Antenna Simulation Tools and Designing of Log Periodic Dipole Antenna with CST Studio

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Abstract: The transmitting and receiving antenna is one of the important elements of the wireless communication systems. To design any type of antenna, different complicated procedures are used. A single test takes large amount of time and also high cost. It also puts limitations on design and designer to make changes time to time to improve performance of antenna. So implementation of whole design in practice is somewhat difficult and consumes more time and cost. Simulators are available and able to provide practical feedback when designing real world systems. This paper represents different simulation software's with their features, availability and also focus on designing log-periodic dipole antenna (LPDA) using CST studio tool. A Computer Aided Design (CAD) tools helps the antenna designers to design an antenna virtually before implementing in practice. Thus both the time and cost of the designing and testing is reduced and implementation of design in practice makes easy. Simulators provide a crucial role in both industry and academia. The simulators can be used as an effective means for teaching or demonstrating antenna concepts to students.

Keywords: Antenna design, Simulators, CAD Tools, Log-periodic dipole antenna, CST studio.

I. INTRODUCTION

A simulator is a collection of software programs which are used to mimic the behaviour of some entity or phenomenon. Simulation is a very important tool that has been changed the view of the world to solve the problem without spending the money in buying the parts, especially in electronics field. It is really cost effective and save the time of designing. The advantage of simulators is that they are able to provide users with practical feedback when designing real systems. By investigating the effects of specific design decisions during the design phase rather than the construction phase, the overall cost of building the system diminishes significantly. Another benefit of simulators is that it can be used as an effective means for teaching or demonstrating concepts to students.

In this paper, example of designing log periodic dipole antenna is taken considering its wide bandwidth and various applications. A log periodic antenna is an array of dipoles with mathematically related lengths and spacing's. A log periodic dipole antenna (LPDA) is a type of broadband antenna with good directivity. LPDA shows a periodic variation with log of the input frequency. It is frequency independent antenna. It can be described by two geometric parameters, a scale factor τ that specifies the relative lengths and a spacing factor σ that specifies the relative spacing of the antenna elements. A third parameter, α, is one-half the apex angle and is derived from τ and σ [1, 2].

LPDA designed using CST studio suit 2013 tool and simulated to obtain antenna parameters such as directivity, antenna pattern and voltage standing wave ratio (VSWR), power loss etc. Tool provides great flexibility to make changes in design and simulate it again and again to overcome the problems in designing.

GUI-based an integrated development environment (IDE) tool allows designer to find parameters of LPDA that need costly equipment, setup and tools in practice. Tools are particularly useful to test and simulate design with different shape of antenna elements (rectangle, oval, round pipe) and type of materials (aluminium, copper or other low loss metals). Not all design and simulation software supports choosing of material, but few supports to choose round or rectangle shape of element.

II. ANTENNA DESIGN AND SIMULATION TOOLS

There are many antenna design CAD tools are available in market and most of them offers free access, few requires to purchase. Some online websites also offers LPDA design and calculating its parameters. The tools mentioned are: 4NEC2, EZNEC, LPCAD, FEKO- EM simulation, Antenna Magus, CST Studio. The details are as follows:

4NEC2: Numerical Electromagnetic Code (NEC) is a simulation method for wire antennas, developed by the Lawrence Livermore Laboratory in 1981 or the Navy. The results are very convenient and the standard for this simulation technique is NEC2. The first version was developed in the year 1995 under the DOS operating System with the Q-basic language. Later on, new versions with additional features and possibilities were created. It is available free of cost at http://www.qsl.net/4nec2 [3]. 4NEC2 is a windows based and also Nec-2 or Nec-4 based tool for both the starting and experienced antenna modeller that can be used to create antenna geometry structure and generate near-field and far-field radiation patterns. Also standing wave ration (SWR), input impedance, front to back ratio for a range of frequencies on a linear or logarithmic graph or Smith Chart can be displayed [4]. Especially 4NEC2 offers a huge amount of possibilities and options such as graphical 3D display. Its main advantages are the optimizing tools and the

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parameter sweeps. It can be downloaded free of charge from the Internet. Furthermore its optimiser and sweeper can be used to antenna and other environment for better performance, gain, SWR, resonance, efficiency and front to back ratio. With the sweeper, the effect of changing one or more antenna variables and/or environment variables for a specified range of values/frequencies can be graphically displayed. But to use one of both optimizers and the sweeper, some basic knowledge about the **Numerical Electromagnetic Code** (NEC) syntax is required [4, 5].

