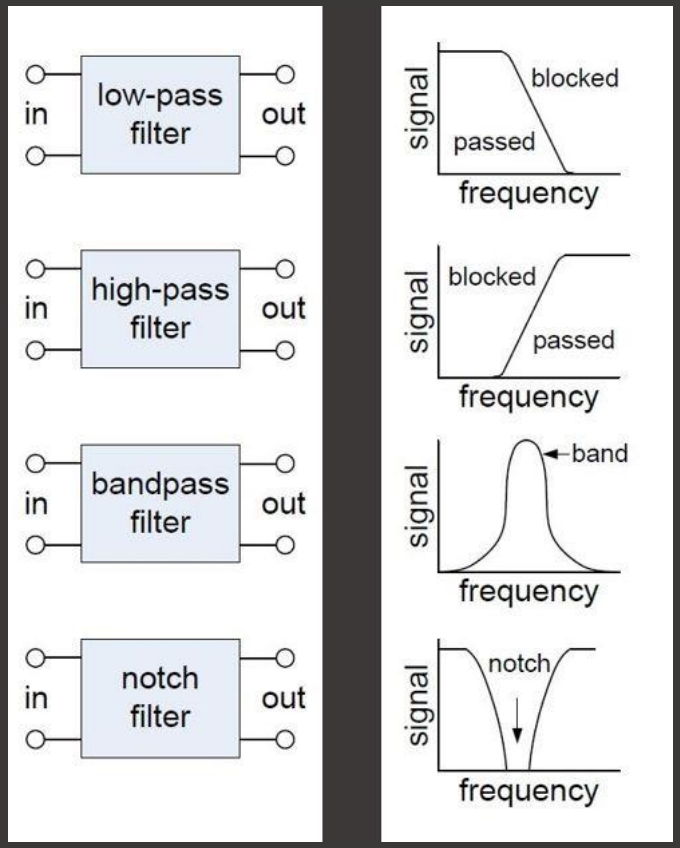
Filtering and Working in the Frequency Domain

