

STABILITY ANALYSIS OF SMPS USING OSCILLOSCOPES

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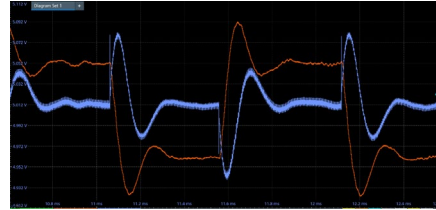
Make ideas real



STABILITY MEASUREMENTS OF A SMPS

► Step response:

- Ability of the SMPS to reach steady state.
- Dynamic response of the converter.



► Control loop response:

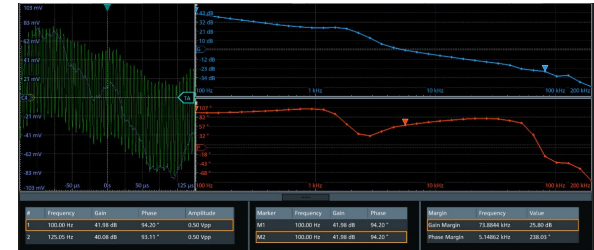
- Determines the phase and gain margins.
- Identifies if there is oscillatory behavior.
- Poor control loop compensation.

► Power supply rejection ratio

- Ability of rejecting noise frequencies at the input

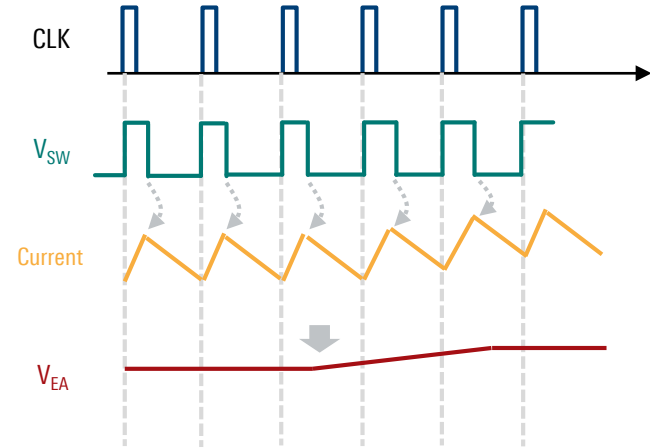
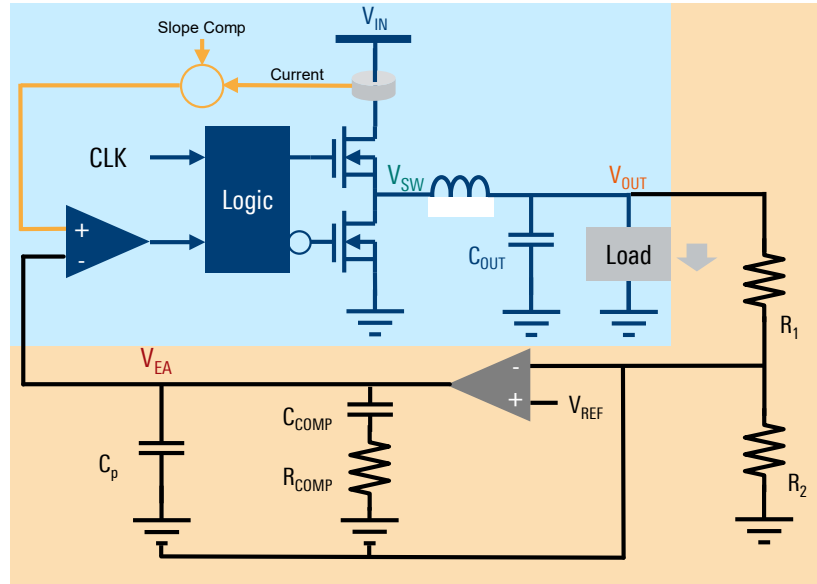
► Input impedance:

- Measures the sensitivity of the circuit to the input power system components
- Identify the negative input impedance of the circuit
- Useful in the design of electromagnetic interference (EMI) filter



