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DEVELOPMENT OF A MICROCONTROLLER BASED LIGHT DEPENDENT RESISTOR (LDR) VEHICLE TRACKING SYSTEM

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Abstract

There has been an increase in the numbers and sizes of vehicle fleets and fleet managers are bordered to keep track of their vehicles on the ply route in order to quickly address any issue regarding the vehicles or the passengers on board by implementing vehicle tracking. This paper presents a vehicle tracking technique for fleet management. This work is expected to serve as a framework for the implementation of Radio Frequency Identification (RFID) tracking method by the institutions transport unit. Light Dependent Resistors (LDRs) are used in this work to detect the position of vehicles on tracked route, the information is relayed to an encoder which in turn passes the information to a RF transmitter. The RF transmitter transmits same, to the base station which is then received by its wireless receiver, decoded by its decoder and formatted it for its Liquid Crystal display (LCD) screen. The system works in real time and does not require line of sight to communicate. The work was found to be reliable.

Introduction

Vehicle fleet can be referred to as a collection of road vehicles that is owned and managed by a firm [1 - 4]. Fleet can be seen as a number of road vehicles, boats or aircrafts being managed as a unit. They may include commercial motor vehicles such as cars, vans and trucks, as well as rail cars. Fleet Management minimizes the risks associated with vehicle investment by firms that rely on transportation such that it improves efficiency and productivity of operations, and reduces their overall transport unit staff costs [1, 3, 5].

Some related works have been carried out over the years on fleet management, which have revealed that one of the efficient measures that could be taken in other to achieve effective fleet management is tracking [6]. Fleet tracking systems are designed to track vehicles owned or being used and managed by an enterprise using combinations of modern information and communication technologies. Most of these technologies are based on Global Positioning System (GPS) devices. Their applications monitor/tracks vehicles by GPS information about geographical locations of the vehicles being tracked.

A vehicle tracking system developed in [7] by Parkinson & Spilker uses existing technologies (GPS, GSM/GPRS and internet) for its navigation and tracking. It applies embedded system comprising of GPS receiver (sensor), microprocessor processing unit and a GSM/GPRS module that sends the position information to the internet. This information can be accessed from anywhere on the net in other to ascertain the where-about of the vehicles being tracked. One of the limitations of this work is its inability to ascertain the position of the vehicles, if there is no availability of GSM network services. Another limitation of this work is its inability to track any vehicle that is out of clear line of sight with the GPS satellite in space.

Medagama, et al., in [8] used Geographical Information Systems (GIS), the Global Positioning System (GPS), the General Packet Radio Service (GPRS) and the Internet to track large fleet of vehicles. The key features of this system are an open-source GIS platform, real-time location information update, and a web-based user interface. The base station consists of GPS devices, communication server, a web-server, a database server and a map server. The tracking devices on the vehicles collects their location information in real-time via the GPS, transmits same continuously through GPRS to a central database at the base station so that users are able to view the current location of each of the vehicles in the fleet via a web-based application. The vehicles positions and other position information are afterward displayed on a digital map. Another related work by Abhishek et al in [7] developed a GPS based system of similar pattern. However, both systems suffers similar defect because they are ineffective when vehicles are close to tall buildings and forests as this prevents clear line of sight with the satellite.

In view of the above, hardly is there any technology adopted in fleet management that is 100% efficient. This due to the fact that they all entail deploying the technology along the tracking route, hence subjecting sensors to harsh geographic

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weather conditions that may either damage the sensors or cause deterioration in performance. Also, breakdown in any of the nodes may affect the entire network, depending on the network topology adopted.

Fleet management of any institution should incorporate deployment of access control of the institution packing lot. Fleet vehicles that go out will definitely return into the lot and has to be identified for proper record keeping and timely management of the fleet. Incorporating same, [9] developed system that controls the access of vehicles in a fleet. This system is designed to monitor attendance and control the access system using Radio Frequency Identification (RFID) based on the leading technology of long range microwave Radio Frequency (RF) band. This system can effectively monitor/track accesses to an area by automatic identification and attendance record. In this case, each vehicle is equipped with an active tag which is previously registered in the database. The active tag communicates at regular intervals with a reader that is within its area of coverage using microwave RF signal. When a reader that is installed near a gateway has received signal from an active sticker/tag, it transmits the signal to the gateway controller such that the RFID system verifies the validity of the sticker. If valid, the time of arrival of the vehicle carrying the identity of the sticker is recorded as part of its attendance procedures, subsequently the relay on the controller drives the gate open to give access permit to the vehicle that is entering the parking lot.

