Design study of recent techniques for Microstrip filters: An Analysis

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***Abstract*— Size miniaturization of microwave filters is highly desirable in the today's rapid changing communications world. Filters play an important role in most RF and Microwave applications. Currently, the electromagnetic spectrum is limited, and the applications are restricted to occupy just a portion of frequency range without affecting the equipment working out of band and also, without being affected by adjacent devices. Microwave filters are designed using many techniques and procedures. This paper presents the detail survey of the key techniques and initiatives made recently for improved response used in the design of microwave filters. It is the main objective of this paper to offer a unique and comprehensive treatment of RF/microwave filters based on the microstrip structure, providing a link to applications of computer-aided design tools, advanced materials, and technologies. This paper covers basic concept, principles, methods, technology selection criteria and several design procedures.**

***Index Terms*— Microstrip, hairpin line, high-pass, low-pass, Band-pass, Band-stop, lumped element, Fractal, PBG (Photonic Band Gap), DMS and DGS.**

1. INTRODUCTION:

Emerging applications such as wireless communications continue challenging RF/microwave filters performance with even more stringent requirements, higher performance, smaller size, lighter weights, and low cost[1],[2].

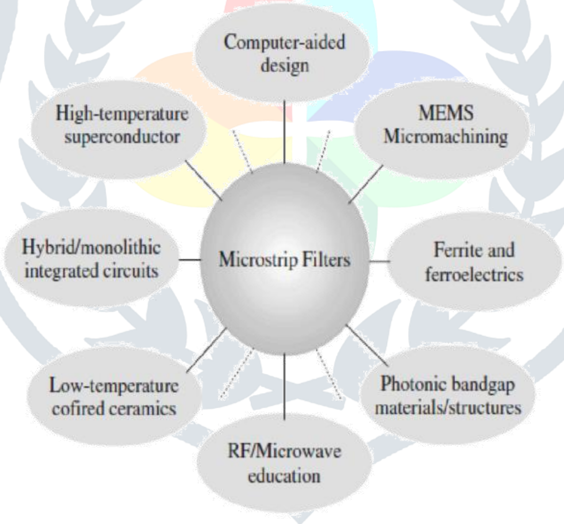

Figure 1: Microstrip filter linkage

Recent advances of materials and fabrication technologies, including monolithic Microwave integrated circuit, micro electro mechanic system (MEMS), high-temperature superconductor (HTS), and low-temperature co fired ceramics (LTCC), has further guided the rapid development of new microstrip and other filters. The filters can be low-pass, high-pass, band pass, and band-stop type. At lower frequencies lumped element inductors and capacitors can be used to design filters while at microwave frequencies usually transmission line sections and waveguide elements are used.

2. REVIEW OF WORK:

Depending on the requirements and specifications, RF/microwave filters may be designed as lumped element or distributed element circuits; they may be realized in various transmission line structures, such as waveguide, coaxial line, and microstrip. In this portion the work reported by scholar in microstrip filters field is analyzed and studied for different parameters as proposed by them.

Parallel-coupled transmission-line-resonator filters. Parallel coupled transmission-line-resonator filters [7]. Among various circuit configurations, the parallel coupled half wavelength resonator filter is widely used. However, the size of a half-wavelength resonator filter seemed too large; also it suffered from the first spurious response at twice the center frequency.

Interdigital band pass filters [8]. In this paper by adopting the quarter-wavelength resonators, e.g., the inter digital and combline filter [9]; the circuit became smaller in size, with the first spurious response appeared at three times the centre frequency.

Design of Highly Selective Microstrip Band pass Filters with a Single Pair of Attenuation Poles at Finite Frequencies: [10] This paper presents the design of a class of highly selective microstrip band pass filters that consist of microstrip open-loop resonators that exhibit a single pair of attenuation poles at finite frequencies. A practical design technique for this class of filters is introduced,

A Novel 1-D Periodic Defected Ground Structure for Planar Circuits: [11] A new one-dimensional (1-D) defected ground unit lattice is proposed in order to improve the effective inductance. Increasing the effective inductance makes it easy to control the cutoff frequency characteristics. The proposed periodic defected ground structure (DGS) provides the excellent cutoff and stop band characteristics.

