THE WAVEGUIDE SANDWICH HARMONIC REJECTION FILTER (1)

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Abstract

A novel technique is presented for a harmonic rejection filter which attenuates only prescribed harmonic bands. This waveguide 'sandwich' filter is constructed from several plates which are dowelled together and results in a very compact and inexpensive device.

Summary

In many communication systems which are restricted to a certain band (e.g. 5.9 → 6.4GHz) the only spurious signals in the system are in the prescribed harmonic bands (e.g. 11.8 → 12.8GHz, 17.7 → 19.2GHz etc.) due to non-linearities in the system. The normal technique of attenuating harmonic bands in waveguide systems is to use a waffle iron or corrugated type of structure, (e.g. 2, 3,) which attenuates all frequencies upto a prescribed harmonic. However, it is normally sufficient to pass the fundamental band and only attenuate the particular harmonic band. A method of achieving this result by an inexpensive and compact structure is presented in this paper. The waveguide 'sandwich' harmonic rejection filter comprises of a sandwich of thin plates of the same thickness, dowelled together and tapped at the ends to accommodate standard waveguide flanges.

Approximate Design Technique for one Harmonic Band

For most applications a simple 'image parameter' design technique is adequate. This enables only two types of plates to be used in the construction of the filter for one harmonic band thus reducing cost. The two different plates types A and B shown in Fig. 1 and 'sandwiched' together as shown in Fig. 2. The basic symmetrical section is a series short-circuited stub symmetrically locating in a length of line, the length being determined by the constraint that all plates are the same thickness. The three unknown parameters, that is the slot length for plates A and B and the number n of plates are determined as follows:-

(a) The difference between the two slot lengths is chosen such that the series stub resonates in the H_{10} mode at the centre of the stopband.

(b) The height of the smaller slot is determined by image matching each basic section at the centre of the passband.

(c) The number of sections n is determined from the stopband bandwidth and level of required attenuation.

Several filters have been constructed using this single band design and a typical response is summarised below:-

Passband 5.9 → 6.4GHz	Return loss > 26dB	
	Ins. loss < 0.1dB	
Stopband 11.8 → 12.8GHz	Ins. loss > 35dB	

Length of filter in WR 137 ≈ 1"

Multiband Design

For higher ordered harmonic bands, account must be taken of higher ordered modes in the waveguide. For example, if the 2nd and 3rd harmonics are to be attenuated the section of the filter attenuating the 3rd harmonic must be of lower impedance (reduced height) to attenuate all modes except the H_{n0}. The number of plates in this section then determine the rejection at $3f_o$ in the H_{10} mode. Sandwich sections rejecting $2f_o$ are connected at both ends of the filter and their image impedances are chosen to match by transformer action, the $3f_o$ section in the main passband. Furthermore, the series stubs in the $2f_o$ section may be modified to attenuate the H_{30} mode at $3f_o$ which may be excited through misalignment of the filter. A typical experimental filter designed in this manner using four different plates is summarised below:-

Passband 5.9 → 6.4GHz	Return loss > 26dB
	Ins. loss < 0.15d
Stopbands 11.8 → 12.8GHz	Ins. loss > 40dB
17.7 → 19.2GHz	

Length of filter in WR 137 ≈ $2\frac{1}{4}$"

Conclusions

For harmonic band rejection, a simple, compact and inexpensive alternative is presented to the conventio tional waffle iron or corrugated waveguide filters. For one or two harmonic bands, built in quantity, the sandwich harmonic rejection filter can be extremely inexpensive since the plates may readily be stamped and its small size enables a systems designer to incorporate it without modifying a system layout. For a large number of hramonic bands the conventional forms are probably more suitable although in particularly important bands, additional attenuation may readily be supplied by the sandwich filter. Additionally, the waveguide sandwich filter is capable of operating in high power conditions.

References

1. J.D. Rhodes, 'The Waveguide Sandwich Filter' British Patent Application No. 19108/72

2. G.L. Matthaei, L. Young and E.M.T. Jones, 'Microwave Filters, Impedance Matching Networks and Coupling Structures', New York, McGraw Hill, 1964.

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Fig 1

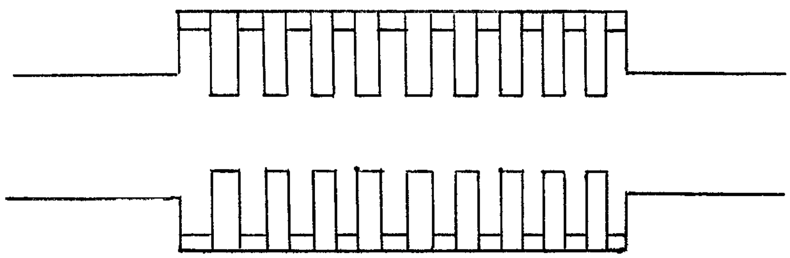

Fig 2