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Journal of Electrical Engineering and Modern Technology

Aims and Scope

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Contents

Simulation of Self Powered Piezoelectric Energy Harvesting Shoe

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ABSTRACT

As the power requirements for microelectronics continue decreasing, environmental energy sources can begin to replace batteries in certain wearable subsystems. Sustaining the power resource for autonomous wireless and portable electronic devices is an important issue. In this spirit, this paper examines a device that can be built into a shoe, (where excess energy is radially harvested) and used for generating electrical power "parasitically" while walking. Piezoelectric polymers hold promise as energy harvesting materials due to their flexibility and strength which make them ideal candidates for use in more diverse applications.

This paper presents a complete system simulation of piezoelectric energy harvesting shoe. The components are described that allows the electrical and mechanical models of the system. The simulations presented here give a detailed description of the performance of the piezoelectric ceramic. The results obtained with the simulation model implemented allow showing how design choices of the system change the periodicity of the transmission and the ability to recharge the battery.

Keywords — piezoelectric polymers, simulation of piezoelectric, periodicity of transmission.

I. INTRODUCTION

Energy has been essential in building up modern society. It is required everywhere from the household light bulb to a mission to Mars. Some energy can be seen, light for example, but most does not have a visible form. Energy is defined in several ways, such as mechanical, electrical, and chemical. All of these definitions are based on where the energy is stored.

Piezoelectricity from the Greek word "piezo" means pressure electricity. It is the property of certain crystalline substances to generate electrical charges on the application of mechanical stress. Conversely, if the crystal is placed in an electric field, it will experience a mechanical strain. Such materials are useful as transducer elements for transducing electrical energy into mechanical energy and vice versa. When an AC voltage is applied, it will cause it to vibrate and thus generate mechanical waves at the same frequency of the input AC field. Similarly, it would sense the input mechanical vibrations and produce the proportional charge at the matching frequency of the mechanical input.

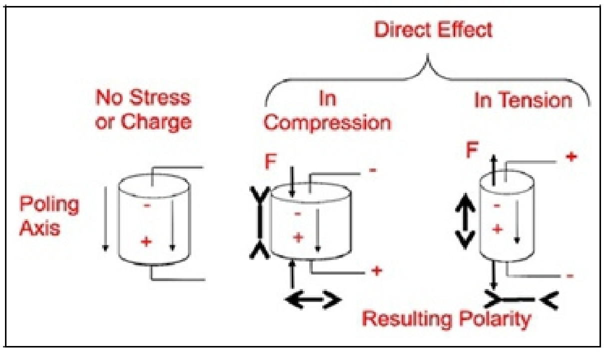

Fig.1.Schematic Direct Piezoelectric Phenomenon

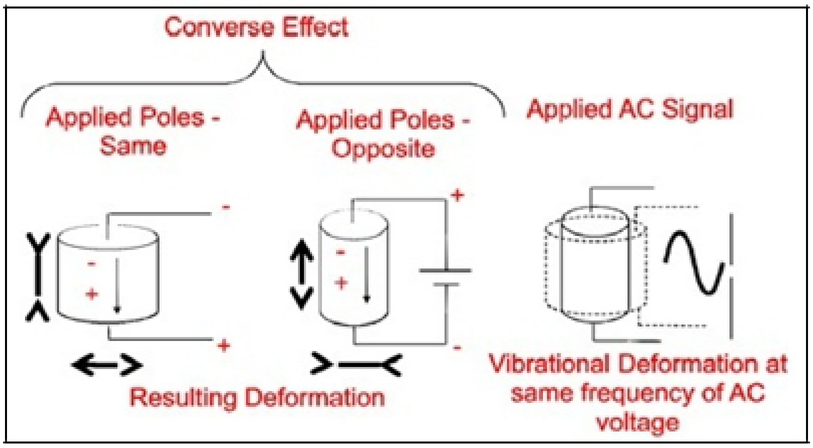

Fig.2.Schematic Inverse Piezoelectric Phenomenon

II. SIMULATION OF PIEZOELECTRIC

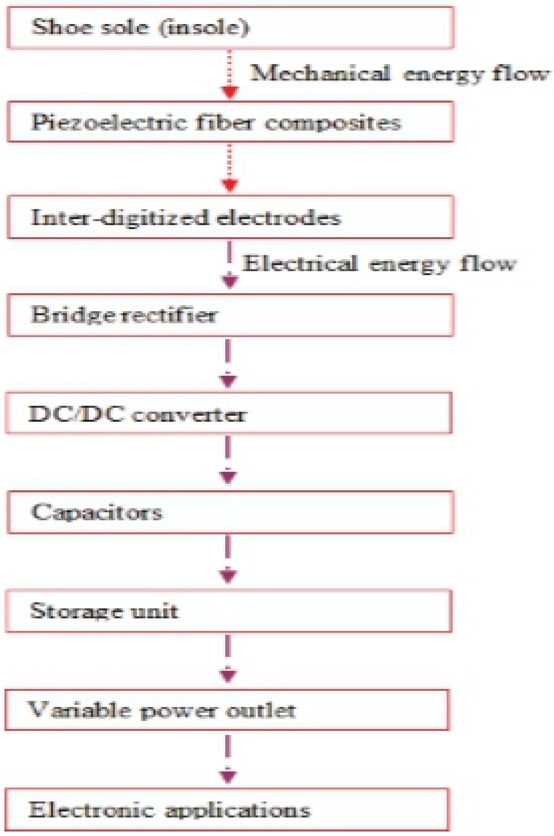

Fig.3.Overall Energy-Harvesting Model.

Basic Circuit for Simulation

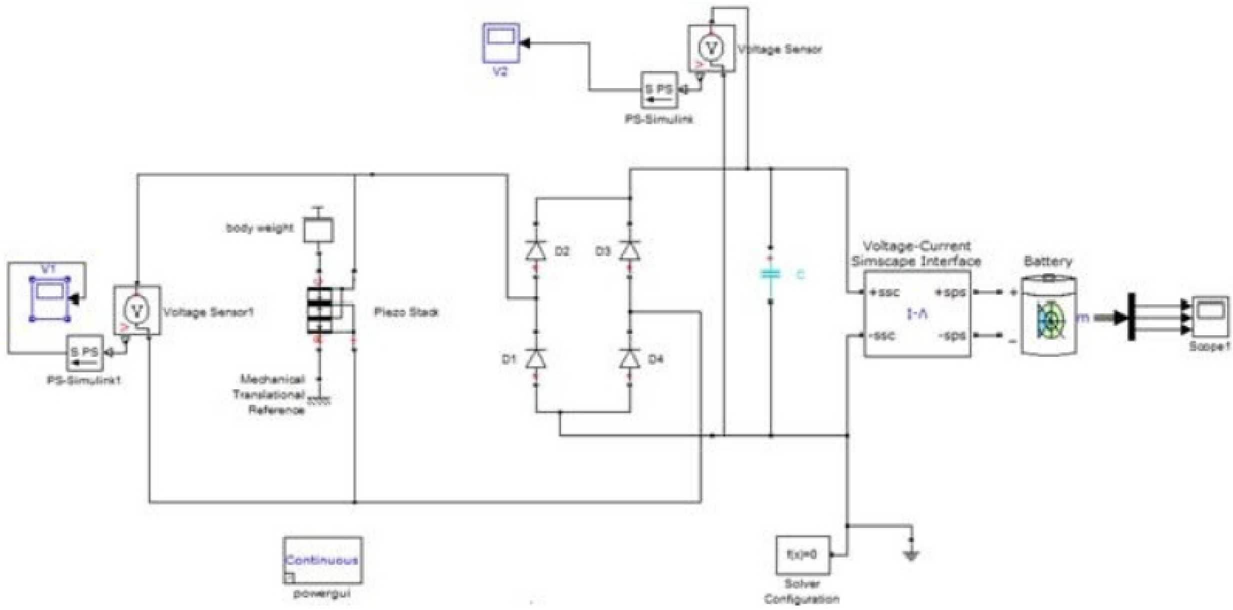

Fig.4.Basic Simulation Model

Description of Circuit Design and Simulation Circuit

The circuit shown in Figure 4 was designed has four phases to represent the overall energy- harvesting circuit modules. The first module (piezo stack) is a mechanical-to- electrical energy conversion module and produces AC power. The second module has rectification (the conversion of AC voltage to DC voltage) unit consist of full bridge rectifier and third unit is an energy-storage unit (intermediate capacitor). The fourth stage is a rechargeable battery that senses the voltage level of the intermediate capacitor and transfers it to the battery charging circuit.

For the purpose of energy harvesting and storage, shoe or sneaker insoles are good sources of mechanical stress, deformation, and vibration when a person is walking or moving his/her feet. With this method, waste-ambient mechanical energy was converted to electrical voltage through a unique energy-harvesting circuit. An overall energy-harvesting model is shown in the circuit below to explain implementation steps and potential applications. In order to have the best efficiency and output power, the circuit was designed and developed according to the ambient-source, characteristics, PZT ceramic-fiber composite and load constraints. The energy- harvesting system is capable of capturing even minute amounts of stress and vibrations, then converting them to electric power sufficient to run low-power electronic systems.

III. RESULTS OF SIMULATION

(a) while a 100 kg man running at a speed of 3 m/s:

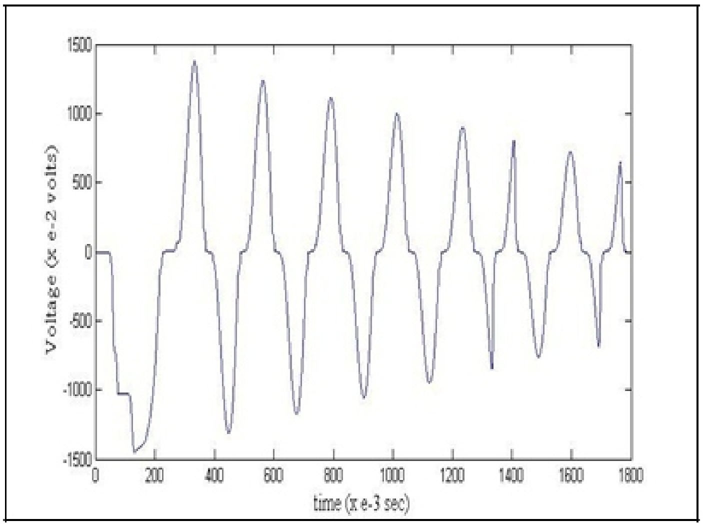

Fig.5.Voltage Produced by Piezo-stack.

