PLANAR INTEGRATED MICROWAVE COMPONENTS FOR TERRESTRIAL AND SATELLITE APPLICATION

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ABSTRACT

A new class of planar integrated microwave components is developed for terrestrial and space application. Triple planar integrated band pass harmonic filters and E-plane single and triple planar antenna diplexers are presented. Design approach, theoretical analysis and results achieved are also included.

INTRODUCTION

The payload in a communication satellite and an earth station requires an antenna diplexer which is situated at the interface between the antenna and the payload.

In a communication satellite the antenna diplexer consists of low loss lowpass harmonic filter for the transmitted power and Tx-reject band pass or high pass filter for the received signal. In an earth station the antenna diplexer consists of Tx-reject low pass filter for the received signal and band pass harmonic filter for the transmitted power. In both the applications the harmonic filters are required to augment the isolation over the received band and provide high attenuation for the second and third harmonics of the high level TWTAs to control spurious emissions and hence minimize interference to other satellite systems.

The present technique of band pass harmonic filters uses a combination of band pass or high pass filter in series with lowpass filter which tends to increase losses and size and limit the power handling capability [1].

This paper presents a new approach for the design of a low loss, high power, reduced size band pass harmonic filter as well as a new type of integrated antenna diplexer useful for application at low frequencies as well as high frequencies.

TRIPLE PLANAR INTEGRATED CIRCUIT BAND PASS AND BAND PASS HARMONIC FILTERS

The proposed structure to achieve such filters is shown in Fig. 1. Triple inductive strips are mounted in the E-plane of a rectangular waveguide. The design approach of such filters is based on choosing the strips spacing and thicknesses to prevent the excitation of the first five non-propagating modes (TE_{mo}, m = 2, 3, 4, 5, 6) as described in [2] for triple inductive posts.

The theoretical analysis for one set of triple inductive strips has been done accurately by expanding the field into suitable eigenmodes in the different regions and matching the tangential field components at the different interfaces using a mode matching technique as described in [3, 4] for single inductive strip in finline. Strips spacings (L & L_1) and thicknesses (C & C_1) have been calculated numerically such that the amplitudes of TE_{30} and TE_{50} modes become equal to zero (amplitudes of higher order even modes are equal to zero due to symmetry). That means that the first higher order mode generated is the TE_{70} mode. Using the resultant equivalent circuit and applying the well known design technique of band pass filters [5] a seven half wave length resonator band pass filter at 14.0-14.5 GHz has been developed. Obviously the higher order mode coupling [3] between the different sets of triple inductive strips across the resonators is much less than in filters using single inductive strips and can be neglected. Lower loss and size can be achieved over the common single planer circuit band pass filters. Comparison between the insertion loss of single and triple filters is demonstrated in Fig. 2.

By reducing the waveguide height, b, such that the cut-off frequency of TE_{01} mode lies equal or above the cut-off frequency of TE_{70} mode, band pass harmonic filters up to at least the third harmonics have been achieved.

Frequency response and out-of-band isolation for seven half wave length resonators filter at 14.0-14.5 GHz are shown in Fig. 3.

Due to dispersion, the second and third pass bands of the filter occur outside the required second and third harmonic frequencies of the pass band (dashed lines in Fig. 3). Fig. 4 shows the comparison of the insertion loss between a seven resonator single and reduced height triple planar circuit filter. While the waveguide height, b, has been reduced in triple planer case by a factor of 3 which means that the unloaded Q of the waveguide decreased by a factor of ≈ 2.5, the insertion loss increased only by 50% in most of

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the pass band with respect to the single planar case, which means that the suppression of higher order modes increase the loaded Q factor and, hence, reduce the losses.

The power handling capability of the filter is equal to that of reduced height waveguide.

By adding small T-Sections onto the centre strip of the triple planar structure, as shown in Fig. 5, additional attenuation at the second and third harmonic frequencies of the pass band could be achieved by creating transmission zeros at these frequencies using TM_{11} coupling as described in [1].

PLANAR INTEGRATED ANTENNA DIPLEXERS

By using E-plane Tee Junction, the integration of single ridge lowpass filter [1] with single planar band pass filter [3] to construct single planar integrated antenna diplexers becomes possible. Fig. 6 demonstrates the proposed structure. A seven half wave length resonator single planar band pass filter integrated to a 21 element single ridge low pass filter through an E-plane Tee Junction. The theoretical analysis based on an accurate model of the Tee Junction taken from [6]. The filter's design is carried out in such a way to absorb the effects of the Tee Junction. Results for this combination for the frequencies 12.2-12.75 and 14.0-14.5 GHz are shown in Fig. 7.

Triple Planar integrated antenna diplexers could be constructed by integrating triple ridge lowpass filters [1] with triple planar band pass filter. Such construction could be used successfully as a power combiner where in both the channels the suppression of harmonics is required.

For both types of integrated antenna diplexers lower loss can be achieved over the conventional diplexers which use separate filters connected to either E-plane or H-plane Tee Junction. In addition, integrated diplexers are cost effective and could be used at low as well as high frequency application.

