Slew Rate of Op Amp Circuits

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The slew rate (SR) is defined as the maximum rate of change of the output of an op amp circuit. The SR in general describes the degradation effect on the high frequency response of the active amplifier (one with an op amp) near or at the rated maximum output voltage swing. This effect is generally due to the compensating capacitor and not to the transistor circuits internal to the op amp. In short, the SR effect is due to the maximum supplied current available for charging up the compensating capacitor.

We know that the current required to charge a capacitor is

$$i = C\frac{dv}{dt} \tag{1.1}$$

The Slew Rate is found from

$$\text{SR} = \frac{dv}{dt}_{\max} = \frac{i_{\max}}{C} \tag{1.2}$$

Suppose that an op amp has a maximum output current of 1 ma. If the compensating capacitor is 1000 pF, the Slew rate is

$$\text{SR} = \frac{1 \text{ ma}}{1000 \text{ pF}} = 10^6 \text{ V/s} = 1 \text{ V}/\mu\text{s}$$

Consider the following example. Suppose that the input signal to a 741-based unity gain amplifier configuration is a 20kHz sine wave. What is the largest possible amplitude of the input signal to avoid distortion due to slewing?

From a spec sheet, we know that the SR for a 741 is $0.5 \text{ V}/\mu\text{s}$. If the input voltage is $v_i(t) = M \sin 2\pi ft$, and the magnitude of the gain at that frequency is unity, then the derivative of the output is found as

$$\frac{dv_0(t)}{dt} = M 2\pi f \cos(2\pi ft)$$

The Slew Rate is found as the maximum of this derivative, or

$$\text{SR} = 2\pi fM$$

or

$$M = \frac{SR}{2\pi f} = \frac{0.5}{2\pi 20,000} = 3.98 \text{ Volts}$$