Design of the SMD Isolator for IMT-2000 handset

Jin-Sup Kim , Jong-Nam Yoon

Wireless Communication Research Center, Korea Electronics Technology Institute, R.O.Korea
Phone : +82-31-6104-259, Fax : +82-6104-263,
E-mail : kim812@nuri.keti.re.kr / yoonjn@nuri.keti.re.kr

ABSTRACT

In this paper, the SMD isolator for IMT-2000 handset is designed, fabricated and analyzed. We have designed the SMD isolator using EM Simulation tool. Electrical results have improved in comparison with a conventional model. It provides an insertion loss of 0.3 dB at 1.95GHz and an isolation of 21.5 dB or more over a frequency range of 1.92 through 1.98 GHz. The size of the isolator is 4X4X1.8mm³.

INTRODUCTION

Nowadays, the wireless communication service is developing rapidly. The world is currently preparing for the advent of IMT-2000 service. By using the IMT-2000 service, everyone can communicate to each other everywhere on earth, over both voice and multimedia services. With increasing demand on data transfer, design of RF linearity is becoming an major issue. The main role of isolator is to protect PAM (Power Amplifier Module) from the reflection signal in the antenna. Therefore, the isolator is placed in the next stage of PAM. In this paper, the design and the fabrication of SMD isolator for IMT2000 handset is discussed emphasizing the feasibility of Lumped element type[1] leading to a well-matched simulation and measured data result.

CONSTRUCTION OF LUMPED-ELEMENT CIRCULATOR

Fig. 1 is equivalent circuit diagram of the circulator that is applied in this paper. The lumped-element circulator[2] consists of a ferrite plate with three coils wound on it so that the RF magnetic fields are oriented at 120 degrees with respect to each other. The length of the coils is much less than the wavelength at the circulator's operating frequency, so they are essentially inductances. The junction resonances are formed by connecting capacitances (C1,C2,C3) at three ports. The capacitors can be connected in the shunt configuration, as illustrated in Fig 1. In designing inductances (L1,L2,L3), it is desirable to set Q value as high as possible in order to decrease the insertion loss. Therefore, it is necessary to adjust the width of inductor to be large so that the Q value increases. Although inductances are controllable by changing the width and length of the coils, their upper limit is limited by the size. Consequently, we have selected the best width and length of the coils by the EM simulation and the proper experiment.

DESIGN OF SMD ISOLATOR

The isolator consist of ferrite plate ($1.5\times1.5\times0.4mm^3$), three conductors, three capacitors on each port, and one resistor to terminate port 3. This isolator can be designed in a size of 0.028cc with 60MHz bandwidth at a center frequency of 1.95GHz. Figure 2 shows the structure of a isolator for simulation. It is simulated by the commercial EM simulation tool, Ansoft HFSS. For this application the ferrite thickness is even less important. A thin disk is advantageous both from a cost point of view and thermal consideration. However if the chosen ferrite is too thin, cross section of the three coils become small, negating any power-handling advantages of the thin ferrite. The width of the coils wound on the ferrite is selected in order to provide the previously calculated inductance. One strip could be used for each port, but usually two or more strips are connected in parallel. This is done to have a better distribution of the RF magnetic field in the ferrite. Paralleling the strips also reduces the total inductance at each port. In this paper, two strips are used in parallel to each other. The coils from adjacent ports are insulated from each other where they cross with the Teflon (PTFE) insulating tape. The insulation thickness should be kept to minimum so that all the coils are close to the ferrite. The crossover points should also have low capacitance.

In this paper, the saturation magnetization Ms (4πMs) used on the ferrite is 1000 Gauss and the external magnetic field is 800Oe. The isolator is simulated and optimised with four critical variables. First, the width of the coils wound on the ferrite is selected to simulate the input impedance and we vary the width of the coils. The input impedance of isolator varying with the coil width is shown in Fig. 3. It is confirmed that the input impedance of proposed isolator is down shifted about 4ohm with ferrite width increased by 0.1mm.

Second, we change the gap of the coils. The input impedance of the isolator varying with the coil gap is shown in Fig. 4. It is confirmed that the resonance frequency of isolator is shifted about 120MHz with 0.1 mm variation on the coil gap.

