Spread Spectrum Crystal Oscillator with Programmability – CY25701 and Its Applications

Author: Amitava Banerjee

Associated Part Family: CY25701

Software Version: CyClockWizard 1.0

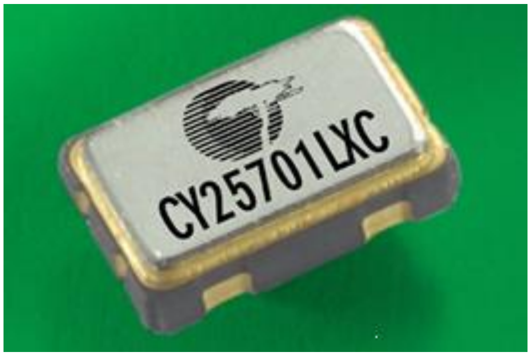
Related Application Notes: AN49107

CY25701 is a programmable spread spectrum crystal oscillator (SSXO) that is used to reduce the EMI in today's high-speed digital electronic systems. This application note discusses the key features and advantages of CY25701 over standard crystal oscillators and explores some applications in which EMI is a key concern.

1 Introduction

The CY25701 programmable spread spectrum crystal oscillator (SSXO) is a valuable tool for optimizing EMI performance. It is offered in an industry-standard 5.0 mm x 3.2 mm LCC package and pinout (Figure 1). CY25701 can replace a traditional fixed-frequency crystal oscillator and provide flexibility and security in the presence of EMI issues or unexpected system frequency marginality.

Figure 1. CY25701 5.0 mm x 3.2 mm 4-Pin LCC Package



Programmable Features	Range
Output Frequency	10–166 MHz
Spread Percentage	Down Spread: up to –4% Center Spread: up to ±2%
Modulation Rate	30.1, 31.5, or 32.9 kHz

2 Spread Spectrum

Spread spectrum capability is the feature that sets CY25701 apart from most other crystal oscillators. When an oscillator is used to provide the system clock, a majority of the data and clock signals throughout the system switch at some multiple of the system clock rate. This causes significant EMI at odd harmonics of the system frequency. With the ability to modulate the system clock frequency, the peak energy of the fundamental frequency and odd harmonics can be dispersed over a wider frequency range. Thus, peak energy in those frequency bands is reduced significantly. Early in the design phase, it is difficult to predict the EMI produced by the overall system. A spread-spectrum clock suppresses EMI during the later stages of development—particularly during EMC compliance testing—and saves a lot of time and redesign effort. More information on spread-spectrum and EMI is available in the following white papers:

- Spread Spectrum Clock Generators for Solving EMI
- EMI and Spread Spectrum Technology

The spread-spectrum profile and spectral plots in Spread Spectrum Parameters illustrate the effect of spread spectrum percentage on EMI reduction.

3 Programmability

Programmability is another attribute that distinguishes CY25701 from other crystal oscillators. If there is a change in the required clock frequency or if the spread percentage needs to be increased or reduced for EMI or stability, CY25701 can be quickly reprogrammed as needed. A fixed-frequency oscillator requires ordering a new device, potentially delaying the project for weeks. Similarly, emission testing may cause significant delays if the amount of EMI reduction cannot be easily modified. Essentially, the programmability of CY25701 gets the design started faster and keeps it moving should any unforeseen EMI or timing issues arise.

For programming CY25701, you need to generate a JEDEC file using CyClockWizard 1.0 and program the device using the CY3675 kit. For further assistance or questions on programmability, contact your local Cypress sales representative.

4 CY25701 Versus Crystal Oscillators

Standard crystal oscillators, commonly found in consumer electronics, have several limitations compared to PLL-based timing solutions. One notable disadvantage is that the output frequency of the oscillator is limited in range. Low-cost quartz crystals are manufactured to operate with a fundamental frequency of ~50 MHz. Above 50 MHz, the complexity of the crystal oscillator design increases, as does the cost. CY25701 uses an internal crystal to generate a reference for the PLL, allowing output frequencies from 10 MHz to 166 MHz. It also provides any frequency in that range with minimal synthesis error (less than 10 ppm) and in most cases zero synthesis error. In contrast, crystal oscillators have long lead times and higher prices for nonstandard frequencies.