Mar-2019



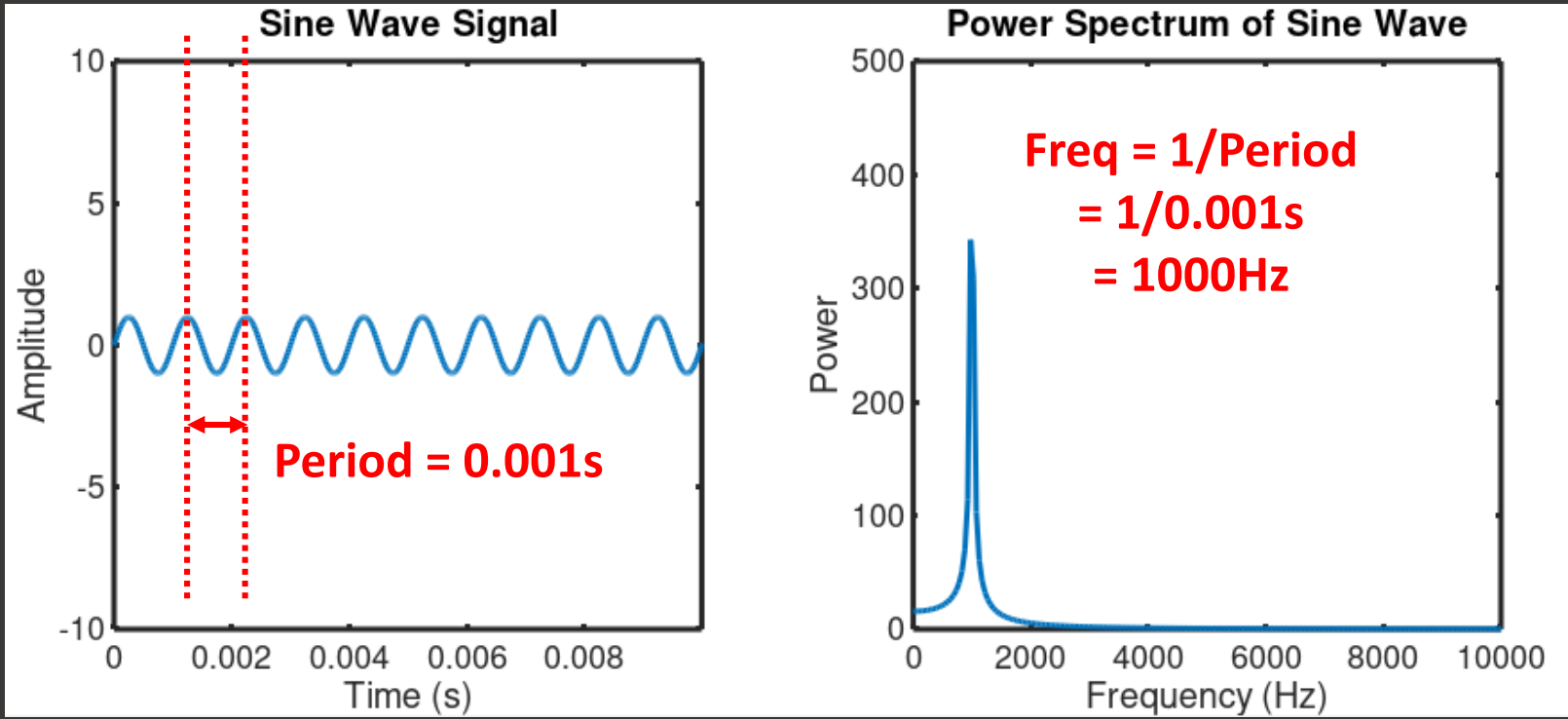
Tonight

1. Quick Review

2. Look at 38.5kHz PWM filter slides

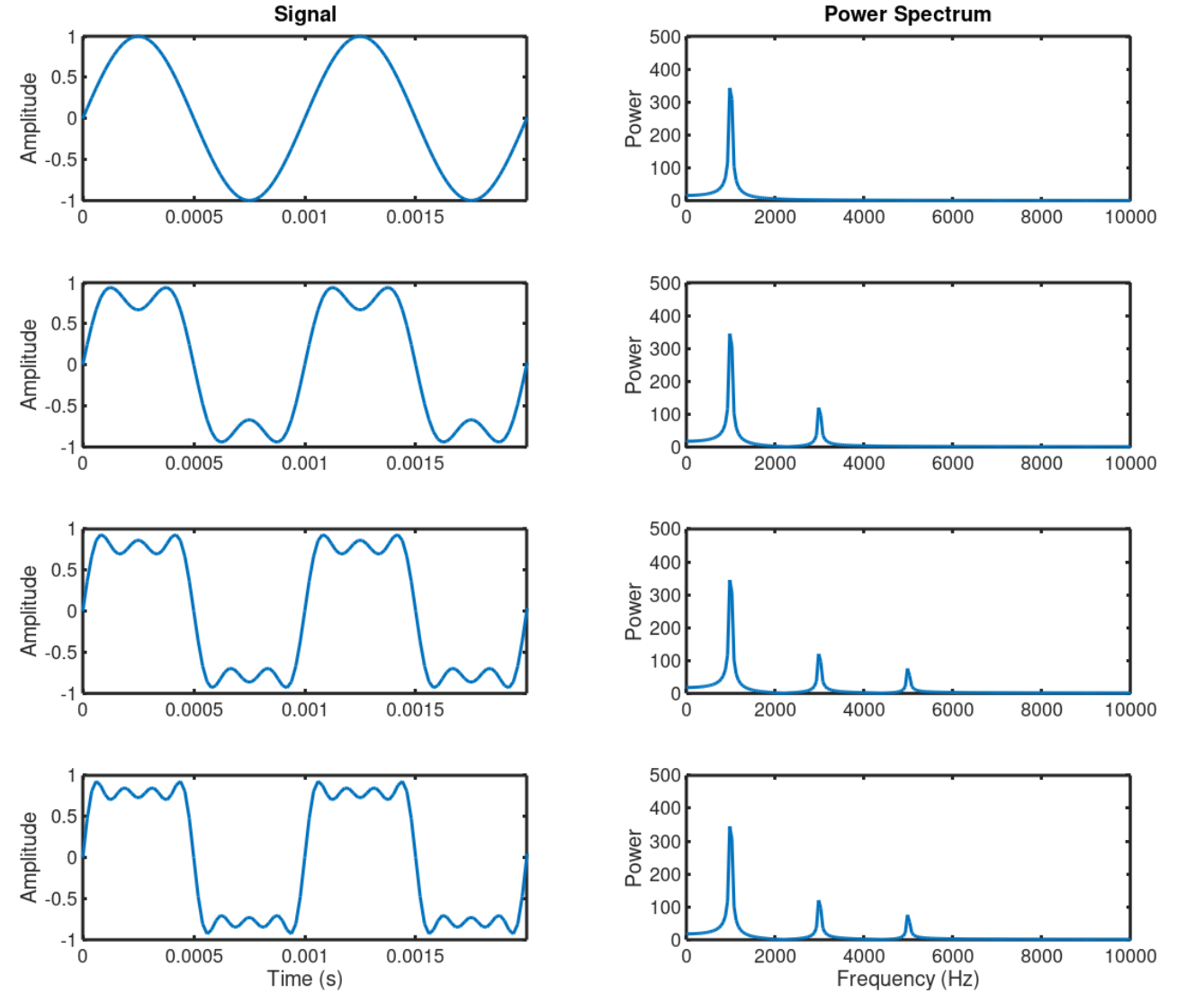
3. Breadboard/test filter

Time vs Frequency Domain

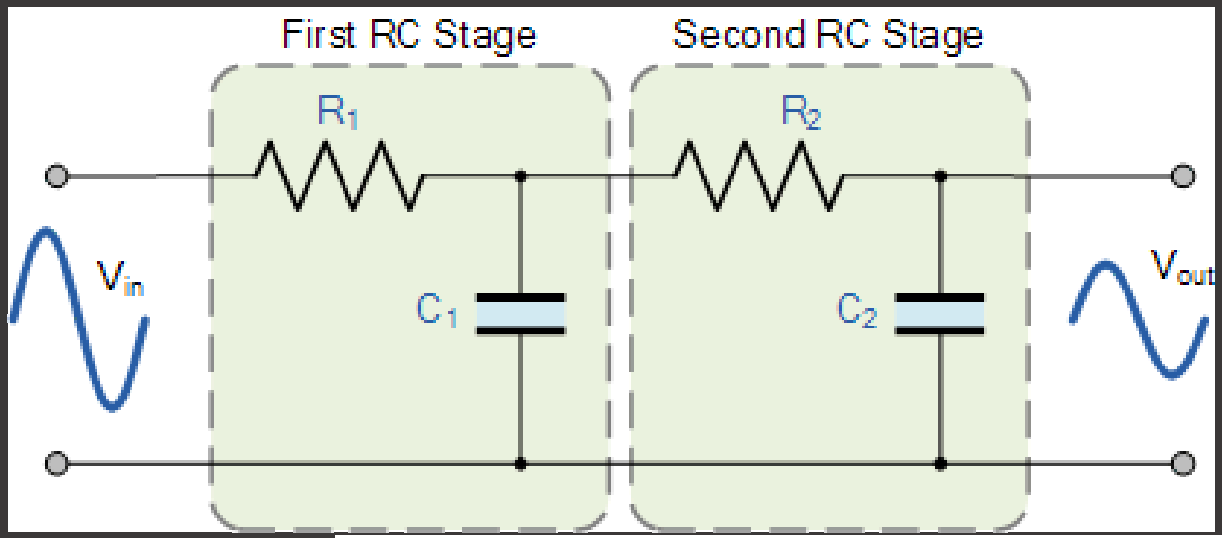


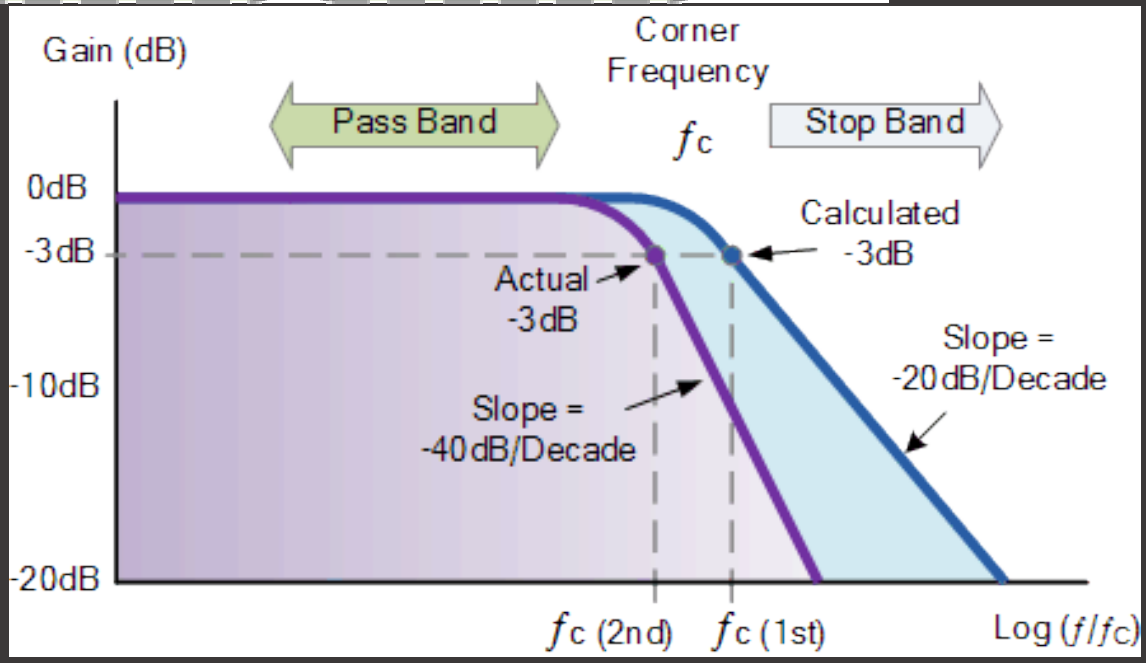
Frequency = 1 / Period

Square Wave = Odd Harmonics



