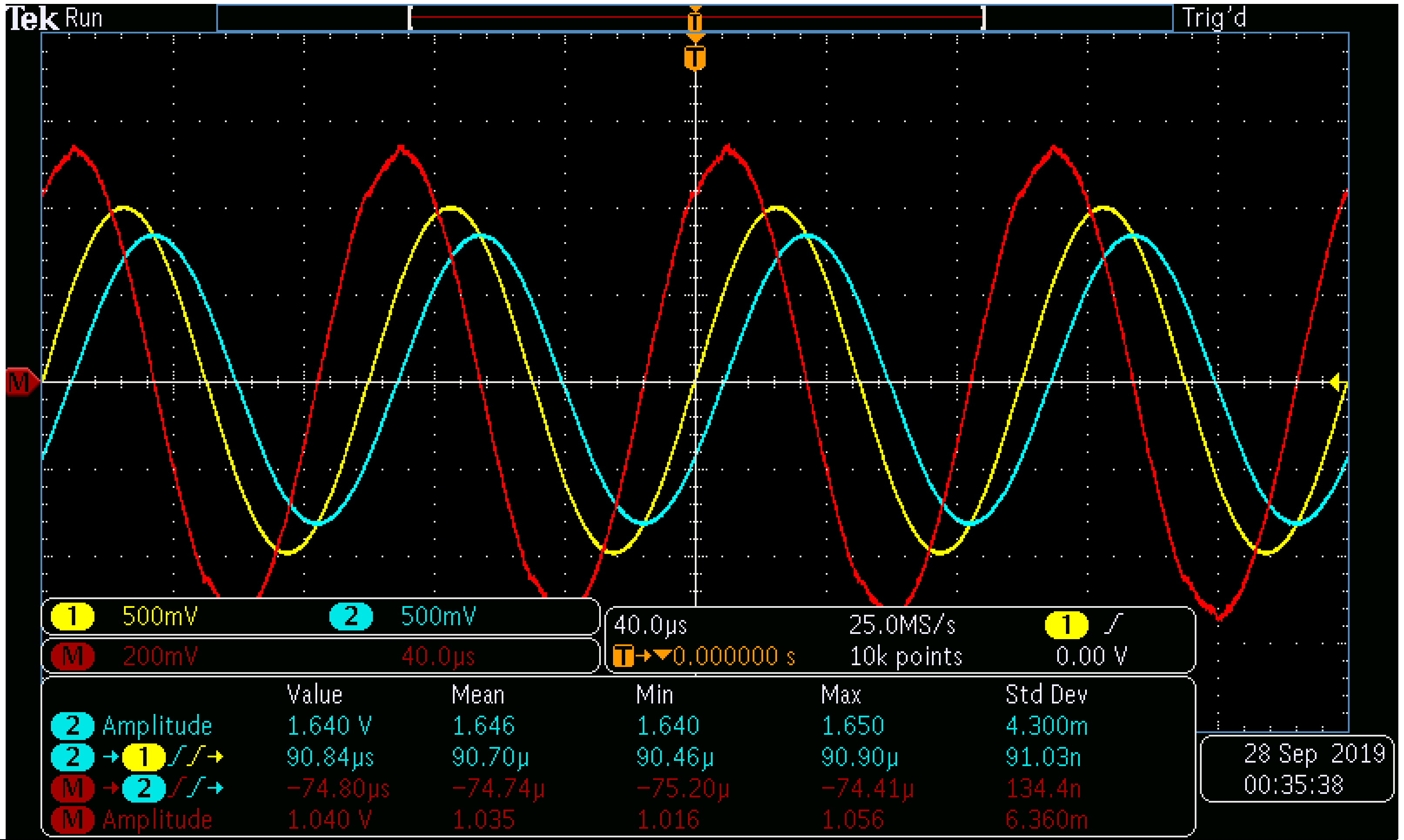
Peter A. Dranishnikov Lab 5 (Manual ref. #6) EEL3112C section 01

Parameters:

