

### Introduction

The VersaClock III is a programmable clock generator intended for high performance data-communications, telecommunications, consumer, and networking applications. There are four internal PLLs, each individually programmable, allowing for four unique non-integer-related frequencies. PLL0 and PLL3 support spread spectrum clock generation capability for electromagnetic interference (EMI) reduction. This application note explains how to configure the VersaClock III for spread spectrum clocking.

### Spread Spectrum Generation on PLL0

PLL0 supports spread spectrum generation capability, which users have the option of turning on or off. Spread spectrum modulation frequency and spread amplitude are fully programmable. The programmable spread spectrum generation parameters are TSSC[3:0], NSSC[2:0], SS\_OFFSET[5:0], SD[3:0] and X2 bits. The spread spectrum generation on PLL0 can be enabled/disabled using the TSSC[3:0] bits. To enable spread spectrum, set TSSC > '0' and A[3:0] > '0' and set NSSC[2:0], SS\_OFFSET[5:0], SD[3:0] as described below. To disable spread spectrum generation, set TSSC[3:0] = '0'.

### Fractional Feedback Divider

PLL 0 has a fractional feedback divider which consists of a 12bit divider and a 4bit sigma-delta modulator. The sigma-delta modulator is used to generate the spread spectrum clock. To enable the sigma-delta modulator, set A[3:0] > '0'. When the A is greater than 0, total feedback divider value M is calculated using Eq.1.

$$M = 2 \times N[11:0] + A[3:0] + 1 \quad (\text{for } A > 0) \quad (\text{Eq.1})$$

$$M = 2 \times N[11:0] \quad (\text{for } A = 0) \quad (\text{Eq.2})$$

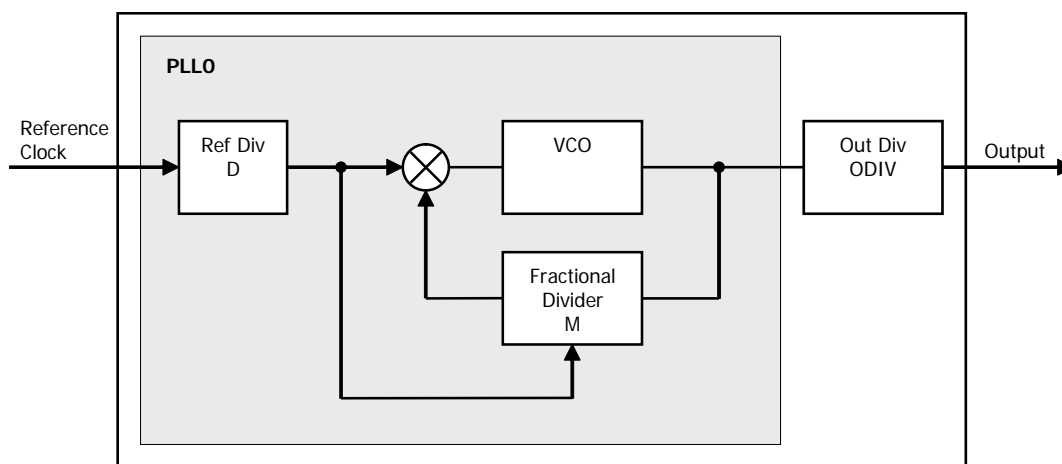


Figure 1-1: PLL 0 Block Diagram

### Spread Spectrum Modulation Frequency

The modulation frequency ( $F_{mod}$ ) can be calculated using equation Eq.3, Eq.4 and Eq.5.  $TSSC[3:0]$  is used to determine the number of phase/frequency detector cycles per spread spectrum cycle (ssc) step.  $NSSC[2:0]$  is used to determine the number of delta-encoded samples used for a single quadrant of the spread spectrum waveform. All four quadrants of the spread spectrum waveform are mirror images of each other.

$$T_{ssc} = TSSC [3 : 0] + 2 \quad (Eq.3)$$

$$N_{ssc} = NSSC [2 : 0] \times 2 \quad (Eq.4)$$

$$F_{mod} = \frac{F_{pfd}}{4 \times T_{ssc} \times N_{ssc}} \quad (Eq.5)$$

Note 1: Valid TSSC integer values range from 5 to 14. Values 0 - 4 and 15 should not be used.

