ECE 615- Lecture 5

Note Title 9/17/2013

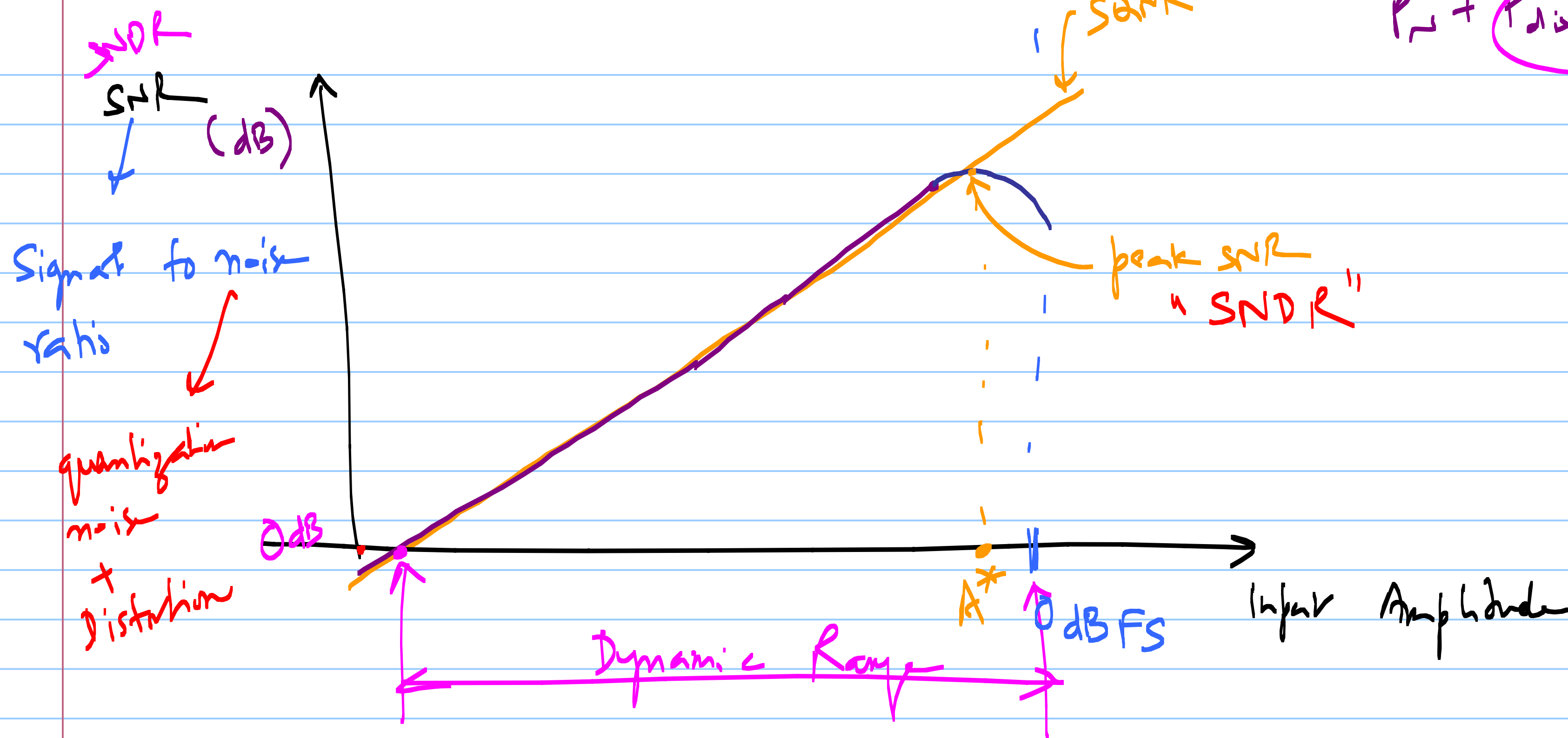
$$P_n = \frac{\Delta^2}{12}$$

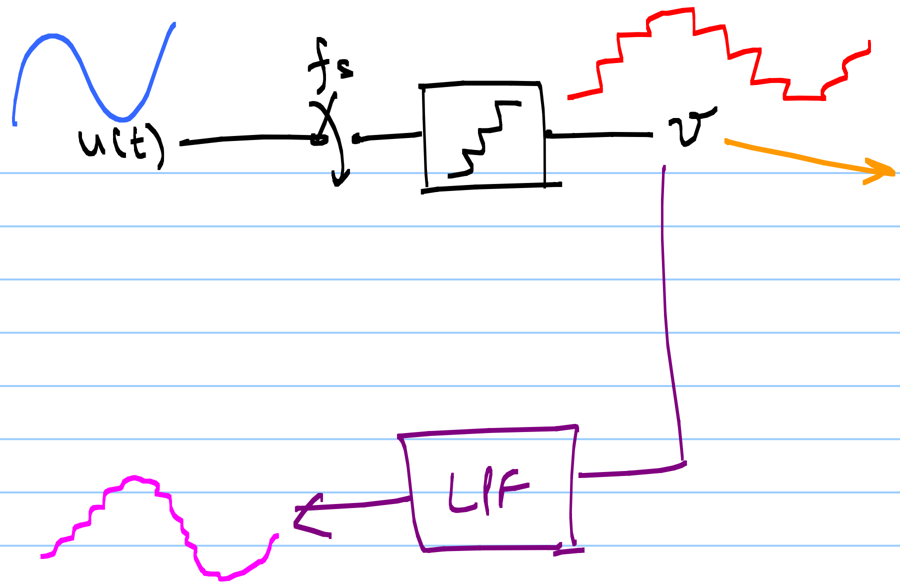
* FS sine input →

$$SQNR = 6.02N + 1.76 \text{ dB}$$

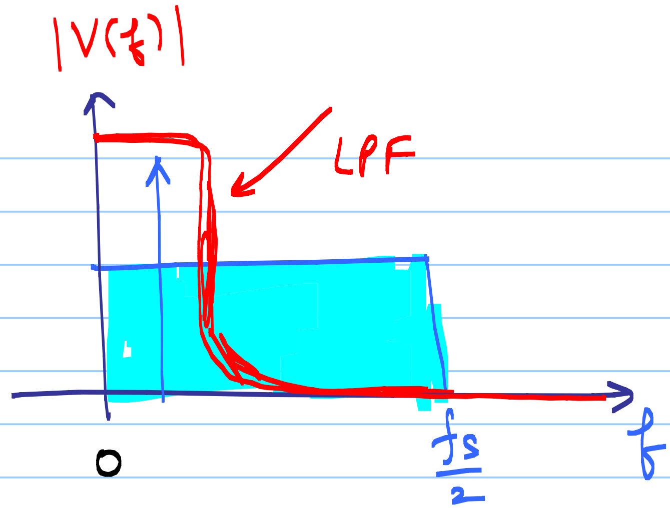
