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**Original Research Article**

# Design, Construction and Assembly of an 8 ft × 4 ft Super Bright Animated Graphics Display

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**ABSTRACT**

*The paper presents the design, construction and assembly of a graphics display with online and offline modes, capable of displaying any two-dimensional and three-dimensional motion picture, that is technologically up-to-date. It uses WS2812B LED strips with an IP65 chip rating to offer longevity, a wireless router and a compatible T-300k controller for interfacing with the LED Edit software which uses a gamma correction method for encoding and decoding huge RGB bits. The graphics display showed relatively constant brightness across the length of the display when the brightness test was carried out in the red, green and blue light. Ultimately, a seamless display of motion graphics on a huge matrix display was achieved.*

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## 1. INTRODUCTION

Media technologies have long helped to orchestrate the social relations of space and time in modern times (McQuire, 2008). From personal hand-held mobile devices to large-scale embedded LED screens, media now routinely permeate urban space. Large screens offer a new mechanism for adding art and cosmopolitan imagination to public spaces. They highlight the ways that interactive technologies create new possibilities for experiencing time, space and community (Papastergiadis et al., 2013).

An LED screen is an electronic device that is made up of light-emitting diodes (LEDs), and can display data, information, images, videos, etc. (Ahn, 2013). LED displays are made up of LED modules or panels based on the dot matrix displays, whether monochrome (single colour), bicolour (two colours) or polychromatic. The latter are in turn made up of LEDs RGB (red, green and blue, the primary colours of the colour plate for screens).

LEDs form pixels, which allows to form characters, texts, images and even video, depending on the complexity of the screen and the control device (Kurdthongmee, 2005).

The market for modular LED matrix displays is dominated by a particular model. This type of LED matrix requires 12 digital pins (6 data pins and 6 control pins), plus 2 more cables for the power supply. The number of pins required to control the LED matrix modules is quite inefficient, apart from the fact that the designer uses the technique of multiplexing to display information. For this reason, research has increased to find new ways to control LED arrays and also new ways to build LED arrays (Castrejon, 2019). The recent emergence of smart LED technology allows innovation in the construction of LED arrays, and also in the research and creation of controllers. Smart LEDs incorporate protocols for serial data transfer, making it possible to control multiple LEDs connected in series via a single data cable.

Samson (2015) developed a design that consisted of 5 V DC power supply connected directly to the GSM modem, main controller and the display unit. The display board was designed to display a scrolling message which was sent from a GSM from any part of the world which entailed the basic capacity to display object, message, and position and create a delay or lag. The design was made based on the multiplexing technique which uses the most common type of LED matrix. Also, Alexander, (2015) created an offline electronic display board with a differentiating characteristic of being re-programmable for an incredible number of times. These works used the traditional LED matrix module with onboard controller for each module.

To avoid the scanning technique of LED displays, this paper proposes the use of smart LED strips which use serial communication interfaces. Such a solution was described in the thesis presented by Castrejon, (2019). He described the design and construction of an LED matrix RGB for projection of images and alphanumeric text using the LEDs smart devices with WS2812B driver and a microcontroller as a control. The LED matrix layout had 30 rows and 33 columns using WS2812B RGB LED strips, shell paper and a wooden drawer and the controller circuit unit included a 32-bit microcontroller for the LED matrix control interface. The results showed new ways to assemble and build LED matrices and also showed that the LED matrices could be controlled without the need to apply fast sweeping techniques for persistence of vision. The design obtained better gloss levels and colour, but consequently resulted in a higher current consumption. Just like the RGB LED display presented by Castrejon (2019), this study presents a similar design with higher dimensions which not only projects images but videos.

