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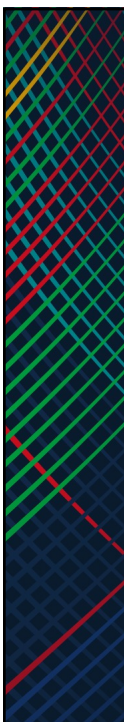
15-348: Embedded Systems Shift Registers

Fall 2022

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(based on original slides by Saquib Razak)

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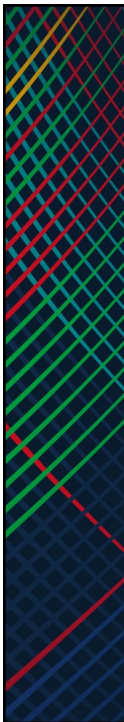
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Motivation

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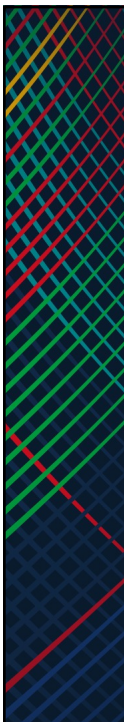


LED Driving

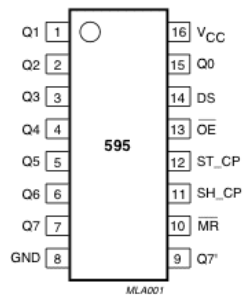
- We can control 8 LEDs by connecting each LED to an I/O pin
 - What if we don't have 8 free I/O pins?
- A shift register allows additional inputs or outputs to be added to a microcontroller
 - Data is stored in the shift-register *serially*

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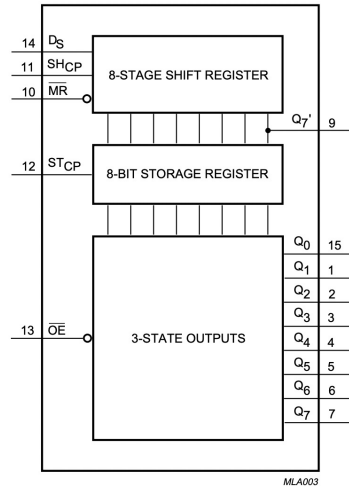
Intro to the 74HC595



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Functional Diagram



PINS 1-7, 15	Q0 - Q7	Output Pins
PIN 8	GND	Ground, Vss
PIN 9	Q7	Serial Out
PIN 10	MR	Master Reclear, active low
PIN 11	SH_CP	Shift register clock pin
PIN 12	ST_CP	Storage register clock pin (latch pin)
PIN 13	OE	Output enable, active low
PIN 14	DS	Serial data input
PIN 16	Vcc	Positive supply voltage

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Usage Example

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Back to the LEDs

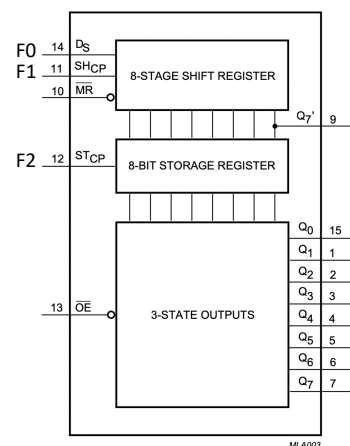
- Let's say we want to connect 8 LEDs to our microcontroller, but without using 8 pins
- We can use a shift register to do it with only 3 pins

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Connections

- We will use F0, F1, and F2 on the microcontroller
 - DS to F0
 - SH_CP to F1
 - ST_CP to F2
- On the 76HC595
 - GND (pin 8) to ground,
 - Vcc (pin 16) to 5V
 - OE (pin 13) to ground
 - MR (pin 10) to 5V
 - Connect 8 LEDs
 - one to each output pin (1-7,15)

