AN49107

Total System Timing and EMI Reduction Using CY254x Spread Spectrum Clock Generators

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Associated Part Family: CY254x (x: 2/4/5/6/7/8/04)

AN49107 describes the features and advantages of the four phase-locked loop (PLL) ICs of the CY254x clock synthesizers. It also explains the EMI noise reduction technique using the spread spectrum method.

1 Introduction

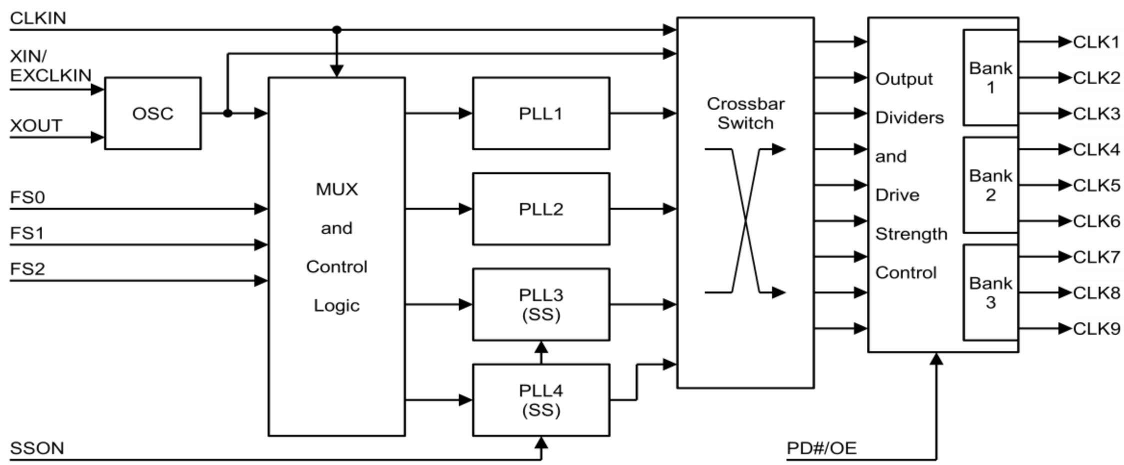
Some applications require a number of independent frequencies to be generated using clock generators. Crystals and clock generators with only one or two PLLs impose a limit on this requirement. Moreover, traditional methods (ferrite beads, filtering, and so on) for EMI reduction compromise design time and accuracy. These limitations and issues are overcome by using the Cypress CY254x families.

In this document, references to the CY254x family has been included. ICs in these families contain four programmable PLLs with multiple clock outputs. Figure 1 shows an example logic diagram of one such IC. For more details, refer to the CY2542, CY25404, and CY2544/46/48 datasheet. The ICs in this family of CY254x are available in a small package size (20-LD TSSOP and 24-pin QFN). A wide range of applications is possible due to the high configurability and robustness of the ICs in this family.

This application note provides details on the following topics:

- CY254x architecture
- EMI noise reduction technique used in the ICs
- CY254x features and advantages
- Configuration modes and techniques
- Use in common applications

Figure 1. Example of Logic Block Diagram of CY254x IC family



2 Multiple Independent Output Frequencies

The CY254x family architecture includes four PLLs, which allow up to four unique frequencies to be generated. These are distinct from the input frequency, which may come from either a crystal or a reference clock input. Two out of four of these PLLs have a spread spectrum capability for EMI reduction in the system. Additionally, the integer output dividers are available on each output for creating related output frequencies.

There are a number of advantages to using a multiple PLL–based solution over discrete crystal resonators or oscillators. They include the following:

- **Cost:** System-on-chip solutions such as CY254x are more cost-effective than quartz crystal devices. They are beneficial for systems requiring frequencies above 50 MHz, where overtone crystals have to be used.
- **Board space:** Replacing the relatively large resonator and oscillator packages with a smaller, lower profile package helps designers optimize board space.
- **Reliability:** Crystals are mechanical devices that have a significantly higher Failures in Time (FIT) rate than silicon devices. Hence, silicon-based clocks provide more reliability.
- **Flexibility and lead time:** Crystals are fixed frequency and have long lead times for nonstandard frequencies. In contrast, PLL-based devices can be instantly reprogrammed to a different frequency, preventing design cycle delays.