↑ effective # of bits

$$SNR = \frac{P_s}{P_n + P_{distortion}}$$



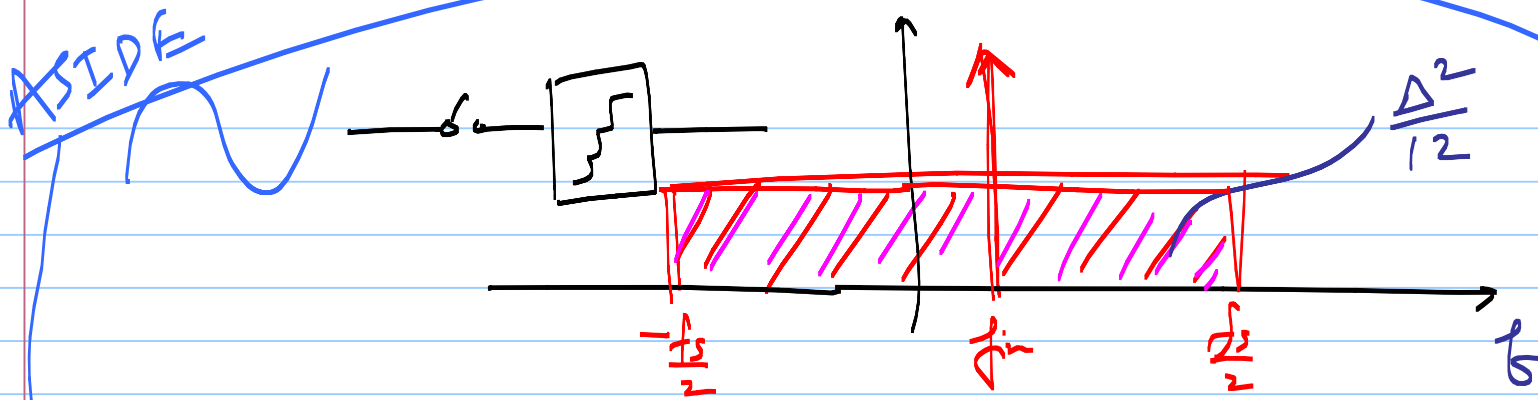


f_s
u(t)
v
LPF

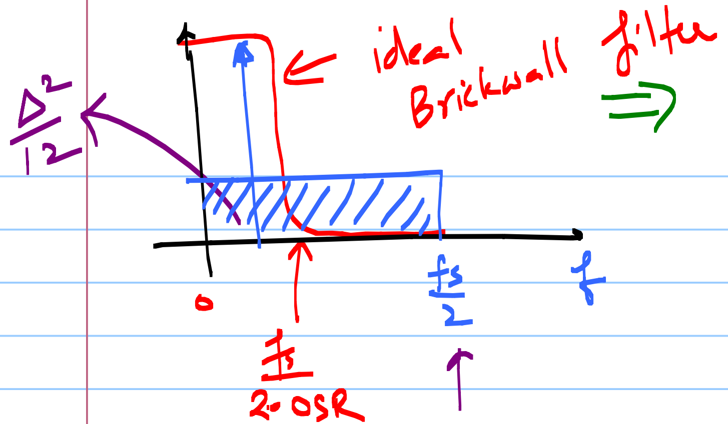


|V(f)|
LPF
0
$\frac{f_s}{2}$
f