Due to these advantages, CY25701 is useful in a number of applications, including set-top boxes, HDTVs, multifunction printers, car audio systems, medical devices, network switches, and a variety of specialty applications.

5 Applications

As consumer electronics becomes smaller, faster, and increasingly more complex, the system designer must consider the most efficient techniques to minimize the resultant rise in EMI. A wide range of consumer products use spread-spectrum clocking as a simple and cost-effective way to reduce system EMI to the desired levels.

5.1 Printers

Consumer printers, such as inkjet, have seen significant advances in resolution and throughput. These advances increase the number of signals used and the print head firing frequency, which in turn compels the designer to maintain an acceptable level of emissions. Previously, engineers took special care in routing signals to avoid EMI, requiring additional design time and often adding layers to the PCB. Additionally, ferrite beads, filters, and shielding were commonly used to mitigate the EMI problem. However, these solutions are marginalized with the introduction of spread-spectrum clocking. When a spread-spectrum–enabled clock is used to drive the system clock of the main processor or graphics ASIC of a printer, output signals from that device switch on the spread-spectrum–enabled clock edges. This effectively suppresses EMI on all output signals.

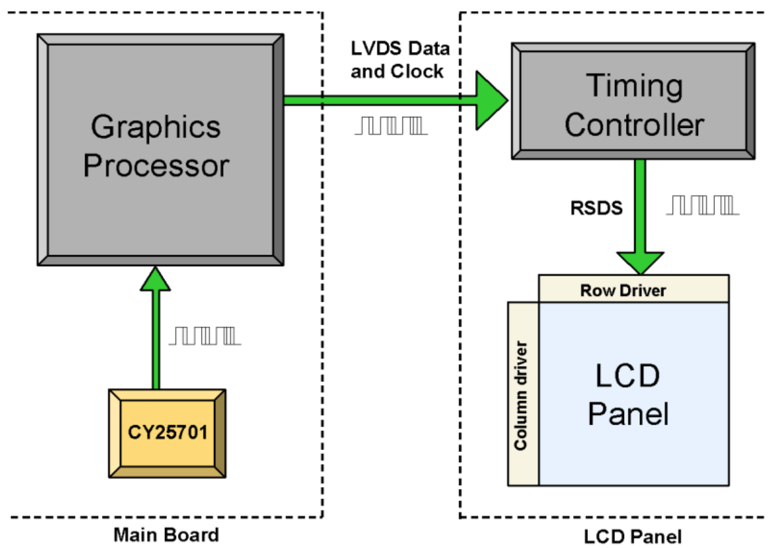
CY25701 allows you to fine-tune the spread percentage and thus the EMI reduction amount. During emission testing, it can be programmed to several different spread-spectrum percentages. Various spread percentages are tested until a setting is found that provides sufficient EMI reduction along with optimal system stability and jitter performance. CY25701 provides the fine-tuning capability in small steps of a 0.25 percent spread to accomplish this goal.

5.2 LCD Panels

Similar to printers, LCD panels have increased in resolution. Smaller displays may also have EMI issues unless preventive measures are taken during design. In applications using small LCD screens, space is almost always a primary concern. Adding ferrite beads or shielding for EMI reduction is unacceptable, making spread-spectrum clocking the preferred solution.

Using CY25701 allows you to save space by integrating the crystal into the small 5.0 mm x 3.2 mm LCC package. Figure 2 shows CY25701 use in a typical LCD TV application. With CY25701 as a spread-spectrum clock source to the graphics processor, EMI is reduced on the LVDS data signals sent to the LCD panel. Most timing controllers also support an external spread-spectrum clock input. This means that the RSDS outputs to the LCD row drivers also benefit from EMI reduction, offering a systemic solution to the LCD panel EMI problem.