3 Programmability

The programmability of the CY254x family provides high flexibility and ease of use. These ICs support configuration changes through an I^2C interface (CY2542 device) or through frequency select pins (CY2542, CY25404, CY2544/46/48 devices).

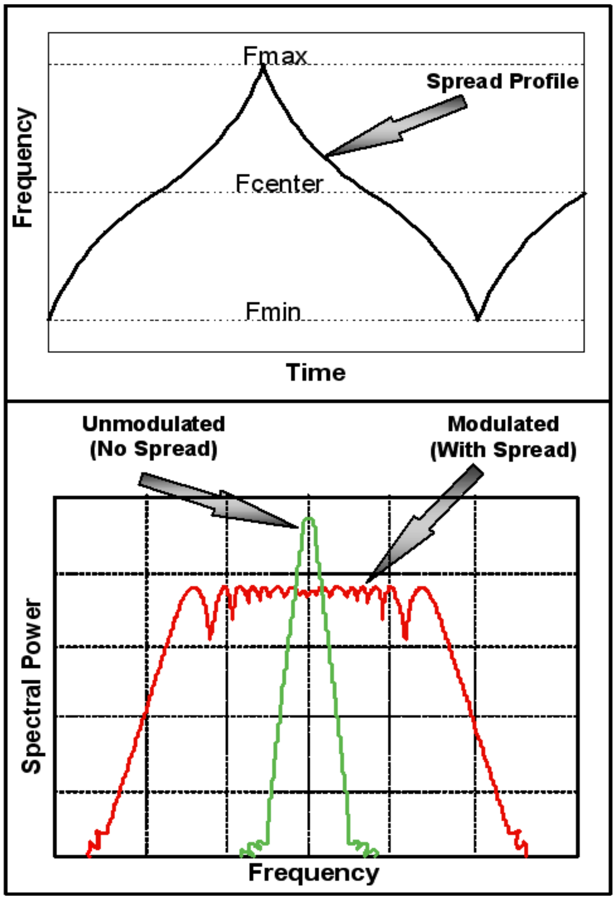
- **Factory and field programming:** Nonvolatile memory included on chip allows programming a custom configuration, which is loaded each time the device is powered up. This is done in the factory or field using an approved third-party programmer.
- **I^2C programming:** An optional I^2C interface allows you to change the default configuration when the device is in operation. Changes made via I^2C do not affect the nonvolatile memory, as they are lost upon power reset. Programming through the I^2C interface provides flexibility in changing several parameters such as output frequency, percentage of spread spectrum, configuration of individual outputs, and PLL selection for power management.
- **Pin programming:** Several parameters can be changed using four input pins. For example, you can change output frequencies, enable or disable PLLs, and manage the spread spectrum percentage. This is useful if the I^2C interface is not required or if a single device must be used across multiple platforms (for example, NTSC/PAL in DTV systems), which improves inventory management.

4 EMI Reduction Using Spread Spectrum

The EMI generated by clocks and timing solutions can cause an increase in ringing, overshoot, and undershoot and can make the system more susceptible to other sources of interference. Using filtering techniques or ferrite beads to reduce EMI issues may be minimally effective for the complete system. An effective method is spread spectrum clock generation, in which the system clock is modulated over a narrow band of modulating frequency, which results in spreading the clock over a broader band. The modulating frequency lies in the range of 30 to 33 kHz, which is broad enough to spread the peak spectral energies of both the fundamental and side harmonics. Figure 2 demonstrates this effect on both the modulated and unmodulated clocks.

The Cypress CY254x family provides efficient EMI reduction using spread spectrum clock generation. Two PLLs are used to implement this technique. For example, an 80-MHz ±0.5 percent system clock output can be generated with one PLL, and a second 33-MHz ±1.0 percent PCI clock output can be generated on the second PLL. As the modulation is centered on the system clock frequency, it is called “center spread spectrum.” Center spread percentages in the range of ±0.25 percent to ±2.5 percent and down spread percentages in the range of –0.5 percent to –5.0 percent are supported in intervals of 0.1 percent, offering the ability to fine-tune to obtain the optimal spread spectrum percentage for system performance.

