Introduction to Frequency Domain

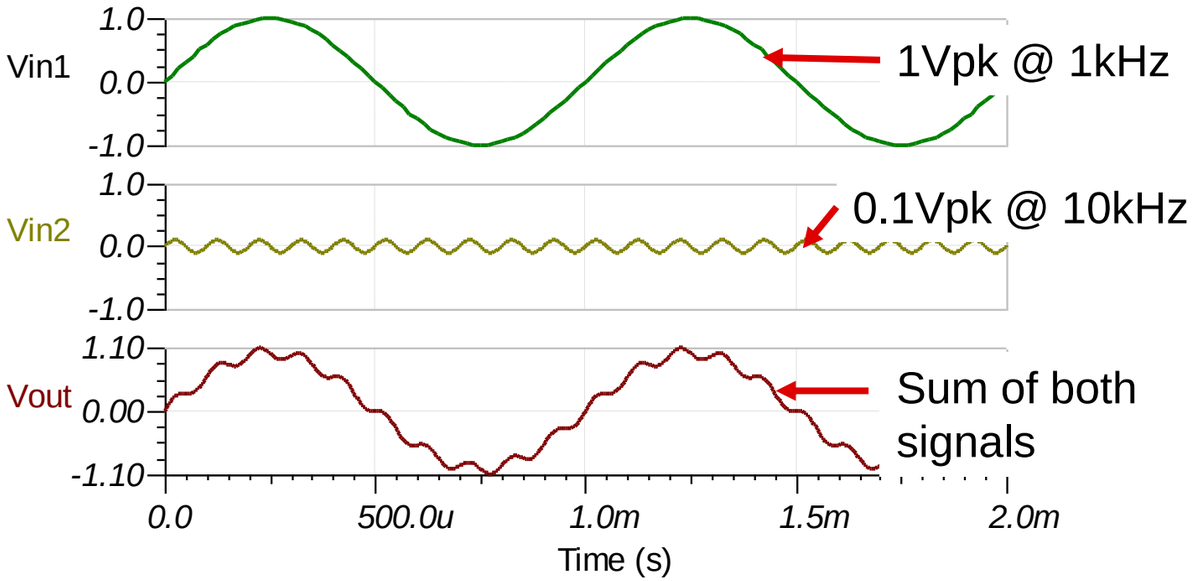
TIPL 4301

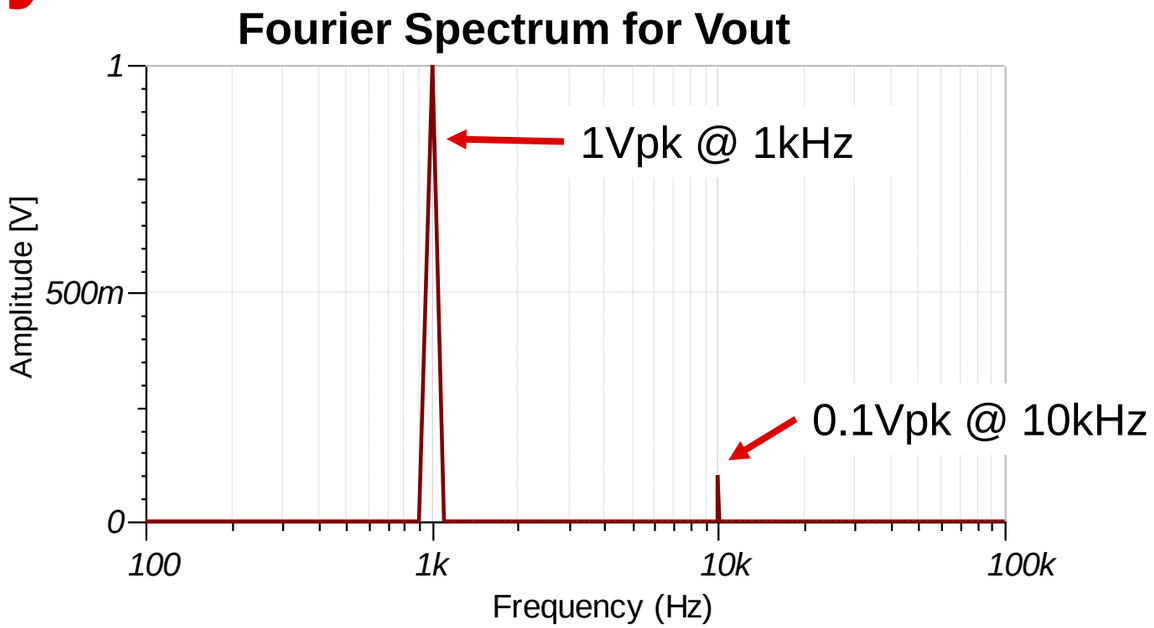
TI Precision Labs – ADCs

Created by Art Kay, Luis Chioye

Presented by Peggy Liska

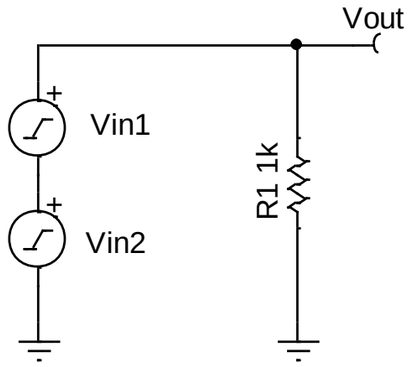