Figure 2. CY25701 Use in an LCD TV Application



5.3 Networking Applications

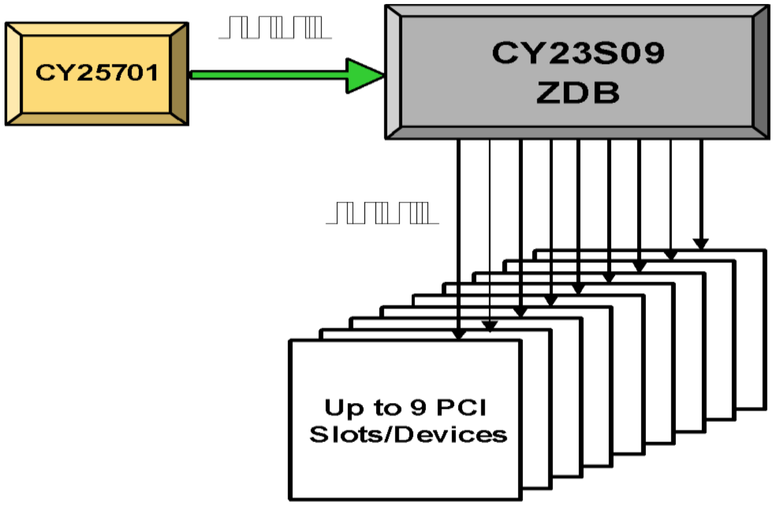
Networking applications require a variety of clocks for different parts of the system. For example, data stream clocking has stringent jitter requirements that are often beyond the specifications of CY25701. For these cases, Cypress offers CY2941X / CY2942X high-performance programmable oscillators and clock generators with superior jitter performance. For more information on CY2941X / CY2942X, see AN210253 - CY294XX High-Performance Clock: Getting Started and Best Design Practices. In other parts of a networking system, CY25701 can be used for EMI reduction and signal integrity.

Many application processors and FPGAs in networking systems accept spread-spectrum clock inputs. Thus, internal PLLs and resulting output signals also maintain the spread, propagating low-EMI signals throughout the system and thereby drastically improving EMI performance. Another benefit in networking applications is that the reduced EMI of the clock and data signals can benefit crosstalk, which is a major concern in such systems. Reducing crosstalk through spread-spectrum helps ease the burden of signal routing by providing more noise margin. CY25701 is an ideal solution for providing the input clock in these situations.

5.4 PCI Clocking

CY25701 is a valuable replacement for a standard oscillator in PCI clocking. Typically, a reference clock is provided to a zero delay buffer (ZDB), which drives the multiple PCI slots. As shown in Figure 3, by combining CY25701 as the reference clock with a spread-aware ZDB, all the generated PCI clocks benefit from the reduced EMI of the CY25701 output.

Figure 3. CY25701 Driving a Spread-Aware ZDB



6 Summary

CY25701 integrates a crystal with a programmable spread-spectrum PLL in a small, industry-standard oscillator package to provide a simple, powerful solution for reducing EMI in various applications. Flexible EMI reduction capabilities and a programmable output frequency enable system designers to save on component cost and development time. Datasheets and other information on CY25701 are available on the CY25701 Product page .

About the Author

Name: Amitava Banerjee

Title: Applications Engineer Staff, Timing Solutions Business Unit

A Spread Spectrum Parameters

A.1 Modulation Profile

Modulating a signal waveform shape represents a modulation profile. There are two well-known profiles: Linear and Lexmark. The Lexmark profile provides better peak reduction than the Linear profile. The waveforms in Figure 4 exemplify the Lexmark profile. The Linear profile is similar to triangular waveforms in shape.

The frequency of waveform shown in Figure 4 is called "modulation frequency".

A.2 Spread Percentage

The peak-to-peak amplitude of the modulating signal represents the spread percentage. The waveforms in Figure 4 capture ±0.5 percent, ±1.0 percent, and ±2.0 percent spread percentage. The percentage of spread represents the deviation from the nominal signal frequency.

A.3 Spread Type

If the nominal signal frequency is at the center of the modulation profile, it is called "center spread". If the signal frequency is at the top of the modulation profile, it is called "down spread".

This appendix contains plots of data taken from CY25701 using a modulation domain analyzer and spectrum analyzer to show the effects of spread-spectrum on EMI reduction. A 50-MHz output frequency is selected, and center spread profiles of ±0.5 percent, ±1.0 percent, and ±2.0 percent spread are generated to compare how much spread percentage can benefit peak reduction. Figure 4 through Figure 7 show a sample of the profiles and EMI reduction provided by CY25701 for fairly typical parameters. Performance may vary depending on the specific configuration details.