Note 2: Valid NSSC integer values range from 1 to 6. Values 0 and 7 should not be used.

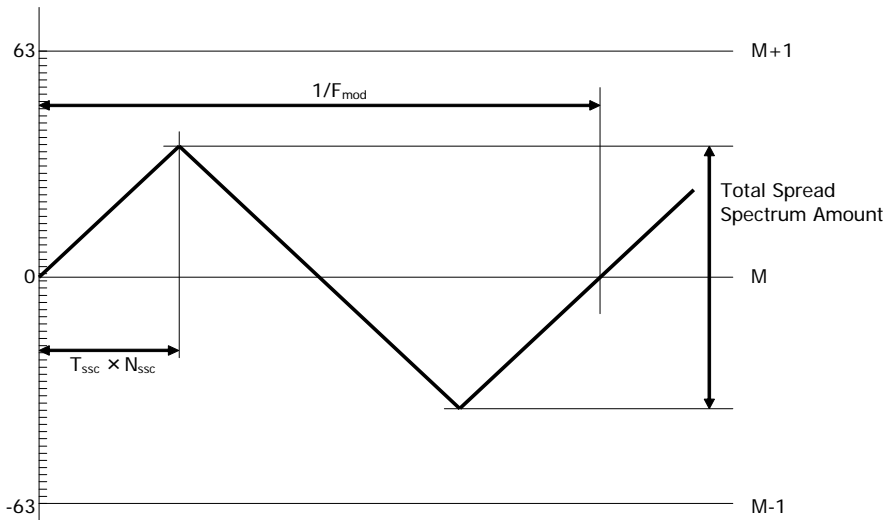


Figure 1-2: Spread Spectrum Profile

### Spread Spectrum Amplitude

The spread spectrum amplitude can be calculated using equation Eq.6 and Eq.7 with SD0, SD1s and NSSC bits. SD0[3:0] and SD1[3:0] are used to determine the amplitude of the spread spectrum. These are delta-encoded samples of the waveform. The NSSC bits determine how many of these samples are used for the waveform. The sum of these delta-encoded samples (sigma delta- encoded samples) determines the amount of spread and should not exceed (63 - SS\_OFFSET). The maximum spread is inversely proportional to the nominal M integer value.

X2 bit is used to double the total value of sigma-delta encoded samples which will increase the amplitude of the spread spectrum waveform by a factor of two. When X2 is '0', the amplitude remains nominal, but if set to '1', the amplitude is increased by x2.

$$\Sigma\Delta = NSSC [2 : 0] \times (SD_0 + SD_1) \times (X2 + 1) \quad (Eq.6)$$

$$\pm Spread \% = \frac{100 \times \Delta\Sigma}{64 \times M} \quad (Eq.7)$$

Note 1: SD0 should be equal to or greater than SD1.

Note 2:  $\pm Spread\%$  is amount of center spread.

