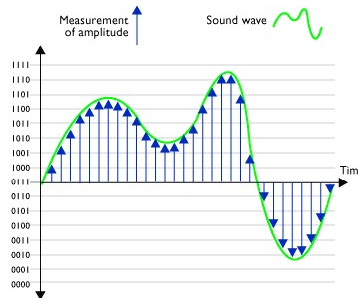
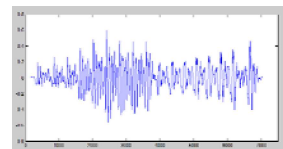


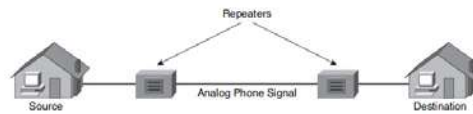
Class 27

Digital & Analog Conversion

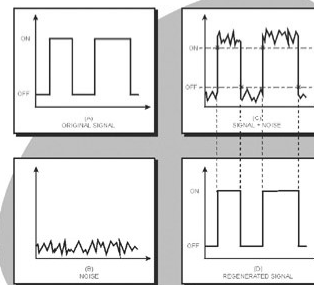


- Information Transmission
 - Voice, audio, image, data
 - Electromagnetic Signals
 - Analog
 - A continuously variable voltage, current or frequency signal.
 - Digital
 - A stream of discrete values that represent a continuously variable signal





Mechatronics
Real Skills Real Jobs



- A/D & D/A Conversion

- **Range** – the span of values being converted
- **Resolution** – the smallest increment of change resolved
 - 4-bit $2^4 = 16$ discrete values
 - 8-bit $2^8 = 256$ discrete values
 - 12-bit $2^{12} = 4096$ discrete values

$$\varepsilon_V = \frac{\Delta V_{fs}}{2^n}$$

Where;

ε_V = voltage resolution

ΔV_{fs} = full scale voltage range

n = A to D conversion bits

- A/D & D/A Conversion

- **Example**
 - **Range** = 2V
 - 4-bit A/D converter
 - Find – voltage resolution

$$\varepsilon_V = \frac{2V}{2^4} = 0.125V$$

$$\varepsilon_V = \frac{\Delta V_{fs}}{2^n}$$

Where;

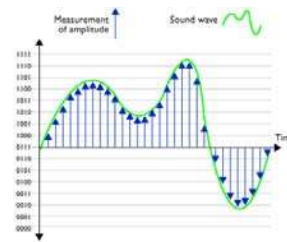
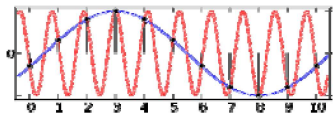
ε_V = voltage resolution

ΔV_{fs} = full scale voltage range

n = A to D conversion bits

- Analog to Digital Conversion

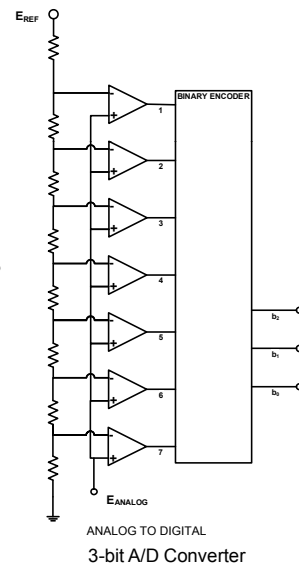
- Nyquist Rate – sampling at $> 2 \times$ highest frequency
 - CD audio – 44.1 kHz sampling rate
 - Human range 20 to 20 kHz
- Prevents aliasing, provides high fidelity



- Analog to Digital Conversion

- Example - data transfer rate
 - 12-bit resolution
 - 44.1 kHz sampling rate
 - Find the data transfer rate in Kbps

$$\text{Transfer_Rate} = \text{resolution} \times \text{sampling_rate}$$



- Analog to Digital Conversion
 - Errors
 - Saturation – analog value exceeds reference
 - Resolution – between bit values
 - Conversion – nonlinearity, zero-offset, scale, hysteresis
 - Accuracy considerations
 - Sampling rate
 - Signal conditioning

- Digital to Analog Conversion

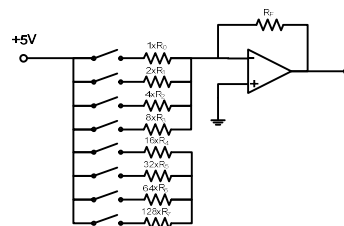
- Resistor network + Op Amp

- Input resistors = $R \times 2^N$
 - N = bit number
 - Feedback resistor
 - Scales output voltage
 - Example
 - $R_f = 5k\Omega$, $R_0 = 5k\Omega$
 - Find bit 3 output

$$R_3 = R \times 2^3 = 5k\Omega \times 2^3$$

$$V_{out} = V_{in} \times \frac{R_f}{R_{in}}$$

$$V_{out} = 5V \times \frac{5000\Omega}{40k\Omega}$$



● Lab 27 – A/D & D/A Conversion

Learning Objectives

- Build and test an op amp D to A conversion circuit
- Build & test an A to D converter using an integrated circuit

		Points Possible
Documentation	Quality of documentation (completeness, neatness, clarity, spelling, grammar, research, calculations shown)	10
Digital to Analog Conversion	Circuit output verified with signature	5
	Scatter plot created and accurate, percent error calculated & accurate	5
Analog to Digital Conversion	Circuit output verified with signature	5
	Scatter plot created and accurate	5
Conclusions	Questions answered completely & accurately	15
	Total	45