UNIVERSITÄT DUISBURG ESSEN

HFT

Bachelor Thesis

Signal-Processing and Display Subsystem for 24 GHz Doppler-RADAR

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Outlines

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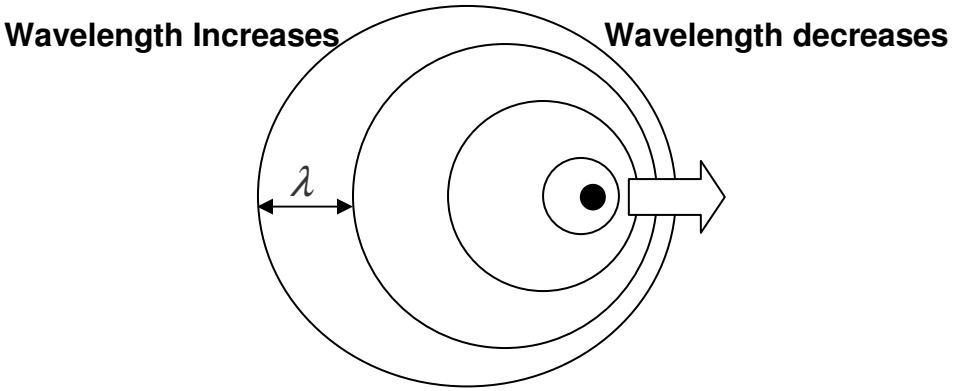
- Introduction to Radar
- Tasks for the Thesis
- Amplification of IF Signals
- Clipping Circuit
- Comparator
- Counter, Display-Subsystem
- IF Filtering
- Hardware Development
- Conclusion

Introduction to Radar

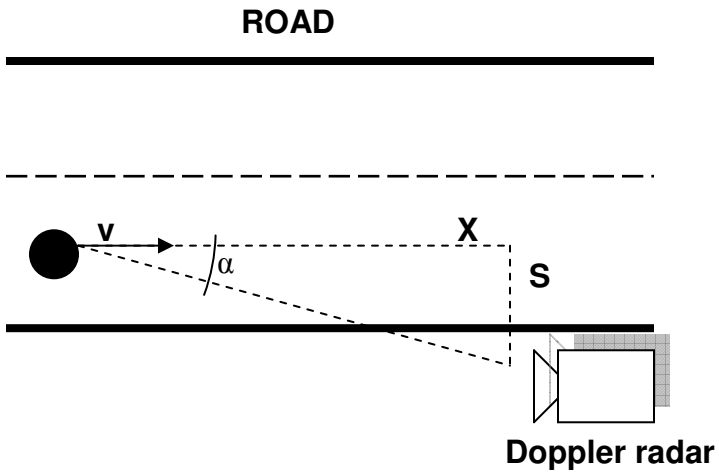
- Doppler Effect

$$f_D = \frac{2 f_o}{c_o} . v_P$$



- Radial Velocity

$$v_p = v . \cos \alpha$$



Tasks of the Thesis

Tasks :

1. Development of a PCB to process the IF-signals, which can be used by the Counter based on TTL technique.

2. Development of a PCB to process the audio-signals from microwaves subsystem.

Tasks of the Thesis

Task 1:

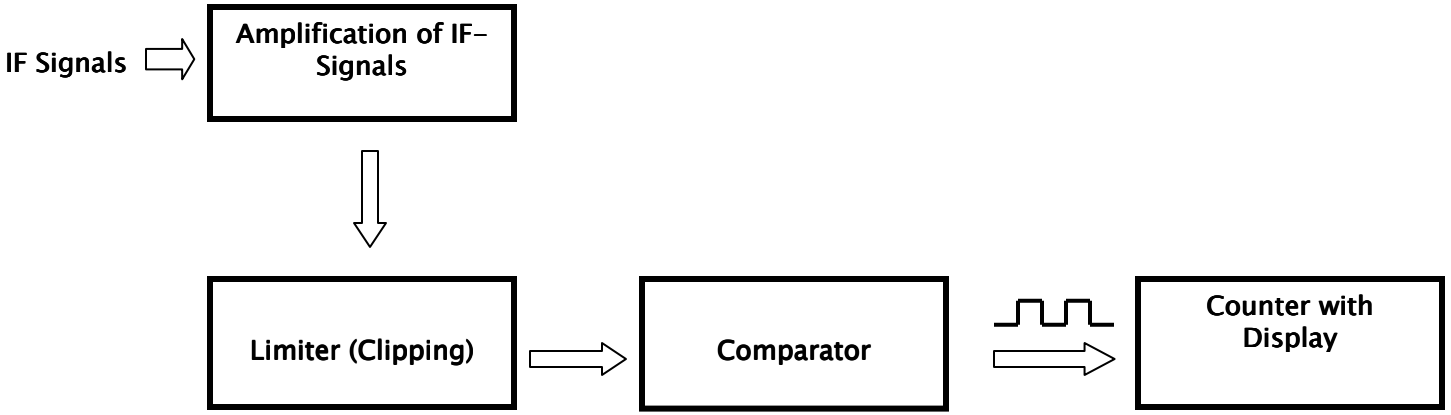


Figure : Block Diagram for Task 1

Tasks of the Thesis

Task 2:

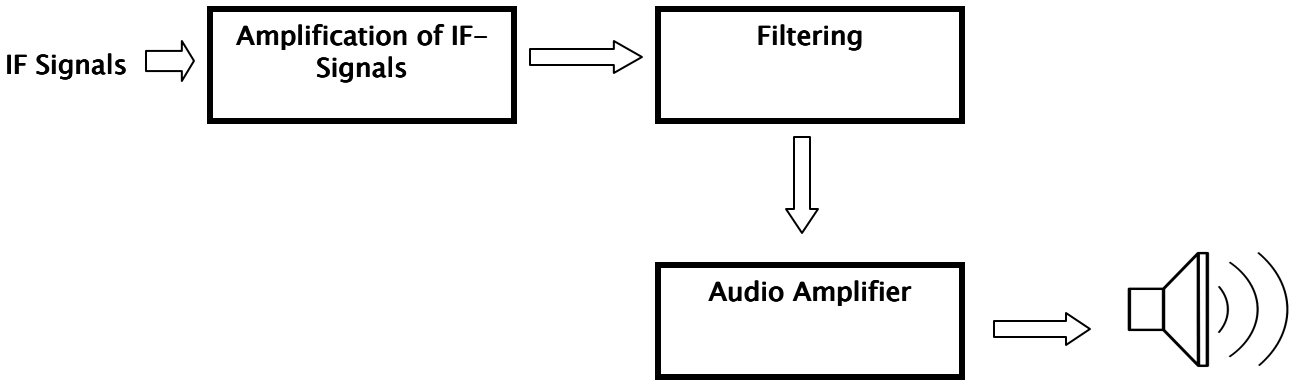
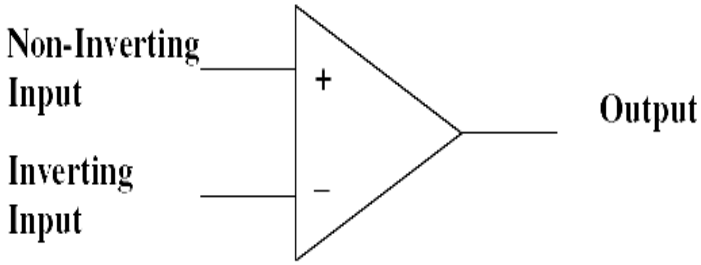


