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APPLICATION NOTE 4713

Eliminate Noise Through Proper Supply Bypass Filtering

By: Walter Chen, Principle Member of the Technical Staff, Applications
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Abstract: If sensitive analog systems are run from one supply without the sufficient bypassing to eliminate noise, undesired degradation in a system's performance will result. This application note provides insight into suitable techniques to overcome this roadblock.

You have combined digital and analog functions together in the final stage of a system design. But then the performance of the analog function, such as an audio amplifier, deteriorates due to the noise originating from the digital circuits. This can happen even after conventional preventive measures (e.g., separating analog and digital grounds, shielding) were taken. Noise interference problems can likely be traced to the coupling of power supplies, sometimes even if separate linear regulators are used.

The 60Hz AC supply noise has been a traditional issue for high-gain audio amplifier systems. A performance measure called power-supply rejection ratio (PSRR) was specifically defined to address this issue. PSRR is defined as:

$$PSRR = \frac{\Delta V_{SUPPLY}}{\Delta V_{OUT}}$$

PSRR can be measured against any frequency of interest, in addition to 60Hz. The degree of interference from the power-supply coupling can be quantified by identifying the PSRR of the affected system and measuring the noise on the power supply of the interfering system.

The following example shows how to eliminate noise interference through proper supply bypass filtering. **Figure 1** is the functional block diagram of a voice-over-IP (VoIP) public address system consisting of an audio amplifier for delivering public announcement and a digital clock for displaying the time. The VoIP name indicates that the system is powered through the Ethernet. The LED digits of the digital clock are driven by the MAX7221 LED driver. Audible high-pitched noise can be heard from the loudspeaker a few feet away, after the audio and digital clock circuits were combined.

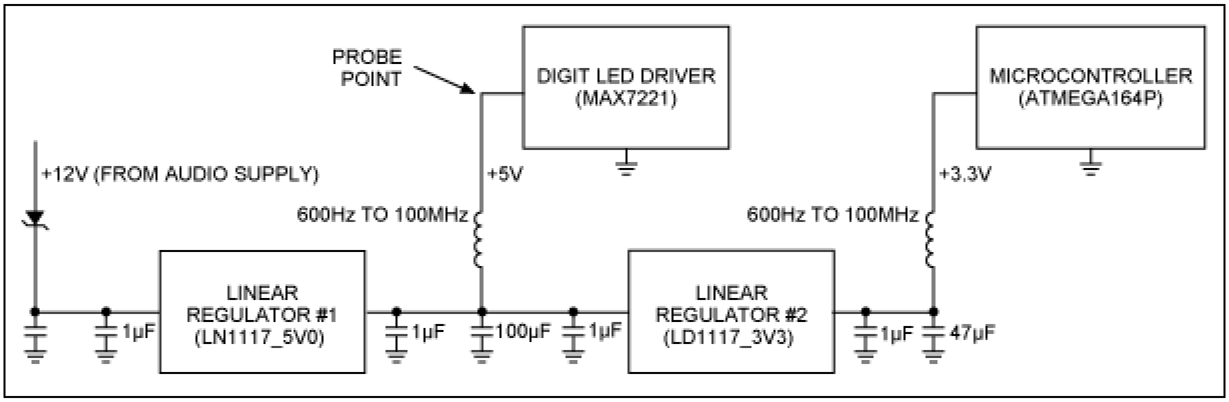

Figure 1. Power supplies for a VoIP system.

On the 5V regulated power supply for the MAX7221, the digital noise has a peak-to-peak value of 300mV, recurring at a frequency of about 12kHz. This noise is caused by the multiplexed driving of 4 LED digits. Note that the noise disappears if audio and LED driver circuits use separate power supplies. Little noise was measured on the 12V input audio system supply.

A third-order LC π lowpass filter (LPF) is used to separate the audio and digital power supplies, as shown in **Figure 2**. Using a 1mH inductor and setting a corner frequency of 1kHz, the capacitor values are calculated as follows:

$$f = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$$

$$C = \frac{1}{4 \times \pi^2 \times f^2 \times L} = \frac{1}{4 \times 3.14^2 \times 1 \times 10^6 \times 1 \times 10^{-3}} = \frac{1}{3.9438 \times 10^4} = 25\mu F$$

The high-pitched noise disappears after this bypass circuit is applied.

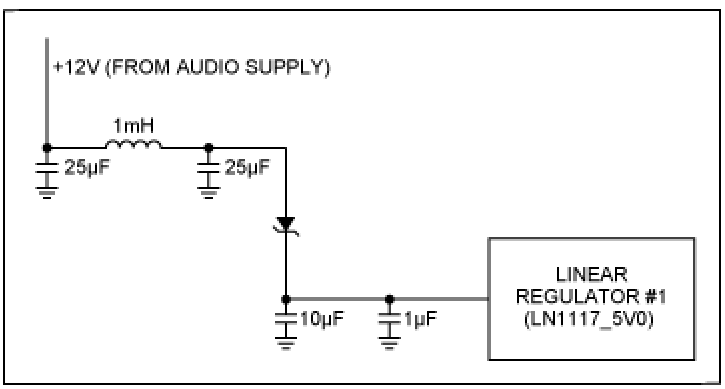

Figure 2. Additional LPF filtering.

Similar power-supply coupling measurement and bypass filtering techniques can be applied to a radio frequency (RF) or image capture system. In an RF system, the transmitter noise often degrades the performance of the receiver; in an image capture system the analog supply of a CMOS camera sensor chip is sensitive to digital noise. The bypass filter should be designed to address noise from the transmitter functional block or from digital circuits associated with the camera chip.

Related Parts		
MAX7221	Serially Interfaced, 8-Digit, LED Display Drivers	Free Samples

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