Microwave Filter Research in Universiti Teknologi Malaysia

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Introduction

Universiti Teknologi Malaysia (UTM) is one of the 26 public universities in Malaysia. It started as a technical school over a century ago. The research on microwave filters in UTM only started in 1999. The Malaysian government has allocated several types of research funds for researchers in the academic, industrial and research institutions. The research on microwave filters in UTM began by developing a computer aided educational filter environment that is suitable for undergraduate laboratory experiments. Mathematical problems were solved using MathCAD mathematical software [1] and the filter configurations were simulated using several simulation software packages. Many final year undergraduates had the opportunities to work on different filter configurations. Some of them worked on simple modifications of designs available in the literature and investigated their frequency response performances. Several master's degree students were also involved, with higher level research investigations. The research on microwave filters progressed with that of antenna designs that are made of normal metals, superconductors and new materials. A doctoral student is currently completing a thesis that focus on parallel-coupled filters.

This paper describes four microwave filter configurations that have been recently developed over the past five years. These are a direct coupled cavity waveguide filter [2], an internally-coupled hairpin-line filter [3], a meander-gap hairpin line filter [4] and a three-element parallel-coupled filter [5].

Direct-Coupled Cavity Waveguide, C_DWB, Filter

An interactive mathematical package that is able to present the performance of the designed direct-coupled cavity waveguide filters of optimum and varying filter orders was developed. A design was aimed for 3.902 GHz VSAT operation. The filter is a robust structure and able to handle high power well. The VSAT communication system is a transportable unit. The antenna consists of a gyrostabilized and motorized C-Band antenna system with radome. The developed mathematical design file consists of formulae related to the derivation of the internal vertical inductive posts physical dimensions such as in [6]. The computations include determining the optimum number of the filter order and the displaying of frequency responses. Good agreement achieved between theory and simulations showed that the simulation software used has verified the theory. The introduction part of the math file is given in Fig. 1. For a 7 order filter, the math and simulated performances are shown in Fig. 2.

Internally-Coupled Hairpin-Line, ICHL, Filter

An internally-coupled hairpin-line bandpass filter based on resonator elements was designed [7]. Investigations on the optimum resonator were first carried out. The final configuration of a 3-element filter is shown in Fig. 3. Parametric investigations were performed using em simulations. The parameters that affect the filter performances were identified. It was found that the design dimensions can be optimized for desired specifications. In addition, the

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performance of the proposed ICHL design is comparable to a corresponding conventional hairpin-line, albeit exhibiting a 46% reduction in size.

Overcoupled Elliptic Meander-Gap Hairpin-Line, OCEMGH, Filter

Various meandered-gap hairpin-line low-pass elliptic filter configurations were designed and investigated. The variations were modified from the elliptic function stepped-impedance hairpin (SIH) LPF [8]. The coupled line supports two quasi-TEM modes, i.e., even- and odd-modes due to the inhomogeneous medium which leads to the inequality of even- and odd-modes phase constants. Meandering of the coupled-line gap and extending some conducting portion of one coupled line while reducing the direct facing portion of the other coupled line, allows the modes to be simultaneously equalized [9]. Hence, the inequality of the modes phase constants is solved. One configuration is the overcoupled MCH filter as shown in Fig. 4(a). It was found that overcoupling reduced the transmission zero, and the cutoff frequency, while more effectively suppressing the third harmonics (Fig. 4(b)).

Three-Element Parallel-Coupled Microstrip Line, 3EPCML, Filter

The research begins with developing modified design equations for improved accuracy of the microwave parallel-coupled bandpass filter. Grooves were then embedded in periodical arrangement. The research has evolved into designs of simple broadband PCML filters with compact design such as of Fig. 5. It exhibits excellent broadband characteristics with bandwidth > 80%, insertion loss > -0.2 dB at pass band and return loss < -13 dB.

