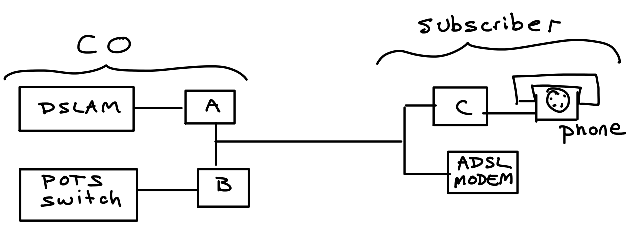
Solutions to Assignment 2

Question 1



Filter A must pass the ADSL signal but not the voice-band signals so it must be a high-pass filter that passes frequencies above 25 kHz and blocks frequencies below 4 kHz.

Filter B must be the opposite, and block frequencies above 25 kHz but pass frequencies below 4 kHz.

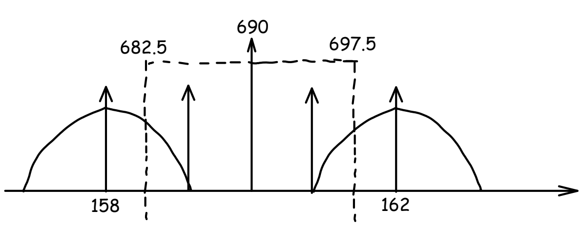
Filter C is the same as filter B.

Question 2

An AM radio station operating with a center frequency of 690 kHz and a bandwidth of 15 kHz would cover frequencies in the range $690 \pm \frac{15}{2}$ kHz (682.5 to 697.5 kHz).

DMT subcarrier are spaced every 4.3125 kHz with carrier 0 at DC so the center frequency of subcarrier i is $4.3125i$.

The DMT subcarrier (channel) numbers immediately below and immediately above the above frequency ranges are $\lfloor \frac{682.5}{4.3125} \rfloor = 158$ and $\lceil \frac{697.5}{4.3125} \rceil = 162$. The upper and lower sidebands of these subcarriers (respectively) would overlap the radio station channel:



Question 3

For an OFDM system using a sampling rate of 10 MHz and an OFDM block sizes of 128 samples the symbol duration is the sample period times the number of samples per symbol or $\frac{128}{10 \times 10^6} = 12.8\ \mu$s. The subcarrier spacing is the inverse of the symbol duration or 78.125 kHz.

The subcarrier center frequency immediately below 6 MHz would be $\lfloor \frac{6 \times 10^6}{78.125 \times 10^3} \rfloor = 76$. To limit the bandwidth to 6 MHz we would have to use subcarriers from 0 to 75.

The resulting bit rate would be the OFDM symbol rate times the number of bits per symbol. Each OFDM symbol would have 75 subcarriers (1–75) each of which could carry 4 bits using 16-QAM. Thus each OFDM symbol would carry $75 \times 4 = 300$ bits and with a symbol rate of 78.125 kHz the bit rate would be $300 \times 78.125 \times 10^3 \approx 23.4$ Mb/s.

Question 4

If the transmit power is 0 dBm, $10 \log(32) = 15$ dB is lost due to the 32-way splitters, and the receiver sensitivity is -27dBm then the margin with no fiber loss is $0 - 15 - (-27) = 12$ dB. If the fiber has a loss of 0.3 dB/km we could use up to $\frac{12}{0.3} = 40$ km of cable (although this would leave no margin).

The maximum coverage area would be given by πr^2 where r is the radius of a circle defining the maximum distance from the optical transmitter. This area is $\pi 40^2 \approx 5000$ km^2.

Question 5

A PC sound card claims to use a 18-bit A/D converter with a sampling rate of 96 kHz.

(a) The theoretical quantization SNR assuming a triangle waveform is $6b$. In this case $b = 18$ and the quantization SNR is 108 dB.

(b) If the signal power is 100 mV RMS, the the quantization noise voltage would be 108 dB less which is:

$$\frac{100}{10^{\frac{108}{20}}} \approx 0.4 \text{ mV}_{\text{rms}}$$

(c) The highest frequency that could be digitized without aliasing is half of the sampling rate or 48 kHz.

(d) According to Wikipedia the highest frequency that humans can hear is about 20 kHz.

Question 6

If the noise impulses happen exactly every 25 μs then there will be 5 of them per 125 μs frame, they will appear in the same place in every frame and thus affect the same speech channels in every frame.

The T1 bit rate is 1.544 Mb/s so the bit duration is about 648 ns and it takes about 5.2 μs to transmit the 8 bits for each speech channel.

It is most likely that each 100 ns noise impulse will affect only one channel and so 5 speech channels in each frame will be affected.

However, there is a small (about 2%) probability that the noise impulse will overlap the last bit of one channel and the first bit of the next in which case 10 of the 24 speech channels in each frame would be affected by the noise.