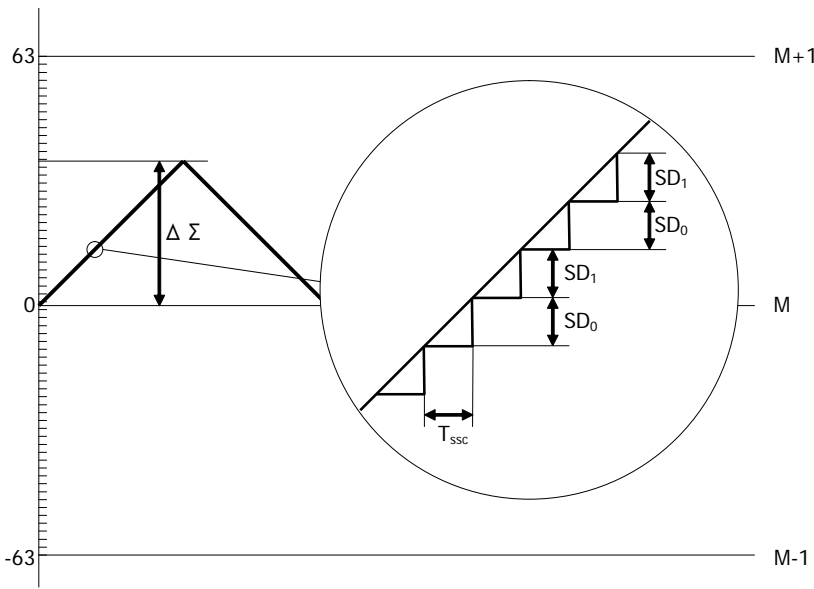


Figure 1-3: Delta-Encoded Samples and Spread Spectrum Amplitude

### Fractional Offset

SS\_OFFSET[5:0] is used to program the fractional offset with respect to the nominal M integer value. The SS\_OFFSET has integer values ranging from 0 to 63.

$$SS\_OFFSET[5:0] \leq 63 - \Delta\Sigma \quad (\text{Eq.8})$$

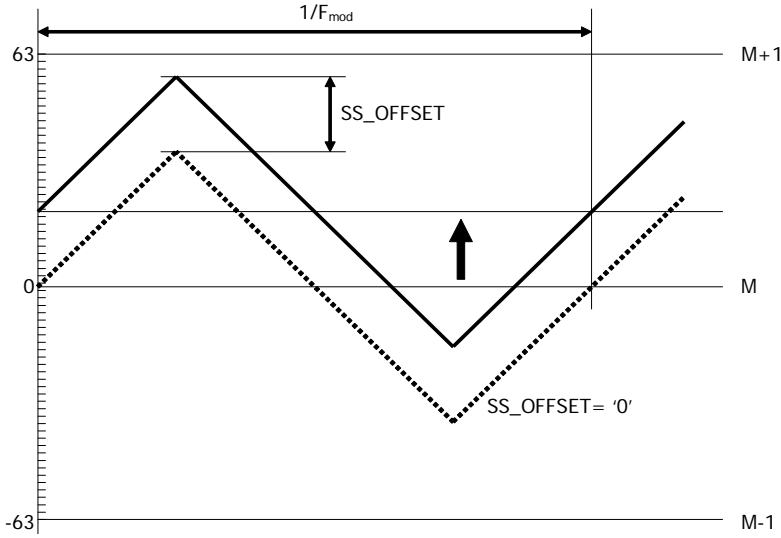


Figure 1-4: Fractional Offset

For center spread, the SS\_OFFSET is set to '0' so that the spread spectrum waveform is centered about the nominal M (Mnom) value. For down spread, the SS\_OFFSET > '0' such the spread spectrum waveform is centered about the (Mideal -1+(SS\_OFFSET/64)) value. The down spread percentage can be thought of in terms of center spread. For example, a down spread of -1% can also be considered as a center spread of ±0.5% but with Mnom shifted down by one and offset.