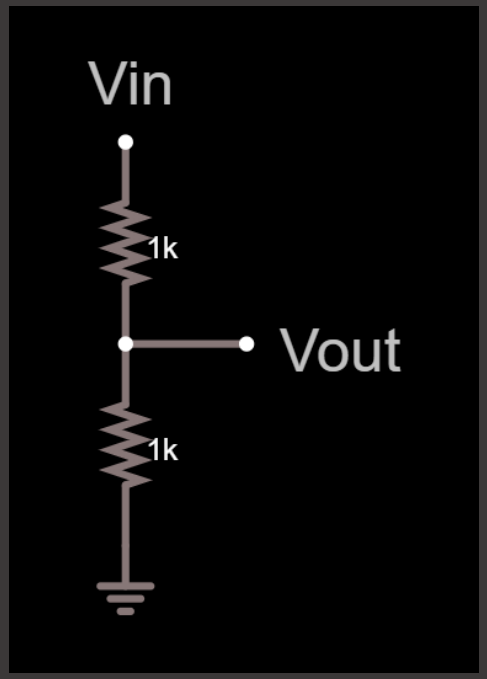
1st and 2nd Order Low Pass Filters



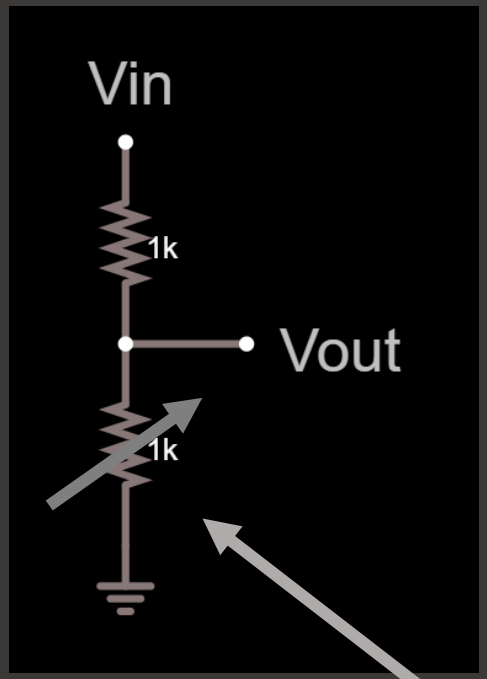


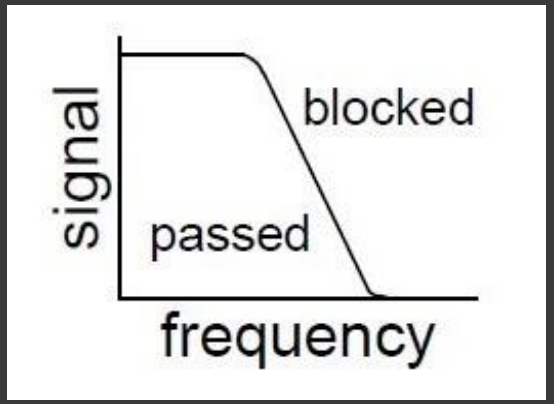
A Conceptual Low Pass Filter

All-pass



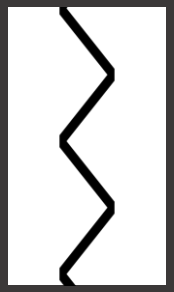
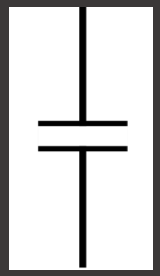
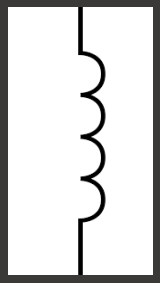
Low-pass



