A Five Mode Single Spherical Cavity Microwave Filter

Lai Sheng–Li and Lin Wei–Gan

Department of Radio Engineering
South China University of Technology
Guangzhou 510641
China

Indexing terms: Five– mode degeneracy, Spherical cavity.

Abstract: Triple–mode degeneracy in cylindrical cavities has been successfully applied to the design of satellite communications filter and multiplexer.

A novel realization of five– mode microwave filters using only TM mode or TE mode degeneracies in a single spherical cavity is presented.

Experimental results obtained with a prototype five–mode quasi–elliptic function filter by exciting and controlling five degenerate mode in a single spherical cavity with a new technique using dielectric coupling. The carves measured well agree in the theoretical volues. This result in singnificant for the degenerated modes applicable to the satellite communications.

INTRODUCTION

Single cavity filters excited in more than two modes were first introduced by Lin in 1951[1], M.R Currie in 1953[2], the interesting case of a spherical cavity, with its unlimited numbers of degeneracies, is investigated for application of the general techuique. In 1984, Lin and Yu[3] presert-ed a synthctical process which realized an elliptic function filter by exciting and controlling four degenerate modes in a single cylindrcal cavity with a new technique using dielectric coupling. In 1988, Bonetti and Williams[4] gave a novel realization of triple– mode filters using only TE mode degeneracies. In 1990, Lai and Lin[5] presents a novel realization of triple– mode, six– pole microwave filters that using only TM mode. Extending the concept of multiple degeneracies to more than four modes is possible, but independent tuning and coupling of the desired mode is difficult to control. In 1990, Bonetti and Williams[6], a 6– pole, Ku– band, pseudo– elliptic bandpass filter which utilizes the sixfold degeneracy of a single rectangular cavity is presented.

This paper presents some of the practical mode degeneracies of a single spherical cavity, together with properties applicable to filter designs.

IF2

DEGENERATE MODES IN A SPHERICAL CAVITY

The resonant frequencies of spherical cavity modes were computed from the field equations in spherical coordinates and the application of appropriate boundary conditions at the bounding surface r = a determine the characteristic values k_{ln} and k'_{ln} for the TE and TM modes, respectively,

$$J_{n+\frac{1}{2}}(k_{ln}a) = 0, (TE) \qquad (1)$$

$$\{\frac{d}{dr}[\sqrt{r}\,J_{n+\frac{1}{2}}(k'_{ln}r)]\}_{r=a} = 0, (TM) \qquad (2)$$

where the integer index l denotes the lth root of (1) or (2) .

The wacelengths of natural resonance are given by

$$\lambda_{ln} = 2\pi / k_{ln}, \quad \lambda'_{ln} = 2\pi / k'_{ln} \qquad (3)$$

TE_{lmn} modes:

l \ n	1	2	3	4
1	α = 4.4934 λ = 1.398 * a f = 214.59 / a	7.7253 0.8133 * a 368.87 / a	10.904 0.5762 * a 520.65 / a	14.066 0.4467 * a 671.59 / a
2	α = 5.7500 λ = 1.0927 * a f = 274.55 / a	8.9819 0.6995 * a 428.88 / a	12.1608 0.5167 * a 580.61 / a	15.3226 0.41006 * a 731.70 / a
3	α = 6.9500 λ = 0.904 * a f = 331.86 / a	10.1819 0.6171 * a 486.15 / a	13.3606 0.4703 * a 637.89 / a	16.5226 0.3803 * a 788.85 / a

TM_{lmn} modes:

l \ n	1	2	3	4
1	β = 2.74400 λ' = 2.289 * a f' = 131.06 / a	6.11700 1.027 * a 292.06 / a	9.31700 0.674 * a 444.84 / a	12.4800 0.503 * a 595.83 / a
2	β = 4.00600 λ' = 1.568 * a f' = 191.28 / a	7.37360 0.852 * a 352.07 / a	10.5738 0.594 * a 504.88 / a	13.7366 0.457 * a 655.88 / a
3	β = 5.20060 λ' = 1.208 * a f' = 248.30 / a	8.57360 0.732 * a 409.33 / a	11.7738 0.533 * a 562.11 / a	14.9366 0.421 * a 713.09 / a

where a (mm), λ (mm), f (GHz).

