Sum of currents entering a node is zero (also holds for closed boundary)

$$\boxed{\sum_{n=1}^{N} i_n = 0 \qquad \text{(KCL)}}$$

Sum of voltages around a closed path is zero, or the sum of voltage drops is equal to the sum of voltage rises

$$\boxed{\sum_{n=1}^{N} v_n = 0 \qquad \text{(KVL)}}$$

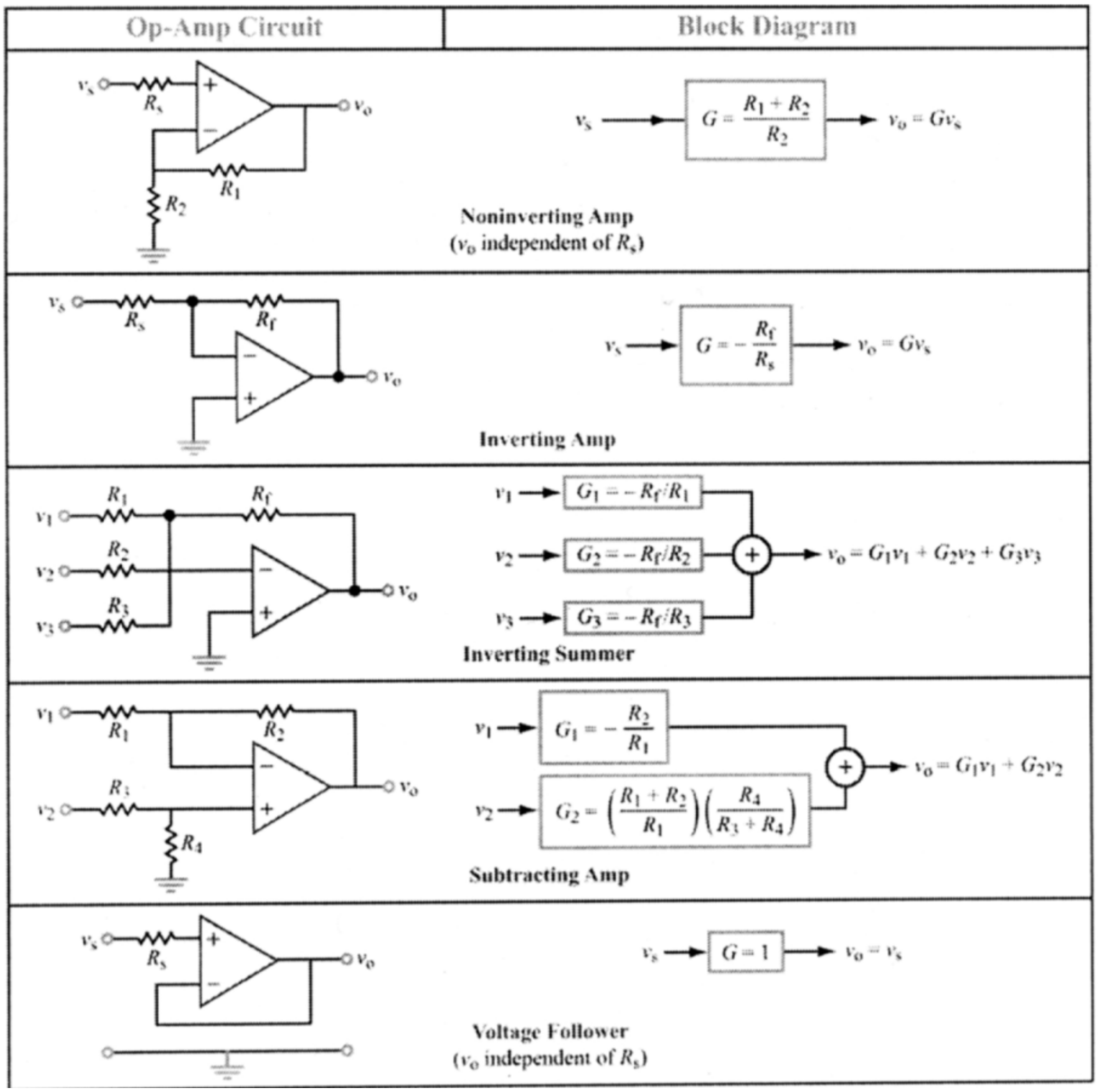

Figure 1: OpAmp Shortcuts

$$\boxed{i^1 = i \qquad i^2 = -1 \qquad i^3 = -i \qquad i^4 = 1}$$

Euler's Formula:

$$\boxed{e^{j\theta} = \cos(\theta) + j\sin(\theta)}$$

Amplitude: $\boxed{c = \sqrt{a^2 + b^2}}$, where:

$$\boxed{\begin{cases} a & = c\cos(\theta) \\ b & = c\sin(\theta) \end{cases}}$$

Important properties:

$$\boxed{a + jb = ce^{j\theta}}$$

$$\boxed{\tan(\theta) = \frac{b}{a}}$$

Rectangular Form:

$$\boxed{n = a + jb}$$

Polar Form:

$$\boxed{n = ce^{j\theta}}$$

Property	R	L	C
$i - v$ relation	$i = \frac{v}{R}$	$i = \frac{1}{L}\int_{t_0}^{t} v\,dt + i(t_0)$	$i = C\frac{dv}{dt}$
$v - i$ relation	$v = iR$	$v = L\frac{di}{dt}$	$v = \frac{1}{C}\int_{t_0}^{t} i\,dt + v(t_0)$
p (power transfer in)	$p = i^2R$	$p = Li\frac{di}{dt}$	$p = Cv\frac{dv}{dt}$
w (stored energy)	0	$w = \frac{1}{2}Li^2$	$w = \frac{1}{2}Cv^2$
Series Combination	$R_{eq} = R_1 + R_2$	$L_{eq} = L_1 + L_2$	$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$
Parallel Combination	$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$	$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2}$	$C_{eq} = C_1 + C_2$
DC Behavior	No change	Short circuit	Open circuit
Instantaneous v change?	Yes	Yes	No
Instantaneous i change?	Yes	No	Yes

$$\boxed{i(t) = I_\infty + (I_o - I_\infty)e^{-\frac{t}{\tau}}}$$

$$\boxed{v(t) = V_\infty + (V_o - V_\infty)e^{-\frac{t}{\tau}}}$$

	RC	RL
τ	RC	L/R

$$\boxed{p = P + P\cos(2\omega t) - Q\sin(2\omega t)}$$

Where:

Average Power:

$$\boxed{P = \frac{V_m I_m}{2}}$$

Reactive Power:

$$\boxed{P = \frac{V_m I_m}{2}}$$

Power Factor

$$= \cos(90 + \theta_v - \theta_i)$$

IF positive, power factor is leading
IF negative, power factor is lagging

Maximum power transfer occurs when the Thevnin impedance is equal to the conjugate of the load impedance

Fourier Series:

$$\boxed{f(t) = a_0 + \sum_{n=1}^{\infty} (a_n \cos(n\omega_0 t) + b_n \sin(n\omega_0 t))}$$

The coefficients of a Fourier series are:

$$\mathcal{F}\begin{cases} a_0 = \dfrac{1}{T}\displaystyle\int_0^T f(t)\,dt \\ a_k = \dfrac{2}{T}\displaystyle\int_0^T f(t)\cos(k\omega_0 t)\,dt \\ b_k = \dfrac{2}{T}\displaystyle\int_0^T f(t)\sin(k\omega_0 t)\,dt \end{cases}$$

For an even function ($f(t) = f(-t)$):

$$\mathcal{F}\begin{cases} a_0 = \dfrac{2}{T}\displaystyle\int_0^{\frac{T}{2}} f(t)\,dt \\ a_k = \dfrac{4}{T}\displaystyle\int_0^{\frac{T}{2}} f(t)\cos(k\omega_0 t)\,dt \\ b_k = 0 \end{cases}$$

For an odd function ($f(t) = -f(-t)$):

$$\mathcal{F}\begin{cases} a_0 = 0 \\ a_k = 0 \\ b_k = \dfrac{4}{T}\displaystyle\int_0^{\frac{T}{2}} f(t)\sin(k\omega_0 t)\,dt \end{cases}$$

