Microcontroller based Timing System for Racing Events

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Abstract - *This paper deals with developing a custom-made electronics system with the help of microcontrollers and WIFI modules. Buying an OEM for testing purposes in a student run project is a costly and a less-innovative process, hence this system is made with the aim of determining the accurate time taken by an all-terrain vehicle to complete a travel between two points with the help of microcontroller and WIFI modules. The aim is to make a cost efficient and compact in size, ready to use system by involving the concepts of embedded systems and internet of things*

***Key Words*: Embedded System, Internet of Things, Automotive Electronics, Microcontrollers, Wireless Communication, Arduino Uno,**

1. INTRODUCTION

IOT (Internet of Things) is a concept where an object can connect with the network without the involvement of any human activity. Internet of Things connects devices embedded in various systems to the internet. When devices/objects can represent themselves digitally then they can be controlled from anywhere. This type of connectivity helps us get more data from more places, ensuring more ways of increasing efficiency and improving safety and security. Many businesses including, manufacturing, utilities, insurance, oil gas, transportation, infrastructure, retail agriculture are getting benefited from this technology. IOT has revolutionized the way organizations improve their performance and increased their day to day comfort in workplaces.

Microcontrollers are the basis of reducing the size of most of the electronics systems being used in the world.

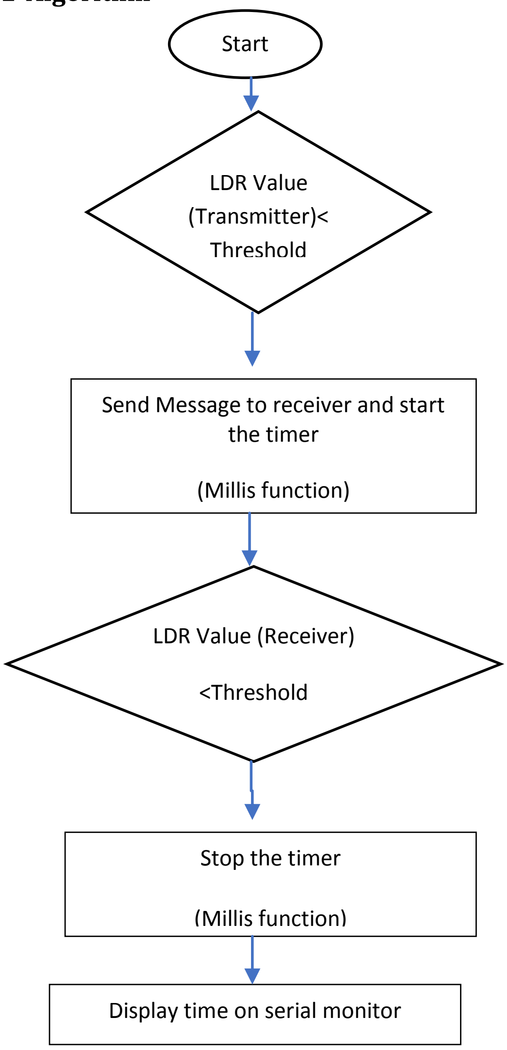
It is having application in almost all of the electronics and electrical equipment's being used around the world these days.

Arduino Uno is a microcontroller based on ATMEGA 328p microprocessors of the AVR family. It has in total 14 digital pins including PWM pins and 6 analog pins. It can be powered with directly a power supply or through a USB cable connected to the PC. Arduino has now become one of the most famous microcontrollers for the prototyping of electronic systems.

Wireless systems are an essential component of the internet of things concept. It enables different device to get connect with each other at a distance with less delay in data transmission and minimal data loss. In this research paper total three WIFI modules have been discussed, which are, NRF24L01, HC 12 and XBEE S2C Pro. Each module's specification and its problems are discussed.

