

Spread Spectrum Clocking Using the CDCS502/503

Justo Lapidra

ICP - Clock Distribution Circuits

ABSTRACT

Spread Spectrum Clocking (SSC) is a common way to overcome EMI issues. This application report provides an overall view of the principles behind SSC. It also includes practical considerations about why, when, and how to use the CDCS502 and CDCS503 SSC clock generator. When SSC is included early in the design process, it can reduce the redesign cycle and drastically decrease the cost of new product development.

Contents

| | | |
|---|--|---|
| 1 | Introduction to Spread Spectrum Clocking | 1 |
| 2 | CDCS502/503 and SSC | 3 |
| 3 | Can I Use the CDCS502/503 in My Application? | 4 |
| 4 | Using the CDCS502..... | 4 |
| 5 | Using the CDCS503..... | 4 |
| 6 | Conclusions | 5 |
| 7 | References | 5 |

List of Figures

| | | |
|---|---|---|
| 1 | CDCS502 With a 25-MHz Crystal, FS = 1, Fout = 100 MHz, and 0%, ±0.5, ±1%, and ±2% SSC | 2 |
| 2 | Time Domain of CDCS502 Cycles vs Output Frequency, Fin = Fout = 32 MHz..... | 2 |
| 3 | Different SSC Shapes..... | 3 |
| 4 | CDCS502 Schematic..... | 4 |
| 5 | CDCS503 Schematic..... | 5 |

List of Tables

| | | |
|---|---|---|
| 1 | CDCS502 Jitter With Fin = 25-MHz Crystal and Fout = 25 MHz..... | 3 |
| 2 | CDCS502 Jitter With Fin = 25-MHz Crystal and Fout = 100 MHz | 3 |
| 3 | Some Example Values for Schematic Shown in Figure 4 | 4 |

1 Introduction to Spread Spectrum Clocking

Due to the periodicity of the digital clock signals, the energy concentrates in one particular frequency and also in its odds harmonics. These levels of energy is radiated and therefore this is where a potential EMI issue arises. Spread spectrum clocking (SSC) is a special way to reduce the radiated emissions of digital clock signals.

SSC is the variation of the frequency of a clock signal in a controlled way. In the frequency domain, the SSC reduces the peak amplitude of a digital clock signal by shifting the frequency. In other words, the energy of the clock is spread. In the time domain, the amplitude of the modulated clock has the same value as the nonmodulated clock. SSC reduces the peak values of the radiation and can help when EMI testing gives problems. [Figure 1](#) shows the results for 0% (blue), ±0.5% (green), ±1% (cyan) and ±2% (red) SSC for the CDCS502. The reduction of the peak amplitude is approximately -8 dB when using ±2% SSC. This reduction in the amplitude is higher when looking at the harmonics, i.e., -13 dB for the seventh harmonic when ±2% SSC is used.

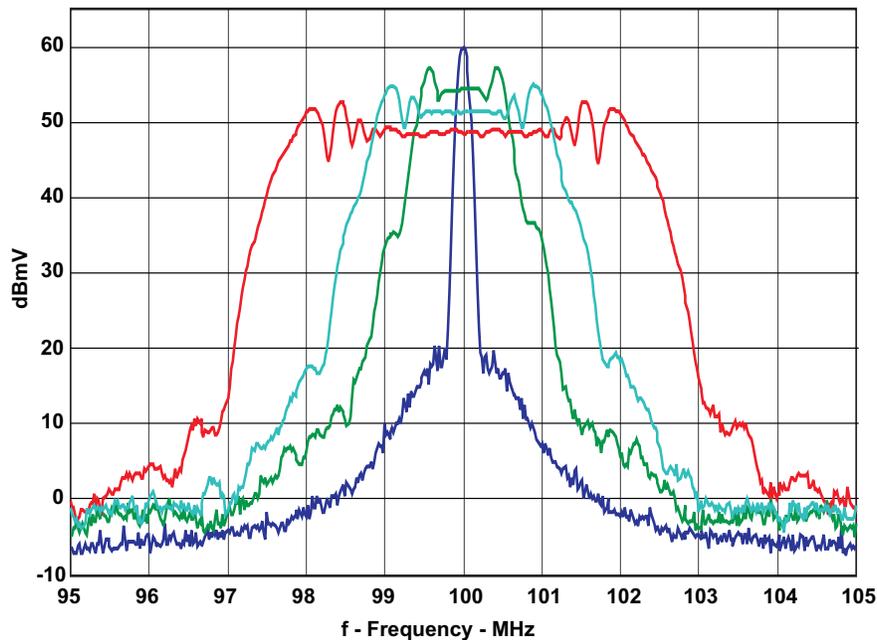


Figure 1. CDCS502 With a 25-MHz Crystal, FS = 1, Fout = 100 MHz, and 0%, ±0.5, ±1%, and ±2% SSC

