Experimental Investigation of Dual Operation EMC-Fed Antenna Having Dual-Perturbed Structures

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Abstract - This paper presents the experimental investigation of a dual-operation antenna operating in the L-band region. The basis of the design is the basic rectangular patch. The patch is perturbed with embedded two L-section structures. The chosen frequencies are 1.575 GHz for Global Positioning System (GPS) satellite receiver and 1.8 GHz for Global System for Mobile (GSM). The antenna has been measured for its one and two-port performance. Optimum feed location was determined to be at the 14.5 mm location from the antenna edge. It was found that the antenna operates well near the designed frequency of operations.

1. Introduction

Future telecommunications systems demand space limited application. Hence, the research work on antenna has grown larger. In addition, there is a need for an antenna which can operate at dual frequencies. One example is on a moving vehicle where the user can detect his/her location while communicating with with another user at the same time. The relevant frequencies could be Global Positioning System, GPS, and Global System for Mobile, GSM. The existence of an antenna, rather than two antennas for transmitting and receiving, is highly desirable. Thus, the problem of limited space can be overcome. Consequently, the total manufacturing cost can be reduced.

2. Dual-Perturbed Structures

The research on microstrip antennas has progressed into the new millennium. The antennas have well known desirable advantages such as small size, low cost, ease of construction, conformability and ease of integration with printed circuits [1],[2]. Dual operation antennas have gained importance in the development of compact structures [3] to [13].

In the research work undertaken, the antenna is finally designed with dual-perturbed structures. The basis of the design is the rectangular patch antenna. Hence, the dimensions of the basic patch antenna is first derived using formulations available in the literature [1], [2]. The board properties are as follows: dielectric relative permittivity $\varepsilon_r = 3.2$, loss tangent $\delta = 0.001$, copper conductivity = 5.882×10^7 S/m and copper thickness = t = 0.035 mm. The derivation of the basic radiating patch is computed using Mathcad software [14]. The designed antenna was later simulated using electromagnetic simulation softwares; Micropatch [15] and Sonnetlite [16].

From the dimensions of the basic patch, investigations on having two L-shaped embedded elements meant for perturbing the rectangular antenna have been successfully performed on the antenna [12]. The structure is illustrated in Figure 1.

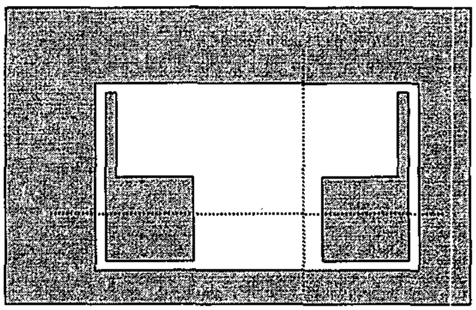

Figure 1: Designed antenna with dual-perturbed structures. The clear area is the copper radiating element.

The dimensions of the patch starts with L = 48 mm, W = 35 mm with f_{r1} = 1.7 GHz and f_{r2} = 2.25 GHz. This allows further finetune of the embedded L-shaped perturbed element. Hence, upon final finetuning, a much smaller antenna size is expected.

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The feeding technique chosen is the electromagnetic coupling type from underneath the substrate.

Having such perturbed structures allow the frequency of operation to be separately controlled by the structure. The desired frequency of operations are 1.575 GHz and 1.8 GHz. The operating frequency ratio is thus 1.14. The GPS frequency has to be the fundamental frequency while the GSM frequency is the second harmonic.

The basic rectangular antenna operating at the same frequency has dimensions equal to W x L = 52.35 x 65.72 mm^2. The simulated perturbed antenna named RPRem was found to be W x L = 35 x 48 mm^2. There is a significant 50 % size reduction.

3. Experimental Investigations

Two sets of RPRem antennas have been implemented and fabricated. The first set, A-RPRem antenna, was fabricated and tested for the best feed location. The structure is as given in Figure 2. There is no specific ground size. The second set, B-RPRem antennas, consists of two identical antennas. The antennas have specific size of ground plane. This is shown in Figure 3.

For both antennas, one and two-port performances have been measured using AntennaLab set-up. A-RPRem antenna was referenced to a Yagi-Uda array shown in Figure 4 for the two-port measurement. The set-up has a frequency range of 1.2 to 1.8 GHz. Hence, the second resonance may not be seen / measured using the set-up.