$$SS\_OFFSET = 63 - \Delta\Sigma \quad (\text{Eq.9})$$

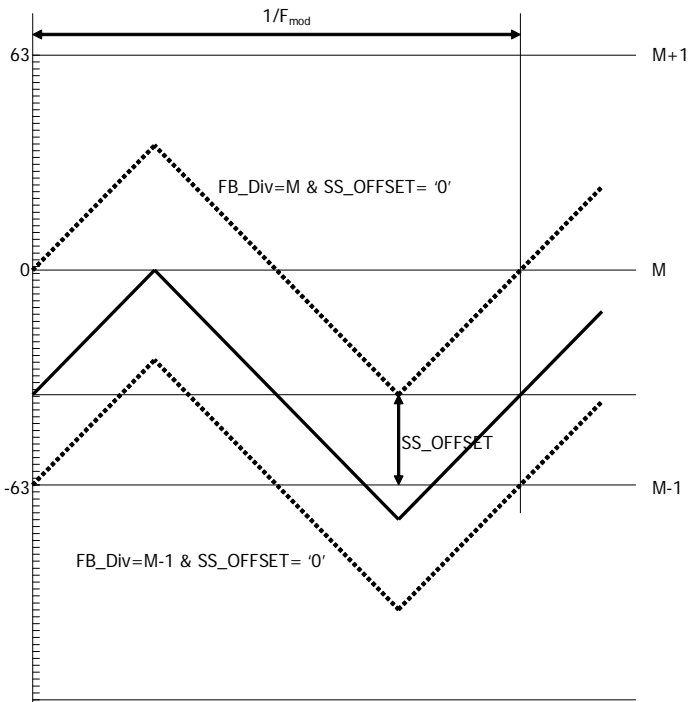


Figure 1-5: Fractional Offset for Down Spread

**Example 1 Center Spread**

Configurations are :

Fref : 25MHz

Fout : 100MHz

Fmod : 33kHz

Spread Spectrum : +/-0.5% of center spread

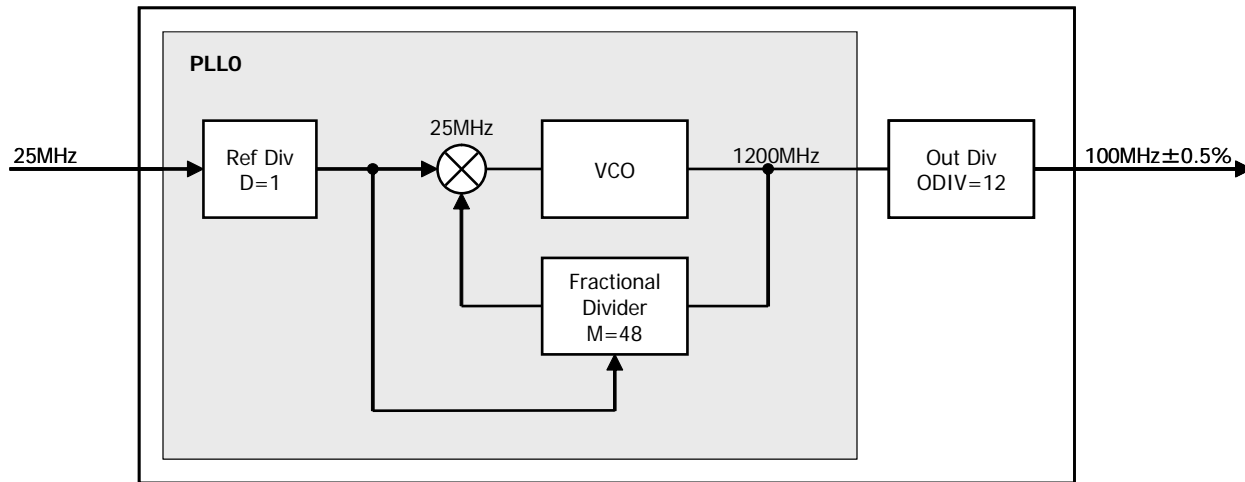


Figure 1-6: PLL0 Configuration for Center Spread

**1, Setup dividers**

Set Reference Divider = 1, Feedback Divider = 48 and Output Divider=12 for 100MHz output. (Refer to Figure 1-6.)

**2, Configure modulation frequency**

We can determine TSSC and NSSC by using Eq.5.

$$N_{ssc} \times T_{ssc} = \frac{25\text{MHz}}{4 \times 33\text{kHz}}$$

Using Eq.3 and Eq.4, we find the closest value is when Nssc = 12 and Tssc = 16. Therefore, NSSC[2:0] = 6, TSSC[3:0] = 14.