Figure 2. Spread Spectrum Profile and Resultant Spectral Power Plot



5 Additional Features

The CY254x family provides additional features that make these clock generators robust and flexible, as discussed in the following sections.

5.1 Output Mapping Capability

Discrete crystal-based solutions are placed at various locations on the board to minimize trace length. This imposes constraints on the board design. CY254x provides a flexible output mapping feature that enables the desired output frequencies to be mapped to any of the nine output pins available, helping to simplify trace routing and reduce trace length.

5.2 Output Drive Strength

Four different drive strength settings are available for each output. This is useful to improve signal integrity when required. Higher drive strength produces a faster edge rate, providing less jitter. Lower drive strength provides a slower edge rate, yielding reduced EMI. In this way, the drive strength setting is used to make a tradeoff among parameters such as EMI and jitter per the application's requirement.

5.3 Edge-Aligned Outputs

Many applications require multiple clock outputs to be edge aligned for proper system operation. In specific cases, the CY254x can support multiple clock outputs that meet this requirement. If output frequencies are derived from the same PLL, then an edge alignment option may be available. Alternatively, if the outputs are derived from the reference input, edge alignment may also be possible. If an application requires edge-aligned outputs, contact your local Cypress Field Applications Engineer for details.

5.4 Frequency Margining

An engineer may want to test how robust the system design is with regard to the clock frequencies used. Traditional timing solutions do not lend themselves to this sort of testing. Separate crystals at the desired margin frequencies must be ordered and then mounted in place of the nominal frequency crystal device. In addition, the desired margin frequency may not be readily available.

With the CY254x frequency margining feature, the engineer simply chooses the frequencies to be tested (for example, ±5.0 percent) and then uses either I^2C programming or frequency select pins to change the output frequency as desired and thus test the system margin. This is a more streamlined process than a crystal-based system timing solution.

5.5 Spread Margining

Similar to frequency margining, the spread margining feature is used to test system tolerance by increasing the percentage of spread spectrum used, either through I^2C programming or frequency select pins. Additionally, spread margining is used to check the peak EMI reduction at several different spread percentages for a given configuration. This helps to find the best spread spectrum percentage for the application quickly and easily.

5.6 Internal Crystal Tuning Capacitors

Crystal resonators are designed for a specific load capacitance. This incurs frequency error. In most cases, external capacitors are used in “trial and error” until the oscillator is tuned to 0 ppm error. To save board space and for convenience, CY254x has built-in tuning capacitors, which are set to reduce or eliminate the ppm error of the crystal oscillator output. The internal capacitance setting ranges from 8 pF to 18 pF when this tuning feature is active.

5.7 Output Bank Settings

There are nine clock outputs grouped in three output driver banks. The Bank 1, Bank 2, and Bank 3 correspond to (CLK1, CLK2, CLK3), (CLK4, CLK5, CLK6), and (CLK7, CLK8, CLK9) respectively. In some ICs (CY2547), only eight clock outputs are available. Separate power supplies are used for each of these banks, and they can be any of 1.8 V, 2.5 V, 3.0 V, or 3.3 V, giving you multiple choices of output clock voltage levels. For the high-voltage devices (2.5 V to 3.3 V core VDD), the individual output banks operate within this range. Thus, one output bank can operate at 2.5 V, while another bank can operate at 3.3 V. This is useful in systems with chips operating at different voltages, and no level shifters are necessary with the output voltage banks available on the CY254x.

