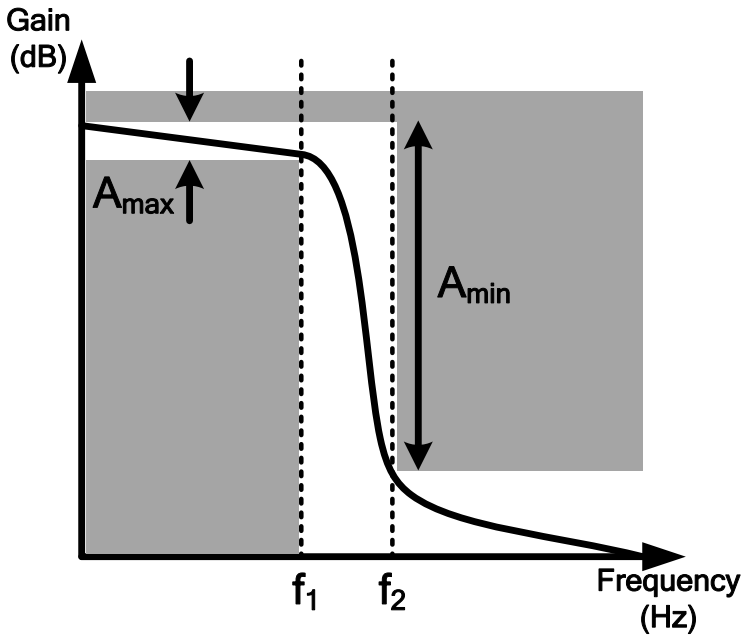
Project 2
Design Guide

High-Speed Circuits & Systems Lab.
Dept. of Electrical and Electronic Engineering
Yonsei University

High-Speed Circuits and Systems Laboratory
HSCS

Goal



Specification
- Butterworth LPF
- Filter DC gain = 0dB
- A_{max} < 0.25dB, A_{min} > 20.3dB
- f_1 = 7kHz, f_2 = 18kHz

I. Filter Design with MATLAB[10]
II. Design an active RC Butterworth LPF[30]
III. Design a switched-capacitor LPF[40]
IV. Report[20]