Note :Maximize NSSC to have the most granularity of the spread spectrum cycle step.

**3, Configure amplitude of spread spectrum**

Use Eq.6 to determine the value of the sigma-delta encoded samples.

$$0.5 = \frac{100 \times \Delta\Sigma}{64 \times 48} \Leftrightarrow \Delta\Sigma = 15.36$$

Use Eq.6 to determine SD0, SD1 and X2. We find the closest value is when SD0 = 2, SD1 = 1 and X2 = 0. The calculated sigma-delta is 18 and the spread amount estimated is ±0.58%. If we set SD0 = 1, SD1 = 1 and X2 = 0, calculated sigma-delta is 12. Then the spread amount estimated is ±0.39%.

**4, Configure fractional offset**

For center spread, SS\_OFFSET is 0.

### Example 2 Down Spread

Configurations are :

Fref : 25MHz

Fout : 100MHz

Fmod : 33kHz

Spread Spectrum : -1.0% of down spread

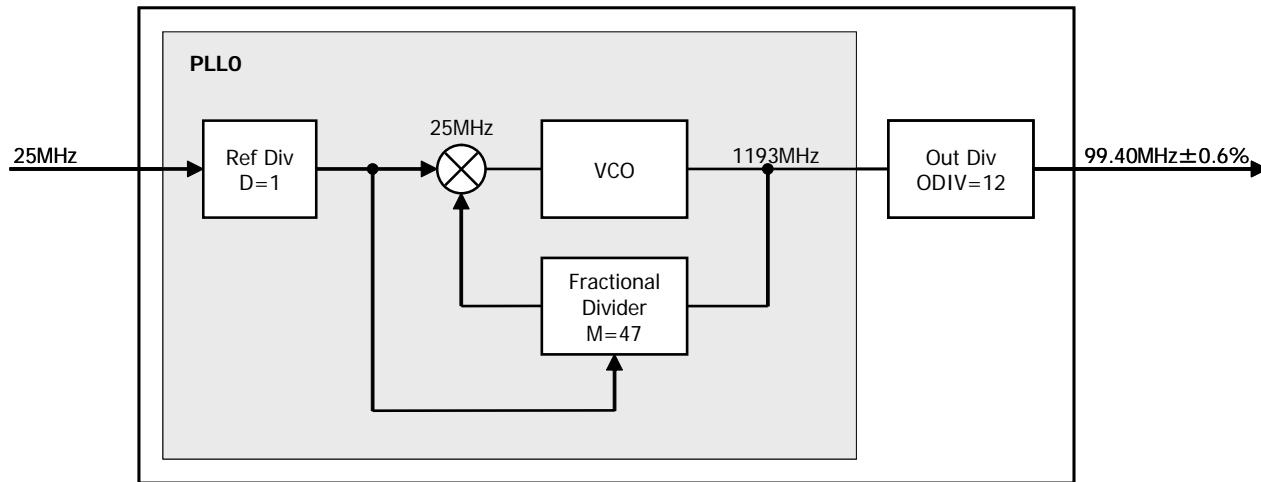


Figure 1-7: PLL0 Configuration for Down Spread

#### 1, Setup dividers

Set Reference Divider = 1, Fractional Divider = 47 and Output Divider=12 for 100MHz output. (Refer to Figure 1-7.) For the down spread, the fractional divider value is set to (Mideal-1) instead of (Mideal).

#### 2, Configure modulation frequency

We can determine TSSC and NSSC by using Eq.5.

$$N_{ssc} \times T_{ssc} = \frac{25\text{MHz}}{4 \times 33\text{kHz}}$$

Using Eq.3 and Eq.4, we find the closest value is when Nssc = 12 and Tssc = 16. Therefore, NSSC[2:0] = 6, TSSC[3:0] = 14

Note :Maximize NSSC to have the most granularity of the spread spectrum cycle step.

