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APPLICATION NOTE 1843

Noise Reduction For ADSL Modem Power

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Abstract: While the MAX1864 offers a cheap solution to multiple output power supplies for ADSL modems, the over-winding on the converter transformer (T2) can be noisy. This is because the transformer usually needs to be gapped to handle the DC current, and gapped cores tend to have larger leakage flux. Noise generated from this leakage flux can be difficult to reduce. The most common problem is that the time-varying flux will induce a voltage on any circuit. The key is to realize that this voltage will be induced and create a high impedance path where this noise voltage can harmlessly be absorbed.

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This problem is illustrated in the ADSL modem diagram below (**Figure 1**). Here we see that the ground is separated into three sections: Ground, switching ground, and earth ground. Even though earth ground and switching ground are isolated, stray magnetic fields still will induce a voltage on the ground loop. It is easy to see that while we desire the noise to show up on the common mode inductor T1, it actually shows up across the ADSL and Ethernet transformer T3 and T4. This is because T3 and T4 present much higher impedance then the common mode inductor T1. This noise also tends to drive the shield on the Ethernet and ADSL outputs.

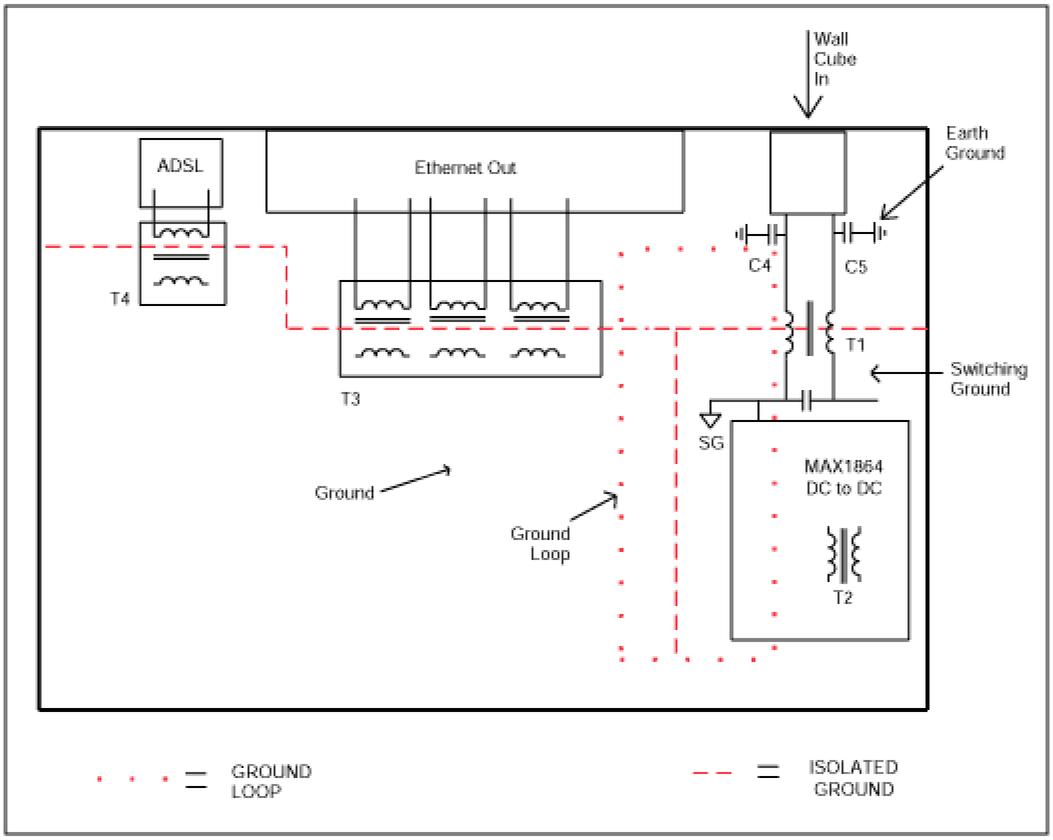

Figure 1. ADSL modem.

