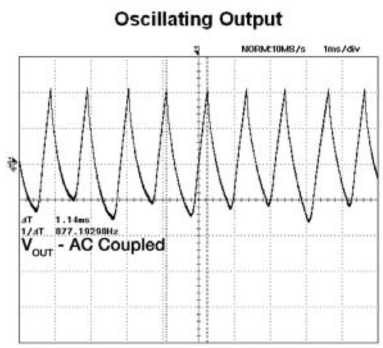
Introduction

These course notes are to be read in association with the PI University video course, *Fixing a Flyback Supply That Has Audible Noise*. In this course, you will learn about the various causes of audible noise in switching power supplies and the steps you can take to fix noise problems.

Audible noise may not be an issue if your power supply is in a sealed enclosure

Keep in mind that some audible noise is normal for switching power supplies and may not be an issue if your design is intended for use in a sealed enclosure. Be sure to test your design in the final enclosure or product before determining if audible noise levels are unacceptable. Audible noise can also be caused by other factors in your design (e.g., an oscillating output voltage), so you first need to ensure that there are no design flaws creating an unacceptable noise level.



An oscillating output can cause noise

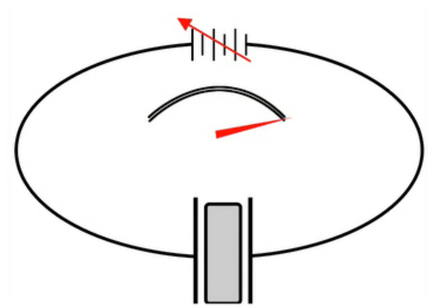
Equipment Required

The following equipment is needed for completion of this course:

1. A programmable AC source or a Variac
2. An electronic load

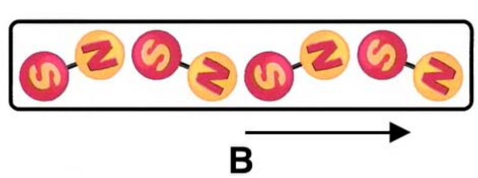
Noisy Components

Audible noise is typically generated by either ceramic capacitors or ferrite transformer cores. Noise in ceramic capacitors is typically caused by the reverse piezoelectric effect. When a voltage is applied across a dielectric structure, it can induce a mechanical stress or strain and cause the material to deform. As this material deforms, it displaces the air around it and causes audible noise.



Reverse piezoelectric effect generates noise in ceramic capacitors

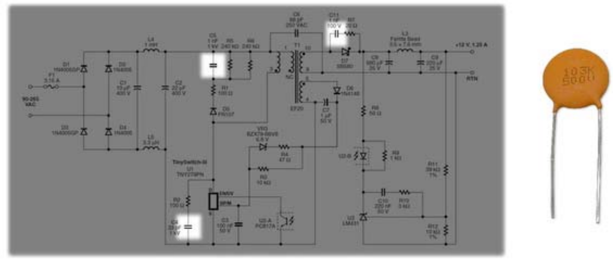
Noise generated by transformer cores is caused by a similar effect called magnetostriction. Many ferromagnetic materials change shape when subject to a magnetic field. As the magnetic field changes in the transformer core, it can cause the core to physically vibrate. When this vibration reaches the mechanical resonance frequency of the transformer, it will be amplified and may cause large amounts of audible noise.



Magnetostriction generates noise in transformer cores

Dealing with Noisy Capacitors

Ceramic capacitors are the most common sources of audible noise in a switching power supply. Because this noise is caused by the reverse piezoelectric effect, which occurs with voltage swings, you can isolate your search down to only ceramic capacitors which experience high dV/dt swings. These include snubber and clamp capacitors, as well as ceramic output capacitors.

