

Frequency LCM Calculator & N/R Finder Tool

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This document contains a brief use example of the LCM Calculator & N/R Finder Tool. These tools are considered beta. Not polished & shiny, but simple and functional.

Note: Units of an outputs is same of units of inputs.

This is a high level overview figure which shows the inputs and outputs of the program. Outputs are updated live as inputs are entered.

The screenshot shows a Windows-style application window titled "Frequency LCM Calculator". The interface is divided into several sections:

- Frequencies Section:** A label "Frequencies" is above a blue header bar. Below it are five input fields labeled f1, f2, f3, f4, and f5, each with a green background. To the right of these fields are five corresponding output labels: "VCO Frequency required with integer dividers", "Divider required to hit frequency 1", "Divider required to hit frequency 2", "Divider required to hit frequency 3", "Divider required to hit frequency 4", and "Divider required to hit frequency 5".
- Worst Combo Section:** A blue rectangular area labeled "Worst Combo".
- Inputs/Outputs Legend:** A green box labeled "Inputs" and a blue box labeled "Outputs" are positioned on the right side of the window.
- Updating Section:** A label "updating..." is above a section containing input and output fields. The inputs are "VCO Frequency" (value 1) and "Reference Freq" (value 1), both with green backgrounds. The outputs are "VCO Frequency target" and "Reference Frequency".
- Calculation Section:** A label "N/R = VCO Frequency / Reference Frequency [with frequencies multiplied up to drop decimals]" is above a section containing input and output fields. The inputs are "VCO Frequency Factors" (value 1.0) and "Reference Freq" (value 1.0), both with blue backgrounds. The outputs are "VCO Frequency target" and "Reference Frequency".
- Reduced Values Section:** A section containing input and output fields. The inputs are "Reduced N" (value 1) and "Reduced R" (value 1), both with blue backgrounds. The outputs are "Elimination of common factors" (twice) and "Phase Detector Frequency" (value 1.0).

Figure 1 - Input Output overview of application

Example

Find solution to output 160 MHz and 200 MHz using LMK0480x.

Part 1 - Find VCO & Divider Solution for 160 MHz and 200 MHz output frequencies.

- 1) Enter 160 and 200 into f1 and f2.
 - a. The red boxes on f1 and f2 indicate that they are the worst case frequency combination and if we were to eliminate one of these frequencies, we would get a better solution. (this is a bit silly, given there are only two) – but this helps to identify frequencies which are “unusual” to other frequencies when many frequencies are input.
 - b. The worst combo is again, a more detailed view of the statement above. It shows the LCM of the frequencies specified in the listbox. If a third frequency were entered, this may result in a more interesting result.

Frequencies		800.0	VCO Frequency required with integer dividers
1	160	5	Divider required to hit frequency 1
2	200	4	Divider required to hit frequency 2
f3			Divider required to hit frequency 3
f4			Divider required to hit frequency 4
f5			Divider required to hit frequency 5

Worst Combo

800.0 f1 and f2

Figure 2 - Required VCO frequency for 160 and 200 MHz outputs with integer dividers.

- 2) The result of Figure 2 determines an 800 MHz VCO frequency will allow divides of 5 and 4 to achieve frequencies of 160 and 200 MHz. However, our devices don't have 800 MHz VCOs.
 - a. Enter a bit of mental arithmetic. $2 \times 800 \text{ MHz} = 1600 \text{ MHz}$; LMK04803 low frequency is 1840 MHz. No go. $3 \times 800 \text{ MHz} = 2400 \text{ MHz}$; LMK04806 frequency range is 2370 to 2600 MHz. 2400 MHz is a valid VCO frequency!
 - b. Enter 2400 MHz to see the updated divide values:

Frequencies		2400.0	VCO Frequency required with integer dividers
1	160	15	Divider required to hit frequency 1
2	200	12	Divider required to hit frequency 2
3	2400	1	Divider required to hit frequency 3
f4			Divider required to hit frequency 4
f5			Divider required to hit frequency 5

Worst Combo

2400.0 f2 and f3
2400.0 f1 and f3
800.0 f1 and f2

Figure 3 - Added VCO frequency to the output frequency mix.

The next step is to find PLL N and R divide values for input and VCO frequencies.

Part 2 - Find PLL N and R divide values for input and VCO frequency

- 3) A VCO frequency of 2400 MHz is solved above. But suppose the customer uses a 10 MHz reference frequency. If using a single PLL loop (possible with LMK04800), simply enter 10 MHz for reference frequency and 2400 MHz for VCO frequency and the PLL N and R values are calculated.
- However, suppose the dual loop mode of LMK04800 is used (normal use case), a VCXO frequency must be selected. Suppose for this example a VCXO frequency of 80 MHz is used.... enter the VCO and reference frequency for the 2nd loop and 1st loop separately.
 - The second loop is Reference is 80 MHz and VCO = 2400 MHz.
 - The first loop is Reference = 10 MHz and VCO = 80 MHz.

VCO Frequency	2400	VCO Frequency target
Reference Freq	80	Reference Frequency
$N/R = \text{VCO Frequency} / \text{Reference Frequency}$ [with frequencies multiplied up to drop decimals]		
VCO Frequency Factors	2 * 2 * 2 * 2 * 2 * 2 * 3 * 5 * 5	VCO Frequency target
Reference Freq	2 * 2 * 2 * 2 * 5	Reference Frequency
Reduced N	30	Elimination of common factors
Reduced R	1	Elimination of common factors
PDF	80.0	Phase Detector Frequency

Figure 4 - Second Loop Solution for PLL N and R.

