J2111A Questions

Can I just calculate the Q from the 3dB points of the impedance curve, I seem to get about the same answer this way?
[ANSWER] We prefer to use the group delay to measure Q, since it is much simpler to obtain Q than calculating it from the 3 dB points. If you like calculating Q from the 3 dB points, that is fine also, just make sure you have enough data points to get reasonable resolution.

Is it okay to extract the Q-value even when the |Zout|'s positive peak is not very steep?
[ANSWER] Yes, this just means that the stability margin is high. The lower the stability margin, the steeper the peak.

I don't see a peak in the group delay, what am I doing wrong?
[ANSWER] Likely you did everything RIGHT! If there is no peak then the stability margin is above 65 degrees.

Is the Q derived from Zclosed, the same as that of T/(1+T) as in Christophe Basso's publications and Maksimovic's book?
[ANSWER] No, it is not. The Q derived in the Basso's and Maksimovic's publications are open loop Q calculated from the voltage reference to the output. The output impedance Q is the closed loop Q.

Could you tell me the conditions in which we can recommend this non-invasive phase margin extraction technique? I want to know a guideline of when to recommend this solution and when not to.
[ANSWER] You can use the non-invasive method any time the phase margin is less than a practical limit of about 65 deg and not equal to zero (oscillating). If the phase margin is higher than 65 deg the group delay peak will be difficult to find. 71 degrees is the theoretical limit.

How accurate is the non-invasive measurement?
[ANSWER] The solution is an EXACT solution for second order systems, so any errors are attributed to measurement accuracy, noise and measurement resolution. For higher order systems it will exactly predict the stability margin as an equivalent second order phase margin. In these higher order systems, the non-invasive solution is a better and more accurate stability representation than a Bode plot.

What devices can I use this measurement for?
[ANSWER] The non-invasive solution applies to most circuits including system level black box stability, input filter stability, linear regulators, LDOs, switching regulators and class D switching amplifiers. The method works in any frequency range, so it is an ideal solution for measuring the stability of high bandwidth opamp buffers for example.

Do I need a special method to measure the impedance for the non-invasive measurement?
[ANSWER] The non-invasive stability assessment works using any impedance measurement method. As long as the mathematical transformation software is included in the instrument and the instrument can provide both impedance magnitude and group delay measurement traces, you can make this measurement. Currently, the software is implemented in the OMICRON Lab Bode 100 and the Keysight E5061B.

How can I get the phase margin from impedance using my HP4194A analyzer?
[ANSWER] Unfortunately, you cannot get the answer using the HP4194A, since that instrument does not include the mathematical transformation software (NISM software).

How can I get the phase margin from impedance using a different analyzer than the OMICRON Lab Bode 100?
[ANSWER] The NISM software, which enables the phase margin measurement feature, for the **Keysight E5061B VNA** can be purchased from Picotest.

Isn't it possible that the peak in impedance or group delay is not due to poor stability? How can I tell?
[ANSWER] Yes, the peak can be a passive resonance and you can tell by measuring the impedance in two operating conditions. We have several application notes and articles discussing this, but the two states are generally with the power applied and with the power off. If the peak exists in both conditions it is passive in nature and not due to a stability concern.

What tips can you provide for getting the best NISM test results?
[ANSWER] We prefer to measure the impedance and the group delay both using log scales in order to maximize the vertical scale for best resolution. Reducing the measurement bandwidth will also result in cleaner signals. Once you find a peak, reducing the frequency range to focus on the peak area will provide better resolution.

I measured the bode plot and the phase margin is good, but the non-invasive measurement says it is bad. Why?
[ANSWER] We have several articles on this subject. You can find two of them at http://powerelectronics.com/power-electronics-systems/five-things-every-engineer-should-know-about-bode-plots and http://powerelectronics.com/power-electronics-systems/when-bode-plots-fail-us. The Bode plot may not provide the correct "stability" indication. That is, the phase margin can be good and the stability performance can be poor. The short answer is that the crossover frequency is not always the frequency where the stability is the poorest. This is not the case for the NISM measurement which is always correct in its stability assessment.

Can I use non-invasive measurement on a multiple loop regulator?
[ANSWER] Yes, you can and it is the only way to check the phase margin performance. We have an article on this subject- http://electronicdesign.com/power/non-invasively-assess-your-multiple-loop-ldo-s-stability

Does the non-invasive method work with digital controlled power supplies?
[ANSWER] Yes, but be aware that some digital supplies include autotuning and so the loop is constantly changing.

Is there someplace that I can get the math for the non-invasive measurement/conversion from impedance?
[ANSWER] Sorry, but no. It is proprietary and we have not published it nor do we have plans to. However, we are implementing the capability in various instruments. If you are interested in having the feature added to your instrument, please contact us.

I used my HP3577 gain phase analyzer and used the math from Fundamentals of Power Electronics Book to get from Q to phase margin. How come the result doesn't agree with my Bode plot?

[ANSWER] There are two reasons. The Q used in Fundamentals of Power Electronics is the open loop Q calculated from the voltage reference to the output and the non-invasive method uses the closed loop Q from the output impedance. The Fundamentals of Power Electronics derivation also does not account for the capacitor ESR, which is a major stability term.

Which analyzers include the non-invasive measurement capability?

[ANSWER] Currently the only instruments that include the transformation are the OMICRON Lab Bode 100 and the Keysight E5061B VNA (software can be purchased from Picotest).

Why is the group delay noisy at low frequency and why do you recommend using a log vertical scale for it?

[ANSWER] The group delay is a measure of the first derivative of the phase angle and so if the phase is steady the Group delay just measures noise. Since we only care about the group delay peak this is not an issue and it is generally easier to determine the Q from the group delay than from the 3dB points.

Is there a mathematical basis for this measurement?

[ANSWER] Yes, the non-invasive method is based on the minor loop theory, which was popularized by Dr. R.D. Middlebrook for the assessment of input filters.