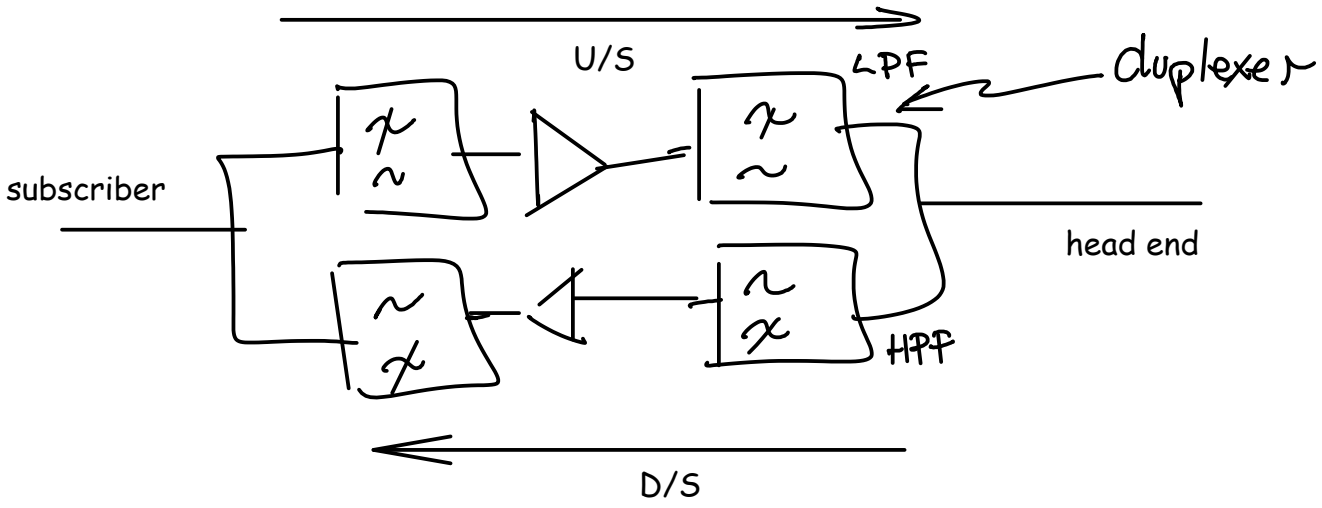
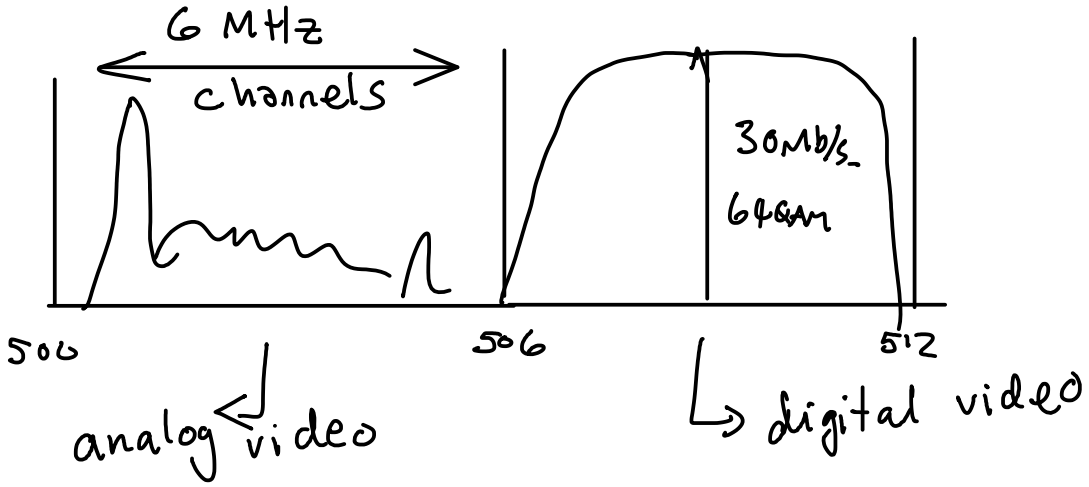
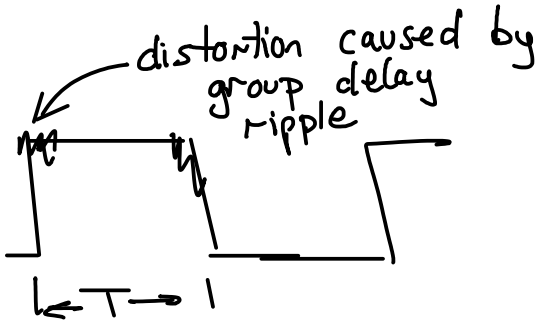
Lecture 5







