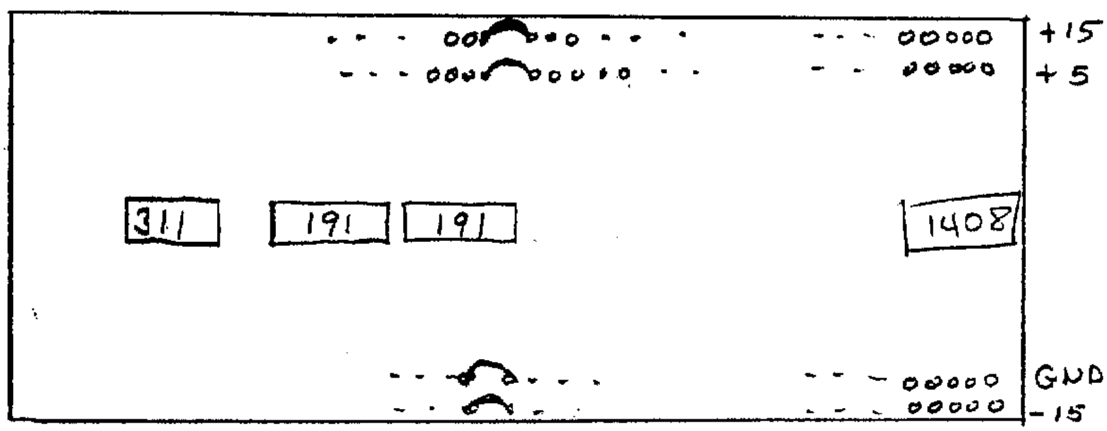
Digital to Analog and Analog to Digital Conversion

The 1408 is an 8–bit current-switching DAC. We will build and use an 8–bit counter to provide the 8–bit input to the DAC. Then we will use a 311 comparator with the counter and DAC to make a tracking DAC.

WIRE YOUR CIRCUITS NEATLY. EACH PART BUILDS ON THE ONE BEFORE IT.

1. **Breadboard Layout**

   You will need ±15 volts as well as +5 and gnd. A suggested layout is shown below

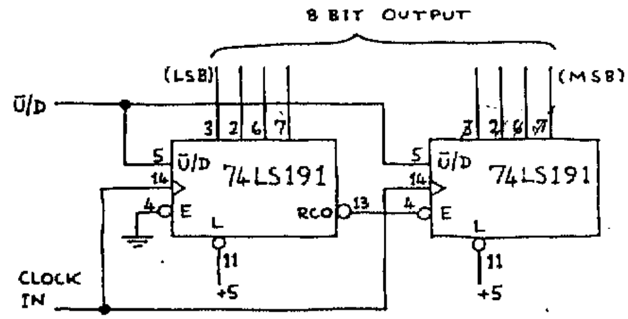


   Its also a good idea to color code the wires. A suggestion: +5V=Red; GND=Black; +15V=White; 15V=Blue.

   Put all the chips on the board and wire up the supply voltages with <u>short</u> leads first.

2. **8–Bit Counter Using Two 74LS191 Chips**

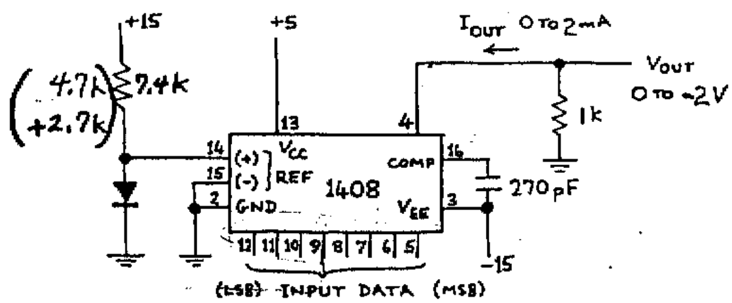
   Refer to the 74LS191 description provided in the texts and the figure below. First make sure the lower order 4-bits are working properly by attaching the 4 output bits to the LAMP MONITORS and clocking with a pulser. Then look at the outputs of the higher 4-bits on the lamp monitors with a 10 Hz clock into the first counter. Connect the $\overline{\mathrm{U}}$/D lead to a LOGIC SWITCH and verify that the 8-bit counter counts up and down.



Fully synchronous 8 bit up/down counter using 74LS191s.

3. D to A Converter

(a) Wire up the 1408 as shown in the figure.



1408 8-bit monolithic current switching digital-analog converter. The current output is converted to a voltage by a 1k resistor.

Note the polarity of the output voltage.

(b) Now connect only the 4 highest order bits from the 8-bit counter to the 1408 DAC's most significant bits, (i.e., pins 8,7,6,5 of the DAC). Clock the 8-bit counter at 10 kHz and observe the output of the DAC on the scope. Reverse the direction of the counter to get the other "staircase" wave.

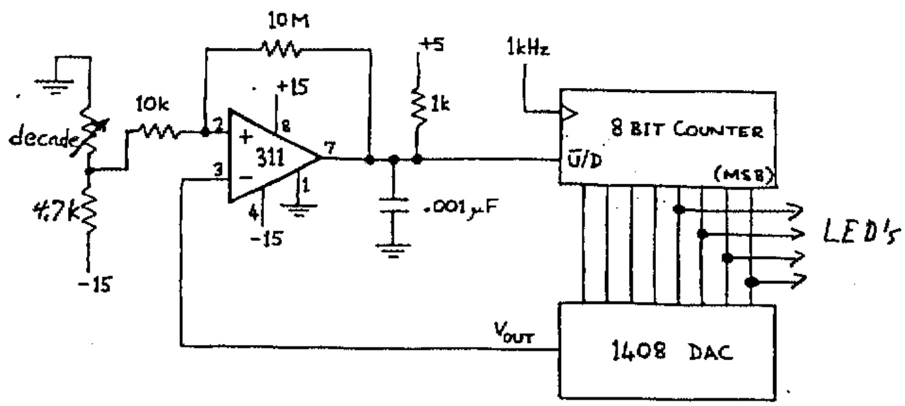
(c) Now connect the lower 4-bits from the counter to DAC and observe the waveshape. You should get a nice ramp.

(d) Use a digital voltmeter on the output of the DAC and step the counter with a pulser. Record several adjacent output voltages near each end and in the middle of the ramp. Is the average step size the same? What analog voltage output corresponds to full scale input? How sensitive is this value to small temperature changes of the reference resistor? *

* Note that the output current is proportional to the current into pin 14.

4. Tracking ADC

(a) By adding a comparator we can make a tracking ADC as shown in the figure



Tracking ADC using 8-bit counter and DAC The addition of hysteresis and capacitor (which slows down the slew rate) to the 311 comparator are to reduce its tendency to oscillate.

The decade resistor simulates an analog input. The 311 compares this with the DAC's output and clocks the counter up or down as required to make the DAC's output equal the analog level. The digital output is then the digital state of the counter.

Display the four most significant bits using the lamp monitors.

(b) Observe the output of the DAC on the scope. Set the CLK to 100 Hz and see what happens when you vary the decade resistor from zero to 500Ω. What happens to the count for more negative values of the input voltage? Why? Do the LED readings make sense? Speed up your ADC by clocking at 1 kHz and observe V_{out} of the 1408 on the scope as you change the decade resistor. Explain.

(c) With the scope input set to AC, turn the input to the max sensitivity and observe the output of the 1408 dancing between two levels of the staircase. Why? To make this easier to see, you can disconnect the four least significant bits driving the 1408.