Thirdly, the input impedance of isolator on the Fig. 5 shows its variation with external capacitance of isolator. It is confirmed that the resonance frequency of isolator is shifted about 100MHz with 1pF variation on the external capacitance.

Finally, the thickness of the isolator is considered. Fig.6 shows the input impedance of the isolator. It is conformed that the resonance frequency of the isolator and the input impedance are changed by varying 0.1mm of the ferrite thickness.

EXPERIMENTAL RESULTS

The SMD Isolator has been designed so that it has a 1.95GHz center frequency and 60MHz bandwidth. As a result, the insertion loss is 0.3dB at 1.95GHz, the input return loss is over 25dB and output return loss is over 22dB. The isolation is over 21.5dB. The insertion loss, input return loss and isolation are shown in Figure 7.

CONCLUSION

In this paper, the SMD Isolator is proposed for IMT-2000 handset. The results from the simulation and the experimental showed that the proposed SMD Isolator has advantages in size and electrical characteristics. Using EM Simulation tool, we could easily design a SMD Isolator so that the simulated and measured data are well- matched. A 1.95GHz SMD Isolator provides the insertion loss less than 0.36 dB, and the isolation is greater than 21.5 dB, while VSWR is less than 1.2 at pass band. The dimension of the presented isolator is 4×4×1.8mm^3 and volume is 0.028cc.

REFERENCES

[1] D.M. Pozar, "Microwave Engineering", Addison Wesley Publishing Company.

[2] Douglas K. Linkhart, " MICROWAVE CIRCULATOR DESIGN", Artech house, 1989.

[3] Y. Konishi, " Lumped element Y circulator", IEEE MTT-13 , 1965, pp. 825-964.

[4] Youhei Ishikawa, " An automatically assembled Miniaturized SMD Isolator for 1.9GHz Band Communication Systems", Electronic Manufacturing Technology Symposium, Jun 1993 pp. 113 -116.

