DESIGN OF COMPACT ANTENNA FOR WI-FI APPLICATION

Dr. K. G. Parthiban[1] | S. L. Arunkumar[2] | Mohammad Azhar Uddin[3] | M. Srinivasan[4]

[1](ECE Department, M.P.Nachimuthu M.Jaganthan Engineering College, Erode, India, kgparthiban@gmail.com)

[2](ECE Department, M.P.Nachimuthu M.Jaganthan Engineering College, Erode, India, arunsubiramanian01@gmail.com)

[3](ECE Department, M.P.Nachimuthu M.Jaganthan Engineering College, Erode, India, hustlethebore@gmail.com)

[4](ECE Department, M.P.Nachimuthu M Jaganthan Engineering College, Erode, India, msrini1100@gmail.com)

Abstract—*There are various types of antennas that can be used for many applications in communication systems. This paper presents the design and comparison of log periodic antenna and rectangular microstrip patch antenna which are used in satellite application, aircraft and wireless applications such as WiMAX, Wi-Fi, bluettoth, etc. In this paper, the antennas are designed to operate at S band with 2.4 GHz frequency. The antennas are designed with Flame Retardant 4 (FR-4) substrate of thickness 1.6mm with a dielectric constant of approximately 4.4. It is given with coaxial feed and has a partial ground plane. The basic theory and designs are analyzed and simulation can be done by using HFSS software. After simulation, the antenna performance characteristics such as VSWR, return loss and radiation patterns are obtained. From the results of log periodic and microstrip patch antenna, the best antenna is fabricated and then tested practically.*

Keywords—Log periodic antenna, Microstrip Patch Antenna, Wi-Fi, HFSS

1. INTRODUCTION

In log periodic antenna, the lengths and spacing of the elements of a log-periodic antenna increase logarithmically from one end to the other. This antenna design is used where a wide range of frequencies is needed while still having moderate gain and directionality. The successive dipoles are connected alternately to a balanced transmission line called feeder. That is to say these closely spaced elements are oppositely connected so that end fire radiation in the direction of the shorter elements is created and broadside radiation tends to cancel. Actually, a coaxial line running through one of the feeders from the longest element to the shortest is used. The center conductor of the coaxial cable is connected to the other feeder so that the antenna has its own balun.

There are different shapes of antenna depending on its application. In general, the Microstrip antenna has many properties which are depending upon its applications. These properties include low profile, light weight, compact and comfort to structure, simple fabrication and Ease of installation. These properties contribute to the application of Microstrip antennas in the military applications, such as aircraft, missiles, space craft, and also in the commercial areas, such as mobile satellite system, cellular mobile communications, broadcast satellite system, wireless communication and global positioning system. The choice of antenna selection is based on the requirements of the application such as frequency band, gain, cost, coverage, weight, etc. Wi-Fi is the most rapidly growing area in modern wireless communication. This gives users the mobility to move around within a broad coverage area and still be connected to the network. This provides greatly increased freedom and flexibility. For the home user, wireless has become popular due to ease of installation, and location freedom. Portable antenna technology has grown along with mobile and cellular technologies. It is important to have the proper antenna for a device. The proper antenna will improve transmission and reception, reduce power consumption, improved lifetime and improved efficiency of the communication device. In this paper, a single band Microstrip patch antenna for WLAN application is designed and simulated using High Frequency Structure Simulation (HFSS) Software. The proposed patch antenna resonates at 2.4GHz frequency.

2. DESIGN / GEOMETRY OF LOG PERIODIC ANTENNA

Radiation energy, at a given frequency, travels along the feeder until it reaches a section of the structure where the electrical lengths of the elements and phase relationships are such as to produce the radiation. As frequency is varied, the position of the resonant element is moved smoothly from one element to the next. The upper and lower frequency limits will then be determined by lengths of the shortest and longest elements or conversely these lengths must be chosen to satisfy the bandwidth requirement. The longest half-element must be roughly 1/4 wavelength at the lowest frequency of the bandwidth, while the shortest half-element must be about 1/4 wavelength at the highest frequency in the desired operating bandwidth.