The data is taken at the fundamental frequency, third harmonic (150 MHz: Figure 6), and ninth harmonic (450 MHz: Figure 7). Because the output generated is approximately a square wave, there is no even harmonic component. The odd harmonic amplitudes are attenuated by a factor of 1/N, where N is the number of the odd harmonic. Spread-spectrum is often used for odd harmonic peak reduction because of the different emission requirements in different frequency bands. The plots show that CY25701 is effective at lowering the peak level of both fundamental and harmonic peaks.

Figure 4. Spread Spectrum Profiles for 50-MHz Output, ±0.5 Percent, ±1.0 Percent, and ±2.0 Percent Spread

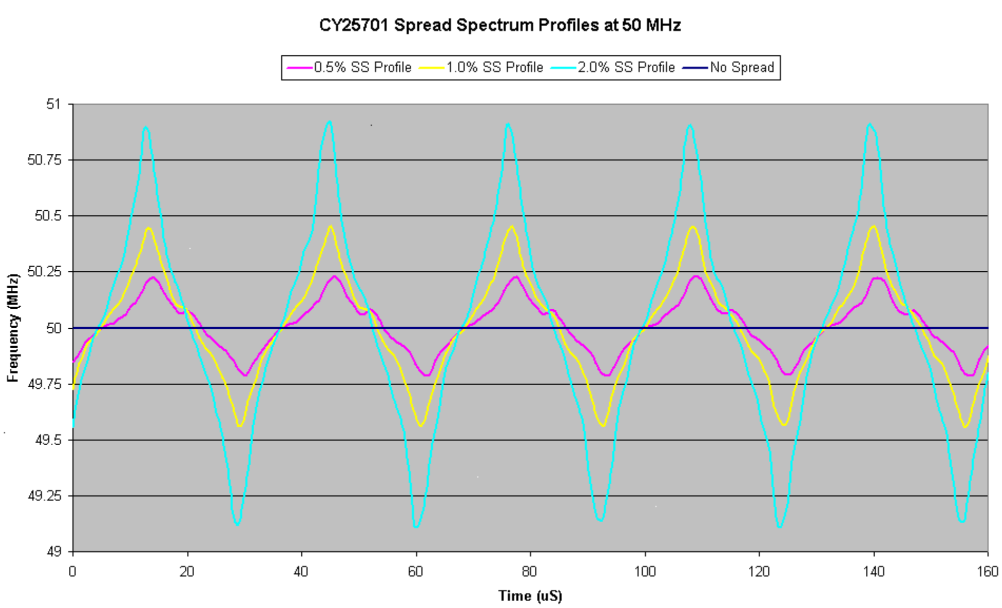


Figure 5. EMI Reduction at Fundamental (50 MHz), ±0.5 Percent, ±1.0 Percent, and ±2.0 Percent Spread

