Keywords: coherent sampling calculator, coherent, coherent sampling, high-speed analog-to-digital converter, ADC, high-speed ADC, FFT, fast fourier transform, sampling frequency, input frequency, sampling window

APPLICATION NOTE 3190

Coherent Sampling Calculator (CSC)

Jun 25, 2004

Abstract: This calculator provides a quick and easy way to select sinusoidal input test tones for the test of analog-to-digital (ADC) converters. Based on the theory of coherent sampling, the calculator allows a user to chose input and sampling frequencies as well as number of integer cycles within the sampling window and the resolution (number of data point) of the FFT.

When evaluating the dynamic performance of analog-to-digital converters (ADCs) using Fast Fourier Transforms (FFTs), one must decide whether to use coherent sampling or window sampling. Maxim's application note "Coherent Sampling vs. Window Sampling" details the advantages and disadvantages of each sampling technique, but, in general, coherent sampling produces the best quality in high-resolution FFTs.

The purpose of coherent sampling is to force an integer number of input cycles within the sampling window. **Figure 1** shows several examples of coherent sampling in the time domain.

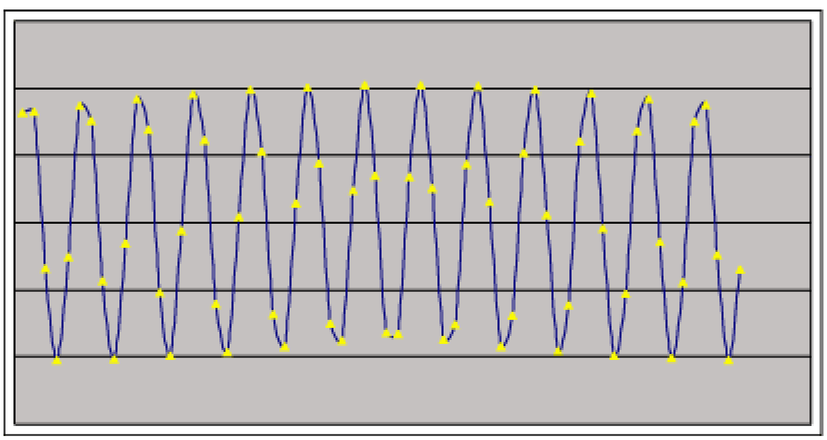

Figure 1a.

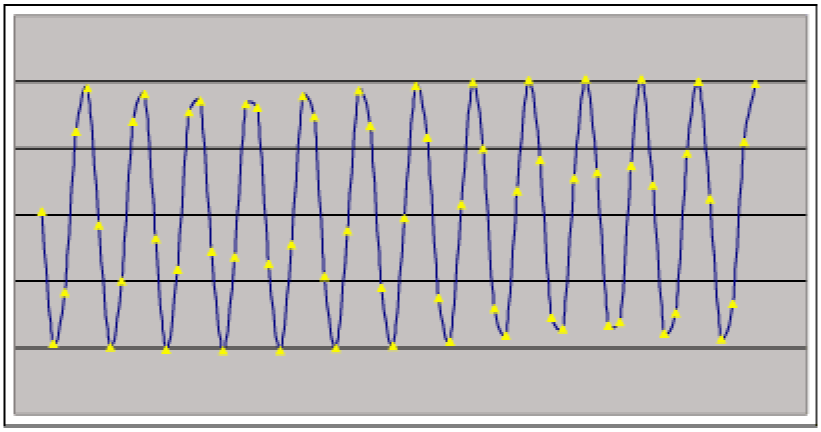

Figure 1b.

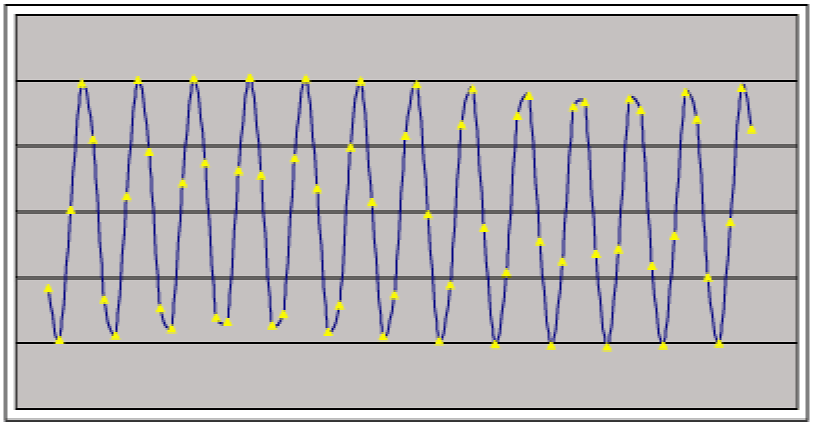

Figure 1c.

