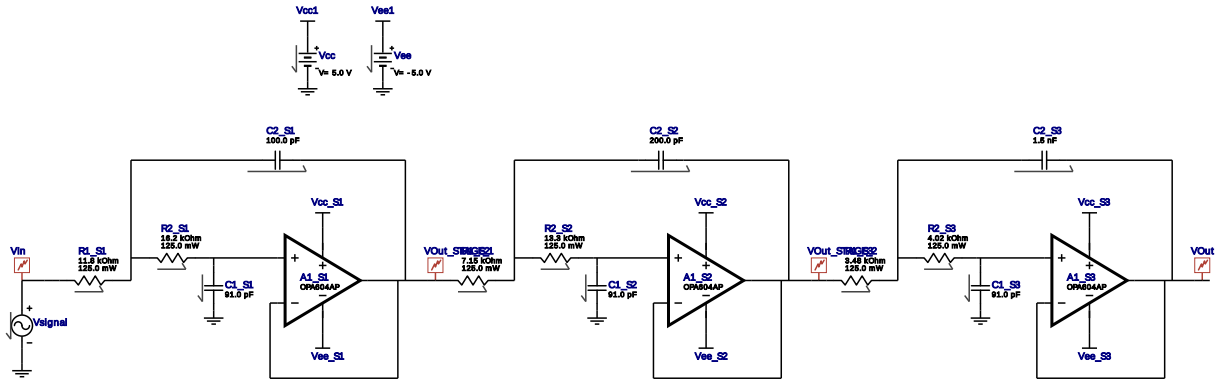
# WEBENCH® Electrical Simulation Report

Type : Lowpass
Response : Butterworth
Topology : Sallen_Key
Order : 6
Stage Qty : 3

Device = OPA604AP
Topology = Custom LP Filter
Created = 2/9/15 4:36:07 AM
User ID = 1198965
Design Id = 11
eSim Id = 1
Simulation Type = Closed Loop Freq Response



