OPERATIONAL AMPLIFIERS

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- Differential Amplifiers: Amplifies input voltages between inverting and non-inverting terminals.
- High input impedance
- Low output impedance
- Vout = A *[Vin(+) - Vin(-)]
- Ideally gain is infinity. In reality it's around 10e6
- So for even small difference in input voltage the output voltage saturates to the supply voltages. (~5V)
- Gain and frequency are inversely related
- Feedback (negative) is most of the time applied to inverting terminal to control the open loop voltage gain.

ASSUMPTIONS:

1. Vin(-) and Vin(+) should always have the same voltage.
2. There is no input currents

OPERATIONAL AMPLIFIERS: REAL WORLD COMPLICATIONS

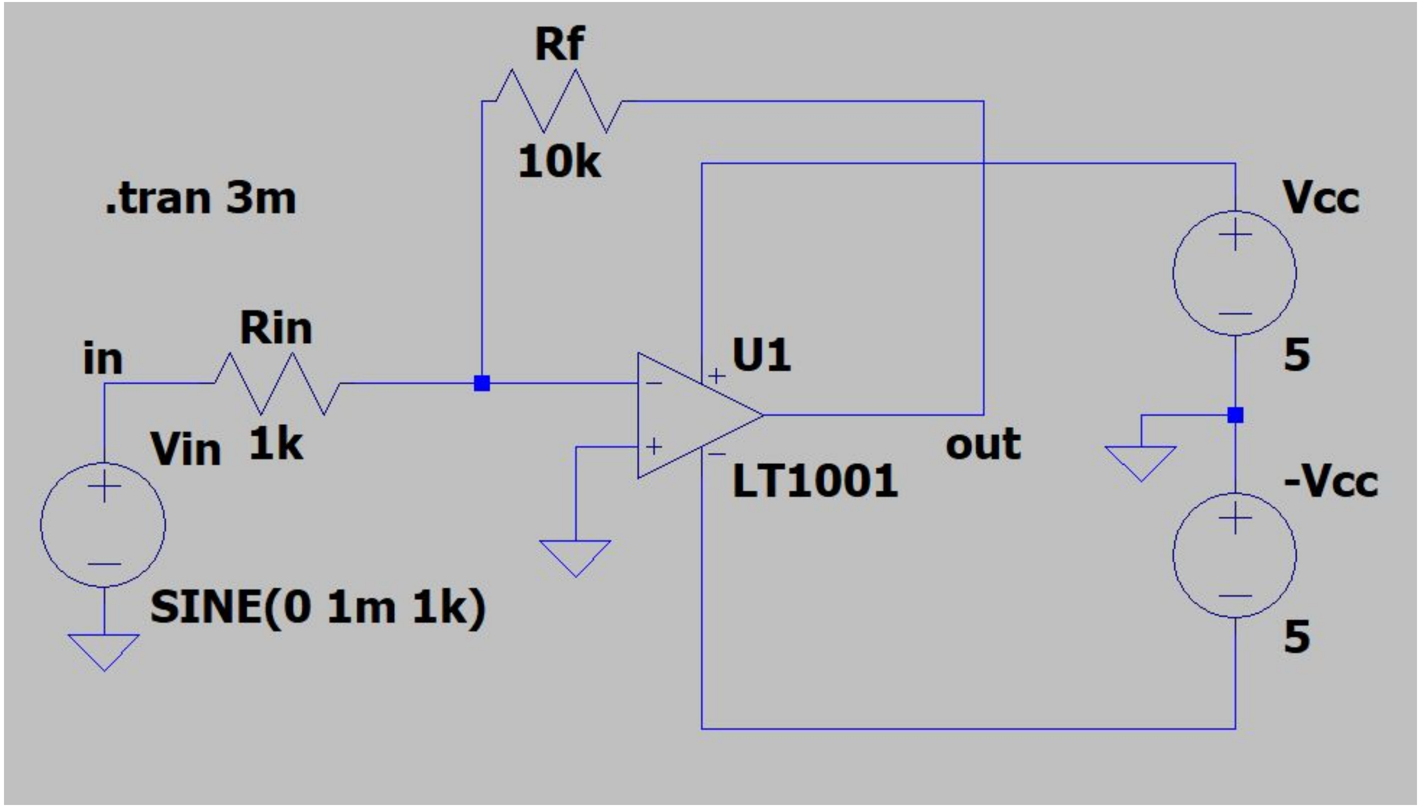
- **Rail to Rail amplifiers** -> swing is bound by supply voltages V(+) and V(-). For higher voltage op amps there is a headroom above an below these bounds.
- **Offset Voltage:** Minute difference Vin(+) and Vin(-).
- **Input bias current:** Current into terminals.
- **Slew Rate**: Rate at which voltage changes in a non instantaneous manner.
    - Slew rate = 2*π*Vpeak*fmax (usually in V/us)
- **Bandwidth**: points beyond where op amp is not fast enough to reproduce singal, i.e. slew rate is not fast enough