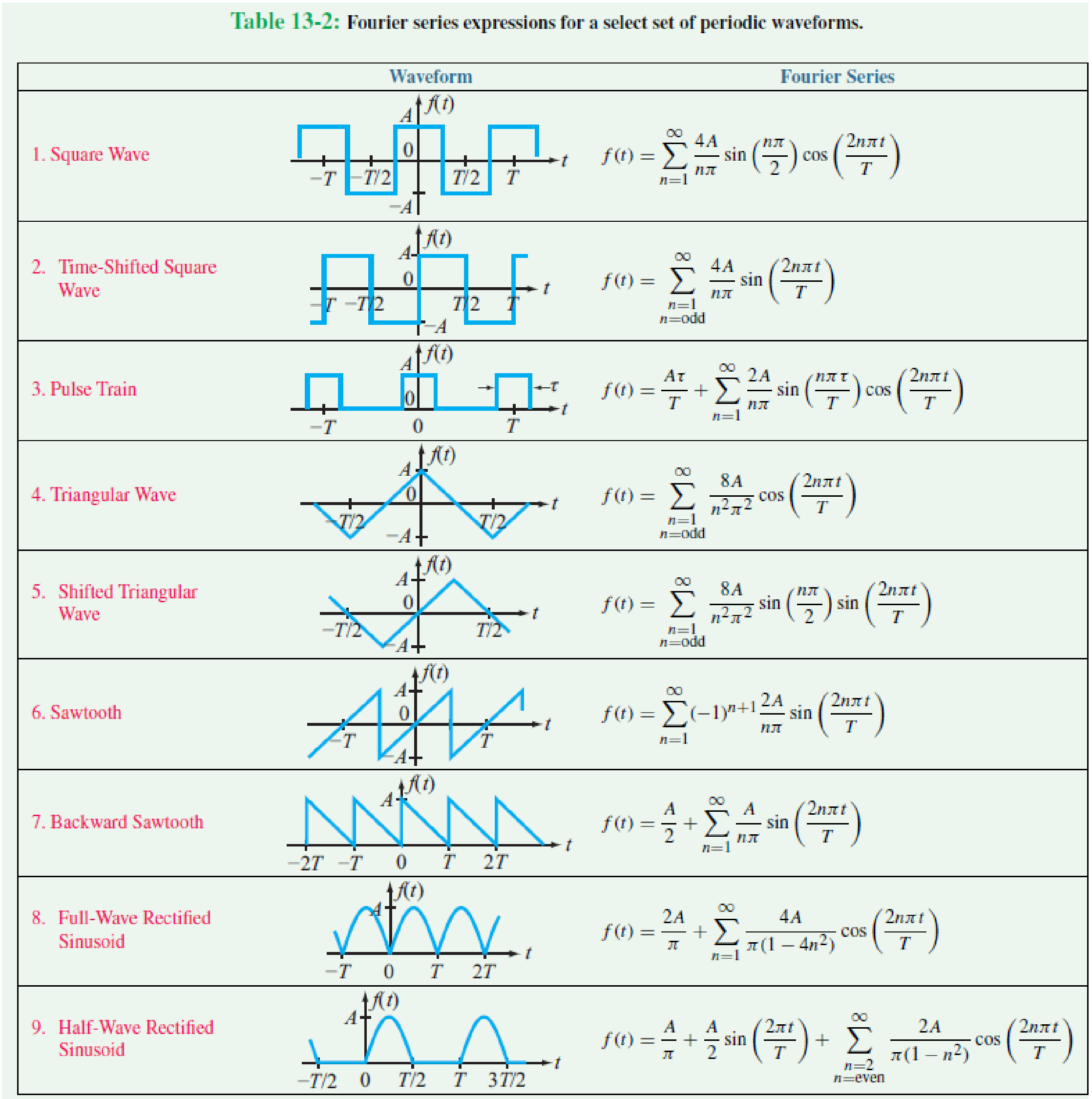

Table 13-2: Fourier series expressions for a select set of periodic waveforms.