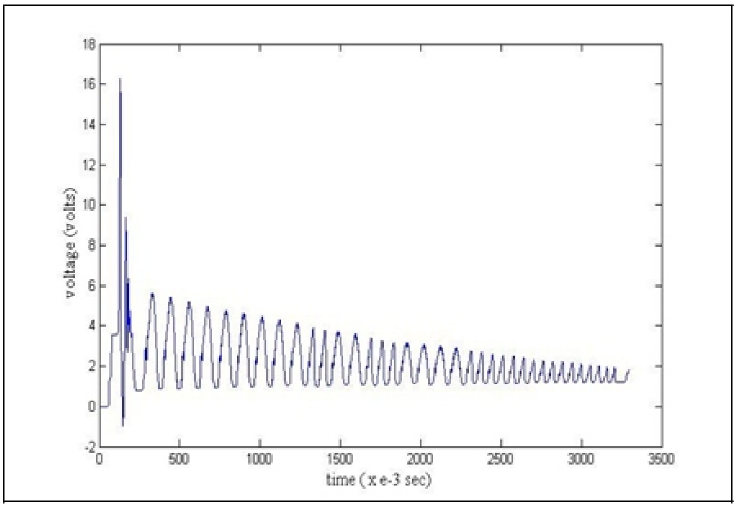

Fig.6.Rectified Voltage Output

Output of 1.2 V Li-ion Battery

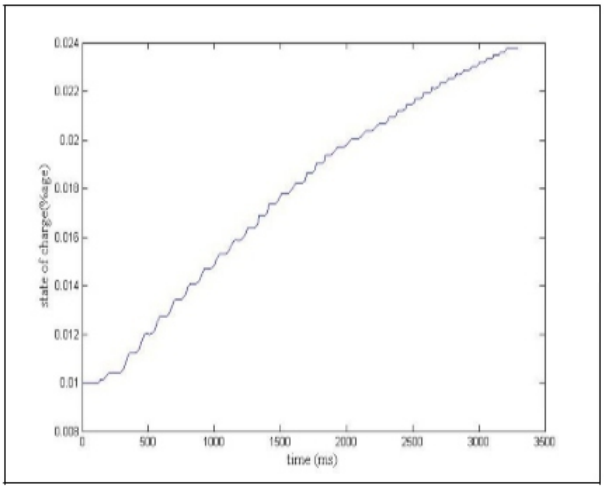

Fig.7.State of Charge

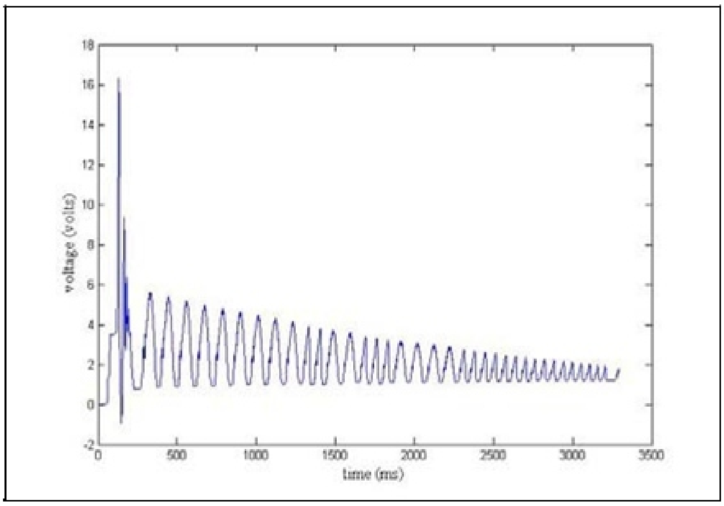

Fig.8.Voltage Output

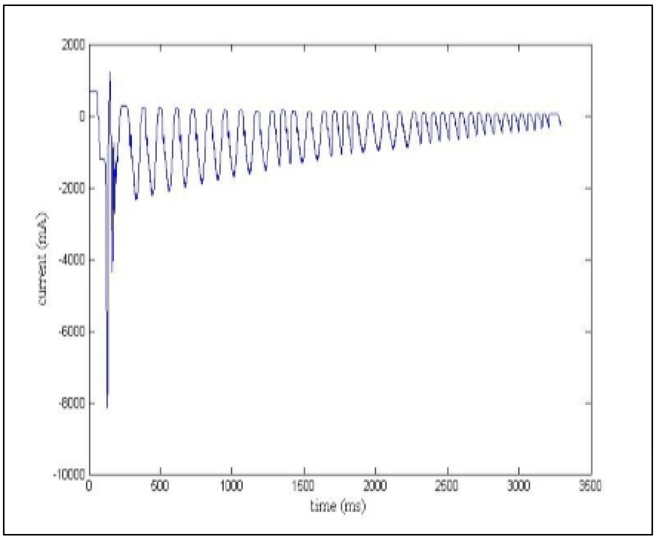

Fig.9.Current Output

(b) while a 100 kg man running at a speed of 6 m/s:

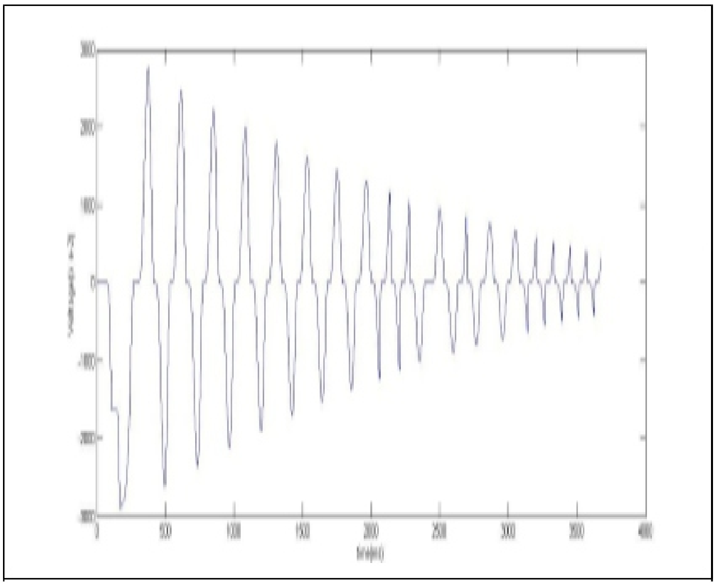

Fig.10.Voltage Produced by Piezo-stack.

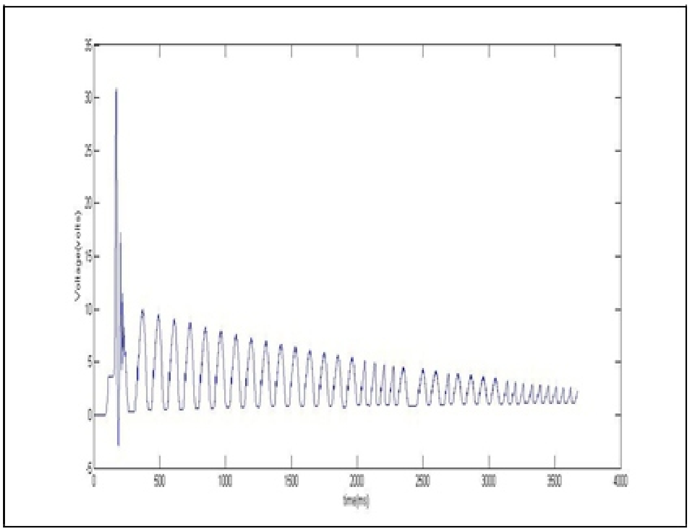

Fig.11. Rectified Voltage Output

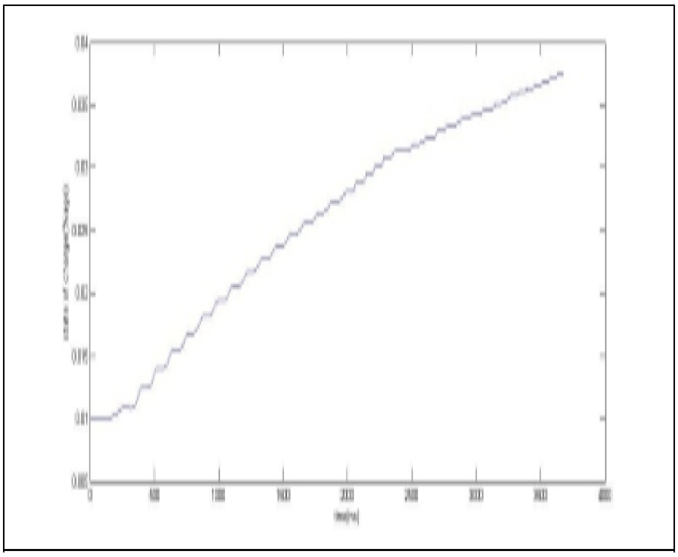

Fig.12.State of Charge

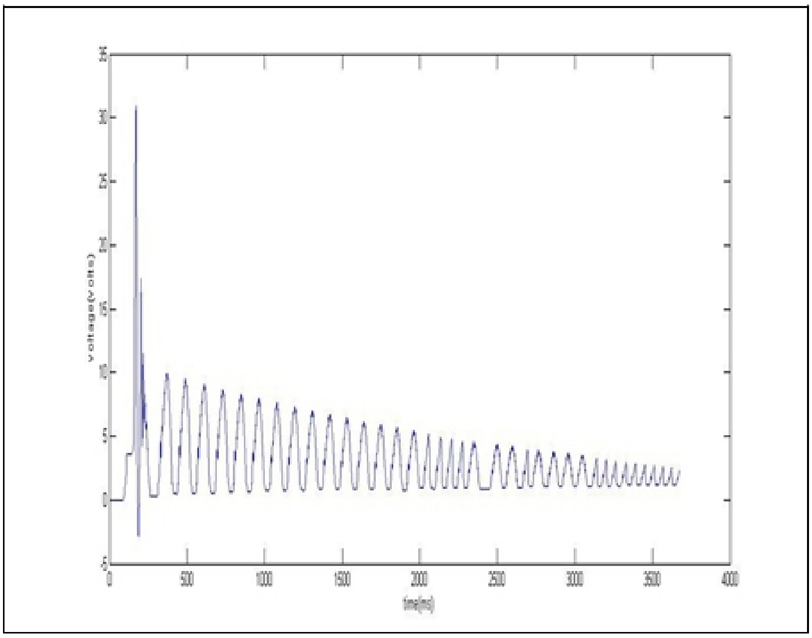

Fig.13.Voltage Output

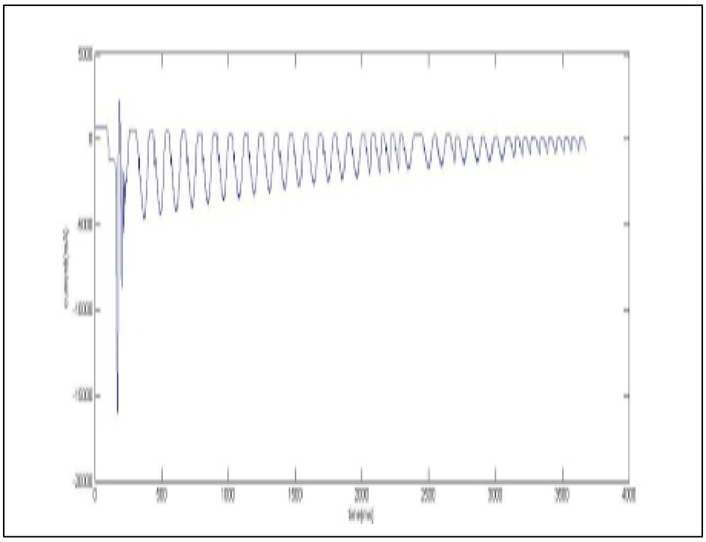

Fig.14.Current Output

© while a 60 kg man running at a speed of 3m/s:

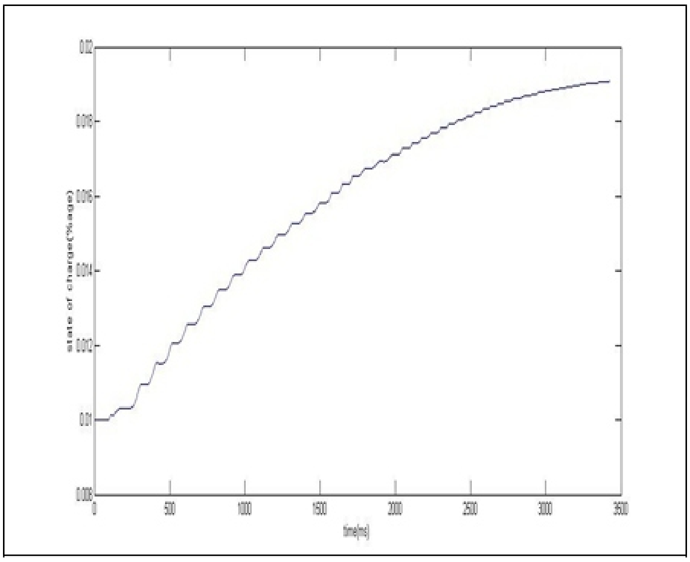

Fig.15.State of Charge

(d) while a 60 kg man running at a speed of 6m/s:

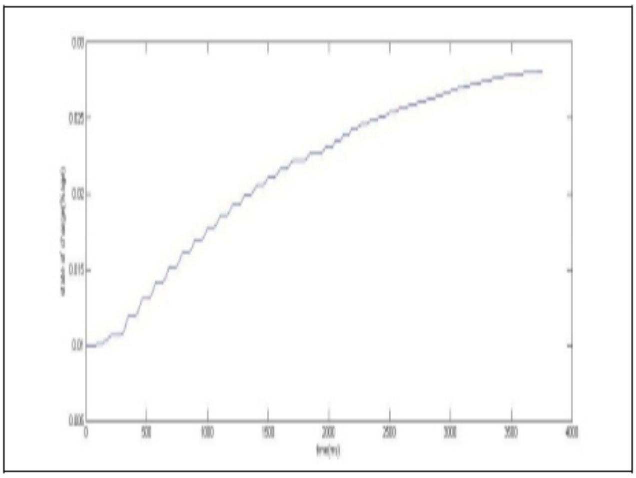

Fig.15.State of Charge

IV. CONCLUSION

On increasing weight and speed, the percentage state of charge increases as shown in Table 1.