BASIC CIRCUITS

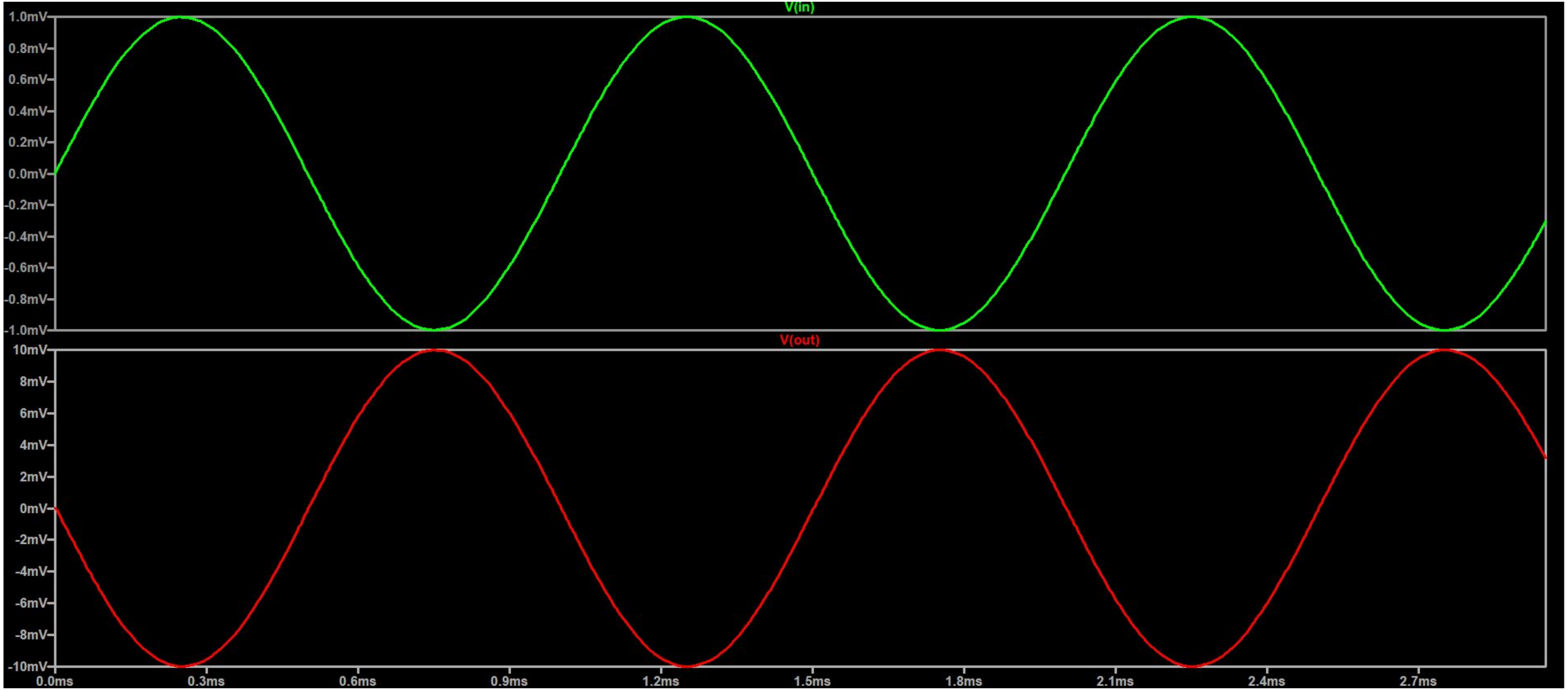
INVERTING AMPLIFIER

G = -Rf / Ri =
10e3 / 1e3 = -10

Input impedance
= R1

