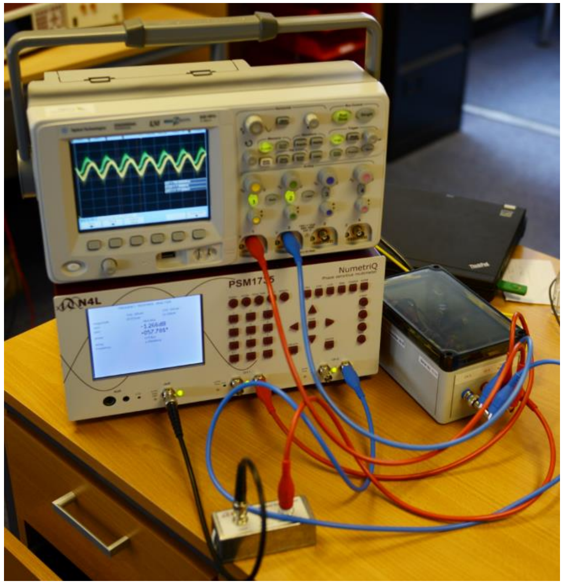
Feedback Loop Response...
Oscilloscope or frequency response analyzer?



Background of Loop Response

- **Quantify** stability and response of a circuit with a feedback loop
- **Inject** perturbation signal
- **Measure** response

<u>Aims of the test and Guidelines</u>

- Determine both **gain and phase** loop response
- **Injection Level** - Should not inject a signal with amplitude more than is necessary, to avoid activating any over voltage circuit protection/affect the large signal behaviour (up to 100mV on secondary of the transformer is ideal)
- Inject into a **location** in the loop in which one side of the generator is high impedance and the other side is low impedance

“Oscilloscope” Approach to Loop Response Measurements

In order to make a measurement with an oscilloscope we must first connect **a function generator** via an injection transformer to the feedback loop. The following steps describe the approach.

1. Select **injection point** in the feedback loop
2. **Connect** oscilloscope either side of injection resistor (**CH1 and CH2**)
3. **AC couple** oscilloscope inputs
4. Set scope to “**bandwidth limiting**”
5. Try to obtain a **good trigger** (Can use third channel if available and trigger from generator.