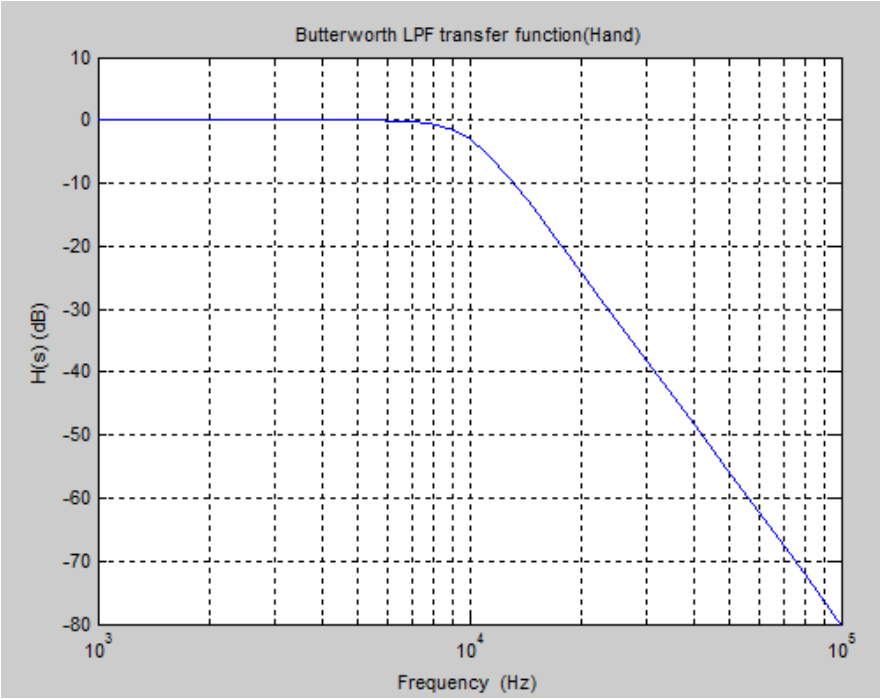
MATLAB

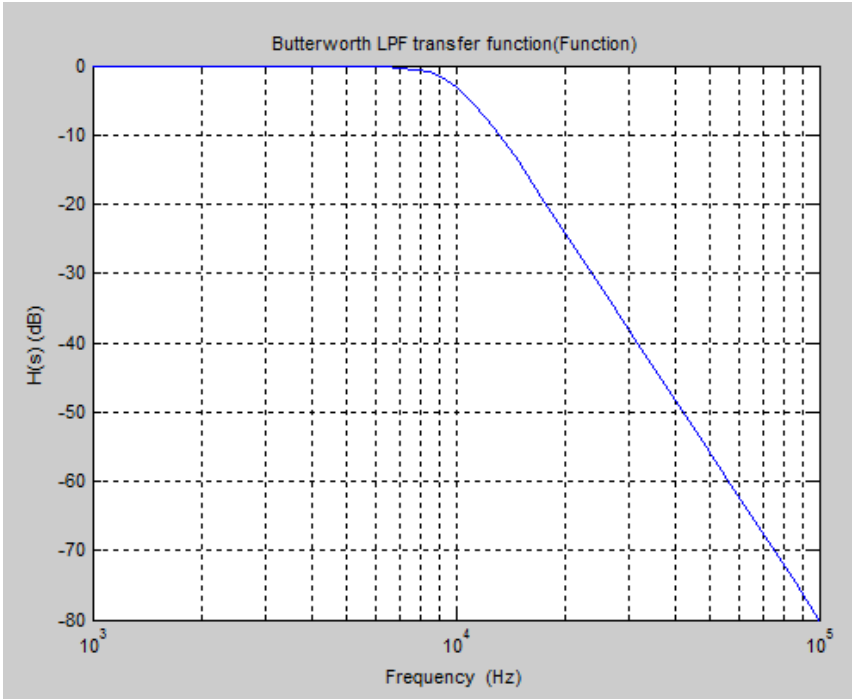
- Hand Calculation ➔ determine the filter transfer function
- Confirm with MATLAB

- Functions to use in MATLAB
  - **poly(A)** : returns a row vector whose elements are the coefficients of the characteristic polynomial
  - **tf(num,den)** : creates a continuous-time transfer function with numerator(s) and denominator(s) specified by num and den.
  - **[z,p,k] = buttap(n)** : returns the poles and gain of an order n Butterworth analog lowpass filter prototype
  - **Bodemag(sys)** : plots the magnitude of the frequency response of the LTI model SYS

  - More detailed function properties : Help ➔ Product help
  - Please attach code in report with annotations

