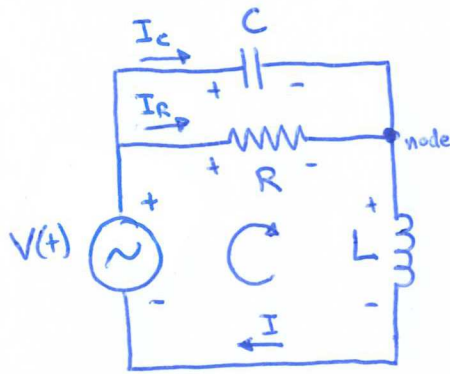


R_{||}CL Differential Equation



Kirchoff's Voltage Law:

$$+V(t) - V_{RL} - L \frac{dI}{dt} = 0 \quad (1)$$

Kirchoff's Current Law:

$$+I_C + I_R - I = 0 \quad (2)$$

Voltage across R: $V_{RC} = I_R R$ solve for I_R : $I_R = V_{RC} / R \quad (3)$

Voltage across C: $V_{RC} = \frac{1}{C} \int I_C dt$ differentiate solve for I_C : $I_C = C \frac{dV_{RC}}{dt} \quad (4)$

Substitute (3) & (4) into (2):

$$C \frac{dV_{RC}}{dt} + \frac{V_{RC}}{R} = I \quad (2a)$$

Introduce 2 variables:

let:

$$x_1 = I$$

$$x_2 = V_{RC}$$

differentiate:

$$\frac{dx_1}{dt} = \frac{1}{L} [V(t) - x_2] \quad (1a)$$

$$\frac{dx_2}{dt} = \frac{1}{C} [x_1 - \frac{x_2}{R}] \quad (2b)$$

equ (1) replacing variables with state variables (x's)

equ (2a) replacing variables with state variables (x's)

Setup calculation table:

index	time	$V(t)$	x_1	x_2	$\frac{dx_1}{dt}$	$\frac{dx_2}{dt}$
					equ. (1a)	equ. (2b)

use:

$$V = V_p \sin(\omega t)$$

R parallel C series L Differential Equation Numerical Solution

Variables

```
R      30      ohm
L      0.1     Henry = ohm s
C      0.001   Farad = s / ohm
```

Initial Conditions

```
t_o      0      s
I_o      0      amps
V_RC_o   0.9    amps/s    <- non-zero initial current
```

Sine Displacement (forcing function)

```
V_p      0      volts    <- zero amplitude forcing function
frequency 5      Hz = cycles/s
omega    = 31.42  rads/s  (omega = 2*pi*frequency)
Period   = 0.20   s      (Period = 1/frequency)
```

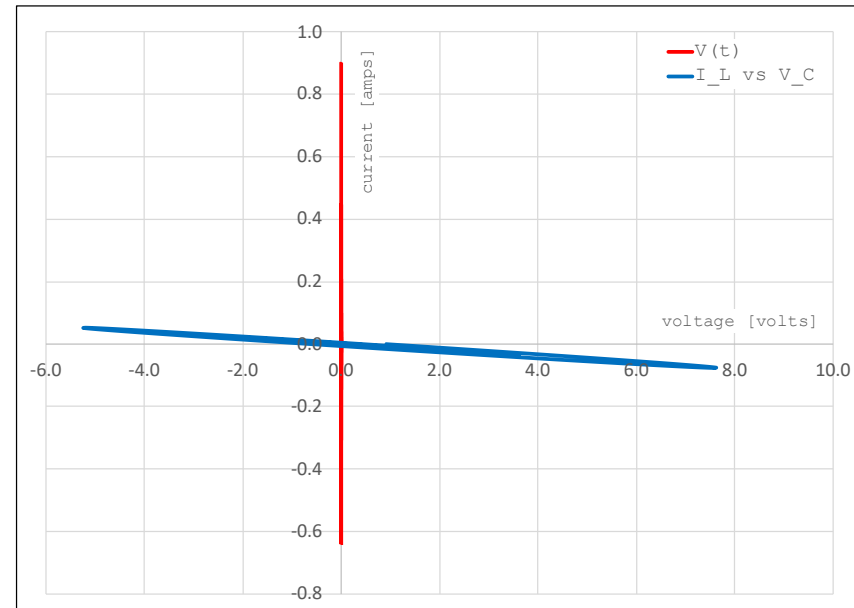
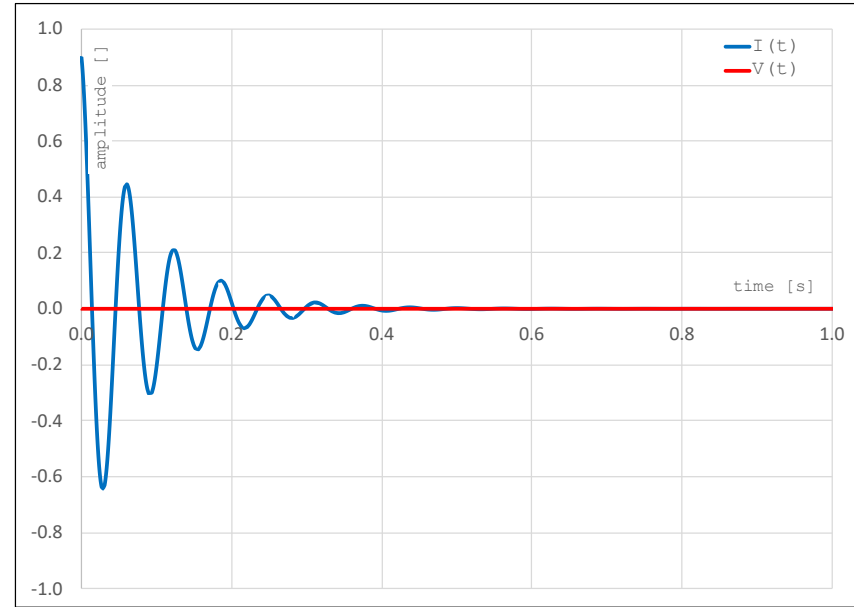
Numerical Parameters

```
dt      = 0.0010  s
```