Waveform	Fourier Series
1. Square Wave	$f(t) = \sum_{n=1}^{\infty} \frac{4A}{n\pi} \sin\left(\frac{n\pi}{2}\right) \cos\left(\frac{2n\pi t}{T}\right)$
2. Time-Shifted Square Wave	$f(t) = \sum_{\substack{n=1 \\ n=\text{odd}}}^{\infty} \frac{4A}{n\pi} \sin\left(\frac{2n\pi t}{T}\right)$
3. Pulse Train	$f(t) = \frac{A\tau}{T} + \sum_{n=1}^{\infty} \frac{2A}{n\pi} \sin\left(\frac{n\pi\tau}{T}\right) \cos\left(\frac{2n\pi t}{T}\right)$
4. Triangular Wave	$f(t) = \sum_{\substack{n=1 \\ n=\text{odd}}}^{\infty} \frac{8A}{n^2\pi^2} \cos\left(\frac{2n\pi t}{T}\right)$
5. Shifted Triangular Wave	$f(t) = \sum_{\substack{n=1 \\ n=\text{odd}}}^{\infty} \frac{8A}{n^2\pi^2} \sin\left(\frac{n\pi}{2}\right) \sin\left(\frac{2n\pi t}{T}\right)$
6. Sawtooth	$f(t) = \sum_{n=1}^{\infty} (-1)^{n+1} \frac{2A}{n\pi} \sin\left(\frac{2n\pi t}{T}\right)$
7. Backward Sawtooth	$f(t) = \frac{A}{2} + \sum_{n=1}^{\infty} \frac{A}{n\pi} \sin\left(\frac{2n\pi t}{T}\right)$
8. Full-Wave Rectified Sinusoid	$f(t) = \frac{2A}{\pi} + \sum_{n=1}^{\infty} \frac{4A}{\pi(1-4n^2)} \cos\left(\frac{2n\pi t}{T}\right)$
9. Half-Wave Rectified Sinusoid	$f(t) = \frac{A}{\pi} + \frac{A}{2} \sin\left(\frac{2\pi t}{T}\right) + \sum_{\substack{n=2 \\ n=\text{even}}}^{\infty} \frac{2A}{\pi(1-n^2)} \cos\left(\frac{2n\pi t}{T}\right)$

Figure 2: Common Fourier Series Table

The Fourier transform is written as:

$$F(\omega) = \mathcal{F}\{f(t)\} = \int_{-\infty}^{\infty} f(t)e^{-j\omega t}\, dt$$

The transforms below are with respect to $-\infty \leq t \leq \infty$, other boundaries must be recalculated

	$f(t)$	$F(\omega)$	
1	$e^{-at}u(t)$	$\dfrac{1}{a+j\omega}$	$a>0$
2	$e^{at}u(-t)$	$\dfrac{1}{a-j\omega}$	$a>0$
3	$e^{-a\lvert t\rvert}$	$\dfrac{2a}{a^2+\omega^2}$	$a>0$
4	$te^{-at}u(t)$	$\dfrac{1}{(a+j\omega)^2}$	$a>0$
5	$t^n e^{-at}u(t)$	$\dfrac{n!}{(a+j\omega)^{n+1}}$	$a>0$
6	$\delta(t)$	1	
7	1	$2\pi\delta(\omega)$	
8	$e^{j\omega_0 t}$	$2\pi\delta(\omega-\omega_0)$	
9	$\cos\omega_0 t$	$\pi[\delta(\omega-\omega_0)+\delta(\omega+\omega_0)]$	
10	$\sin\omega_0 t$	$j\pi[\delta(\omega+\omega_0)-\delta(\omega-\omega_0)]$	
11	$u(t)$	$\pi\delta(\omega)+\frac{1}{j\omega}$	
12	$\operatorname{sgn} t$	$\frac{2}{j\omega}$	
13	$\cos\omega_0 t\, u(t)$	$\frac{\pi}{2}[\delta(\omega-\omega_0)+\delta(\omega+\omega_0)]+\frac{j\omega}{\omega_0^2-\omega^2}$	
14	$\sin\omega_0 t\, u(t)$	$\frac{\pi}{2j}[\delta(\omega-\omega_0)-\delta(\omega+\omega_0)]+\frac{\omega_0}{\omega_0^2-\omega^2}$	
15	$e^{-at}\sin\omega_0 t\, u(t)$	$\frac{\omega_0}{(a+j\omega)^2+\omega_0^2}$	$a>0$
16	$e^{-at}\cos\omega_0 t\, u(t)$	$\frac{a+j\omega}{(a+j\omega)^2+\omega_0^2}$	$a>0$
17	$\operatorname{rect}\left(\frac{t}{\tau}\right)$	$\tau\operatorname{sinc}\left(\frac{\omega\tau}{2}\right)$	
18	$\frac{W}{\pi}\operatorname{sinc}(Wt)$	$\operatorname{rect}\left(\frac{\omega}{2W}\right)$	
19	$\Delta\left(\frac{t}{\tau}\right)$	$\frac{\tau}{2}\operatorname{sinc}^2\left(\frac{\omega\tau}{4}\right)$	
20	$\frac{W}{2\pi}\operatorname{sinc}^2\left(\frac{Wt}{2}\right)$	$\Delta\left(\frac{\omega}{2W}\right)$	
21	$\displaystyle\sum_{n=-\infty}^{\infty}\delta(t-nT)$	$\displaystyle\omega_0\sum_{n=-\infty}^{\infty}\delta(\omega-n\omega_0)$	$\omega_0=\frac{2\pi}{T}$
22	$e^{-t^2/2\sigma^2}$	$\sigma\sqrt{2\pi}e^{-\sigma^2\omega^2/2}$	

