XP Power

XPerts in Power - Module 14
Ripple and Noise

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Module Content

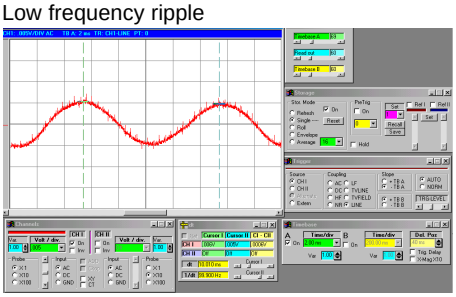
- What is ripple and noise?
- Causes of ripple and noise
- Effects of ripple and noise
- Common mode noise
- Measuring techniques
- Reducing ripple and noise
- Specifying

What is ripple and noise

Unwanted ac voltage superimposed on the output rail(s) of power supplies
Ripple and noise are produced as a result of power supply operation and referred to as differential or symmetrical noise. This is measured between the output terminals of the power supply and can be divided into four components

- Low frequency ripple typically at twice the line frequency (ac input power supplies)
- Ripple at the switching frequency due to the PWM regulating action of the power supply
- High frequency spike noise with a repetition rate equal to the switching frequency
- Aperiodic noise which is unrelated to the line or switching frequency

Low frequency ripple



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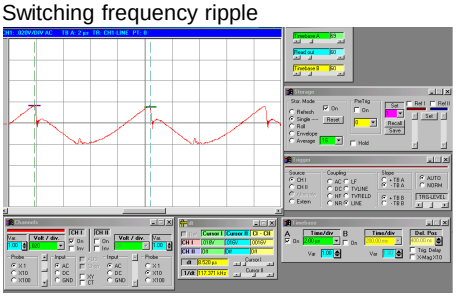
Switching frequency ripple



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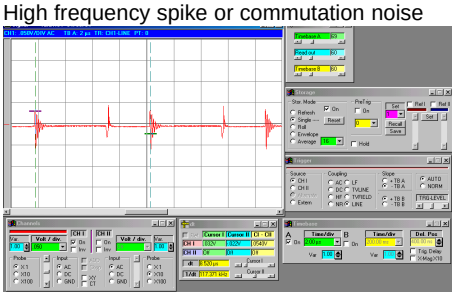
High frequency spike or commutation noise



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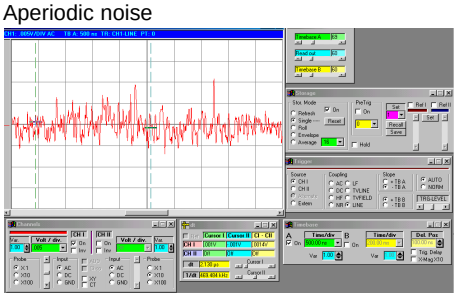
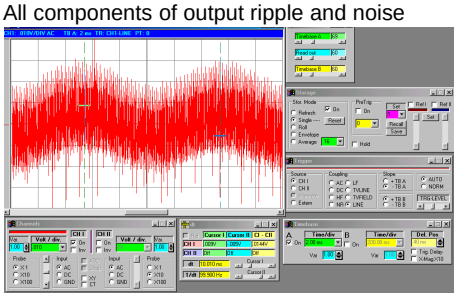
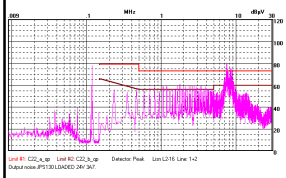
Aperiodic noise



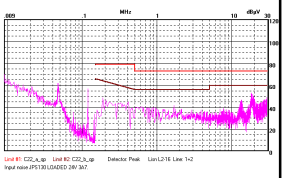
All components of output ripple and noise



All components of ripple and noise (spectrum)



Output noise



Input noise

Output noise can exceed Levels set in EN 55022 for conducted input noise

Causes of ripple and noise

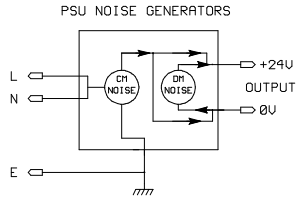
- Low frequency ripple - Input AC to DC conversion results in approximately 5% p-p, the feedback loop then reduces this to typically 0.2%
- Ripple at the switching frequency – PWM averaging circuit parasitics (output capacitor esr,esl)
- High frequency spike – Due to fast switching edges (needed for good efficiency). Unfortunately other circuit components such as diodes do not respond quickly enough, and the resulting conflict causes excessive currents which induce noise spikes.
- Aperiodic noise – Component thermal noise, significant in linear power supplies which have noise at microvolt levels. Other sources can be external i.e. conducted/radiated susceptibility

Effects of ripple and noise

- Reduces accuracy in analogue signal processing
- Erodes susceptibility margins of uP and logic circuits
- Increases EMC tasks particularly for networked equipment
- Degrades performance of audio/visual equipment

Common mode noise (Noise we prefer to ignore!)