Table1. Variation in State of Charge(%age) with speed and weight.

speed/weight	100kg	60kg
3 m/s	0.02372	0.01908
6 m/s	0.03743	0.02803

In order for these devices to be useful, several criterions must be met. First, they must generate enough power. For most of the applications discussed so far, the requisite 1-5 mW of power is already being produced in our simulation. Till now we have studied various parameters of piezoelectric and done simulation using these parameters. Further we have simulated simple charging of the Li-ion battery and obtained various plots.

V. ACKNOWLEDGEMENT

It is our great privilege to express our deep gratitude and indebtedness to our guide Mr. ASHUTOSH SHUKLA, for leading us to the topic, "SIMULATION OF SELF POWERED PIEZOELECTRIC ENERGY HARVESTING SHOE", as well as providing us all the necessary guidance and the inspirational support throughout the project work. We are grateful for the hours he spent in discussing and explaining even the minute details of the work in spite of his hectic work schedule. He listened patiently and authoritatively as he guided and gave his valuable suggestions.

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Speed Control of Seperately Excited DC Motor using Adaptive PID Controller

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A B S T R A C T

This paper deals with the idea to find perfection for Model Reference adaptive PID Control (MRAPIDC) by providing smooth control to the separately excited DC Motor. The PID controller is integrated with the adaptive observer to simplify the implementations. The output of the system is compared to a desired response from a reference model. The control parameters are updated based on this error. The goal is for the parameters to converge the ideal values to match the response of the reference model.

Keywords----Separately Excited DC Motor (SEDM), Model Reference Adaptive Control (MRAC), Model Reference Adaptive PID Control (MRAPIDC).

I. INTRODUCTION

Direct Current (DC) Motors have been dominating the field of adjustable speed drives for over a century. It is due to their excellent operational properties and control characteristics; hence are used extensibly in variable-speed drives. DC motor can provide a high starting torque and is used to obtain speed control over a wide range.One of the aims of this paper is to present a way of designing an adaptive observer for separately excited DC motor.

II. MODELING OF DC MOTOR

A separately excited Dc motor could be characterized by the following mathematical model[2]:

$$m_d = m + d_L + d_U$$

$$v_a(t) = R_a i_a(t) + L_a \frac{di_a(t)}{dt} + e_b(t)(2) \qquad (1)$$

$$e_b(t) = K_b m(t) i_f(t)(3)$$

$$K_N + I_a(t) = J\frac{dm(t)}{dt} + Bm(t) + T_L(4)$$

$$v_f(t) = R_f i_f(t) + L_f \frac{di_f(t)}{dt} \qquad (5)$$

Where, va(t) is the armature supply voltage (V); ia(t), the armature current (A); eb(t), theback emf (V);vf(t), the field supply voltage (V);if(t), the field current (A);Ra , the armature resistance (Ω); La, the armature inductance (H); Rf, the field resistance (Ω); Lf, the field inductance (H); Td(t), the developed torque (Nm); ω(t), the motor speed (rad./s); TL, the load torque (N-m); J, inertia of the system (kg-m); Bm,viscous friction coefficient (Nms); Kb, motor constant. The Simulink Model of DC Motor is shown in figure 1.

On taking Laplace transform of the system differential equations (2)–(5) with zero initialconditions, we may write,

$$I_a(s) = \frac{V_a(c) - E_b(c)}{R_a + cL_a} \quad (6)$$

$$E_b(s) = K_b I_f(s) m(s) \quad (7)$$

$$m_N(s) = \frac{K_N + I_a(c) - T_L}{B + cJ} \quad (8)$$

$$I_f = \frac{V_f(c)}{R_f + cL_f} \quad (9)$$

From equations (6) and (8) the transfer function of the DC motor with no load torque and uncertainties (d = 0) is obtained from let TL = 0:

$$\frac{m(s)}{V_a(s)} = \frac{\frac{K_N}{JL_a}}{\left[s^2 + \frac{(JR_a + BL_a)}{JL_a} s + \frac{(BR_a + K_N K_b)}{JL_a}\right]}$$

First considering the case with only load disturbances $T_L \neq 0$

$$d_L = \frac{-T_L\left(\frac{R_a}{JL_a} + c\left(\frac{1}{J}\right)\right)}{\left[c^2 + \frac{(JR_a + BL_a)}{JL_a} c + \frac{(BR_a + K_N K_b)}{JL_a}\right]} \quad (10)$$

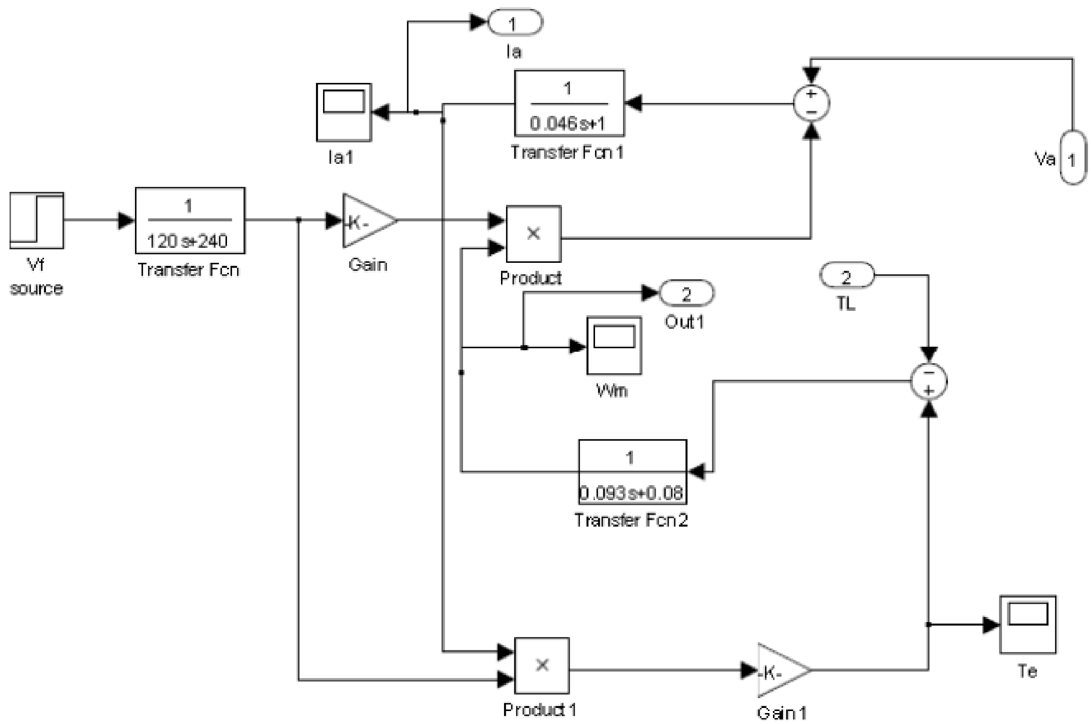

Figure 1: Simulink Model of Separately Excited DC Motor

III. MODEL REFERENCE ADAPTIVE PID CONTROL (MRAPIDC):

The idea behind Model Reference Adaptive Control is to create a closed loop controller with parameters that can be updated to change the response of the system to match a desired model. In Model Reference Control (MRC), a good understanding of the plant and performance requirements it has to meet allow the designer to come up with a model, referred to as the Reference Model, that describes the desired I/O properties of the closed loop plant. When the plant parameters and the disturbances are slowly or slower than the dynamic behaviour of the plant, then a MARC control is used. The model reference adaptive control scheme is shown in figure 2. The adjustment mechanism uses the adjustment parameter known as control parameter Θ to adjust the controller parameters. The tracking error and the adaption law for the controller parameters were determined by MIT Rule [6].

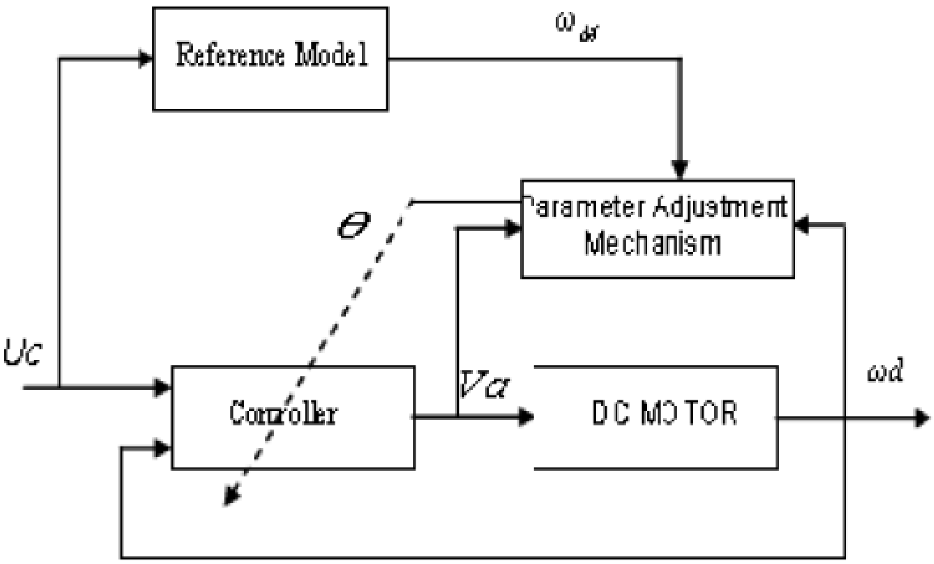

Figure 2: Structure of Model Reference Adaptive Control

MIT (Massachusetts Institute of Technology) Rule is that the time rate of change of Θ is proportional to negative gradient of the cost function (J) that is:

$$\frac{d8}{dt} = -y\frac{dJ}{d8} = -ys\frac{ds}{d8} \qquad (11)$$

The adaption error,s = yp(t) — yM(t). The component of ds⁄d8 are the sensitivity derivatives of the error with respect to adjustable parameters vector Θ. The parameter γ is known as the adaption gain. The MIT rule is a gradient scheme that aims to minimize the squared model error ε2 from cost function [1]:

$$J(8) = \frac{1}{2}s^2(t) \qquad (12)$$

The aim is to develop parameter adaption laws for a PID control algorithm using MIT rule. The reference model for the MRAPIDC generates the desired trajectory yM, which the DC motor speed yp has to follow.

