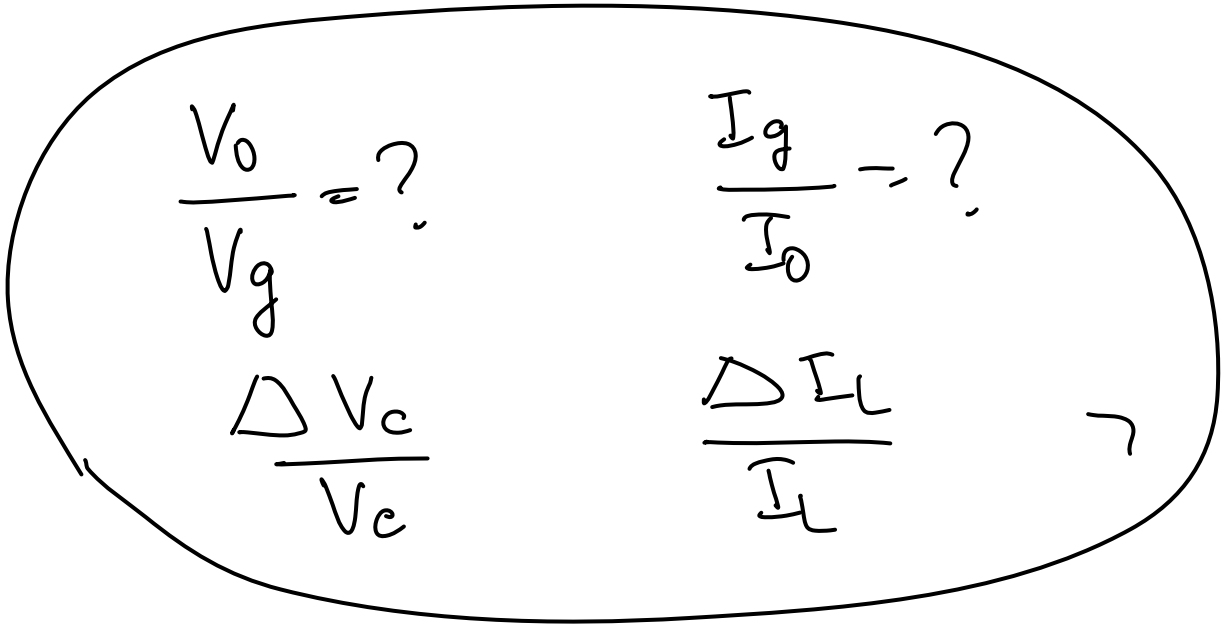
Switched Mode Power Conversion

Problem Set 03

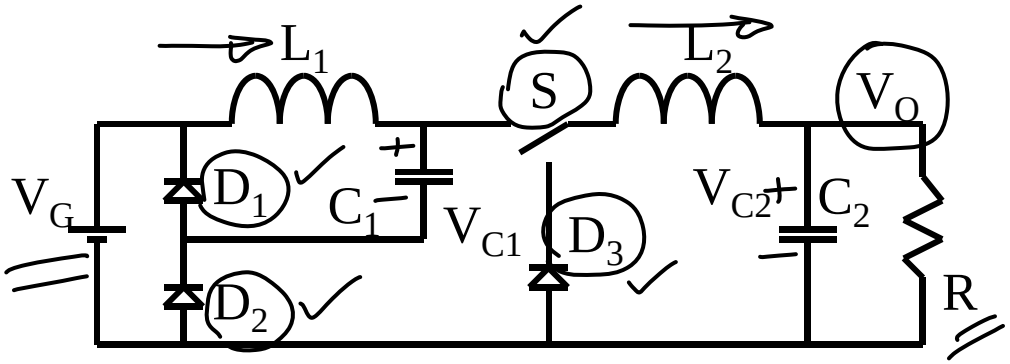
Selected Problems:
Power Conversion Circuits



