Engineering Notes For a Holiday Light Display

Bruce MacKinnon KC1FSZ
Wellesley Amateur Radio Society

Edaville Railroad (17 million bulbs, mechanical sequencers)

Rockefeller Center, NYC

Dyker Heights, Brooklyn, New York


MORE
HILL
HAVE A REALLY
GOOD TIME TONIGHT
ONE WAY
ONE WAY
COME
FROM
AWAY
1540 BROADWAY
H&M
MARRIOTT
MARQUIS
ILLUMINATION
THE SECRET
LIFE OF
DESPICABLE ME
SK-II
LEVI'S
COFFEED
Thom Schoelle

Zoning Laws - Times Square, NYC (exciting)

In addition, each of the ***signs*** required to meet the standards of this paragraph (a)(3)(iii) shall have either: a minimum of 20 percent of its ***surface area*** continuously electrically animated either by means of flashing borders, writing, pictorial representations, emblems or other figures of similar character or by means of ***flashing sign surface area*** serving as a field or background thereto; or, a minimum of 50 percent of its ***surface area*** continuously mechanically animated.

Zoning Laws - Wellesley, MA (boring)

of a particular property.

Animated Sign - Any sign, or part of a sign, that uses any movement or change of lighting or color to depict action or create a special effect or scene.

d. Consideration of whether the proposed sign(s) is:

i. Sized and located so as to avoid obscuring existing architectural features such as columns, sill lines, roof eaves, and cornices;

ii. Comprised of materials and colors that reflect the character of the building to which it is attached or associated with; and

iii. Displaying graphics, symbols, logos, and/or letters of a size that are proportional to the sign and the building to which it is attached or associated with, does not create a sign with a cluttered appearance, and are legible and visible to both vehicle operators and pedestrians; such graphics, symbols, logos, and/or letters on secondary signs should be proportionally smaller than those on a primary sign.

KC1FSZ Zoning Law

NO HOLIDAY LIGHTS UNTIL

AFTER THANKSGIVING!

Technology Fundamentals

Conventional incandescent light strings - typically 300 bulb/60 ft sections (~$10).

All two-prong connectors removed.

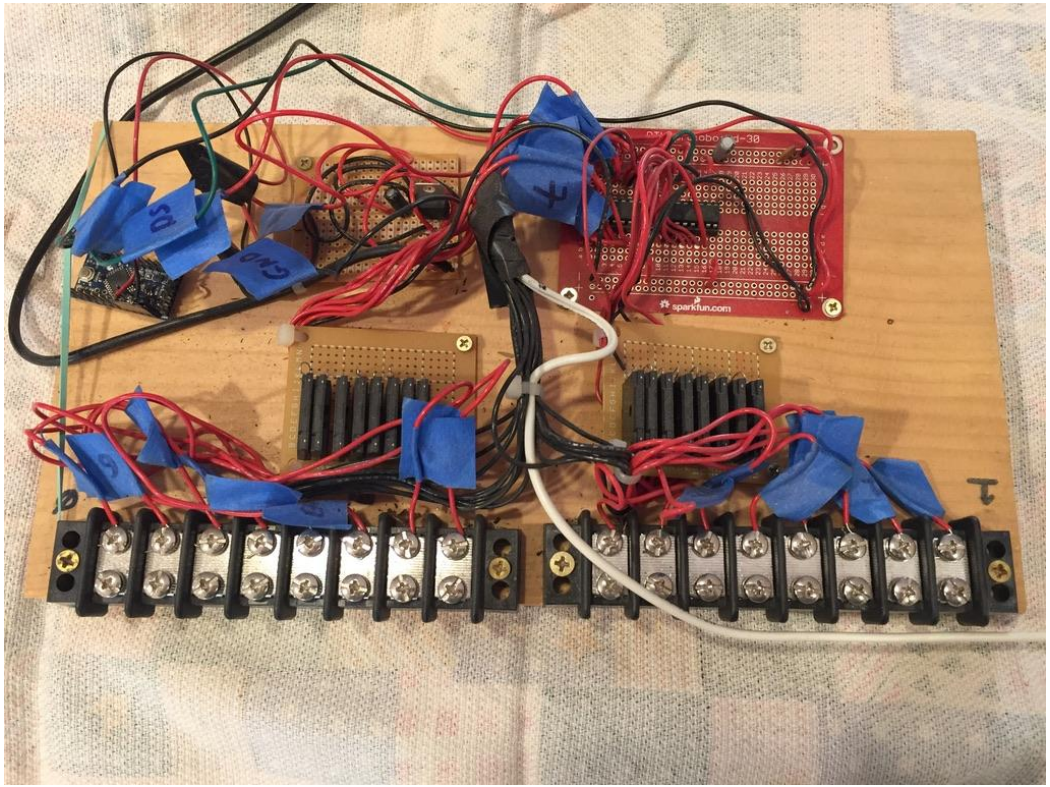
All UL-listing and other regulatory/warning labels removed.