Time Domain vs. Frequency Domain



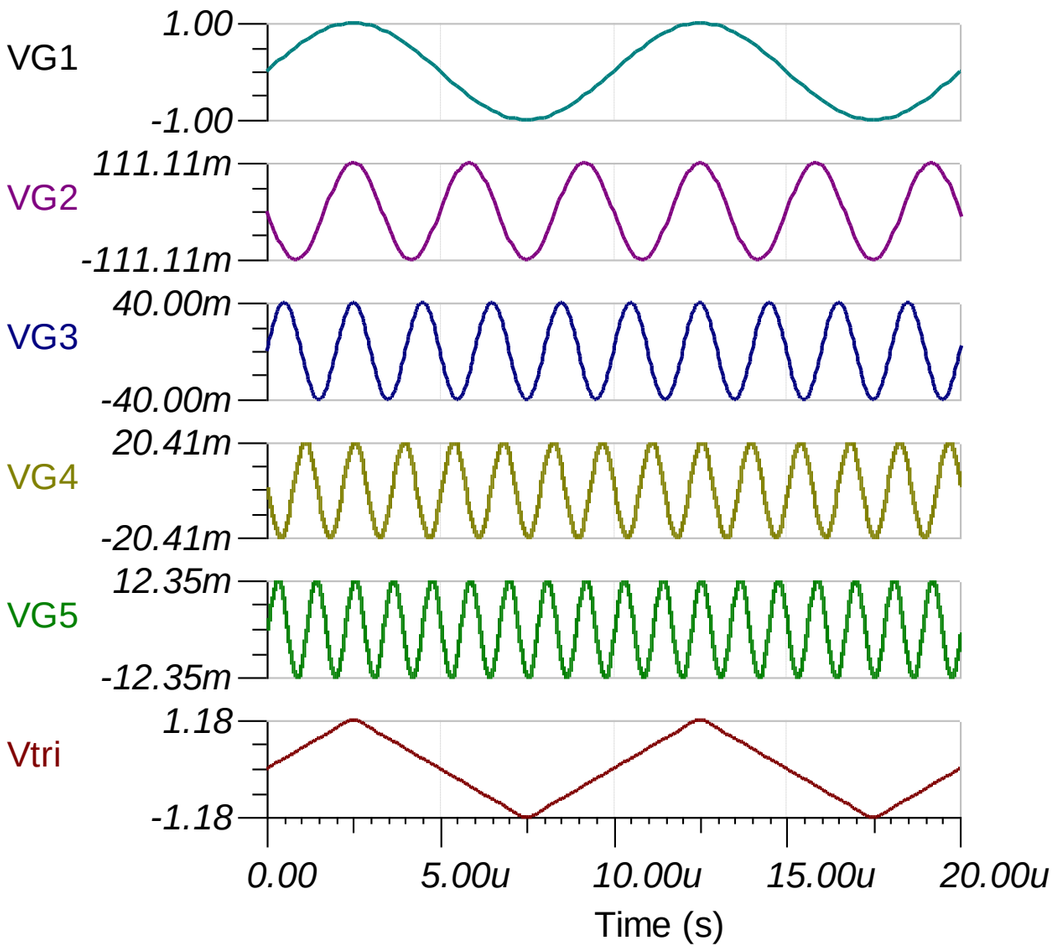


Time Domain

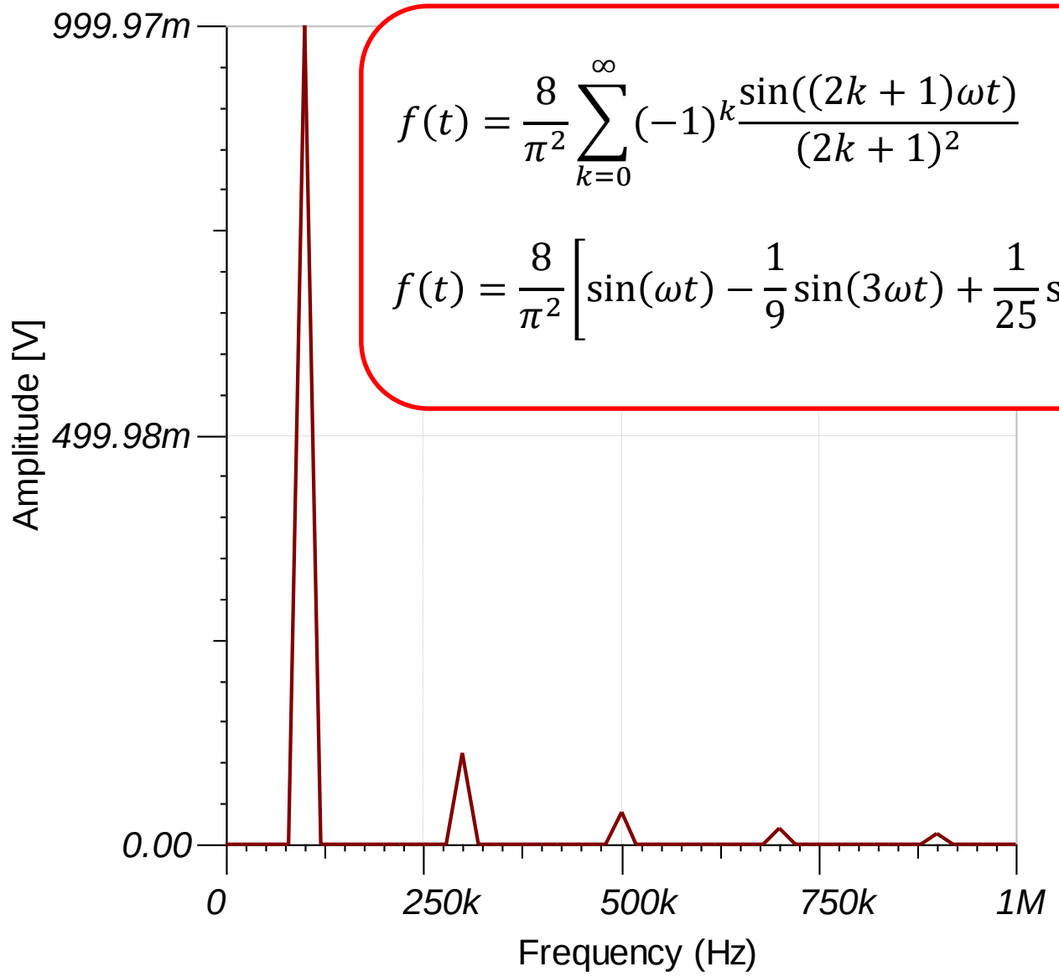
Frequency Domain



Infinite Series for a Triangle Wave



Time Domain

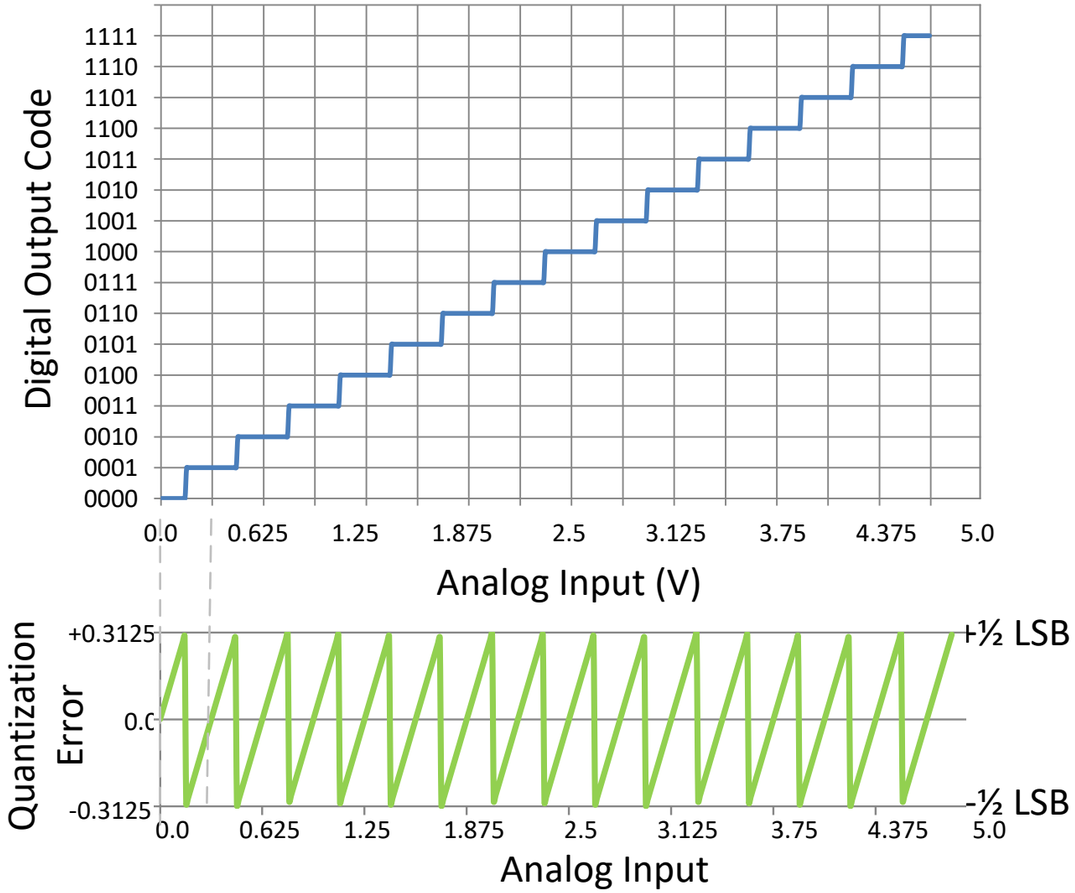