	Nominal	Actual
C	10^{-8} F	1.045×10^{-8} F
R	1000 Ω	980.48 Ω
L	10^{-3} H	9.96×10^{-3} H
f	10^{4} Hz	10000 Hz
t	10^{-4} s	0.0001 s
ω_o	62831.85 rad/s	62831.85 rad/s
V_{in}	1 V_m	1 V



RC Circuit:

	Theory (Ω)	Experimental (Ω)	% Deviation
X_c	-1523.013809	-1581.45	3.84%
Z magnitude	1811.32882	1896.48	4.70%
Z θ	-57.22753056	-57.456	0.40%

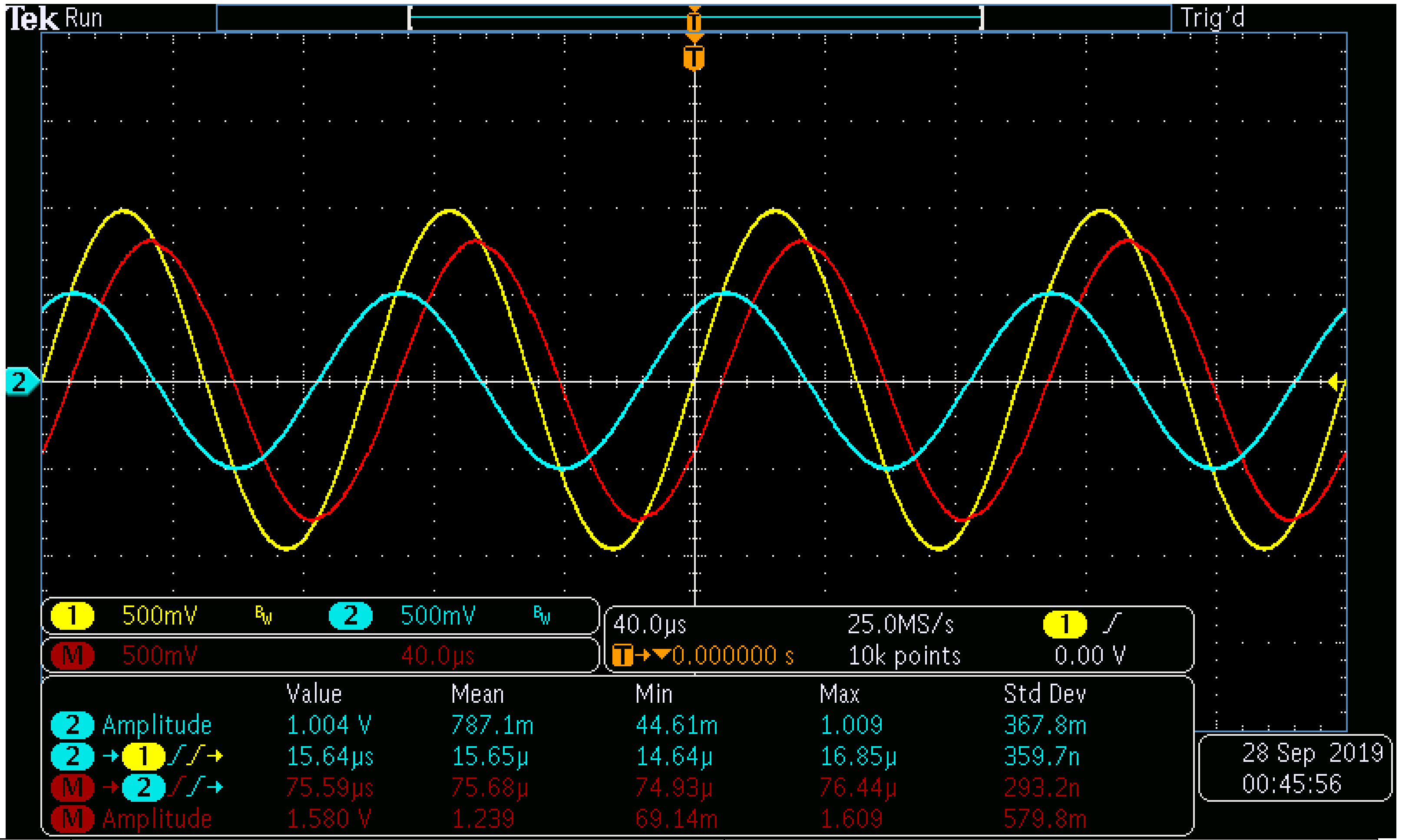
	theory magnitude (V_m)	theory θ (degrees)	exp mag (V_m)	exp delay (s)	exp θ (degrees)	% dev magnitude	% dev θ	theory complex rectangular	experimental complex rectangular
V_C	0.840826797	-32.77246944	0.834	-9.300×10^{-6}	-33.480	0.81%	2.16 %	0.706989702019343-j0.455143123926907	0.695621413633384-j0.460072656104111
V_R	0.541304256	57.22753056	0.517	1.596×10^{-5}	57.456	4.49%	0.40 %	0.293010297980657+j0.455143123926907	0.278118665168127+j0.435819926213911

