Spread Spectrum Timing for Hard Disk Drive Applications

What is EMI? Why is it a design concern?

When electrical current flows in a circuit an electromagnetic field is created. The strength of this field depends on the frequency and magnitude of the current flow. This field radiates outward from the wires and electronic traces in the equipment that it flows in. Any radiation that is an unwanted by-product of the electrical circuitry's desired function is called Electro-Magnetic Interference (EMI). This radiation has the potential for either degrading the performance of the equipment that generates it, or other (external) equipment in proximity to it. This occurs through the basic "generator" process that happens when there is relative motion between any conductor and any electro-magnetic field. If the levels of these induced currents are great enough they can cause malfunctions in equipment, degrade performance or render it totally useless. Even worse is when they cause other systems to degrade or malfunction. A good example of this is a piece of computing equipment interfering with (and therefore degrading the performance of) a common TV or radio receiver.

While some levels of EMI are considered acceptable others are clearly not. Determining whether one device will impact the functionality of another is too complex to include as an element in a user manual/guide. To protect consumers from experiencing these problems, federal regulatory agencies such as the FCC have established measurable limits on the amount of EMI that any piece of electronic equipment may emit at any frequency.

In order to sell an electronic product in the commercial market within the boundaries of the United States, the FCC requires the product have its electromagnetic emissions measured in a specified environment called an EMI 'range'. Further, the device must have electro-magnetic emissions in very specified frequency bands well below specified values. Here the precise levels and amount of energy emitted in specified frequency bands are measured against set maximum limits and recorded. Europe, Japan, Asia, and the U.S. all have different sets of limits, so in order to sell an electronic product into the entire world market, it must be tested to each of the corresponding governing bodies specifications. The test facility may be a small room with a large number of antennae which are use to sense/measure the magnetic waves being emitted (called a closed site) or a large outdoor area taking up many acres (called an open site). These test facilities and the equipment and methods used must be approved/certified by the government in order for the results to be used in the legal certification of compliance with the emission standards they will be required to comply too.

EMI is a growing problem; traditional methods of addressing it are not effective enough

There are two well-established and unchanging trends in the electronics industry: Products are getting faster and cheaper. Each of these factors individually impacts a design's ability to pass federally mandated electromagnetic interference (EMI) testing. Faster speeds result in more EMI at higher frequencies, and lower cost structures reduce the budget a designer has to meet EMI requirements. Many methods have been used to try to reduce EMI emissions, each with inherent limitations or drawbacks.

There are many methods used to reduce EMI and all have positive and negative effects on the overall product. Adding more power and ground layers to increase shielding is a very good "correct by design" technique but it adds a cost that is usually prohibitive in mass produced consumer products. Metallic casing is not an option for handheld and portable systems in which weight is such a serious concern; it also adds cost. Perhaps the most familiar method of addressing EMI is by adding passive components or changing the values of existing ones to adjust edge rates to move energy from one harmonic to another. As system speeds rise, timing budgets become more constrained, preventing designers from altering the edge rate too drastically. Here signal performance (clean and fast edge rates) is sacrificed and the repeatability of the "fix" in production can often be poor due to component tolerance consideration.

Contrasted with these "fixes" is Spread Spectrum Timing (SST) technology. This is a "correct by design" method that is implemented during the design effort. It is applied to the fundamental clock frequency at its source and, unlike adding passives, benefits every harmonic. In fact, the higher the harmonics, the more EMI suppressing effect it provides. The amount of benefit varies from design to design, and there are several factors that influence it. *Figure 1* shows a block diagram of the concept, not the actual implementation.

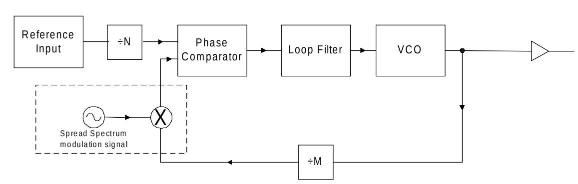

Figure 1. Concept

Basically, the frequency of the output is slowly swept through a range of frequencies rather than being delivered at a single constant frequency. As a result, the peak energy emitted is time distributed across a wider band of frequencies, resulting in reduction in the averaged peak emissions as measured in regulatory testing (see *Figure 2*).

Cypress Semiconductor Corporation • 3901 North First Street • San Jose • CA 95134 • 408-943-2600
November 21, 2000

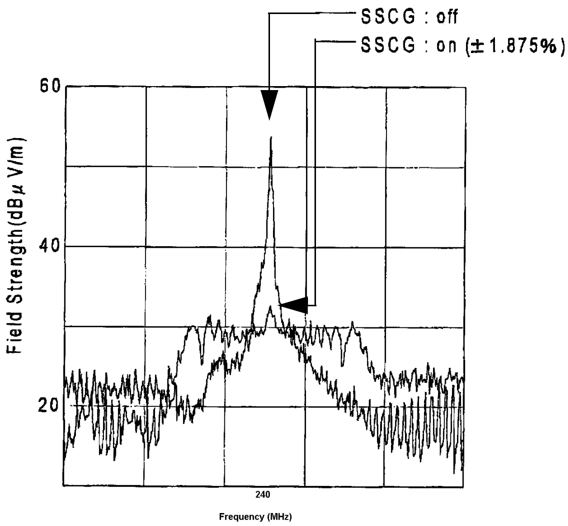

Figure 2. Measured EMI

Using SST in a Hard Disk Drive

The first HDD vendor to implement Spread Spectrum timing did so as a result of problems experienced when combining multiple hard drives in a single chassis. They had developed a drive that functioned well and begun large-scale manufacturing, but were unable to find a customer as a result of outstanding EMI issues. The EMI of all the drives was additive, and even the prospect of redesigning the boards to add layers was considered, despite the fact that tens of thousands of drives were already built. Instead, by turning to SST, they were able to solve all their EMI problems simply by adding a single 8 pin PREMIS™ part which they managed to rework into those devices. Turning a profit from the then-EMI-compliant drives rather than scrapping them made the small added cost quite financially rewarding.

The benefits when applying SST to a subsection of the overall design were so dramatic that the technology is quickly migrating into additional designs and appears that it is becoming standard.

The system block diagram which is being manufactured now is described in *Figure 3*.

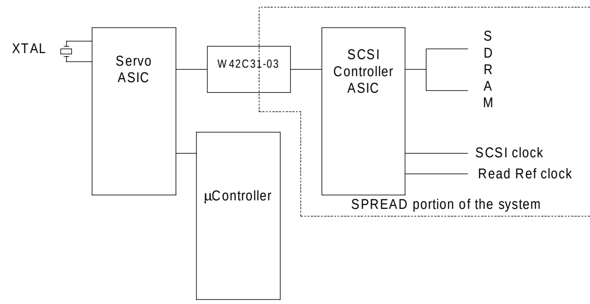

Figure 3. System Block Diagram

By implementing SST in the SCSI/SDRAM portion of the design, this customer was able to achieve a significant (>10 dB for many harmonics) amount of reduction in the measured peak EMI of the system. Since the micro controller was used in part for drive control timing circuitry, it would not work well with a SST signal, but if that function were migrated to the Servo ASIC, additional reduction could be achieved by using the Spread Spectrum to drive the μC as well.

By designing with Spread Spectrum from inception, it is possible to save significant amounts of time and money.

PREMIS is a trademark of Cypress Semiconductor. It stands for Peak Reducing EMI Solution.