Measurements

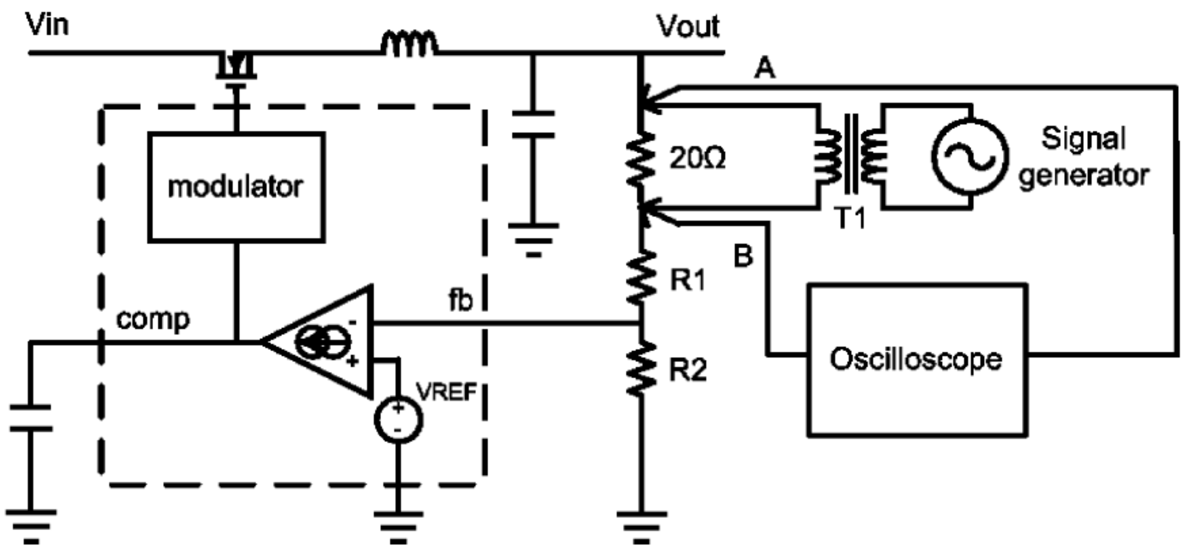
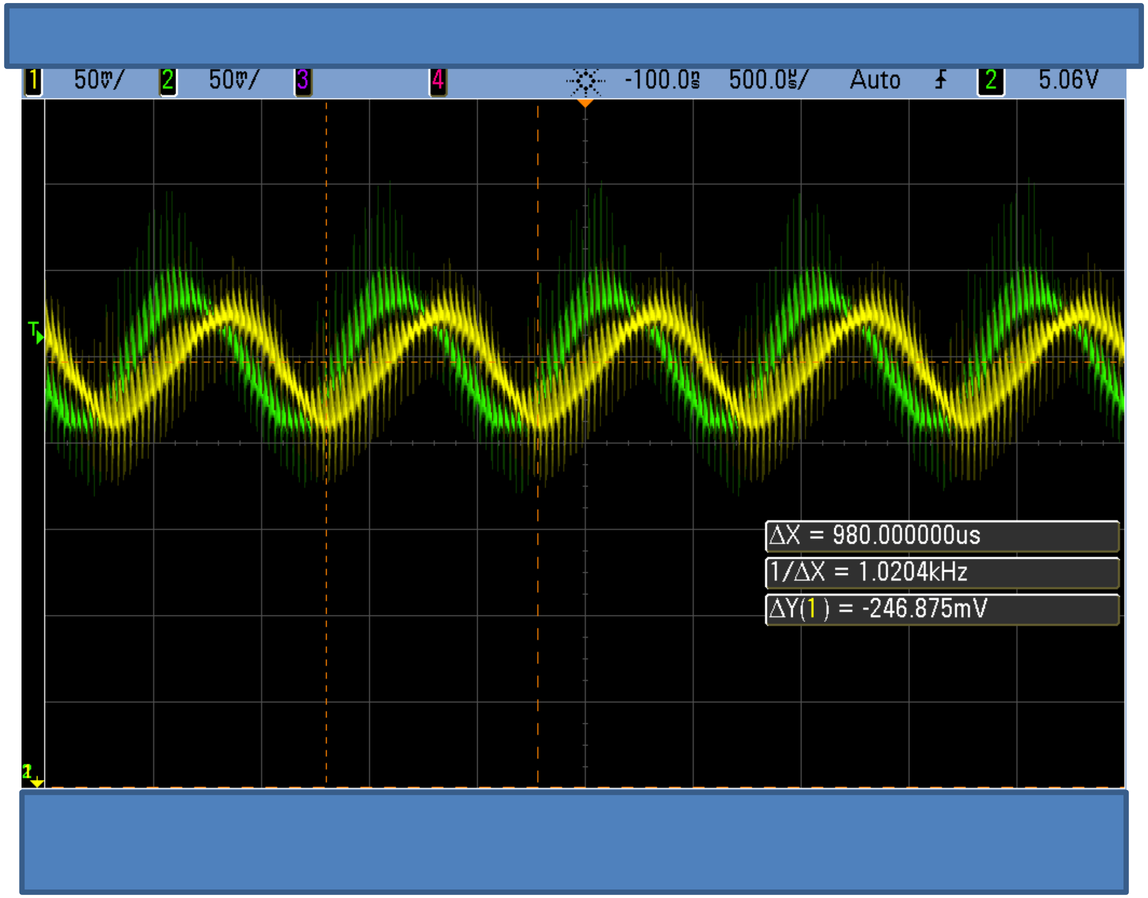


Figure 1. Measurement Setup

- **Generator is powered** on at the first frequency point of interest and the measurements can commence.
- Generator is **stepped** in frequency
- Oscilloscope must be **manually adjusted** and the gain and phase between the two signals are taken.
- Takes a **significant amount of time** and uncertainty in the measurement is large due to the fact that there is a lot of noise on the signal relative to its magnitude.
- The first frequency point of interest is the point at which the gain becomes zero **(phase margin),** at this frequency the designer will record the phase margin and the frequency at which this occurs.

