Analogue Electronics

Waveforms

$V(t) = V_{DC} + V_0 \sin(\omega t + \phi)$

Sine Waveforms

$v(t) = V_0 \sin(\omega t + \phi)$

$= \frac{1}{T}\int_0^T \sin(\omega t + \phi)\, dt$

for sine waveform through origin $V_{DC} = 0$

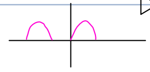
Sine r.m.s

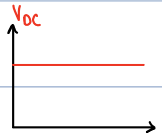
$V_{rms} = \frac{V_{0-pk}}{\sqrt{2}}$

$I_{rms} = \frac{I_{0-pk}}{\sqrt{2}}$

r.m.s value: equivalent amplitude of D.C.-only signal for which resistor dissipate same power

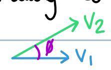
sine passing through diode (+ve only)





Phasors

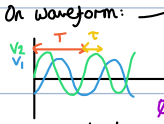
- rotating vectors



Magnitudes are V_2 and V_1 length

ϕ, angle between is phase difference

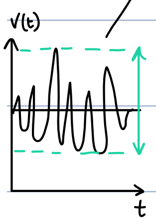
On waveform:

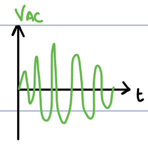


V_2 is leading

V_1 lagging

$\phi = \frac{\tau}{T} \times 2\pi$





$V_{peak-peak} = V_{max} - V_{min}$

$V(t) = V_{DC} + V_{AC}$

Mean value $(\bar{V})$

$= \frac{1}{t_2 - t_1}\int_{t_1}^{t_2} V(t)\, dt$

Slew Rate

$\max\left(\left|\frac{dv}{dt}\right|\right)$

→ gradient of V-t waveform

square wave ≈ ∞

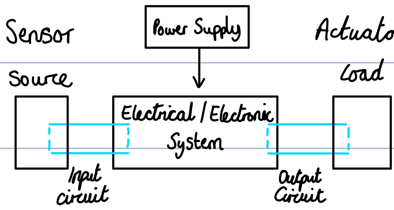
for non-periodic waveform: period / frequency doesn't apply

→ slew rate can still be defined

→ not found mathematically, only by observing signal for long time.

Complete System

Sensor — Source; Power Supply; Actuator — Load



Types

inductive (Henry)

Capacitive (Farad)

Resistive (ohms)

change electrical parameter from physical quantity

generate electric energy from other forms of energy

Piezoelectric (strain)

Photoelectric (light)

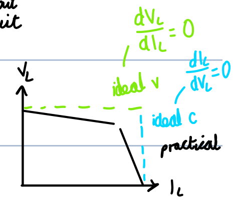
Inductance (magnetic field)

Capacitance (electric field)

Sensors

monitor physical input, output electrical signal

Thevenin and Norton Equivalents



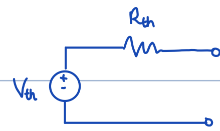
Ideal Voltage source:

- Zero resistance

→ all voltage dropped across circuit

Application of load doesn't change values

Series voltage source

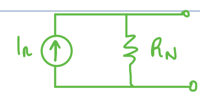


Ideal current source:

- infinite resistance

→ doesn't react to applied voltage

Parallel, current source



Method:

- R_{Th}: zero all sources and calculate equivalent total resistance

→ Voltage source = short (as V $R_{int} = 0$)

Current source = open (as I $R_{int} = \infty$)

- $V_{th} = V_{OC}$ → remove load and calculate voltage across open output

- $I_N = I_{SC}$ → short output and calculate I through short

Features

Never perfect reflection of associated quantities

→ noise, interference and distortion

Small signals

→ insufficient power drive actuators

Processing

Interpretation

Display

Actuation

Storage

Amplification

Filtering

described by transfer function

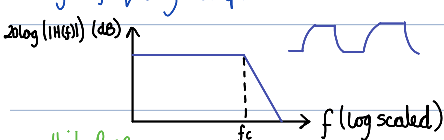
$H(f) = \frac{V_{out}(f)}{V_{in}(f)}$ in freq. domain

or $|H(f)|\,(dB) = 20\log_{10}\left(\left|\frac{V_{out}(f)}{V_{in}(f)}\right|\right)$

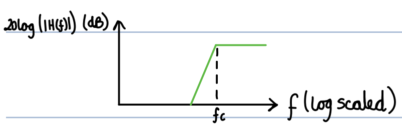
dB scaled gives straight line approximations

Low Pass - lets low, pass

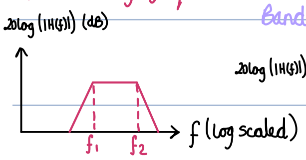
- Attenuates and phase shifts higher frequency components



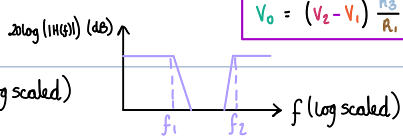
High Pass



Band Pass - allows band of freq.

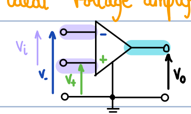


Band Stop



Op-Amps

- 'ideal' voltage amplifiers



- differential input, single-ended output

$V_0 = A_V(V_+ - V_-)$

Characteristics

$R_o = 0$

↳ V_o unaffected by load value

$R_i \approx \infty$

↳ draws no current from source

→ $I_i = 0$

→ $V_i = 0$

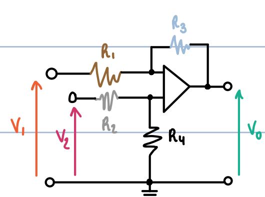
$V_{gain}\ (A_V) \approx \infty$

↳ voltage ranges limited by PSU clipping

Differential amp

- Subtracts one signal from another

- Input voltages determined by potential dividers formed by external resistors



$V_0 = (V_2 - V_1)\frac{R_3}{R_1}$

Unity Gain Buffer

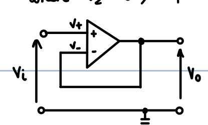
(aka V follower / V buffer)

- Non-inverting

- Gain = 1

↳ buffer

- Extreme of non-inverting where $R_2 = 0$, $R_1 = \infty$



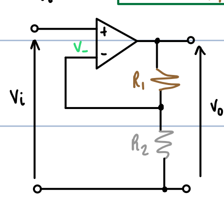
Non-Inverting amp

$V_- = V_+ = V_i$

↳ determined by R_i and potential divider formed by R_1 and R_2

$V_- = V_i = V_o \frac{R_1}{R_1 + R_2}$

$G_V = \frac{V_o}{V_i}$ → $G_V = 1 + \frac{R_2}{R_1}$



Inverting amp

- Changes polarity

- Controlable input R

-ve feedback forces $V_- = V_+$

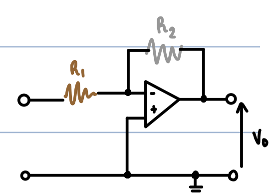
↳ maintains $V_- = 0V$

↳ virtual earth amplifier

- Currents I_1 and I_2 equal and opposite

↳ $\frac{V_o}{R_2} = -\frac{V_i}{R_1}$

∴ $G_V = -\frac{R_2}{R_1}$



Cascading Amps

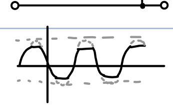
- Amps in series:

$A = A_1 \times A_2 \times A_3$

$A(dB) = A_1(dB) + A_2(dB) \ldots$

increases amp.

Clipping: limits max range of signal → e.g



sine clipped → square