Figure 3: Table of Common Fourier Transforms

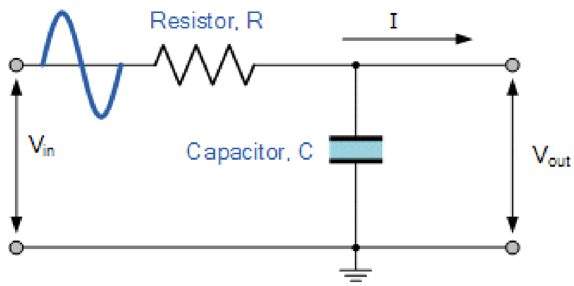

Figure 4: Passive Low Pass Filter $\left(f_c = \frac{1}{2\pi RC}\right)$

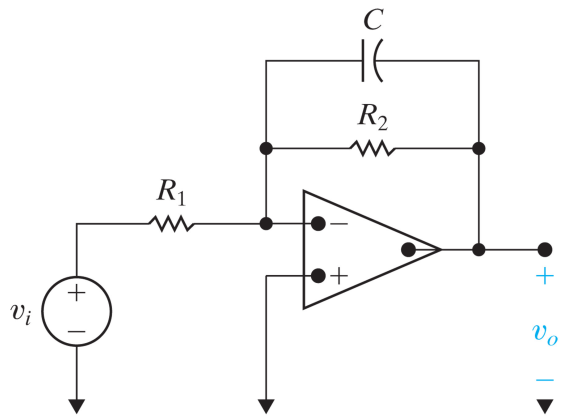

Figure 5: First Order Active Low Pass Filter

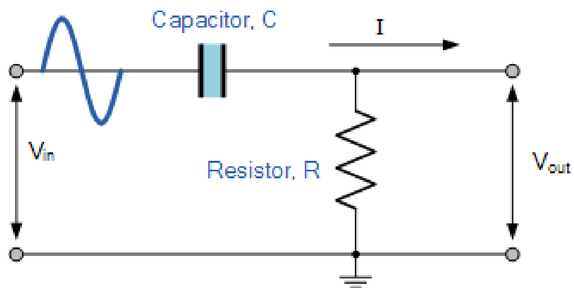

Figure 6: Passive High Pass Filter $\left(f_c = \frac{1}{2\pi RC}\right)$

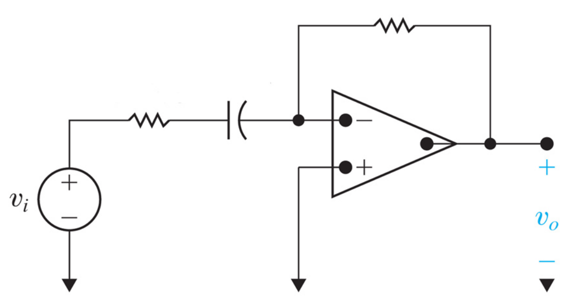

Figure 7: First Order Active High Pass Filter