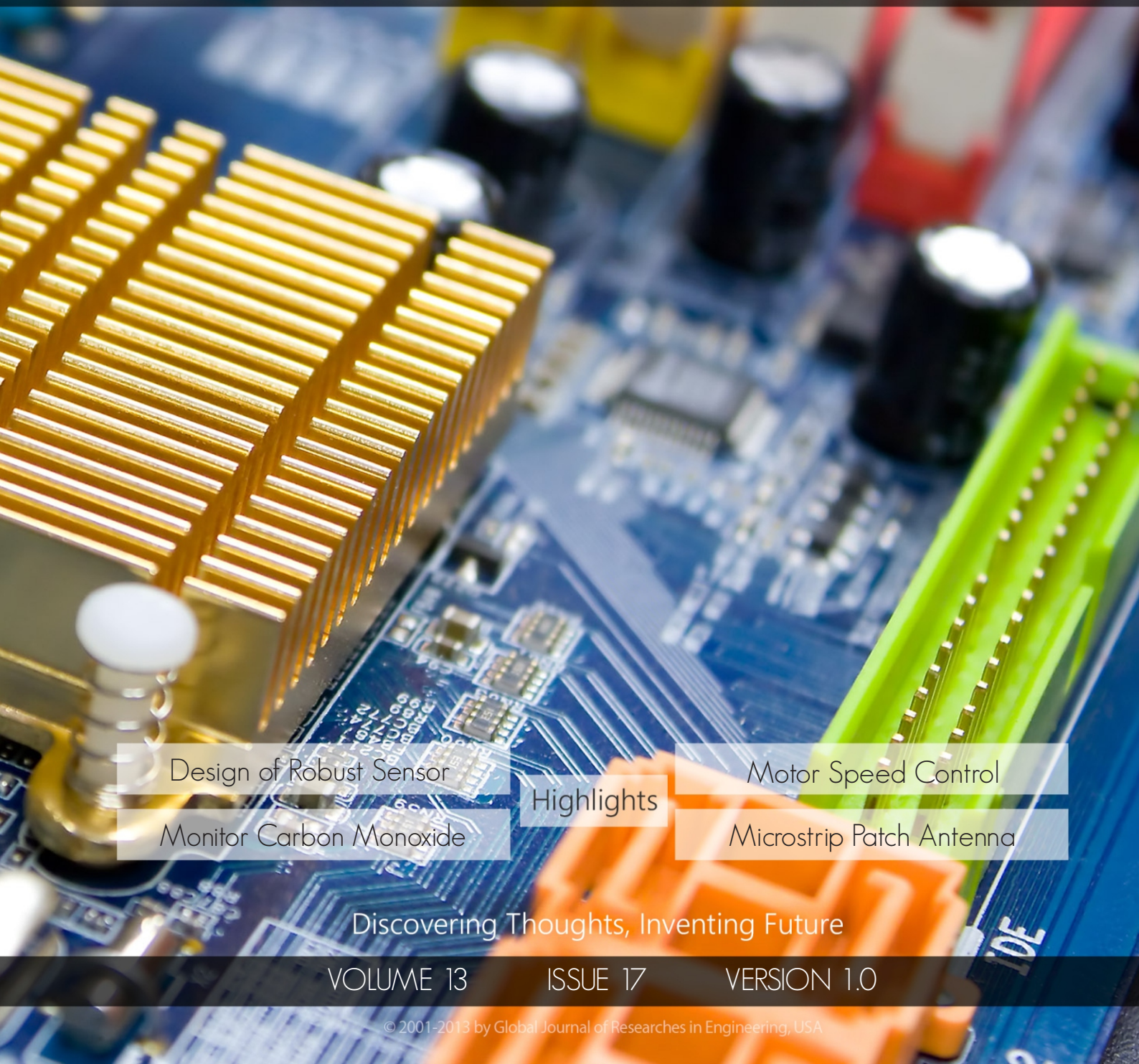
Online ISSN : 2249-4596
Print ISSN : 0975-5861

Global Journal

of Researches in Engineering: F

Electrical and Electronic Engineering



Design of Robust Sensor

Monitor Carbon Monoxide

Highlights

Motor Speed Control

Microstrip Patch Antenna

Discovering Thoughts, Inventing Future

VOLUME 13 ISSUE 17 VERSION 1.0

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Electrical and Electronics Engineering
Volume 13 Issue 17 (Ver. 1.0)

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Contents of the Volume

Global Journal of Researches in Engineering
Electrical and Electronics Engineering
Volume 13 Issue 17 Version 1.0 Year 2013
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Design of Robust Sensor Nodes to Monitor Carbon Monoxide and Natural Gas Levels

By Elizabeth Rufus, Paritosh Sinha, Prabhat Suman & Sanket Jaiswal
VIT University, Oman

Abstract- In the present scenario, effective real time pollution monitoring equipments require large number of nodes (preferably >50) which are capable of interaction and hence provide reliable information. Increasing the number of sensors increases the possibility of determining the exact amount of gas levels in the surrounding environment. Hence the sensor nodes and the wireless network should together work cohesively to determine the correct levels of the gas desired to be monitored. Also it is important that the sensor node has low power consumption and is robust in extreme climatic conditions. Our main focus is to develop many such sensor nodes and develop a simple protocol to effectively use them. In this paper we have only considered the design of one such node which can sense the levels of Carbon Monoxide, and hence a solid-state semiconductor Carbon Monoxide gas sensor is used. The paper describes the parameters like robustness, low power requirements and a highly efficient mode of communication to design a sensor node.

Indexterms: *microcontroller, gas sensor.*

GJRE-F Classification : *FOR Code: 850499, 290901*

Strictly as per the compliance and regulations of :

Design of Robust Sensor Nodes to Monitor Carbon Monoxide and Natural Gas Levels

Elizabeth Rufus [α], Paritosh Sinha [σ], Prabhat Suman [ρ] & Sanket Jaiswal [ω]

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Indexterms: microcontroller, gas sensor.

I. Introduction

The impact of pollution on the overall quality of life has been massive. Be it social or scientific, pollution has adversely affected all hemispheres of one's life. The influence of Carbon Monoxide in such circumstances cannot be ignored. The impact has been felt greatly in the developing countries where the technological advancements are leading to increasing amount of Carbon Monoxide levels. To measure the levels, these countries require not only accurate but inexpensive methods of gas detection. The proposed wireless sensor network will satisfy these requirements and provide a satisfactory solution.

Plentiful of research works have been published on the ways to develop and design sensor nodes to detect and monitor Carbon Monoxide levels in the environment. For example, [1] describes development of sensor nodes with precise calibration techniques used for accurate determination of various gas levels in the atmosphere. Although the technique used is effective for near accurate measurements, the design is not robust as the reliability of sensors is not guaranteed in harsh conditions.

Another design as described in [2] involves using a PIC microcontroller and a self-devised protocol to establish a connection between the sensor node and a central computer system. The sensor node in the specified work contains a temperature sensor, resistive type humidity sensor, light to frequency converter, air contaminants sensor, natural Gas (methane) sensor and a Carbon Monoxide sensor. The design is tested in critical climatic conditions and found to perform with the same reliability and accuracy. But the above proposed design does not have the capability to handle a large number of nodes. For the specific task in hand, our setup requires communication among at least 50 nodes. More number of nodes will increase the possibility of accurate measurement of CO levels as sensor measurements are specific to concentration levels of CO in the vicinity of the node. To enable effective communication among a large number of sensor nodes, SimpliciTI protocol is used. SimpliciTI enable wireless communication among a maximum of 100 nodes, which is apt for our project requirements. Moreover as discussed in [1], large number of sensor nodes will allow reconstruction of pollutant flow and the density profiles of pollutants across the (3D) space.

[3] Discusses a novel technique which is used to measure Carbon Monoxide and Carbon Dioxide levels in an indoor environment using the infrared absorption principle. The proposed system also uses a PIC microcontroller for data acquisition. Our proposed design uses a MSP430F2274 microcontroller to use its capability of functioning in low power modes. The particular microcontroller has 5 low power modes to suit the requirements of the application. But the design in [3] lacks accuracy due to the relative newness of the idea. More research is required to enhance the robustness and accuracy of the sensor node. [4] Describes use of a singleSB-95 sensor to detect two gases, carbon monoxide and methane. The use of sensor is unique as, the same sensor detects two different gases for two different temperatures but the response to any one particular gas is delayed, because of the lack of the ability of the sensor to detect the two gases simultaneously.

The remainder of the paper is organized as follows. Section II describes the specific characteristics the sensor node should possess for the desired application. Section III describes the selection of hardware and the algorithm of the code dumped into the nodes. Section IV displays a sample application to test the establishment and efficiency of the

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communication network. Section V is the conclusion and future possibilities of the paper.

II. Sensor Node Design Requirements

The primary requirement of the sensor node is that it should have low power consumption. Hence hardware component selection should be done keeping in mind their compatibility with the power requirements of the node. Low power consumption will prolong the life of the node, making it apt for actual implementation.

Further to elongate the life of the node, we need to select sensors which need not be replaced in frequent intervals. For the specific application we need sensors to have a lifetime in years. Since many of the gas sensors rely on depletable reactive elements, they need to be replaced more than once a year. This makes them undesirable for our specific application. Also we need to keep in mind the fact that the design requires a collection of greater than 50 nodes which necessitates use of low cost sensors. All these factors will be taken into consideration while selecting the sensor for our application.

To enhance the robustness of the sensor node, it is important that the sensor is responsive at high temperatures, in the range of -20oC to 50oC. This temperature range will be suitable for our design because most of the environmental conditions will be in this particular temperature range.

The last requirement of the sensor node is to have a two way communication with the central computer system. This will allow the user to control the inaccessible sensor node from a distant location in case of varying environmental conditions. Also the user will have the capability of disabling the sensor nodes in case of an emergency like horrid weather conditions or natural calamities.