Switched Mode Power Conversion

Problem Set 03

Problem No. 1



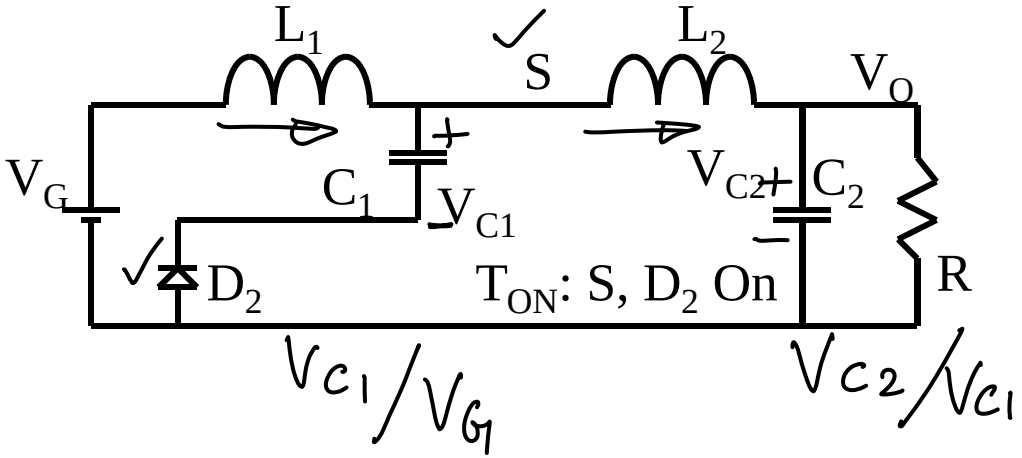
T_{ON}: S, D_2 On

T_{OFF}: D_1, D_3 On

Switched Mode Power Conversion

Problem Set 03

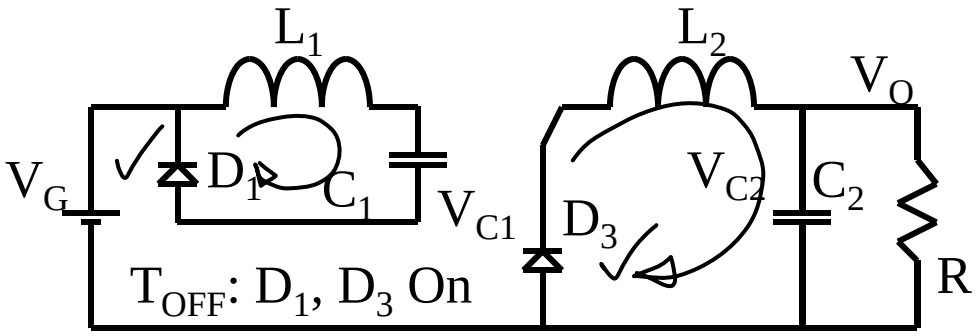
Problem No. 1



$\frac{T_{ON}}{T_S} = D$

T_{ON}

+



T_{OFF}

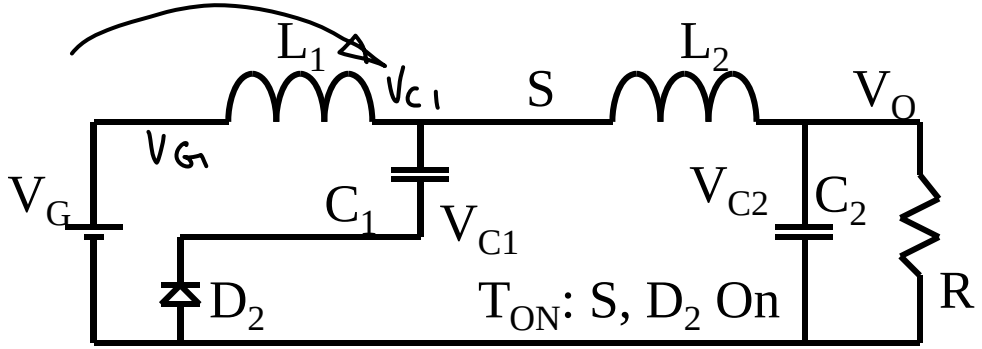
T_S

Switched Mode Power Conversion

Problem Set 03

Problem No. 1

$V_{C1} = D V_G$



$(V_G - V_{C1})\ T_{ON}$

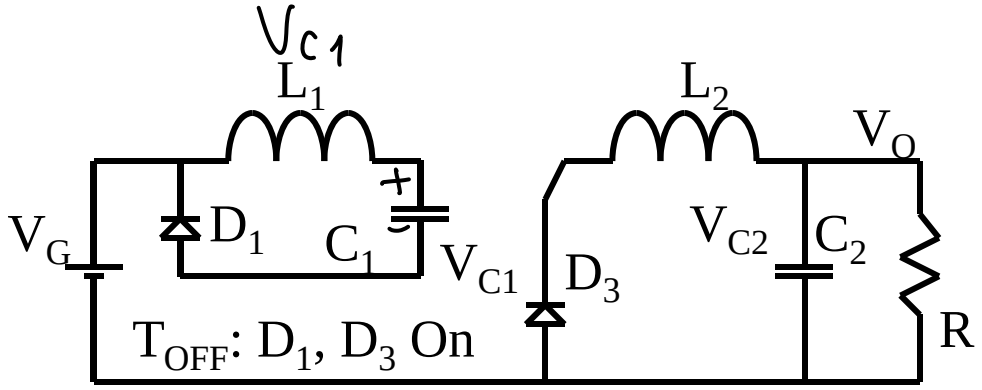
$+$

$(-V_{C1})\ T_{OFF}$

0

$V_{C1} \times T_S = V_G T_{on}$

$V_{C1} = D V_G$



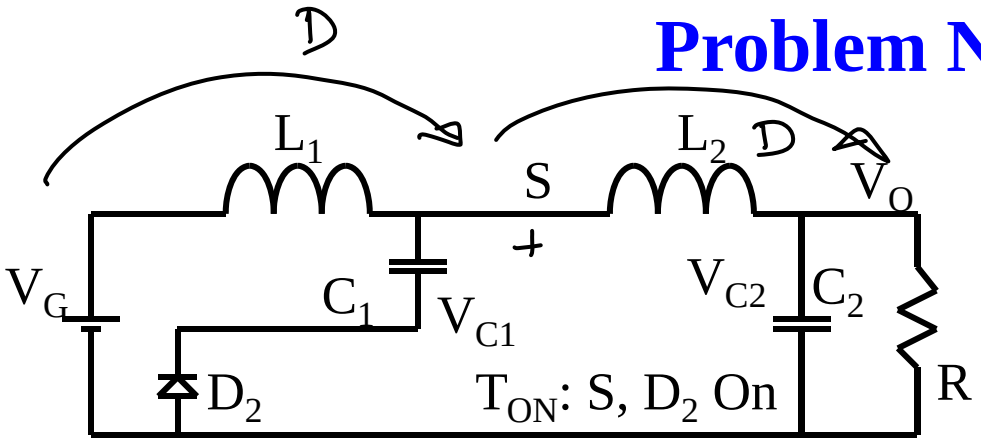
$V_O = D^2 V_G$

Volt-sec Balance on L_1

Switched Mode Power Conversion

Problem Set 03

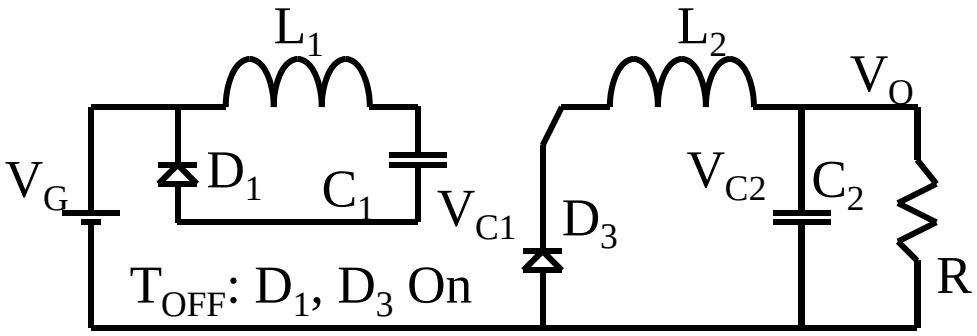
Problem No. 1



$$(V_{C1} - V_{C2})\, T_{ON} + (-V_{C2})\, T_{OFF} = 0$$

$$V_{C1}\, T_{ON} = V_{C2}\, T_S$$

$$V_{C2} = D\, V_{C1}$$



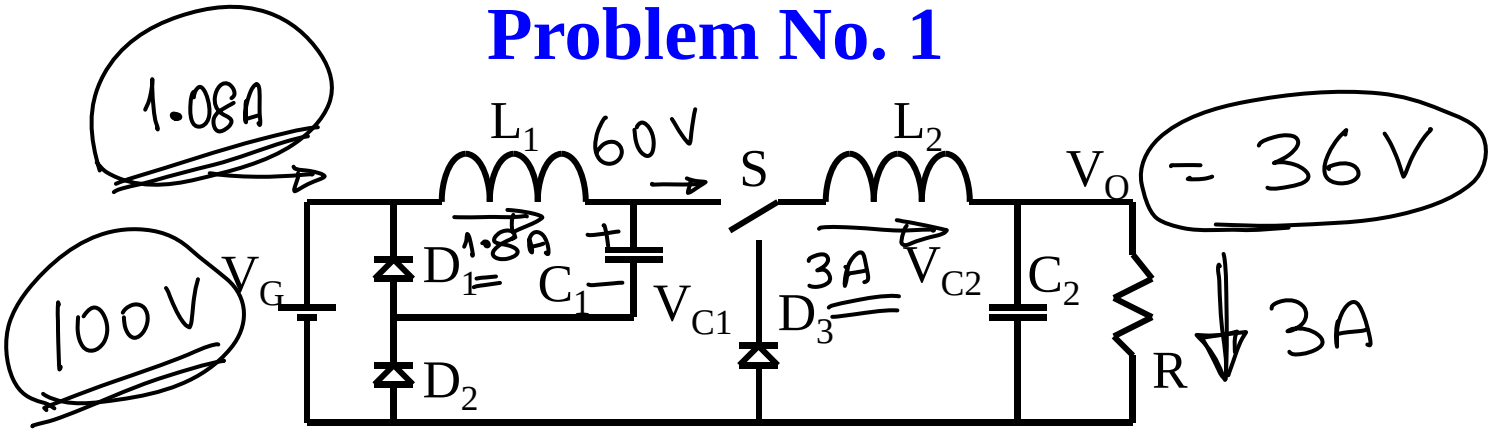
$$V_{C2} = V_O = D^2 V_G$$

Volt-sec Balance on L_2

Switched Mode Power Conversion

Problem Set 03

Problem No. 1



$100\ I_G = 36 \times 3$

$I_G = \frac{36 \times 3}{100} = 1.08A$

T_{ON}: S, D_2 On

T_{OFF}: D_1, D_3 On

V_G: 100 V; D: 0.6; R:12 ohm; T_S: 20 µs;

L_1, L_2, C_1, C_2: ??