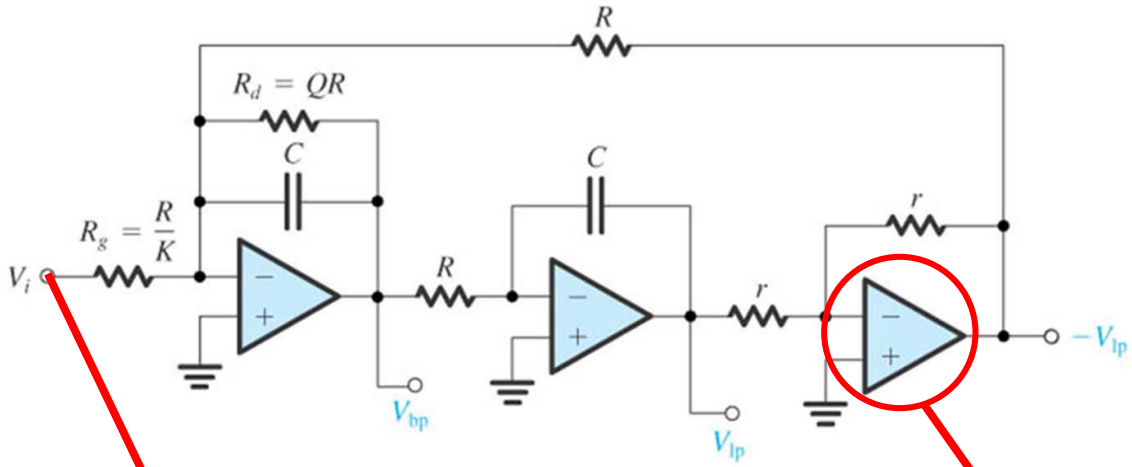
Result Example



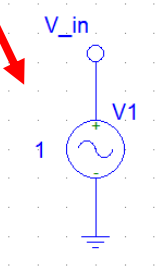


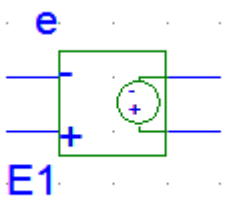
Active RC LPF

- Tow-Thomas Filter
  - $R \leq 2M\Omega$
  - $10pF \leq C \leq 100pF$



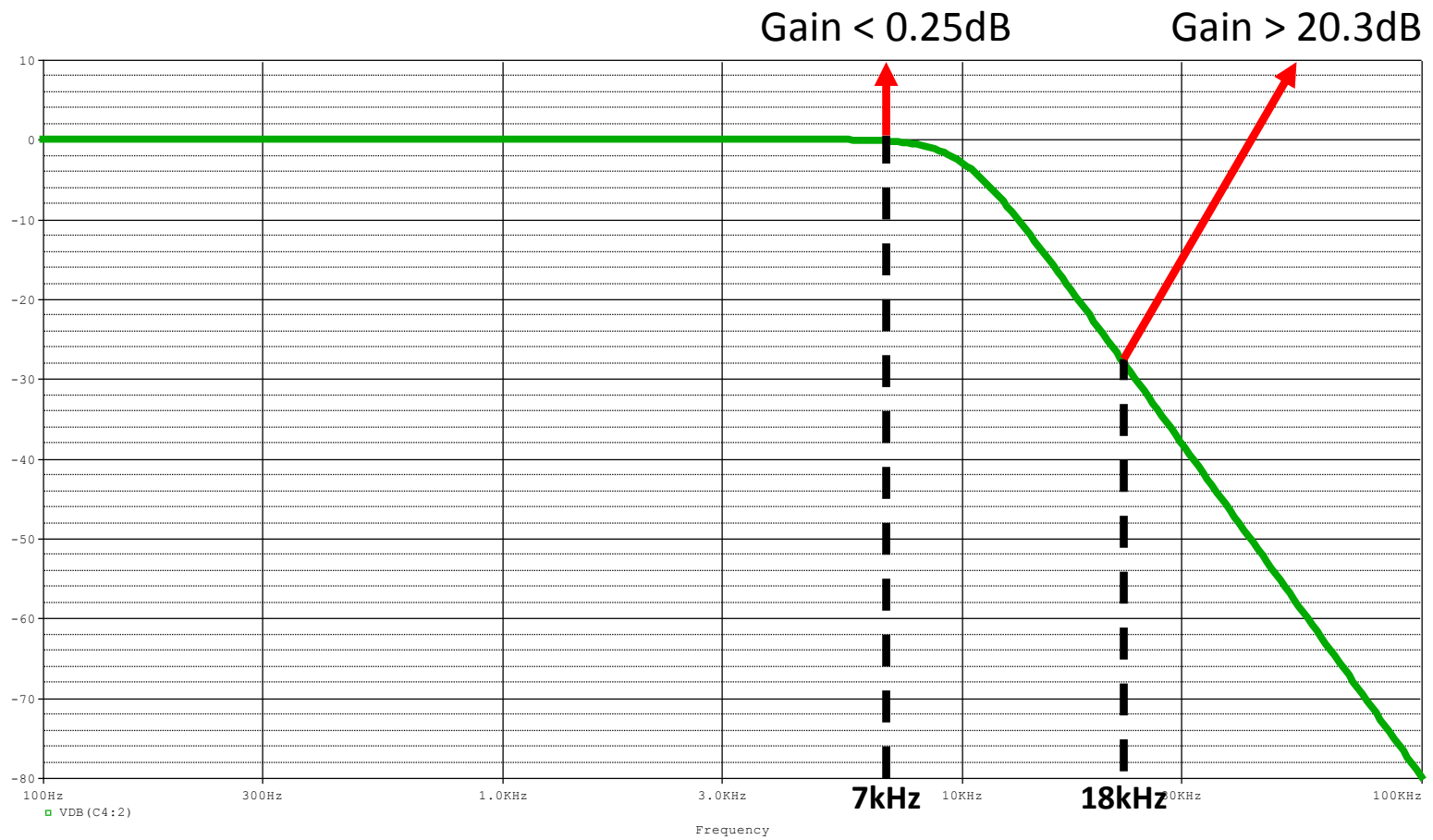
Input



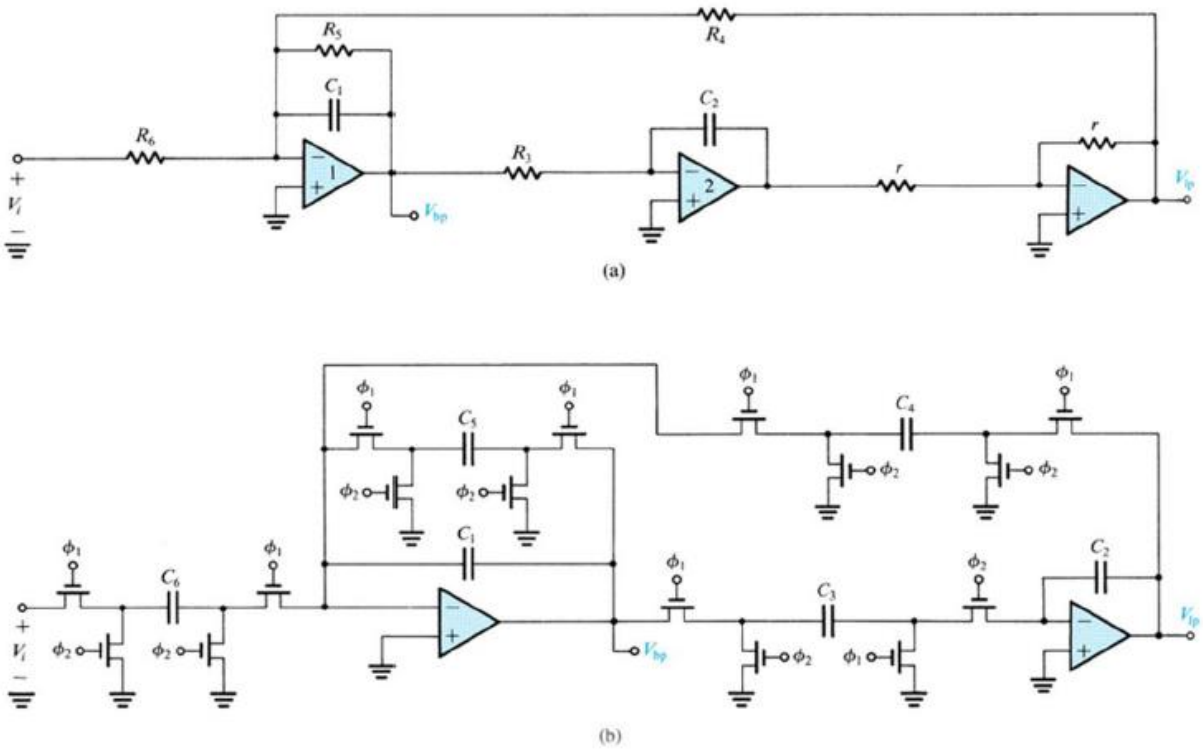


Gain : 10^6

Result Example

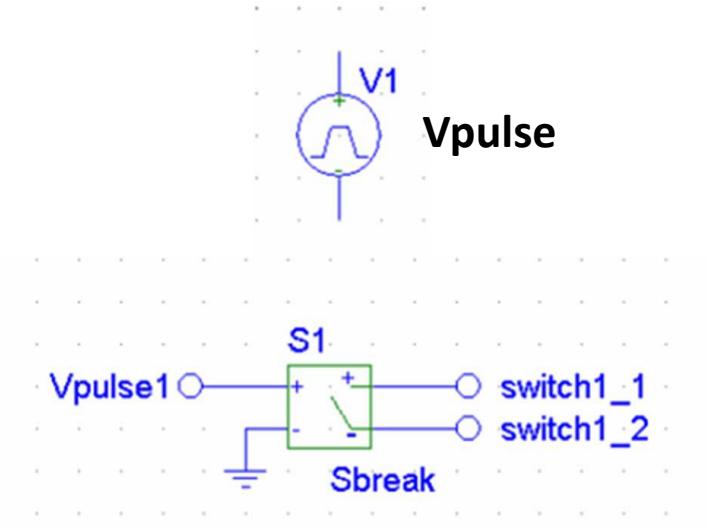