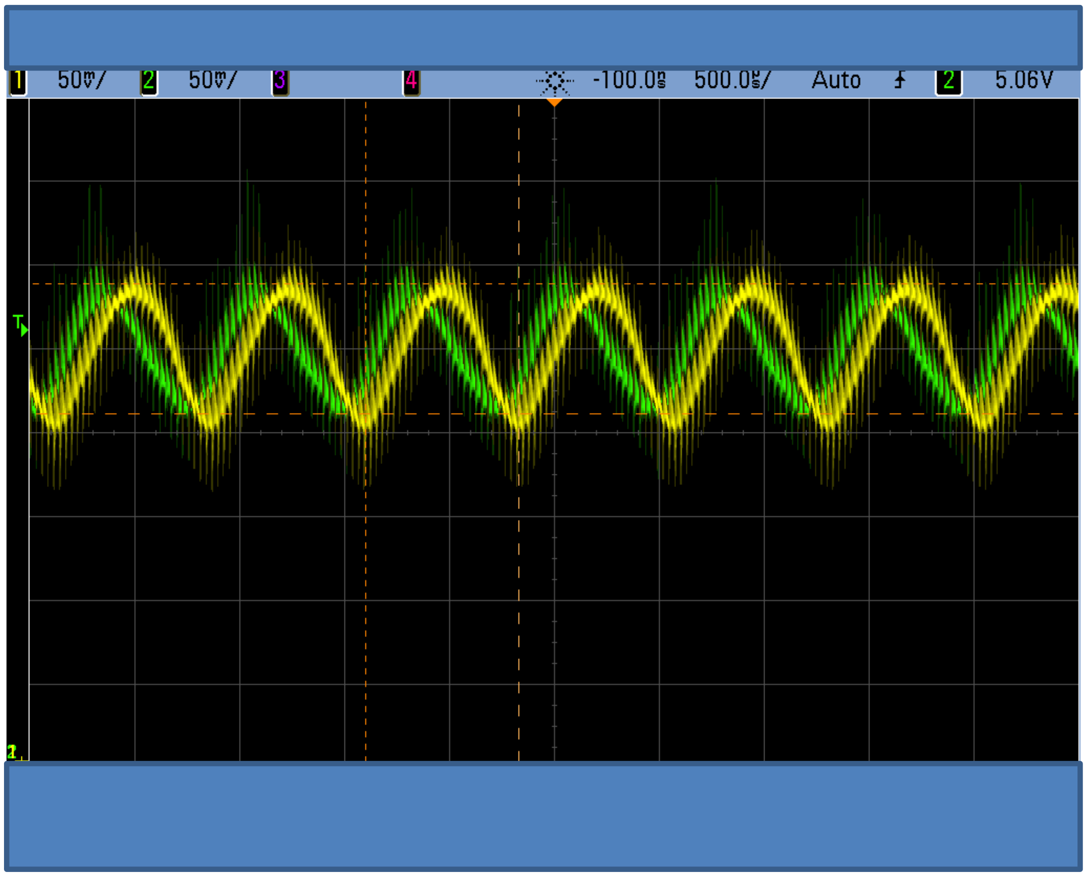
Phase Margin

From the screen shot below we can see an approximate **0dB** measurement (20log(CH2/CH1) is first seen at 1.024kHz (100mVpk to pk)