$I_{L2} = 3A$

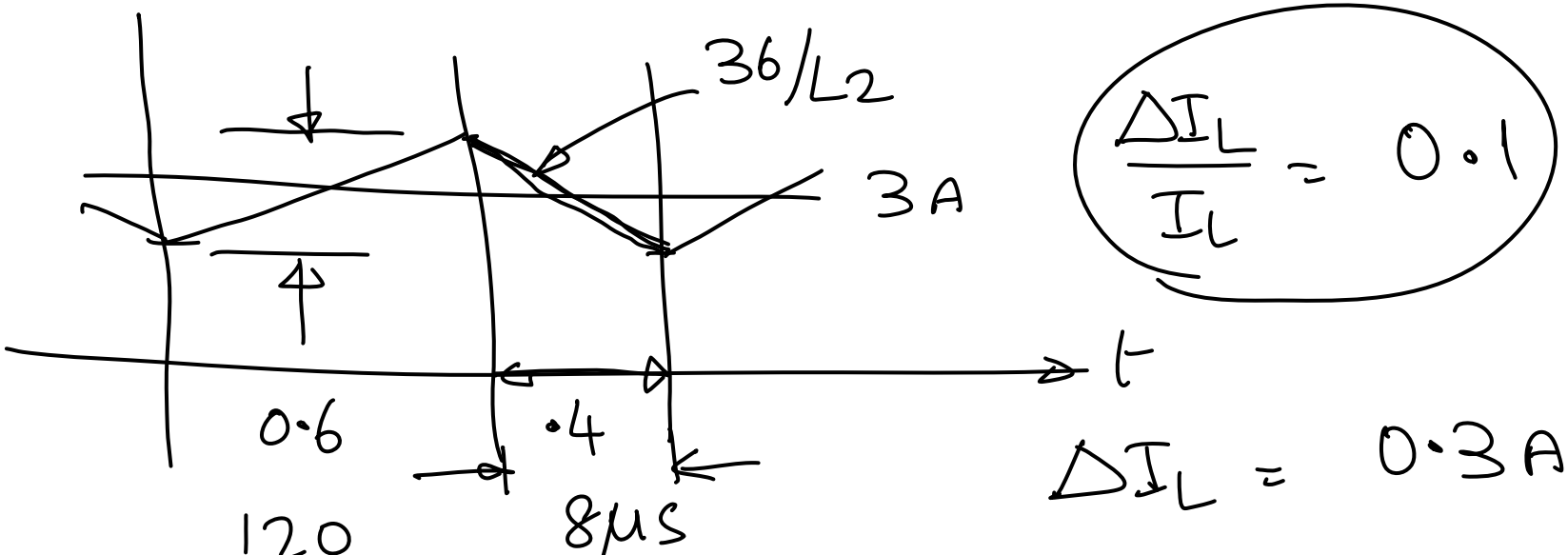
$I_G = 1.08A$

$I_{L1} = 1.8\ A$

Switched Mode Power Conversion

Problem Set 03

Problem No. 1



$\frac{\Delta I_L}{I_L} = 0.1$

$\Delta I_L = 0.3A$

$L_2 = \frac{36 \times 8\mu}{.3} = \frac{120}{.3} \times 8\mu$ → 960μH

$\frac{36}{L_2} 8\mu = 0.3A$

$L_2 = 960\mu H$

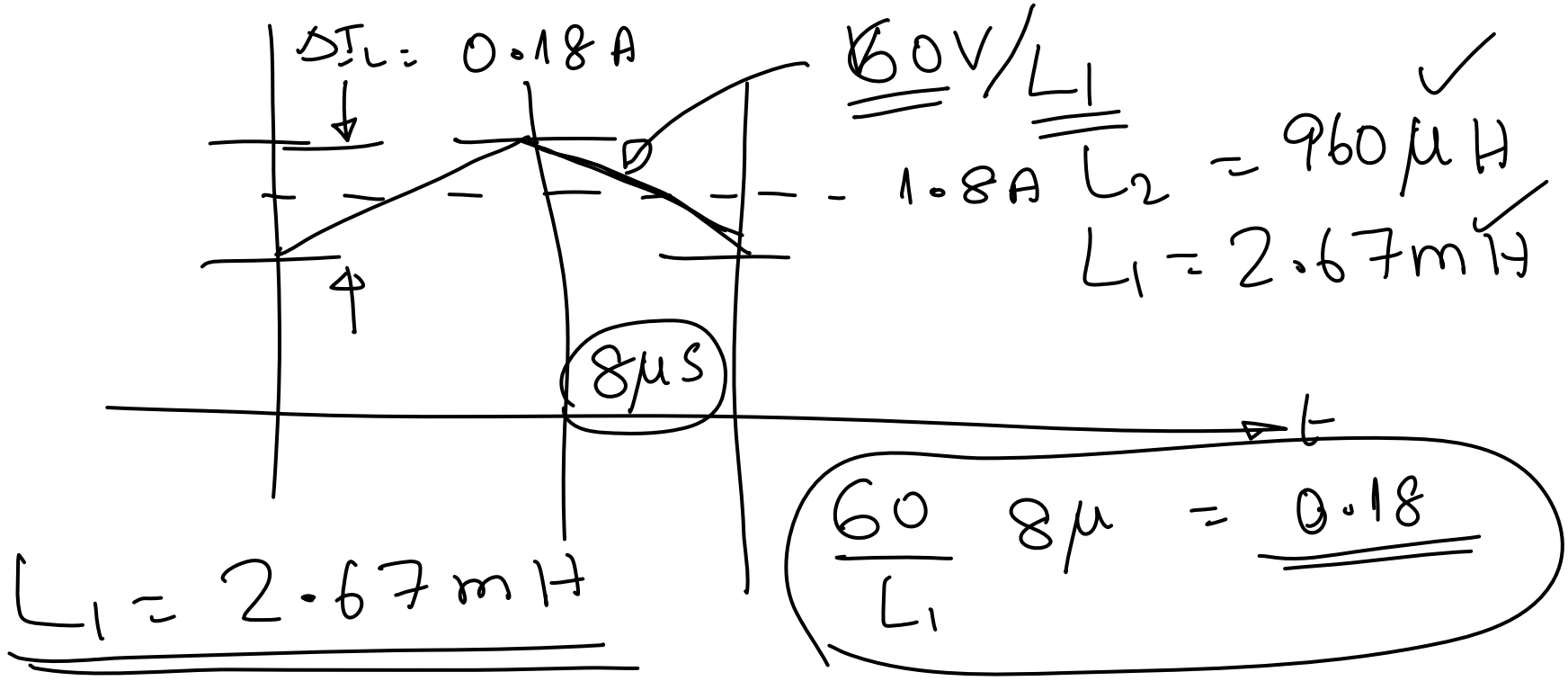
V_G: 100 V; D: 0.6; R:12 ohm; T_S: 20 μs;

L_2: ??

