EECE 290, Problem solving

Session 7

Review quiz 1

Summary opamps

- Analysis with ideal opamps:
  - $v_p - v_n = 0$,
  - $i_p = i_n = 0$
    $V_{CC}^{-} \leq v_0 \leq V_{CC}^{+}$
  - Implies negative feedback.

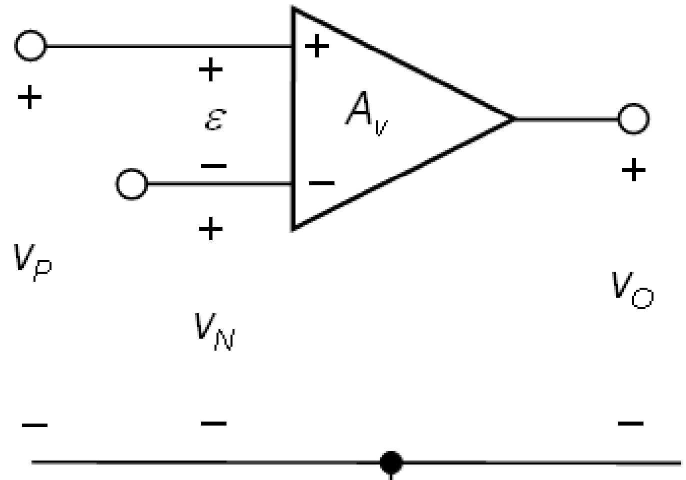
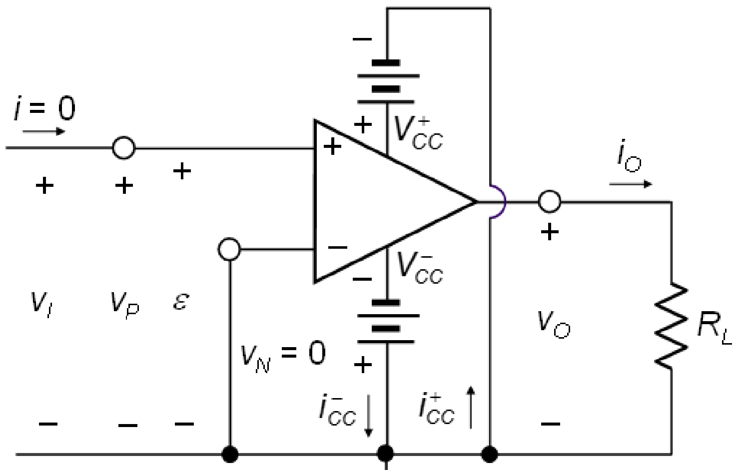


Figure 13.1.1



(b) Figure 13.1.2

Basic configurations

- Non-inverting:
- Unity-gain:
- Inverting:
- Perfect integrator:
- Perfect differentiator:

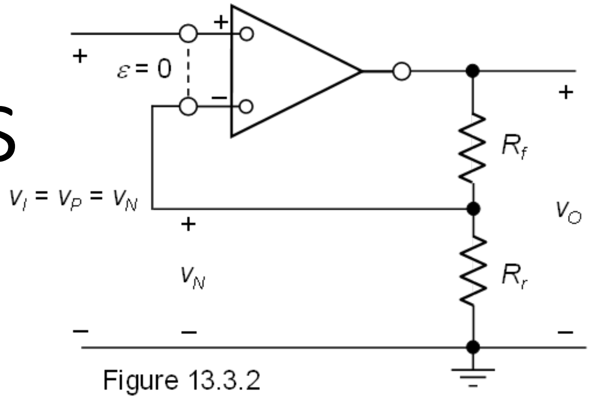


Figure 13.3.2

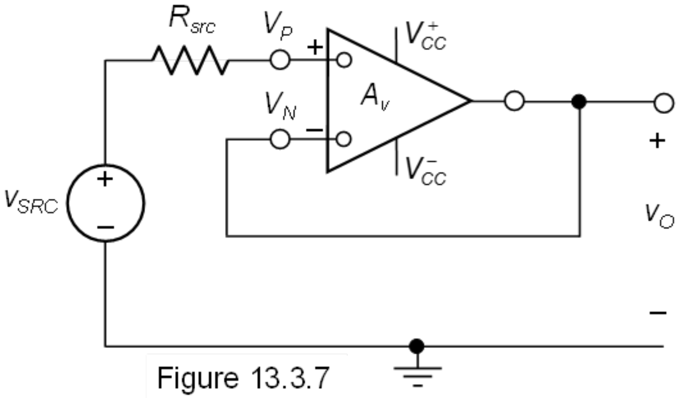


Figure 13.3.7

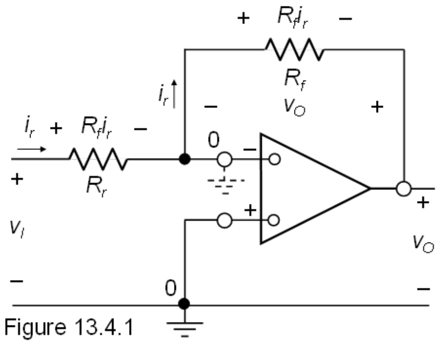


Figure 13.4.1

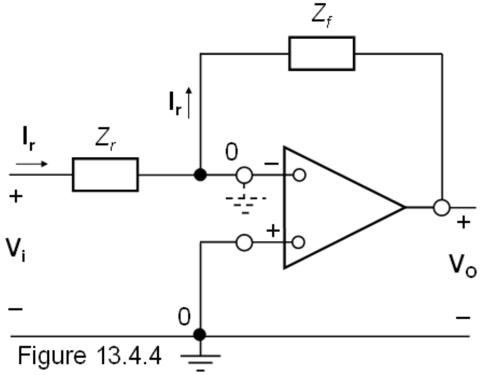


Figure 13.4.4

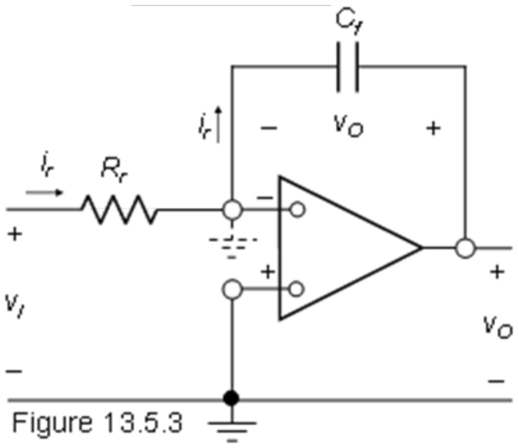


Figure 13.5.3

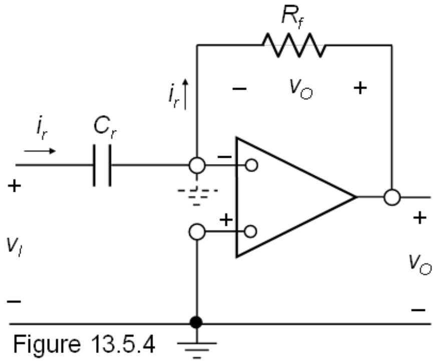


Figure 13.5.4

Basic configurations cont'd

- Adder:

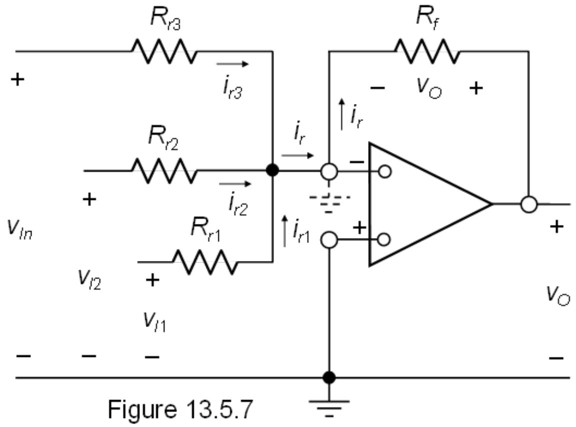


Figure 13.5.7

- Difference amplifier:

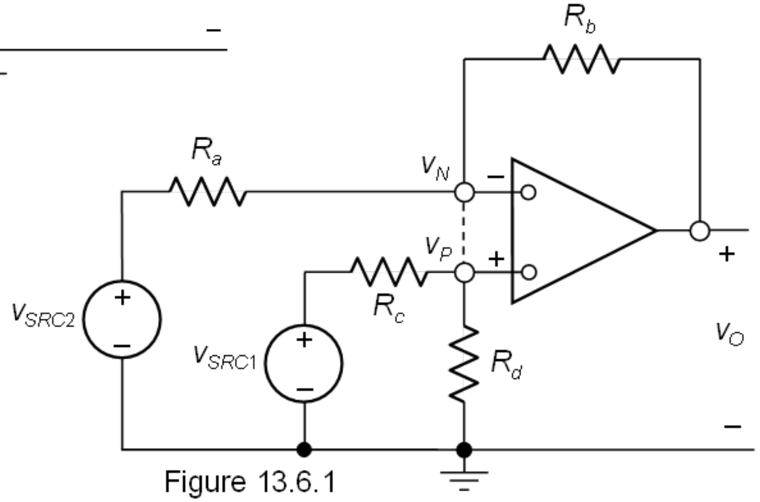
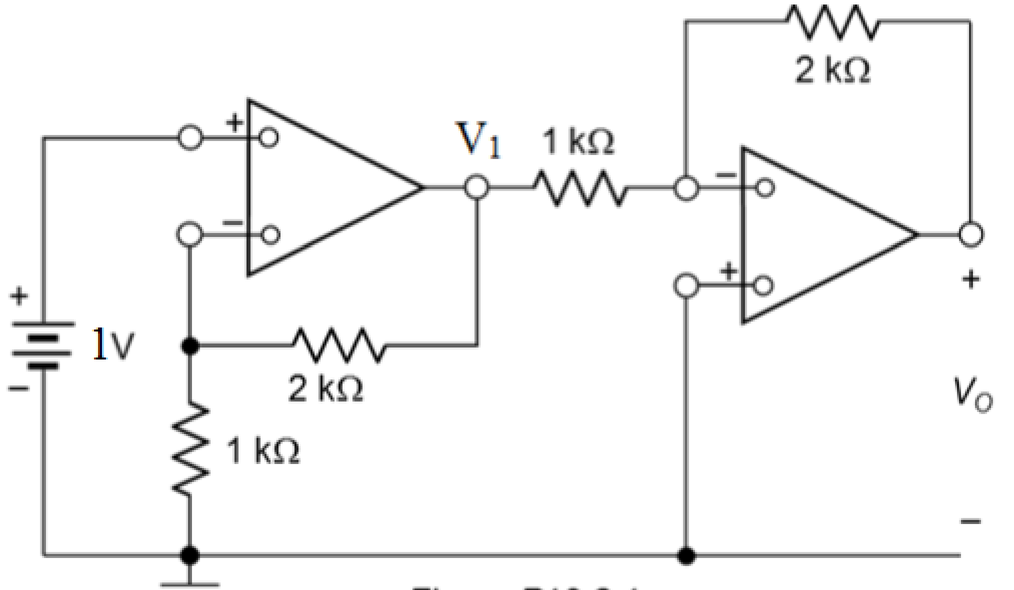