The measured return loss responses for the best feed location determination are as given in Figures 5 to 8. It was found that the best feed location is 14.5 mm. The corresponding return loss is −15 dB at 1.585 GHz. In Figure 9 is the excellent broadband return loss response of the Yagi-Uda array antenna. The measured return loss response of the B-RPRem antenna is given in Figure 10. It showed a good return loss of −15 dB at a shifted 1.625 GHz.

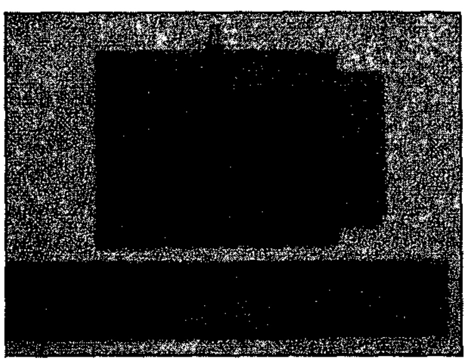

Figure 2: Fabricated A-RPRem EMC-fed antenna.

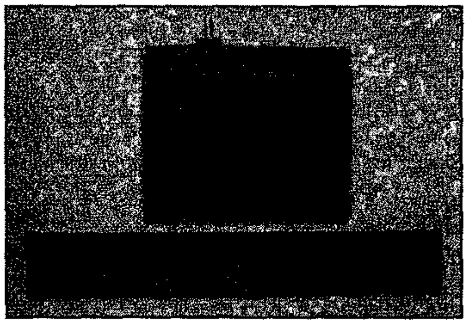

Figure 2: Fabricated B-RPRem EMC-fed antenna.

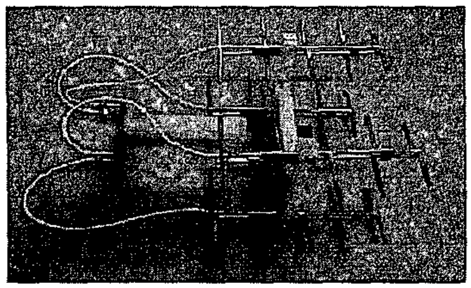

Figure 4: Yagi-Uda array reference antenna.

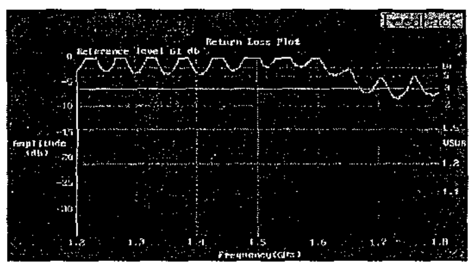

Figure 5: Measured return loss reponse of A-RPRem antenna at 3.5 mm feed location.

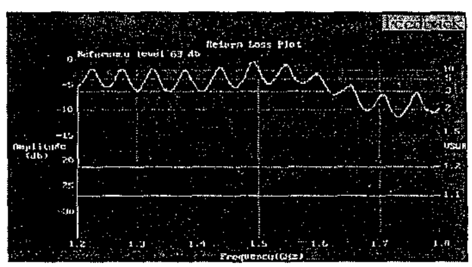

Figure 6: Measured return loss reponse of A-RPRem antenna at 7 mm feed location.

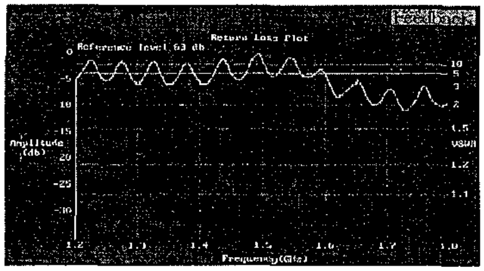

Figure 7: Measured return loss reponse of A-RPRem antenna at 10.5 mm feed location.

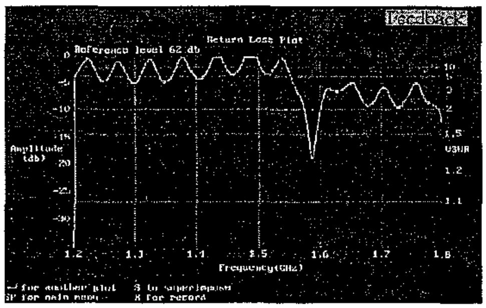

Figure 8: Measured return loss reponse of A-RPRem antenna at 14.5 mm best feed location.