EZNEC: The EZNEC software is created and marketed by Roy Lewallen, W7EL. It is GUI based with many powerful features. The package comes with a number of example models and there is an extensive indexed helpfacility with information on all aspects of the program. It is needed to be registered and takes no fees for it and can be obtained from www.eznec.com. EZNEC and all antenna modelling packages are based upon a simulation engine family named as NEC [6].

LPCAD: This program helps to create geometry design based on the antenna variables, which we enter as an input. After the design is created we can save it in different format. The .LPD format can be used within programme only. The .NEC format can be used in NEC-2, GNEC, EZNEC, 4NEC2, NEC-4 codes. This programme may be used to calculate and analyse complete antenna performance. The final design can be printed using local printer connected to PC using software [8]. LPCAD 3.51 is the most current released version. LPCAD 3.51 runs fine under Windows 2000, XP, Vista, Win 7 and likely Win 8. This version is released in April 2015 with fixing some bugs. It is available for free and can be obtained from http://wb0dgf.com/lpcad35.zip [7].

FEKO- EM simulation: It is developed by EM Software & Systems-S.A. (Pty) Ltd. A number of FEKO licensing options are available to FEKO users and users who would like to evaluate or work with FEKO. But it is possible to evaluate a full version of FEKO with technical support which is free. It is available at www.feko.info [9]. FEKO is a comprehensive electromagnetic simulation software tool for the electromagnetic field analysis of 3D structures. It offers multiple state-of-the-art numerical methods for the solution of Maxwell's equations, enabling its users to solve a wide range of electromagnetic problems encountered in various industries. FEKO is well-suited to the analysis of wire antennas, horn and aperture antennas, reflector antennas, micro-strip antennas, phased array antennas, broadband antennas and more. Many special formulations enable the analysis of practical antenna problems. Applications include EMC analysis, antenna design, micro-strip antennas and circuits, dielectric media, scattering analysis, cable modelling and many more. The core of the program FEKO is based on the method of moments (MoM). The MoM is a full wave solution of Maxwell's integral equations in frequency domain [10].

Antenna Magus: Antenna Magus is a software tool that helps to accelerate the antenna design and modelling

process. Good starting designs and parameterised models of antennas can be exported to CST MICROWAVE STUDIO® (CST MWS) for further design. Each antenna in the database can be designed for various objectives and estimated to assess its performance. All designs are validated and the export functionality makes the powerful capabilities of CST MWS even more accessible by providing with fully parametric CST MWS models of design. Antenna Magus is a product of Magus (Pty) Ltd. It can be purchased through CST distribution channels. Antenna Magus is a software tool to accelerate the antenna design and modelling process. An evaluation copy can be downloaded from https://www.cst.com/Products/ Antenna Magus/Evaluation [11, 12].

CST Microwave Studio: CST (Computer Simulation Technology) MICROWAVE STUDIO® (CST MWS) is a specialist tool for the 3D EM simulation of high frequency components. CST MWS enables the fast and accurate analysis of high frequency (HF) devices such as antennas, filters, couplers, planar and multi-layer structures and SI and EMC effects. It is available as a part of CST Studio suit. It comprises CST's tools for the design and optimization of devices operating in a wide range of frequencies - static to optical. CST STUDIO SUITE benefits from an integrated design environment which gives access to the entire range of solver technology. System assembly and modelling facilitates multi-physics and co-simulation as well as the management of entire electromagnetic systems [13].

CST develops and markets high performance software for the simulation of electromagnetic fields in all frequency bands. It is powerful modelling software. Latest available software is CST studio suit 2015. It is not available free of cost but need to purchase from CST's official website https://www.cst.com/Products/CSTS2 [14].

III. STEPS TO DESIGN LPDA IN CST STUDIO SUITE 2013

The basic steps of designing of LPDA for frequency range of 80MHz to 1000 MHz frequency range are mentioned. Before beginning to design an antenna one must have calculated antenna parameters like desired frequency band (upper frequency and lower frequency of operation), number of elements, length of each element and spacing between each element etc.

