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International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Design and Construction of a Remote Web-Based Digital Display System

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Doi: https://doi.org/10.55248/gengpi.5.0724.1738

A B S T R A C T

A new approach to maximize the efficiency of display system is conducted which requires the use of an ESP8266 microcontroller having an inbuilt wireless fidelity (WIFI) module capable of retrieving every information from the database in which it is connected to remotely. Two ATmega328P microcontrollers were used to drive two rows of four Light emitting diode (LED) P10 modules consuming current of 2.16A and voltage of 3.17V operating on 12V with 10.5A at 100% brightness level on steady display with ESP8266 retrieving every information for display at a maximum of 5 seconds. Static message verifiable in this research measures to 15 characters maximum with spaces inclusive. A responsive website is developed to upload and display the present and previous messages of the digital display system. The website enables the admin to add, edit and delete any message from the database while a user can only see the list of messages that has been uploaded to the database. The design and construction of this digital display system is considered successful after the design of the circuit and implementation of the website for upload were achieved. Further research should be conducted to minimize the use of microcontrollers and also consider using liquid crystal display (LCD) as light emitting diode (LED) has been used in this system.

Keywords: ESP8266 microcontroller, P10 modules, ATmega328P microcontrollers, Responsive website, Database

INTRODUCTION

Communication and the need to constantly be in touch with one another are very vital and cannot be over stressed. Communication is the body of all data transferred to one or both parties during an interaction using various means, whichever is available or preferred. Communication requires a sender, a message, a medium and a recipient. The ability to display a short message can be a useful application to any sector in any functional society.

Many well established and cutting-edge universities in the world rely on notice boards hanging on the wall to display information. Over time, to change or manage information is a difficult process, so a technological advanced wireless notice board system is required. A LED display board is perfect for this application. It can be used both indoor and outdoor which makes it a universal fit for any event. The LED display board is very efficient and cost-effective way to spread messages to thousands of people. The underlying technology enables real-time updates, customization of messages, and remote management, making it a versatile tool for conveying information effectively and engaging the target audience.

Technology today has advanced to such an extent that there has become the need for electronic display systems capable of displaying messages, graphics, logos and moving animation to satisfy all purposes, whether it be for business or domestic use that are sure to capture the attention of any audience. Light

Emitting Diodes (LED) have been around us for over 30 years, this simple semiconductor emits light when the current that passes through the junction does so at low voltage, and it has proven useful for saving energy.

Scrolling display board is a common sight today as advertisement is going digital. The use of light emitting diode (LED) scrolling display board at big shops, shopping centers, railway station, bus stands and educational institutes are becoming an effective mode of communication in providing information to the people. But these off-the-shelf units are somewhat inflexible in terms of updating the message instantly. If the user wants to change the message it needs to be done using a computer and hence the person needs to be present at the location of the display board. It means the message cannot be changed from wherever or whenever. Also, the display board cannot be placed anywhere because of complex and delicate wiring. Hence a system wherein the display board need not be reprogrammed to display a new message can be adopted using a wireless technology (Gupta *et al.*, 2013).

The use of automated LED display boards has grown in recent years. This is due to a number of factors, including the increasing availability of low-cost LED display technology, the growing demand for real-time information, and the need for more efficient ways to communicate with large audiences.

This study is therefore aimed at improving upon what has earlier been done by different investigators in respect to the design and implementation of automated LED display boards. This study aims to explore these aspects in greater detail and seeks to contribute to the existing body of knowledge by

proposing an innovative design for an Automated LED Display Board system. The proposed system will leverage web application technology to enable wireless transmission of messages, thereby enhancing the functionality and user-friendliness of the system.

LITERATURE REVIEW

Saini *et al.* (2014) designed a Smart LED display board having an SMS driven automatic display board which can replace the programmable electronic display. A design receiver display board can be programmed from an authorized mobile phone using AT89S51 Microcontroller, GSM Module, DM74154(4-Line to 16-Line Decoders/De-multiplexers), electrically erasable and programmable read only memory (EEPROM), MAX232 used as MODEM Interfacing-IC, LED display. The prototype of the GSM based display was efficiently designed. It has facilities to be integrated with a display board thus making it truly mobile as it accepts the SMS, stores it, validates it and then displays it in the LED module. The SMS is deleted from the SIM each time it displayed to the end, thus making room for the next SMS. Only one SMS can be displayed at a time. These limitations can be eliminated by the use of powerful/advanced microcontrollers such as ESP 32, Raspberry pi and extended RAM. The prototype can be implemented using commercial display boards such as P10 display matrix, LCD screens etc. In this case, it can solve the problem of instant information transfer.