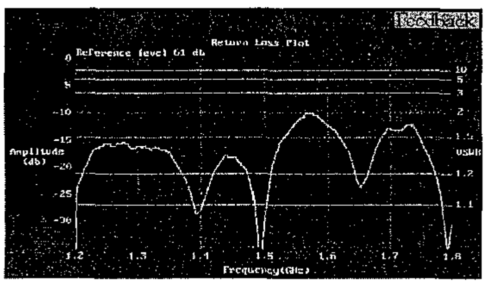

Figure 9: Measured return loss response of the Yagi-Uda array receive reference antenna.

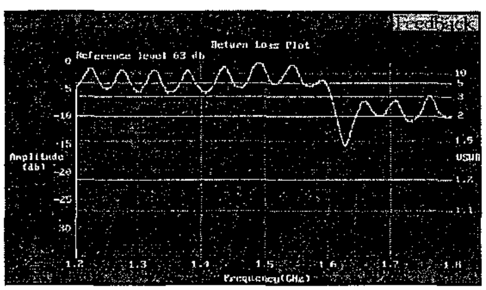

Figure 10: Measured return loss response of B-RPRem EMC-fed antenna.

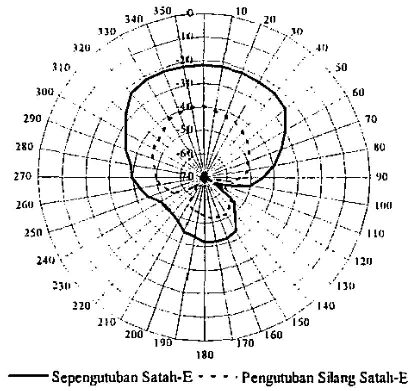

Figure 11: Measured E-field radiation patterns of the A-RPRem antenna at first resonance.

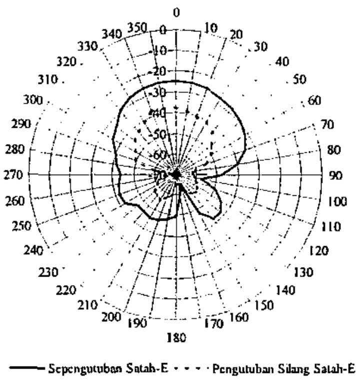

Figure 12: Measured E-field radiation patterns of the A-RPRem antenna at second resonance.

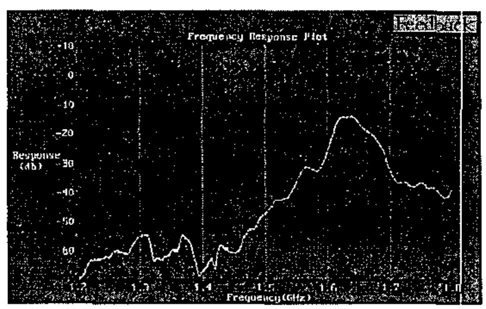

Figure 13: Measured frequency response of the B-RPRem EMC-fed antenna. Peak is at

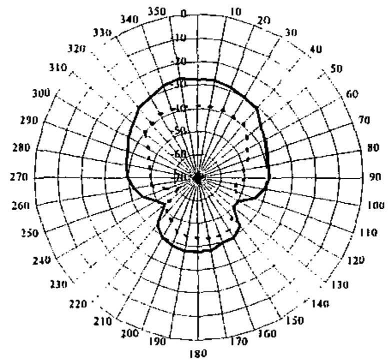

Figure 14: Measured E-field radiation patterns of the B-RPRem antenna at first resonance.

Figures 11 and 12 showed the measured E-field radiation patterns of the A-RPRem antenna at first and second resonance, respectively. The half power beamwidths are large, as expected. The cross-polar patterns are low indicating good radiation properties.

4. Summary

The overall performance indices of the A-RPRem and B-RPRem antennas are given in Table 1.

Table 1: Measured performance indices of the antennas.

	A_RPRem		B_RPRem	
	f_1	f_2	f_1	f_2
Frequency, GHz	1.585	> 1.8	1.625	> 1.8
$\|S_{11}\|$, dB	-18	< -12	-15	< -9
$\|S_{12}\|$, dB	-26	-20 hingga -30	-14	
HPBW	80°	65°	80°	
BW, MHz	24		30	
VSWR	1.28	< 1.7	1.43	< 2.09

The empty boxes showed no data obtained due to over-range.

The perturbed single-element antenna has been further modified to produce dual-perturbed structures. The main motivation is that, the dual-frequency characteristic is also easily controlled by the corresponding perturbed structure.

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