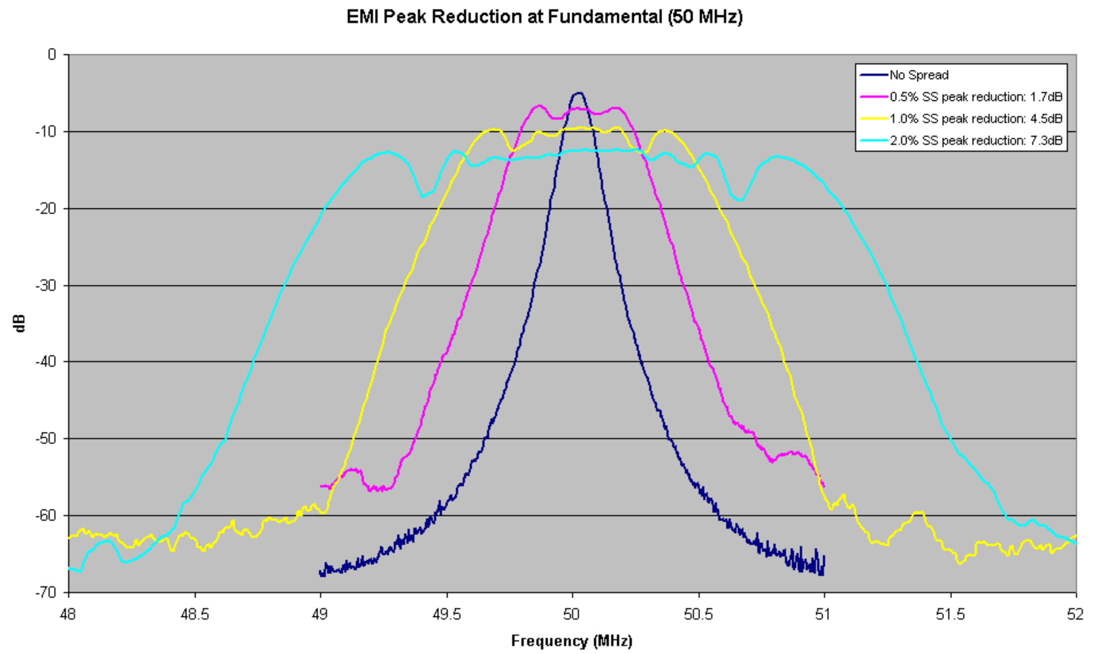


Figure 6. EMI Reduction at Third Harmonic (150 MHz), ±0.5 Percent, ±1.0 Percent, and ±2.0 Percent Spread

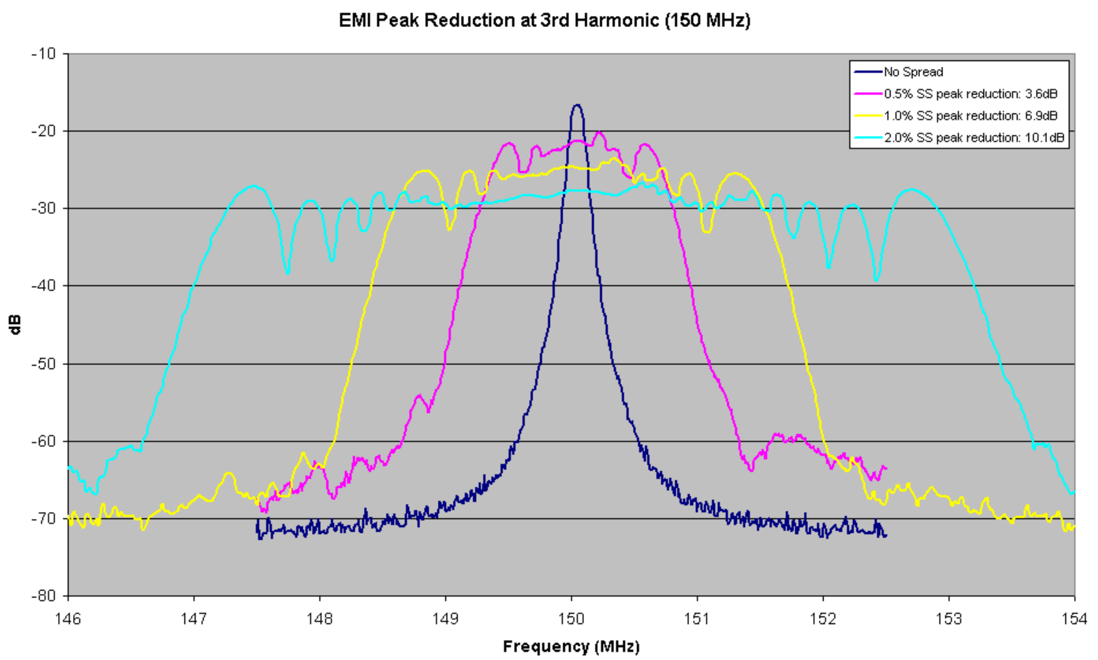
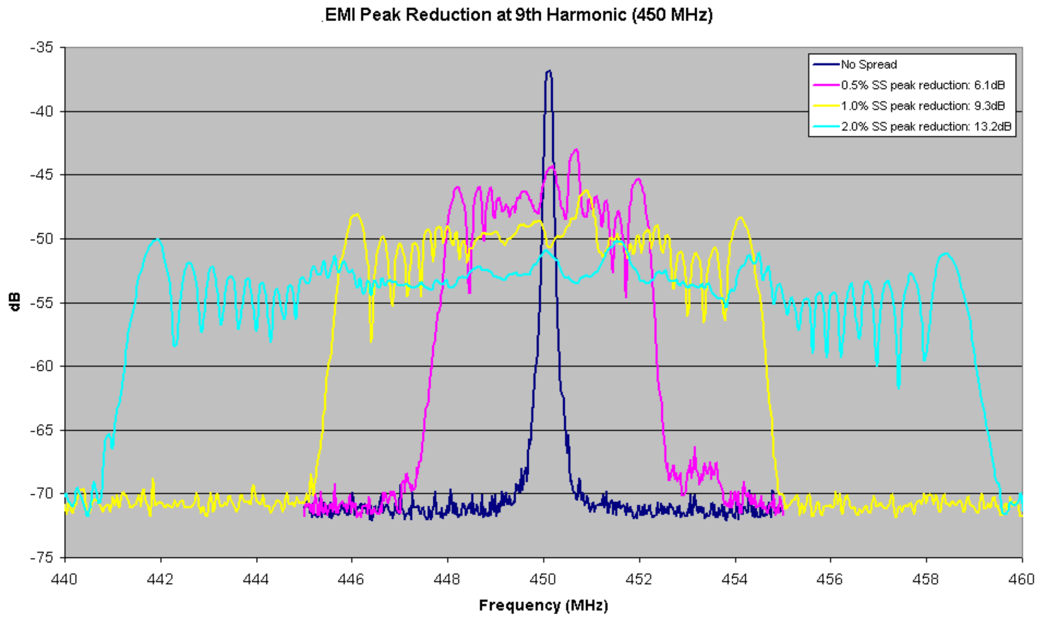


