POWER INTEGRITY THROUGH PDN IMPEDANCE MEASUREMENT

MICROAPPS
2019 Paris

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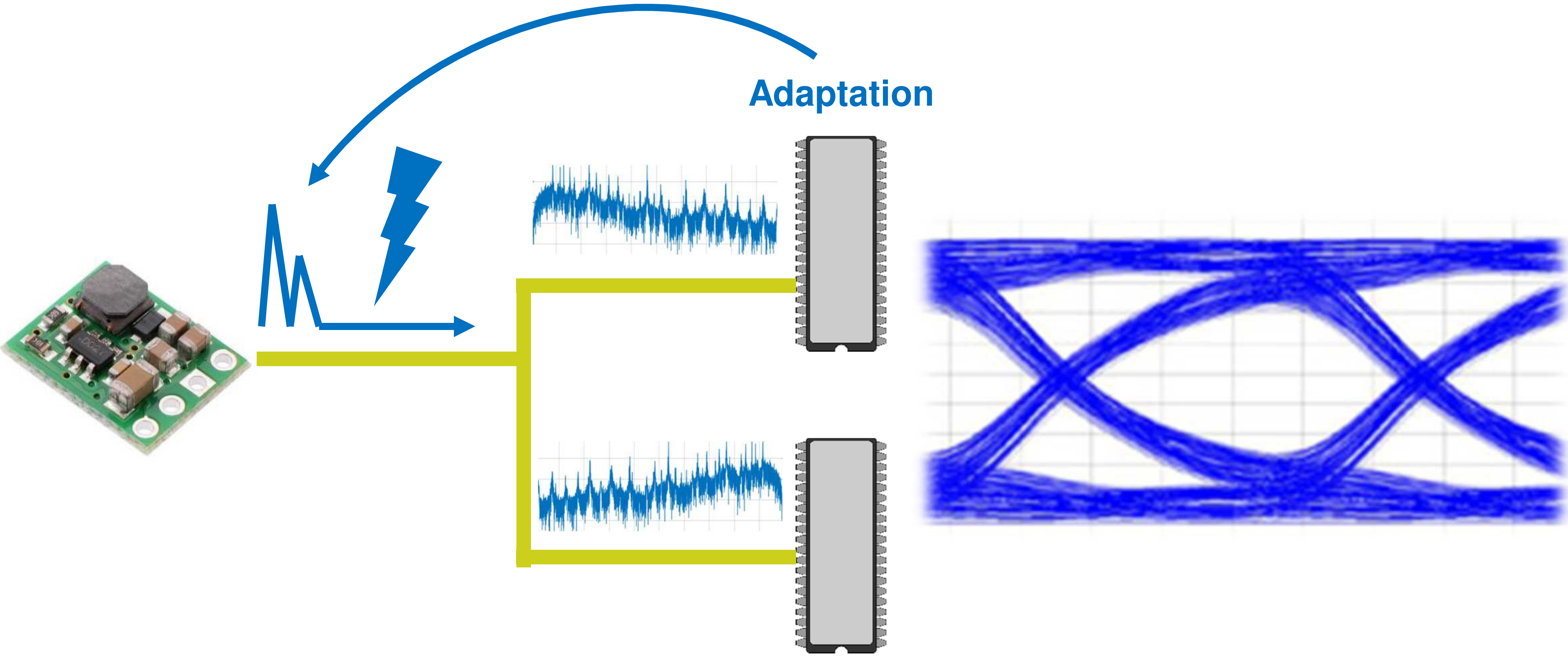
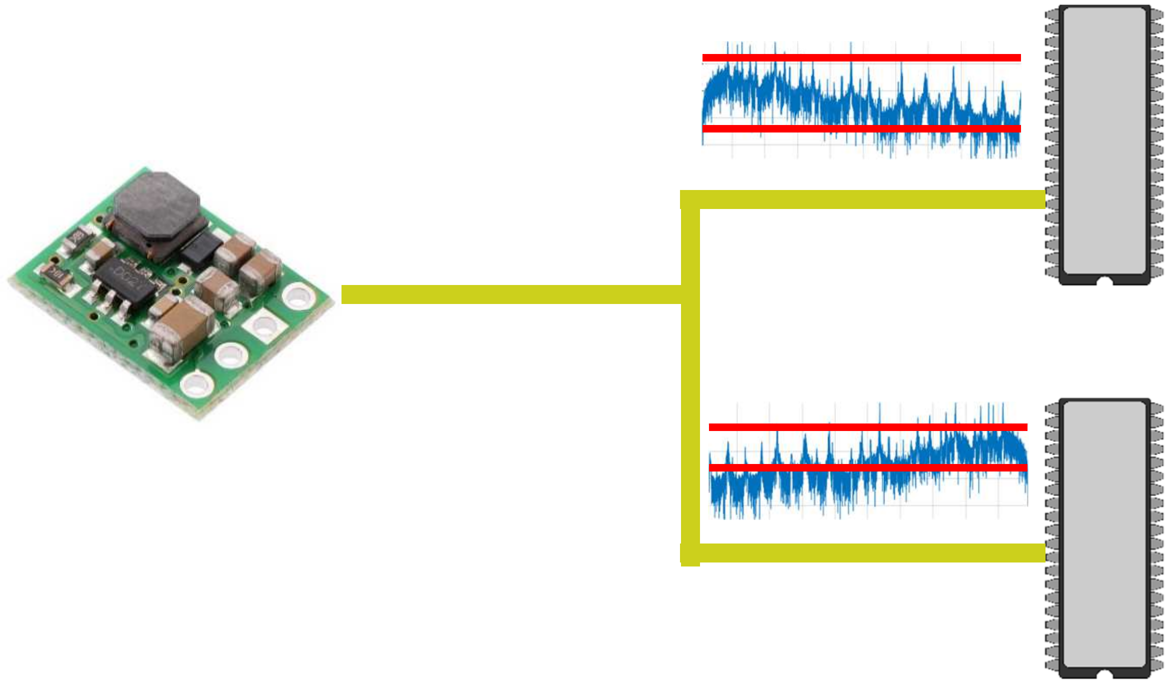
ROHDE&SCHWARZ
Make ideas real