In this study, the design and construction of an RGB LED display to implement an animated graphic display with the use of 7,680 WS2812B LED chips arranged into an 8 × 4 ft screen is presented. The animated graphic display presented in this study is one of the largest and most complicated intricate displays ever made in any part of the world. Due to the complexity of the display, people, institutions and enterprises hardly decide to make it. In comparison to the previous researches, the current design achieved a higher dimension and thus resolution for a large screen LED display that shows motion pictures and it incorporates the IP65 chip which means that it has protection against dust and water droplets. In addition, it alleviated the drawback associated with past researches by incorporating a wireless router to enable the online mode by wireless means as well as the offline mode of operation.

## 2. MATERIALS AND METHODS

### 2.1. Design of Graphic Display

The primary intention of the research is to design and produce an 8ft × 4ft animated graphics display using WS2812B LED strips capable of displaying visual animations. Figure 1 shows the block diagram of the animated graphics display that connects all the components required for the study.

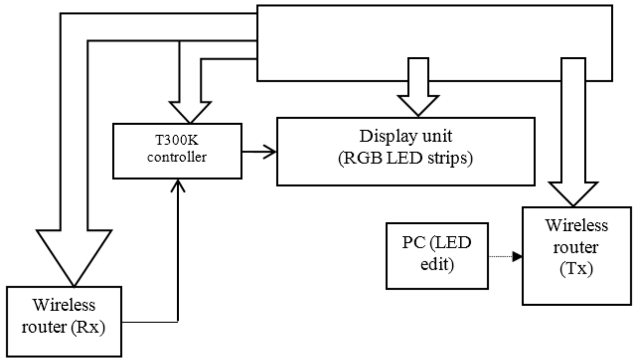



Figure 1: Block diagram of the animated graphics display

The design starts at the power supply unit which had the following power supply considerations. The power rating for the needed number of chips was computed using Equation (1).

$$Power\ rating = Power\ per\ chip \times Number\ of\ chips. \quad (1)$$

This yielded: $0.25 \times 120 = 30\ W\ per\ each\ 2m\ row$

One data line of the T-300k controller controls 8 rows of WS2812B chips. Thus, power required is $30 \times 8 = 240\ W$. For the 8 data lines, the power rating is $240 \times 8 = 1920\ W$. Considering the MEAN WELL 5V power supply, the total output power is given as:

$$Power = voltage \times current \quad (3)$$

This yielded: $= 5V \times 100\ A = 500\ W$

For the four power supply units, the resulting power is: $4 \times 500 = 2000\ W$

In this study the MEAN WELL power supply with a rating of 5 V and 100 A was chosen. Also, from its physical construction, the MEAN WELL power supply unit had 3 output ports which means that the total power of the power supply can be effectively transferred without too much power dissipation. The specifications of the MEAN WELL power supply unit used are given in Table 1.

Table 1: Specifications of MEAN WELL power supply

| Specification | Values |
|---|---|
| Size ($L \times W \times H$) | 9.7 × 5.0 × 2.5 in |
| Ripple and noise (mV P-P) | 150 |
| Load regulation | 2.0% |
| Line regulation | 0.5% |
| Input voltage (VAC) | 90 – 132 V, 180 – 264 V |
| Input frequency | 47 – 63 Hz |
| Efficiency | 78% |
| Operation temperature | 20 – 60 ºC |

Due to internal resistance, a display degradation (gradual reduction of brightness as length increases from left to right) will occur. Thus, there is need for the connection of both ends of the graphics display to the power, $V_{cc}$ and ground of the supply. The illustration of the power supply connections is shown in Figure 2. According to the block diagram used for the graphics display setup (Figure 1), the next component of interest is the T-300K controller. The total pixel requirement of the graphics display is 7680 pixels (120 pixels x 64 pixels). From the list of LED controllers that support the WS2812B chip strip, only the T-8000 and T-300K controllers have the ability to support 8192 pixels. The T-300K controller was selected for this project because the T-8000 controller does not support offline mode control which is an added advantage in the current design. Lastly, in the host computer, the LED Edit 2012 software was installed and was used to upload video to be converted and executed across LED strips. The software supports all the various rules-shape and special shape processing.