Kalyan (2014) constructed a GSM Based Smart Message Display Board containing a mixture of wireless technology with LED Display Boards formalized by designing and integrating the hardware and software with AT89S51 microcontroller, GSM module, and moving LED display. The message is distributed through a mobile phone through by the GSM module SIM. Number authentication is authorized by AT89S51 microcontroller and the stored numbers in EEPROM is compared with the incoming number. The message will be valid solely when the incoming cell phone number is validated. Authentication result is displayed on LCD whether the number is matched or not matched and the message is finally displayed on moving LED (Light emitting diode) display. Additionally, a similar SMS is itself sent by GSM module to Multiple LED Display Boards that are connected via completely different GSM modules.

Jagtap *et al.*. (2016) designed and constructed E-NOTICE board with handmade LED Board using PIC18f2550 microcontroller, LED, MAX232 interface IC. In this project design digital notice board input is provided from personal computer to Notice board. Here basically serial communication is done through MAX233 which converts the signals from RS232 serial port to signal suitable for transistor-transistor logic (TTL) compatible logic circuits. It typically converts Rx, Tx, CTS and RTS signals. In this project the PIC18f2550 microcontroller used has 2048bytes of SRAM and 256bytes of EEPROM. This controller provides good facility of serial communication. However, the display board is handmade which is done by soldering the LEDs as a matrix. In this board five 8*8 matrixes are designed in which 256 letters can only be sent at a time. Also, the designed scrolling display board scroll its messages using shift register IC 78HFF. The column of each matrix is connected to shift register so that messages will get shifted horizontally from left to right. ULN2803 also is required for current driving which act as a current sinker which is capable to sink 500mA current.

Jayanthi *et al.* (2017) designed a Digital Notice Board in Schools and Colleges by Implementing IoT with Audio Alert System which is built around ARM controller 11 Raspberry-pi that represent the heart of the system. Display is obtained on projector or LCD monitor. Wi-Fi is used for Data transmission. At any time, we can add or remove or alter the image according to the requirement. A transmitter, authorized PC or mobile is used for sending notices or messages. At the receiving end Wi-Fi is connected to raspberry pi. The raspberry pi is dedicated to Ethernet. When an authorized user sends a notice from his system, it is received by the receiver. The message may be a voice note or image. The Wireless communication system developed allows the exchange of data wirelessly over a computer network, including high speed wireless connections when data is received from authenticated user.

Arijaje. *et al.* (2018), designed and constructed a Programmable Scrolling Matrix Display that scrolls the following characters “WELCOME TO PHYSICS DEPARTMENT”. Dot Matrix Display is based on the logic output signals of a digital signal processor (DSP) and microcontroller or other logic device. The Perspex board measuring 0.3x1.5 meters was acquired and holes of 4mm were drilled for the Perspex in order to allow the LED measuring 5mm in diameter fit tightly into the drilled holes. The circuit diagram was achieved after careful design and calculation had been done. The complete work was simulated and routed with proteus and after the design, construction and testing, the simulated programmable scrolling matrix display device was ascertained to be working satisfactorily. Thereafter the actual components were then assembled on a printed circuit board.

Sujay *et al.*(2019) designed and constructed a Digital Notice Board Using ESP8266 WI-FI Module, ATmega8 microcontroller, ULN2803 and LED dot matrix panel. It is configured, to get message in showcase toolbox through Wi-Fi from an authorized cell phone. The Wi-Fi module gets a message from the authorized cell phone and the message is extracted by the microcontroller from the Wi-Fi module and is displayed on the grid show board. Sequential to parallel correspondence is utilized for the whole procedure from WIFI module to the microcontroller and from microcontroller to the framework show. The result obtained after testing shows that the dot matrix LED panel is a high-power load to drive this load and ULN 2803 relay driver also performed as expected.