Hence, there is need for a model that is capable of tracking fleet vehicles in real time and using the radio wave as its signal carrier to ensure continuous tracking all the time. In this paper, we present a framework for the implementation of vehicle tracking using radio frequency identification (RFID), based on light dependent resistor (LDR) coupled route, for vehicle tracking in fleet management. It is capable of keeping track of the vehicles in real time. It does not require line of sight between the different modular units to be able to communicate with their base station and no GSM network is needed for tracking to occur. This ensures that vehicles in fleet within the tracking route are continually tracked for real time report and fleet management. The remaining part of the paper is structured into Case study description, Design methodology, Simulation and Development, Discussion of Outcomes and Conclusion.

Case Study Description

This work considers a case study of FUT-Minna transport unit showing how this work can be applied to address a real life problem. This fleet management system is made up of a central base station wherein the position of each vehicle in the fleet is monitored via liquid crystal display (LCD). This system is as well expected to cover only an administrative area of FUT-Minna, Gidan Kwano(GK) campus. This work has integrated different technologies (i.e. Microcontroller, wireless, software e.t.c) to achieve vehicle tracking objectives. The layout of the considered tracking route is illustrated in Figure 1.

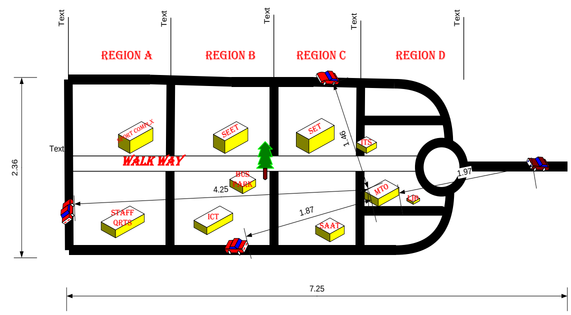

Figure 1: Model of FUTMinna, Gidan Kwano Campus.

Layout of the F.U.T. Gidan Kwanu (GK) campus route being tracked in this work is divided into regions labeled A through E in Figure 1. The black thick lines depicts the motor routes of GK campus that were been coupled with Light Dependent Resistors (LDR). Region E is part of GK campus that is immediately after the entrance gate into the campus. Region D is the one ahead of E when going further into the campus from the gate. MTO, Information Technology Service (ITS) and the junction joining the routes to the staff quarters and the one leading to School of Engineering and Engineering Technology (SEET) are found in Region D. Next to it is Region C, where School of Environmental Technology (SET) and School of Agriculture and Agricultural Technology (SAAT) are located, after which Regions B and A are located. School of Information and Communication Technology (SICT), SEET and the motor park are in Region B while Works complex and Staff quarters are in region A. A vehicle being tracked/monitored is expected to take off from the motor park at the beginning of the day and return to park at the end of the day. It is as well expected that fleet vehicles shuttles within the territorial region covered by the tracked routes. It is as well assumed in this work that the base station is integrated into the motor park.

Design Methodology

The method that have been applied in this work includes development of block diagram and circuit diagram, Simula-

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tion of the design, building of prototype based on the design, development of required firmware into prototype and demonstration of the prototype on a modeled routes of the layout in Figure 1. The block diagram of the system, showing the various devices that make up its circuitry is as shown in Figure 2.