N. Bello and O. Obasohan / Nigerian Research Journal of Engineering and Environmental Sciences
8(1) 2023 pp. 117-126

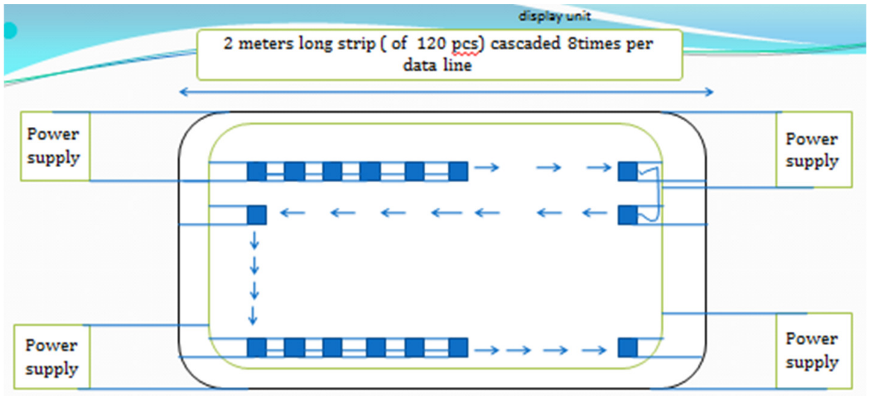



Figure 2: Power supply connection to mitigate display degradation

## 2.2. Principle of Operation

The screen made up of the WS2812B LED strips are powered using 4 MEAN WELL power supply units which are connected in series to yield a total power supply of 2000W. Each strip is connected to the power supply lines from both ends of the extended power supply lines as shown in Figure 2. The T-300 K controller is powered by the AC mains of 240V.

In the offline mode control, the LED file needs to be stored in a FAT formatted SD card. This was accomplished with the LED edit software. The video signal generated by the T-300K controller was fed into the WS2812B chips from the 8 output ports of the controller. One output port was fed to 8 rows of the LED strips (that is 960 chips) and the 8 rows were connected together such that the output of one LED strip is fed to the input of the other in a cascaded manner. Therefore, the 8 ports of the controller controls 64 rows of LED strip. As the video signal gets to each LED chip, the appropriate colour is shown.

## 2.3. Casing Design

The material used for the casing of the design was made of steel. Steel was chosen due to its strength, durability, corrosion resistance, solder wettability, and shielding of electromagnetic waves (Cheng et al., 2017). For the display screen, acrylic glass was used.

## 2.4. Coupling Components of the Design

The implementation of the design started with construction of the animated graphic display and it required some tools and materials. The construction entailed layout, proper alignment, and strapping of the $120 \times 64$ WS2812B chips on the acrylic glass and then the overall coupling in the entire casing. Figures 3 – 7 show the steps taken in the physical construction of the animated graphics display.

Figure 3: Marking out of the Black PCB for the layout

Figure 4: Cutting out of the Black PCB

N. Bello and O. Obasohan / Nigerian Research Journal of Engineering and Environmental Sciences
8(1) 2023 pp. 117-126

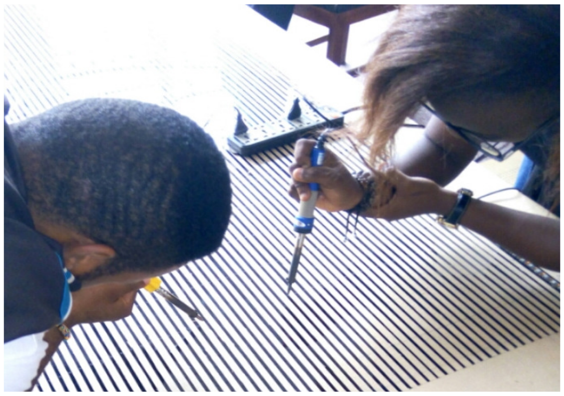


Figure 5: Marking of pilot hole


Figure 6: Drilling the pilot holes


Figure 7: Transformer copper wires were passed through the holes in patterns in order to effectively hold the strips to the board