III. Test Module, Coding Algorithm and Hardware Selection

To test the working our proposed design, we intend to use evaluation module EZ430-RF2500 provided by Texas Instruments. The module contains a set of two target boards, one assigned as access point and the other as end device. The access point target board is connected to central computer system using a USB port. The USB port provides the power supply for the access point. The end device is powered by two AAA batteries, each 1.5V. The module EZ430-RF2500 has an inbuilt temperature sensor which provides accurate readings in the range of ±0.1oC. Each target board consists of the following components.

- A microcontroller (MSP430F2274)
- A RF transceiver chip (CC2500)
- A chip antenna

The evaluation module also contains a software simulator (IAR embedded workbench) to debug and dump the code into the target boards. The module uses SimpliciTI protocol to develop RF communication among the target boards. The protocol can easily handle 100 nodes or more and hence is perfect for our particular application. The protocol provides with the option of using range extenders to increase the detection range of the target boards. The range extension can be done up to 4 hops. The communication topology used in the SimpliciTI protocol depends upon the target boards which are active. If both the access point and end device are in ON condition, store and forward peer to peer protocol is used. Else when only end devices are in ON condition, peer to peer protocol is used. The major advantage of using the SimpliciTI protocol is that there is very less latency in the response to the input from sensor nodes. Also as mentioned earlier, the protocol can handle large number of nodes which will help us in carrying out the reconstruction of pollutant flow and the density profiles of pollutants across the (3D) space.

Now we will be discussing the various components which are going to be used in the sensor node. Following is the block diagram of the proposed design for our sensor nodes.

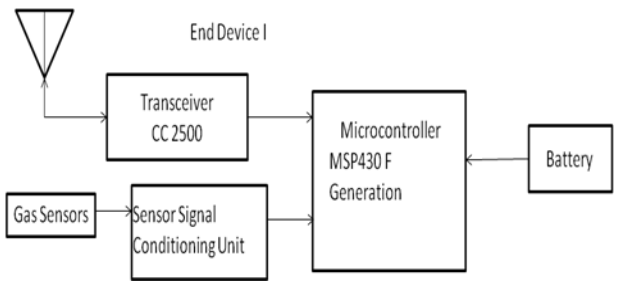


Figure 1 : Block diagram for end device

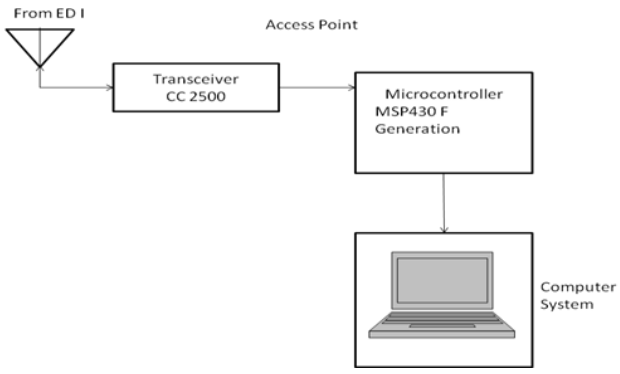


Figure 2 : Block diagram for access point

For each of the sensor nodes we require a processing unit, which is fulfilled by using a MSP430F2274. MSP430F2274 is an ultra low power consuming microcontroller which contains two

configurable operational amplifiers. The microcontroller has one active and five software selectable modes of operation. Low power mode 3 is selected for the microcontroller in which the CPU, Main Clock and the Sub-Main Clock are disabled. The Auxiliary Clock is the only clock which is active. The microcontroller also contains a 10-bit A/D with integrated reference which will be very useful to convert the received analog values from the Carbon Monoxide gas sensor into microcontroller compatible digital values. Additionally, the microcontroller has an exceptional capability of waking up from standby mode in less than 0.1 µs. All these specifications make the MSP430F2274 a perfect choice for our application.

RF transceiver chip CC2500 is used for the purpose of communication among the nodes. CC2500 is a low cost low power RF transceiver which is suitable for most of the common day applications. It operates in the 2400-2483.5 MHz ISM/SRD band system. The chip operates in the range of -40oC to 85oC which increases the robustness of our sensor node. Also the CC2500 has a built in analog temperature sensor, which assists in reducing the cost of the sensor node, simultaneously providing us with the option of monitoring a new physical parameter. Additionally, the chip has low current consumption and high sensitivity.

The code which is dumped into the target boards of EZ430-RF2500 too are of immense importance, as they provide possibilities of increasing the accuracy and decreasing the power consumption of the sensor nodes. To understand the code we need to know that both access point and end device have separate codes dumped into them. Due to limited hardware semaphores are used, which enable maximum extraction out of the possible hardware. The factory code contains 3 semaphores sJoinSem, sSelfMeasureSem and sPeerFrameSem. The function of semaphore is to limit the hardware to only one specific function at any particular time. This means that if at any moment, anyone of the semaphore is set, the other two have to be low.

The three semaphores are used for three different purposes. The semaphore sJoinSem is set every time an end device attempts to join the network. The semaphore sPeerFrameSem is set when the end device sends a frame to the access point. These frames contain the data acquired from the Carbon Monoxide sensor. The semaphore sSelfMeasureSem is set when the access point needs to measure the temperature using its inbuilt temperature sensor. Since our central computer systems do not require an interface with the gas sensor, we can ignore and remove the sSelfMeasureSem semaphore to increase the efficiency of our code. The semaphore technique increases the responsiveness of the network as all the end devices can attach themselves to the network at any point of time.

The flowchart below describes the code algorithm for the access point node. As described before, setting high of a semaphore depends on the activity shown from the end device. Thus the code is responsive to any activity from the end device ay any point of time, decreasing the latency in the network.

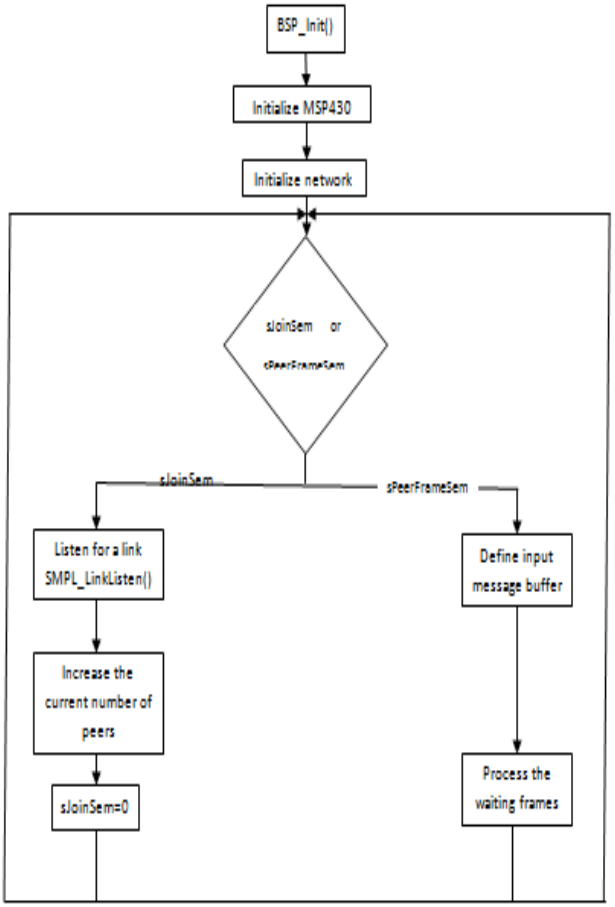


Figure 3 : Algorithm for Access Point

IV. Working and Discussion

To test the response of our network, we used the evaluation module EZ430-RF2500. Input was fed from the end device using switches, response to which was viewed on a laptop and also simultaneously using two LEDs.

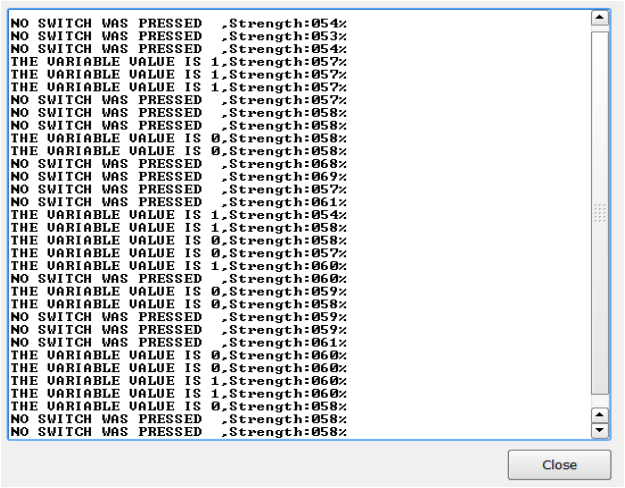


Figure 4 : Output at the console window

Figure [4] shows the console window of EZ430-RF2500 sensor monitor software. It acts like a HyperTerminal window for the output of the access point.