A Vertically Periodic Defected Ground Structure and Its Application in Reducing the Size of Microwave Circuits: [12] The microstrip and coplanar waveguide transmission lines combined by a vertically periodic defected ground structure (VPDGS) are proposed. The slow-wave effect, equivalent circuit, and the performances are shown. Two series microstrip lines in input and output matching networks of the amplifier are reduced to 38.5% and 44.4% of the original lengths, respectively, due to the increased slow-wave effects, while the amplifier performances are preserved.

The Design, Fabrication and Measurement of Microstrip Filter and coupler Circuits: [13] These practical microstrip examples provide a valuable tutorial on the use of many different engineering resources: published references, comprehensive EDA tools, EM analysis and rapid prototyping equipment.

Design of a Microstrip Band pass Filter Using Advanced Numerical Models:[14] This article describes the design, simulation, construction and performance of a microstrip filter, using advanced analytical component models and TDR based measurements.

Improved Circuit Model for DGS based Low pass Filter: [15] This circuit gives improved circuit model for the DGS slot based LPF which accounts for losses and mutual coupling between the slots.

Magnetically tunable micro-strip band-stop filter: Design optimization and characterization: [16] This gives ultra-small band-stop filters made with continuous Fe films and with multi-layered Fe/Cu films.

Compact Microstrip Low pass Filter Based on Defected Ground Structure and Compensated Microstrip Line: [17] An improved defected ground structure (DGS) with compensated microstrip line is investigated for low pass filter (LPF) applications. With this structure, the basic resonant element exhibits the elliptic-function low pass responses. An equivalent lumped L-C circuit model is presented and its corresponding L-C parameters are also extracted by using parametric relationships. Based on the equivalent circuit model, a 3-pole LPF, using 3 DGS units cascaded, is optimally designed and implemented; measurements show good consistency with calculations.

Microstrip Dual-Mode Band Reject Filter: [18] Novel microstrip dual-mode band reject filters using triangular patch resonators are investigated. It is shown that with simple circuit topologies highly selective notch filters can be realized.

Frequency Switchable Microstrip Filter for Microwave Frequencies: [19] This paper presents a frequency agile parallel-coupled microstrip filter. The centre frequency of the device may be switched very rapidly between two discrete values by applying optical illumination to a pair of silicon dice, which are mounted on the printed side of the board.

A New Defected Ground Structure for Different Microstrip Circuit Applications:[20] In this paper, a microstrip transmission line combined with a new U-headed dumb-bell defected ground structure (DGS) is investigated. The proposed DGS of two U-shape slots connected by a thin transverse slot is placed in the ground plane of a microstrip line. A finite cutoff frequency and attenuation pole is observed and thus, the equivalent circuit of the DGS unit can be represented by a parallel LC resonant circuit in series with the transmission line. A two-cell DGS microstrip line yields a better low pass filtering characteristics. The simulation is carried out by the MOM based IE3D software and in the experimental measurements a vector network analyzer is used. The effects of the transverse slot width and the distance between arms of the U-slot on the filter response curve are studied.

Ultra-Wideband Band pass Filter Using Multilayer Slot Coupled Transition: [21] New Ultra-Wideband (UWB) band pass filters are proposed and tested. The filters are composed of two microstrips - Conductor-Backed Co-Planar Waveguide (CBCPW) transitions and a multiple-mode resonator, constituted by a line section. The both cases, where the line section is a microstrip or a

CBCPW are tested. First, simulated and experimental results for the transition are presented, showing that a wide operating band is obtained. Then, the results for the proposed filters that use this transition structure are presented.