The most important parameters of spread spectrum clocking are:

- Amount of SSC
- Center or down spread
- SSC profile
- Modulation frequency

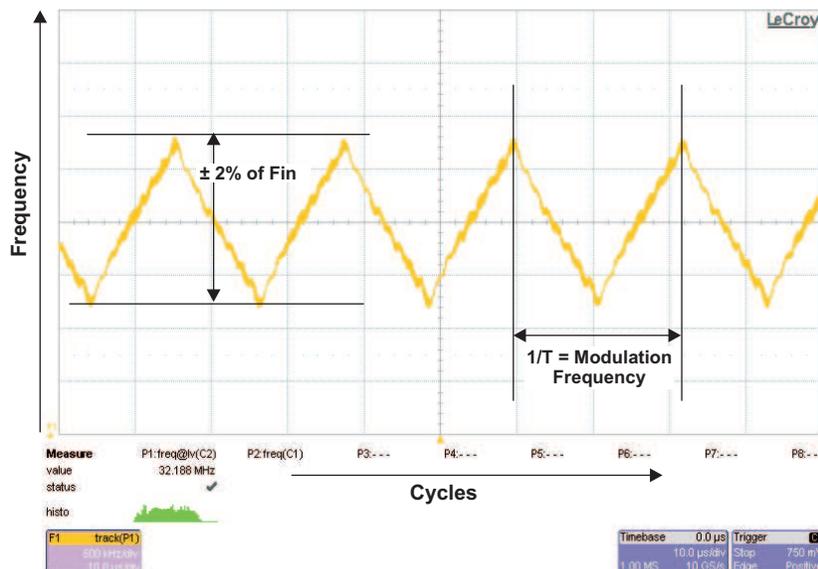


Figure 2. Time Domain of CDCS502 Cycles vs Output Frequency, Fin = Fout = 32 MHz

The amount of SSC finally selected has to meet two requirements.

- Pass EMI testing
- SSC device's jitter has to be within the jitter specifications of the system using the clock signal.

The SSC can be either centered around the output frequency or down spread. Normally, when it is

specified using "±", it means that the SSC is centered. When only "-" is used, then it means that it is down spread. For example, if ±1% SSC is selected for a 32-MHz output frequency, it means that the output frequency oscillates between 32.32 MHz (32 MHz + 0.32 MHz) and 31.68 MHz (32 MHz – 0.32 MHz). This means that some clock cycles are above 32 MHz. This can be a problem if the system is already running at its maximum frequency. In this case, use only a down-spread SSC.

SSC profiles can be implemented in several ways. The most common way to design an SSC is using a triangular shape. This is because it is relatively easy to design compared with some more complicated ways, like for example, the Hershey shape (Figure 3). The CDCS502 and CDCS503 use triangular modulation as shown in Figure 2. Figure 3 shows different SSC shapes.

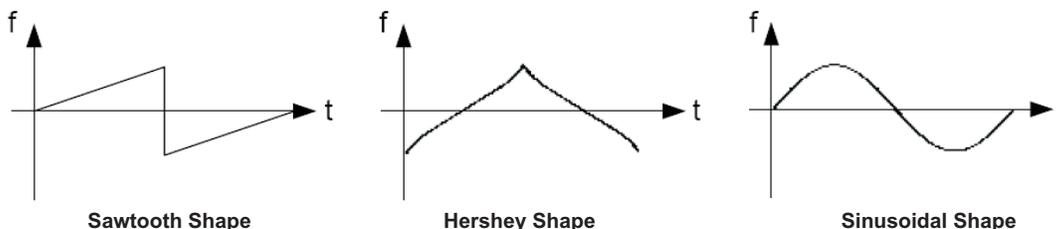


Figure 3. Different SSC Shapes

For the CDCS502 and CDCS503, the modulation frequency is a parameter that is a function of the input frequency. The device is normally designed to force the modulation frequency to be above 30 kHz and below 100 kHz in order to avoid interference in audio applications. Modulation frequency can be either constant or random. It causes the gaps when measuring SSC; this can be seen in the spectrum analyzer.

2 CDCS502/503 and SSC

The CDCS502 and CDCS503 have a triangular modulation profile, as can be seen in Figure 2. For both devices, SSC is centered; the amount of SSC can be configured using pins SSC_SEL0 and SSC_SEL1. Therefore, these two control pins have four SSC spread amount options, 0%, 0.5%, 1%, and 2%.