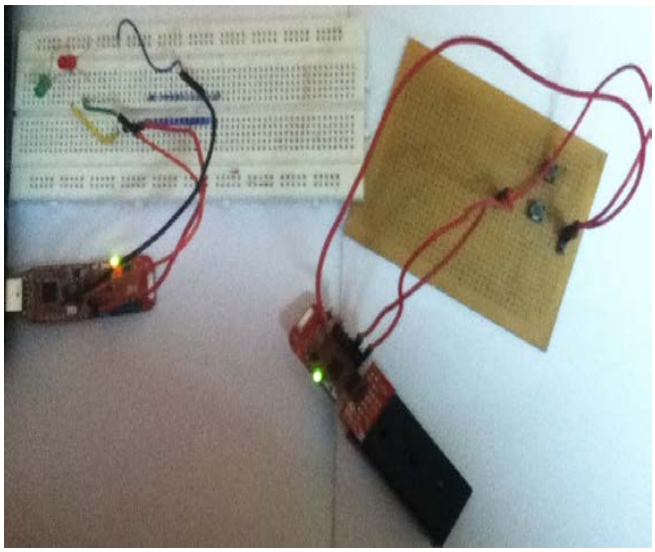
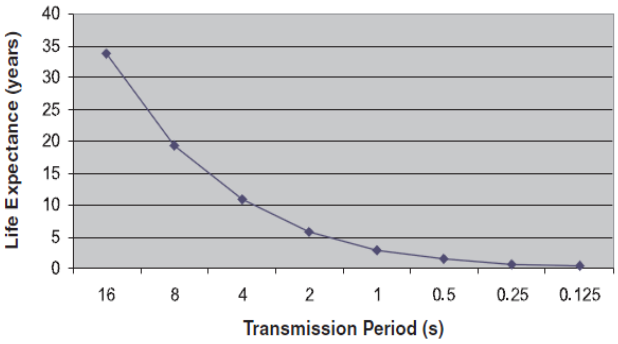


Figure 5 : Hardware Setup

In figure[5] we notice two target boards. The target board on the right, from where the input is provided using switches, is the end device. The target board on the left is the access point. The end device transmits the value of 0 or 1 depending upon the input given from the switch. The same Input is later reflected on the console window, displaying the values of 0 or 1. The red and green LEDs glow separately in response to the different input values provided by the end device. If no input is provided, the console window displays the default message "NO SWITCH WAS PRESSED". Also each message contains information about the received signal strength from the end device. These values can be used to estimate (but not accurately determine) the distance of the sensor node from the central computer system or the access point.



Life expectance vs. Transmission Period [13]

Life expectancy of the sensor node is a very essential characteristic for our specific application. Increasing the lifetime of the sensor node would imply less frequent replacement of power supply sources at the remote areas where the sensor node is established. The above graph displays a technique which can be used to increase the lifetime of the sensor node. If the time difference between two transmissions is increased, the life expectance of the sensor nodes can be stretched to 40 years [13].

V. Conclusion

This paper presents a technique to design robust sensors with increased lifetimes. The ability of the sensor network to handle a large number of nodes will help in carrying out various processes of environment monitoring like reconstruction of pollutant flow and the density profiles of pollutants across the space. Hence the technique provides new opportunities to explore new ways of monitoring the gaseous pollutants, especially carbon monoxide in the air space. In the same way any other parameter may be efficiently detected by developing an appropriate sensing node. Although the fabrication results are not provided, actual implementation of this technique will help by providing more insights on ways to improve the accuracy of the readings of the carbon monoxide sensor, while simultaneously keeping the cost factor to a minimum.

VI. Acknowledgement

The facilities offered in the Electronics Laboratory in VIT University are thankfully acknowledged.

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Global Journal of Researches in Engineering
Electrical and Electronics Engineering
Volume 13 Issue 17 Version 1.0 Year 2013
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Performance Analysis of Maximal-Ratio Combining and Equal Gain Combining in Fading Channels

By Sohag Sarker, Tanzila Lutfor & Md. Zahangir Alam
Pabna University of Science and Technology, Bangladesh

Abstract- In this paper, the performance of a single-input-multiple-output (SIMO) scheme is analyzed under Rayleigh and Rician fading channel using Maximal-Ratio Combining (MRC) and Equal Gain Combining (EGC). In this scheme, a single transmit antenna, which maximizes the total received signal power at the receiver is used and number of received antenna is varied to analyze performance. The Bit Error rate(BER) using two combining techniques under fading channels is derived for BPSK, QPSK and 16-QAM.

Keywords: rayleigh fading, rician fading, maximal-ratio combining, and equal gain combining.

GJRE-F Classification : FOR Code: 090699

Strictly as per the compliance and regulations of :

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I. Introduction

In wireless communications, radio propagation refers to the behavior of radio waves when they are propagated from transmitter to receiver through medium [1]. The transmission path between the transmitter and receiver can vary from simple line-of-sight to one that is severely obstructed by buildings, mountains, and foliage which cause reflection, diffraction, and scattering[2]. The wireless channel environment mainly governs the performance of wireless communication systems. The wireless channel is dynamic and unpredictable rather than the typically static and predictable characteristics of a wired channel which make an exact analysis of the wireless communication system often difficult. A unique characteristic in a wireless channel is a phenomenon called 'fading', the rapid fluctuations of the signal amplitude over time and frequency. In addition to AWGN, fading is another source of signal degradation that is characterized as a non-additive signal disturbance in the wireless channel. Fading may either bemulti-path (induced) fading, which is due to multipath propagation, orshadow fading which is due to shadowing from obstacles that affect the propagation of a radio wave. The fading phenomenon in the wireless communication channel is modeled for 800MHz to 2.5 GHz by extensive channel measurements in the field. Includes the ITU-R standard channel models specialized for SISO. The MIMO (Multiple Input Multiple Output), MISO (Multiple Input Single Output), and SIMO (Single Input Multiple Output) systems have been recently developed by the various research and standardization activities, aiming at high-speed wireless transmission and diversity gain [3] which improves the performance of the communication links over radio fading channels[1].The basic concept of diversity is that if one signal path is week at a particular point of time, another independent path may be just fine. Here receiver is provided with multiple copies of the same information signal which are transmitted over two or more real or virtual communication channels. Thus it can be considered as the diversity is the repetition or redundancy of information [4].

Diversity-combining techniques are often used to combat the deleterious effect of channel fading [5,6]. Maximal ratio combining (MRC) or equal-gain combining (EGC) are widely applied to reduce the system bit error rate (BER) [6].

The *relative* advantage of diversity is greater for Rayleigh fading than Rician fading, because as the Rice factor *K* increases there is less difference between the instantaneous received signal-to-noise ratios on the various diversity branches [7].However, the performance will always be better with Rician fading than with Rayleigh fading, for a given average received signal-to-noise ratio and diversity order.

II. System Model

Let us consider the transmission ofthe band-pass signal,

$$s(t) = \mathrm{Re}[\tilde{s}(t)e^{j2\pi f_c t}] \qquad (1)$$

where, $\tilde{s}(t)$ = complex envelope of transmitted signal, f_c= carrier frequency, Re[z]= real part of z.If the channel is composed of N propagation paths, then the noiseless received band pass waveform is

$$r(t) = \mathrm{Re}[\sum_{n=1}^{N} C_n e^{j2\pi[(f_c + f_{D,n})(t-\tau_n)]}\tilde{s}(t-\tau_n)] \qquad (2)$$

where, C_n is the amplitude of n^{th} propagation path, $\tau_n$is time delay associated with n^{th} propagation path.

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Now, the received band pass signal,

$$r(t)=\mathrm{Re}[\tilde{r}(t)e^{j2\pi f_c t}] \quad (3)$$

where, the received complex envelope,

$$\tilde{r}(t)=\sum_{n=1}^{N} C_n e^{-j\varphi_n(t)}\tilde{s}(t-\tau_n) \quad (4)$$

$$\varphi_n(t)=2\pi\{(f_c+f_{D,n})\tau_n - f_{D,n}t\} \quad (5)$$

Now, the channel impulse response,

$$g(t,\tau)=\sum_{n=1}^{N} C_N e^{-j\varphi_n(t)}\delta(\tau-\tau_n) \quad (6)$$

where $g(t,\tau)$ is the channel response at time t due to an impulse applied at time t-τ, δ(.) is the dirac delta function[4].

Here, the channel assumed to be wide sense stationary (WSS), so the received complex envelope $g(t)=g_I(t)+jg_Q(t)$; where, $g_I(t)$ and $g_Q(t)$ are independent identically distributed zero mean Gaussian random variables at time t_1 with variance b_0.Under these conditions, the received complex envelope's magnitude$\alpha(t) = |g(t)|$ has a Rayleigh distribution at any time t_1, that is $P_\alpha(x)=\frac{x}{b_0}exp\left\{-\frac{x^2}{2b_0}\right\}$.The average envelope power is$E[\alpha^2] = \Omega_p=2b_0$.
So, for Rayleigh distribution,

$$P_\alpha(x)=\frac{2x}{\Omega_p}\exp\{\frac{-x^2}{\Omega_p}\}\ (x\geq 0) \quad (7)$$

For Rician fading, line of sight (LoS) component will be present; so equation (7) can be re-written for Rician channel as:

$$P_\alpha(x)=\frac{2x}{\Omega_p}\exp\{\frac{-x^2+s^2}{2b_o}\}I_0(\frac{xs}{b_0})\ (x\geq 0) \quad (8)$$

where, $s^2=m_I^2(t)+m_Q^2(t)$

Where, $m_I(t)$ and $m_Q(t)$ corresponds to in-phase and quadrature component of LoS signal as:

$$m_I(t)=s\cdot\cos(2\pi f_m\cos\theta_0 t+\phi_0)$$

$$m_Q(t)=s\cdot\sin(2\pi f_m\sin\theta_0 t+\phi_0)$$

where, $f_m\cos\theta_0$ and $\varphi_0$are the Doppler shift and random phase off set associated with the LoS or specular component, respectively.The Rice factor (K)is the ratio of the specular power $s^2$to scattered power $2b_0$, that is, $K= s^2/2b_0$. When K = 0 the channel exhibits Rayleigh fading, and when K =∞ the channel does not exhibit any fading at all [7].

a) Maximal Ratio Combiner (MRC)

In MRC, each signal branch is multiplied by a weight factor that is proportional to the signal amplitude. Signals from all the MR branches are weighted according to their individual SNR and then summed.