Switched Mode Power Conversion

Problem Set 03

Problem No. 1



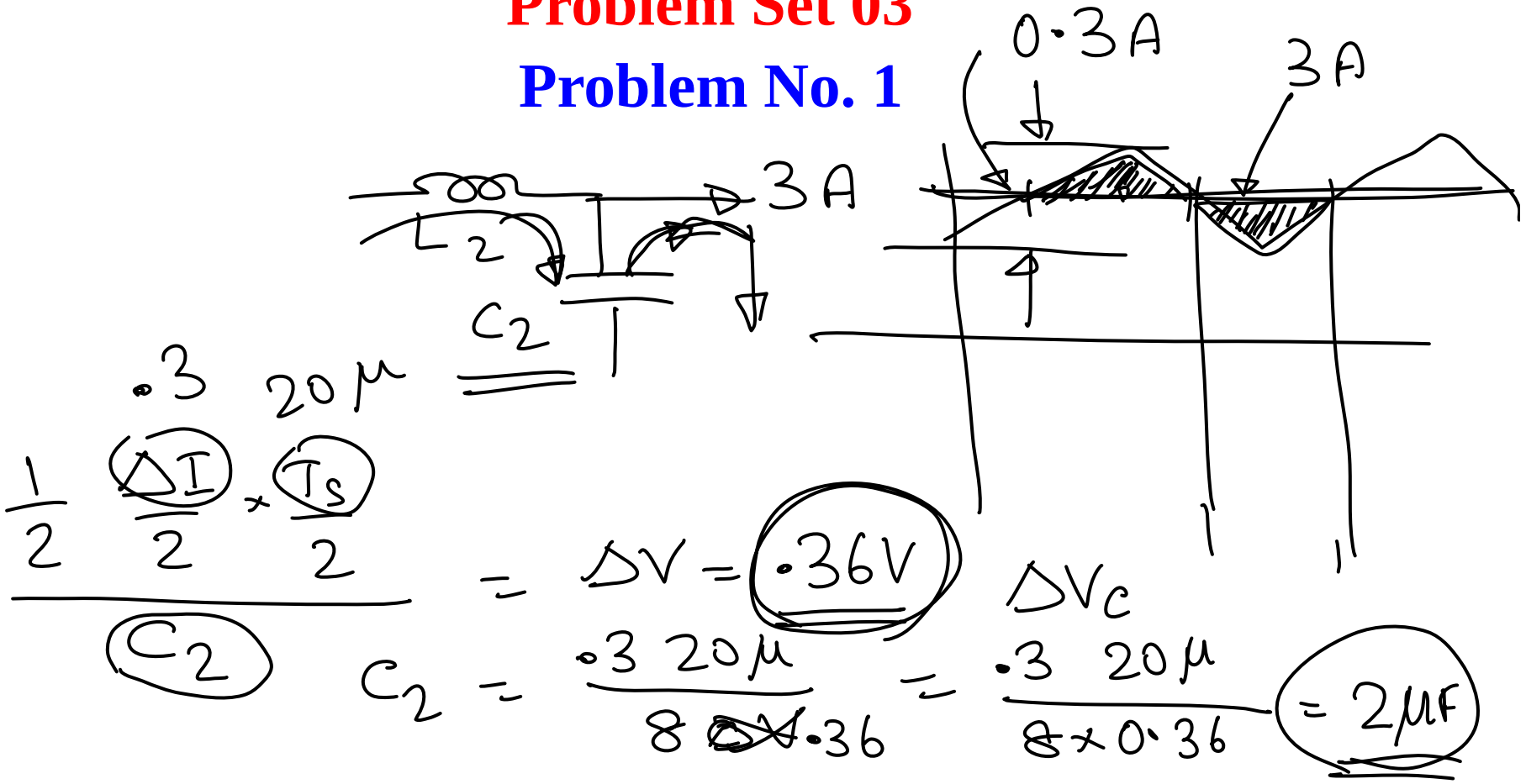
V_G: 100 V; D: 0.6; R:12 ohm; T_S: 20 μs;

L_1: ??

Switched Mode Power Conversion

Problem Set 03

Problem No. 1



V_G: 100 V; D: 0.6; R:12 ohm; T_S: 20 µs;

C_2: ??

Switched Mode Power Conversion

Problem Set 03

Problem No. 1

$V_0 = 36\,V$ $\quad I_0 = 3\,A$

$I_{L2} = 3\,A$ $\quad I_{L1} = 1.8\,A$

$V_{C1} = 60\,V$ $\quad V_{C2} = V_0 = 36\,V$

$L_1 = 2.67\,mH$ $\quad L_2 = 960\,\mu H$

$C_1 = 24\,\mu F$ $\quad C_2 = 2\,\mu F$

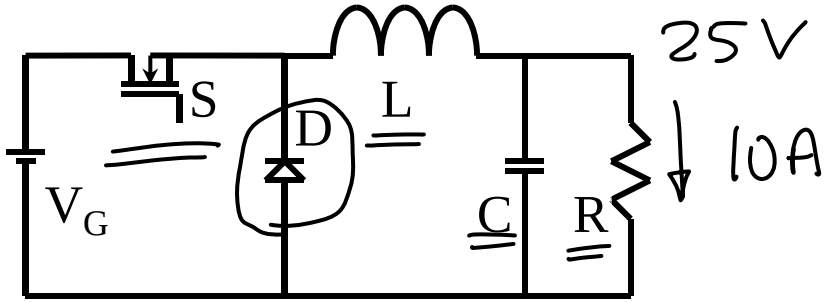
V_G: 100 V; D: 0.6; R:12 ohm; T_S: 20 µs;

C_2: ??

Switched Mode Power Conversion

Problem Set 03

Problem No. 2



D = 0.4

T_S = 20 μs

L = 20 μH

ΔI_L = ?

E_L = ?

I_S = ?

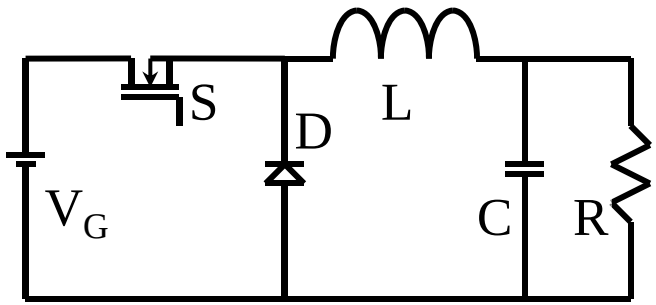
Loss in S = ?

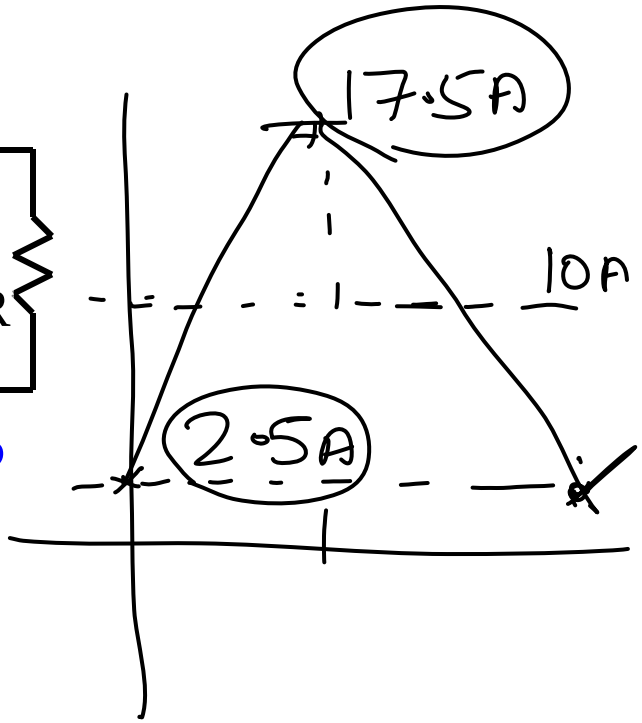
D: 0.4; I_O:10 A; T_S: 20 μs; L: 20 μH; V_O: 25 V;

Switched Mode Power Conversion

Problem Set 03

Problem No. 2





Ripple Current ?

