If $V_{in} > V_{ref}$ then $V_{out} = V_{cc}$

If $V_{in} < V_{ref}$ then $V_{out} = 0$
A/D Converter Resolution and Quantization

- If the voltage input voltage is 3.2516 V, the lowest 5 comparators will be turned on, and the highest 2 comparators will be turned off.

- The output of the 3-bit flash A/D converter will be 5 (101).

- For a 3-bit A/D converter, which has a range from 0 to 5 V, an output of 5 indicates that the input voltage is between 3.125 V and 3.750 V.

- A 3-bit A/D converter with a 5 V input range has a quantization value of 0.625 V.

- The quantization value of an A/D converter can be found by:

\[ \Delta V = \frac{V_{RH} - V_{RL}}{2^b} \]

where \( V_{RH} \) is the highest voltage the A/D converter can handle, \( V_{RL} \) is the lowest voltage the A/D converter can handle, and \( b \) is the number of bits of the A/D converter.
A 1050 Hz signal sampled at 500 Hz
- The heart of a D/A converter is an inverting op amp circuit

- The output voltage of an inverting op amp circuit is proportional to the input voltage:

\[ V_{\text{out}} = \frac{-RF}{R_0} V_{R0} \]
Digital-to-Analog (D/A) Converters

- An inverting op amp can produce an output voltage which is a linear combination of several input voltages.
Digital-to-Analog (D/A) Converters

- By using input resistors which scale by factors of 2, a summing op amp can produce an output which follows a binary pattern.

\[
V_{out} = \frac{-R_F}{R_0} \left( V_{\text{Ref}} - \frac{2R_F}{R_0} V_{\text{Ref}} - \frac{4R_F}{R_0} V_{\text{Ref}} - \frac{8R_F}{R_0} V_{\text{Ref}} \right)
\]

\[
= \frac{-R_F}{R_0} \left[ V_{\text{Ref}} + 2V_{\text{Ref}} + 4V_{\text{Ref}} + 8V_{\text{Ref}} \right]
\]

\[
= \frac{-R_F}{R_0} V_{\text{Ref}} \left[ 1 + 2 + 4 + 8 \right]
\]
Digital-to-Analog (D/A) Converters

- By using switches on the input resistors, a summing op amp can produce an output which is a binary number (representing which switches are closed) times a reference voltage.

4-Bit Digital-to-Analog Converter

\[ V_{\text{out}} = \frac{-R_F}{R_0} V_{\text{Ref}} \]

\[ B = B_3 B_2 B_1 B_0 \]