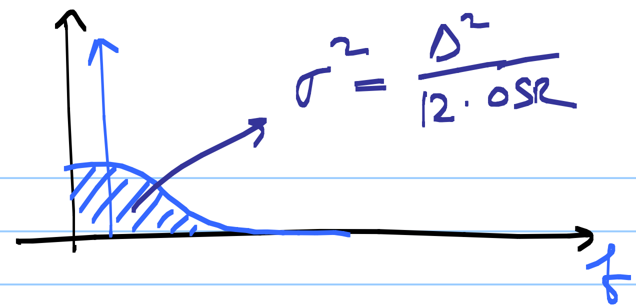
ASIDE



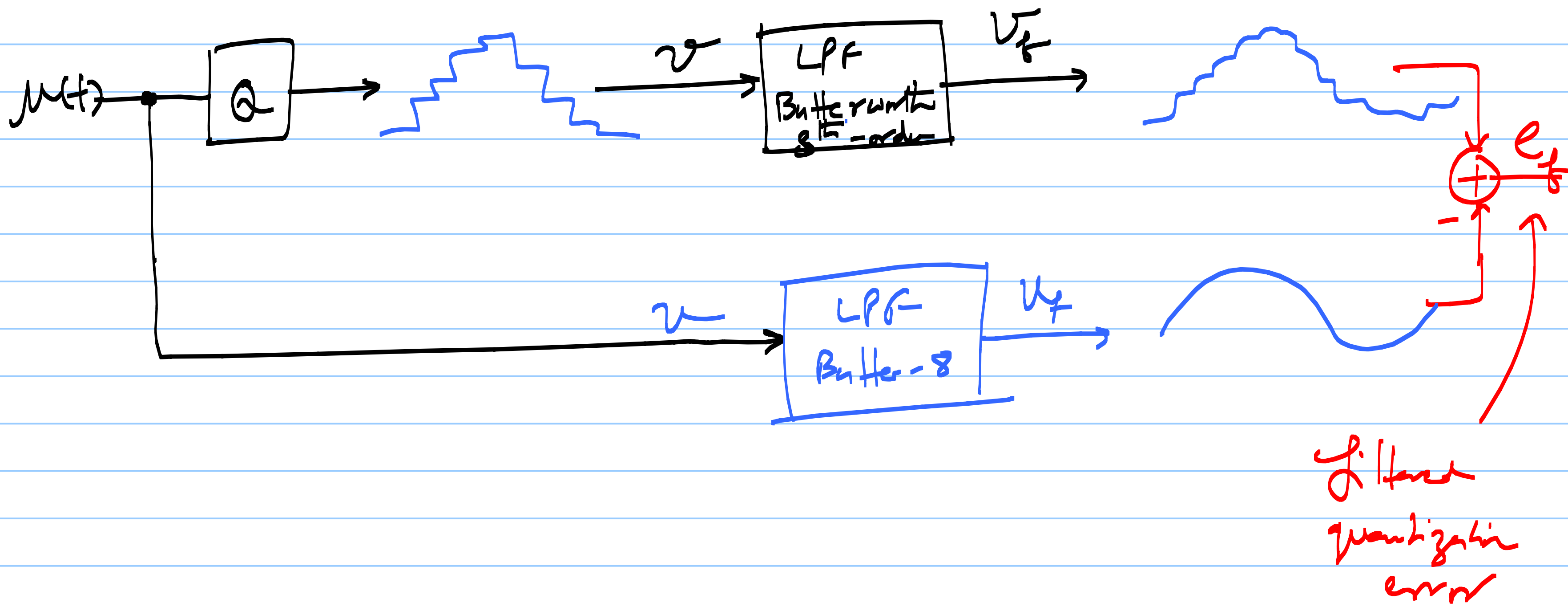
$$OSR = \frac{f_s/2}{BW}$$



$\frac{\Delta^2}{12}$
ideal Brickwall filter
0
$\frac{f_s}{2 \cdot OSR}$
$\frac{f_s}{2}$
f

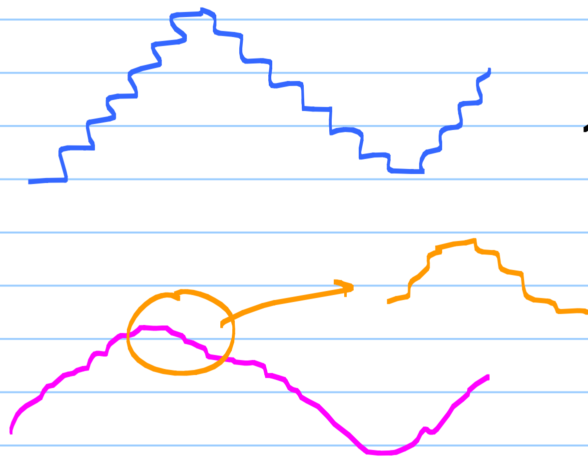