The modulation frequency (f_{mod}) of the CDCS502/503 depends on f_{IN} . It can be calculated using the following formulas. FS is the status of the Frequency Selection pin.

$$FS = 0: f_{mod} = f_{IN} / 708$$

$$FS = 1: f_{mod} = f_{IN} / 620$$

Table 1 and Table 2 show jitter values for the CDCS502 when using a 25-MHz crystal. Table 1 has FS set to LOW, and therefore the output frequency is 25 MHz. Table 2 results were obtained when setting FS to HIGH, and therefore the output is 100 MHz. The values are typical and measured over 10k cycles.

Table 1. CDCS502 Jitter With Fin = 25-MHz Crystal and Fout = 25 MHz

| SSC Amount | Cycle-Cycle Jitter (ps) | Period pk-pk Jitter (ps) |
|------------|-------------------------|--------------------------|
| 0% | 36 | 41 |
| ±0.5% | 93 | 512 |
| ±1% | 117 | 1001 |
| ±2% | 195 | 1990 |

Table 2. CDCS502 Jitter With Fin = 25-MHz Crystal and Fout = 100 MHz

| SSC Amount | Cycle-Cycle Jitter (ps) | Period pk-pk Jitter (ps) |
|------------|-------------------------|--------------------------|
| 0% | 36 | 41 |
| ±0.5% | 72 | 178 |
| ±1% | 72 | 292 |
| ±2% | 78 | 529 |

3 Can I Use the CDCS502/503 in My Application?

In order to know if the CDCS502/503 can be used in a given application, the jitter tolerance of the system must be known. For example, in several DSPs, peak-to-peak jitter tolerance is specified as a factor of the period. For example, the TMS320DM6467 Digital Media System-On-Chip specifies maximum period jitter as $0.02UI$. Where UI is the period of the input clock. If the frequency is 27 MHz, then $UI = 37.037$ ns and therefore period jitter is 0.02×37.037 ns = 0.740 ns = 740 ps. This limit is within the limits of the CDCS502/503 for 0% and $\pm 0.5\%$ SSC.

Some other applications are only sensitive to cycle-to-cycle jitter. As can be seen in [Table 1](#) and [Table 2](#), this parameter does not increase in the same amount as the period jitter does.

4 Using the CDCS502

[Figure 4](#) shows a typical schematic using the CDCS502. Note that resistors R1, R2, R3, and R4 footprints are available on a printed-circuit board in order to fine tune the amount of SSC when doing EMI testing. The final configuration depends on the jitter tolerance of the device connected to the CDCS502 and the EMI tests results.

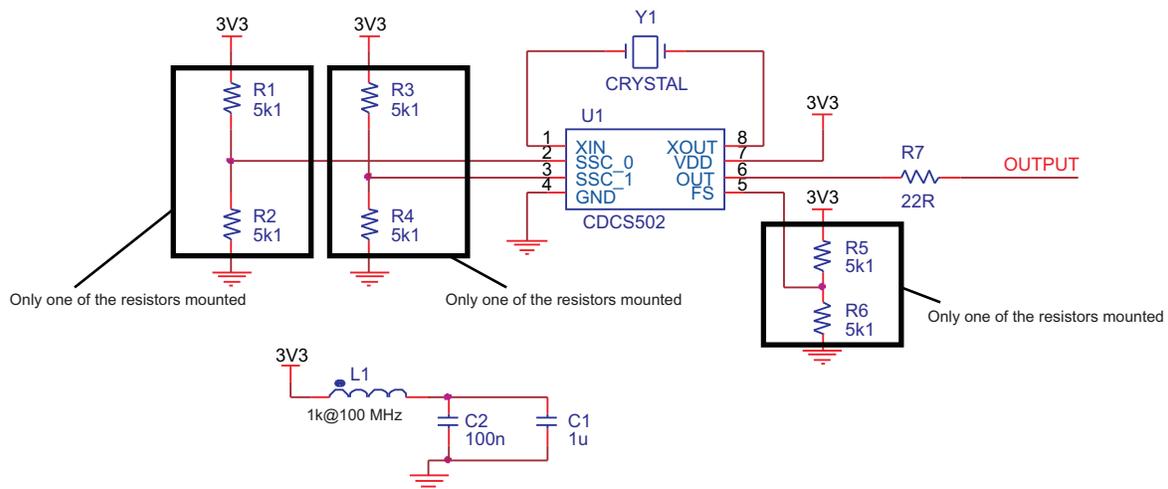


Figure 4. CDCS502 Schematic

[Table 3](#) shows some example values for the schematic shown in [Figure 4](#).