Conclusion

This paper presents the research carried out on four selected microwave filters in Universiti Teknologi Malaysia. The filters are based on waveguide and microstrip configurations.

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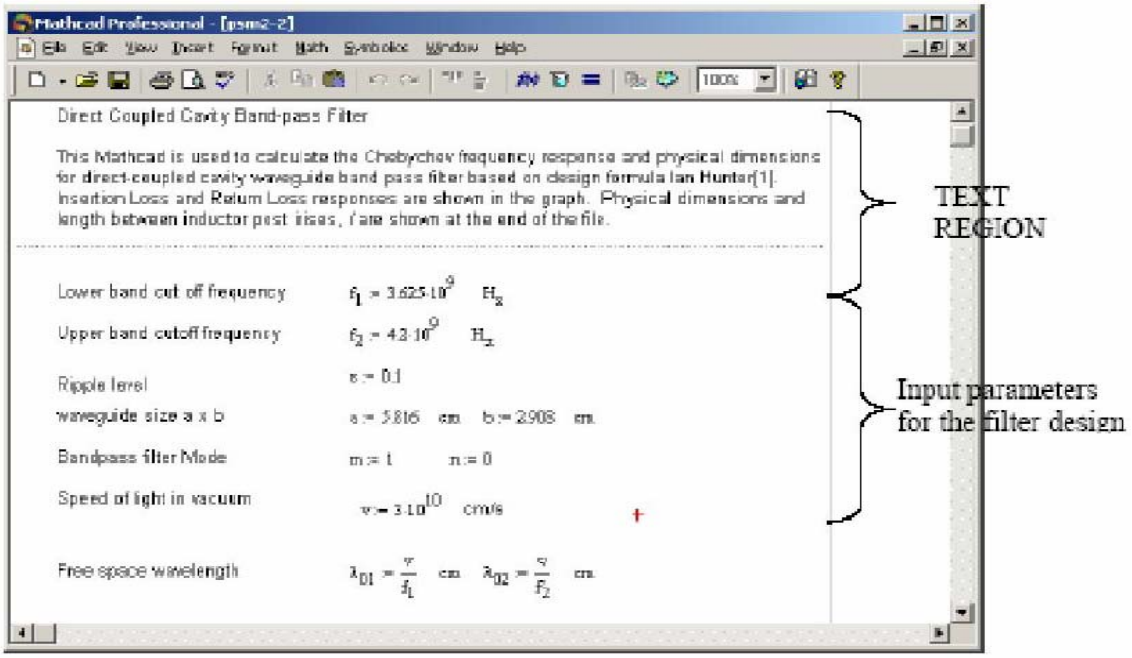


Figure 1. Introduction of MathCAD design file for C_DWB filter.