Standard second order differential equation was chosen as the reference model:

$$H_M(s) = \frac{b^M}{c^2 + a_{M1}c + a_{M0}} \qquad (13)$$

$$H_M(s) = \frac{b^M}{c^2 + a_{M1}c + a_{M0}} \quad (13)$$

Considering the adaption law of MRAPIDC structure as [5]:

$$u(t) = (K_p e(t) + K_i \int e(t)dt - K_d e^{x}(t) y_p) \quad (14)$$

Where: $e(t) = u_c - y_p$, K_p is proportional gain, K_i is integral gain, K_d is derivative gain and u_c is a unit step input. Taking Laplace transform of equation (14) we get:

$$U = (K_p E + \frac{K^i}{c} E - sK_d y_p) \quad (15)$$

After applying this control law to the system it is possible to give the following closed loop transfer function:

$$Y_p = G_p((K_p + \frac{K^i}{c})(u_c - y_p) - sK_d y_p) \quad (16)$$

Applying MIT gradient rules for determining the value of PID controller parameters ($K^{\cdot}_p$, $K^{\cdot}_i$ and $K^{\cdot}_d$). The tracking error equation (13) satisfies:

$$s = \frac{(G_p K_p c + G_p K_i) U_c}{(c(1 + G_p K_p) + G_p K_i + c^2 G_p K_d)} - Y_M \quad (17)$$

Since exact formulas cannot be used instead some approximations are required. An approximation is made valid when parameters are closed to ideal value as follows [8]: Denominator of plant ≈ Denominator model reference, then gradient method.

$$\frac{dK}{dt} = -y \frac{6J}{6K_i} = -y \left(\frac{6J}{6s}\right)\left(\frac{6s}{6F}\right)\left(\frac{6F}{6K}\right) \quad (18)$$

Where $\frac{6J}{6s} = s$, $\frac{6s}{6F} = 1$

Then the approximate parameter adaption laws are as follows:

$$K_p = \left(-\frac{y_p}{c}\right) s \left(\frac{c}{a_0 c^2 + a_{N1} c + a_{N2}}\right) e \quad (19)$$

$$K^{\cdot}_i = \left(-\frac{y^i}{c}\right) s \left(\frac{1}{a_0 c^2 + a_{N1} c + a_{N2}}\right) e \quad (20)$$

$$K_d = \left(\frac{y^d}{c}\right) s \left(\frac{c^2}{a_0 c^2 + a_{N1} c + a_{N2}}\right) Y_p \quad (21)$$

IV. SIMULATION RESULTS:

In this part, some simulation is carried out for MRAPIDC separately excited DC motor controller. Matlab software is used for the simulation of control systems. Figure 3 shows the Simulink models for both MRAPIDC along with the motor under control. The parameters of separately excited DC motor are considered as:

Km = Kb = 0.55; Ra =1Ω; La =0.046 H; J = 0.093 Kg^2.m; B = 0.08 Nm/s/rad.

Also, the second order transfer function of the Model Reference as follows:

$$H_M = \frac{16}{s^2 + 8s + 16}$$

This reference model has 16% maximum overshoot, settling time of more than 2 seconds and rise time of about 0.45 seconds. In simulation, the constants gammas were grouped in five sets as in table 1.

Table 1: Groups of Gammas

set	1	2	3	4	5
y_p	0.2	0.4	0.6	0.8	1.0
y_i	0.8	1.6	2.4	3.2	4.0
y_d	0.48	0.96	1.44	1.92	2.4

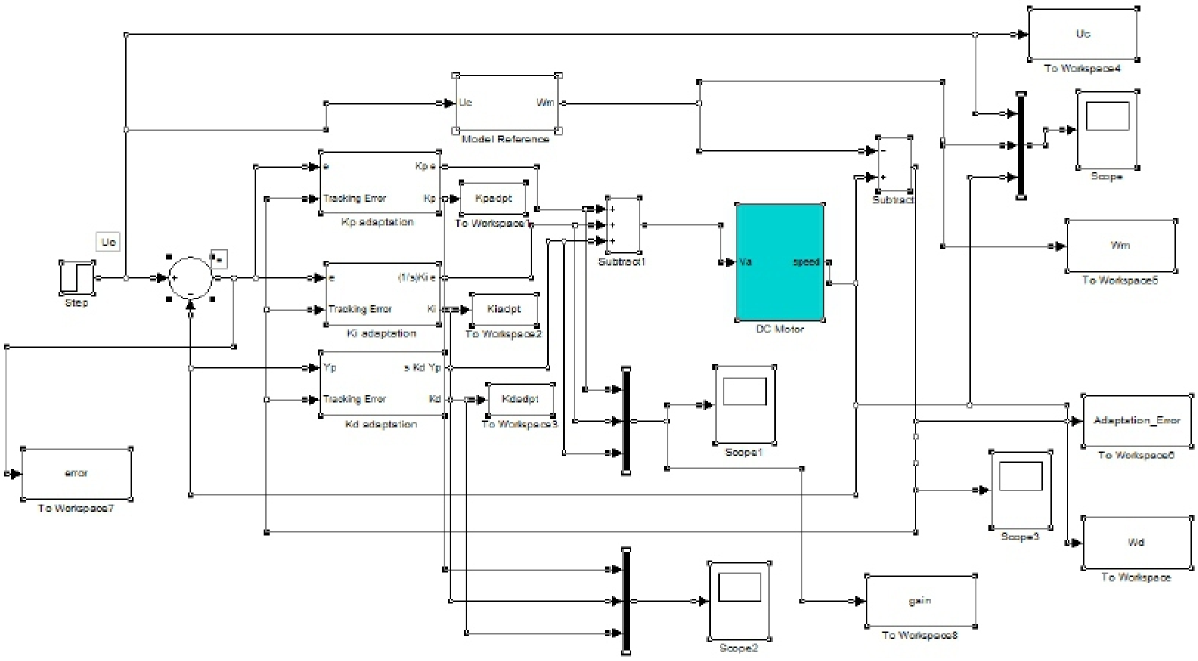

Figure 3: Simulink Model for MRAPIDC

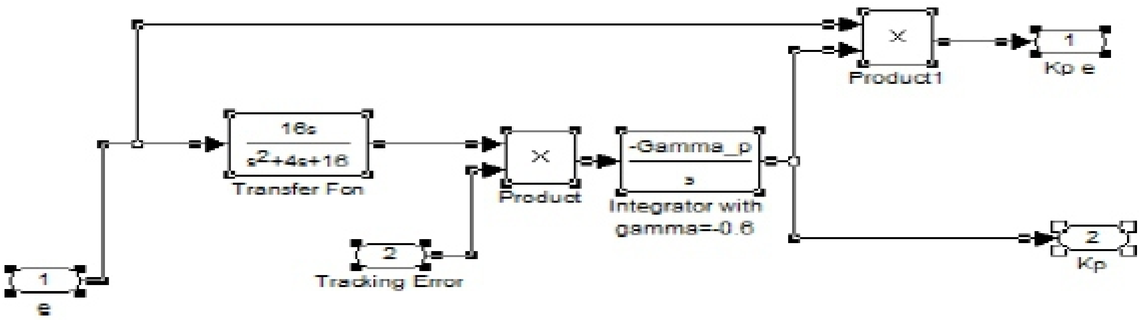

Figure 4: Simulink Model for Proportional Adaption Gain (MIT rule)

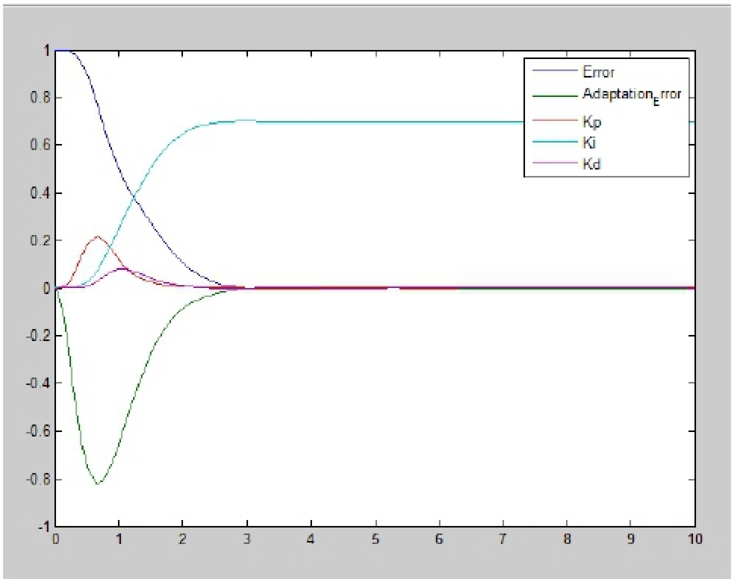

Figure 5: Error, Adaption Error and Adaption PID Gains

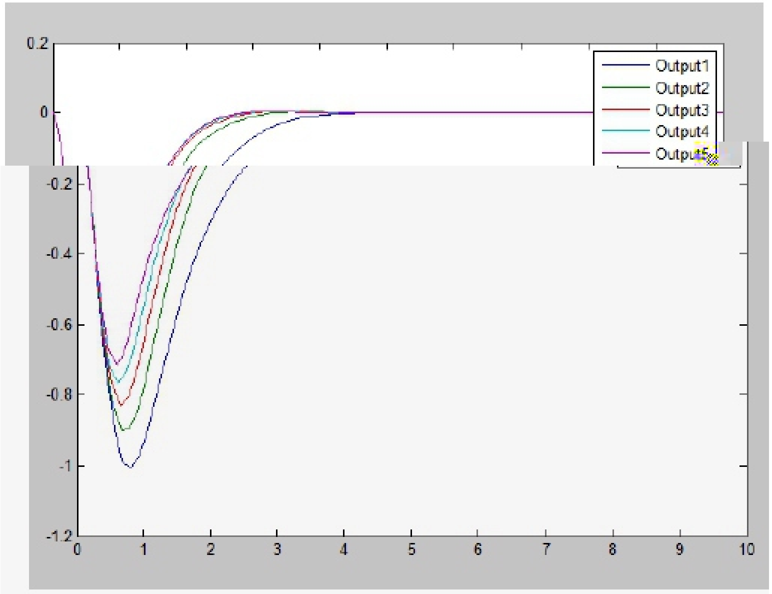

Figure 6: Adaption Error for Different Groups ofγ's

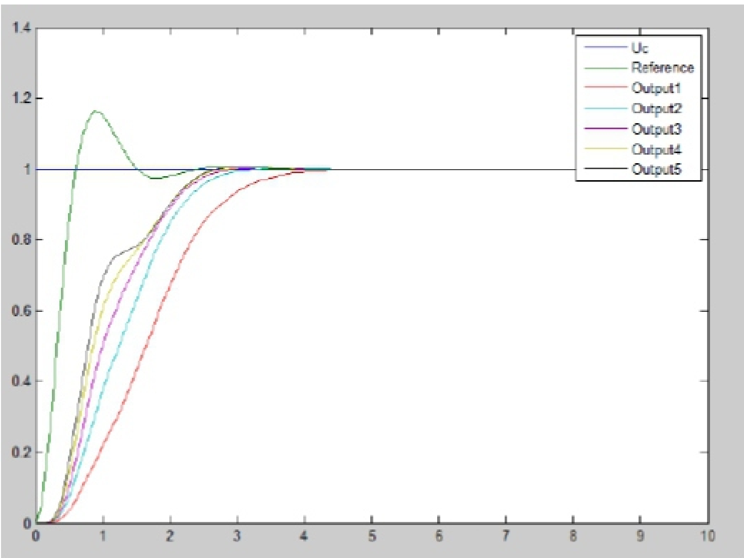

Figure 7: Output Speed for Different Groups of γ's

As shown in figure 7 for low adaption gains, the actual speed has no oscillation but too much delay, so poor performance. Increasing adaption gains the output speed response improved towards matching the desired speed value of model reference. The adaption error is shown in figure 6, while figure 5 shows the error, adaption error and adaption gains for certain groups of gammas. As a result MRAPIDC achieves satisfactory performance. The transient performance specifications are shown in table 2. These simulations show that MRAPIDC requires less information of the process at the same time achieves good performances.

Table 2: Characteristic Values for no Load Speed

Specifications	**Set of Gammas**				
	1	**2**	**3**	**4**	**5**
Rise time(sec)	1.15	0.71	0.54	0.46	0.44
Settling time(sec)	3.2	1.34	1.46	1.29	1.42
% max overshoot	0	1	3.8	6.1	8.2

V. CONCLUSION:

It is found that the speed control of the separately excited Dc motor is satisfactory by the use of MRAPIDC. MRAPIDC achieves its desired performance and adaptation gains are responsible to improve the transient performance of the speed response in terms of rise time, overshoot, settling time and steady-state for step speed response.

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How Probability Sampling Differentiate with Non- Probability Sampling

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A B S T R A C T

Almost any type of sample has some utility when estimating population quantities. The focus in this paper is to indicate what type or combination of types of sampling can be used in various situations to differentiate with probability sampling and non-probability sampling. Several of these methods have little or no utility in the scientific area but even in the best of circumstances, particularly complex ones, both probabilistic and non-probabilistic procedures have to be used because of lack of knowledge and cost. Researchers collect information by a wide variety of methods, ranging from the experimental designs used in the physical sciences through to the surveys more common in the social sciences. Many of these methods of gathering information involve a choice of experimental subject. For example, we may want to choose the patients to be examined in a medical study, or the respondents to be interviewed in a survey.