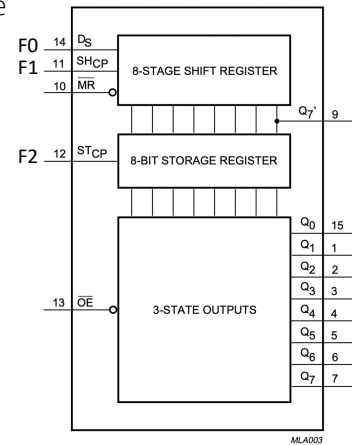


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Writing to the Shift Register

- We are going to bit-bang the device
 - Manually set the correct values and pulse the clock pin

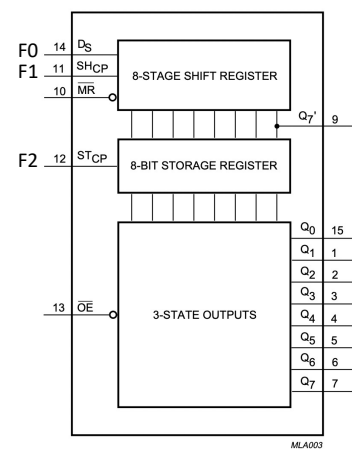


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Writing to the Shift Register (1st bit)

To write the sequence 10010110 to the LEDs

- Clear F1 (SH_CP)
- Make F0 **High** (DS)
- Set F1 (SH_CP)

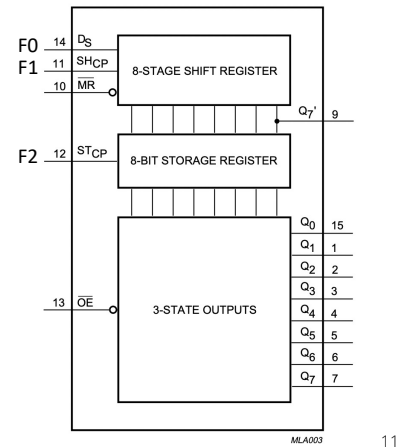


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Writing to the Shift Register (2nd bit)

To write the sequence 10010110 to the LEDs

- Clear F1 (SH_CP)
- Make F0 **Low** (DS)
- Set F1 (SH_CP)

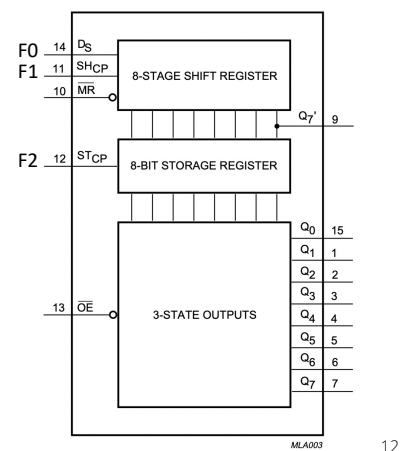


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Writing to the Shift Register (3rd bit)

To write the sequence 10010110 to the LEDs

- Clear F1 (SH_CP)
- Make F0 **Low** (DS)
- Set F1 (SH_CP)

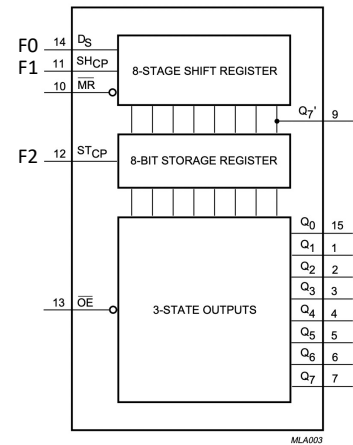


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Writing to the Shift Register (4th bit)

To write the sequence 10010110 to the LEDs

- Clear F1 (SH_CP)
- Make F0 **High** (DS)
- Set F1 (SH_CP)



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Writing to the Shift Register (Other bits)