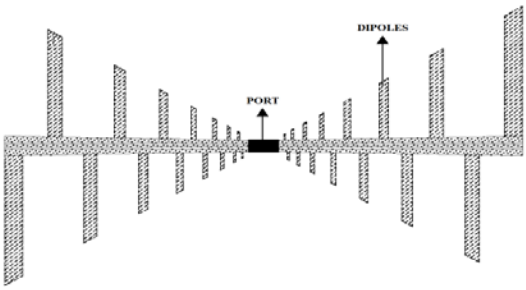

Fig 1. Structure of Log Periodic Antenna

Consider the above figure showing the schematics of the logarithmic periodic antenna with the lengths of the dipole elements, the spacing from the virtual apex to the dipole elements, the wire radius of the dipole elements, the spacing between the quarter wave-length dipoles are proportional with the geometric scale factor, τ , which is always smaller than 1.

A. Antenna Design

The proposed antenna is designed for a resonating frequency of 2.4 GHz. The substrate material used is FR4 which has the relative permittivity of 4.4. The substrate thickness is 1.6mm. The dimensions of the antenna can be calculated by using the following relationship.

i. Scale Factor:

The length (L) and the width (W) are related to the scale factor τ by:

$$\tau = (l_{n+1} + l_n) / l_n = (w_{n+1} + w_n) / w_n \quad (1)$$

ii. Spacing factor:

It relates distance between two adjacent elements with the length of the larger element, can be defined as:

$$\sigma = R_{n+1} - R_n / 2l_{n+1} \quad (2)$$

iii. Relative Spacing:

$$\alpha = \tan-1\ [\ 1-\tau 2\sigma\ ] \quad (3)$$

iv. Active region bandwidth:

Bar can be related with the fundamental design parameters by the following equation:

$$Bar = 1.1 + 7.7\ (1-\tau)2 \cot \alpha \quad (4)$$

In practice a slightly larger structure bandwidth, Bs is usually designed to reach the desired bandwidth, *B*. These bandwidths are related by:

$$Bs = B\ Bar = B\ (\ 1.1 + 7.7\ (1-\tau)2 \cot \alpha\ ) \quad (5)$$

Where, B = fmax / fmin.

v. Number of Dipole Elements:

It is given by the equation:

$$N = 1 + \frac{\log(B_S)}{\log(\frac{1}{\tau})} \quad (6)$$

B. Antenna Modelling:

From the above relationships, the proposed antenna can have the following dimensions. The following Table 1 can have the dimensions of the antenna that is listed below.

3. ANALYSIS OF LOG PERIODIC ANTENNA

The proposed log periodic antenna can be analyzed and simulated by using HFSS antenna simulation software. Fig. 2 shows the design geometry of the proposed Microstrip patch antenna for S band applications.

TABLE I. DIMENSIONS OF LOG PERIODIC ANTENNA

Parameters	**Value**
Operating Frequency	2.4 GHz
Dielectric Constant	4.4
Thickness of Substrate	1.6 mm
Length of Substrate	39.42 mm
Width of Substrate	62.34 mm
Width of Port	16.79 mm
Tau (τ)	0.7
Sigma(σ)	0.84

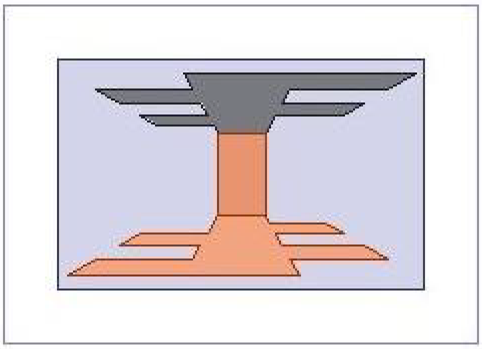

Fig. 2. Design of the log periodic antenna in HFSS

4. DESIGN / GEOMETRY OF MICROSTRIP PATCH ANTENNA

In its basic form, a Microstrip patch antenna consists of a radiating patch which is built on the dielectric substrate and substrate is attached on the ground plane as shown in Fig. 3. The patch is generally made of conducting material such as copper or gold and can take any possible shape.