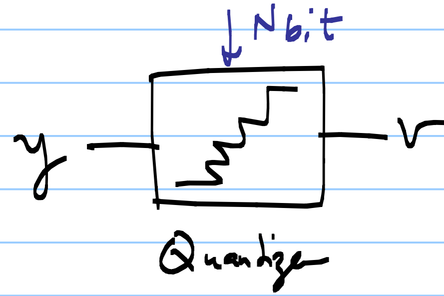
$\sigma^2 = \frac{\Delta^2}{12 \cdot OSR}$
f

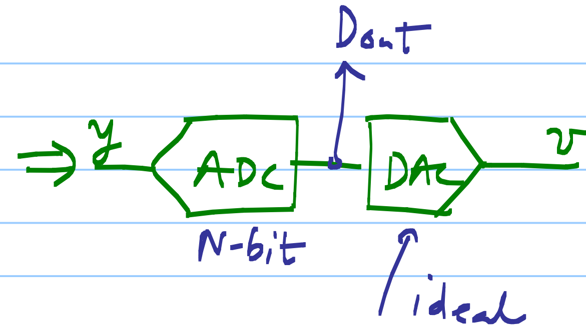


m(t)
Q
v
LPF
Butterworth
8th-order
v_f
v
LPF
Butter-8
v_f
+
-
e_f
filtered
quantization
error