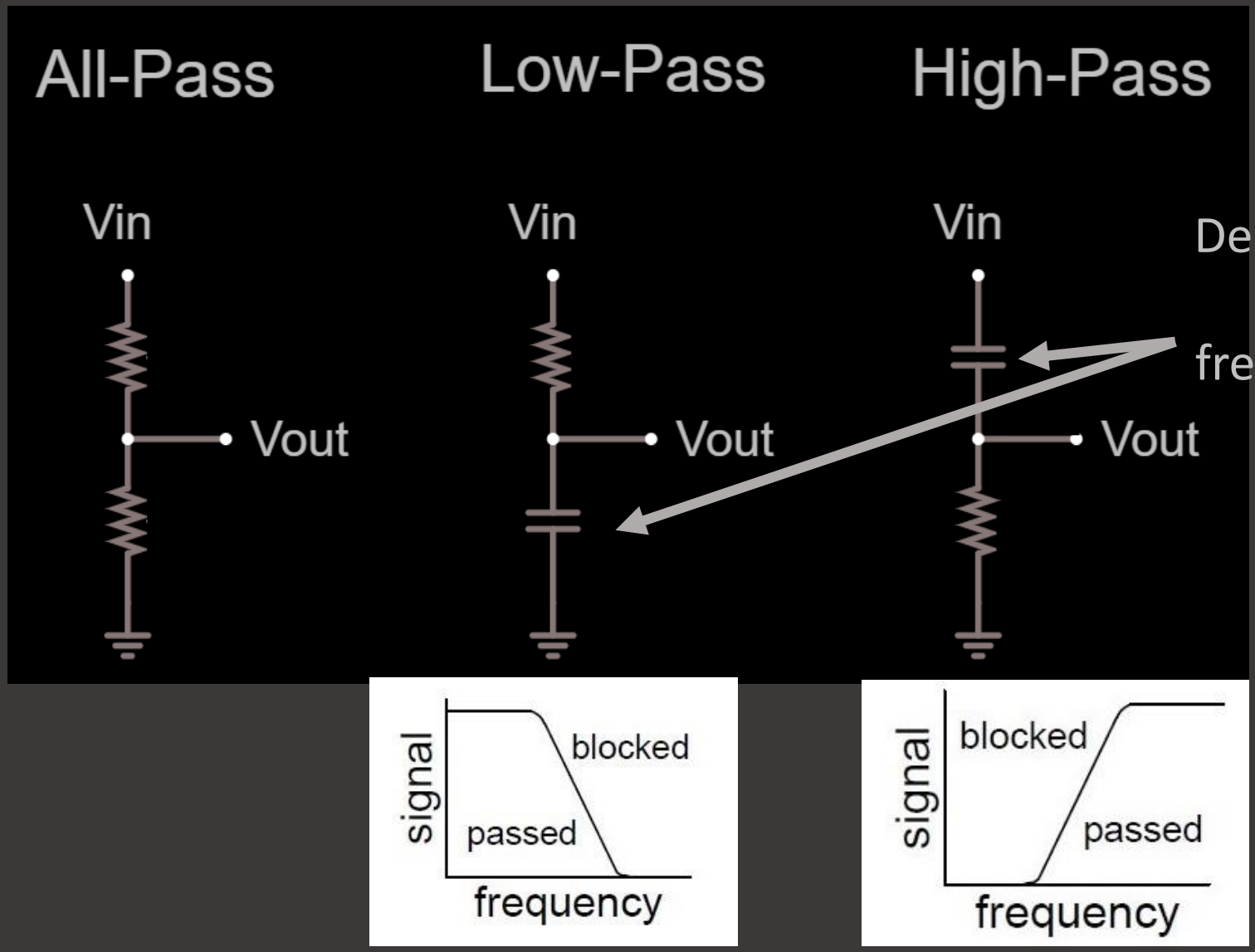


Decreases with frequency

RLC Components vs Frequency

	DC Resistance/ AC Reactance	Change w/ freq?
	R	=
	$X_C \propto \frac{-1}{fC}$	↓
	$X_L \propto fL$	↑

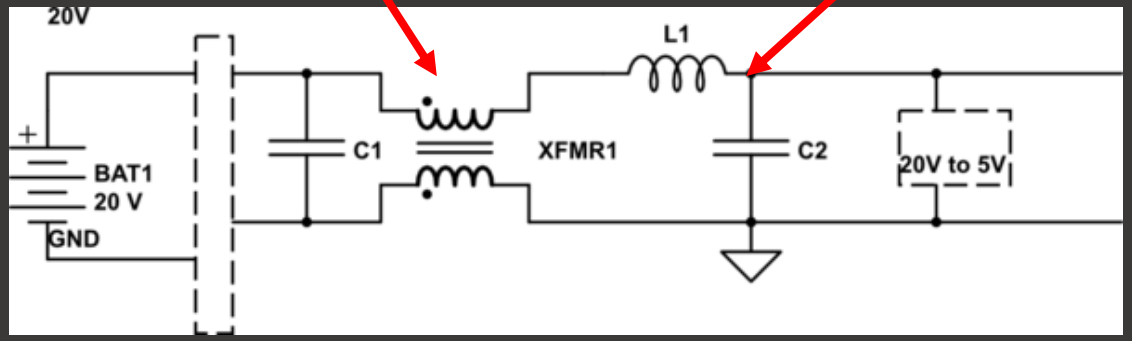
RC Filters


All-Pass
Low-Pass
High-Pass
Vin
Vin
Vin
Vout
Vout
Vout
Decreases with frequency
signal
blocked
passed
frequency
signal
blocked
passed
frequency