Figure 13.6.1

$V_O = ?$



A. 12 V

B. -12 V

C. 2 V

D. -2 V

E. 6 V

F. -6 V

Complex power

using rms values : $S = VI^* = P + jQ = Z\,|I|^2 = (R + jX)\,|I|^2 = Y^*\,|V|^2 = (G - jB)\,|V|^2$

$|S|=|V|\,|I|=|Z|\,|I|^2=|Y|\,|V|^2$

L: $S=jQ=jX|I|^2=j\omega L|I|^2=j|V||I|$
C: $S = jQ = -jB|V|^2=-j\omega C|V|^2=-j|V||I|$

R: $S = P =R|I|^2=G|V|^2=|V||I|$

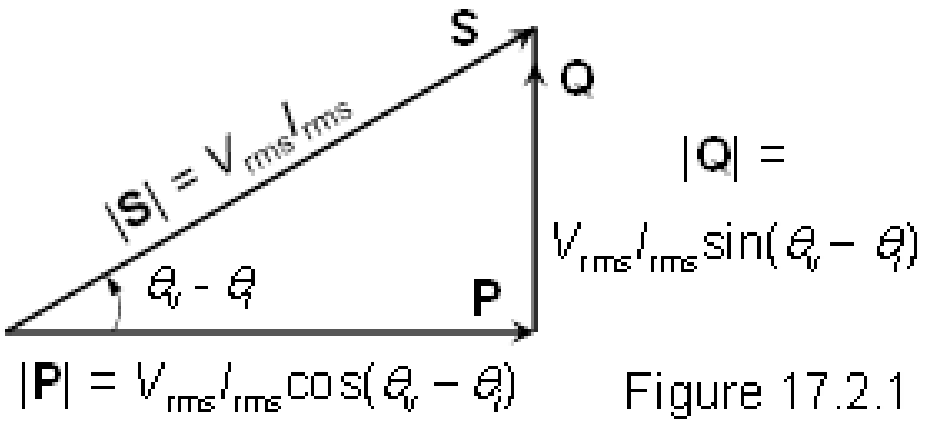


Figure 17.2.1

power factor: $\cos(\theta_v - \theta_i)$ lagging or leading (current with respect to voltage)

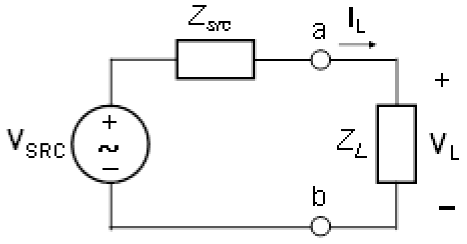


Figure 17.4.7

Maximum power transfer: $Z_L = Z_{src}^*$

using rms values: $S = VI^* = P + jQ = Z\,|I|^2 = (R + jX)\,|I|^2 = Y^*\,|V|^2 = (G - jB)\,|V|^2$

A current source of 0.1 A_{rms}, a capacitance of –j2 Ω and an inductance of j4 Ω are connected in series, what is the value of S?

A. j20 mVA
B. -j20 mVA
C. -j2 mVA
D. j2 mVA

Step function: $u(t) = \begin{cases} 0 & t < 0 \\ 1 & t > 0 \end{cases}$

Impulse (Dirac, delta) function: $\begin{cases} \delta(t) = 0 & t \neq 0 \\ \int_{-\infty}^{\infty} \delta(t)\, dt = 1 \end{cases}$

$u(t)=\int_{-\infty}^{t} \delta(\tau)\, d\tau$, $\delta(t)=du(t)/dt$

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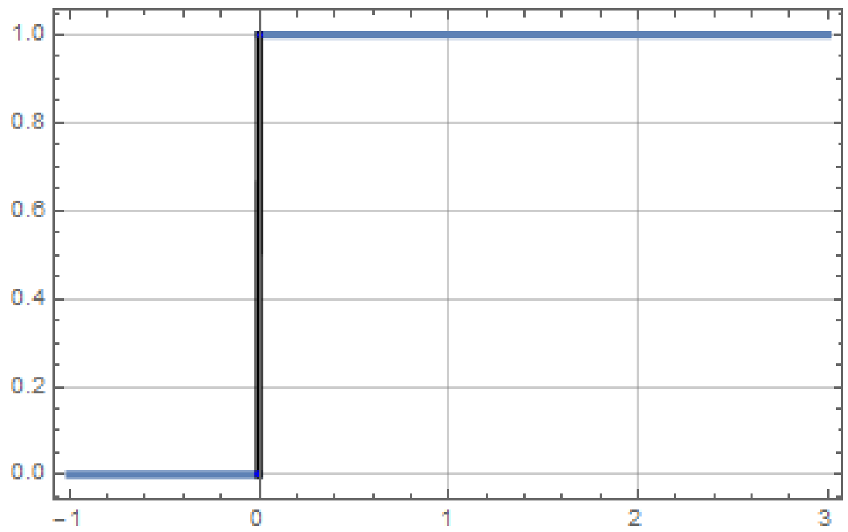