Homebrew controller for animated sequencing.

Microcontroller-driven (Arduino).

Light strings cabled to controller using raw lamp cord.

Homebrew Controller - 16 Channels



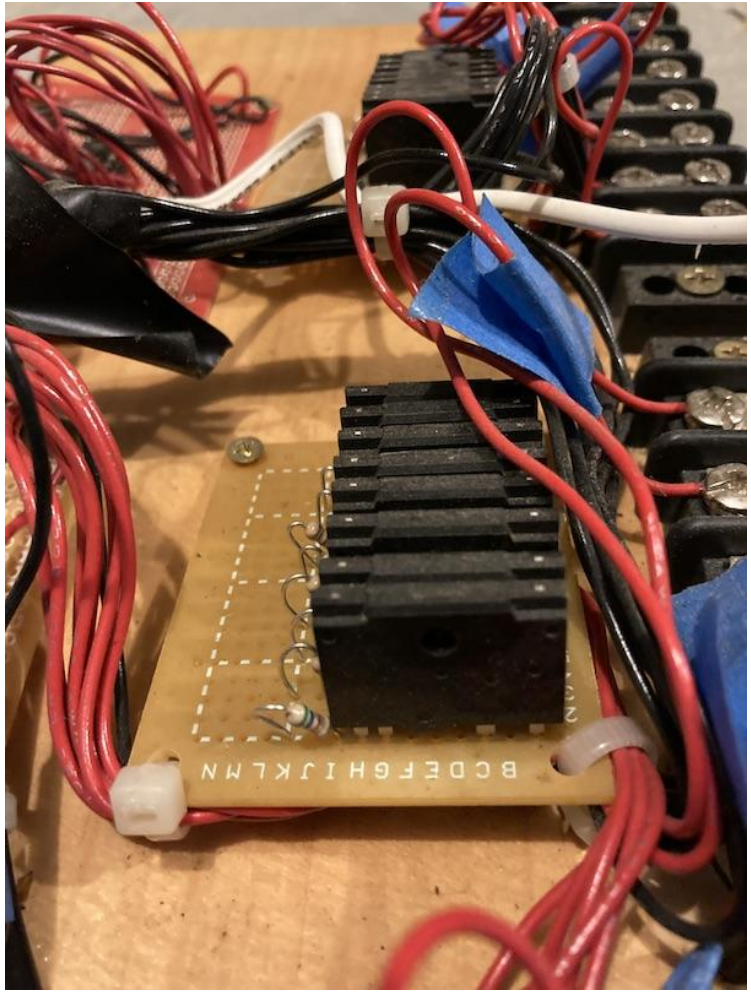
Solid State Relays

Sharp S108T02 relay that is capable of switching 8A at 125V.

MOSFET triac switch that is optically coupled to a 1.5V control signal.

Can switch in 10ms.

Minimal RFI/EMI.



Controller - Arduino Pro Mini

Channel Scalability

Arduino Controller is cheap (6$)

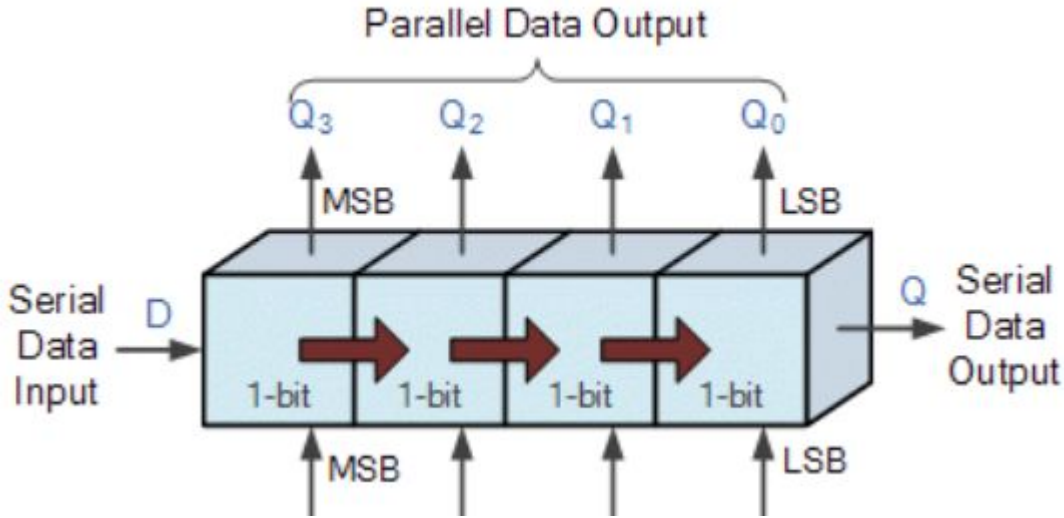
But has limited GPIO pins

Solution: Shift registers!