Switched-Capacitor LPF

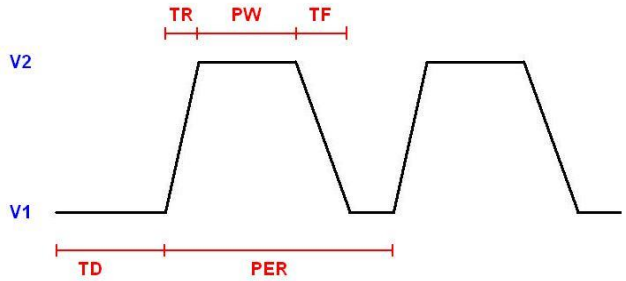


Replace resistors with switched capacitors such as (a)➔(b)

Pspice elements



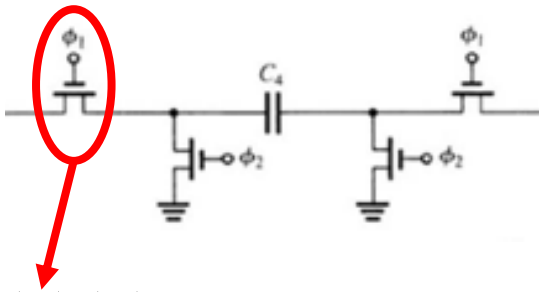
- Vpulse
  td : time delay
  tr : rising time
  tf : falling time
  PW : pulse width
  PER : period

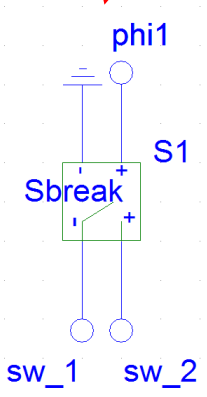


- Sbreak
  -Ideal switch