#### 3, Configure amplitude of spread spectrum

Use Eq.7 to determine the value of the sigma-delta encoded samples.

$$0.5 = \frac{100 \times \Delta\Sigma}{64 \times 47} \Leftrightarrow \Delta\Sigma = 15.04$$

Use Eq.6 to determine SD0, SD1 and X2. We find the closest value is when SD0 = 2, SD1 = 1 and X2 = 0. The calculated sigma-delta is 18 and the spread amount estimated is ±0.60%. If we set SD0 = 1, SD1 = 1 and X2 = 0, the calculated sigma-delta is 12. Then the spread amount estimated is ±0.40%.

#### 4, Configure fractional offset

For down spread, use Eq.9 to determine the value of the fractional offset.

$$SS\_OFFSET = 45$$

## Spread Spectrum Generation on PLL3

PLL3 supports spread spectrum generation capability, which users have the option of turning on and off. The technique is different from that used in PLL0. The spread spectrum generation on PLL3 can be enabled/disabled using the SSENb bit. To enable spread spectrum, set SSENb = '1'.

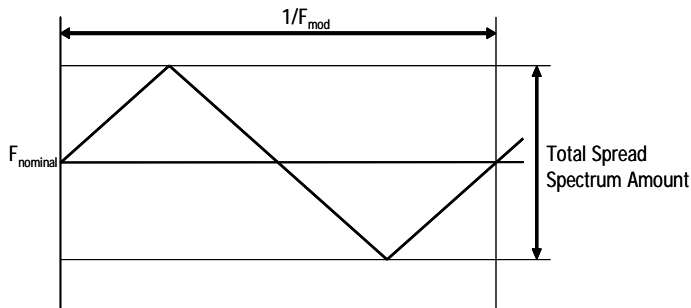


Figure 2-1: Spread Spectrum Profile

The modulation frequency is configured using SS\_D3[7:0].

$$SS\_D3 = \frac{F_{ref}}{4 \times F_{mod}} \quad (Eq. 10)$$

Note : The reference input clock selected is used to determine the modulation frequency. Valid integer SS\_D3 values range from 3 to 255.

The spread spectrum amount is configured using SSVCO[15:0].

$$SSVCO = 2 \times \frac{F_{vco}}{F_{ref}} \times SS\_D3 \times \left( 1 + \frac{SS}{400} \right) + Offset \quad (Eq. 11)$$

SS is the total spread spectrum amount. (i.e. center spread +/-0.5% has a total spread of 1.0% and down spread -0.5% has a total spread of 0.5%.) The offset value is used to fine-tune the spread spectrum amount. The offset should be set to '0' initially.

### Example 1 Center Spread

Configurations are :