MATERIALS AND METHOD

Materials

The implementation of this remote web based digital display system requires some materials for the development of the hardware to enable the display of information to the public. These materials were purchased with appropriate specification capable of maintaining the device efficiency.

Table 1:list of components

S/N	COMPONENTS	QUANTITY	SPECIFICATIONS
1	ESP 8266	1	ISM 2.4GHz PA +25dB 502.11b/g/n
2	P10 MODULE	8	Pixel Pitch: 10mm Pixel Density: 10000Pixel/m2 Colour: Red Module Resolution: 32X16 Module Size: 320X160 Pixel Configuration: 1R Brightness: >650 Brightness Scan Method: 1/4s Drive Mode: Cross Flow Drive Voltage: 5V Power Cable: 20cm
3	Atmega328P microcontroller	1	Atmega328P
4	DC Buck converter	1	8A 300W
5	Battery management system (BMS)	1	15A 4S (4 in series)
6	Power supply	1	15V 3A
7	MOBILE WIFI (MIFI)	1	4G, ZLT M30S
8	Real Time Clock (RTC)	1	DS3231
9	SWITCH	1	15AMP
10	Capacitor	2	22pf
11	Quartz Crystal Oscillator	1	15MHz
12	Lithium battery cells	23	3.7v
13	Polarized Capacitor	1	100uf, 16v
14	Light emitting diode (LED)	1	5mm
15	Resistor	1, 2	$10k\Omega$, $1k\Omega$

16	Copper wire	2 rolls	0.5mm 6 core, 1mm twin core.

Circuit Block Diagram

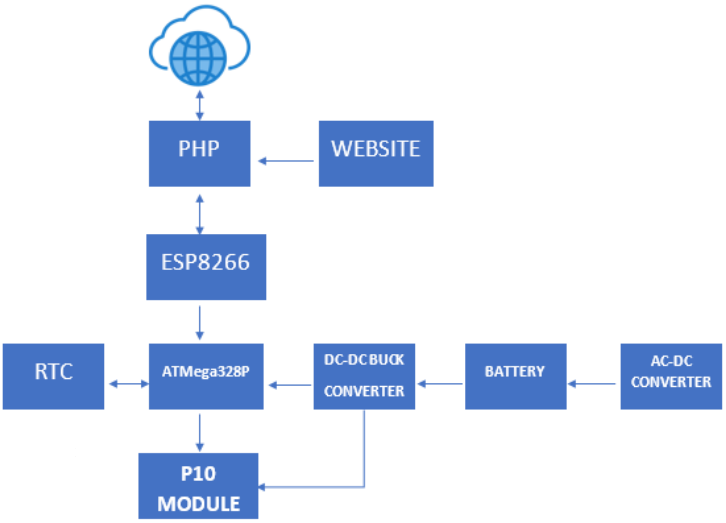

Fig. 3.1 Block diagram of remote web based digital display system

Description of Block Diagram

The block diagram describes the entire process through which the remote web-based digital display system carryout its functionality using all the indicated electronic components. The website is used to input the information to the database through the PHP written script from the admin dashboard. The PHP script retrieve the information from this same database when queried by the ESP8266 microcontroller of which both must establish a network connection by sending 200 as a parameter from the PHP script that must be recognized by the ESP8266 through the network protocol. The ESP8266 carry out this operation by connecting with the provided MiFi to access the internet and every information fetched are sent to the Atmega328P microcontroller to display on the P10 modules. The Atmega328P can only accept 5V hence an AC-DC converter is used to convert the wall outlet voltage of 230V-250V to a constant 12V DC voltage. This is then connected to the battery management system connected with the battery 3 in series which gives out a constant 5V through the DC-DC buck converter. The Atmega328P and the P10 modules needs a maximum of 5V, hence the buck converter output is connected to it. The RTC also is being queried by the Atmega328P to update the time while a 2k ohms resistor is used to step down the voltage of the ESP8266 to 3.3V.