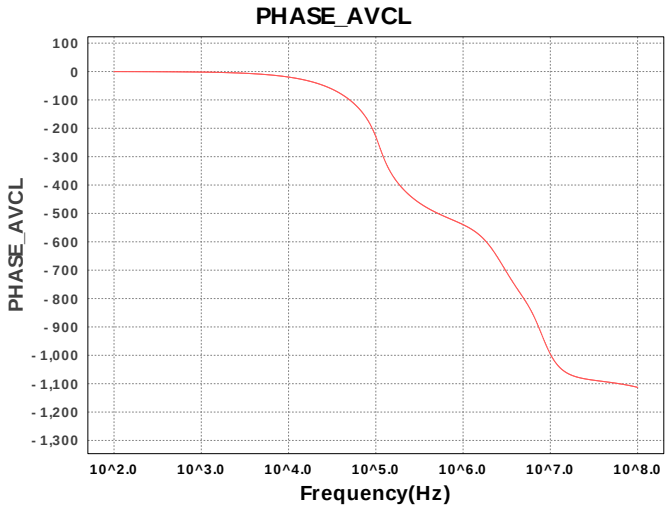

## Electrical BOM

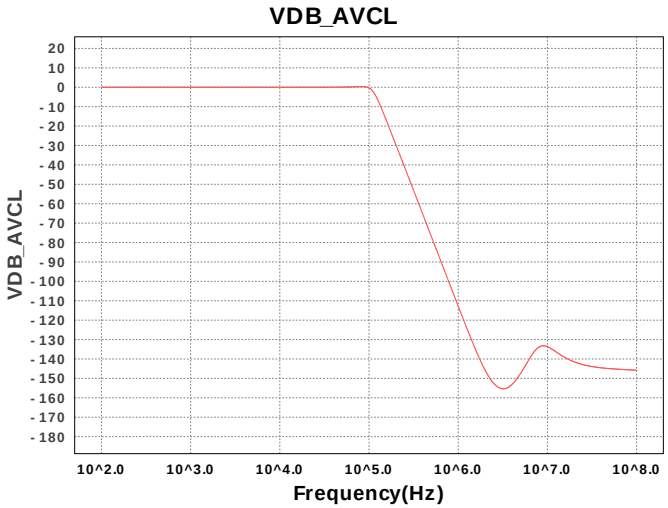
| # | Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|---|---|---|---|---|---|---|---|
| 1. | A1_S1 | Texas Instruments | OPA604AP | GbwTyp= 20.0 MHz<br>VccMin= 9.0 V<br>VccMax= 48.0 V | 1 | $1.05 | DIP 0 mm$^2$ |
| 2. | A1_S2 | Texas Instruments | OPA604AP | GbwTyp= 20.0 MHz<br>VccMin= 9.0 V<br>VccMax= 48.0 V | 1 | $1.05 | DIP 0 mm$^2$ |
| 3. | A1_S3 | Texas Instruments | OPA604AP | GbwTyp= 20.0 MHz<br>VccMin= 9.0 V<br>VccMax= 48.0 V | 1 | $1.05 | DIP 0 mm$^2$ |
| 4. | C1_S1 | Samsung Electro-Mechanics | CL05C910JB5NCNC<br>Series= C0G | Cap= 91.0 pF<br>VDC= 50.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0402 3 mm$^2$ |
| 5. | C1_S2 | Samsung Electro-Mechanics | CL05C910JB5NCNC<br>Series= C0G | Cap= 91.0 pF<br>VDC= 50.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0402 3 mm$^2$ |
| 6. | C1_S3 | Samsung Electro-Mechanics | CL05C910JB5NCNC<br>Series= C0G | Cap= 91.0 pF<br>VDC= 50.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0402 3 mm$^2$ |
| 7. | C2_S1 | Kemet | C0402C101J5GACTU<br>Series= C0G | Cap= 100.0 pF<br>VDC= 50.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0402 3 mm$^2$ |
| 8. | C2_S2 | Samsung Electro-Mechanics | CL05C201JB5NNNC<br>Series= C0G | Cap= 200.0 pF<br>VDC= 50.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0402 3 mm$^2$ |
| 9. | C2_S3 | AVX | 04025A151JAT2A<br>Series= C0G | Cap= 1.5 nF<br>VDC= 50.0 V<br>IRMS= 0.0 A | 1 | $0.02 | 0402 3 mm$^2$ |
| 10. | R1_S1 | Panasonic | ERJ-6ENF1182V<br>Series= 225 | Res= 11.8 kOhm<br>Power= 125.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0805 7 mm$^2$ |
| 11. | R1_S2 | Panasonic | ERJ-6ENF7151V<br>Series= 225 | Res= 7.15 kOhm<br>Power= 125.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0805 7 mm$^2$ |
| 12. | R1_S3 | Panasonic | ERJ-6ENF3481V<br>Series= 225 | Res= 3.48 kOhm<br>Power= 125.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0805 7 mm$^2$ |
| 13. | R2_S1 | Panasonic | ERJ-6ENF1622V<br>Series= 225 | Res= 16.2 kOhm<br>Power= 125.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0805 7 mm$^2$ |

| # | Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|---|---|---|---|---|---|---|---|
| 14. | R2_S2 | Panasonic | ERJ-6ENF1332V<br>Series= 225 | Res= 13.3 kOhm<br>Power= 125.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0805 7 mm$^2$ |
| 15. | R2_S3 | Panasonic | ERJ-6ENF4021V<br>Series= 225 | Res= 4.02 kOhm<br>Power= 125.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0805 7 mm$^2$ |

## Simulation Parameters

| # | Name | Parameter Name | Description | Values |
|---|---|---|---|---|
| 1. | Vsignal | AC<br>DC | AC Voltage Source Amplitude<br>AC Voltage Source DC Offset | 1 V<br>0.0 V |
| 2. | Vcc | V | Vcc Supply Rail Value | 5.0 V |
| 3. | Vee | V | Vee Supply Rail Value | -5.0 V |