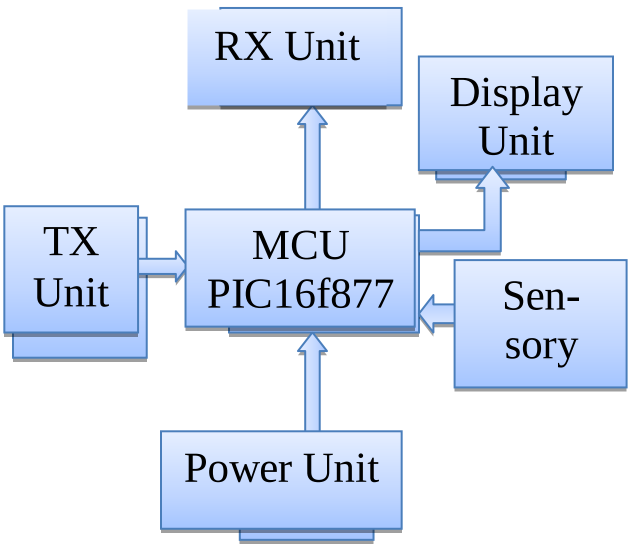

Figure 2: System Design Methodology

These devices include the power subunit, the Transmitter (TX) subunit, the receiver (RX) subunit, the sensor unit, the display subunit and the Controller subunit (MCU). This block diagram is a generalized composition that actually constitutes three units, namely LDR sensors unit, transmitter unit and receiver unit. Functions of each of the different parts that make up the circuits of the tracking device are listed and explained below.

A. The Power Unit

Power Supply is the device that transfers electric power from a source to a load using electronic circuits as shown in Figure 3. Power supplies are used in many industrial, aerospace applications and consumer products. It is required that power supply units are small in size, light, cheap, high power conversion efficiency, possess electrical isolation between the source and load, low harmonic distortion of input/output waveforms and high power factor (PF) from an Alternating Current AC voltage source. Some power supplies require regulation of output voltages, especially conversion of utility AC input power into regulated voltage(s), required for electronic equipment.

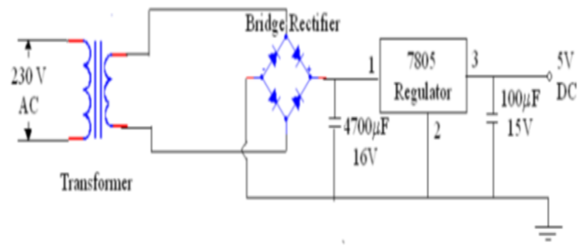

Figure 3: The Power Unit design Circuit.

It supplies the entire subunits and their circuitries with the required amount of energy. The voltage requirement for the design is a +5Volts, hence the power unit is designed such that it delivers a fixed and steady voltage of +5V. It consists of a 24V step down transformer on the input side, which supply the bridge rectifier system with the required energy. The bridge rectifier module KB9206, which has four diodes, converts the AC input voltage from the transformer into DC voltage. The output of the bridge rectifier consisting of ripples is passed through the 4700µF capacitor to filter off the ripples. The LM7805 regulates the voltage and ensure that its output does not exceed +5V at any moment.

B. Sensor Unit

The sensor unit is used to detect the presence of tracked vehicle in the region it is mounted. Each region, including the park, is allocated a sensor. The sensors are mounted at strategic places on the route segment in each region to form sensor coupled routes.

The sensor of choice in this work is light dependent resistor (LDR; 10mm) whose resistance either increases or decreases depending on the amount of light intensity it is being exposed to [10], such that the presence of vehicle in its vicinity produces shadow over the LDR and make it to conduct signal. When a vehicle comes in range with any of the sensors, it detects the location of that vehicle and relays it to an encoder which encode and forwards it to a wireless transmitter that send it wirelessly to the base station. LDR's resistance depends largely on the illumination of the environment [11]. LDRs are very useful tools in a light/dark circuits. LDRs can be used to turn on a light when the LDR is in darkness or to turn off the light when the LDR is in light. In this context, LDR is used as a sensor that detects the position of the vehicle in fleet. Four LDRs are mounted at different regions as defined earlier, within the tracking route of the vehicles. In this work, the regions are A, B, C and D as shown in Figure 1. Some LDRs are shown in Figure 4 (Courtesy of Adafruit Industries, NY 10013).

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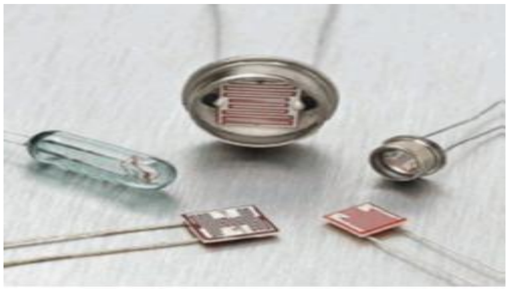

Figure 4: Different varieties of LDR

Figure 5 describes the interconnection of the LDR and other circuitries.