In Matlab



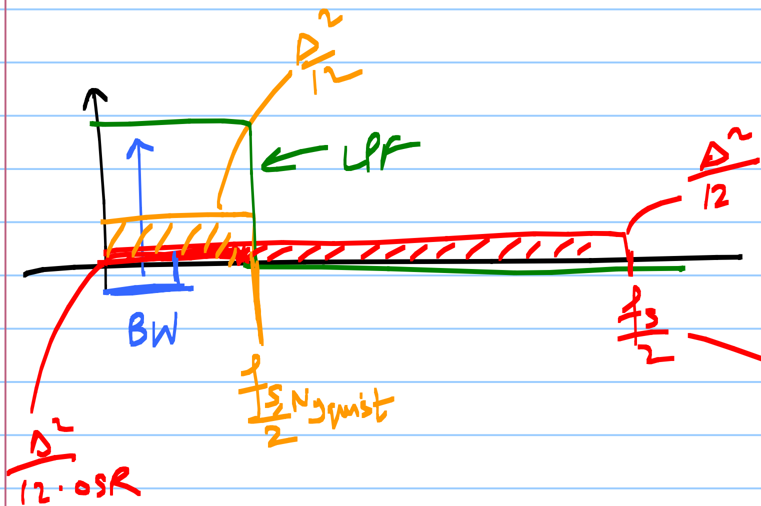




Signal Bandwidth = $\frac{f_s}{2 \cdot OSR}$

Nyquist-rate BW = $\frac{f_s}{2}$

OSR = 1

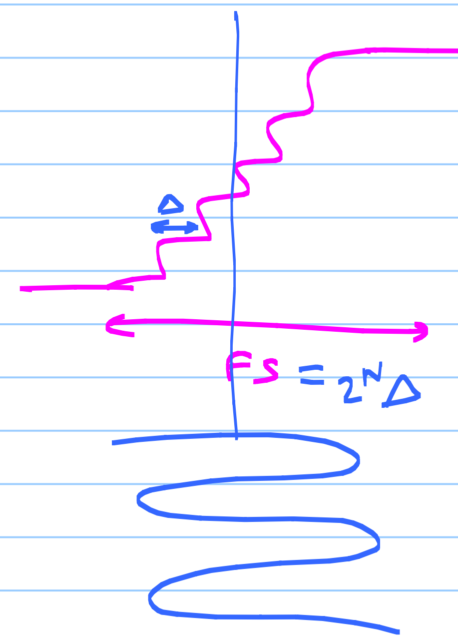


$f_s = OSR \times f_{s,nyquist}$ → 2^m

* Trading sampling-rate with effective resolution of the quantizer

Oversampling $\Rightarrow$ SQNR has increased by a factor close to the OSR

$$SQNR = 10\log_{10}\left(\frac{A^2/2}{\frac{\Delta^2}{12\cdot OSR}}\right) = 10\log_{10}\left(\frac{\frac{(2^{N-1}\Delta)^2}{2}}{\frac{\Delta^2}{12\cdot OSR}}\right)$$



$$= \underbrace{6.02N + 1.76}_{\text{Same as before}} + \boxed{10\log_{10} OSR}$$

Same as before

Extra term

$N_{inc} =$

$$10 \log_{10}(OSR) \Rightarrow 0.5 \log_2(OSR)$$

* for every doubling in OSR ⇒ 0.5 bit increase in resolution

$$N_{eff} = \frac{SQNR - 1.76}{6.02}$$

$$\Delta N_{eff} = \frac{\Delta SQNR}{6.02} = \frac{10 \log_{10}(OSR)}{6.02} = \frac{10 \times \log_2(OSR)}{6.02 \times \log_2 10}$$

$$= \frac{10 \times \log_{10} 2 \cdot \log_2(OSR)}{6.02}$$

($\log_{10} 2 \rightarrow 0.301$)