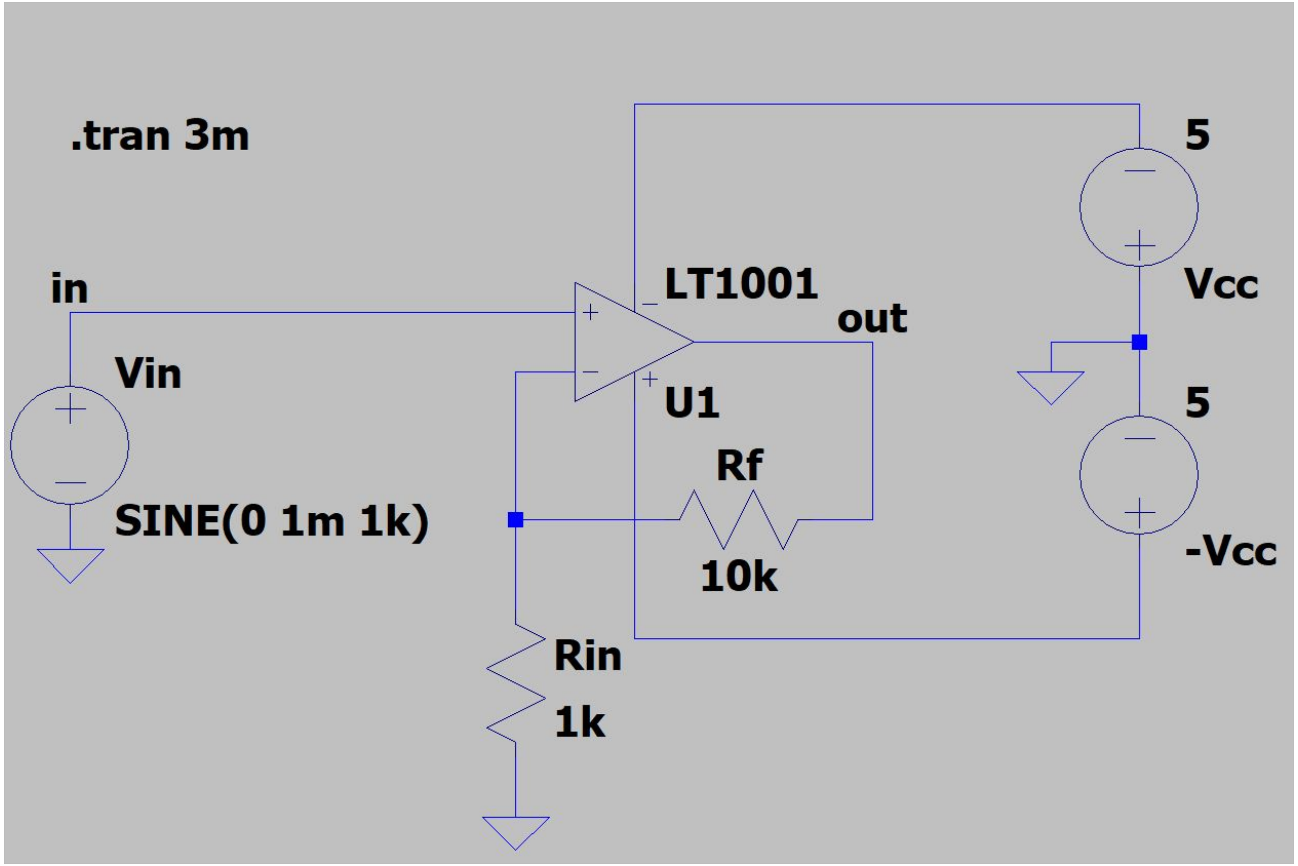


INVERTING AMPLIFIER



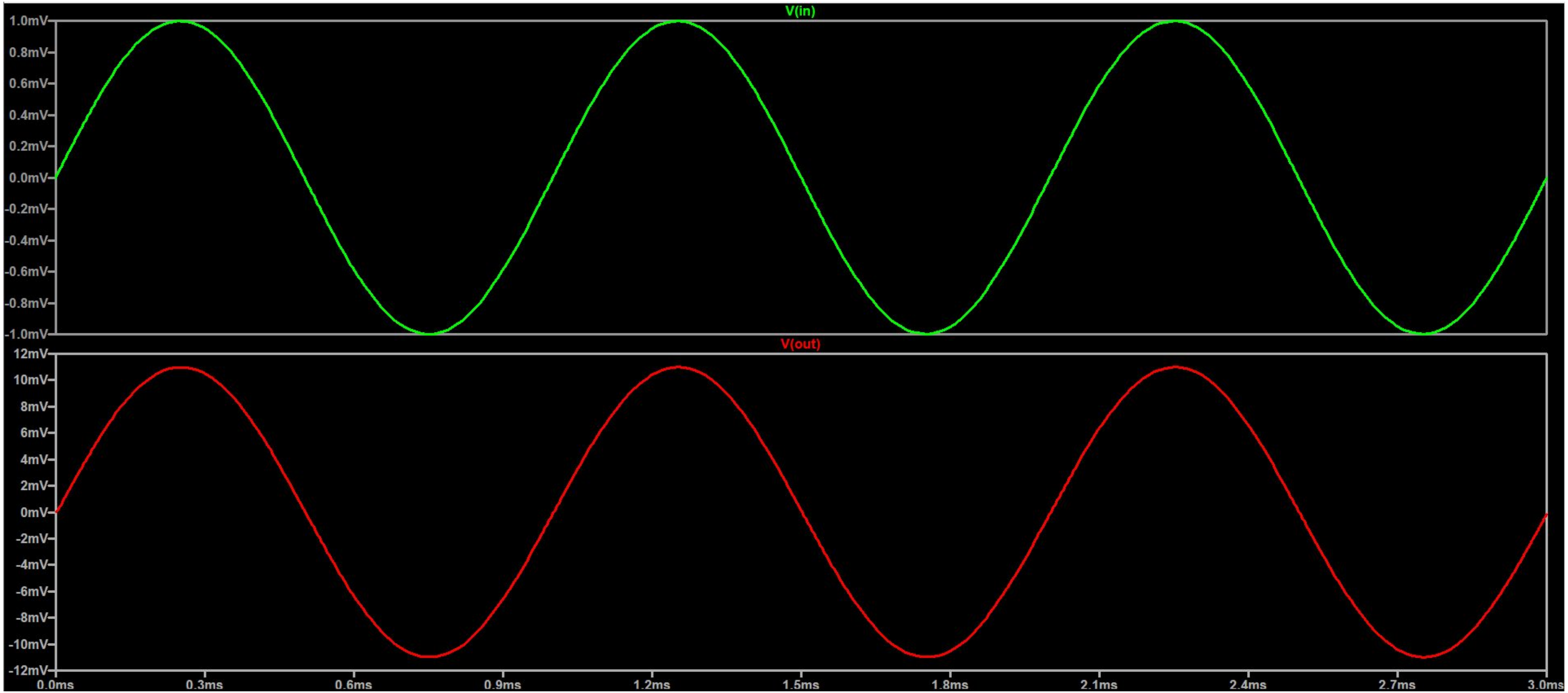
NON-INVERTING AMPLIFIER

G = 1+ Rf / Ri =