Exercise 1: What is the Shannon capacity of this channel? What is the maximum symbol rate if the symbol period is to be more than 10 times the group delay ripple? What is the maximum area (in km^2) that can be serviced by one DOCSIS CMTS assuming a velocity factor of 0.66?

$$C = B \log_2\left(1 + \frac{S}{N}\right)$$

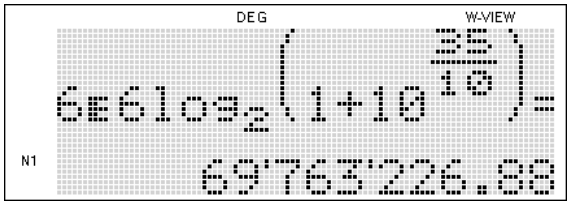
$$= 6 \times 10^6 \log_2\left(1 + 10^{\frac{35}{10}}\right)$$

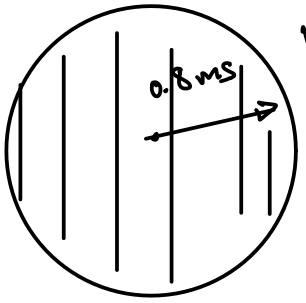
$$\approx 70 \text{ Mb/s}$$

$$T > 10 \times 75\text{ns}$$

$$\geq 750\text{ns}$$

$$f_{symbol} \leq 1.3 \text{ MHz}.$$





$v = 2 \times 10^8$ m/s

$v = \frac{d}{t}$

$d = v \cdot t$

$= 2 \times 10^8 \cdot 0.8 \times 10^{-3}$

$= 1.6 \times 10^5$

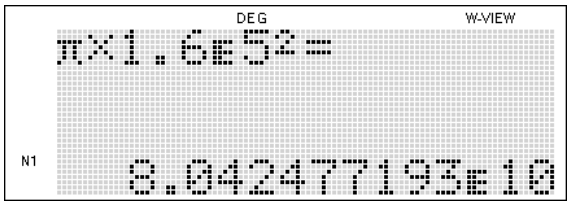
$= 160$ km

$A = \pi r^2$

$= 3.14 \left(1.6 \times 10^5\right)^2$

$= 8 \times 10^{10}$ m^2

8×10^4 km^2 80,000 km^2.



Exercise 2: Again compute the Shannon capacity based on the CNR and the maximum symbol rate based on a period equal to 10 times the group delay ripple.

assume 1 MHz upstream bandwidth channel

25 dB CNR = $10^{2.5} \approx 320$

$C = B \cdot \log_2\left(1 + \frac{S}{N}\right) = 10^6 \cdot 8 \approx 8$ Mb/s

for 200 ns delay spread,

use symbol period $\approx 10\times$ delay spread $\approx 2\,\mu s$

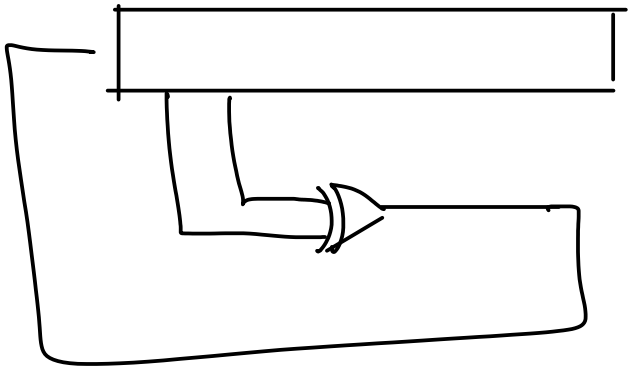
$\therefore$ symbol rate $\approx$ 500 kHz

