POWER INTEGRITY THROUGH PDN IMPEDANCE MEASUREMENT

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ROHDE & SCHWARZ
Make ideas real
POWER INTEGRITY AND SIGNAL INTEGRITY

Adaptation
POWER INTEGRITY AND SIGNAL INTEGRITY

Usually small value!

\[ Z_{PDN\ target} < \frac{V_{L\ noise}}{I_{L\ worst-case}} \]
HOW TO MEASURE IMPEDANCE WITH VNA

1. Reflection setup

2. Transmission setup

3. Shunt-transmission setup
REFLECTION SETUP

\[ \Gamma = \frac{b_1}{a_1} = S_{11} \]

\[ \Gamma = \frac{Z_L}{Z_1} - 1 \]

\[ \frac{Z_L}{Z_1} + 1 \]

Measurement
REFLECTION SETUP

\[ \Gamma = \left. \frac{b_1}{a_1} \right|_{b_2=0} = S_{11} \]
REFLECTION SETUP

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\[ \Gamma = \frac{Z_L}{Z_1} - 1 \]

\[ \frac{Z_L}{Z_1} + 1 \]

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

Z probe = 50 Ω \(\rightarrow\) \(Z_L = 50 \Omega\)

Z probe \(\neq\) 50 Ω \(\rightarrow\) \(Z_1 = 50 \Omega + \text{Probe } Z\)
REFLECTION SETUP – VALIDITY

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

Most wave reflected \((\Gamma \to 1)\)?

High uncertainty!

Approx. 10% uncertainty between 10 \(\Omega\) and 200 \(\Omega\)
TRANSMISSION SETUP

Low uncertainty only at high $Z$

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

\[ \frac{b_2}{a_1} \bigg|_{b_1=0} = S_{21} \]
SHUNT-TRANSMISSION SETUP

\[ Z_L = \frac{50}{2} \cdot \left( \frac{S_{21}}{1 - S_{21}} \right) \]
SHUNT-TRANSMISSION SETUP
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Usually small value!

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

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

Can measure in mΩ range
SHUNT-TRANSMISSION SETUP

Measurement of 32µΩ (@ DC) resistor
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

\[ Z_L = \frac{50}{2} \cdot \left( \frac{S_{21}}{1 - S_{21}} \right) \quad \text{Approx. 1 x mΩ to 1 x kΩ} \]

\[ Z_L = \frac{10 \cdot 50}{2} \cdot \left( \frac{S_{21}}{1 - S_{21}} \right) \quad \text{Approx. 10 x mΩ to 10 x kΩ} \]
SHUNT-TRANSMISSION SETUP – 10:1 PROBES