$$\boxed{\Delta N_{eff} = 0.5 \times \log_2(OSR)}$$

$\frac{1}{2}$ bit extra per doubling in OSR

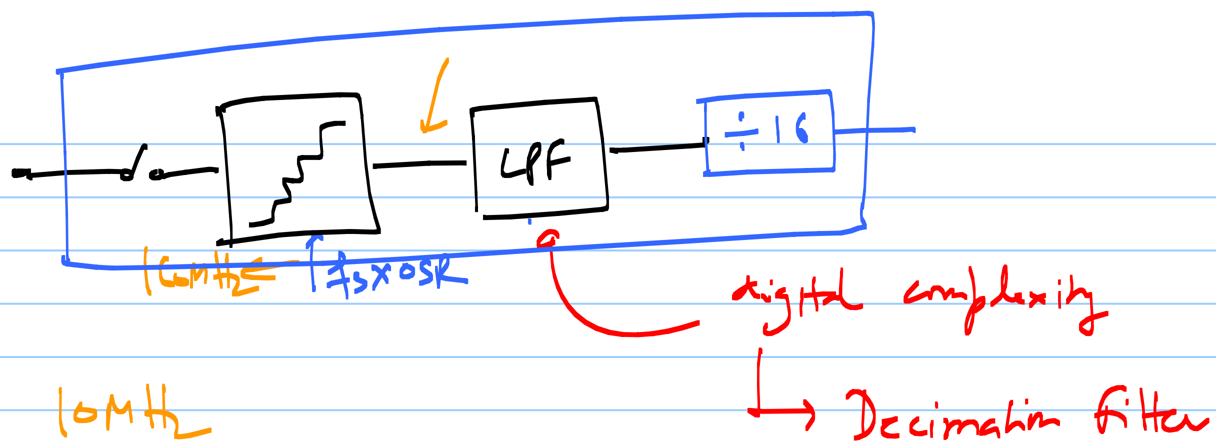
OSR = 256

N_0 = 4 bit quantizer

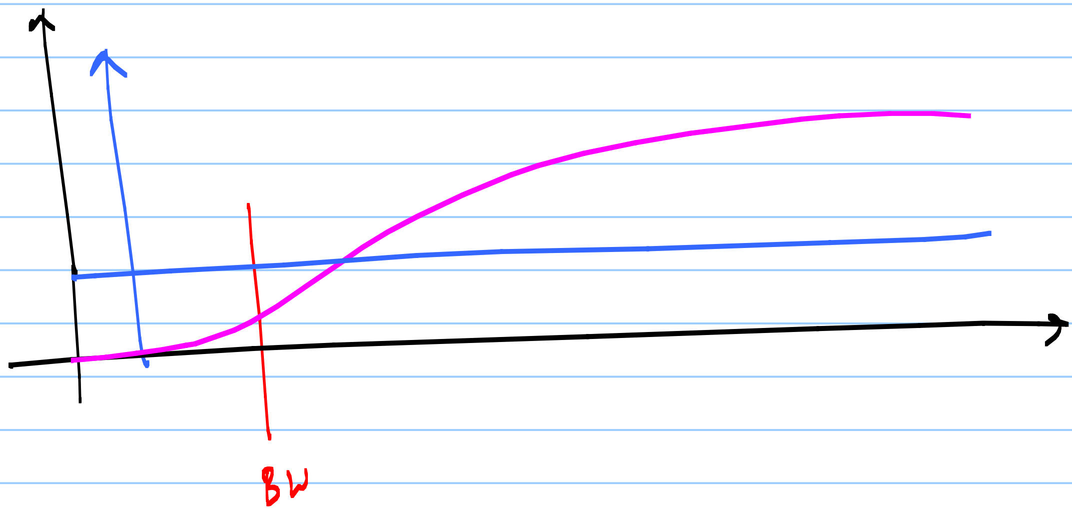
$$N_{eff} = N_0 + \frac{1}{2} \cdot \log_2(OSR)$$

$$= 4 + \frac{1}{2} \log_2(256)$$

$$= 8 \text{ bits}$$



10MHz


BW