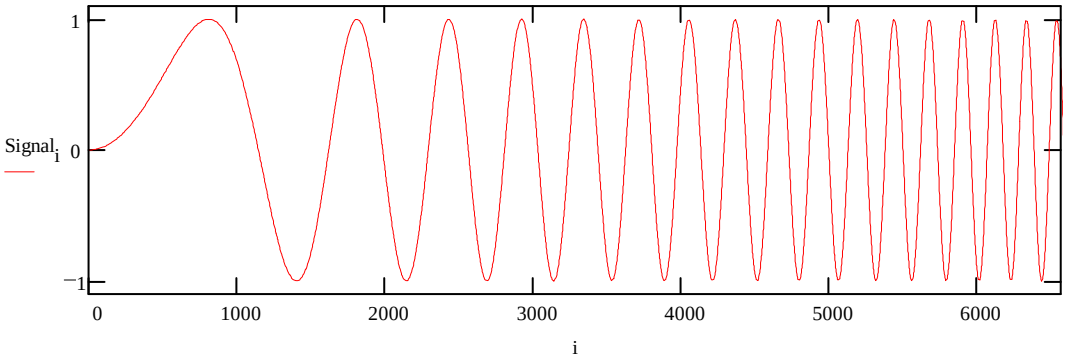
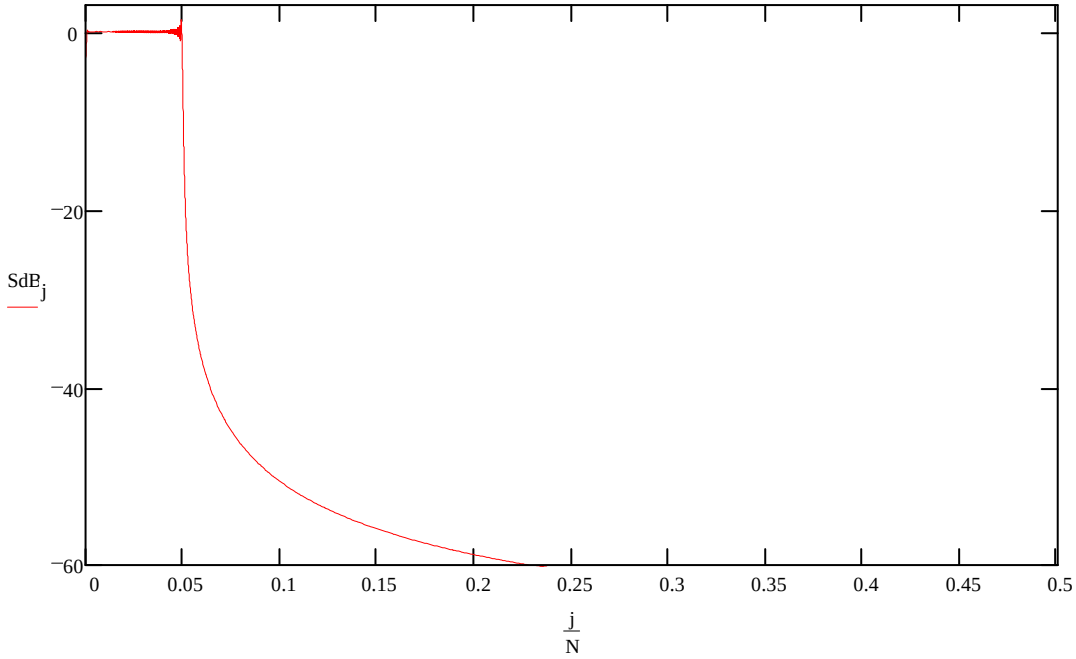
Digitization of analog signals

Alan Bloom 10/29/2006

$N := 65536 \quad i := 0 .. N - 1 \quad f_i := \frac{i}{40 \cdot N} \quad Signal_i := \sin\left(2 \cdot \pi \cdot f_i \cdot i\right)$ **Swept sine wave, f = 0 - F_S / 20**



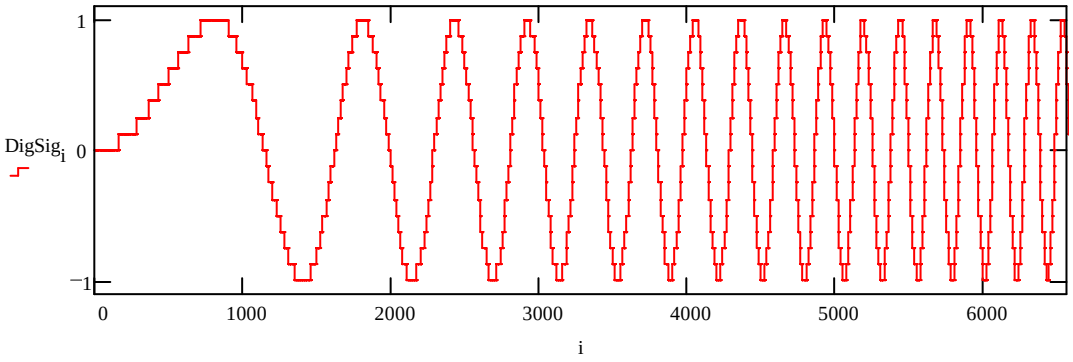
$Spectrum := FFT(Signal) \quad j := 0 .. \frac{N}{2} \quad SdB_j := 20 \cdot \log\left(\frac{|Spectrum_j|}{|Spectrum_{50}|}\right)$ **Analog signal:**



