

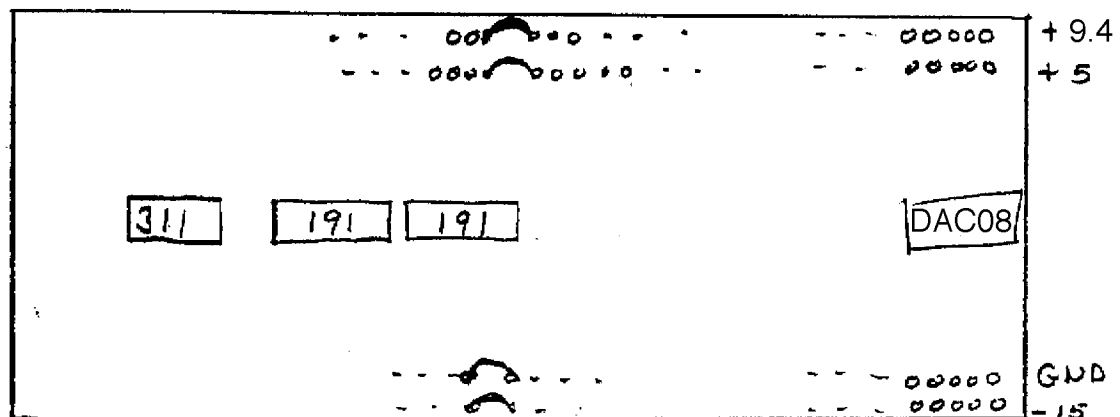
Digital to Analog and Analog to Digital Conversion

The DAC08 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 +9.4V, -15V as well as +5 and gnd. A suggested layout is shown below

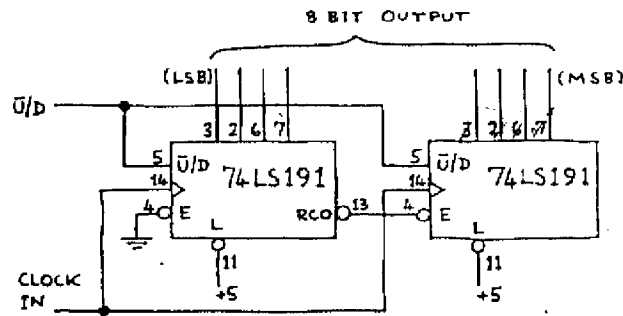


Its also a good idea to color code the wires. A suggestion: +5V=Red; GND=Black; +9.4V =White; -15V=Blue.

Put all the chips on the board and wire up the supply voltages with short 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 \bar{U}/D lead to a LOGIC SWITCH and verify that the 8-bit counter counts up and down.

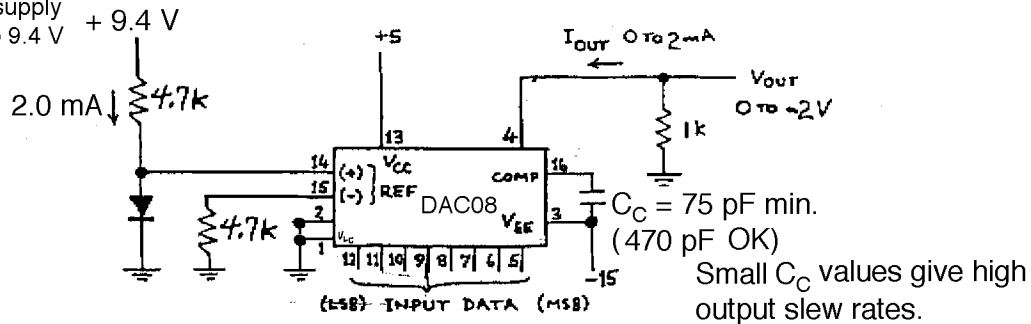


Fully synchronous 8 bit up/down counter using 74LS191s.

3. D to A Converter

(a) Wire up the DAC08 as shown in the figure:

Set pos. supply voltage to 9.4 V



DAC08 8-bit monolithic current switching digital-analog converter. The current output is converted to a voltage by a $1k$ resistor.

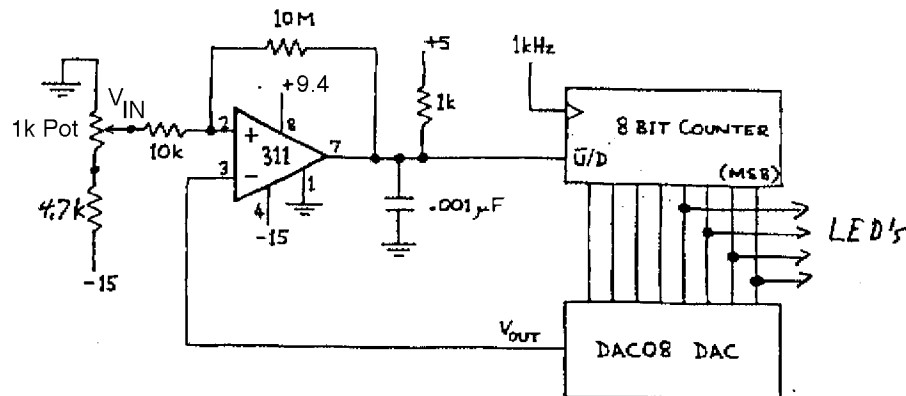
Note the polarity of the output voltage.