Fref : 25MHz

Fout : 100MHz

Fmod : 33kHz

Spread Spectrum : +/-0.5% of center spread

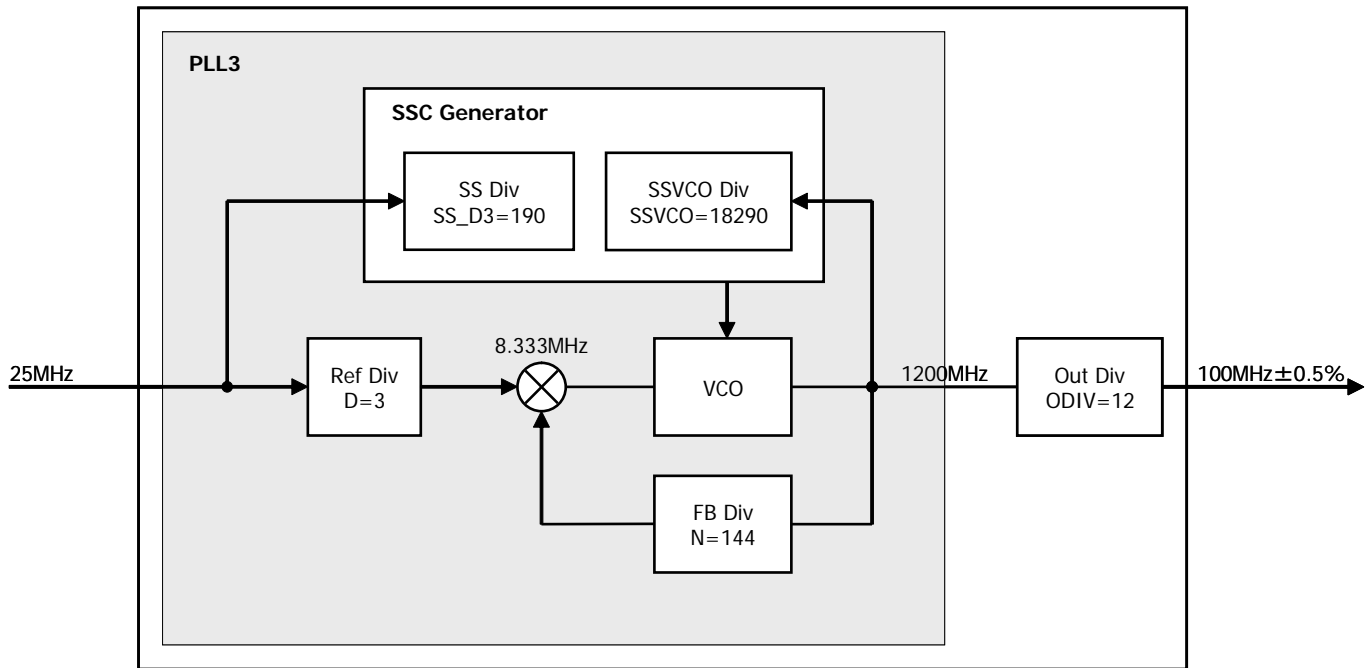


Figure 2-2: PLL3 Configuration for Center Spread

#### 1, Setup dividers

Set Reference Divider = 3, Feedback Divider = 144 and Output Divider=12 for 100MHz output. (Refer to Figure 2-2.)

#### 2, Setup SS\_D3 for modulation frequency

Use Eq.10 to determine the value of the SS\_D3.

$$SS\_D3 = \frac{25\text{ MHz}}{4 \times 33\text{ kHz}}$$

$$= 189.3939 \dots$$

Either round up or down to the nearest integer value. When SS\_D3 = 190, Fmod is 32.8947kHz.

#### 3, Setup SSVCO for spread spectrum amount

Use Eq.11 to determine the value of SSVCO.

$$SSVCO = 2 \times \frac{1200}{25} \times 190 \times \left(1 + \frac{1}{400}\right) + 0$$

$$= 18285.6$$

Either round up or down to the nearest integer value. When SS\_D3 = 18286, the spread amount estimated is ±0.50%.



### Example 2 Down Spread

Configurations are :

