

A Spreadsheet for Calculating the Frequency Response of the ADS1250-54

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ABSTRACT

The ADS1250, ADS1251, ADS1252, ADS1253 and ADS1254 (ADS1250-54) family of high-resolution analog-to-digital converters (ADCs) share an advanced delta-sigma ($\Delta\Sigma$) topology. This application note reviews the frequency characteristics of these devices and shows how to use a companion Microsoft Excel™ spreadsheet (ADS1250-4 Frequency Response.xls), available for download from the TI web site, to calculate the frequency response.

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1 Topology

The ADS1250-54 devices use a 4th order, delta-sigma modulator followed by a 5th order SINC filter, as shown in Figure 1. Note that the ADS1250 also incorporates a PGA from 1 to 8 before the modulator; the ADS1253 and ADS1254 include a 4-channel multiplexer. The modulator samples the analog input signal at a rate f_{MOD} and produces a digital output. By virtue of the modulator design, the noise is concentrated at the higher frequencies. The digital filter receives this signal and performs a low-pass function, thereby increasing resolution by removing the modulator high frequency noise. In filtering the signal, the digital filter reduces or decimates the data rate to f_{DATA} . The ratio between the modulator rate and the output data rate ($f_{\text{MOD}} / f_{\text{DATA}}$) is referred to as the oversampling ratio or decimation rate, and is fixed at 64.

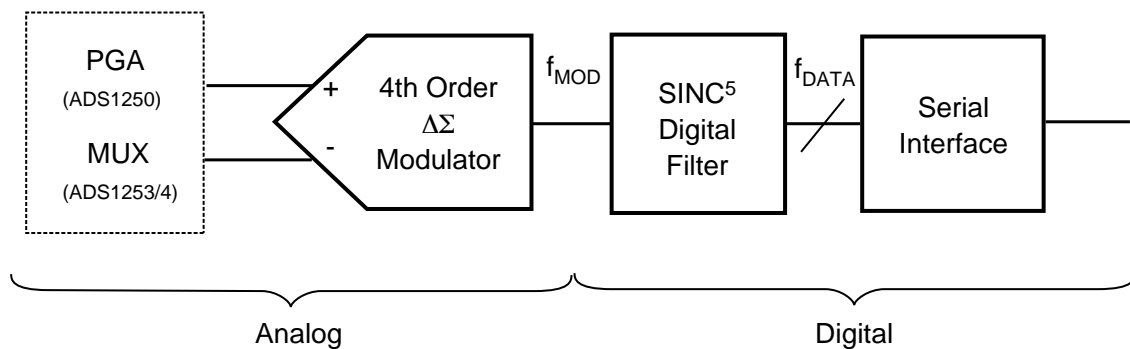


Figure 1. ADS1250–54 Block Diagram

2 Frequency Response

The digital filter sets the overall frequency response as a function of the modulator rate. The modulator rate is in turn 1/6 of the master clock frequency, f_{CLK} . (See the relevant product datasheets for more detail). The frequency response is given by the following equation:

$$|H(f)| = \frac{\left| \sin\left(\frac{64\pi f}{f_{MOD}}\right) \right|^5}{64 \left| \sin\left(\frac{\pi f}{f_{MOD}}\right) \right|^5} = \frac{\left| \sin\left(\frac{384\pi f}{f_{CLK}}\right) \right|^5}{64 \left| \sin\left(\frac{6\pi f}{f_{CLK}}\right) \right|^5} \quad \text{Equation 1}$$

The response is a low-pass function with notches (or “zeros”) at the data output rate and multiples thereof. At these frequencies, the filter has zero gain. To help illustrate the filter characteristics, Figure 2 shows the response for:

$$f_{CLK} = 6\text{MHz} \rightarrow f_{MOD} = 1\text{MHz} \rightarrow f_{DATA} = 15.6\text{kHz}$$