$\Delta I = 15\,A$

D: 0.4; I_O:10 A; T_S: 20 μs; L: 20 μH; V_O: 25 V;

Switched Mode Power Conversion

Problem Set 03

Problem No. 2

Ripple Current ?

$\Delta I = 15\ A$

$I_{pk} = 17.5\ A$

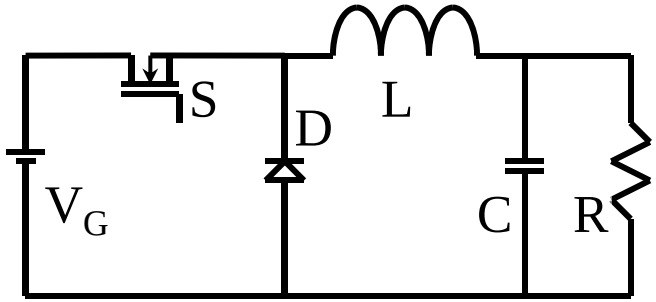
$I_{min} = 2.5\ A$

D: 0.4; I_O:10 A; T_S: 20 μs; L: 20 μH; V_O: 25 V;

Switched Mode Power Conversion

Problem Set 03

Problem No. 2



Peak Stored Energy in L ? $\frac{1}{2} L I^2$

$E = 0.5 \; 20\mu \; 17.5^2$

$= 30625 \mu J = \underline{30.63 \text{ mJ}}$

D: 0.4; I_O:10 A; T_S: 20 μs; L: 20 μH; V_O: 25 V;

Switched Mode Power Conversion

Problem Set 03

Problem No. 2

Peak Stored Energy in L ?

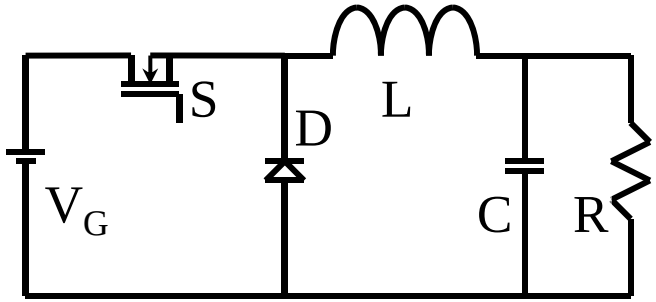
Peak E = 30.63mJ

D: 0.4; I_O:10 A; T_S: 20 μs; L: 20 μH; V_O: 25 V;

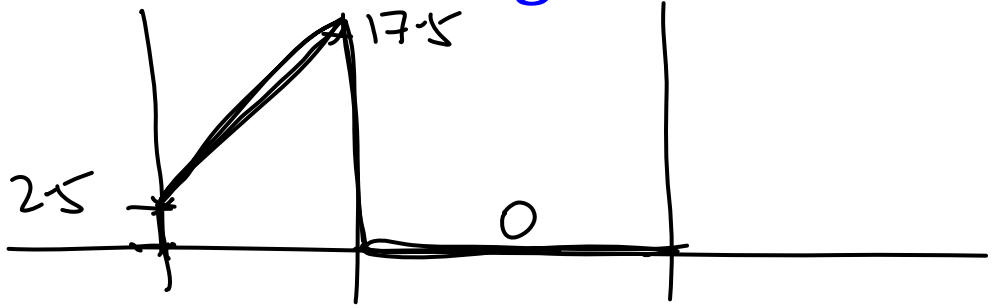
Switched Mode Power Conversion

Problem Set 03

Problem No. 2



RMS Current Through Switch ?



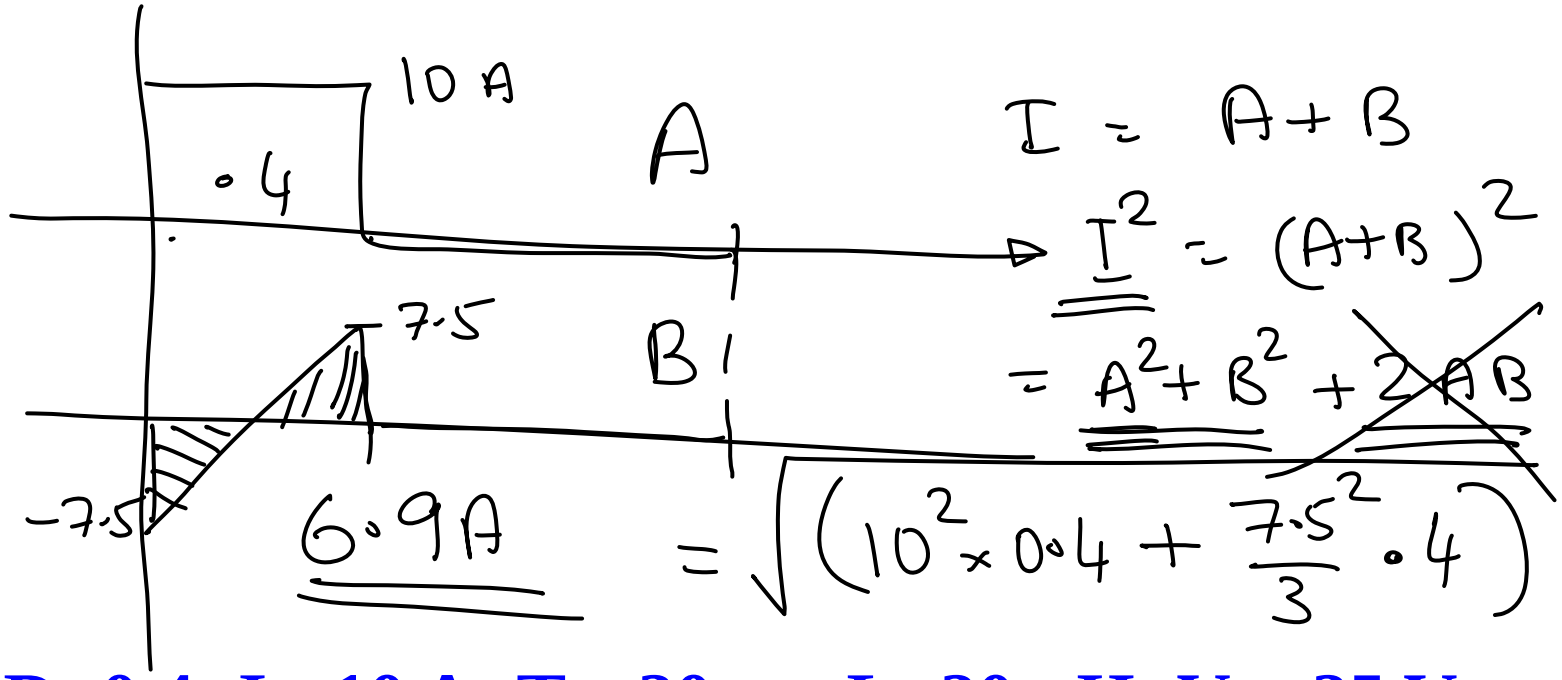
D: 0.4; I_O:10 A; T_S: 20 μs; L: 20 μH; V_O: 25 V;

