GENERATING SINE WAVE USING 8051

Component required:

8051 Microcontroller, DAC, Resistor and Capacitor etc.

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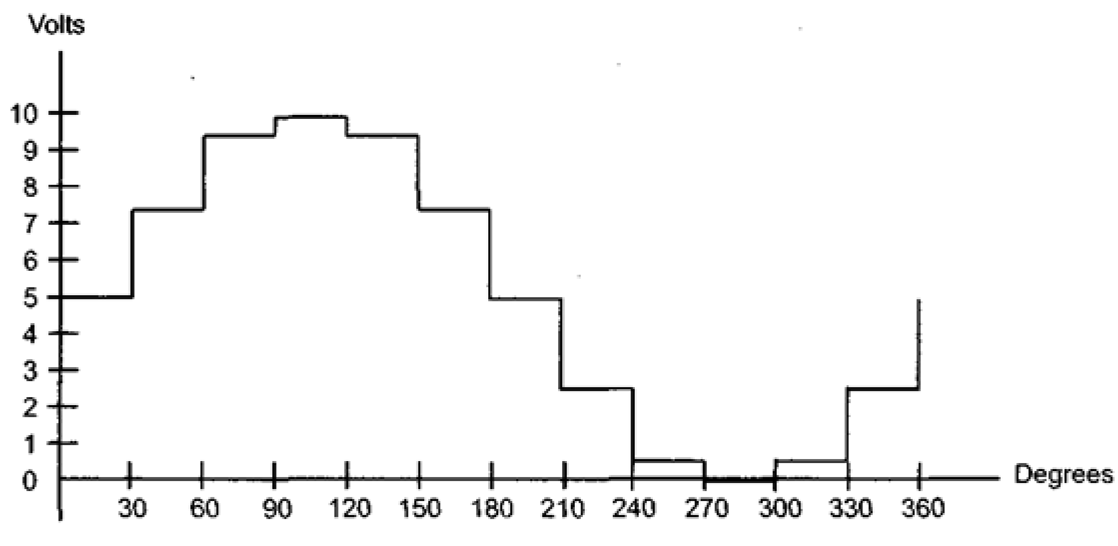
Generating a sine wave:

To generate a sine wave, we first need a table whose values represent the magnitude of the sine of angles between 0 and 360 degrees. The values for the sine function vary from -1.0 to +1.0 for 0- to 360-degree angles. Therefore, the table values are integer numbers representing the voltage magnitude for the sine of theta. This method ensures that only integer numbers are output to the DAC by the 8051 microcontroller. Table 13-7 shows the angles, the sine values, the voltage magnitudes, and the integer values representing the voltage magnitude for each angle (with 30-degree increments). To generate Table 13-7, we assumed the full-scale voltage of 10 V for DAC output (as designed in Figure 13-18). Full-scale output of the DAC is achieved when all the data inputs of the DAC are high. Therefore, to achieve the full-scale 10 V output, we use the following equation.

$$V_{out} = 5\text{ V} + (5 \times \sin\theta)$$

V_{out} of DAC for various angles is calculated and shown in Table 13-7. See Example 13-5 for verification of the calculations.



Angle vs. Voltage Magnitude for Sine Wave

Angle vs. Voltage Magnitude for Sine Wave

Angle 9 (degrees) Sin 0	V_{out} (Voltage Magnitude) 5 V + (5 V X sin 6)	Values Sent to DAC (decimal) (Voltage Mag. X 25.6)
0 0	5	128
30 0.5	7.5	192
60 0.866	9.33	238
90 1.0	10	255
120 0.866	9.33	238
150 0.5	7.5	192
180 0	5	128
210 -0.5	2.5	64
240 -0.866	0.669	17
270 -1.0	0	0
300 -0.866	0.669	17
330 -0.5	2.5	64
360 0	5	128

Verify the values given for the following angles: (a) 30° (b) 60°.

Solution:

(a) $V_{out} = 5\text{ V} + (5\text{ V} \times \sin\theta) = 5\text{ V} + 5 \times \sin 30° = 5\text{ V} + 5 \times 0.5 = 7.5\text{ V}$
DAC input values = 7.5 V × 25.6 = 192 (decimal)

(b) $V_{out} = 5\text{ V} + (5\text{ V} \times \sin\theta) = 5\text{ V} + 5 \times \sin 60° = 5\text{ V} + 5 \times 0.866 = 9.33\text{ V}$
DAC input values = 9.33 V × 25.6 = 238 (decimal)

To find the value sent to the DAC for various angles, we simply multiply the V_{out} voltage by 25.60 because there are 256 steps and full-scale V_{out} is 10 volts. Therefore, 256 steps /10 V = 25.6 steps per volt. To further clarify this, look at the following code. This program sends the values to the DAC continuously (in an infinite loop) to produce a crude sine wave. See Figure 13-19.

