DESIGN, FABRICATE AND TESTING OF FEED NETWORK FOR 2X2 ARRAY ANTENNA

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Special dedication to my beloved mama and ayah, my entire sibling and my kind hearted supervisor Mrs. Maisarah Binti Abu, my lecturer En. Mohamad Zoinol Abidin Bin Abdul Aziz and my dearest friends.

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ABSTRACT

This reports describe the design, fabricate and testing of feed network for 2x2 array antenna. This feed network was designed using Microwave Office 2004. The project that had developed can support at IMT (International Mobile Telecommunication) 2000 band which is operating at frequency of 1.8 GHz to 2.2 GHz with mobile station transmitting and it applied to many microwave and millimeter-wave systems and devices such as antenna feeders, power amplifiers, etc. We investigate a design method of multi-stage, multi-way microstrip power dividers to construct a compact low-loss power divider with numbers of outputs. First, we describe an integration design technique of multi-way power dividers founded on the planar circuit approach in combination with the segmentation method, and design Wilkinson 2-way power dividers. Next, we successfully design a 4-way power divider consisting of 2 way dividers of three-stage structure using a similar technique. The main characteristic of this project is for uniform power distribution, isolation and return loss.

ABSTRAK

Laporan ini menerangkan proses merekabentuk, fabrikasi dan pengujian rangkaian suapan bagi tatasusunan 2x2 antena. Rangkaian suapan ini telah direka bentuk dengan perisian Microwave Office 2004. Projek yang telah dibangunkan ini akan menyokong jalur lebar IMT 2000 di mana ia beroperasi pada frekuensi 1.8 GHz hingga 2.2 GHz dan ia digunakan dalam pelbagai sistem gelombang isyarat mikro dan milimeter serta peralatan seperti amplifier, penyambung antena dan banyak lagi. Reka bentuk penyalur hubung ini diselidik melalui kaedah berperingkat iaitu peringkat pembahagi kuasa menggunakan teknik Wilkinson untuk membina pembahagi yang padat yang mempunyai kehilangan kuasa yang rendah pada keluaran. Pertama, menerangan mengenai reka bentuk pencantuman bermula di peringkat pembahagi dua kuasa Wilkinson. Seterusnya, reka bentuk pembahagi 4 kuasa Wilkinson berjaya disiapkan yang mengandungi struktur pembahagi dua kuasa Wilkinson melalui kaedah yang sama. Objektif utama projek ini dibangunkan adalah untuk memperoleh pembahagi kuasa yang seragam, sisihan dan kehilangan balikan.

CONTENT

LIST OF ABBREVIATIONS

IMT	International Mobile Telecommunication
FTD	Frequency Time Domain
VSWR	Voltage Standing Wave Ratio
SMT	Surface Mount Thickness
RF	Radio Frequency
EM	Electromagnetic
IEEE	Institute of Electrical and Electronic Engineers
PCB	Printed Circuit Board
UV	Ultra Violet
SNR	Signal to Noise Ratio

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LIST OF SYMBOLS

α_{mn}	Phase difference between the input signals at port m and port n
λ	Wavelength
λ_g	Guided wavelength
b	Coupling coefficient
Z_o	Characteristic impedance
C	Coupling
D	Directivity
I	Isolation
L	Transmission line length
Θ	Phase shift
w	Transmission line width
h	Substrate height
ε_r	Dielectric constant
ε_{eff}	Effective dielectric constant
c	Velocity of light in free space
f	Operating frequency
$tan\ \delta$	Dissipation factor
ε_o	Permittivity of free space
μ_o	Permeability of free space
M	Mitre variable

CHAPTER I

INTRODUCTION

1.1 PROJECT BACKGROUND

This reports documents the design, fabricate and testing of feed network for 2x2 array antenna at IMT 2000 (International Mobile Telecommunication) band using Microwave Office 2004. The feed network builds from many techniques such as Wilkinson power divider, split-tee, directional coupler, and T-junction power divider. The aim of this project is to design feed network using Wilkinson technique. IMT 2000 consist two types that is Core Frequency Band and Extension Band. Additional, for IMT 2000-Core Frequency Band is operating at FTD mode in the bands 1920-1980 MHz paired with 2110-2170 MHz with mobile station transmitting. The main characteristic for this project is for uniform power distribution, isolation and return loss.