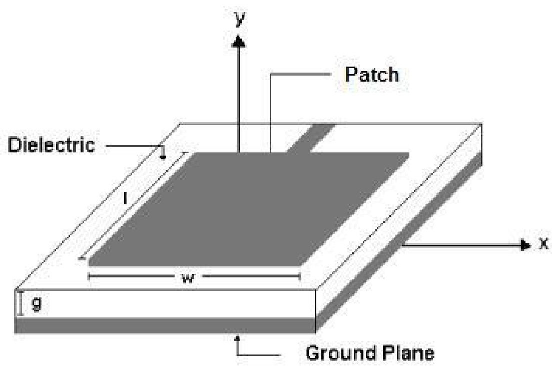

Fig. 3. Structure of Microstrip Patch Antenna

The radiating patch and the feed lines are usually photo etched on the dielectric substrate. The relative permittivity of the dielectric substrate is very important for the calculations of the antenna dimensions. In order to simplify analysis, the patch is generally square, rectangular, circular, triangular, and elliptical or some other common shape. In this paper, the rectangular patch can be used. Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation.

A. Antenna Design

The proposed antenna is designed for a resonating frequency of 2.4 GHz. The substrate material used is FR4 which has the relative permittivity of 4.4. The substrate thickness is 1.6mm. The dimensions of the antenna can be calculated by using the following relationship.

i. Width of the Patch:

$$W = \frac{C_0}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad (7)$$

Where,

C_0 =free space velocity of light.

fr = resonating frequency.

εr= relative permittivity of substrate.

ii. Effective dielectric Constant:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2}, W/h > 1 \quad (8)$$

Where,

h = Thickness of the substrate.

W= Width of the patch.

iii. Effective Length:

$$L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}} \quad (9)$$

iv. Patch length extension:

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)} \quad (10)$$

v. Length of the patch:

$$L = L_{eff} - 2\Delta L \quad (11)$$

vi. Width of the substrate:

$$W_g = 6h + W \quad (12)$$

vii. Length of the substrate:

$$L_g = 6h + L \quad (13)$$

B. Antenna Modelling:

From the above relationships, the proposed antenna can have the following dimensions. The following Table 2 can have the dimensions of the antenna that is listed below.

With these following parameter values, the antenna can be designed in HFSS software.

TABLE II DIMENSIONS OF MICROSTRIP PATCH ANTENNA

Parameters	Value
Operating Frequency	2.4 GHz
Dielectric Constant	4.4
Thickness of Substrate	1.6 mm
Length of Patch	29.44 mm
Width of Patch	38.04 mm
Length of Substrate	90.85 mm
Width of Substrate	66.7 mm
Length of Feed Line	28.54 mm
Width of Feed Line	3.06 mm

C. Method of Feeding:

Feeding technique influences the input impedance and polarization characteristics of the antenna. There are three most common structures that are used to feed planar printed antennas. These are coaxial probe feeds, Microstrip line feeds, and aperture coupled feeds. Microstrip line fed structures are more suitable compared to probe feeds, due to ease of fabrication and lower costs. Serious drawbacks of this feed structure are the strong parasitic radiation and it requires a transformer, which restricts the broadband capability of the antenna. In this paper, the Microstrip line feeding can be used to radiate the power of the proposed antenna. The strip line can be united with the patch of the antenna.

5. ANALYSIS OF MICROSTRIP PATCH ANTENNA

The proposed Rectangular Microstrip patch antenna can be analysed and simulated by using HFSS antenna simulation software. Fig. 4 shows the design geometry of the proposed Microstrip patch antenna for S band applications.

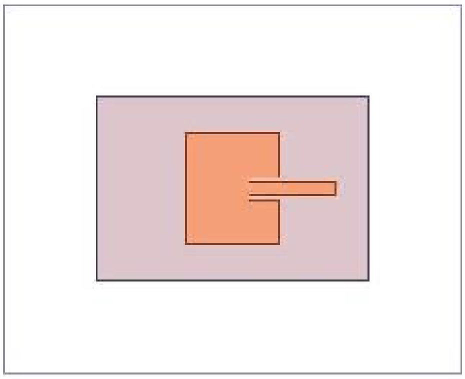

Fig. 4. Design of the microstrip patch antenna in HFSS

6. SIMULATED RESULTS

1. Log Periodic Antenna

The parameters S11 for the designed antenna were calculated and the simulated return loss results are shown in Fig. 5. The resonating frequency 2.4GHz with the corresponding value of return loss as -11 dB.

