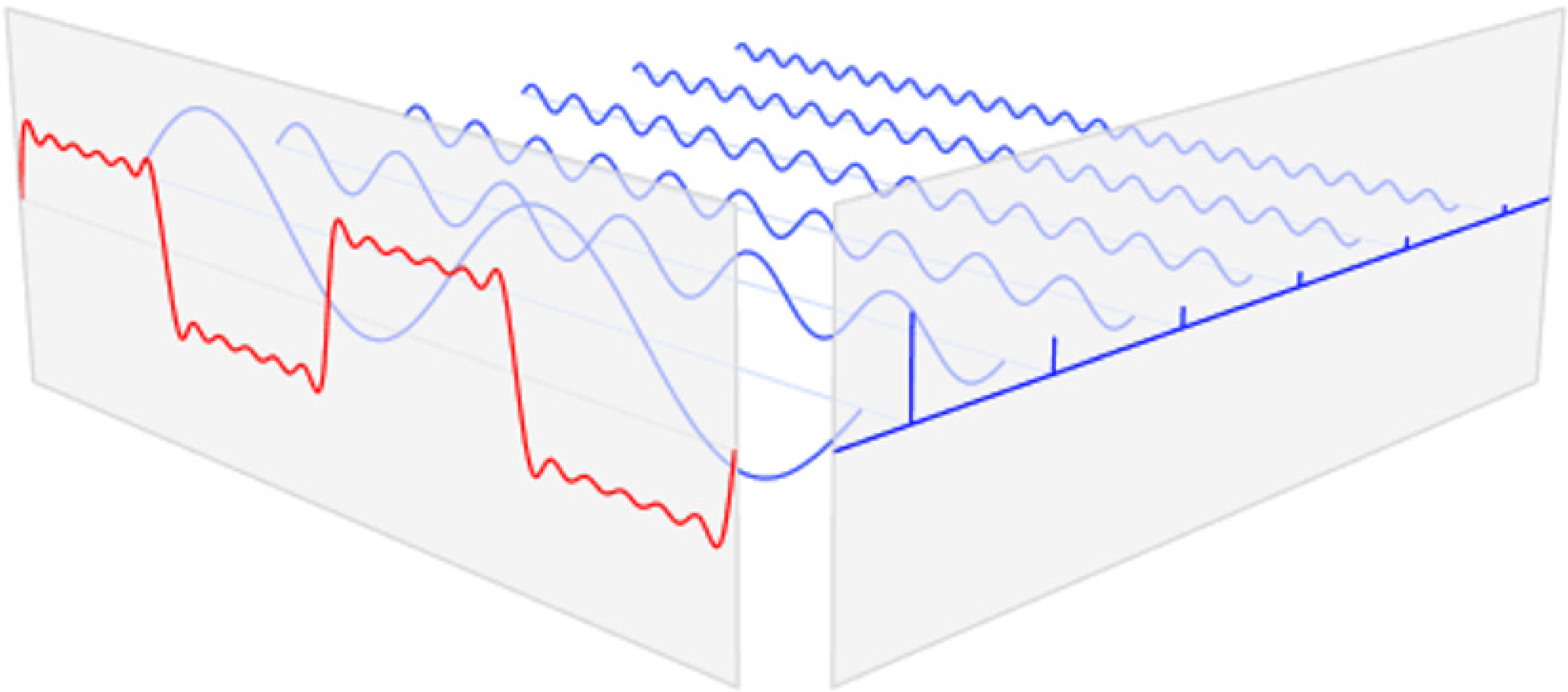
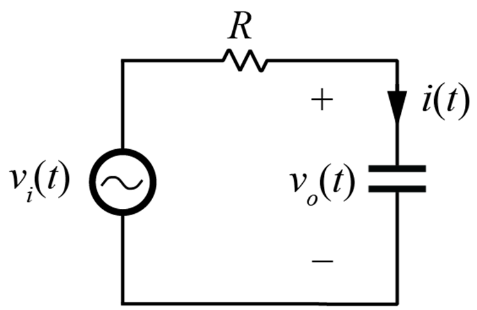