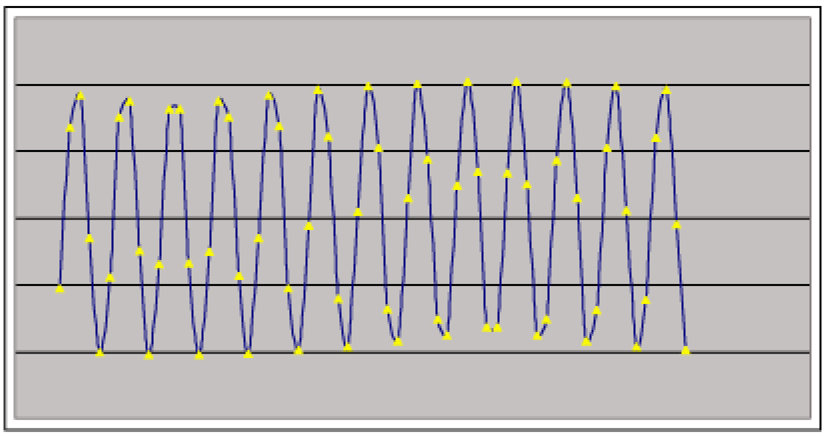

Figure 1d.

Figure 1a-d. Coherently sampled data contains an integer number of cycles within the sampling window. These figures show four sets of coherently sampled data. Each data set has 13 cycles within the sampling window and contains 64 data points. $N_{WINDOW}=13$, $N_{RECORD}=64$

Mathematically, coherent sampling is expressed as:

$$\frac{f_{IN}}{f_{SAMPLE}} = \frac{N_{WINDOW}}{N_{RECORD}}$$

where:

- f_{IN} is the input frequency of the ADC under test.
- f_{SAMPLE} is the sampling frequency of the ADC under test.
- N_{WINDOW} is the integer number of cycles within the sampling window. This value must be an odd or prime number.
- N_{RECORD} is the number of data points used to create your FFT. This value must be a power of 2.

Finding an f_{IN} and an f_{SAMPLE} that satisfy the above relationship is an iterative process. An Excel spreadsheet titled "Coherent Sampling Calculator" is available for download to simplify the process. Alternatively, a simplified web-based version of the Coherent Sampling Calculator is available.

The "Coherent Sampling Calculator" requires four input variables:

- $f_{DSAMPLE}$ is the desired sampling frequency of the ADC under test.
- f_{DIN} is the desired input frequency of the ADC under test.
- N_{RECORD} is the number of data points used to create your FFTs. This value must be a power of 2.
- SIGFIG is the desired number of significant figures after MHz in the coherent sampling results.

From the four variables listed above the "Coherent Sampling Calculator" will provide a coherent sampling frequency ($f_{CSAMPLE}$) and input frequency (f_{CIN}).

The Coherent Sampling Calculator includes a macro that allows the user to view the detailed intermediate steps of the calculation process. By default, the spreadsheet is set to hide these detailed calculations, however by clicking the "Show_Detailed_Calculations" button the user can get additional information such as the size of the coherent sampling window ($t_{CWINDOW}$) and the number of input cycles in the coherent sampling window ($N_{CWINDOW}$).

Figures 2-3 show examples of coherently sampled FFTs taken using the coherent sampling calculator and the MAX1211EVKIT.