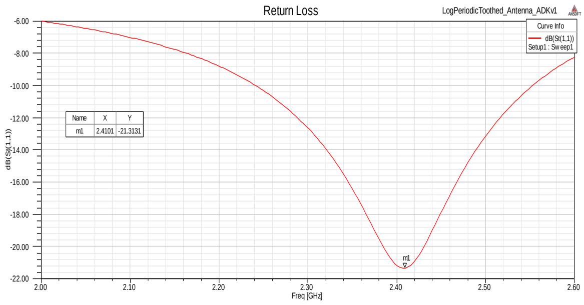

Fig. 5. Simulated return loss curve of log periodic antenna

The Radiation pattern for the proposed rectangular Microstrip patch antenna can be shown in Fig. 6. This can be shown below. This proposes the function of Theta with X-Y direction radiation.

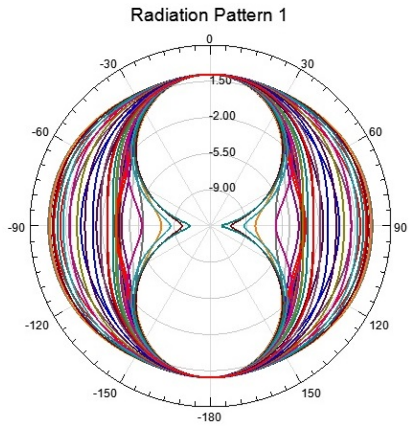

Fig. 6. Radiation Pattern of log periodic antenna

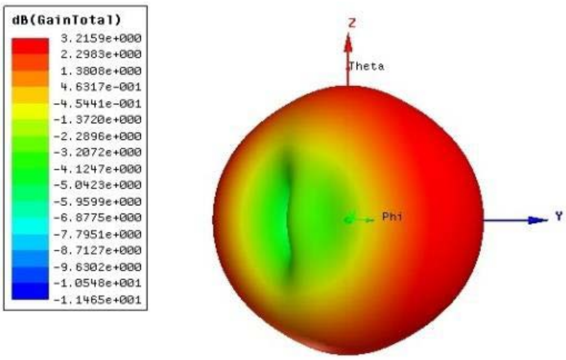

Fig. 7. 3D Polar Plot f of log periodic antenna

Fig. 7 shows the directivity of log periodic antenna with a gain of 3.21 dB.

The VSWR is the Voltage Standing Wave Ratio which gives the voltage reflection of antenna. Fig. 8 shows the VSWR of log periodic antenna.

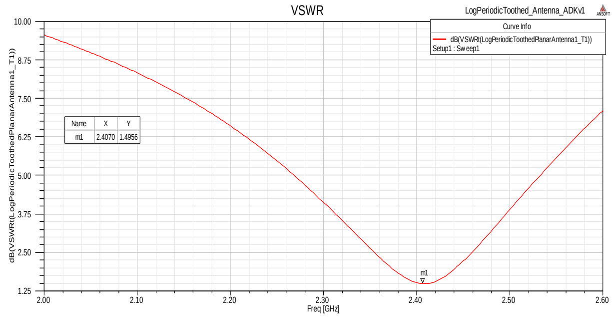

Fig. 8. Simulated VSWR curve of log periodic antenna

2. Microstrip Patch Antenna

The parameters S11 for the designed antenna were calculated and the simulated return loss results are shown in Fig. 9. The resonating frequency 2.4GHz with the corresponding value of return loss as -11 dB.

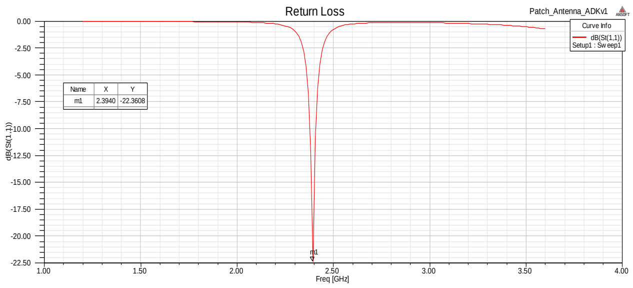

Fig. 9. Simulated return loss curve of Microstrip Patch Antenna

The Radiation pattern for the proposed rectangular Microstrip patch antenna can be shown in Fig. 10. This can be shown below. This proposes the function of Theta with X-Y direction radiation.