POWER INTEGRITY AND SIGNAL INTEGRITY



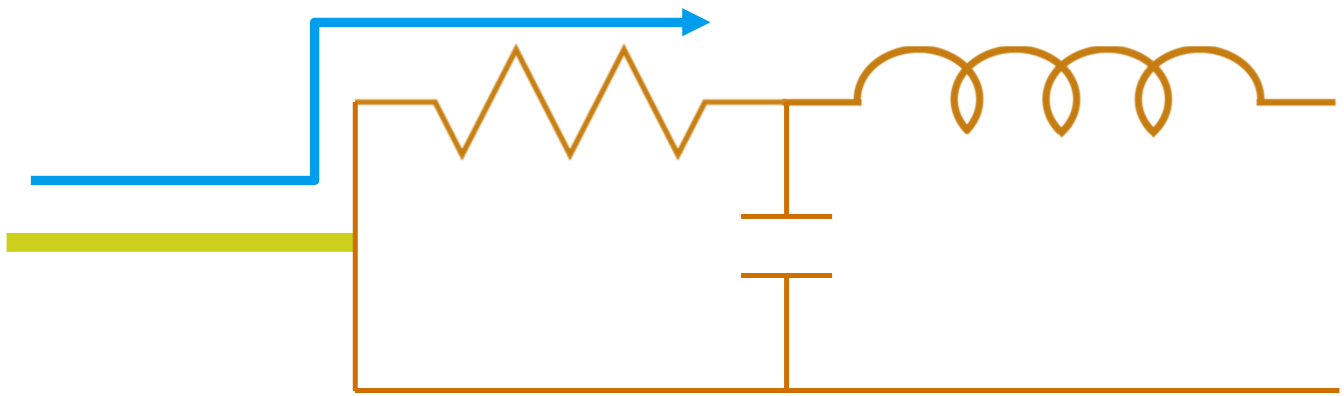
POWER INTEGRITY AND SIGNAL INTEGRITY



Usually small value!

