Design and Characterization of Microstrip Diplexer

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Abstract— The paper focuses on a systematic design process and realization of a diplexer in printed circuit configuration.The diplexer is practically a 3 port structure having one input and two output ports.The structure consist of two filters having different passband with a common input port (diplexer input) and output ports of two filters acts as diplexer output.In this work the diplexer is required to meet some stringent specifications regarding size, insertion loss and return loss at input and output ports.

Keywords— Insertion loss,Isolation, Return loss and Crossover point amplitude.

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I. Introduction

As the frequency spectrum becomes more crowded, modern microwave communication system demands for filters with high selectivity and low insertion loss.The modified chebyshev type filters with transmission zeros can be realized using cross coupling between resonators. The frequency response of a diplexer is obtained from that of the dual integrated filters with different resonant frequencies.The design technique based on coupling matrix becomes useful in determining the coupling coefficients.The attenuation pole of the one filter can be adjusted to the centre frequency of the other.

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II. Design

Conventional design procedure of the microwave diplexer consists of two steps. First step is design of microwave filters which are usually bandpass/bandstop structure sometimes combined with lowpass/highpass filters.Second step is the combination of developed filters using matching networks.Usually different types of T-junctions are used. The main requirement for any diplexer is a high isolation between filters and low VSWR on the common port. Very often a connection of different filters to common port causes interaction and degradation of initial transfer characteristics of filters and additional reconfiguration of filters is required

Here the filter design has been done at two different frequency bands (Filter 1, 8-12 GHz) and (Filter 2, 13-17 GHz).The basic configuration of the filters are shown in Figure 1.Here the coupling gap between the fingers of the hairpin configuration and their relative width are taken as design parameter for optimization. The simulation tools are used to investigate the performance of the individual filters and the combined responses as a diplexer. It was observed that the design dimensions are critical in deciding the filter responses. The line dimension and coupling gaps are optimized to meet the specification and final pcb design is generated. The diplexer is designed to provide an Insertion Loss ≤ 3 dB between CP and Port 1 (within 10 ± 0.250 GHz) and an IL ≤ 3 dB between CP and Port 2 (within 15 ± 0.250 GHz).

Interdigital bandpass filter of the proposed microstrip diplexer has been designed considering few facts.The space between the fingers of pseudo-interdigital line is the same as that between feeding lines and pseudo-interdigital lines. For easier fabrication these two spaces were chosen to be the same. It was found that decreasing the space between resonators will broaden the bandwidth whereas increasing will cause higher insertion loss.

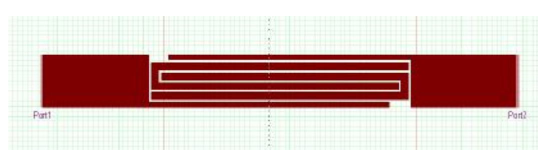

Figure 1. Diplexer Filter Configuration

The width of the resonators and feeding line also chosen to be identical. The length of the inner fingers of pseudo-interdigital line is λg/4 where λg is the guided wavelength at center frequency of respective filters. External resonator of the pseudo-interdigital line, which is coupled with feeding line, is chosen to be 0.5 mm longer as it decreases the center frequency(The centre frequency is defined by the length of resonators In order to develop a diplexer two bandpass filters with pass band of 2.5 and 3.6 GHz were designed and combined with a matching power divider and T junction. Connection of both filters to common port using traditional T-junctions causes introduction of additional losses and degradation of transmission of one of the filters In order to improve transmission and reflection characteristics of diplexer modified T-junction was used in which one branch is connected through straight line, the other at an angle 45° with appropriate power divider. Degradation of individual filter characteristics is caused by integration of two filters at a single point and this can be reduced by increasing the space between pseudo interdigital lines. The layout of designed diplexer is shown on the Figure 2

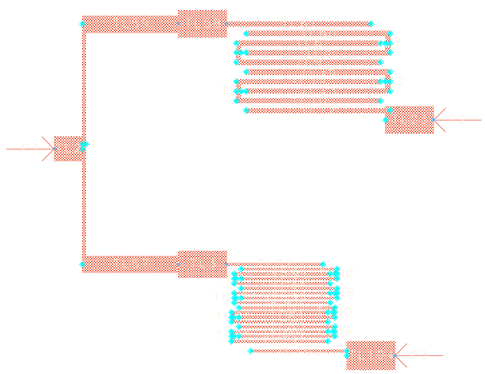

Figure 2. Diplexer Layout

Simulation

The filter structure was simulated by using Agilent ADS *Momentum* Simulator and S-parameter responses are shown in Figure 3.

