Instrumentation: Operational Amplifiers

Medical Electrical Equipment (BME590L)

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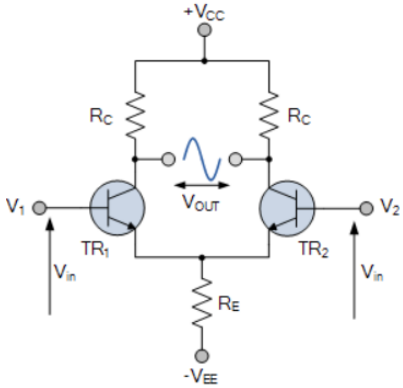
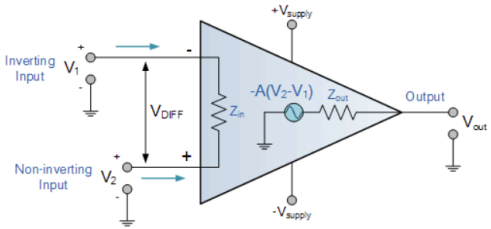
BJT Differential Amplfier



Operational Parameters

- Common Mode Gain: Gain when $V_1 = V_2$
- Common Mode Rejection Ratio (CMRR)

Ideal Operational Amplifier Model



- Open Loop Gain (A_{VO}) $\rightarrow \infty$
- Input Impedance (Zin) $\rightarrow \infty$
- Output Impedance ($Zout$) $\rightarrow 0$
- Bandwidth $\rightarrow \infty$
- Offset Voltage $\rightarrow \infty$

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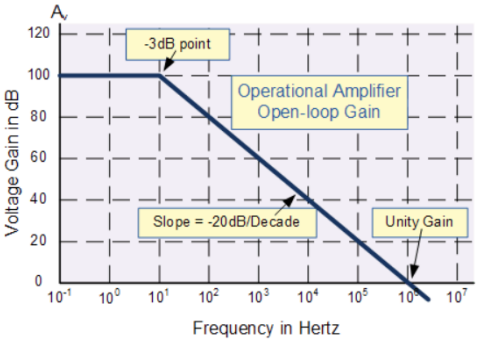
Realistic Op Amps



Gain Bandwidth Product

- Output current is very limited (not a power source!)
- Output voltage limited to $\pm$ supply voltages

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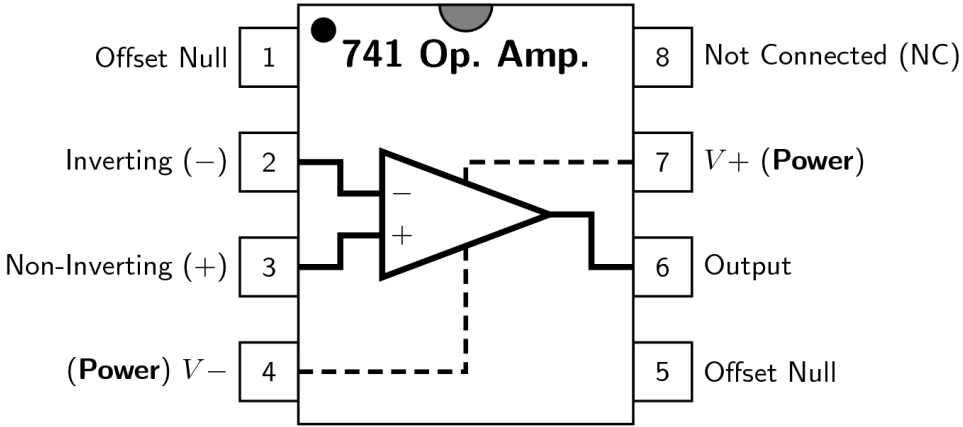
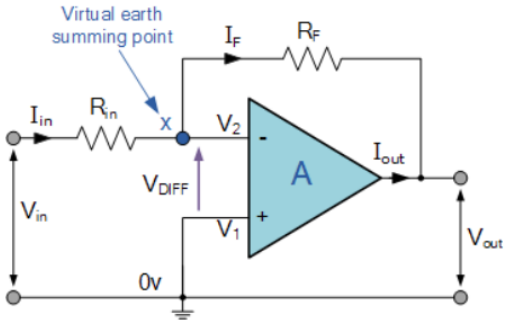
741 Pinout


