# Lecture 4

"bridge taps"

Exercise 1: Based on the diagram above, are the ADSL signals higher or lower in frequency than the conventional telephone signals?

pairs

bridge taps (not at end)

higher (> 4 kHz)

$h(t)$

bridged taps cause reflections (echoes)
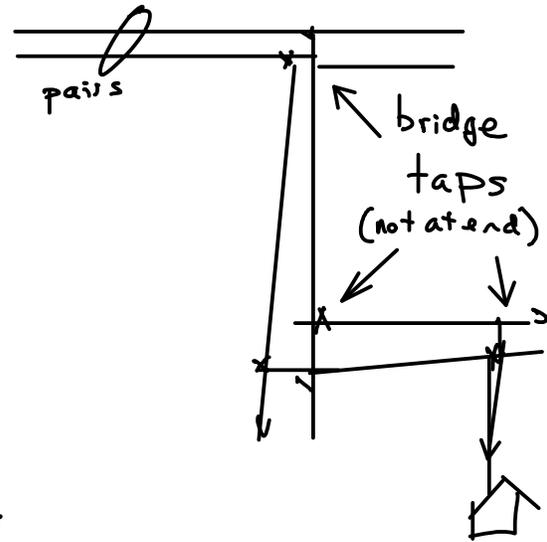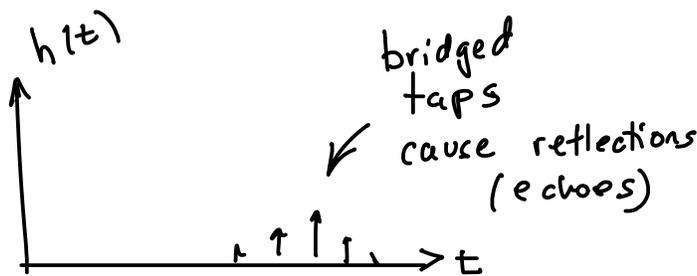
Exercise 2: Calculate the maximum upstream and downtream transmit powers (*consider only the frequencies where the power is highest*)?

PSD = power spectral density

PSD in dBm/Hz

−36.5 peak

−36 dB/octave

21 dB/octave

−90 dBm/Hz

−50 dBm power in any 1 MHz sliding window above 4545 kHz

−97.5 peak +15 dBrn 0-4 kHz

−92.5 peak

0   4   25.875   1104   4545   11 040   Frequency in kHz
3093

T1532670-99
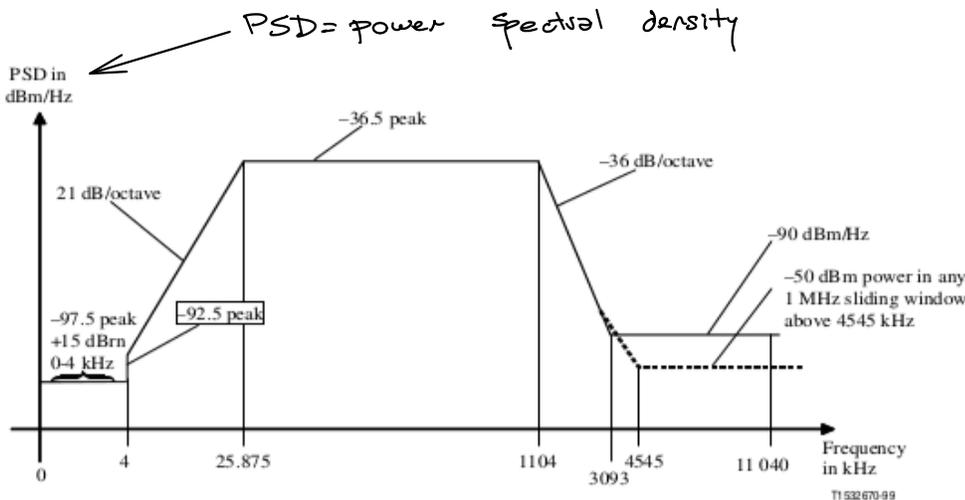
Figure A.1/G.992.1 – ATU-C transmitter PSD mask

B/W × PSD = Power

$Power = 10^6 \cdot 250 \times 10^{-9} = 0.25 \ W$

bandwidth =

$$\begin{array}{r} 1104 \\ - \ 25.875 \\ \hline \end{array}$$

$\approx 1 \ MHz$
$= 10^6 \ Hz$

$PSD = -36 \ dBm/Hz$

$0.25 \ \mu W /Hz$

$10^{\left(\frac{-36}{10}\right)} \ mW$

$250 \ nW /Hz$

$$224\,nW = 250 \times 10^{-9}\,W$$
$$224\,\mu W = 250 \times 10^{-6}\,W.$$

$$-36\ dBm = 10^{\left(\frac{-36}{10}\right)} = 250 \times 10^{-6}\ mW$$

$$= 250 \times 0^{-9}\ W$$

OFDM   Symbol

$$f_s = 2.208\ MHz$$

subcarriers (tones)