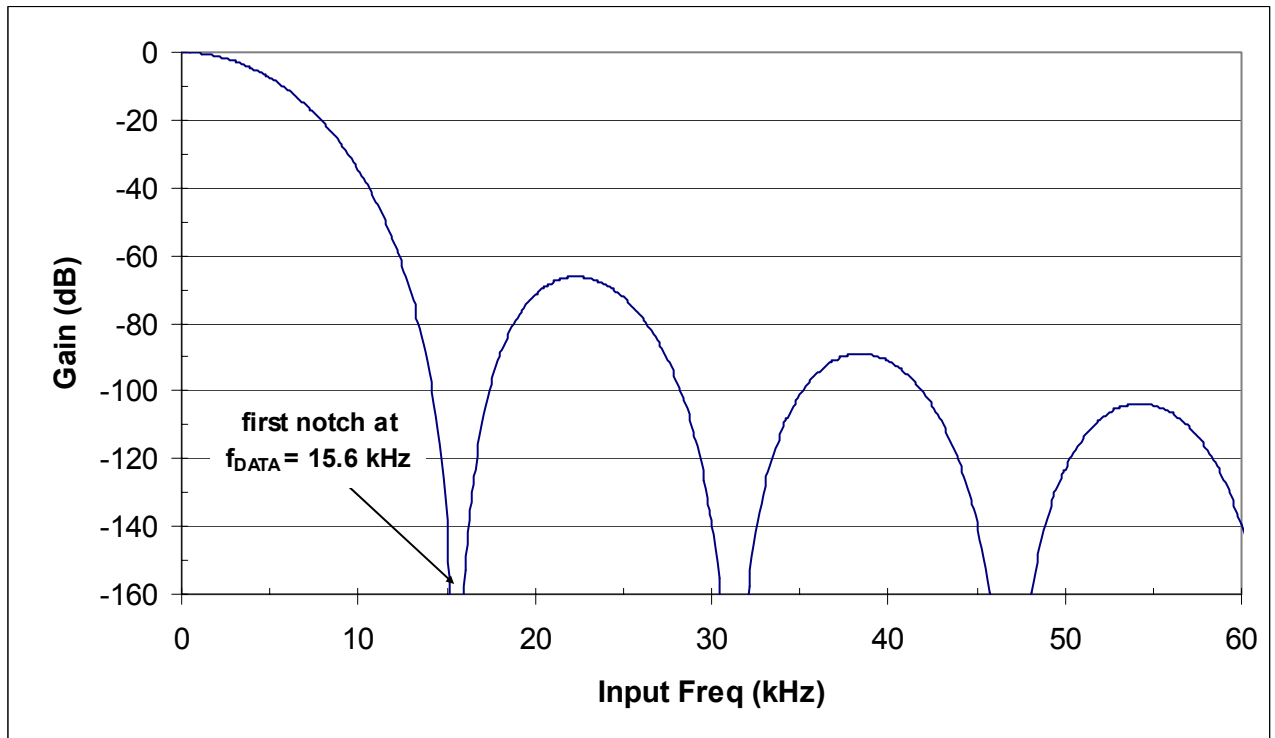


Figure 2. Frequency Response Illustrating Notches at Multiples of f_{DATA} ($f_{CLK} = 6\text{ MHz}$)

The digital filter low-pass characteristic repeats at multiples of the modulator rate. Figure 3 shows the response plotted out to 2.0MHz. Notice how it repeats at 1MHz and 2MHz.