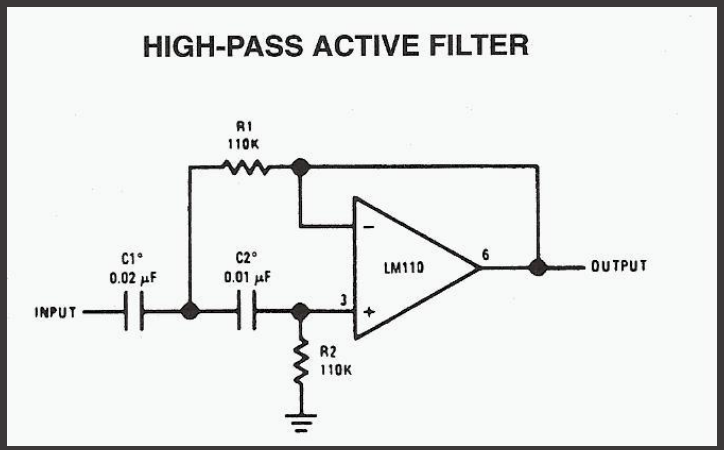
Other filter topologies

Common Mode Choke

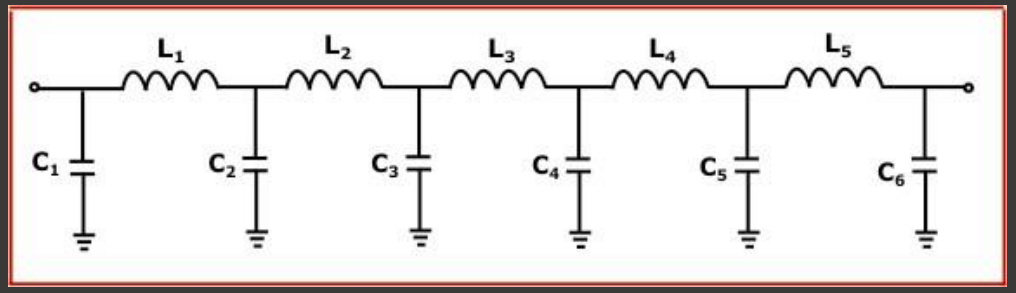
2nd order LC filter



2nd order active filter

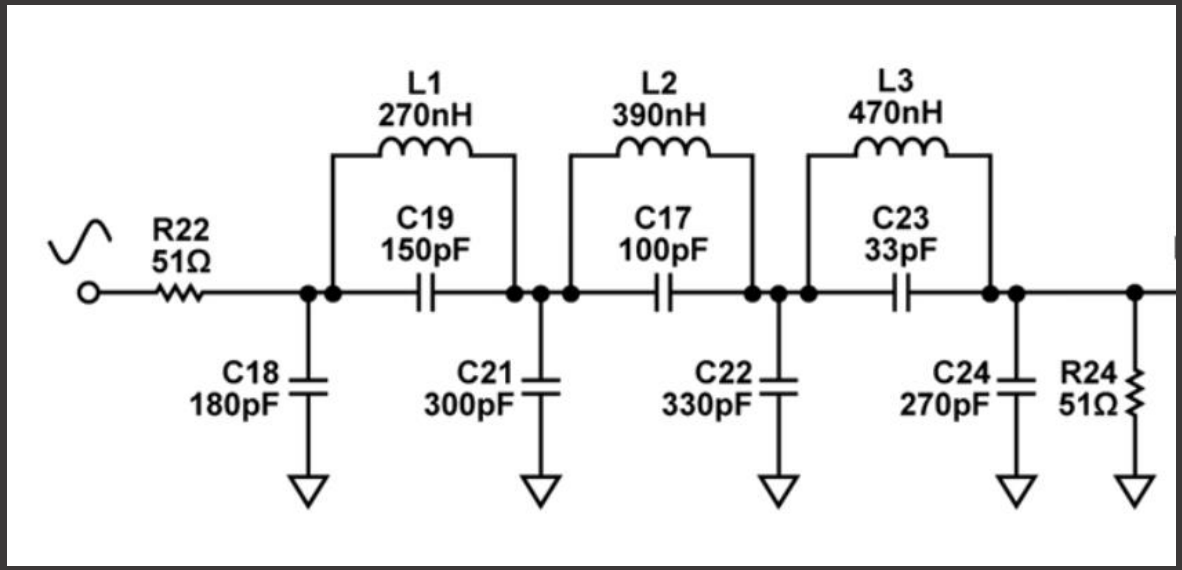


11th order LC filter



Other filter topologies

7th order elliptical filter

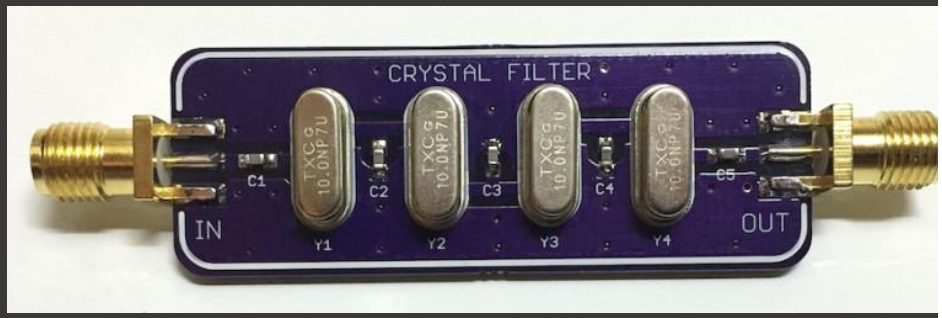