The steps are as follows:

1. Open CST Studio Suite from desktop by double clicking on its icon. Design environment open & shown in Fig. 1.
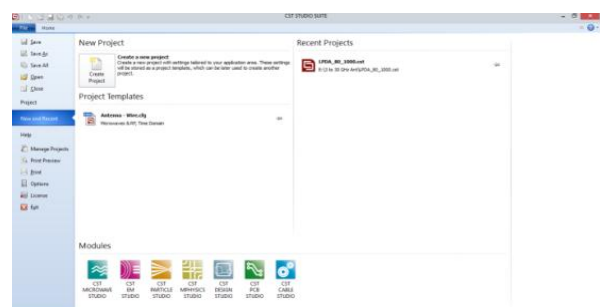

Fig.1. CST Studio Suit 2013 design environment

2. Now click on "Create Project". New Project window will appear and is shown in Fig. 2.
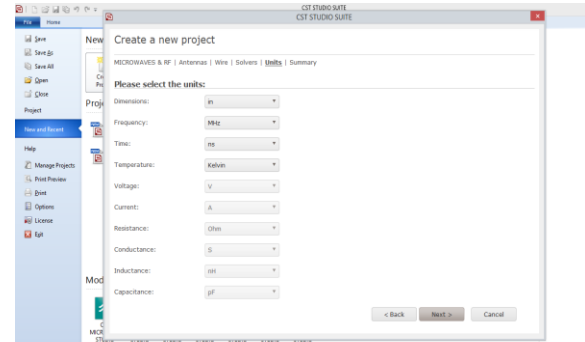

Fig. 2. New Project window.

3. Now click on "Microwave& RF" section. Select "Antenna" from side panel and then "Next". Screen shot is shown in Fig. 3.

Fig.3. Application Area and work flow

4. Select "Wire" to design array type antenna e.g. LPDA and click "Next". Its picture is shown in Fig.4.

Fig.4. Workflow

5. Now Select "Time domain" and click "Next". The window appear is shown in Fig. 5.

Fig.5. Solver for selected workflow

6. Select desired units to your project as shown below and click "Next". Screen shot is shown in Fig. 6.

Fig. 6. The unit selection window.

7. Give the appropriate name to project and click on "Finish". Its window is shown in Fig. 7.

Fig.7. Summery window for new project

8. New design environment will open and is shown in Fig. 8.
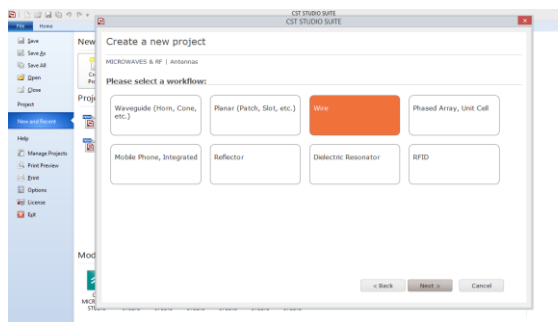
Fig.8. New design environment.
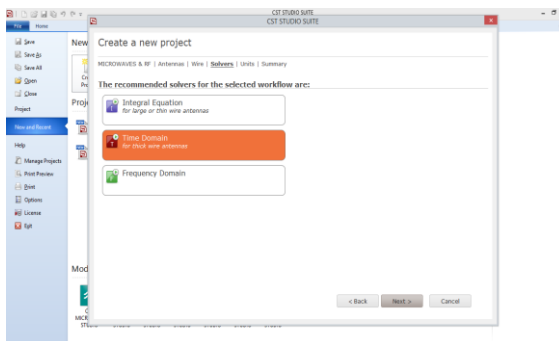
9. Use modelling plane for design log-periodic antenna. Choose different shapes to design antenna and save. Its window screen shot is shown in Fig.9.

Fig.9. Modelling plane.