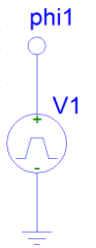
Pspice Schematic

- $10pF \leq C \leq 100pF$
- Sampling frequency = 500kHz
- Need transient simulation!
- Input : impulse

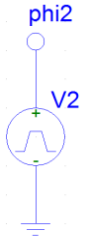




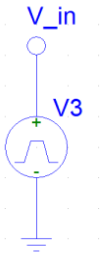
V1=0, V2=1, td=1u, tr=tf=1p, PW=1u, Period=2u



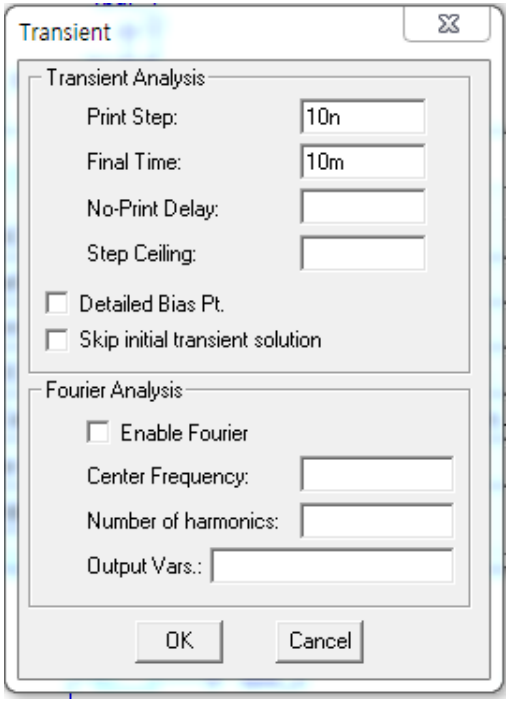
V1=1, V2=0, td=1u, tr=tf=1p, PW=1u, Period=2u