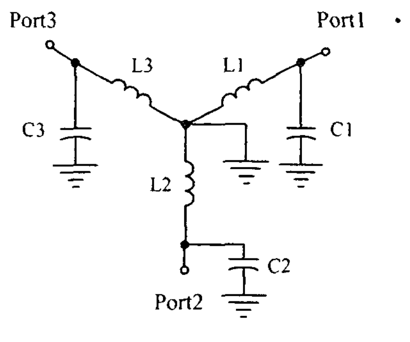


Fig 1. Equivalent circuit of the Lumped-element circulator

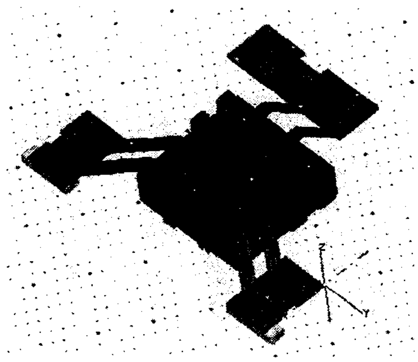


Fig 2. 3D Model of SMD Isolator for EM simulation

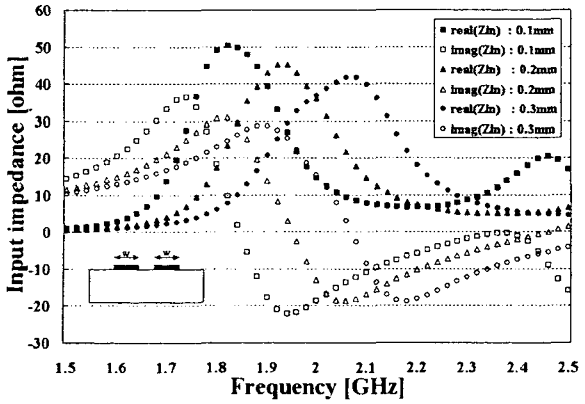


Fig 3. Input impedance of the isolator varying with the coil width

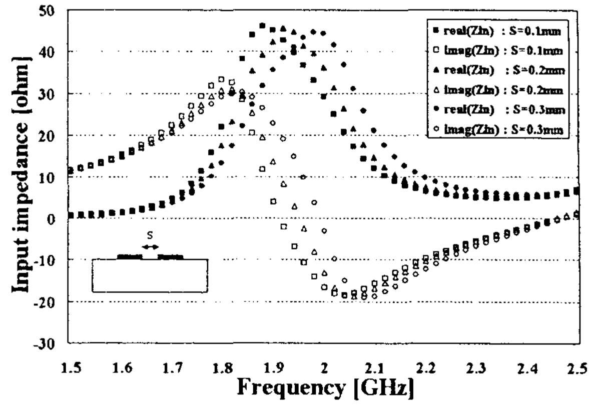


Fig 4. Input impedance of the isolator varying with the coil gap

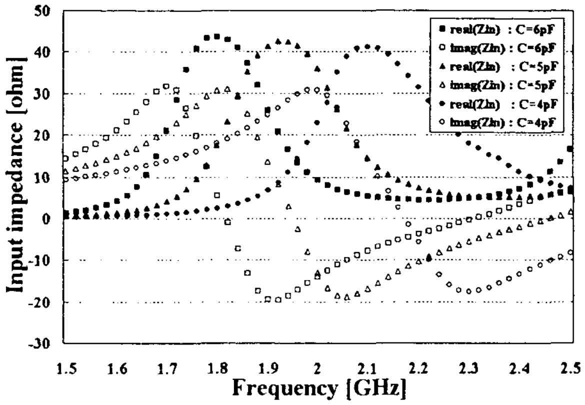


Fig 5. Input impedance of the isolator varying with external capacitor

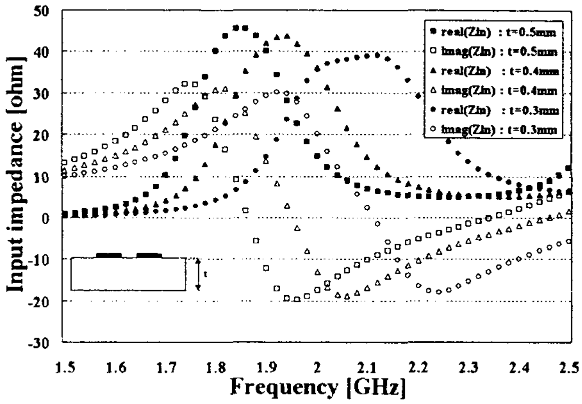
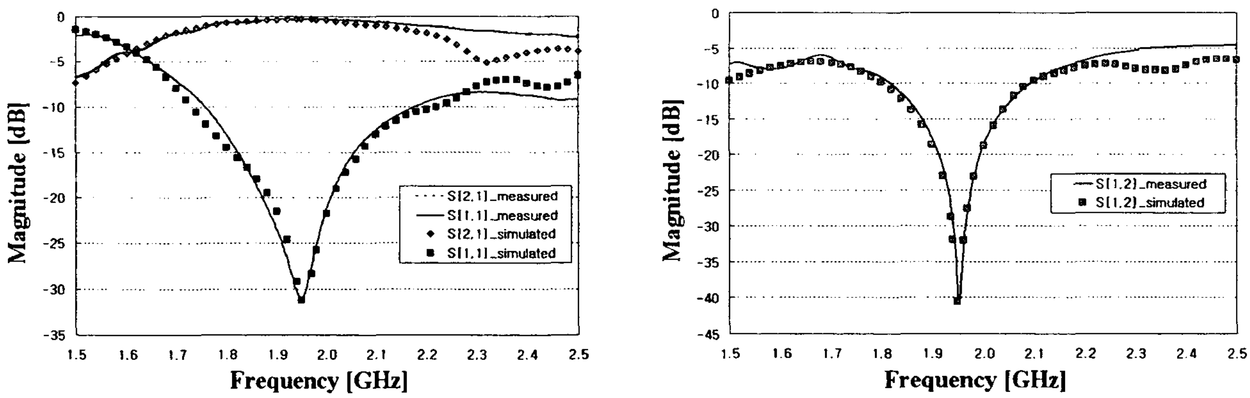


Fig 6. Input impedance of the isolator varying with the ferrite thickness.



(a)

(b)

Fig 7. Simulated and Measured data *of SMD Isolator for IMT-2000 handset*
(a) insertion loss and input return loss (b) isolation