Planar Small Antenna Module for Global Positioning System

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Prototype of a novel planar antenna module for Global Positioning System (GPS) is developed. The antenna module consists of a circularly polarized antenna and two stages of low noise amplifiers. The size of this module is 28 mm × 15 mm × 2 mm. The module works in 3 V voltage operation. The module is small, thin and lightweight, which is suitable for mobile navigation equipments.

The circularly polarized antenna receives 1575 MHz right-handed circularly polarized wave which is used on GPS. The antenna consists of two layered metal patterns. These layers are connected each other by via hole. The metal pattern is formed on both sides of one PCB. Electrical size of the antenna is about $\lambda/8$ square. Our antenna is quite smaller than a conventional ceramic patch antenna commonly used for GPS equipments of $\lambda/2$ square size. The smaller size of this antenna enables to use conventional PCB with high dielectric constant ($\varepsilon r = 10$) instead of relatively expensive ceramic block. Actual antenna size is about 12 mm square.

The antenna consists of a lot of rectangular small metal segments. We analyzed induced currents on each segment using method of moment to calculate axial ratio and input impedance of the antenna. We defined two directional currents I_v and I_h, which are perpendicular to each other, on each segment. The axial ratio (AR) is calculated as shown in equation (1). The axial ratio of designed antenna is about 2.5 dB (less than 3 dB). Therefore this antenna can receive GPS signal successfully in spite of small electrical size.

$$|AR| = \left| \frac{|I_L| + |I_R|}{|I_L| - |I_R|} \right| \quad I_L = I_V + I_H \angle 90^\circ \quad I_R = I_V \angle 90^\circ + I_H \quad I_V = \Sigma I_v \quad I_H = \Sigma I_h \tag{1}$$

The antenna and the low noise amplifier are formed on PCB. The two layered antenna is formed on both sides of PCB. Circuit pattern of two stages amplifiers is formed on one side, and ground plane is formed on the other side. On calculation of the axial ratio, we considered currents, which are induced on the antenna and the ground plane.

High gain design of first stage amplifier causes capacitive input impedance ($200 - j100\,\Omega$) of FET. Therefore, we designed antenna impedance about $200 + j100\,\Omega$ to achieve conjugate matching. The impedance of the conventional $\lambda/2$ patch antenna is about $50\,\Omega$. However, the input impedance of the low noise amplifier is not $50\,\Omega$. Therefore conventional design method requires large scale matching circuit with distributed lines. Our design method successfully omits such large scale matching circuit because it is possible to design antenna impedance and axial ratio simultaneously. We chose bipolar transistor at second stage of the amplifier to achieve output impedance around $50\,\Omega$. Hence the module can be connected to conventional demodulator directly.

REFERENCES

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