After the construction, was the connection of the power supply to the animated graphics display. Firstly, six 5 mm holes were drilled at each corner of the clearance point of the acrylic glass. The copper cable to be used for power supply were stripped and the length of the bare part was equal to 4ft at each end. The total length of the copper cable was 16 ft per cable.  The stripped part of the six (6) cables were passed through the holes. Of the six power cables, 3 were used for negative while the other 3 were used for positive. The positive cable of the LED strip was soldered to the positive cable of the power supply in proper sequence at both horizontal ends of the LED strip to ensure that the power is adequately distributed between the 3 power cables. Similarly, the process was repeated for the negative wires of the LED strip. The 3 positive cables of the power supply were connected to the 4 MEAN WELL power supply. The 4 MEAN WELL power supplies were looped together to ensure adequate power supply of the system. The same process was done for the negative cables. Thereafter, the power supply cable of the T-300K controller was connected to the input of the MEAN WELL power supply so that there will be just one connection to the AC mains. Eight connectors were fixed to the 8 data lines of the T-300K controller. Each of the connectors connected to the LED strip array was such that each data line of the T-300K controller controls just 8 lines of LED strip. The bridge mode allows the connection of two TP-link wireless routers/LANs together or a TP-link and a wireless access point. Also, the online control using the TP-link wireless router allows the connection of the TP-link to the internet.

Launching the LED edit software and producing the LED file for an offline mode of graphics display, requires creating the project and configure some parameters to suite the design as shown in Table 2.

Table 2: Settings for configuring the LED Edit software

| Parameters | Values |
|---|---|
| Controller type | T-300k-WS2811 |
| Port setting | 1024 lights per ports |
| Frame rate | 30fps |
| Sequence of channel | GRB |
| Horizontal pixel | 120 pixels |
| Vertical pixel | 64 rows |
| Max number of lights per port | 960 |
| Pattern | Under the left horizontal |

The next step was to proceed to the stage of video recording and exporting. The steps taken are listed as follows:

i. To record the video into the SD card:
   a. Open a video file from the video Effect Option.
   b. The record button is selected from the menu to start recording, and stop button is selected at the end of recording.
   c. Next, the Export Effect on the menu option is used to export to LED format and save to the SD card.

ii. To record multiple videos into the SD card:
   a. Open a video file from the video Effect Option
   b. The record button is selected from the menu to start recording, and the stop button is selected at the end of recording, taking note of the “Prog: (number of frames)” while the software is not closed
   c. Open another video file from the video Effect Option
   d. Repeat the same recording process as the former, taking note of the new increased “Prog: (number of frames)”
   e. Next, the Export Effect on the menu option is used to export to LED format and save to the SD card.

## 3. RESULTS AND DISCUSSION

Figures 8 and 9 are the results showing the setting configuration in the LED Edit software prior to producing and exporting the LED file to broadcasted on the display. Figures 10 – 12 shows the final stages of the design which were the mounting of the casing onto the router, T-300k controller, power supply units and the main display screen. It also shows the test that was carried out on with an approximately 2 minutes video LED file that was generated with the LED edit software.

