Homework 5 Solution

4.8 $0 = -T_m + P_{SV}$

(a) $0 = -P_{SV} + 0.7 - \frac{1}{.05}\left(\frac{376.9}{2760} - 1\right)$

$P_{SV} = 0.704834$

$T_m = 0.704834$

(b) $0.2\frac{dP_{SV}}{dt} = -P_{SV} + 0.7 - \frac{1}{.05}\left(\frac{376.8}{2760} - 1\right)$

$P_{SV}(0) = 0.704834$

$0.4\frac{dT_m}{dt} = -T_m + P_{SV}$ $\quad T_m(0) = 0.704834$

$P_{SV} = A_1 e^{-5t} + B_1$ $\quad B_1 = P_{SV_{ss}} = 0.71014$

$0.704834 = A_1 + 0.71014$ $\quad A_1 = -0.0053$

$P_{SV} = -.0053e^{-5t} + 0.71014$

$\frac{dT_m}{dt} = 2.5\left[-T_m - .0053e^{-5t} + .71014\right]$ $\quad T_m(0) = 0.704834$

$T_m = A_2 e^{-5t} + A_3 e^{-2.5t} + B_2$

$B_2 = T_{m_{ss}} = 0.71014$

$T_m(0)$: $\quad 0.704834 = A_2 + A_3 + 0.71014$

$A_3 = -A_2 - 0.005306$

$\left.\frac{dT_m}{dt}\right|_0 = 0 = -5A_2 - 2.5A_3$

$0 = -5A_2 - 2.5(-A_2 - 0.005306)$

$2.5A_2 = 0.013265$ $\quad A_2 = 0.005306$

$A_3 =$

$T_m = 0.005306e^{-5t} - 0.010612e^{-2.5t} + 0.71014$

2. Calculate expected final frequency with outage of generator at bus 54.

All the generators in the system have a governer with a 5% droop

Generation loss due to the outage : 106.8 MW

Total MVA of the remaining generators : 40 + 180 + 180 + 450 + 160 + 57 + 85 + 150 = 1102 MVA

$$\therefore \Delta f = - \frac{R * \Delta P_{gen,\,MW}}{\sum_{\text{Online Gen}} S_{i,\,MVA}} = - \frac{0.05 \times 106.8}{1102} = -0.004813 \text{ p.u}$$

$$= -0.288784 \text{ Hz}$$

$$\therefore \text{Final frequency} = 60 - \Delta f = 59.71 \text{ Hz}$$ ✓

3. Calculate the initial value of P_{ref}. $P_{mech} = 1.0$

$$V_1 \rightarrow \frac{1 + sT_r}{rT_r s} \rightarrow V_2 \quad : \quad V_1 = 0$$

