Assignment 02 Summary

- Plot 1A on page 1.3 shows the graphs for 1a, 1d for the first-order transfer function model of the dynamic loads for the signal given in 1a.
- Plot 1B on page 1.4 shows the graphs for 1a, 1d for the first-order transfer function model of the dynamic loads for the signal given in 1c.
- Plot 1C on page 1.5 shows the graphs for 1b, 1d for the second-order transfer function model of the dynamic loads for the signal given in 1a.
- Plot 1D on page 1.6 shows the graphs for 1b, 1d for the second-order transfer function model of the dynamic loads for the signal given in 1c.
- Note: Since the static load curve for 1a and 1d is virtually numerically equal for the given set of load voltages (refer to the curves plotted in Desmos 1), their curve $P_{Li}^{static}(t)$ and $P_{Li}(t)$ has only been plotted once in all the graphs.

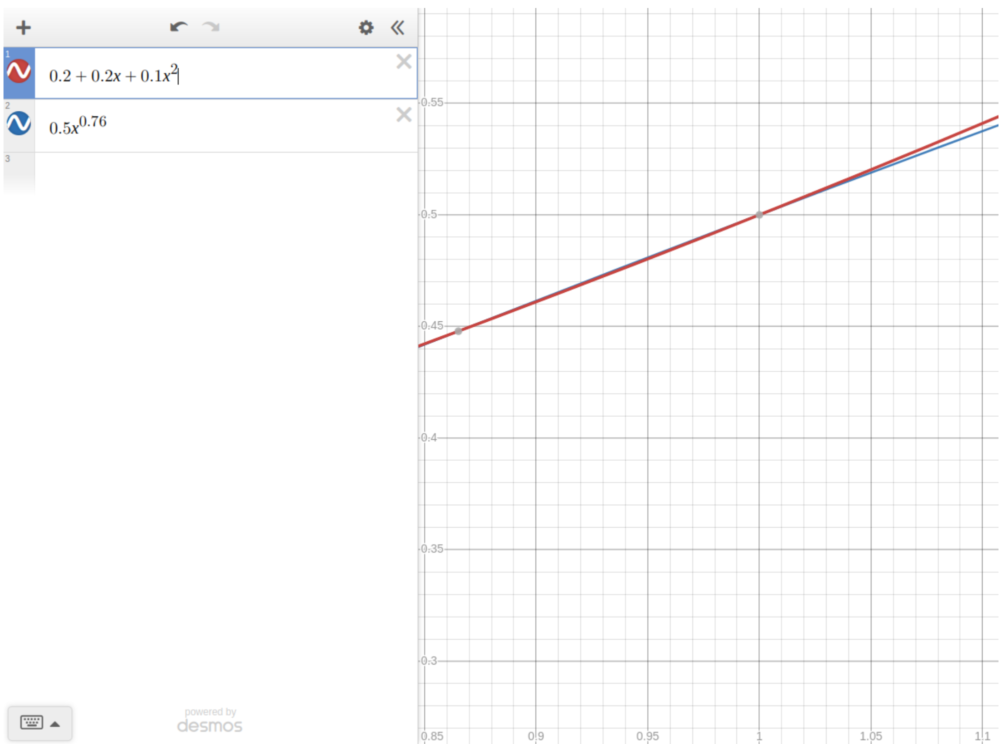


Figure 1: Comparsion of the two static load curves for relevant load voltages.

