Rapid Prototyping of Structural Electronics: A Wireless Approach towards Printing of Electronic Objects (IOT)

Akhil Raj
Student
Department of Electronics and Communication Engineering
HKCET, Pampakuda Ernakulam, Kerala, India

Anand B Nair
Student
Department of Electronics and Communication Engineering
HKCET, Pampakuda Ernakulam, Kerala, India

Basil Mathew
Student
Department of Electronics and Communication Engineering
HKCET, Pampakuda Ernakulam, Kerala, India

Sanath Kumar P Sapre
Student
Department of Electronics and Communication Engineering
HKCET, Pampakuda Ernakulam, Kerala, India

Nitheesh Kurian
Assistant Professor
Department of Electronics and Communication Engineering
HKCET, Pampakuda Ernakulam, Kerala, India

Abstract

With today's technology excelling in the field of internet of things, rapid prototyping can be easily incorporated into the same. By rapid prototyping of electronics, a hassle free production of electronic objects can be achieved. In this paper, we propose a 3D printing technology capable of prototyping electronic objects while connected to internet and which can be accessed from anywhere in the world. The system consists of an Arduino Mega 2560 R3 board (ATmega 2560 IC), Arduino Ethernet shield, RAMPS 1.4 (Reprap Arduino Mega Pololu Shield), NEMA 17 stepper motors, A4988 stepper motor drivers, LCD controller. The Arduino Ethernet shield is used to establish communication between the Arduino mega board and a specifically designed mobile application through internet. Through the mobile application, the printer can be controlled and print file can be sent from anywhere over the internet.

Keywords- Rapid Prototyping, IOT, 3D Printing

I. INTRODUCTION

By means of conventional technology, the design and development of an electronic product requires various steps like concept, research, circuit design, packaging, printed circuit design, trial production, then comes the actual manufacturing. Thus the development of an electronic product by conventional techniques consumes a great amount of time as well as money. With 21st century technologies being more focused on efficiency and cost reduction in manufacturing, better production method are being developed day by day. One such technology is the rapid prototyping [1] technology. By rapid prototyping technology, we can produce objects of our desired shape. All we need is the CAD model of the shape to be produced. Thus the manufacturing industry can be greatly revolutionized by this technology. This technology has potential in the field of electronics .In this paper we'll implement a system capable of prototyping structural electronic products while being connected to a mobile application via internet and thus reducing the time for manufacturing by a great extent. The system can be controlled both from the internet as well as the system itself.

II. LITERATURE SURVEY

Traditional technologies for manufacturing in electronics industries consume a great deal of time and money, even for the simplest design various steps have to be covered before the actual manufacturing takes place. The oldest technologies for manufacturing electronics were traditional soldering done by hand using a soldering iron and other required materials. This technique required skill as well as labor for quality results. Hence the efficiency of this technique was very low. This technique was made more efficient by technological advancements leading to bulk soldering or wave soldering. Using bulk or wave soldering [2], we could place a lot of electronic components into the PCB simultaneously, thus reducing the time required for component placing.

Since time and money are the main constraints in any industry, traditional technologies have above said limitations. To overcome these limitations various other methods are being implemented.

Our system makes use of rapid prototyping technology for manufacturing. 3D printing[3] itself is being vastly used nowadays in variety of fields but till now 3D printing was limited to object fabrication using different materials like plastics (ABS, PLA etc.). With this system we propose to incorporate 3D printing technology with electronics manufacturing and produce a fully functional electronic device in lesser number of steps compared to traditional technologies for manufacturing.

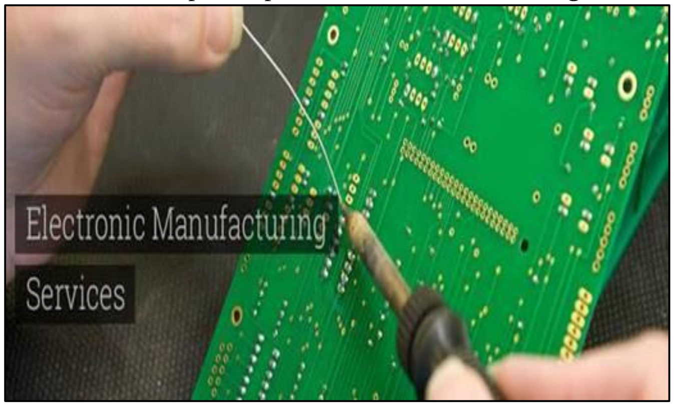


Fig. 1: Conventional Electronic Manufacturing Techniques

Fig. 2: 3D Printed Electronic Device without Components

The above figure shows an electronic device manufactured by rapid prototyping technology. The main advantage of this device is that it can be produced in a single stage, thus reducing both time and cost of production.