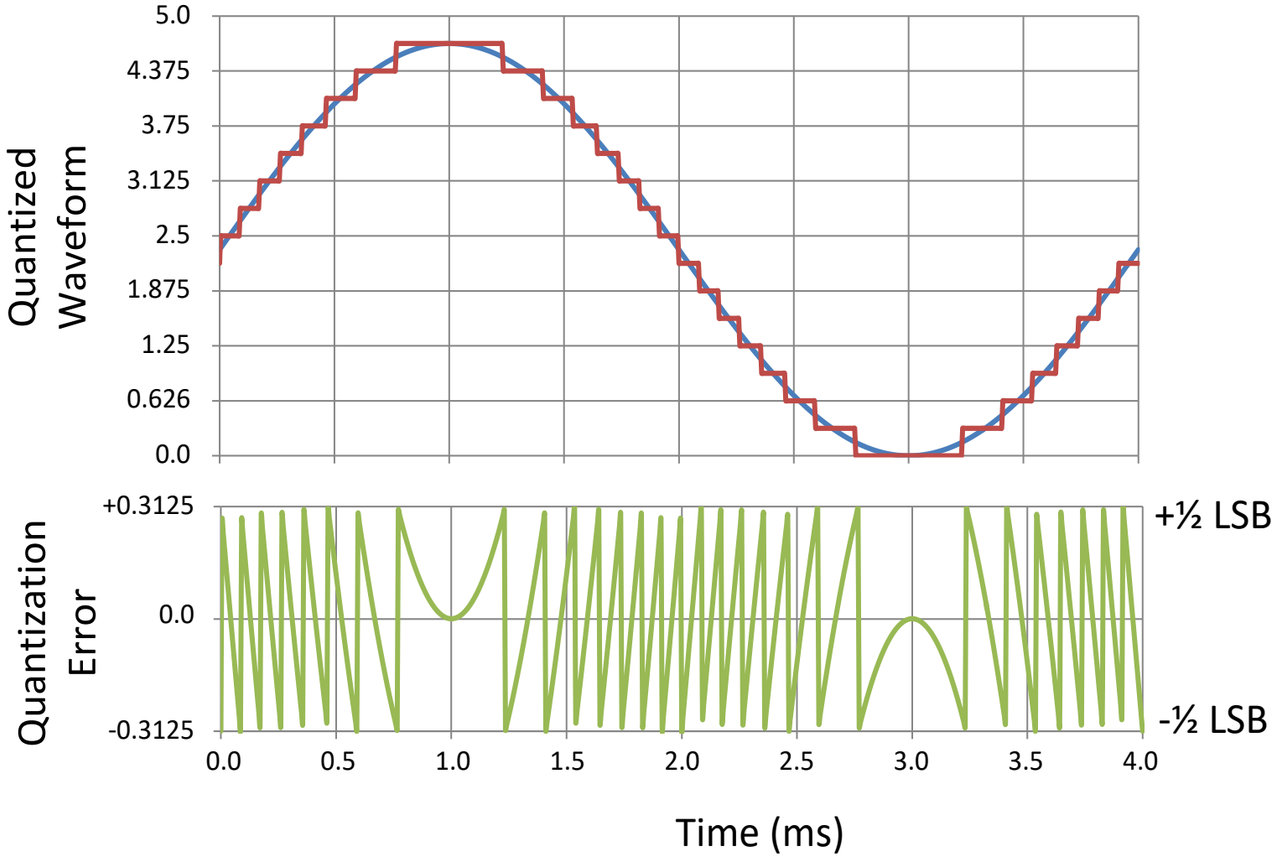
$$f(t) = \frac{8}{\pi^2}\sum_{k=0}^{\infty}(-1)^k \frac{\sin((2k+1)\omega t)}{(2k+1)^2}$$

$$f(t) = \frac{8}{\pi^2}\left[\sin(\omega t) - \frac{1}{9}\sin(3\omega t) + \frac{1}{25}\sin(5\omega t) - \cdots\right]$$

