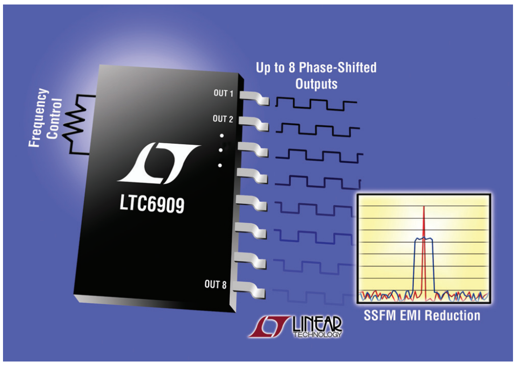


IDEAL SOLUTION FOR EMI

As the demand for energy efficiency increases, more electronics are being designed with switching regulators in place of linear regulators. Power systems with multiple switching regulators are becoming commonplace; as the number of regulators increases, the impact of electromagnetic interference (EMI) also grows. One of the simplest, most cost-effective techniques for EMI reduction is the use of a multiphase, spread-spectrum clock.

MULTIPHASE SYNCHRONIZATION

The operating frequency of most switching regulators can be controlled with an external clock, which, in turn, sets the fundamental frequency of generated EMI. This feature can be useful to set the EMI outside of a sensitive band and is a particularly valuable feature when operating multiple switching regulators together. Multiple independently running switching regulators have the potential to generate large peak EMI, as clock frequencies approach each other and create beat frequency conditions. Similarly, if multiple regulators are operated on a single clock, the EMI will be synchronized and very concentrated. One solution is for each regulator to be driven with the same clock frequency, but with different phases.

Multiphase synchronization refers to the technique of externally driving multiple switchers with a single clock frequency that has a time shift placed between each regulator. This reduces peak switching current by staggering the turn-on for each switcher such that there is input current drawn where previously there was a dead band. As a result, multiple switching regulators synchronized out of phase, versus in phase, have a lower peak current and therefore lower EMI. Also, the frequency of EMI increases after phase synchronization. As a result, EMI filtering is more effective since filtering is more effective at higher frequencies.

SPREAD SPECTRUM FREQUENCY MODULATION (SSFM)

In addition to multiphase synchronization, EMI can be improved by continuously varying

LINEAR TECHNOLOGY CORP.
Milpitas, CA

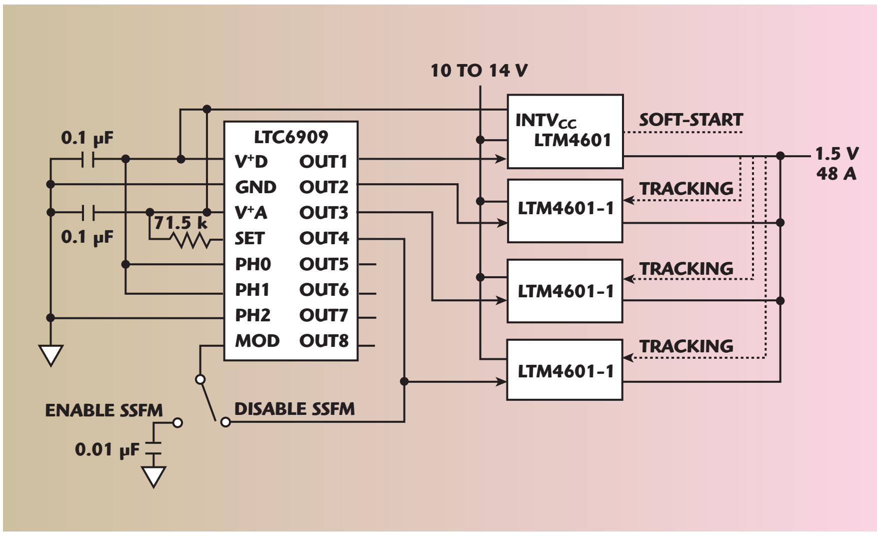


Fig. 1 Block diagram of LTC6909 multiphase silicon oscillator with spread spectrum modulation.

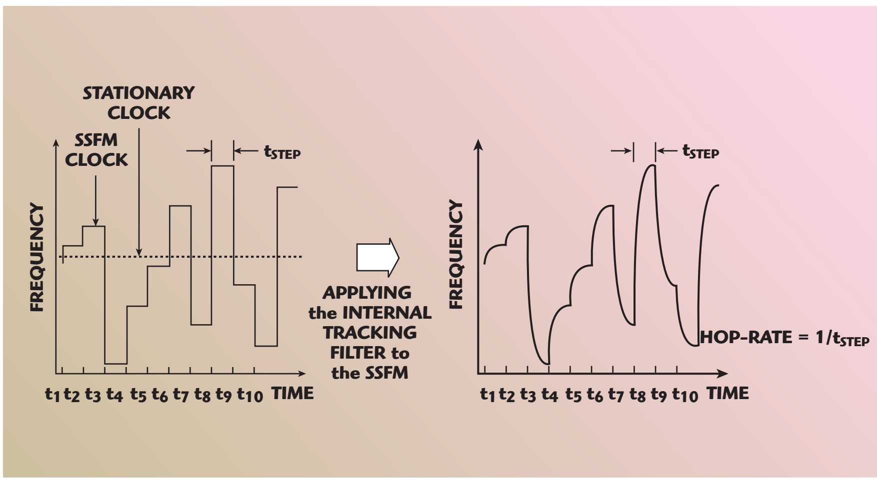


Fig. 2 Pseudorandom modulation and internal tracking filter of LTC6909.

the frequency of the switching regulator clock. This technique, referred to as SSFM, improves EMI by not allowing emitted energy to stay in any receiver's band for a significant length of time. There are four primary considerations for maximum SSFM effectiveness: The bandwidth of the impacted receiver; the method for modulating the frequency; the amount of frequency spreading; and the rate of modulation.