Digital-to-analog (DAC) converter:

The digital-to-analog converter (DAC) is a device widely used to convert digital pulses to analog signals. In this section we discuss the basics of interfacing a DAC to the 8051.

Recall from your digital electronics book the two methods of creating a DAC: binary weighted and R/2R ladder. The vast majority of integrated circuit DACs, including the MC1408 (DAC0808) used in this section, use the R/2R method since it can achieve a much higher degree of precision. The first criterion for judging a DAC is its resolution, which is a function of the number of binary inputs. The common ones are 8, 10, and 12 bits. The number of data bit inputs decides the resolution of the DAC since the number of analog output levels is equal to 2", where *n* is the number of data bit inputs. Therefore, an 8-input DAC

such as the DAC0808 provides 256 discrete voltage (or current) levels of output. Similarly, the 12-bit DAC provides 4096 discrete voltage levels. There are also 16-bit DACs, but they are more expensive.

MC1408 DAC (or DAC0808)

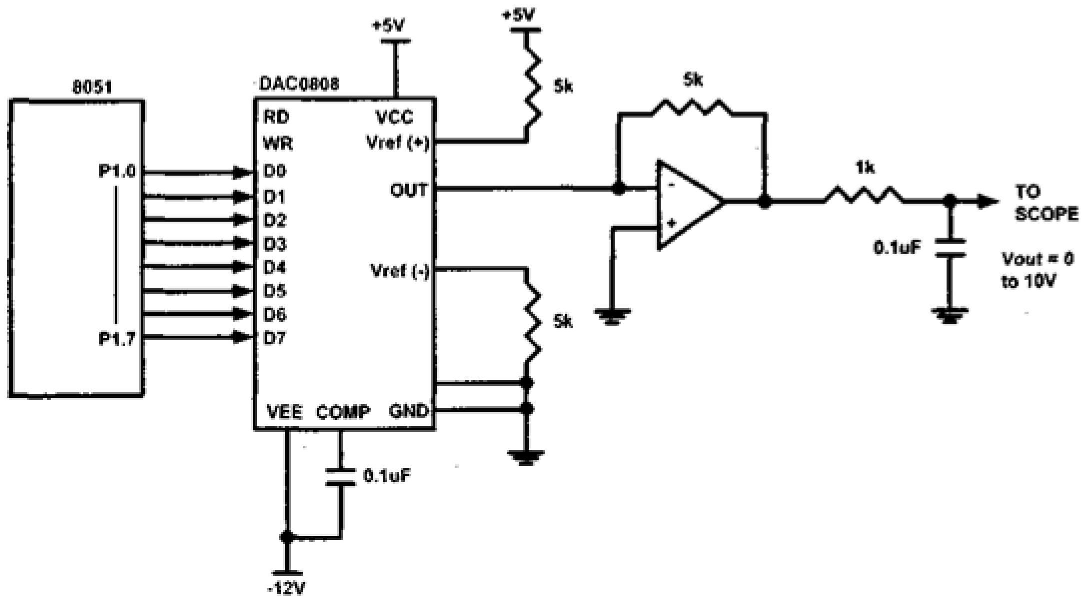
In the MC1408 (DAC0808), the digital inputs are converted to current (I_{out}), and by connecting a resistor to the I_{out} pin, we convert the result to voltage.

The total current provided by the I_{out} pin is a function of the binary numbers at the DO - D7 inputs of the DAC0808 and the reference current (I_{re}f), and is as follows:

$$I_{out} = I_{ref}\left(\frac{D7}{2} + \frac{D6}{4} + \frac{D5}{8} + \frac{D4}{16} + \frac{D3}{32} + \frac{D2}{64} + \frac{D1}{128} + \frac{D0}{256}\right)$$

where DO is the LSB, D7 is the MSB for the inputs, and $I_{re}f$ is the input current that must be applied to pin 14. The $I_{re}f$ current is generally set to 2.0 mA. Figure 13-18 shows the generation of current reference (setting $I_{re}f$ = 2 mA) by using the

standard 5-V power supply and IK and 1.5K-ohm standard resistors. Some DACs also use the zener diode (LM336), which overcomes any fluctuation associated



8051 Connection to DAC808