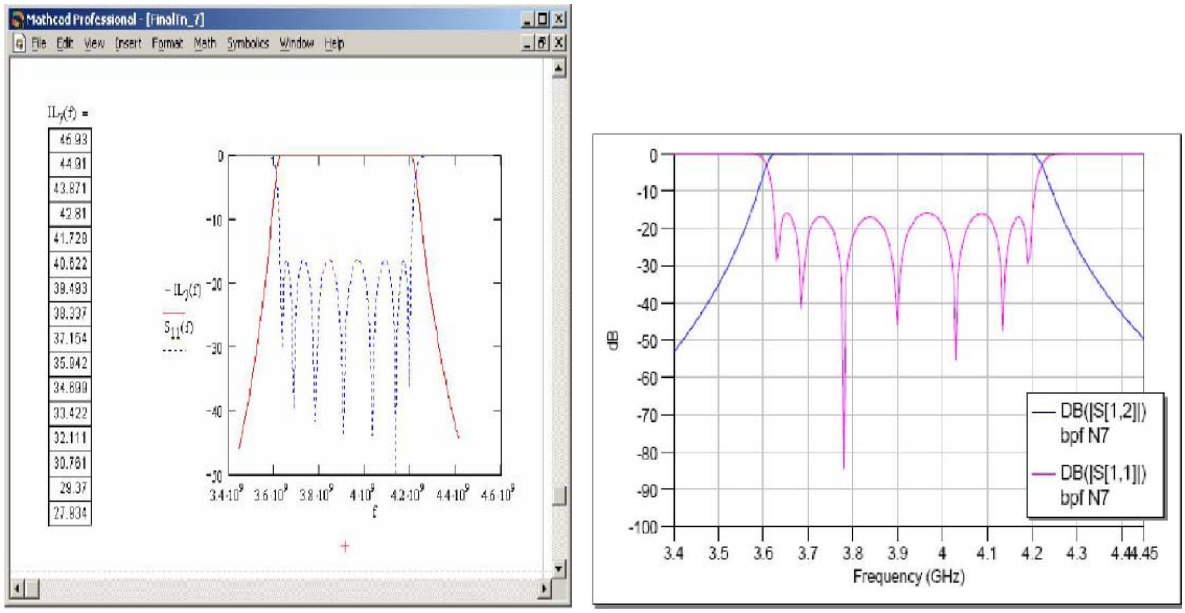
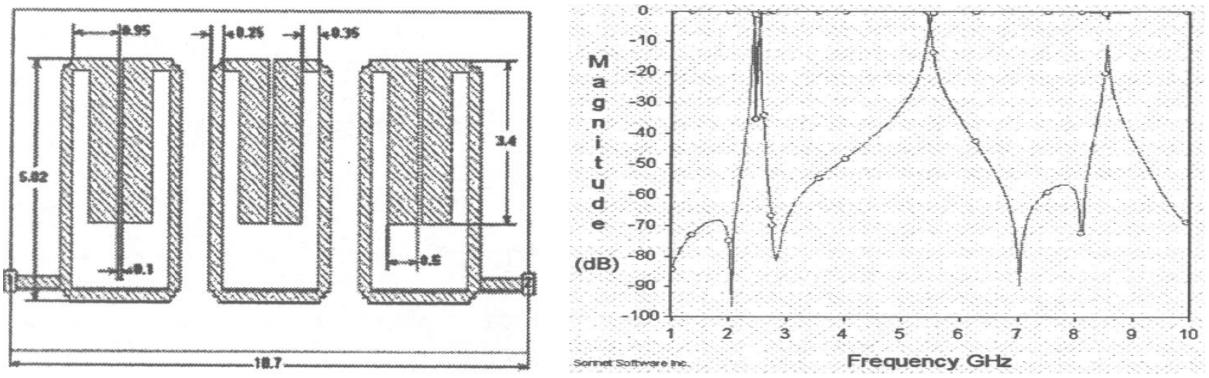
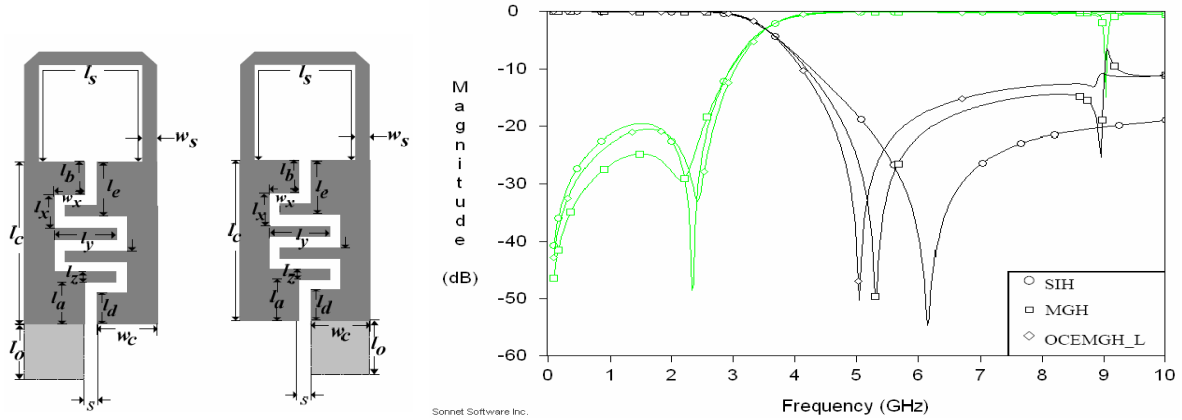


Figure 2. Responses of C_DWB filter (a) in MathCAD (b) from simulations.