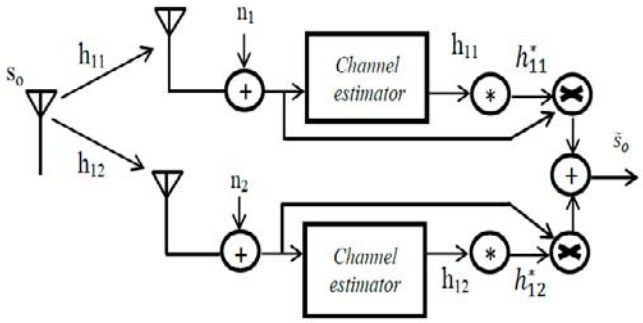

Figure 1 : MRC with 1 Tx and 2 RX

Our system, as indicates in fig-1, modeled with 1 transmitter and 2 receivers. The symbol to be transmitted is weighted with transmit weighting vector to form the transmitted signal vector. Thus the resulting receive signal can be represented as [1]:

$$\tilde{r}_1=h_{11}\tilde{s}_0+n_1 \quad (9)$$

$$\tilde{r}_2=h_{12}\tilde{s}_0+n_2 \quad (10)$$

Where, h_{11} and h_{12} represents the channel coefficients for receive antenna 1 and 2 respectively at time t and, $n_1$and n_2 represents additive white Gaussian noise with zero mean and unit variance [8].
The combined signal can be written as:

$$\hat{s}_o=h_{11}*\tilde{r}_1+h_{12}*\tilde{r}_2 \quad (11)$$

This system, particularly designed for 1 Transmitter antenna and L Receiver Antennas. Thus the channel consists of 1*L statistically independent coefficients which form the channel matrix $\mathbf{h} = [h_{11}\ h_{12}\ \ldots\ldots\ldots h_{1L}]^T$. Then the received signal vector can be written as the product of the Transmitted signal and the channel coefficient plus noise.

$$\tilde{\boldsymbol{r}}=\boldsymbol{h}*\boldsymbol{x}+\boldsymbol{n} \quad (12)$$

where, $\tilde{\boldsymbol{r}}\triangleq(\tilde{r}_1,\ \tilde{r}_2,\cdots,\tilde{r}_L)^T$, the noise vector $\mathbf{n} = [n_1\ldots\ldots\ldots\ldots n_L]^T$. Here, the noise is assumed to be uncorrelated and white Gaussian with the signal [5].

As it is inevitable that MRC realizes Maximum Likelihood (ML) detector, the receiver chooses the message vector $\tilde{s}_m$ that maximizes the metric,

$$\mu(\tilde{\mathbf{s}}_m)=-\sum_{K=1}^{L}\left\|\tilde{\mathbf{r}}_K-h_{1K}\tilde{\mathbf{s}}_m\right\|^2$$

$$=-\sum_{K=1}^{L}\{\left\|\tilde{\mathbf{r}}_K\right\|^2-2\,\mathrm{Re}(h^*_{1k}\tilde{\mathbf{r}}_K,\tilde{\mathbf{s}}_m)+\left|h_{1K}\right|^2\left\|\tilde{\mathbf{s}}_m\right\|^2\} \quad (13)$$

The diversity combiner generates the sum

$$\tilde{\boldsymbol{r}} = \sum_{k=1}^{L} h_{1k}^{*} r_k \tag{14}$$

After weighting, co-phasing and combining, the envelope of the composite signal component can be written as:

$$\alpha_M = \sum_{K=1}^{L} \alpha_K^2 \tag{15}$$

The weighted sum of the branch noise power is

$$\sigma_{\dot{n},tot}^2 = N_0 \sum_{k=1}^{L} \alpha_k^2 \tag{16}$$

Hence the symbol energy to noise ratio is

$$\gamma_s^{mr} = \frac{\alpha_M^2 E_{av}}{\sigma_{\dot{n},tot}^2} = \sum_{K=1}^{L} \frac{\alpha_k^2 E_{av}}{N_0} = \sum_{k=1}^{L} \gamma_K \tag{17}$$

where E_{av} is the average symbol energy in the signal constellation.

Here, it is assumed that all antennas are balanced and uncorrelated and γ has a chi-squared distribution with 2L degrees of freedom i.e.,

$$p_{\gamma_s}^{mr}(x) = \frac{1}{(L-1)!(\bar{\gamma}_c)L} x^{L-1} e^{-x/\bar{\gamma}_c} \tag{18}$$

Where, $\bar{\gamma}_c = E[\gamma_k]$; k=1.....L (19)

For BPSK the bit error rate can be represted as:

$$P_b = \int_0^{\infty} P_b(x) P_{\gamma}(x) dx$$

$$= \int_0^{\infty} Q(\sqrt{2x}) \frac{1}{(L-1)!(\bar{\gamma}_c)^L} x^{L-1} e^{-x/\bar{\gamma}_c} dx \tag{20}$$

Similarly, bit error rate for M-QAM as follows [9] :

$$P_{QAM} = 1 - (1 - P_{QAM,Rician,\sqrt{M}})^2 \tag{21}$$

where,

$$P_{QAM,Rician,\sqrt{M}}$$

$$= (1 - \frac{1}{\sqrt{M}}) \sum_{n=0}^{\infty} \frac{(LK)^n e^{-LK}}{\Gamma(n+1)} * \left[1 - \sum_{i=0}^{L+n-1} \mu (\frac{1-\mu^2}{4})^i \binom{2i}{i} \right]$$

and $\mu = \sqrt{\frac{3\bar{\gamma}_s}{2M - 2 + 3\bar{\gamma}_s}}$

b) Equal Gain Combiner(EGC)

The similarity between EGC and MRC is that in both cases diversity branches are co-phased, but for EGC diversity branches are not weighted. The complete channel vector is required anyway and MRC might as well be used. In EGC, the receiver maximizes the metric

$$\mu(\tilde{\boldsymbol{s}}_m) = \sum_{k=1}^{L} Re(\tilde{\boldsymbol{r}}_k e^{-j\Phi_k}, \tilde{\boldsymbol{s}}_m) =$$

$$\sum_{k=1}^{L} Re\left(e^{-j\Phi_k} \int_0^T \tilde{r}_k(t) \tilde{\boldsymbol{s}}_m^*(t)\, dt \right) \tag{22}$$

The combiner generates the sum

$$\tilde{\boldsymbol{r}} = \sum_{k=1}^{L} e^{-\Phi_k} \tilde{\boldsymbol{r}}_k \tag{23}$$

The envelope of the composite signal, after co-phasing and combining, is

$$\alpha_E = \sum_{k=1}^{L} \alpha_k \tag{24}$$

And LN_0 is the sum of branch powers. The resulting symbol energy-to-noise ratio is

$$\gamma_{\boldsymbol{s}}^{eg} = \frac{\alpha_E^2 E_{av}}{LN_0} \tag{25}$$

With EGC, the average symbol energy-to-noise ratio is

$$\widetilde{\gamma}_s^{eg} = \frac{E_{av}}{LN_0} E\left[\left(\sum_{k=1}^{L} \alpha_k \right)^2 \right]$$

$$= \frac{E_{av}}{LN_0} \sum_{i=1}^{L} \sum_{l=1}^{L} E[\alpha_k \alpha_l] \tag{26}$$

The bit error probability, with coherent BPSK signaling, is

$$P_b = \int_0^{\infty} P_b(x) P_{\gamma_s^{eg}}(x)\, dx$$

$$= \frac{1}{2}\left(1 - \sqrt{1 - \mu^2}\right) \tag{27}$$

where $\mu = \frac{1}{1 + \widetilde{\gamma}_c}$

The Probability of error can be expressed as the following equation as well:

$$P_S = \frac{1}{\pi} \int_0^{\infty} \mathrm{Re}\, al\{G(\omega)\phi_x^*(\omega)\} d\omega \tag{28}$$

The formula can be calculated using Gauss-Chebychev quadrature (GCQ)

$$G(\omega) = \frac{1}{\sqrt{\pi\omega}} \times$$

$$\left\{ F(\frac{\omega}{2\sqrt{\kappa_2}}) - \exp(\frac{-\omega^2}{4\kappa_2} \sin^2(\eta)) \times F(\frac{\omega \cos(\eta)}{2\sqrt{\kappa_2}}) \right\}$$

$$+ j\omega \frac{1}{2\pi} \int_0^{\eta} \frac{\sin^2(\theta)}{\kappa_2} \times \phi(1, \frac{3}{2}; \frac{-\omega^2 \sin^2(\theta)}{4\kappa_2})\, d\theta \tag{29}$$

Where, $\eta = \pi - \pi/4$ and $\kappa_2 = \sin^2(\pi/4)$ and F (.) denotes Dawson's integral. [10]

III. Simulation Results

In this section, we discussed the simulation results of the BER Vs SNR performance of BPSK, QPSK and 16-QAM modulation schemes with MRC and EGC diversity combining techniques over Rayleigh and Rician fading channels using one or more receiving antennas with the help of MATLAB.

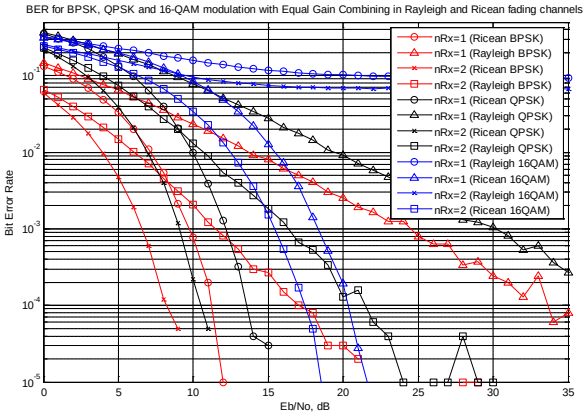

Figure 1 : BER for BPSK,QPSK and 16-QAM modulation schemes with Equal Gain Combining technique in Rayleigh and Rician fading channels

In Figure 1, it is observable that at very low SNR value area, the system performance is comparatively better under deployment of BPSK and Rician fading channel with Equal Gain Combining technique. It is also observable that with increasing number of receiving antennas BER is decreasing significantly.

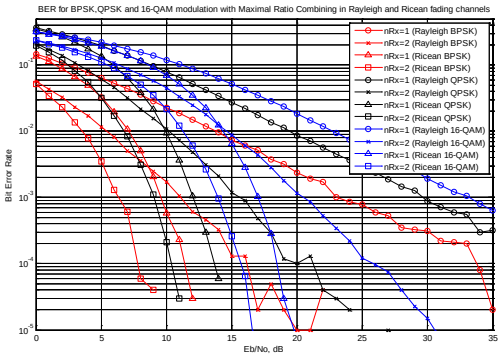

Figure 2 : BER for BPSK,QPSK and 16-QAM modulation schemes with Maximal Ratio Combining Technique in Rayleigh and Rician fading channels

In Figure 2, it is observed that with Maximal Ratio Combining technique, BPSK performs comparatively better than QPSK with Rician fading channel. It is also observable that BER decreases significantly with increasing number of receiving antennas.