CONTROL LOOP RESPONSE

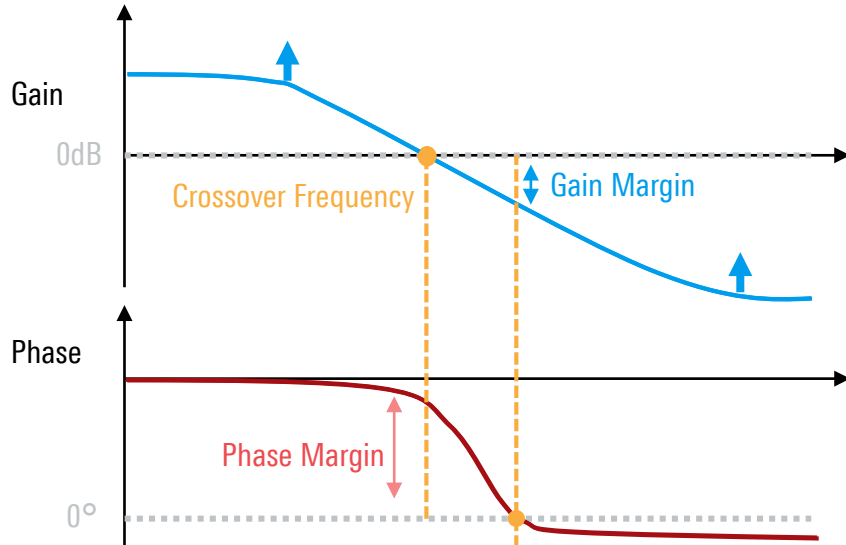
CLOSED LOOP IN POWER DESIGN



CONTROL LOOP RESPONSE

GAIN AND PHASE MARGIN

This is the measurement of how far we are from the point of non-stability



Crossover Frequency is when Gain plot crosses the 0dB

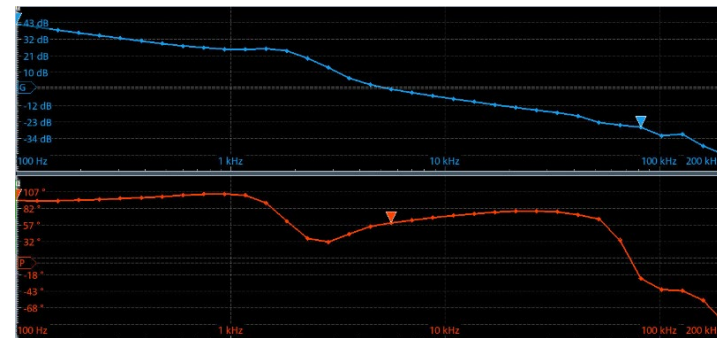
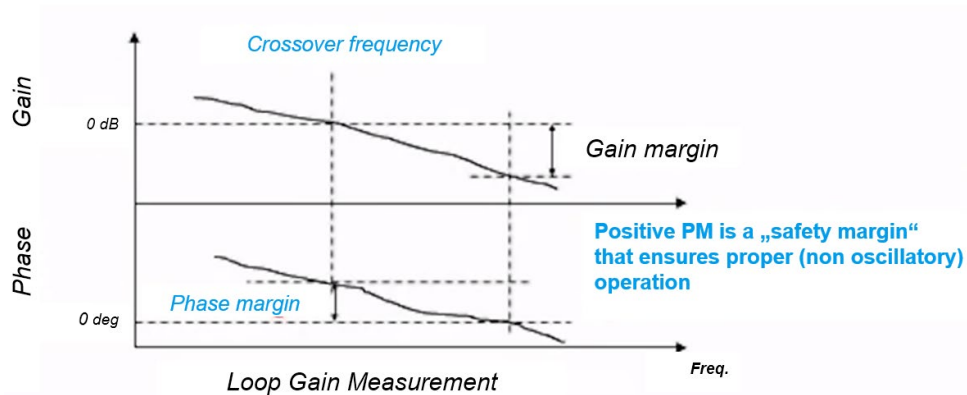
If apply gain on the system, there is no change on the phase (e.g. gain changes with the input voltage variation)

Crossover frequency start to move

The amount of gain we can add before the crossover point reach 0° is known as the Gain Margin.

