THE ELECTRONIC TUNING AND ANALYSIS OF A SLOTTED DIELECTRIC RESONATOR FILTER

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ABSTRACT

There have been a variety of electronic tuning techniques developed to replace mechanical plungers used in Dielectric Resonator(DR) filters[1]. This paper presents some results of a new method known as **Invasive Varactor Tuning** of a DR filter, the term invasive referring to the fact that the tuning element is inside the DR. The structure is analysed using the three dimensional transmission line matrix technique[2]. Several variations on the slot size have been simulated and the results reported.

INTRODUCTION

The characteristics and applications of the technique known as invasive varactor tuning of a DR have been presented by us at a number of recent colloquia [3,4]. A typical filter is shown in Fig.1.

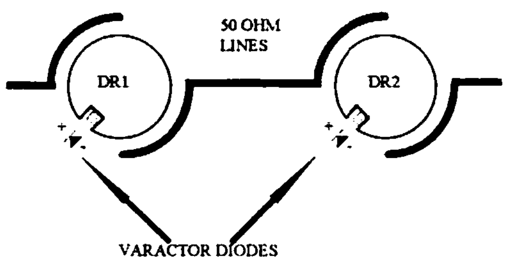

Figure 1. A two cavity tuneable DR filter fo=5GHz, tuning range = 150MHz , 2dB IL variation

The signal is coupled to the slotted DRs via microstrip arcs. The slots are aligned at 45^0 so that there is negligible effect on the field coupling. Tuning of the filter is achieved by either mechanical (plunger) methods or by inserting a varactor housed in a carrier into the slot with metallised sides. The purpose of the metallisation is to uniformly displace a proportion of the TE01 mode field perturbed by the slot, through the varactor. The amount of field displacement and hence tuning of the modes resonant frequency will depend upon the value of capacitance between the metallised slot sides. The Q factor of the structure will be affected by the introduction of a low Q device, i.e. the introduction of a varactor into the high Q DR. This can be minimised through the use of high quality varactors with Qs in excess of 6000.

STRUCTURE MODELLING

In order to simulate the response of the DR filter in the TLM simulator, the following assumptions are made. Firstly, the surface impedance of the metal cavity which contains the DR and the microstrip coupling arcs are assumed to be zero. Secondly, the Q factor of the filter is determined by the 50 Ohm

coupling lines. This will be true in situations where the DR has a very high dielectric Q factor (QD) in the modelling process, which in this case is 15000 @ 4GHz.
The simulated filter was constructed using a cube shaped mesh. The mesh was aligned to the top and bottom of the cavity and the DR in the z-direction. An example of the mesh in the xy direction is shown in Fig.2 . The mesh is finer where the field fringing is maximum.

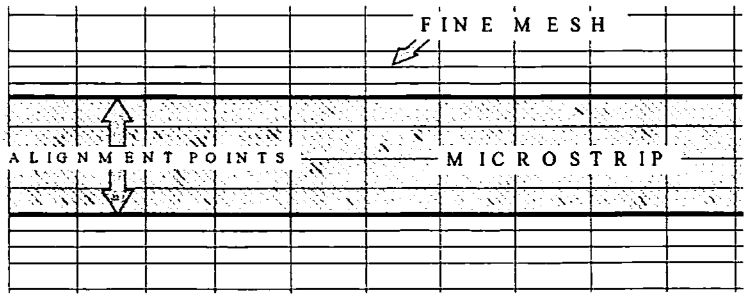

Figure 2. An example of the mesh alignment in the xy co-ordinates

In the simulator used [2], factors such as 'run time' and the frequency at which the field pattern is to be displayed must be manually entered into the solver. Since the DR is a very high Q device, the field energy will remain within the structure for a comparatively long time, and therefore, the simulator must also be run for a long time. The frequency at which the field is to be displayed can be approximated if the results from the actual filter are known. In this case the simulator was run twice with the results from the first run being entered into the second simulation.

PRACTICAL RESULTS

A Wiltron Network analyser was used to measure the response of a two cavity, invasively tuned filter.The resulting graph is shown in Fig.3. Each 'peak' represents the frequency response of the filter when the varactor voltage was varied in steps between 0V and 28V. The plunger height was set to achieve the flattest tuning response over that voltage range [5]. The filter used a Marconi varactor with a capacitance ratio of 6 and a Q factor of 6@10GHz and gave a tuning range of around 5% of the filter's centre frequency, i.e. 150MHz @ 5GHz with an insertion loss variation of 2dB .

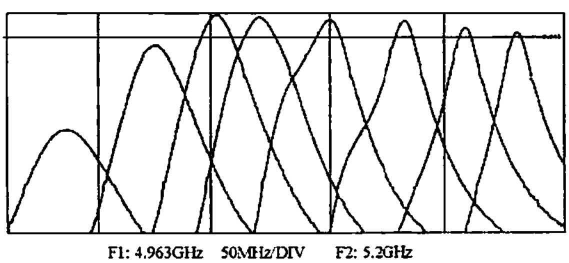

Fig.3 Electronic tuning of a two cavity DR filter

Practical results suggest that a varactor with Q in excess of 7000 causes little degradation in a practical filter circuit, whereas the amount of frequency tuning will depend upon the slot depth-to-width ratio and the capacitance ratio of the varactor itself.The capacitance and losses of the holder must also be taken into account and be kept to a minimum.

SIMULATED RESULTS

The graph, Fig.4, shows the measured response of a single cavity DR filter (see solid trace) alongside the simulated response which is shown as a thin line with circles. The actual values for the TE_{01} responses are a centre frequency of 4.75GHz for the measured filter with a bandwidth of 12.4 MHz. The resonant frequency for the simulated response was 4.762GHz with a bandwidth of 16 MHz.

