MINIATURISED X-BAND BANDPASS FILTER FOR SATELLITE APPLICATION

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Abstract

In this paper, a miniaturized X-band Bandpass Filter(BPF) module which employs a pair of stepped impedance resonator is reported. The rapid growth in satellite communication and increasing demand for new technologies is to meet the challenge of size reduction, performance and cost requirements. The satellite communications industry created demand for low-mass narrow-band low-loss filters with severe specifications on amplitude selectivity and phase linearity. For this purpose, there has recently been increasing interest in bandpass filters. These filters operating in X-band are specially used for Military applications.

Index Terms: Microstrip filter, Stepped Impedance Resonator,X-band or SHF Bandpass Filters, Military application.

I. INTRODUCTION

Filters with different configurations are essential in modern satellite communication and the filters are generally used for rejection of unwanted signals and also allow the wanted signals in the passband with linear phase response, yet of course design of such a filter is practically impossible, some compromises are made. The paper work deal with the design and development of filter in X-band frequency.

X band or SHF (Super High Frequency) satellite communication is widely used by the military forces for beyond line of sight communication. X band is used because it provides a compromise between the characteristics of different frequency bands which is particularly suited to the needs of Military users. The characteristic includes Interferance Resilience, Rain Resilience, Terminal size, Date rates. The most famous filter in microwave applications is the bandpass filter. The filter can be either wideband or narrow band. Since the filter frequency is especially suitable for military applications it is used for data transmission in a secured way in narrow band of 8 to 9 GHz itself. Novel Microstrip open loop resonator bandpass filter based on a basic stepped-impedance resonator is proposed in [7]. The optimal design for a miniaturized stepped-impedance resonator is employed by this layout, which can be reduce the filter size and improve the spurious suppression. A modified λ/4 stepped impedance resonator (SIR) is proposed, in which a shunt open stub is loaded between the low impedance line and high impedance line of a conventional λ/4 SIR. Based on this modified λ/4 SIR, a compact dual-band band pass filter (BPF) with high selectivity is presented in [9].A new approach of designing a bandpass filter by applying a combination of microstrip and cylindrical shape of dielectric resonators for have a compact size, good sharpness on the sides, and small loss. Numerous technique in practice to suppress harmonic resonance spurious radiation [10]. We will look at military applications, which, with the invention of radar, were the first real driver for microwave technology. This led to advances in the design of narrowband and wide-band filters. Following this, we will examine satellite communications, which began in the 1960s.

II. MILITARY APPLICATIONS

World War II and the invention of radar led to significant developments in filters at various laboratories in the U.S.

One of the critical parts of any military system is the electronic countermeasures (ESM) system and its associated ESM system. The ESM system detects and classifies incoming radar signals by amplitude, frequency, pulse width, etc., and the ESM system can then undertake appropriate countermeasures, such as JAMMING. One methods of classifying signals by frequency is to split the complete microwave band of interest into smaller sub-bands. Typical specifications of X-band frequency range is of 2–4, 4–8, 8–12, and 12–18 GHz. This paper is presented with filter structure that suits for the frequency between 8-9 GHz. This is used heavily for space research, deep space operations, environmental and military communication satellites.

III. SATELLITE COMMUNICATION

Satellite communications began with the Intelsat I–III series of satellites, which established the viability of voice communications in the late 1960s. In 1971, the Intelsat IV series was launched. RISAT -2 or radar imaging satellite 2 is an Indian radar reconnaissance satellite that is part of India's RISAT programme.

RISAT -2 's main sensor is an X-band synthetic aperture radar from Israel Aerospace Industries(IAI).Three NASA ground stations in the Deep space Network, Goldstone(California), Tidbinbilla(Canberra) provide Data and Tracking services at X-Band with uplink Frequency of 7145-7190 MHz and downlink frequency of 8400-8450MHz.

IV. DESIGN METHODOLOGY

The filter structure of BPF is given in Fig.1 resembling a pair of stepped impedance resonator which appears as the symbol *Addition with a stub* connecting each filter is designed. The idea of using this filter structure is to provide increased transmitted power with a better insertion loss and return loss. The size, shape of the filter will influence the perfect matching of the filter. Most of the planar bandpass filters built on microstrip structures are large in size and their first spurious resonance frequencies at 2*f0* and 3*f0* is the center frequency, which may be closed to the desired frequencies.

Therefore SIR, is presented not only to reduce the size but also to control the spurious mode frequencies.