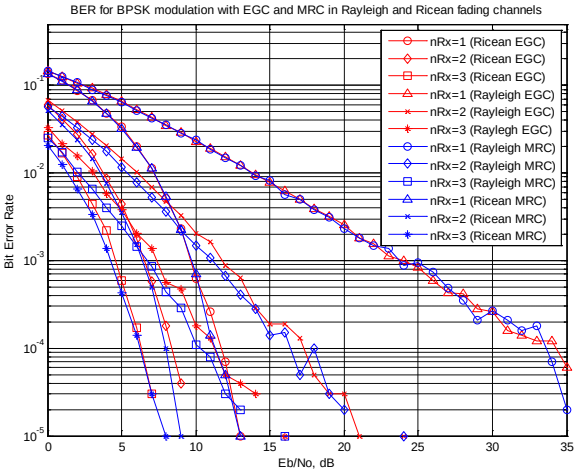

Figure 3 : BER for BPSK modulation schemes with EGC and MRC in Rayleigh and Rician fading channels

Figure 3 shows the BER for BPSK modulation schemes with EGC and MRC in Rayleigh and Rician fading channels. We observed that with single receiving antenna BER for BPSK is same in both Maximal Ratio Combining technique and Equal Gain Combining technique. With two or more receiving antennas Maximal Ratio Combining technique performs better than Equal Gain Combining technique with BPSK.

IV. Conclusion

In this paper, we have investigated simulation results of Maximal ratio combining and Equal Gain Combining under Rayleigh and Rician fading channels using various modulation techniques. In the context of system performance, it can be concluded that BPSK Maximal Ratio Combining technique gives satisfactory results than Equal Gain Combining. The results presented in this paper are expected to provide useful information and guidelines to radio systems design engineers to exploit the use of diversity combining under realistic imperfect channel estimation scenarios.

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Global Journal of Researches in Engineering
Electrical and Electronics Engineering
Volume 13 Issue 17 Version 1.0 Year 2013
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Bandwidth Enhancement of Compact Rectangular Microstrip Patch Antenna

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Abstract- A compact single feed rectangular microstrip patch antenna using dielectric substrate 4.2, loss tangent .0012 and having substrate height of 1.6 is used. The compact antenna of dimension (14mm X 18.6mm X 1.6mm) is used and analyzed on MoM based simulating software IE3D. A probe of different radius has been taken to improve the Bandwidth of the proposed structure. Simulation results show that antenna can realize wide band characteristics and single band of 4.148 GHz (impedance bandwidth of 76.53%) has been achieved.

Keywords: microstrip antenna, wide band, band width enhancement, probe radius, IE3D.

GJRE-F Classification : FOR Code: 291701, 290903p

Strictly as per the compliance and regulations of :

Bandwidth Enhancement of Compact Rectangular Microstrip Patch Antenna

Vivek Singh Rathor [α] & J. P. Saini [σ]

Abstract- **A compact single feed rectangular microstrip patch antenna using dielectric substrate 4.2, loss tangent .0012 and having substrate height of 1.6 is used. The compact antenna of dimension (14mm X 18.6mm X 1.6mm) is used and analyzed on MoM based simulating software IE3D. A probe of different radius has been taken to improve the Bandwidth of the proposed structure. Simulation results show that antenna can realize wide band characteristics and single band of 4.148 GHz (impedance bandwidth of 76.53%) has been achieved.**

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I. Introduction

Microstrip patch antennas are popular for their well-known attractive features of low profile, light weight, and compatibility with monolithic microwave integrated circuits (MMICs). Because of their attractive feature they are in great demand in wireless communication applications. The main disadvantage of this microstrip antenna narrow bandwidth, which is due to the resonant nature of the patch structure.[4] Conventional microstrip antennas in general have a conducting patch printed on a grounded microwave substrate, and have the attractive features of low profile, light weight, easy fabrication, and conformability to mounting hosts.[1] However, conventional microstrip patch antenna suffers from very narrow bandwidth, typically about 5% bandwidth with respect to the center frequency. This poses a design challenge for the microstrip antenna designer to meet the broadband techniques [3]. To overcome this problem of narrow bandwidth, many proposals and techniques have been analyzed and investigated such as probe fed stacked antenna, microstrip patch antennas on electrically thick substrate, slotted patch antenna and stacked shorted patches, the use of various impedance matching and feeding techniques, the use of multiple resonators. [14] The development of antenna for wireless communication also requires an antenna with more than one operating frequency. This is due to many reasons, mainly because there are various wireless communication systems and many telecommunication operators using various frequencies. Therefore one antenna that has multiband characteristic is more desirable than having one antenna for each frequency band. [7] Our aim is to increase the operating bandwidth the simulation has been carried out by IE3D. So we want an antenna which offers a low profile, wide bandwidth, compact antenna element. Among these standards, the following frequency bands can be mentioned: (1) PCS-1900 requires a band of 1.85–1.99 GHz; (2) IEEE 802.11b/g requires a band of 2.4–2.484 GHz; (3) IEEE 802.11a requires a band of 5.15–5.35 GHz and an additional band of 5.725–5.825 GHz; (4) HiperLAN2 requires a band of 5.47–5.725 GHz besides the band of 5.15–5.35 GHz. [2, 6, 7, 12]

To overcome the above problem, a microstrip antenna structure with a typical Kite symbol shaped patch is proposed which exhibits good enhanced impedance bandwidth of up to 76.53% depending upon the radius of probe.

II. Antenna Design

The dielectric constant of the substrate is closely related to the size and the bandwidth of the microstrip antenna. Low dielectric constant of the substrate produces larger bandwidth, The resonant frequency of microstrip antenna and the size of the radiation patch can be similar to the following formulas while the high dielectric constant of the substrate results in smaller size of antenna [1].The Length of ground plane of Antenna is 24 mm and Width is 28.2 mm, L & W of the patch is 14 mm & 18.6 mm the radius of the coaxial probe feed is taken as 0.5 mm. The material used for substrate is glass epoxy with dielectric constant of 4.2, loss tangent .0012 and substrate height of 1.6 mm. The proposed structure is shown in fig 1.

The patch width, effective dielectric constant, the length extension and also patch length are given by

$$W = \frac{c}{2f\sqrt{\varepsilon_r}} \qquad (1)$$

where **c** is the velocity of light, ε_r is the dielectric constant of substrate, f is the antenna working frequency, W is the patch non resonant width, and the effective dielectric constant is ε_{eff} given as,

$$\varepsilon_{eff} = \frac{(\varepsilon_r + 1)}{2} + \frac{(\varepsilon_r - 1)}{2}\left[1 + 10\frac{H}{W}\right]^{-\frac{1}{2}} \qquad (2)$$

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The extension length Δ is calculates as,

$$\frac{\Delta L}{H} = 0.412 \frac{\left(\varepsilon_{eff} + 0.300\right)\left(\frac{W}{H} + 0.262\right)}{\left(\varepsilon_{eff} - 0.258\right)\left(\frac{W}{H} + 0.813\right)} \quad (3)$$

By using above equation we can find the value of actual length of the patch as,

$$L = \frac{c}{2f\sqrt{\varepsilon_{eff}}} - 2\Delta L \quad (4)$$

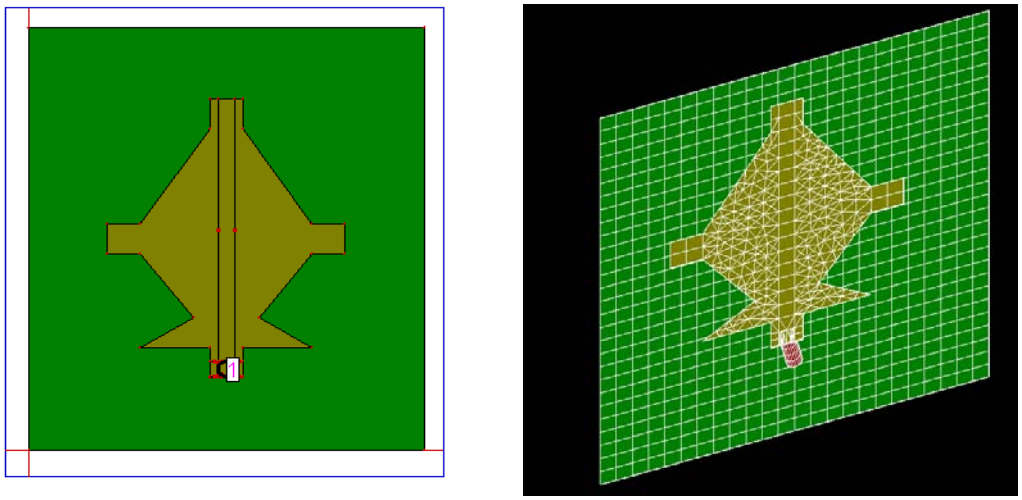
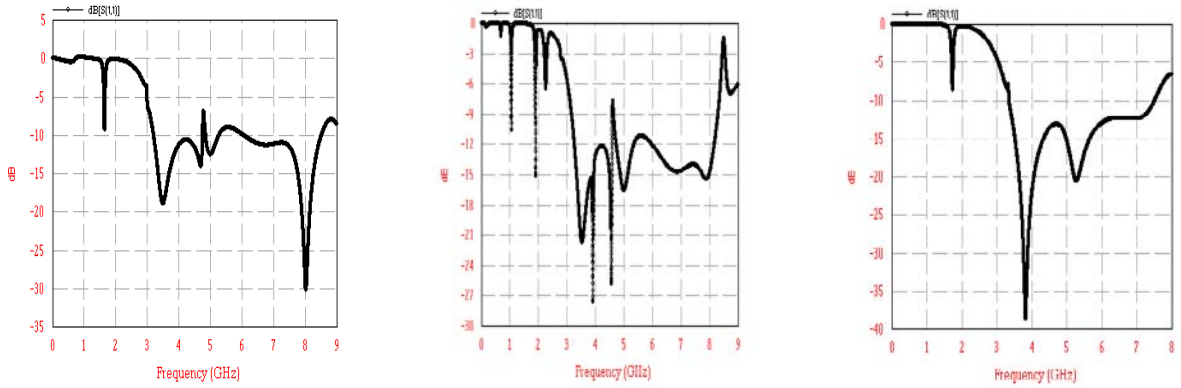