$$\frac{1}{T}$$
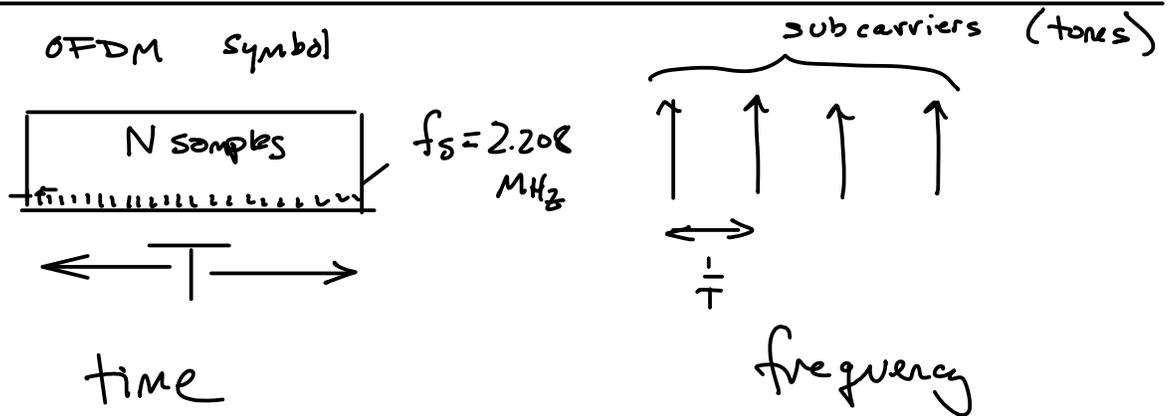
time

frequency

$N = 512$ samples

$$T = \frac{1}{4.3125} = 231.$$

$$T = N \cdot \frac{1}{f_s} = \frac{512}{2.208}\ \mu s$$

allows ISI to decay

5ns /m X

Guard Time:

guard time. $= 32$ samples $= 14.5\ \mu s.$

32 copied

$$512 + 32 = 544\ \text{samples}$$
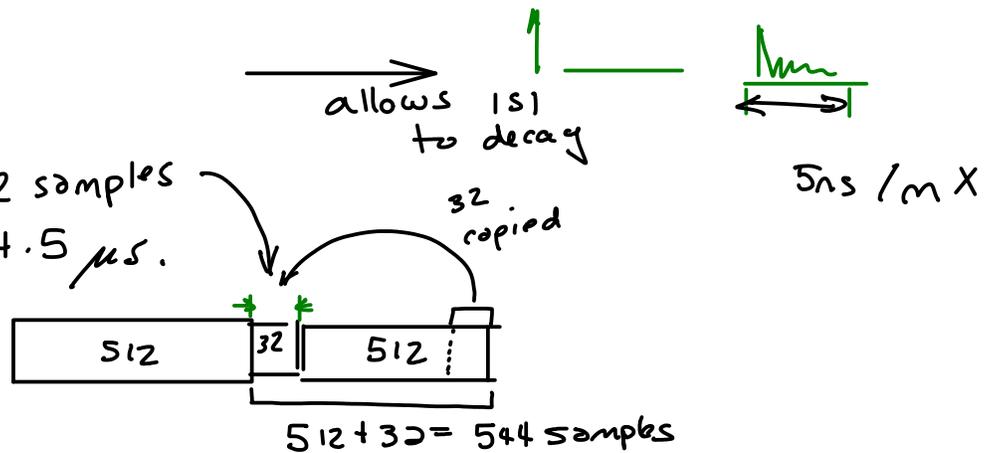
Exercise 3: What is the equation for subcarrier number as a function of frequency? What ranges of subcarrier numbers are used for the upstream and downstream?

$$i = 0 \ldots 255$$

$$f_i = i \times 4.3125 \text{ kHz}$$

highest tone = 255

4.3125 kHz spacing

$$f_{i-1} \qquad f_i \qquad f_{i+1}$$
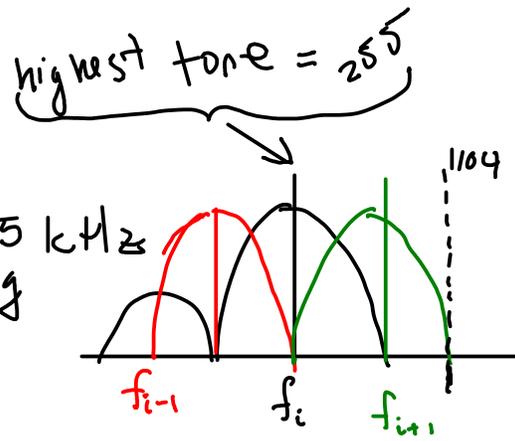
1104

US: $25.875 - 138 = 6 - 32$

DS: $25.875 - 1104 = 6 - 256$

US $8 - 24$

DS $32 - 200$

$$f_0 = 0$$
$$f_1 = 4.3125$$
$$f_2 = 8.625$$
$$f_3 = 12.9375$$
$$\vdots$$
$$f_{256} = 1104$$

Exercise 4: Is this an additive or convolutional (multiplicative) ~~interleaver?~~ Does it need framing synchronization?

scrambler

convolutional — scrambling based on data
— no need for synchronization

No need for framing to determine start of scrambling sequence.

Exercise 5: How many errors per codeword can be corrected?

$$\frac{\# \text{ of parity bytes}}{2} \qquad \left(t = \frac{k - n}{2} \right)$$