$$Z_{PDN\,target} < \frac{V_{L\,noise}}{I_{L\,worst-case}}$$

POWER DELIVERY NETWORKS AND TRANSMISSION LINES



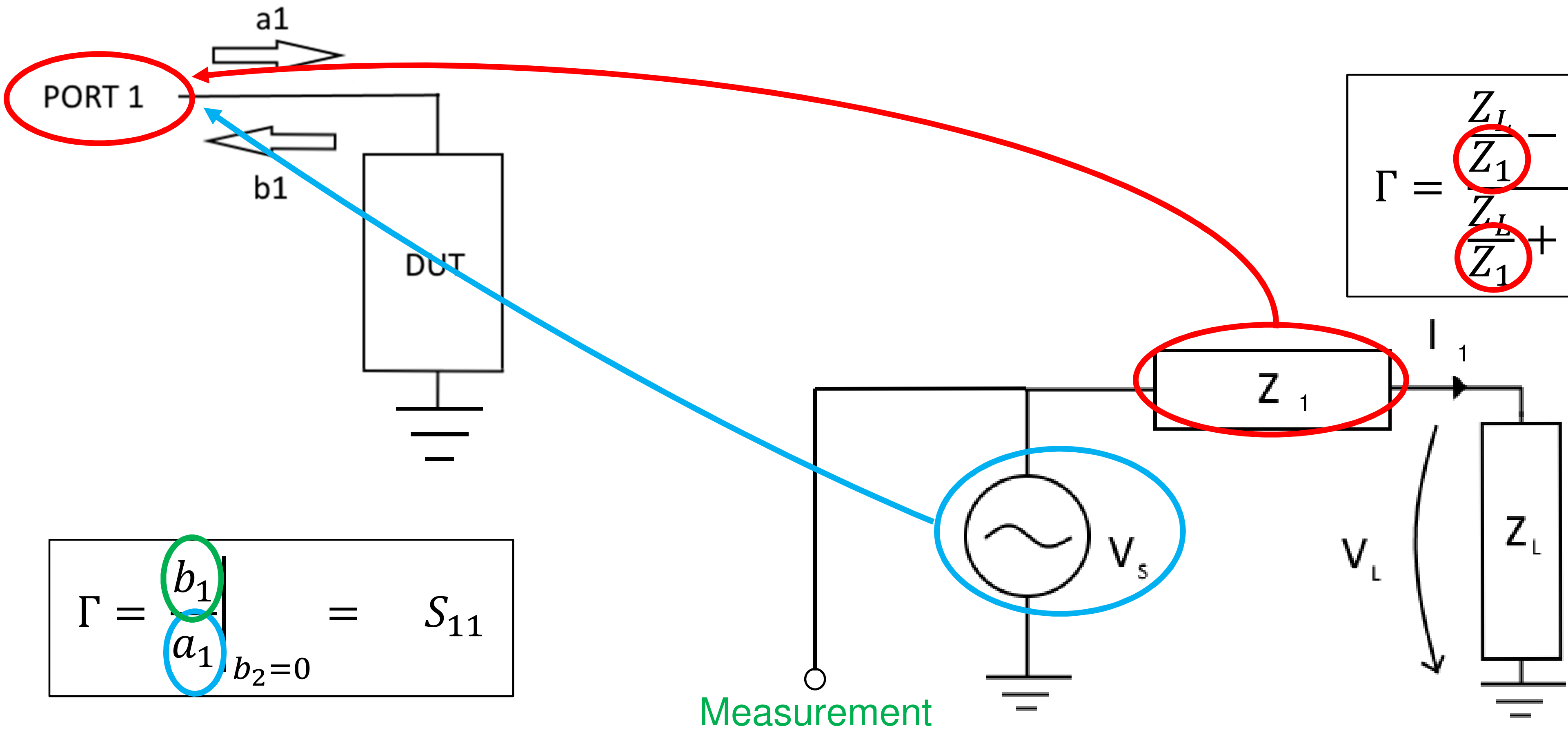
HOW TO MEASURE IMPEDANCE WITH VNA

1. Reflection setup

2. Transmission setup

3. Shunt-transmission setup

REFLECTION SETUP



$$\Gamma = \frac{\frac{Z_L}{Z_1} - 1}{\frac{Z_L}{Z_1} + 1}$$

$$\Gamma = \left.\frac{b_1}{a_1}\right|_{b_2=0} = S_{11}$$

REFLECTION SETUP

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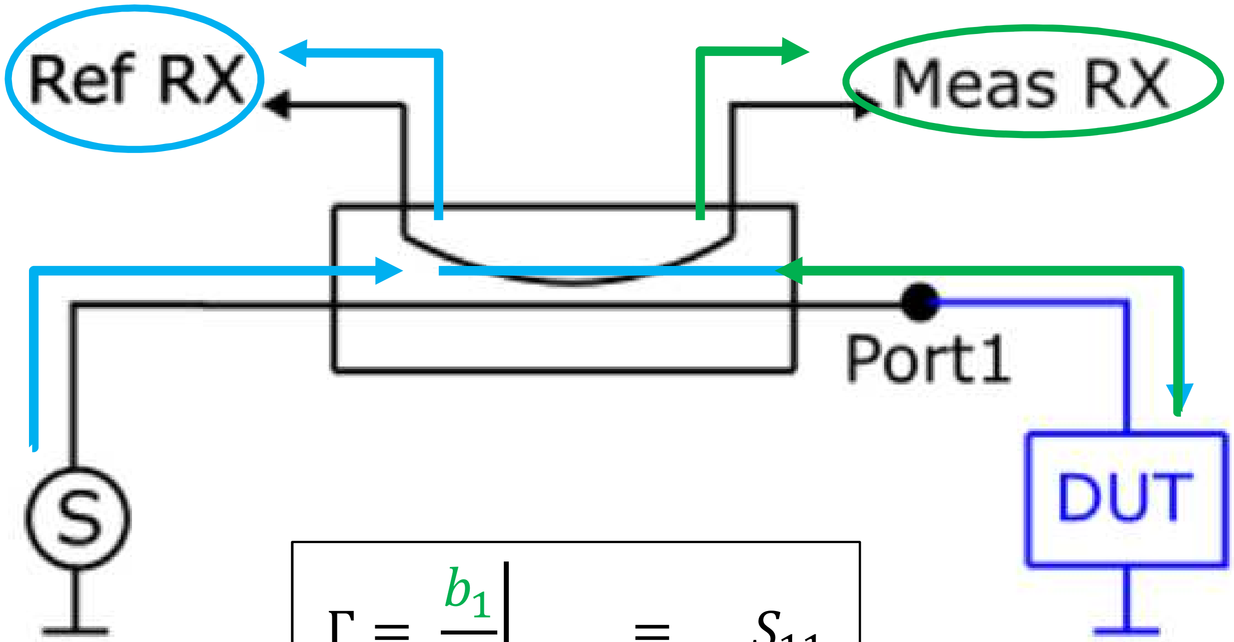