In many racing events there is a need to compute the timing of completing the event by every team. One major thing which has to be taken under consideration is that most of the teams differ in the timings with a fraction of seconds. Hence computing the actual time with few digits after decimal is necessary. Buying an OEM timing system costs high and it showcase high lack of engineering implementation. The aim of the paper is to make a customized timing system using microcontroller and WIFI module. This can be done by following the algorithm below: -

1.1 Algorithm



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2. METHODOLOGY

A pair of wireless modules is interphased with a pair of Arduino Uno's' as the microcontroller. The starting end module is set as the transmitter and the other as the receiver. The wireless module is placed on an Arduino shield. This shield is used to interphase the WIFI module with the Arduino. A laser is pointed on the LDR which sits on the Arduino shield. Now, at the starting end, when the vehicle moves it cuts the path of the laser. This causes the transmitter to send a message at the receiving end. As the receiver receives the message it starts the timer. When the vehicle interferes the laser beam now at the receiving end, the timer stops, and the final time is displayed on the screen with up to four decimals accuracy.

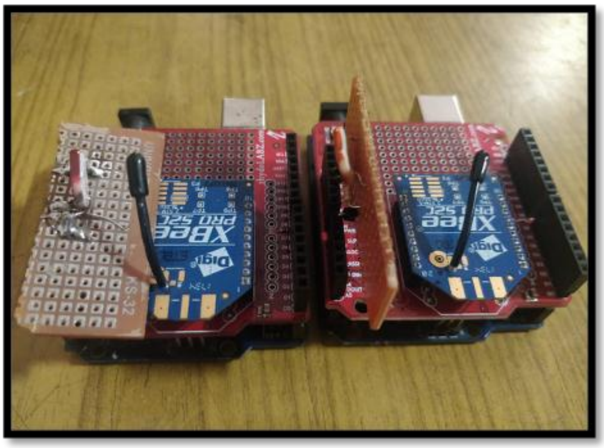

Figure 1 - Two XBee Modules connected to Arduino Uno.

2.1 Precautions to be taken: -

- Metal objects between the transmitter and receiver can block the path of signal or reduce the transmission distance, also ground planes or metal objects above or below the antenna of the WIFI module hinders proper functioning of the system, hence the timing system should not be closed in a metal enclosure.
- Both the LDRs should be appropriately covered to avoid any external source of light.
- Laser should be powerful and should be pointed directly and continuously on the LDR.
- An external Antenna should be used (e.g. SM-A Antenna) if the distance between the transmitter and the receiver is more than 200m.
- The Laser's path should not be interfered by any external factor during the travel of the vehicle.

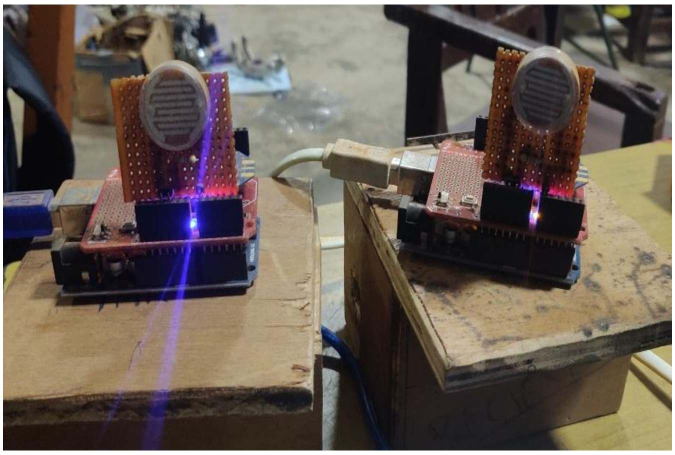

Figure 2- LDR connected with the Arduino shield

The following is the benchmarking of all the WIFI modules used for best results.

2.2 NRF24L01

Specifications: - Supply voltages: - 0.3V to + 3.6V. Power: - 60mW. Temperature Operating - 40°C to + 85°C Storage Temperature - 40°C to + 125°C. [1]

NRF24L01 configured as primary Rx (PRX) receives data through 6 different data pipes These data pipes have unique address as shown in figure 3, but they share the same frequency, which means that up to 6 different nRF24L01 configured as primary Tx (PTX) can communicate with one nRF24L01 configured as PRX, and the nRF24L01 configured as PRX will be able to distinguish between them. Data pipe 0 has a unique 40-bit configurable address. Each of data pipe 1-5 has a unique 8-bit address and shares the 32 most significant address bits. NRF24L01 uses the data pipe address when acknowledging a received packet. This means that NRF24L01 will transmit ACK with the same address as it receives at. In the PTX device data pipe 0 is used to receive the acknowledgement, and therefore the receive address for data pipe 0 has to be equal to the transmit address for receiving the ACK. NRF 24L01 while in use displayed a lot of limitations which included: -

- Any physical interruption in between the line of sight of the two WIFI modules caused loss of data.
- Its range is 1Km in ideal conditions but practically it was not more than 50-100 feet's.