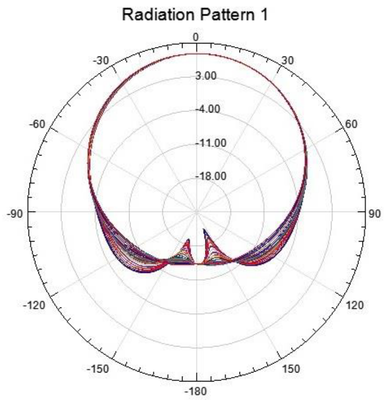

Fig. 10. Radiation Pattern of Microstrip Patch Antenna

Fig. 10 shows the directivity of log periodic antenna with a gain of 6.39 dB.

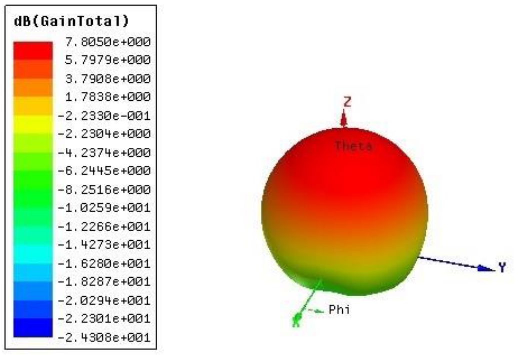

Fig. 11. 3D Polar Plot of Microstrip Patch Antenna

Fig. 12 shows the VSWR of microstrip patch antenna.

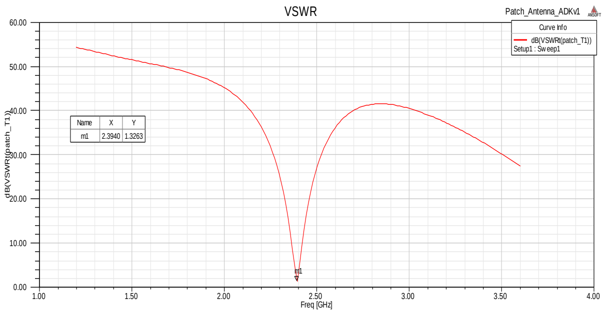

Fig. 12. Simulated VSWR curve of Microstrip Patch Antenna

7. CONCLUSION

From the results of both log periodic and microstrip antenna, we can fabricate microstrip antenna because of the following comparison.

TABLE III COMPARISONS OF LOG PERIODIC AND MICROSTRIP PATCH ANTENNAS

Parameter	Log Periodic Antenna	Microstrip Patch Antenna
Return Loss	-11	-14
VSWR	1.84	1.49
Gain	3.21	6.39

A Microstrip line fed single frequency Microstrip patch antenna has been designed and simulated using HFSS 13.0 Antenna Simulation software. It is operating at the frequency of 2.4 GHz which is the Wi-Fi communication with IEEE 802.11 standard. The simulated corresponding value of return loss as -14 dB which is small enough and frequency is closed enough to the specified frequency band feasible for Wi-Fi application. The fabricated antenna is shown below.

The return loss of the fabricated antenna is -15 dB as shown in Fig. 14. It is obtained from Vector Network Analyzer.

