AN-42036

PCB Grounding System and FAN2001/FAN2011 High Performance DC-DC Converters

Introduction

Ground wiring can often limit system performance. The purpose of this application note is to help the system designer utilize the benefits of the FAN2011 and FAN2001 families of high performance step-down DC-DC regulators, to avoid PCB layout related problems and maximize overall system performance. The basic concept of "star grounding" is presented and ways of implementing star grounding for systems like a cell phone, are shown.

Grounding Issues

Ground is defined as a reference potential for linear circuit elements such as amplifiers, voltage references, and A/D converters. It is used as the return for power systems elements such as switching regulators, power amplifiers, and digital circuit blocks. It is also used as a shield to prevent the propagation of electromagnetic noise in the circuit. Because of these diverse uses, care must be taken in laying out the PCB ground system to avoid interference between different areas of the board.

The finite resistance of the grounding path may couple the noise generated by the power elements into the signal path of the precision circuit elements, as shown in Figure 1.

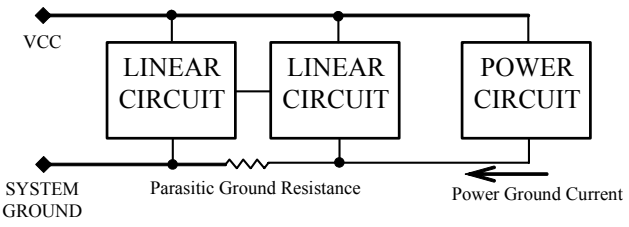


Figure 1. Coupling of Ground Current Noise

If a ground connection carries substantial current, a voltage drop will develop in the ground because of the basic resistance of the ground material. This voltage drop makes local ground different than zero volts, depending on circuit topology and element location. If the current is high and if there are ground sensitive circuits connected to this current path, the voltage drop across the parasitic ground resistance will produce offsets in the voltage measurements of the sensitive linear circuit. In the case of a switching regulator, where the power current is time varying, noise is induced in the system. Linear circuits are referenced to ground and some parameters of the converter such as load regulation and overall output voltage accuracy are affected by this noise. Another related issue of the ground system is its tendency to carry inductively induced currents. Since the ground system can be spatially extended, it is possible to generate circulating currents in the ground caused by changing external magnetic fields. Because the ground system has usually low resistance, the ground loop currents can become quite large. This often happens in larger systems that magnetically couple to the 50 or 60 Hz power supply lines, which are common in many areas. These circulating currents can then induce noise in the sensitive linear circuits through parasitic ground resistance, as shown in Figure 2.

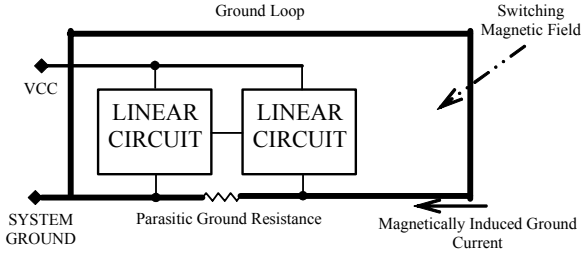


Figure 2. Coupling of Magnetically Induced Ground Current Noise

The Star Ground Technique

In all systems, the correct choice of the ground junction point or single point ground reference, as it is sometimes called, is important. The power management area in particular requires special care as it supplies the current for the whole system. It is necessary to first evaluate the flow of the power supply and signal currents, and then configure the path of the return currents and the location of the junction point. This is necessary to minimize the introduction of DC offsets and noise into the signal return paths.

In star grounding, a common point is chosen to which to connect all ground lines. A physical point is chosen on the circuit board to serve as the star ground point and all grounds radiate from that point to the separate parts of the system. Any one of the ground lines radiating from the star ground may star again, forming a local star ground for a sub-circuit. Special care must be taken to separate the signal ground from the power ground at a star, such that no power current will flow through any signal line ground. Cell phone system design is complex as it compounds various sub-circuits such as analog baseband, digital baseband, audio amplifiers, LCD

controller, power and battery management, and RF transceiver. Such a system is shown in Figure 3 with a general scheme of a "star" ground connection. Ideally, all grounds would converge on the main star and a single point ground reference would be generated at that location. It is physically difficult to bring all the traces on a board to a physical location and make contact at a mathematical point to avoid current generated interference. Therefore, the main star might be broken into sub-stars. This shifts the burden to coupling signals from one star to another, which have slightly different, time variable ground reference potentials. Signal coupling between different blocks would have to be differential to avoid all ground problems.