Supplemental data:

Experimental circuit current: 0.000283655622927675+j0.000444496497851982 A

RL Circuit:

	Theory (Ω)	Experimental (Ω)	% Deviation
X_L	625.8052566	623.7106	0.33%
Z mag	1163.173783	1241.114	6.70%
Z theta	32.54863159	31.212	4.11%



	theory magnitude (V_m)	theory θ (degrees)	exp mag (V_m)	exp delay (s)	exp θ (degrees)	% dev magnitude	% dev θ	theory complex rectangular	experimental complex rectangular
V_L	0.53801527	57.45136841	0.503	1.565×10^{-5}	56.340	6.51%	1.93%	0.289460430428336+j0.453511950939089	0.278794529804557+j0.418667660741854
V_R	0.842935092	-32.54863159	0.79	-8.670×10^{-6}	-31.212	6.28%	4.11%	0.710539569571664-j0.453511950939089	0.675652039401563-j0.409382854614734

Supplemental data:

Experimental circuit current: 0.000689103336530641-j0.000417533100741202 A

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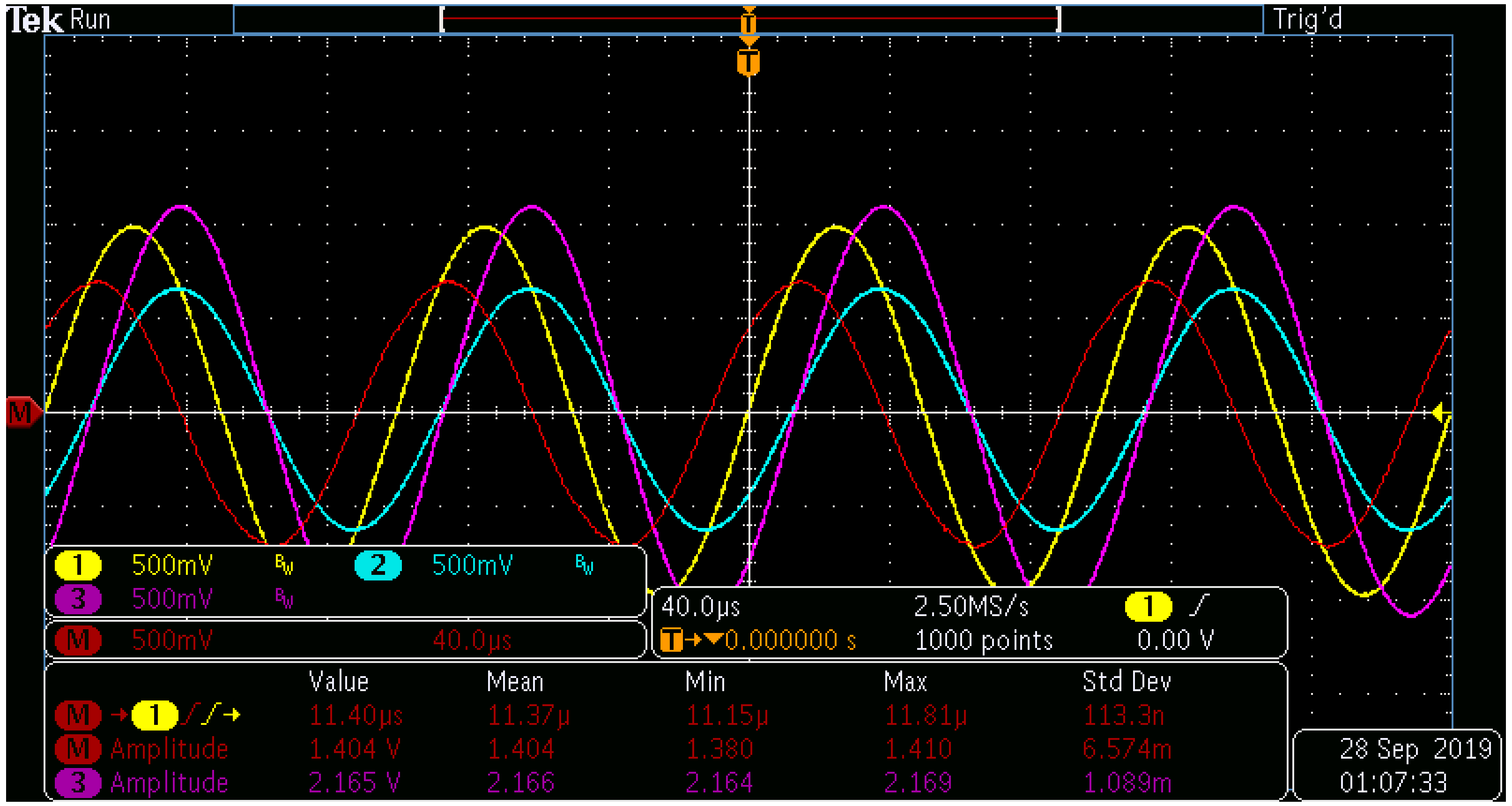
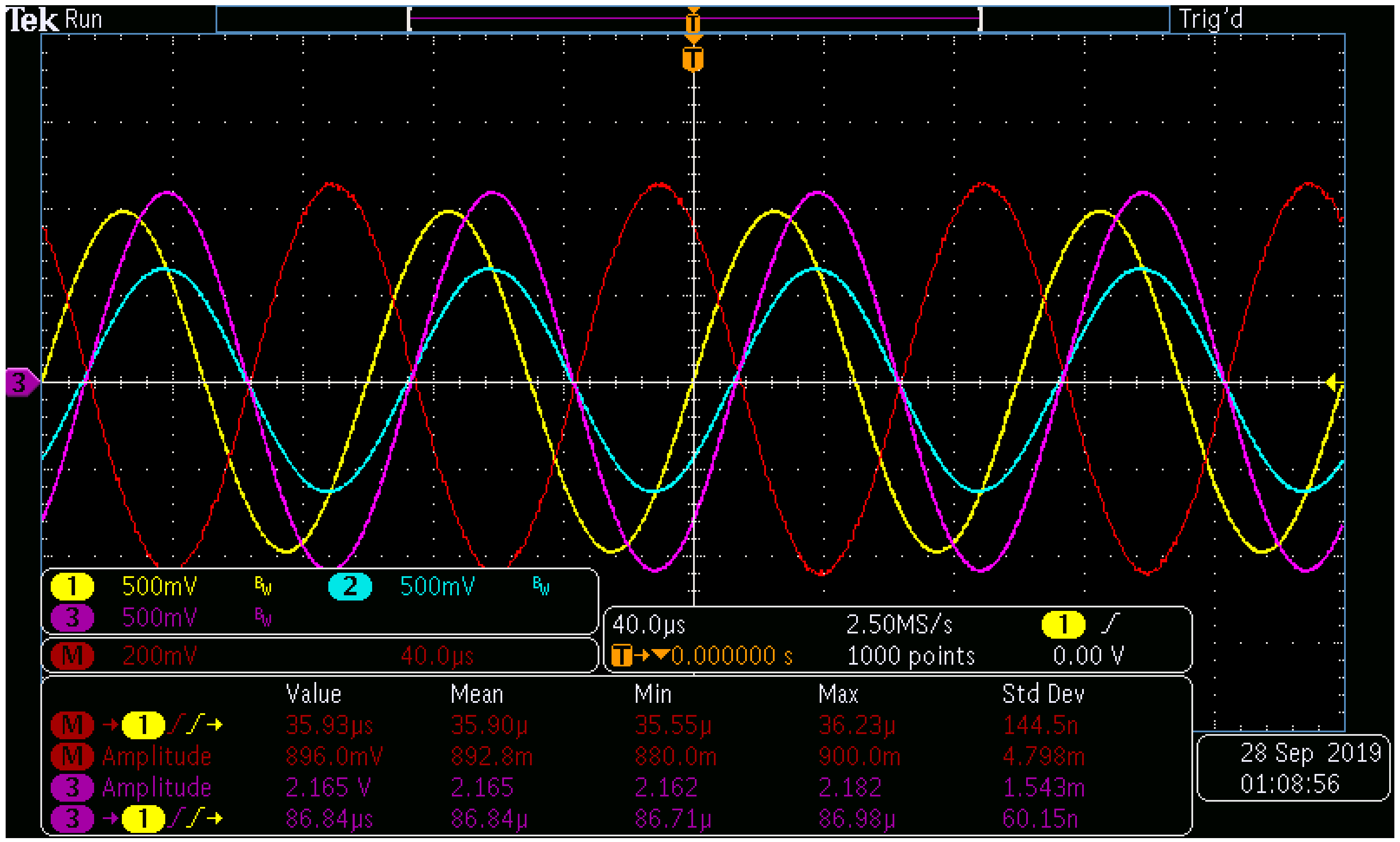
RCL Series Circuit:

	Theory (Ω)	Experimental (Ω)	% Deviation
X_c	-1523.013809	-1509.06	0.92%
X_L	625.8052566	618.5189	1.16%
Z mag	1329.031308	1392.727	4.79%
Z theta	-42.46071928	-40.932	3.60%





	theory magnitude (V_m)	theory θ (degrees)	exp mag (V_m)	exp delay (s)	exp θ (degrees)	% dev magnitude	% dev θ	theory complex rectangular	experimental complex rectangular
vc	1.145957812	-47.53928072	1.084	-1.316E-05	-47.376	5.41%	0.34%	0.773618457071704-j0.845419297821795	0.734067722575404-j0.797621826853402
vl	0.470873224	132.4607193	0.4443	3.590E-05	129.240	5.64%	2.43%	-0.317879256259661+j0.347382169029931	-0.281050922938001+j0.344111709646297
V_R	0.737740333	42.46071928	0.704	1.137E-05	40.932	4.57%	3.60%	0.544260799187957+j0.498037128791864	0.531863323232626+j0.461234653294771

Supplemental data:

Theoretical circuit current: 0.000555096278545159+j0.000507952358836349 A

Experimental circuit current: 0.000542451985999333+j0.000470417196979817 A

Questions:

1. What is the phase relationship between R, L, and C components in a series AC circuit?

Per the phasor diagram (last page) in a sinusoidal steady-state series RLC circuit, the resistor voltage phasor is orthogonal to the inductor and capacitor voltage phasors. The inductor and capacitor voltage phasors oppose each other by 180 degrees. The sum of the component voltage phasors is equal to the voltage source phasor V_{in}.