- Continue until you've shift in 8 bits

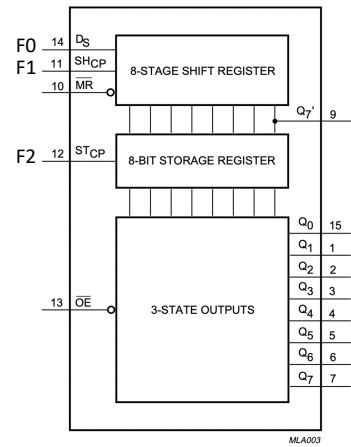
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Output the Bits

Send it to the output

- Clear F2
- Set F2

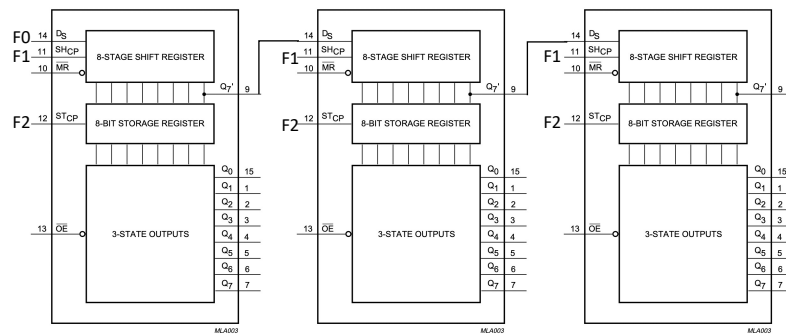


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Further Expansion

- What if you need more than 8-bits?
 - Add another shift register
 - You can chain them together by connecting Q7' to DS on the next one
 - Bit shifted out of one becomes the input to the next



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4-Digit, 7-Segment Display

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Common Anode 7-Segment Display

7-SEGMENT-DISPLAY CA

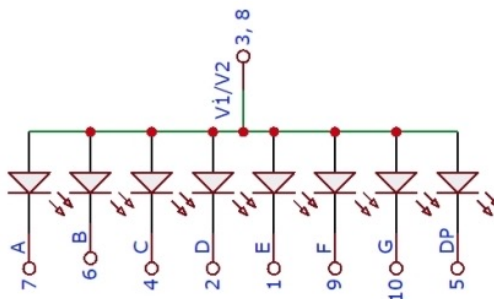
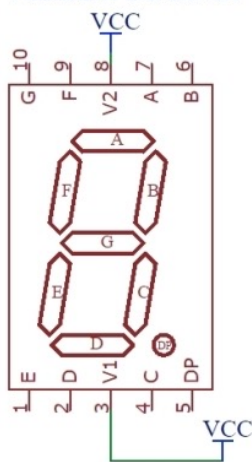
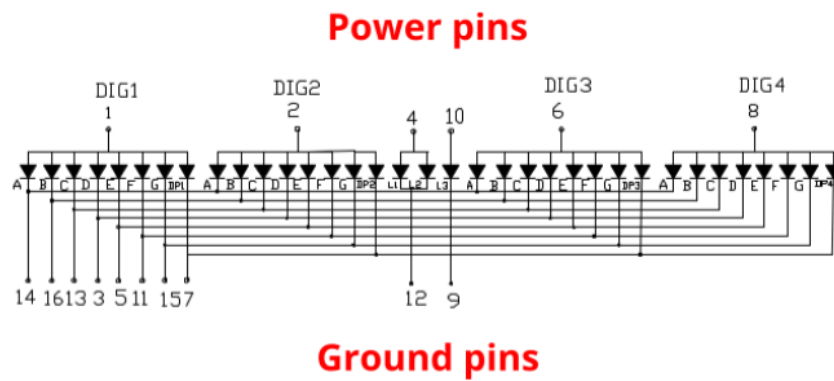


Image Source: <https://protosupplies.com/product/led-7-segment-0-56-red-ca/>

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4-Digit, 7-Segment Display



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Limitation

- The 4-Digit display can only configure one unique digit at a time
- So how do you display different digits simultaneously?
 - Just switch between digits really fast, and the human eye won't notice
 - Probably around 60-100 times per second

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