741 Op. Amp.
Offset Null
1
Inverting (−)
2
Non-Inverting (+)
3
(Power) V−
4
8
Not Connected (NC)
7
V+ (Power)
6
Output
5
Offset Null
−
+

Negative Feedback: Inverting Amplifier



- Negative Feedback
- $V_- = V_+$
- Gain = $\frac{V_{out}}{V_{in}} = -\frac{R_f}{R_i}$

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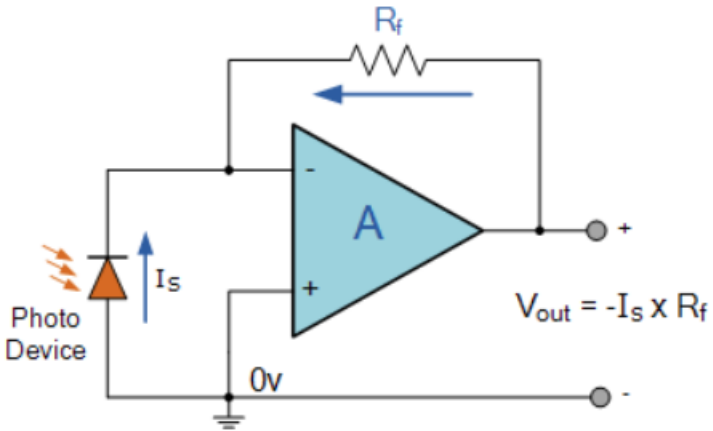
Transimpedance Amplifier



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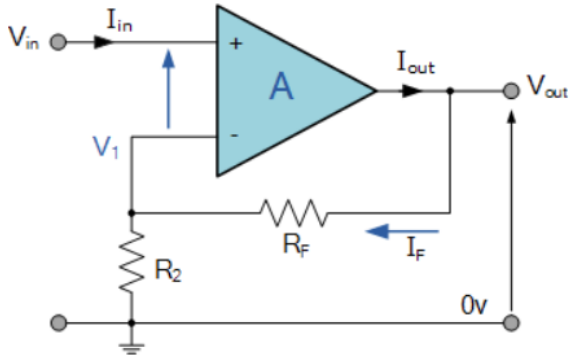
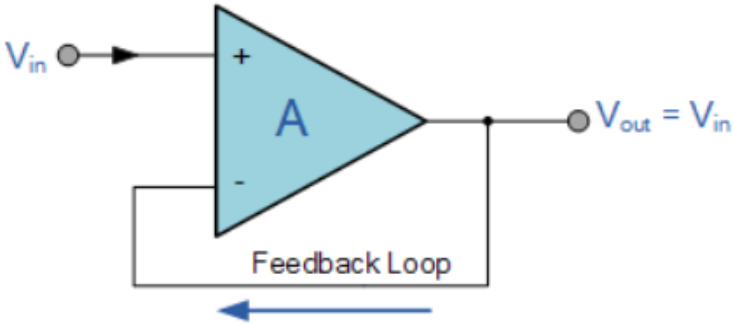
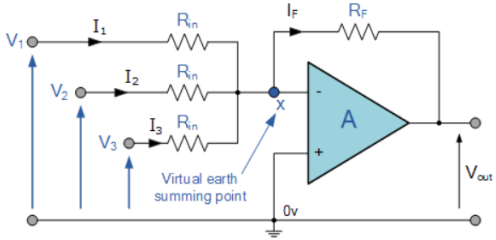
Non-Inverting Amplifier