$$-\Delta\omega + P_{ref} - R \cdot V_2 = V_1$$

Since $\Delta\omega = 0$, $R = 0.04$, and $V_1 = 0$

$$P_{ref} = R \cdot V_2 = 0.04 V_2 \rightarrow (1)$$

$$V_2 = V_3 \rightarrow (2)$$

$$-\left(\frac{V_4}{V_3}\right)^2 + H_{dam} = 0$$

$$\left(\frac{V_4}{V_3}\right)^2 = H_{dam} = 1$$

$$\therefore V_4 = V_3 \rightarrow (3)$$

$$(V_4 - q_{NL}) \times A_t = P_{mech}$$

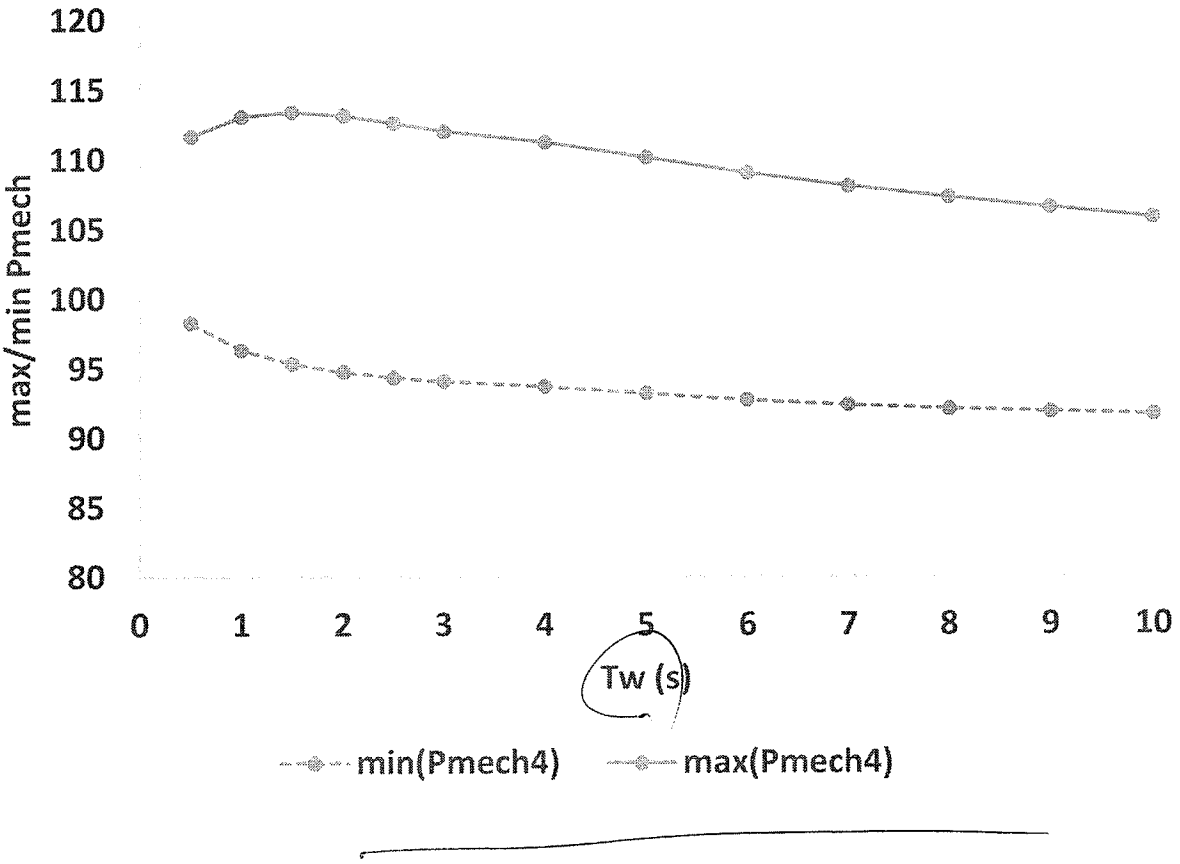
$$(V_4 - 0.05) \times 1.2 = 1.0$$

$$\therefore V_4 = 0.05 + \frac{1}{1.2} = 0.8833$$

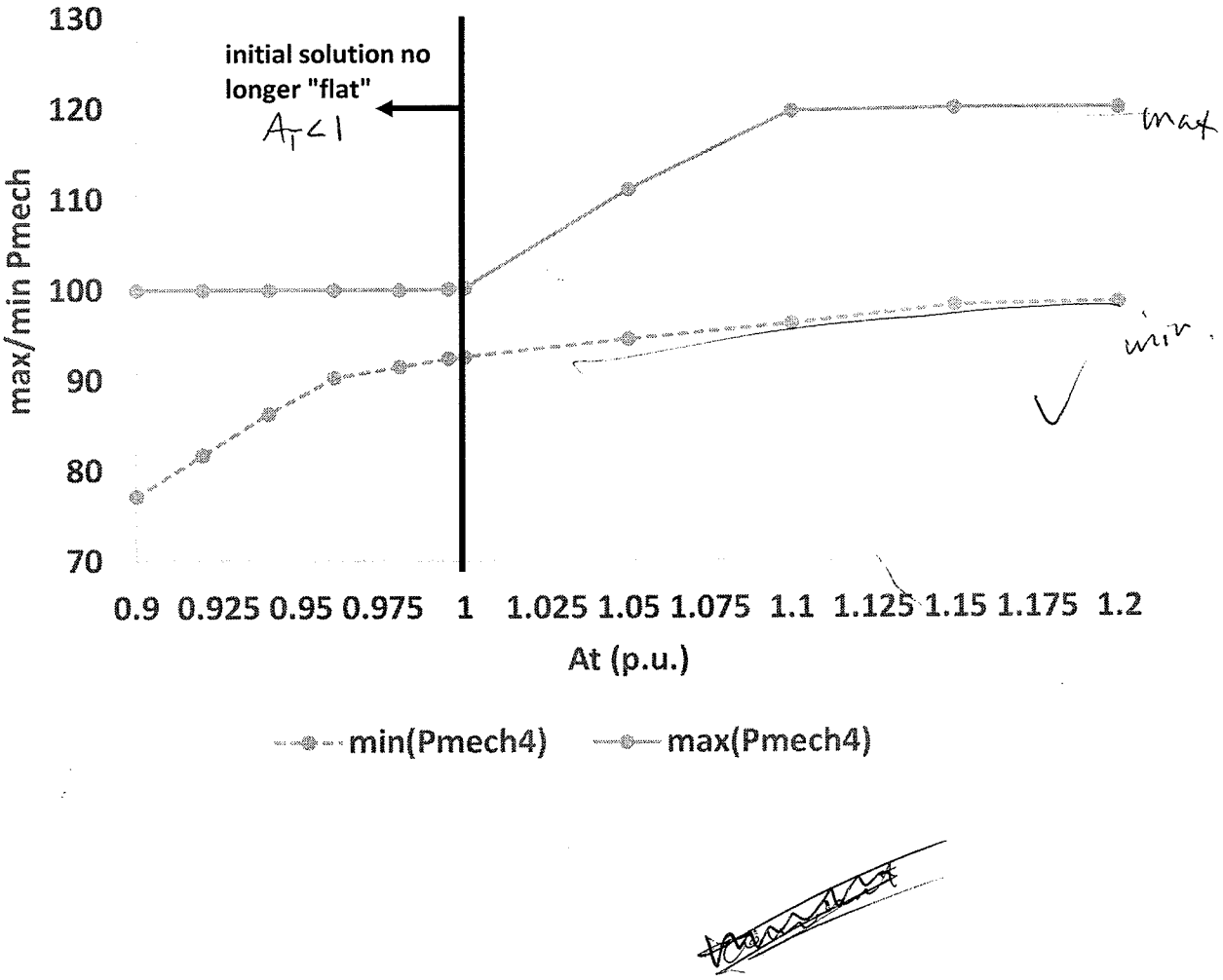
$$\therefore \text{from } ② \text{ and } ③ \quad V_2 = V_3 = V_4 = 0.8833 \quad \checkmark$$

$$\therefore \text{From } ①, \quad P_{reg} = 0.04 \cdot V_2 = 0.0353$$

Problem 4


120
115
110
105
100
95
90
85
80
max/min Pmech
0
1
2
3
4
5
6
7
8
9
10
Tw (s)
min(Pmech4)
max(Pmech4)

Problem 5


130
120
110
100
90
80
70
max/min Pmech
initial solution no longer "flat"
$A_T < 1$
max
min
0.9 0.925 0.95 0.975 1 1.025 1.05 1.075 1.1 1.125 1.15 1.175 1.2
At (p.u.)
min(Pmech4)
max(Pmech4)