Timing ICs Keep Beat with Needs of Today's Embedded Market

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Timing devices represent a substantial, steadily growing multi-billion-dollar market that encompasses both clock generator and buffer ICs and frequency control devices. The large size of the timing market is not surprising if you consider that virtually all electronic devices contain a timing IC. Given the importance of timing products to the electronics industry, it's surprising how slowly timing technology has evolved in recent years. In fact, over the past two decades, timing device suppliers have delivered clocking and frequency control products with a surprisingly slow rate of innovation. However, recent trends in the embedded market and the entry of new suppliers in that segment are driving innovation in timing technology that will help designers improve system performance, simplify their designs and decrease their reliance on timing devices with historically long lead times.

A Snapshot of Timing Devices in Embedded Applications

Classic embedded designs historically have focused on such applications as network and storage systems, industrial automation and controls, point of sale (POS) systems, test and measurement equipment, home and building automation, and medical systems. (See Figure 1 for an example of a clock IC used in a storage application with PCI-Express connectivity.)

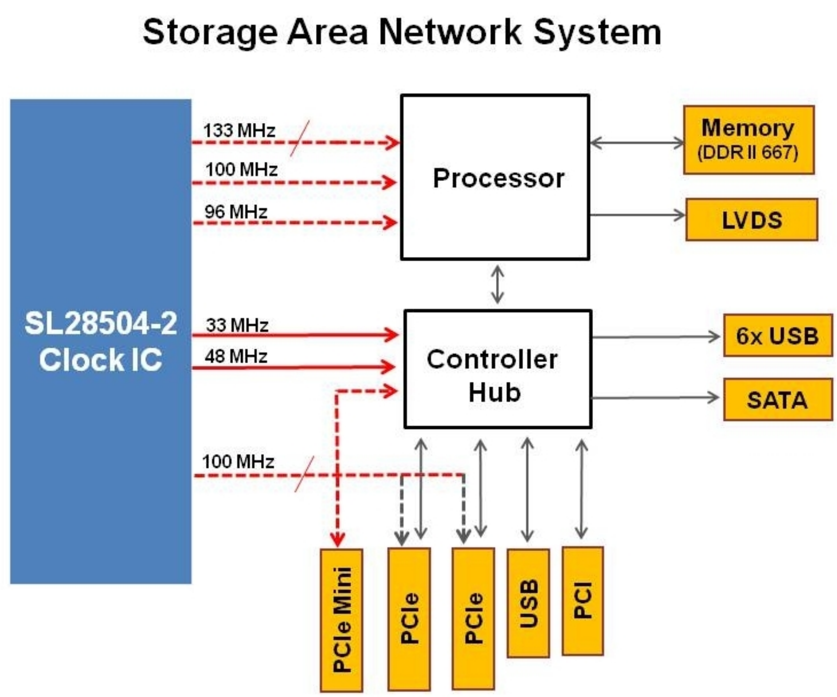

Figure 1. Storage Area Network System with Embedded-Optimized Clock IC

Mainstream x86 PC chipsets, or slightly modified versions of these chipsets, generally are used in embedded applications. To meet the requirements of embedded systems, x86 chipsets have to achieve industrial grade compliance, and they typically have life spans of more than six years. If legacy chipset architectures required modifications to the main system clock, the changes would be infrequent and relatively minor, and it often made sense to accommodate these clock changes by adding discrete components to the board. To a great degree, this trend has kept the timing requirements of embedded systems very similar to their mainstream PC predecessors. Differences were mainly associated with the longer production life spans of certain products and their conformity to industrial grades. In short, embedded systems have not required frequent or significant changes to timing device architectures.

In the past seven or eight years, however, the basic computation architecture of CPUs, graphics/VGA controllers, memory controllers and I/O interfaces has become overwhelmingly pervasive in a multitude of emerging end products that require an operating system and only a limited number of applications. This market dynamic has broadened the embedded market from being primarily industrial to include a wider range of consumer and enterprise systems, as well as small-form-factor processing modules. Timing devices have evolved accordingly to address the changing requirements of today's embedded systems.

A New Generation of Timing Devices

To understand how timing technology is evolving to meet the needs of embedded applications, it is helpful to understand three recent trends in main system design.

- The first factor to consider is the recent integration of basic timing functions in mainstream PC chipsets that historically would have been provided externally as part of the total timing solution. The embedded version of these chipsets might require smaller timing components often in the form of expansion buffers or standalone complementary clock generators.

- A second factor is the introduction of new chipsets focused exclusively on embedded applications and relying primarily on external main system clock generators. These timing devices would have the flexibility to address a multitude of form factors ranging from tiny processor modules to large-scale main boards.

- A third factor is the increased dissemination of processing architectures beyond x86 that present somewhat different system clocking requirements, mainly in the consumer and enterprise segments of the embedded applications.

