SATELLITE L-BAND OUTPUT MULTIPLEXER UTILIZING SINGLE AND DUAL MODE DIELECTRIC RESONATORS

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ABSTRACT

A four-channel, contiguous band output multiplexer for L-band satellite applications is described. The filters feature single and dual mode dielectric resonators and operate at power levels up to 13 Watts in vacuum. The design of the multiplexer was optimized to meet different requirements for each of the filters. Excellent electrical performance in a relatively small package was obtained by use of high performance dielectric resonators and a coaxial line combiner.

INTRODUCTION

The next generation of GOES weather satellites will extensively utilize L-band frequencies to transmit required information to ground stations. For efficient combining of separate transmitters at common antenna output, high performance multiplexers are usually used. However, at low microwave frequencies such as L-band , the size and weight of high Q-factor components necessary to obtain low multiplexer loss are limiting factors. For this reason, the use of dielectric resonators was considered. Inherent features of these resonators such as relatively small size, lower weight and very high Q-factor make these devices very well suited for this demanding application. In Figure 1, a comparison of a cavity dual mode filter and a dielectric resonator filter is presented showing a dramatic size reduction . Since this is an output multiplexer operating in vacuum, power handling issues associated with dielectric resonators had to be included in the design. Additional factors affecting the design of the multiplexer included varying requirements for individual channels, such as different bandwidth, rejection , and operation outside of the usable band.

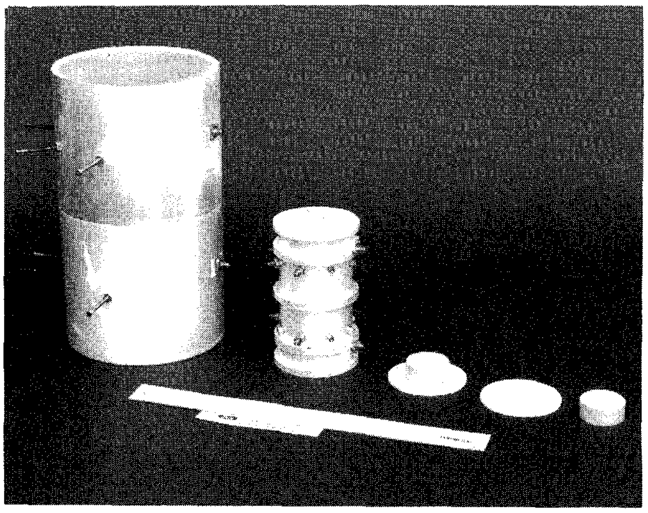

Figure 1 Comparison of Cavity and Dielectric Filters

MULTIPLEXER DESIGN

The basic characteristics required for the multiplexer filters are listed in Table I. Initial analysis showed that rejection requirements could be met by 4 -pole filters (channels # 1-3) and in the case of channel #4 , by a 3-pole filter. Singly terminated prototypes of the desired filters were used as starting points for the multiplexer design. Previous multiplexer designs at 4 and 12 GHz had used waveguide manifolds as the combining structure. However, size and weight constraints ruled out this option at L-band. Instead, a common coaxial 6 port junction was used. Each channel filter was connected to one of the ports via a semi-rigid coaxial cable. A shorted, variable length stub was added to the 5th port with the remaining port serving as the output. The filter parameters, shorted stub length, and cable lengths were computer optimized for best performance. Figure 2 shows the computed performance of the multiplexer.

TABLE I BASIC MULTIPLEXER CHARACTERISTICS

						ELECTRICAL PERFORMANCE		
CHANNEL	CENTER FREQ(MHZ)	# OF POLES	MODE TYPE	FILTER TYPE	EQ. RIPPLE BANDWIDTH	INSERTION LOSS(DB)	LOSS FLATNESS(DB)	ADJ. CH. REJECTION
1	1676	4	DUAL	ELLIPTIC	5	<1.2	<1.0	>16
2	1685.7	4	SINGLE	CHEBYCHEV	4.2	<1.4	<1.6	>18
3	1691	4	DUAL	ELLIPTIC	3.8	<1.4	N/A	>16
4	1694.5	3	SINGLE	CHEBYCHEV	2.5	<2.0	<1.8	>16