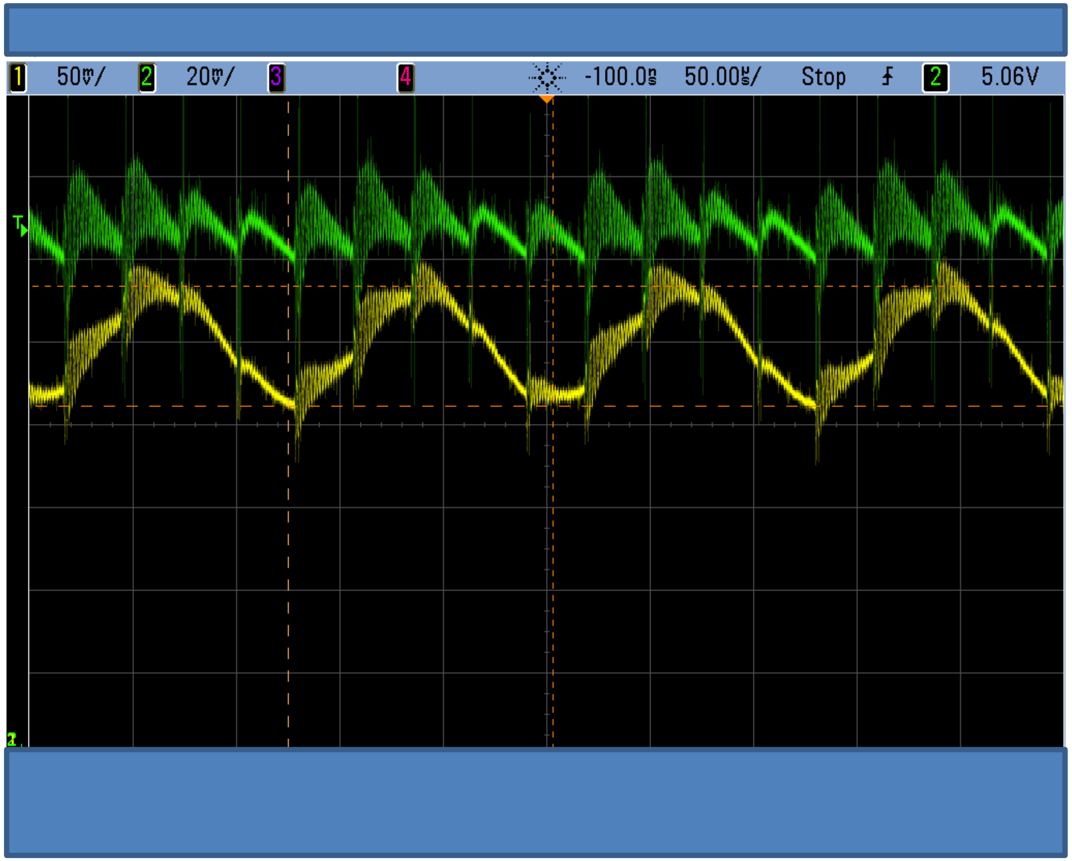
Uncertainty

As the frequency is increased it is unclear as to where the 0dB crossover actually occurs. As seen, at **1.37kHz** the signal still appears to be 0dB which will cause a lot of Confusion when determining the 0dB crossover frequency.



