Multicolor LED Display Board

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Abstract — *LED-based signage and matrix displays are bringing new dimensions of versatility and eye-pleasing visual effects to a growing number of outdoor and indoor applications. It is relatively simple to drive several LEDs individually. However, as the number of LEDs increases, the amount of resources needed to operate these LEDs will grow to an unmanageable level. The goal of this project is to increase the overall redundancy, and ease-of-use during installation, this system provides adaptive real-time fault detection and failover behaviors to ensure reliability in rigorous outdoor environments. The designed system is inherently redundant and the ability to sustain failure of its components increases with the size of the display*

Index Terms — Multiplexing, LEDdriver TLC5940, Pixel Pitch, Gray Scale, DC, SPI, ringing effect, DMA.

I. Introduction

Large format LED video displays are now considered to be a staple in the professional touring music industry as well as in the advertising industry. These video walls are comprised of individual panels that are electrically and mechanically connected to form a larger display. As video resolutions increase, the size and complexity of video walls increases, often adding multiple points of failure to a system and increasing setup time. These offer great flexibility but often incur substantial maintenance costs. These arrays are often found outside and are exposed to harsh weather conditions. Most of the display boards are one way open loop systems where the data is sent from the controller to the display board, if any fault occurs, it will be noticed by the observer itself, also in some cases that fault may be left as it is, for significant amount of time where it can cause further damage. This system is a closed loop system with various kinds of fault detection mechanism.

II. Brightness Control of an LED

A. Multiplexing of LED Matrix

The light output of an LED is dependent on the current flowing through it. However, that is not a recommended method of controlling brightness because we will need a very precise current source/sink. The preferred technique for brightness control is through Pulse Width Modulation (PWM).

LEDs are often arranged in matrices in order to make efficient use of resources. In a matrix format, LEDs are arranged in rows and columns. The matrix arrangement demands that LEDs be driven in multiplex. The multiplex sequence inevitably requires more complex processing but is more efficient compared to individually driving each LED. In multiplexing we divide each scanning period into time slots.

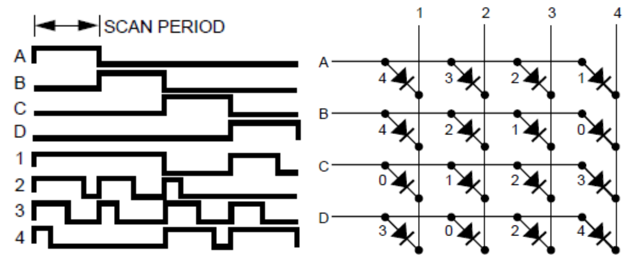


Figure 1. Individual LED brightness control technique

Thus, we get a time domain hierarchy. In Figure.1, the timing diagram on the left shows 4 scan periods (A to D) and 4 time slots within each scan period. Each scan period corresponds to one row of LEDs. The figure on the left shows the relative brightness of each LED. Brightness decreases from 4 to 0.

B. LED Drivers

Smaller LED matrix of size below 4X4 can easily be driven using Microcontroller alone, but for larger display consisting of more than 1000 LEDs we need dedicated PWM generating ic. TLC5940 is a 16 channel constant-current sink LED driver. Each channel has an individually adjustable 4096-step grayscale PWM brightness control and a 64-step constant current sink or dot correction. Dot correction adjusts the brightness variations between the LED channels. Both grayscale and dot correction are accessible via a serial interface. In TLC5940 reference current for the output channel is created via an on-chip voltage reference and a supplied reference resistor. Based on the device recommendation, a 1% tolerance reference resistor of 2k-ohms can be used this allows a full-scale output of 19.5 mA. Maximum data transfer rate of TLC5940 is 30 MHz. TLC5940 features two error information circuits. The LED open detection (LOD) indicates a broken or disconnected LED at an output terminal. The thermal error flag (TEF) indicates an over temperature condition.