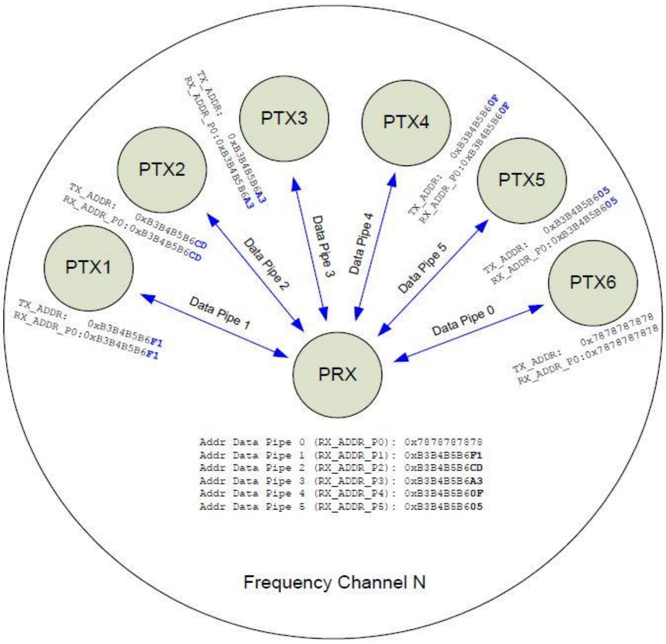

Figure 3-NRF24L01 module

2.3 HC-12

HC-12 wireless module is a multichannel wireless data transmission module. Its working frequency band is 433.4-473.0MHz, multiple channels can be set, in steps of 400 KHz, and there are in total 100 channels. The maximum transmitting power of module is 100mW (20dBm), the receiving sensitivity is -117dBm at a baud rate of 5,000bps in the air, and the communication distance is 1 Km line of sight. There is an antenna pedestal ANT1 for the PCB on the module, and user can use external antenna of 433Mhz frequency band through coaxial cable; There is also an antenna solder eye ANT2 in the embedded in the module, and it is convenient for user to weld spring antenna. We can select one of these antennas according to use requirements. The module adopts multiple serial port transparent transmission modes, and user could select them by AT commands according to the requirements. The four modes in which HC 12 works are FU1, FU2, FU3 and FU4.

The following is a brief description of the four modes:

- FU1 mode had an idle work current of 3.6mA and a transfer delay of 15-25ms. It is basically a power saving mode and generally used for short distance communication.
- FU2 mode had an idle work current of 80mA and a transfer delay of 500ms.
- FU3 mode had an idle work current of 16 uA and a transfer delay of 4-80ms.
- FU3 mode had an idle work current of 16 mA and a transfer delay of 1s. It is used for ultra-long-distance communication, but the data propagates with a lot of delay.

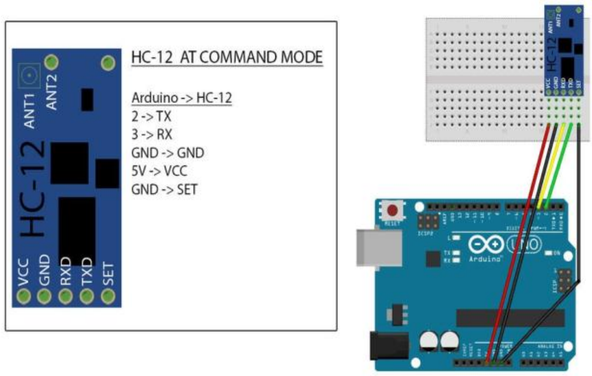

Figure 4- HC-12 with Arduino

Though according to the datasheet of the HC 12 Module it should provide a range of 1.6 Km line of sight, but on practical grounds, it was less. It gave a line of sight range of about 100ft that too when kept at around 1m distance from the ground. On keeping the system on ground, it stopped working completely. As we had to keep our system on ground and then operate it therefore, we had to change the module. And thus, we adopted the XBEE Pro S2C module for the system.

