ELECTRICAL LIMITATIONS

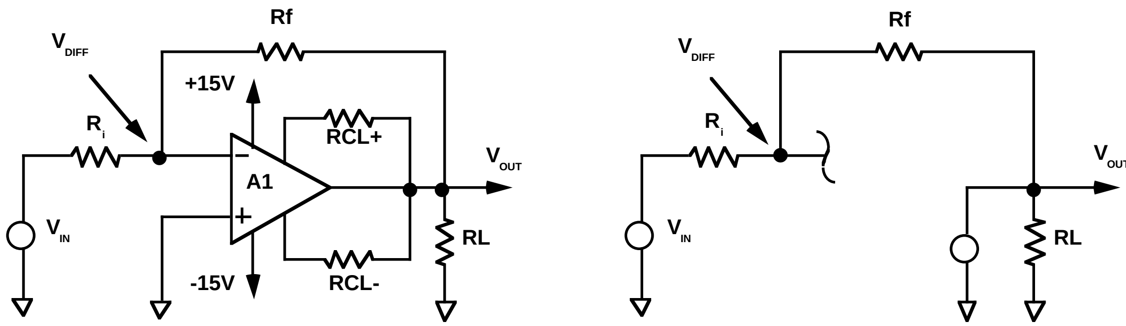
EFFECTS ON THE AMPLIFIER

- Slew Rate Limiting
- Output Saturation
- Current Limiting
- Shut Down
- Common Mode Requirements

Power amplifiers and small signal op amps share many limitations. Understanding the limitations of a standard op amp will help you design more accurate, reliable circuitry. It helps to have a good understanding of what happens to an amplifier when it operates outside of its linear region. Most of these electrical limitations can be traced to this common denominator.

NON-LINEAR OPERATION

OPEN LOOP MODEL

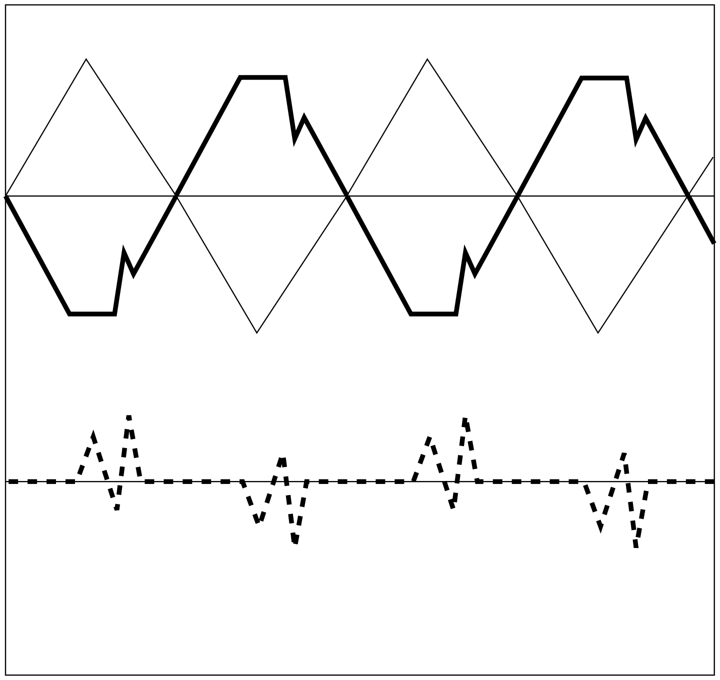


CLOSED LOOP OPEN LOOP

When an amplifier is operated in a closed loop it exhibits linear behavior. A violation of any of the limitations mentioned earlier will effectively open the loop. Once the loop is opened, Vin and Vout appear as two independent voltage sources. Rf and Ri function as a simple voltage divider between the two resistors. This voltage appears as a differential input voltage. In cases where the output stage is in a high impedance state, such as power off or thermal shutdown, Vout goes away and Vin is divided down by the series combination of Rin, Rf and Rload.

NONLINEAR BEHAVIOR

OUTPUT SATURATION & CURRENT LIMIT



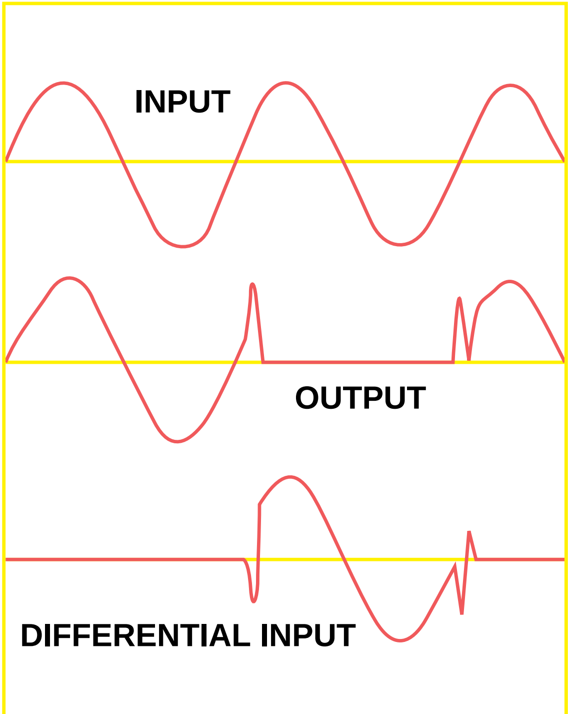
INPUT

OUTPUT

Vdiff

Output saturation and current limit exhibit similar behavior — clipping on the amplifier output. This clipping produces differential input voltages.

