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A Literature review: Chebyshev Filters for Microwave Frequency Applications

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Abstract— This paper reviews critically for filter of microwave frequency range. The parameters selected to review are technique, measuring parameters, advantages and limitation to get the review of different existing methods. Observed chebyshev is good for frequency range 1 to 3 GHz.

Key words: Microwave Filter, low pass Filter (LPF), High pass Filter (HPF), Defected Strip line Structure (DSS), Suspended Strip line Structure (SSS)

I. INTRODUCTION

It is very important to reduce the losses like a insertion loss and return loss in various communication. The chebyshev filter gives better response. With the fast development of wideband wireless communication, BPF with characteristics of high performance, low-cost, low insertion loss (IL) and compact BPF are highly desirable. For the next generation of wireless communication system, the integration of the BPF and DMS into one structure brings many benefits especially in reducing the overall physical volume of the RF systems.[1]planar microwave High pass filters (HPFs) are an essential component in many communication systems. To develop dual-band operation systems, a planar type of dual- band BPFs have been intensively researched recently. One of the direct design methods for the dual-band BPFs is to parallel connect two single-band BPFs. In two monolithic narrowband BPFs with different center frequencies are parallel connected by dual-band impedance matching networks. Thus, each single-band BPF is responsible for filtering one pass band. Using a similar technique, a dual- band BPF for ultra-wideband (UWB) systems has been developed. In below, the multi-band filter was presented which uses 7th degree of Chebyshev based on low pass filter prototype. [3] Another type of dual-band BPFs is formed by inserting band stop filtering response in between a wide pass band to divide it into two Pass bands In , a band stop filter (BSF) is cascaded after a wideband BPF, and in , the BSF is integrated into the BPF filter. Both designs have successfully realized the dual-band design and have the capability to adjust the bandwidths of each pass band and the rejection band. However, it still needs tuning and an optimizing process after the combination of the BPF and BSF, even if detailed synthesis and design procedures are available for the two basic filter components. To simplify the dual-band BPF design process, some frequency transformation techniques have been proposed. A method by successive frequency transformations from a low pass to a band pass, and then to a dual-band band pass frequency response has been proposed. After the transformation, the dual-band BPF is realized with only -inverters and series *LC* resonators. a mapping method based on transferring a single-band resonator to a multiple-band network has been used to construct the filter function and the corresponding filtering structure. However, for the existing designs based on frequency transformations, they are limited to the narrowband dual-band BPF design.[3]

However, this paper uses coupling

topology method to produce multi-band filter. The DMS with band reject response has the advantages in term of good frequency selectivity, low loss and simple circuit topology. The DMS is made by defect the conductor line of the structure and etching a narrow slot in the micro strip line. DMS is more easily integrated with other microwave circuits in order to reduce the size compared to DGS. In DMS, there is no etching in the ground plane and this avoids any incremental leakage through the ground plane.[1]

On the other hand, a great amount of research work has been focused on applying the fundamental-order and its higher order resonances to build up various dual-band BPFs, as discussed. Stepped-impedance coupled lines and inductively coupled by short-circuited stubs have been proposed, respectively.

To reduce the overall size of the circuit, single ring/patch resonators have also been used to form a dual- mode dual-band BPFs. Other techniques include using the even/odd modes of a dual-mode resonator to form different coupling path for each pass band,. The general design procedure for these types of filters follows by assigning the first- and second-order resonances of the resonator to the center frequencies of each band, deriving the dual-band –inverters and applying the BPF prototype to design each pass band. However, due to the approximate conditions used, they are only applicable to narrowband design[3].

II. PERFORMANCE ANALYSIS

The design of generalized Chebyshev High pass filter (HPF) and integrated with Defected Strip line Structure (DSS) using Suspended Strip line Structure (SSS). The study involves circuit analysis to determine generalized Chebyshev responses with a transmission zero at finite frequency in order to produce a reduced number of elements values of prototype circuit. The simulation performance results show promising results that could be proved in the experiment works. This new class of integrated LPF and DSS would be useful in any RF/ microwave communication systems particularly in wideband applications where the reduction of overall physical volume, weight and cost is critical to maintaining its good performance.[1]With the fast development of wideband wireless communication, BPF with characteristics of high performance, low-cost, low insertion loss (IL) and compact BPF are highly desirable. For the next generation of wireless communication system, the integration of the BPF and DMS into one structure brings many benefits especially in reducing the overall physical volume of the RF systems.[3]

A. Suspended Strip line Structure (SSS)

This band pass filter is simulated using SSS in order to improve the overall filter performance. The impedance of the SSS which is based on Transverse Electromagnetic (TEM) transmission line is related to its static capacitance to ground per unit length