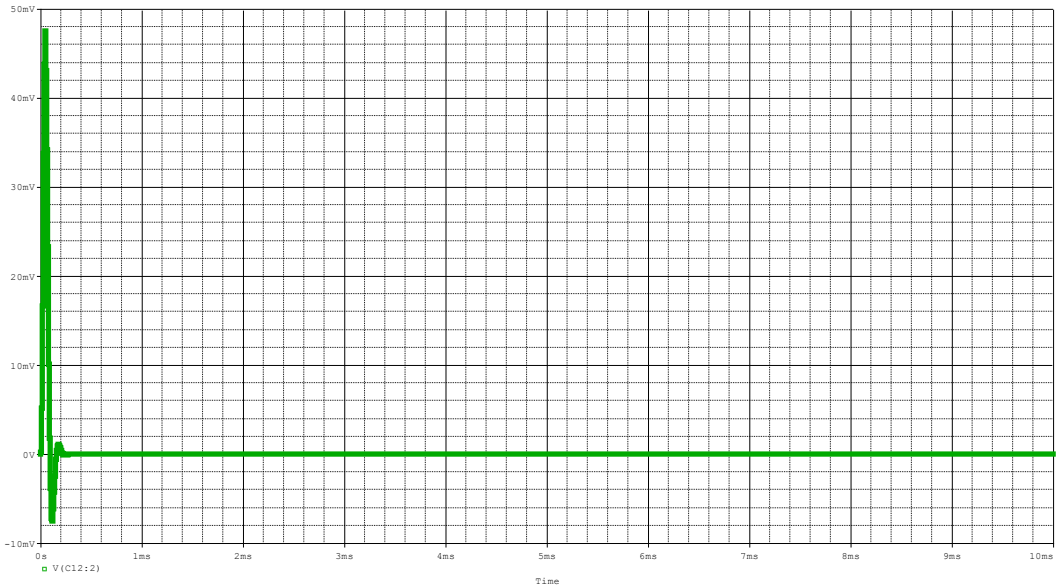
V1=0, V2=1, td=1u, tr=tf=0, PW=1u, Period = 2



Transient Simulation

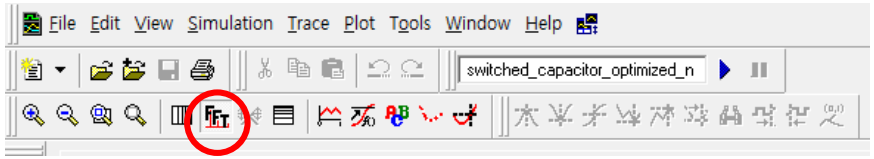


Put 20n~30n in step ceiling for higher resolution

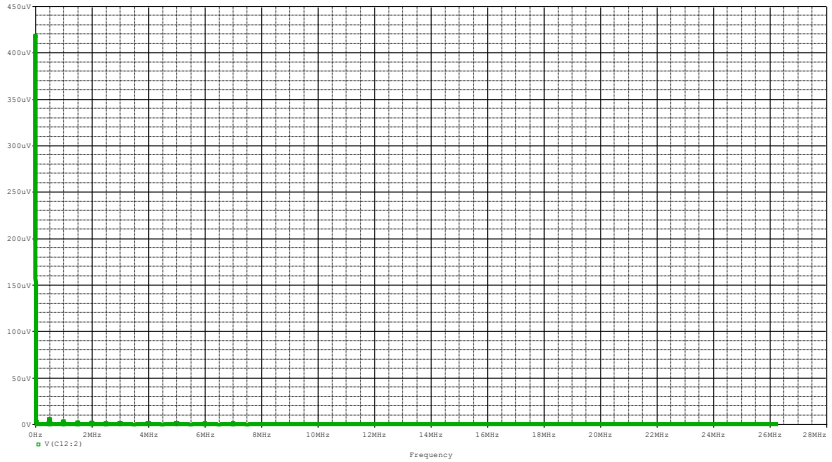


<Output result>

Need FFT!



Result Example



Maximum 0.4dB peaking is allowed

1. Scale(100Hz to 30kHz)
2. x-axis Log scale
3. Place Vdb marker

Do not worry about DC gain value!
Please mark important points in graph

Grading Policy

- MATLAB[10], Active RC filter[30], Switched-capacitor filter[40], Report[20]
- List R,C values with reasonable explanation and mark important points in graph.
- For switched-capacitor filter, design with smaller total capacitance will get more points. Grade policy is followed in table.

Grade A (5 teams)	10 points
Grade B (5 teams)	8 points
Grade C (5 teams)	6 points
Grade D (4 teams)	4 points
Grade E (4 teams)	2 points

- Three best designs will be selected and their designers will be given opportunities to present their results in class in English for extra 5 points.
- Deadline : 6:00 PM , 24 May. 2015 @ B629(Hardcopy)