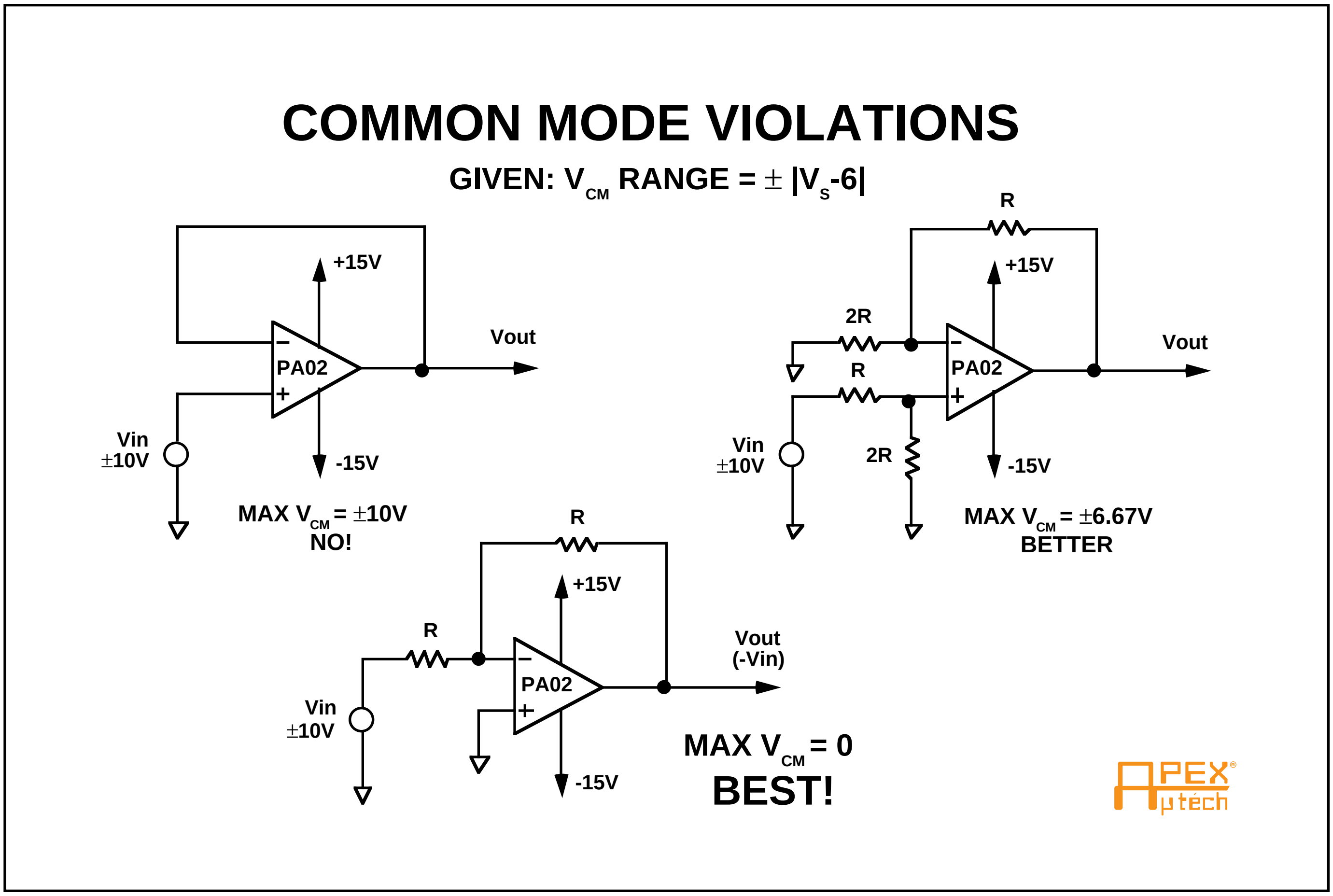
Any type of clipping can result in an overdriven condition internal to the amplifier. This can lead to recovery problems ranging from simple long recovery to ringing during recovery.



NONLINEAR BEHAVIOR

THERMAL
SLEEP
MODE

The situation with sleep mode is similar to thermal shutdown. In both cases, the amplifier is disabled by some circuitry which results in the output going into a high impedance state. One additional caution is that when coming out of sleep mode, an amplifier may saturate to one of the rails before recovering.



In an inverting configuration, the op amps non-inverting terminal is usually tied to ground, making the inverting terminal a "virtual ground." This results in zero common mode voltage: a desirable benefit. However, operating the amplifier in a non-inverting mode results in the common mode voltage being equal to the voltage at the non-inverting terminal.

The schematics above illustrate the problem. The amplifier used in this example cannot have any common mode voltage that approaches within 6 volts of either supply rail. The first example shows a unity gain follower. This is the configuration where common mode violations are most common. Note that the input voltage is equal to the common mode voltage. In our example the input voltage exceeds the common mode range.

In the second example the input signal is first attenuated and then gained back up to result in a lower common mode voltage but a unity gain non-inverting transfer function. That is:

$$V_o = V_i(2R/(2R+R))(1+R_f/R_i)$$
$$\text{where } R_f = R \text{ and } R_i = 2R$$

The third example shows the best approach to eliminating common mode violations: use inverting configurations. In this case the input voltage is still 10 volts, the output voltage is 10 volts, but the common mode voltage is zero, eliminating the problem. Of course this does invert the phase of the output signal.