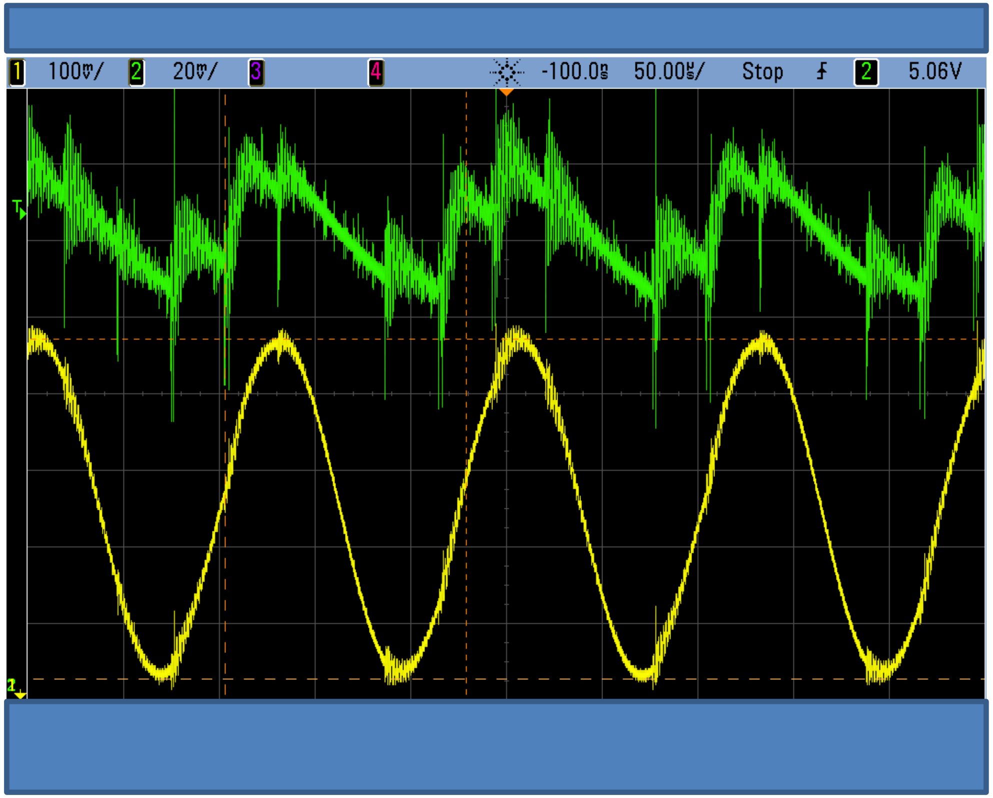
Gain Margin

Our next point of interest is the **gain margin**, this will prove to be more difficult as the signal on channel 2 (the return signal) will be very small. In the case of this power supply under test , around **3mV** at the Zero degree crossover. In fact, the DSO is unreadable if we inject an acceptable signal level (<100mV)



Gain margin continued

- **Overdriving the loop -** A somewhat reasonable picture of the waveform is possible if we overdrive the feedback loop and inject a signal which would cause saturation/disturbance to the loop itself



The Frequency Response Analyzer Approach

An alternative approach would be to use a frequency response analyzer, this instrument will automatically sweep throughout the frequency range of interest, extract the fundamental frequency with a **DFT algorithm** based upon the injected Frequency and provide automatic gain and phase margin calculation.
This approach is **faster**, more **accurate** and more **reliable** than the approach with an oscilloscope.

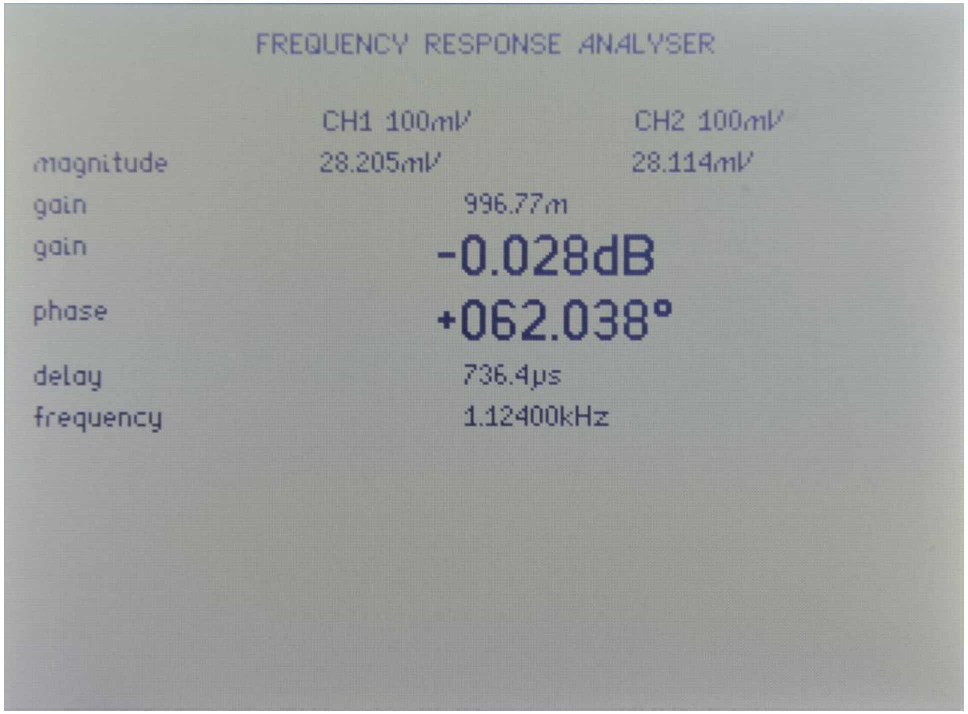
To begin, we **AC couple** both inputs, **set the generator** injection signal via an injection Transformer. We then set the sweep parameters (In this case we will sweep from 50Hz to 20kHz.

We are then ready to make a swept measurement.