This choice can be made using probability-based methods, where the choice is by some "mechanical" procedure involving lists of random numbers, or the equivalent. Alternatively, the choice may be made by other methods, invoking some element of judgement. Methods involving judgement are sometimes referred to as purposive selection, judgement selection, or non- probability selection.

Key Words: probability-based samples, quality assessment; Non-sampling errors

INTRODUCTION

The word Probability derives from probity, a measure of the authority of a witness in a legal case in Europe, and often correlated with the witness's nobility. In a sense, this differs much from the modern meaning of probability, which, in contrast, is used as a measure of the weight of empirical evidence, and is arrived at from inductive reasoning and statistical inference.

HISTORY OF PROBABILITY THEORY

The branch of mathematics known as probability theory was inspired by gambling problems. The earliest work was performed by Girolamo Cardano (1501-1576) an Italian mathematician, physician, and gambler. In his manual Liber de Ludo Aleae, Cardano discusses many of the basic concepts of probability complete with a systematic analysis of gambling problems. Unfortunately, Cardano's work had little effect on the development of probability because his manual, which did not appeared in print until 1663, received little attention.

In 1654, another gambler named Chevalier de Méré created a dice proposition which he believed would make money. He would bet even money that he could roll at least one 12 in 24 rolls of two dice. However, when the Chevalier began losing money, he asked his mathematician friend Blaise Pascal (1623-1662) to analyze the proposition. Pascal determined that this proposition will lose about 51% of the time. Inspired by this proposition, Pascal began studying more of these types of problems. He discussed them with another famous mathematician, Pierre de Fermat (1601-1665) and together they laid the foundation of probability theory.

PROBABILITY THEORY:

Probability sampling means that everyone in a given population has an equal chance of being surveyed for a particular piece of research. Let's say we want to know how many people would choose blue as their favorite color. If we wanted to answer that question in the context of the average American, that would mean that everyone in the United States would have an equal chance of being sampled for the study. The same holds true for sub-segments of the population. For example, if you wanted the opinions of pregnant moms, a probability sample would mean that every pregnant mom would have an equal chance of participating in the research.

In probability sampling every element in the population has a known nonzero probability of selection. The simple random is the best known probability sample, in which each member of the population has an equal probability of being selected.

Probability sampling designs are used when the representativeness of the sample is of importance inthe interestof wider generalisability. When time or other factors,rather than generalisability, become critical, non-probability sampling is generally use In probability-based sampling, the first step is to decide on the population of interest, that is, the population we want the results about. This could be, for example, all persons aged 18 years or over who are resident in private households in New Zealand.

We then establish a frame - a listing, at least in principle - of all the units of that population. For our example of the persons in private households, we might use a geographic frame. Private dwellings would be listed according to the geographic area they are in, and people listed inside dwellings.

We select a sample from this frame using a probabilistic algorithm. It is important that every element of the frame has a known chance of being selected, and that we can calculate the probability of selecting the sample we end up with.

The sample might well be selected in several stages. In our example geographical areas might first be selected, then dwellings inside these areas. Finally, people might be selected inside the dwellings.

In saying that we use a probabilistic algorithm to select the sample, one important feature is that interviewers will have no choice about who they are to interview. The algorithm specifies who is to be in the sample.

To produce our results, we combine the responses from the sample in a way which takes account of the selection probabilities. Our aim is that, if the sampling were to be repeated many times, the expected value of the results from the repeated samples would be the same as the result we would get if we surveyed the whole population.

Because we know the probability of getting each sample we select, we can also calculate a sampling error for the results. The sampling error tells us the amount of variation in the results due to the sampling alone. It gives a measure of the quality of the sample design, and of the survey results.

BIG PROBLEMS IN PROBABILITY THEORY ?

Most branches of mathematics have big, sexy famous open problems. Number theory has the Riemann hypothesis and the Langlands program, among many others. Geometry had the Poincaré conjecture for a long time, and currently has the classification of 4-manifolds. PDE theory has the Navier-Stokes equation to deal with.

So what are the big problems in probability theory and stochastic analysis? I'm a grad student working in the field, but I can't name any major unsolved conjectures or open problems which are driving research. I've heard that stochastic Löwner evolutions are a big field of study these days, but I don't know what the conjectures or problems relating to them are.

NON PROBABILITY SAMPLING:

Non-probability sampling comes in various shapes and sizes, but the essence of it is that a bias exists in the group of people you are surveying. Let's think about it in the context of our fictional color preference survey. If I asked the question to all of my friends, the results are not representative of anything other than the opinion of my friends and, specifically, those friends to whom I decided to send the survey. Another example of non-probability sampling would occur if I were to send you the survey and then ask you to pass the survey onto a friend. This effect, called snowballing, creates a biased sample wherein not everyone has an equal chance of being sampled.

The selection of units in non-probability sampling is quite arbitrary, as researchers rely heavily on personal judgment. It should be noted that there are no appropriate statistical techniques for measuring random sampling error from a non-probability sample. Thus projecting the data beyond the sample is statistically inappropriate. Nevertheless, there are occasions when non- probability samples are best suited for the researcher's purpose Any sampling procedure where the final samples' is not obtained by means of "real life probability sampling" will be classified here as a non-probability sampling procedure.

Typically, there are no known inclusion probabilities, and sometimes there is not even an exactly defined population. A few well-known examples of non-probability selection procedures are the following:

Self-selected respondents. An invitation to answer a number of questions is given to a large (and often not well-defined) group of people, for example by announcement in a newspaper or on an

internet site. Anyone who reads the invitation is allowed to answer, but usually only a very small fraction do in fact respond.

Respondents selected by interviewers. The interviewers have the freedom to select people to interview, for example, in the street or in a shopping mall. Sometimes the freedom is restricted by quota rules, saying that there has to be, for example, the same number of men and women.

Respondents selected by experts. An expert or a researcher contacts a number of persons who happen to be available and who are believed in some sense to be "typical members" of the larger group of people that one is really interested in.

PROBLEM IN NON-PROBABILITY SAMPLING

This is more biased, because the individuals chosen are not at random. They also might not represent what another population thinks

CONTRAST OF PROBABILITY AND NON-PROBABILITY SAMPLING:

Probability sampling procedures, in contrast to the remaining class of non-probability sampling procedures. Under ideal text-book conditions, probability sampling is usually described along the following lines:

(1) A sample of units is to be selected from the population, using some known randomization mechanism.

(2) It is possible (at least in principle) to list all the samples that can be obtained using this procedure.

(3) We know the probability of each possible sample, when this procedure is used.

(4) For each unit in the population we can find its inclusion probability, that is, the probability that it will be selected. The inclusion probability can be obtained, for example, by adding the probabilities of all the possible samples that contain this special unit.

(5) Each unit in the population is to have a strictly positive inclusion probability. This is a necessary and sufficient condition for the existence of an unbiased estimator of the population total.

Probability Sampling	Non-probability Sampling
You have a complete sampling frame. You have contact information for the entire population	**Used when there isn't an exhaustive population list available**. Some units are unable to be selected, therefore you have no way of knowing the size and effect of sampling error (missed persons, unequal representation, etc.).
You can select a random sample from your	Not random.
You can generalize your results from a random sample. With this data collection method and a decent response rate, you can extrapolate your results to the entire population.	**Can be effective when trying to generate ideas and getting feedback**, but you cannot generalize your results to an entire population with a high level of confidence. Quota samples (males and females, etc.) are an example
Can be more expensive and time-consuming than convenience or purposive sampling.	**More convenient and less costly**, but doesn't hold up to expectations of probability theory

CONCLUSION:

Probability samples are expensive but provide results that can be extrapolated to a wide population.

Non-probability samples are less expensive but are limited in extrapolating results. Interpretation of results should be viewed with caution.

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Analysis of Patch Antenna for Parameter Enhancement at 1.911GHZ

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ABSTRACT

In this paper work, A patch antenna and our proposed metamaterial patch antenna are simu- lated and compared. A rectangular microstrip patch antenna along with the innovative metama- terial structure is proposed at a height of 3.2mm from the ground plane. This work is mainly fo- cused on increasing the potential parameters of microstrip patch antennas and analyzing the dual band operation of proposed antenna.This structure produces a better performance com- pared to simple RMPA. The implementation of the metamaterial as the substrate in a rectangular microstrip patch antenna produces high value of return loss.

Rectangular Microstrip Patch antenna loaded with metamaterial (MTM) is proposed for better improvement in the impedance bandwidth and reduction in the return loss at operating frequen- cy 1.911 GHz. The proposed antenna is designed at a height 3.2 mm from the ground plane. At 1.911 GHz, the bandwidth is increased up to 27.2 MHz in comparison to RMPA alone of bandwidth 6.5 MHz. The Return loss of proposed antenna is reduced by -19.15dB. Microstrip Patch antenna has advantages than other antenna is lightweight, inexpensive, easy to fabricate and achieve radiation characteristics with higher return loss. CST MICROWAVE STUDIO is used to design the metamaterial based rectangular microstrip patch antenna.

Keywords- Rectangular microstrip patch antenna (RMPA), Metamaterial (MTM) Impedance Bandwidth, Return loss.

I. INTRODUCTION

In modern wireless communication systems, the microstrip patch antennas are commonly used in the wireless devices. Therefore, the miniaturization of the antenna has become an important issue in reducing the volume of entire communication system [1].

Microstrip antennas are largely used in many wireless communication systems because of their low profile and light weight [2].

The “patch” is a low-profile, low –gain, narrow – bandwidth antenna. Aerodynamic considera- tions require low-profile antenna on aircraft and many kinds of vehicles. Typically a patch con- sists of thin conducting sheet about 1 by 1/2λ0 mounted on Substrate. Radiation from the patch is like radiation from two slots, at the left and right edges of the patch. The “slot” is the narrow gap between the patch and the ground plane. The patch –to-ground-plane spacing is equal to the thickness t of the substrate and is typically about λ0/100. Advantage of patch antenna than sever- al antenna is lightweight and inexpensive. The electric field is zero at the center of patch, maxi- mum at one side, minimum on the opposite side. The important parameters of any type antenna are impedance bandwidth and return loss. The impedance bandwidth depends on parameters re- lated to the patch antenna element itself and feed used. The bandwidth is typically limited to a few percent. This is a disadvantage of basic patch antenna.

Metamaterial based rectangular mi- crostrip patch antenna improves the bandwidth and return loss in significant way. CST MI- CROWAVE STUDIO is a software package for the electromagnetic analysis and design, use to design the metamaterial based rectangular microstrip patch antenna. The software contains four different simulation techniques like transient solver, frequency domain solver, integral equation solver, Eigen mode solver and most flexible is transient solver.

V.G. Veselago in 1968 provided a theoretical report on the concept of metamaterial (MTM) [3]. A Left-Handed metamaterial or double-Negative Metamaterial exhibits negative permittivity and permeability [4]. The currently popular antenna designs suitable for the applications of wire- less local area network (WLAN) and world- wide interoperability for microwave access (Wi- MAX) have been reported [5].

II. DESIGN SPECIFICATIONS

The RMPA parameters are calculated from the following formulas. Desired Parametric Analysis [6][7].
Calculation of Width (W):

$$W = \frac{1}{2f_r\sqrt{\mu_0 \varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r + 1}} = \frac{C}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \qquad (1)$$

Where
C = free space velocity of light,
r =Dielectric constant of substrate
The effective dielectric constant of the rectangular microstrip patch antenn (2)

Actual length of the patch (L):

$$L = L_{eff} - 2\Delta L \qquad (3)$$

Calculation of length extension:

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)}$$

(4)

III. ANALYSIS OF RECTANGULAR MICROSTRIP PATCH ANTENNA AND METAMATERIAL STRUCTURE WITH SIMULATED RESULTS

The Rectangular Microstrip Patch Antenna is designed on FR-4 (Lossy) substrate at 50Ω matching impedance dielectric constant εr = 4.3 and height from the ground plane d=1.6mm.The parameter of rectangular microstrip patch antenna are L= 35.8462 mm, W= 46.0721 mm, Cut Width= 5mm, Cut Depth= 10mm, length of transmission line feed= 35.58mm, with width of the feed= 3mm shown in figure1.

