Fan-Beam Optical Tomography System with Remote Computer Control

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ABSTRACT

This paper represents the configuration of optical tomography sensor by using infrared emitter and phototransistor. The projection geometry of the sensor is based on the combination of two orthogonal and two rectilinear projections arrays. A fixture is designed for holding all emitter-receiver pairs in parallel. Selection of phototransistor is explained so that the tomography sensor developed is free of noise cause by surrounding environment. This paper describes all points to be considered when design an optical tomography sensor.

Keywords: Optical tomography, Fan Beam, Microcontroller

1. Introduction

The method of projection implemented in fan beam optical tomography system needs more control of the LEDs projection compared to other projection such as parallel projection. A common method implemented is to use a 555 timer to trigger a binary counter that is followed by a decoder to select the active LED. Besides that, a mono multivibrator is also used in order to control the duty cycles of the signals generated. By using this method, the frequency and duty cycles of the signals can only be changed by physically adjusting the variable resistors. Besides that, the sequence of the LED projection is also fixed at either clockwise or anti-clockwise.

This paper discusses another method used to control these parameters that is by using the M68HC11E1 micro controller. This micro controller has a very suitable feature to implement this method that is the timer functions. It has five 16-bit output compare timers that are compared simultaneously to a 16-bit free running counter. The size of the free running counter is four bytes, which means that it counts from 0 to 65535. Therefore, this timer can produce signal with frequency in the range about 2 MHz – 30 Hz (assuming 8MHz crystal being used as clock, so the E clock is 8MHz/4, and timer pre-scaled at 1). The resolution for this timer is the one E clock cycle count of the free running counter which is 1/2 MHz = 500ns. Interrupt routine can be set so that certain action can be taken when the timer is triggered [1]

As for the programmable sequence of the LED, this can be achieved by replacing the counter as the controller to select the active LED. This counter can easily be replaced by a general-purpose input output port (GPIO) of the micro controller. LED sequence can then be stored in the EEPROM or RAM of the micro controller and read as the program is executed. The communication link to provide this sequence as well as the parameters of the timer can be downloaded from a host computer by using the RS 232 link supported by the micro controller Serial Communication Interface (SCI) function.

2. Hardware Construction

2.1 LED Sequence Controller

A basic system of the micro controller MC68HC11E1 is constructed together with the serial communication function to provide link for programming the micro controller by a host computer. In order to control the sequence of the LED, the sequence is stored in a memory location so that it can be read one by one. During the development of this controller, the sequence was hard coded into the assembly program to verify the hardware connections [4]. After verification, the sequence will be downloaded from a remote computer and stored in the Random Access Memory (RAM). Since it is stored in RAM, it needs to be downloaded every time it is used. However, the download process is simple and fast. The sequence can also be saved in the Electrical Erasable Programmable Read Only Memory (EEPROM) of the micro controller[3].

Now that the sequence is in place, it needed to be processed and sent out to the output GPIO ports (replacing the counter function). However, there are only two ports with 8 bits each. This is insufficient to control up to 32 LEDs. Therefore, two 4 to 16 binary decoder has been used to decode the binary values from the micro controller in order to select which LED to turn on or off. Five bits are required to be the input of these decoders where four bits are for the selection of LED and the fifth bit, which is the MSB bit, is used to select the active decoder. To control the LED, another signal is required which is the LED_ON signal. The difference between these two signals is that LED_ON signal determines whether the LED is ON or OFF, while the other five bits determines *which* LED to ON or OFF. Therefore, the combination of both signals will choose the appropriate LED and turn it ON for a period determined by the LED_ON signal. This requires some logic gates to be implemented as shown in the Figure 1.[5]