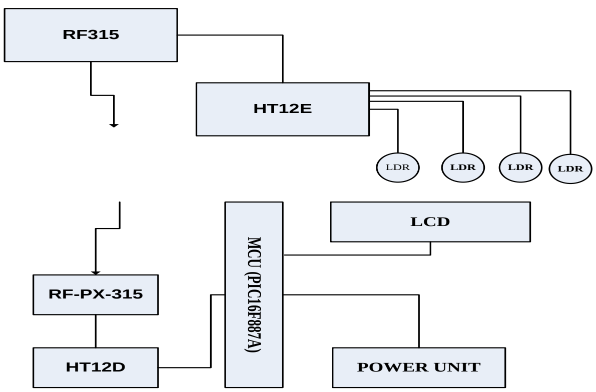

Figure 5: Interconnection of LDR and other Circuitry.

C. Transmitter (Tx) Unit

The functions of transmitter unit, shown in Figure 6, in this work is conversion of position data information by sensor status into bits string, encoding of the bits string into the format decode-able by the receiver at the base station and its subsequent transmission via an RF transmitter (RF315 module).

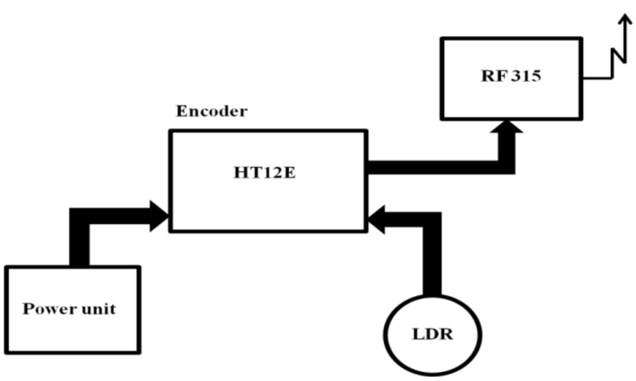

Figure 6: Transmitter (TX) Unit.

The unit consists of an encoder and an RF transmitter. The encoder is one of the principal elements of the transmitter unit as it is responsible for the encoding of the required information for transmission. The transmitted information is expected to be received by the receiver unit at the base station with the help of its RF receiver device, decoded back by its decoder device into the original bit string and subsequently formatted by the Microcontroller for onward display by it on the LCD device at the base station.

The encoder of choice in this work is HT12E. The HT12E encoder module which is an Integrated Circuit (IC) of 2^{12} series of encoders are most often used in combination with a similar 2^{12} series of decoders for many applications. The HT12E basically converts the parallel inputs into serial output and has the capability of encoding 12bits. The HT12E is an active low device depending on the voltage level on its TE pin. It is designed to be paired with 2^{12} series of decoders in remote control system applications. It is mainly used in interfacing RF and infrared circuits. HT12E converts the parallel inputs into serial output by encoding 12 parallel data bits, of 8 address bits and 4 data bits, into serial form for onward transmission through an RF transmitter. When a latched low level signal is received in transmission enable(TE) pin which is active low, HT12E begins a 4-word transmission cycle of the programmed addresses/data and header bits via an RF medium. This cycle is repeated as long as TE is kept at low level. As soon as TE returns to high level, the encoder output completes its last cycle and stops operation.

The RF transmitter that is chosen in this work is RF315. It is required for RF communication of data between the receiver unit at the base station and its host transmitter. These RF modules are very small in dimension and Restriction of Hazardous Substance (RoHS) directive compliant. The low cost RF receiver can be used to receive RF signal from transmitter at a specific frequency which is determined by the transmitter device specifications. Its super regeneration design ensures excellent sensitivity to weak signals. The RF transmitter module is shown in Figure 7 (courtesy of Holy Stone Enterprise Co., Ltd.).

Figure 7: RF Transmitter Module

D. Receiver (Rx) Unit

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The receiver unit comprises of the following: PIC16F877A Microcontroller that coordinate other devices in the unit by executing its firmware routines to perform required functions, RF-RX-315 RF signal receiver that receives transmitted values in RF signal and transform it into the original digital format in bit strings, HT12D decoder device, 4 X 20 display units and power source as shown in Figure 8.