- Now connect only the 4 highest order bits from the 8-bit counter to the DAC08 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.
- Now connect the lower 4-bits from the counter to DAC and observe the wave-shape. You should get a nice ramp.
- 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 DAC08 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 V_{IN} from 0 to -1V by varying the 1k pot. 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 DAC on the scope as you change V_{IN} using the 1k pot. Explain.
- (c) With the scope input set to AC, turn the input to the max sensitivity and observe the output of the DAC dancing between two levels of the staircase. Why? To make this easier to see, you can disconnect the four least significant bits driving the DAC.



FEATURES

- Fast settling output current: 85 ns**
- Full-scale current prematched to ± 1 LSB**
- Direct interface to TTL, CMOS, ECL, HTL, PMOS**
- Nonlinearity to 0.1% maximum over temperature range**
- High output impedance and compliance: -10 V to $+18$ V**
- Complementary current outputs**
- Wide range multiplying capability: 1 MHz bandwidth**
- Low FS current drift: ± 10 ppm/ $^{\circ}$ C**
- Wide power supply range: ± 4.5 V to ± 18 V**
- Low power consumption: 33 mW @ ± 5 V**
- Low cost**

GENERAL DESCRIPTION

The DAC08 series of 8-bit monolithic digital-to-analog converters provide very high speed performance coupled with low cost and outstanding applications flexibility.

Advanced circuit design achieves 85 ns settling times with very low "glitch" energy and at low power consumption. Monotonic multiplying performance is attained over a wide 20-to-1 reference current range. Matching to within 1 LSB between reference and full-scale currents eliminates the need for full-

scale trimming in most applications. Direct interface to all popular logic families with full noise immunity is provided by the high swing, adjustable threshold logic input.

High voltage compliance complementary current outputs are provided, increasing versatility and enabling differential operation to effectively double the peak-to-peak output swing. In many applications, the outputs can be directly converted to voltage without the need for an external op amp. All DAC08 series models guarantee full 8-bit monotonicity, and nonlinearities as tight as $\pm 0.1\%$ over the entire operating temperature range are available. Device performance is essentially unchanged over the ± 4.5 V to ± 18 V power supply range, with 33 mW power consumption attainable at ± 5 V supplies.

The compact size and low power consumption make the DAC08 attractive for portable and military/aerospace applications; devices processed to MIL-STD-883, Level B are available.

DAC08 applications include 8-bit, 1 μ s A/D converters, servo motor and pen drivers, waveform generators, audio encoders and attenuators, analog meter drivers, programmable power supplies, LCD display drivers, high speed modems, and other applications where low cost, high speed, and complete input/output versatility are required.

FUNCTIONAL BLOCK DIAGRAM

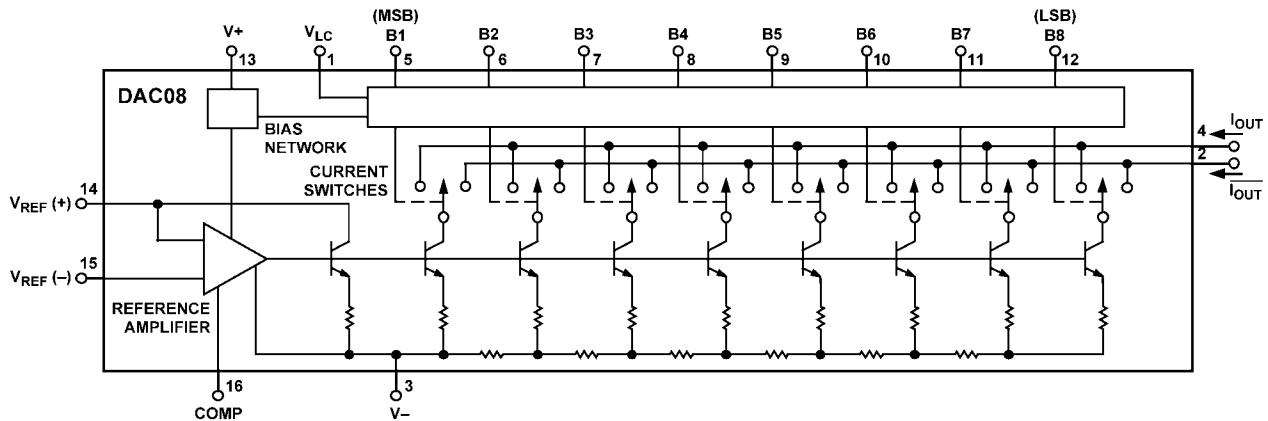


Figure 1.