PROTOTYPE DESIGN

Figure (1) depicts the mode routing selected for the five– mode filter implementation, and Figure (2) shows the position of tuning and coupling screws. Input and output connections are provided via coaxial probes.

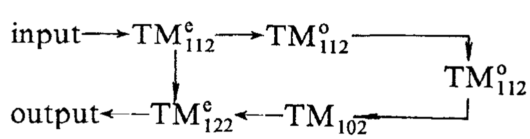

Figure (1) . Mode Routing for Five–Mode Filter Realization

presented a synthctical process which realized an elliptic function filter by exciting and controlling five degenerate modes in a single spherical cavity with a new technique using dielectric coupling.

MEASURED PERFORMANCE

Figure (3) shows the measured transmission and return losses of the prototype five- mode single spherical cavity filter, and Figure (4) depicts the measured out-of-band response. Figure (5) show the external cavity construction.

CONCLUSIONS

The practical multiple- mode degeneracies of spherical cavities which are directly applicable to multimode bandpass filter designs have been presented.

REFERENCES

(1) Lin Wei–Gan, "Microwave Filters Employing a Single Cavity Excited in More Than one Mode" , J. Appl. phys. vol. 22, no. 8, pp.989–1011, Aug.1951.

(2) Malcolm R. Curric, "The Utilization of Degenerate Modes in a Spherical Cavity, " J. Appl. phys. vol. 24, no. 8, pp.998–1003, August 1953.

(3) Lin Wei- Gan and Yu Zhiyuan, " Four Degenerated Modes in A Single Cylindrical Cavity, "Journal of China Institule of Communications, vol.7, no.2, March 1986.

(4) R.R.Bonetti and A.E.Williams, "A TE Triple- Mode Filter, " IEEE Trans. Microwave Theory Tech. MTT- S Digest 1988, pp.511–514, (R–2) .

(5) Lai Sheng–Li and Lin Wei–Gan, " A TM Tripl- Mode Microwave Filters, " IEE Electronics Letters 6th December 1990, vol. 26, no.25, pp.2112–2113.

(6) R.R.Bonetti and A.E.Williams, "A Hexa- Mode Bandpass Filter, " IEEE Trans Microwave Theory Tech. , MTT- S Digest 1990, pp.207–210. (F–2) .