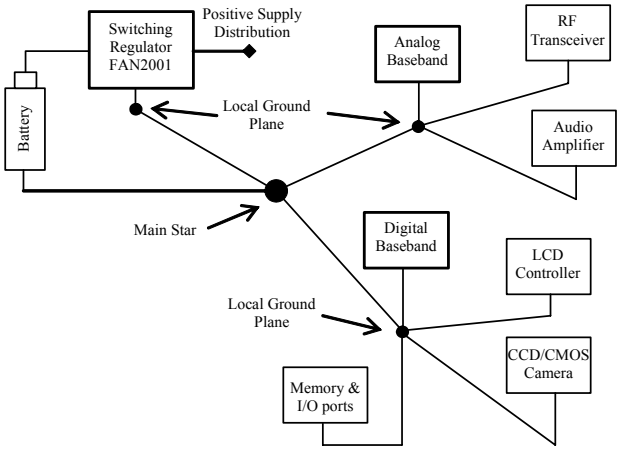


Figure 3. Star Ground Connection for a Cell Phone

FAN2011 and FAN2001 Regulators

The FAN2011 and FAN2001 series of regulators uses a current mode control loop with a fast transient response that ensures excellent line and load regulation. A star ground connection ensures that the highest performance is achieved. The local ground plane for the switching regulator is shown in Figure 4.

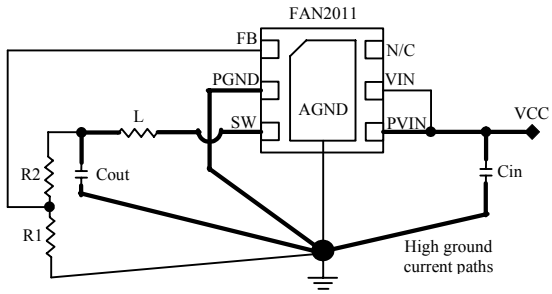
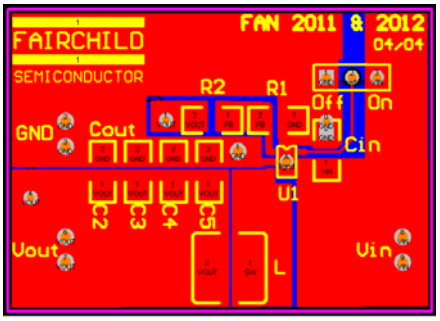
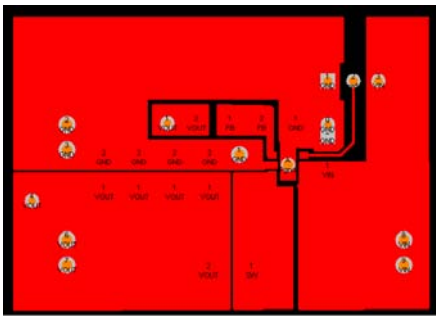


Figure 4. Star Ground Connection for High Performance DC-DC Converters

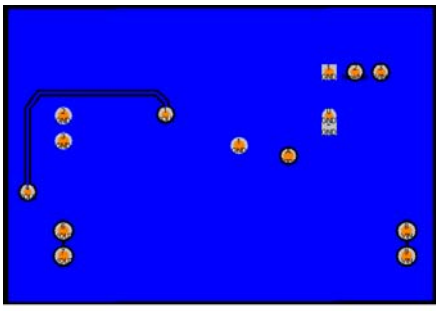
To benefit from the high performance of the FAN2011/ FAN2001 families of regulators, care must be taken designing the PCB layout. The high ground current paths are identified in Figure 4 by bolded lines. The voltage feedback signal, internally connected to an error amplifier, is sensitive to noise and the resistors must be routed separately from the high current paths. If large ground noise is coupling into the feedback signal the device may become unstable and depending on the noise magnitude, the output voltage will be out of regulation. The internal reference of the device is connected to AGND pin. This pin should also be routed separately from the high current paths directly into the "star." Any DC offset introduced into the analog ground pin will affect the load regulation and consequently the regulator's DC output voltage accuracy. An optimum PCB layout for the FAN2011 family is shown in Figure 5.



Composite



Top Layer



Bottom Layer

Figure 5. PCB Layout

Summary Points:

- Printed circuit board traces have substantial resistance.
- The star ground technique eliminates ground noise problems due to PCB resistance.
- When designing a PCB layout, first evaluate the flow of power supply and signal currents, and then configure the path of the return currents and the location of the junction point. This will minimize the introduction of DC offsets and noise into the signal return paths.
- To benefit from the high performance of the FAN2011 and FAN2001 families of DC-DC regulators, local star ground techniques should be considered for the switching regulator embedded in an application system.