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MINIATURE FILTERS AND EQUALIZERS UTILIZING DUAL MODE DIELECTRIC RESONATOR LOADED CAVITIES

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ABSTRACT

A novel approach in high performance, dual mode filters and equalizers is described. Miniature, light weight, temperature stable designs utilize dual mode, dielectric resonator loaded cavities. The basic configurations and performance characteristics are presented.

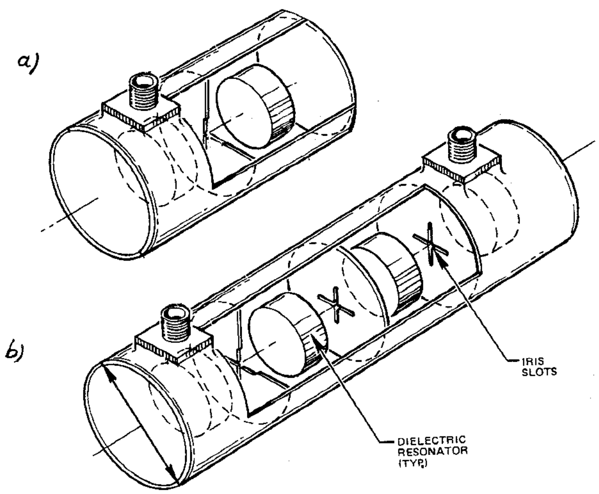

Figure 1.

Typical configurations of dual-mode dielectric resonator loaded cavity filters and equalizers.
a) Equalizer (4-pole)
b) Filter (8-pole)

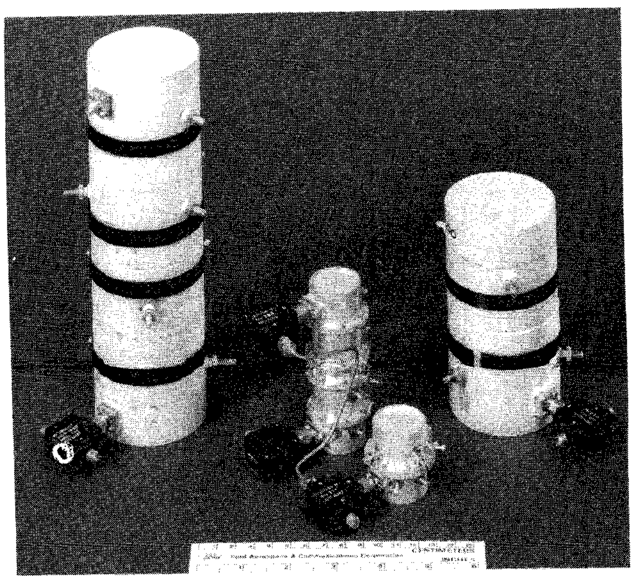

Figure 2.

Standard GFRP versus Dielectric resonator loaded cavity filters and equalizers.

Introduction

A typical communication satellite transponder contains a large number of high performance cavity type filters and equalizers, usually implemented in INVAR or GFRP (Graphite Fiber Reinforced Plastic). Due to severe constraints imposed on the size and weight of these filters, a dual mode approach, which utilizes degenerate cavity modes, is preferred. Also, in a dual mode configuration, steep rejection elliptic function filters requiring coupling between nonadjacent cavities can be conveniently realized. However, even when using a dual mode configuration, the size and weight of cavity type communication transponder filters and equalizers are still much larger than other components of the transponder utilizing MIC technology, and thus a major constraint to the satellite layout. A dielectric resonator offers a substantial reduction in size and weight, as well as good temperature stability compared to a traditional cavity. Single mode filters using dielectric resonators ($TE_{01\delta}$ cyl. mode, $TE_{11\delta}$ rec.) have been reported by several authors.[1-6] In our novel approach, properties of degenerate, hybrid mode in a cylindrical dielectric resonator are utilized to realize 4 GHz, miniature dual mode filters and equalizers[7]. A conventional, quasi-elliptic, cavity filter configuration is modified by an addition of the dielectric resonator. A dramatic reduction in size (1/12 volume) and weight (1/3) as compared to conventional, already light-weight graphite epoxy cavity filters was achieved. Additionally, excellent temperature stability of $\approx$ 1/ppm/degree C (better than INVAR), and minimal degradation of resonator Q, have been demonstrated in the new filters. Due to small size and reduced weight, the filters and equalizers reported are comparable with MIC components. Also lower production cost makes them ideally suited for communication satellite transponder applications. Design and tuning are similar to cavity type filters.

Bandpass Filters

Typical configurations for the filters and equalizers is presented in Fig. 1 (photograph in Fig. 2). The 8-pole, quasi-elliptic filters and 4-pole, reflection type equalizers in a circulator configuration, were fabricated using Resomics C (Murata Mfg. Co.) ceramics mounted in a silver plated aluminum waveguide below cut-off. Average Q factor of the resonators was in the range of 1/tan $\approx$ 8000 (4 GHz). Typical performance of the 8-pole filters is presented in Fig. 3 The excellent insertion loss performance achieved ($\approx$ .5 dB) corresponds to a Q = 7200 and indicates that minimal degradation of the resonator Q due to the presence of metal walls, tuning and coupling arrangements takes place. A side-by-side comparison of C-band input filter methods of implementation is presented in Table 1.