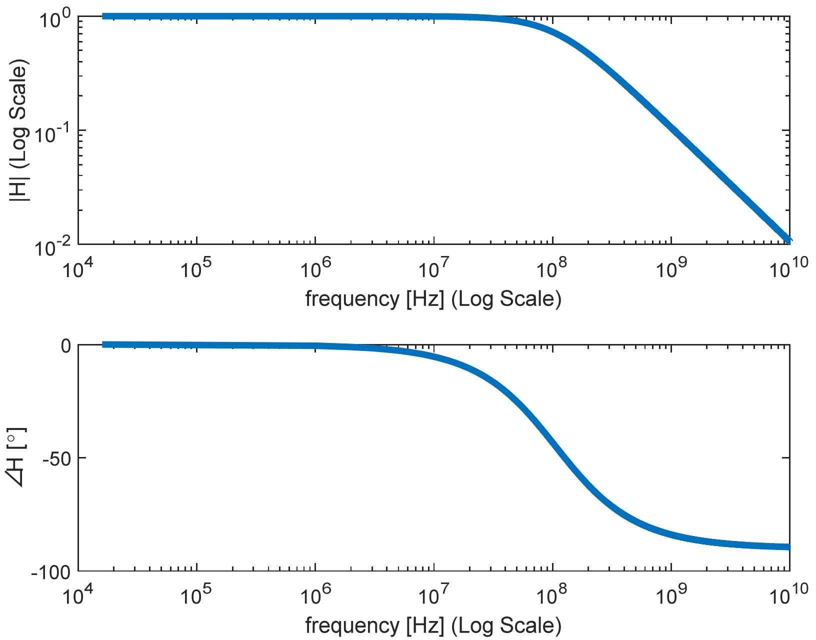
Fourier Series & Frequency Domain