2. Based on measurements, does Kirchhoff's Voltage Law apply to the three tested circuits? (show work)

Circuit 6.1: $-V_{in} + V_c + V_r = 0$

$$V_c + V_r = V_{in}$$
$$0.834\angle -33.48° + 0.517\angle -57.46° = 1$$
$$0.6956 - j0.4601 + 0.2781 + j0.4358 \approx 1$$
$$0.9737 - j0.0243 \approx 1$$

Circuit 6.2: $-V_{in} + V_L + V_R = 0$

$$V_L + V_R = V_{in}$$
$$0.2788 + j0.4187 + 0.6757 - j0.4094 \approx 1$$
$$0.9545 + j0.0093 \approx 1$$

Circuit 6.3: $-V_{in} + V_R + V_C + V_L = 0$

$$V_R + V_C + V_L = V_{in}$$
$$0.7341 - j0.7976 - 0.2811 + j0.3441 + 0.5319 + j0.4612 \approx 1$$
$$0.9849 + j0.0077 \approx 1$$

Differences in the sum of component voltages compared to the source voltage is likely due to one of the following reasons: parasitic capacitance in the probes, test equipment, breadboard, resistor, and wires. Additionally, most components have a tolerance between 5-10% of the nominal value that is frequency dependent.

3. In general, how would the phasor diagram of Circuit 6.1 change if the frequency was raised?

As the frequency increases, the phase angle of the resistor voltage would approach the phase angle of the source, while the capacitor voltage phase angle approaches -90 degrees (or 90 degrees lagging) from the source voltage phasor.

4. In general, how would the phasor diagram of Circuit 6.2 change if the frequency was lowered?

As the frequency decreases, the phase angle of the resistor voltage would approach the phase angle of the source, while the inductor voltage phase angle approaches 90 degrees (or 90 degrees leading) relative to the source voltage phasor.

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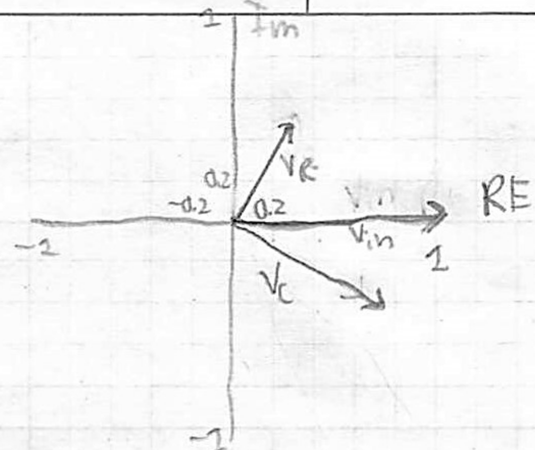
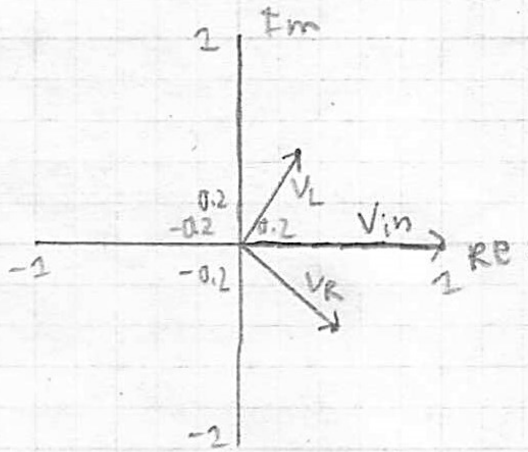
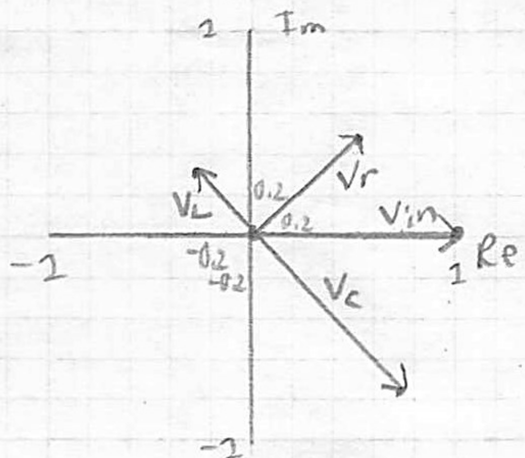


Voltage Phasors for 6.1 circuit



Voltage Phasors for 6.2 circuit



Voltage phasors for 6.3 circuit