Figure : Block Diagram for Task 2

Amplification of IF-Signals

Operational Amplifier



- Very large open loop gain
- Differential Input stage
- Uses feedback to control the relationship between the input and output

The Golden Rules

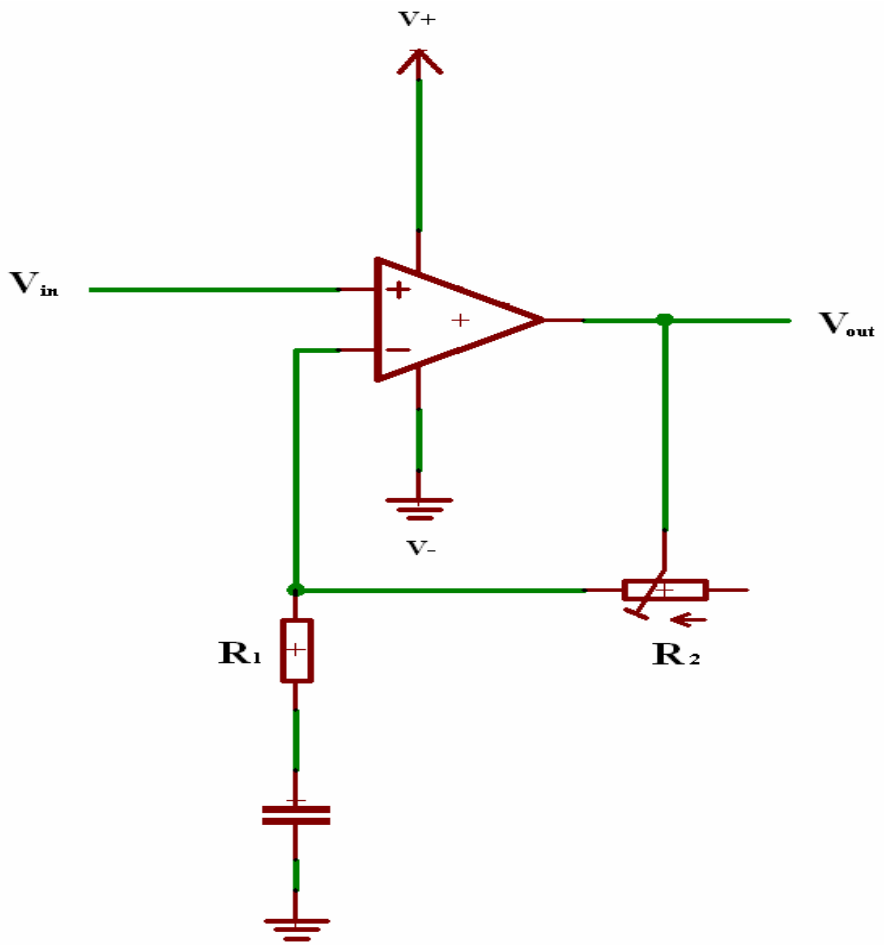
1. The voltage difference between the inputs is zero.
2. The input draw no current.

Amplification of IF-Signals

Non-Inverting Amplifier

- $V_{in} = V_+ = V_- = V_{out} \cdot \left[\frac{R_1}{R_1 + R_2} \right]$
- Open-Loop Gain *A*
- Closed-Loop Gain

