

Audible Noise in Switch Power Supply

Abstract: This paper discusses the audible noise becomes a more and more important index for some special application, and introduces audible noise in switch power supply.

Introduction:

In recent years, there has been strong demand for noise reduction of switch power supply due to increasing concern about environmental problems, especially, such as hospitals, schools, laboratories, and offices. Usually, the electrical equipments should be required the lower the better, therefore, the audible noise becomes a very important index when customer choose switch power supply.

1: What's the audible noise?

Definition: Audible noise is any sound that the eardrum can detect, either deliberate (music, speech, etc.) or unintended, and the audible sound leads to people to feel annoyance, but also significantly impact people's health, it's audible noise, polluted the living environment.

Audible noise frequency range: The range of the sound frequencies normally heard by the human ear. The audible range spans from 20Hz to 20,000Hz, but for most engineering investigations only frequencies between about 40Hz and 10,000Hz are considered.

Sound pressure level:

- The Sound pressure level (SPL) L_p as $L_p = 20 \log (P / P_{ref})$
Where log stands for the logarithm to the base 10 (ordinary logarithm).
- The unit used to express the sound pressure level is the decibel, abbreviated dB
- Degree of loudness.

- A unit for expressing the relative intensity of sounds on a scale from Zero for the average least perceptible sound to about 120 for the average pain level. Sounds in excess of 120dB may cause immediate irreversible hearing impairment,

The decibel (dB) table below compares some common sounds and shows how they rank in potential harm to hearing. 70dB is the point at which noise begins to harm hearing. To the ear, each 10dB increase seems twice as loud.

Sound Levels and Human Response		
Common sounds	Noise Level [dB]	Effect
Rocket launching pad (no ear protection)	180	Irreversible hearing loss
Carrier deck jet operation Air raid siren	140	Painfully loud
Thunderclap	130	
Jet takeoff (200 ft) Auto horn (3 ft)	120	Maximum vocal effort
Pile driver Rock concert	110	Extremely loud
Garbage truck	100	Very loud

Firecrackers		
Heavy truck (50 ft) City traffic	90	Very annoying Hearing damage (8 Hrs)
Alarm clock (2 ft) Hair dryer	80	Annoying
Noisy restaurant Freeway traffic Business office	70	Telephone use difficult
Air conditioning unit Conversational speech	60	Intrusive
Light auto traffic (100 ft)	50	Quiet
Living room Bedroom Quiet office	40	
Library Soft whisper (15 ft)	30	Very quiet
Broadcasting studio	20	
	10	Just audible
	0	Hearing begins

2: Sources of audible noise in a switch power supply

Usually, cooling fans and magnetic components are the sources of the audible noises in a switch power supply, and magnetic components do not generate big squeal when they operate at constant ultrasonic frequencies (>20KHz switch frequency), only the switch

power supply work in some certain conditions. For example burst mode at light load condition, which can cause the burst switching bundles in the range of human hearing.

2.1: Magnetic components audible noise

Magnetic components can produce audible noise, since they contain many physically movable elements, such as coils, isolation tapes and bobbins. The current in the coils produces electromagnetic fields which generate repulsive and /or attractive forces between the coils. This can produce a mechanical vibration in the coils, ferrite cores or isolation tapes, and human’s ears just can hear the noise, when the switching frequency of power supply is in the range of 20Hz to 20 KHz.

How to reduce the magnetic components audible noise:

- Varnish the magnetic components

The most effective way to reduce the audible noise in the magnetic components is to remove the possibility of physical movement of elements by using adhesive material or by varnishing. This damps mechanical resonance of the magnetic components as well.

- Change the magnetic components design

Using some customized core to optimize space; reducing the flux swing in some special condition, because the amplitude of mechanical vibration is closely related to the flux swing. We can know that the flux swing can be reduced by reducing current peak as following formula, so we can reduce the audible noise by reducing current peak.

$$\Delta B = \frac{L_m I_{bp}}{N_p A_e} \times 10^6 \quad (T)$$

Where L_m is the transformer primary side inductance, I_{bp} is the current peak, A_e is the

cross-sectional area of the core in mm² and N_p is the number of turns of transformer primary side, ΔB is the flux swing.

- Fix the operating switch frequency

Try to avoid the switch frequency in the range of audible noise bandwidth.

2.2: Fan audible noise

With the smaller enclosures and higher system performance, the smaller and higher speed cooling fans were required in the system, and the increasing of airflow and speed will increase fan noise. The Fan's audible noise originates from several sources.

- Aerodynamic noise

It's a result of turbulence caused by the fan blades. The frequency and magnitude of the noise generated by a cooling fan increases with rotational speed.

- Mechanical noise

It is caused by bearings, or unbalanced rotating elements that can cause vibration. If this vibration is at a frequency that matches any resonant frequencies of the enclosure it can be amplified to an intolerable or even destructive level.

How to reduce the fan audible noise in switch power supply

- Optimum fan design, choose an optimized fan in switch power supply.
- Minimize obstacles in front and behind the fan.
- Obstacles on the intake side of the fan negatively impact the noise level more than on the exhaust side.
- Lower the RPM of the fan operating speed (this action also lowers airflow)
- Remove fan by Optimized the heat transfer coefficient to chassis and enhanced power efficiency.

3: What's Audible noise of CoolX600?

With the Optimized heat transfer coefficient and enhanced extremely high efficiency, CoolX600 removed the fan for 600 W operation, its means that CoolX600 is zero audible noise. CoolX600 without fan is not only benefit to audible noise, but also the MTBF, reliability. MTBF increases remarkably by 25%

References

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