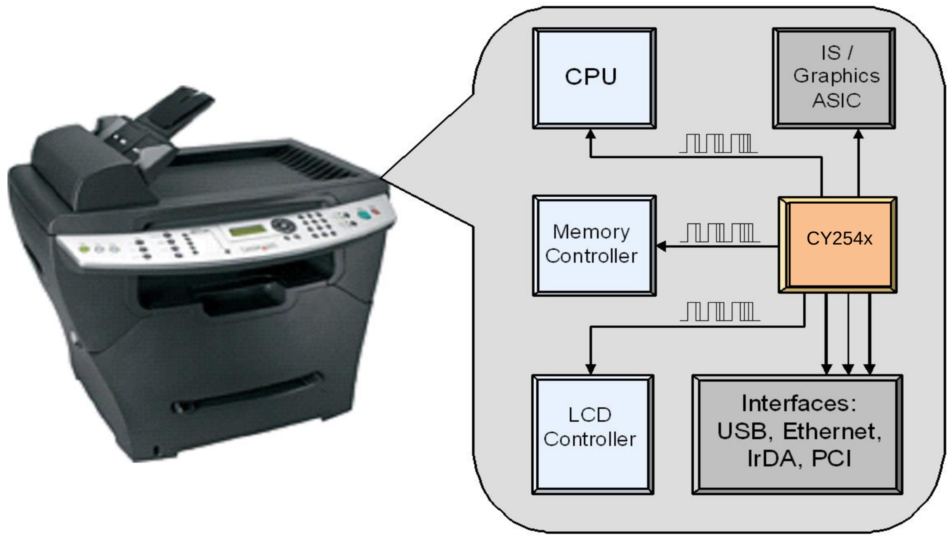
6 CY254x Common Applications

The CY254x is suitable for use in many consumer electronics applications and even networking products because of its low power consumption, small package size, device performance, features, and flexibility.

6.1 Multifunction Printer

Printers are among the first consumer electronic applications to implement spread spectrum clocking EMI reduction. Lexmark holds a patent for the optimal modulation profile for peak EMI reduction. Cypress licenses this Lexmark profile to provide maximum EMI suppression for a given frequency and spread percentage. Multifunction printers often use multiple spread spectrum frequencies. Figure 3 shows an application where the CY254x provides spread spectrum outputs for the system CPU, memory controller, and LCD controller. In addition, the two non-spread spectrum PLLs of the CY254x are used to provide frequencies for image processing and various interfaces such as USB, PCI, IrDA, and Ethernet.

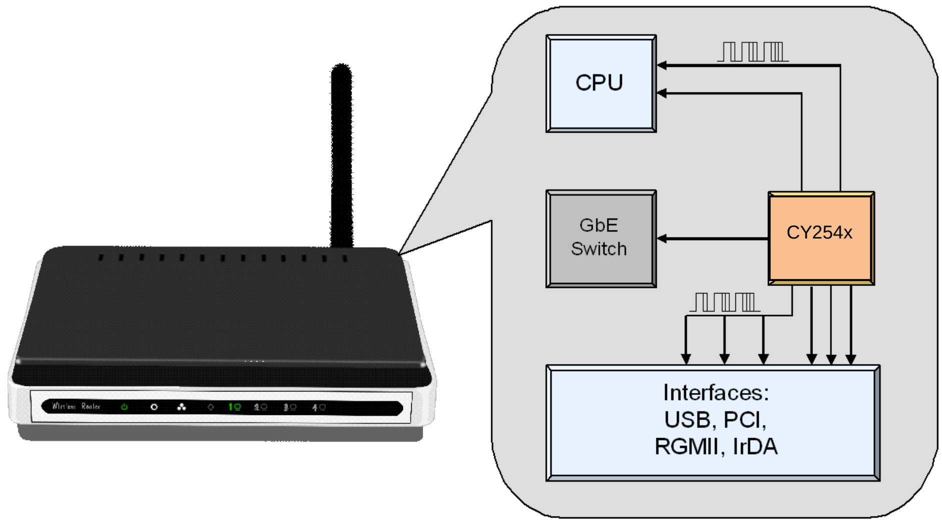
Figure 3. CY254x in a Multifunction Printer Application



6.2 VoIP Router

Networking applications commonly require a variety of clocks. These are provided by CY254x for processors, PHY, and interfaces. In Figure 4, the processor requires a spread spectrum clock for the system clock, and the PCI interface also uses spread spectrum to reduce EMI. Networking applications often use multiple copies of a certain clock frequency with edge alignment to meet stringent system timing requirements. Typically, buffers with zero delay are used to generate multiple phase-aligned copies of a given frequency. However, the CY254x has an edge align feature and up to nine output buffers available, potentially eliminating the need for separate buffers.