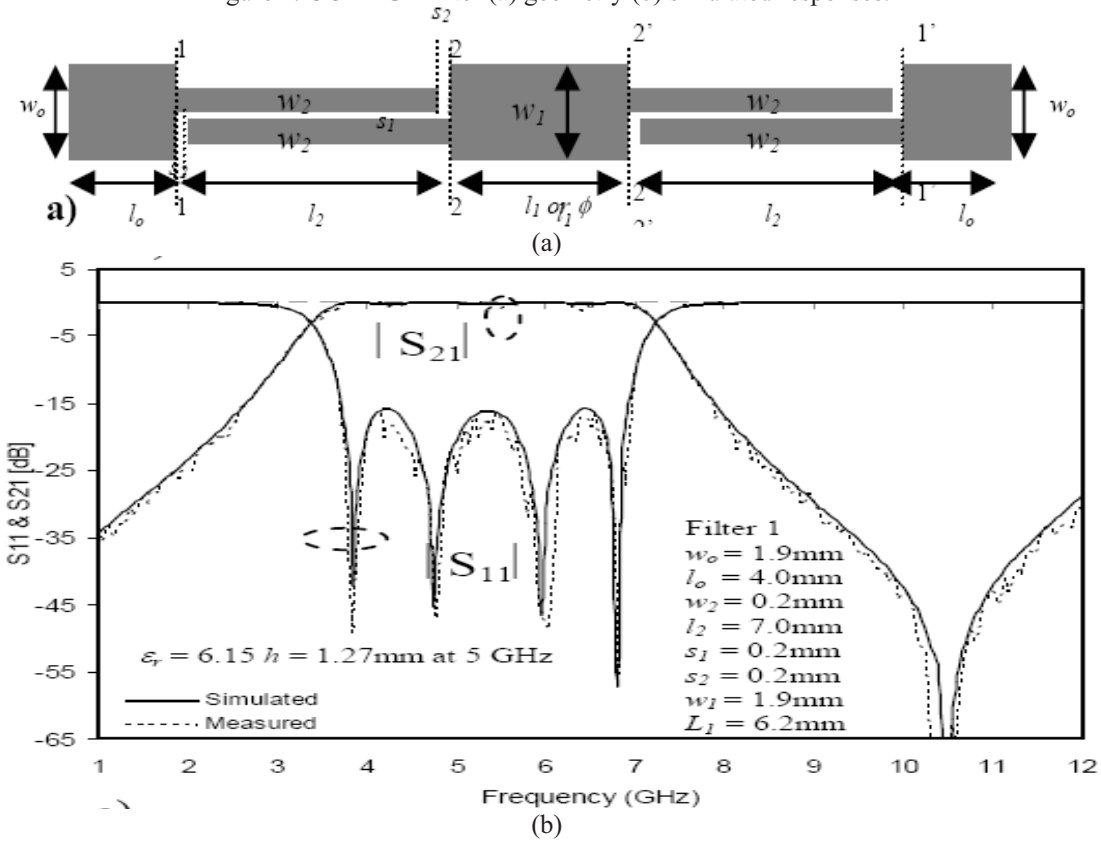
(a) (b)

Figure 3. ICHL filter (a) geometry (b) simulated responses.



(a) (b)

Figure 4. OCEMGH filter (a) geometry (b) simulated responses.



(a) (b)

Figure 5. 3EPCML filter (a) geometry (b) simulated and measured responses.