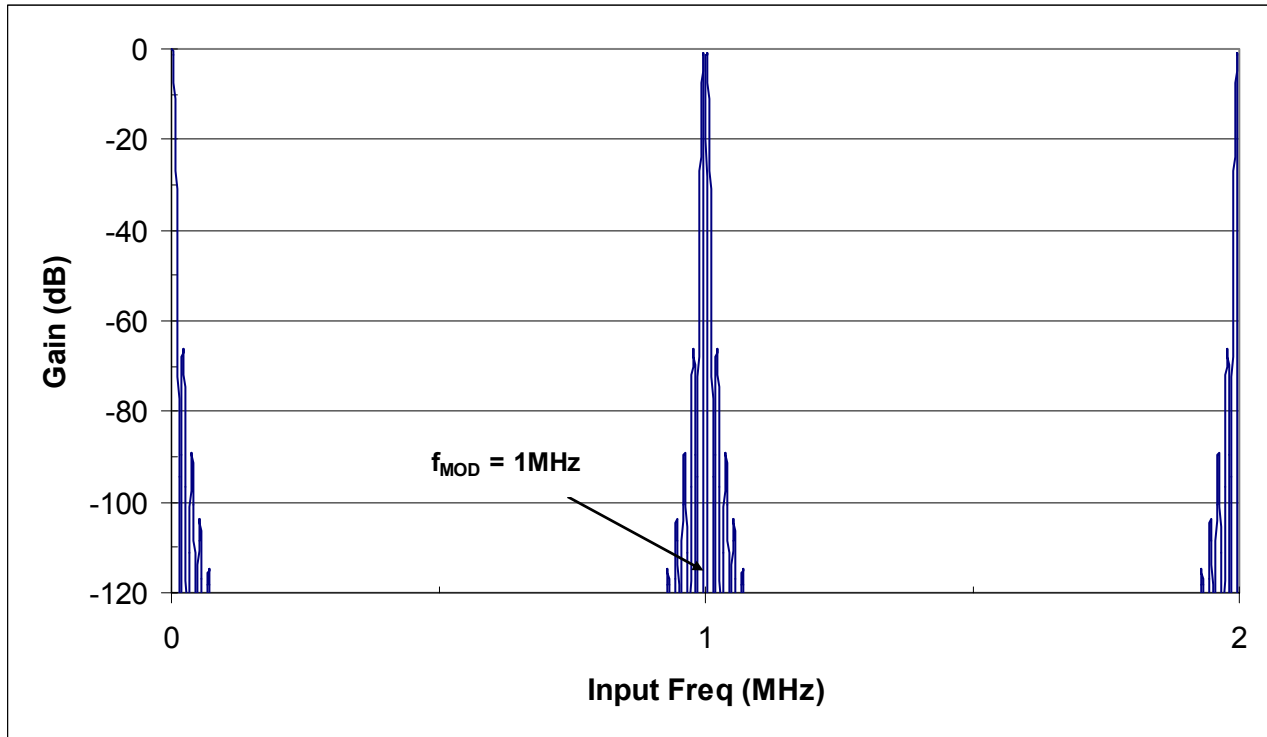


Figure 3. Frequency Response Illustrating Response at Multiples of f_{MOD} ($f_{\text{CLK}} = 6\text{MHz}$).

As a practical note, the digital filter will attenuate high-frequency noise on the inputs up to the frequency where the response repeats (nearly up to 1MHz input in Figure 3). To prevent external noise above this frequency from reducing performance, make sure to remove any high-frequency noise with anti-aliasing filtering before the ADC inputs. A simple RC filter with a corner frequency above the signal band, but below f_{MOD} , typically suffices.

3 Excel Spreadsheet

The companion Microsoft Excel spreadsheet to this application note (see *References*) calculates the ADS1250–54 frequency response for a given CLK frequency. Before using this sheet, make sure that the Analysis ToolPak is available as shown in Figure 4. This menu is found under **Tools/Add-Ins** in Microsoft Excel (version 2002).