EE 523 A02

ARYAN RITWAJEET JHA

$\boxed{1.1}$

$\boxed{1.}$

$P_{L_i} = P_{L_i}^S + P_{L_i}^D$

$Q_{L_i} = Q_{L_i}^S + Q_{L_i}^D$

100 MW = 1.00 pu

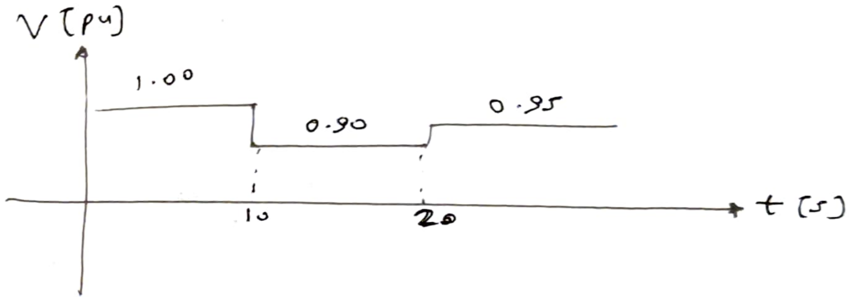
50 MVAR = 0.50 pu

@ MVA_B = 100 MVA

$P_{L_i}^S = 0.5\, V_i^{0.75}$

$Q_{L_i}^S = 0.8\, V_i^{0.65}$

Signal 1:
$V_1(t)$



System 1

$H_1(s)$:

$V_i \rightarrow \boxed{0.5 \times \frac{1}{1+s4}} \rightarrow P_{L_i}^P$

$\boxed{\tau_p = 4s}$

$V_i \rightarrow \boxed{0.2 \times \frac{1}{1+s3}} \rightarrow Q_{L_i}^D$

$\boxed{\tau_Q = 3s}$

System 2 :

$H_2(s)$ =

$V_i \rightarrow \boxed{0.5 \times \frac{1}{1+0.002s+0.025s^2}} \rightarrow P_{L_i}^P$

$\boxed{\omega_{dp} \approx \omega_{np}}$ $\boxed{M_{pp} \approx 99.95\%}$

$\omega_{np} = \sqrt{\frac{1}{0.025}}$

$\boxed{\omega_{np} = 2\sqrt{10}}$

$\xi_p = \cancel{5e-4.5}$

$\boxed{\xi_p = 5\sqrt{10}e-5} \approx 0$

$V_i \rightarrow \boxed{0.2 \times \frac{1}{1+0.002s+0.05s^2}} \rightarrow Q_{L_i}^P$

$\boxed{\omega_{nQ} = 2\sqrt{5}}$

$\boxed{\xi_Q = \sqrt{5}e-4 \approx 0}$

$\boxed{\omega_{dQ} \approx \omega_{nQ}}$ $\boxed{M_{pQ} \approx 99.95\%}$

$\xi_p = \frac{0.002\sqrt{10}}{2 \times 2 \times 10}$

$\xi_p = \frac{0.0002\sqrt{10}}{2}$

$\xi_p = \frac{0.0001\sqrt{10}}{2}$

$\xi_p = \frac{0.00005\sqrt{10}}{}$

$\xi_Q = \frac{0.002}{2\sqrt{5} \times 2}$

$\xi_Q = \frac{1e-3}{2\sqrt{5}}$

$\xi_Q = \sqrt{5}e-4$

We can approximate system 2 as:

$\boxed{1.2}$

$H_2(s)$

$$V_i \longrightarrow \boxed{0.5 \times \frac{1}{1 + 0.025 s^2}} \longrightarrow P_{L_i}^{II\,D}$$

$$V_i \longrightarrow \boxed{0.2 \times \frac{1}{1 + 0.05 s^2}} \longrightarrow Q_{L_i}^{II\,D}$$

$\cancel{P_{L_i}^D(t) \approx 20.5}$

II ∘ Undamped system

$\Rightarrow H_2(s)$

$$V_i \longrightarrow \boxed{0.5 \times \frac{\frac{1}{0.025}}{\frac{1}{0.025} + s^2}} \longrightarrow P_{L_i}^D$$

$$V_i \longrightarrow \boxed{0.2 \times \frac{\frac{1}{0.05}}{\frac{1}{0.05} + s^2}} \longrightarrow Q_{L_i}^D$$

$\Rightarrow \cancel{P_{L_i}^D = 0.5 \times \sqrt{40}\,\sin(\sqrt{40}\,t)} \times V_i(s)$

