Non-Ideal Switch Characteristics

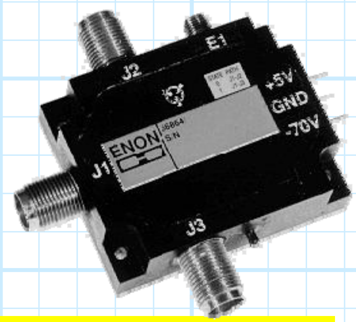
Q: *How **fast** can we **switch** between one state and the other?*

A: Well; it **depends**.

There are **two** standard **technologies** for constructing microwave switches:

1. **Solid-state** switches, and

2. **Electro-mechanical** switches.



Solid-state switches are constructed with **electronic** devices—diodes and/or transistors.

Solid state switches generally exhibit **very fast** switching speeds—typically a few **micro-**seconds or less.

Electro-mechanical: slow

Alternatively, electro-mechanical switches use "relays"—**mechanical** switches activated by an **electromagnet**.

These electromagnetic switches are **relatively slow**, with switching speeds on the order of 10s or 100s of **milli**-seconds—4 or 5 **orders** of magnitude **slower** than solid-state switches!

Solid-State: compression and distortion

Q: *Ack!*

***Why** would a radio engineer ever choose such **stinky slow** switch?*

A: The problems with **solid-state** switches are precisely the **same** problems encountered with **other** devices constructed with diodes/transistors (e.g., **amplifiers** and **mixers**).

→Namely: **compression** and **distortion**!

Thus, a solid-state switch has a **1 dB compression** point, as well as a **3rd-order intercept** point (IP3).

Moreover, these parameters are similar in **value** to other components constructed with electronic devices.

Electro-mechanical: high power; Solid-state: low power

For example, the **1dB compression** point of a solid-state switch is generally similar to that of a microwave **amplifier**—from **10 to 20 *dBm*.**

Thus, for **higher power** applications, a radio engineer **must** use an **electro-mechanical** switch.

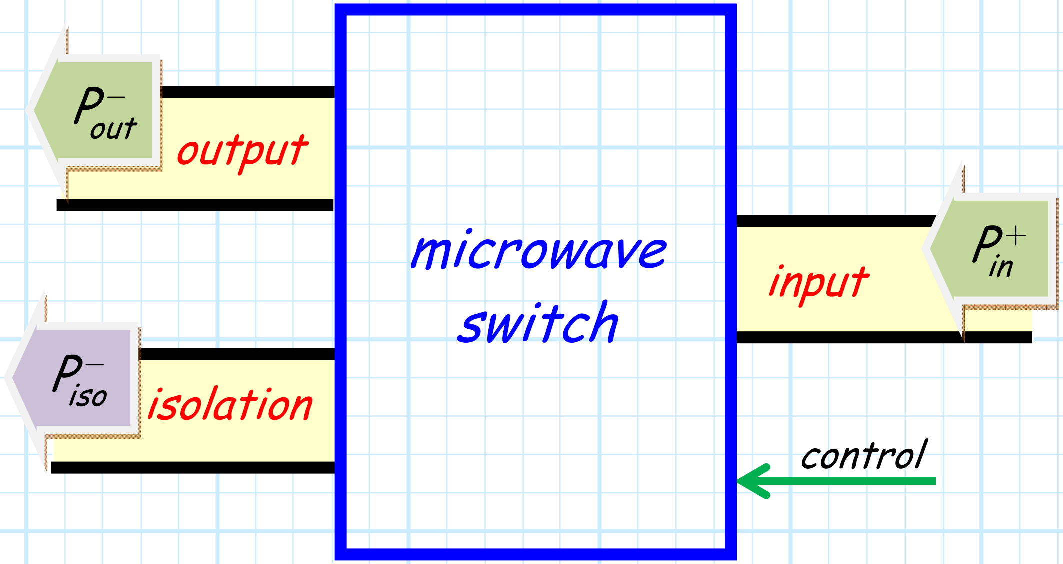
Since these **relay** switches use **no** non-linear devices, there is **no** compression or distortion—the **maximum** power is generally determined by the **transmission lines** themselves!

Q: *Are there any **other** non-ideal characteristics of microwave switches?*

A: Of **course** there are!

Definitions

First, we **define** the ports and their respective energy flow in **this** manner→



The **input port** is simply the port (it could be any of the three!) at which a **matched source** happens to be connected.

The **output port** is the port to which this input port is **connected** internally by the switch; we assume the output port is terminated in a matched load.

The **isolation port** is the **disconnected** port; we likewise assume that it has a matched load connected to it.

Isolation and Insertion Loss

Insertion Loss

$$dB[IL] = -10\log_{10}\left[\frac{P_{out}^{-}}{P_{in}^{+}}\right] = +10\log_{10}\left[\frac{P_{in}^{+}}{P_{out}^{-}}\right]$$

Insertion Loss indicates the loss encountered as a signal propagates **through** the switch.

Ideally, this value is 0 *dB*; **typically**, this value is around **1 *dB***.

Isolation

$$dB[Isolation] = -10\log_{10}\left[\frac{P_{iso}^{-}}{P_{in}^{+}}\right] = +10\log_{10}\left[\frac{P_{in}^{+}}{P_{iso}^{-}}\right]$$

Isolation is a measure of how much power "**leaks**" into the **disconnected** port.

Ideally, this value would be very **large**—typical switch isolation is **30 to 50 *dB***.