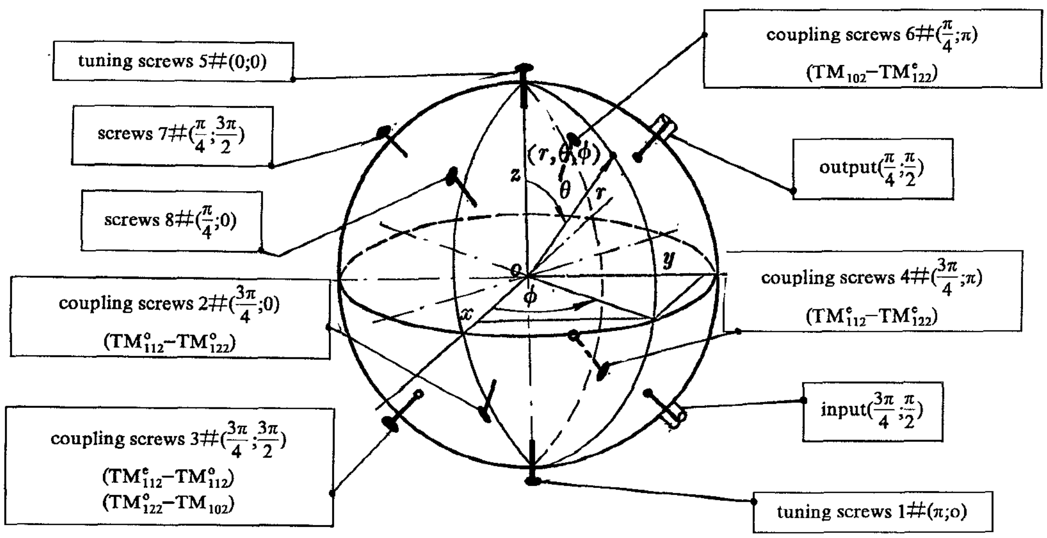

Figure (2) .Five–Mode Filter Tuning and Coupling Screws Configuration

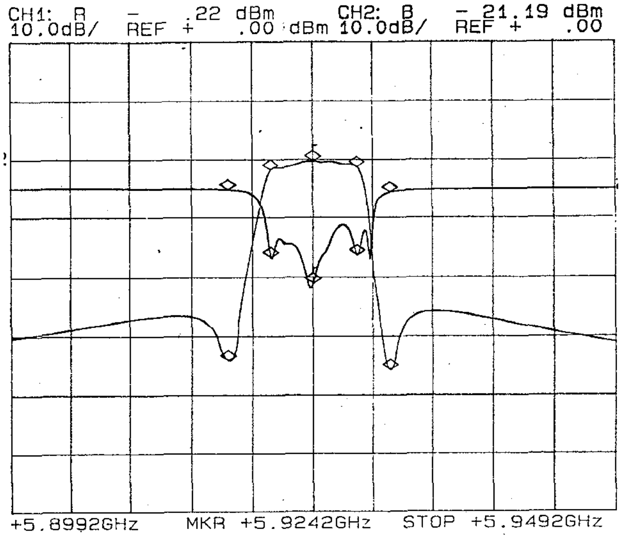

Figure (3) Measured Filter Response

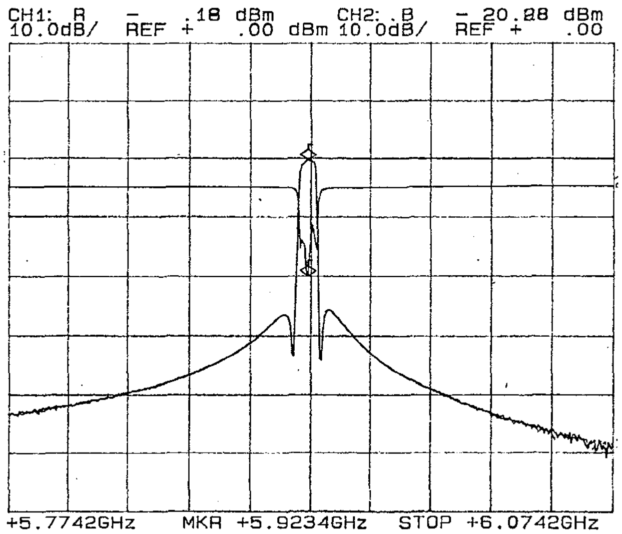

Figure (4) Measured Out–of–Band Response

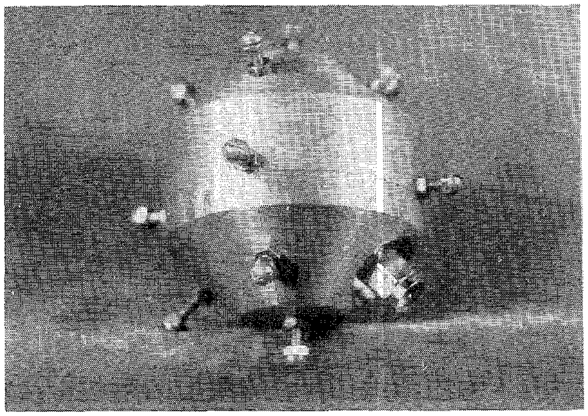

Figure (5) External Construction of Five–Mode Spherical Cavity