$\Rightarrow P_{L_i}^D = \cancel{\sqrt{10}\,\sin(\sqrt{40}\,t) \times V_i(s)}$

$\Rightarrow \boxed{P_{L_i}^D = \cancel{\sqrt{10}\,\sin(2\sqrt{10}\,t)}} \boxed{\cancel{\times V_i(s)}}$

$Q_{L_i}^D = \cancel{0.2 \times \sqrt{20}\,\sin(\sqrt{20}\,t)}$

$\Rightarrow \boxed{Q_{L_i}^D = \cancel{\frac{0.4\sqrt{5}}{\sqrt{5}}\,\sin(2\sqrt{5}\,t) \times V_i(s)}}$

$$\frac{V_i}{s} \longrightarrow \boxed{K\omega \times \frac{\omega_n}{\omega_n^2 + s^2}} \longrightarrow \begin{matrix} P_{L_i}^D(t) \\ Q_{L_i}^D(t) \end{matrix} = (K V_i(t)) \times \{1 - \cos(\omega_n t)\}$$

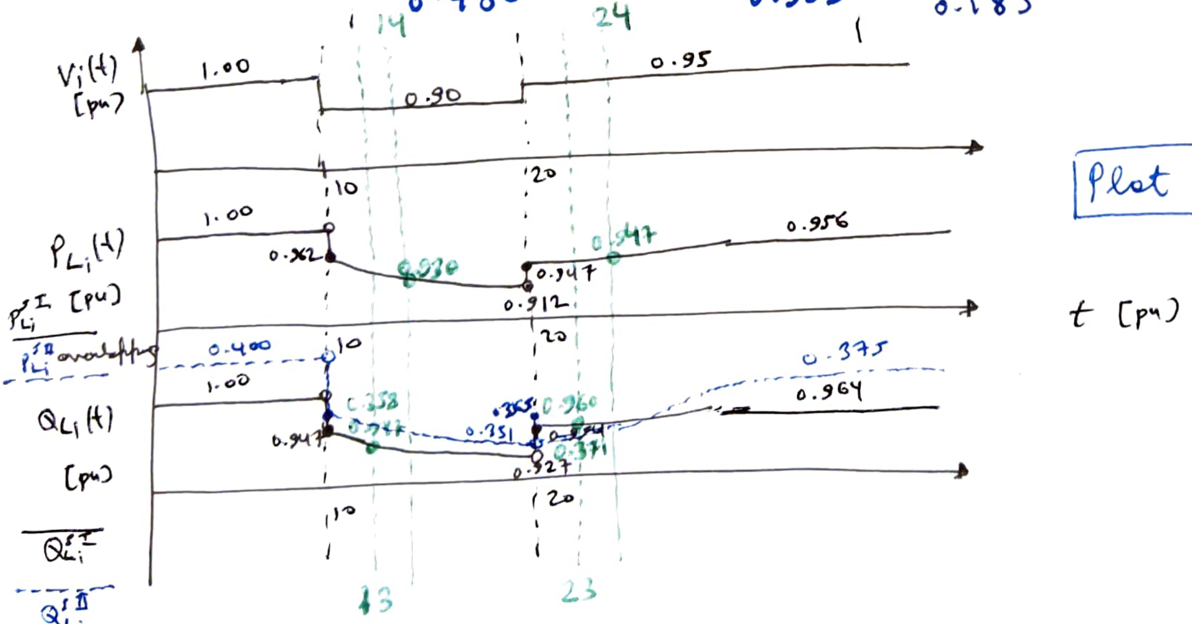
Here

$$\boxed{P_{L_i}^{II\,D}(t) = 0.5\,V_i(t)\{1 - \cos(2\sqrt{10}\,t)\}}$$

$$\boxed{Q_{L_i}^{II\,D}(t) = 0.2\,V_i(t)\{1 - \cos(2\sqrt{5}\,t)\}}$$

Calculations for Signal I for IO Systems: Static Loads I and II

t	$V_i(t)$	$P^{I_S}_{L_i}(t)$	$P^{I_D}_{L_i}(t)$	$P^{I}_{L_i}(t)$	$Q^{I_S}_{L_i}(t)$	$Q^{I_D}_{L_i}(t)$	$Q^{I}_{L_i}(t)$
10^-	1.00	0.500 0.500	0.500	1.000 1.000	0.800 0.200	0.200	1.000 ~~1.00~~ 0.400
10^+	0.90	0.462 0.461	0.500	0.962 0.961	0.747 0.171	0.200	0.947 0.371
10+3=13	0.90	0.462 0.461	—	—	0.747 0.171	~~0.930~~ 0.187	0.934 0.358
10+4=14	0.90	0.462 0.461	0.418	~~0.8~~ 0.930 0.929	0.747 0.171	—	—
20^-	0.90	0.462 0.461	0.450	0.912 0.911	0.747 0.171	0.180	0.927 0.351
20^+	0.95	0.481 0.480	~~0.450~~ 0.450	~~0.931~~ 0.931 0.930	0.774 0.185	0.180	0.954 0.365
20+3	0.95	0.481 0.480	—	—	0.774 0.185	0.186	0.960 0.371
20+4	0.95	0.481 0.480	0.466	0.947 0.946	0.774 0.185	—	—
∞	0.95	0.481 0.480	0.475	0.956 0.955	0.774 0.185	0.190	0.964 0.375