According the simulation diplexer has very good transmission and reflection characteristics on the first channels while the second channel's characteristics should be improved through further investigation. The isolation between channels is more than 20 dB.The dimension for the second bandpass filter is very stringent for fabrication point of view and hence a little relaxation is required to get appropriate tolerance in practical fabrication process.The simulation and optimization using iterative procedure has been carried out to obtain best possible response within our fabrication limits.The matching circuit is properly designed, simulated and two filters are integrated with the matching circuit to form the diplexer circuit.which is again simulated to have the required response.

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Development

Alumina substrate having thickness of 10 mil is used to fabricate the pcb containing the diplexer(Figure 4.).The pcb is mounted within a package containing the diplexer base and integrated properly. The fabrication part was taken care by CNC milling and integration using precision connector has been performed which is very critical from mechanical point of view..

Measurement Results

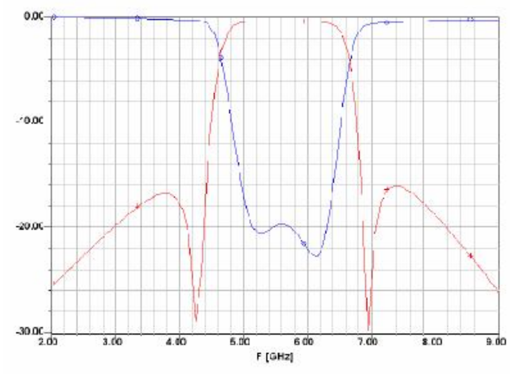
The fabricated diplexer is tested using Network Analyzer and measured result is satisfactory. The measured result of this diplexer unit is shown in Figure 5.

The Return Loss (RL) for Port 1 (within 10 ± 0.250 GHz): > 15 dB and

RL for Port 2 (within 15 ± 0.250 GHz): > 15 dB

RL for CP (within 10 ± 0.250 GHz AND 15 ± 0.250 GHz): > 15 dB and

Isolation between Port 1 and Port 2 (Measured at 12.5 GHz, spot frequency) ≥ 25 dB



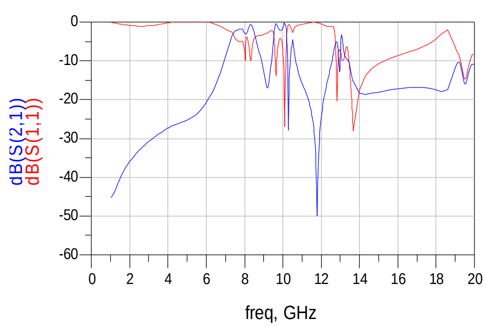
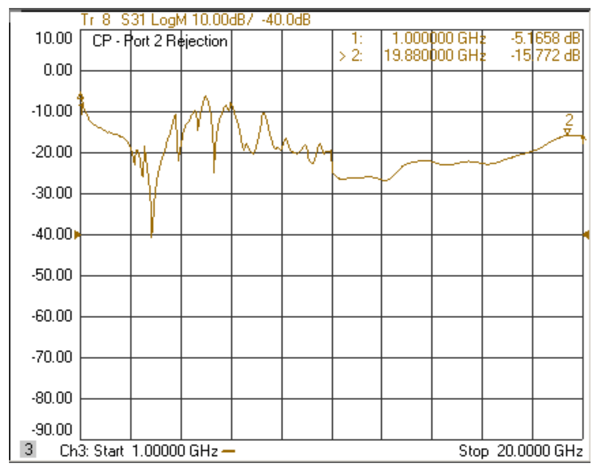


Fig. 3. Simulated reflection coefficient S11 (blue) and transmission coefficient S21(red) of the two bandpass filters



CONCLUSION

The miniaturized microstrip diplexers designed by integrating two bandpass filters with common resonator sections have been proposed in this paper. This concept has been verified by the diplexer circuits. Which is formed by connecting two parallel-coupled bandpass filters with matching circuits.They are composed of only 3 pair of resonators,respectively. The results show that these sizes are extremely small and their isolations are also fairly good. Good agreement between measurement and simulation has also been obtained.

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Acknowledgment

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