The simple RMPA is inspired by metamaterial structure at 1.794 GHz.

Table1.Rectangular Microstrip Patch Antenna Specifications

parametrs	Dimension	Unit
Dielectric con-stant	4.3	-
Loss tangent (tan)	0.02	-
Thickness (h)	1.6	Mm
Operating frequency	1.794	GHz
Length L	35.85	Mm
Width W	46.07	Mm
Cut width	6	Mm
Cut depth	10	Mm
Path length	35.57	Mm

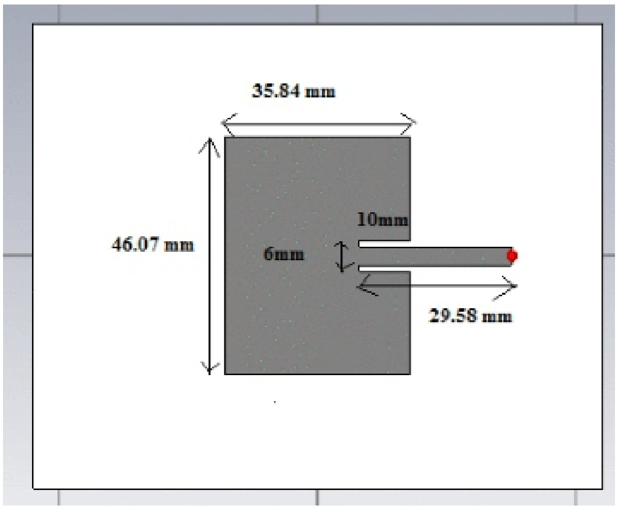

Figure1. Rectangular microstrip patch antenna at 1.911 Ghz.

CST-software is used to design the Rectangular microstrip patch antenna (RMPA) at oprating frequency 1.794 Ghz.

However, their employment raises some problems, such as, difficulty impedance matching or increasing of surface waves in the Substrate that could decline the radiation efficiency and the radiation pattern. Bandwidth of the antenna may be considerably becomes worse [8].

Simulated result of Return loss and bandwidth of Rectangular Microstrip Patch antenna(RMPA) is shown in fig 2.

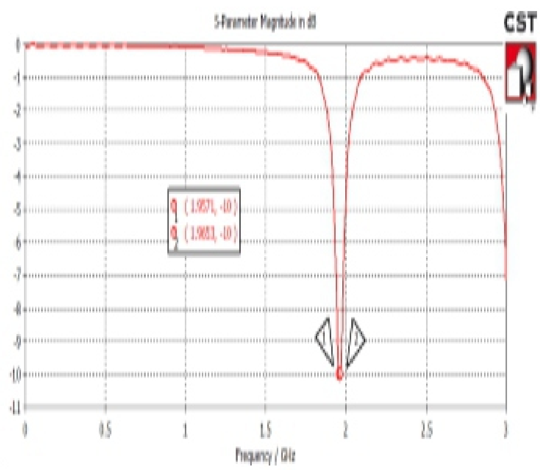

Figure 2. Simulation of return loss and bandwidth of RMPA.

The bandwidth of simple RMPA is 10.1MHz and Return loss is -10.3 dB.

The Rectangular microstrip patch antenna has 3D Radiation pattern at 1.794 GHz as shown in figure3. The radiation pattern shows the directivity of simple RMPA is 6.832 dB.

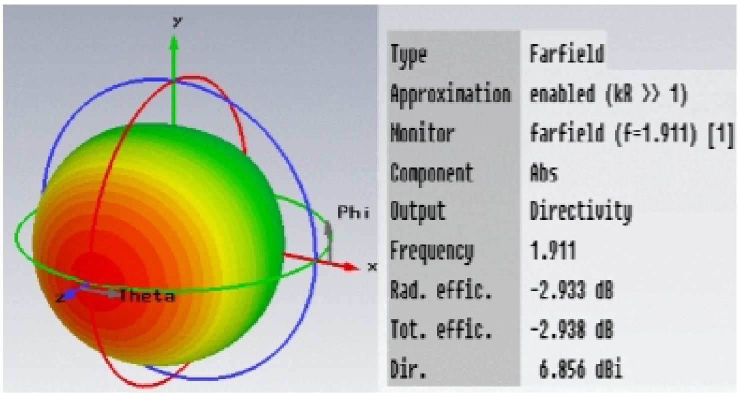

Figure 3. Radiation pattern of RMPA at 1.911 GHz.

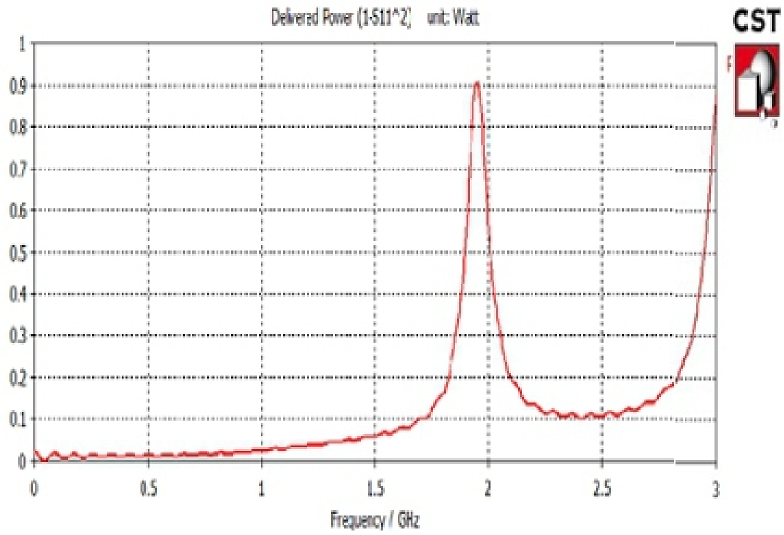

Figure 4. Delivered power to RMPA. The maximum power deliver to patch antenna is above 0.90 watt.

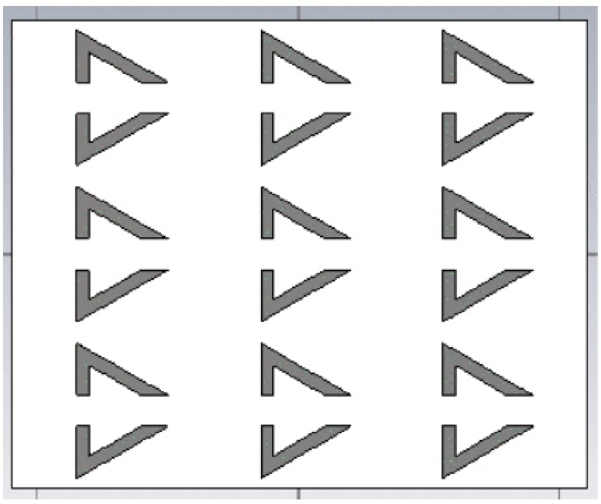

Figure 5. Design of proposed metamaterial structure at the height of 3.2 mm from ground plane.

In this metamaterial design, symmetrically cut H and five hexagonals are loaded on the patchantenna. Hexagonals is distributed equally with each other and cut horizontally with 6 mmwidth. This design gives the better improvement in impedance bandwidth and reduction in return loss.

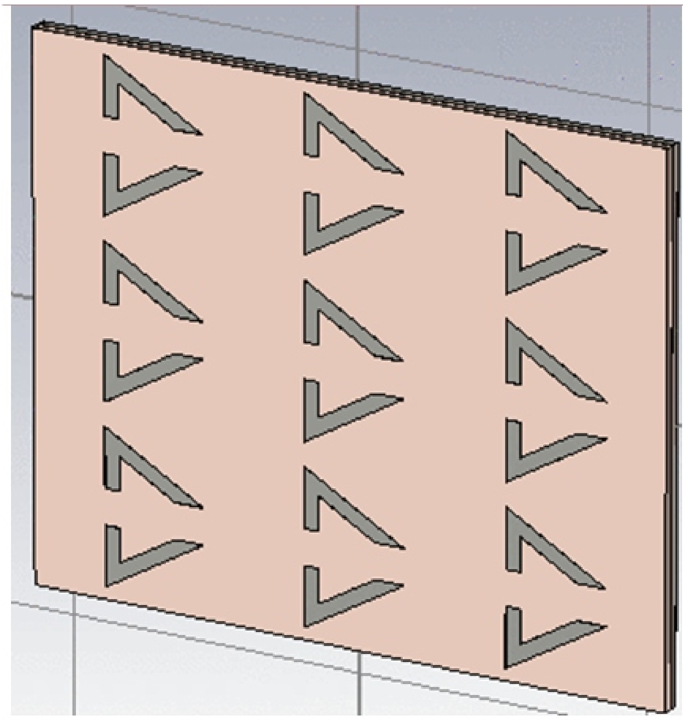

Figure 6. Rectangular microstrip patch antenna with proposed metamaterial structure.

Simulation result of Return loss and bandwidth of Rectangular microstrip patch antenna loaded with metamaterial structure is shown in Fig 7.

The proposed metamaterial structure reduces the return loss by 20.7dB and increases the band- width up to 16.9 MHz.

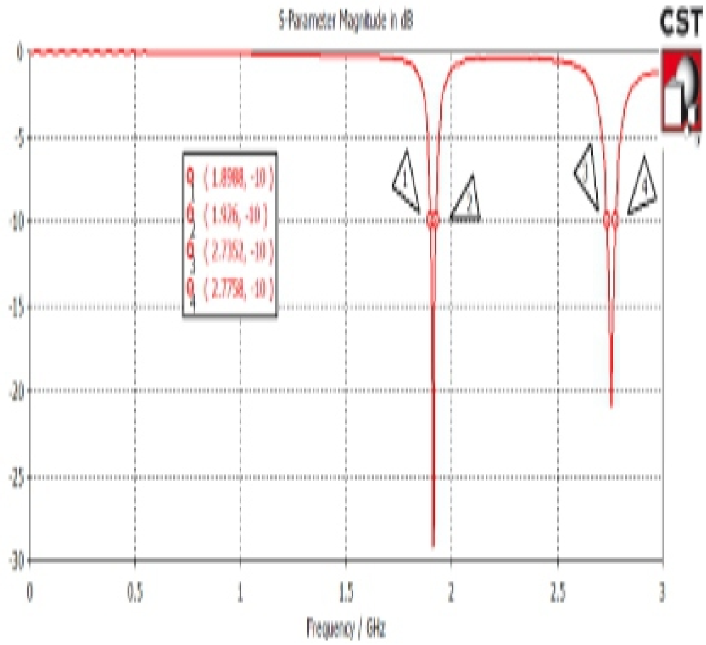

Figure 7. Simulation of Return loss and impedance bandwidth of RMPA with proposed metematerial structure at operating frequency 1.794 GHz.

The Simulated result of RMPA loaded with hexagonal shaped metamaterial is showing return loss of -30.1dB and Bandwidth of 27 MHZ.

It is clear that the Directivity of proposed antenna is almost unaffected in comparison to simple RMPA alone.

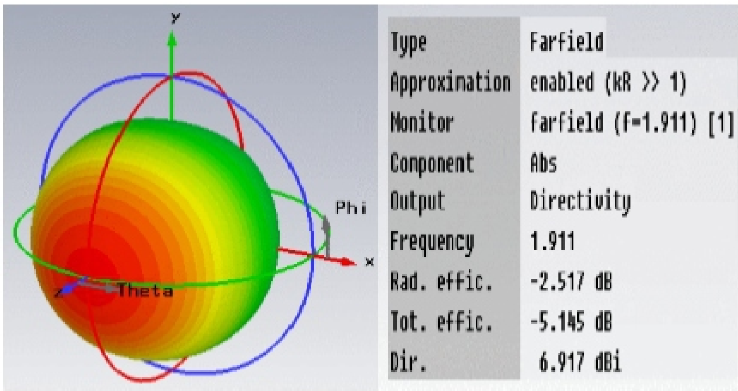

Figure 8. Radiation pattern of proposed antenna showing Directivity of 6.856 dBi.