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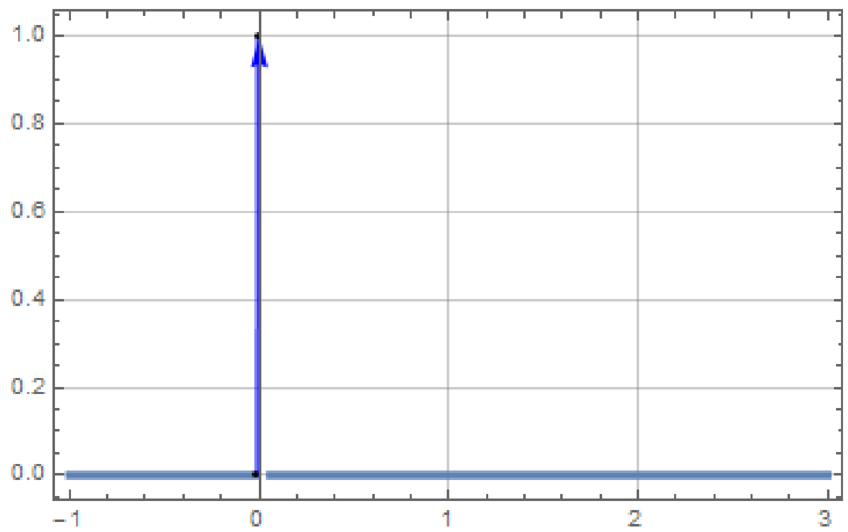


Properties:

If t is time in s, then $\delta(t)$ has dimension of s^{-1}!

Sifting property: $\int_{a}^{b} f(t)\, \delta(t - t_0)\, dt = \begin{cases} f(t_0) & a < t_0 < b \\ 0 & \text{elsewhere} \end{cases}$

Even symmetry: $\delta(-t)=\delta(t)$

Scaling: $\delta(at) = \frac{1}{|a|}\, \delta(t)$

Laplace Transform

- Complex domain: $s = \sigma + j\omega$; e^{st}

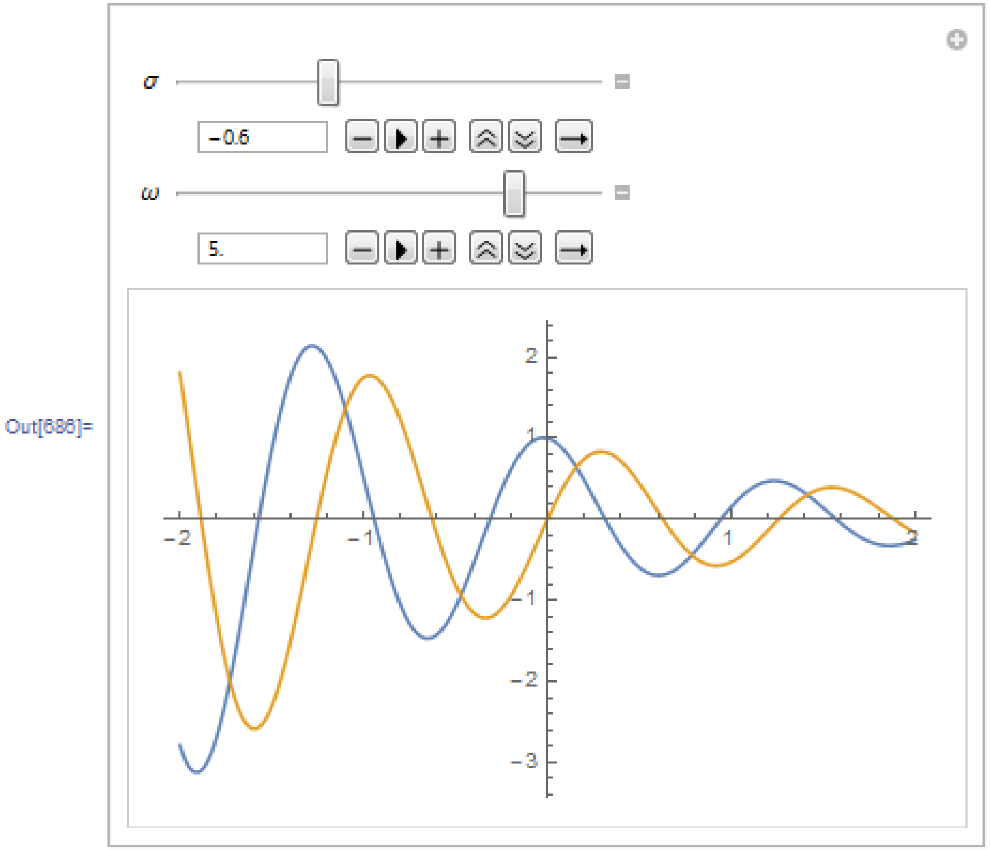
$$\mathcal{L}\{f(t)\}=F(s)=\int_{0^-}^{\infty} f(t)\, e^{-st}\, dt$$

$$\mathcal{L}^{-1}\{F(s)\} = f(t) = \frac{1}{2\pi j}\int_{\sigma-j\infty}^{\sigma+j\infty} F(s)e^{st}\,ds$$