Phase Margin

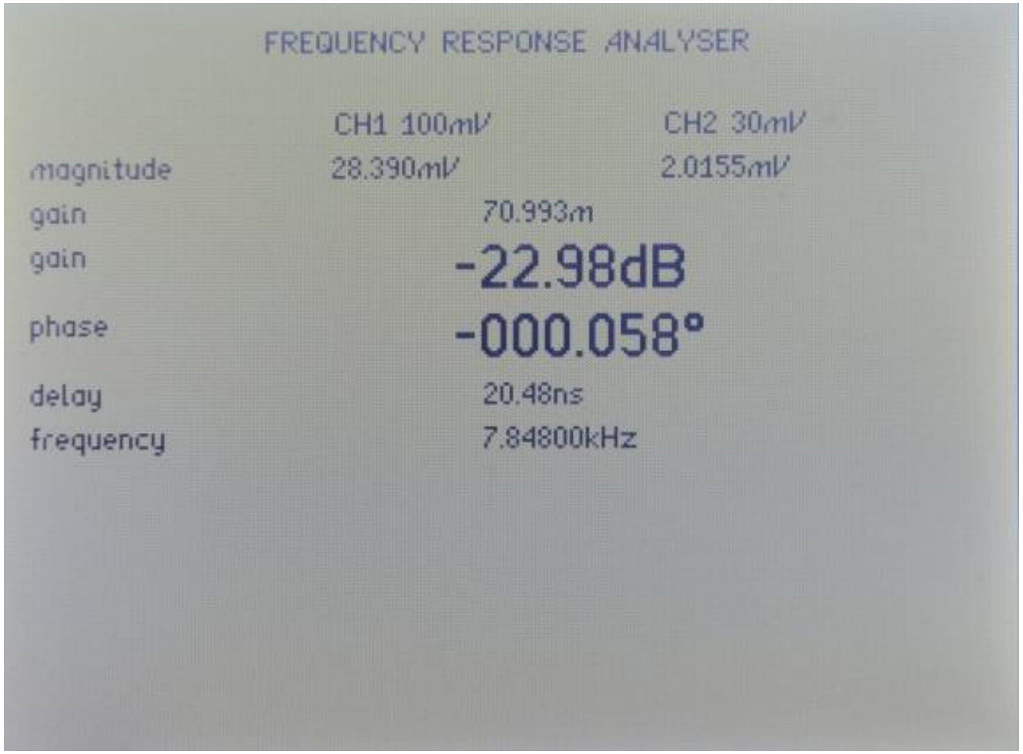
- Using the **DFT technique** the instrument will have the ability to extract a **small signal fundamental** which is immersed in noise
- The picture below illustrates the low signal level at which the zero dB point

can be measured, with excellent stability and repeatability.



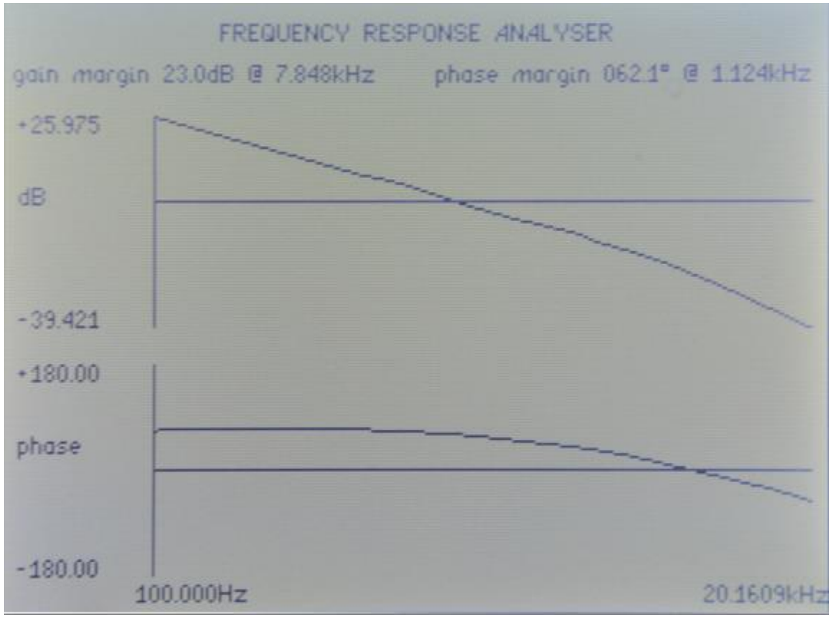
Gain Margin

The gain margin can also be measured with relative ease compared to that with the oscilloscope. In this case we have a signal level of 2mV on Channel 2 giving a gain of 22dB at the zero degree crossover point.