Buffer / Follower

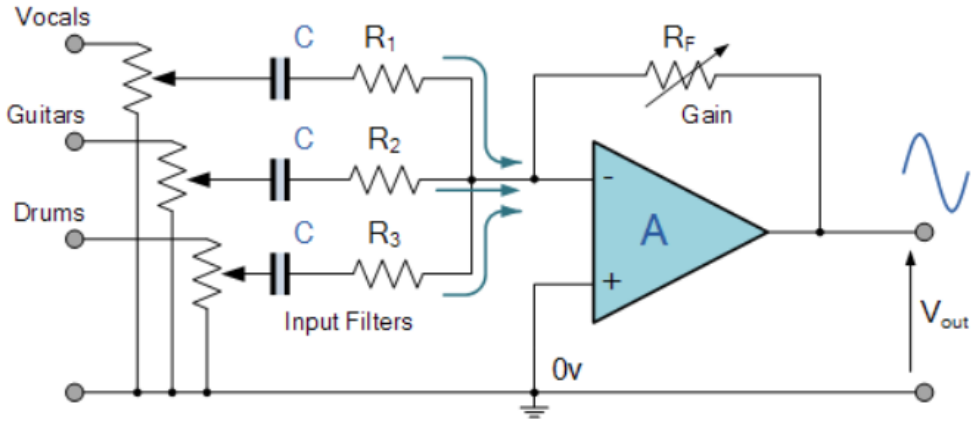


Summing Amplifier (Inverting)

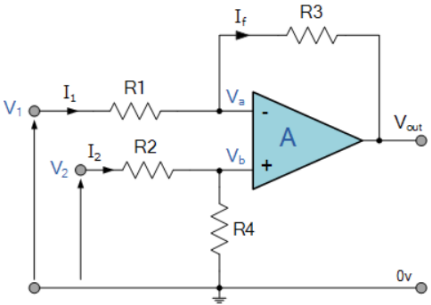


- Can weight sums with different R_{in} / branch.
- R_f controls overall gain.
- Finite input impedance.
- This was the R-2R DAC!

Audio Mixer


Vocals
Guitars
Drums
C
R1
C
R2
C
R3
Input Filters
RF
Gain
-
+
A
Vout
0v

Differential Amplifier



- If $R_1 = R_2$ and $R_3 = R_4$, $V_{out} = \frac{R_3}{R_1}(V_2 - V_1)$
- Finite input impedance.
- Hard to find equal pair resistors to adjust gain!

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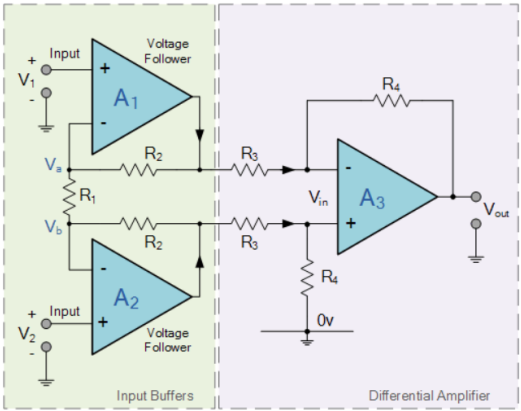
Instrumentation Amplfier



- Buffered input impedance.
- Single ΔR gain (R_1).
- $V_{out} = (V_2 - V_1)[1 + \frac{2R_2}{R_1}](\frac{R_4}{R_3})$

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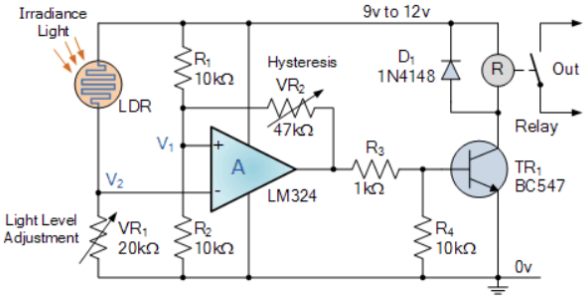
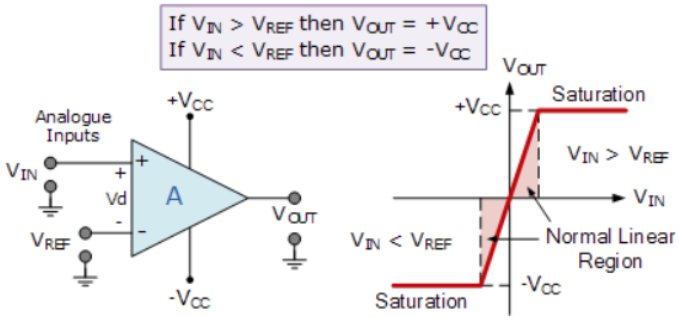
Light-Activated Relay