Input Spectrum

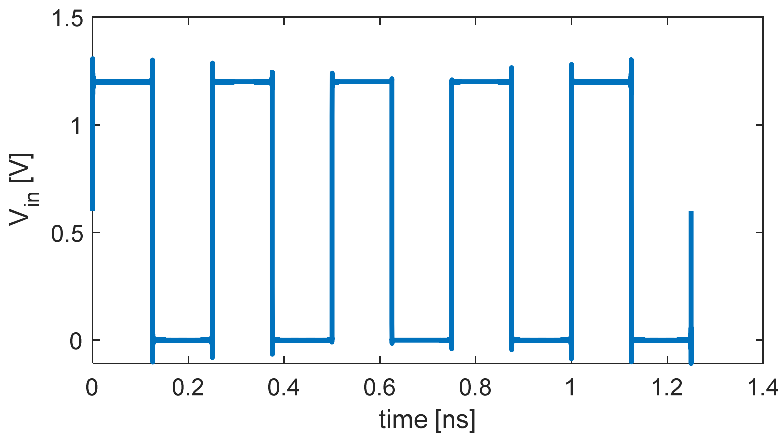


Application: Digital Communication

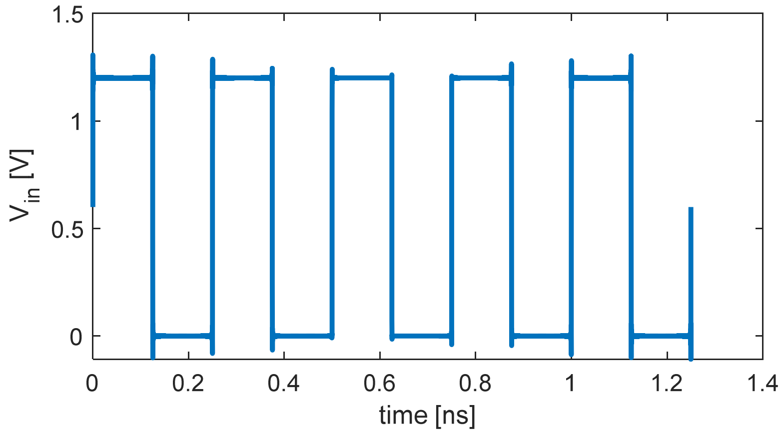


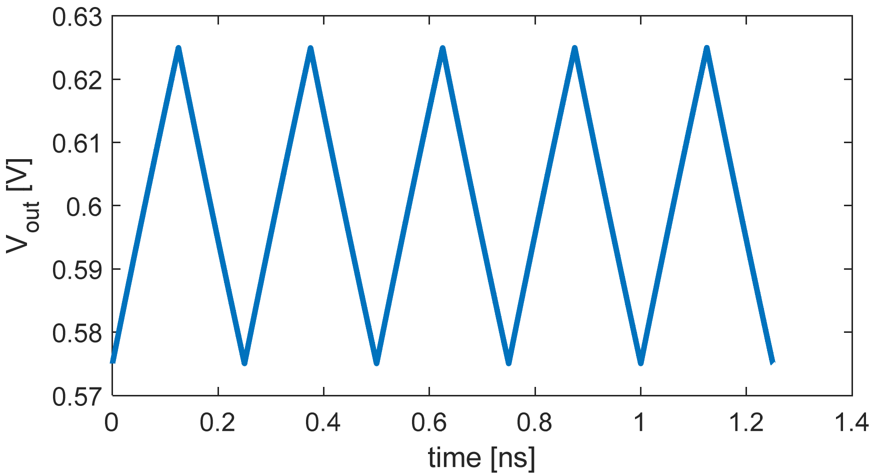


Applying Superposition

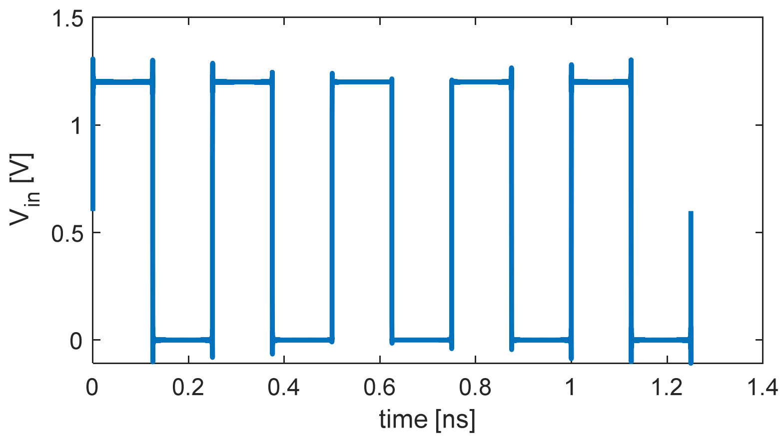


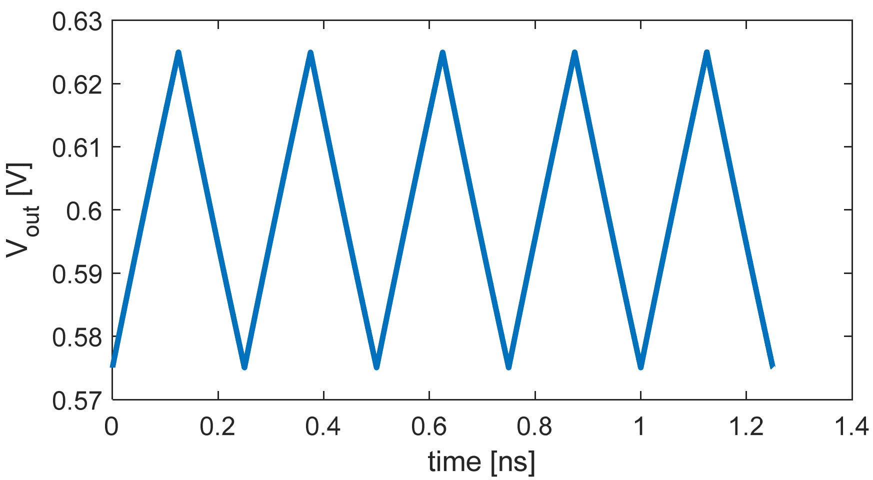
Calculated Output Voltage

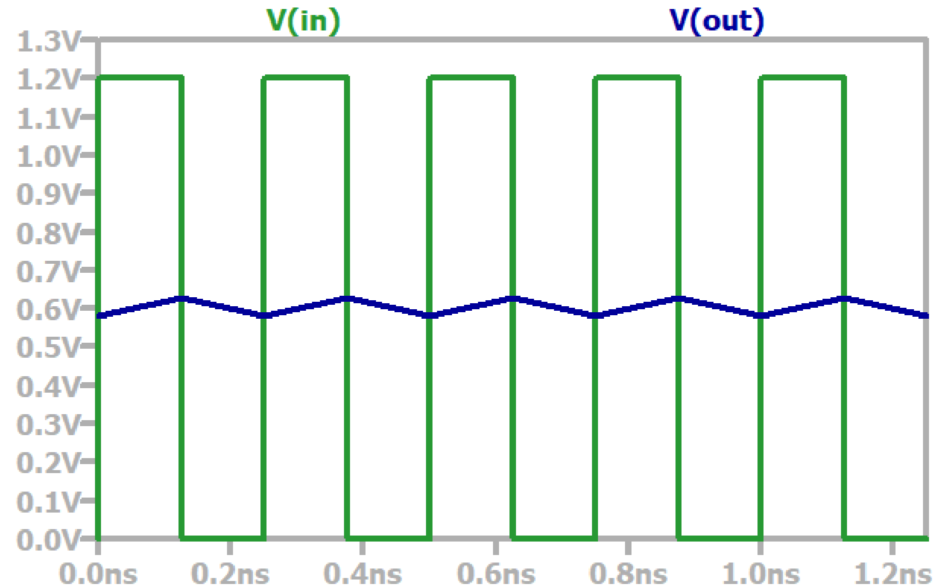


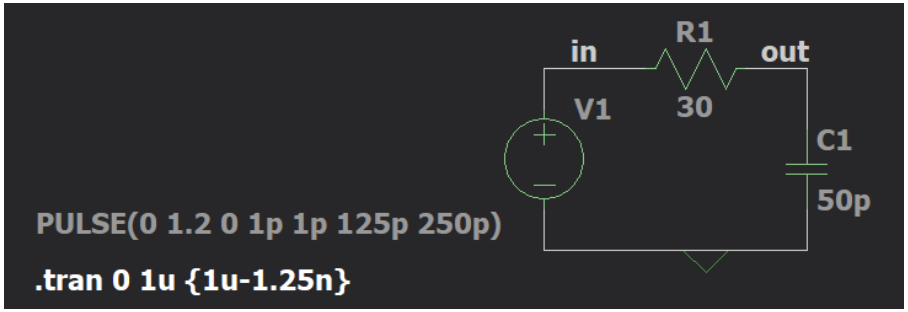


Simulation Verification

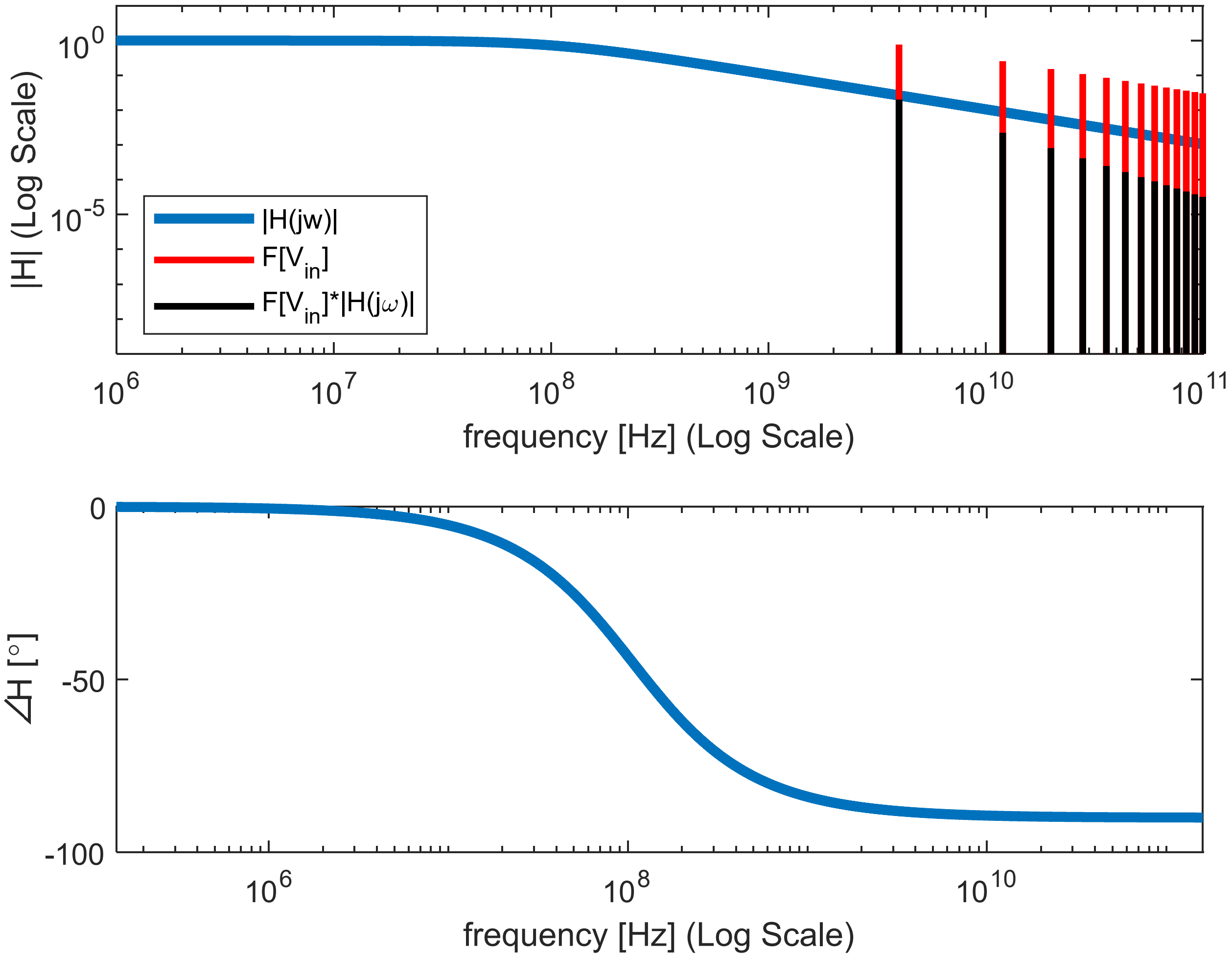