Numerical Solution

time [s]	V(t) [volts]	x_1 (I) [amps]	x_2 (V_RC) [volts]	dx_1/dt [amps/s]	dx_2/dt [volts/s]	V_C [volts]	I_L [amps]
0.0000	0.0000	0.0000	0.9000	-9.0000	-30.0000	0.9000	0.0000
0.0010	0.0000	-0.0090	0.8700	-8.7000	-38.0000	1.7700	-0.0090
0.0020	0.0000	-0.0177	0.8320	-8.3200	-45.4333	2.6020	-0.0177
0.0030	0.0000	-0.0260	0.7866	-7.8657	-52.2389	3.3886	-0.0260
0.0040	0.0000	-0.0339	0.7343	-7.3433	-58.3633	4.1229	-0.0339
0.0050	0.0000	-0.0412	0.6760	-6.7596	-63.7611	4.7989	-0.0412
0.0060	0.0000	-0.0480	0.6122	-6.1220	-68.3954	5.4111	-0.0480
0.0070	0.0000	-0.0541	0.5438	-5.4381	-72.2376	5.9549	-0.0541
0.0080	0.0000	-0.0595	0.4716	-4.7157	-75.2677	6.4264	-0.0595
0.0090	0.0000	-0.0643	0.3963	-3.9630	-77.4745	6.8227	-0.0643
0.0100	0.0000	-0.0682	0.3188	-3.1883	-78.8550	7.1416	-0.0682
0.0110	0.0000	-0.0714	0.2400	-2.3997	-79.4148	7.3815	-0.0714
0.0120	0.0000	-0.0738	0.1606	-1.6056	-79.1674	7.5421	-0.0738
0.0130	0.0000	-0.0754	0.0814	-0.8139	-78.1341	7.6235	-0.0754
0.0140	0.0000	-0.0762	0.0033	-0.0326	-76.3435	7.6268	-0.0762
0.0150	0.0000	-0.0763	-0.0731	0.7309	-73.8313	7.5537	-0.0763
0.0160	0.0000	-0.0755	-0.1469	1.4692	-70.6394	7.4067	-0.0755
0.0170	0.0000	-0.0741	-0.2176	2.1756	-66.8156	7.1892	-0.0741
0.0180	0.0000	-0.0719	-0.2844	2.8437	-62.4128	6.9048	-0.0719
0.0190	0.0000	-0.0690	-0.3468	3.4679	-57.4886	6.5580	-0.0690
0.0200	0.0000	-0.0656	-0.4043	4.0427	-52.1045	6.1538	-0.0656
0.0210	0.0000	-0.0615	-0.4564	4.5638	-46.3249	5.6974	-0.0615
0.0220	0.0000	-0.0570	-0.5027	5.0270	-40.2170	5.1947	-0.0570
0.0230	0.0000	-0.0519	-0.5429	5.4292	-33.8494	4.6518	-0.0519
0.0240	0.0000	-0.0465	-0.5768	5.7677	-27.2919	4.0750	-0.0465
0.0250	0.0000	-0.0407	-0.6041	6.0406	-20.6144	3.4709	-0.0407
0.0260	0.0000	-0.0347	-0.6247	6.2468	-13.8867	2.8462	-0.0347
0.0270	0.0000	-0.0285	-0.6386	6.3856	-7.1770	2.2077	-0.0285
0.0280	0.0000	-0.0221	-0.6457	6.4574	-0.5522	1.5619	-0.0221
0.0290	0.0000	-0.0156	-0.6463	6.4629	5.9237	0.9156	-0.0156
0.0300	0.0000	-0.0092	-0.6404	6.4037	12.1891	0.2753	-0.0092
0.0310	0.0000	-0.0028	-0.6282	6.2818	18.1865	-0.3529	-0.0028
0.0320	0.0000	0.0035	-0.6100	6.0999	23.8621	-0.9629	0.0035
0.0330	0.0000	0.0096	-0.5861	5.8613	29.1666	-1.5490	0.0096
0.0340	0.0000	0.0155	-0.5570	5.5696	34.0557	-2.1060	0.0155
0.0350	0.0000	0.0211	-0.5229	5.2291	38.4901	-2.6289	0.0211
0.0360	0.0000	0.0263	-0.4844	4.8442	42.4362	-3.1133	0.0263
0.0370	0.0000	0.0311	-0.4420	4.4198	45.8659	-3.5553	0.0311

