Lab #6: Time-Multiplexed LED Display using Programmable Timers

Introduction

Real-time systems often require precise timing of data sampling and control operations. This is usually achieved through the use of programmable timer circuits that periodically interrupt the main processor at precise time intervals. To study timed interrupt-driven operation, this lab will require you to design and implement a time-multiplexed LED display using one of the microcontroller's programmable timers to interrupt the CPU.

The human eye is capable only capable of perceiving things that happen below a certain speed. Because of this, we are able to trick the human eye into perceiving things that aren't actually happening; one example of this would be varying the duty cycle of an LED in order to trick the human eye into believing the LED is glowing dimmer. In this lab, you will trick the human eye into perceiving a single image displayed on an LED matrix by turning on all of the LEDs in a single row or column at once and quickly cycling through all of the rows or columns.

The LightKey M15088-A LED Matrix

You will be provided a LightKey M15088-A LED Matrix in lab. Figure 1 shows the circuit schematic from the datasheet, while Figure 2 presents the same information in an easier to read format. The discrepancy between the labeling of rows and columns between Figures 1 and 2 is due to the orientation of the pins inserted into the breadboard. It is important to note that the M15088-A LED Matrix does not contain any internal resistances, so you will need to insert these yourself.

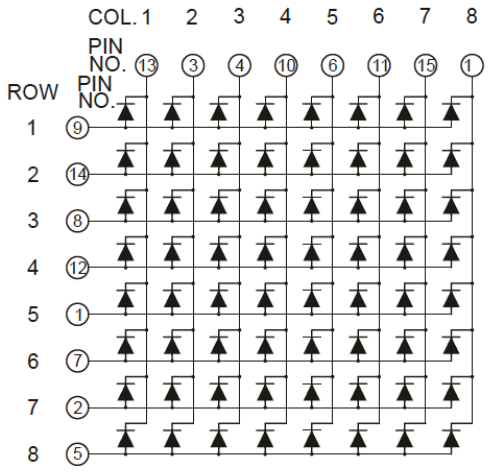

Figure 1: M15088-A LED Matrix Schematic from Datasheet

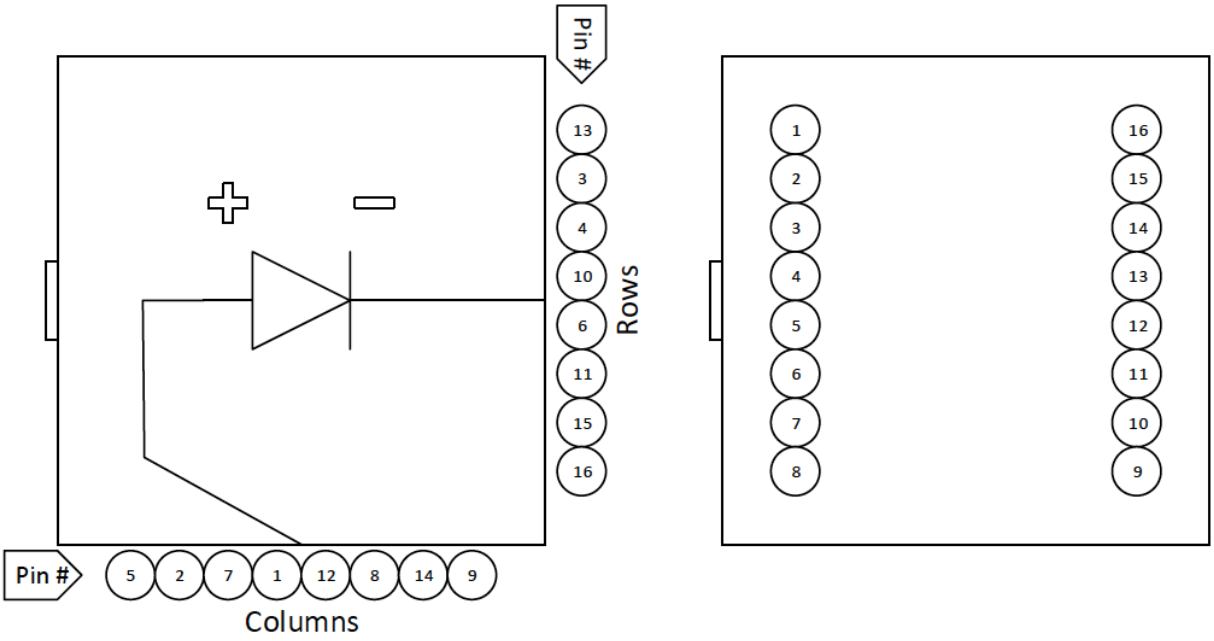

Figure 2: Simplified Schematic of M15088-A

Pre-Lab Assignment

Reading

Study the Monday lab lecture slides, *STM32L100 Reference Manual (Chapter 18 – General-Purpose Timers TM9/TM10/TM11*), and Chapter 14 of the Cady text, 2nd edition, which describes the HCS12 timers, or chapter 9 of the Valvano text, which describes the Cortex-M and LM3S/TM4C microcontroller timers. Links to ELEC 2220 lectures on the STM32 microcontroller programmable timers and interrupt operation are available on Prof. Nelson's ELEC 3040/3050 web page.