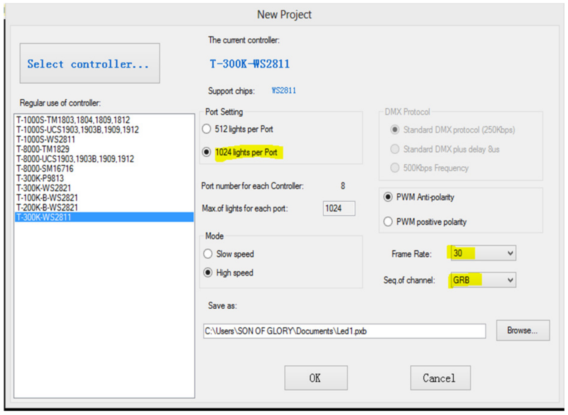



Figure 8: Creating a new project

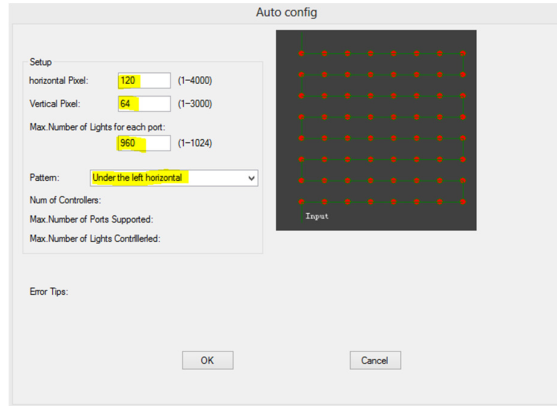



Figure 9: Setting the light layout

Figure 10: Casing of the router, T-300k controller and the power supply units

Figure 11: Mounting of the casing onto the graphics display

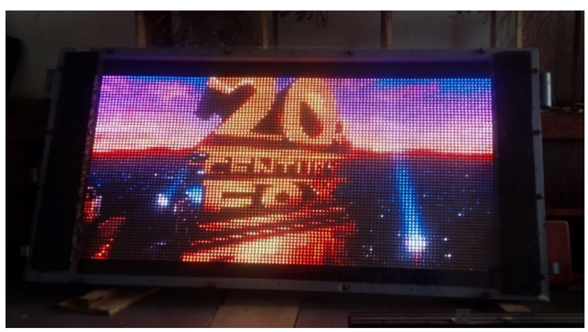


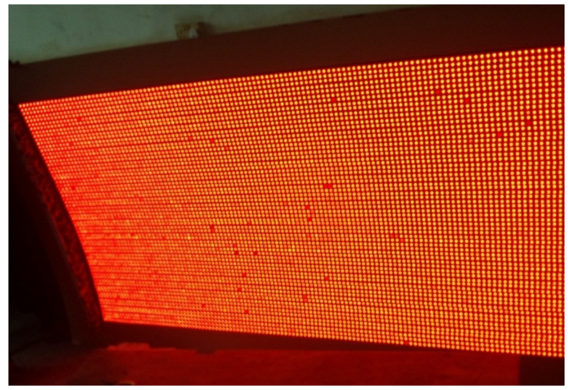
Figure 12: Display test of the design

In addition, continuity, resistance, online mode (RJ45), online mode (wireless), offline mode and the power consumption tests were carried out on the design. In the continuity test, a digital multi-meter was used to ensure that there was no contact between positive and negative cables at all points and to check for proper connection of positive cables at all points. This was necessary because after soldering, it was not expected that the design would be error-free. The positive and negative cables of the LED chip array were soldered to the power supply cables of the MEAN WELL power supply in such a manner that the power is evenly distributed by the 3 pairs of power supply cable. For the resistance test, the relative resistance of each power supply line was measured with a multi-meter to ensure the ability of the power supply units to withstand short circuit current. The two online and offline tests checked for the availability of these features, the refresh rate of the display and faulty LED strips. Lastly, the power consumption test was performed using the offline mode to determine the total and average power consumptions. The test was carried out by measuring the power consumption at full red, blue, green, and white colour displays. The observations and conclusions for the various tests carried out are summarized in Table 3.

