EMI Suppression Techniques with Spread Spectrum Frequency Timing Generator (SSFTG) ICs

Introduction

Electromagnetic Interference (EMI) is a major challenge for designers of electronic devices. In the US, the Federal Communications Commission (FCC) tightly regulates the maximum amount of EMI that any electronic device may emit. The FCC regulations are designed to make sure that electronic devices will not interfere with each other (you shouldn't lose your TV reception when you talk on your cordless phone). Frequency references, whether crystal oscillators, VCOs, or IC-based PLLs, are a major source of EMI on circuit boards. A relatively new technique, which involves modulating the reference frequency, is able to substantially reduce the amount of EMI created by the frequency reference. *Figure 1, EMI Reduction*, shows a comparison of the amplitude of a modulated frequency reference to an unmodulated one. This technique is often called “spread spectrum.” This application note describes how spread spectrum works, what the benefits are, and what some of the limitations are.

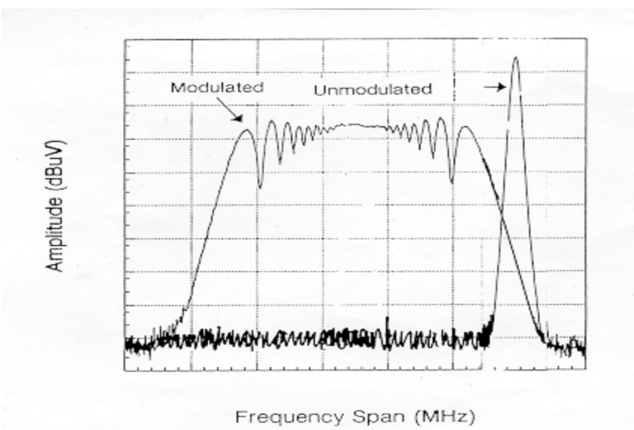

Figure 1. EMI Reduction

Electronic devices must meet maximum EMI radiation limits as specified by the US FCC and other comparable regulatory agencies in other countries. *Figure 2, FCC Requirements*, is a comparison of maximum allowable EMI for several different regulatory agencies. New FCC requirements call for PC motherboards to be able to pass EMI tests “open box,” so manufacturers will NOT be able to rely on the shielding provided by the case in meeting EMI requirements.

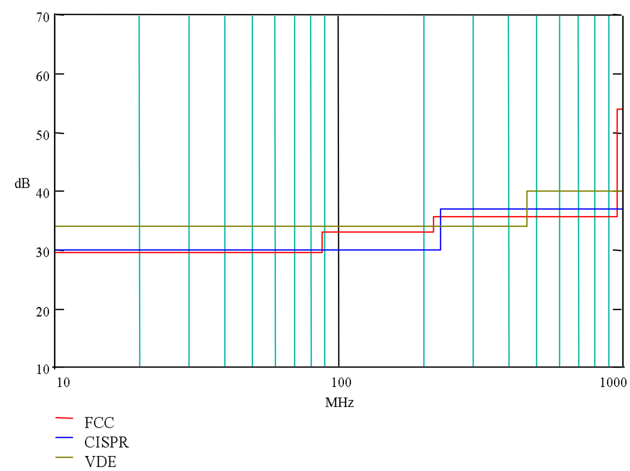

Figure 2. FCC Requirements

Cost Savings with EMI Suppression

Use of an EMI suppression-enabled clock IC can result in a reduction of system radiated EMI of 10 dB of more. This can result in dramatic cost savings for the system, of anywhere from less than $1, to $5–10 or more. Conventional techniques for reducing EMI include shielding ground planes, filtering components and shielding. Going from a two-layer board to a four-layer board to insert additional ground planes could easily cost $5–6. Filtering EMI typically uses ~$.25 worth of resistors, inductors, and capacitors, and often $.70 worth of common mode chokes and toroids. In many cases filtering will not be enough to allow a system to pass EMI tests, in which case costly shielding may be required. Shielding can easily add several dollars to the cost of a system.

“Spread Spectrum” EMI Suppression

Since the FCC and other regulatory bodies are concerned with peak emissions, not average emissions, anything that can reduce the peak energy will help a product meet FCC requirements. In the spread spectrum technique, instead of concentrating all of a frequency reference's energy on a single frequency, the energy is spread out by modulating the frequency. This results in the energy being spread over a frequency range, instead of being concentrated on one particular frequency. The reduction in system EMI can be as great as 10 dB. The reduction is greatest at the higher harmonic frequencies. See *Figure 3, EMI Reduction vs. Harmonic*.