III. PROPOSED METHODOLOGY

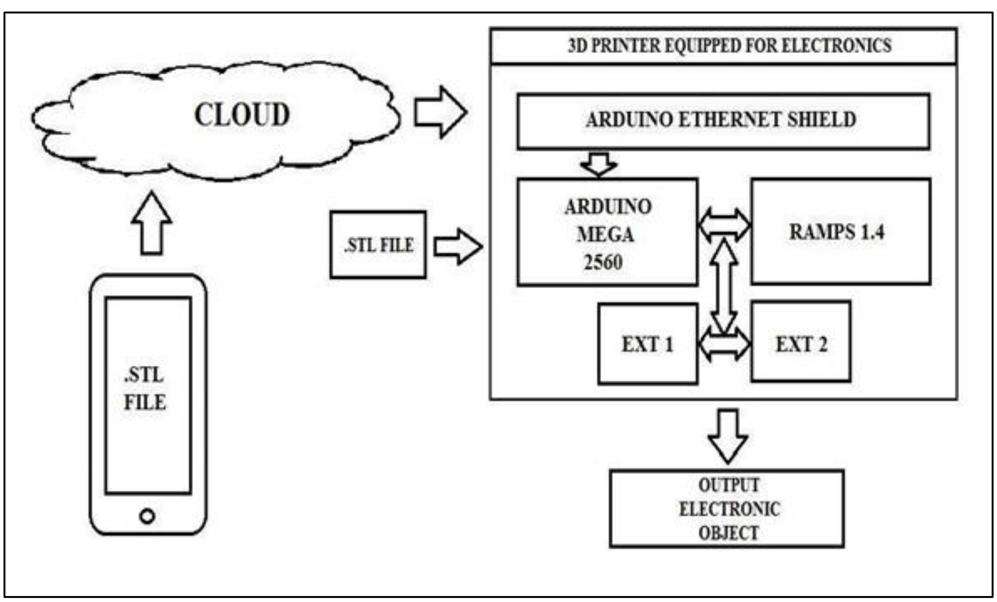


Fig. 3: Block Diagram of the Proposed System

The above shown is the block diagram of the system. The input to the system is a .STL (stereo lithography) [4] file. Input can be given either directly to the system or through the cloud. Input through internet is basically obtained from a mobile device. The file present in the mobile device is accessed with the help of a specifically designed mobile application. This print file can be sent to the cloud with the help of the application, the 3d printer which is also connected to the cloud receives the print command along with the file so that printing can be started. The Arduino mega board is connected to the internet using an Arduino Ethernet shield. This Arduino Ethernet shield helps the system to be connected to the network at all times. The system is always online and searches for the print command. Whenever the command is received the printer analyses the print file prepare the print bed and auto leveling procedure is executed, only after which actual printing can take place.

IV. HARDWARE IMPLEMENTATION

The basic hardware components used in the system are Arduino mega 2560 r3 board, Arduino Ethernet shield, NEMA 17 stepper motors, RAMPS 1.4 boards and two extruder's one for the object printing and the second for the conductive ink. Our system consists of 5 NEMA 17 stepper motors out of which 3 are used for the XYZ movements of the printer. The other two are used for feeding the filaments to the extruders.