Rev. C

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BASIC CONNECTIONS

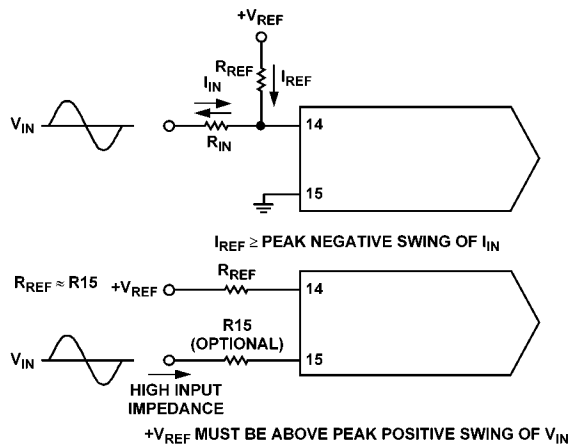


Figure 23. Accommodating Bipolar References

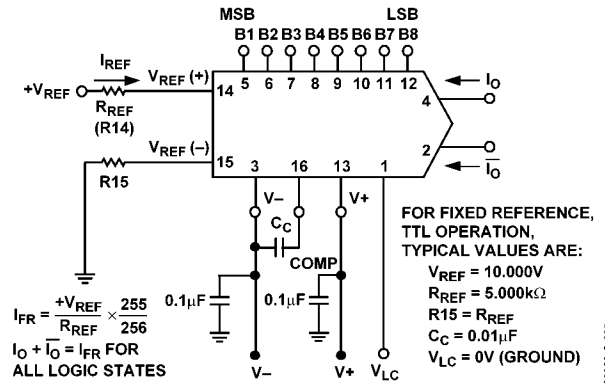
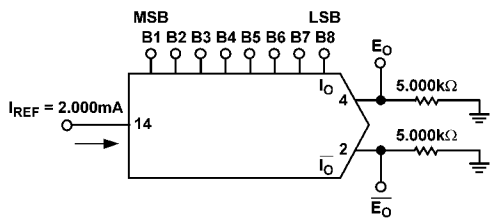
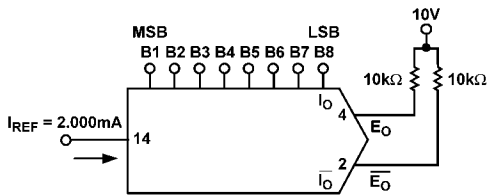


Figure 24. Basic Positive Reference Operation



	B1	B2	B3	B4	B5	B6	B7	B8	I_O	\bar{I}_O	E_O	\bar{E}_O
FULL RANGE	1	1	1	1	1	1	1	1	1.992	0.000	-9.960	-0.000
HALF SCALE +LSB	1	0	0	0	1	0	0	1	1.008	0.984	-5.040	-4.920
HALF SCALE	1	0	0	0	1	0	0	0	1.000	0.992	-5.000	-4.960
HALF SCALE -LSB	0	1	1	1	0	1	1	1	0.992	1.000	-4.960	-5.000
ZERO SCALE +LSB	0	0	0	0	0	0	0	1	0.008	1.984	-0.040	-9.920
ZERO SCALE	0	0	0	0	0	0	0	0	0.000	1.992	0.000	-9.960

Figure 25. Basic Unipolar Negative Operation



	B1	B2	B3	B4	B5	B6	B7	B8	E_O	\bar{E}_O
POS. FULL RANGE	1	1	1	1	1	1	1	1	-9.920	+10.000
POS. FULL RANGE -LSB	1	1	1	1	1	1	1	0	-9.840	+9.920
ZERO SCALE +LSB	1	0	0	0	0	0	0	1	-0.080	+0.160
ZERO SCALE	1	0	0	0	0	0	0	0	0.000	+0.080
ZERO SCALE -LSB	0	1	1	1	1	1	1	1	+0.080	0.000
NEG. FULL SCALE +LSB	0	0	0	0	0	0	0	1	+9.920	-9.840
NEG. FULL SCALE	0	0	0	0	0	0	0	0	+10.000	-9.920

Figure 26. Basic Bipolar Output Operation

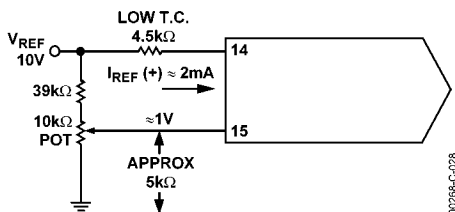


Figure 27. Recommended Full-Scale Adjustment Circuit

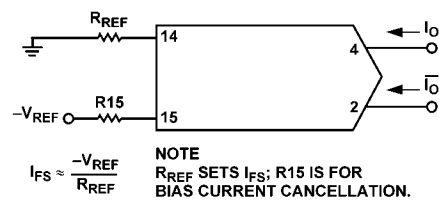


Figure 28. Basic Negative Reference Operation