## Design Inputs

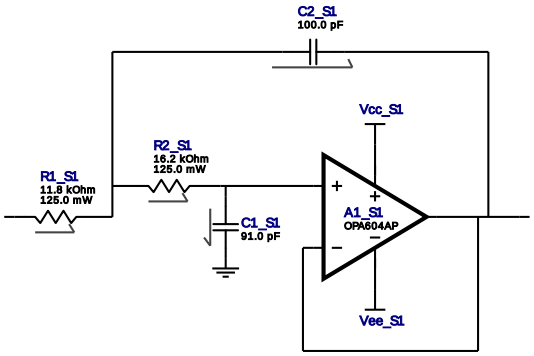
| # | Name | Value | Description |
|---|---|---|---|
| 1. | CapacitorTolerance | E24 | Capacitor series - 5 Passive capacitance tolerance |
| 2. | DualSupply | +/-5.0 V | Power supply(s) to active chips |
| 3. | FilterOrder | 6.0 | |
| 4. | FilterResponse | Butterworth | |
| 5. | FilterTopology | Sallen_Key | |
| 6. | FilterType | Lowpass | |
| 7. | Gain | 1.0 V/V | |
| 8. | NumberOfStages | 3.0 | |
| 9. | PassbandFrequency | 100.0 kHz | |
| 10. | ResistorTolerance | E96 | Resistor series - 1% Passive resistor tolerance |
| 11. | SeedCapacitance | 100.0 pF | Seed Capacitance to start design of filter |
| 12. | SettlingTimeErrorBand | 100.0 m% | Settling Time Error Band |
| 13. | SettlingTimeSpecification | 100.0 µsec | Settling Time Specification |
| 14. | StepResponseOvershootSpec | 20.0 % | Step Response Overshoot |
| 15. | StopbandAttenuation | -100.0 dB | |
| 16. | StopbandFrequency | 1000.0 kHz | |

## Design Assistance

1. **OPA604AP** Product Folder : http://www.ti.com//product/OPA604 : contains the data sheet and other resources.

# Filter Stage :1

| | |
|---|---|
| Cutoff Frequency | 100.0 kHz |
| Gain Bandwidth | 5.2 MHz |
| Stage Gain | 1.0 V/V |
| Stage Q | 520.0 m |
| Stage Topology | Sallen_Key |
| StageNo | 1.0 |

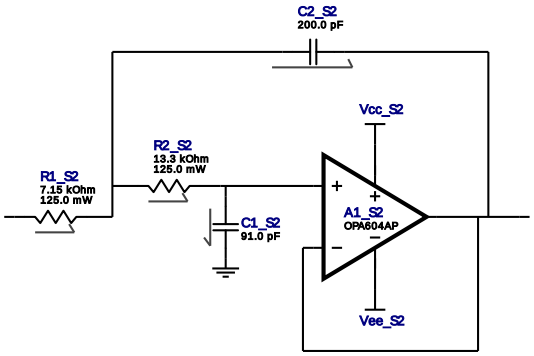



## Electrical BOM

| # | Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|---|---|---|---|---|---|---|---|
| 1. | A1_S1 | Texas Instruments | OPA604AP | GbwTyp= 20.0 MHz<br>VccMin= 9.0 V<br>VccMax= 48.0 V | 1 | $1.05 | DIP 0 mm² |
| 2. | C1_S1 | Samsung Electro-Mechanics | CL05C910JB5NCNC<br>Series= C0G | Cap= 91.0 pF<br>VDC= 50.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0402 3 mm² |
| 3. | C2_S1 | Kemet | C0402C101J5GACTU<br>Series= C0G | Cap= 100.0 pF<br>VDC= 50.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0402 3 mm² |
| 4. | R1_S1 | Panasonic | ERJ-6ENF1182V<br>Series= 225 | Res= 11.8 kOhm<br>Power= 125.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0805 7 mm² |
| 5. | R2_S1 | Panasonic | ERJ-6ENF1622V<br>Series= 225 | Res= 16.2 kOhm<br>Power= 125.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0805 7 mm² |