simulates a
step response



R parallel C series L Differential Equation Numerical Solution

Variables

R 50 ohm
L 1 Henry = ohm s
C 0.001 Farad = s / ohm

Initial Conditions

t_o 0 s
I_o 0 amps
V_RC_o 0 amps/s

Sine Displacement (forcing function)

V_p 0.5 volts
frequency 5 Hz = cycles/s
omega = 31.42 rads/s (omega = 2*pi*frequency)
Period = 0.20 s (Period = 1/frequency)

Numerical Parameters

dt = 0.0010 s

Numerical Solution

time [s]	V(t) [volts]	x_1 (I) [amps]	x_2 (V_RC) [volts]	dx_1/dt [amps/s]	dx_2/dt [volts/s]	V_C [volts]	I_L [amps]
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.0010	0.0157	0.0000	0.0000	0.0157	0.0000	0.0000	0.0000
0.0020	0.0314	0.0000	0.0000	0.0314	0.0157	0.0000	0.0000
0.0030	0.0471	0.0000	0.0000	0.0470	0.0468	0.0000	0.0000
0.0040	0.0627	0.0001	0.0001	0.0626	0.0929	0.0001	0.0001
0.0050	0.0782	0.0002	0.0002	0.0781	0.1536	0.0002	0.0002
0.0060	0.0937	0.0002	0.0003	0.0934	0.2286	0.0005	0.0002
0.0070	0.1091	0.0003	0.0005	0.1085	0.3174	0.0011	0.0003
0.0080	0.1243	0.0004	0.0009	0.1235	0.4196	0.0019	0.0004
0.0090	0.1395	0.0006	0.0013	0.1382	0.5347	0.0032	0.0006
0.0100	0.1545	0.0007	0.0018	0.1527	0.6622	0.0050	0.0007
0.0110	0.1694	0.0009	0.0025	0.1669	0.8017	0.0075	0.0009
0.0120	0.1841	0.0010	0.0033	0.1808	0.9526	0.0108	0.0010
0.0130	0.1986	0.0012	0.0042	0.1943	1.1143	0.0150	0.0012
0.0140	0.2129	0.0014	0.0053	0.2075	1.2864	0.0203	0.0014
0.0150	0.2270	0.0016	0.0066	0.2204	1.4682	0.0270	0.0016
0.0160	0.2409	0.0018	0.0081	0.2328	1.6592	0.0351	0.0018
0.0170	0.2545	0.0021	0.0098	0.2448	1.8588	0.0448	0.0021
0.0180	0.2679	0.0023	0.0116	0.2563	2.0664	0.0564	0.0023
0.0190	0.2810	0.0026	0.0137	0.2674	2.2814	0.0701	0.0026
0.0200	0.2939	0.0028	0.0160	0.2779	2.5031	0.0861	0.0028
0.0210	0.3065	0.0031	0.0185	0.2880	2.7310	0.1045	0.0031
0.0220	0.3187	0.0034	0.0212	0.2975	2.9643	0.1257	0.0034
0.0230	0.3307	0.0037	0.0242	0.3065	3.2026	0.1499	0.0037
0.0240	0.3423	0.0040	0.0274	0.3149	3.4450	0.1772	0.0040
0.0250	0.3536	0.0043	0.0308	0.3227	3.6910	0.2080	0.0043
0.0260	0.3645	0.0046	0.0345	0.3300	3.9399	0.2425	0.0046
0.0270	0.3751	0.0050	0.0384	0.3366	4.1911	0.2810	0.0050
0.0280	0.3853	0.0053	0.0426	0.3426	4.4439	0.3236	0.0053
0.0290	0.3951	0.0056	0.0471	0.3480	4.6977	0.3707	0.0056
0.0300	0.4045	0.0060	0.0518	0.3527	4.9517	0.4224	0.0060
0.0310	0.4135	0.0063	0.0567	0.3568	5.2054	0.4792	0.0063
0.0320	0.4222	0.0067	0.0619	0.3602	5.4581	0.5411	0.0067
0.0330	0.4304	0.0071	0.0674	0.3630	5.7092	0.6085	0.0071
0.0340	0.4382	0.0074	0.0731	0.3651	5.9580	0.6816	0.0074
0.0350	0.4455	0.0078	0.0791	0.3665	6.2039	0.7606	0.0078
0.0360	0.4524	0.0082	0.0853	0.3672	6.4463	0.8459	0.0082
0.0370	0.4589	0.0085	0.0917	0.3672	6.6845	0.9376	0.0085

