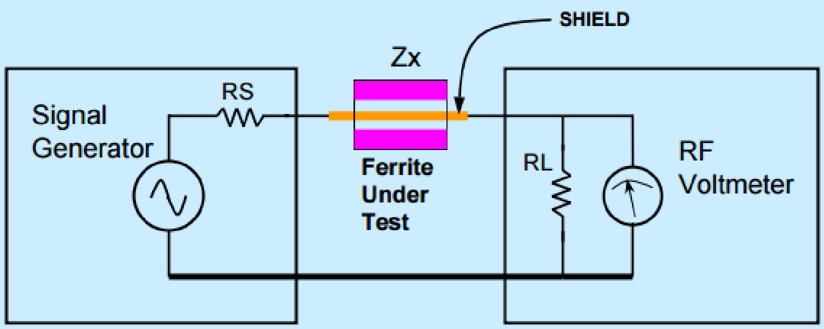
IMPEDANCE MEASUREMENTS

FREQUENCY RESPONSE MODE

- Does NOT allow measuring separately the Resistive and Inductive components
- Ease of sweeping the frequency
- Reference level = 0 dB = short in place of ferrite



RS and RL are generally 50 ohms

To calculate Zx from attenuation readings in + dB's:
(assumes that Zx is resistive)

$$Zx = (RL + RS)\,.\,\left(10^{\left[\frac{dB}{20}\right]} - 1\right)$$

Signal gen voltage: **E**
RF Voltmeter voltage: **e1 at calibration, e2 with the ferrite inserted**

$$\mathbf{e1 = E \cdot \frac{RL}{RL + Rs}}$$

Calculate the voltage divider

$$\mathbf{K1 = \frac{e1}{E} = \frac{RL}{RL + RS}}$$

K1 is the reference voltage ratio at calibration (called the 0 dB ref. level)

$$\mathbf{K2 = \frac{RL}{RL + RS + Zx}}$$

K2 is the voltage ratio with the ferrite inserted (will read some dB lower)

The linear attenuation caused by the ferrite is:

$$\mathbf{K = \frac{K2}{K1}}$$

Using the equations for K1 and K2 above:

$$K = \frac{\dfrac{RL}{RL+RS+Zx}}{\dfrac{RL}{RL+RS}}$$

Note that K is <= 1

$$K = \frac{RL + RS}{RL + RS + Zx}$$

Simplify

$$Zx = \frac{RL + RS}{K} - RS - RL$$

Solving for Zx:

$$Zx = \frac{RL + RS - K\cdot(RL + RS)}{K}$$

Rearrange

$$Zx = \frac{(RL + RS)\cdot(1 - K)}{K}$$

Rearrange

$$K = 10^{\left(\frac{-dB}{20}\right)}$$

Computing K from the positive dB measured

$$Zx = \frac{(RL + RS)\cdot(1 - K)}{K}$$

Eq. repeated

$$Zx = (RL + RS)\cdot\left(\frac{1}{K} - 1\right)$$

Rearrange

$$Zx = \left(10^{\frac{dB}{20}} - 1\right)\cdot(RL + RS)$$

After substuting K from the dB, above

$$Zx = \frac{(RL + RS)\cdot(1 - K)}{K}$$

Eq. repeated

Note that: K = S21, the S parameter describing the transmission ratio.

$$Zx = \frac{(RL + RS)\cdot(1 - S21)}{S21}$$

Substitute S21 for K

With RL=RS=50 ohms, we get:

$$Zx = 100\cdot\frac{(1 - S21)}{S21}$$

This is the equation that the VNA computes to display Zx in the series mode

Note that the VNA measures S21 as a complex quantity:

It has a magnitude and an angle or Real and Imaginary parts.

Example

$$dB := 1, 1.1 .. 50 \qquad RL := 50 \qquad RS := 50$$

$$Zx(dB) := \left(10^{\frac{dB}{20}} - 1\right) \cdot (RL + RS)$$