CONCLUSIONS

A cost effective new class of planar integrated microwave components is developed for terrestrial and space application. Band pass harmonic filters with 60dB suppression up to at least the third harmonic has been presented using triple planar integrated circuits. Low loss and size and high power handling capability have been achieved. Comparison of measured results between single and triple planar technique has been demonstrated.

Finally, single and triple planar integrated antenna diplexers are also presented and measured results of single planar case has been demonstrated.

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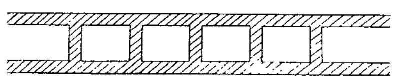
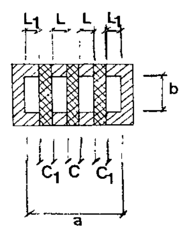
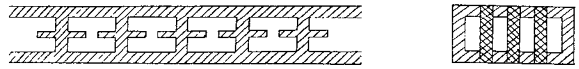


(a)



(b)

Fig. 1 Triple Planar Integrated Circuit Band Pass Filter
(a) Slot Pattern (b) Cross Section



(a) (b)

Fig. 5 Triple Planar I.C. Band Pass Filter with TM Coupling
(a) Slot Pattern with T-Sections in Centre Strip
(b) Cross Section

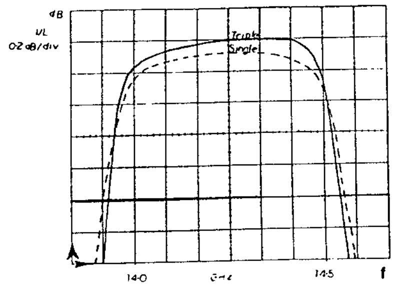


Fig. 2 I/L of Single and Triple Filters

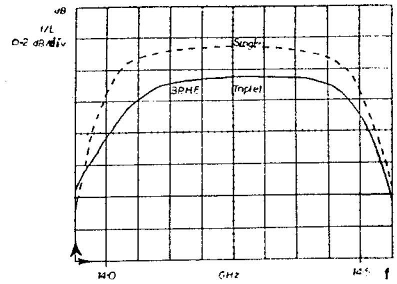


Fig. 4 I/L of Single and Triple B.P. Harmonic Filters

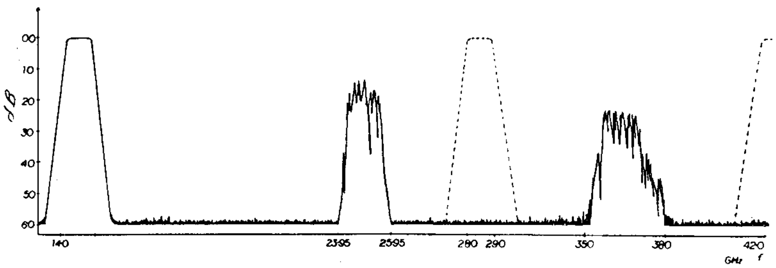
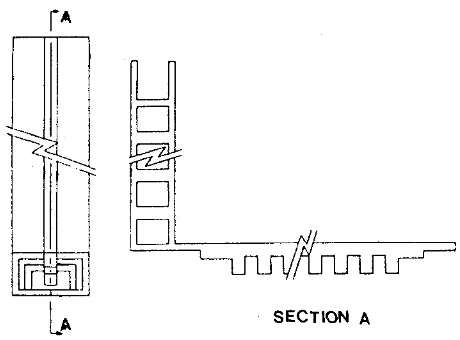
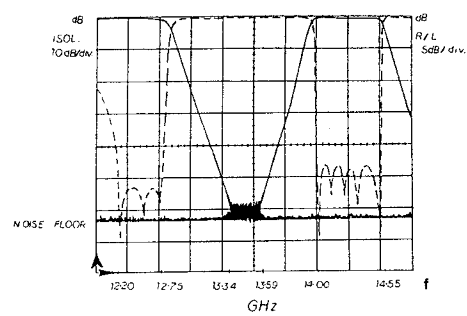


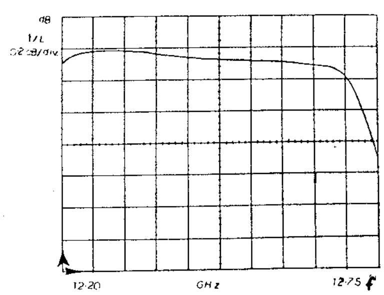
Fig. 3 Out-of-Band Isolation of Triple Band Pass Harmonic Filter





(a)

Fig. 6 Single Planar Integrated Antenna Diplexer



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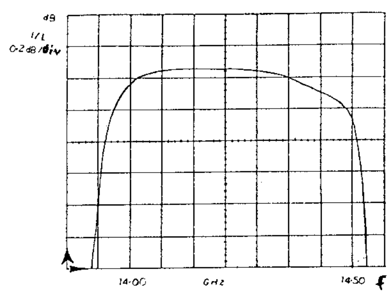

(c)

Fig. 7 Measured Results for Single Planar Integrated Antenna Diplexer
(a) Return Loss and Out-of-Band Isolation
(b) I.L. of the Low Pass Channel
(c) I.L. of the Band Pass Channel