The general performance characteristics of a power divider are isolation, amplitude balance, phase balance, VSWR, power handling capability and insertion loss. As an indication of high performance, a power divider has a typical isolation of 20 dB and the higher the isolation, the less chance of leakage between the output ports. Generally, the isolation will degrade at higher frequencies.

Amplitude and phase balances, sometimes referred to as amplitude and phase tracking, are also important indications. These are simply the amplitude and phase differences between the powers at the output ports. Amplitude balance typically increases with the number of output ports. The VSWR indicates how well the input and output ports are matched to each other and to external connections. In addition, the power handling capability is of high importance to the designer. The rating is usually given for matched conditions or matched power rating

1.2 SCOPES OF WORK

This project is divided into three parts:

a) The first phase is about the types of feed network. There are 4 types included corporate, series, space and hybrid feed. For corporate feed, the patch length to each element from feed point is equal, thereby produce equal phase of excitations. For series feed, construction is little more complex and tough because it uses up less space. As the wave travels through the microstrip line, it is attenuated because of the power radiated from each element. In space feed, this type can reduce losses, weight and size of feed network. For hybrid feed, it is build from a combination of series and corporate design.

b) The second phase of my project is about feeding techniques. This project include the Wilkinson power divider, split-tee, directional coupler, hybrid and T-junction power divider. For Wilkinson technique, it can be made with arbitrary power division. This divider is often made in microstrip or stripline form. The directional coupler also can be design for arbitrary power division, while hybrid junction usually has equal power division. Hybrid junction have either a 90° (quadrature) or a 180°(magic-T) phase shift between output port.

c) The third phase of this project is performance requirement of feed network. In feed network, the characteristic included impedance, VSWR, gain, return loss, reflection coefficient, isolation, coupling and directivity.

1.3 PROBLEM STATEMENTS

The feed network is typically a constrained feed consisting of power dividers cascading to obtain certain power distribution for the radiator. In principle, either resistive or reactive loaded power dividers may use in the feed network. The problem that exists in this project is the isolation and return losses in each output port.

1.4 PROJECT OBJECTIVES

For propose, the Wilkinson type power divider is the best technique to design the feed network for 2x2 array antenna. The Wilkinson power divider is such a network, with the useful property of being lossless, when the output ports are matched, that is only reflected power is dissipated.

Otherwise, this project is to analyze the characteristic impedance, VSWR, gain, return loss, reflection coefficient, tangent loss, isolation, coupling and directivity of feed network.

1.5 PROJECT METHODOLOGY

a) The information of power divider and feed network for array antenna is research. All the relevant information that can be use in this project must be record. At the same time, the characteristic of feed network such as gain, return loss, reflection coefficient, tangent loss, isolation and directivity have to study.

b) The software Microwave Office (MWO 2004) has to learn. They will use in this project for design and simulate the circuit of power divider.

c) Meet the specification such as the dielectric substrate and impedance matching. Appropriate components will choose including the connector, FR4 board and SMT chip resistor.

d) Design and redesign the circuit.

e) All planning of the project are monitor to the supervisor.

f) Fabricate the circuit and apply onto the microstrip board.

g) Testing and analyze the circuit using vector network analyzer.

h) Verify the result.