These market trends are impacting clock IC suppliers that have traditionally derived a major part of their revenues from the PC industry. Clock IC vendors that have dominated the PC timing device market are now finding themselves facing rapidly declining revenue in the PC clock market, coupled with an under investment in other key growth markets, such as communications and consumer electronics.

To satisfy the requirements of today's embedded systems, new players in the timing industry have introduced highly customizable clock generator ICs that integrate non-volatile technology. These timing devices address a wide range of customer requirements by providing application-specific clocking solutions customized to meet the frequency, type of output, jitter, phase, skew and other interface requirements for a particular application.

Perhaps the most significant limitation of traditional programmable clock solutions is that they require I^2C-based firmware or BIOS development. In many applications, an I^2C interface is either not available or not desirable. New generations of configurable timing devices are now available to address the deficiencies associated with traditional I^2C programmability solutions. These new timing products can be customized entirely at the factory or by using Web-based utilities. This customizable approach benefits the system design by alleviating the burden of using BIOS memory space and allocation of scarce firmware resources, as well as by assisting in boot time reduction. Once the device is customized, I^2C programming may still be used for post-boot features such as hot swapping where the clock would need to be enabled on the fly at detection of a hardware card plug-in.

Another emerging trend in timing device technology is to provide flexibility in frequency generation and tuning capabilities of the clock signals. This latter capability has recently become important to developers due to the increased dissemination of differential signaling in embedded applications. In addition, the ability to provide features to help embedded designers minimize power consumption for mobile applications and green initiatives as well as conformity with governmental regulations, such as FCC regulations in the United States, have become common requirements.

Finally, timing devices are offered in a variety of package types that were not available a decade ago. These packages – some as tiny as 1.2 mm x 1.4 mm – are now available to address varying requirements for small form factors and manufacturability in today's embedded applications.

Using Clock ICs to Combat EMI

Clock generator and buffer ICs are now available with built-in features, such as programmable edge rates, programmable impedance, programmable skew and spread spectrum technology, that can be used to combat electromagnetic interference (EMI) in embedded applications. These features can also be used to reduce radio frequency interference (RFI) in applications where interference with 3G/4G radios must be optimized to improve device operation.

Slowing the edge rate, as shown in Figure 2, is the quickest method to reduce EMI. For many clock vendors, edge rate control typically applies to the entire bank, which limits the ability to tune each signal for its particular load. If one receiver requires a fast edge rate, all other receivers in the same output bank will have that same fast edge rate, resulting in higher EMI. Timing devices with programmable edge rate controls for each individual output allow board designers to customize each output to its own load and trace length.

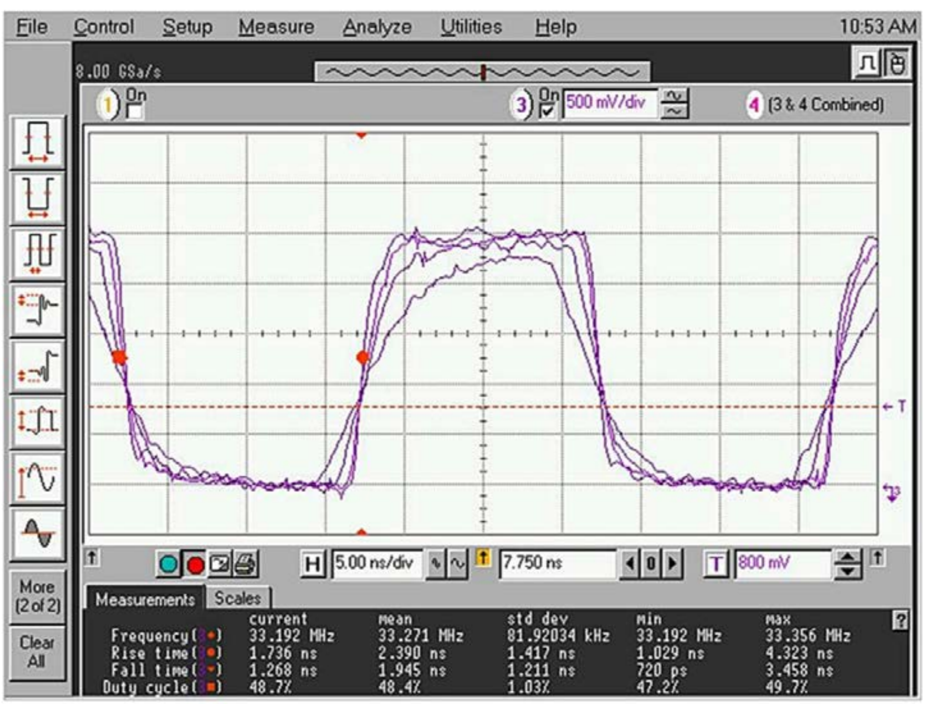

Figure 2. Edge Rate Control Is an Effective Technique for Controlling EMI

When multiple outputs of the same frequency are switching at the same point in time, the end result is large EMI spurs at harmonics of the clock frequency as well as increased noise at the power supplies due to the combined amount of switching current. By programming each clock output skew to be delayed relative to other outputs, the spur energy is spread out, which reduces peak EMI and power supply switching noise.