Similarly phase margin refers to how much phase lag to make 0° at 0dB gain

TYPICAL CLR MEASUREMENT INTERPRET RESULTS



Designer must optimize response speed and stability for their applications

- Higher 0 dB cross-over frequency = Faster response to load changes
- Higher phase margin ($>45^\circ$) at 0 dB cross-over frequency = More stability
- Lower gain at higher frequencies = Better noise immunity (output ripple)
- Monotonic non-increasing curve

PROBES

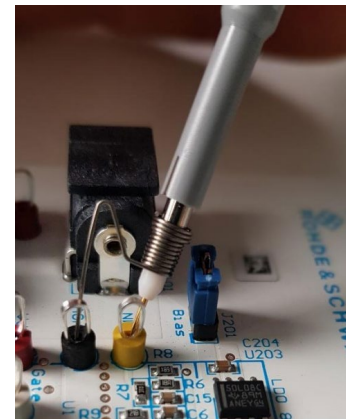
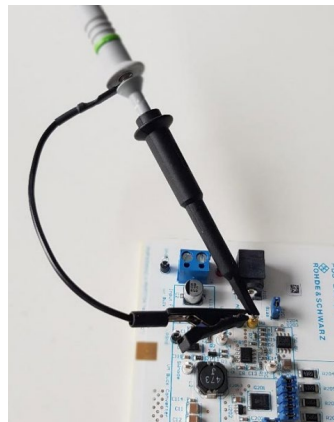


- ▶ 1:1 probe (es. RT-ZP1X)

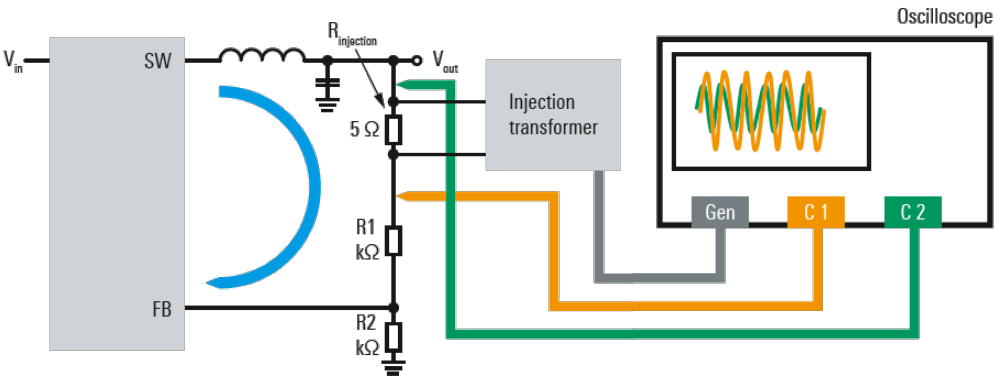
A 1:1 probe is preferred since it:

- + Optimizes vertical sensitivity
- + Minimizes oscilloscope noise floor by 10x
- Bandwidth is limited

- ▶ Is important to keep in mind the additional noise generated by the ground wire.
- ▶ Loop ground is reduced to a minimum when using ground spring instead of ground lead