While we like to think that an isolation transformer has infinite impedance, this is true only at DC. In fact most isolation transformers act as capacitors for AC signals. When leakage flux from a magnetic circuit is induced in a loop the capacitance of the isolation transformer in series with the loop inductance forms a resonant circuit. This is usually observed as a spike (at the switching frequency) with a ringing frequency. Without some form of lossy element these circuits can exhibit a high Q. Common mode chokes are designed to be lossy at switching frequencies so they can absorb ringing energies and increasing the loop inductance, lowering the ringing frequency and hence the circuit Q.

To solve this problem we must make the noise show up on common mode inductor T1. The easiest way to do this is to move C4 and C5 from the earth ground to the ground. This will allow the common mode inductor, T1, to absorb the induced voltage, as shown in **Figure 2**.

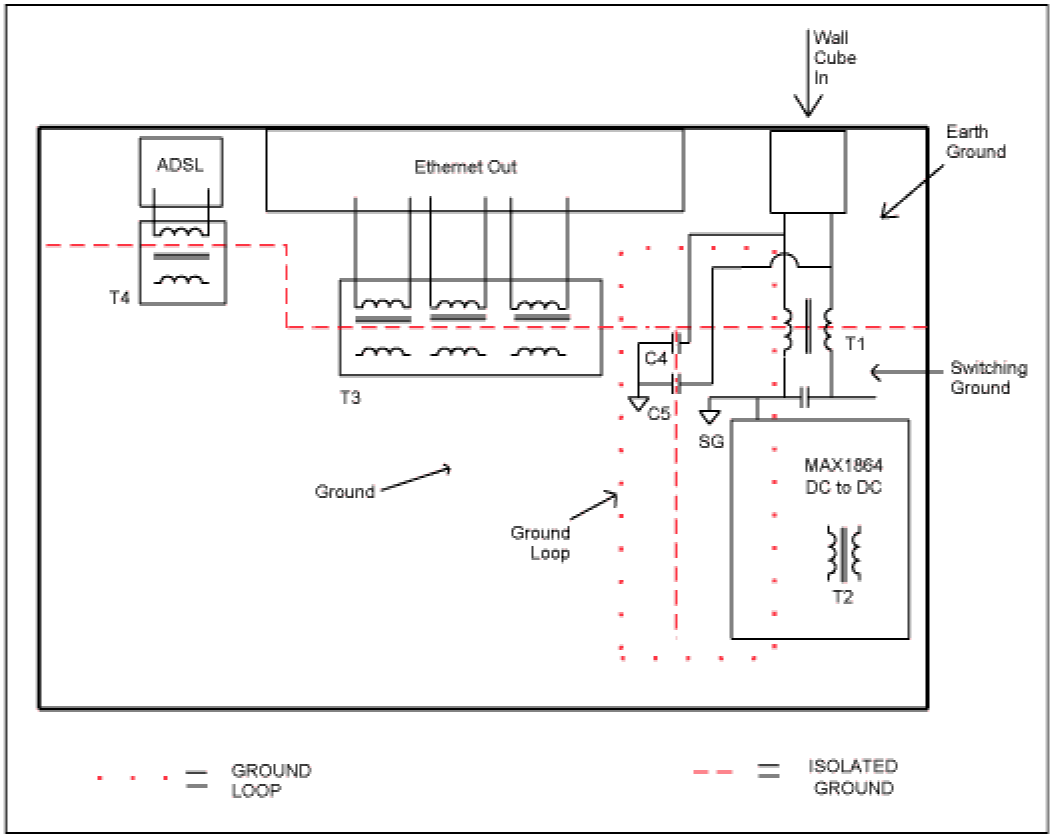

Figure 2.

Another way to force the voltage across T1 is to place capacitors across the isolation transformers T3 and T4. This lowers the impedance across T3 and T4 so that T1, C4 and C5 can absorb the noise. This is shown in Figure 2 below. This also swamps the parasitic capacitance of the isolation transformer, which lowers the resonant frequency and the circuit Q.