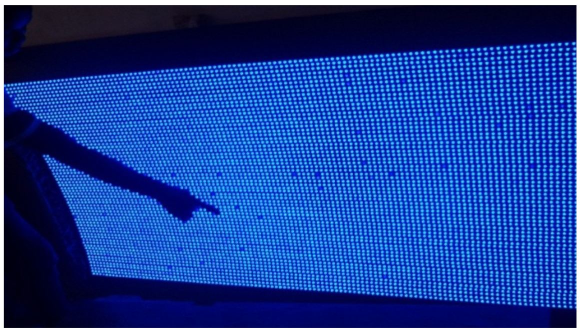
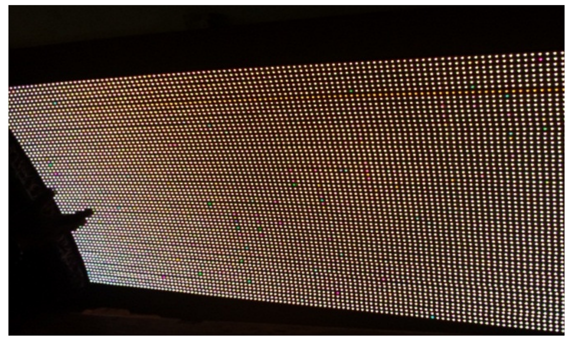
Table 3: Results of the standardized test carried out

| Test | Observation | Conclusion |
|---|---|---|
| Continuity test | The multi-meter buzzed when the two cables were continuous and did not buzz when it was not continuous | The LED strips were properly connected to the power supply cables on the board |
| Resistance test | Forward bias: 0 ohms<br>Reverse bias: 46 ohms | This shows that the mean well power supply was properly connected together and connected to the LED strip array |
| Offline mode test | The display system displays exactly what was recorded and stored in the SD card | Test was successful |
| Online mode test (using RJ45) | The display system displays exactly what was showing in the laptop (video and text) | Test was successful |
| Online mode test (wireless) | Both routers were communicating wirelessly, and the graphic display was showing exactly what was being displayed in the laptop. | Test was successful |
| Power consumption test | The power drawn by the display for:<br>Full white: 1138 W<br>Full red: 198 W<br>Full green: 681 W<br>Full blue: 572 W | |

Compared to the RGB LED matrix modules that dominate the market, the WS2812B LED matrix used on this study has a lower number of interface wires, the ability to hold data transmitted, avoiding the need to use scanning techniques to contain the data of the LED matrix. Thus, by not using sweeping techniques, such as multiplexing, the pixels of the Matrix LEDs can achieve higher levels of brightness and colour and allows for the building of flexible screen, roll-up or curve (Figures 13). But however, the current consumption is 10 times higher since it reaches high brightness by not using sweeping techniques (Mohan et al., 2003). Also, due to the times required by the transmission protocol of data for WS2812B LEDs, only 990 LEDs can be controlled to play animations at a rate of 30 frames per second. Furthermore, since the data transmission between the WS2812B LEDs is in series, if one of the matrix LEDs is damaged, communication is interrupted causing the matrix to be inoperable, until the moment in which the damaged LED is replaced.

(a) (b)

(c) (d)

Figure 13: Brightness test of the graphics display (a) animated graphic display for all green colour (b) animated graphic display for all red colour (c) animated graphic display for full blue colour (d) animated graphic display for all white colour

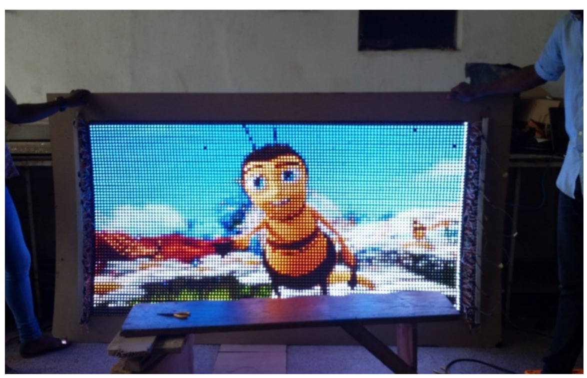


Figure 13: Animated graphic display when displaying video

## 4. CONCLUSION

The study successfully designed and constructed a graphics display capable of displaying two- or three-dimensional motion pictures with online and offline modes. The measurements of the LED matrix (64 × 120 pixels) were designed to be able to project animations or videos at 30 frames per second. It was accomplished with the LED Edit software, which is specialized for the control of the LED matrices. The design attained high brightness levels which is necessary for outdoor use for visibility.

## 5. ACKNOWLEDGMENT

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## 6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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