CONTROL LOOP RESPONSE SETUP



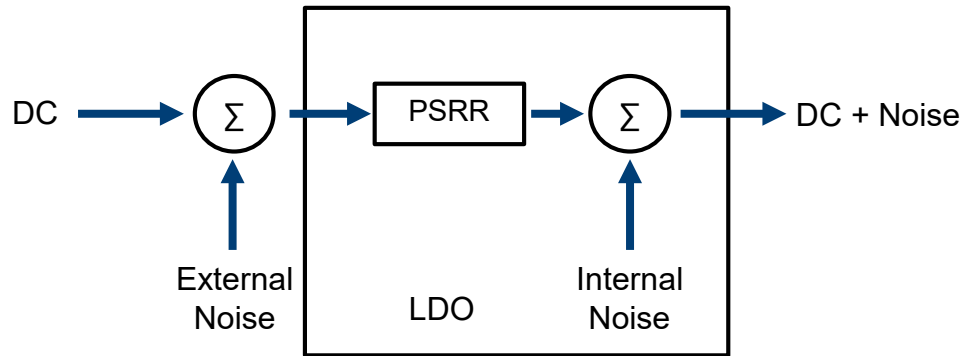
POWER SUPPLY REJECTION RATIO

WHAT IS PSRR?

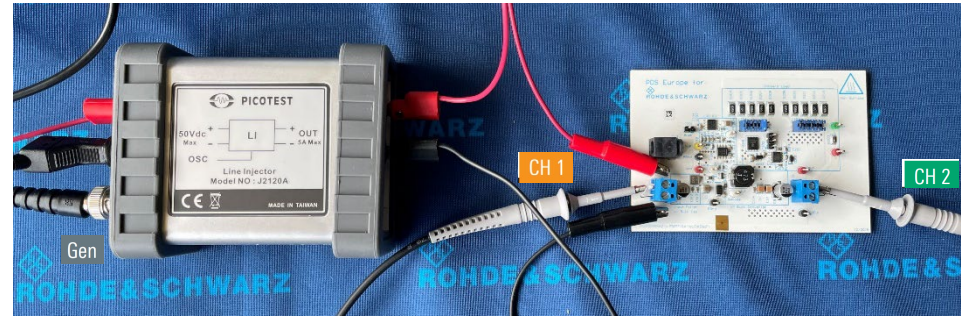
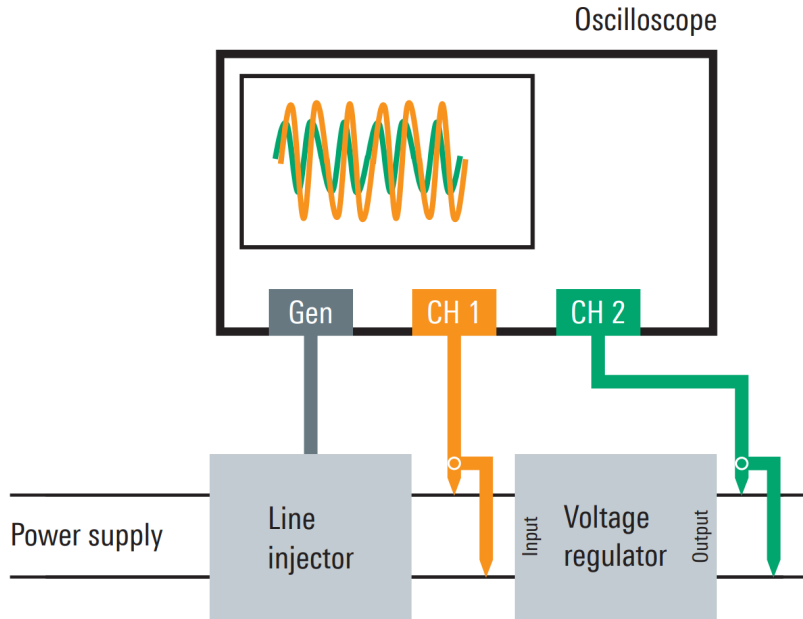
- ▶ Power Supply Rejection Ratio (PSRR) determines how much noise from the input couples into the output and can be expressed as:

$$PSRR (dB) = 20 \log\left(\frac{V_{ripple} (in)}{V_{ripple} (out)}\right)$$

- ▶ Measures the ability of generating power while rejecting frequency components at the input
- ▶ Ideally the rejection ratio is infinite.



MEASUREMENT SETUP FOR PSRR



DEMO