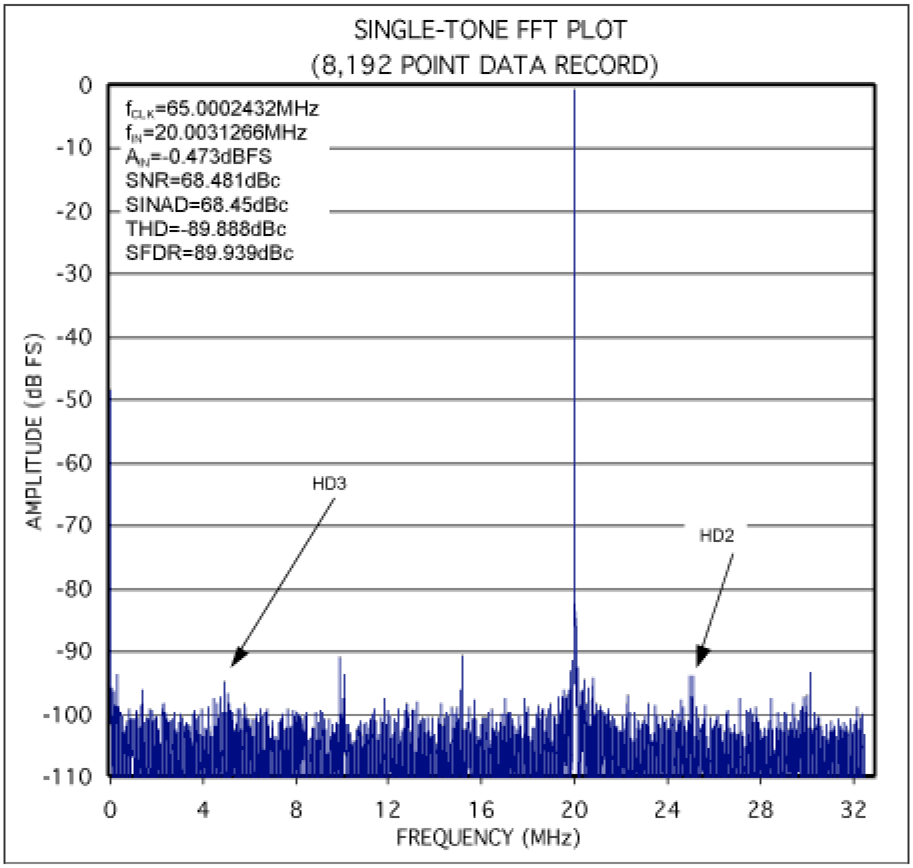

Figure 2. Coherently sampled FFT from the MAX1211EVKIT.
f_{CIN}=20.0031266MHz
$f_{CSAMPLE}$=65.0002432MHz
$N_{CWINDOW}$=2521
N_{RECORD}=8192

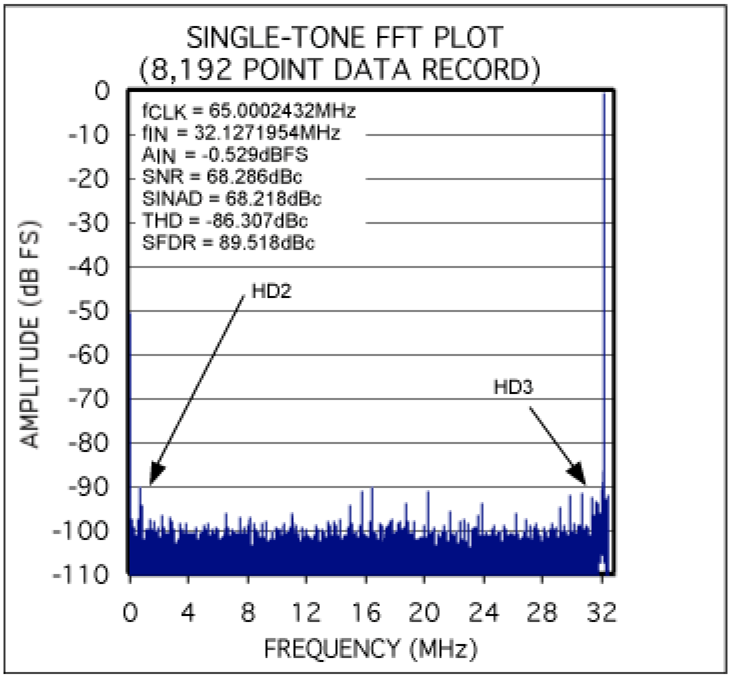

Figure 3. Coherently sampled FFT from the MAX1211EVKIT.
f_{CIN}=32.1271954MHz
$f_{CSAMPLE}$=65.0002432MHz
$N_{CWINDOW}$=4049
N_{RECORD}=8192

Related Parts		
MAX1121	1.8V, 8-Bit, 250Msps Analog-to-Digital Converter with LVDS Outputs for Wideband Applications	Free Samples
MAX1124	1.8V, 10-Bit, 250Msps Analog-to-Digital Converter with LVDS Outputs for Wideband Applications	Free Samples
MAX1127	Quad, 12-Bit, 65Msps, 1.8V ADC with Serial LVDS Outputs	Free Samples
MAX1190	Dual 10-Bit, 120Msps, 3.3V, Low-Power ADC with Internal Reference and Parallel Outputs	Free Samples
MAX1193	Ultra-Low-Power, 45Msps, Dual 8-Bit ADC	Free Samples
MAX1198	Dual, 8-Bit, 100Msps, 3.3V, Low-Power ADC with Internal Reference and Parallel Outputs	Free Samples
MAX1208	12-Bit, 80Msps, 3.3V ADC	Free Samples
MAX1215N	1.8V, 12-Bit, 250Msps ADC for Broadband Applications	
MAX12529	Dual, 96Msps, 12-Bit, IF/Baseband ADC	Free Samples
MAX12555	14-Bit, 95Msps, 3.3V ADC	

MAX12559	Dual, 96Msps, 14-Bit, IF/Baseband ADC	Free Samples
MAX1430	15-Bit, 100Msps ADC with -76.8dBFS Noise Floor for IF Applications	
MAX1434	Octal, 10-Bit, 50Msps, 1.8V ADC with Serial LVDS Outputs	Free Samples
MAX1438	Octal, 12-Bit, 65Msps, 1.8V ADC with Serial LVDS Outputs	Free Samples
MAX1449	10-Bit, 105Msps, Single +3.3V, Low-Power ADC with Internal Reference	Free Samples
MAX19588	High-Dynamic-Range, 16-Bit, 100Msps ADC with -82dBFS Noise Floor	Free Samples

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