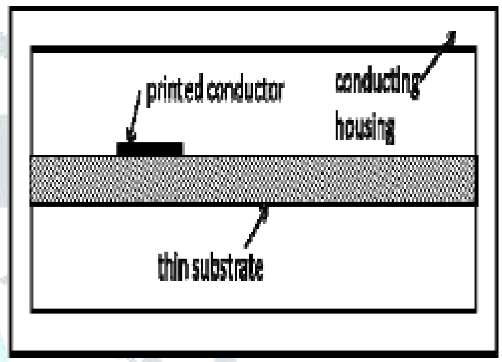


Fig. 1: Suspended Strip line Structure [2]

B. Circuit Analysis of the Dual-Band Filters

Three prototypes of the proposed wideband dual-band BPFs are illustrated. For every section of the circuits, it is a quarter-wavelength long with respect to the middle frequency of the two passbands. According to the discussion, filter produces three transmission poles within the passband with the half-wavelength resonator and shortcircuited stubs contributing to one and two pole(s); filter produces five poles in the passband with the steppedimpedance MMR and short-circuited stubs contributing to three and two poles, respectively. Therefore, connecting these two BPFs in parallel, produces a total of six poles with the parallel connected MMRs and the short-circuited stubs contributing to four and two poles, respectively.[3]

$$S_{11} = \frac{Y_0^2 - Y_{\text{ine}}Y_{\text{ino}}}{(Y_0 + Y_{\text{ine}})(Y_0 + Y_{\text{ino}})} \quad \text{-------------------- (1)}$$

$$S_{21} = \frac{Y_0(Y_{\text{ino}} - Y_{\text{ine}})}{(Y_0 + Y_{\text{ine}})(Y_0 + Y_{\text{ino}})} \quad \text{-------------------- (2)}$$

$$F_{\text{cir}} = \frac{S_{11}}{S_{21}} = \frac{Y_0^2 - Y_{\text{ine}}Y_{\text{ino}}}{Y_0(Y_{\text{ino}} - Y_{\text{ine}})} \quad \text{-------------------- (3)}$$

C. Dual-Pass band Filter

The second design example corresponds to a double- pass band filter for the 1.3/2.5 GHz dual band. For its lower and upper pass bands, equirriple- and maximally-flat filtering functions with 3 dB absolute bandwidths of 400 and 100 MHz (i.e., 3 dB relative bandwidths of 30 and 4%) have been selected, respectively. Furthermore, an in-band power matching level greater than 25 dB for the first band has been forced. It could be employed in dual-channel receivers for emerging wireless systems, such as software-defined/cognitive Radio [4].

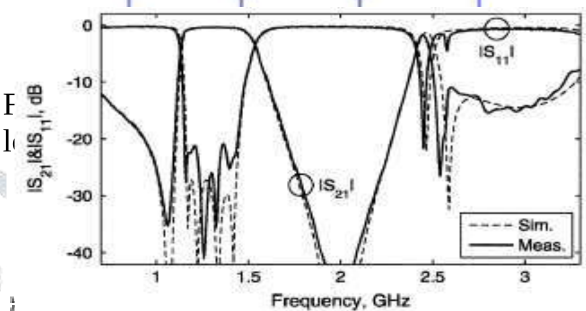


Fig. 2: Simulated and measured power transmission and reflection responses of the developed micro strip dual- pass band filter prototype [4]

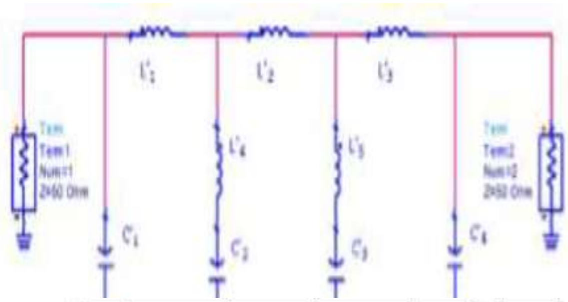
III. EXPLANATION OF ALL EXISTING METHODS-

A. Design of Low pass Filter (LPF)

A systematic filter design starts with a classical low pass lumped element equivalent circuit or prototype. It consists of series and shunt inductors and capacitors and their combination to form either series or parallel resonators. The generalized Chebyshev has equiripple response in pass band but with arbitrary placed transmission zeros in the Stop band offering selectivity nearly as good as the same degree elliptic filter. Generalized Chebyshev filter prototype is more preferred due to the transmission zeros can be placed independently as accordance to design specification. In synthesize the element values for generalized Chebyshev low pass filter prototype which can be used to transform into any filter response. The doubly terminated low pass prototype network satisfies the insertion-loss (IL) for the generalized Chebyshev response [1].