1 + 10e3 / 1e3 =
11



Input impedance is high equal to op amp impeadance

NON-INVERTING AMPLIFIER



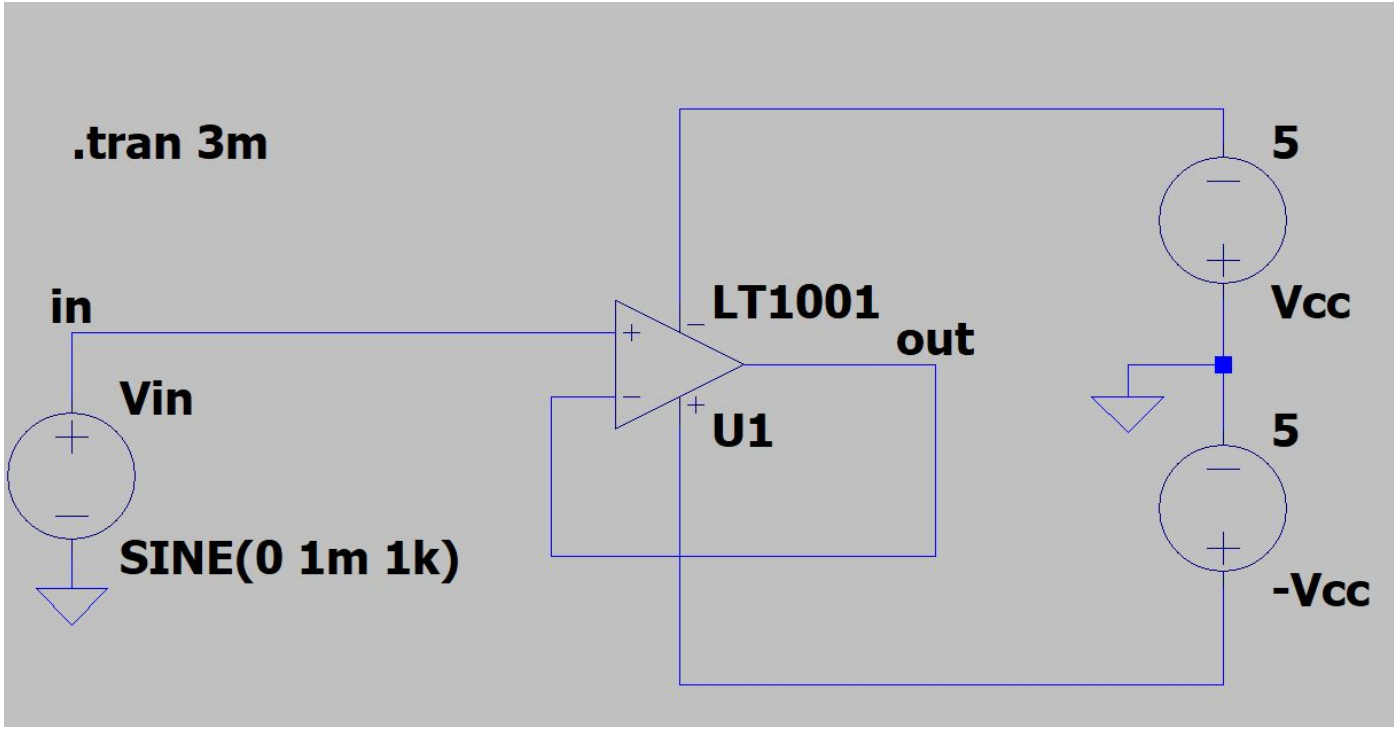