74HC595 (8 bit, chainable)

Only three GPIO pins needed:

Data Out, Shift Clock, Latch



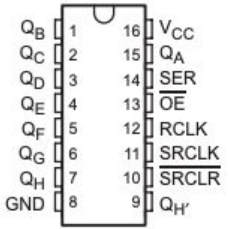
Nostalgic for 74-Series Logic?

CD74HC595
8-BIT SHIFT REGISTERS
WITH 3-STATE OUTPUT REGISTERS

SCHS353 – JANUARY 2004

- 8-Bit Serial-In, Parallel-Out Shift
- Wide Operating Voltage Range of 2 V to 6 V
- High-Current 3-State Outputs Can Drive Up To 15 LSTTL Loads
- Low Power Consumption, 80-μA Max I_{CC}
- Typical t_{pd} = 14 ns
- ±6-mA Output Drive at 5 V
- Low Input Current of 1 μA Max
- Shift Register Has Direct Clear

DW, E, M, NS, OR SM PACKAGE
(TOP VIEW)



description/ordering information

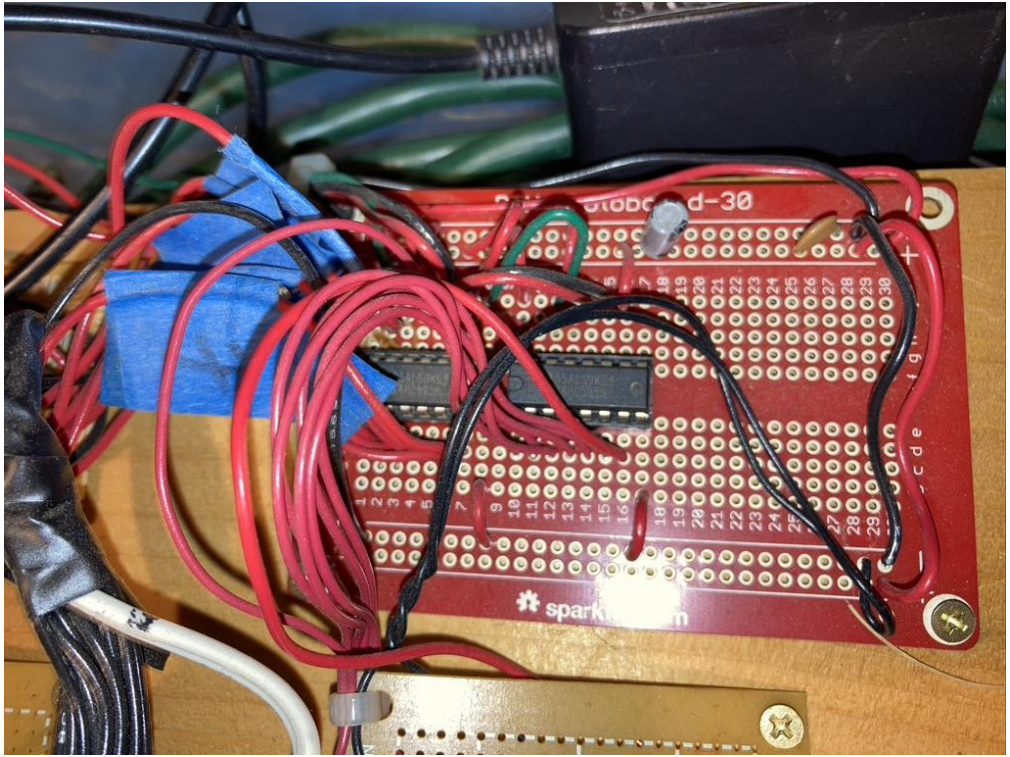
The CD74HC595 device contains an 8-bit serial-in, parallel-out shift register that feeds an 8-bit D-type storage register. The storage register has parallel 3-state outputs. Separate clocks are provided for both the shift and storage registers. The shift register has a direct overriding clear ($\overline{SRCLR}$) input, serial (SER) input, and serial output for cascading. When the output-enable ($\overline{OE}$) input is high, the outputs are in the high-impedance state.

Both the shift register clock (SRCLK) and storage register clock (RCLK) are positive-edge triggered. If both clocks are connected together, the shift register always is one clock pulse ahead of the storage register.