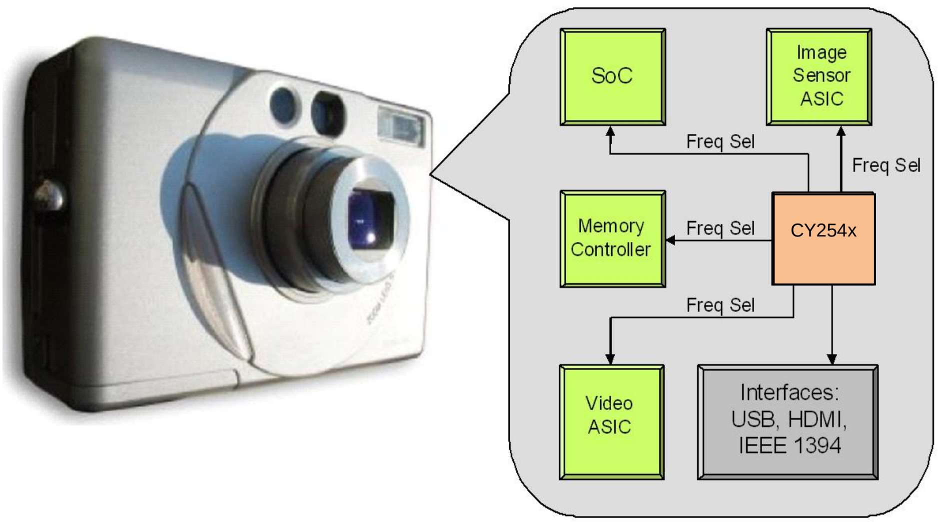
Figure 4. CY254x in a VoIP Router Application



6.3 Digital Multimedia Camera

Multimedia cameras are becoming complex and require various frequencies for different functionality. Additionally, different standards (such as NTSC/PAL) use different clock frequencies. Also, different ASIC vendors typically require different frequencies. A flexible clock device is crucial to optimizing system performance across platforms. Figure 5 shows an example where the CY254x is used to provide clocks for the processor, image sensor ASIC, video ASIC, memory controller, and interfaces. The ability to switch frequencies via input select pins and I^2C allows the system designer to use a single CY254x device to meet the different clock frequency requirements of various platforms and video standards.