$f_s = \frac{1}{T_s}$

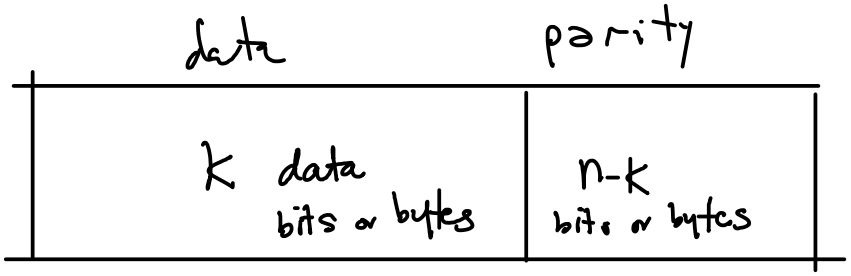
GF = Galois Field

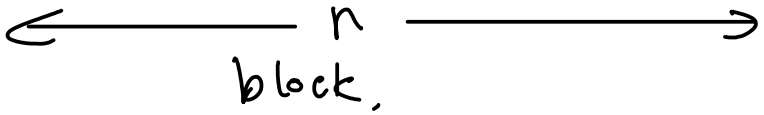
GF(2) : 0, 1

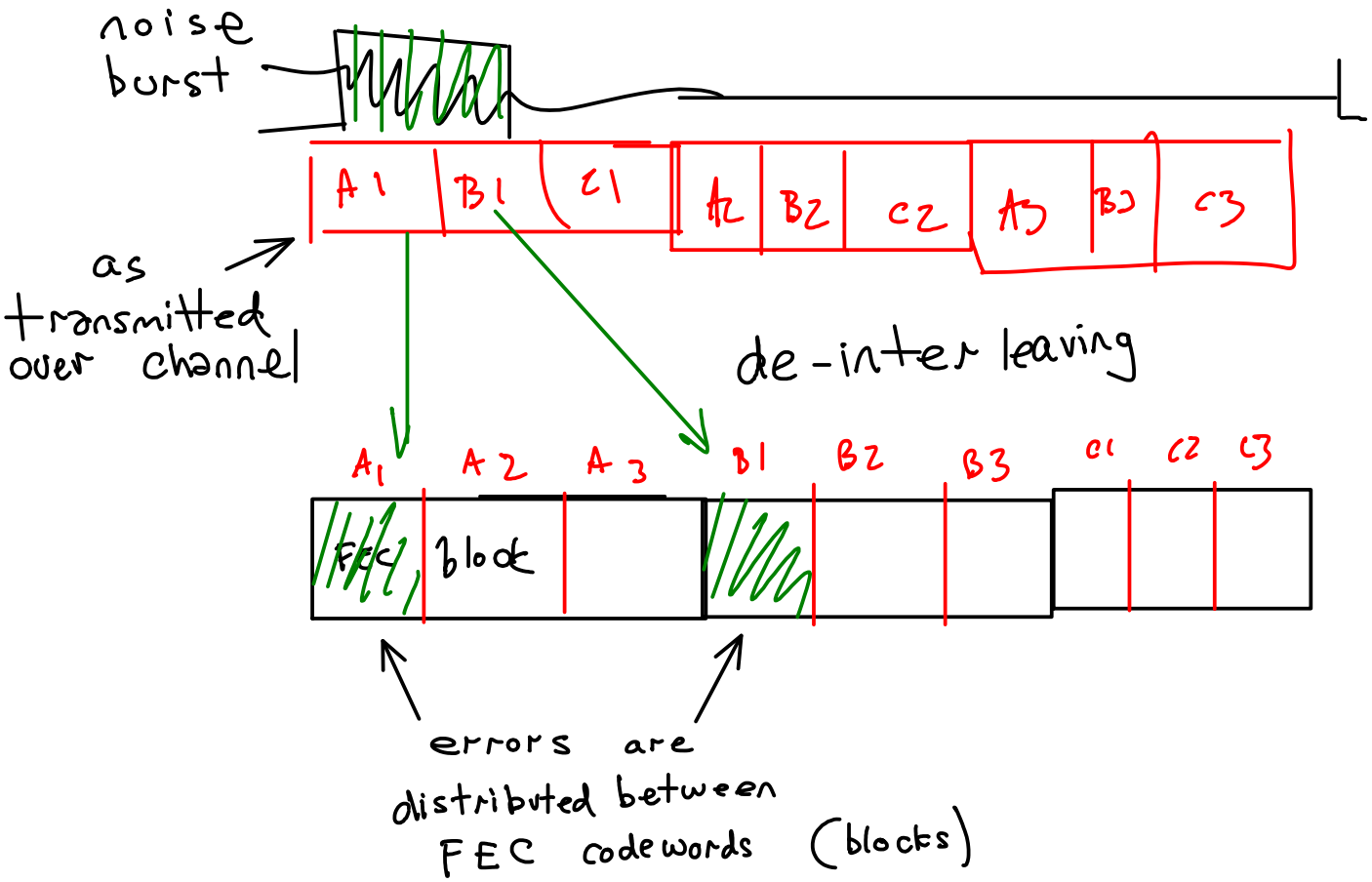
GF(256) : 0 255



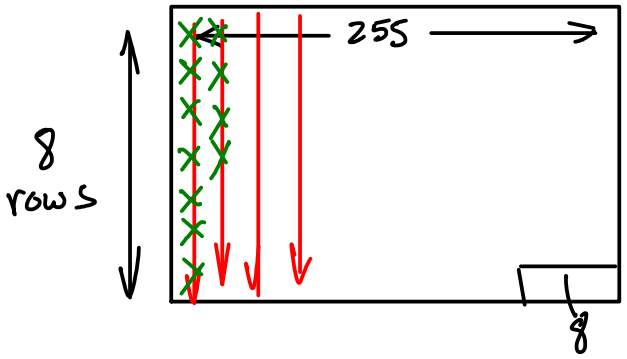
LFSR = Linear Feedback Shift Register







Exercise 3: Assuming 255 bytes per codeword, what is the maximum number of interleaver rows? If an error burst starts with the first byte, what is the longest error burst that will result in 2 or fewer errors per codeword? t or fewer errors per codeword? How many errors will appear at the output of the decoder for error burst of this length or shorter?



$8 \times 255 = 2040$

longest error burst for 2 errors per codeword is 16 (8 rows) because

t errors " " $8t$ (t columns)