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After completing the design use Boolean tool to add component and make them single one piece. Please refer YouTube link, https://www.youtube.com/watch?v=sX00Wv16v5k

10. This is complete design of our antenna. Designed antenna picture window is shown in Fig.10.
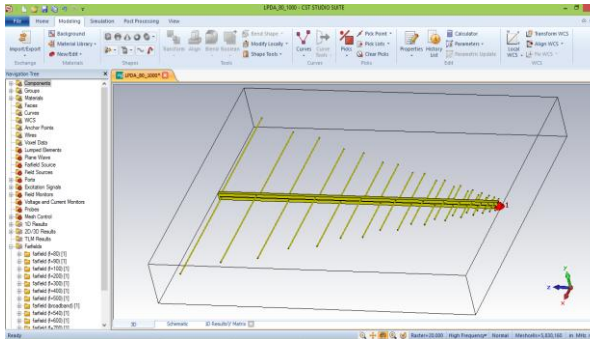
Fig.10. Designed log periodic dipole antenna

11. Use modelling plane shown in fig. 9 and add port. Its picture is shown in Fig.11.
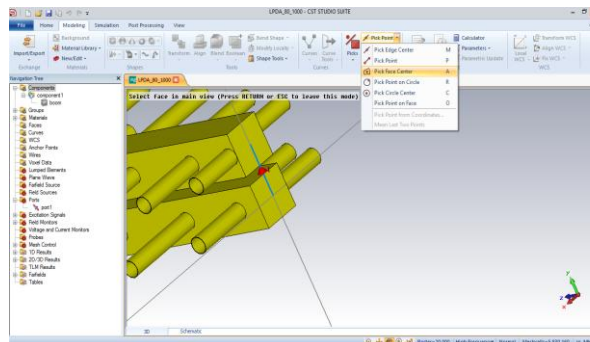
Fig.11. Discrete Port is added to feed point

12. Select simulation plane and input frequency range for antenna and then click "OK". The picture is shown in Fig.12.
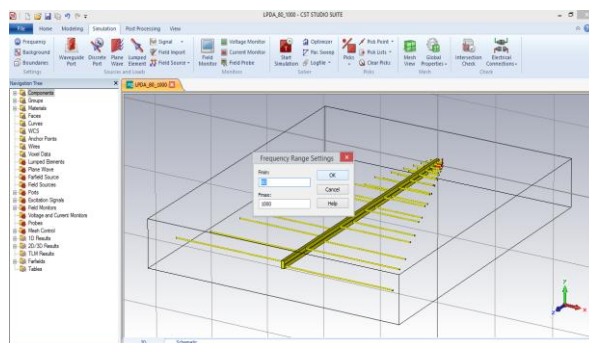

Fig.12. Frequency range for antenna

13. Now select "field monitor" from simulation plane, then select far-field and enter frequency to be monitored.

Number of frequencies can be entered, and also different fields can be monitored. Its window is shown in Fig.13.
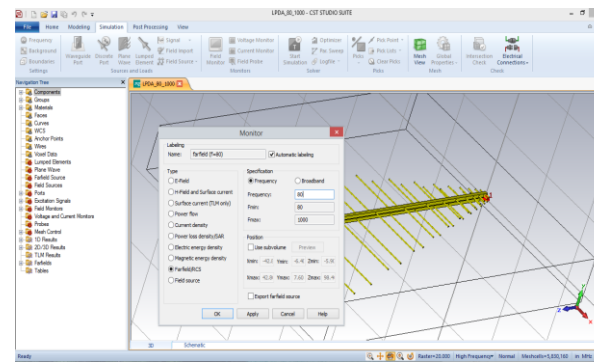

Fig.13. Select fields to be monitored

14. Now click on "start simulation" to start and in s-parameter setting tick on "Normalize to fixed impedance" and enter 50 in text box. Then click "Start". It is shown in Fig.14.
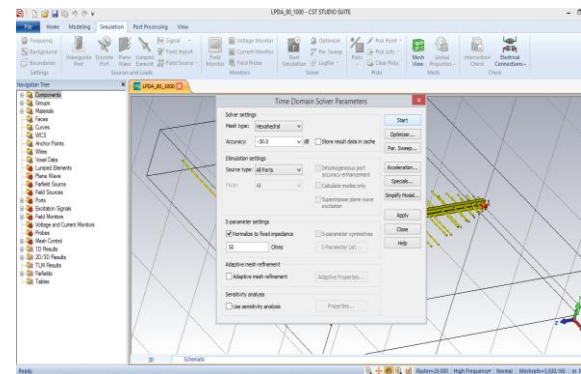

Fig.14. Time domain solver parameters.

Here the designing steps are shown for open boundary condition; therefore we have not entered boundary conditions in simulation process. So it may take more time to successful completion of simulation of deign. Large design will take more time. For our design it took an hour or more to complete.