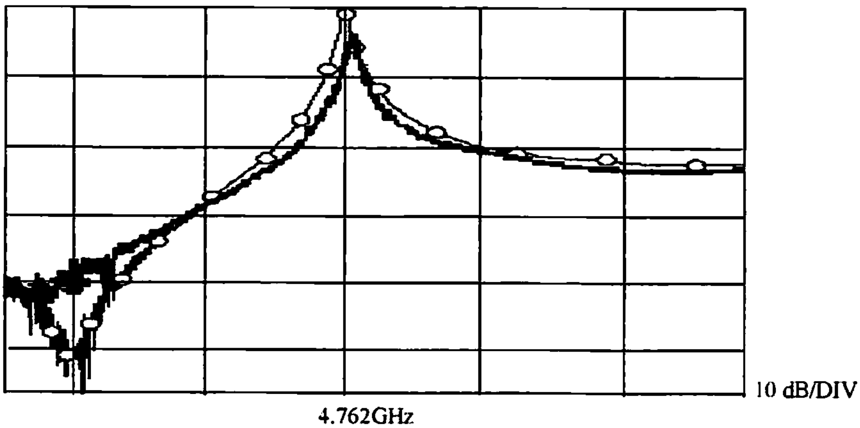

Fig.4 Measured and simulated response

Figure 5 shows the simulated field pattern of the TE_{01} mode for a DR with a slot cut into it. Darker arrows indicate a stronger field strength.

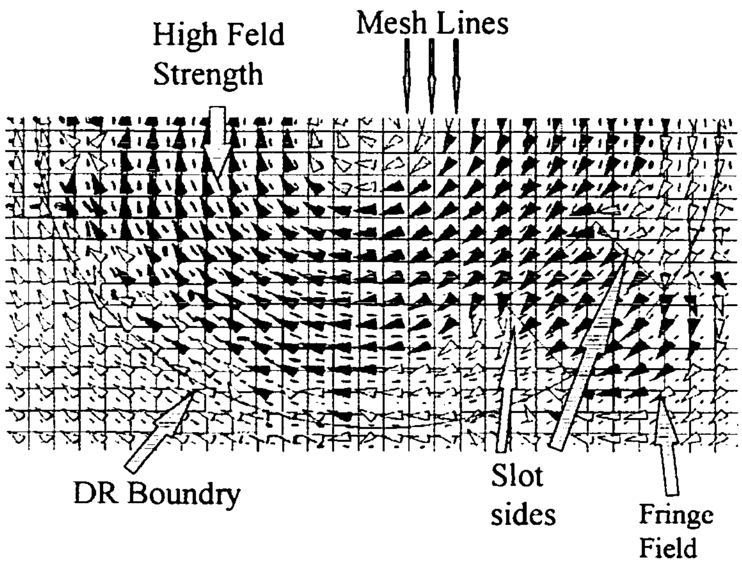

Fig.5 Simulated electric field pattern for a DR with a slot cut into it, in a single metal cavity

Several simulations of the single cavity slotted DR filter containing slots of various depths and widths were run to determine the most efficient slot width- to- depth ratio. This is shown in Fig.6. In a practical situation, the varactor width governs the slot width. Hence, any change in resonant frequency can be compensated for by varying the slot depth as can be seen from Fig.6 .

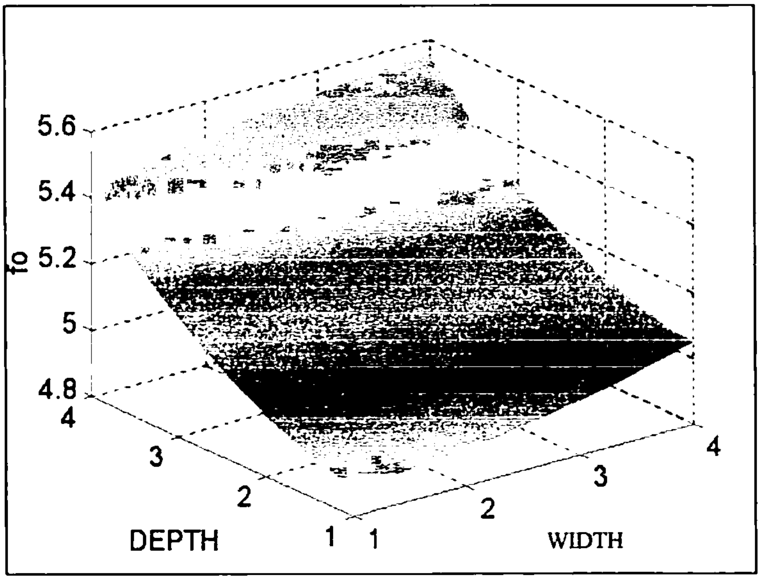

Fig.6 The resonant frequency for a given slot width or depth. Fo = resonant frequency of the TE_{01} mode.

CONCLUSIONS

An electronic tuning technique has been presented which uses a varactor to vary the amount of displacment current through a slot cut into a DR. This process is analoguous to reducing the amount of capacitance in an equivalent lumped circuit. The introduction of a varactor in this circuit varies the amount of added capacitance resulting in a shift in the resonant frequency along with a variation in the Q factor of the filter. The amount of frequency tuning and Q degradation will depend upon the type of varactor used, along with the parasitic capacitance and losses of the varactor carrier.

ACKNOWLEDGEMENTS

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KEY REFERENCES

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