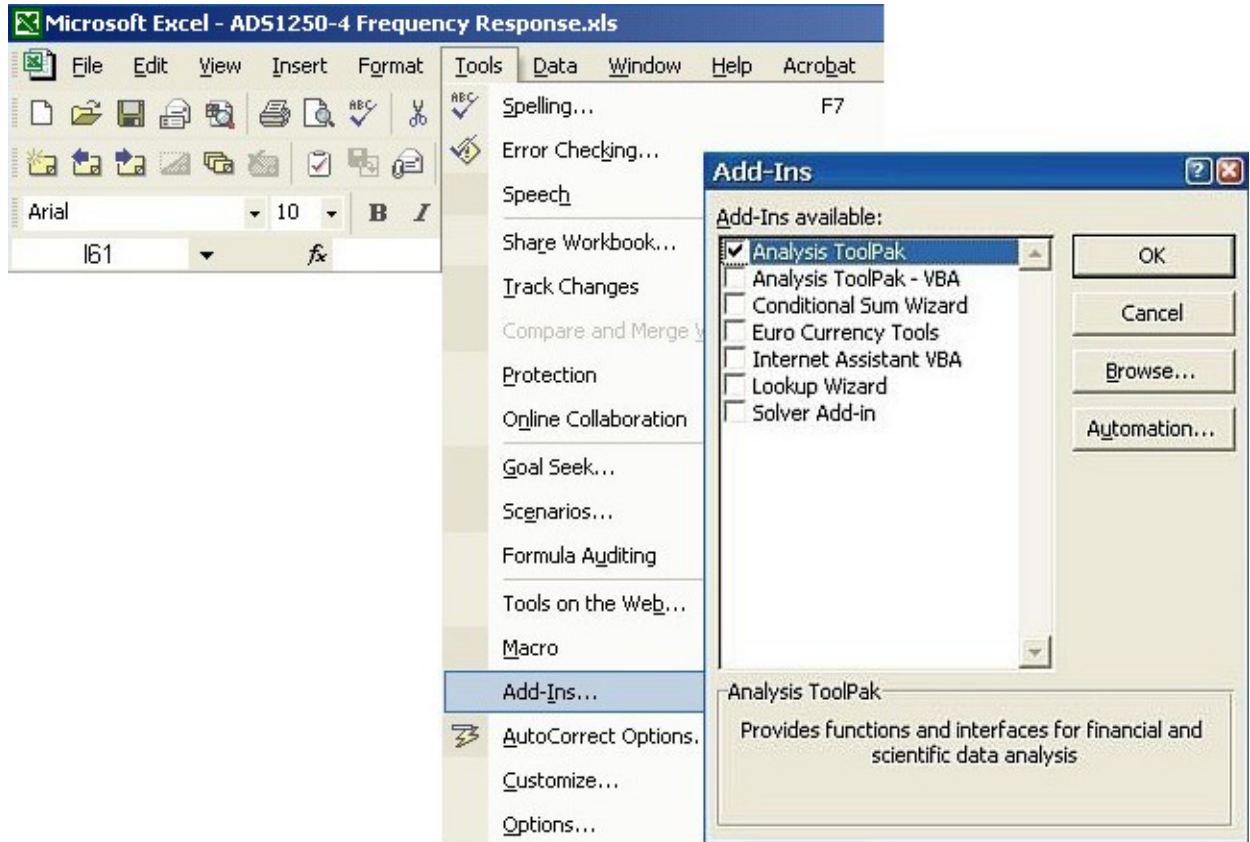


Figure 4. Analysis ToolPak Add-In for Microsoft Excel

With the analysis toolpak installed, simply open the spreadsheet and enter the appropriate CLK frequency in cell C6. You can also enter a specific input frequency of interest in cell C7. Figure 5 shows the spreadsheet. The modulator sampling rate (f_{MOD}), the output data rate (f_{DATA}) and the gain at the frequency specified in cell C7 are calculated in cells C9-C11. The frequency response is plotted in the area to the right. The spreadsheet is protected (without a password) so that only the CLK frequency and Input Frequency cells (C6 and C7) can be edited. If you want to adjust the plot (for example, to change the X- or Y-axis scale), use the standard Excel graphing controls.