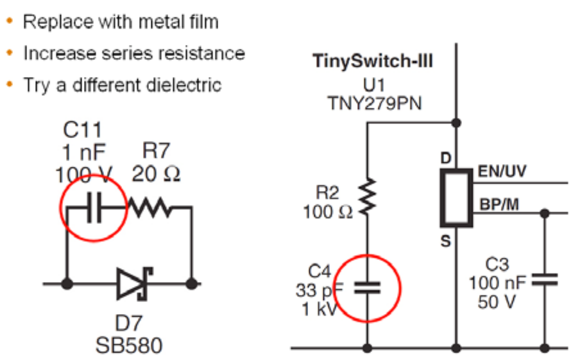


Capacitors experiencing high dV/dt swings will generate noise

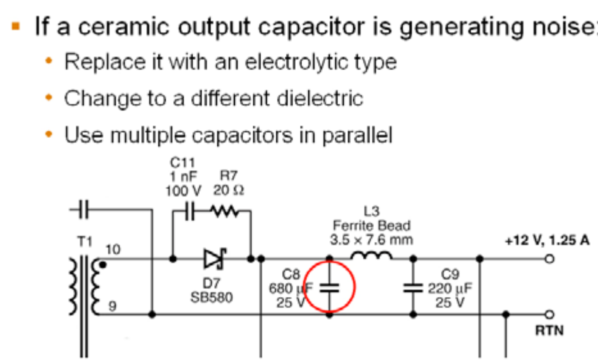
The general approach for identifying if a ceramic capacitor is generating noise is to replace it with a metal film type with the same value and appropriate voltage rating. If the noise level reduces, then you have located a noise source in your circuit.

If a clamp capacitor is generating noise, consider replacing it permanently with a metal film type, trying a ceramic capacitor with a different dielectric material, or changing the clamp type (e.g., switch to a Zener clamp circuit).

If a snubber capacitor is generating noise, consider replacing it permanently with a metal film type, or increase the value of the resistor in series to reduce the dV/dt seen across the capacitor. Alternatively, switch to a ceramic capacitor with a different dielectric and see if the noise level is reduced.



Methods for fixing a noisy clamp capacitor



Methods for fixing a noisy output capacitor

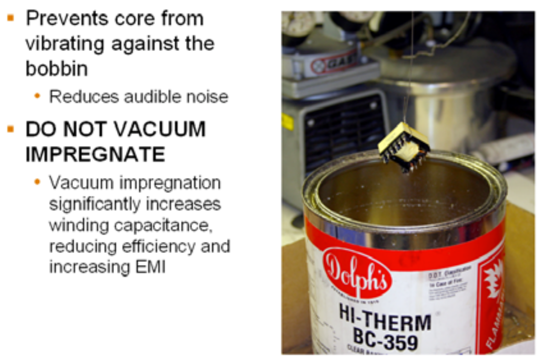
If a ceramic output capacitor is identified as a noise source, consider replacing it with an electrolytic type or changing to a capacitor with a different dielectric. Also consider replacing the capacitor with multiple ceramic capacitors in parallel. The reduction in each capacitor size will reduce its surface area and change the mechanical resonance of the capacitor.

Dealing with Noisy Transformers

The transformer is the other common source of audible noise in a power supply. To begin debugging the transformer, first confirm that it is not being stressed by an improper design. Verify that the input voltage and output loading you are providing match that entered into the *PI Expert* specification. If the power supply is being run below the specified minimum input voltage or above the specified output load, then regulation may be lost for part of the incoming AC cycle, causing increased flux levels in the core and generating audible noise.

Check external conditions before blaming the transformer

If the loading and input voltage are both correct, check that the input bulk capacitor value is correct per the value specified in *PI Expert*. If the input capacitor is too small, the DC bus voltage will droop too low between AC refresh cycles, again causing regulation to be lost for part of the incoming AC cycle.



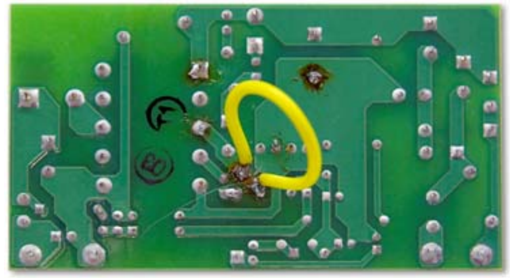
Use dip varnishing to reduce noise

Dip varnishing a transformer core will prevent the core from vibrating against the bobbin and will reduce audible noise. When specifying a varnishing technique with your vendor, always use dip and do not vacuum impregnate. Vacuum impregnation significantly increases winding capacitance and will reduce efficiency and increase EMI.