Switched Mode Power Conversion

Problem Set 03

Problem No. 2

Rms Current Through Switch ? 6.9A

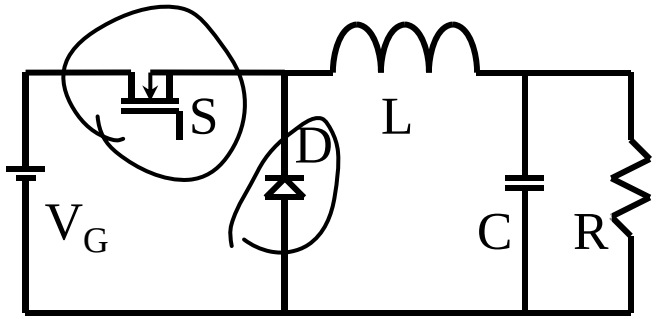


D: 0.4; I_O:10 A; T_S: 20 µs; L: 20 µH; V_O: 25 V;

Switched Mode Power Conversion

Problem Set 03

Problem No. 2



6.9A

Loss in the Switch (R_{ds}(on) = 20 mΩ) ?

$I_{rms}^2 R_{ds(on)}$

$6.9^2 \quad 20\ m\Omega = 0.95\ W$

D: 0.4; I_O:10 A; T_S: 20 μs; L: 20 μH; V_O: 25 V;

Switched Mode Power Conversion

Problem Set 03

Problem No. 2

Loss in the Switch ($R_{ds}(on)$ = 20 mΩ) ?

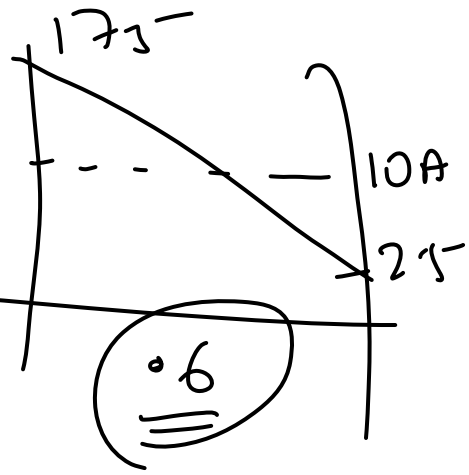
$P_S = 0.95\ W$

$I_{av} = 10 \times 0.6 = 6\ A$

$V_D = 1\ V$

$P_{loss} = 6A \times 1V = 6W$

$17.5A \times 20m\Omega = .35V$

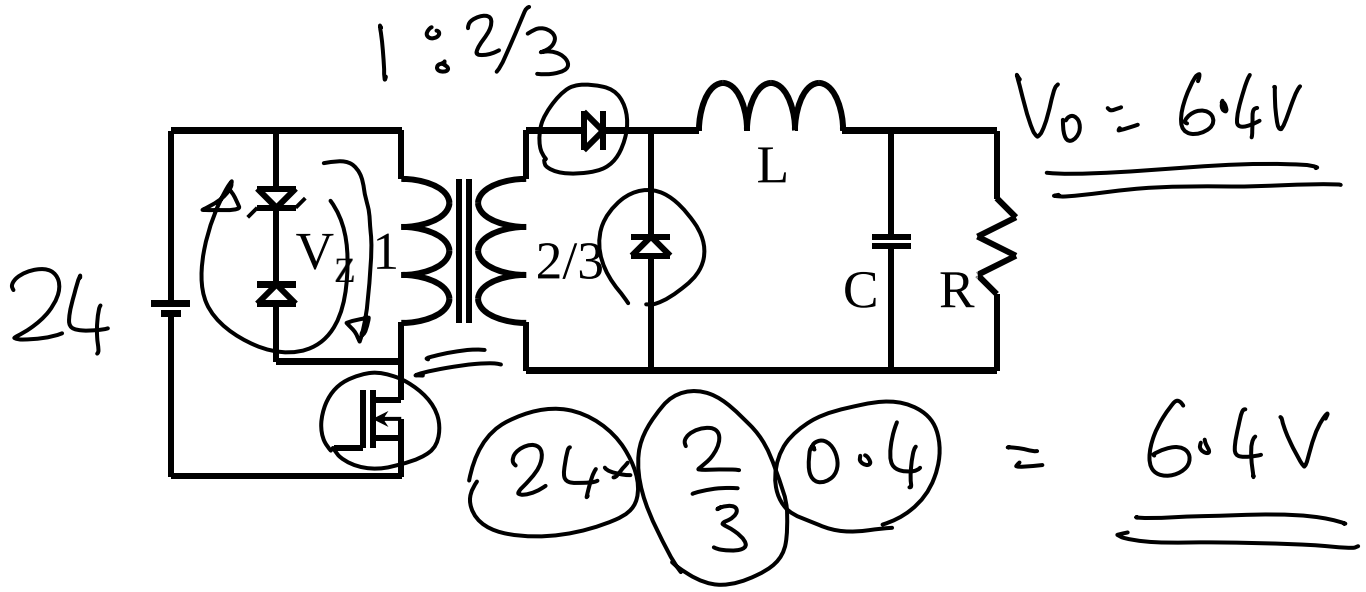


D: 0.4; I_O:10 A; T_S: 20 µs; L: 20 µH; V_O: 25 V;

Switched Mode Power Conversion

Problem Set 03

Problem No. 3

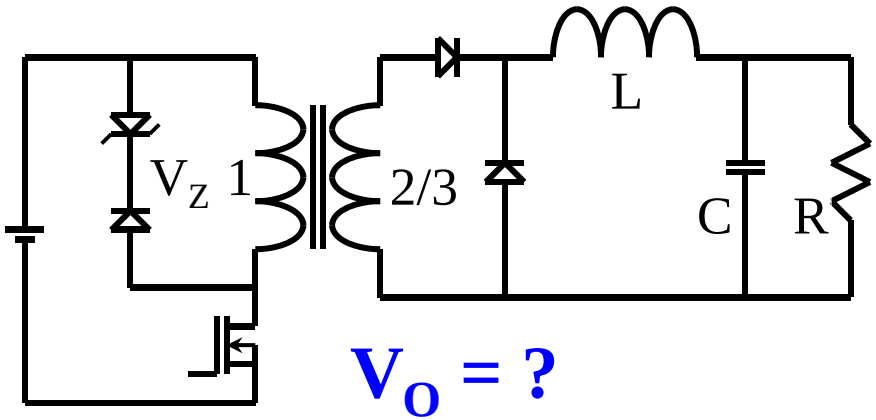


V_G: 24 V; D: 0.4; R:1.0 ohm; T_S: 20 μs;

Switched Mode Power Conversion

Problem Set 03

Problem No. 3



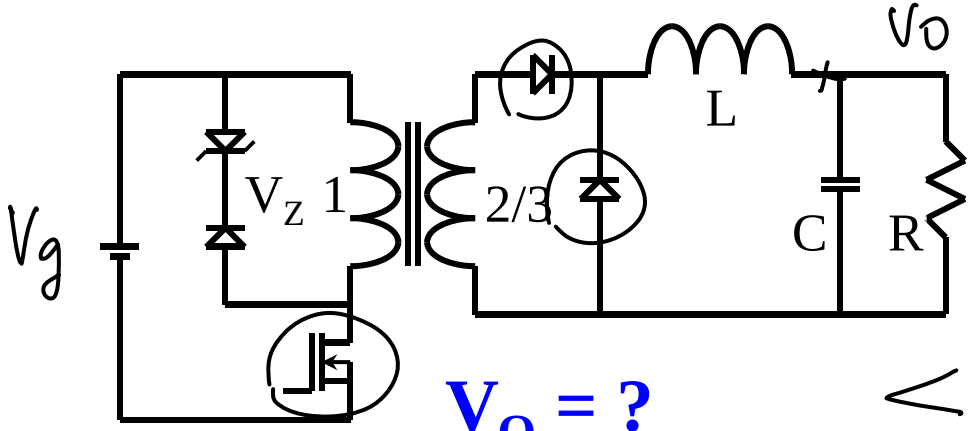
V_O = ?