IV. RESULTS

After successful completion of simulation process results are generated in side panel. Select far-field to view far-field patterns of Log Periodic Dipole Antenna. Other 1D or 2D results are also available. Far field patterns can be viewed in 2D or 3D by selecting far field tool is shown if Fig.15.
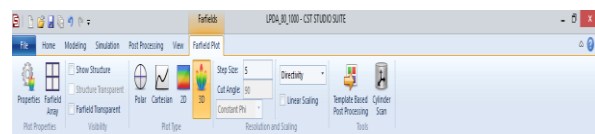

Fig. 15. Selection tool for 2D or 3D.

Result of far-field patterns

3D far field plots for 80MHz designed antenna is shown in Fig. 16.
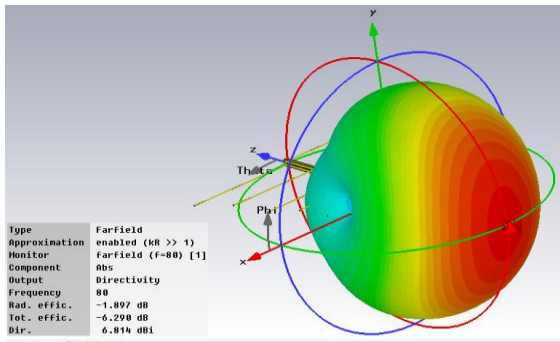
Fig.16. 3D far field pattern at 80 MHz

2D far field plots for designed LPDA for different frequencies (80, 100, to 1000 MHz) is shown in Fig. 17.
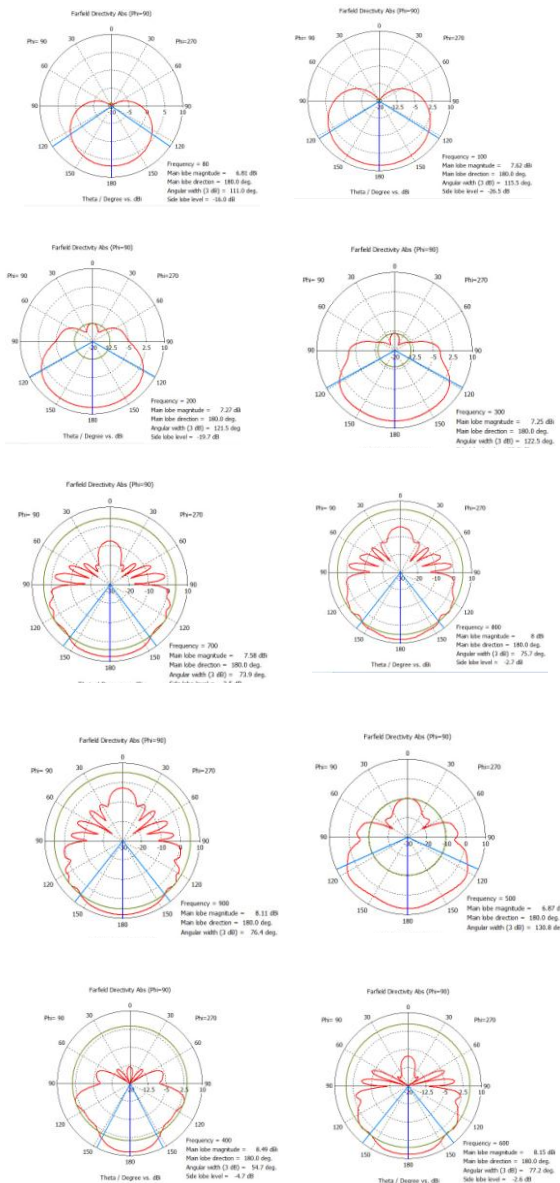

Fig.17. Antenna far field plots.

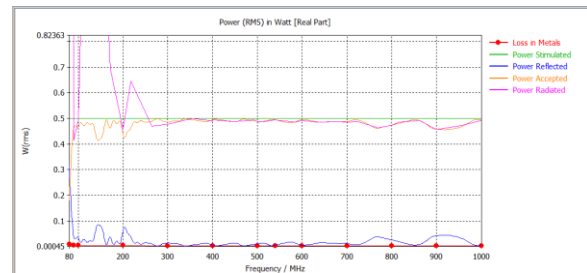Power plot for designed LPDA is shown in Fig. 18.