Figure 1 : Top view of the microstrip patch antenna

III. Simulated Results

In this section various parametric analysis of the proposed antenna are done and presented. Parameter of the antenna has been investigated to improve bandwidth, gain and return loss performance of the antenna. The return loss plot of structure with probe of different radius is shown is shown in fig 2 (a, b, c)



(a) (b) (c)

Figure 2 : Return loss plot of the microstrip patch antenna with probe of different radius (a).5mm (b) 0.4mm (c) 0.16mm

In proposed antenna the return loss is -18dB at 3.5 GHz and -30 dB at 8GHz. While the frequencies range of band below -10 dB and VSWR $<$ 2 is 3.208 GHz - 4.763 GHz, 4.853 GHz - 5.293 GHz and 6.029 GHz-8.533 GHz shown in fig 2(a). We can see that there is no resonant frequency at 3.9GHz and 4.5 GHz in fig 2 (a) while in fig 2 (b) return loss at 3.9 GHz Frequency is around 28 dB and at 4.5GHz it is 26 dB, at 3.5 GHz we get the return loss of around 22 dB. The frequency range we are getting below 10 dB and VSWR $<$ 2 is 1.899GHz – 1.912GHz, 3.189GHz – 4.601GHz and 4.655GHz – 8.29 GHz. In fig 2(c) the return loss at around 3.9 GHz is around 39 dB and band below 10 dB (VSWR $<$ 2) is ranging from 3.362 GHz – 7.53GHZ.

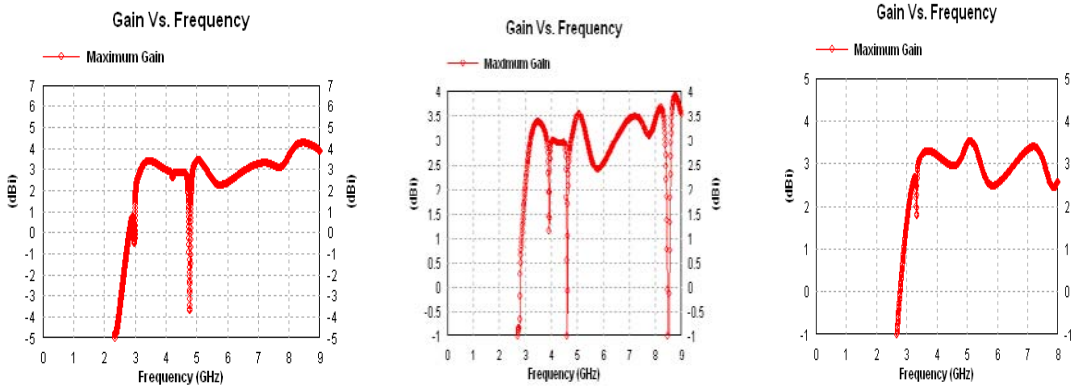
a) Effect of Parameter (radius r of probe) on Band of Proposed Design

If the radius of the probe is decreased from 0.5 mm to 0.4 mm dramatically changes will appear in the result. We can see the details given in table 1, we are getting three bands of frequency in first structure when radius is 0.5 mm but when we decrease the radius we get two band in which we get the bandwidth of 36.25% in first band and 56.16% in the second band the max. Gain remains the same in band 1 as in the previous case but in band two the max. Gain is reduced by only 0.5 dBi. Max. Efficiency remains almost same and max. Directivity is around 6.5 dBi. Now if we further decrease the radius of probe from 0.4 mm to 0.16 mm (sl.no.3, fig.1) we achieve impedance bandwidth of 76.53 % which is almost double the frequency in the first stage when radius of the probe is 0.5 mm with max. Gain of 3.5 dBi, efficiency 90 % and max. Directivity of 5.5 dBi.

Table 1 : Parameters on probes of different radius

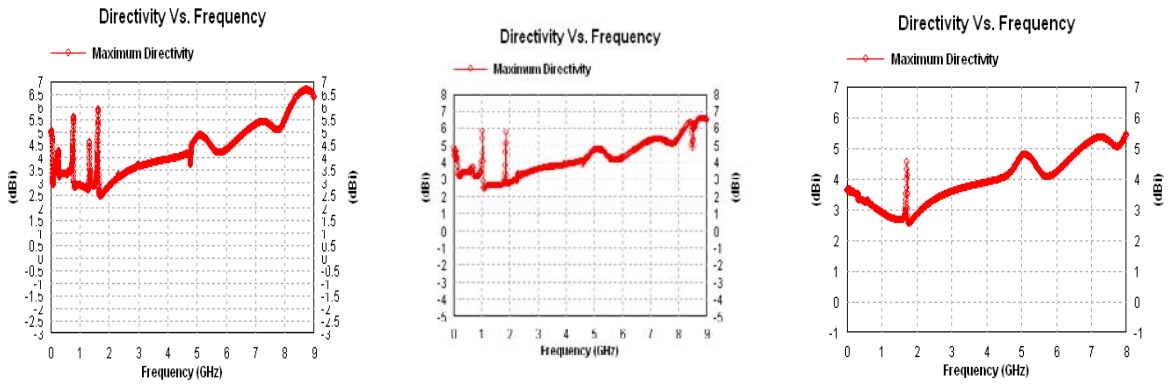
Serial No.	Radius of probe	Band of Freq. (in GHz)	%Bandwidth	Max. Gain	% Efficiency	Max. Directivity
1	0.5 mm	3.208 - 4.763 4.853 - 5.293 6.029 - 8.533	39.02 % 8.67 % 3.39 %	3.5 dBi 3.5 dBi 4.5 dBi	90% 65 % 65 %	6.75 dBi
2	0.4 mm	3.189 – 4.601 4.655 – 8.29	36.25 % 56.16 %	3.5 dBi 4.0 dBi	90 % 75 %	6.5 dBi
3	0.16 mm	3.362 – 7.53	76.53 %	3.5 dBi	90 %	5.5 dBi

Total gain versus frequency plot is shown in fig3.Max. Directivity versus frequency plot and efficiency versus frequency plot are shown in fig 4 and 5. 3D Radiation pattern plot, 2D Elevation Pattern Gain display plot and 2D azimuth pattern Gain display plot is shown in fig.6, 7 and 8 respectively.



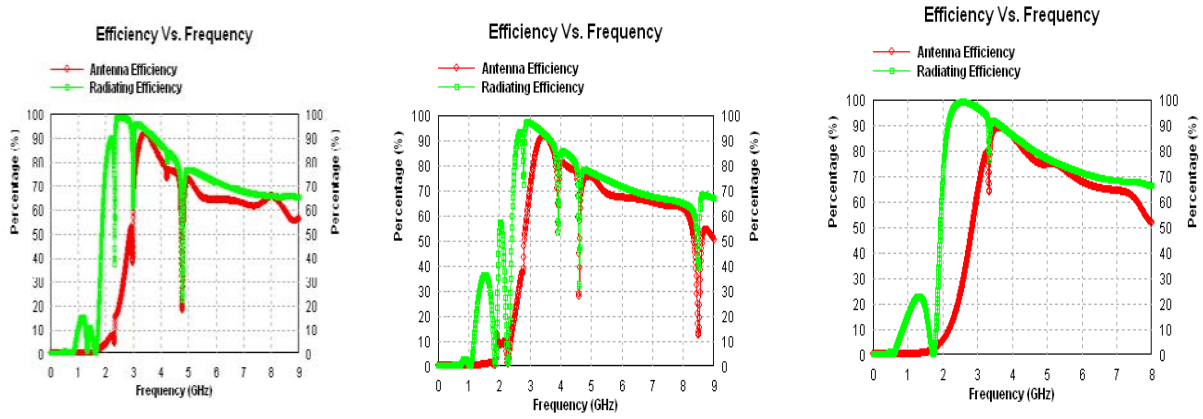
(a) (b) (c)

Figure 3 : Maximum gain plot of microstrip patch antenna for probe of radius (a) 0.5 mm (b) 0.4 mm (c) 0.16 mm



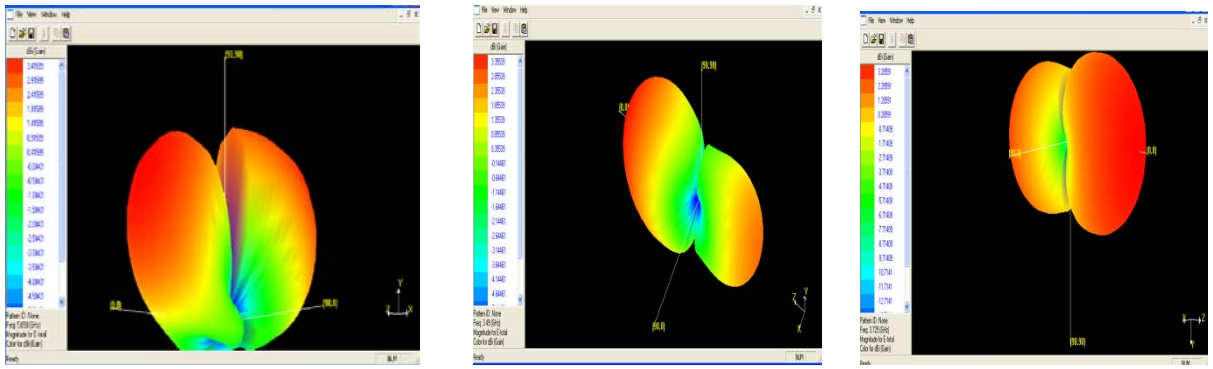
(a) (b) (c)

