Pushing and Pulling

As if oscillators didn't already have enough **problems** (e.g., spurs, phase noise, frequency drift) we must consider **two** more!

1. Frequency **Pushing**

2. Frequency **Pulling**

Let's first tackle **pushing**.

Frequency Pushing

Every oscillator needs a **power supply**! Oscillator output power must come from somewhere—typically, this somewhere is a **D.C. voltage** source.

Unfortunately, the operating frequency ω_0 of an oscillator is **sensitive** to this supply voltage. In other words, as the D.C. supply voltage **changes**, the output frequency can also **change**.

We call this phenomenon **frequency pushing**.

Frequency pushing is expressed in terms of **Hz/V** or **Hz/mV**, and can be **either** a positive or negative value.

For example, consider an oscillator with frequency pushing of **-500 Hz/mV** .

If its power supply voltage increases by **20 mV**, then the operating frequency will **change** by:

$$(20\ mV)\left(-500\ \frac{Hz}{mV}\right) = -20{,}000\ \text{Hz}.$$

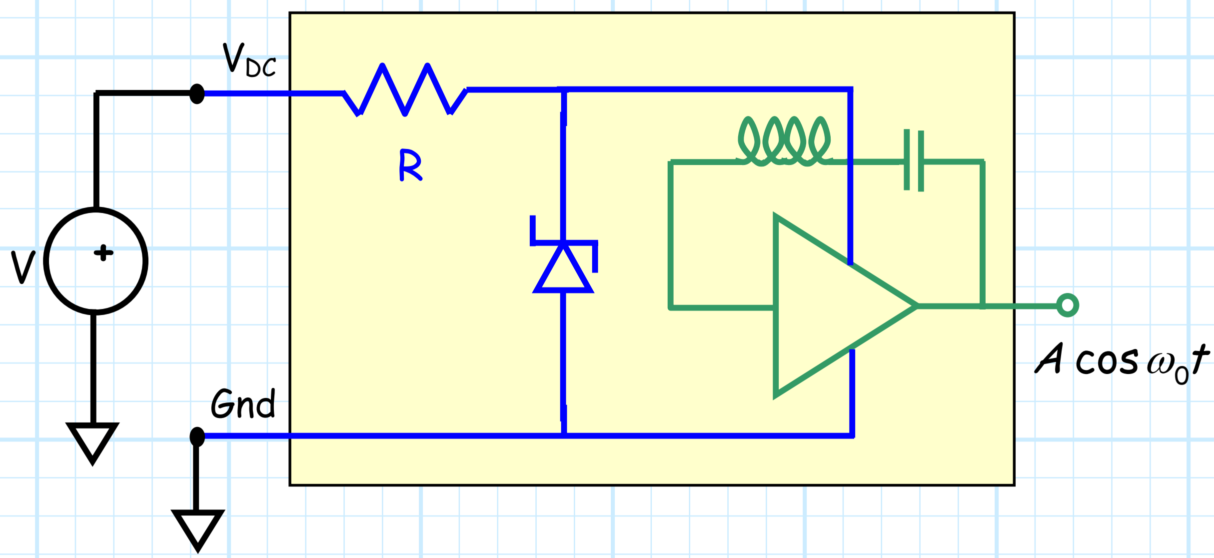
In other words, the operating frequency will **drop** by **20 kHz**!

The effect of frequency **pulling** can be **minimized** by:

1. Using a **high-Q** resonator.

2. **Regulating** the power supply voltage **very** well.

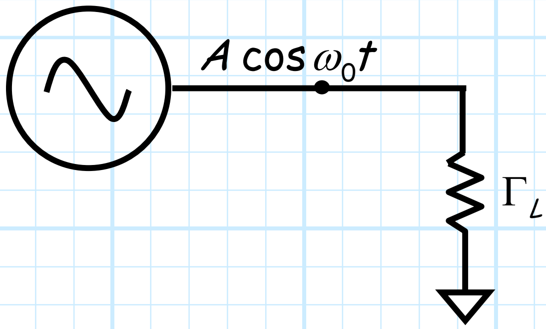
The **best** (and thus most expensive) oscillator devices will employ their own (shunt) **voltage regulator**, right at the oscillator circuit!



Pick a **zener** diode such that the **line regulation** is small !

Frequency Pulling

The output of an oscillator will **always** be attached to **something** (otherwise, what's the point?).



Unfortunately, the **impedance** of this load can affect the operating **frequency** of the oscillator! As Γ_L changes, so can the frequency ω_0 (e.g., $\omega_0(\Gamma_L)$).

This phenomenon is called **frequency pulling.**

The oscillator is designed assuming that the load is **matched**, so that the specified oscillator frequency typically represents the case when $\Gamma_L = 0$.

Frequency pulling is specified as the **maximum deviation** from this nominal frequency, given some **worst case** load.

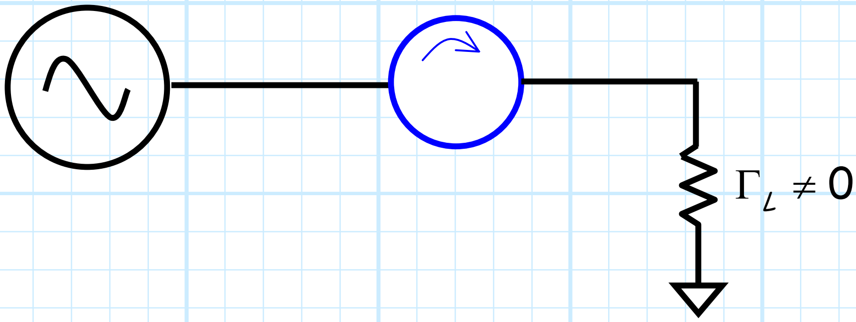
For example, a frequency pulling **specification** might read:

"less than 2 kHz at VSWR = 2.5"

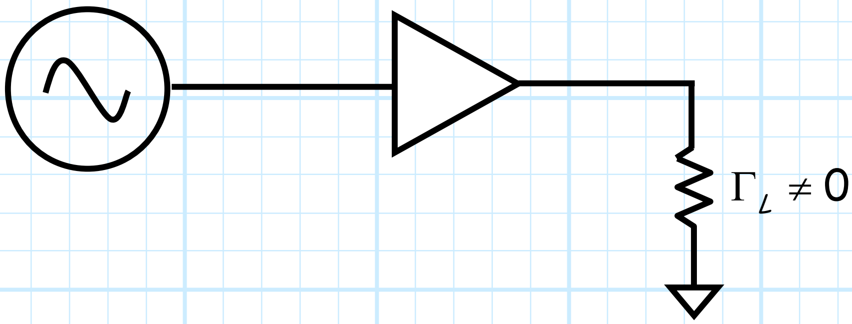
or

" no more than 5 kHz at 10 dB return loss"

We can minimize frequency pulling by **isolating** the oscillator from the load. E.G.,:



Recall that an amplifier typically has very large **reverse isolation**, so that we can use it to isolate the oscillator as well:



In either case, the oscillator "thinks" it is delivering its power to a **matched** load. The frequency of the oscillator will therefore be its nominal (i.e., matched load) value, even though the load may be poorly matched.

Q: ***Why*** *would the load be* ***poorly*** *matched? Wouldn't we want to deliver the oscillator power to some* ***matched*** *device, like a coupler or amplifier or filter ?*

A: Actually, one of the most **common** devices that an oscillator finds itself attached to is the **Local Oscillator** (LO) port of a **mixer**—a port that has a notoriously **poor** return loss.

Frequency **pulling** can be a real **problem**!