STABILITY CHARACTERIZATION OF CIRCUIT AND STRUCTURE IN CERAMIC DUALBAND ANTENNA SWITCH MODULE BY PROBING METHOD

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Abstract - A compact antenna switch module for GSM/DCS dualband applications based on a multilayer low temperature co-fired ceramic (LTCC) substrate is presented. Its size is 4.5×3.2×0.8mm^3 and insertion loss is lower than 1.0dB at Rx mode and 1.2 dB at Tx mode. To verify the stability of the developed module to the process window, each block that is diplexer, LPF's and bias circuit is measured by probing method in the variation with the thickness of ceramic layer and the correlation between each block is quantified by calculating the VSWR. In the mean while, two types of bias circuits -lumped and distributed- are compared. The measurement of each block and the calculation of VSWR give good information on the behavior of full module. The reaction of diplexer to the thickness is similar to those of LPF's and bias circuit, which means good relative matching and low value of VSWR, so total insertion loss is maintained in quite wide range of the thickness of ceramic layer at both band. And lumped type bias circuit has smaller insertion itself and better correspondence with other circuit than distributed stripline structure. Evaluated ceramic module adopting lumped type bias circuit has low insertion loss and wider stability region of thickness over than 6um and this can be suitable for the mass production. Stability characterization by probing method can be applied widely to the development of ceramic modules with embedded passives in them.

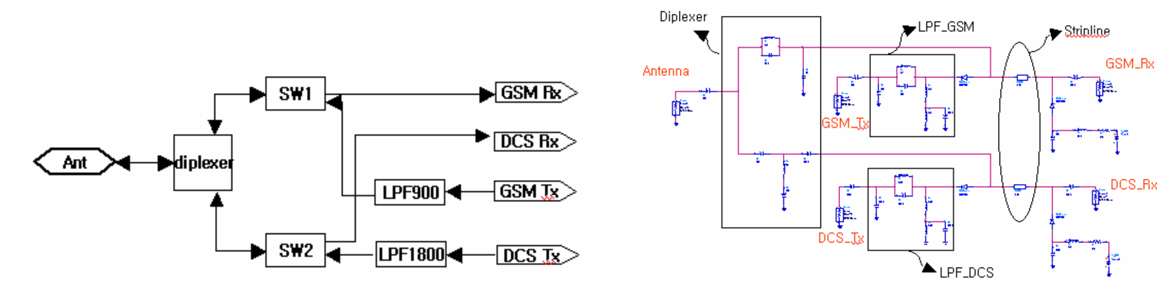
1. Introduction

Nowadays, research on ceramic device using LTCC are being performed vigorously especially for telecommunication like filter, multiplexer, balun, coupler etc.. In ceramic module, size reduction is possible due to the 3-dimensional circuit evaluation but this makes some problems like coupling between patterns and many kind of parasitics. So it is important to quantify the characteristics of components embedded in ceramic module.

In this research, the analysis on the behavior of each block in the variation with the geometry of ceramic module, which gives us the optimum structure insensitive to the process errors.

2. Circuit of Dualband ASM

Dualband ASM consists of Diplexer for band selection, switching circuit for Rx/Tx mode conversion and LPF's for the suppression in higher stopband region. Fig. 1 shows the block diagram and circuit.



(a) Block diagram (b) Circuit

Fig. 1. The block diagram and circuit of dualband ASM

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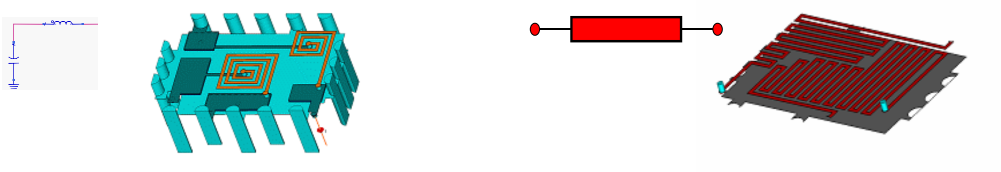
In Rx mode, an incoming signal to antenna arrives Rx port thru diplexer and turned off bias circuit. So relative matching condition between diplexer and bias circuit has a large effect on the total insertion loss in Rx mode. In bias circuit, lumped π network and distributed stripline with quarter wave length are adopted and compared. The shape of each type is shown in Fig. 2.

The other side, the signal from Tx port gets to antenna thru LPF and diplexer.



(a) Lumped π network (b) Distributed (stripline)

Fig. 2. The circuit and actual shape of bias circuit

3. Experimental Result

Dualband ASM module with the size of 4.5×3.2×0.8mm^3 was fabricated and its feature is enough for handset application. Insertion loss at Rx mode is lower than 1dB at each band and lower than 1.2dB at Tx mode. The shape of dualband ASM is shown in Fig. 3.