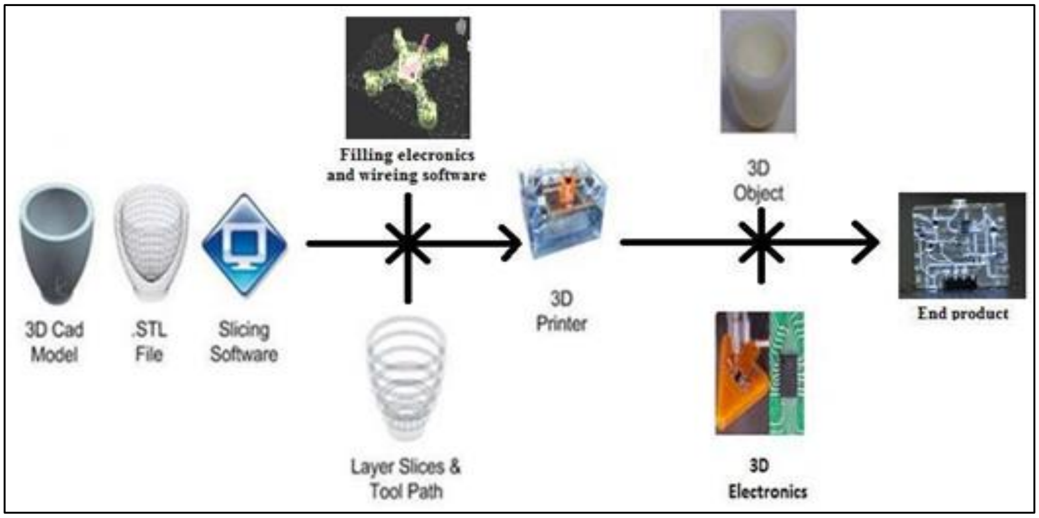


Fig. 4: Basic working of the system

A 3D CAD model of the object to be printed is given as the input to the system. The CAD model is then converted into a STL file which is layered down to various slices using the slicing software which is open source software easily available for download. This sliced file is then given to a filling electronics and wiring software. This software creates cavities for electronic connections and components according to the circuit. The file obtained at this stage is the input file for the 3D printer. When the file reaches the 3D printer, the Arduino mega board analyses it and generates commands for controlling the stepper motors. After this, the printing process starts. The printer continues to print the plastic shell of the device until the cavity regions are reached. When the cavities are reached, the printer first prints the circuit connections with conductive ink. When the component cavities are reached (components like IC's), the printer stops and the components need to be placed in the appropriate cavities manually. Once all the components are placed at that section, the printer can resume it work to completion. After completion, we will get a working prototype model of the device.

V. SOFTWARE IMPLEMENTATION

The major software's used in our system are Mobile application, slicing software and wiring and electronic filling software. The mobile application is used to access the 3D printer remotely. The mobile application is also capable of sending the print file via internet as well as checking the status of the 3D printer. It keeps on monitoring the status of the 3D printer as the print object needs an individual attention at the time of component placement. The application receives a notification when the above mentioned step is reached. The most important software needed to generate the print file is slicing software which converts the 3 dimensional designed CAD model into a file which consists of several slices, this file is readable by the printer. The slicing of the CAD model is done so as to define the path of the extruder for printing which is fed to motor drivers by the controller as commands. Achieving a complete print file for this system is incomplete without the wiring and component filling software. This software converts the sliced model from the slicing software and it is embedded with the electronic circuit path. This path specially defines where the conductive ink should be printed and where the cavities for placing components must be made. The output of this software is the main input for the system.

VI. RESULTS

As expected, the system worked normal at standard conditions. The mobile application deploys the print file perfectly through internet. However, when multiple files are uploaded, the system accepts only the first file. The architecture of the program can be modified to overcome this problem.

Better and faster prints were achieved when the extruder nozzle size was 0.4mm and the layer height was kept under 0.3 mm. the print achieved with the conductive filament works optimally when print temperature is kept between 215-230 oC and the print bed temperature at 50-100 oC.

To get appropriate friction for the print, we made use of masking tape which helped us remove the printed device from the print bed easily.