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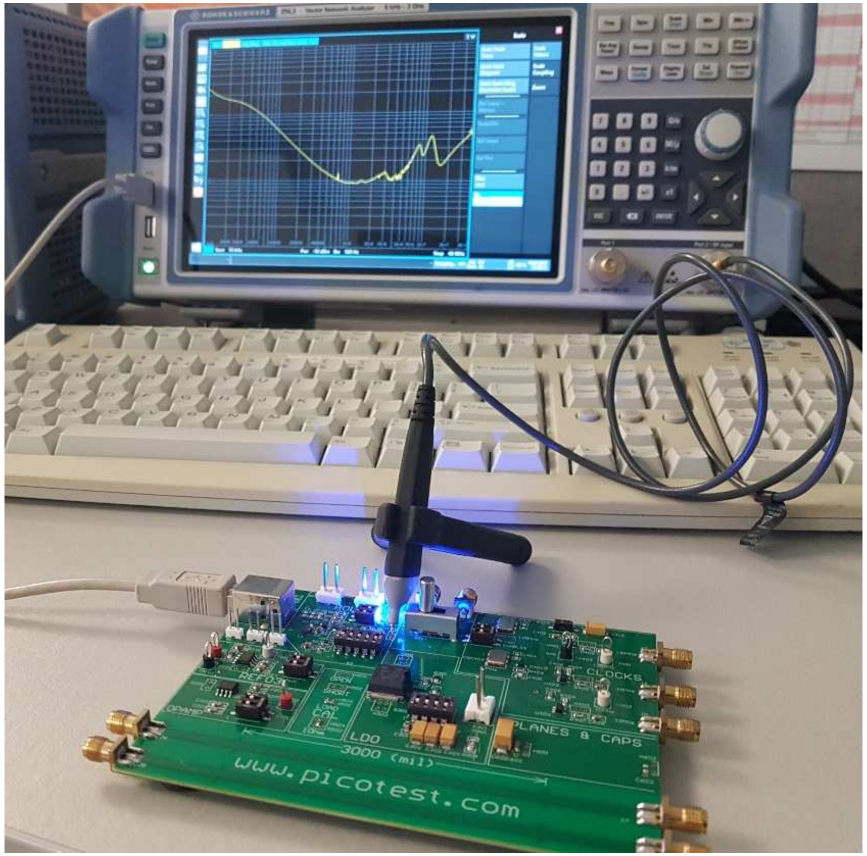
REFLECTION SETUP



$$\Gamma = \left.\frac{b_1}{a_1}\right|_{b_2=0} = S_{11}$$

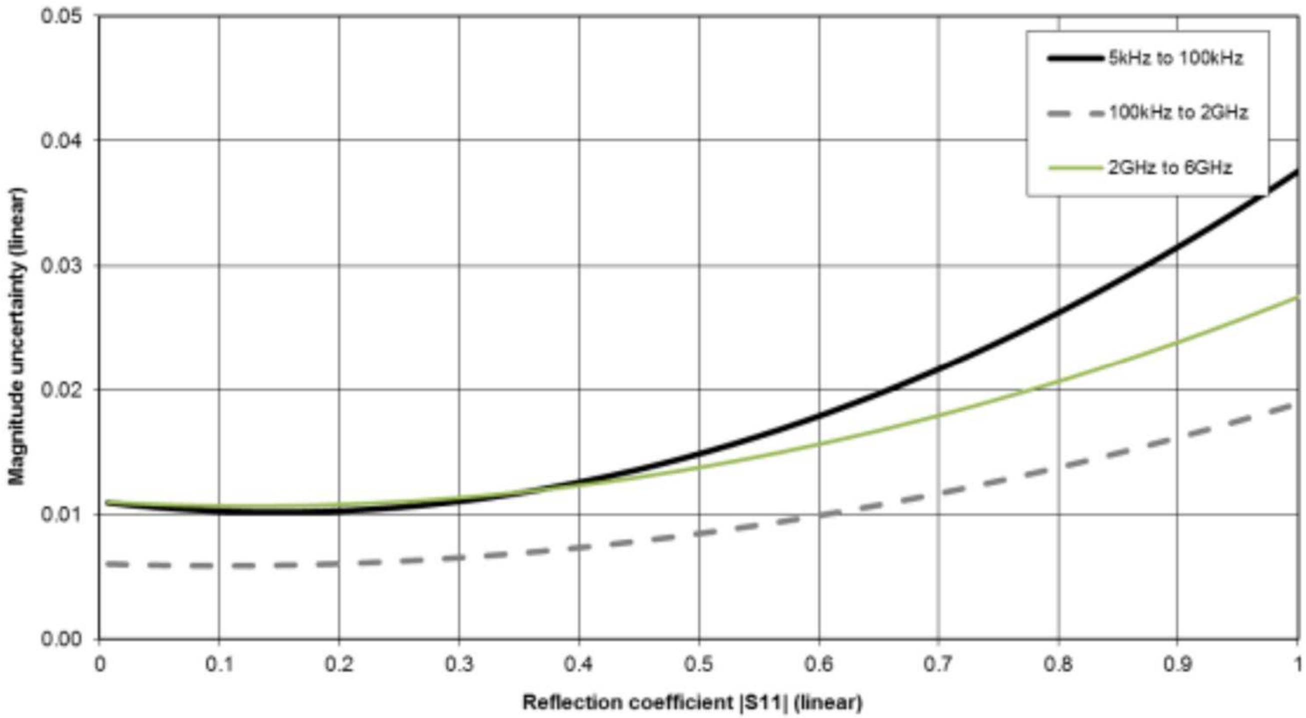
$$\Gamma = \frac{\frac{Z_L}{Z_1} - 1}{\frac{Z_L}{Z_1} + 1}$$