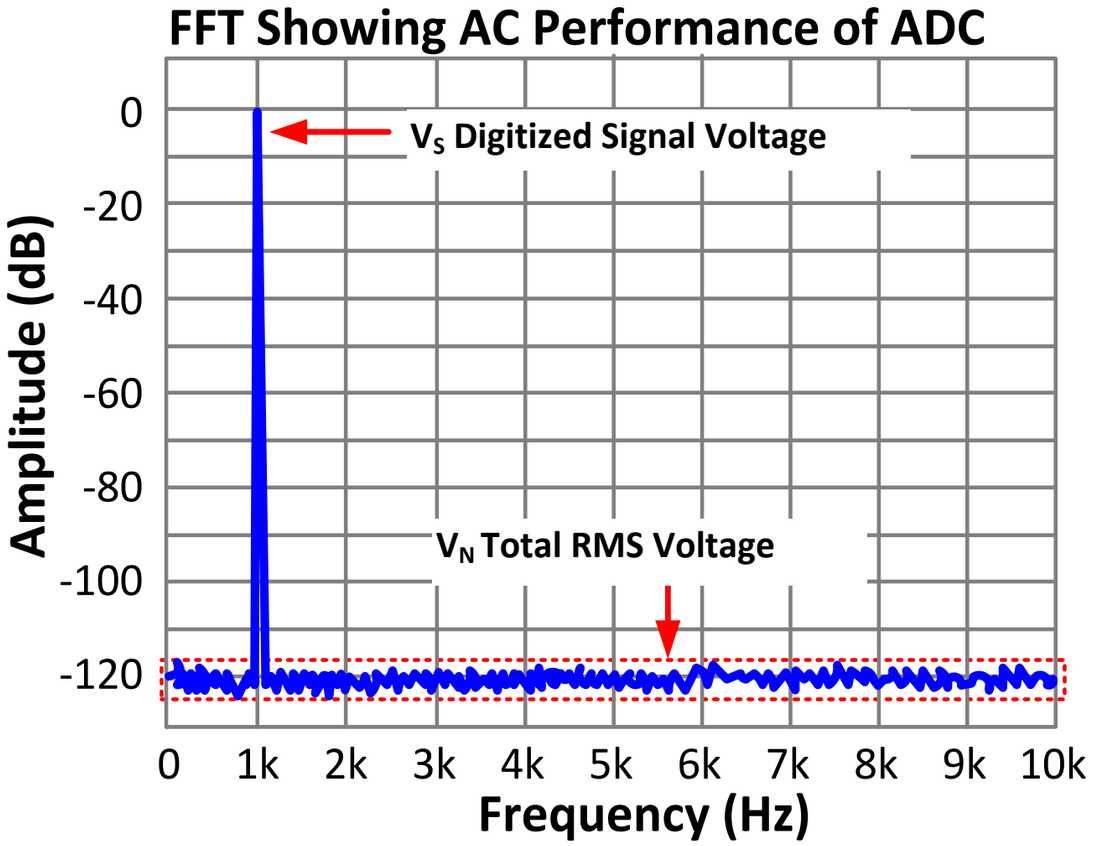
Frequency Domain

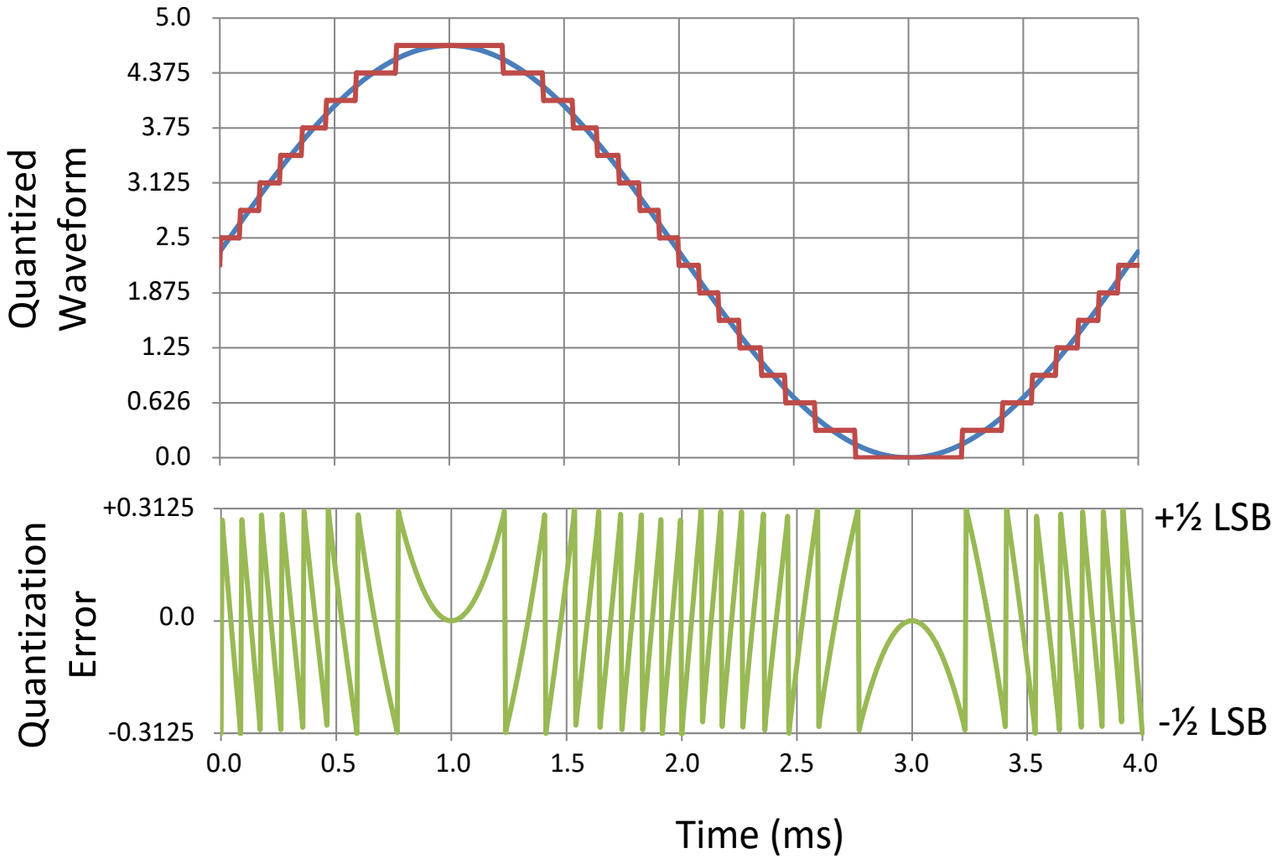
Dynamic Characteristics



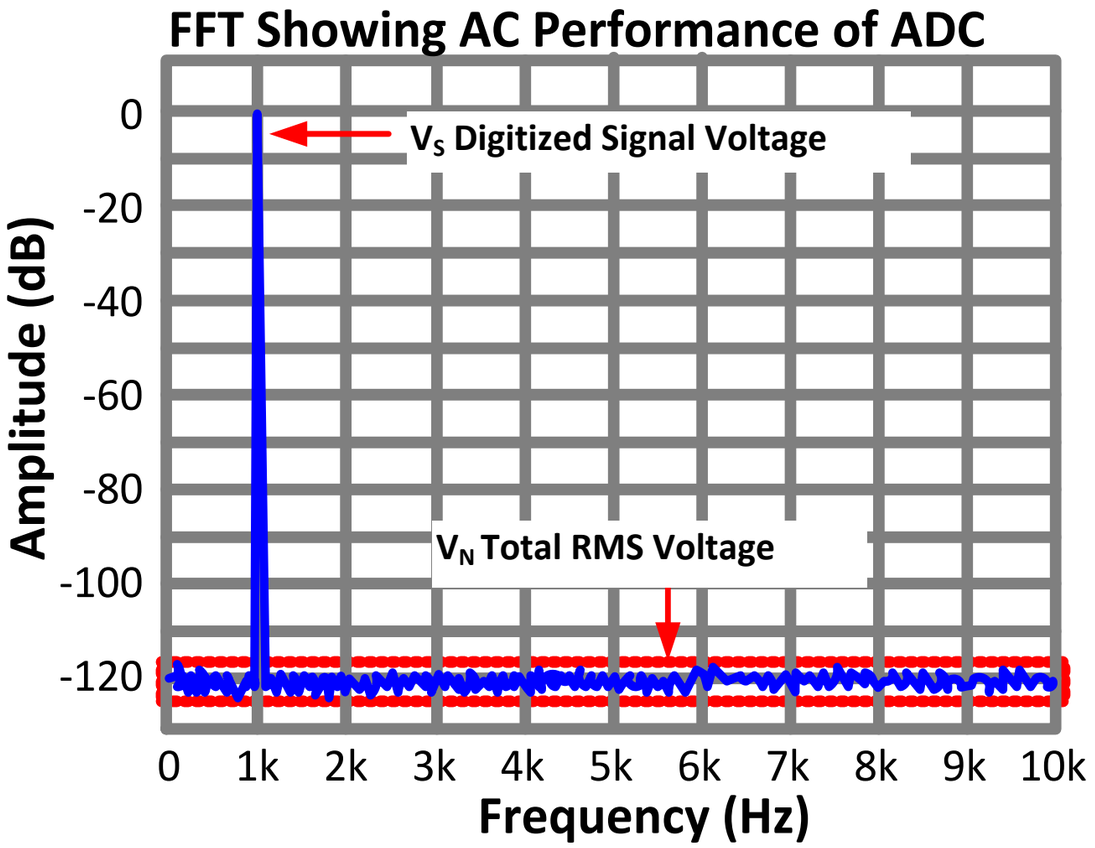


Signal to Noise Ratio (SNR)





Signal to Noise Ratio (SNR)



