Design and Study of QWT FED Microstrip Patch Antenna at 6.5 Ghz Application

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Abstract- We design the QWT fed micro strip patch antenna at 6.5 GHz application. The first stage is to design square shaped patch Antenna and feeding is done with the QWT feed to match the impedance of 50 ohm. In the simple rectangular microstrip patch, two slots in the patch have been made. The two slots have been made along two corners of the patch. The parametric changes provide the result for 6.5 GHz applications. The frequency 6.5 GHz is chosen because the frequency gives extremely high performance i.e the return loss response exhibiting the characteristic three transformation zeros exceeds 40 dB.

Keywords- *Quarter Wavelength Transformer, Axial Ratio*

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I. Introduction

Antenna is a transducer designed to transmit or receive electromagnetic waves. Microstrip antennas have several advantages over conventional microwave antenna and therefore are widely used in many practical applications. Such as, they are lighter in weight, low volume, low cost, low profile, smaller in dimension and ease of fabrication and conformity. The need for antennas to cover very wide bandwidth is of continuing importance, particularly in the field of electronic warfare and wideband radar and measuring system. Although microstrip patch antennas have many very desirable features, they generally suffer in devices such as varactor diodes.

A microstrip patch antenna (MPA) consists of a conducting patch of any planar or nonplanar geometry on one side of a dielectric substrate with a ground plane on other side. It is a popular printed resonant antenna for narrow-band microwave wireless links that require semi hemispherical coverage. Due to its planar configuration and ease of integration with microstrip technology, the microstrip patch antenna has been heavily studied and is often used as elements for an array. A large number of microstrip patch antennas have been studied to date.

II. Quarter-wave length transformer

Quarter-wave length transformer is a component that can be inserted between the transmission line and the load to match the load impedance to the transmission line's characteristic impedance. This model exemplifies some of the characteristics of a quarter-wave transformer. In particular, the model simulation shows that the transformer only provides matching for one particular frequency, namely that for which the transformer is a quarter of a wavelength long. The objective of this part is to design a single micro-strip patch antenna which consists of patch, quarter wave transformer and feed line. For the patch antenna design, a rectangular patch antenna will be design. Since a 50 Ω surface mount adapter (SMA) connector is going to be used to connect the feed line to the coaxial cable, the feed line will be a 50 Ω feed line. The feed line will be feed to the patch through a matching network which is a quarter-wave transformer.

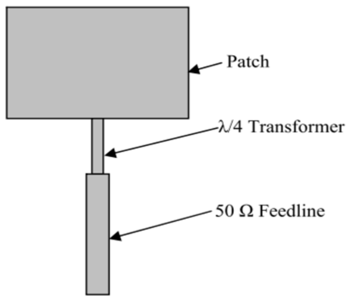

Fig1.1 Patch antenna with quarter wave transformer

The impedance of the quarter-wave transformer is given by the equation

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$Z1 = \sqrt{Rin * Z0}$ ……………………. (1.1)

Where *Z1* is the transformer characteristic impedance and *Z0* is the characteristic impedance (real) of the input transmission line, *Rin* is the edge resistance at resonance.

Design Specifications

Before designing the antenna, the first step is to consider the specification of the antenna base on it application. After performing some research, the various parameters are listed below.

Table-1.2 Design Specifications of microstrip patch antenna

Length of patch	10.7066 mm
Width of patch	16 mm
Frequency	6.5 GHz
Substrate	Glass epoxy
Dielectric Constant	3.38
Substrate Height	1.524 mm

Calculations for the patch antenna dimension

To design one simple patch antenna following Parameters needs to be calculated:

length, width and eventual feed line for microstrip antenna.

To calculate the length of the patch antenna the fringing fields that occurs needs to take into account. The electric field does not end abruptly at the edges and therefore create the "fringing fields". These fields can be represented as two radiation slots which mean that the patch looks electrically larger than the physical size. Because of that the calculated length need to be extended with the fringing factor ΔL so the antenna design is for patch with $L=\lambda/2$ and no fringing.

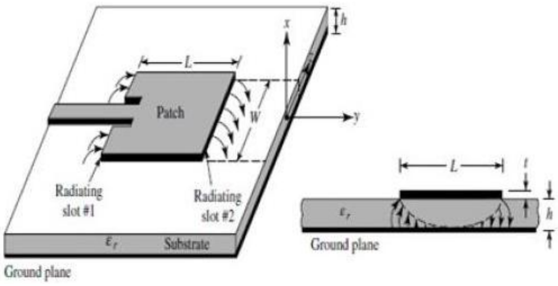

Fig 1.2 Fringing field

For a half - and quarter wave patch the resonate frequency is given by

$f = 12\sqrt{\epsilon_o \mu_o}(L+\Delta L)\sqrt{\varepsilon_{reff}}$ ……………………………. (1.1)

where ϵ_o is the permittivity in vacuum, μ_o is the permeability in vacuum, ΔL is the fringing factor and ε_{reff} is the effective electric constant which take the fringing field outside the patch into account.