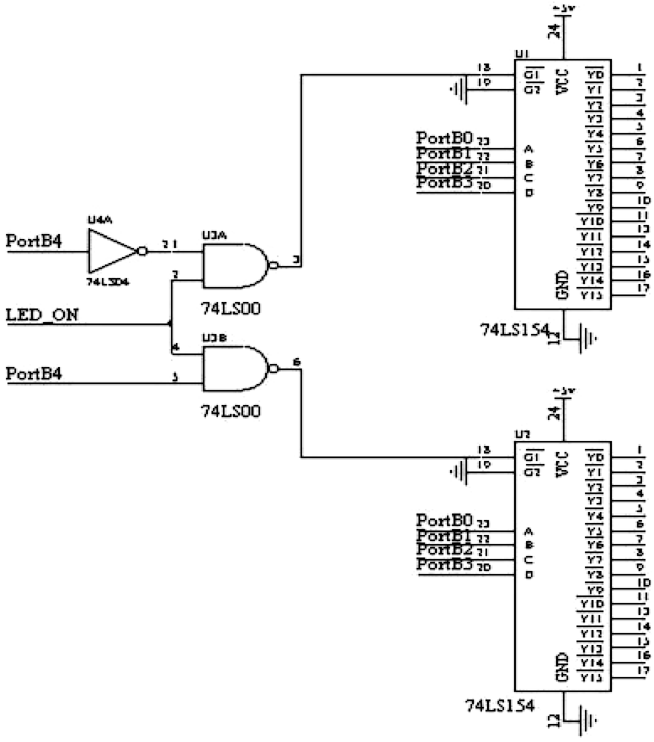

Figure 1. Decoding circuit to control LED sequence

2.2 LED Driver

The sequence controller described earlier in 2.1 only provides logic signals of the LED. This logic signals should not be used to drive the high current LEDs. So, a switching method for LED driver is used. Since the LED needs high current (almost 0.1 A) to create super bright light beam, the open-collector buffer is used. The open-collector circuit topology will provide current when it is HIGH and accept current when it is LOW. This is very suitable for this type of application. A common open-collector buffer is the 74LS07, which has 6 buffers in a single 14 pin DIP chip is selected to be implemented as the LED driver circuit. The signal from the decoder can then be connected to the inputs of these buffers, providing signals to turn ON or turn OFF the 32 LED. Shown in Figure 2 is the circuit for open-collector topology [4].

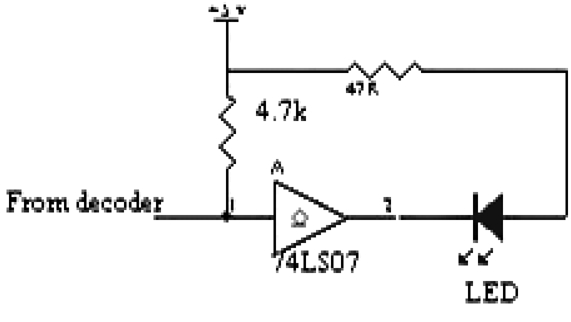

Figure 2. Circuit for open-collector topology

The circuit topology shown above is active low type where LOW signal from decoder will turn ON the LED while HIGH signal will turn OFF the LED. The 4.7k resistor functions as a current provider when the input signal is HIGH. When the buffer's input signal is LOW, the current flows from the +5v source through the 47 Ω resistor to the LED and then to the ground of the buffer which accepts current now. Therefore, the current through the LED is 5/47 which is 106.38 mA. This current is considered high in micro controller circuit and may destroy the decoder if this (open-collector) topology is not used. This circuit configuration also simplifies design compared to using transistor as a switch. In this latter approach, the base current of the transistor has to be calculated carefully to determine the base resistance so that it will operate in either saturation or cutoff region. By using buffers, voltage level instead or current level is determined as inputs.

Thus, there are 32 buffers (in 6 DIP of 74LS07) and two 4 to 16 decoders used to construct the complete circuit of the LED Controller. 4.7kΩ resistors are used to provide HIGH signal while the 47Ω resistors are used to limit the current of the super bright LEDs. The complete circuit of the LED Controller (decoding part) is shown in Figure 3.