$$G = \frac{V_{out}}{V_{in}} = 1 + \frac{R_2}{R_1}$$

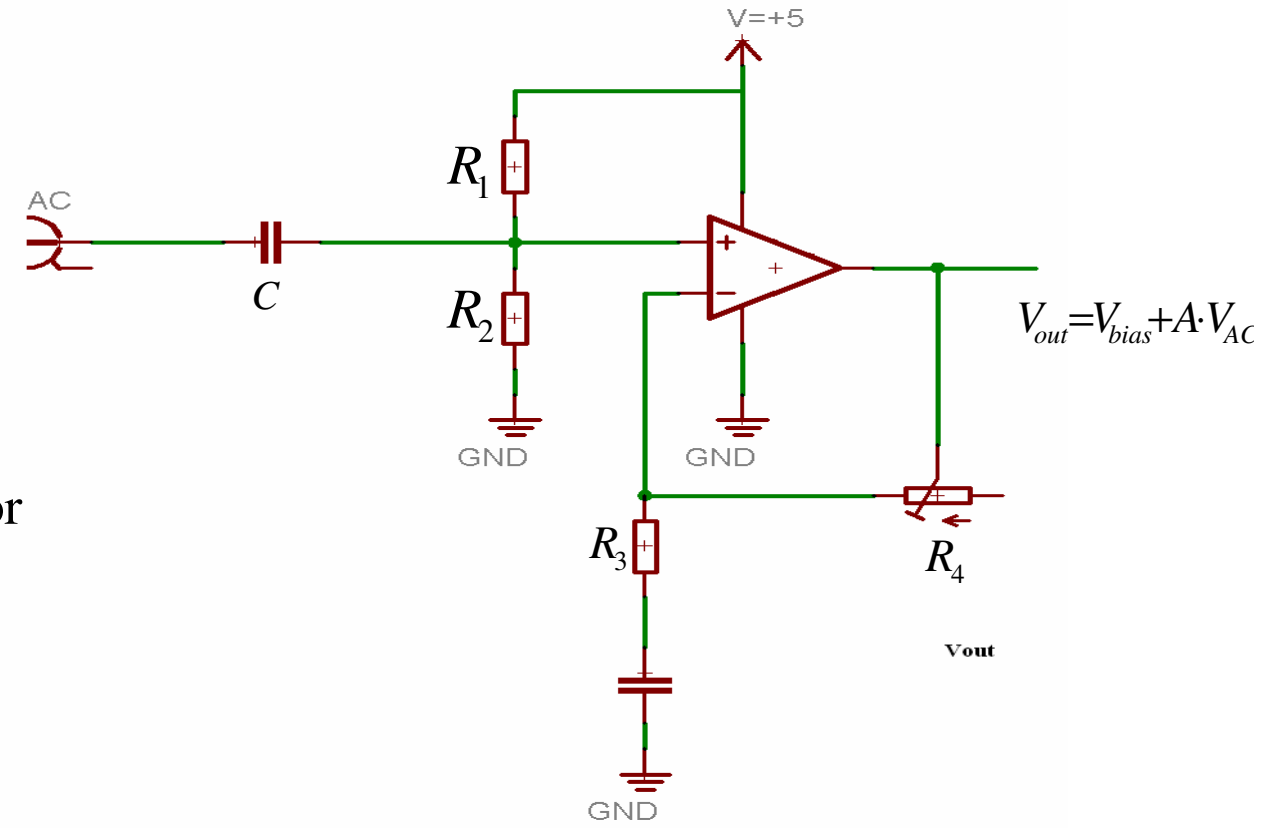


Amplification of IF-Signals

Specifications

- $V_{in} = 10\,mV$
- $G = 20\,dB$
- $V_{CC} = +5V$
- $V_{bias} = +2.5V$
- DC blocking capacitor

$$f_c = \frac{1}{2.\pi.(R_1 \parallel R_2).C}$$

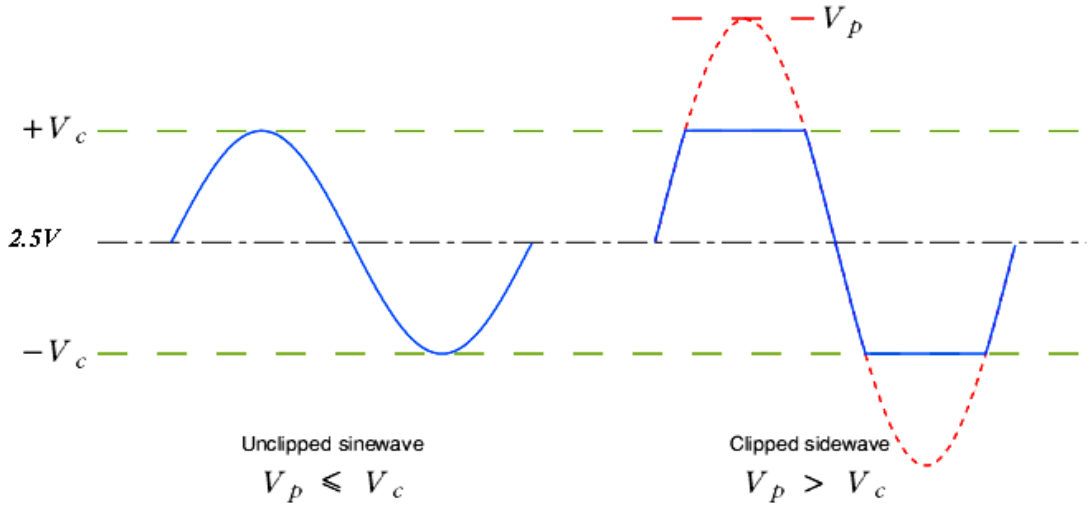


Result:

$$G \approx 19.08\,dB$$

Clipping

- Limits the amplitude of the signal.
- DC supply rail (5V and 0V).

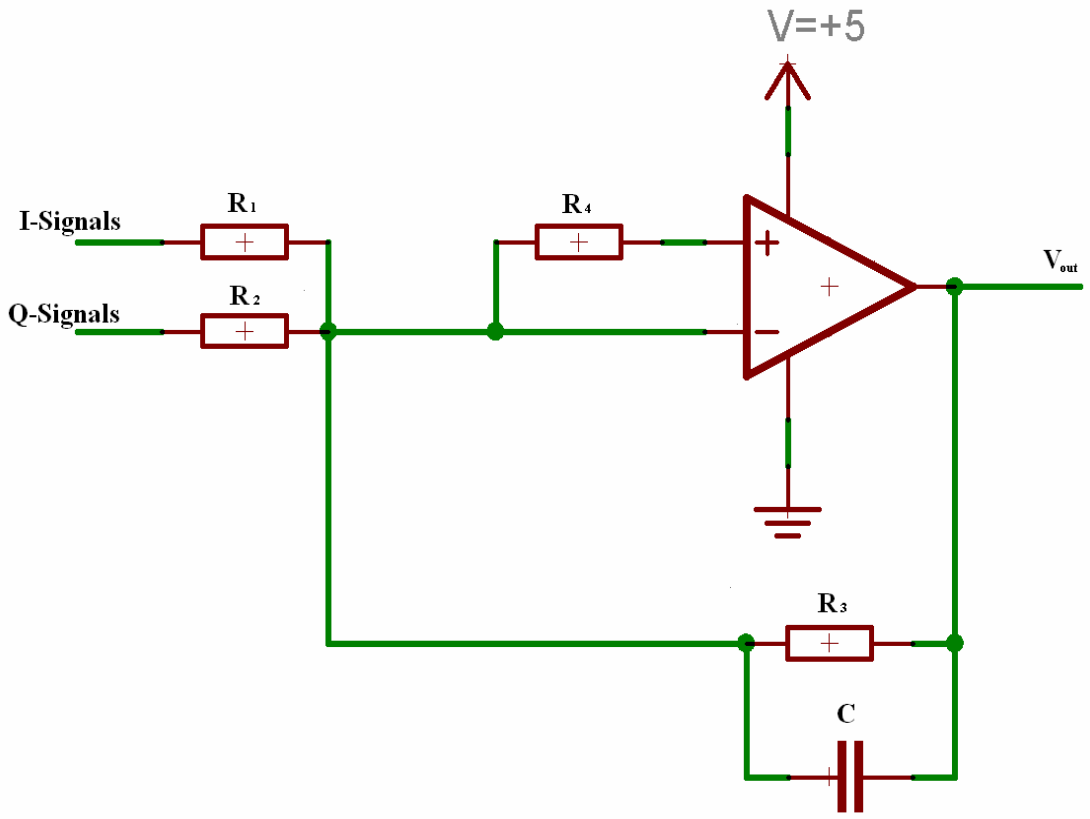


Summing of I/Q Signals

- Gain $G = -\frac{R_3}{R_{1,2}}$
- $V_{out} = -R_3\left(\frac{V_1}{R_1} + \frac{V_2}{R_2}\right)$
- Unity Gain $R_1 = R_2 = R_3$