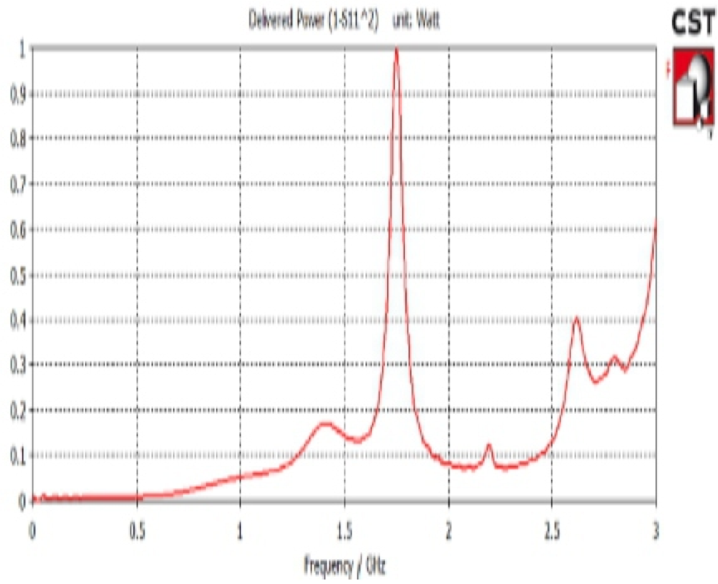

Figure12. Delivered power to reduced size RMPA loaded with metamaterial structure.

The maximum power deliver to proposed figure 12.

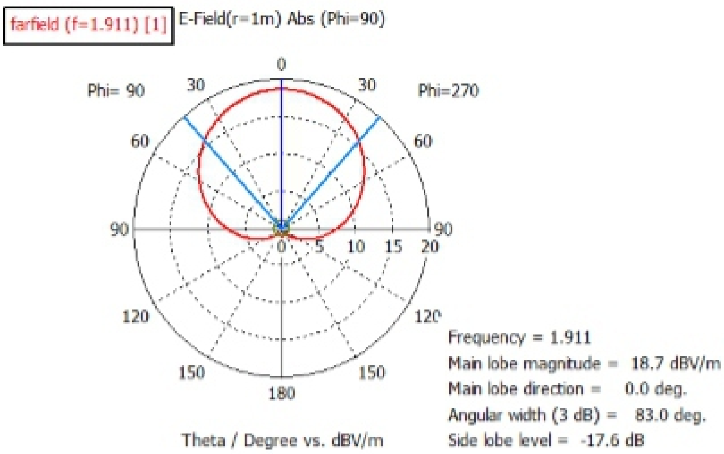

Figure13. E Field of the reduced size RMPA loaded with Metamaterial

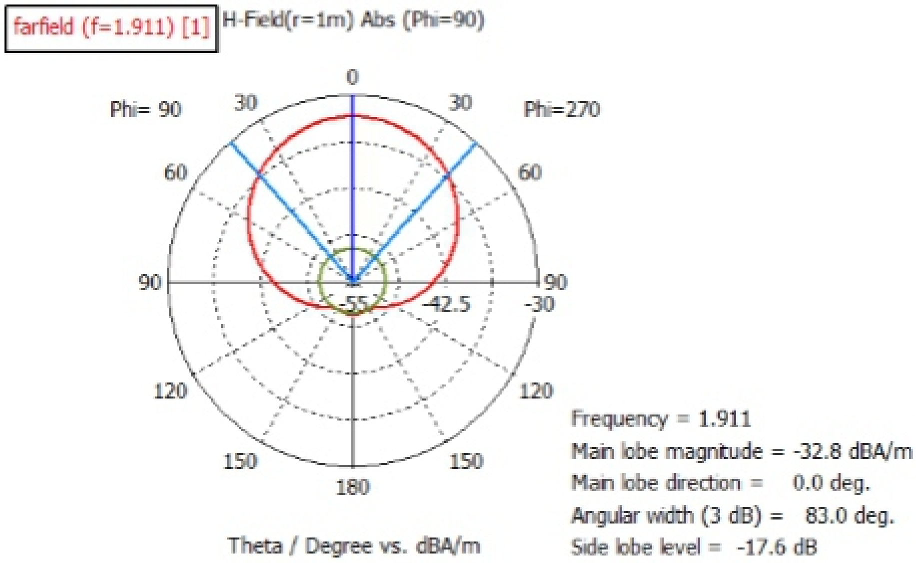

Figure14. H Field of the reduced size RMPA loaded with Metamaterial.

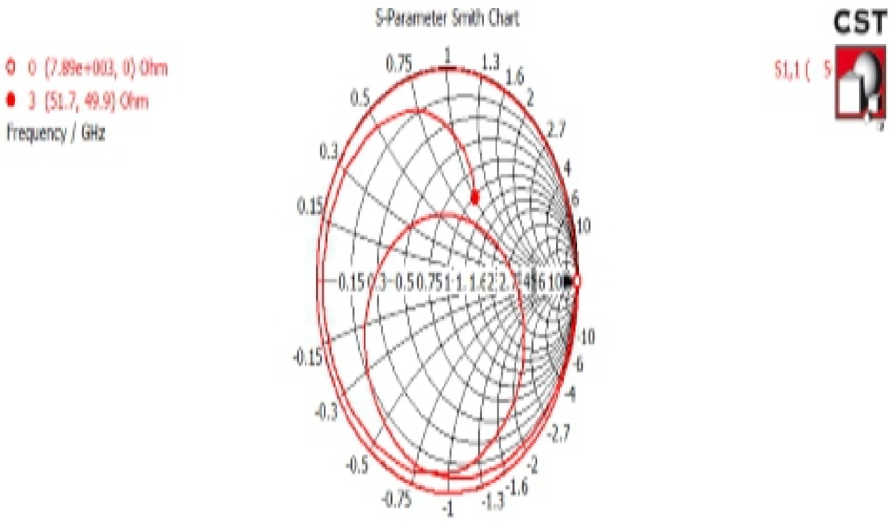

Figure 15. Smith chart of simple Rectangular microstrip patch antenna.

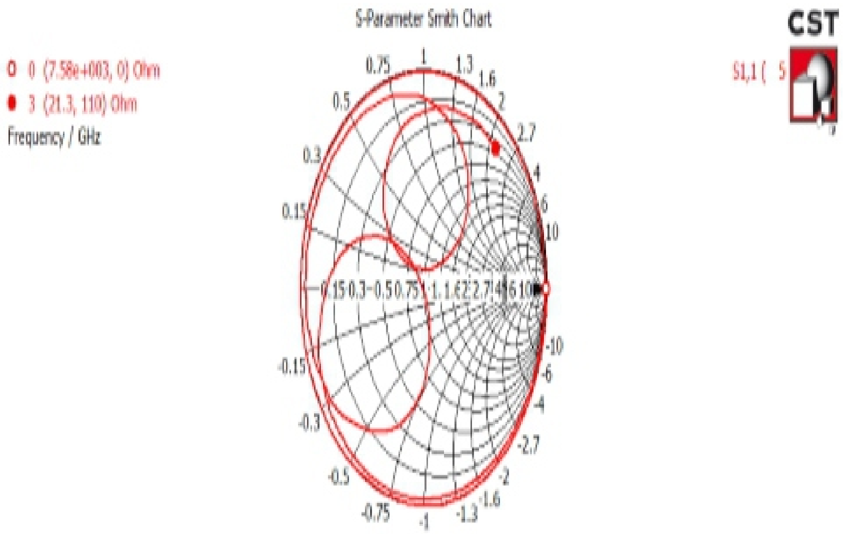

Figure 16. Smith chart of PMPA loaded with metamaterial.

The smith chart is very useful when solving transmission problems. The real utility of the Smith chart, it can be used to convert from reflection coefficients to normalized impedances (or admit- tances), and vice versa.

Smith chart of RMPA loaded with symmetrically cut H and hexagonal shaped metamaterial structure at 1.794 GHz. Above Fig. shows the impedance variation in the simulated frequency range and received impedance matching for proposed antenna at characteristic impedance.

IV. SIMULATION RESULTS

In this paper, Rectangular microstrip patch antenna loaded with symmetrically cut H and hexagonal shaped metamaterial structure is simulated using CST-MWS software. The pro- posed design in comparison to RMPA alone, found that the potential parameters of the proposed antenna is increased. This is clear from Fig.2 & Fig.7 that the return loss is reduced by 20.7 dB and bandwidth is increased by 16.7MHz. From the Fig.9, it is clear that the Directivity of pro- posed antenna design is almost unaffected. The maximum power deliver to proposed rectan- gular microstrip patch antenna is 1 watt.

V. CONCLUSION

The main drawback of Patch Antenna was impedance bandwidth. For this purpose, Rectangular microstrip patch antenna loaded with symmetrically cut H and Hexagonal shaped metamaterial structure has been proposed and analyzed in this paper. The simulated results provide that, improvement in the bandwidth is 16.9 MHz and the Return loss of proposed antenna is reduced by 20.7 dB. It is clear that we can easily overcome the drawbacks of RMPA by using the proper- ties of Metamaterial (MTM). By using Metamaterial, the maximum power delivered to proposed antenna is 1 watt as compared to the RMPA delivered power of 0.9 watt.

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Multirate DSP and its Technique for Low Power High Speed VLSI of Interpolator Unit

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A B S T R A C T

Paper Presents Multirate DSP and its techniques of the system which includes sampling rate conversion. This technique is necessary for systems with different input and output sampling rates, as the proposed multirate device is Interpolator; In order to build interpolator FIR filter with upsampler: Shift register, D F/F and Multiplexer circuits are design and Simulation done on Active HDL and ALTERA QUARTUS–II platform. The circuit obtained is verified and implemented successfully. Then it is synthesized using 45 nm library in synopsis tool with constraint of low power and area. The circuit uses device level and circuit level optimization to obtain a very low power. Reduction of power consumption is important for VLSI system and also it becomes one of the most critical design parameter. There are many reasons to change the sample rate of a sampled data signal. Here, author discuss the two basic operations in a multirate system i.e. decimation and interpolator. Also the use of multirate filters at the interfaces of continuous & sampled data which results in a cost reduction components as well as improvement of signal quality. The proposed approach achieves comparable reductions because of a hybrid allocation scheme and multiple optimization iterations. The usefulness of the proposed system for low power design of FIR filters in interpolator is shown.

Keywords: VLSI-Very large scale integrated circuit, PCS -Personal communication services-, Active HDL-Hardware description language, RTL-Register transfer logic, DSP-Digital signal processing, VHDL-Very high speed hardware description language

I. INTRODUCTION

In single-rate systems, only one sampling rate is used throughout a digital signal processing systems, whereas in multirate systems the sampling rate is changed at least once. Multirate systems have gained popularity since the early 1980s and they are commonly used for audio and video processing, Communication systems, and transform analysis, there are many reasons to change the sample rate of a sampled data signal. Applications include conversion of variable rate input data to fixed rate output data in a modulator and the inverse task of converting fixed rate input data to variable rate output data in a demodulator. Another application involves sample rate changes so that filtering can be performed at the Nyquiest rate of the signal being processed. In one major application, the multirate filter is used to increase the sample rate of a sampled data signal prior to its delivery for processing by the digital to analog converter involved in transferring the signal between the sampled data world and the continuous world. In the other major application, the multirate filter is used to decrease the sample rate of a sampled data signal after being formed at the output of an analog to digital converter so that filtering can be performed at the Nyquist rate of the signal being processed. [8]. In the other major application, the multirate filter is used to decrease the sample rate of a sampled data signal after being formed at the output of an analog to digital converter. But due to the limited power-supply capability of current battery technology, PCS devices needed low-power VLSI design to minimize the total power consumption, while maintaining the system performance [1]. In general, the direct implementation of the system has a constraint that the speed of the processing elements must greater than input data rate. It cannot compensate the speed penalty under low supply voltage. Therefore, the processing elements can be operated at a lower supply voltage to reduce the power dissipation and the data throughput rate is not degraded. Basic operations of multirate processing are Upsampler, Downsampler, Decimation and Interpolation.