$\mathcal{L}\{\delta(t)\}=1;$

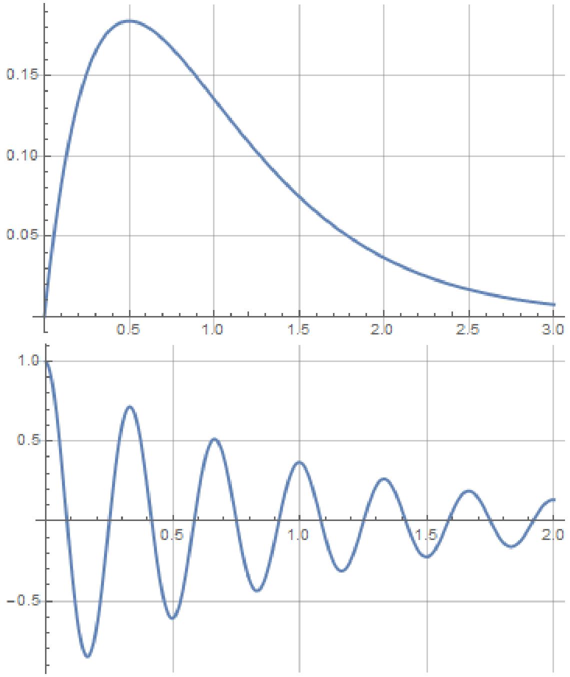
$\mathcal{L}\{u(t)\}=1/s;$

$\mathcal{L}\{e^{-at}\}=1/(s+a)$



$$\lim_{t\to 0^+} f(t) = \lim_{s\to\infty} sF(s)$$

$$\lim_{t\to\infty} f(t) = \lim_{s\to 0} sF(s)$$



TYPE	f(t) (t > 0⁻)	F(s)
Impulse	$\delta(t)$	1
Step	$u(t)$	$\frac{1}{s}$
Ramp	$t\,u(t)$	$\frac{1}{s^2}$
Exponential	$e^{-at}\,u(t)$	$\frac{1}{s+a}$
Sine	$\sin\omega t\,u(t)$	$\frac{\omega}{s^2+\omega^2}$
Cosine	$\cos\omega t\,u(t)$	$\frac{s}{s^2+\omega^2}$
Damped Ramp	$t\,e^{-at}\,u(t)$	$\frac{1}{(s+a)^2}$
Damped Sine	$(\sin\omega t)e^{-at}\,u(t)$	$\frac{\omega}{(s+a)^2+\omega^2}$
Damped Cosine	$(\cos\omega t)e^{-at}\,u(t)$	$\frac{s+a}{(s+a)^2+\omega^2}$

OPERATIONAL TRANSFORM

Operation	$f(t)$	$F(s)$
Multiplication by a constant	$Kf(t)$	$KF(s)$
Addition/subtraction	$f_1(t) + f_2(t) - f_3(t) + \cdots$	$F_1(s) + F_2(s) - F_3(s) + \cdots$
First derivative (time)	$\frac{df(t)}{dt}$	$sF(s) - f(0^-)$
Second derivative (time)	$\frac{d^2f(t)}{dt^2}$	$s^2F(s) - sf(0^-) - \frac{df(0^-)}{dt}$
nth derivative (time)	$\frac{d^nf(t)}{dt^n}$	$s^nF(s) - s^{n-1}f(0^-) - s^{n-2}\frac{df(0^-)}{dt} - s^{n-3}\frac{df^2(0^-)}{dt^2} - \cdots - \frac{d^{n-1}f(0^-)}{dt^{n-1}}$
Time integral	$\int_0^t f(x)\,dx$	$\frac{F(s)}{s}$
Translation in time	$f(t-a)u(t-a), a > 0$	$e^{-as}F(s)$
Translation in frequency	$e^{-at}f(t)$	$F(s+a)$
Scale changing	$f(at), a > 0$	$\frac{1}{a}F\left(\frac{s}{a}\right)$
First derivative (s)	$tf(t)$	$-\frac{dF(s)}{ds}$
nth derivative (s)	$t^nf(t)$	$(-1)^n\frac{d^nF(s)}{ds^n}$
s integral	$\frac{f(t)}{t}$	$\int_s^\infty F(u)\,du$

$$\mathcal{L}\{\delta(t)\} = 1$$
$$\mathcal{L}\{u(t)\} = \frac{1}{s}$$
$$\mathcal{L}\{e^{-at}u(t)\} = \frac{1}{s+a}$$
$$\mathcal{L}\{f(t-a)\} = e^{-as}F\{s\}$$

