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APPLICATION NOTE – 002
Testing loop stability the PSM Range

Introduction

Any closed loop feedback system can become unstable if, at any frequency, the phase delay round the loop is 360° or more while the loop gain is greater than 1 (0dB). At values close to 360° and 0dB the system can exhibit erratic behaviour even though it will not have sustainable oscillations. In order to preserve controlled behaviour of the closed loop system, 2 criteria are typically applied:

Phase margin: The phase delay round the loop should be less than 315° (45° margin) when the loop gain is greater than 0dB.

Gain margin: The loop gain should be –20dB or lower when the loop phase delay reaches 360°.

PSM units are ideally suited to measuring the gain/phase response of a control loop by injecting a small disturbance and analysing the results. All PSM units use DFT analysis (Discrete Fourier Transform) to measure the relative gain and phase of the signal round the loop at the specific test frequency, rejecting any other frequency components present (such as noise or ripple). The test frequency can be swept automatically over the desired frequency range and the results viewed on the screen or printed out.

Making the connections

In order to inject a small disturbance into the control loop, it is necessary to insert a small resistor (10Ω to 100Ω) into the loop at a suitable point where the small resistance has negligible effect (such as in series with the feedback resistors).
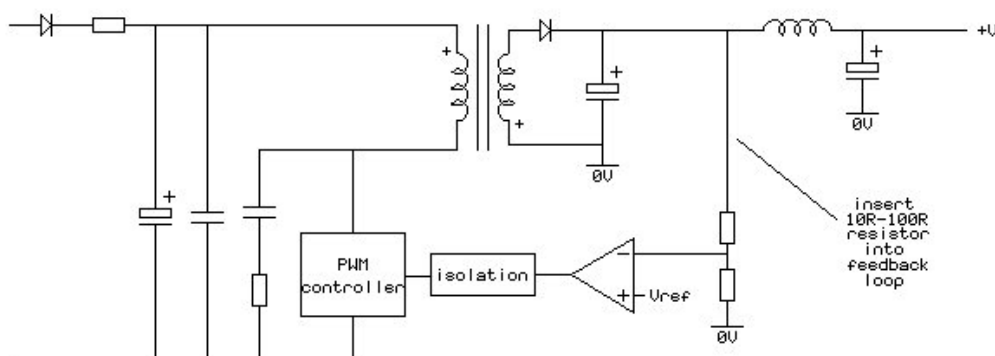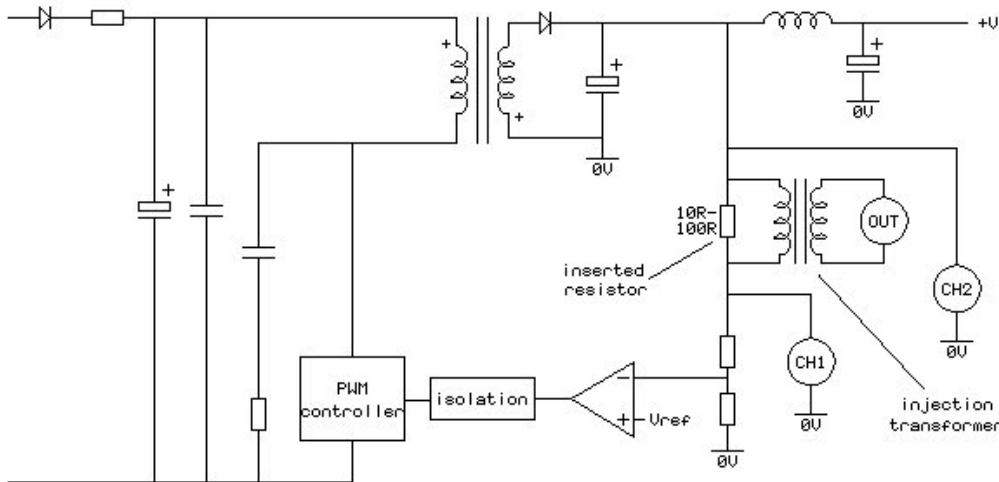

Simplified schematic of a switching power supply

When laying out a new pcb it is worth tracking the resistor in permanently so that tests may easily be done at any time without disturbing the wiring.