ORDERING INFORMATION

T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
	PDIP – E	Tube of 25	CD74HC595E	CD74HC595E
	SOIC – DW	Tube of 40	CD74HC595DW	HC595M
		Reel of 2000	CD74HC595DWR	

Two 74HC595 Shift Registers



Theoretical Display Speed/Size

8 MHz Arduino

20us GPIO clock (50 kHz)

X16 channels = 3.2ms (3 kHz) for the entire chain

But a reasonable startup time for the incandescent holiday bulbs is around 15ms

So the maximum usable frequency (MUF) for refresh is around 1.06 kHz

Therefore, a 48 channel system should work fine (50 kHz / 1.06 kHz)

Start building!

Boxed Up Outside - (Plastic Storage Bin)

2020

2019

Pandemic Graduation Tribute

The Next Wave - Addressable LEDs

Most modern displays today leverage LED technology

Pixel LED technology invented by Worldsemi in 2007

Originally developed for commercial billboards, jumbotrons, etc. (**TIMES SQUARE!**)

Each LED has RGB elements

24-bits per LED (256 levels of R/G/B)

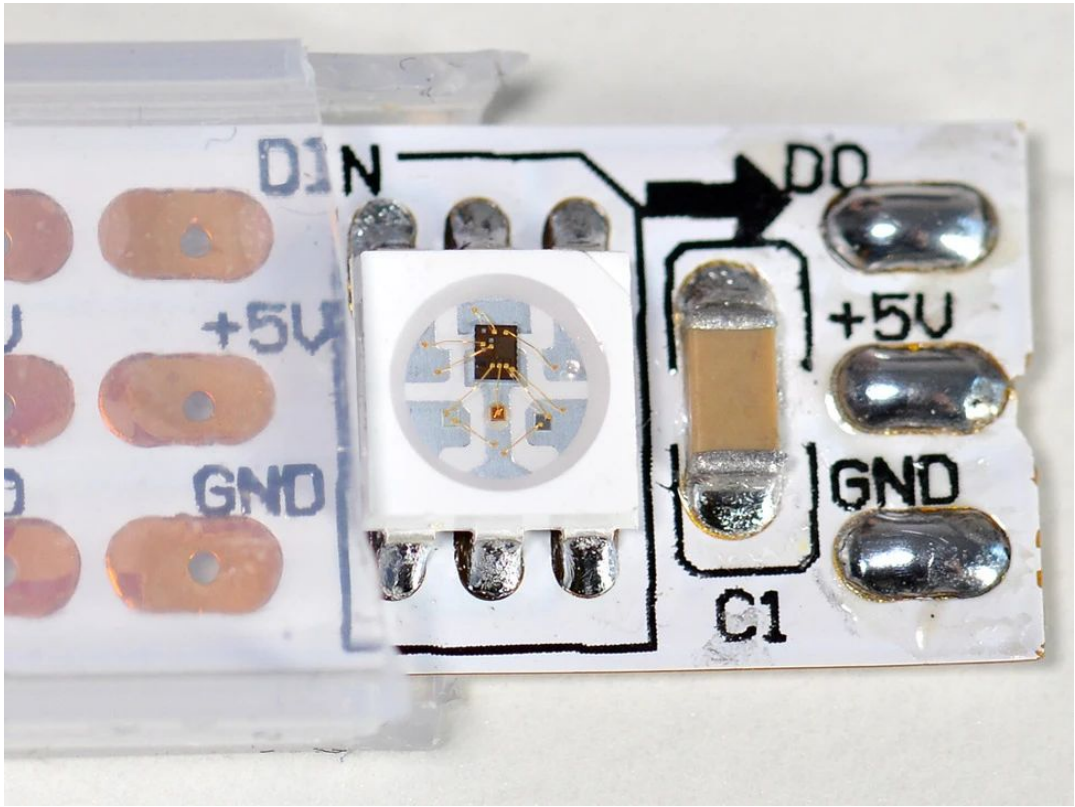
Each LED on the string is independently addressable

LED contain embedded controller chip: WS2811, WS2812, WS2812B, WS2813

Strings are $50-$100, depending on quality

NeoPixel String - Arduino Controllable

Close-Up of NeoPixel Strip Element



WS281x Technicals

One-wire serial protocol

Clock runs at approximately 1.25us (800 kHz)

Each LED on the strip takes 24 bits and then passes to the next

A “long clock” restarts the sequence - 300us

A 450 LED string can be updated at a rate of 60 Hz

Designed for full-motion video

Holiday Hams

Use your technical skills to light up the neighborhood!

The Santa Net on 3916 KC at 8:15 PM Eastern - Starting 26 Nov.

Annual WARS holiday party: 5 December 2PM to 4PM.