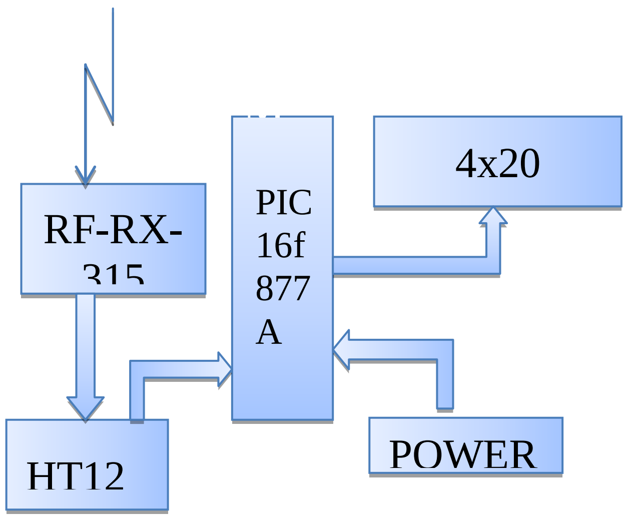

Figure 8: The interconnection of the Receiver unit.

The HT12D module is also a 2^{12} series integrated circuit decoder. The HT12D converts the serial input into parallel outputs and decodes the serial addresses and data received into parallel data and sends them to output data pins. The interconnection between the RF receiver and the decoder is as shown in Figure 8.

These series of decoders are mainly used for remote control system applications, like burglar alarm, car door controller, security system etc. It is mainly provided to interface RF and infrared circuits. In simple terms, HT12D converts the serial input into parallel outputs by converting the addresses and data received via RF receiver into its parallel forms at the output data pins. Data authentication is done by comparing address field of the received serial input data with the local addresses in not more than three attempts continuously, the input data is then decode in the absence of error or unmatched codes. A valid transmission is indicated by a high signal at the decoder's VT pin. HT12D is capable of decoding 12 bits, of which 8 are address bits and 4 are data bits in this work. The data are stored on a 4 bit latch output pins which retains its values until new data is received.

The RF-RX-315 module shown in Figure 9 (courtesy of Holy Stone Enterprise Co., Ltd.), receives the transmitted signal and passes the information onto the HT12D decoders, whose function is to decode and pass the information decoded to the controller unit for processing.

Figure 9: The RF Receiver Module

Liquid Crystal Display (LCD) technology has enjoyed significant advances in recent years[12]. The quality of LCD panels has improved dramatically while at the same time their costs have reduced. LCDs are now found in products as small as mobile phones and as large as 42-inch flat panel screens. It is used in this work to display information about the location of a vehicle in the fleet. It is shown in Figure 10 (Courtesy of Hitachi).

The essence of display units is to give visual information of the current location of the tracked vehicles. The adopted LCD in this work has the capability of displaying 80 characters, 20 characters by 4 lines, at a time. Each line is made to display position information on each of the four regions under coverage. The displayed line is either “Vehicle in Region” or “Vehicle not in Region”. Therefore, only an LCD screen is required to cover the four regions.

Figure 10: LCD Screen

The PIC16F877[12] microcontroller from Microchip Technology shown in Figure 11 (courtesy of Microchip Technology) was adopted because of its compactness, portability, high performance, programmability and miniaturized features. This device has the overall control of all the devices in the receiver unit and allocates its processing time to these devices according to its control logic. Since it is a programmable device it provides the facility to update the device without changes in hardware, it also reduces the hardware required to implement the entire circuit.

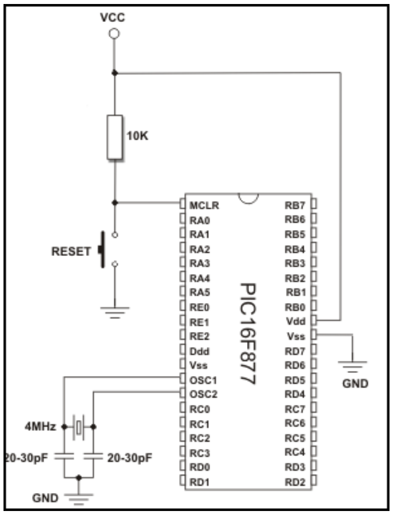

Figure 11: The basic connection of the PIC16F877A.

The PIC16F877A is a 40pin, 8bit type CMOS IC Micro-controller unit. Some of the basic features of the 16F877A that supports its selection for the design includes, its low power consumption (2.0V to 5.0V), 8K flash ROM, 256 EEPROM, 5 I/O pin-out, 8 Analog to Digital Converters (ADC) and its RISC architecture (35-words per instruction).

