School of Advanced Technology

Lab 6: Serial – Parallel Conversion, Multiplexing, Binary Counters

Lab Objectives:

1. Determine key operating parameters for a typical shift register.
2. Achieve basic control of a shift register by demonstrating manual operation.
3. Show basic control of a single bit travelling through a set of eight LEDs and one shift register
4. Implement a bar graph level meter, consisting of sixteen LEDs.
5. Run a 2-digit 7-segment display from two shift registers

Required Equipment:

- Computer with Arduino IDE & Teensy extensions installed and working
- Teensy board and USB cable
- All components required for the previous lab (7-segment displays)
- 8-bit shift register (2 x SN74HC595)
- 8 LEDs: green (4 x), yellow (4 x), red (8 x) – or your choice
- Resistors – suitable for maintaining LED currents to the limits specified for the shift register

References and Resources:

- You will need to combine this lab with the circuitry and code from the previous lab.
- http://arduino.cc/en/tutorial/ShiftOut - very handy tutorial from Arduino reference pages
- Course textbooks: Chapter 6, “Beginning Arduino”
- Parts List-Explanations file with part numbers, for referencing data sheets
- Data sheet for the shift registers

Task 1: Determine Operating Parameters for the 74HC595 Shift Register

1. Find the data sheet for the shift register (use the parts list to identify the part number). A shift register is a very common IC (integrated circuit). An online search using the part number as a keyword would lead to the vendor’s specification datasheets. Identify the part in your electronics parts package. There are two of them.
2. Using the datasheet, identify the pinout and the marking which designates pin 1.
3. Using the datasheet, identify the appropriate voltage & current parameters. It's important to know what the required voltage & current parameters are for the shift register IC
4. Use Ohm’s law and other formulae as required when determining a suitable value for the current limiting resistors which will be used to drive the bank of LEDs.

Task 2: Verify Correct Operation of a Single Shift Register

1. Using the data sheet from the previous task, plan out the placement of a shift register with a set of 8 LEDs and their accompanying resistors. Note that you will need to save space for 8 more LEDs and the 7-segment displays from last lab, since they will be needed in later steps.
2. Identify the shift register signals that you will need to control via the Arduino. As a minimum, you should consider the SERial input (SER), the Shift Register clock (SRCLK), and the output Register clock (RCLK).
3. Wire up a shift register and a set of eight LEDs.

Demo #1: Manually Clock in an 8-bit number to Shift Register

Refer to demonstration completed in theory class or this video:
https://www.youtube.com/watch?v=6fVbJbNPrEU

1. Connect the inputs of a shift register to switches that have been connected as either pull-up or pull-down as dictated by either an active low or an active high input. At the very minimum, the three shift register inputs that need to be wired to pushbuttons are SER, SRCLK and CLK.
2. The output enable and the master reset pins can be hardwired into either the Vcc or GND rails as needed instead of pushbuttons. Be certain to leave the master reset pin wire easily accessible and relatively longer – you will occasionally need move this wire to and from the Vcc and GND rails.

Demo #2: Single bit travelling sequentially to each LED to the maximum, then back down to the LSB

The objective of this task is to implement a bar graph display which spans ***eight*** LEDs and ***one*** shift register.

1. Start simple: choose a random pattern of On/Off for eight LEDs, and verify your ability to control a single shift register by creating that pattern. Consider carefully whether the LSB or MSB needs to be loaded first!
2. Implement the code to light up a single LED and make it "travel", bouncing from end to end at some pleasing speed.

Demo #3: Add 8 more LEDs and one more shift register

1. Wire up the second shift register with an additional 8 LEDs.
2. Implement a bar graph which displays a pattern smoothly varying between 0–> full –> 0 (no LEDs lit, one by one each LED lights up until all of them are lit up, and finally count backwards, turning off all of the LEDs one at a time, until none of the are lit). The display should change at a speed which is clearly discernible.

Demo #4: 7-Segment Display

1. Modify your circuit and code as necessary so that the shift registers are now connected to the 2x7-Segment displays. You will likely need to adjust the speed of the pattern so that digital value is easily discernible.
2. Demonstrate your circuit counting from 00 to 99.

Deliverables:

Complete the demo of: [2 marks each item]

1. Manually clock in an 8-bit number to one shift register using only switches.
2. Single bit travelling up and down through 8 LEDs.
3. Bar graph with 16 LEDs and 2 shift registers.
4. Build and demonstrate a cascaded pair of 7-segment digital displays, driven programmatically from two shift registers.