$$Z_L = Z_1 \cdot \frac{1 + S_{11}}{1 - S_{11}}$$

Z probe = 50 Ω → Z_1 = 50 Ω

Z probe ≠ 50 Ω → Z_1 = 50 Ω + Probe Z

REFLECTION SETUP – VALIDITY



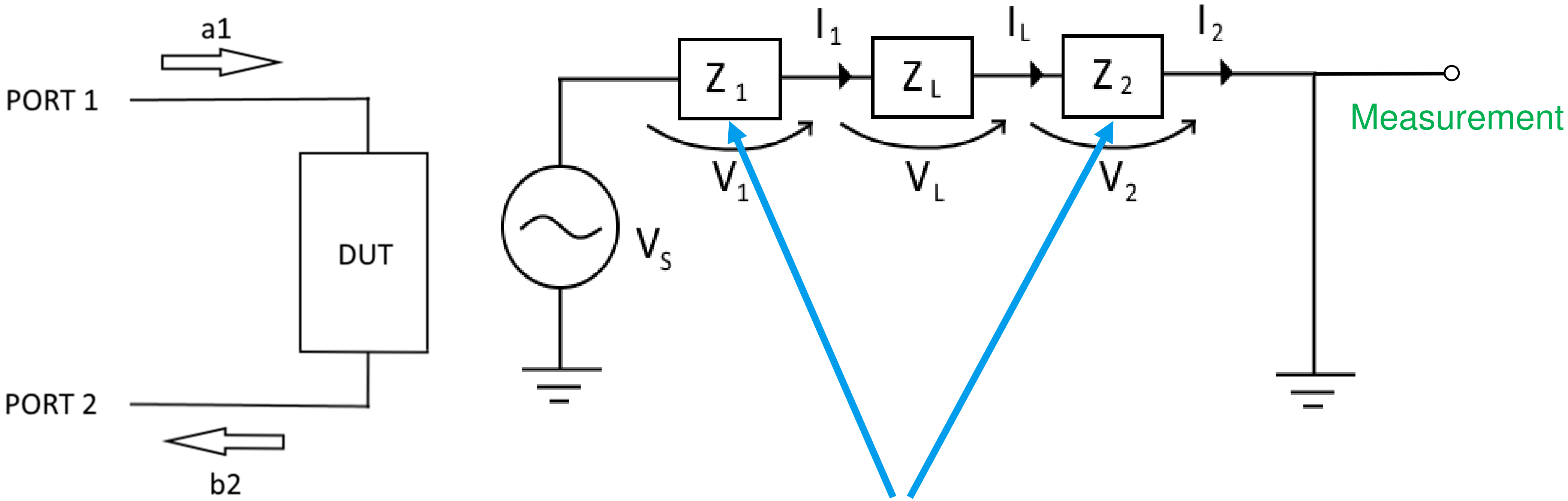
$$Z_L = 50 \cdot \frac{1 + S_{11}}{1 - S_{11}}$$

Most wave reflected
(Γ → 1)?

High uncertainty!