Most of today's embedded systems implement differential clocking approaches for higher bandwidth; many board designers neglect the effects these signal formats can have on EMI and system performance. Mismatch in the edge slew rate and skew between true and complement signals will create common mode energy that radiates EMI, as well as an unstable cross-point that causes data loss. Since clock trees in these systems commonly drive multiple buses with differential outputs, any differential clock misalignments can generate a large amount of common mode energy. By using the I^2C-programmable or factory-configurable skew and edge rate features, each I/O can be individually tuned to the PCB environment for cross point optimization and EMI reduction.

Programmable impedance also allows board designers to optimally match load impedance without having to modify discrete termination networks or PCB trace design. Mismatched trace impedance causes reflections that generate clock overshoot and undershoot, resulting in increased EMI and glitches in the clock circuitry of the receiving device.

Time for Mass Customization

Frequency customization has become a given, but what about addressing other parameters that developers care about when designing their systems and meeting their milestones, such as signal optimization or end product compliance with federal regulatory requirements? It's still hard to convince system designers that there is such a thing as "mass" customization in timing, enabling the best-fit timing solution regardless of the application without months of lead times or a lot of non-recurring engineering (NRE) expenses.

Now that embedded designs have expanded beyond classic industrial systems and have migrated into faster-paced consumer and enterprise markets, there is a greater sense of urgency to get products to market quickly. Today's timing device suppliers must be able to respond quickly to the developer's customization needs. Until recently, custom configurations were achieved through changes in the IC design, layout, masks and new wafer developments. This customization process often required lengthy lead times of three to four months to deliver working products to the customer.

Factory- and web-customization of timing devices represents a significant advantage by enabling the embedded developer to avoid having to develop BIOS subroutines for the sole purpose of configuring the clock. The developer gets an added bonus of receiving clock samples in a couple of weeks instead of months – 60 percent faster than mask-customized clocks.

Perhaps the most significant benefit to embedded developers provided by web-customized, programmable timing devices is that they are no longer only available for the highest volume applications. Using web-based clock configuration utilities, such as Silicon Labs' ClockBuilder (shown in Figure 3), embedded designers can now expect platform-specific timing solutions with lead times as short as two weeks regardless of the size of their project. Now, anyone with an Internet connection can configure timing devices online and enjoy the benefits of having fully customized, application-specific clocks and oscillators with lead times as short as two weeks.

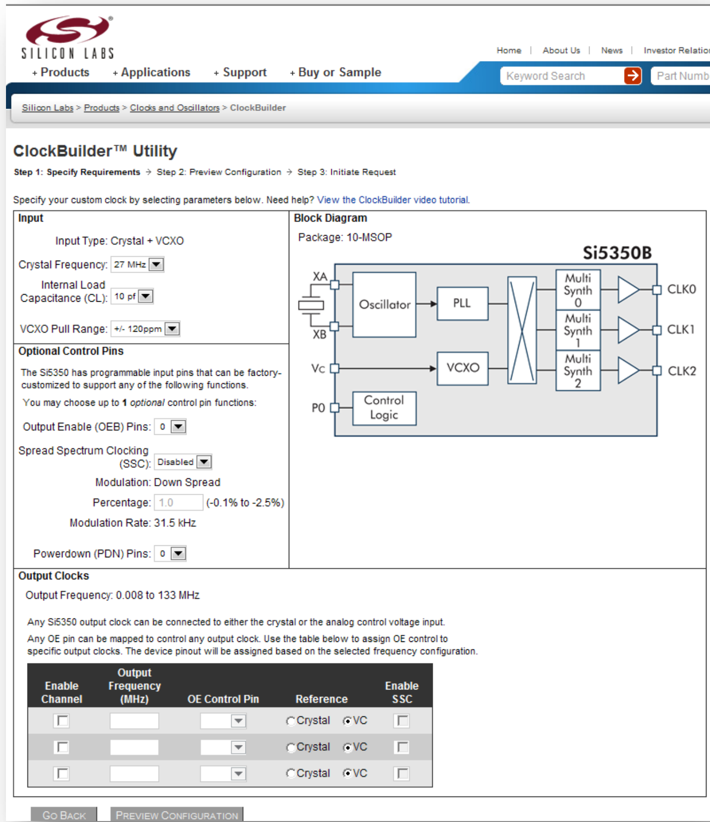

Figure 3. Web-Based Utilities Enable Rapid Customization of Timing Devices

Conclusion

Timing technology has been slow to change over the last several decades, but the pace of change has dramatically accelerated as innovative, new suppliers in the timing market respond to the need for greater flexibility, more customization, better performance and smaller form factors – all within lead times measured in days rather than many weeks. It's time for embedded system designers to rethink their assumptions about what timing ICs can do to help them meet their system design goals.

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