# Filter Stage :2

| | |
|---|---|
| Cutoff Frequency | 100.0 kHz |
| Gain Bandwidth | 7.1 MHz |
| Stage Gain | 1.0 V/V |
| Stage Q | 710.0 m |
| Stage Topology | Sallen_Key |
| StageNo | 2.0 |

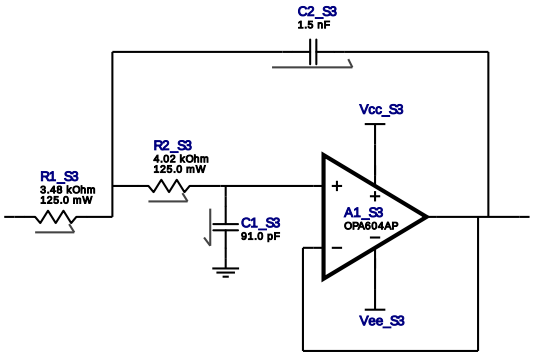



## Electrical BOM

| # | Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|---|---|---|---|---|---|---|---|
| 1. | A1_S2 | Texas Instruments | OPA604AP | GbwTyp= 20.0 MHz<br>VccMin= 9.0 V<br>VccMax= 48.0 V | 1 | $1.05 | DIP 0 mm² |
| 2. | C1_S2 | Samsung Electro-Mechanics | CL05C910JB5NCNC<br>Series= C0G | Cap= 91.0 pF<br>VDC= 50.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0402 3 mm² |
| 3. | C2_S2 | Samsung Electro-Mechanics | CL05C201JB5NNNC<br>Series= C0G | Cap= 200.0 pF<br>VDC= 50.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0402 3 mm² |
| 4. | R1_S2 | Panasonic | ERJ-6ENF7151V<br>Series= 225 | Res= 7.15 kOhm<br>Power= 125.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0805 7 mm² |
| 5. | R2_S2 | Panasonic | ERJ-6ENF1332V<br>Series= 225 | Res= 13.3 kOhm<br>Power= 125.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0805 7 mm² |

# Filter Stage :3

| | |
|---|---|
| Cutoff Frequency | 100.0 kHz |
| Gain Bandwidth | 19.3 MHz |
| Stage Gain | 1.0 V/V |
| Stage Q | 1.93 |
| Stage Topology | Sallen_Key |
| StageNo | 3.0 |




## Electrical BOM

| # | Name | Manufacturer | Part Number | Properties | Qty | Price | Footprint |
|---|---|---|---|---|---|---|---|
| 1. | A1_S3 | Texas Instruments | OPA604AP | GbwTyp= 20.0 MHz<br>VccMin= 9.0 V<br>VccMax= 48.0 V | 1 | $1.05 | DIP 0 mm² |
| 2. | C1_S3 | Samsung Electro-Mechanics | CL05C910JB5NCNC<br>Series= C0G | Cap= 91.0 pF<br>VDC= 50.0 V<br>IRMS= 0.0 A | 1 | $0.01 | 0402 3 mm² |
| 3. | C2_S3 | AVX | 04025A151JAT2A<br>Series= C0G | Cap= 1.5 nF<br>VDC= 50.0 V<br>IRMS= 0.0 A | 1 | $0.02 | 0402 3 mm² |
| 4. | R1_S3 | Panasonic | ERJ-6ENF3481V<br>Series= 225 | Res= 3.48 kOhm<br>Power= 125.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0805 7 mm² |
| 5. | R2_S3 | Panasonic | ERJ-6ENF4021V<br>Series= 225 | Res= 4.02 kOhm<br>Power= 125.0 mW<br>Tolerance= 1.0% | 1 | $0.01 | 0805 7 mm² |