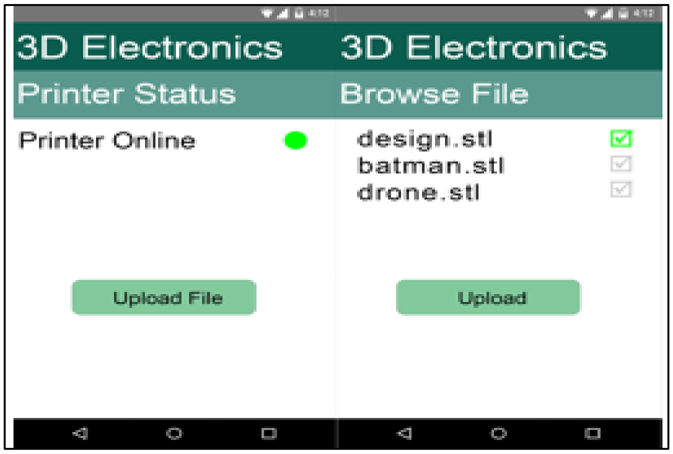


Fig. 5: Mobile Application Interface

The above shown figure is the mobile application that is used to control the printer via internet.as the figure shows there is an option to upload the print file from the mobile device. Once the file is selected from the device the file can be uploaded to the printer. The application also monitors the status of the printer and displays it on the screen. This is illustrated in above shown figure.

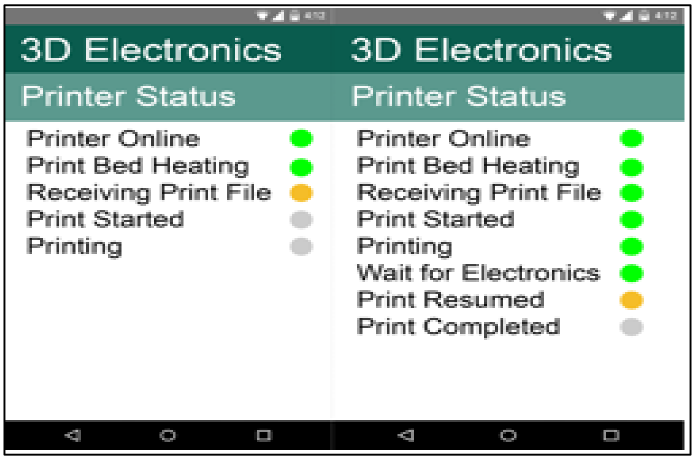


Fig. 6: Monitoring the printer status

Figure 6 shows how the mobile application monitors and displays the status of the printer while it is working. The status is marked by using different colors. Green is used to indicate that the process is completed. Yellow is used to indicate the currently executing process. Gray is used to indicate upcoming processes. This application provides flexible accessibility to the system, thus making it convenient to use.

VII. CONCLUSION

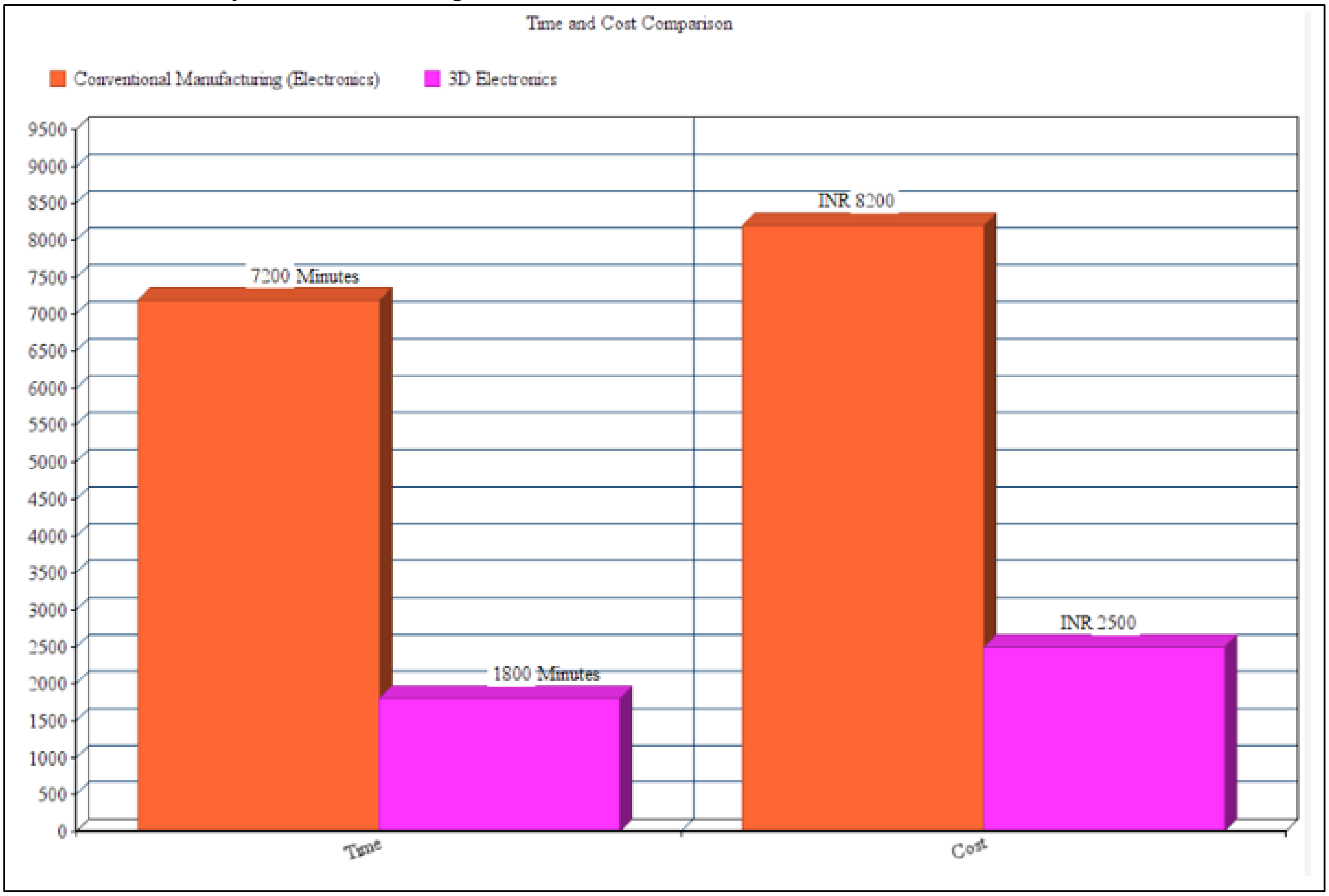
This paper represents development of a prototype towards 3D electronics [6]. The prototype is capable of printing electronic devices with all the electronic connections embedded in it.