C. High Side Driver

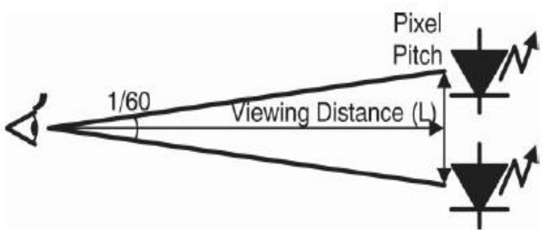
In order to turn on and off the rows of LEDs, a high side, low on resistance switch can be used. TPS1120 P-channel is an ideal driver for this, it features a 3.3 volt logic level threshold. The low threshold voltage allows the switch to be fully turned on with a wide range of supply voltage that would be used. In order to minimize the number of pins used between the multiplexing LED panel and the shield, as well as providing the required voltage level shifting a 4-16 decoder is used. 74HC154 was chosen for this task because of its high speed and low operating voltage. Its use made possible to control all sixteen MOSFETs in a deterministic fashion while using only six control lines. Four row-select lines were used to select the power MOSFET to enable/disable, while two additional control lines were used to disable all the rows independent of four row lines, turning off any image can be displayed

III. IMPLEMENTATION

A. Board Design

One LED display system comprises a huge number of LED lamps and a large power supply. Optimizing LED lamp density is a key item to consider when designing a system. This density of LED lamps is discussed as a distance of each pixel, or *pixel pitch*. If the pixel pitch is too tight, it won't improve image output quality once it is finer than the human eye can detect, and adds to the cost. The human eye can distinguish two individual light sources when these two points form 1/60 of one arc degree (= one minute of arc). Equation.1 gives out the relation between pixel pitch and viewing distance however as a thumb rule we have "Required Pixel Pitch in millimeter (*mm*) = Viewing distance in meter(*m*)", this empirical formula is holds good for large display boards.

$$D_{pp} = 2 * L * \sin\{\frac{1}{60} * \frac{1}{2}\} \tag{1}$$



B. Frame Rate/Frame Refresh Rate

Human Eye takes images at a rate of 20-25 frames per second(FPS), hence the traditional camera and TVs have a frame rate of 24FPS,when an analog TV camera views another analog TV screen, it creates a zebra mix comprising video images and black bands. This is caused by the synchronized TV camera and TV screen scanning rate. The same problem occurs when a camera taking a shot of an LED screen uses the time-multiplexing anode drive. Examples include a TV camera capturing an image of a concert stage with an LED display enlarging a performer on the back wall, or a TV camera viewing a stadium score/display panel at a sport event. To avoid this issue, LED displays today need to operate faster than camera systems, especially in a professional use LED display market. The frame rate of the display board is decided to be 50FPS, which means we get 20ms to display Red Green and Blue color and 6.667ms to display one color. The size of the board is 32X32(mXm), which needs 6 TLC5940 to be daisy chained and controlled using SPI Protocol.

Table 1. Specifications of the board

Parameter	Symbol	Value
Frame Refresh Rate	FR	105Hz=9.5ms
No. of drivers	Nic	6
Output per IC	N_{OUT}	16 outputs per ic
Grayscale value	GS	4096(12Bit)

$$F_{GSCLK}=FRR*GS*m*3 \tag{2}$$

Using the parameters of Table 1,F_{GSCLK}=41.29MHz.

$$F_{DATA}=192*FRR*m*3 \tag{3}$$

Using the parameters of Table 1, F_{DATA}=1.935MHz.

Table 1, gives the design specifications of the board, based on the values and Equation 1 and 2, F_{GSCLK} and F_{DATA} are calculated.

C. PCB

The software used for the PCB board design is Proteus 8.0, 2 sided PCB board is desired for this board. Since the working frequency is nearly 20Mhz, special care must be taken in PCB design to reduce the noise. A thin layer of grounded copper is placed both on top and bottom layer wherever High frequency path travels. Also to reduce ringing effect a 22ohm resistor is connected very close to the Controller. Datasheets of all the ic s are referred and pads are designed and packages are made and used. The PCB is outsourced. Figure 2, shows a the solder path for a typical 4X4 matrix which is the prototype of the bigger matrix. The total LED matrix is divided into 4 smaller sizes of 16X16 matrices. The LED used is smd RGB 5050 LED, PLCC-6 package. The total size of the board is 400mmX400mm, which is controlled by two control boards attached directly to the matrix, in order to reduce noise interference and data loss during data transmission.

IV. CONTROLLER

Microcontroller used here is FRDM KL25Z128, which is an Arm cortex M0+ based low power, general purpose microcontroller. This has core frequency of 48Mhz and it comes with Open SDA application which makes it very easy to program this microcontroller. The software used for the programming is CodeWarrior. In the beginning a image is taken and converted in a 32X32 size Unit12 True color matrix using Matlab. Additional offset is added to the respective RGB matrices as per demanded by the board.