RECEIVER

Whenever considering EMI, the designer should understand the bandwidth of the EMI affected receiver(s). These receivers could be real system devices, or they could be receivers used for regulatory conformance per CISPR 16-1. The receiver's bandwidth determines two important characteristics: The range of frequencies for which the receiver will respond and the receiver's response time when subjected to EMI.

MODULATION METHOD

Most switching regulators exhibit ripple that varies with frequency; more ripple at lower switching frequencies and less at higher switching frequencies. As a result, a switcher's ripple will exhibit an amplitude modulation if the switching clock is frequency modulated. If the clock's modulating signal is periodic, such as a sine-wave or triangle-wave, there will be a periodic ripple modulation and a distinct spectral component at the modulating frequency. Since the modulating frequency is much lower than the switcher's clock, it may be difficult to filter out. This could lead to problems, such as audible tones or visible display artifacts, due to supply noise coupling or limited power supply rejection in the downstream circuitry. A pseudorandom frequency modulation can avoid this periodic ripple. With pseudorandom frequency modulation, the clock shifts from one frequency to another in a pseudorandom fashion. Since the switcher's output ripple is amplitude modulated by a noise-like signal, the output looks as if there is no modulation and the downstream system implications are negligible.

MODULATION AMOUNT

As the range of SSFM frequencies increases, the percentage of in-band time is reduced. If the emitting signal enters the receiver's band infrequently and for short periods, relative to its response time, significant EMI reduction occurs. For example, frequency modulation of ± 10 percent is more effective at reducing EMI than frequency modulation of ± 2 percent. However, switching regulators have a limited range of frequencies for which they can tolerate. As a general rule, most switching regulators can easily tolerate frequency variation of ± 10 percent.

MODULATION RATE

Similarly to the modulation amount, as the rate of frequency modulation increases, the time that EMI will be "in-band" for a given receiver will decrease and EMI will be reduced. There is a limit, however, to the rate of frequency change (dF/dt) that a switcher can track. The solution is to find the highest modulation rate that does not impact the switcher's output regulation.

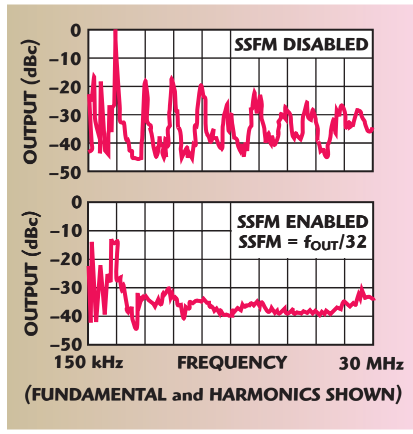
IDEAL SOLUTION

Silicon oscillators provide an ideal platform for multiphase, spread-spectrum switching regulator clocks. In addition to having an on-board clock generator, these solid-state devices can combine spread spectrum modulation and multiphase outputs.

With this in mind, Linear Technology developed the LTC6909, a precision spread spectrum silicon oscillator with eight separate multiphase outputs. A single resistor selects the output frequency from 12.5 kHz to 6.67 MHz. Three logic inputs set the output phase relationship in a range of 45° to 120°, allowing the LTC6909 to provide synchronization for up to eight phases (see ***Figure 1***). A pseudorandom spread spectrum frequency modulation can be enabled with frequency spreading of ± 10 percent of the center frequency. The user selects one of three modulation rates to ensure that the modulation rate does not exceed the regulator's bandwidth.

In addition, the LTC6909 has an innovative filter that tracks the SSFM modulation rate and provides smoothing between frequency transitions (see ***Figure 2***). Using the LTC6909 results in a significant improvement in EMI, as shown in the output frequency spectrum from 150 kHz to 30 MHz (9 kHz resolution BW) displayed in ***Figure 3***.

In summary, using multiple switching regulators in a single system can present a significant EMI concern. In addition to standard layout, filtering and shielding practices, the use of multiphase synchronization and spread-spectrum frequency modulation can dramatically improve EMI performance. Linear Technology's LTC6909 offers a straightforward solution. With little effort, this small, low power and robust silicon oscillator can easily prove its worthiness.



▲ *Fig. 3 EMI improvement using the LTC6909 with SSFM enabled.*

Greg Zimmer is a product marketing engineer at Linear Technology responsible for the management of silicon oscillators and other signal conditioning products. His background includes technical marketing, applications engineering and analog design. He received his BS degree in Electrical Engineering/Computer Science from the University of California, Berkeley, and his BA degree in Economics from the University of California, Santa Cruz.

Linear Technology Corp.,
Milpitas, CA
(408) 432-1900,
www.linear.com.

RS No. 300