Measured Ratio:

$$SNR(V/V) = \frac{V_S}{V_N}$$

Measured dB:

$$SNR(dB) = 20 \cdot log\left(\frac{V_S}{V_N}\right)$$

Ideal ADC SNR:

$$SNR(dB) = 6.02 \cdot N + 1.76$$

Where N is the number of bits
e.g. N = 10 for a 10 bit converter

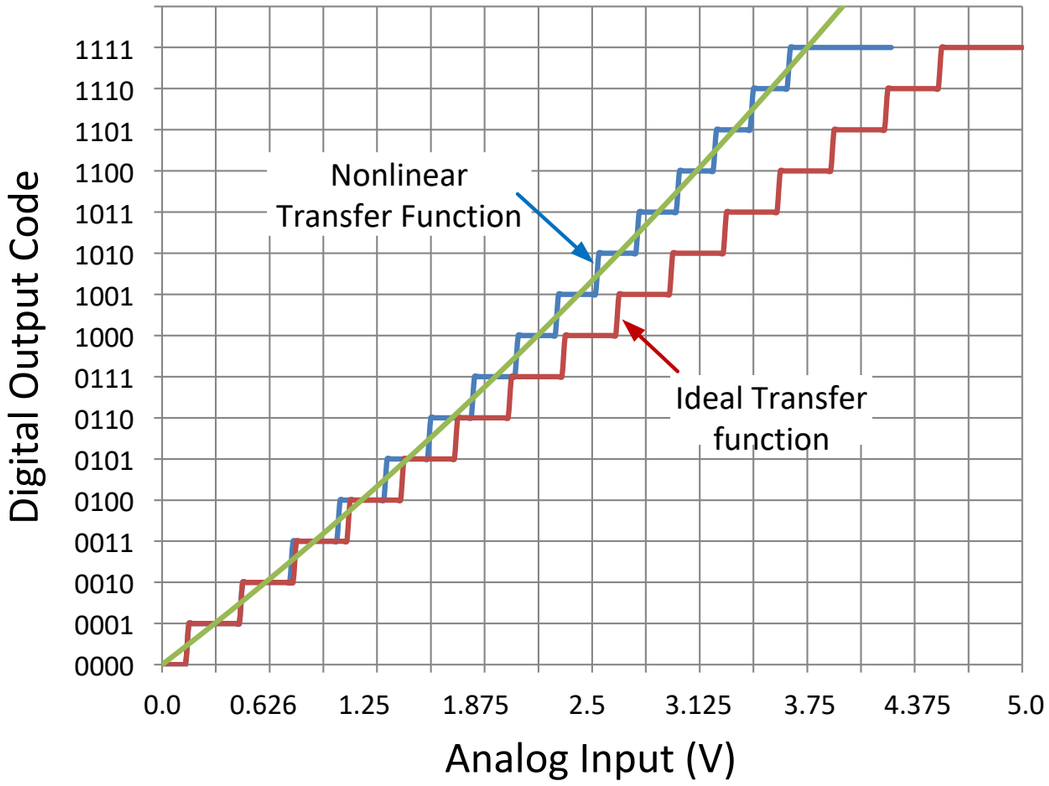
Ideal SNR calculation from Resolution

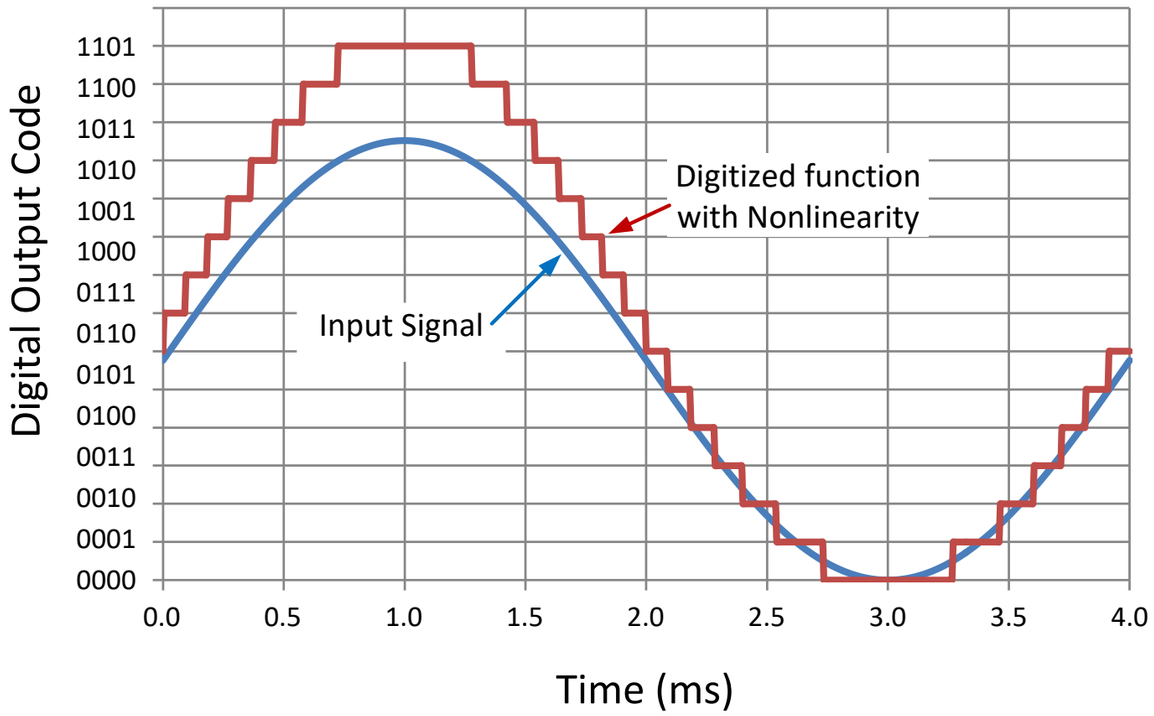
According to the previous equation:

$$SNR = 6.02N + 1.76\ dB$$

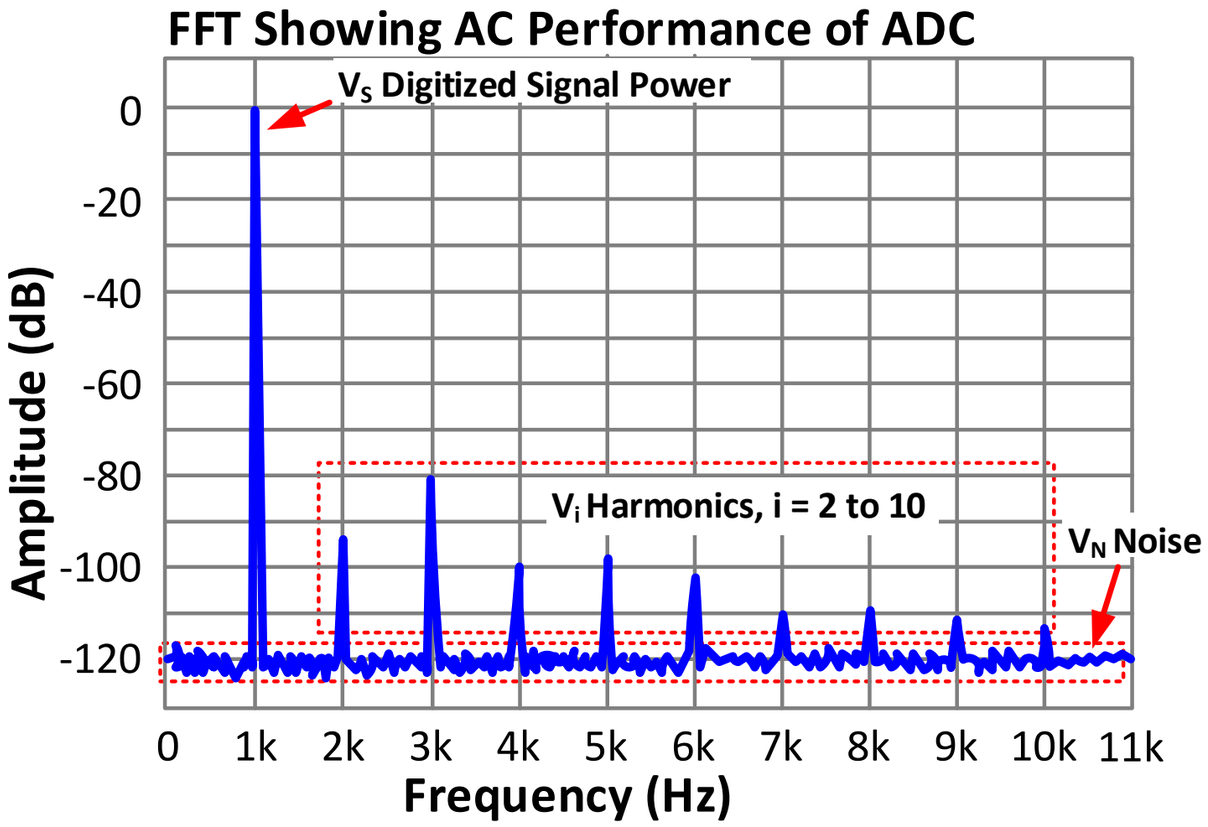
ADC Resolution N (bits)	Levels (2^N)	SNR (dB)
8	256	**49.92**
10	1024	**61.96**
12	4096	**74.00**
14	16384	**86.04**
16	65536	**98.08**
18	262144	**110.12**
20	1048576	**122.16**