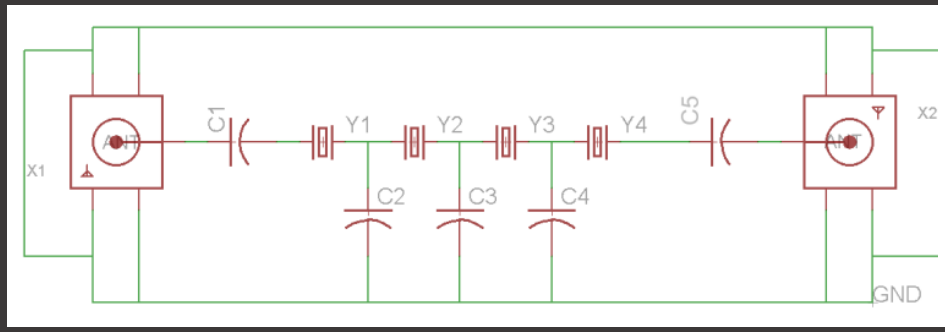
2nd order active filter

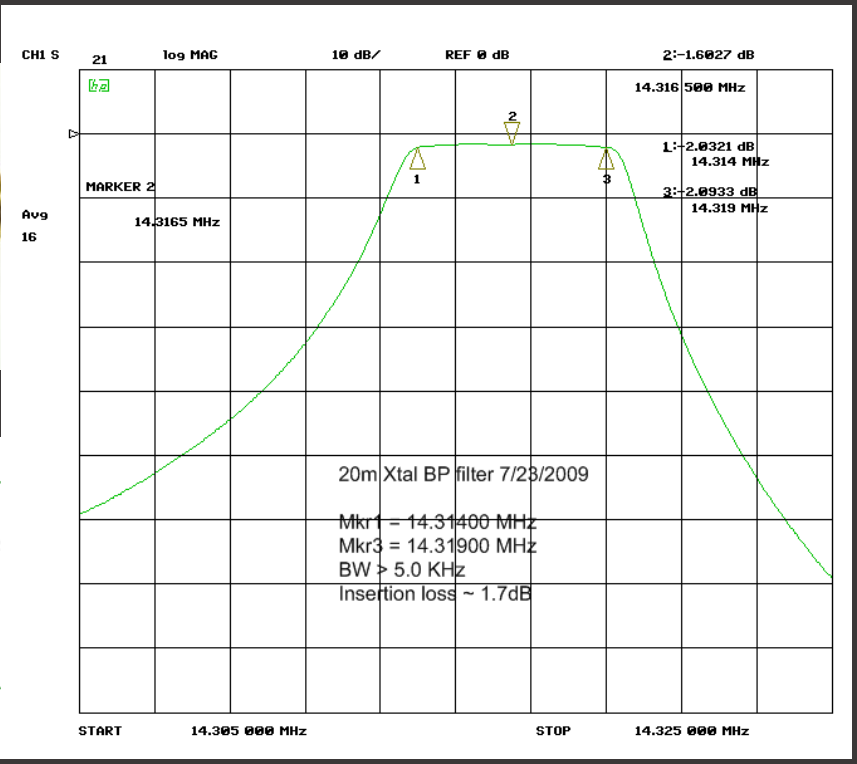
11th order LC filter

Crystal Bandpass Filters

4 pole crystal filter

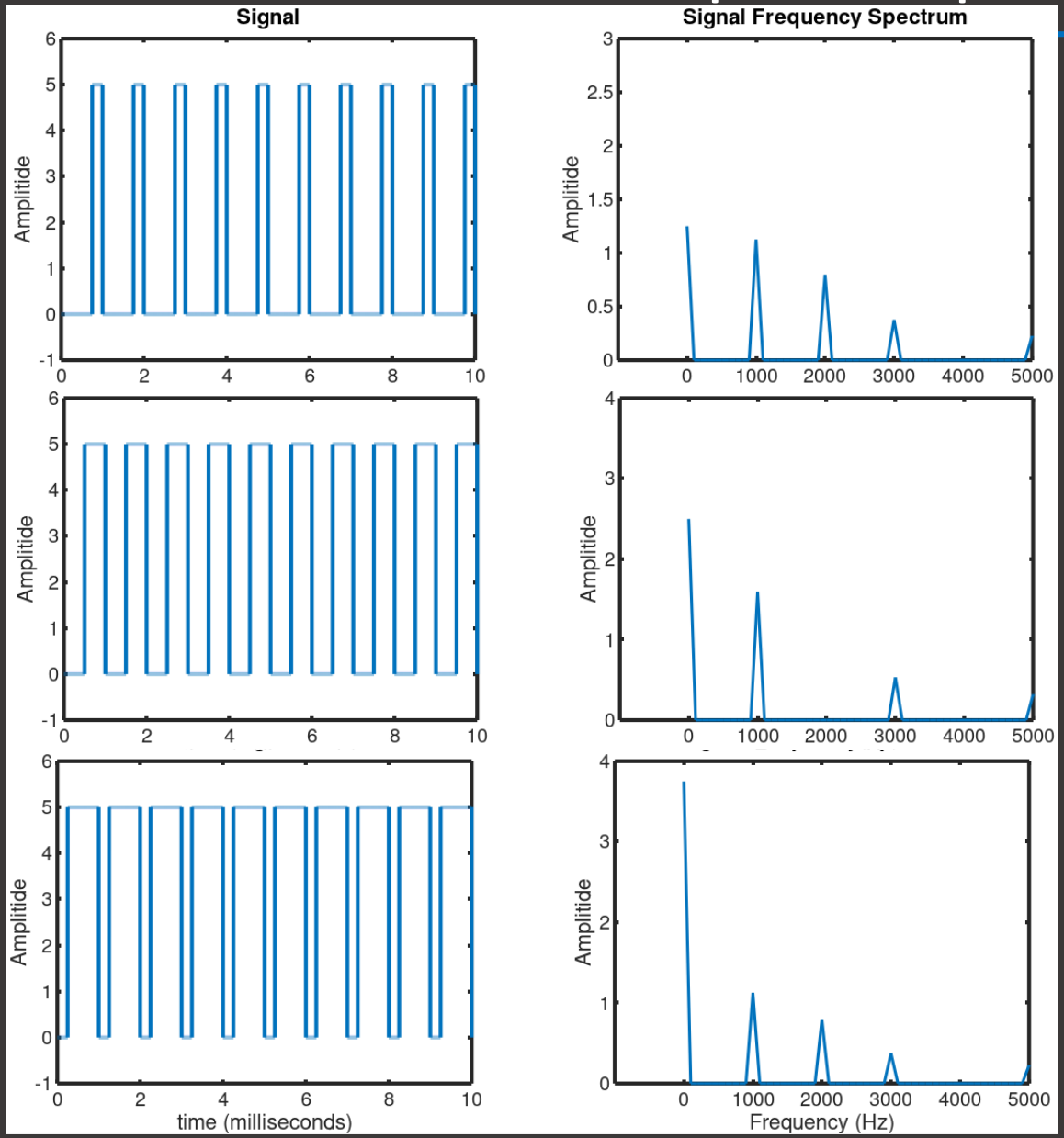






https://hackaday.com/2016/03/13/designing-a-crystal-ladder-bandpass-filter/

PWM Freq Components

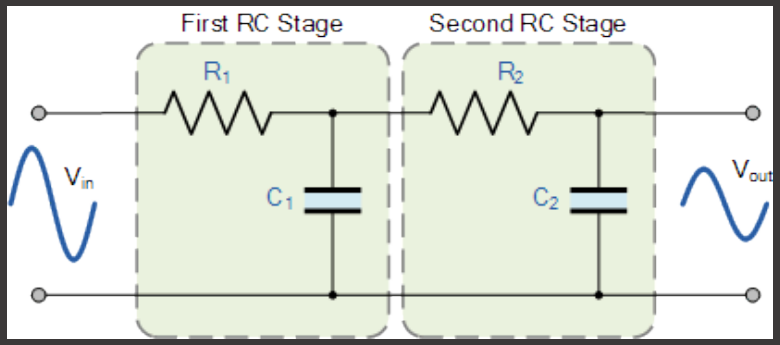


