Assignment 3

Due Wednesday, October 29. Show your work. Submit your assignment using the appropriate dropbox on the course web site. Assignments submitted after the solutions are made available will be given a mark of zero.

Question 1

In this question you will use Matlab (or Freemat or Octave) to investigate how the channel frequency response affects the shape of a pulse.

Use one of the above programs to create a 100-point vector of time values from 0 to 1 (second):

```
t=[-0:0.01:1];
```

and plot an approximation to one cycle of square wave (one positive and one negative pulse) using the first three odd harmonics of a sine wave:

```
plot( sin(2*pi*t) + ...
 1/3*sin(2*pi*3*t) + 1/5*sin(2*pi*5*t) )
```

(a) show the plot generated by this statement

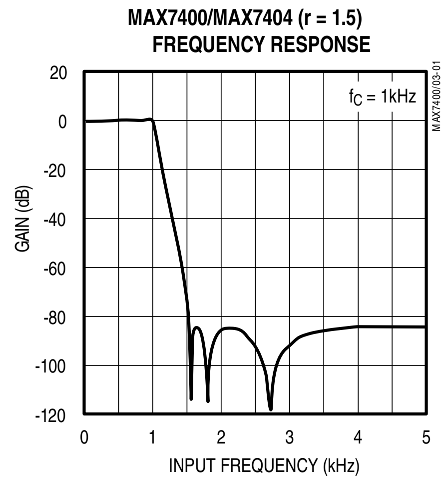
(b) generate a plot of the waveform at the output of a channel whose transfer function drops off by 6 dB per harmonic (i.e. the component at 3 Hz is −6 dB relative to the fundamental and the harmonic at 5 Hz is −12 dB). Assume the channel is linear phase. Show the statement you used to create the plot.

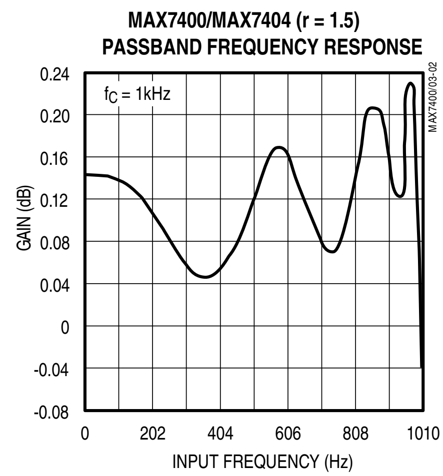
(c) repeat the above for a channel whose transfer function delays the 3 Hz harmonic by 0.1 s and the 5 Hz harmonic by 0.2 s[1]

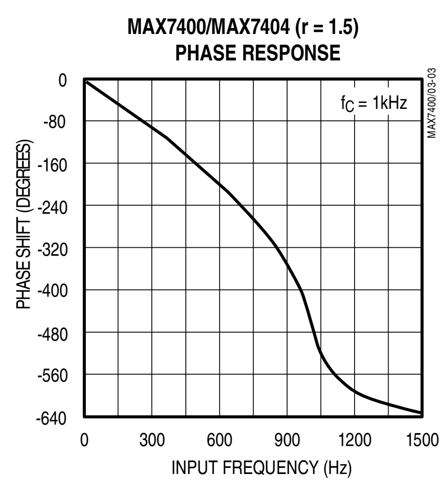
Question 2

The following graphs show the frequency response of the Maxim MAX7404 switched-capacitor filter operating at a nominal 1 kHz bandwidth.

[1]Hints: *Subtracting* T from the time argument of a function delays it by T seconds. Use parentheses as necessary to specify operator (multiplication vs subtraction) priority.







Use these graphs to estimate the following (including units):

(a) the -3 dB bandwidth

(b) the -20 dB bandwidth

(c) the roll-off in the transition between passband and stopband in dB per octave

(d) the minimum stopband attenuation

(e) the passband ripple

(f) the phase shift and (excess) delay at 500 Hz

(g) the (approximate) maximum deviation from linear phase over the frequency range 0-1 kHz

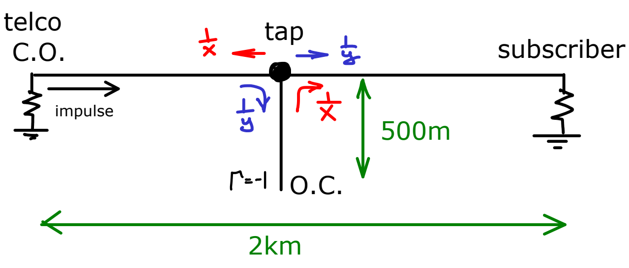
Question 3

(a) The noise power at the output of an amplifier with 20 dB gain and a bandwidth of 1 MHz is -91 dBm. What is the noise figure in dB?

(b) Sometimes the *noise temperature* (T) of an amplifier is specified instead of the noise figure (F). T is computed by assuming F is 1 and computing the temperature which would result in the same level of noise. What is the apparent noise power at the input of the above amplifier in Watts? What is its noise temperature?

Question 4

A telephone cable runs 2 km from the telephone company's central office (CO) to a subscriber. A tap located at a point 1 km along this line is connected to a 500 m long unterminated loop:



Assuming:

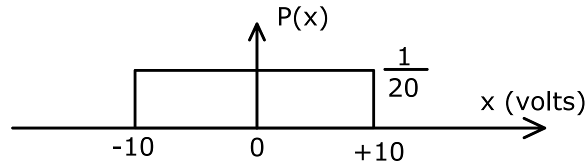
- the attenuation of the cable is 5 dB/km at all frequencies of interest,
- the line is properly terminated at the CO and subscriber ends,
- the signal is reflected from the end of the unterminated line with no attenuation but inverted in polarity, and
- the signal splits equally in two each time it hits the tap but there is no reflection,

draw the impulse response of the channel between the CO and the subscriber.

Hint: Trace the paths an impulse would take from the input to the output of the channel. Take into account that the signals are attenuated as they travel along the lines.

Question 5

(a) Noise that has an equal ("uniform") probability of taking on any voltage between -10 V and $+10$ V:



is added to an RS-232 signal with signaling levels of +/-5V.

Draw the probability distribution of the voltage of the signal plus the noise added together when a '1' bit is being transmitted. What range of voltage levels will result in the receiver making an error when receiving a '1' bit? What is the probability that the receiver will make an error when a '1' bit is transmitted?

(b) If the noise has a Gaussian distribution with a mean of 0V and a standard deviation of 3V, what is the probability that the noise has a value greater than 5V? What is the probability of error if a '1' bit is transmitted?