$\mathcal{L}\{(t-1)\ u(t-1)\}=?$

A. e^{-s}/s^2
B. e^{-s}/s
C. $e^{-s}/(s+1)$
D. $1/(s-2)$
E. $1/s^2$
F. e^{-s}

LT for circuits

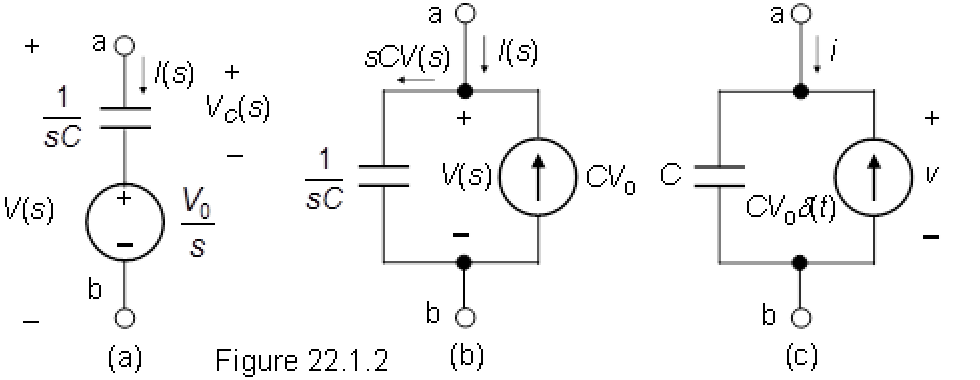


Figure 22.1.2

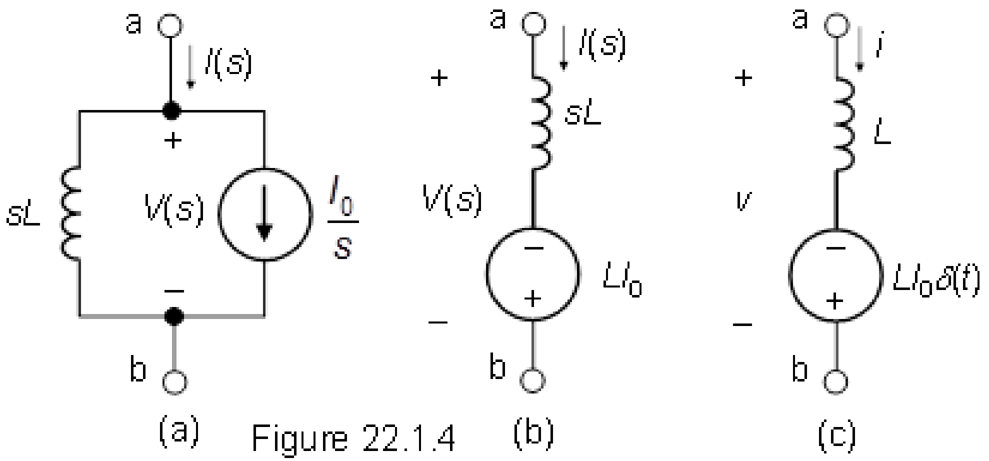
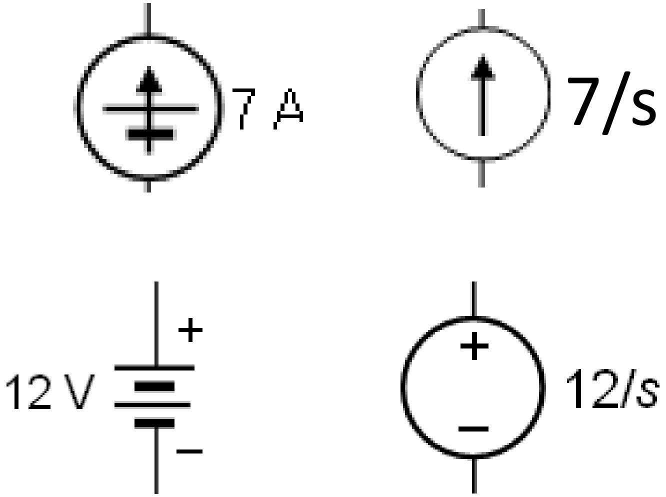


Figure 22.1.4

- Convert circuit with initial conditions to s-domain.
- Apply circuit analysis.
- Apply ILT to result

(in s domain) to get expression in time domain.



An inductance of 2 H has an initial current of 4 A. In the s-domain circuit this is modeled by a voltage source

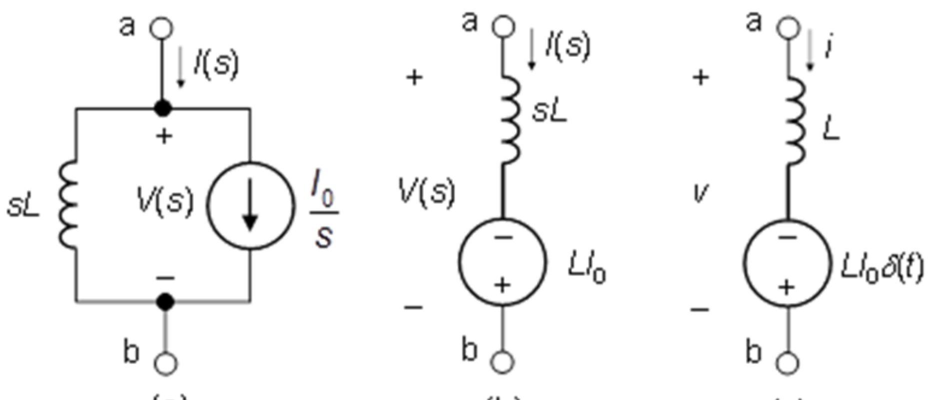
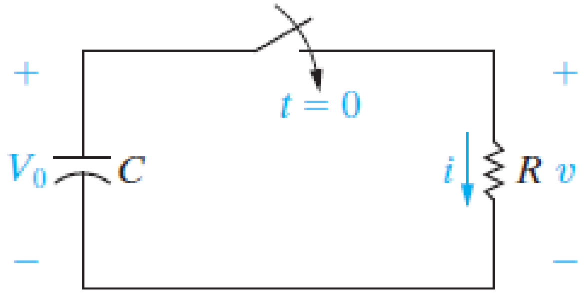
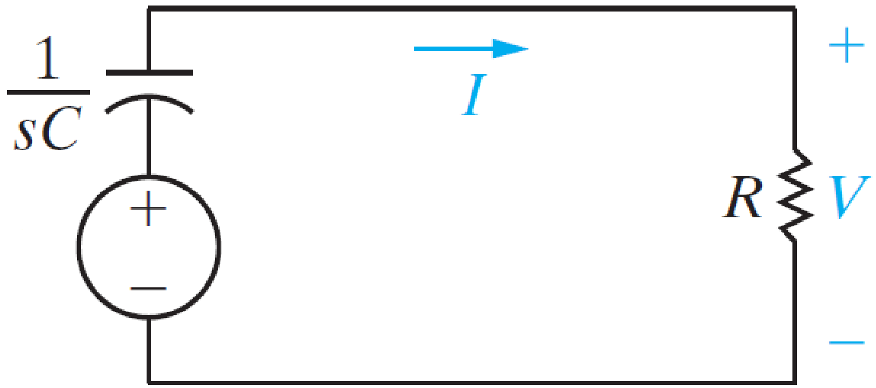