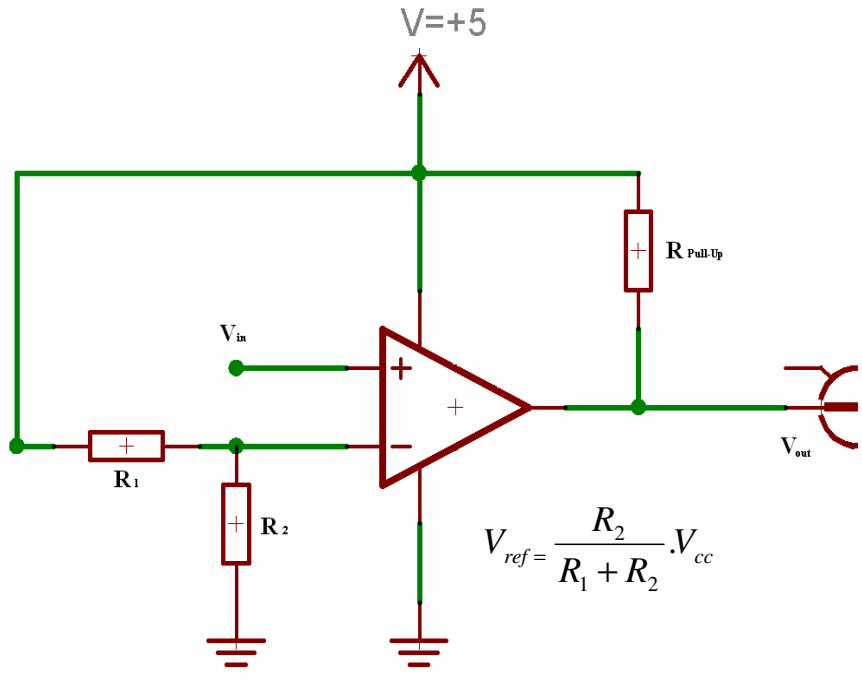
$$V_{out} = -(V_1 + V_2)$$

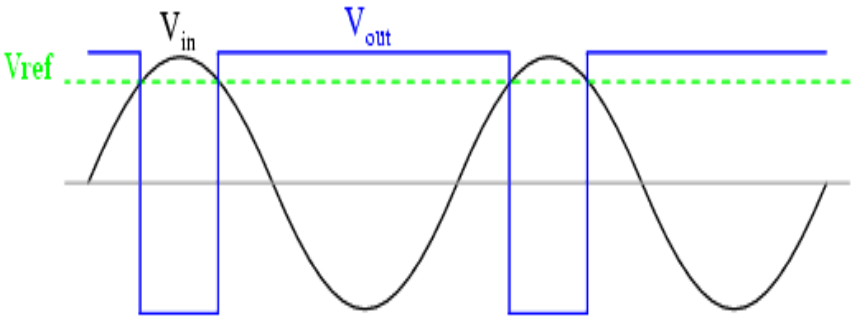
- $f_C = 2KHz$



Comparator

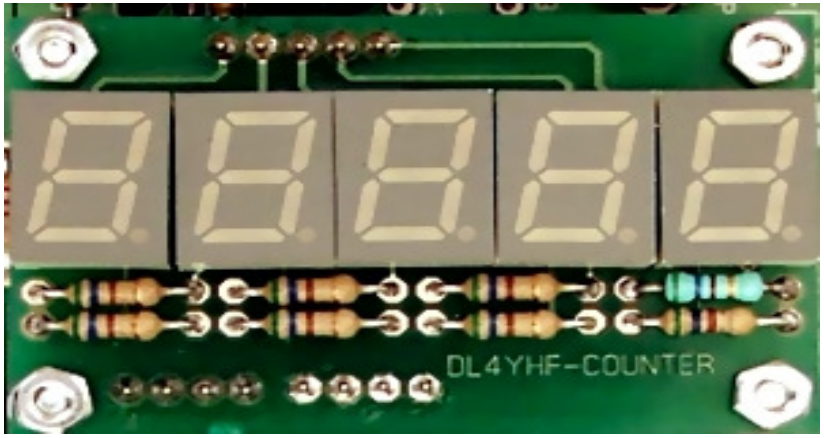
- $V_{out} = A(V_+ - V_-) = \begin{cases} +V_{CC} & V_{in} > V_{ref} \\ 0 & V_{in} < V_{ref} \end{cases}$
- „pull-up“ resistor.