Figure 7. EMI Reduction at Ninth Harmonic (450 MHz), ±0.5 Percent, ±1.0 Percent, and ±2.0 Percent Spread



Higher spread-spectrum percentages provide superior EMI reduction. Applications that require significant EMI reduction can use a higher spread-spectrum percentage to meet emission standards, depending on the system sensitivity to frequency deviation. More sensitive systems can use a lower percentage spread (down to 0.5%) and still gain several decibels of peak reduction, as shown in CY25701 spectral plots.

Document History

Document Title: AN45324 - Spread Spectrum Crystal Oscillator with Programmability – CY25701 and Its Applications

Document Number: 001-45324

Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	2267050	CXQ	04/02/2008	New application note
*A	3216723	CXQ	04/05/2011	No change. Added Document history page.
*B	3565491	BASH	03/29/2012	Reviewed and updated the whole document. Updated template.
*C	4790578	XHT	06/08/2015	Corrected broken link. Updated template.
*D	5884082	AESATMP9	09/14/2017	Updated logo and copyright.
*E	6237572	XHT	12/04/2018	Replaced FLEXO with CY294XX in Section 5.3 Updated template

Worldwide Sales and Design Support

Cypress maintains a worldwide network of offices, solution centers, manufacturer's representatives, and distributors. To find the office closest to you, visit us at Cypress Locations.

Products

Arm® Cortex® Microcontrollers	cypress.com/arm
Automotive	cypress.com/automotive
Clocks & Buffers	cypress.com/clocks
Interface	cypress.com/interface
Internet of Things	cypress.com/iot
Memory	cypress.com/memory
Microcontrollers	cypress.com/mcu
PSoC	cypress.com/psoc
Power Management ICs	cypress.com/pmic
Touch Sensing	cypress.com/touch
USB Controllers	cypress.com/usb
Wireless Connectivity	cypress.com/wireless

PSoC® Solutions

PSoC 1 | PSoC 3 | PSoC 4 | PSoC 5LP | PSoC 6 MCU

Cypress Developer Community

Community | Projects | Videos | Blogs | Training | Components

Technical Support

cypress.com/support

Cypress Semiconductor
198 Champion Court
San Jose, CA 95134-1709