Approx. 10% uncertainty
between 10 Ω and 200 Ω

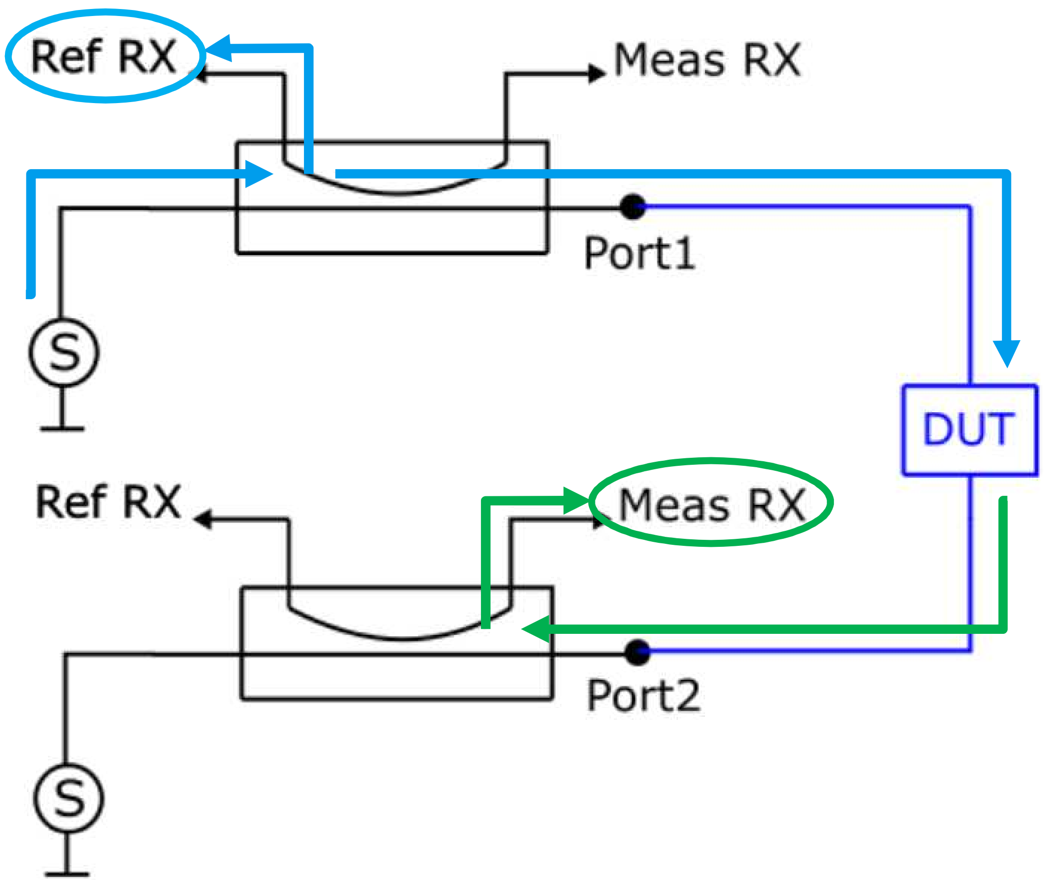
TRANSMISSION SETUP



Low uncertainty only at high Z

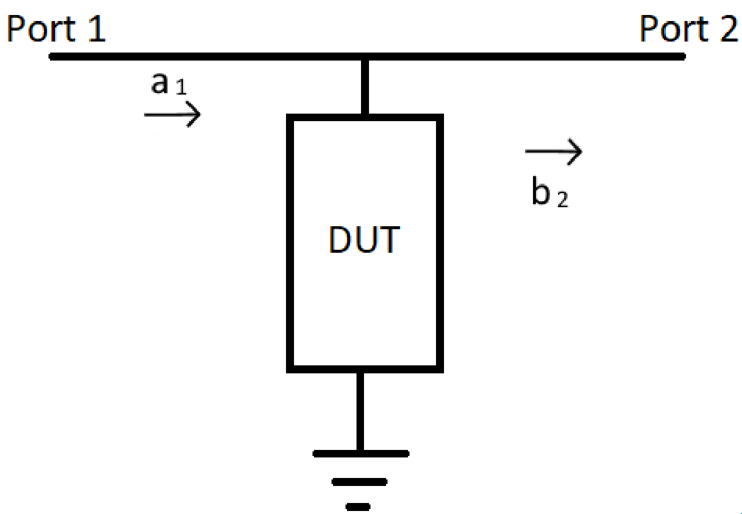
$$Z_L = \frac{50}{2} \cdot \left(\frac{1 - S_{21}}{S_{21}}\right)$$