VCO Frequency	80	VCO Frequency target
Reference Freq	10	Reference Frequency
$N/R = \text{VCO Frequency} / \text{Reference Frequency}$ [with frequencies multiplied up to drop decimals]		
VCO Frequency Factors	2 * 2 * 2 * 2 * 5	VCO Frequency target
Reference Freq	2 * 5	Reference Frequency
Reduced N	8	Elimination of common factors
Reduced R	1	Elimination of common factors
PDF	10.0	Phase Detector Frequency

Figure 5 - First Loop Solution for PLL N and R.

- 4) The solver determines the reduced fraction for N/R to maximum phase detector frequency. However, for the first PLL, this is not always desirable. To decrease the phase detector frequency, simply increase PLL N and R by multiplying both N and R by the same value.
- For example, to reduce the phase detector frequency in Figure 5 to 1 MHz, multiply R and N by 10. Therefore PLL1 R = $8 * 10 = 80$ and PLL1 N = $1 * 10 = 10$.

Part 3 – Selecting an optimum reference oscillator input frequency given a specified VCO frequency and “starting point” reference oscillator frequency.

Suppose a customer has a reference frequency of 10.24 MHz and wants to generate clock outputs of 156.25 MHz, 125 MHz, and 100 MHz. We can use the Clock Design Tool to configure this solution, but will find because of the low 160 kHz phase detector frequency, the performance may not as good as we’d like.

How can we chose a different reference oscillator frequency to improve PLL performance by increasing phase detector frequency? Roughly speaking, *increasing the number of common factors* between the VCO and OSCin frequencies will improve phase detector frequency. The best case is to pick the reference oscillator by dividing the VCO frequency by some integer value “N” – but if it is desired to chose a reference frequency more closely related to the originally intended reference oscillator, consider the following method:

Step 1) Enter the VCO frequency & Reference frequency into the bottom half of the application. If the VCO frequency is not known, use the LCM calculator in the top half of the application to determine a VCO frequency inside a valid clocking device VCO tuning range.

Note, if a low frequency like 625 MHz is returned as LCM, be aware that multiple devices could work as any device with a VCO frequencies of $n \cdot 625$ MHz could be used.

The screenshot shows a software interface for calculating PLL parameters. It includes input fields for VCO Frequency (2500) and Reference Freq (10.24). Below these, it displays the prime factorization of both frequencies: VCO Frequency Factors are $2^4 \cdot 5^6$ and Reference Freq factors are 2^{10} . The interface then calculates the reduced N (15625) and reduced R (64), which are used to determine the Phase Detector Frequency (PDF) of 0.16 MHz. The value 0.16 is circled in red.

updating...		
VCO Frequency	2500	VCO Frequency target
Reference Freq	10.24	Reference Frequency
N/R = VCO Frequency / Reference Frequency [with frequencies multiplied up to drop decimals]		
VCO Frequency Factors	2 * 2 * 2 * 2 * 5 * 5 * 5 * 5 * 5 * 5	VCO Frequency target
Reference Freq	2 * 2 * 2 * 2 * 2 * 2 * 2 * 2 * 2 * 2	Reference Frequency
Reduced N	15625	Elimination of common factors
Reduced R	64	Elimination of common factors
PDF	0.16	Phase Detector Frequency

Step 2) Entering 2500 MHz as VCO frequency and 10.24 MHz as reference frequency results in factors of “2500 MHz VCO” as $2^4 \cdot 5^6$ and “10.24 MHz OSCin” as 2^{10} . This setup results in 160 kHz PDF. To increase PDF frequency we can...

(a) multiply VCO frequency by OSCin factors not included in VCO factors.

- In this case, multiply VCO frequency by 2, 2^2 , 2^3 , ..., 2^6 will improve phase detector frequency.

(b) multiply OSCin frequency by VCO factors not included in OSCin factors.

- In this case, multiply OSCin by 5, 5^2 , 5^3 , ..., 5^6 will improve phase detector frequency.

The improvement to phase detector frequency is the same as the factor used. So if for example the VCO frequency was doubled from 2500 to 5000 MHz, the PDF would increase from 160 kHz to 320 kHz. If for example the OSCin reference was increase 5 times, the PDF would increase $160 \text{ kHz} \cdot 5 = 800 \text{ kHz}$ as illustrated below.

Frequency LCM Calculator

Frequencies

2500.0

VCO Frequency required with integer dividers

f1

156.25

16

Divider required to hit frequency 1

f2

125

20

Divider required to hit frequency 2

f3

100

25

Divider required to hit frequency 3

f4

Divider required to hit frequency 4

f5

Divider required to hit frequency 5

Worst Combo

2500.0 f1 and f3

625.0 f1 and f2

500.0 f2 and f3

updating...

VCO Frequency

2500

VCO Frequency target

Reference Freq

51.2

Reference Frequency

N/R = VCO Frequency / Reference Frequency
[with frequencies multiplied up to drop decimals]

VCO Frequency Factors

2 * 2 * 2 * 5 * 5 * 5 * 5 * 5

VCO Frequency target

Reference Freq

2 * 2 * 2 * 2 * 2 * 2 * 2 * 2 * 2 * 2

Reference Frequency

Reduced N

3125

Elimination of common factors

Reduced R

64

Elimination of common factors

PDF

0.8

Phase Detector Frequency