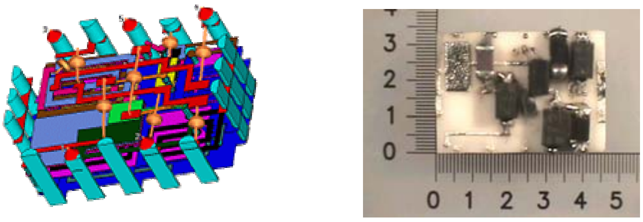
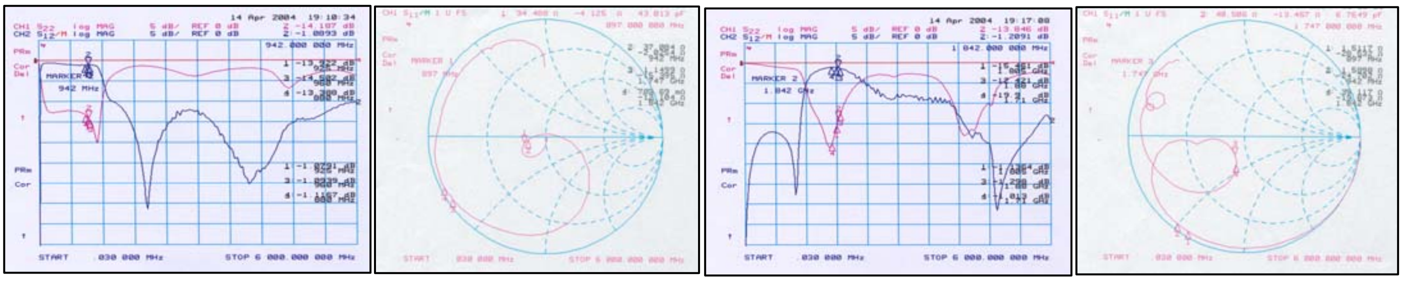


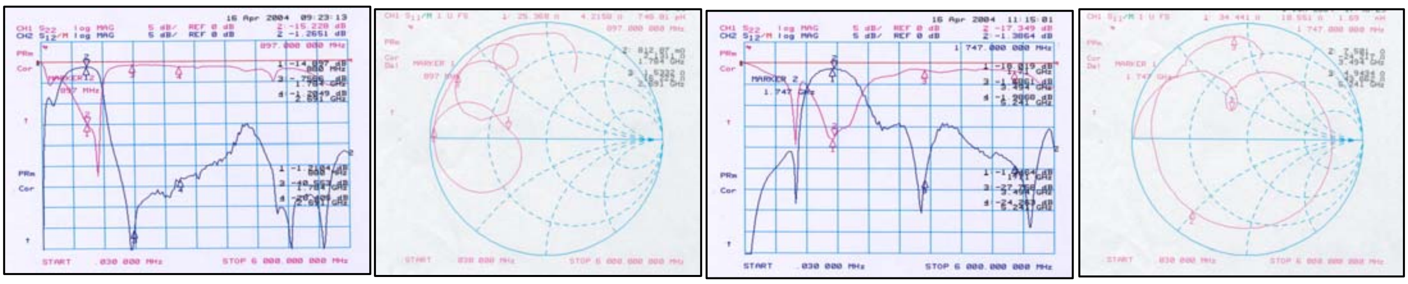
Fig. 3. The shape of Dualband ASM

As mentioned before, behavior of each block can be changed due to the effect of the pattern close to that, so the feature of each block in the state of integration should be measured. In our research, each block is characterized by probing method and the results are as follows.