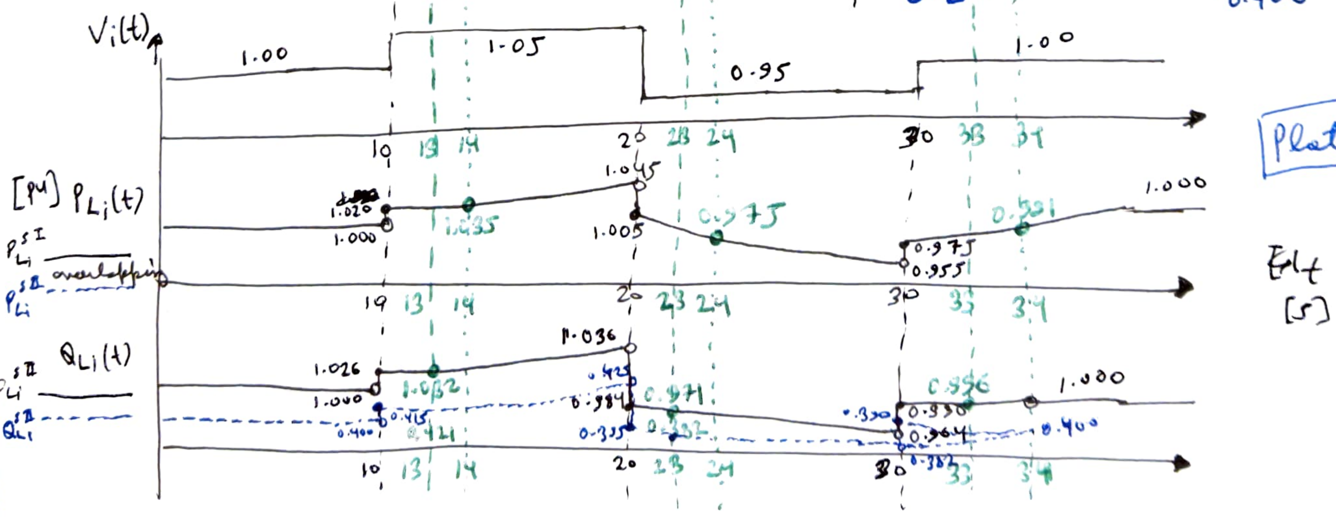


Plot 1A

Calculations for Signal II for ID Systems: Static Loads I and II

1-4

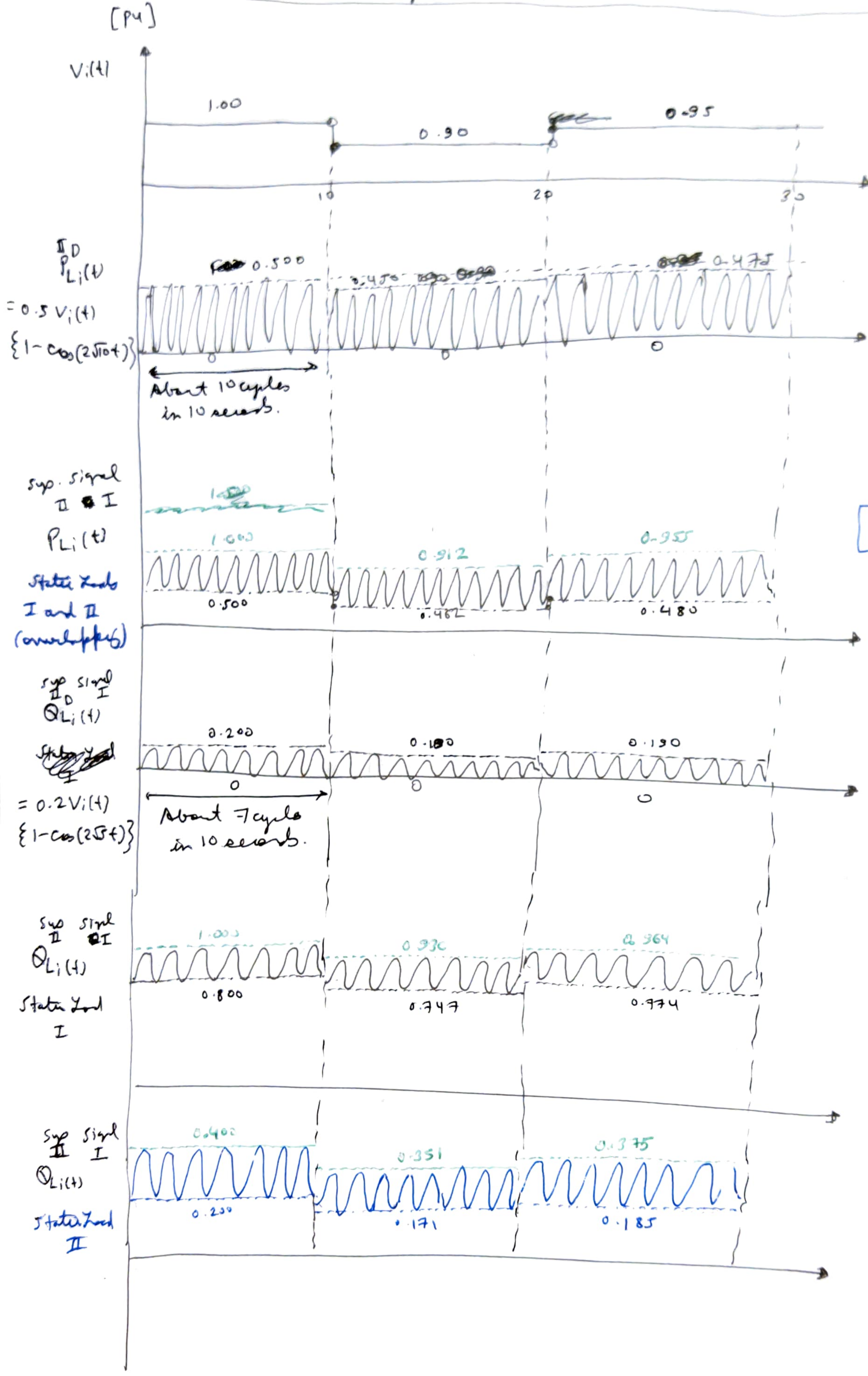
t	$V_i(t)$	$P_{L_i}^{sI}(t)$	$P_{L_i}^{P}(t)$	$P_{L_i}^{I}(t)$	$Q_{L_i}^{sI}(t)$	$Q_{L_i}^{ID}(t)$	$Q_{L_i}^{I}(t)$
10^-	1.00	0.500 0.500	0.500	1.000 1.000	0.800 0.200	0.200	1.000 0.400
10^+	1.05	0.519 0.520	0.500	1.019 1.020	0.826 0.215	0.200	1.026 0.415
10+3	1.05	0.519 ~~0.520~~ 0.520	—	—	0.826 0.215	0.206	1.032 0.421
10+4	1.05	0.519 0.520	0.516	1.035 1.036	0.826 0.215	—	—
20^-	1.05	0.519 0.520	~~0.529~~ 0.525	1.044 1.045	0.826 0.215	0.210	1.036 0.425
20^+	0.95	0.481 0.480	0.525	1.006 1.005	0.774 0.185	0.210	0.984 0.395
20+3	0.95	0.481 0.480	—	—	0.774 0.185	0.197	0.971 0.382
20+4	0.95	0.481 0.480	0.494	0.975 0.974	0.774 0.185	—	—
30^-	0.95	0.481 0.480	0.475	0.956 0.955	0.774 0.185	0.190	0.964 0.375
30^+	1.00	0.500 0.500	0.475	0.975 0.975	0.800 0.200	0.190	0.990 0.390
30+3	1.00	0.500 0.500	—	—	0.800 0.200 ~~0.200~~	0.196	0.996 0.396
30+4	1.00	0.500 0.500	0.491	0.991 0.991	0.800 0.200	—	—
∞	1.00	0.500 0.500	0.500	1.000 1.000	0.800 0.200	0.200	1.000 0.400



