Design and Fabrication of Printed Circuit Board for IoT Applications

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Abstract. Printed circuit boards are used for various product manufacturing and assisting purposes. This paper deals with a multifaceted trainer board for integrating various modules for Internet of Things (IoT) applications. As IoT plays a major role in the upcoming technological growth, the next generation of students need to learn about the hardware and software involved in a more effective manner. Also hardware is vital for hands-on training. To guide the students and aspirants to apply various ideas onto one board requires a perfect trainer board. Moreover, this trainer board should be well flexible to handle a vast variety of modules. Arduino Mega, is one example, where programming and interfacing of modules are easy and well-suited to develop IoT applications. This novel trainer board is designed for interfacing with the Arduino Mega, HC-05 (Bluetooth module) and Node MCU (Wi-Fi module) that are embedded on the board. The main purpose is to interface various Analog/ Digital /PWM pins with various devices. Each Digital or analog pins are connected with 3-port or 4-port female headers to enable various modules to be linked with the board. Also, each 3 or 4-port header pins are connected with power supply and ground by default and there are interlinks between Analog/digital I/O. The board and external modules can be powered with 5V, 9V and 12V which can be selected based on the application.

1. Introduction
Most Printed Circuit Boards (PCBs) for basic gadgets are straightforward and made out of a solitary layer. More refined equipment, for example, PC design cards or motherboards can have various layers [1, 2], generally up to twelve layers. PCBs are found in various other electronic gadgets, for example, TVs, radios, digital cameras and cellphones. Various kinds of PCBs are utilized in an assortment of different fields.

PCBs are the sheets that are used as the base in many hardware components both as a physical help piece and as the wiring territory for the surface-mounted and socketed segments. They are mostly made out of fiberglass, composite epoxy, or any composite material.

The assembly cycle of PCBs with installed dynamic segments requires a few adjustments on the development layer arrangement, including the utilization of more slender layers and heterogeneous composite materials. From the perspective of second level interconnection, the expansion in thickness
and complexity in the development of electronic board prompts an expansion of the absolute tar content. As exhibited in a past work, this expansion of the proportion among gum and glass has a significant result on the mechanical conduct of the gatherings, especially on the weakness obstruction of part weld joints. A test procedure was created so as to assess the thermo-mechanical conduct of PCB with implanted dynamic parts and its effect on dependability of electronic congregations. This technique incorporates base material portrayal, thermo-mechanical investigation and component reenactments. The continuous increase of electronic circuit thickness in recent times has led to the maximum limits of dimensional decrease of the components in the circuit. With the means to bring elective arrangements permitting to make considerably more unpredictable circuits with all the more impressive capacities, the current improvement of the electronic gatherings needs to utilize three dimensional structures. This paper will zero in on the strategy created so as to build up the board with extra ports of installed circuit sheets.

A viable PCB configuration can help in lessening the potential outcomes of errors and the odds of short out. An inventive PCB fashioner has incredible opportunities to innovate the field. Madhu G M [3] paper deals with the plan and usage of Smart Home Controller wherein the client can control their gadgets utilizing the Android Application running on a Smart Phone. The regulator is planned with the Arduino microcontroller (Node MCU) at the buyer end and is connected with the web through Wi-Fi. In this framework, each gadget is associated with the web through the IOT convention and controlling is done through HTTP demands sent from the Android versatile application. The API (Application Programming Interface) associates the worker and android application and permits it to cooperate and trade information with the worker. At whatever point the client sends demands from android application, the API associates with the worker and it sends solicitation to the regulator, further to which the regulator performs ON/OFF capacity of the gadget dependent on the solicitation received.

Jong-In Ryu et al [4] deals with a conservative module for a Bluetooth and GPS by utilizing both interposer and installing innovation. Interposer innovation with scarcely discernible difference/pitch and inserting innovation are proposed to execute a minimized module. Capacitors are implanted in the PCB and are called as System-on-Package (sop). A Bluetooth IC and a GPS IC are mounted in interposer. In side view, ICs, interposer substrate, and a PCB with capacitors are consecutively situated from top to base. This module is made out of a Bluetooth IC, a GPS IC, interposer with 30 um line width, and a PCB with 17 shunt capacitors. Capacitors are inserted by utilizing chip-first cycle so capacitors are situated in PCB substrates [5]. In this cycle, surface mounting innovation (SMT) is utilized as a major aspect of proposed measure. SMT can mastermind a ton of parts in needed position. Motion issue can be unraveled by controlling temperature and speed of transport line. Subsequently, different capacitors can be installed in this module.

Cheng Li et al [6] suggested that, the plan get together and testing of a multi-sensor stage that could be utilized to distinguish explicit boundaries of encompassing climate is introduced. This stage will be bundled utilizing System-Level combination and could be utilized as one of the hubs in a sensor organization. It is made out of business off-the-rack parts, which permits minimal effort and adaptable segment determination. The sensors included are a pneumatic force sensor, a surrounding light sensor, and a movement GPS beacon.