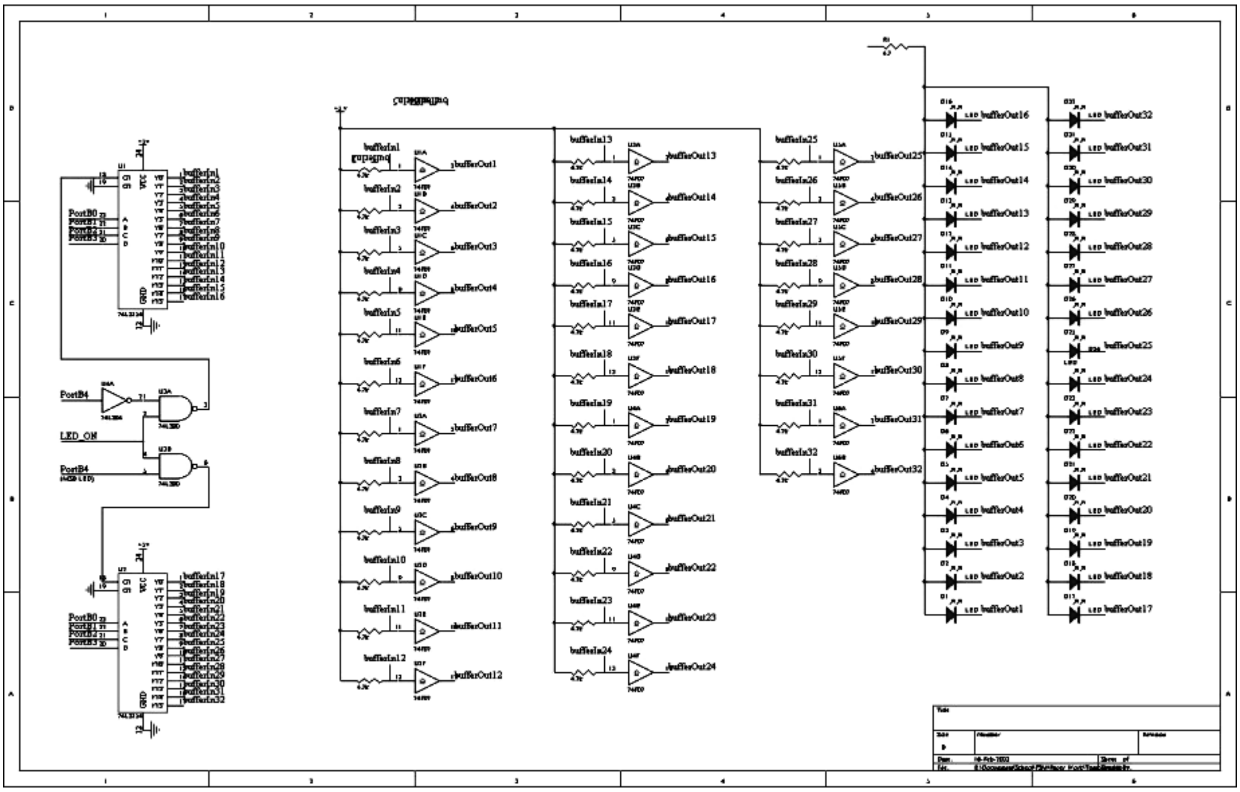

Figure 3. Complete circuit for LED Controller (decoding part)

3. Software Development

Basically, the programming of the micro controller for the LED sequence is based on the flow chart in Figure 4 and Figure 5. Figure 4 shows the protocol to download a sequence from a host computer to the micro controller, while Figure 5 shows the protocol that will execute the downloaded sequence. For the programming of the signal generator, the algorithm is based on the flow chart in Figure 6.

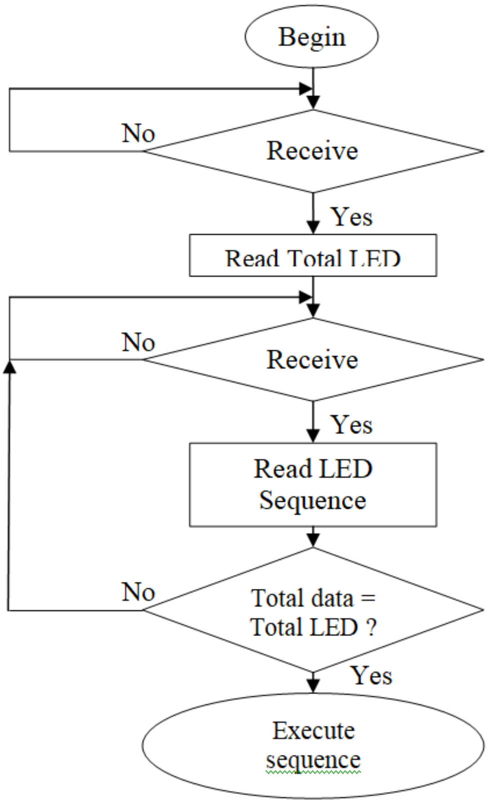

Figure 4. Protocol to download a sequence from a host computer to the microcontroller