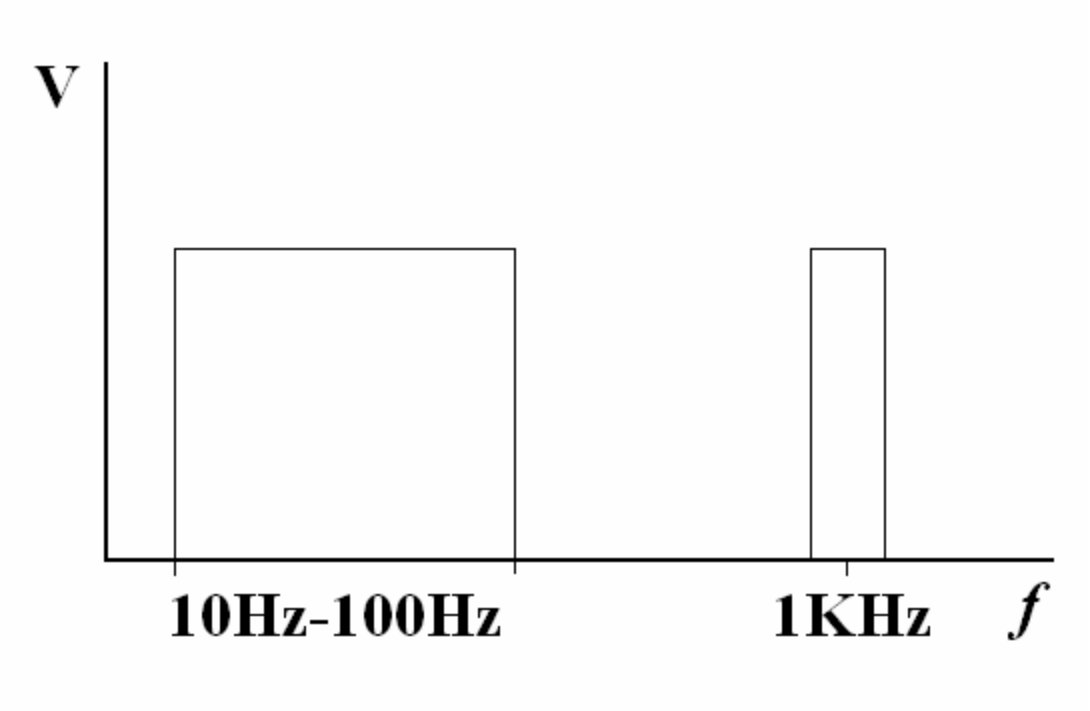
Counter, Display Sub-system

- Counts the events in set period of time.
- Counts to 50 MHz.
- Seven segments color display



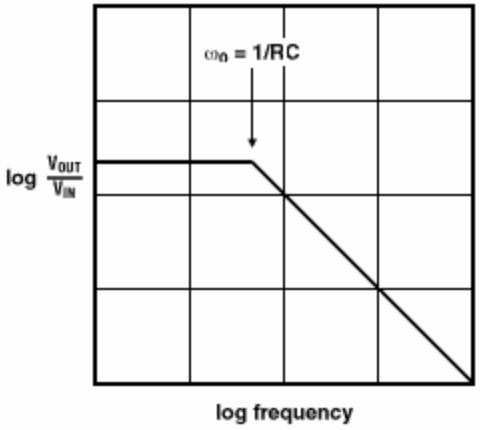
IF Filtering

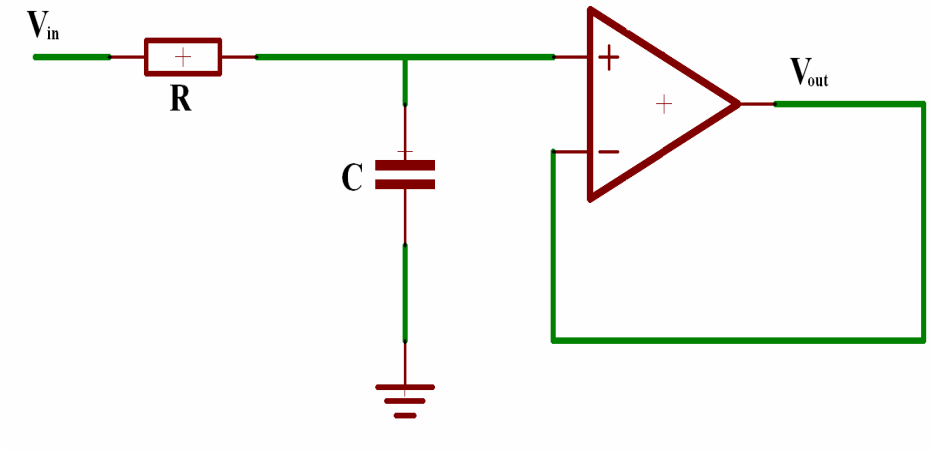
Specifications

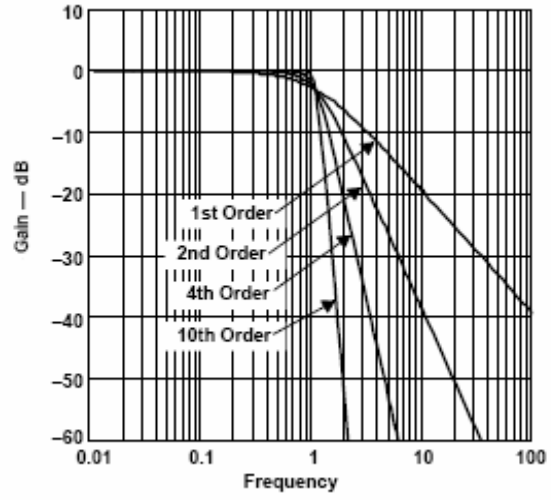


Low-Pass Filter

- Lower frequency range (Active filters).
- $H(j\omega) = \dfrac{G}{\prod_i \left(1 + j\omega a_i + (j\omega)^2 b_i\right)}$
- Higher order – longer passband flatness