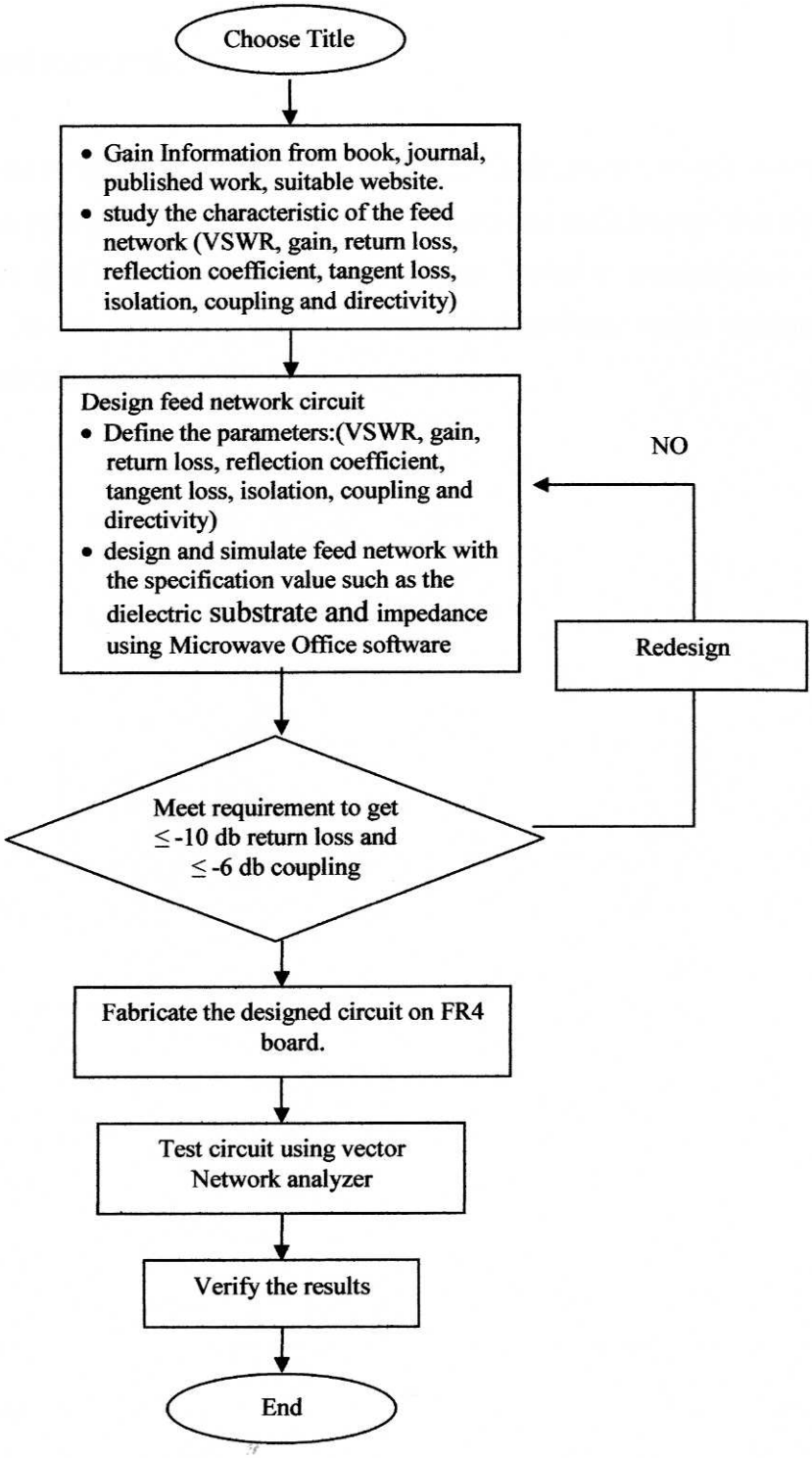

Figure 1.1: Project Methodology in a flowchart

1.6 EXPECTED RESULTS

The expected result in this project is to get the ≤-10 dB return loss and isolation. Wilkinson power divider provides good matching and isolation performance at arbitrary design frequencies (IMT Band). To achieve perfect isolation performance, this Wilkinson power divider requires a quarter-wavelength matching, which occupies a large space in the circuit substrate.