Comparator



- Large open-loop gain pushed output to rails
- Remember: Flash ADC

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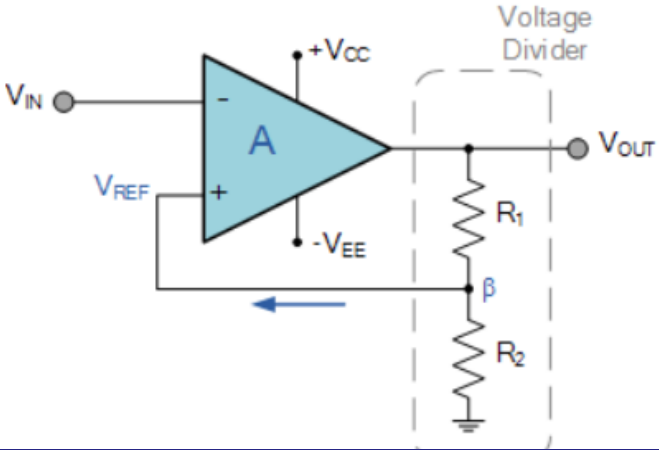
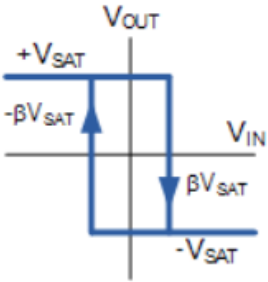
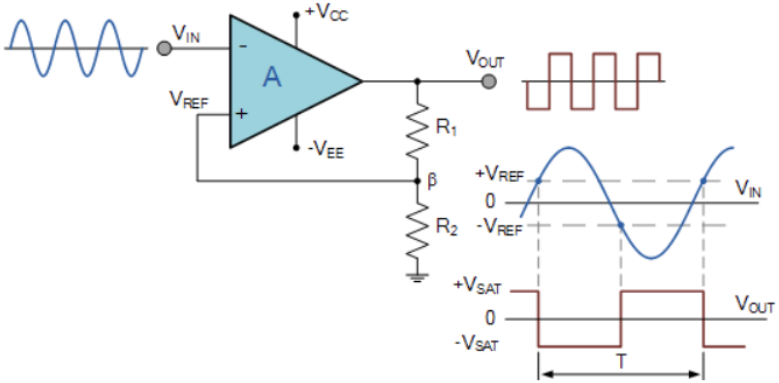
Schmitt Comparator (Hysteresis)

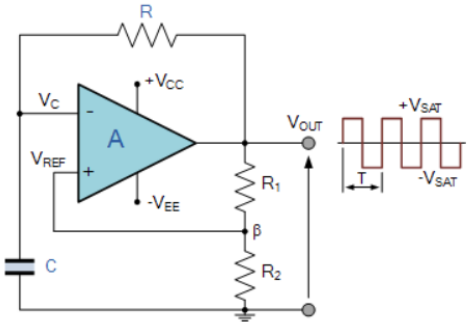


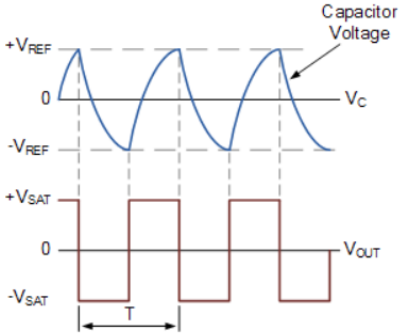


Sine-to-Rect Converter



Multivibrator





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Before next lecture...

- Read chapter on operational amplifiers.
- Make sure that you understand how all of these circuits work.

References

- `Practical Electronics for Inventors`, Chapter 8 (Operational Amplifiers)
- `https://www.electronics-tutorials.ws/opamp`