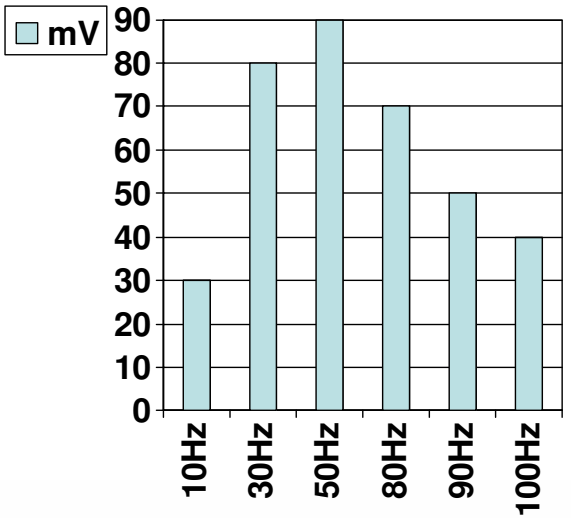


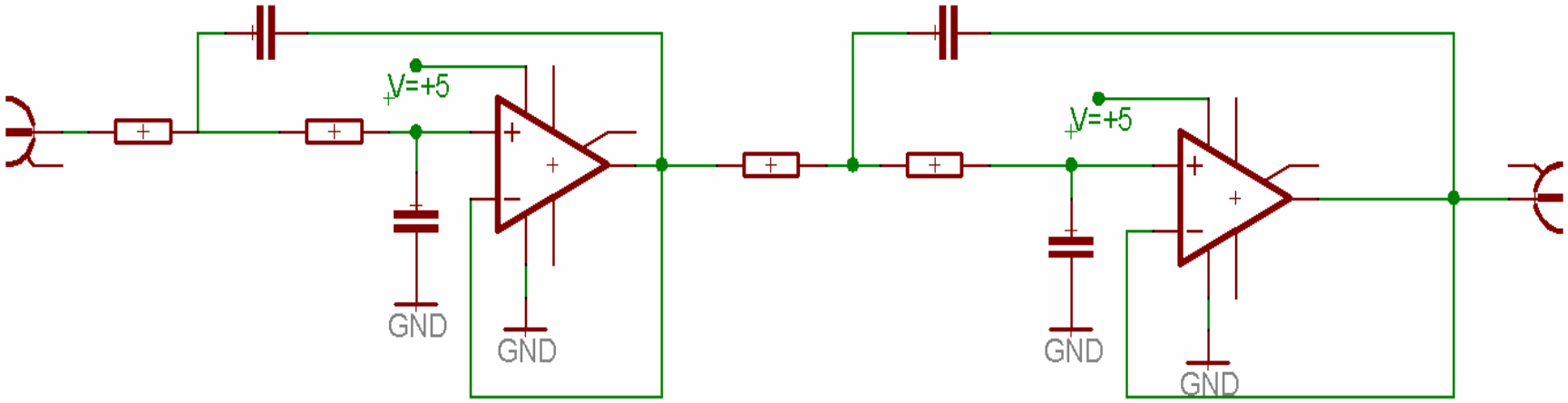




IF Filtering

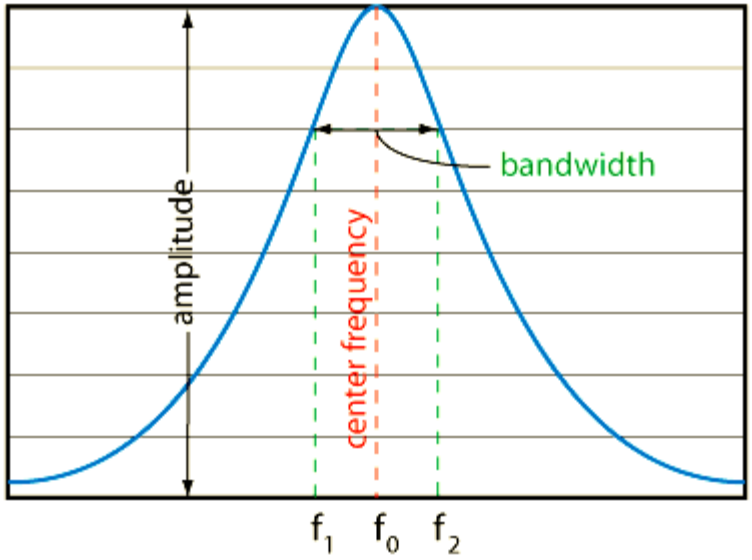
- Sallen-Key Topology.
- Unity Gain.
- 10Hz – 100Hz.

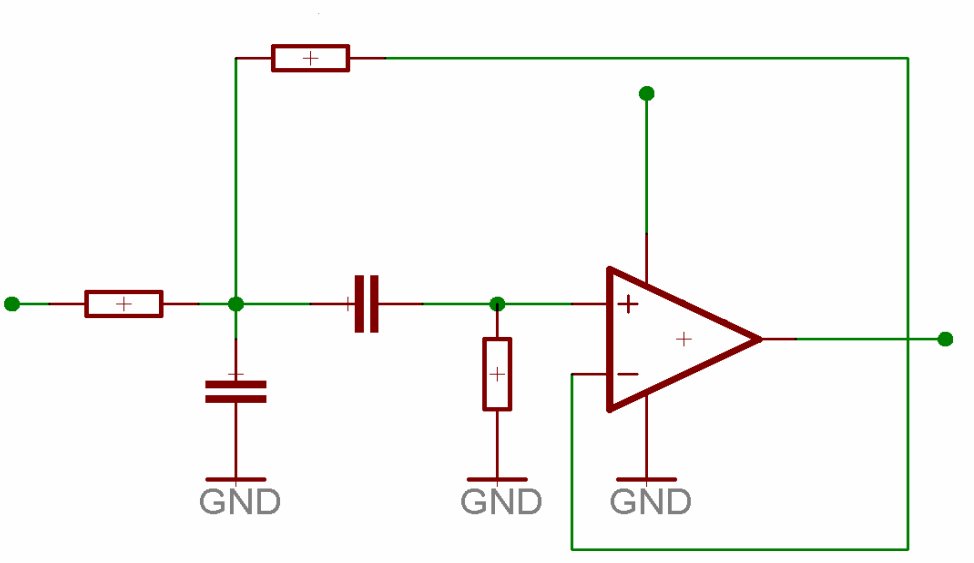


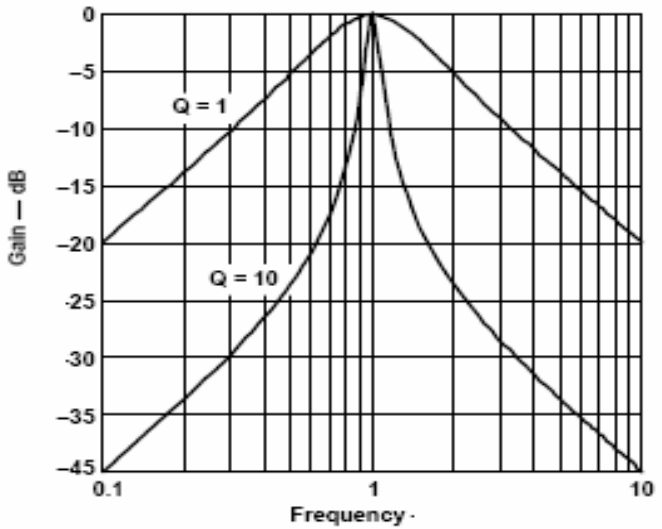


Band-Pass Filter

- Passes band of frequency.
- High Q – very selective filter.
- $$H(j\omega) = \frac{G_o B}{(j\omega)^2 + j\omega B + \omega_o^2}$$