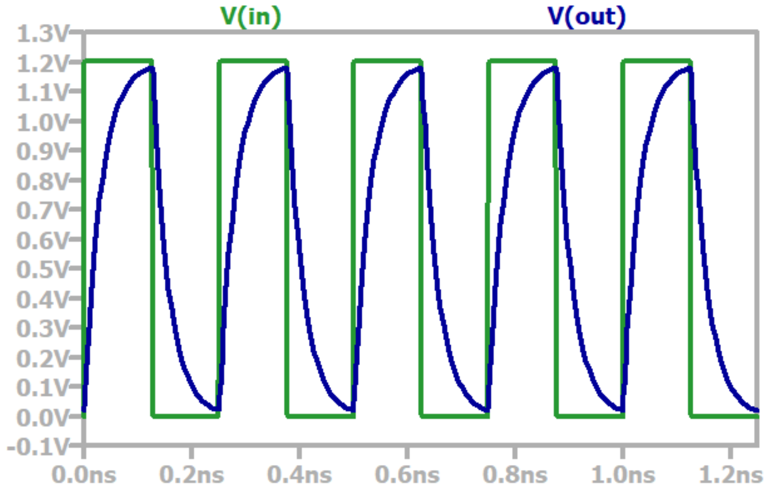


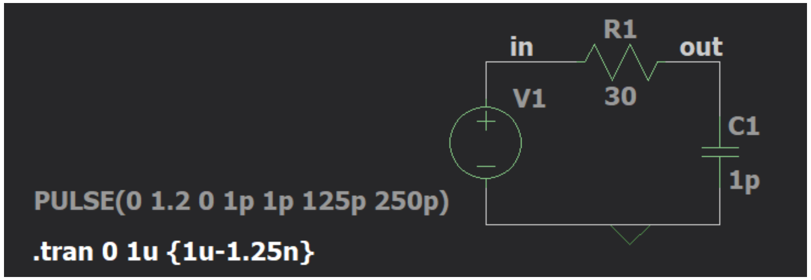




Frequency Domain Interpretation




V(in)
V(out)
1.3V
1.2V
1.1V
1.0V
0.9V
0.8V
0.7V
0.6V
0.5V
0.4V
0.3V
0.2V
0.1V
0.0V
-0.1V
0.0ns
0.2ns
0.4ns
0.6ns
0.8ns
1.0ns
1.2ns


R1
in
out
V1
30
C1
1p
PULSE(0 1.2 0 1p 1p 125p 250p)
.tran 0 1u {1u-1.25n}

Complex Form of Fourier Series

Fourier Series Representation

Assume we have some function $f(t)$ which is periodic with period $T_0 = \frac{2\pi}{\omega_0}$