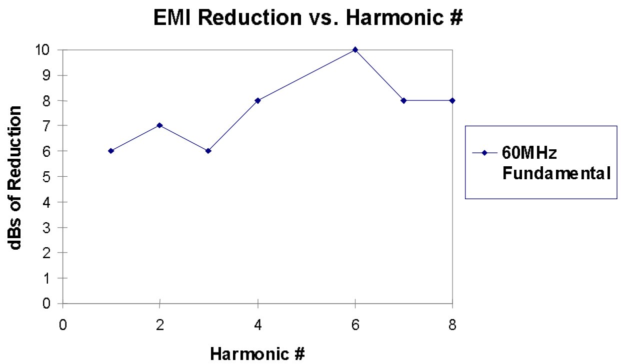

Figure 3. EMI Reduction vs. Harmonic

The same total amount of energy is still present; however, the peak value is reduced. In theory it would be possible to spread the signal so far that the energy density can be reduced all the way to thermal noise floor, in which case there would be no harmful emissions in the environment at all. Minimum signal to noise ratio requirements will of course dictate a higher level be used in practice.

Calling this technique “spread spectrum” is a different usage than is conventional in communications usage. In it's conventional usage, spread spectrum means that information is being encoded in a way that it is distributed over a wide bandwidth, as with Code Division Multiple Access. With clock ICs, there is no “information” being spread over a bandwidth, we are simply modulating a reference. Since it has become common practice to call these devices “spread spectrum clocks,” we will also use that nomenclature.

The amount of EMI reduction is directly related to the depth of modulation of the reference frequency. Typical modulations are ±0.5%, or ±1%. The greater the modulation, the greater the EMI reduction, to a point. For example, a 100-MHz reference signal, with a ±0.5% modulation, the reference frequency is swept between 99.5 MHz and 100.5 MHz.

When center modulation (±) is used, system processing performance of a CPU will be the same as for a CPU using a non-modulated clock. Some system designers are concerned about overboosting processors; if you use a processor designed for a 100-MHz reference, and that reference spends a substantial part of its time at 100.5 MHz, the processor may be operating at a higher than rated speed during that period of time. To alleviate this concern, modulation can be specified as “down only,” e.g., –0.5%. A –0.5% modulation, in the same 100-MHz example, would only vary from 99.5 to 100 MHz. This is achieved by moving the center frequency down. What is specified as “100 MHz, with –0.5% modulation” could really be thought of as “99.75 MHz with ±0.25% modulation.” Using down spread only will result in some small performance degradation of a CPU, as the nominal 100-MHz signal is now something less than that.

The modulation frequency selected also affects the EMI suppression performance. Modulation frequencies selected are typically between 25 kHz and 100 kHz based on empirical observations as to the optimal compromise between EMI suppression performance, impact on jitter performance, and ability of the device receiving the reference to track the variations in frequency.

The best dispersion of energy does NOT come with a simple triangular waveform; research and empirical observation, have shown that a complex waveform with precise variations in the transition time actually results in significantly better performance. Cypress has a patent pending way of implementing this complex wave form which allows us to very closely track the ideal wave form. Our technology allows Cypress to achieve EMI reductions typically 2–3 dB better than is available from competing devices. *Figure 3, EMI Reduction vs. Harmonic*, shows the actual improvement of EMI that was obtained in measurements of a PC motherboard with a Spread Spectrum clock.

Effects on System Performance

Using the spread spectrum technique generally has minimal or no impact on other system performance considerations.

Slow, controlled modulation as is used does not introduce short term jitter; Cypress SSFTGs typically display the same sub-250-ps cycle-to-cycle jitter shown by non-spread spectrum clocks. The spreading frequency range can be chosen to avoid clock periods shorter than system minimums.

Tests have shown no performance degradation when using Cypress SSFTGs with Pentium II-class microprocessors.

Use of spread spectrum clocks in applications where they are placing a pixel position, such as printers or faxes may require additional application techniques to maintain the same level of apparent resolution. Cypress will supply additional application notes for these types of systems. Please contact your sales representative for additional information.