If the transformer core used is a long type, then try redesigning using a standard core length. Long core variants, for example EEL and EERL compared with the similar EE and EER, have much lower mechanical resonant frequencies. The lower resonant frequencies tend to increase audible noise. Note that switching to a short core may result in having to use a larger core size to provide sufficient winding window area.

Diagnosing Pulse Bunching

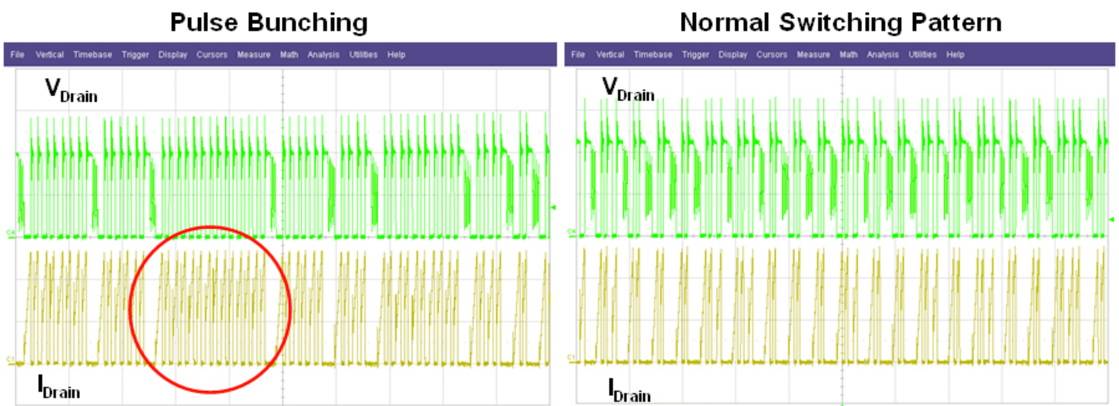
Another cause of audible noise is a phenomenon known as pulse bunching. Pulse bunching refers to the tendency in some designs for the conducted current pulses to group together, followed by an extended number of skipped pulses. The grouping of pulses introduces components into the switching frequency pattern that are often in the audible range. This tends to occur most frequently in supplies using on/off control, such as *TinySwitch* or *PeakSwitch* designs.



Insert a current loop to investigate pulse bunching

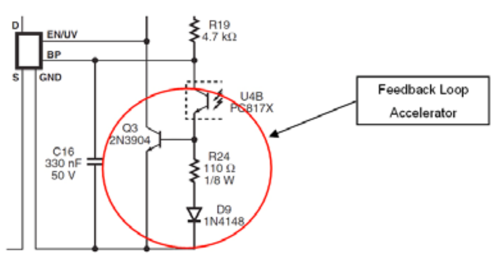
To identify if pulse bunching is occurring in your design, break the MOSFET drain trace and insert a current loop to monitor the drain current switching pattern. The equipment and procedures to measure the drain switching current can be found in the PI University Course Notes, *Techniques for Measuring Drain Voltage and Current*. With a current probe and an oscilloscope, capture a set of drain switching pulses on a wide time scale with the supply operating at normal load. If you see a number of pulses conducted in a row, followed by two or more skipped pulses, your supply is likely experiencing pulse bunching.

In the figure shown below, the switching waveform on the left exhibits extreme pulse bunching. The switching waveform on the right shows a more normal pattern, where the conducted and skipped cycles are more or less evenly distributed.



Waveforms for a circuit experiencing pulse bunching (left)compared to a normal switching pattern (right)

Pulse bunching in a design indicates that the feedback circuit is too slow, introducing lag in the controller's response. Begin debugging this problem by first verifying that all the component values in your feedback circuit match those specified by *PI Expert*. Also try using a D-type optocoupler in your design, which has a much higher gain than standard optocouplers. You may also wish to add a feedback loop accelerator circuit to improve response times. This circuit ensures that the optocoupler transistor always operates in the active-region, preventing it from saturating and giving it a faster response.



Add a feedback accelerator loop to improve response times

For More Information

If you have any questions or comments about the information presented in this course, please email PIUniversity@powerint.com.