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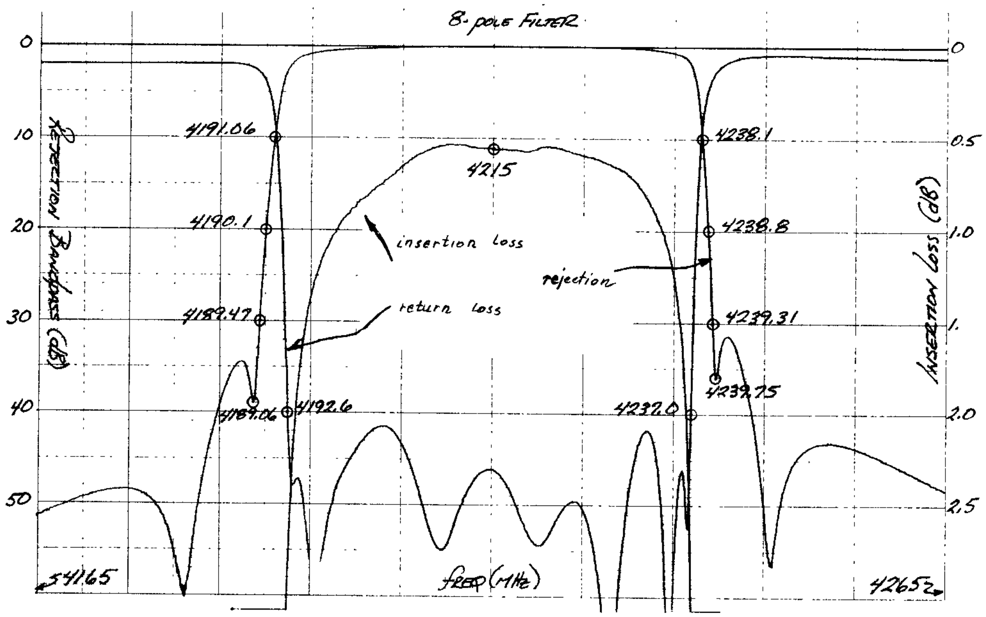

Figure 3

Typical performance of narrow band 4 GHz, 8-pole filter utilizing dielectric resonator loaded cavities

	Graphite Fiber Reinforced Plastic	Thin-Wall Invar	Dielectric Resonator
4 GHz Narrowband, Dual-Mode Filter Configuration	8-pole	8-pole	8-pole
Size, cm	6.25 dia x 20.3 (2-1/2" dia x 8")	6.25 dia x 20.3 (2-1/2" dia x 8")	2.54 dia x 10.2 (1" dia x 4") (1/12 volume)
Weight, g	170	300	50 – 60
Insertion Loss, dB	0.4	0.4	0.5
Electrical Performance	Reproduces Breadboard Very well	Comparable	Comparable
Temperature Stability	1-3 ppm/°C	1-2 ppm/°C	1-2 ppm/°C
Dimensional Stability	Very careful Control of Fabrication Processes Necessary	Very careful Control of Fabrication Processes Necessary	Expected to be Superior
Production Cost	Graphite fabrication expensive	Invar fabrication-tion expensive	Recurring cost lower

Table 1.

Comparison of Data for Different Construction Techniques

Equalizers

The performance of an equalizer implemented using dielectric resonator design is shown in Fig. 4.

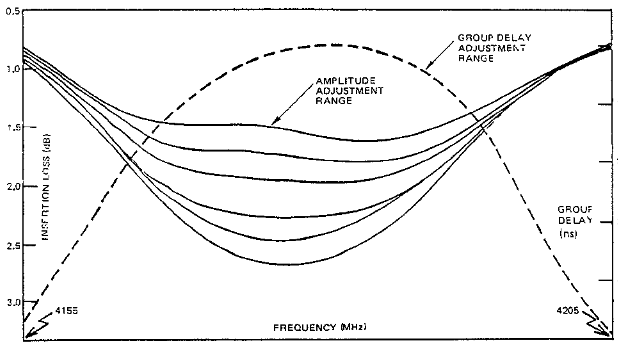

Figure 4

Performance of 4-pole equalizer with dissipative tuning screw.

In addition to the large size and weight reduction of this type of equalizer, another advantage is the feature that amplitude response can be adjusted to meet flatness requirements of the typical communication channel. It is well known that matching Q of the filter and equalizer almost perfect compensation of the combined amplitude response can be realized[8]. However, in typical transponder applications, the amplitude responses of the output filters have to be taken into consideration. Therefore, it is desirable to have an additional amplitude shaping capability to compensate also for the amplitude variation of the output filter. In this case, compensation was accomplished by adjusting the Q factor of one electrical cavity of the equalizer. The "dissipative" tuning screw approach was selected. As can be seen, a wide range of amplitude adjustment is possible with the same group delay response.

CONCLUSION

The bandpass filters and equalizers which have been developed compare favorably with metallized cavity implementations. Due to their relatively small size and light weight, they are ideally suited for size and weight constrained applications (e.g., satellite transponder). Additional advantages are incurred due to their excellent temperature stability and lower cost. In the development, it has been shown that standard design and synthesis methods can be used to successfully implement this type of filters and equalizers.

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