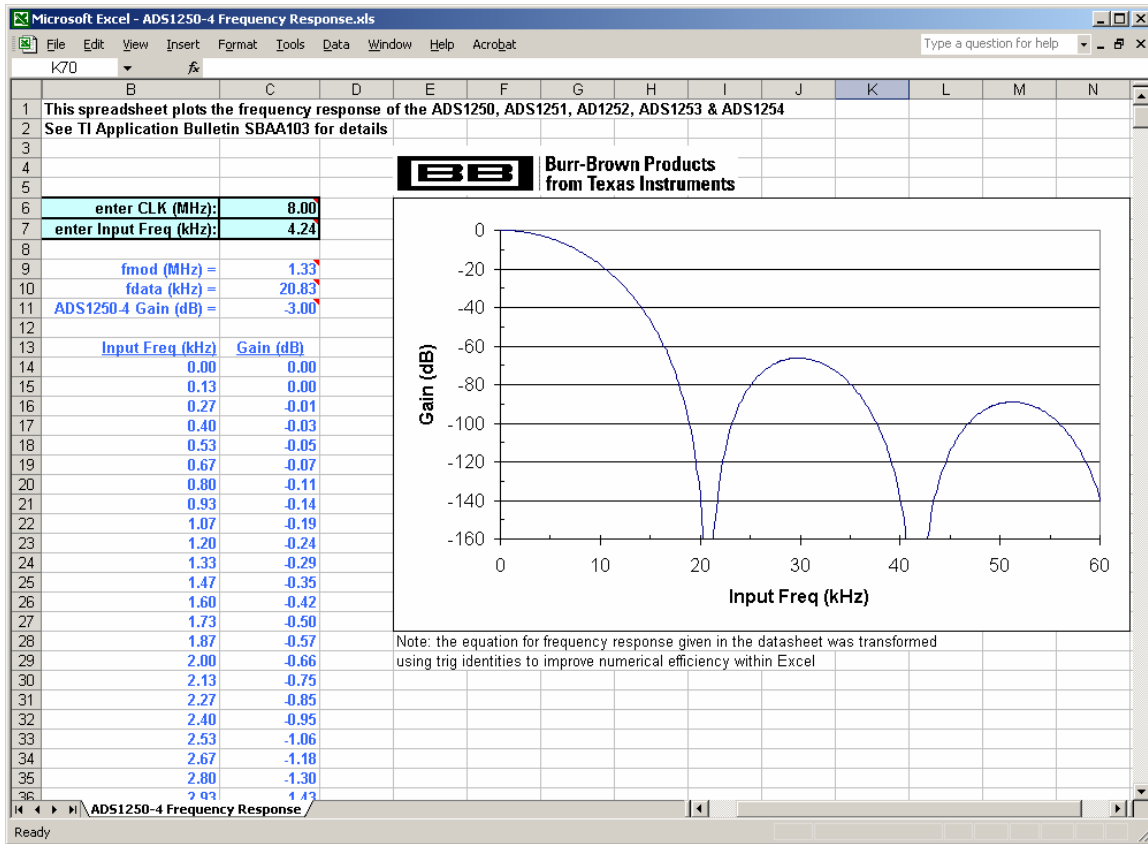


Figure 5. ADS1250–4 Frequency Response Excel Spreadsheet

4 ADS1250–54 Summary

Table I summarizes the maximum CLK frequency and the corresponding modulator sampling, output data rate and -3dB signal bandwidth for each device.

Table 1. Summary of ADS1250–54

Product	Maximum CLK Frequency	Modulator Sampling Rate: f_{MOD}	Data Rate: f_{DATA}	Signal Bandwidth (- 3dB)
ADS1250	9.6MHz	1.6MHz	25.0kHz	5.09kHz
ADS1251	8.0MHz	1.3MHz	20.8kHz	4.24kHz
ADS1252	16.0MHz	2.7MHz	41.7kHz	8.48kHz
ADS1253	8.0MHz	1.3MHz	20.8kHz	4.24kHz
ADS1254	8.0MHz	1.3MHz	20.8kHz	4.24kHz

5 References

ADS1250 product datasheet (SBAS114)

ADS1251 product datasheet (SBAS184)

ADS1252 product datasheet (SBAS127a)

ADS1253 product datasheet (SBAS199)

ADS1254 product datasheet (SBAS213)

ADS125x Frequency Response.xls (Microsoft Excel file)



ADS125x Frequency
Response.xls

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