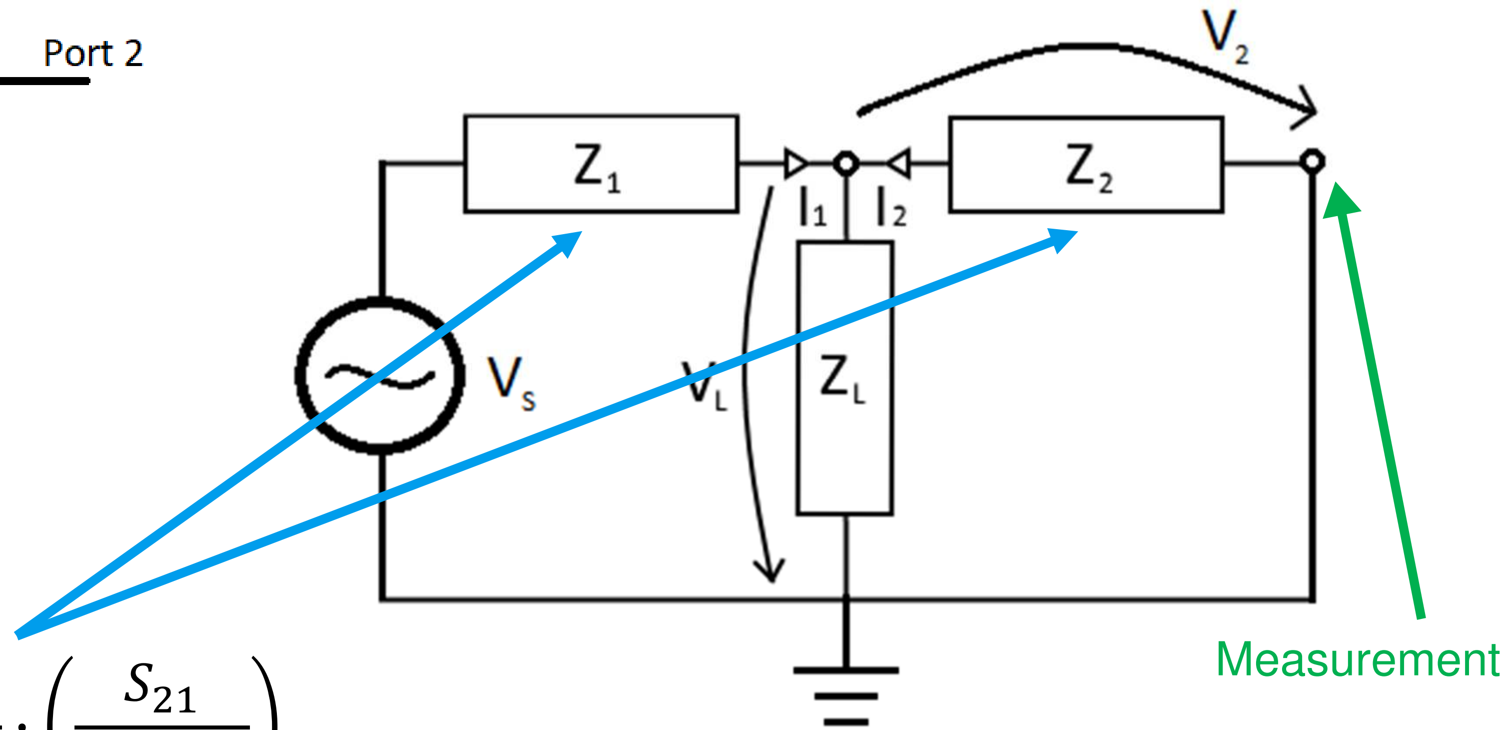
TRANSMISSION SETUP



$$\left.\frac{b_2}{a_1}\right|_{b_1=0} = S_{21}$$

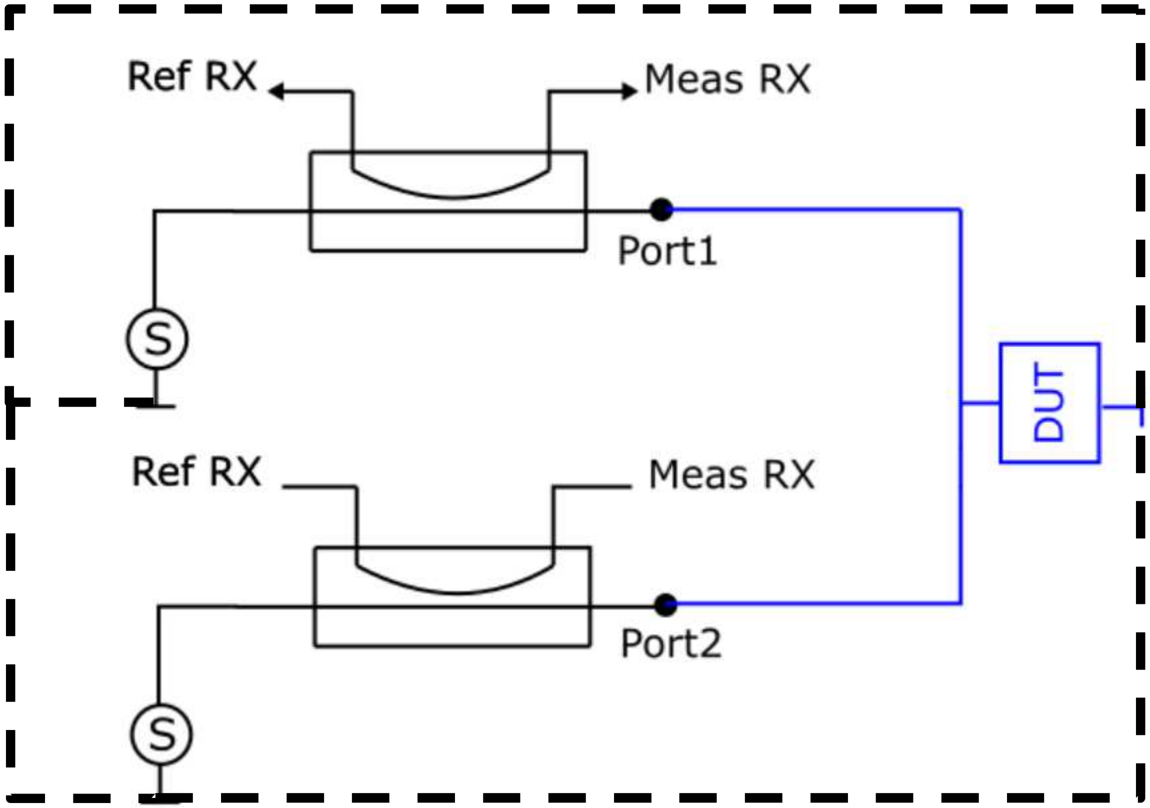
SHUNT-TRANSMISSION SETUP





$$Z_L = \frac{50}{2} \cdot \left(\frac{S_{21}}{1 - S_{21}} \right)$$

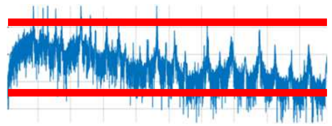
SHUNT-TRANSMISSION SETUP

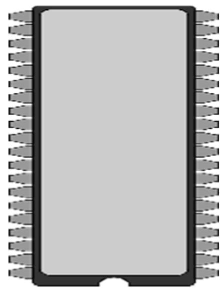


SHUNT-TRANSMISSION SETUP

Usually small value!