Plot 1B

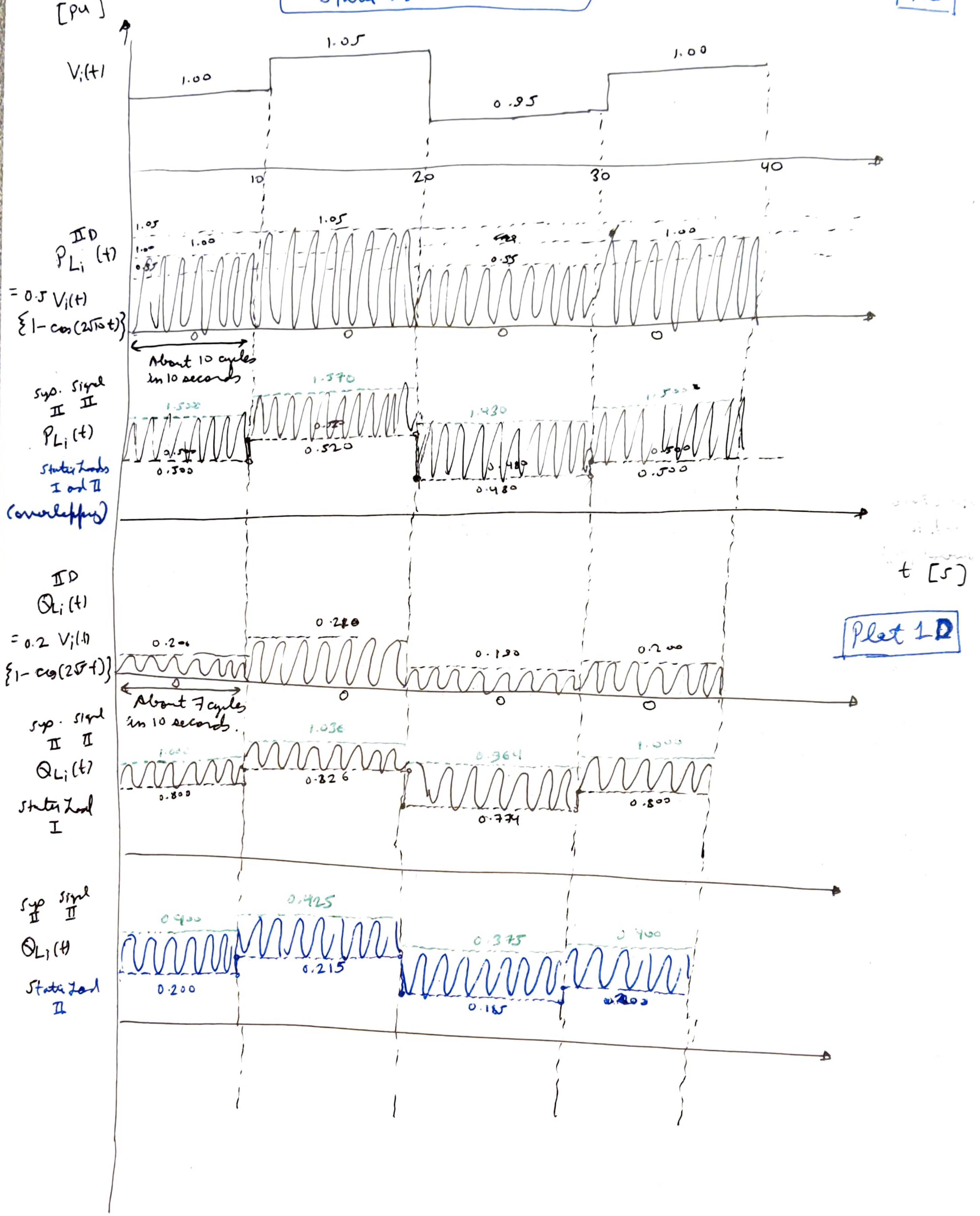
Graphs for Signal I for IIO System Static Loads I and II

