Pushing and Pulling

As if oscillators didn't already have enough **problems, e.g.:**

* spurious signals
* phase noise
* frequency drift (in *ppm*!)

we must now consider **two** more annoyances!

1. Frequency **Pushing**
2. Frequency **Pulling**

→ Let's first tackle **frequency 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.

An example

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:

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

→ In other words, the **carrier** frequency will **drop** by **20 *KHz***!

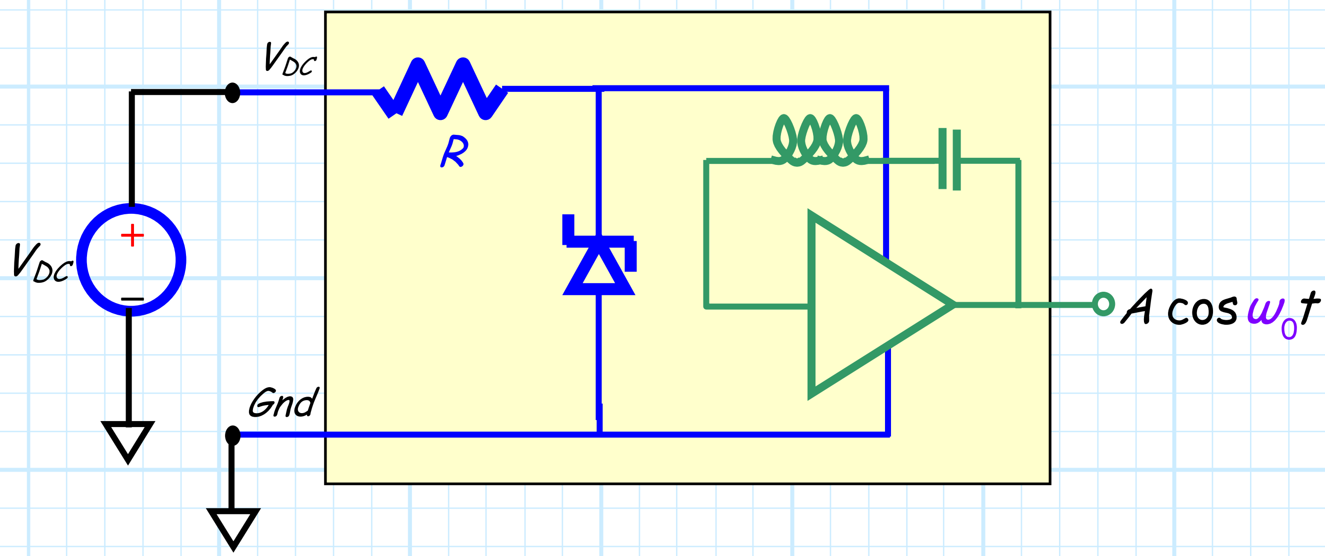
Regulate the voltage!

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

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

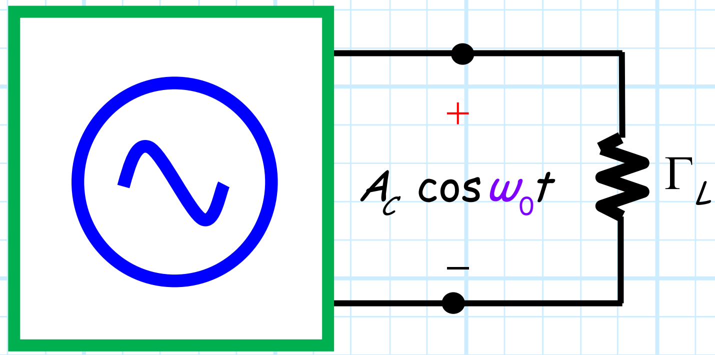
2. **Regulating** the power supply voltage **very** well.

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



We always attach a load—of some type

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



A microwave oscillator is typically designed as a **matched device** (i.e., its **output impedance** is numerically equal to Z_0).

Likewise it is **assumed** that the source is attached to a load is **matched** (i.e., $\Gamma_L = 0$).

Frequency Pulling

However, we know that the load cannot be **perfectly** matched (i.e., $\Gamma_L \neq 0.0000000...$),

And—unfortunately—the **actual impedance** of this load can affect the operating **frequency** of the oscillator!

→ As Γ_L changes, so too will the carrier frequency ω_0!