COMPONENT VALUE OF LUMPED ELEMENT [1]

Elements	Value
C’$_1$ = C’$_4$	0.54456 pF
C’$_2$ = C’$_3$	0.5836 pF
L’$_1$ = L’$_3$	1.432756nH
L’$_4$ = L’$_5$	0.718748 nH
L’$_2$	1.30526 nH



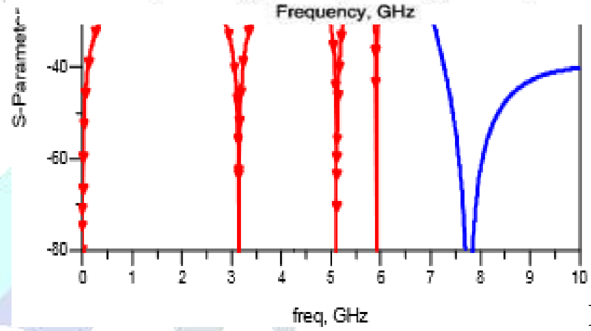


Fig 3 (b): simulated frequency response of generalized chebyshev low pass filter [1]

B. Design Of High pass Filter (HPF)

In this section, a systematic filter development using the low pass filter prototypes as a starting point will be demonstrated. A dual type of the generalized Chebyshev low pass prototype filter is used as described in Section II. This dual type of low pass prototype will satisfy the generalized Chebyshev with three transmission zeroes. The transformation to high pass filter [2] signal-interference filtering sections shaped by two in-parallel stepped-impedance transmission lines are applied to frequency- asymmetrical micro strip filter design. When realizing single-pass band filters, a different selectivity for the lower and upper stop band can be generated, making them appropriate for duplexing devices. In the case of double- pass band filters, fully-asymmetrical dual bands in terms of bandwidth, cutoff slopes and class of filtering transfer function can be shaped. Examples of design curves to adjust the performances of the synthesized signal-interference section filtering profile are given, e.g., bandwidth or in-band ripple level for Chebyshev-type functions. To show practical viability, a duplexer and a spectrally-asymmetrical dual- pass band filter circuit are also built and characterized [4].

COMPONENT VALUE OF LUMPED ELEMENT [1]

Elements	Value
$C'_1 = C'_7$	1.0003 pF
$L'_2 = L'_6$	2.3763 nH
$C'_3 = C'_5$	1.02619 pF
$L'_3 = L'_5$	4.7368 nH
L'_4	2.6084 nH

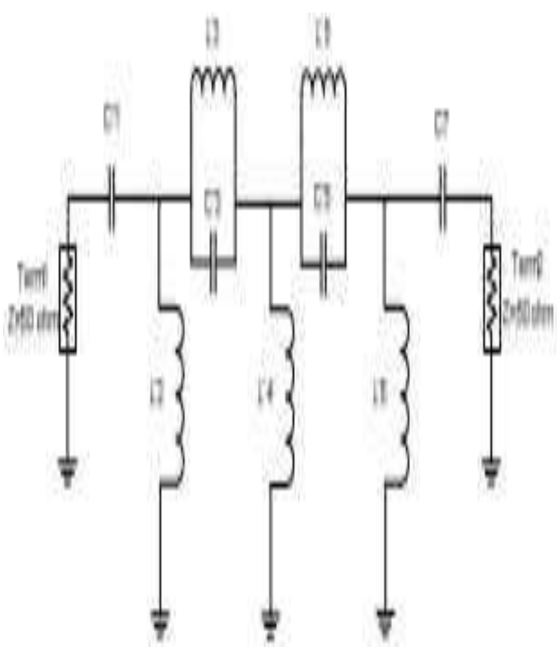


Fig. 4(a): Chebyshev high pass filter prototype [2]

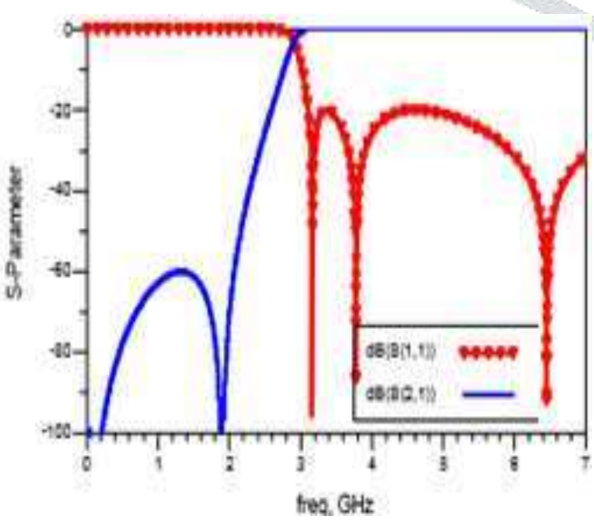


Fig. 4(b): Simulated frequency response of generalize chebyshev high pass filter [2]