Applications of Artificial Neural Network Techniques in Microwave Filter Modeling, Optimization and Design: [22] This paper reviews state-of-the-art microwave filter modeling, optimization and design methods using artificial neural network (ANN) technique. Innovative methodologies of using ANN in microwave filter analysis and synthesis are discussed. Various ANN structures including wavelet and radial basis function have been utilized for this purpose.

Design of Compact Stop-Band Extended Microstrip L0w-PassS Filters by Employing Mutual coupled square-shaped D G S: [23] A new technique to reduce the size, improve the rejection in the stop-band of a low-pass filter using modified defected ground structure (DGS) is proposed. An equivalent circuit model is used to study the DGS characteristics. The parameters are extracted by using a simple circuit analysis method. Several comparisons between the EM simulations and the circuit simulations of the new structure are demonstrated to show the validity of the proposed equivalent circuit model.

Semicircular Microstrip Low Pass filters: [24] This paper presents semi-circular microstrip low pass filter with the sharp rejection and wide stop band. The proposed filter design is based on the calculations of filter parameters from traditional Hi-Low impedance method and is available in the literature of microstrip filter.

A High Rejection Low-Pass Filter Embedded Photonic Band-Gap Structure: [25] The performances of the periodic surface structures of defected shapes on the ground plane for low-pass filter (LPF) co-design are studied. Simulated results with full wave electromagnetic analyses are in good agreement with those experimental data. The optimal structure of double periodic structure bringing about the perturbation electromagnetic waves will be determined.

A Compact Microstrip Band stop Filter: [26] In this paper, a novel microstrip band stop filter by etching a square split ring in the center of microstrip line is proposed. Low insertion loss in the pass band, high rejection level and integrated structure should be mentioned as advantages for this resonator.

Miniaturized Band-Stop Filter Based on Multilayer- Technique and New Coupled Octagonal Defected Ground Structure (DGS): [27] In this paper, we proposed a new compact DGS band-stop filter with broad pass band and low insertion loss in the stop-band. The philosophy of the structure behind this new microstrip band-stop filter is simple as it is composed of a pair of octagonal DGS-slots and an open-stub as compensated microstrip capacitance. The filter will be realized through direct electromagnetic coupling and slow wave effect methods. With this configuration, the BSF with higher compactness, broad pass band and sharp transition characteristics was realized.

A New Microwave Band stop Filter Using Defected Microstrip Structure (DMS): [28] This paper presents a new band stop filter by creation of some slots on the strip. These slots perform a serious LC resonance property in certain frequency and suppress the spurious signals. In the high frequencies applications, the board area is seriously limited, so using this filter; the circuit area is minimized. The proposed filter is very suitable for high density MMIC circuits.

Modeling of Modified Split-Ring Type Defected Ground Structure and Its Application as Band stop Filter: [29] The shape of a popular split-ring defected ground structure (DGS) is modified by selecting different width of the sides with respect to microstrip line. The frequency characteristics of proposed DGS unit show an attenuation zero close to the attenuation pole frequency. The unit cell is modeled by 3rd order elliptical low pass filter and an equivalent circuit is presented accordingly. For proposed DGS, both pole and zero frequencies are obtained at lower values compared to split-ring DGS unit with uniform width.

Performance of Two Microstrip Low Pass Filters on EBG Ground Plane: [30] This paper compares the performance of two microstrip filters designed and fabricated on an EBG ground plane. The proposed filter designs show sharp rejection and wide stop band. The design is based on the calculation of parameters from traditional high-low impedance method. A comparison of the results show that Chebyshev low pass filter offers wider rejection band width in comparison to maximally flat low pass filter designed on EBG structure.

IMPROVING FREQUENCY RESPONSE OF MICROSTRIP FILTERS USING DEFECTED GROUND AND DEFECTED MICROSTRIP STRUCTURES: [31] In this work, the introduction of Defected Microstrip Structures and Defected Ground Structures is presented to improve the performance of a traditional stepped-impedance microstrip low pass filter. The attenuation in the stop-band is enhanced by more than 15 dB and selectivity is increased, without modifying the insertion loss in the pass band.