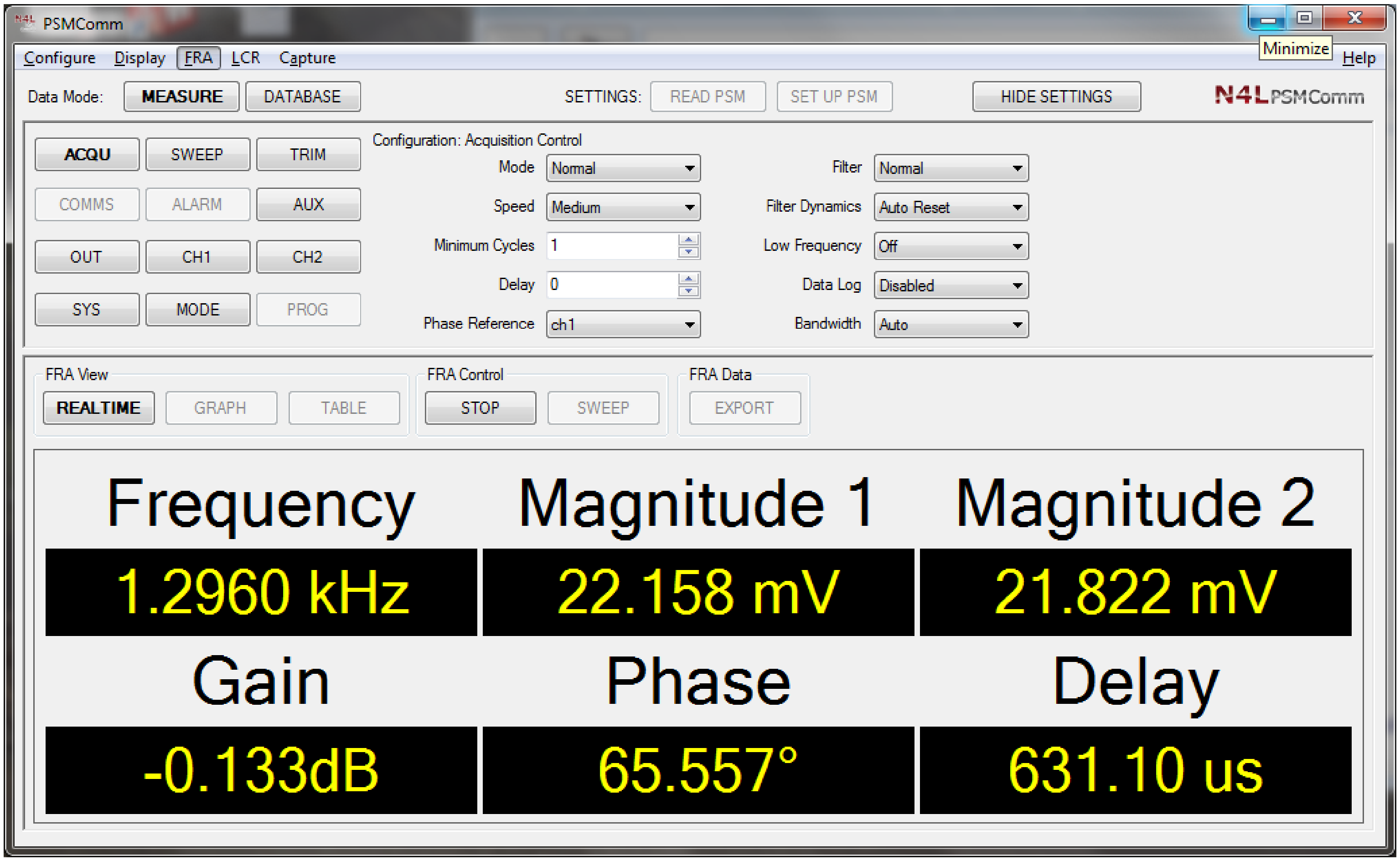
Bode Plot

An FRA (in this case an N4L PSM1700) will provide **automatic gain** and **phase** margins quickly and accurately. As seen below for this power supply we have a gain margin of 23dB @ 7.848kHz and a phase margin of 62.1 degrees at 1.124kHz.