The Stepped Impedance Resonators (SIRs) have been found advantageous in designing microstrip bandpass filters with good passband and stop band performance. One of the key features of an SIR is that its resonant frequencies can be tuned by adjusting its structural parameters, such as the high Z and low Z segments.

In this design, two resonators are used as input and output resonators with the central stub having three small via. The base substrate is FR4 with dielectric constant, εr =4.6 and thickness of about 1.6mm and the loss tangent of about 0.2.

A. Design of stub part of the filter

The input impedance of an open-circuited line is given as:

$$Zin=-jZo.\cot\beta l$$

where *l* is the length of the stub, *p* = 2rr/A, *Zin is* the input impedance, and *Zo* is the characteristic impedance. If the transmission line is a quarter-wavelength, this impedance will be zero, or it is equivalent to a short circuit.

The input impedance of a short-circuited line is given as:

$$Zin=-jZo.\tan\beta l$$

The design of the filter is shown in Fig 1. With the dimensions are presented in Table 1 as follows

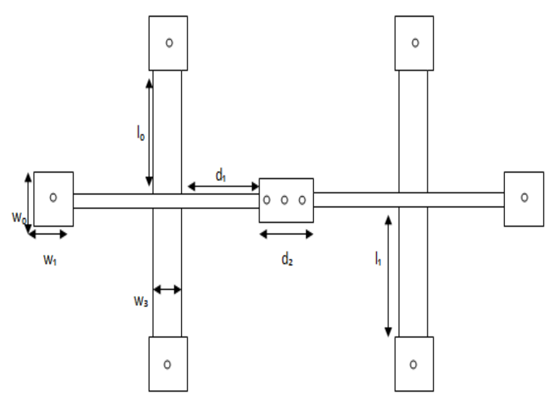

Fig.1 Top view of the structure with the impedances

Parameters	Value
w_o	1.4 mm
w_1	1.4 mm
w_3	1 mm
l_o	3.2 mm
l_1	3.4 mm
d_1	2.8 mm
d_2	1.6 mm

Via D = 0.04 mm

Table.1

V. FILTER DESIGN TECHNIQUE

The design consists of two vertical and two horizontal stubs with one small via in each stub and three small via in the center stub which is connecting the structure. Both the resonator structure resembles each other in its dimension. The filter has a total length of 17.6 mm with a height of 9.8 mm. Various dimensional parameters of the structure includes w_o=1.4 mm , w_1= 1.4 mm ,w_2= 1 mm ,l_o= 3.2 mm ,l_2=3.4 mm, d_1= 2.8 mm, d_2=1.6 mm with the Via has a diameter of 0.04 mm and it is designed using the schematic simulation of ADS and optimization features.

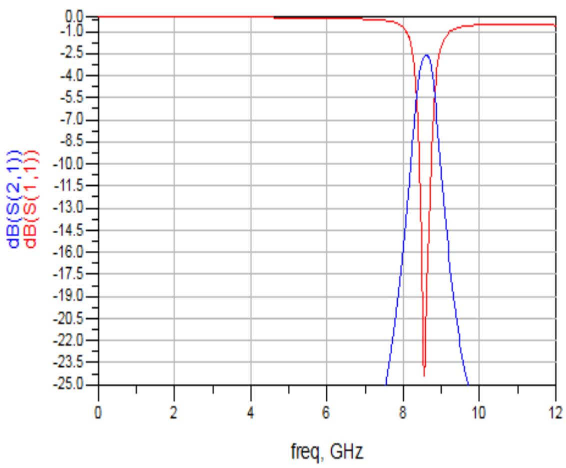

Fig 2. Simulated performance of the filter

VI. SOFTWARE SIMULATION AND RESULT

A X-Band microstrip bandpass filter is designed to make the frequency between 8-9GHz .The filter material is FR4, whose dielectric constant is 4.6, thickness is 1.6 mm. The simulated filter as shown in Fig 1 occupies an area of about 17.6 mm which predicts the excellent return loss of -23.917dB in the passband and insertion loss of -2.644 dB throughout the operation frequency of X-band communication as shown in Fig 2. and as the simulated result shows it has good Out Of Band Rejection characteristics

Parameters	Values
Insertion Loss	-2.5dB
Return Loss	-23.91dB

Table.2

VII. CONCLUSION

This paper proposed a simple design procedure of microstrip bandpass filter based on the stepped-impedance resonator. The calculated design values were used in the simulation tool (Advanced Design System) to calculate the performance of the filter. The results shown in Fig.2 indicated that the passband agrees well with the target. Given a characteristics impedance ratio an SIR is shown to have a good out of band rejection and narrow passband for certain length ratios of the segments.

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