Modeling and Characterization for Microstrip Filters in the Manufacturing Process through the Unscented Transform and Use of Electromagnetic Simulators: [32] This paper presents the unscented transform(UT) applied to uncertainty modeling of manufacturing tolerances at the design stage of microwave passive devices. The process combines the UT with electromagnetic simulations and assumes that the numerical sources of error are negligible in comparison to the imperfections due to the manufacturing process. The technique was validated with the simulation, construction, and test of several sets of identical microstrip filters with very good results.

Designing Microstrip Band pass Filter at 3.2 GHz: [33] Band pass filters play a significant role in wireless communication systems. Transmitted and received signals have to be filtered at a certain center frequency with a specific bandwidth. In designing of microstrip filters, the first step is to carry out an approximated calculation based on using of concentrated components like inductors and capacitors. After getting the specifications required, we realized the filter structure with the parallel-coupled technique.

IMPROVED SELECTIVITY COMPACT BAND - STOP FILTER WITH GOSPER FRACTAL-SHAPED DEFECTED GROUND STRUCTURES: [34] A novel band-stop filter using Gosper fractal-shaped defected ground structures has been designed and manufactured. The improvement in the filter selectivity has been achieved by introducing a multi resonance fractal-shaped defect leading to a higher filter order, simultaneously maintaining its compact size. The experimental results prove the validity of proposed solution and its utility in novel miniaturized and severe requirement filter applications.

COMPACT SUB-WAVELENGTH MICROSTRIP BAND-REJECT FILTER BASED ON INTER-DIGITAL CAPACITANCE LOADED LOOP RESONATORS: [35] In this article, the microstrip band-reject filters based on inter-digital capacitance loaded loop resonators (IDCLLRs) are proposed by using meandered microstrip line, which enhances the coupling to the resonators and provides more structural parameters for flexible design. First, an IDCLLR-based single-stage meandered prototype of band-reject filter has been designed and fabricated. The measured frequency response shows 2.2% relative stop-bandwidth (10 dB) with 21 dB maximal insertion-loss at 3.34 GHz. Furthermore, the resonant frequencies versus inter-digital length are studied.

A Novel Band pass Filter Using a Combination of Open-Loop Defected Ground Structure and Half-Wavelength Microstrip Resonators: [36] This paper deals with a defected ground structure (DGS) open-loop resonator analysis and band pass filter design, using coupled DGS and microstrip resonators. The combination of DGS and microstrip resonators allows using top and bottom sides of the microwave substrate, therefore the resonators can partially overlap and a desired coupling coefficient can be easily achieved.

An Improvement of Defected Ground Structure Low pass/Band pass Filters Using H-Slot Resonators and Coupling Matrix Method: [37] A novel compact wideband high-rejection low pass filter (LPF) using H-DGS is presented. The proposed filter has neither open stub nor cascaded high-low impedance elements. It consists of two coupled H-slots in the ground plane along with a compensated line. The effect of the new slot on the filter performance is examined. The comparison with the conventional filters shows that the proposed one guarantees a large rejected-band of 20dB from 2.5 to 16 GHz.

New U-Shaped DGS Band stop Filter: [38] In this paper, new microstrip band stop filters with single band, dual-band and tri-band by using U-shaped defected ground structures are presented without the assistance of coupled lines or certain resonators and the application of DGS is developed. The proposed band stop filters have good performances of low loss, multi- band operation, transmission zeros which improve the filter frequency selectivity, and miniaturization because of the cascade of DGS and minimum defected patterns which reduce the circuit size.

Miniaturization of band stop filter using double spurlines and double stubs: [39] This paper presents a new type of compact band stop filter. The proposed filter topology consists of double spurlines and double open stubs. Double spurlines are introduced to a conventional open stub filter for filter circuit size miniaturization and band stop region improvement. It is clearly shown that the rejection region of the proposed filter is wider and deeper compared to the conventional open stub filter without any cascading circuits or periodic structures. The proposed filter is designed with Finite-Difference Time-Domain Method (FDTD).