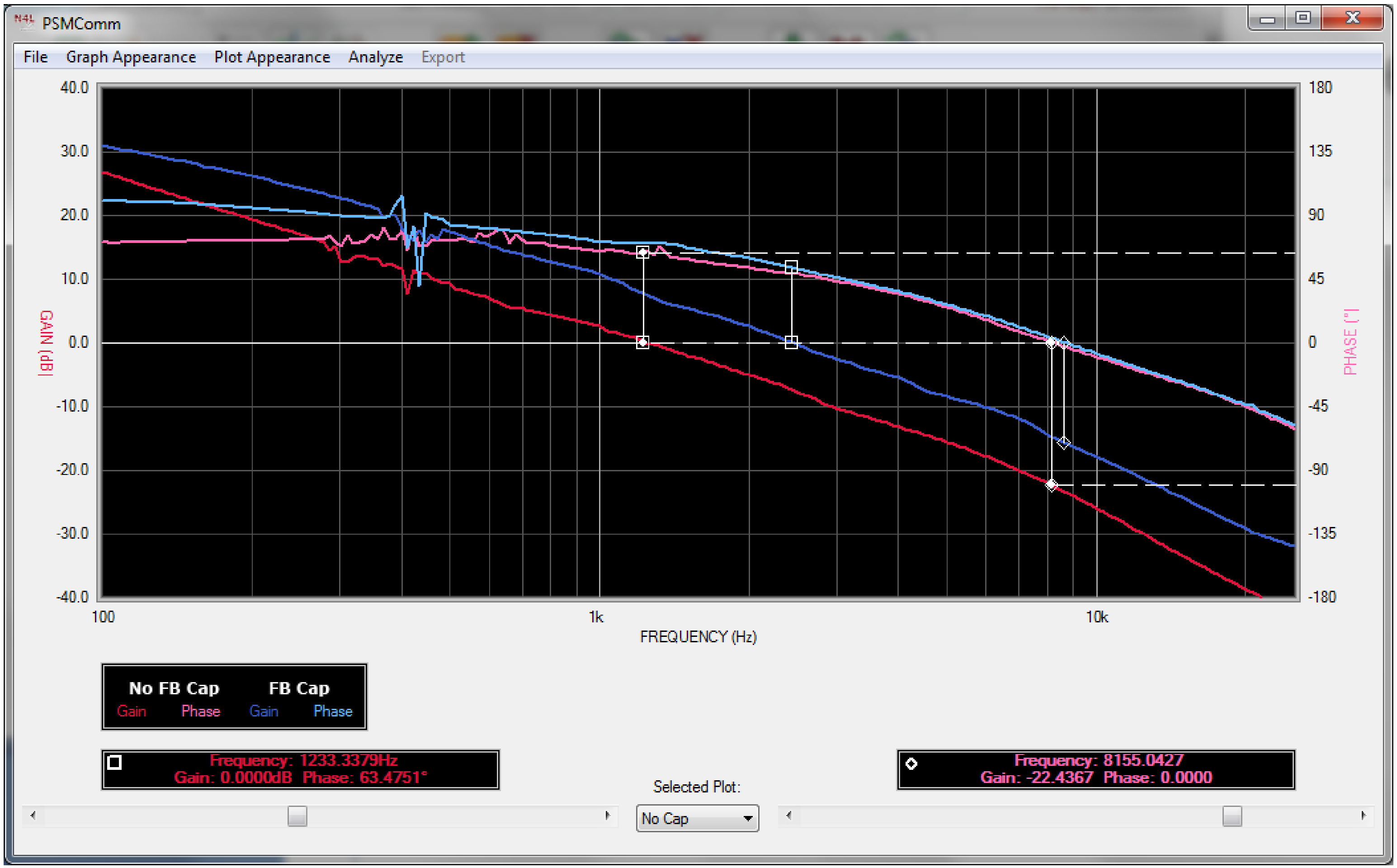
Software

All frequency response measurements can be recorded to software and compared during development.



Software to aid development

Results can be compared quickly, as illustrated below you can see two Gain/Phase plots with and without an extra feedback capacitor.



Thank you


N4L
Precision Power Analyzer
PPA5530
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