Figure 22.1.4

A. of 4/s in parallel
B. of 4/s in series
C. of 2/s in parallel
D. of 2/s in series
E. of 8 in parallel
F. of 8 in series

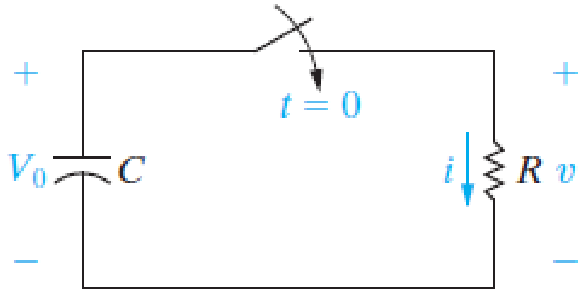
C=0.5F. Right before switching V_o=8V. The value of the voltage source should be

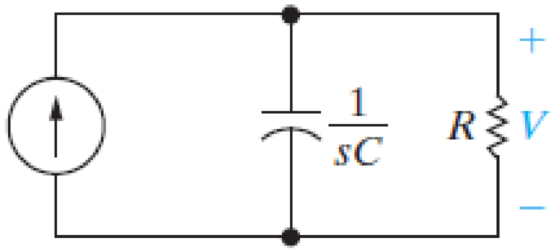




A. 8/s
B. 8
C. 4
D. 4/s
E. -8
F. -4

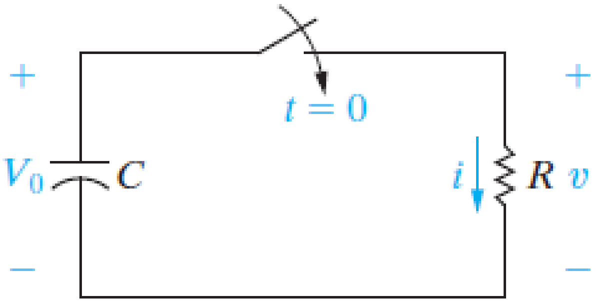
C=0.5F. Right before switching V_o=8V. The value of the current source should be

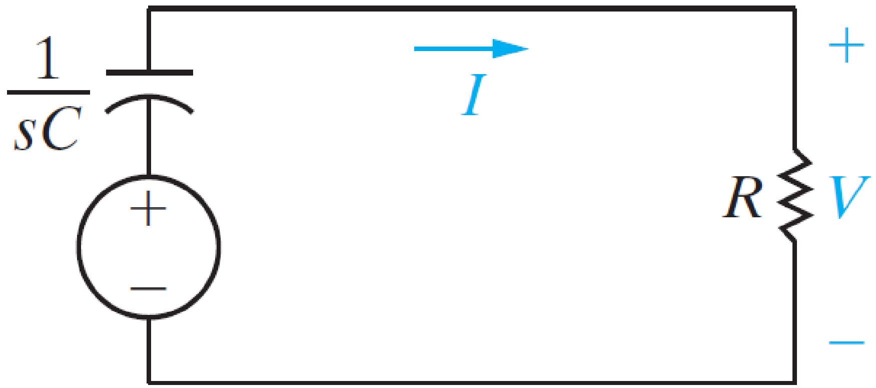




A. 8/s
B. 8
C. 4
D. 4/s
E. -8
F. -4

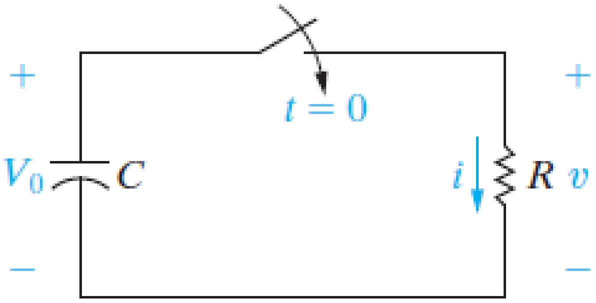
C=0.5F, R=4Ω. Right before switching V_o=8V. I(s)=