Schematic Circuit Diagram

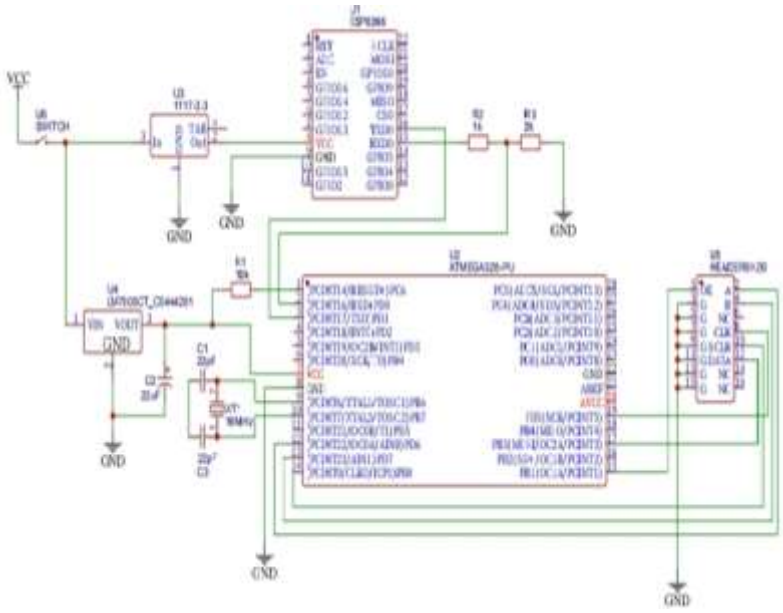

Fig. 2: The Remote Web-Based Digital Display Circuit

Method of Circuit Implementation

The VCC supplied by the bulk converter regulates to a constant 3.3V by a voltage regulator U3 1117 for the ESP8266, and a constant 5V by a voltage regulator LM7805CT for the ATmega328P in which a 22µf paralleled with it to increase the voltage. Pin 7 of the ATmega328P is the VCC which is pulled up with a 10KΩ resistor to the reset pin to prevent interruption of the functionality of the ATmega328P. Pin 8 of the ATmega328P microcontroller is the ground pin (GND) which is grounded with every other ground pin of the circuit component. Pin 9 and Pin 10 of the microcontroller is connected in parallel with the crystal oscillator of 16MHz with 2 capacitors of 22pf connected in series to collectively keep the clock frequency at natural frequency. Pin 2(RX) and Pin 3(TX) of the ATmega328P is connected with the Pin 15(RX) and Pin 16(TX) of the ESP8266 for serial communication between the two microcontrollers where a design which result to the evaluation of two resistors R_1=1kΩ and R_2=2kΩ made for TX pin to keep the received voltage by the ESP8266 at 3.3V. Pin 12, 13, 14, 15, 17, 19 of the ATmega328P is connected to the data pins of the P10 modules pin 1, 2, 4, 8, 10, 12 while pin 3, 5, 7, 9, 11, 13 are grounded as ground pins.

Design for the circuit was made before it was etched and soldered to prevent damage to the microcontrollers. The ESP8266 can only permit maximum voltage of 3.3V and the Atmega328P allow 5V as supplied by the buck converter. Voltage regulator was attached to VCC of the ESP8266 to regulate the input voltage to 3.3V and another voltage regulator is also attached to maintain the 5V supplied by the buck converter to the ATmega328P but since serial communication will have to occur between the two microcontrollers through the RXD and TXD pin then a voltage divider must be applied. Hence applying the voltage divider principle, it is given that;

$$Vout = Vin\frac{R_2}{R_1 + R_2} \quad (1)$$

We need $Vout = 3.3V, where\ Vin = 5V$. Hence, equation (1) becomes,

$$3.3V = \frac{5VR_2}{R_1 + R_2}$$

$$3.3(R_1 + R_2) = 5R_2$$

$$\Rightarrow 3.3R_1 + 3.3R_2 = 5R_2 \quad (2)$$

Collecting like terms

$$3.3R_1 = 5R_2 - 3.3R_2$$

$$3.3R_1 = 1.67R_2$$

$$\frac{R_1}{R_2} = \frac{1.67}{3.3}$$

$$\frac{R_1}{R_2} = 0.5$$

$$R_1 = 0.5R_2 \quad (3)$$

According to equation (3) therefore, when $R = 1k\Omega, R_2 = 2k\Omega$. This value of resistors must be used to keep the voltage of the ESP8266 at 3.3V when connected with the ATmega328P.