Fig.18. Power plot

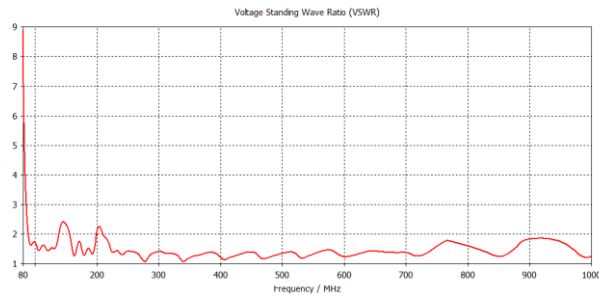VSWR for designed LPDA is shown in Fig. 19.

Fig.19. VSWR plot

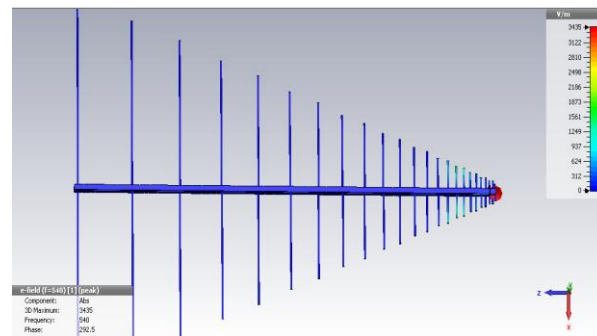Electric field distribution in structure at 540MHz is shown in Fig. 20.

Fig.20.e-field distribution in structure

V. CONCLUSION

There are number of software available in market and online for free or paid they cannot provide great flexibility to design LPDA. Few software's have some lake of facilities. But as some are free of cost they helps better. Here CST studio suit 2013 is used to design LPDA which provide many facilities to design an antenna. It provides easy way to draw the structure by mean of GUI. Its GUI interface is very powerful so any beginner can draw and design antenna structure. Here great flexibility is provided for design and simulation also. Results shown are of open boundary condition. But better study of CST studio can help anyone to use different boundary condition. Boundary condition and mesh setting allows designer to reduce solving time of solver. Different far-field patterns, e-field patterns and many more can be generated using its powerful solver. Designer can view 2D or 3D antenna farfield patterns as mentioned in result section. It provides

animation of current distribution in antenna structure for e-field. This is powerful package to design nearabout all types of antennas using only a microwave part of software. Rests has different use. Its advantage is that it doesn't require any knowledge of programming.

To execute software powerful PC is required having high speed processor, large size of RAM memory and hard disk. Paper represents the designing for antenna using CST Studio. One can use 4NEC2, if having better knowledge of antenna parameters and programming. The advantage of simulators is that they are able to provide users with practical feedback when designing real antenna. This allows the designer to determine the correctness of a design before the system is actually constructed. Consequently, the user may explore the merits of alternative designs without actually physically building the systems. By investigating the effects of specific design decisions during the design phase rather than the construction phase, the overall cost of building the antenna diminishes significantly. Another benefit of simulators is that it can be used as an effective means for teaching or demonstrating antenna concepts to students. The tools will helps to design, construct and measure the LPDA parameters.

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BIOGRAPHIES

Vijay Kale (M.Sc, M.Phil, Ph.D, PGDIM, ADCSSA) is working as Assistant Professor (Department of Electronic science, KTHM College, Nashik, Maharashtra, India). He has been in the teaching profession (UG and PG) since last 27 years. He has been presented research paper in international conferences (USA, Bangkok). He published research papers in national and international journals. He received R. Chandrasekhar award from Indian Physics Association (IPA), Savitribai Phule Pune University. He has written five books. He worked as project guide for M.Sc. (Electronic Science) and research guide to M. Phil. students. He has worked on several academic committees of Savitribai Phule Pune University. He has worked as a resource person in refresher course, workshop etc. He is presently working on ARM microcontroller based sensor application, Wireless sensor application, e-CALLISTO etc.

Dnyandev Patil is working as M. Phil. student (Department of Electronic science, KTHM College, Nashik). His research activity is in antenna designing and Sensor based embedded system. He had completed project entitled Smart Energy Meter and Wind Speed Measurement using microcontroller.