VOLTAGE FOLLOWER / BUFFER

Ri=infinity
Rf = 0
Gain = 1

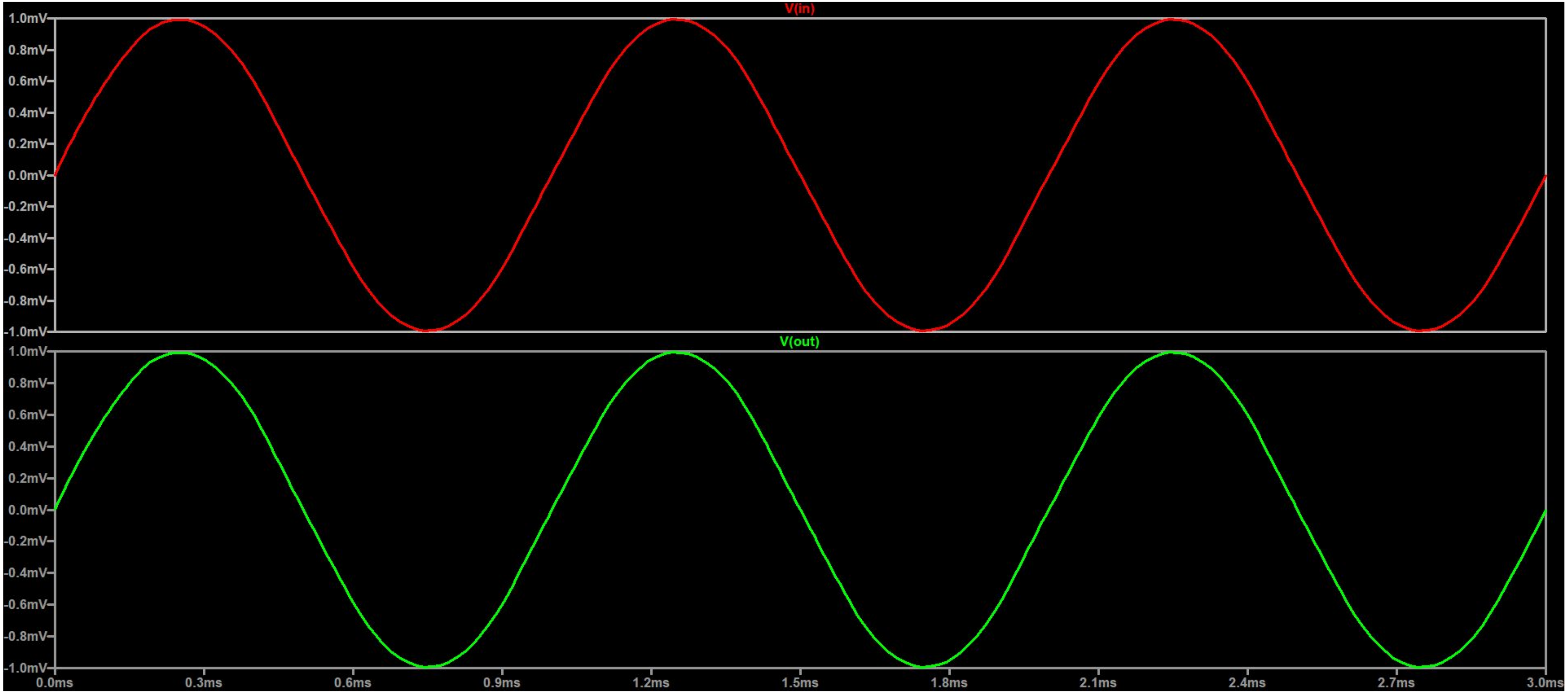
Output voltage follows input voltage.