The microcontroller controls and coordinates the activities of the other devices in the receiver (base station) unit. It does initialize itself and other devices at power up, restores their parameters at when due, ascribe decode routings of the received LDR information and display received information in the appropriate format on the LCD, executes its routines in order to coordinate these devices in accordance with the designated programs and supply preset data values of these devices which ascertain their compliance and performance under the supervision of its control program [12]. An ideal voltage for PIC16F877A is 5V (Direct Current) which should not be higher than 5.5V else, it can be harmful. It also should not be less than 2V because it will be an under voltage. This required 5V source is readily achieved by using voltage regulator in the Power subunit. The control logic of the microcontroller that coordinates the functions of the receiver unit is depicted in Pseudo code form below and in the flowchart in Figure 12.

Control Logic Pseudo Code:

```
Start
Do
   If Sensor A = =1
Lcd out “Vehicle in range”
   Else
Lcd out “Vehicle out of range”
    If sensor B == 1
Lcd out “Vehicle in range”
     Else
Lcd out “Vehicle out of range”
    If sensor C == 1
Lcd out “Vehicle in range”
    Else
Lcd out “Vehicle out of range”
    If sensor D ==1
Lcd out “Vehicle in range”
    Else
Lcd out “Vehicle out of range”
While (1)
```

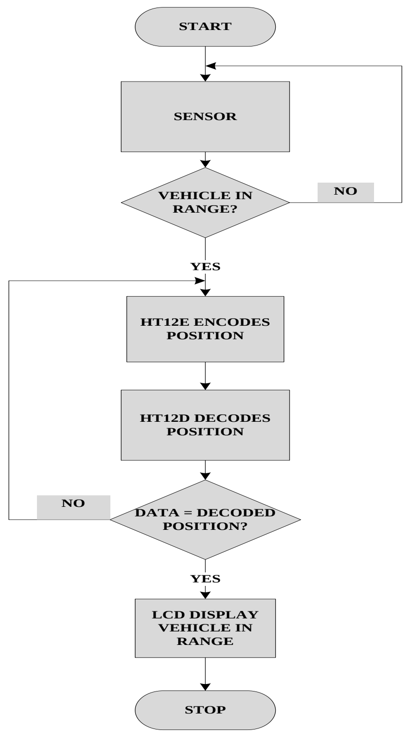

Figure 12: Flow Chart for System Design.

The steps of the flow chart are as follows:

Step 1- System initialize
Step2 - Sensor detects vehicle
Step3 -Sensor relays position information to decoder
Step4 -Decoder sends same to RF transmitter
Step5 -RF receiver receives position information
Step6 -Does data match the data on the decoder?
Step7 -No: control goes back to decoder SYE
Step8 -: display position information on LCD.

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The Microcontroller processes any successfully sent information and displays it on the LCD screen.

Simulation and Development

The simulation exercise of this work utilizes the stages of control logic code formation and circuit diagram development.

Hardware prototype of the units was developed in one casing using Vero-board component mounting and pins' jump-wire interconnections. The implementation was evaluated on a modeled road of the case study of Figure 1.

The net list of the simulation was generated by using components explained in Design Methodology section. The simulation was done in Proteus virtual environment, which was done safely without the fear of hardware failure. Proteus is integrated development environment software that aids circuit designs and testing without actual fabrication of the hardware. The programming aspect was done using the MikroC PRO for PIC complier. The MikroC Pro is a special development tool for PIC microcontrollers as it provides a platform for ease of programming and translation into hex binary files.

Simulating circuits in virtual environment can save both time and cost to produce the hardware. The control logic code was implemented, by using its flowchart in Figure 12, in MicroC Pro compiler and then activated for virtual simulation of the combined circuits of the transmitter and receiver in Figure 13 in Proteus simulation environment. The outcome of the design and development in form of prototype was evaluated on a physical model of the LDR-coupled tracking routs of the Figure 1 as explained in Discussion of Outcomes section. It was found to be proficient and realistic.