$$Z_{PDN\ target} < \frac{V_{L\ noise}}{I_{L\ worst-case}}$$

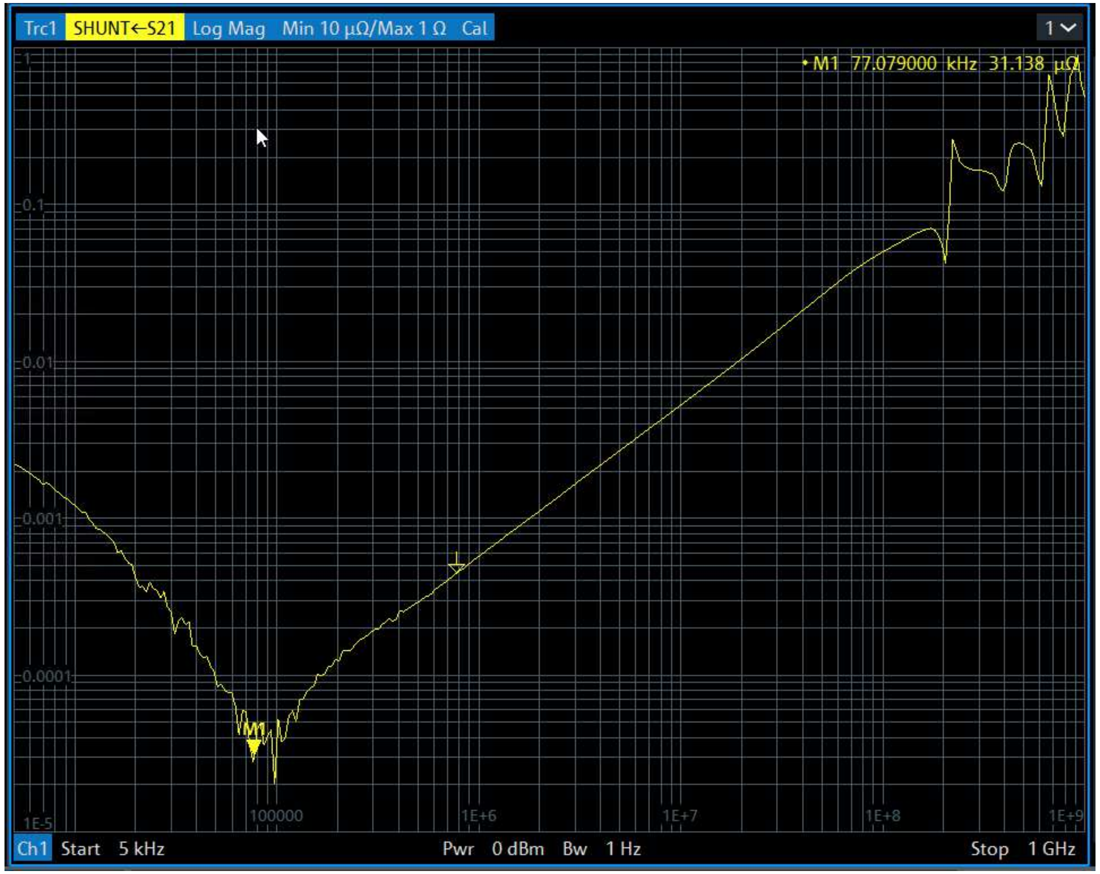




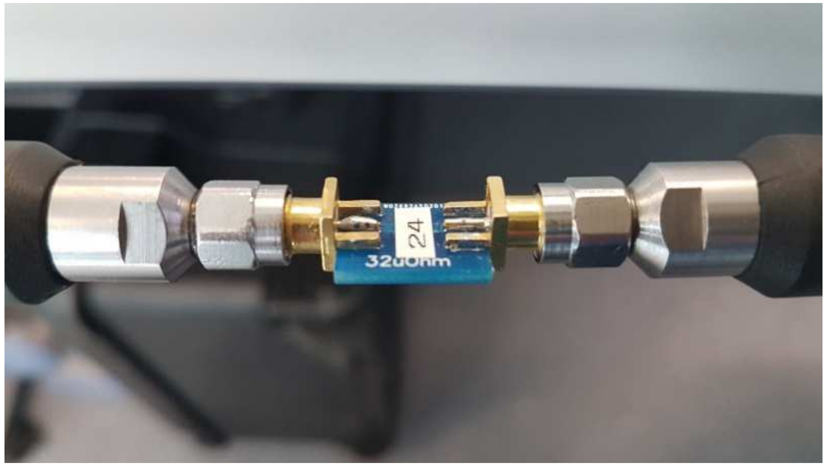
$$Z_L = \frac{50}{2} \cdot \left(\frac{S_{21}}{1 - S_{21}} \right)$$

<u>Can measure in mΩ range</u>

SHUNT-TRANSMISSION SETUP



Measurement of
32µΩ (@ DC) resistor



SHUNT-TRANSMISSION SETUP

Not enough Z span?

$$Z_L = \frac{Z_0}{2} \cdot \left(\frac{S_{21}}{1 - S_{21}} \right)$$

Use high-Z probes!

SHUNT-TRANSMISSION SETUP

$$Z_L = \frac{50}{2} \cdot \left(\frac{S_{21}}{1 - S_{21}} \right)$$

Approx. 1 x mΩ to 1 x kΩ

$$Z_L = \frac{10 \cdot 50}{2} \cdot \left(\frac{S_{21}}{1 - S_{21}} \right)$$

Approx. 10 x mΩ to 10 x kΩ

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SHUNT-TRANSMISSION SETUP – 10:1 PROBES