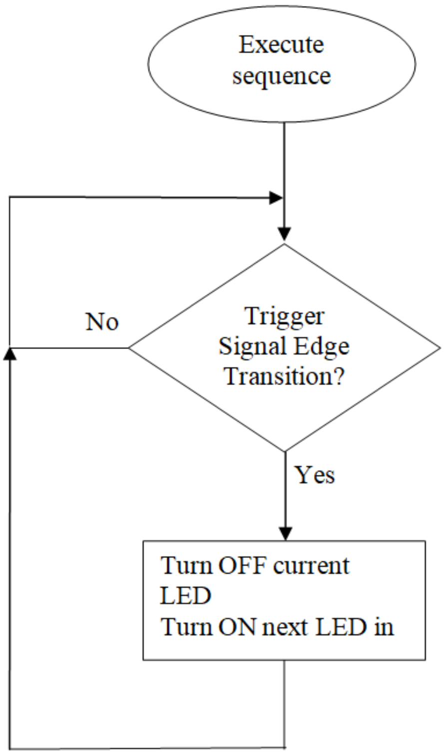

Figure 5. Protocol for executing the downloaded sequence

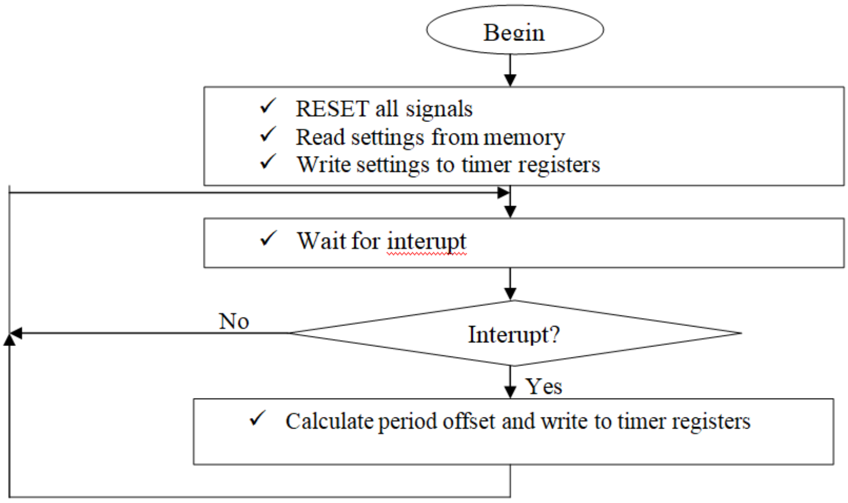

Figure 6. Algorithm for signal generator

4. Results

Shown in Figure 7 below is the sensor fixture seen from diagonal view. Current LED 0 is turned ON and the IDC cables are connected to the connectors. Shown in Figure 8 is the top view of the LED Controller hardware.

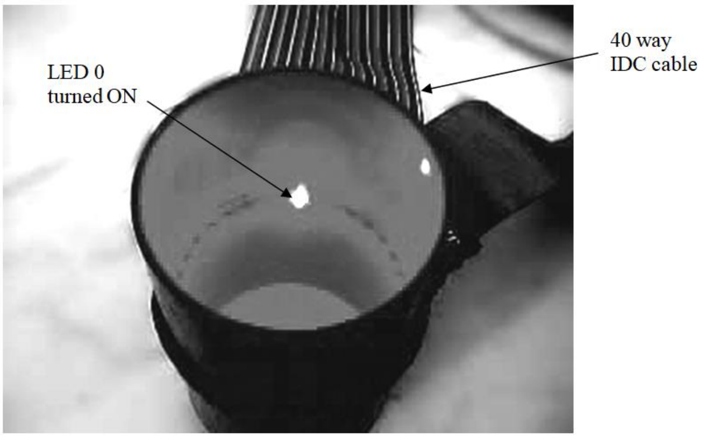

Figure 7. Diagonal view of sensor fixture

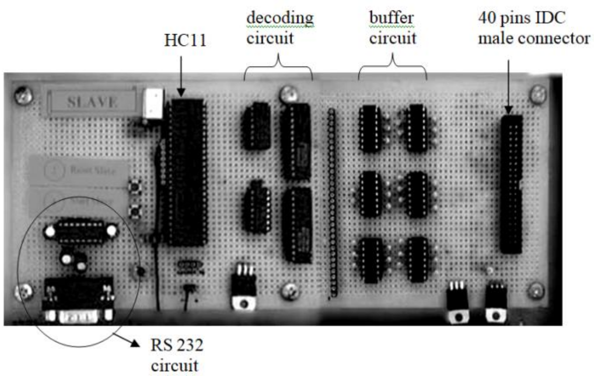

Figure 8. Top view of LED Controller hardware

5 References

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