$\left\lfloor \frac{3}{2} \right\rfloor = \lfloor 1.5 \rfloor = 1$

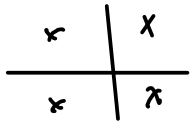
$\frac{256^k}{(256)^n}$

$$t = \left\lfloor \frac{n-k}{2} \right\rfloor$$

there will be zero output errors if the input to the decoder has t or fewer errors per codeword.

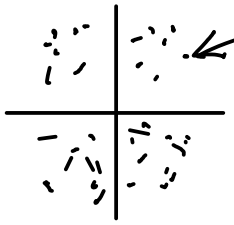
Exercise 4: What are the minimum and maximum bit rates for these symbol rates and modulation formats, not including FEC or other overhead?

QPSK $\equiv$ 4-QAM



4 phases $\Rightarrow$ 2 bits / symbol

M-QAM



M amplitudes & phases

e.g. 4-QAM
64-QAM
256-QAM

bit rate = symbol rate $\times \frac{\text{bits}}{\text{symbol}}$ $\rightarrow \log_2(M)$

for QPSK $M=4$
$\log_2(4) = 2$

e.g. min 160 kHz $\times$ 2 = 320 kb/s (QPSK at 128 kHz)

max 5120 kHz $\times \log_2(256) = 5120 \times 8 = 40.96$ Mb/s.