Integrated Silicon-Based EMI Suppression Devices Help Move Smartphone Design Forward

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Smartphone and tablet feature sets are beginning to rival high end consumer appliances. As typical camera resolution ranges from 8 Megapixel to 12 Megapixel, and larger format displays possess higher resolution and pixel-density than most home televisions systems including provisions for MHL or HDMI video out, smartphones are becoming the pocket media center for technologists. While form factor and electromechanical interference (EMI) remain a primary concern for smartphone designers, provisioning all of the high end peripherals in a format which is comfortable to hold and carry, creating a clean EMI ecosystem and not interfering with the wireless transmit and receive functions remains a complex challenge.

Emerging high speed serial interfaces, such as Mobile Industry Processor Interface (MIPI), High Definition Multimedia Interface (HDMI) and Mobile High-Definition Link (MHL), and Universal Serial Bus (USB) are supplanting traditional parallel interfaces and offer the necessary data rates to support high end peripherals. Serial interfaces permit data to move at higher speeds while reducing the total number of lines necessary between the baseband or applications processor and the various peripheral elements (such as primary/secondary displays, camera interfaces, etc). The underlying problem presented in smartphone design is collocation: noisy data lines, for camera, display, and connectivity, packaged so closely together creates an environment for EMI and crosstalk, which can degrade the performance preventing the smartphone from achieving and maintaining connectivity while the camera or display are energized.

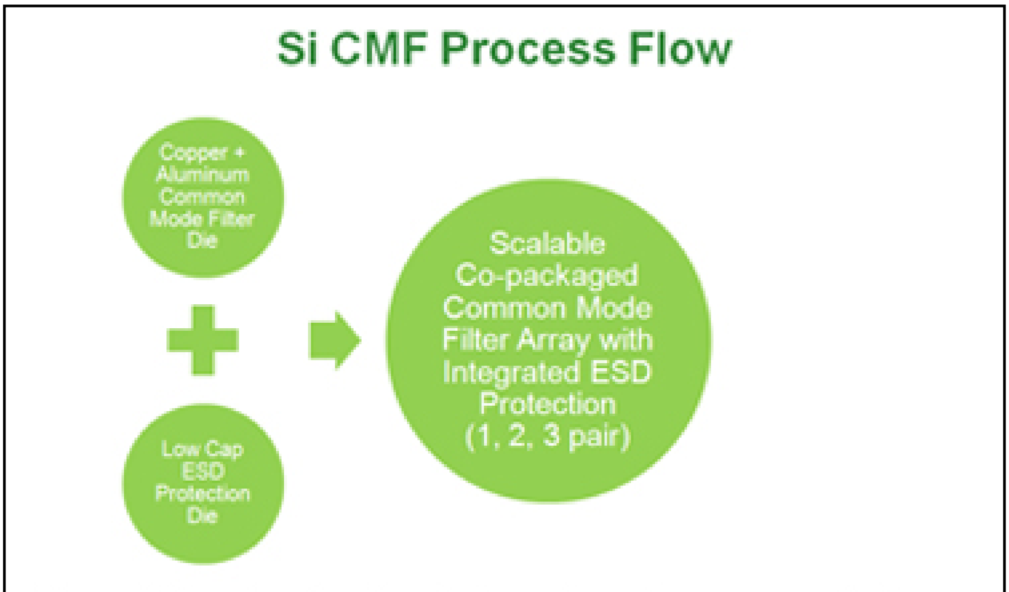

Figure 1. Manufacturing flow for silicon based common mode filters.

EMI is counter measured most effectively through passive filtering. Because the interfaces are serial, the use of conventional common mode filter (CMF) devices, based on either ceramic and ferrite construction, proved to be adequate in the cell phone designs of the past. Low frequency CMFs attenuated low frequency common mode noise adequately, but their utility for today's content rich smartphones has passed. These devices are no longer appropriate due to the fact that traditional CMFs need a significant amount of room to suppress an adequate amount of noise, therefore they tend to be large and bulky, not a selling feature for most compact and popular smartphones.

Conventional CMFs with more compact dimensions do not strongly suppress noise within the 700 MHz - 2500 MHz frequency range. Despite being able to attenuate low frequency noise, ferrite based devices fly back at higher frequencies, polluting important 3/4G cellular radio bands. Furthermore, there is no provision in ceramic and ferrite based CMFs for electrostatic discharge (ESD) protection, something which is vital for smartphones using fine line geometry chipsets which are highly susceptible to ESD damage. Without silicon based ESD protection, baseband and applications processors can be subject to kilovolt levels of ESD attack, which have the potential to kill the processors and the phone functionality.

There are also concerns about the overall robustness of CMFs using ceramic or ferrite substrates, as they tend to be brittle in nature and can easily be damaged through incidental flexing of the rigid or flexible PCBs found in today's smartphones. If the core of the CMF is fractured, then the device will be rendered useless against EMI, as well as susceptibility to mechanical stress as these devices tend to have inherent performance issues when operating at higher temperatures. Ferrite cores saturate when they are above +85°C, causing resistance levels to increase, and affecting filtering behavior. In smartphones, the nominal internal temperature can reach +85°C while the power amplifier is in operation and the handset is communicating over the cellular network.

