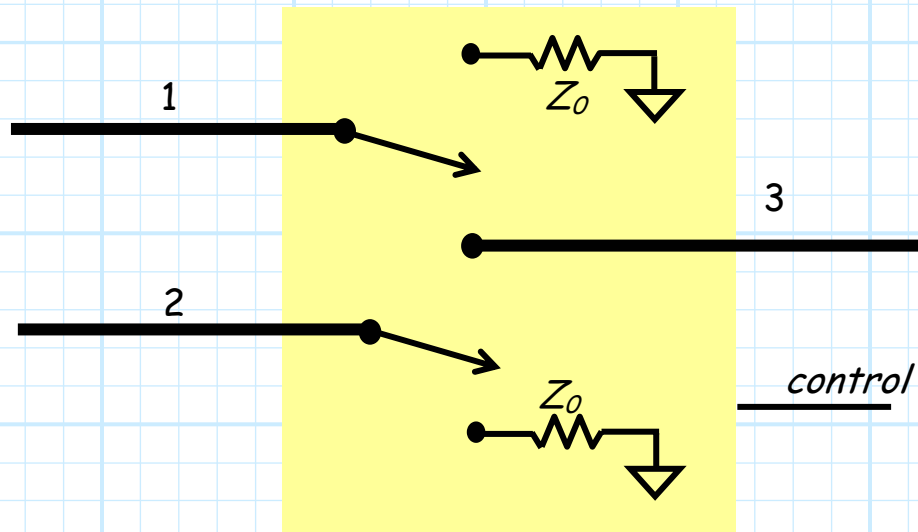


# Microwave Switches

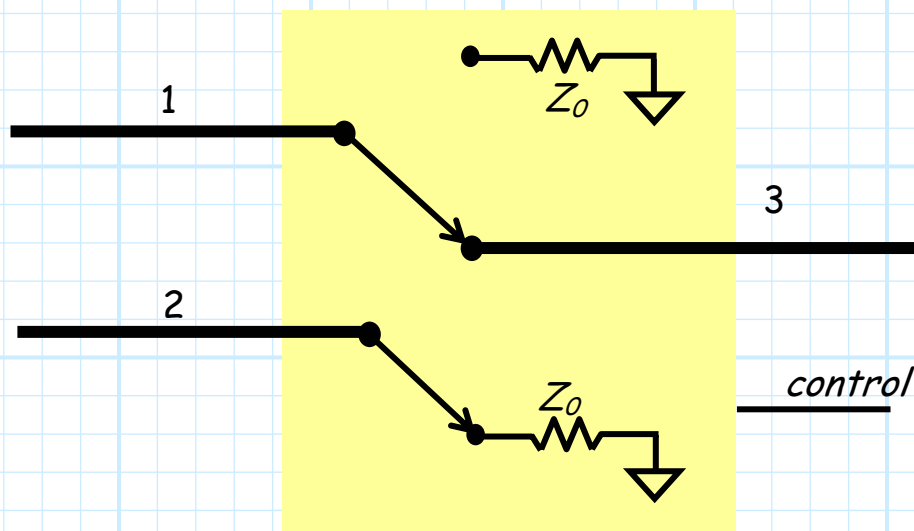
Consider an **ideal** microwave SPDT switch.



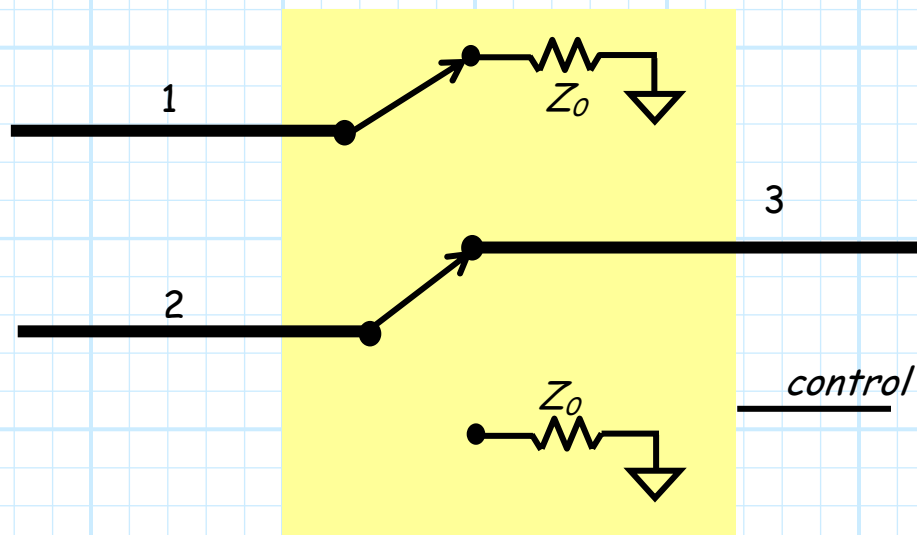
The **scattering matrix** will have one of two forms:

$$S_{13} = \begin{bmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{bmatrix} \quad S_{23} = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

where  $S_{13}$  describes the device when port 1 is **connected** to port 3:



and where  $S_{23}$  describes the device when port 2 is **connected** to port 3:

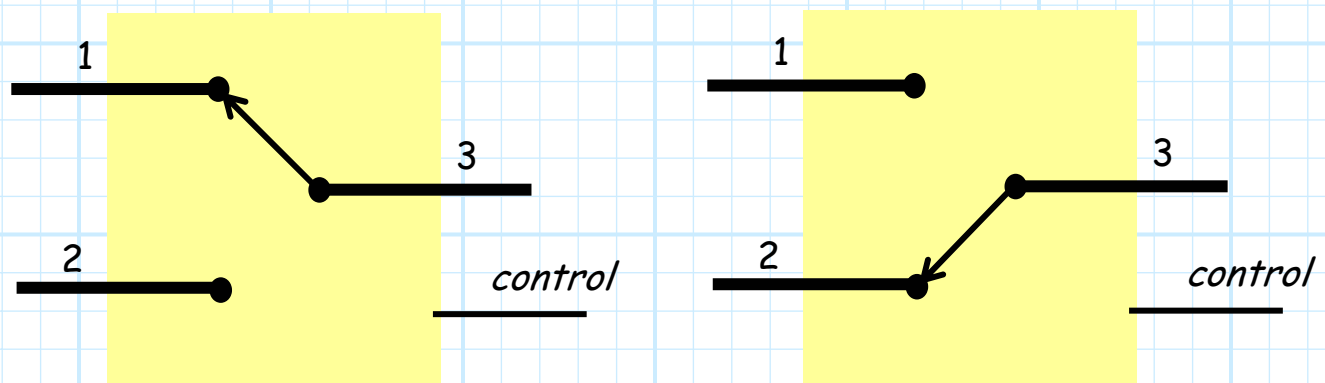


These ideal switches are called **matched**, or **absorptive switches**, as ports 1 and 2 remain matched, even when **not connected**.

This is in contrast to a **reflective switch**, where the disconnected port will be perfectly reflective, i.e.,

$$S_{13} = \begin{bmatrix} 0 & 0 & 1 \\ 0 & e^{j\phi} & 0 \\ 1 & 0 & 0 \end{bmatrix} \quad S_{23} = \begin{bmatrix} e^{j\phi} & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

where of course  $|e^{j\phi}| = 1$ .



Of course, just as with **all** ideal components, the ideal switch does **not** exist!

Using the fact that switches are **reciprocal** devices, we can write for  $S_{13}$  for a non-ideal switch:

$$S_{13} = \begin{bmatrix} S_{11} & S_{21} & S_{31} \\ S_{21} & S_{22} & S_{32} \\ S_{31} & S_{32} & S_{33} \end{bmatrix}$$

We can therefore consider the following **parameters** for specifying switch performance.

### Insertion Loss

$$IL = -10 \log_{10} |S_{31}|^2$$

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

$$Isolation = -10 \log_{10} |S_{32}|^2$$

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 - 50 dB.

## Return Loss

$$\text{Return Loss} = -10 \log_{10} |S_{11}|^2$$

Just as we have **always** defined it! We of course want this value to very high (typical values are 20 to 40 dB). However, we find for **reflective** switches, this value can be nearly 0 dB for the **disconnected** port!