2.4 XBEE PRO S2C

The XBee/XBee-PRO Zigbee RF Modules provide wireless connectivity to end-point devices in Zigbee networks. Using Zigbee PRO, these modules can be connected to each other Zigbee devices, including devices from other vendors. With the XBee, users can have their Zigbee network up-and-running in a span of minutes without configuration or additional development. The XBee/XBee-PRO Zigbee RF Modules are compatible with other devices that use Zigbee technology. These include ConnectPortX gateways, XBee and XBee-PRO Adapters, Wall Routers, XBee Sensors, and other products with the Zigbee name.

Though the final system was made with XBEE S2C pro wireless module, it had a disadvantage of having a higher cost than the other two wireless modules. But due to its better performance it was chosen as the final module for the timing system.

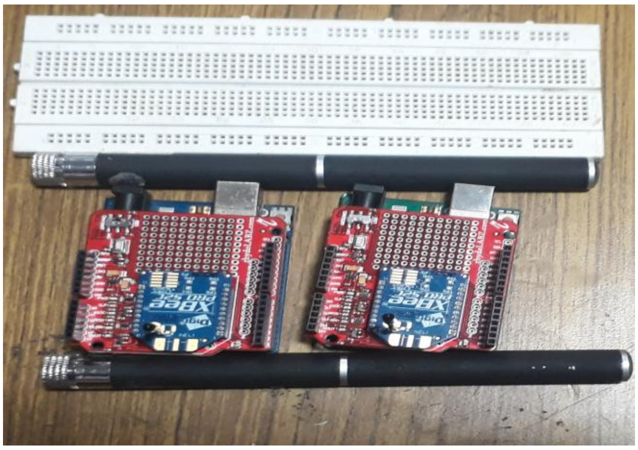

Figure 5- XBEE Module interphase with Arduino with the help of Arduino shield

2.5 XCTU

XCTU is a platform designed to interphase with the XBEE/XBEE Pro and Zigbee modules through a simple GUI The XBee API framework helps to develop and interpret XBEE in API mode. API mode provides simple communication between multiple devices without defining our own protocols. Both the transmitter and receiver are configured with the help of XCTU and then the communication between the two is made.

Result

The laser was fixed at one end and the ZigBee setup which had LDR on it was placed on one end. This was the transmitting end. Both were 1.5 m apart; the laser was made to point at the LDR constantly. A same setup parallel to the transmitting end was placed 100ft apart from it, this was the receiving end. The ATV was made to sprint at full throttle from the transmitting end to the receiving end. The timer started as soon as the vehicle interfered the transmitting end's laser beam, and the final time with four digits decimation was displayed on the serial monitor of the receiving end as soon as the vehicle interfered the receiving end's laser beam.

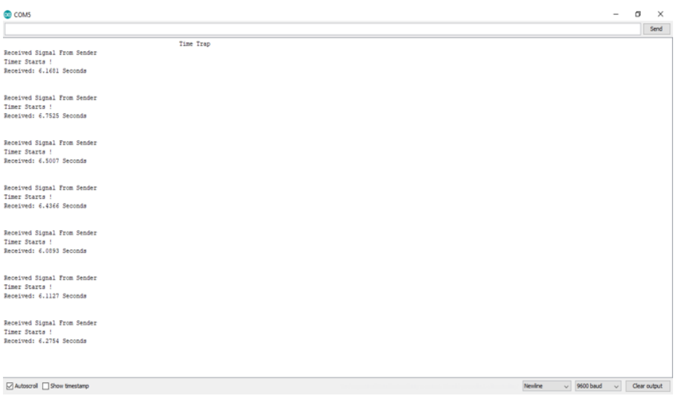

Figure 6- Time of seven trial runs on Arduino serial monitor

Conclusion

Optimization and customization of components makes it more efficient and easier to use. Main issues faced by such improvisations are reliability and serviceability. Testing the new system in all the configuration and in all the rugged condition makes it more robust to use. The timing system discussed in this paper was developed and packaged well, it gave the correct timings and helped the vehicle to improve in its acceleration by increased rate of testing. IOT and embedded systems have become an essential tool in developing systems to improve its performance and efficiency.

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