C. Dual-Passband Filter

The second design example corresponds to a doublepassband filter for the 1.3/2.5 GHz dual band. For its lower and upper passbands, equirriple- and maximally-flat filtering functions with 3 dB absolute bandwidths of 400 and 100 MHz (i.e., 3 dB relative bandwidths of 30 and 4%) have been selected, respectively. Furthermore, an in-band power matching level greater than 25 dB for the first band has been forced. It could be employed in dual channel receivers for emerging wireless systems, such as softwaredefined/ cognitive radios.[4] For the synthesis of the folded-configuration coupling matrix for Chebyshev or other filtering functions of the most general kind, including the fully canonical case, i.e., prescribed finite-position transmission zeros in an the degree mnetwork. The method is based on then "N + 2" transversal network coupling matrix, which is able to accommodate multiple input/output couplings, as well as the direct source–load coupling needed for the fully canonical cases. Firstly, the direct method for building up the coupling matrix for the transversal network is described. A simple nonoptimization process is then outlined for the conversion of the transversal matrix to the equivalent "N + 2" folded configuration coupling matrix. The folded matrix may be used directly to realize microwave bandpass filters in a variety of technologies, but some of these could require awkward-to-realize cross-couplings. This paper concludes with a description of two simple procedures for transforming the transversal and folded matrices into two novel network configurations, which enable the realization of advanced microwave bandpass filters without the need for complex inter-resonator coupling elements.[5]

IV. COMPARISON TABLE OF EXISTING METHODS

Comparison of observations given in all reference papers is discussed here.

Table 1: Comparison of all existing methods

S NO.	REFRENCE PAPER	TECHNIQUE	MEASURING PARAMETER	ADVANTAGE	DISADVANTAGE
	Design of Generalized Chebyshev Lowpass Filter with Deffected Strip line Structure(DSS) [1]	Integration of LPF and DSS	LPF at 6 GHz Insertion loss (s21) = 0dB Return loss (s11) = -18dB SSS LPF at 6.2 GHz Insertion loss (s21) = 0.3dB Return loss (s11) = -15dB DFS LPF at 3.2GHz Insertion loss (s21) = -40dB	It produce good selectivity and low loss character, DSS is easier to integrate with other microwave circuit, simple circuit topology	There is no etching in ground plane and this avoids any incremental leakage through ground plane
2	Transformation of Generalized ChebyshevLowpass Filter Prototype to Suspended Stripline Structure Highpass Filter for Wideband Communication Systems [2]	SSS (Suspended Stripline Structure)	HPF at 3.1 GHz Insertion loss (s21) = -40dB Return loss (s11) = -20dB SSS at 3 GHz Insertion loss (s21) = 0dB Return loss (s11) = -20dB	It has very low loss characteristics and excellent selectivity , design has very sharp rejection easier to determine the minimum stop band insertion loss	
3	Synthesis and Design of Wideband Dual-Band Bandpass Filters With Controllable In-Band Ripple Factor and Dual-Band Isolation [3]	Dual band BPF for ultra wide band (UWB) system	Center freq = 1.03/2.85GHz 3 dB FBW= 94.8/35.8% Insertion loss = 0.65/0.45dB	Controllable band ripple factor	This method a require complex design process and relatively large circuit size
4	Signal-Interference Stepped-Impedance-Line Microstrip Filters and Application to Duplexers [4]	Signal interference filter design	For duplexer Isolation = 40dB For dual pass band filter In band power is grater then 20dB	Unequal power attenuation levels and cut off slope at each pass band side , wide band duplexer and a dual band BPF can built	Signal interference filter structure is their inability to carry out frequency asymmetrical filtering action.
5	Advanced Coupling Matrix Synthesis Techniques for Microwave Filters [5]	Folded matrix is used to realize microwave BPF	N+2 transversal matrix Return loss = 22dB Parallel connected two port Return loss = 23dB Cul-de-sac network Return loss = 23dB	The rejection lobe level and group delay equalization performance have been preserved intact, it is used to directly design of microwave filter	

From above table we can conclude that for chebyshev low pass filter at 6 GHz the Insertion loss (s21) = 0dB,Return loss (s11) = -18dB and for chebyshev high pass filter at 3.1 GHz Insertion loss (s21) = -40dB ,Return loss (s11) = -20dB is found . it can further design for chebyshev band pass filter for better performance results. There are various method to reduce insertion loss and return loss.

V. CONCLUSION

In this paper Literature review concludes that The LPF provides a cut-off frequency at 6GHz with minimum stop band insertion loss of -19 dB. This type of generalized Chebyshev characteristic which offers good selectivity is very useful to minimize the overall filter size because it requires a lesser number of elements in the circuit compared to conventional Chebyshev characteristic. Therefore, this new class of microwave filter would be useful in any microwave communication systems where the reduction of overall physical volume is very important while still maintaining the good performance such as in ultra wide band (UWB) and radar applications.

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