$$f(t) = a_0 + \sum_{k=1}^{\infty} a_k \cos(k\omega_0 t) + b_k \sin(k\omega_0 t)$$

$$\boxed{a_k = \frac{2}{T_0}\int_{t_0}^{t_0+T_0} f(t)\cos(k\omega_0 t)\,dt}$$

$$\boxed{b_k = \frac{2}{T_0}\int_{t_0}^{t_0+T_0} f(t)\sin(k\omega_0 t)\,dt}$$

$f(t)$ can be expressed this way if

1. $f(t)$ is single-valued
2. $\int_{t_0}^{t_0+T_0} |f(t)|\,dt$ exists
3. $f(t)$ had finite discontinuities and max/min per period

Alternate forms

$$f(t) = a_0 + \sum_{k=1}^{\infty} A_k \cos(k\omega_0 t + \varphi_k) \quad \begin{cases} A_k = \sqrt{{a_k}^2 + {b_k}^2} \\ \varphi_k = \tan^{-1}\left(\frac{b_k}{a_k}\right) \end{cases}$$

$$f(t) = \sum_{k=-\infty}^{\infty} c_k e^{jk\omega_0 t} \quad \begin{cases} c_k = \frac{1}{2}(a_k - jb_k) \\ c_{-k} = \frac{1}{2}(a_k + jb_k) \\ c_0 = a_0 \end{cases}$$

$$\boxed{c_k = \frac{1}{T_0}\int_{t_0}^{t_0+T_0} f(t) e^{-jk\omega_0 t}\,dt}$$

Non-periodic Waveforms: Fourier Transform