1.5

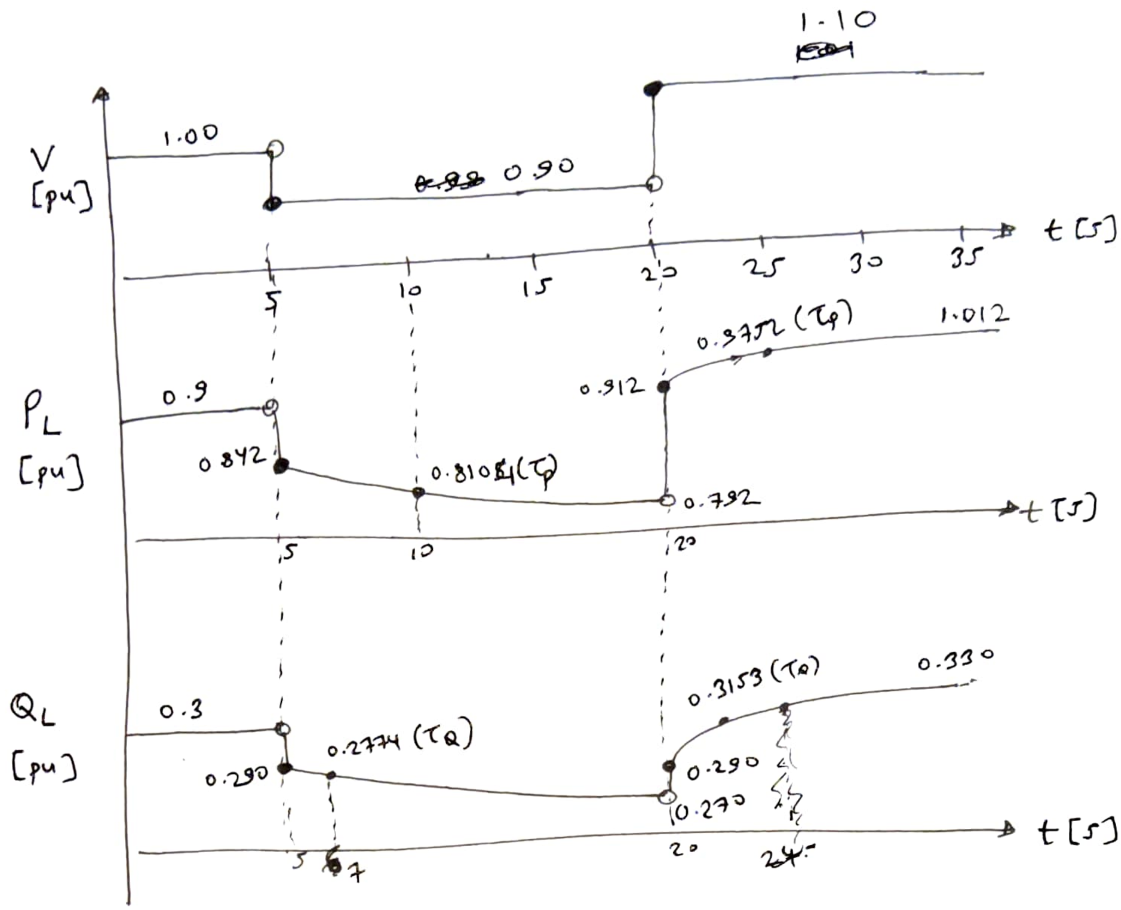


Plot 1C

Calculation Graphs for Signals I and II for II O system: Static Loads I and II.



2.



$$P_L(t) = P_{Lo} + MV + GV^2 + P_{LD}(t)$$

where $P_{LD}(s) = \dfrac{a_{op}}{1 + b_{op} s}$

$$Q_L(t) = Q_{Lo} + HV + BV^2 + Q_{LD}(t)$$

where $Q_{LD}(s) = \dfrac{a_{oQ}}{1 + b_{oQ} s}$

	t	$V(t)$	$P_L(t)$	$Q_L(t)$	$P_L(t)$	$Q_L(t)$
(i)	5^-	1.00	0.900	0.300	$P_{Lo} + M + G + a_{op}$	$Q_{Lo} + H + B + a_{oQ}$
(ii)	5^+	0.90	0.842	0.290	$P_{Lo} + 0.9M + 0.81G + a_{op}$	$Q_{Lo} + 0.9H + 0.81B + a_{oQ}$
O_{1p}	$5 + \tau_p = 9.5$	0.90	0.8106	-	$b_{op} = 4.5$	-
O_{1Q}	$5 + \tau_Q = 7$	0.90	-	0.2774	-	$b_{oQ} = 2$
(iii)	20^-	0.90	0.792	0.270	$P_{Lo} + 0.9M + 0.81G + 0.9a_{op}$	$Q_{Lo} + 0.9H + 0.81B + 0.9a_{oQ}$
(iv)	20^+	1.10	0.912	0.290	$P_{Lo} + 1.1M + 1.21G + 0.9a_{op}$	$Q_{Lo} + 1.1H + 1.21B + 0.9a_{oQ}$