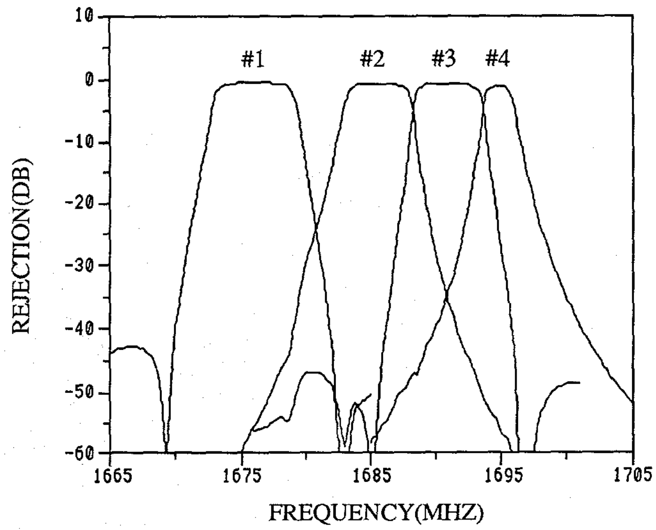

Figure 2 Multiplexer Computed Performance

MULTIPLEXER IMPLEMENTATION

The 4 channel multiplexer was built and excellent performance was achieved. At first, individual channel filters were tuned in doubly-terminated configuration. Two filters (#1 and #3) were implemented using dual mode dielectric resonators [1], and the remaining two filters utilized a single mode in a dielectric resonator [2]. This was necessary due to different power handling capabilities of these configurations (especially peak power) and the rationale for this choice will be discussed in the power handling section of this paper. Typical performance of a dual mode filter is shown in Figure 3. Single mode filter characteristics are shown in Figure 4. Excellent insertion loss performance of both configurations is a result of the extremely high Q-factor of the dielectric resonators obtained in an actual mounting arrangement (typically greater then 12,000).A photograph of the multiplexer is shown in Figure 5. Its measured performance is shown in Figure 6 demonstrating remarkable correlation with the theoretical response(Figure 2). The developed multiplexer has undergone the full space qualification procedure (including high levels of vibration) and at the present time is in flight production.