25% Duty Cycle

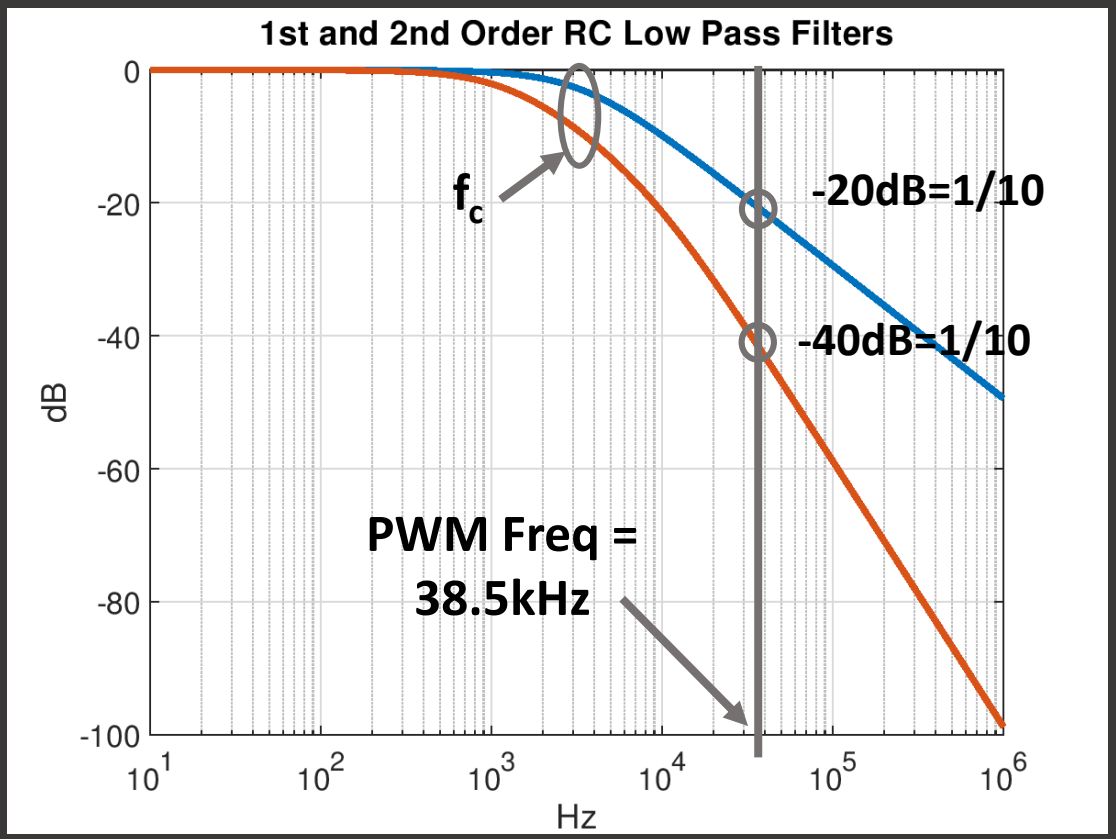
50% Duty Cycle

75% Duty Cycle

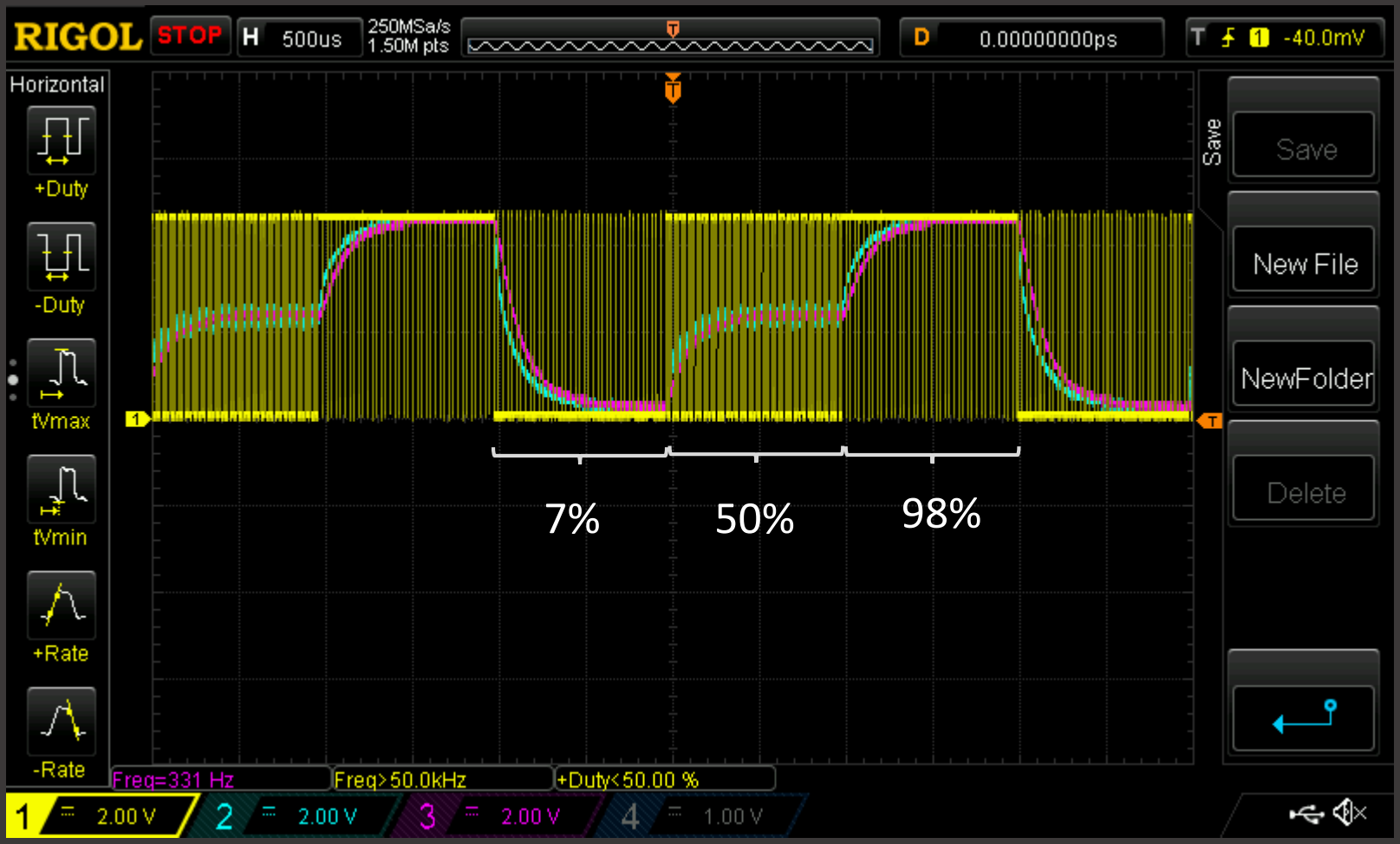
Example PWM Filters



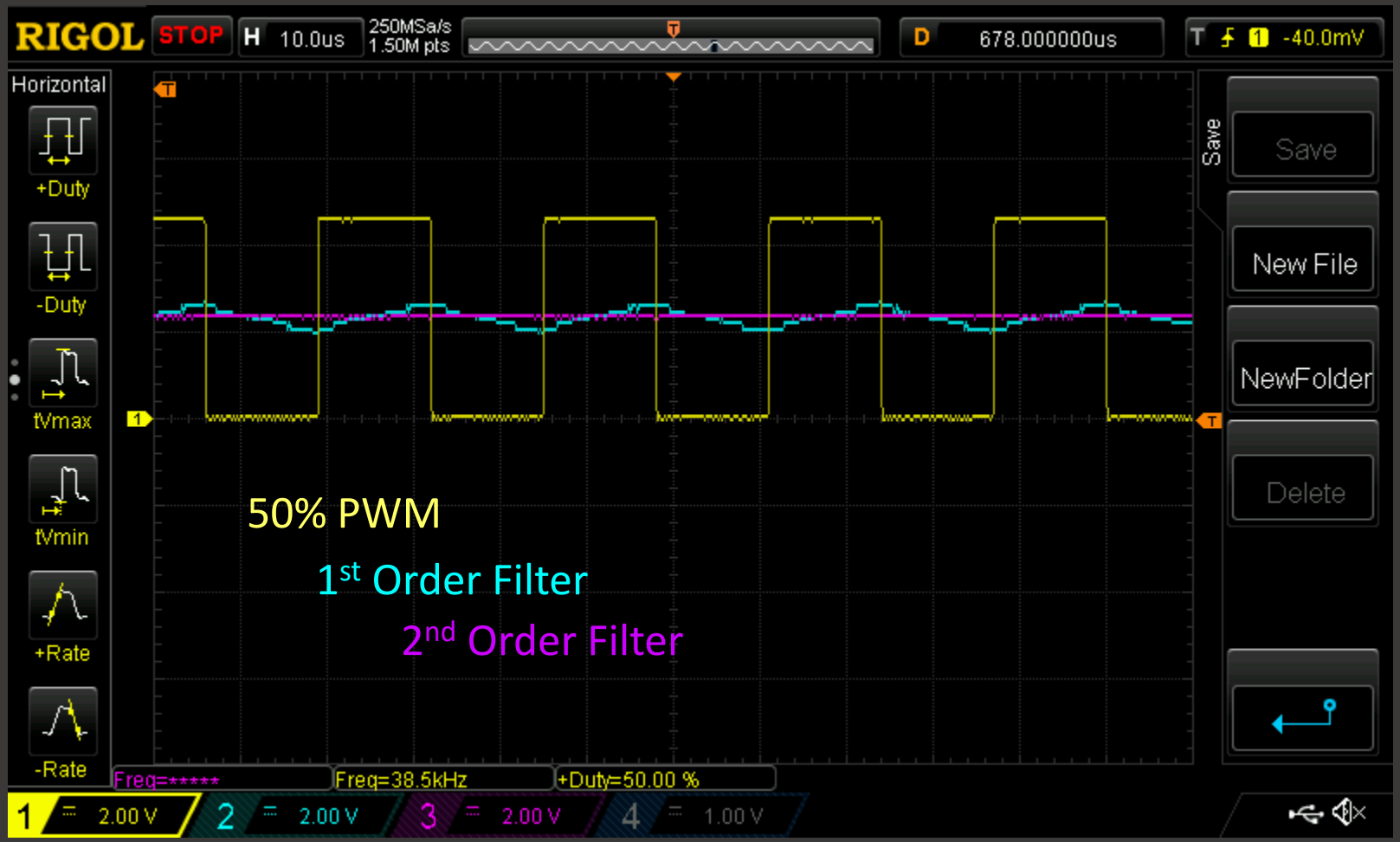
R1 = R2 = 470 Ohms
C1 = C2 = 0.1µF
1st order $f_c = 1/(2\pi RC)$ = 3.39kHz



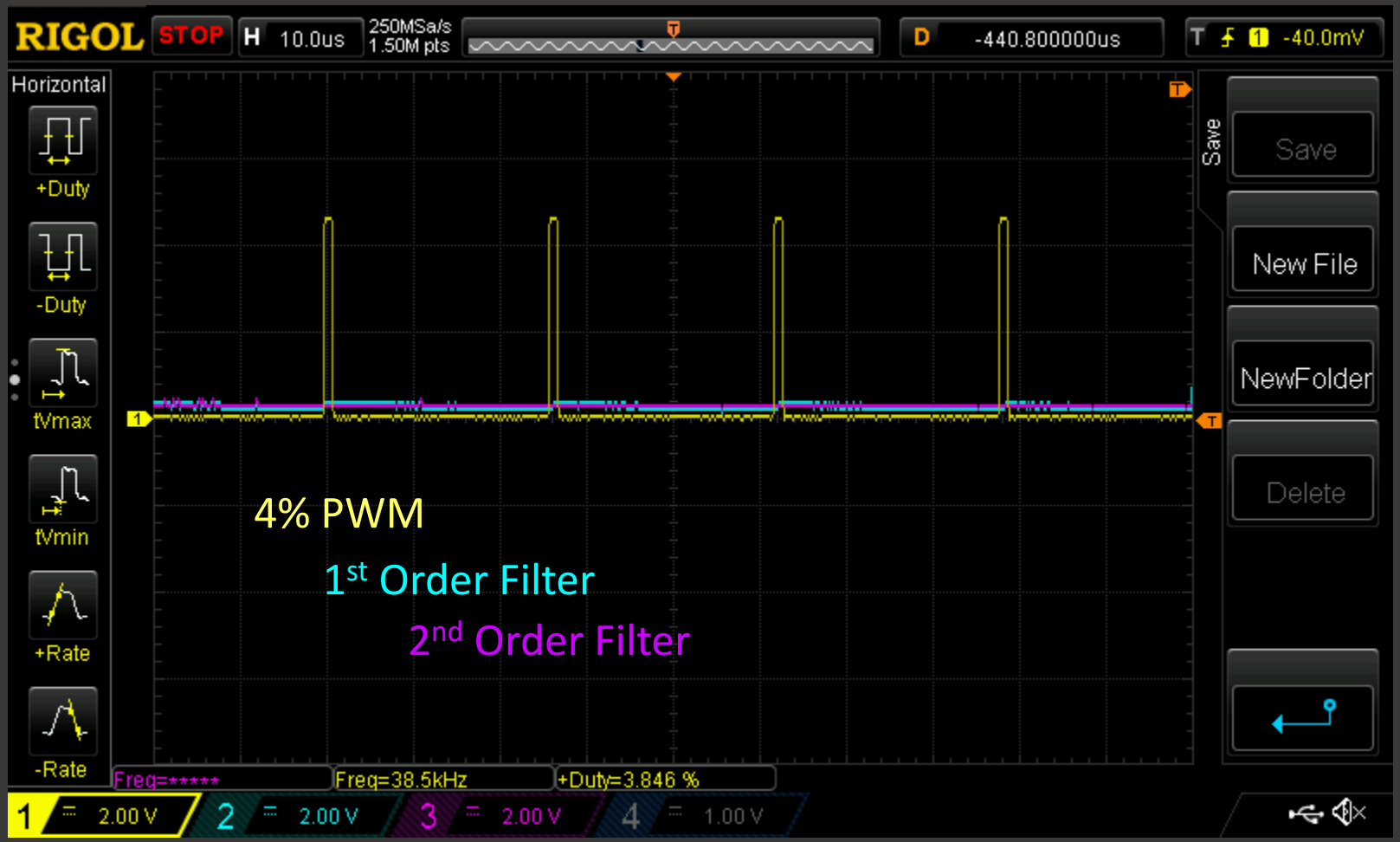
PWM Signal – 4%, 50%, 98%



PWM Signal – 50%



PWM Signal – 4%


RIGOL
STOP
H 10.0us
250MSa/s
1.50M pts
D -440.800000us
T -40.0mV
Horizontal
+Duty
-Duty
tVmax
tVmin
+Rate
-Rate
Save
Save
New File
NewFolder
Delete
4% PWM
1st Order Filter
2nd Order Filter
Freq=*****
Freq=38.5kHz
+Duty=3.846 %
1 2.00 V
2 2.00 V
3 2.00 V
4 1.00 V

PWM Transition – 98% to 4%