The accessibility of the prototype is very flexible as it can be accessed through internet via mobile application or through the prototype itself. The main advantage of this prototype over the existing system is that it can print working electronic devices by being controlled through internet. This prototype can be seen as a viable replacement of the existing system that manufactures electronic devices. Since this system is connected and can be controlled via internet, we can see that it is a potential application of Internet of Things (IoT).

The figure shown below is the comparison chart of an electronic device manufactured using conventional technologies and our proposed system. We can see that manufacturing using conventional technologies consumes lot more of time and money when compared to our prototype.

We can see that the device manufactured using conventional manufacturing technologies takes 7200 minutes i.e. 120 hours and INR 8200 to be completed. The time and cost required for the same device to be manufactured by 3D electronics is 1800 minutes i.e. 30 hours and INR 2500 respectively. These figures are far lesser when compared to conventional manufacturing techniques.

From the above statistics, we can see that 3D electronics technology can save a great deal of time and money [5] as well as the overall efficiency of the manufacturing industries.



REFERENCES

[1] D. Pham and R. Gault, ''A comparison of rapid prototyping technologies,'' Int. J. Mach. Tools Manuf., vol. 38, nos. 10–11, pp. 1257–1287, 1998.

[2] C. Chua, K. Hong, and S. Ho, ''Rapid tooling technology. Part 1. A comparative study,'' Int. J. Adv. Manuf. Technol., vol. 15, no. 8, pp. 604–608, 1999

[3] D. Espalin, D. W. Muse, F. Medina, E. MacDonald, and R. B. Wicker, ''3D Printing multi-functionality: Structures with electronics,'' Int. J. Adv. Manuf. Technol., Mar. 2014.

[4] A. J. Lopes, E. MacDonald, and R. B. Wicker, ''Integrating stereo lithography and direct print technologies for 3D structural electronics fabrication,'' Rapid Prototyping J., vol. 18, no. 2, pp. 129–143, 2012.

[5] M. Ruffo, C. Tuck, and R. Hague, ''Make or buy analysis for rapid manufacturing,'' Rapid Prototyping J., vol. 13, no. 1, pp. 23–29, 2007.

[6] 3D Printing for the Rapid Prototyping of Structural Electronics, IEEE Access, date of publication March 13, 2014