Fref : 25MHz

Fout : 100MHz

Fmod : 33kHz

Spread Spectrum : -1.0% of down spread

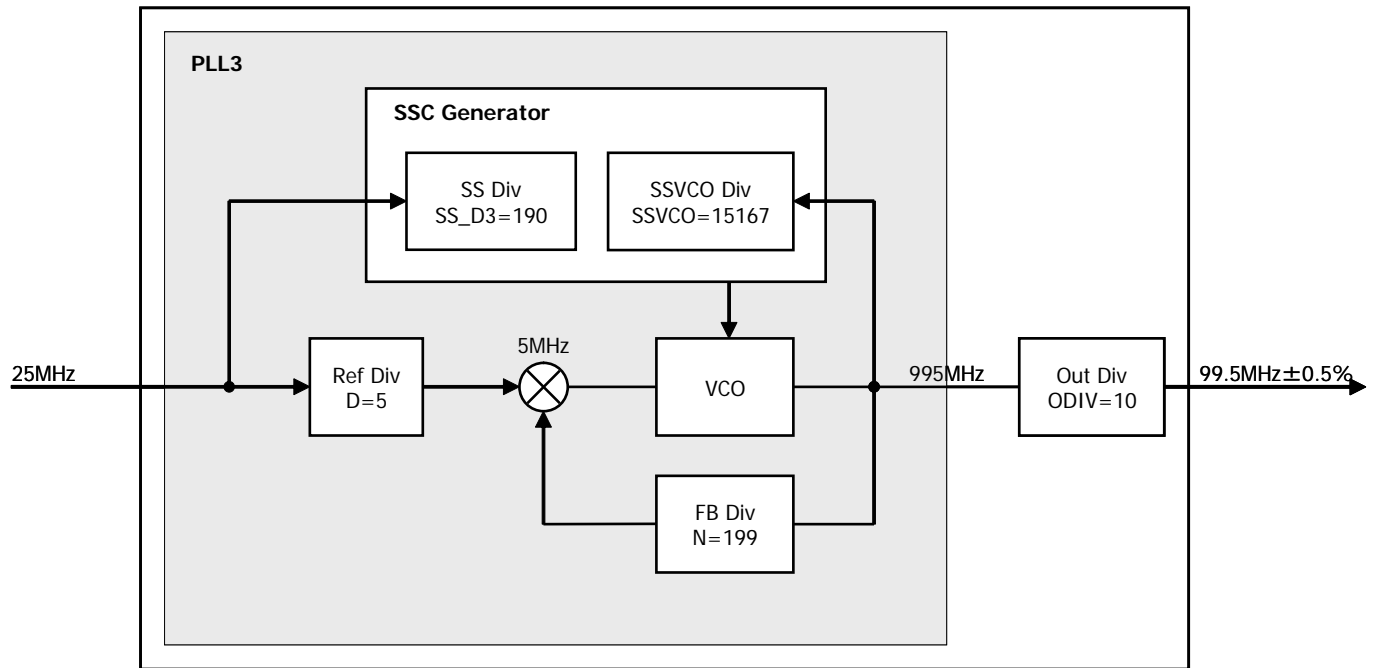


Figure 2-3: PLL3 Configuration for Down Spread

#### 1, Setup dividers

100MHz with down spread of 1.0% can be considered as 99.5MHz with center spread of 0.5%.

Set Reference Divider = 5, Feedback Divider = 199 and Output Divider=10 for 99.5MHz output. (Refer to Figure 2-3.)

#### 2, Setup SS\_D3 for modulation frequency

Use Eq.10 to determine the value of the SS\_D3.

$$SS\_D3 = \frac{25\text{ MHz}}{4 \times 33\text{ kHz}}$$

$$= 189.3939 \dots$$

Either round up or down to the nearest integer value. When SS\_D3 = 190, Fmod is 32.8947kHz.

#### 3, Setup SSVCO for spread spectrum amount

Use Eq.11 to determine the value of SSVCO.

$$SSVCO = 2 \times \frac{995}{25} \times 190 \times \left(1 + \frac{1}{400}\right) + 0$$

$$= 15161.81$$

Either round up or down to the nearest integer value. When SS\_D3 = 15162, the spread amount estimated is ±0.50%.

## Revision History

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<u>Rev</u>	<u>Date</u>	<u>Pages</u>	<u>Description</u>
0	08/20/09	p.1-10	Initial release

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**Corporate Headquarters:**  
6024 Silver Creek Valley Road  
San Jose, CA, USA  
95138

**For Sales:**  
1-800-345-7015 or  
408-284-8200  
Fax: 408-284-2775  
[www.idt.com](http://www.idt.com)

**For Tech Support:**  
1-800-345-7015  
408-284-4555  
Fax: 408-284-4547  
Email: [idtcmd-support@idt.com](mailto:idtcmd-support@idt.com)

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