In order to provide electrical isolation, the PSM generator is connected across the inserted resistor via a signal transformer. As most loop tests are carried out over a range of around 20Hz to 30kHz, commonly available audio transformers are ideal. If the transformer available is not 1:1, then connect as a step down transformer so that the generator amplitude is reduced.

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Connect the PSM to input channel 1 from the loop input to 0V and connect input channel 2 from the loop output to 0V. The PSM inputs are fully floating and do not need external isolation.

Simplified schematic of a switching power supply showing connections for loop stability measurements
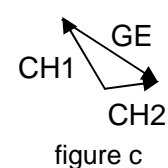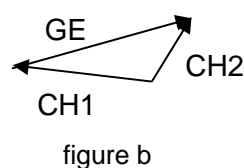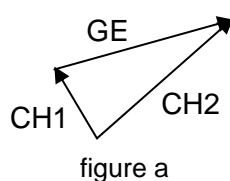
Setting the amplitude

It is important that the generator amplitude is set to a suitable level to so that the signals can be measured reliably but the control loop is not overdriven.

Put the PSM into gain/phase analyser mode (press FUNC or use MODE menu on the PSM2200, or press FRA on the PSM1700/35)).

Using the OUT menu, set the generator to a frequency at the lower part of the control loop bandwidth, set minimum amplitude (enter 0 and the minimum will be inserted), and turn on the output. Either by looking at the measurement on CH2 or by using an oscilloscope connected to the output, slowly increase the amplitude of the generator (using UP key or OUT menu) until a small but stable signal is present on CH2.

Having found an appropriate signal level, enter the measured value from CH1 in the 'ac level' field of the TRIM CONTROL menu (press OUT then NEXT on the PSM2200 or use trim menu on the PSM1700/35). Set the 'ac trim data' field to CH1 and set the 'tolerance' field to 10% or 20% if the signal is very low. This will ensure that all frequencies are tested with a similar level of disturbance; the PSM will automatically adjust the generator amplitude to meet the trim criteria (this technique is also known as amplitude compression).

This can be an important feature as the same generator level used at all frequencies may present problems. Consider the three vectors – disturbance amplitude (generator), CH1, and CH2 – as shown in figure a. As these form a complete loop, if the disturbance amplitude is not adjusted (by controlling the generator), then the loop input signal is effectively increased as the gain of the system reduces (figure b), and the loop is likely to be overdriven:

figure a

figure b

figure c

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By controlling the generator signal to maintain a constant loop disturbance (amplitude compression controlled by CH1, figure c), overdriving of the control loop can be avoided. By setting the TRIM CONTROL parameters appropriately, the PSM can provide the amplitude compression function automatically as the frequency is changed. The PSM unit makes an audible beep when the generator amplitude is adjusted.

Try a few frequency points manually (use LEFT/RIGHT keys or OUT menu) to verify that the generator can be adjusted appropriately and that the control loop is not overdriven.

Making the measurements

Set the frequency range of interest for the sweep (press SETUP then NEXT on the PSM2200 or SWEEP mode on the PSM1700/35) and press START to begin the frequency sweep. The results may be viewed on the screen as a table or graph using the DISP key on the PSM2200 or TABLE and GRAPH keys on the PSM1700/35. When viewing the graph, a cursor may be moved across the screen using the LEFT and RIGHT keys.

All PSM units are fully operable by communications over RS232 and the results read back as comma delimited ASCII data (refer to manual for commands). The data can then be imported into an application for inclusion in reports and all units can be controled by N4L dedicated control software.

Hints and tips

If the signals are very noisy, or if the level has to be kept very small to prevent overdriving the control loop, select 'slow' speed in the SETUP menu. This will have the effect of slowing the sweep (~2.5 seconds per point) but increases the selectivity of the measurement.

The measured phase may be displayed either in the range of 0° to 360°, or -180° to +180°. Set the convention to be used in the SYSTEM menu.

The settings may be stored in any of the non-volatile program locations 1-100, then recalled when needed.