Figure 5. CY254x in a Digital Multimedia Camera Application

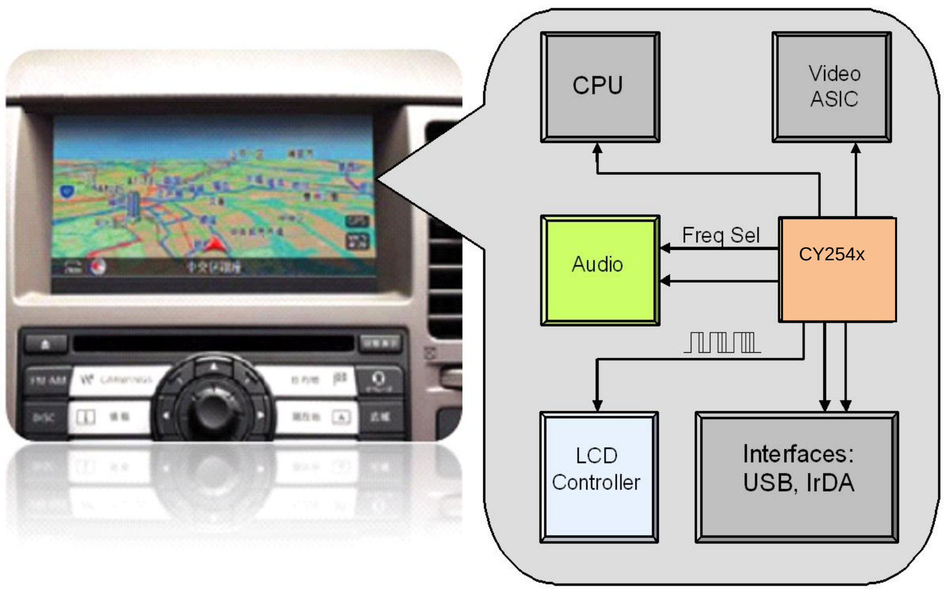


6.4 Car Navigation

Many times, additional features are required after a product is manufactured. Thus, a requirement for additional clock frequencies in the system arises. In most cases, LCD displays use spread spectrum for the panel clock to reduce EMI. Multiple frequencies may be required for different audio standards. The processor, video ASIC, and interfaces may also need independent frequencies. Figure 6 shows an example of a built-in car navigation application. It uses the spread spectrum and frequency select capability of the CY254x to implement the total system timing solution with a single clock chip.

Two key aspects of the CY254x are its low power consumption and small package size. These allow the device to be used in portable, battery-powered applications such as personal navigation devices, personal media players, and even mobile handsets.

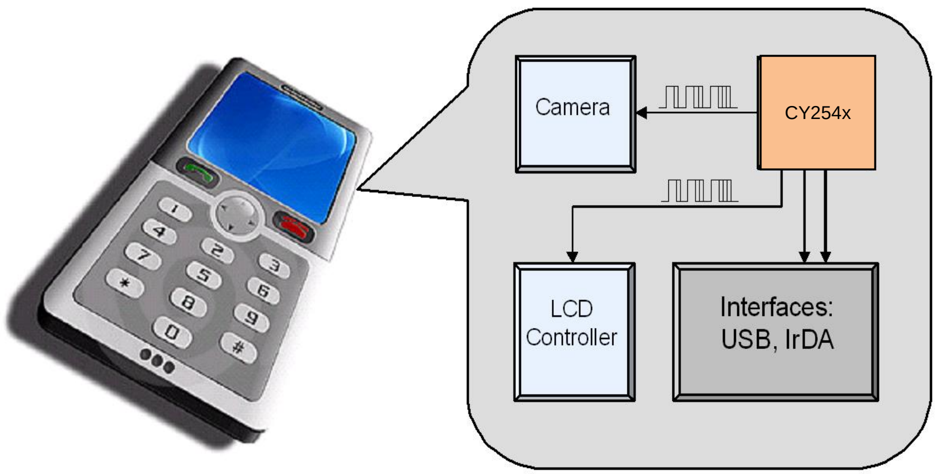
Figure 6. CY254x in a Car Navigation Application



6.5 Mobile Phone

Mobile phones have become highly integrated devices and in many cases do not require more than one or two clock frequencies for the entire design. However, integration takes time, and cutting-edge platforms are often more modular to add new features to enter the market quickly. In these cases, more clock frequencies may be necessary. Also, these added features increase the likelihood of EMI issues, making the capability for spread spectrum clocking desirable. Figure 7 shows an example where the CY254x is used to provide a spread spectrum–enabled clock to the LCD controller and the camera module. Clocks for the USB and IrDA interfaces are also supplied. The small package and low power consumption make it more convenient to use such clock devices instead of discrete crystal oscillators.

Figure 7. CY254x in a Mobile Phone Application



7 Summary

The versatile, feature-rich CY254x four-PLL spread spectrum clock generator is useful in a variety of consumer electronics applications due to its EMI reduction and integration capabilities. As it is programmable, you can create or reconfigure a customized configuration quickly. For more information on the CY254x family of devices, visit http://www.cypress.com or contact your local Cypress Field Applications Engineer.

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Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	2578955	10/06/2008	CXQ	New application note
*A	3211466	04/01/2011	CXQ	Updated template.
*B	3401622	10/14/2011	BASH	Updated template. Converted from FrameMaker to Word. No change in content.
*C	3719996	08/22/2012	CINM	Changed document title. Updated template. Content update. Fixed grammar issues.
*D	5028275	10/13/2015	XHT	Updated template. Changed author. Corrected typo to 50 MHz from 50 Hz on page 2.
*E	5493473	02/13/2017	XHT TAVA	The part number representation changed to CY254x. Minor modification in the Programmability section. Update to new template. Completing sunset review
*F	6069734	02/13/2018	XHT	Updated to new template. Completing sunset review.

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