Design, Simulation and Construction a Low Pass Microwave Filters on the Micro Strip Transmission Line: [40] In this paper a low pass microwave filter has been designed. The filter has designed by step impedance method in which the alternative part characteristic linear impedance is too high or too low design. In this filter with changing every high or low impedance characteristics such as length or width desired characteristics can be rich and it has stimulated by using of HFSS software, and relying on full-wave analytical methods in three dimensional work page.

Microstrip Low-Pass Filters by Using DGS with Folded T-Shaped Arms, [41] In this paper, two novel Low-Pass Filters (LPFs) using Defected Ground Structure (DGS) slot with a pair of folded T-shaped arms are presented. The resonant frequency of the slot can be easily controlled by changing the folded T-shaped dimensions, without changing the area taken by the structure. Using this slot, two quasi-elliptic LPFs were designed, fabricated, and tested.

STUDY AND REALIZATION OF DEFECTED GROUND STRUCTURES IN THE PERSPECTIVE OF MICROSTRIP FILTERS AND OPTIMIZATION THROUGH ANN: [42] The variation of dimensions of defects studied with their corresponding change in capacitance, inductance as well as frequency response. The defects dimensions are modeled with respect to frequency using the artificial neural network. Optimizing the convergence of Artificial Neural Network (ANN) classifiers is an important task to increase the speed and accuracy in the decision-making. The frequency response of the micro strip filter is modeled with respect to the variation in dimension of DGS using CST microwave studio.

RF Phase Shifter Using Coupled Microstrip Square Rings Tunable Band pass Filter: [43] This paper presents a study, optimization and simulation of tunable band pass filter centered at 2.4GHz and used as phase shifter based on coupled microstrip square ring loaded by varactor diodes. We have performed an electromagnetic simulation on Momentum software of ADSTM; we have used the power of the Momentum software for the optimization and simulation of our circuit. Good results were obtained; the filter results in an insertion loss of 0.35 dB−0.26 dB over tuning range and 3 dB bandwidth of 300MHz−360MHz.

Design of A Wide Stop band Harmonic Suppressed Microstrip Low Pass Planar Filter Using Defected Ground Structure: [44] In this paper an analysis is made of the filter characteristics of the popular low pass planar filter originally designed by J.S Hong and M.J Lancaster. It is noticed that a spurious harmonic at 2.9 GHz appear in the filter characteristics. This paper presents a novel design of a wide stop band low pass planar filter using defected ground structure, which eliminates the 2.9 GHz harmonic from the filter output. The simulation and analysis of the low pass planar filter is performed using the Ansoft HFSS V.11 simulator

Microstrip Low-Pass Filters by Using DGS with Folded T-Shaped Arms: [45] In this paper, two novel Low-Pass Filters (LPFs) using Defected Ground Structure (DGS) slot with a pair of folded T-shaped arms are presented. The resonant frequency of the slot can be easily controlled by changing the folded T-shaped dimensions, without changing the area taken by the structure. Using this slot, two quasi-elliptic LPFs were designed, fabricated, and tested.

Design and Analysis of Hairpin Line Band pass Filter: [46] Hair pin line band pass filter are compact structures they may conceptually be obtained by folding the resonator of parallel-coupled half wave length resonator. This type of U shape resonator is so called hair pin resonator. However to fold the resonator, it is necessary to take into account the reduction of the coupled line length, which reduces the coupling between resonators. Also the two arm of each hair pin resonator are closely spaced. They function as a pair of coupled line themselves. Which can have an effect on the coupling as well. The design filter have 25.77% fraction band width at mid band frequency at 2 GHz.

3. CONCLUSION

This research paper presents a comprehensive overview of all possible technique of design and simulation. A brief review of the few milestone works has been presented and analyzed that you may use any procedure, still you can achieve perfect design provided performance parameters are taken care of as desired by particular use. The fields of design of filters are still in the earlier phase of development, with the anticipation of much more innovative advancement to come, over the months and years ahead.

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