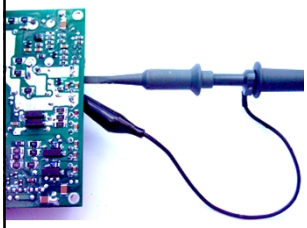
Common mode (asymmetrical) noise is measured between output and ground (and/or input)
Differential mode (symmetrical) noise is measured between output terminals



CM noise is unavoidably converted to DM noise for all measuring techniques. Even using a differential scope cannot completely eliminate CM from a DM measurement (due to slight imbalances and the wide range of frequencies involved)

Most output noise specifications do not include a separate measurement for CM noise. Most rely on a specific measuring technique which combines both types of noise and allows more consistent measurements to be made.

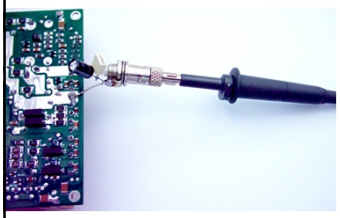
Measuring techniques



Measuring output noise using a scope probe with hook and separate ground lead, gives a large reading for high frequency noise.

Due to the size of loop created by the ground lead and probe hook, this technique converts considerable CM noise to DM. And for the same reason is also more susceptible to pick up from radiated noise.

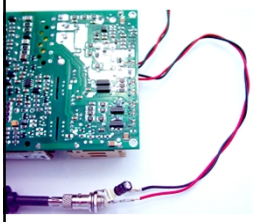
Measuring techniques



Some common techniques include measuring output noise with an extra capacitor across the measuring probe, this is an attempt to reduce the measuring bandwith to lower the reading. Cheating!

Other excuses for this technique include"reducing pick up from radiated noise"

Measuring techniques

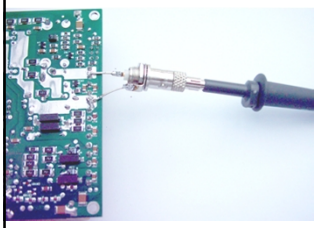


Another technique is to measure the noise some distance from the power supply, and then using capacitors close to the probe to reduce noise.

The excuse being noise at the customer's pcb is more important then at the power supply.

The length of cable (in conjunction with the additional capacitors) has the effect of reducing the noise, cheating!

Measuring techniques



Respectable methods include using a scope probe without a separate ground lead and measuring directly at the power supply terminals.

A 20MHz scope bandwidth is common, this also gives significant attenuation at higher frequencies, but if the bandwidth is stated this is not regarded as cheating!

CM noise significantly affects the host equipment and is an important part of output noise. Measuring techniques for output noise should be consistent when comparing power supplies.

Reducing ripple and noise

- Low frequency ripple – Additional very large capacitor in parallel with the output
- Ripple at the switching frequency – Additional low impedance capacitor in parallel with the output (more attenuation possible when using a series choke before the capacitor)
- High frequency spike – Ferrite sleeves on output leads, additional ceramic capacitors in parallel with output and from each output terminal to ground/chassis (close to point of interest)
- Aperiodic noise – Depending on problem frequency, one or a combination of the above

Specifying

- Output ripple and noise is usually specified as a peak to peak voltage measured with a limited bandwidth (using a scope with a slow timebase setting, all components are then included
- Can also be specified as PARD (Periodic And Random Deviations) as a pk-pk voltage and commonly with a bandwidth 20Hz to 20MHz.
- Sometimes specified as an rms voltage, but this tends to hide the amplitude of high frequency spike noise (due to very narrow spike pulse widths). Often meters and scopes capable of measuring rms values have significant limitations on crest factor and bandwidth, which may lead to inaccurate results. RMS figures are more suitable for noise and ripple waveforms with a low crest factor such as from linear power supplies (crest factor=peak voltage/rms voltage).

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