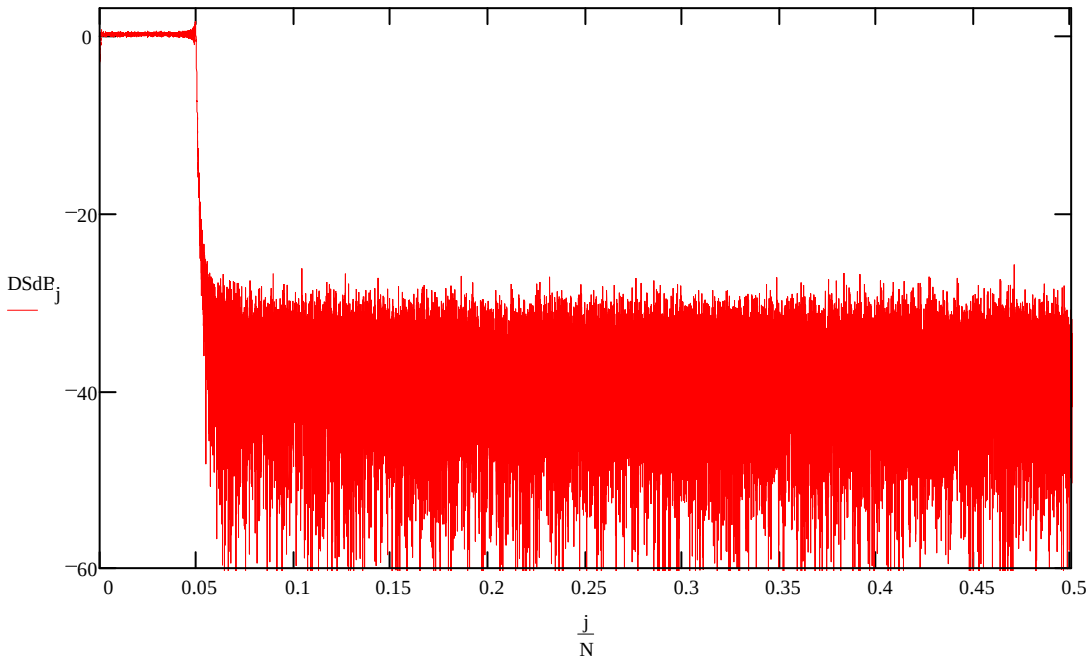
Digitization in amplitude

$$DigSig_i := \frac{floor(Signal_i \cdot 8 + 0.5)}{8}$$

4-bit digitization: 16 levels



$$DigSpectrum := FFT(DigSig) \qquad DSdB_j := 20 \cdot \log\left(\frac{|DigSpectrum_j|}{|DigSpectrum_{50}|}\right)$$



6 dB per bit?

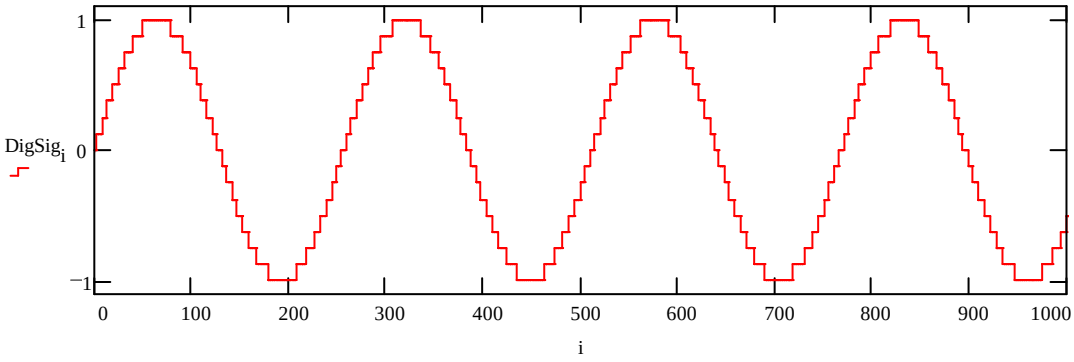
$$Sig := \sqrt{\sum_{k=0}^{floor(0.05 \cdot N)} \left(|DigSpectrum_k|\right)^2} \qquad Noise := \sqrt{\sum_{k=floor(0.05 \cdot N)}^{0.5 \cdot N} \left(|DigSpectrum_k|\right)^2}$$

$$20 \cdot \log\left(\frac{Sig}{Noise}\right) = 23.765$$

Check: 6 * 4 bits = 24 dB

Digitization in amplitude, constant-frequency signal:

$$Freq := \frac{1}{256} \qquad Signal_i := \sin(2\cdot\pi\cdot Freq\cdot i) \qquad DigSig_i := \frac{\mathrm{floor}\left(Signal_i\cdot 8 + 0.5\right)}{8}$$



$$DigSpectrum := FFT(DigSig) \qquad DSdB_j := 20\cdot\log\left(\frac{\left|DigSpectrum_j\right|}{\left|DigSpectrum_{Freq\cdot N}\right|} + 0.000001\right)$$