O_{2P}	$20 + \tau_p = 24.5$	1.10	0.9752	-	$b_{op} = 4.5$	-
O_{2Q}	$20 + \tau_Q = 22$	1.10	-	0.3153	-	$b_{oQ} = 2$
(v)	∞	1.10	1.012	0.330	$P_{Lo} + 1.1M + 1.21G + 1.1a_{op}$	$Q_{Lo} + 1.1M + 1.21G + 1.1a_{oQ}$

(iii) − (ii) ⇒ $0.1\, a_{0P} = 0.05$ ⇒ $\boxed{a_{0P} = 0.5}$

$0.1\, a_{0Q} = 0.02$ ⇒ $\boxed{a_{0Q} = 0.2}$ (vi)

O_{1P}, O_{2P} ⇒ $\boxed{b_{0P} = 4.5}$

(i), (iii) (iv), (v)

O_{1Q}, O_{2Q} ⇒ $\boxed{b_{0Q} = 2}$

(i), (ii), (iv) and (vi) ⇒ $\boxed{P_{L0} = 0}$, $\boxed{M = 0.2}$, $\boxed{G = 0.2}$ $\boxed{Q_{L0} = 0}$ $\boxed{H = 0.1}$ $\boxed{B = 0}$

~~and~~ ~~[illegible]~~

Thus

$$P_L(t) = 0.2V + 0.2V^2 + P_D(t)$$

where $$P_{LD}(s) = \frac{0.5}{1 + s4.5}$$

$$Q_L(t) = 0.1V^2 + Q_{LD}(t)$$

where $$Q_{LD}(s) = \frac{0.2}{1 + s2}$$

Ans

— × — × — × — × — × —