Table 3. Some Example Values for Schematic Shown in [Figure 4](#)

| R1 or R2 Mounted? | R3 or R4 Mounted? | R5 or R6 Mounted? | Multiplication Factor | SSC |
|-------------------|-------------------|-------------------|-----------------------|-------------|
| R1 | R3 | R5 | X4 | $\pm 2\%$ |
| R1 | R3 | R5 | X4 | $\pm 2\%$ |
| R2 | R3 | R6 | X1 | $\pm 0.5\%$ |
| R2 | R4 | R6 | X1 | $\pm 0\%$ |

5 Using the CDCS503

[Figure 5](#) shows a typical schematic using the CDCS503. Note that resistors R8, R9, R10, and R11 footprints are available in a printed-circuit board in order to fine tune the amount of SSC when doing EMI testing. The final configuration depends on the jitter tolerance of the device connected to the CDCS503 and the EMI tests results.

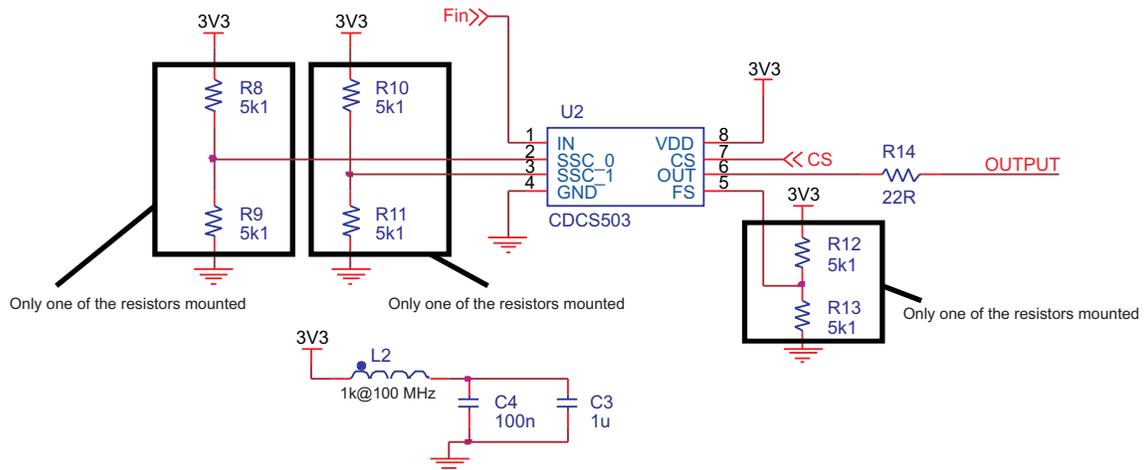


Figure 5. CDCS503 Schematic

6 Conclusions

Spread Spectrum Clocking is one of the most common technologies used for overcoming EMI issues. The CDCS502 and CDCS503 can help if used in an early stage of the design phase. The fine tuning of the SSC can be achieved using the control pins of these devices.

Additionally, the CDCS502/503 can work as a clock multiplier (x4) to generate a higher frequency, adding SSC when needed.

7 References

1. CDCS502, Crystal Oscillator/Clock Generator With Optional SSC, data sheet ([SCAS868](#))
2. CDCS503, Clock Buffer/Clock Multiplier With Optional SSC, data sheet ([SCAS872](#))

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

| | |
|-----------------------------|--|
| Amplifiers | amplifier.ti.com |
| Data Converters | dataconverter.ti.com |
| DLP® Products | www.dlp.com |
| DSP | dsp.ti.com |
| Clocks and Timers | www.ti.com/clocks |
| Interface | interface.ti.com |
| Logic | logic.ti.com |
| Power Mgmt | power.ti.com |
| Microcontrollers | microcontroller.ti.com |
| RFID | www.ti-rfid.com |
| RF/IF and ZigBee® Solutions | www.ti.com/lprf |

Applications

| | |
|--------------------|--|
| Audio | www.ti.com/audio |
| Automotive | www.ti.com/automotive |
| Broadband | www.ti.com/broadband |
| Digital Control | www.ti.com/digitalcontrol |
| Medical | www.ti.com/medical |
| Military | www.ti.com/military |
| Optical Networking | www.ti.com/opticalnetwork |
| Security | www.ti.com/security |
| Telephony | www.ti.com/telephony |
| Video & Imaging | www.ti.com/video |
| Wireless | www.ti.com/wireless |

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2009, Texas Instruments Incorporated