Input impedance is equal to op amp gain.

So it acts as buffer, i.e.separating input and output circuits with high impedance but with same voltage.

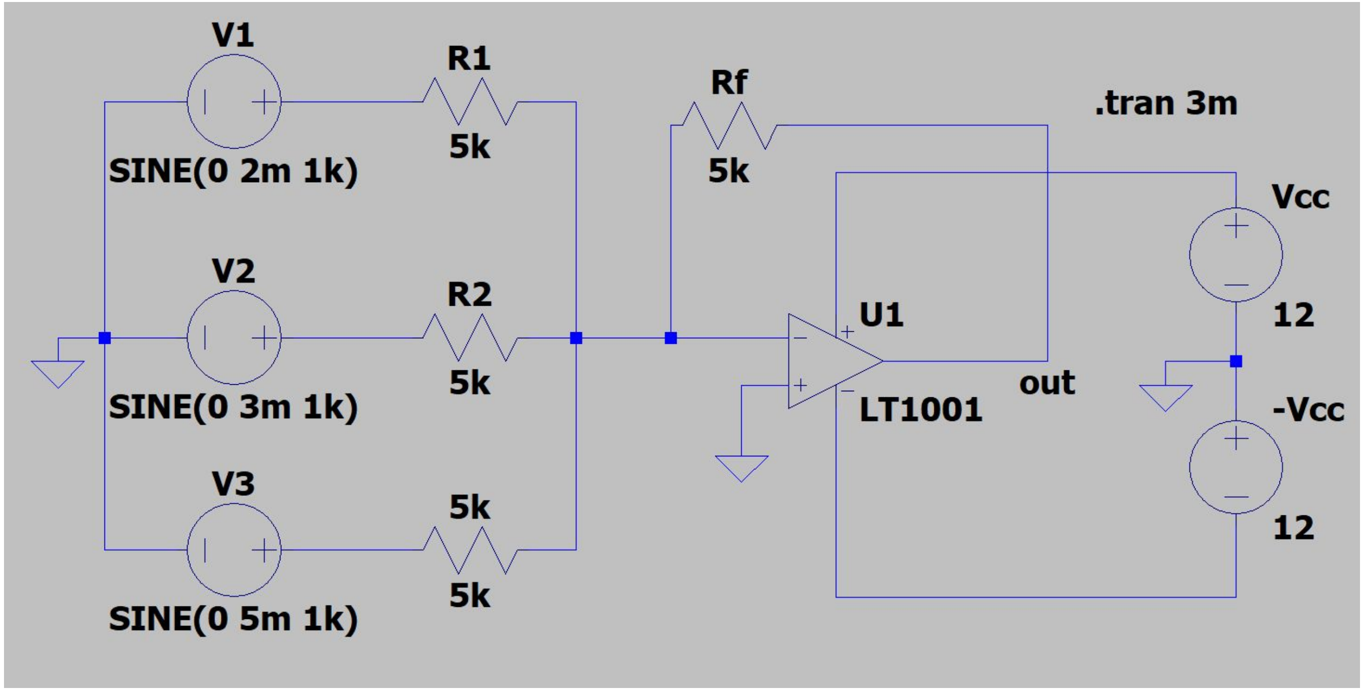


VOLTAGE FOLLOWER / BUFFER



SUMMING AMPLIFIER

Vout = -Rf[V1/R1 + V2/R2 + V3/R3]
= 5k*[2m/5k + 3m/5k + 5m/5k]
=10mV



SUMMING AMPLIFIER