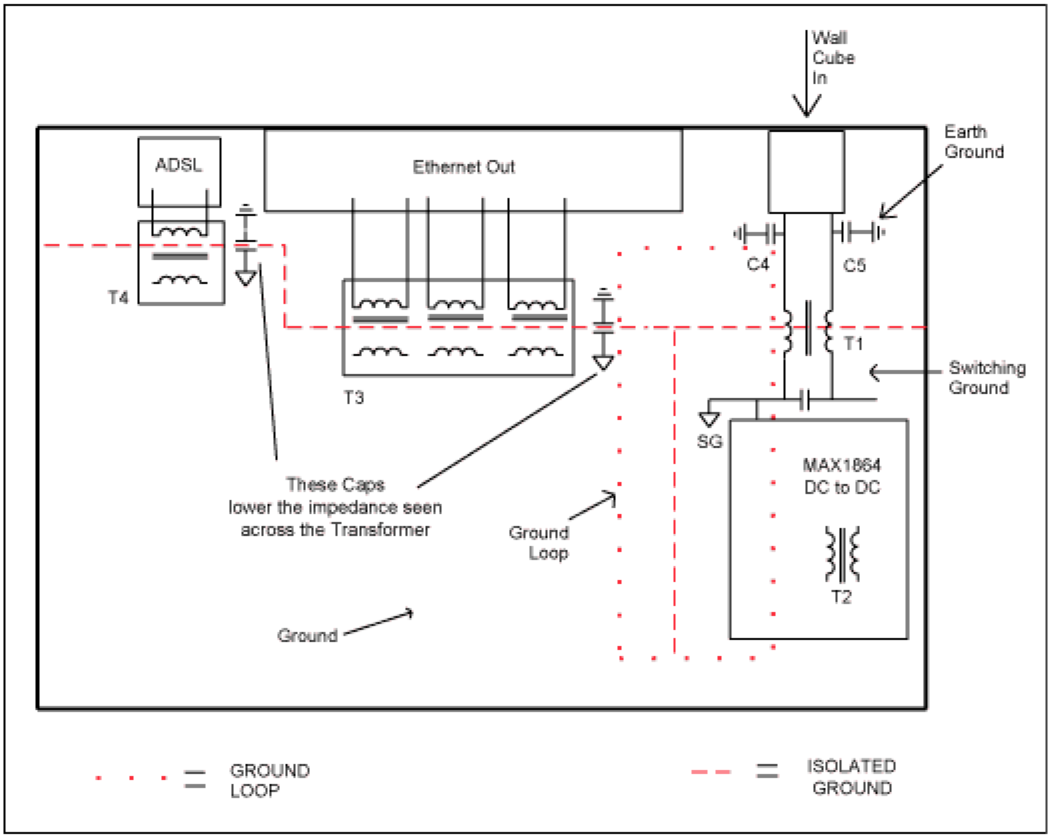

Figure 3.

Reducing radiated flux from the source (T2) offers a method to further reduce the noise. Placing a copper shield around the gap on the core is one way to reduce flux leakage from the transformer. Care must be taken to avoid the copper shield acting as a shorted turn within the transformer. Another method is to slow the time varying field that induces the noise voltage. By placing a capacitor across the transformer the rate of change of the magnetic field can be slowed down, reducing the induced noise. Because a reduced slew rate will reduce efficiency a compromise must be made between efficiency and noise.

Any of the methods mentioned above can help to reduce noise problems. The type of noise you intend to reduce may change the solution. In order to determine the best solution you should first know the frequency of noise to be reduced and how much (dB) noise reduction is needed. With switch-mode power supplies, noise from 50kHz to 2MHz is the most troublesome. This area is tough because the components to handle this band must be near to ideal. Ground planes and large capacitors are far from ideal and behave like inductors in this environment. This is why the high impedance of the common mode filter is so important. Understanding this can lead to the best configuration of components for your application.

Related Parts		
MAX1864	xDSL/Cable Modem Triple/Quintuple Output Power Supplies	Free Samples

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