Figure 4 : Directivity versus frequency plot of microstrip patch antenna for probe of radius (a) 0.5 mm (b) 0.4 mm (c) 0.16 mm



(a) (b) (c)

Figure 5 : Efficiency versus frequency plot of the microstrip patch antenna for probe of radius (a) 0.5 mm (b) 0.4 mm (c) 0.16 mm



(a) (b) (c)

Figure 6 : 3D Radiation pattern plot of the microstrip patch antenna for probe of radius (a) 0.5 mm (b) 0.4 mm (c) 0.16 mm

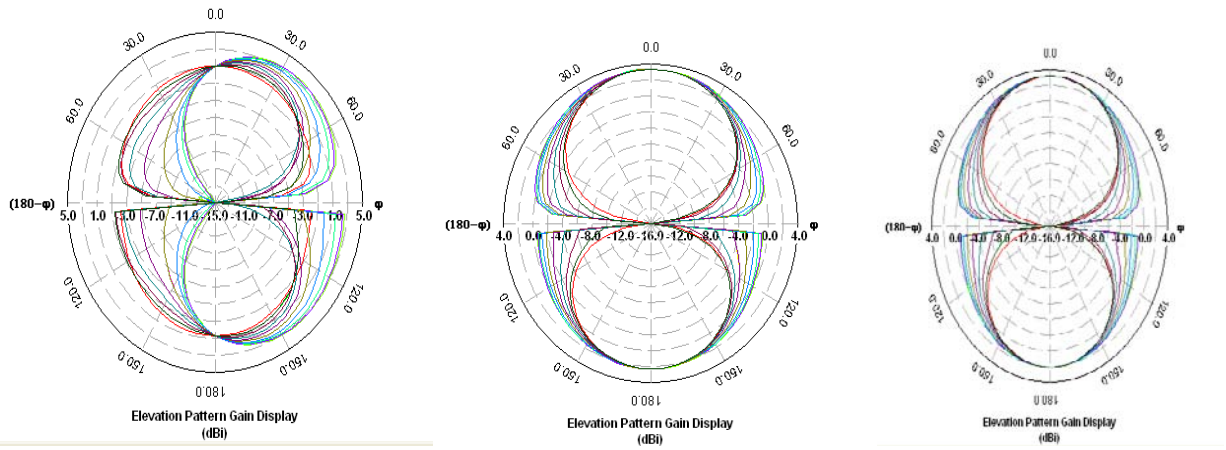
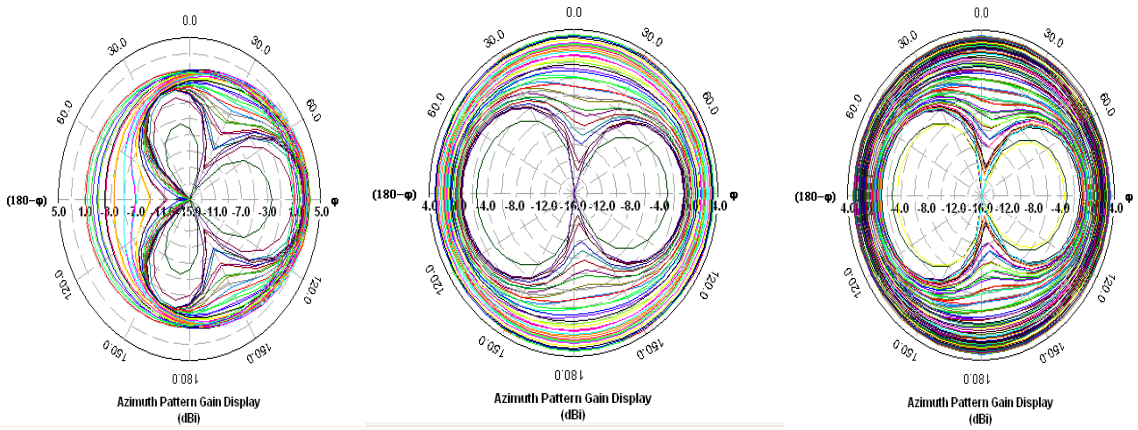


Figure 7 : 2D Elevation Pattern Gain Display (dBi) for probe of radius (a) 0.5 mm (b) 0.4 mm (c) 0.16 mm



(a) (b) (c)

Figure 7 : 2D Azimuth Pattern Gain Display (dBi) for probe of radius (a) 0.5 mm (b) 0.4 mm (c) 0.16 mm

IV. Conclusion

In this paper a compact size microstrip antenna has been designed having good impedance matching as well as high antenna efficiency of about of about 90% is achieved by changing the radius of the probe. The impedance band width has been enhanced from 39 % to 76.53 %. The proposed antenna have larger impedance bandwidth of 76.53% covering the frequency range from 3.362 GHz -7.53 GHz which is suitable for WLAN (upper band application).

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Global Journal of Researches in Engineering
Electrical and Electronics Engineering
Volume 13 Issue 17 Version 1.0 Year 2013
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4596 & Print ISSN: 0975-5861

Comparative Study on DC Motor Speed Control using Various Controllers

By K. Venkateswarlu & Dr. Ch. Chengaiah
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Abstract- Electrical machines like DC motors, brushless DC motors, permanent magnet DC motors are being controlled with power electronics converters. The control has become precise with invention of Micro Controllers and power devices like IGBT, Power MOSFET. In this paper the attempt is made to simulate a speed control of separately excited DC motor with PID and fuzzy controllers. The aim of development of this paper is towards providing efficient method to control speed of DC motor using analog Controller. With the availability of MATLAB/SIMULINK, Fuzzy Controller for comprehensive study of modeling analysis and speed control design methods has been demonstrated.

Keywords: DC motor, open loop, closed loop system, speed control, PID controller and fuzzy controller.

GJRE-F Classification : FOR Code: 090699

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Comparative Study on DC Motor Speed Control using Various Controllers

K. Venkateswarlu [α] & Dr. Ch. Chengaiah [σ]

Abstract- **Electrical machines like DC motors, brushless DC motors, permanent magnet DC motors are being controlled with power electronics converters. The control has become precise with invention of Micro Controllers and power devices like IGBT, Power MOSFET. In this paper the attempt is made to simulate a speed control of separately excited DC motor with PID and fuzzy controllers. The aim of development of this paper is towards providing efficient method to control speed of DC motor using analog Controller. With the availability of MATLAB/SIMULINK, Fuzzy Controller for comprehensive study of modeling analysis and speed control design methods has been demonstrated.**

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I. Introduction

The field of electrical energy will be divided into three areas: Electronics, Power and Control. Electronics basically deals with the study of semiconductor devices and circuits at lower power. Power involves generation, transmission and distribution of electrical energy. Modern manufacturing systems are automated machines that perform the required tasks. The electric motors are perhaps the most widely used energy converters in the modern machine tools and robots. These motors require automatic control of their main parameters such as speed, position, acceleration etc...

In this paper separately excited DC drive system is used, because of their simplicity, ease of applications such as reliability and favorable cost have long been a backbone of industrial applications and it will have a long tradition of use as adjustable speed machines and a wide range of options have evolved for this purpose. In these applications, the motor should be precisely controlled to give the desired performance.

Many varieties of control schemes such as proportional, integral, derivative, proportional integral (PI), PID, adaptive, and FLCs, have been developed for speed control of dc motors. The important aspect of the speed control of a dc motor is the armature voltage control method. By varying voltage to the armature of a dc motor, the speed of the motor can be varied. Speed of a DC motor can be controlled by PID controller also.

In this paper mainly concentrated on speed control of separately excited DC motor. the design of a mathematical model of the separately excited DC motor using MATLAB code has been done and SIMULINK model is used for studying the performance characteristics of dc motor and mainly concentrated on the design of PID controller and Fuzzy logic controller using MATLAB/ SIMULINK model.

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II. Mathematical Modeling of Separately Excited DC Motor

In order to build the DC motor's transfer function, its simplified mathematical model has been used. This model consists of differential equations for the electrical part, mechanical part and the interconnection between them. The electric circuit of the armature and the free body diagram of the rotor is shown in the Fig 1. and the physical parameters of the motor is shown in table1.

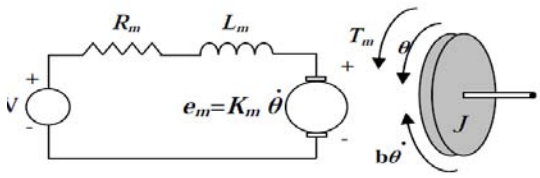

Figure 1 : The electric circuit of the armature and the free body diagram of the rotor for a DC motor

Table 1 : Physical parameters of the DC motor

J	Moment of Inertia of the Rotor(kg.m^2)	0.01
b	Damping ratio of the Mechanical System (Nms)	0.1
Km	Motor Constant (Nm/A)	0.01
Rm	Motor Electric Resistance(Ω)	1
Lm	Motor Electric Inductance(H)	0.5
V	Input Voltage(Volt)	6
ℵ	Rotating Speed(r/s)	600

The motor torque, Tm, is related to the armature current (I), by a constant factor K_t. The back emf (e_m) is related to the rotational speed by the following equations.

$$T_m = K_t I \quad (1)$$

$$e_m = K_e \dot{\theta} \quad (2)$$

Assuming that, Kt(torque constant) =Ke(electromotive force constant) =Km (motor constant).