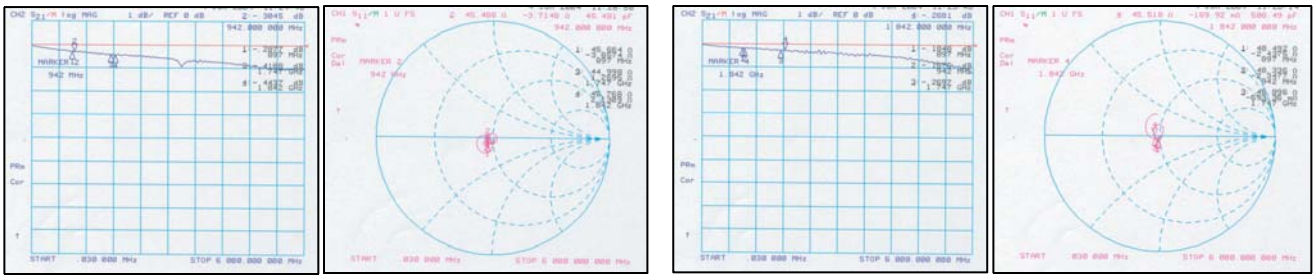
(a) GSM part (B) DCS part

Fig. 4. The characteristics of Diplexer



(a) GSM part (B) DCS part

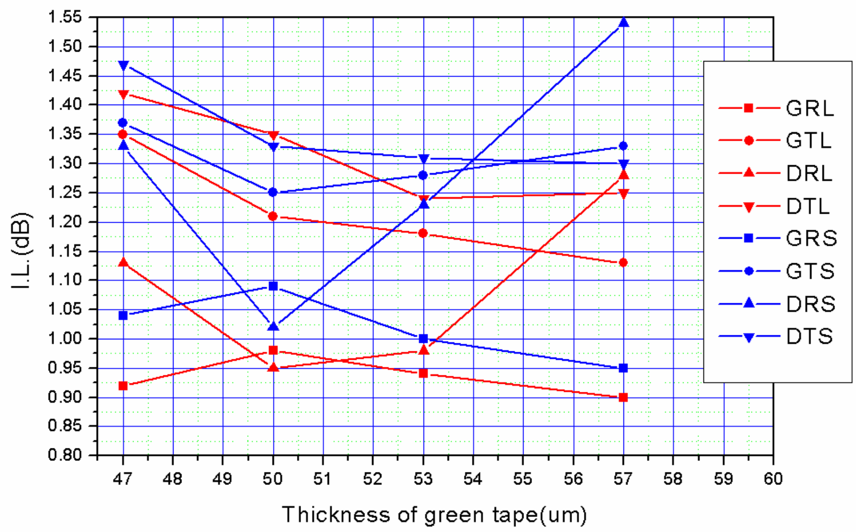
Fig. 5. The characteristics of LPF



(a) GSM part (B) DCS part

Fig. 6. The characteristics of Bias circuit- stripline

To verify the stability of 3-dimensional structure of ASM to the process window, many kinds of ASM with the various thickness of ceramic layer are fabricated and compared. In the mean while, the lumped and distributed type bias circuits are compared also. Fig. 7 shows the insertion loss of each band in the variation with the thickness of ceramic layer and type of bias circuit



G:GSM **D**:DCS **R**:Rx **T**:Tx **L**:lumped **S**:stripline

Fig. 7. Insertion loss in the variation with the thickness of ceramic layer

At Rx mode, insertion loss is decided by the relative matching between diplexer and bias circuit as Fig. 8. So the correlation of behaviors of two blocks to the thickness of ceramic layer is more important than feature of each block itself.

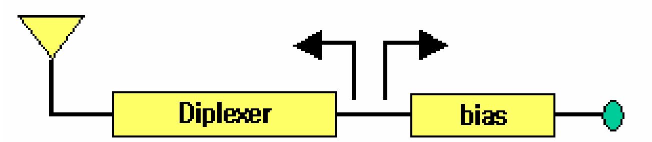


Fig. 8. The concept of relative matching at Rx mode

The behaviors of diplexer and bias circuit with thickness variation are measured respectively and relative matching parameter, VSWR(Voltage Standing Wave Ratio) is calculated at each case.

Table. 1 The value of VSWR(Voltage Standing Wave Ratio) at Rx mode

	GSM_Rx				DCS_Rx			
t(um)	47	50	53	57	47	50	53	57
Lumped	1.327	1.425	1.445	1.36	1.785	1.377	1.6	1.895
Stripline	1.311	1.537	1.47	1.356	1.781	1.611	1.761	2.141

The behaviors in Fig. 7 agree with the result of calculation in Table 1 and some facts are founded. Firstly, the total insertion loss is decided by the relative matching characteristics mainly. Secondly, insertion loss in lumped type bias circuit is smaller than that in distributed one for the same relative matching because of its own loss of the longer line in distributed structure. And finally, dependency on the thickness of ceramic layer in lumped type is smaller than that in distributed type.

In considering the total characteristics of dualband ASM at GSM Rx mode, the correlation of behavior between diplexer and bias circuit is quite good, so the insertion loss is maintained in the range of thickness of ceramic layer from 47um to 57um in both type of bias circuit. But insertion loss is maintained in the range of 48~54um in lumped structure and 49~51um in distributed at DCS Rx mode respectivelsy. So adopting lumped type bias circuit gives us wider stability region of thickness 48~54um at Rx mode. In considering behaviors at Tx mode also, the stability region of dualband ASM with lumped type bias circuit is located between 48um and 54um and this can be more wider by improving the correlation of diplexer of DCS part and bias circuit at DCS Rx mode.

The feature of dualband ASM at the thickness in the middle of stability region is summarized in Table 2.

Table 2. The characteristics of Dualband ASM

Band/Mode	Insertion Loss(dB)	Attenuation @2fo(dB)	Attenuation @3fo(dB)
GSM_Rx	0.93		
DCS_Rx	0.95		
GSM_Tx	1.15	-43	-30
DCS_Tx	1.23	-31	-33

4. Conclusion

A fully integrated dualband antenna switch module for GSM/DCS bands is developed, and its insertion loss is lower than 1.0dB at Rx mode and 1.2dB at Tx mode respectively. Each block of dualband ASM, diplexer, LPF's and bias circuit is measured by probing method and correlation between each block is quantified in the variation with the thickness of ceramic layer. Applied circuit and structure in this research have the stability region of thickness 48~54um and it can be more wider by improving the circuit topology from the viewpoint of correlation. Lumped type bias circuit has better correlation with diplexer and smaller insertion loss and insensitivity to the thickness variation than distributed type. The stability characterization by probing method can be used widely in developting many kinds of ceramic modules with embedded passives in them.

Reference

[1] D. Pozar, *Microwave Engineering*. New York: Wiley, 1998.

[2] G. L. Mattahaei, L. Young, and E. M. T. Jones, *Microwave Filters, Impedance-Matching Networks, and Coupling Structures*, Dedham, MA: Artech House, 1980.