Lab 7

1. Wien Bridge Oscillator

(a)

Frequency	Magnitude	phase
100 Hz	880 m V_{pp}	74.66°
500 Hz	2.8 V_{pp}	29.16°
1000 Hz	3.18 V_{pp}	3.84°
2000 Hz	2.96 V_{pp}	−18.91°
3000 Hz	2.56 V_{pp}	−35.76°
4000 Hz	2.16 V_{pp}	−48.46°
5000 Hz	1.84 V_{pp}	−51.36°
10 k Hz	1.04 V_{pp}	−70.44°
30 k Hz	400 m V_{pp}	−61.44°
20 k Hz	600 m V_{pp}	−78.05°

Cutoff is near 1K Hz, hence we are taking more measurements ⇒

⇒ 1.1 kHz	3.2 V_{pp}	316 m deg
1.2 kHz	3.2 V_{pp}	−4.5°
1103 Hz	3.2 V_{pp}	0 deg

At the cut-off frequency, the output voltage is maximum and the phase difference b/w the input and output is 0.

(b) Resonance Condition ⇒ $F_o = \frac{1}{2\pi RC}$ will have phase difference of 0°.

Oscillations ⇒ If loop gain $A\beta = 1$ then the circuit sustains oscillation.

(c) Cutoff frequency $= \frac{1}{2\pi RC} = 1.59$ kHz

$R = 10k\Omega$ $C = 10nF$

(d)

Measured frequency = 1.174 kHz

V_{pp} = 21 V

(e) at $R_1 = R_2 = 5k\Omega$

Measured frequency = 2.4 kHz

V_{pp} = 21.2 V

2. Sallen-Key Active Low-pass Filter

$F_c * FSF = \frac{1}{2\pi RC\sqrt{mn}}$

↓

frequency scaling factor

Quality factor $Q = \frac{\sqrt{mn}}{m+1}$

$F_c = 1$ kHz 1 V_{pp} input

(a) Butter worth $R_2 = 18.4\ K\Omega$ $C_1 = 0.01\ \mu F$

$R_1 = mR_2$ $C_2 = nC_1$

FSF = 1 $Q = \frac{1}{\sqrt{2}}$ $f_c = 1\ kHz$

$$10^3 \times 1 = \frac{1}{2\times\pi\times 18.4\times10^3\times 10\times10^{-9}\sqrt{mn}} \quad \text{——①}$$

$$\frac{1}{\sqrt{2}} = \frac{\sqrt{mn}}{m+1} \quad \text{——②}$$

from ① $\sqrt{mn} = 0.8649$

from ② $m+1 = \sqrt{2}(0.8649) \Rightarrow m = 0.22325$

$n = 3.3506$

$R_1 = 4.1078K$ $C_2 = nC_1 = 33.5\ nF$

frequency	magnitude	frequency	magnitude
10 Hz	1.048 V_{pp}	150 Hz	1.016 V_{pp}
50 Hz	1.048 V_{pp}	200 Hz	992 V_{pp}
100 Hz	1.04 V_{pp}	250 Hz	968 V_{pp}
500 Hz	856 mV_{pp}	300 Hz	960 V_{pp}
1000 Hz	536 mV_{pp}	350 Hz	928 V_{pp}
1.5 kHz	400 mV_{pp}	400 Hz	936 V_{pp}
2 kHz	272 mV_{pp}	450 Hz	904 V_{pp}
2.5 kHz	168 mV_{pp}		
3 kHz	112 mV_{pp}		
3.5 kHz	72 mV_{pp}		
4 kHz	96 mV_{pp}		
5k Hz	72 mV_{pp}		
7.5 kHz	48 mV_{pp}		
10 kHz	40 mV_{pp}		

(b) Chebyshev $R_2 = 7.32\ k\Omega$ $C_1 = 0.01\ \mu F$

FSF = 0.8414 Q = 1.3049

$$10^3 \times 0.8414 = \frac{1}{2\times\pi\times 7.32\times10^3\times10\times10^{-9}\times\sqrt{mn}} \quad \text{—①}$$

$$1.3049 = \frac{\sqrt{mn}}{m+1}$$

from ① $\sqrt{mn} = 2.584$

from ② $m+1 = \frac{2.584}{1.3049} \Rightarrow m = 0.98022$

$\Rightarrow n = 6.8177$

$\Rightarrow R_1 = 7.175\times10^3\ \Omega$

$C_2 = 68.177\ nF$

$R_2 = 7.32\ k\Omega$

$C_1 = 10nF$

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frequency	magnitude
50 Hz	1.016 V
100 Hz	1.024 V
150 Hz	1.040 V
200 Hz	1.054 V
250 Hz	1.088 V
300 Hz	1.112 V
350 Hz	1.144 V
400 Hz	1.184 V
450 Hz	1.216 V
500 Hz	1.256 V
1000 Hz	0.704 V
600 Hz	1.280 V
700 Hz	1.200 V
800 Hz	1.048 V
900 Hz	0.864 V
1500 Hz	0.304 V
2000 Hz	0.160 V
3000 Hz	0.080 V
3500 Hz	0.056 V
5000 Hz	0.032 V
7500 Hz	0.016 V
10 K Hz	0.008 V

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3. Multiple - feedback active band-pass filter

(a) $R_1 = 68\,k\Omega$ $R_2 = 180\,k\Omega$ $R_3 = 2.7\,k\Omega$

$C_1 = C_2 = 0.01\,\mu F$

(b) $F_o = \frac{1}{2\pi C}\sqrt{\frac{R_1+R_3}{R_1R_2R_3}}$ $C = C_1 = C_2$

$\text{Bandwidth} = \frac{F_o}{Q}$ $Q = \pi F_o C R_2$

$$F_o = \frac{1}{2\times\pi\times 10^{-8}\times\sqrt{\frac{(68+2.7)\times10^3}{68\times10^3\times2.7\times10^3\times180\times10^3}}}$$

$= 736.135\,Hz$

$$\text{Bandwidth} = \frac{F_o}{Q} = \frac{1}{\pi R_2 C_2} = 176.9285\,Hz$$

frequency	magnitude
50 Hz	80 mV_{pp}
100 Hz	100 mV_{pp}
150 Hz	152 mV_{pp}
200 Hz	208 mV_{pp}
250 Hz	240 mV_{pp}
300 Hz	312 mV_{pp}
350 Hz	400 mV_{pp}
400 Hz	576 mV_{pp}
450 Hz	800 mV_{pp}

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500 Hz	1.088 V
~~1000 Hz~~	~~896 mVpp~~
600 Hz	896 mVpp
700 Hz	568 mVpp
800 Hz	400 mVpp
900 Hz	328 mVpp
1000 Hz	272 mVpp
1500 Hz	160 mVpp
2000 Hz	104 mVpp
2500 Hz	96 mVpp
3000 Hz	80 mVpp
3500 Hz	64 mVpp
5000 Hz	56 mVpp
7500 Hz	40 mVpp
10 k Hz	40 mVpp

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