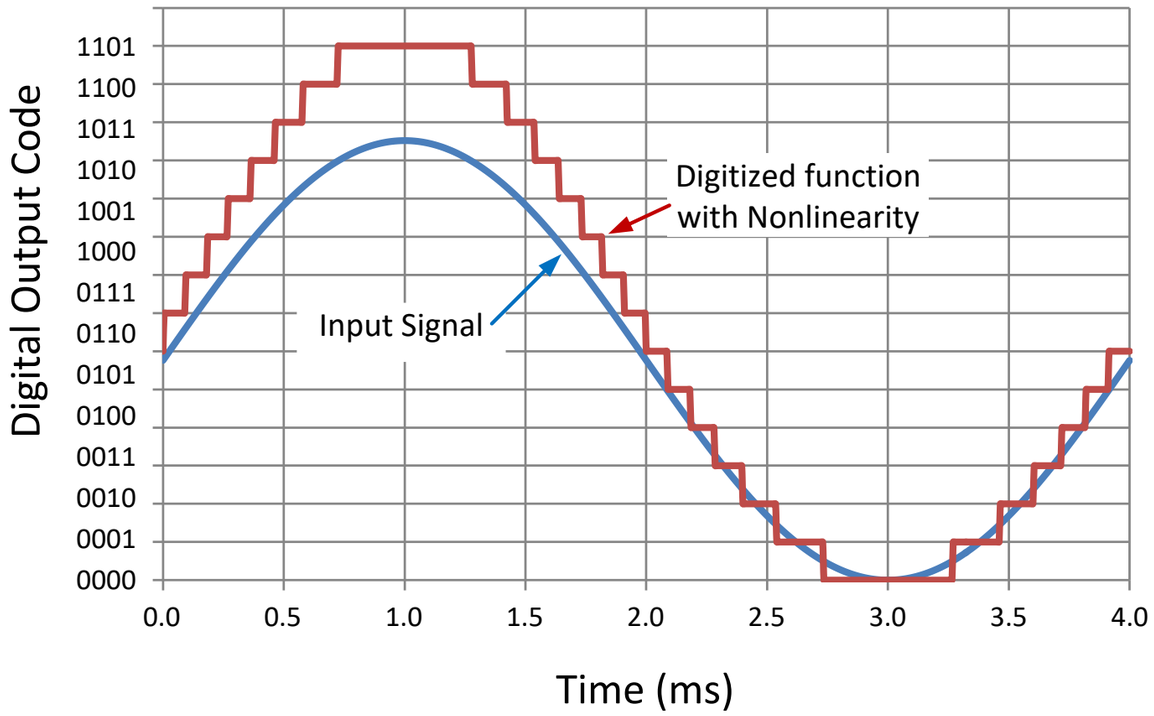
Nonlinearity



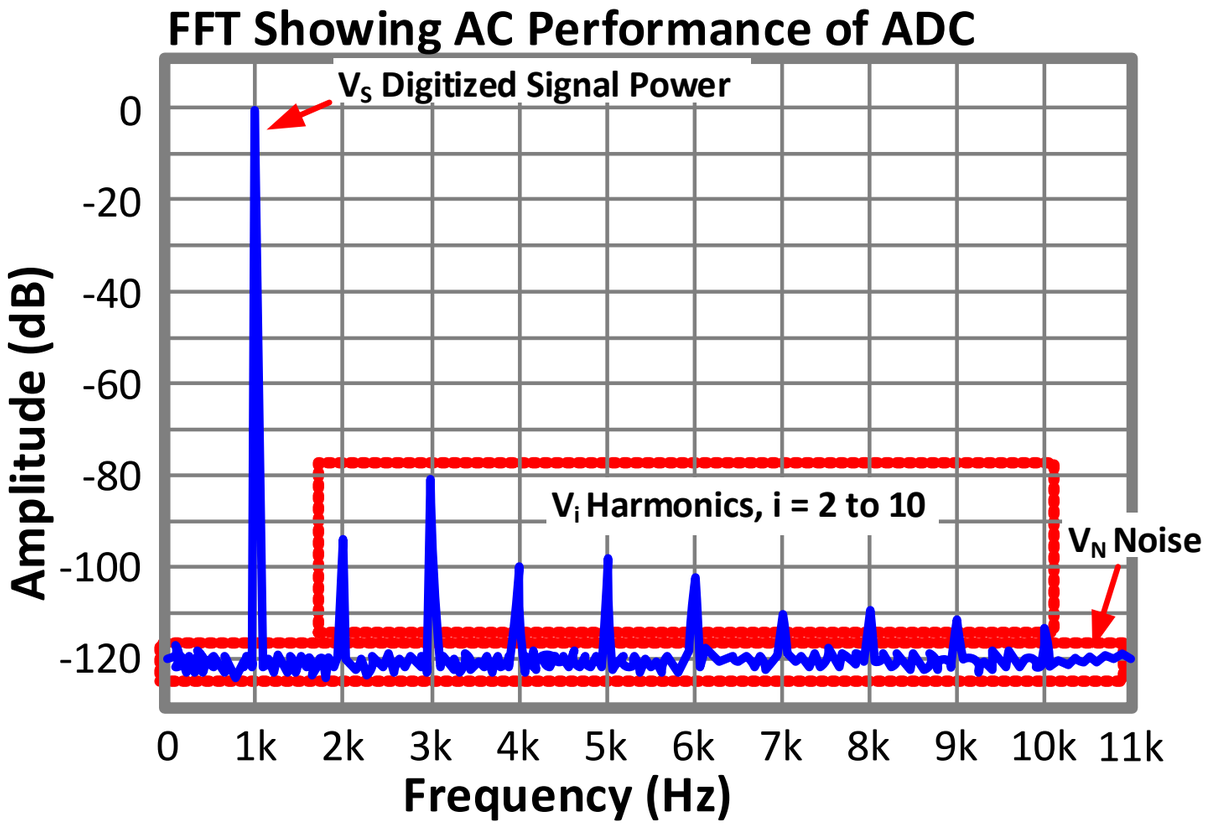


Total Harmonic Distortion (THD), SINAD





Total Harmonic Distortion (THD), THD+N, SINAD



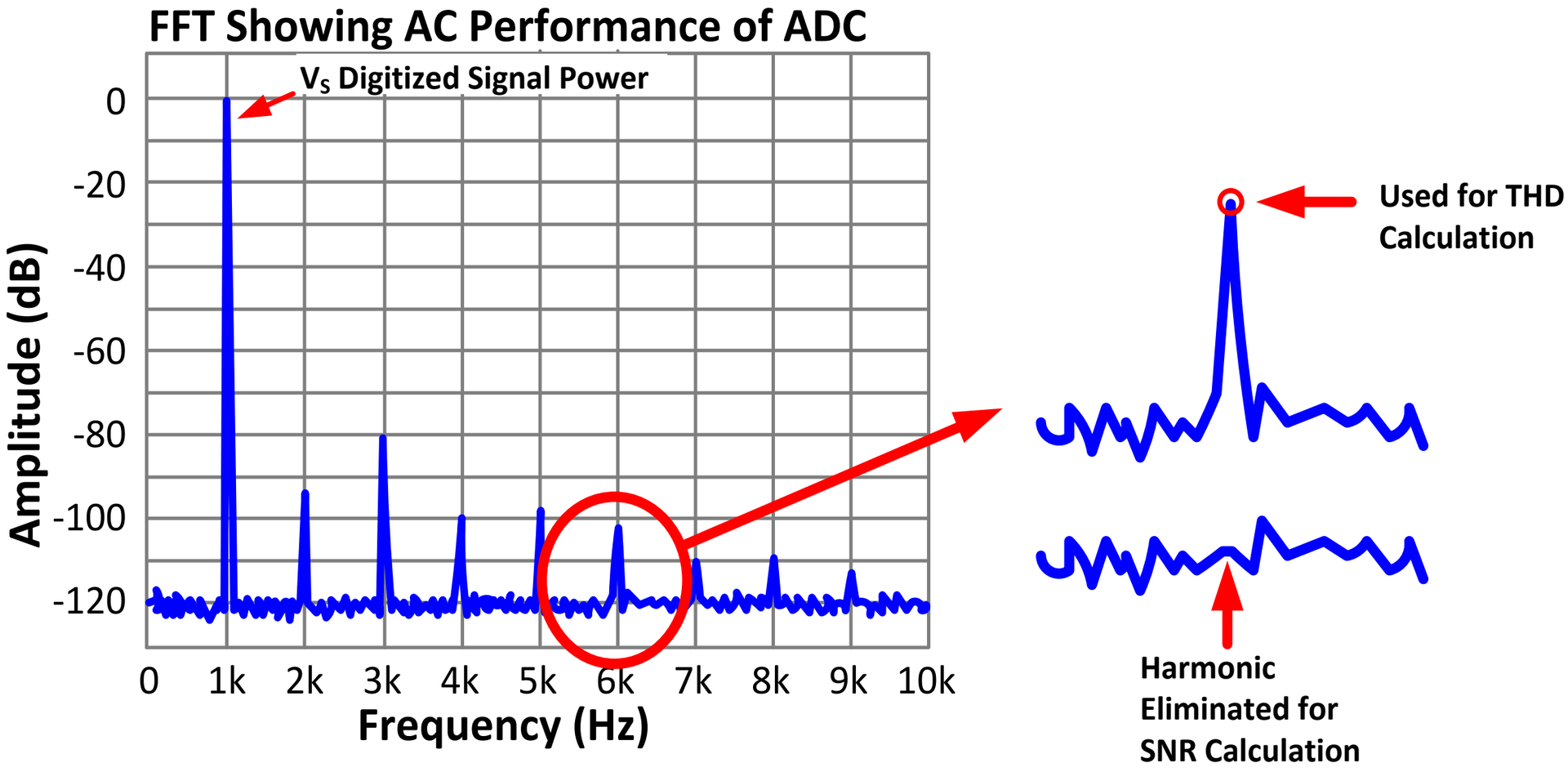
$$THD(\%) = \sqrt{\frac{\sum_{i=2}^{10} {V_i}^2}{{V_S}^2}} \cdot 100$$

$$THD(dB) = 20 \cdot log\left(\sqrt{\frac{\sum_{i=2}^{10} {V_i}^2}{{V_S}^2}}\right)$$

$$(THD + N)(dB) = 20 \cdot log\left(\sqrt{\frac{\sum_{i=2}^{10} {V_i}^2 + {V_N}^2}{{V_S}^2}}\right)$$

$$SINAD(dB) = 20 \cdot log\left(\sqrt{\frac{{V_S}^2}{\sum_{i=2}^{10} {V_i}^2 + {V_N}^2}}\right)$$

Total Harmonic Distortion (THD), THD+N



Thanks for your time!
Please try the quiz.