Different tasks and trainings are occurring each day in the field of IoT, as Arduino assumes a primary part for the apprentices just as item advancement organizations. Building up a task incorporates different testing and interconnection with sensors, supporting modules however with regards to the field of testing then various handy issues will confront when interconnected with wires.
2. Proposed Method

The proposed work is to develop a multipurpose board to interface various modules to Arduino Mega Micro controller which is embedded with Node MCU as prime Wi-Fi connecting tool and Bluetooth module HC-05 as primary module for Bluetooth interface. The main board, Microcontroller, Node MCU, Bluetooth module is supplied with power with the help of 5V- Easy power module. This module primarily converts 230V AC supply to 5V DC supply with 500mA of current which suffices the need for IoT trainer board. Arduino Mega consists of 54 digital pins including 14 PWM pins, 16 analog pins, 4 UARTs along with USB, Power jack and ICSP module. The Pins are categorized into various sets so that sufficient number of modules is connected as well as all the pins are used effectively.

Additional port can be customized for interfacing LoRa WAN device, RYLR890 a LoRa WAN transceiver device for experimenting various interconnecting devices or adjacent trainer boards which can be application specific or industrial devices. The design is illustrated in Figure 1.

3. Analysis and Implementation

The Arduino and ESP 8266 the Transmitter pin TX0 is connected to the receiver of the module and Receiver RX0 from Arduino to the transmitter of the node MCU. The node MCU is energized from Easy power supply. The Arduino and Bluetooth module are integrated by connecting transmitter pin TX1 from the Arduino to the Receiver of the Bluetooth module. The receiver RX1 is connected with the transmitter pin TX of the HC-05. This links the controller with the Bluetooth device for data transfers and the Bluetooth module is powered from the easy power device. Figure 2 illustrates the connections between the Arduino and the Node MCU, and the HC-05.

![Diagram](image-url)

**Figure 1.** Block Diagram of proposed design

**Figure 2.** Integration of Arduino with Node MCU and HC-05
3.1 Interconnecting RYLR890 and Serial port of trainer board

- A 5V power supply
- Reset button to any one Transmitter port
- Transmitter to receiver port of the board and vice versa to establish connection
- A Ground connection

➢ To include the LoRa Device to the serial port of the board then key word used is, *serial write(str)* or *serial write(buf, len)* in transmitting circuit. For the receiving circuit we can use either *serial 1 read()* or *serial 2 read()*.

3.2 Classification of Analog and digital pins into sets

The lists of modules that are embedded in the trainer board are

a. Arduino Mega 2560 Rev 3
b. Bluetooth Module Hc-05
c. Node MCU- ESP 8266
d. LoRa RYLR 890 (optional)
e. Easy power 5V

3.2.1. 4 pin set. A four-pin set is required to connected external module, with two pins for power supply i.e., positive and negative terminals. Third pin is for Data IN and fourth pin is for Data OUT. The sensors can be analog and digital, hence a part of Analog pins are used and parts of digital pins are combined to sets to integrate digital I/O sensors. Analog pin sets {A5,A6; A7,A8; A9,A10; A11,A12; A13,A14} Digital pin sets are {22,24; 26,28; 30,32; 34,36; 38,40; 42,44; 46,48; 50,52}.

3.2.2. 3 pin set. A three-pin set is required to connected external module with two pins for power supply i.e., positive and negative terminals. Third pin is for Data transfer which can be input or output type. The sensors can be analog and digital, hence a part of Analog pins are used and parts of digital pins are combined to integrate digital I/O sensors. Analog pin sets {A0; A1; A2; A3; A4; A15} Digital pin sets are {21; 23; 25; 27; 29; 31; 33; 35; 37; 39; 41; 43; 45; 47; 49; 51; 53}.

PWM pins are connected separately with male headers for multi skilled usage. One pair of TX0, RX0 are connected with node MCU and other set of TX1, RX1 are connected to the Bluetooth module and therefore the remaining 12 pins are headed out for connections. Figure 3 depicts the classification of the different pin sets.

![Figure 3. Pin category](image-url)
3.3 Leverage in power supply
Sensors are modules with variety of voltage needs and these power needs cannot be satisfied with just one voltage 5V. The board is designed in such a way that three types of Voltage 5V, 9V, 12V can be sourced wherein three jump pins are given near sets of each sensor. When the sensor need 5V then short pin is used to short the Vcc pin and the 5V track line; two parallel lines run viz. 9V and 12 V that can be used based on the need of sensors.