V_G: 24 V; D: 0.4; R:1.0 ohm; T_S: 20 μs;

Switched Mode Power Conversion

Problem Set 03

Problem No. 3



V_O = ? < 6.4 V

$$\left[\left(V_g - V_T - I_p R_p\right)\frac{2}{3} - V_d - I_l R_l - I_l R_s - V_O\right] T_{ON}$$

$$\left(-V_d - I_l R_l - V_O\right) T_{OFF}$$

V_t: 0.4 V; V_d: 0.8 V; R_p: 30 mΩ; R_s: 60 mΩ; R_l: 15 mΩ;

Switched Mode Power Conversion

Problem Set 03

Problem No. 3

V_O = ?

V_t: 0.4 V; V_d: 0.8 V; R_p: 30 mΩ; R_s: 60 mΩ; R_l: 15 mΩ;

V_G: 24 V; D: 0.4; R:1.0 ohm; T_S: 20 μs;

Switched Mode Power Conversion

Problem Set 03

Problem No. 3

V_O = ?

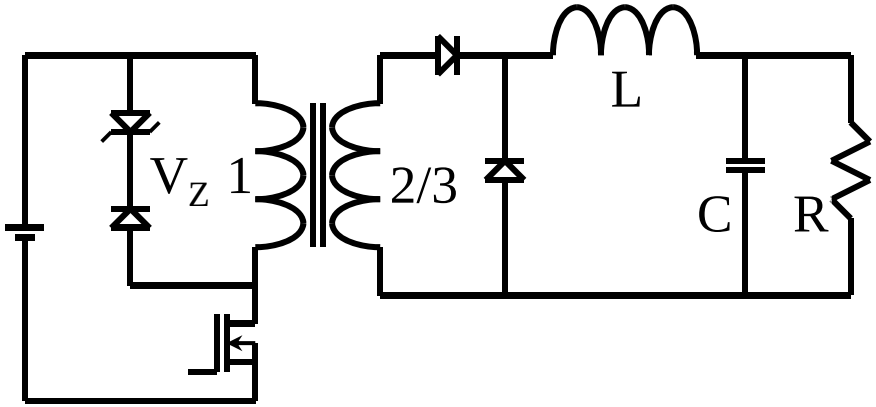
V_t: 0.4 V; V_d: 0.8 V; R_p: 30 mΩ; R_s: 60 mΩ; R_l: 15 mΩ;

V_G: 24 V; D: 0.4; R:1.0 ohm; T_S: 20 μs;

Switched Mode Power Conversion

Problem Set 03

Problem No. 3



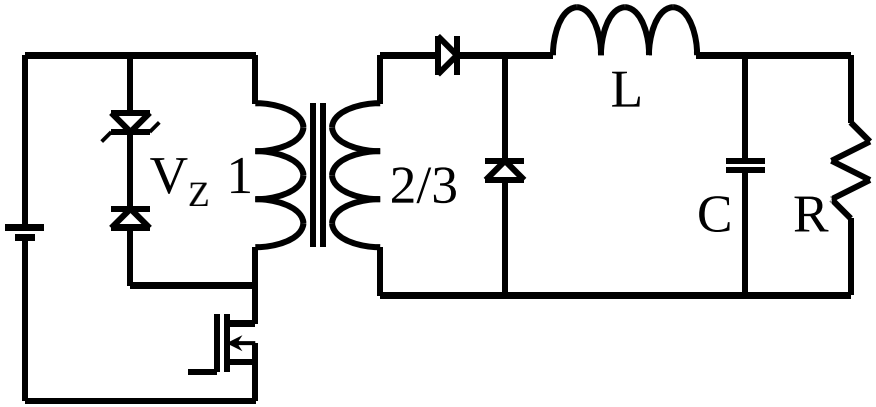
Magnetisation Loss: ?

Lm: 500 μH

Switched Mode Power Conversion

Problem Set 03

Problem No. 3



Magnetisation Loss: ?

Lm: 500 μH

Switched Mode Power Conversion

Problem Set 03

Problem No. 3

Magnetisation Loss:

Lm: 500 μH

Switched Mode Power Conversion

Problem Set 03

Problem No. 3

Efficiency: ?

Lm: 500 μH

Switched Mode Power Conversion

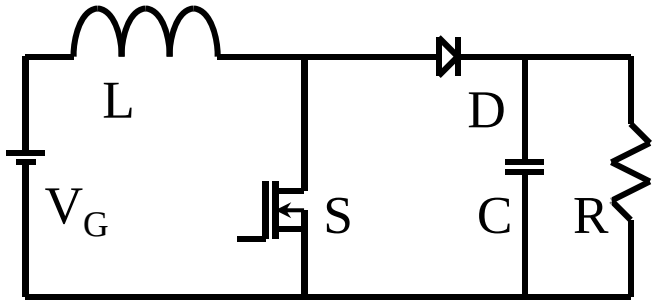
Problem Set 03

Problem No. 3

Switched Mode Power Conversion

Problem Set 03

Problem No. 4

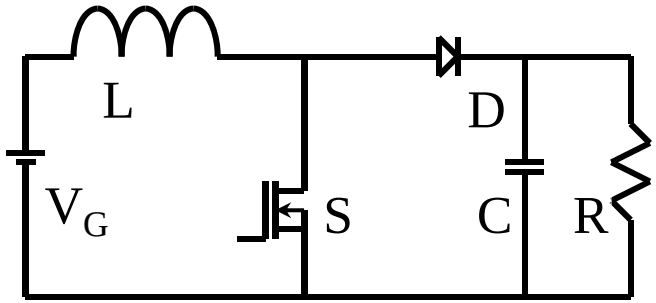


V_G: 20 V; D: 0.5; R: 50 ohm; V_O: 50 V; L = 20 μH;

Switched Mode Power Conversion

Problem Set 03

Problem No. 4



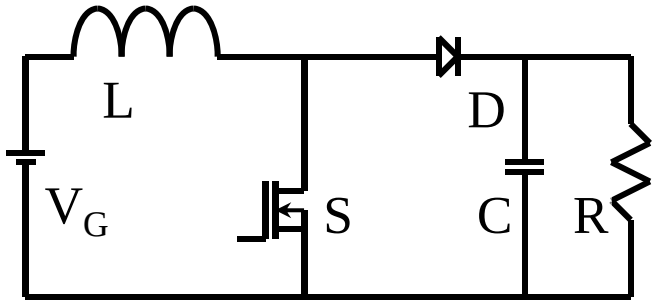
What is the Conduction Mode?