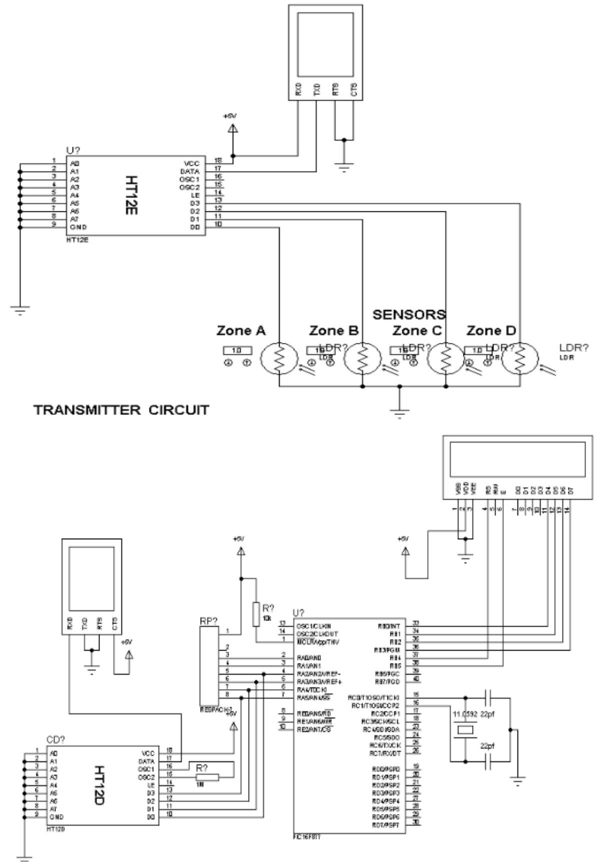

Figure 13: Receiver and Transmitter Circuits.

Discussion of Outcomes

Certain characteristics of the adopted LDR were measured before its application. A lighted bulb was place at different arbitrary distances from the LDR and the resistance was measured at each distance. Five different measurements that were taken are tabulated below.

Table 1. Effect of variation in light intensity on LDR resistance

S/NO	Distance (cm)	Resistance (Ohm)
1	1	0.20
2	2	0.39
3	3	0.60

4	4	0.81
5	5	1.00

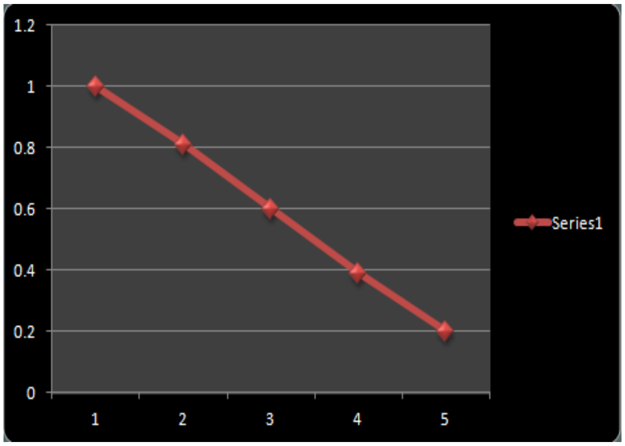

Figure 14: Graph of resistance of LDR versus Light intensity in Table 1.

After a test on the different components and the whole circuit, a modelled car was used to test the tracking ability of the system. As soon as the car comes into the transmission range of any of the LDRs on the tracked route any of the following information is displayed depending on the transverse LDR.

a) Vehicle in region A
b) Vehicle out of range from region A
c) Vehicle in region B
d) Vehicle out of range from region B
e) Vehicle in region C
f) Vehicle out of range from region C
g) Vehicle in region D
h) Vehicle out of range from region D

Conclusion

This paper shows the advantages of ICT in efficient and effective management of company resources, particularly amidst high fuel costs. In addition, this system utilizes minimal resources for position information collection by just mounting sensors at strategic positions, thus reducing the cost of acquiring position information effectively. Furthermore, this design allows the system administrator to know about the vehicle location irrespective of any obstruction between modules, as compared with other positioning systems that require clear line of sight in other to transmit position data. Therefore, this system can indicate the position of the vehicle timely, and can be adopted for implementation in FUT-Minna transport unit or any other institution.

We do not hesitate to recommend in this work, that a combination of LDR, RFID with another technology (like GPS) can be considered in other to improve tracking accuracy and applicability in fleet management, irrespective of LDR tracking technique advantages in form of inexpensive resources, real time response, precise information, low cost of maintainability and ruggedness.

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