Optimized Voltage Supply

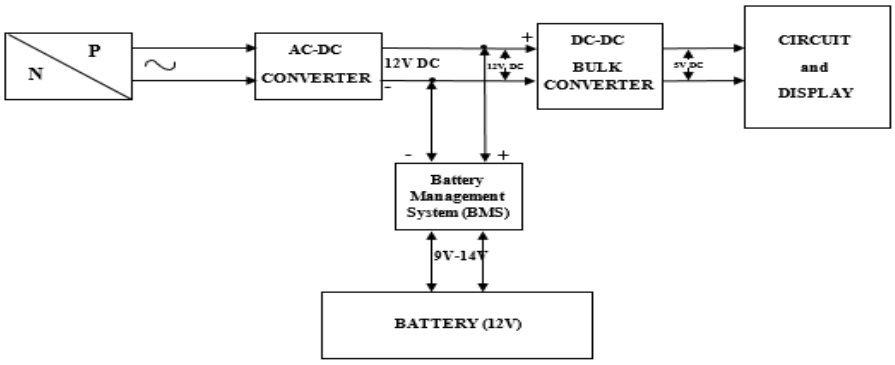

Fig. 3 Voltage Supply

The wall outlet is expected supply minimum and maximum alternating voltage of 230V and 250V respectively. An AC-DC converter is connected to the input to step down the voltage to 12V and convert the AC to DC which charges the battery through the BMS and powers the circuit and display board respectively. The BMS protect the battery from damage and enables the circuit and display get powered from the battery when the wall outlet no longer supplies any voltage. The DC-DC converter ensures the voltage going into the circuit and display is always kept at a constant 5V DC voltage supply.

Software Implementation

Arduino software used for Embedded C++, VS CODE EDITOR used for HTML, CSS, JAVASCRIPT, PHP (Laravel).PROTEUS 8 used for simulation

Testing

In every research, testing must be carried out or conducted to confirm every design credibility.

The implementation of the remote web based digital system is expected to be tested to verify the success or failure of the display system. After designing the battery system, circuit components and the power supply, they are all tested individually to confirm the accuracy of each of the part of the system to maximize its efficiency. The website also confirms to display the information on the display board and on the frontend of the website.

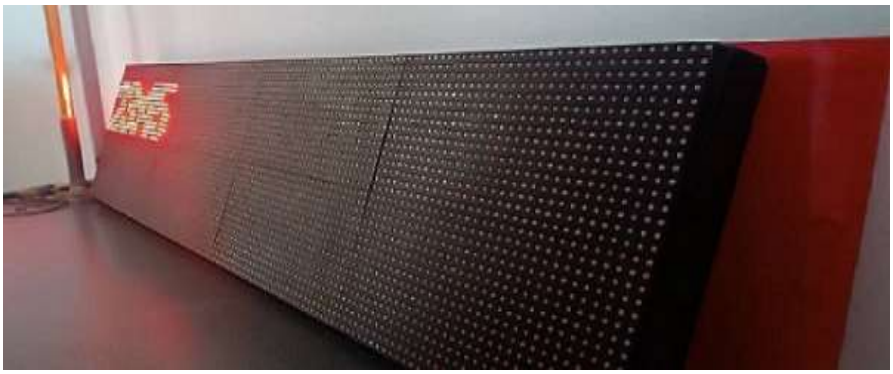

Fig. 4 Display board during Testing

RESULTS AND DISCUSSION

Experimental Results

Table 2: Battery voltage and Current

QTY	VOLTAGE	CURRENT
4	3.21	11.09
4	3.20	10.25
4	3.21	10.98
4	3.20	10.20

Table 3: Voltage and Current Consumption on Steady Display

Component	Voltage	Current
BMS	11.54V	1.34A
P10 LED Modules	3.71V	2.16A

Remote Web-based Digital display system

Fig. 5: Display Board Showing Time, Static and Scrolling Text.