V_G: 20 V; D: 0.5; R: 50 ohm; V_O: 50 V; L = 20 μH;

Switched Mode Power Conversion

Problem Set 03

Problem No. 4



What is the Average Input Current?

V_G: 20 V; D: 0.5; R: 50 ohm; V_O: 50 V; L = 20 μH;

Switched Mode Power Conversion

Problem Set 03

Problem No. 4

Periodic Input Current Waveshape

Switched Mode Power Conversion

Problem Set 03

Problem No. 4

Periodic Input Current Waveshape

Switched Mode Power Conversion

Problem Set 03

Problem No. 4

Switching Frequency?

Switched Mode Power Conversion

Problem Set 03

Problem No. 4

Conduction Parameter?

Switched Mode Power Conversion

Problem Set 03

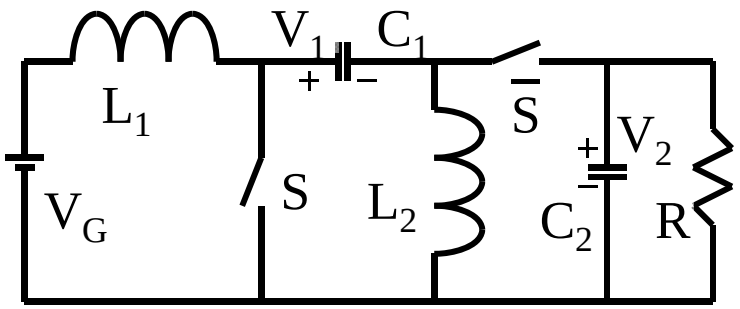
Problem No. 4

V_G: 20 V; D: 0.5; R: 50 ohm; V_O: 50 V; L = 20 μH;

Switched Mode Power Conversion

Problem Set 03

Problem No. 5

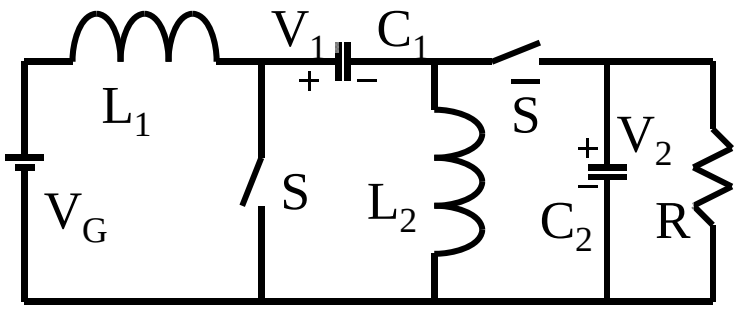


V_G: 40 V; D: 0.35; R: 20 ohm;

Switched Mode Power Conversion

Problem Set 03

Problem No. 5



Volt-Sec Balance & V_1 and V_2

Volt-Sec Balance on L_2

Switched Mode Power Conversion

Problem Set 03

Problem No. 5

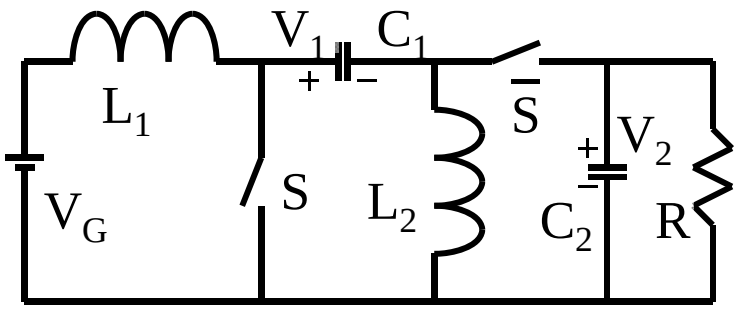
Volt-Sec Balance & V_1 and V_2

Volt-Sec Balance on L_2

Switched Mode Power Conversion

Problem Set 03

Problem No. 5



Volt-Sec Balance & V_G and V_1

Volt-Sec Balance on L_1

Switched Mode Power Conversion

Problem Set 03

Problem No. 5

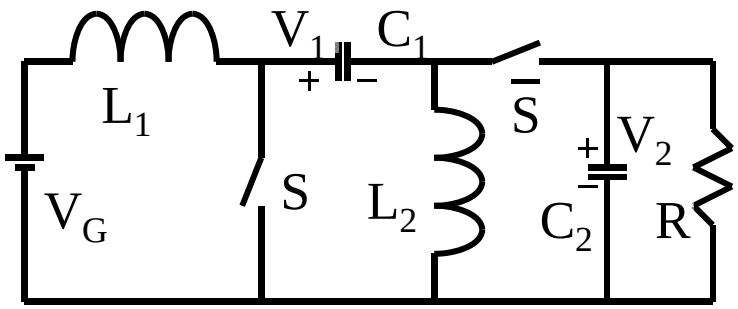
Volt-Sec Balance & V_G and V_1

Volt-Sec Balance on L_1

Switched Mode Power Conversion

Problem Set 03

Problem No. 5



Periodic Current in L_2

Voltage Across L_2

Switched Mode Power Conversion

Problem Set 03

Problem No. 5

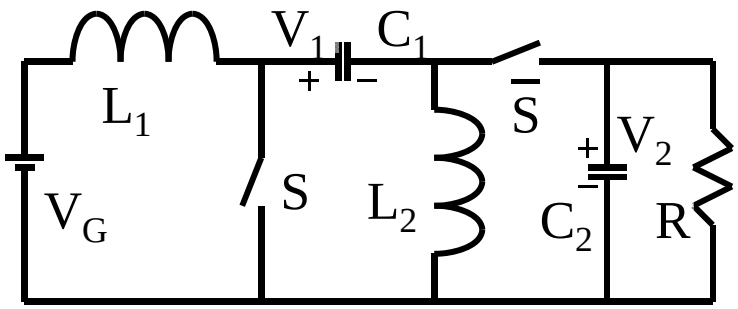
Periodic Current in L_2

Voltage Across L_2

Switched Mode Power Conversion

Problem Set 03

Problem No. 5



Periodic Current in L_2

Border Between CCM and DCM

Switched Mode Power Conversion

Problem Set 03

Problem No. 5

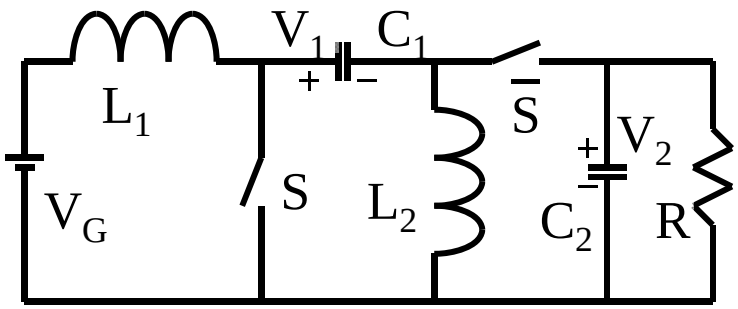
Condition on $K = 2L_2/RT_S$

Border Between CCM and DCM

Switched Mode Power Conversion

Problem Set 03

Problem No. 5



V_G: 40 V; D: 0.35; R: 20 ohm;