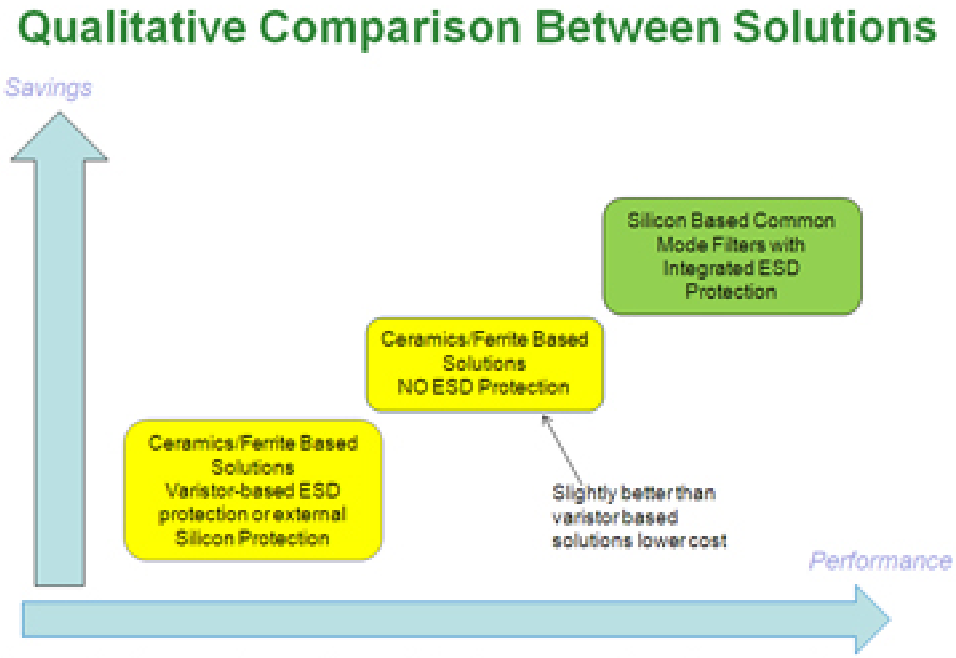

Figure 2. Comparison of cost effectivenss and performance for filtering solutions currently on the market.

Integrating EMI and ESD Together

For the reasons stated, it is clear that the specifying of conventional CMFs represents a major hurdle if the evolution of smartphones is to continue. It sets a limitation on the complexity of these products and the levels of functionality they can carry.

Innovative semiconductor technology has been developed to respond to this hurdle, allowing manufacturers to realize the feature-rich smartphone set out in their product roadmaps and the adoption of high speed serial interfaces such as MIPI, USB, and HDMI. Filter devices using CMF coils embedded in a silicon substrate, rather than ones using ceramic and ferrite materials, permit the differential signals needed by MIPI and HDMI to pass virtually unimpeded, while demonstrating a high degree of effectiveness when it comes to filtering common mode noise.

Among the IC suppliers to first appreciate the growing necessity to move away from conventional filtering was ON Semiconductor. This lead the company to embark on the development of silicon based CMF products made up of coil pairs that have an aluminum base with copper then deposited on them during subsequent semiconductor processes.

The co-packing of individual dies via a strategy of integration (as shown in Figure 1) results in the creation a turnkey solution for

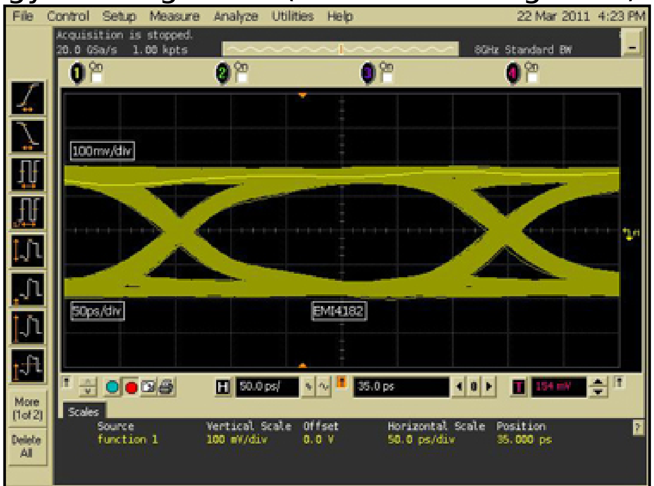

Figure 3. The signal integrity of a silicon based CMF in a HDMI 1.4 environment.

smartphone design teams that combines both noise rejection and ESD protection elements. By offering filtering and protection in a single compact device, in contrast to specifying discrete CMFs and transient voltage suppressor (TVS) diodes, valuable board space can be saved, the bill-of-materials lowered, the procurement process simplified, and assembly made easier (see Figure 2), without the signal integrity being noticeably degraded. These pioneering devices can deliver a 15 dB common mode rejection level at cut off frequencies between 500 MHz and 3 GHz, as well as protection from ±15 kV contact strikes (making them more than an order of magnitude more effective than varistor based ESD solutions). They can pass signals that support HDMI 1080p 24 bit full color, without signal degradation (see Figure 3).

In conclusion, the rising popularity of bandwidth-intensive applications, the transition from parallel to serial interfaces, and the implementation of larger, higher resolution displays in next generation smartphones are set to cause serious difficulties in terms of data transfer. Progress now being made in semiconductor technology has resulted in the advent of devices capable of suppressing EMI to deeper levels and higher frequencies than previously possible as well as adding ESD protection into the mix. This means that the industry is in a position to provide the highly integrated, smaller footprint, cost effective suppression/protection solutions needed to move smartphone design further forward.