Analysis of Battery Voltage and Current of the Circuit

Table 2 is the result of the battery voltage and current gotten from the testing of 16 batteries before assembling them together. 3.21V, 3.20V, 3.21V and 3.20V were recorded from four (4) batteries in parallel with an equivalent current of 11.09A, 10.25A, 10.98A and 10.20A respectively. The four parallel batteries are series to get an equivalent voltage of 12.82V. however, its nominal voltage which is 12V will always be considered as a reference voltage where its current is evaluated to be 10.5A.

Static messages also took 5 seconds to display on the display board as it is confirmed using ELECTRONIC LAB., PHYSICS/ELECT., WELCOME, and ELECT. LAB. respectively.

Analysis of Circuit Voltage and Current Consumption on Steady Display

Table 3 is the voltage and current consumed by the display system on a steady display. The BMS supply 11.54V and 1.34A from the battery on 40% charge to the system. The LED display modules receive 3.71V consuming 2.16A displaying all information as shown in The Remote Web-Based Digital Display Circuit.

Mathematically,

$$P = IV \tag{4}$$

Hence, the power consumed by the display on steady display is evaluated as;

$$\Rightarrow \boldsymbol{P} = (\mathbf{3.71} \times \mathbf{2.16})\boldsymbol{W} = \mathbf{8.0136}\boldsymbol{W}$$

Reducing the current consumed by the display at the same voltage by introducing a resistor will cause the brightness level to drop becoming more beneficial to the sight of the audience except when far from the display.

Analysis of the Remote Web-based Digital Display System

Fig. 5 is the implementation of the digital display system showing the time synchronized from the real time clock, Static message: PHYSICS/ELECT. Retrieved from the database and the scrolling text: THE WAY INFRARED OBSTACLE DETECTORS OPERATE IS BY SENSING THE HEAT THAT OBJECTS EMIT as it is what was uploaded through the admin dashboard.

Responsive Website

Visual Studio was used to develop a responsive website capable of displaying the information of the display board which is intended to aid students not within the display board to get informed. It also serves as a medium through which the information gets uploaded to the database from which the display board fetches its information for display. Fig. 6 depicts the view of the website on desktop mode, i.e view from a laptop showing the Home, Our Work, Displayed, About Us and Sign In tabs respectively. Using https://phy-elect-rsu.com grant access to the website.

Signing in as an admin with the authorized login details open the dashboard which permit the admin to add static text, scrolling text as indicated, and editing and deleting text from the database.

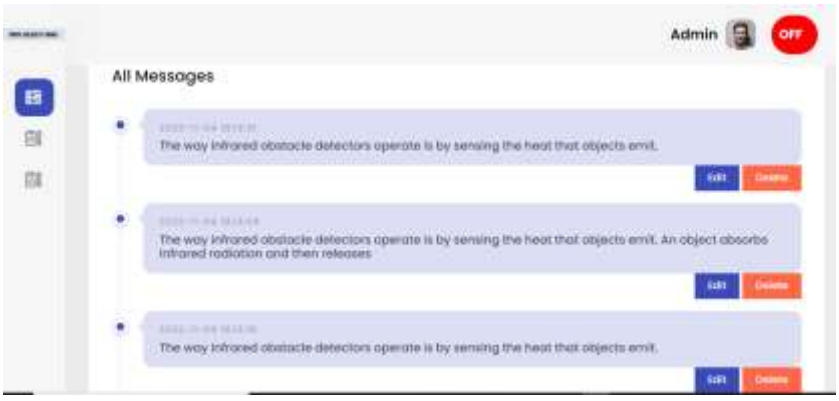

Fig. 6 Admin Dashboard

CONCLUSION

The web based digital display system was designed and constructed using Atmega328P and Esp8266 microcontrollers. The development and implementation of the web-based digital display system has demonstrated significant potential for enhancing communication and information dissemination through the display of messages using LED technology. The digital display system is considered successful after the implementation of the website for upload, manual upload and construction of the hardware, efficient batteries capable of keeping the display steady and the design of the circuit were achieved.. The efficiency of the circuit is optimally good due to the etching of the circuit as it prevents shut circuit of the device.

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