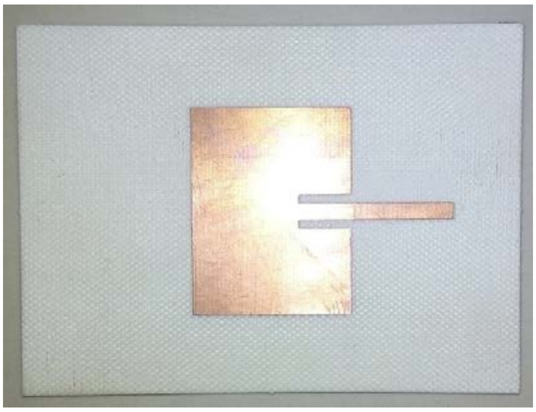

Fig. 13. Fabricated Microstrip Patch Antenna

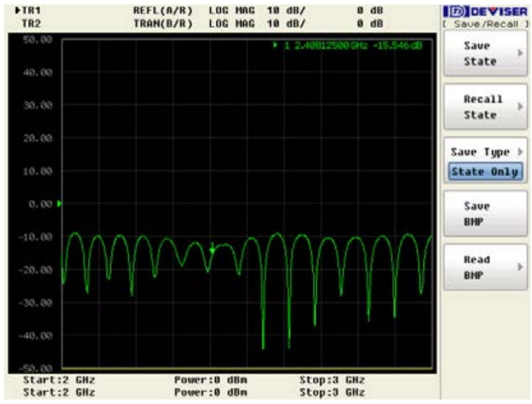

Fig. 14. Return Loss of Fabricated Microstrip Patch Antenna

REFERENCES

[1] Thunyawat Limpiti and Ajalawit Yodchai Chantaveerod (2016),'Design of printed Log Periodic Dipole Antennafor 0.8–2.5 GHzband Applications', ECTI-CON, pp. 1-4.

[2] Saad Shoukat, Sadiq Ullah, Sajjad Rahim, Babar Kamal, Usman Ali (2016), 'Design of a Dual Band Frequency Patch Antenna for GSM and Wi-Fi Applications', ICE Cube.

[3] Thennarasan Sabapathy, Muzammil Jusoh, R. Badlishah Ahmad, Muhammad Ramlee Kamarudin, Ping Jack Soh (2015), 'A Ground Plane Truncated, Broadly Steerable Yagi-Uda Patch Antenna', Vol.15, pp. 1069-1072.

[4] Sally I. El-Henawy, Amr M. Safat, Hadia S. El-Hennawy (2016), 'Recofigurable Pattern Beam Steering Loop Antenna', MECAP.

[5] Yong-Ling Ban, Chuan Li, Chow-Yen-Desmond Sim, Gang Wu, Kin-Lu Wong (2016), '4G/5G Multiple Antennas for Future Multi-mode Smartphone Applications', Vol.4, pp. 2981-2988.

[6] Pradeep Kumar, Neha Thakur, Aman Sanghi, Microstrip Patch Antenna for 2.4 GHZ Wireless Applications, International Journal of Engineering Trends and Technology (IJETT) – Volume 4 Issue 8- August 2013.

[7] Neha Ahuja, Rajesh Khanna , Jaswinder Kaur, "Design of Single Band Rectangular Patch Antenna for WLAN Application", International Conference on Recent Advances and Future Trends in Information Technology (iRAFIT2012).

ABOUT THE AUTHORS:

Dr. K. G. Parthiban.
Vice Principal & HOD / ECE
M.P.Nachimuthu M.Jaganathan Engineering College He received Post graduate degree in Master of Engineering in Process Control & Instrumentation from Annamalai received Ph.D in Anna University Chennai (Jan 2017) respectively. He is currently serving as Associate Professor in MPNMJ Engineering College, Chennimalai, Erode. He has 11years of teaching experience. He has presented more than 25 research papers in various national and International conferences. He also published a book on “Electric Circuits and Electron Devices”. He also published two papers in national journals in Bio Medical field. His area of interest includes Soft Computing techniques and Bio medical signal processing.

Mr. S. L. Arun Kumar.
arunsubiramanian01@gmail.com
He is an UG Scholar. He is currently pursuing his Bachelor of Engineering in Electronics and Communication Engineering in MPNMJ Engineering College, Chennimalai, Erode, Tamilnadu.

Mr. Mohammad Azhar Uddin.
hustlethebore@gmail.com
He is an UG Scholar. He is currently pursuing his Bachelor of Engineering in Electronics and Communication Engineering in MPNMJ Engineering College, Chennimalai, Erode, Tamilnadu.

Mr. M. Srinivasan.
msrini1100@gmail.com
He is an UG Scholar. He is currently pursuing his Bachelor of Engineering in Electronics and Communication Engineering in MPNMJ Engineering College, Chennimalai, Erode, Tamilnadu.