From Fig.1 and physical parameters of system mentioned above, the following equations can be written based on Newton's law combined with Kirchhoff's laws.

$$J\ddot{\theta} + b\dot{\theta} = K_m i - T_L \quad (3)$$

$$L_m \frac{di}{dt} + R_m i = V - K_m \dot{\theta} \quad (4)$$

Transfer Function Model of DC Motor

Using Laplace Transforms, the above equations can be expressed in terms of s-domain

$$s(Js+b)\dot{\theta}(s) = K_m I(s) - T_L(s) \quad (5)$$

$$(L_m(s)+R_m)I(s) = V(s) - K_m s\theta(s) \quad (6)$$

By eliminating I(s), the following open-loop transfer function can be obtained, where the rotational speed is the output and the voltage V is the input. When the motor is used as a component in a system, it is desired to describe it by the appropriate transfer function between the motor voltage and its speed. For this purpose assuming (load torque) $T_L = 0$ and (friction torque) $T_F = 0$, since neither affects the transfer function.

$$\left.\frac{\dot{\theta}(s)}{V(s)}\right|_{T_L(s)=0} = \frac{K_m}{(Js+b)(L_m s + R_m) + K_m^2} \quad (7)$$

III. PID Controller

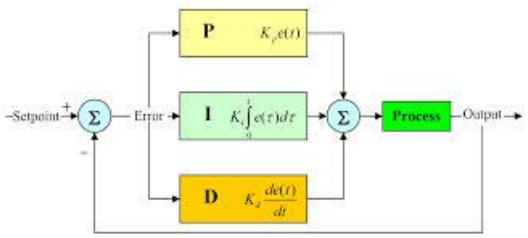

Figure 2 : PID Implementation

The PID control is most widely used in industrial applications. PID controller is implemented to control the speed of DC motor. The implementation of a PID controller is shown in fig (2). The error between the reference speed and the actual speed is given as input to a PID controller. The PID controller depending on the error changes its output, to control the process input such that the error is minimized. A detailed information about the theory and tuning of PID controllers is given in [1]. The Transfer function of a PID controller is given as,

$$c(s) = K_p\left(1 + \frac{1}{T_I * s} + T_D * s\right) \quad (8)$$

The proportional control (K_p) is used so that the control signal u(t) responds to the error immediately. But the error is never reduced to zero and an offset error is inherently present. To remove the offset error the Integral control action (T_I) is used. To Derivative control (T_D) is used to damped out oscillations in the process response. Also, the presence of derivative control reduces the need of K_p being large to achieve stability.

By tuning the gains of the PID controller and producing the optimum response using trial and error method. With the help of MATLAB programming, the performance of separately excited DC motor with and without PID controller was obtained and results are tabulated in table2.

Table 2 : PID controller responses

response	Open loop (sec)	Closed loop (sec)	with PID controller (sec)
Rise Time	1.1362	1.0173	0.1195
Settling Time	2.0653	1.8476	16.0587
Settling Min	0.0901	0.0825	0.8841
Settling Max	0.0999	0.0908	1.0878
Overshoot	0	0	8.7813
Undershoot	0	0	0
Peak	0.0999	0.0908	1.0878
Peak Time	5.2388	4.6398	0.2337

Here a clear cut comparison is given for various values like rise time, dead time etc... in table 2. By employing this PID controller it can be seen that drastically reduced from 1.1362 in open loop to 0.1195 in closed loop system. Coming to peak time there is significant change from open loop to PID controlled system i.e. from 5.2388 seconds to 0.2337 but coming to settling time there is a drastic change from 2.0653 to 16.0857, this is not desirable. There is change in dead time i.e. improvement in dead time from 4 sec to 1 seconds in this system.

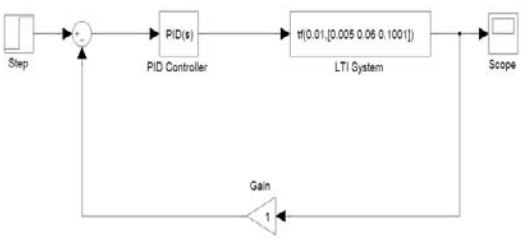

Figure 3 : Simulink model of PID controller

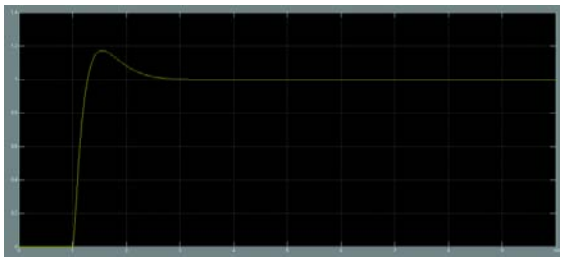

Figure 4 : Response of PID controller

IV. Fuzzy Controller

Fuzzy logic control (FLC) is a control algorithm based on a linguistic control strategy which tries to account the human's knowledge about how to control a system without requiring a mathematical model. The approach of the basic structure of the fuzzy logic controller system is illustrated in Fig 5.

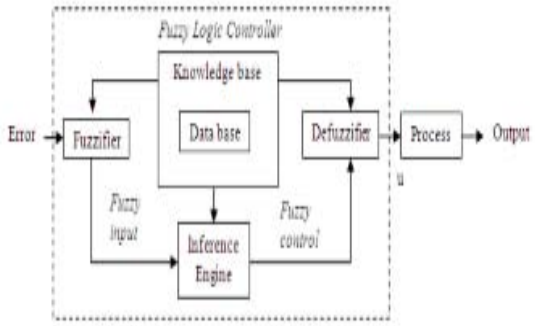

Figure 5 : Structure of Fuzzy Logic Controller

Basically, the Fuzzy Logic controller consists of four basic components: fuzzification, a knowledge base, inference engine, and a defuzzification interface. Each component affects the effectiveness of the fuzzy controller and the behavior of the controlled system. In the fuzzification interface, a measurement of inputs and a transformation, which converts input data into suitable linguistic variables, are performed which mimic human decision making. The results obtained by fuzzy logic depend on fuzzy inference rules and fuzzy implication operators. The knowledge base provides necessary information for linguistic control rules and the information for fuzzification and defuzzification. In the defuzzification interface, an actual control action is obtained from the results of fuzzy inference engine.

Input and outputs are non-fuzzy values and the basic configuration of FLC is featured in Fig6. In the system presented in this study, Mamdani type of fuzzy logic is used for speed controller. Inputs for Fuzzy Logic controller are the speed error (e) and change of speed error. Speed error is calculated with comparison between reference speed, ω ref and the actual speed, ω act.

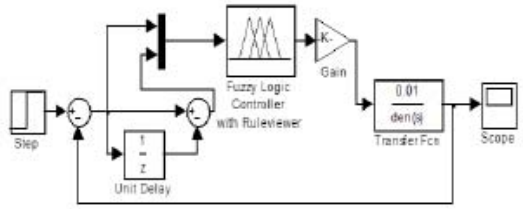

Figure 6 : Simulink model for FUZZY controller

Fuzzy Rule Matrix

The control rules that relate the fuzzy output to the fuzzy inputs which are derived from general knowledge of the system behavior is shown in table 3. Some of the control rules are developed using trial and error method.

Table 3 : Rule Matrix Table

de / e	NB	N	Z	P	PB
NB	NVB	NB	N	NS	Z
N	NB	N	NS	Z	PS
Z	N	NS	Z	PS	P
P	NS	Z	PS	P	PB
PB	Z	PS	P	PB	PVB

To illustrate the control of motor by the fuzzy rule matrix, 5valid rules from the rule matrix table are identified for Zero & Positive small of error and change in error.

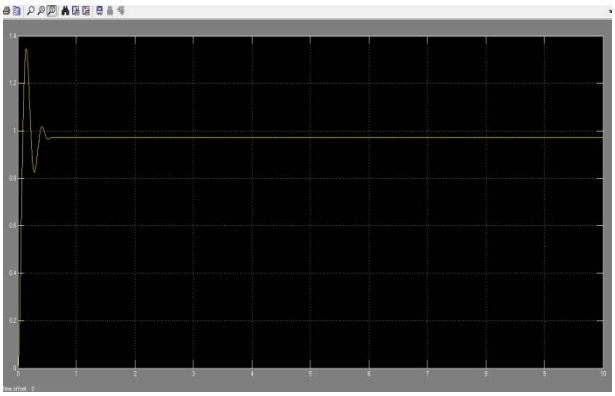

Figure 7 : Response with FUZZY controller

Table 4 : Comparison of results

Open Loop (sec)	Closed Loop(sec)	PID (sec)	FUZZY (sec)
Rise Time: 1.1362	Rise Time: 1.017	Rise time: 0.1195	Rise time: 0.2
Settling Time: 2.0653	Settling Time:1.847	Settling time: 16.0587	Settling time: 0.6
Peak: 0.0999	Peak: 0.090	Dead time: 1	Dead time: 0
Peak Time: 5.2388	PeakTime: 4.6398		

All these shows a great change in the performance of the system. However there is peak overshoot and steady state error .This steady state error can be removed by increasing the gain and peak overshoot automatically will reduce as load is employed on the system. Hence these will not pose any problem on system performance. The above Simulink results are tabulated in Table 4.

From fig7 there is no dead time in the system i.e. dead time is 0. Hence we have reached one of our aim .there is a considerable decrease in rise time which is in the order of 0.2sec. This shows how fastly the system is responding. system has reached its steady state before 0.6 seconds, all these shows a great change in the performance of the system.

V. Conclusions

Speed response characteristics of separately excited dc motor were obtained by mathematical model using MATLAB coding and SIMULINK model. The response is found to be not satisfactory i.e. response doesn't satisfy the desired design requirements like rise time, settling time, peak value, steady state error and dead time etc. There exists a dead time of 1 sec which is a major drawback to the system by conventional method.

To overcome the above drawback we employed PID controller design, by proper tuning of K_P, K_I and K_D to improved the characteristics like steady state error. But the above designed system failed to reduce the dead time of the system. Hence in order to reduce the dead time modern technique like FUZZY controller was employed.

FUZZY controller is proposed to replace conventional PID controller to improve the system characteristics. The corresponding step response is very smooth and ripples free. The rule base adopted is of MAMDANI type and its rule viewer is presented.

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2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
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- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
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- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

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- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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ISSN 9755861