385-22-H-16

NAME OF THE SCHOLAR : AHMED HAMEED REJA

NAME OF THE SUPERVISOR : PROF. SYED NASEEM AHMAD

DEPARTMENT : ELECTRONICS AND COMMUNICATION ENGINEERING

TITLE: METAMATERIAL BASED MICROWAVE FILTER DESIGN

Miniaturization of microwave (MW) wireless devices such as filters created a demand on developing compact, low-cost, and robust multi-band MW components. This thesis presents several simulated designs for different types of metamaterial (MTM) filters depending on conventional filters concepts. This is based on adding different structures aiming to miniaturize devices applicable for use in MW wireless applications. This involves the design of lowpass filters (LPFs), bandpass filters (BPFs), and stopband filters (SBFs) based on MTM structures such as split ring resonators (SRRs), complementary split ring resonators (CSRRs), metallic via holes (MVHs), and interdigital capacitors (IDCs). With respect to the common types of conventional filter design such as the parallel coupled filters, stepped-impedance filters, and end coupled filters. Some designs depend on the prototype third order Chebyshev filter, while others depend on different techniques of design. The overall size of each of the new filters is reduced by adding tacitly new structures as compared to conventional microstrip filters. The proposed MW filters are designed from microstrip transmission lines (TLs) embedded with different structures resonators.

In this thesis, the basic significance of negative refractive index (n) as left-handed materials (LHMs), single negative (SNG) and composite right-/left- handed (CRLH), are investigated as different types of MW filters design within potential MW applications. A proposed technique is hereby applied in the design of planar MW filters. For this purpose, the microstrip filters of various types are designed using the proposed technique and the results are compared with some other available works. Several MW filters have been conventionally designed then mutated into MTM filters by embedding new components as follow.

a) Stepped-impedance MW LPFs are presented. A conventional stepped-impedance LPF with a cutoff frequency of 1.9GHz is proposed. Replacing unit cell of rectangular split ring resonator (SRR) instead of low–impedance lines acts as a shunt capacitor in conventional design. This concept can be used to achieve compactness, low insertion loss (IL), sharp cutoff, and high selectivity in stepped-impedance LPF design. The effect of etching rectangular- or square- shapes complementary split ring resonators (CSRRs) in the ground of microstrip line to get new MTM

LPFs is also presented. Simulating results indicate that the proposed filters achieve a flat pass-band without any ripples, corresponding to numbers of unit cells of CSRRs. Reduction in size of the filter has also been achieved by using square CSRRs up to 30%.

b) SBFs and BPFs types are proposed depending on SRRs and MVHs as MTM components. SBFs are presented by adding SRRs in two parallel sides as close as possible to strip line. These filters are transformed into BPFs by adding MVHs that intersect the upper strip line and the ground plane passing through dielectric material. The processes of adding several numbers of SRRs and taking many widths of strip conductor are studied and simulated. Narrow BPF with magnificent size reduction could be obtained by MVHs. On the other hand, an end-coupled, half wavelength resonator dual BPF is proposed. The filter is designed to have a fractional bandwidth equals 10.9% at resonant frequency of 5.5GHz. The process of etching rectangular shape SRRs instead of open-ended microstrip TLs for planar BPF is presented.

c) Broadband MW parallel-coupled BPFs are proposed. Two filters design with resonant frequencies of 10.5GHz and 9GHz are presented. A SRRs module as a simple circuit built for MW filters design with dual-band frequency response has been investigated. The effects of adding SRRs on these conventional filters to get new MTM dual-band MW filters have also been realized.

d) Tuning fork (TF) shape feed-lines and CSRRs are the tools used to realize new UWB MW filters. Two TFs are inter-coupled in the upper side of the microstrip line between the input port and output port covering the host TLs. The bandwidth of the filter containing TFs is ultra-wideband and equal to 11.8GHz operating at 6.1GHz center frequency. Additionally, a new technique to improve the matching between the host TLs and CSRR cells has been proposed. These MTM filters combine negative characteristics of permeability and permittivity which are created by using TFs and CSRRs components respectively to create an UWB response with better performance and size reduction. On the other hand, a design of an UWB BPF has been presented based on CRLH-TL concept. The coupled lines formed as interdigital capacitive arrangement and CSRR cells are the components used to achieve an UWB MW microstrip filter with reduction in size and appreciable performance. The bandwidth attained by this filter equals 5.6GHz with center frequency of 3.2GHz. The ID-coupled lines elements are connected to the ports (input and output) in the upper plane of the microstrip line through closed rings, whereas the CSRR cells are etched in the ground plane of the microstrip line. Simulation results indicate that the filter has a flat pass-band with insertion loss of better than -1dB and an appreciable return loss in the frequency range of 0.4 to 6.0 GHz. The quality factor of 0.570 has been achieved and the fractional bandwidth exceeds 100%.