Quiz: Introduction to Frequency Domain

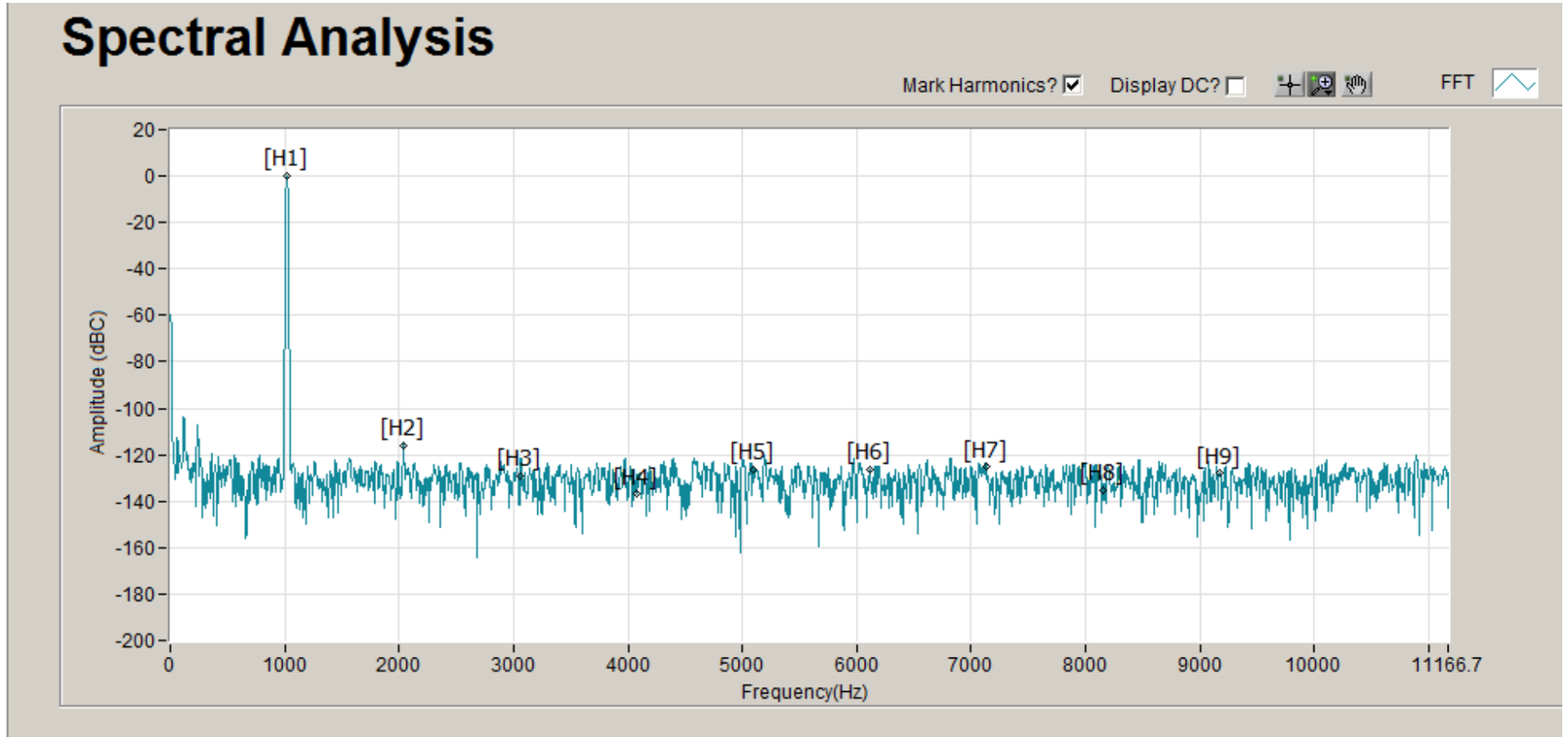
TIPL 4301

TI Precision Labs – ADCs

Created by Art Kay

Quiz: Introduction to Frequency Domain

1. (T/F) The FFT shown below could be the spectrum for a 1kHz square wave.
   a) True
   b) False



Quiz: Introduction to Frequency Domain

2. (T/F) Any periodic waveform can be represented as an infinite series of sinusoidal waveforms.
   a) True
   b) False

3. An ideal 12 bit converter will _____.
   a) Not have any noise
   b) Have quantization noise
   c) Have non-linearity due to quantization

4. Non-linearity is directly related to _____.
   a) Noise
   b) Distortion
   c) SFDR
   d) Numerical limitations of the FFT

Quiz: Introduction to Frequency Domain

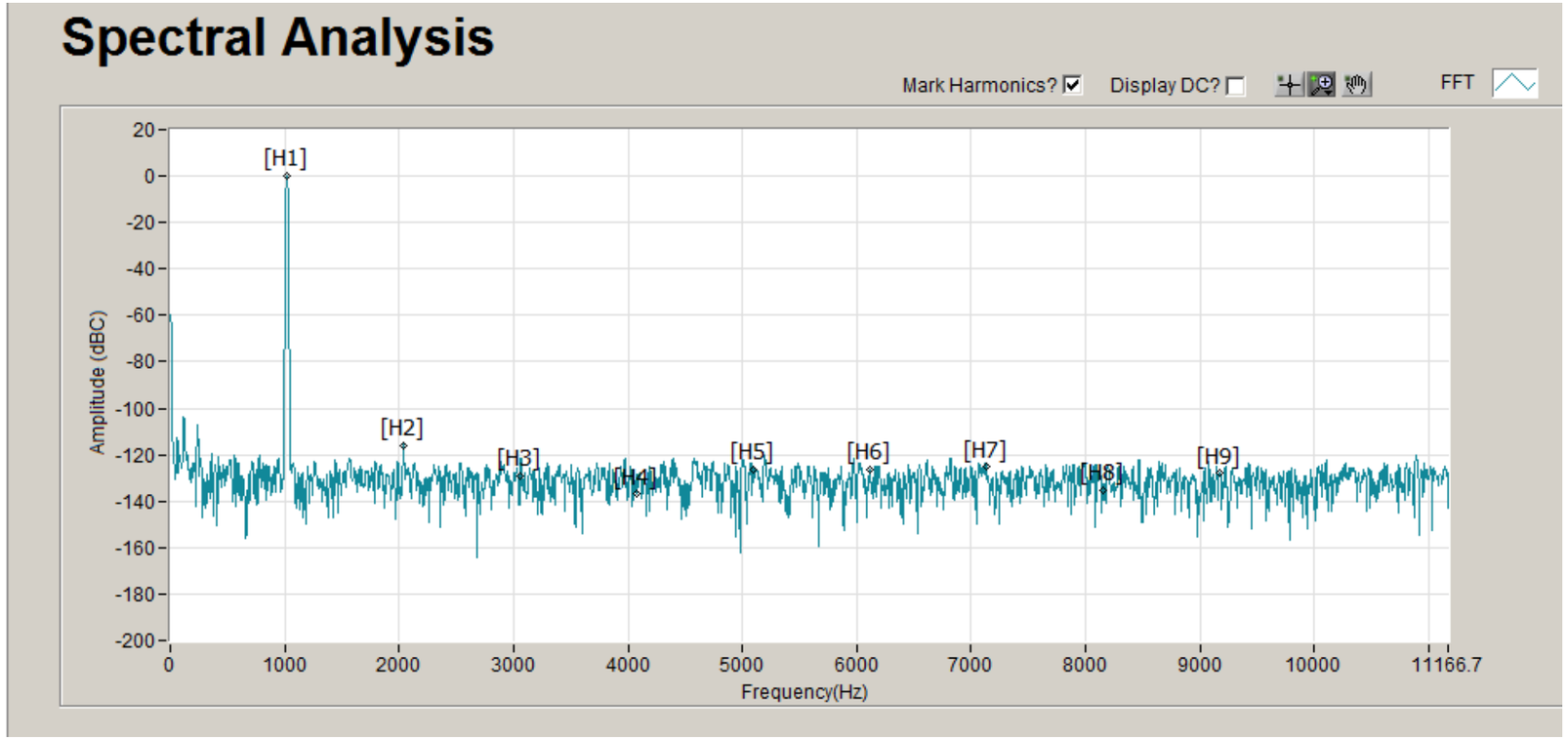
5. What is the SNR for an ideal 16 bit converter?
   a) 61.96dB
   b) 74dB
   c) 98.08dB
   d) 110.12dB

6. For the IEEE ADC test standard, how many harmonics are used in the THD calculation?
   a) 5, from 1 to 5
   b) 9 harmonics, from 2 through 10
   c) This depends on the level of distortion. For high distortion signals more harmonics are used.
   d) The IEEE spec doesn't specify number of harmonics.

Solutions

Quiz: Introduction to Frequency Domain

1. (T/F) The FFT shown below could be the spectrum for a 1kHz square wave.
   a) True
   b) False



Quiz: Introduction to Frequency Domain

2. (T/F) Any periodic waveform can be represented as an infinite series of sinusoidal waveforms.
   a) **True**
   b) False

3. An ideal 12 bit converter will _____.
   a) Not have any noise
   b) **Have quantization noise**
   c) Have non-linearity due to quantization

4. Non-linearity is directly related to _____.
   a) Noise
   b) **Distortion**
   c) SFDR
   d) Numerical limitations of the FFT

Quiz: Introduction to Frequency Domain

5. What is the SNR for an ideal 16 bit converter?
   a) 61.96dB
   b) 74dB
   c) 98.08dB
   d) 110.12dB

6. For the IEEE ADC test standard, how many harmonics are used in the THD calculation?
   a) 5, from 1 to 5
   b) 9 harmonics, from 2 through 10
   c) This depends on the level of distortion. For high distortion signals more harmonics are used.
   d) The IEEE spec doesn't specify number of harmonics.