From Figure 7, we can write that

$$I = \frac{V_{REF}}{3R} \tag{9}$$

From Figure 6, we can see that the current contribution by the LSB = 0.0625I. If the same principle is repeated with DCBA = 0010, DCBA = 0100 and DCBA = 1000, we would find that the respective current contributions would be $0.125I$, $0.25I$ and $0.5I$. Using the principle of superposition, we can therefore write

$$V_{OUT} = -\left(D \times \frac{I}{2} + C \times \frac{I}{4} + B \times \frac{I}{8} + A \times \frac{I}{16}\right) R_F. \tag{10}$$

Substituting (9) into (10) gives

$$V_{OUT} = -\frac{V_{REF}}{3R}\left(\frac{D}{2} + \frac{C}{4} + \frac{B}{8} + \frac{A}{16}\right) R_F. \tag{11}$$

DAC symbol

The symbol for a DAC is shown on Figure 8.

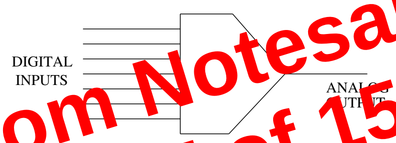

Figure 8: DAC symbol

Preview from Notesale.co.uk
Page 7 of 15

Specifications of DACs

Resolution The smallest change that can occur in the analog output as a result of a change in the digital input. Resolution gets finer with an increase in the number of bits e.g. a 10-bit DAC has a finer resolution than a 4-bit DAC for the same output range. *An ideal DAC should have an infinitely small resolution*.

Linearity In a DAC, equal increments in the numerical significance should result in equal increments in the analog output voltage. In an actual circuit, the input-output relationship is not linear. This is due to errors in the resistor values and voltage drops across the switches. The linearity of a converter is a measure of the precision with which the linear input-output relationship is satisfied. The linearity error is the maximum deviation of the step size from the ideal step size.

When the capacitor has fully discharged, $V_{OUT} = 0$. Substituting this in equation (17) gives

$$t = T_2 = \frac{V_{IN} T_1}{V_{REF}}. \tag{18}$$

Hence

$$\text{discharge time} \propto \text{input voltage } V_{IN} \tag{19}$$

i.e. larger input voltages V_{IN} will require more time to discharge.

The charging and discharging graphs are shown on Figure 14.

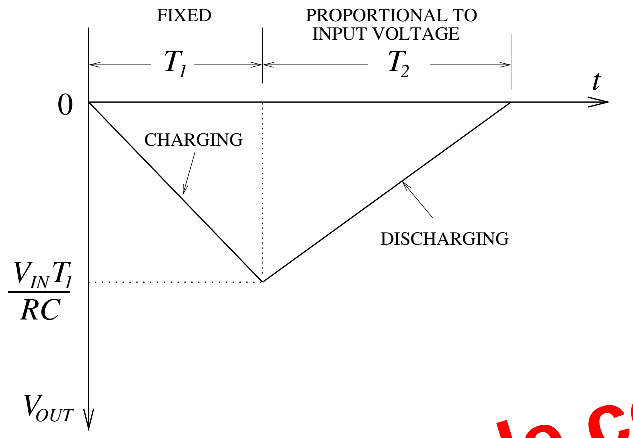

Figure 14: Dual-Slope ADC:charging and discharging graphs

Preview from Notesale.co.uk
Page 13 of 15

For the dual-slope ADC, a comparison of 3 analog input voltages V_1, V_2 and V_3 where $V_1 < V_2 < V_3$ is shown in Figure 15.

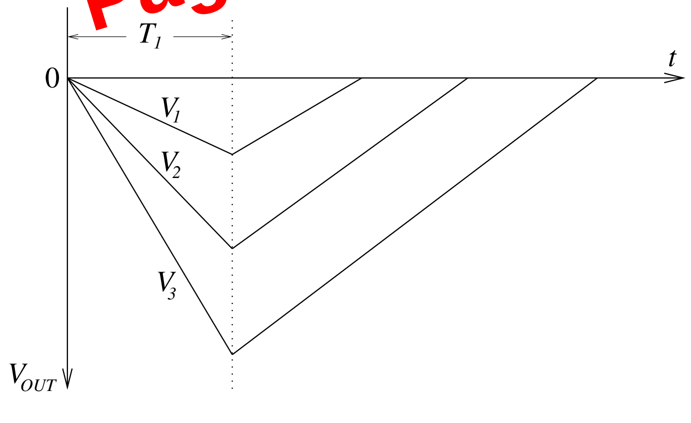

Figure 15: Dual-Slope ADC with analog inputs V_1, V_2 and V_3 where $V_1 < V_2 < V_3$

Dual-slope converters are very accurate , but they are slow as they are essentially counting converters. They are commonly used in digital multimeters, and panel meters where conversion speed is not very important. Advantages of dual slope ADCs compared to other ADCs are simplicity, low cost and relative immunity to noise due to the long conversion time.