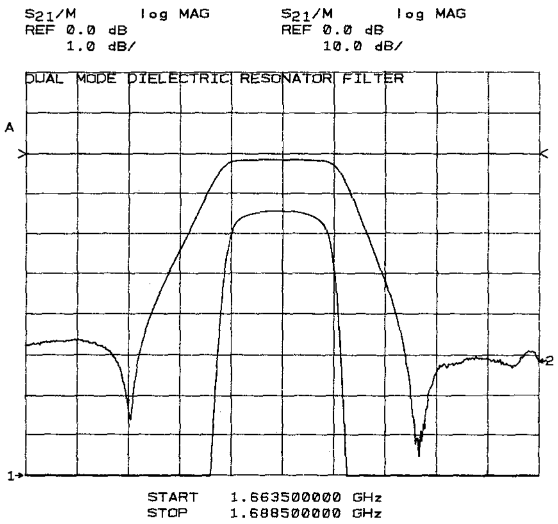

Figure 3 Dual Mode Filter Performance

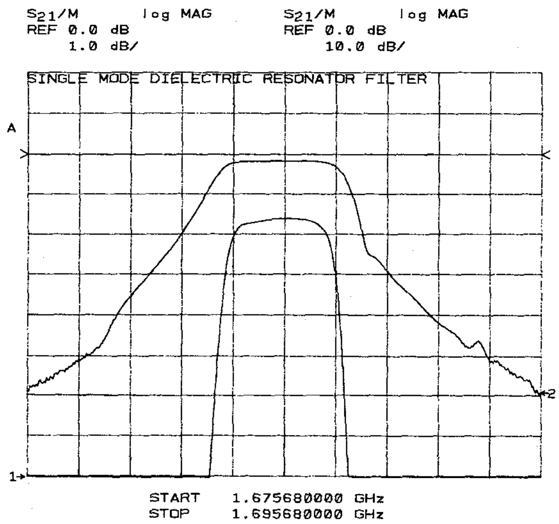

Figure 4 Single Mode Filter Performance

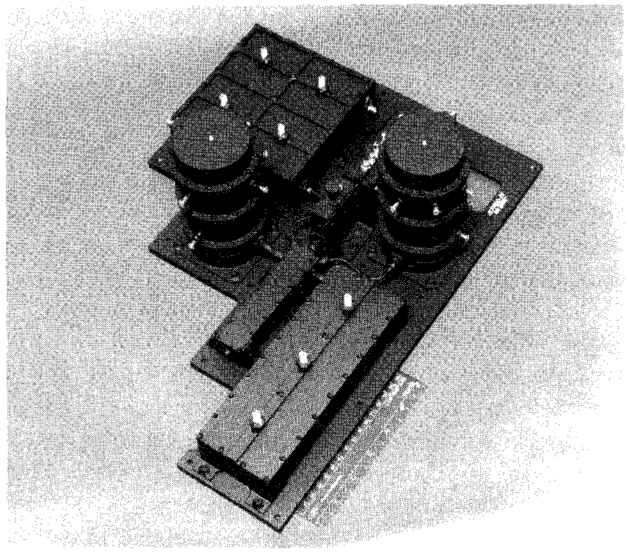

Figure 5 4 Channel L-Band Multiplexer in Flight Configuration

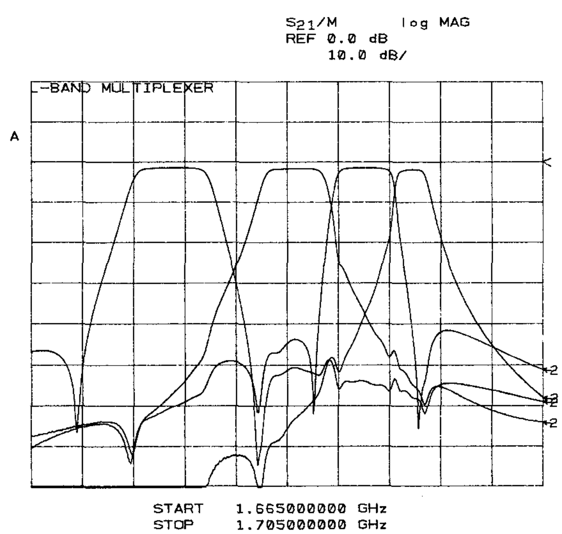

Figure 6 Multiplexer Measured Performance

MULTIPLEXER POWER HANDLING

Since the multiplexer operates in vacuum, thermal problems associated with efficient transfer of generated heat must be taken into consideration. Available dielectric resonator materials have relatively low thermal conductivity and the same is true for low loss materials used to mount the resonators. Also, one of the filters (#2) additionally required the ability to tolerate full power applied at frequencies beyond the passband. This is very difficult from a power handling point of view since maximum absorption of power in a filter occurs at group delay peaks typically located at frequencies slightly beyond passband ,and at the same frequencies , peak power in a filter increases by group delay ratio (group delay at the peak/ group delay at the center) [3]. These two factors initially caused significant problems in dual mode filters, especially since design margins required a filter to be tested at a power level 6dB above nominal 13 Watt operation. Arcing was experienced in the mounting side of the dielectric resonator. This was solved by special shaping of the resonator (beveled edges) .
Modified dual mode filters successfully passed 50 Watt power tests.(Figure 7). For even higher power handling (including out of band) , the single mode design with a boron nitride mounting was selected. This particular configuration successfully passed 80 Watt power tests .

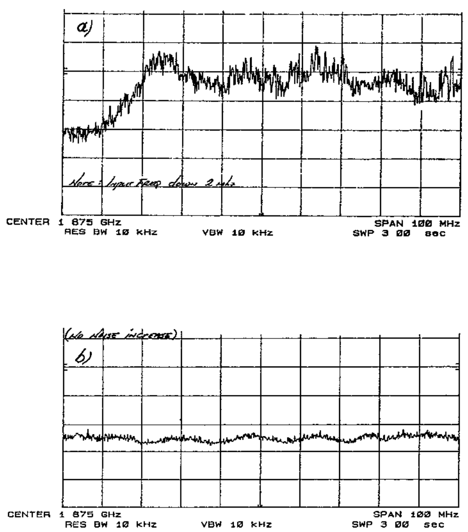

Figure 7 Results of Power Test of Dual Mode Filters in Vacuum
a) noise increase due to arcing prior to resonator modification
b) after modification

CONCLUSIONS

The developed multiplexer configuration has excellent electrical characteristics combined with small size , low weight and high power handling capabilities. This space qualified design represents an important advance in contiguous output multiplexers utilizing dielectric resonators.

REFERENCES;

[1] S.J.Fiedziuszko , " Dual-mode Dielectric Resonator Loaded Cavity Filters" IEEE Trans.Microwave Theory Tech.,vol.MTT-30,pp.1311-1316, Sept.1982.

[2] S.J.Fiedziuszko ,C.Ziegler "Narrow Bandpass Dielectric Resonator Filter with Mode Suppression Pins" U.S.Patent #4,962,723 Sept.8,1987.

[3] G.L.Matthaei, L.Young, and E.M.T.Jones" Microwave Filters, Impedance-Matching Networks, and Coupling Structures ",New York:
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