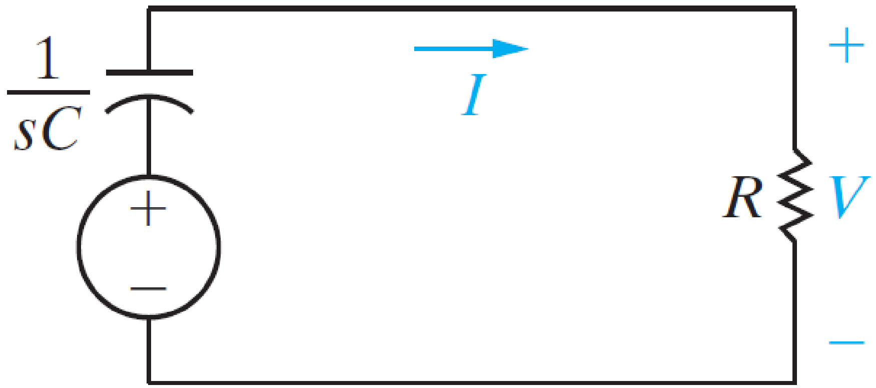




A. 2
B. 2/s
C. 2/(s+2)
D. 2/(s+1/2)
E. 4/(s+1/2)
F. 8/(s+2)

C=0.5F, R=4Ω. Right before switching V_o=8V. i(t)=





A. $4e^{-t/2}$
B. $2e^{-t/2}$
C. $2e^{-2t}$
D. $4e^{-2t}$

P13.2.20 Determine V_O in Figure P13.2.20.

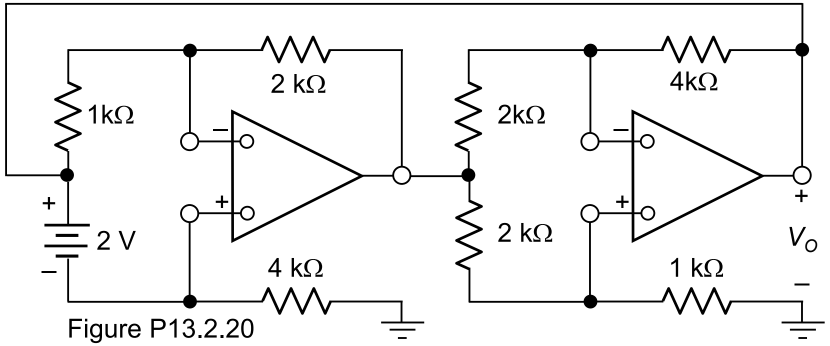


Figure P13.2.20

P17.1.27 Determine the complex power delivered by $\mathbf{V}_{SRC1}$ and $\mathbf{V}_{SRC2}$ in Figure P17.1.27 given that L_1 absorbs 4 kW at a power factor of 0.6 lagging, L_2 absorbs 3 kW at a power factor of 0.6 leading, and the complex power absorbed by L_3 is 12 + *j*5 kVA. Assume that $\mathbf{V}_{SRC1} = 400\angle 0°$ V rms and $\mathbf{V}_{SRC2} = 400\angle 90°$ V rms.

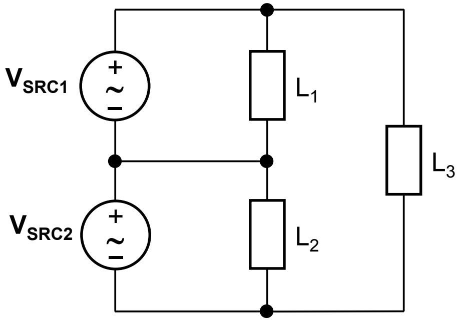
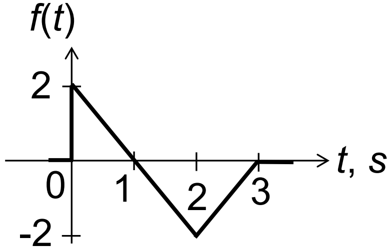


Figure P17.1.27

P12.2.9 Determine the LT of the derivative of *f*(*t*) in Figure P21.2.9.



Determine the ILT of $F(s) = \dfrac{8s^2 + 4s + 6}{(2s+3)(s+4)}$

P22.2.5 Both switches in Figure P22.2.5 are opened at *t* = 0 after being closed for a long time. Determine $i_O(t)$.

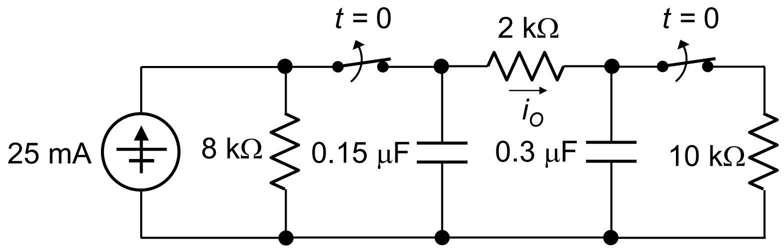


Figure P22.2.5

Ans. 3 V.

Ans. $\mathbf{V}_{\mathbf{SRC1}}$ delivers 12.5 + *j*1.83 kVA, and $\mathbf{V}_{\mathbf{SRC2}}$ delivers 6.5 + *j*4.5 kVA.

Ans. $2\left(1-\frac{1}{s}\right)+\frac{2e^{-2s}}{s}\left(2-e^{-s}\right).$

Ans. $4\delta(t)+\left(3.6e^{-1.5t}-23.6e^{-4t}\right)u(t).$

Ans. $10e^{-5t}$ mA, *t* is in ms.