Effective electric constant given by the formula

$\varepsilon_{reff} = \varepsilon r + 12 + \varepsilon r - 12\sqrt{1+12hW}$, W/h>1 …… (1.2)

Fringing factor gives by formula

$\Delta Lh = 0.412(\varepsilon_{reff}+0.3)(Wh+0.264)(\varepsilon_{reff}-0.258)(Wh+0.8)$ ……………… (1.3)

To optimize the length and resonant frequency with formula

$L = 0.48\lambda_g \sim 0.49\lambda_g$

$\lambda_g = cf_r\sqrt{\varepsilon_r}$ …………(1.4)

where *c* is the velocity of light in vacuum. The actual length of patch can now be determined by

$L = 12f_r\sqrt{\varepsilon_{reff}}\sqrt{\mu_0\varepsilon_0} - 2\Delta L$ ……………..(1.5)

Width of the patch antenna

The width of the patch gives by formula

$W = 12f_r\sqrt{\mu_0\varepsilon_0}\sqrt{2\varepsilon_r+1} = \upsilon_0 2f_r\sqrt{2\epsilon_r+1}$…………..(1.6)

Where υ_0 is the free-space velocity of light.

It is recommended that the width of the patch is in following interval

$L<W<2L$

QWT Fed antenna for 6.5 GHz

The first stage is to design square shaped patch antenna and feeding is done with the QWT feed to match the impedance of 50 ohm. The parametric changes provide the result for 6.5 GHz applications.

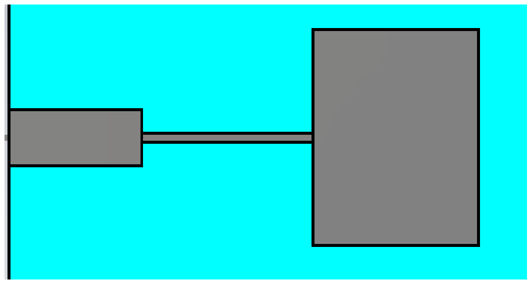

Fig 1.3 CST design of QWT Fed Antenna

Return Loss.

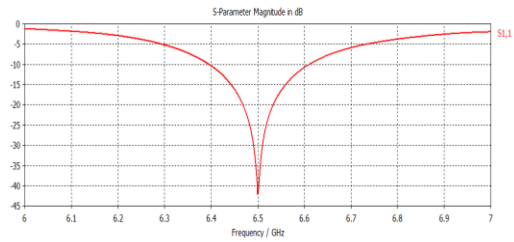

Fig 1.4 Return loss (in dB) for QWT fed antenna at 6.5 GHz.

Radiation Pattern

The radiation pattern is usually a graphical representation of the radiation properties including power flux density, radiation intensity, field strength and polarization as a function of angle. Radiation patterns are also taken at phi=0 and phi=90 values related to object direction. Gain obtained is 8.097 dB.

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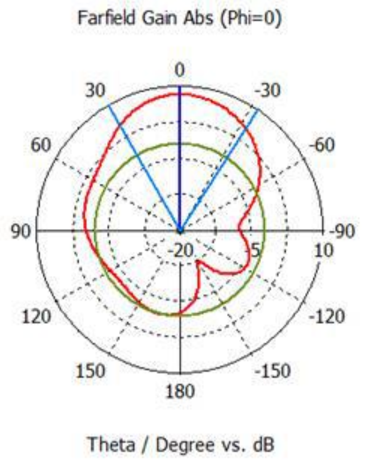

Fig 1.5 Radiation pattern for QWT fed antenna at H-plane, ϕ=0.

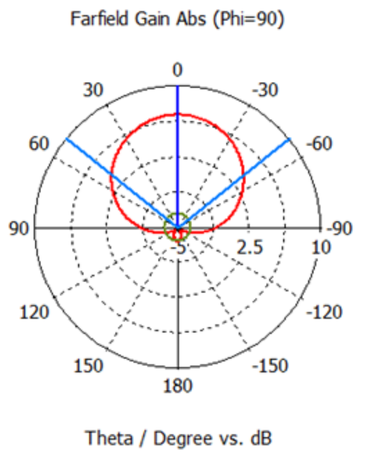

Fig 1.6 Radiation pattern for QWT fed antenna at E-plane, ϕ=90

Axial Ratio

Axial Ratio is a property of an elliptically polarized field. AR is the ratio of major and minor axes of the polarization ellipse. For polarization axial ratio is taken at theta =0 and phi=0 values and this shows that the antenna is linearly polarized as it is 30 dB.

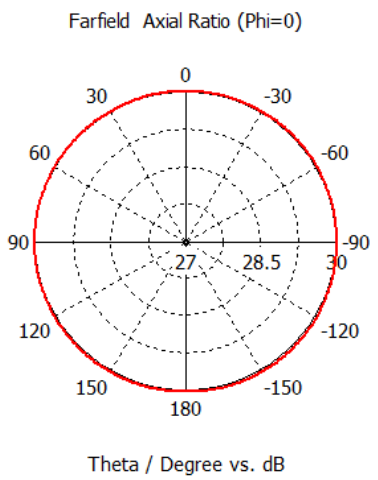

Fig 1.7 Axial Ratio for QWT fed antenna at H-plane, ϕ=0.

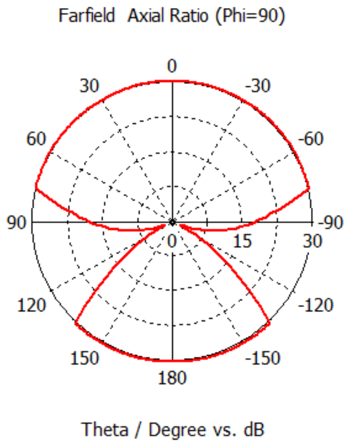

Fig 1.8 Axial Ratio for QWT fed antenna at E-plane, ϕ=90. The Axial Ratio obtained is 30 dB.

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