A big matrix of size 192X24 is formed with 8 bit data placed in the order needed by the TLC5940 ic, each data separated by comms for one image and exported as .txt file. This matrix is loaded into the microcontroller and further processed by it. One of the two SPI of the Microcontroller board is used to send data to the TLC5940 at a speed of 921.6KHz, a timer is used to output 20Mhz clock output, and PIT gives an interrupt every 4096 clock cycles. Here DMA is used to update the data of the SPI buffer which reduces the delay in data transfer and the cycle repeats. DMA gets the starting memory location of the data block in the microcontroller and then it transfers the data living the core to handle other tasks.

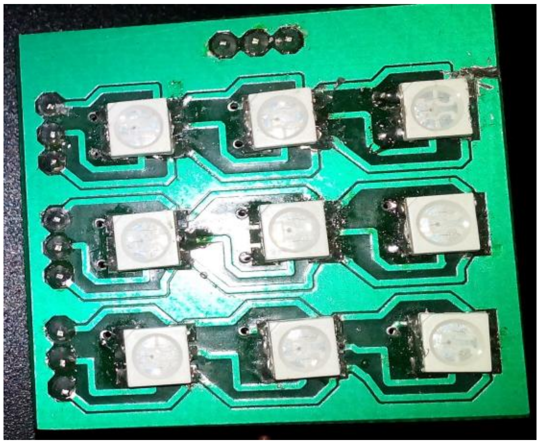
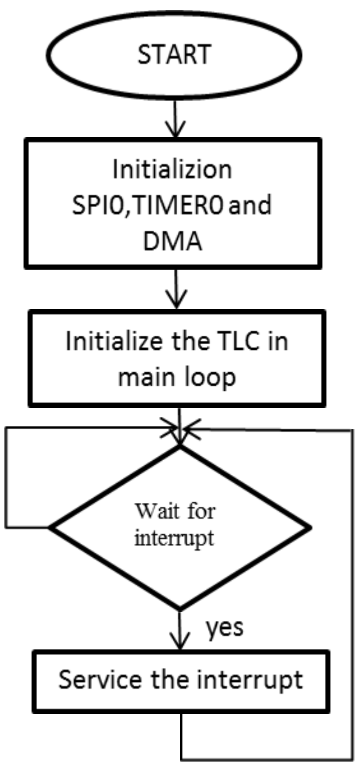


Figure 2. Prototype 3x3 LED Matrix

Flow Chart of the Program



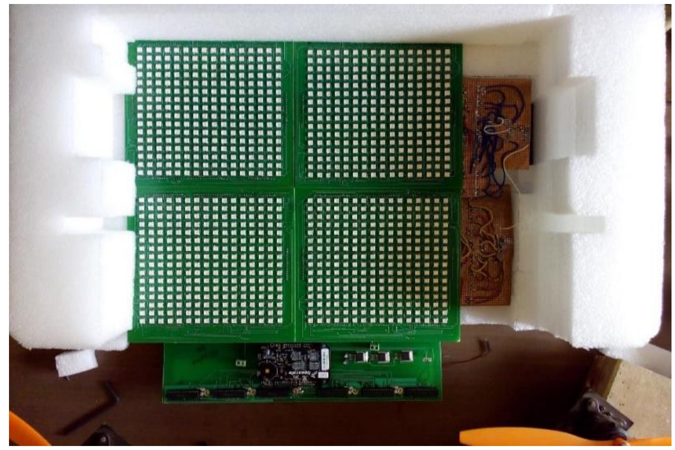


Figure 3. Complete module

V. Result and Conclusion

The project demonstrates viability for use of LED display boards to ease display installation, while also permitting more flexibility in its installation and tolerance to failure. Figure 3 shows the complete 32X32 LED module. This system successfully demonstrates the usefulness of redundancy networking schemes for large display boards. The three areas of the design that is panel designing, powering the board and high level software concurrency. The whole modle designed and build in the institute except the PCB board which was out of the scope of the institute and hence PCB etching was outsourced. Since the system frequency is increased to a higher value than the previous values, now one controller can control 4 such Matrices.

VI. References

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