Software Design

Building on your previous projects, design a C program that initializes timer module TIM10, initializes the displayed picture to 'P', then enters a "do-nothing" loop to wait for timer or D-Pad interrupts. LED Display operation is to be as follows:

1. When one of the four arrow keys is pressed, the corresponding arrow should be displayed on the LED display.
2. When the 'Pause' button is pressed, the LED display is to display the letter 'P'.
3. When the 'Reset' button is pressed, the LED display is to toggle between displaying the assigned character in positive or negative. See Figure 3 below to see what these look like.

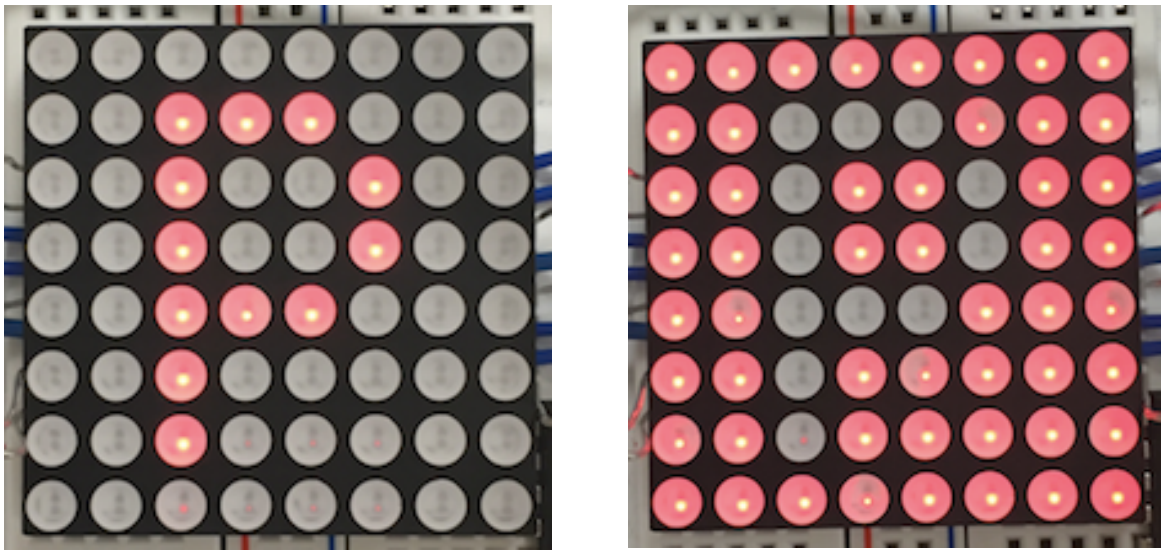

Figure 3: Example of Positive Display (Left) and Negative Display (Right)

In your laboratory notebook, record the following ***prior to lab***.

1. Flowcharts for the program and two interrupt service routines (D-pad and timer)
2. Draft program and the two interrupt service routines (or directions to content on H: drive)
3. A plan for testing the display methodology
4. Wiring diagram for connecting the M15088-A LED Matrix to your microcontroller
5. Calculations showing what value of resistance should be placed in series with the LED matrix based on the M15088-A datasheet and the maximum current a GPIO pin can supply or sink from the ARM STM32L100RC datasheet

Lab Procedure

1. Implement your hardware design, using connections from previous labs. This project requires the D-Pad (PB[7-0] and PA[1]) and 16 pins to control the LED display: PC[15:0]. You may also find it useful to connect additional LEDs to unused GPIO pins to display debugging information.
2. Compile, download, and test your program. To begin, verify that you can still use your D-Pad algorithm to read the correct value. Next, ensure that the LED matrix is connected and will operate the way you intend by connecting the wires to +3V and GND on your microcontroller to light up individual LEDs.

Deliverables this Week

Lab notebooks are to be submitted to the GTA at the end of your lab session.

The Students will be required to show the GTA the following:

1. LED Matrix displaying an image with minimal flickering
2. Oscilloscope measurement showing how often each column is output to the LED Matrix
3. Image on LED Matrix changes with button press