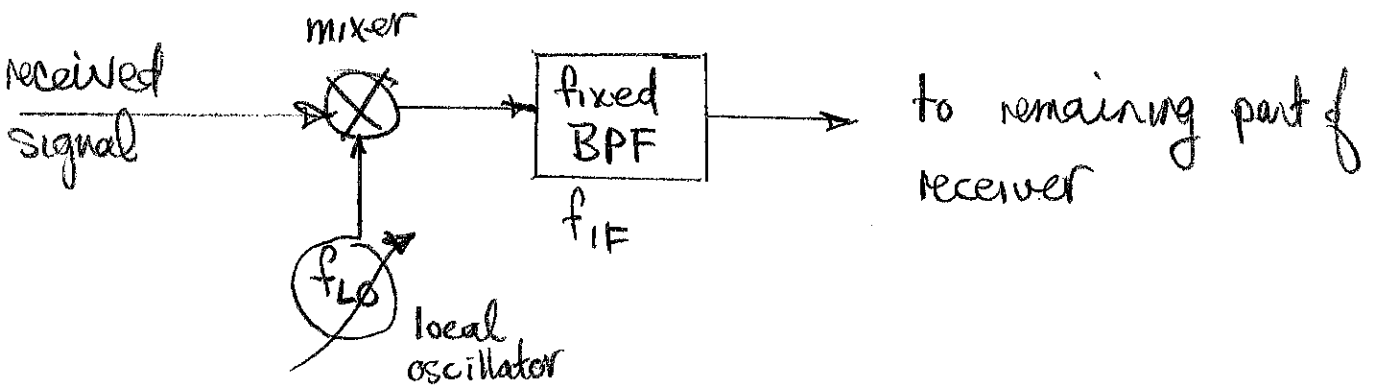
EE3TR4 Midterm Solutions 2016 dReilly

a) This question addresses the superheterodyne receiver system.



The BPF centre freq. f_{IF} is somewhere between f_1 and 0 Hz. (See figure in the question).

The local oscillator freq. f_{LO} is adjusted so that the lower freq. image (at freq $f_i - f_{LO}$) of the desired signal after the mixer aligns with f_{IF}, & therefore passes through the BPF. All other signals are rejected.

$$f_{LO} = f_i - f_{IF} \qquad i = 1, 2, 3, 4.$$

More detail is given in the Lecture Notes on Amplitude Modulation.

1b. The reason is that if the signal is mixed directly to baseband then the receiver oscillator must be exactly in phase with the transmit oscillator, otherwise the output signal will be distorted.

This issue is discussed in detail in the tutorial notes Tutorial 4 Quadrature DSB/SC.

Q2 The spike at $2/T$ must be suppressed by 20 dB relative to the spike at $1/T$.

20 dB is equiv to a power ratio of

$$-20 = 10\log_{10} P \rightarrow P = 10^{-2}$$

∴ the filter must suppress by a factor of 10^{-2}

We set cutoff freq. $f_0 = 1/T$

∴ at freq $2f_0$, $|H(2f_0)|^2 \leq 10^{-2}$

$\therefore$ we find n s.t.

$$\frac{1}{1+(2)^{2n}} \leq 10^{-2}$$

$$-\log_{10}\left(1+2^{2n}\right) \leq -2$$

$$\simeq -\log_{10} 2^{2n} = -2n\log_{10}2 \leq -2$$

$$2n \geq \frac{2}{\log_{10}2} \qquad n \geqslant \frac{1}{\log_{10}2} \simeq \frac{1}{0.3} = 3.33$$

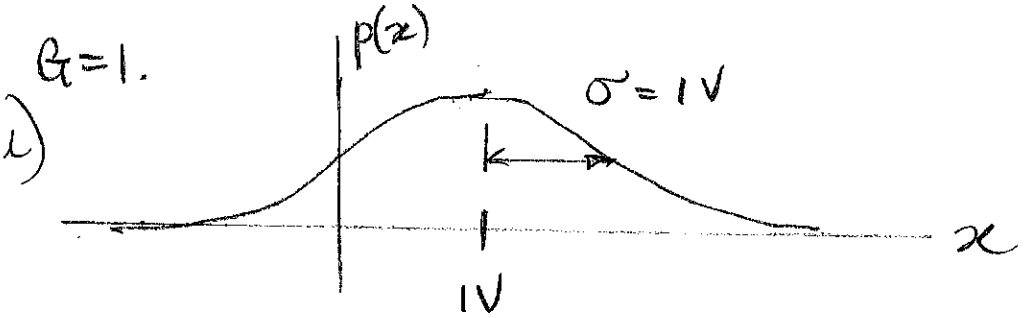
$\therefore$ take $n = 4$.

Q3 The DC voltage is equivalent to the mean value of $x(t) = 1V$.

The rms value of the noise after the amplifier is G volts.

Since the pdf of the noise is Gaussian, once we know the mean & std. dev, we are all set.

i) G = 1.



ii) G = 2