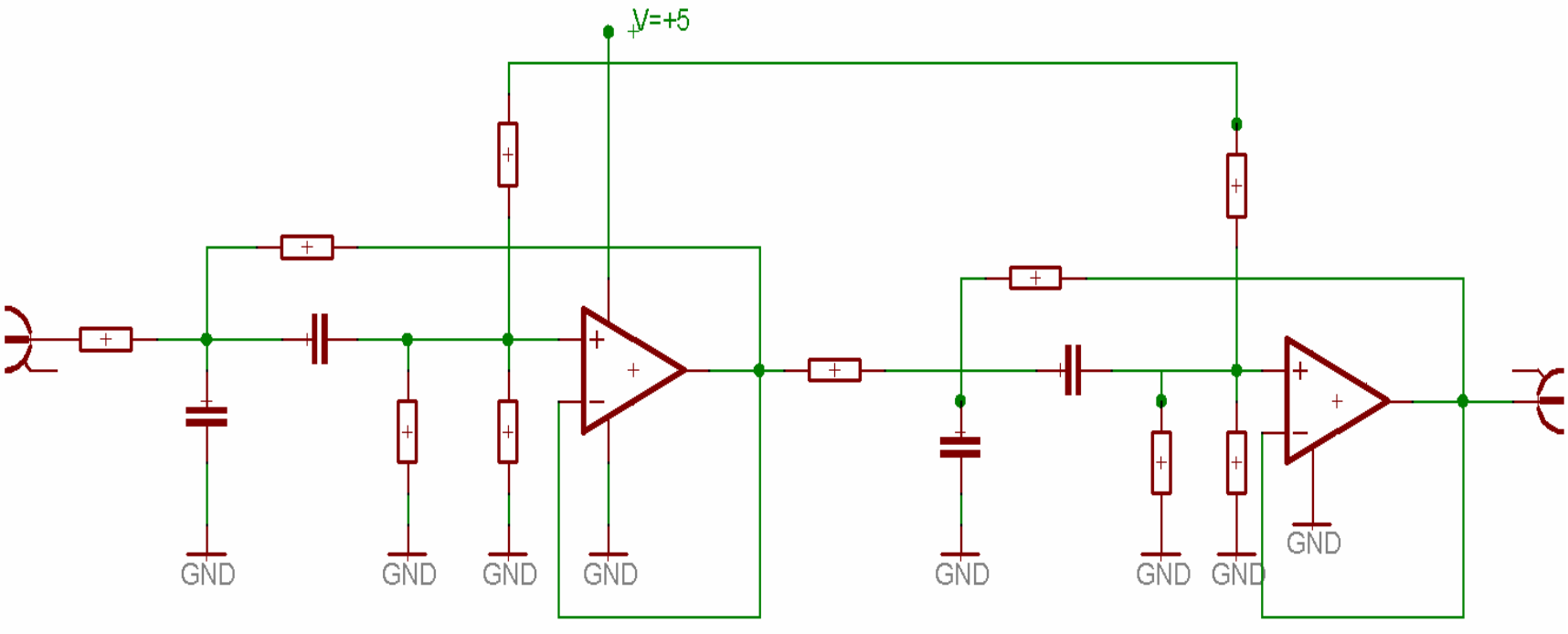




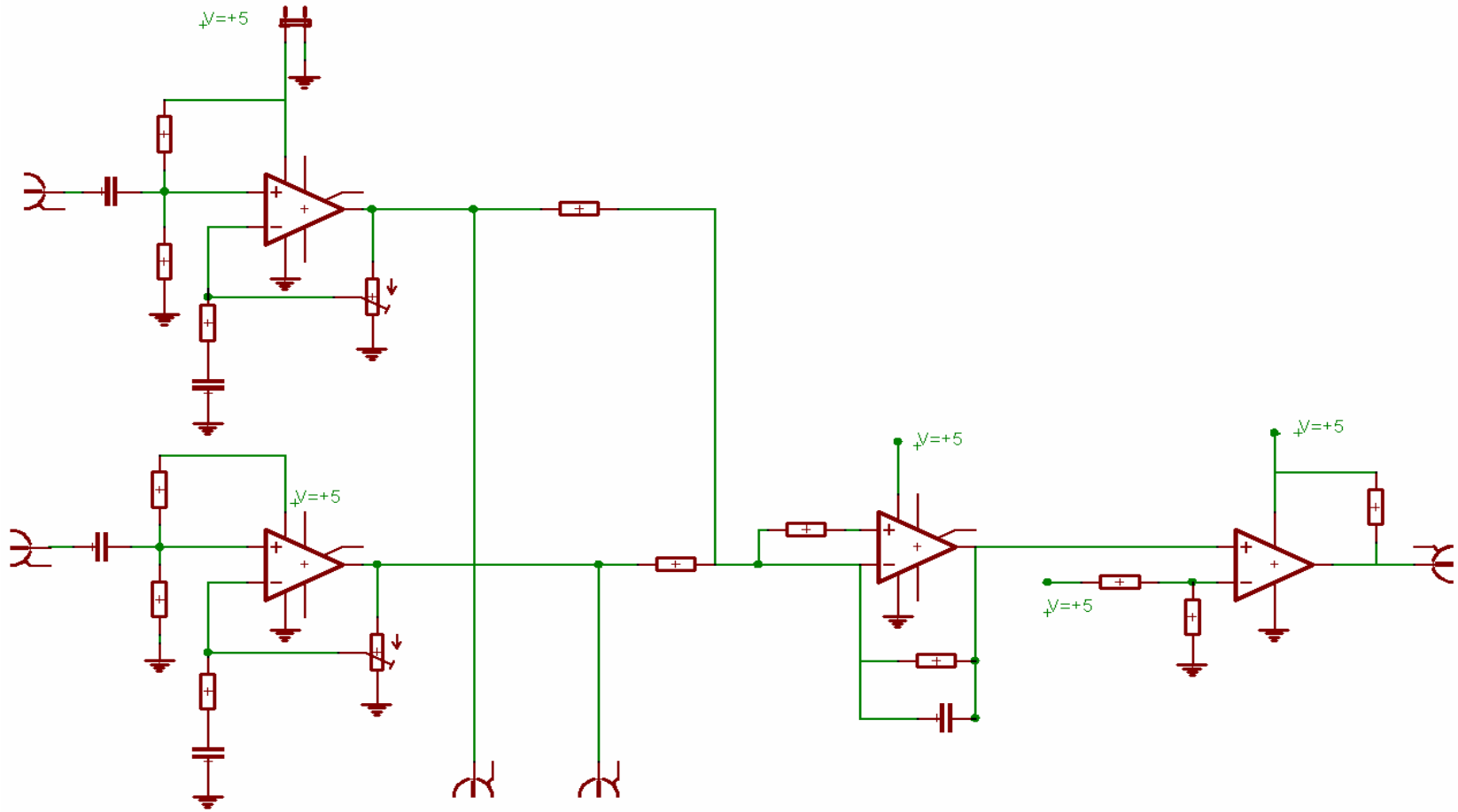


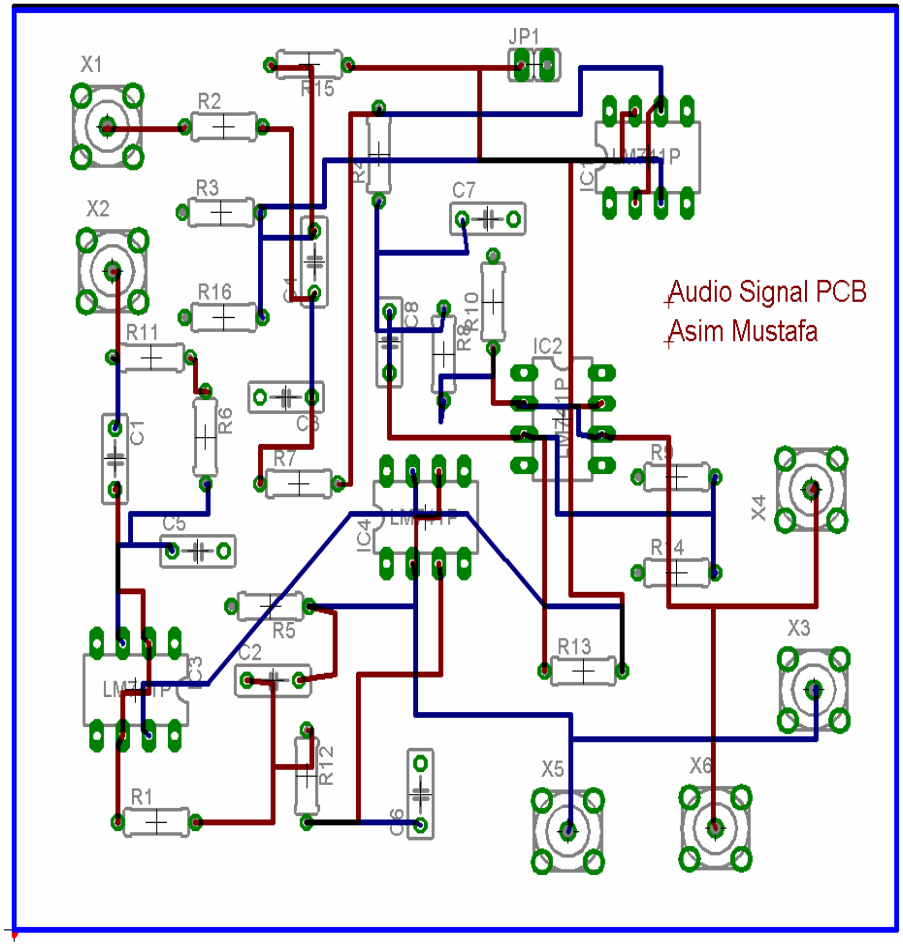
IF Filtering

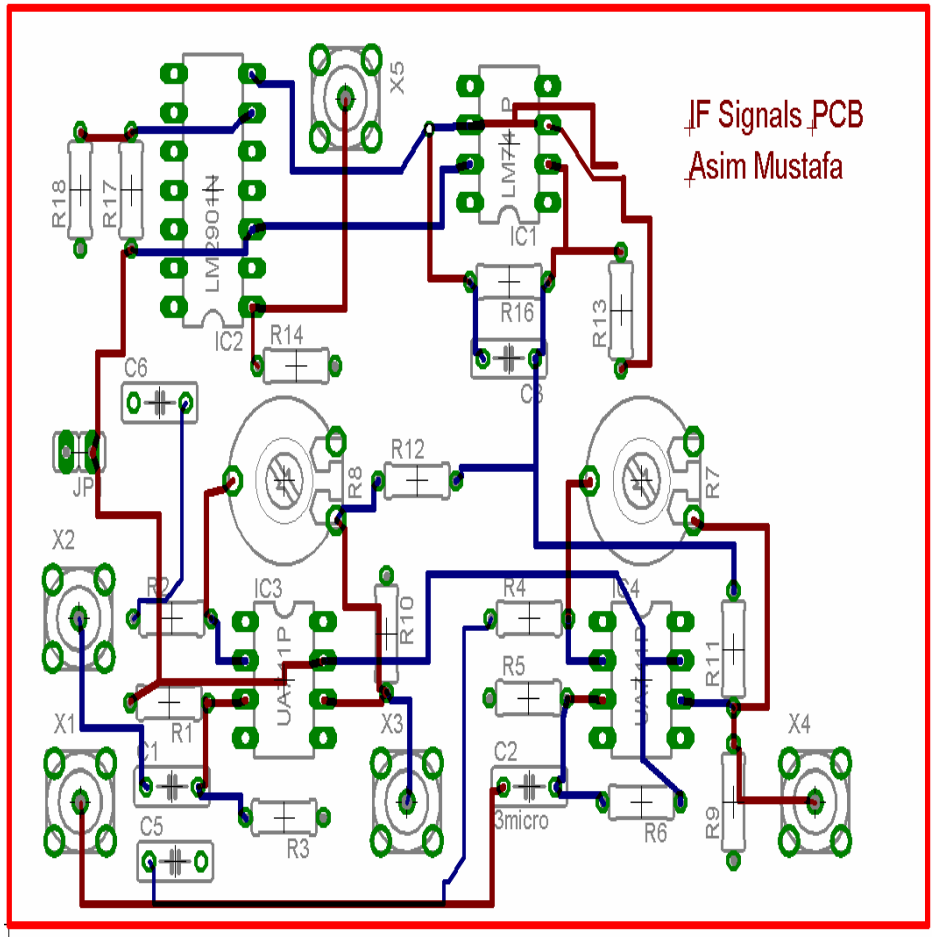
- Sallen-Key Topology.
- Unity Gain.
- 1KHz



Hardware Development




Audio Signal PCB
Asim Mustafa
JP1
X1
X2
X3
X4
X5
X6
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R15
R16
C1
C2
C3
C5
C6
C7
C8
IC2
IC3
IC4


IF Signals PCB
Asim Mustafa
X1
X2
X3
X4
X5
JP
R1
R2
R3
R4
R5
R6
R7
R8
R9
R10
R11
R12
R13
R14
R16
R17
R18
C1
C2
C5
C6
3micro
IC1
IC2
IC3
IC4
LM2904N

Conclusion

- PCB for processing the I/Q signals have been achieved.
- Tested for the funtional tests.
- Audio signals have been processed and signal can be heared.
- Undesired frequencies were attenuated.
- Topologies with less and cheap elements have been implemented.

Thank you for your attention!