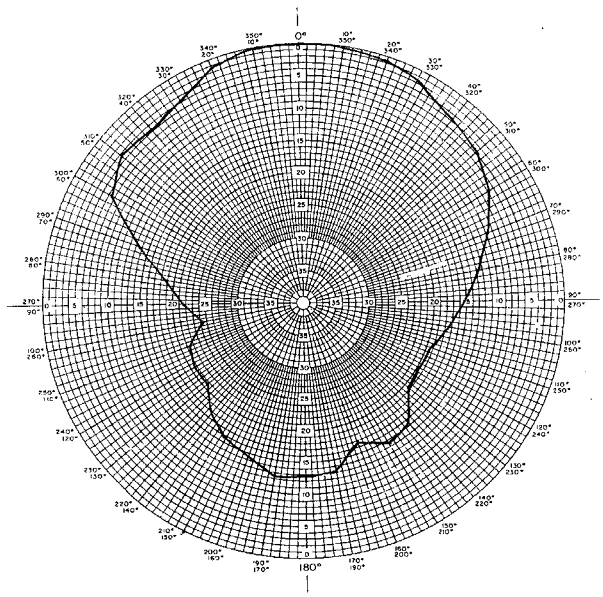

Fig 9. Radiation pattern of active microstrip patch antenna

Fig 9. is shown Radiation pattern of active microstrip patch antenna.

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3. CONCLUSION

In this paper propose active microstrip antenna which rectangular patch antenna is integrated with GaAs FETs low noise amplifier. From experimental results of low noise amplifier are demonstrated good matching impedance at 900 MHz. Futhermore, experimental results of active microstrip antenna show high gain and good matching impedance at 912.7 MHz.

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