This phenomenon is called **frequency pulling.**

Specify as a "worst case"

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:

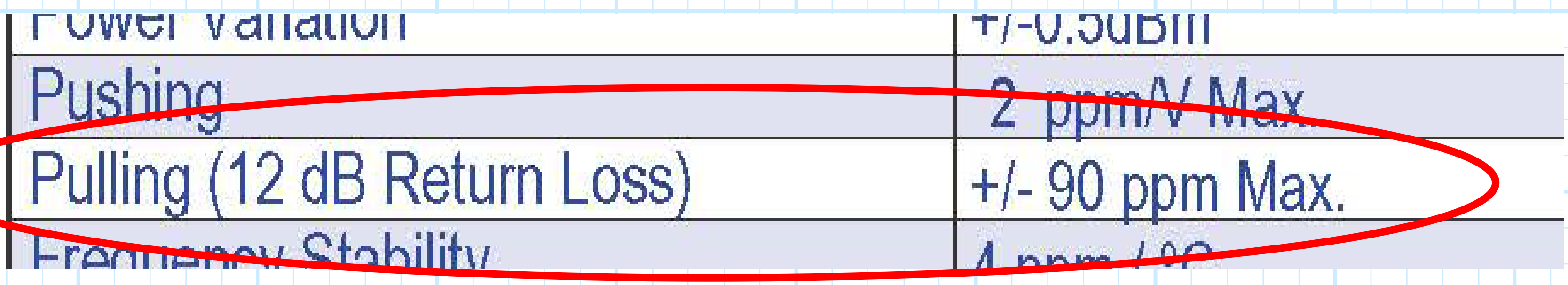
*"**less than** 2 KHz at VSWR = 2.5"*

Or,

*"**no more** than 5 KHz at 10 dB return loss"*

Or,

*"**a maximum of** 100 ppm at 12 dB return loss"*

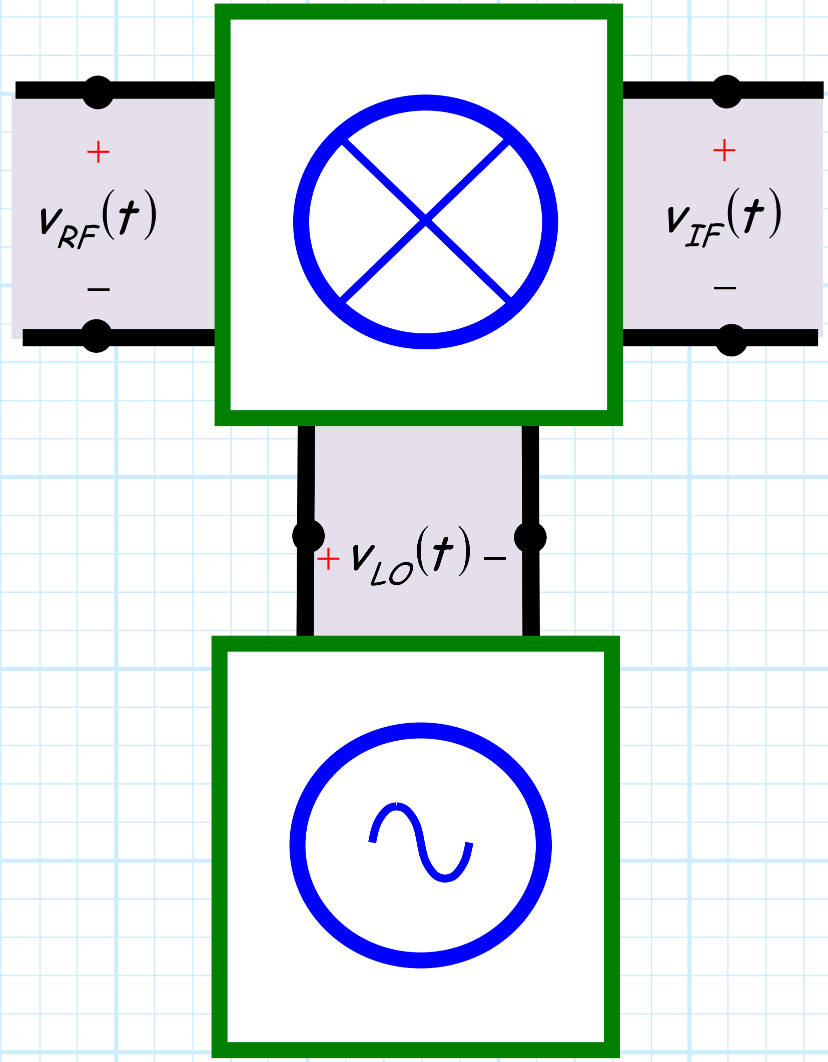


Power Variation	+/-0.5dBm
Pushing	2 ppm/V Max.
Pulling (12 dB Return Loss)	+/- 90 ppm Max.
Frequency Stability	4 ppm / °C

Pulling can actually be a significant problem!

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**!