A. Upsampling: An Upsampler with sampling factor L, where L is a positive integer and every Lth sample is taken from x[n] with all others zero which develops an output sequence xe[n] with a sampling rate that is L times greater than that of the input sequence

Fig.1 Block-diagram representation

B. Downsampling:

A down-sampler with a down-sampling factor M, where M is a positive integer[3], develops an output sequence y[n] with a sampling rate that is (1/M)th of that of the input sequence x[n]. If the original sequence contains frequency components above π / M, the downsampler should be preceded by a low-pass filter with cutoff frequency π / M.

Fig. 2 Block diagram representation

C. Decimation: -Decimation is a technique for reducing the number of samples in a discrete- time signal [3]. The element which implement this technique is referred to as a decimator.

D. Interpolation: Interpolation is the exact opposite of decimation. It is an information preserving operation, in that all samples of x[n] are present in the expanded signal y[n]. The mathematical definition of L-fold interpolation is defined by Equation 2 and the block diagram notation is depicted in Figure 4. Interpolation works by inserting (L–1) zero-valued samples for each input sample. The sampling rate therefore increases from Fs to LFs.Expansion process is followed by a unique digital low-pass filter called an anti-imaging filter. Although the expansion process does not cause aliasing in the interpolated signal, it does however yield undesirable replicas in the signal's frequency spectrum. In Figure 3 below, it depicts 3-fold interpolation of the signal x[n] i.e. L = 3. The insertion of zeros effectively attenuates the signal by L, so the output of the anti- imaging filter must be multiplied by L, to maintain the same signal magnitude [9].

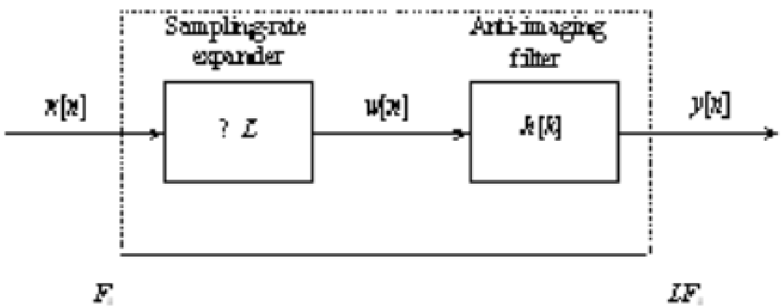


Fig.3.Block Diagram of interpolator

II. MULTIRATE DESIGN METHODOLOGY

Since, the data rate in the multirate implementation is M-times slower than the original data rate while this feature to either the low-power implementation, or the speed-up of the DSP systems. This design methodology provides a systematic way to design low-power DSP systems at the architectural level. The multirate implementation provides a direct and efficient way to compensate the speed penalty in low-power designs at the architectural level.

Authors design the interpolator procedure can be extended for an arbitrary M.

III. RESULT

Implementation of the interpolator by using active HDL Quartus-II shown as follows

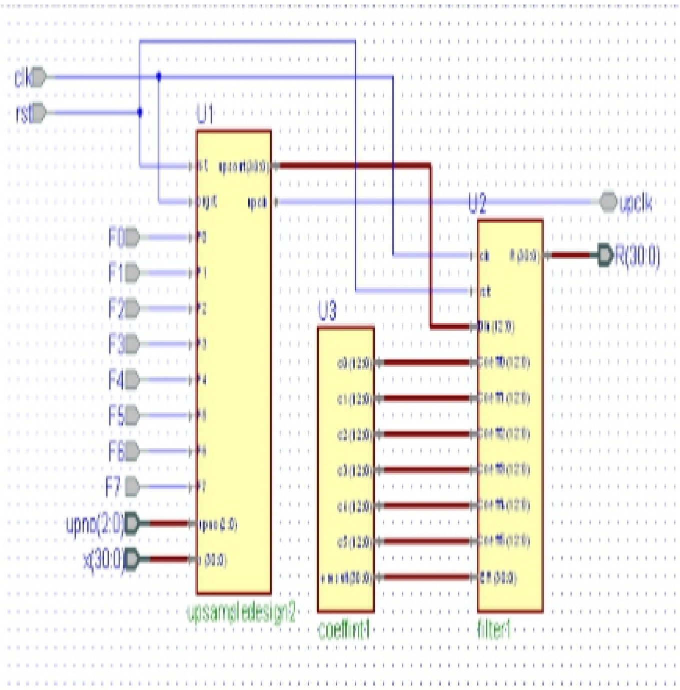


Fig. 4 Block diagram Interpolator

Simulation of Interpolator:

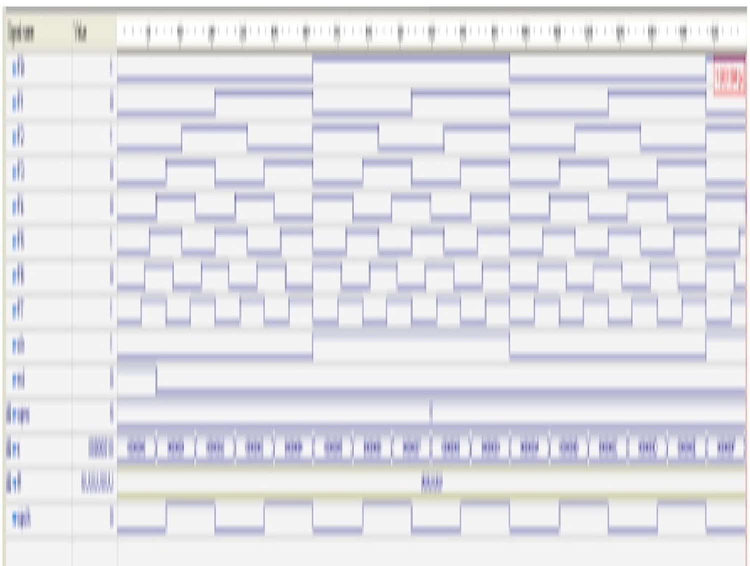


Fig.5 Design Waveform for a Interpolator

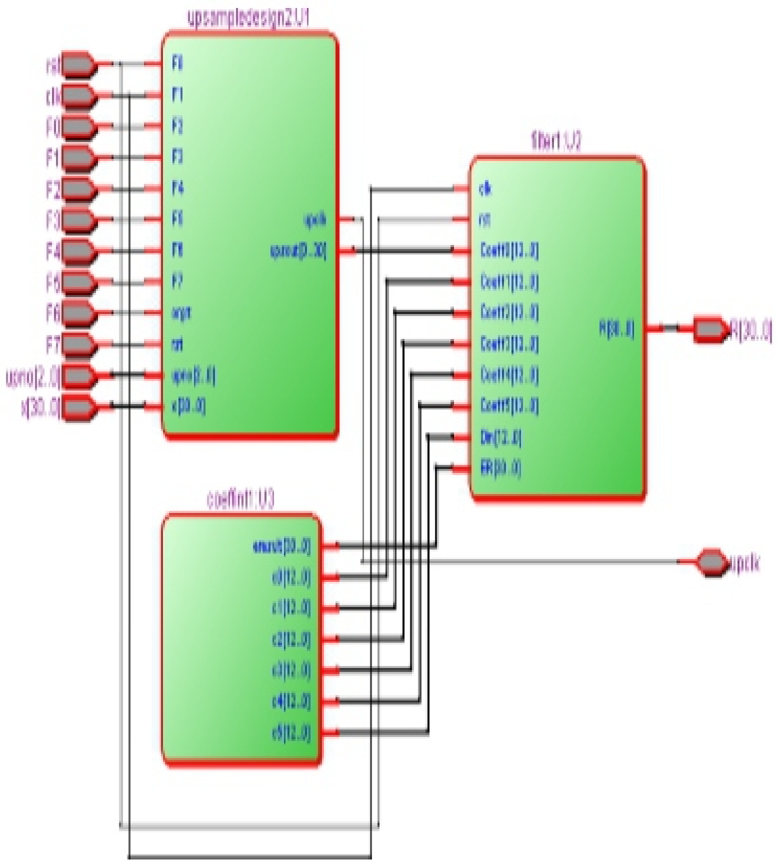
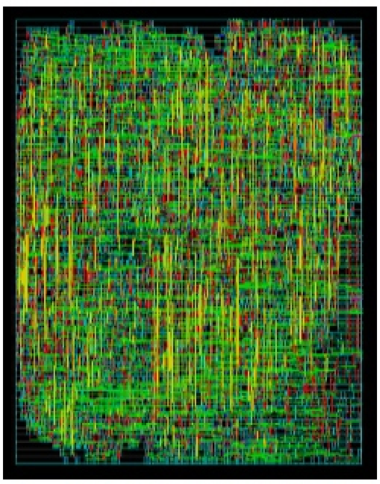


Fig.6 RTL View of interpolator

Simulation and Synthesis of Interpolator:

Then, it is synthesized using 45 nm library in synopsis tool with constraint of low power and area. The following report for power and area is obtained. Also, we obtained design vision schematic and encounter layout for interpolator as shown in figure 7 and figure 8.



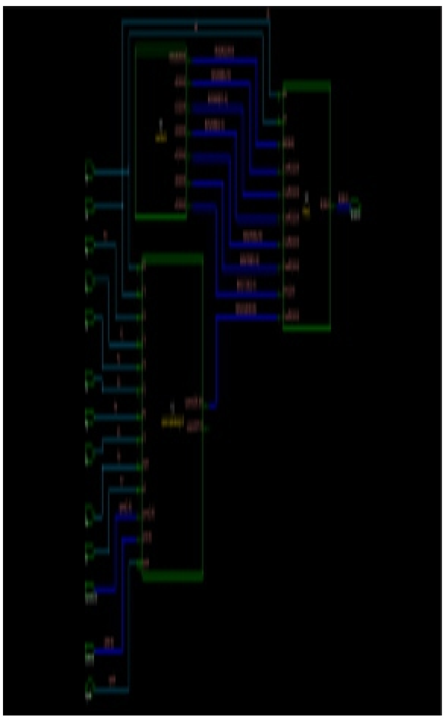


Fig.7 Design vision schematic **Fig.8 Encounter Layout**

Interpolator Area/Power Report

****

Report: Area

Design: Interpolator_1 Version: B-2008.09

Date : Wed Apr 10 17:41:44 2013

****

Library(s) Used:

gscl45nm (File: /home/raj/libfortech/45n/gscl45nm.db)

Number of ports: 76

Number of nets: 1226

Number of cells: 155

Number of references:52

Combinational area: 16781.698437

Noncombinational area: 825.968018

Net Interconnect area:undefined (No wire load specified)

Total cell area:17607.666454

Total area: undefined

Loading db file '/home/raj/libfortech/45n/gscl45nm.db'

Information: Propagating switching activity (low effort zero delay simulation). (PWR-6)

****

Report: Power

-analysis effort low Design: Interpolator_1 Version: B-2008.09

Date : Wed Apr 10 17:41:51 2013

****

Library(s) Used: gscl45nm (File: /home/raj/libfortech/45n/gscl45nm.db)

Operating Conditions: typical Library: gscl45nm

Wire Load Model Mode: top Global Operating Voltage = 1.1V

Power-specific unit information:

Voltage Units = 1V

Capacitance Units = 1.000000pf

Time Units = 1ns

Dynamic Power Units= 1mW(derived from V, C, T units)

Leakage Power Units = 1nW

Cell Internal Power =139.4195 uW (81%)

Net Switching Power = 33.0861uW (19%)

Total Dynamic Power =172.5056 uW (100%)

Cell Leakage Power =95.8968uW

IV. CONCLUSION

The low power and area constrain is verified for the implementation of module of interpolator after optimization with multirate signal processing approach is presented. Authors have used Active-HDL for simulation of design using Quartus –II platform. Authors have used synopsis tool of 45 nm library to design vision and the encounter layout. Also, design the model of interpolator with top level system design approach and low-power methodology and area for system. The results are found satisfactory. Also, the result of design of interpolator using optimization at device level and circuit level by factor M found satisfactory. Physical testing verified that implementation worked correctly for all factors. The low power design using multirate approach reduces the power consumption to a great extent. The proposed methodology provides a systematic way to derive low power and low area system.

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