

Gain In Bandwidth of a Microstrip Antenna With Negative Inductor

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ABSTRACT:

4G communication requires high gain, easy integrated array circuits. Various communication systems require single radiating element operating in wide band. Microstrip antenna has all these advantages but it has some limitations like low gain, low bandwidth and surface wave propagation. Using negative inductor overcomes this disadvantage of Microstrip antenna. In this paper, an active integrated single patch Microstrip antenna is proposed and its radiating pattern and gain performance is optimized with analysis. A Microstrip antenna patch operating at 50 input impedance, 10.5 GHz and having 13.4% bandwidth has been utilized as a reference. With the proposed antenna design, radiation pattern can be as large as about 1.75 times that of an antenna without inductive loading. This value increases to 25% by utilizing the negative inductor circuit at the input port of reference antenna.

KEY WORDS: Microstrip Antenna, Negative Inductance, 4G, FET

INTRODUCTION:

Now a days, microwave integrated circuits (MICS) have received great deal of interest for many application systems. They are easy to produce and more reliable with improved performance at low cost. The radiation pattern of a rectangular patch antenna can be controlled by inductive loading. For these reasons, integrated antennas to be used as RF (Right Front) at antenna terminals. The purpose of this study is to investigate the effects on radiation performances of loading a microstrip element with active inductive load.

EVALUATION:

MICROSTRIP PATCH ANTENNA :

MPA consists of metallic patch on one side and dielectric substrate on another side. The length of the patch (L) is equal to one half of the dielectric wavelength which corresponds to the resonant frequency. The dielectric substrate material determines the size and bandwidth of an antenna. Larger the dielectric constant smaller is the size of antenna but it reduces the bandwidth and efficiency of the antenna while decreasing the dielectric constant increases the bandwidth and thereby increasing the size of the antenna. But there is limit on increasing the value of dielectric constant. The width W of the Microstrip antenna determines the input impedance and radiation pattern. Larger width indicates an increase in bandwidth. As shown in Figure 1. " h " is the height of substrate. Here rectangular patch antenna is used. There are various methods for improving the bandwidth and gain MPA like changing the shape of patch, using multilayer structures, different feeding techniques, array method, using different dielectric substrates etc.

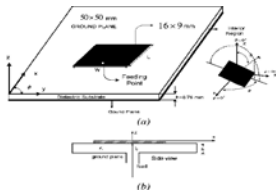


Figure 1: Antenna Configuration (a) top view and (b) side view.

Microstrip antennas exhibit a parallel LCR circuit. For this, the input impedance of an antenna can be expressed as :

$$Z = R_{max}/1+jQ \dots\dots\dots (1)$$

Where , R_{max} is the resonant resistance

Q = Quality factor

$$v = f/f_r - f_r/f \dots\dots\dots (2)$$

Where f_r = resonant frequency.

For lower and upper band edge frequencies f_1 and $f_2 = S$

And relative bandwidth (BW) can be written as:

$$BW = f_2 - f_1/f_r \dots\dots\dots (3)$$

The quality factor can be expressed as:

$$Q = 1/BW \sqrt{(S \cdot R_{norm} - 1) \cdot (S - R_{norm})/S} \dots\dots\dots (4)$$

It can be shown from eqn. (4) that decreasing the quality factor is also effective way to enhance the antennas impedance bandwidth.

$$\text{Eqn. (4) reduces to } BW_{(R_{norm}=1)} = 1/Q \cdot S - 1/VS \dots\dots\dots (5)$$

The Admittance :

A parallel RLC circuit of a narrow band frequency can be written as :

$$Y_{ant} (f_r + \Delta f) = G_{ant} - jB_{ant}$$

$$\approx \frac{1 + 4Q^2 (\Delta f/f_r)^2}{R_{norm} - 2jR_{norm}Q(\Delta f/f_r)} \dots\dots\dots (6)$$

Where the frequency shift from resonance is:

$$\Delta f_{max} = f - f_r$$

$$\text{And, } \Delta f_{max}/f_r = 1/2Q\sqrt{2R_{norm} - 1} \dots\dots\dots (7)$$

For parallel type resonance, the bandwidth is –

$$BW = 2G_{ant}/w_0 (dB/dw)w_0 \dots\dots\dots (8)$$

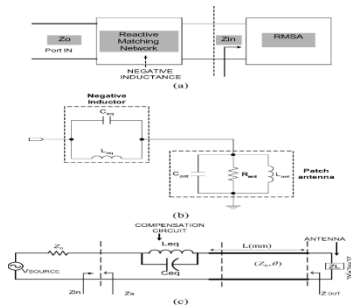


Figure 2. (a) Matching block diagram, (b) equivalent circuit of the MPA with negative inductance, (c) equivalent circuit model both matched to source and the antenna.

The calculated return loss level is increased by using reactive matching network. This compensation network could transform the frequency dependent complex antenna impedance Z_0 over a large bandwidth which is the requirement here. Thus, it is important to select suitable components for optimizing the matching levels which will maximize the bandwidth. This resonant load can be realized by a cascade of negative inductor or capacitor segments connected to an appropriate point of the patch antenna.

PROPOSED ACTIVE COMPENSATED ANTENNA:

The 50 input impedance of the antenna is obtained. TLYA – 5CH200 which has permittivity of 3.20 and thickness of 0.78 mm has been used as a substrate material.

The patch dimensions of width $w = 16$ mm and length $L = 9$ mm have been selected with ground plane dimensions of 50x50 mm used. The designed antenna operates at 10.5GHz with -21.5 dB at resonant frequency.

Then the equivalent inductance and capacitance can be written as:

$$L_{eq} = -C_g/B_m$$

$$C_{eq} = C_{gs}$$

The negative inductance compensation circuit having two same type of FET have been simulated.

CONCLUSION:

Use of negative inductor to overcome the limitations of Microstrip patch antenna is an interesting research area. The researchers from various disciplines are being attracted towards this because of its unique properties. In this paper, introduction to negative inductance, various types, and methods to overcome the limitations of microstrip patch antenna have been discussed. From comparative analysis we observe that use of negative inductance in MPA can improve the bandwidth from 13.1% to 25.2% with a minimum deep point of -36.33 dB. have resulted in surprising improvements in various parameters like gain, bandwidth, radiation etc.

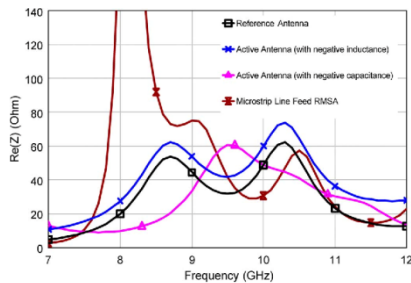


Figure 3. Variation of antenna impedances.

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