Leverage of interconnecting RYLR890 transceiver device is listed below
- Long range transmissions
- Low power consumption when compared to Wi-Fi and 5G as this device consumes only 25mW.
- Bandwidth required is very less and subsequently the throughput is decreased.
- Main drawbacks on IoT is said to be low security system but since LoRa is added to this system, it connects to only authenticated devices and it can also choose networks.
- Gateways can be obtained and LoRa can be made into a private network within the industry or labs to connect between the devices.
- LoRa connected with cloud and secondary storage devices is an add on.

3.4 PCB board design
The top and bottom view of the designed printed circuit board as shown in Figure 4 and Figure 5 has the foot components of Arduino Mega, Node MCU- ESP 8266, Bluetooth module HC-05 and a standalone power supply. The track of 5V and 9V can be seen clearly and also the third link from the edge is the ground. Analog and digital pins are separately grounded.

Figure 4. Top view of deigned PCB

Figure 5. Bottom view of deigned PCB

In the PCB board, the female 3 port pins is soldered for 3 port module junction and male 3 port headers for shorting power supply end to switch between 5V and 9V. Four port header pins are
soldered in the place of 4 port bases. For the Arduino to sit on the PCB male header pins are soldered. To embed Node MCU and Bluetooth Module female header pins are soldered. Easy power module which is the stand alone supply for the board is directly embedded on the board. In addition, two more adapters are given to supply 5V and 9 V for the sensors. Figure 6 shows the PCB with the modules mounted.

![Figure 6. Isometric view of multifaceted PCB with modules mounted](image)

### 4. Conclusion

Printed circuit board is multifaceted and has wide arms to extend and support all modules and varying needs like heterogeneity in power supply; single/dual way data transfer for sensors; analog/digital data transfer type assisted with a Bluetooth and Wi-Fi module for wireless connection. These facilities are leverage for aspirants to give hands on experience. The project objective was achieved with many features. Multiple sensors were integrated to check the board; connectivity checking was done once before and after soldering of the bases. The project designed is a double layer board. The power sets could give non lagging resource for all sensors, Arduino, Node MCU and blue tooth module. The designed board was compact as it did not occupy much space and it was finally fixed onto a wooden frame to resemble a perfect trainer board product.

### 5. Future work

In future the PCB design can be extended to have even more number of equipments like memory storage, any other feasible controllers, LAN, display devices like screens and also printers. It can also be designed on customer specific basis for selling this project as a market-based product. Future works can also be extended by adding a bread board to the trainer board and also some LED testing ports. If the controller is improvised; the modified version of the board can also have a raspberry pi or any other high-end controllers/processors.

The base material is usually a glass-reinforced epoxy, which is FR-4. This material is affordable and flame resistant. The proposed PCB design is composed of two layers. There are also some other factors which the design should be focused on is Copper traces which are created from a solid material and it’s based on the base material; Via is crucial which helps in establishing many connections with various types; Selecting part and various specification for the components plays a vital role as it is dependent on market availability and feasibility. Design of manufacture rule, signal and power integrity is highly essential to ensure quality performance of the proposed work [7].

#### 5.1 Advantages of proposed method

- Size of the proposed trainer board is compact 7’6”x 4’4” in inches which really fits into a hand, this factor is essential because the trainer board can be mounted to any mobile robot and directly programmed for testing. This can also support further applications such that they can also fit into distribution board for IoT applications.
- Cost of the Trainer board with basic modules listed is around 2000 Indian rupees.
- Plug in and play design
- Advanced LoRa transceiver devices can be interfaced easily
- Upgrading of the board is easy
- There is no need for any additional support or infrastructure.
- Prototyping for projects is easy.
- On board, ESP 8266, Bluetooth module, Easy power supply.
- Purpose of the trainer board is to learn IoT hands-on projects with ease.
- Extendable ports like Joy stick port, LCD display port, membrane keypad, additional bread board connection.
- Easy to program.
- Analog and digital sensor ports which is 3 pin or 4 pin I/O supported by 5V or 9 V or 12V individual supply.

5.2 Limitations of other trainer boards
- Trainer board is large in size 9x12 in inches
- Costs minimum of 15000 Indian rupees
- Inbuilt bread board consumes large space for direct prototyping applications
- Actuators like stepper motor, servo, LED and RGB are embedded on to the board. This can be useful only for testing applications but when it comes to prototyping, extended wires will have to be used on board which is not feasible
- Range and limit of sensors available inbuilt are IR, Temperature, Humidity, Luminous, Ultrasonic sensors which are fixed on board, some application note these sensors need to be mounted on some external support for testing purposes. Damage or defects in sensors are difficult to replace.
- There are no defined ports for variety of sensors viz. categories consisting of both analog and digital ports with added advantage of 3 and 4 port pins.
- Miscellaneous components like LCD display, Potentiometer, bread board, sensor holder may not be needed all the time for applications.

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