HW 10

12.5

G_1	G_2	G_3
$S_1 = 200$ MVA	$S_2 = 300$ MVA	$S_3 = 500$ MVA
$R_1 = .03$ p.u.	$R_2 = .04$ p.u.	$R_3 = .05$ p.u.

a) $R_{1,new} = R_{1,old}\left[\frac{100\text{ MVA}}{200\text{ MVA}}\right] = (.03\text{ p.u.})(1/2) = .015$ p.u.

$R_{2,new} = R_{2,old}\left[\frac{100\text{ MVA}}{300\text{ MVA}}\right] = (.04\text{ p.u.})(1/3) = .0133\bar{3}$ p.u.

$R_{3,new} = R_{3,old}\left[\frac{100\text{ MVA}}{500\text{ MVA}}\right] = (.05\text{ p.u})(1/5) = .0100$ p.u.

$$\beta = \frac{1}{R_{1,new}} + \frac{1}{R_{2,new}} + \frac{1}{R_{3,new}} = \frac{1}{.015} + \frac{1}{.0133\bar{3}} + \frac{1}{.0100} = 241.68$$

b) $\Delta f = \left(\frac{-1}{\beta}\right)\Delta p_m = \left(\frac{-1}{241.68}\right)(-1.5) = 6.206 \times 10^{-3}$ per unit $(60) = 3.72 \times 10^{-1}$ Hz

The steady state frequency increase 3.72×10^{-1} Hz.

c) $\Delta P_{m,1} = \frac{-1}{.015}(6.206 \times 10^{-3}\text{ p.u.}) = -.4137$ p.u. $(100\text{ MW}) = -41.37$ MW

$\Delta P_{m,2} = \frac{-1}{.0133\bar{3}}(6.206 \times 10^{-3}\text{ p.u.}) = -.4666$ p.u. $(100\text{ MW}) = -46.66$ MW

$\Delta P_{m,3} = \frac{-1}{.0100}(6.206 \times 10^{-3}\text{ p.u.}) = -.6206$ p.u. $(100\text{ MW}) = -62$ MW

12.6 a) $\Delta f = \left(\frac{-1}{241.68}\right)\left(\frac{100}{100}\text{ per unit}\right) = -4.1377 \times 10^{-3}$ p.u.

$\Delta f = (-4.1377 \times 10^{-3}\text{ p.u.})(60) = -.24826$ Hz

b) $\Delta P_{m,1} = \left(\frac{-1}{.015}\right)(-4.1377 \times 10^{-3}\text{ p.u.}) = .27584$ p.u. $(100\text{ MW}) = 27.58$ MW

$\Delta P_{m,2} = \frac{-1}{.0133\bar{3}}(-4.1377 \times 10^{-3}\text{ p.u.}) = .31040$ p.u. $(100\text{ MW}) = 31.04$ MW

$\Delta P_{m,3} = \frac{-1}{.0100}(-4.1377 \times 10^{-3}\text{ p.u.}) = .41377$ p.u. $(100\text{ MW}) = 41.377$ MW

12.9 a) $R_{1,New} = (.04\ p.u.)\left(\frac{1000\ MVA}{500\ MVA}\right) = .08\ p.u.$

$R_{2,New} = (.06\ p.u.)\left(\frac{1000\ MVA}{750\ MVA}\right) = .08\ p.u.$

$\beta = \frac{1}{R_{1,N}} + \frac{1}{R_{2,N}} = 25\ p.u.$

b) $\Delta f = \frac{-1}{\beta}(\Delta pm) = \left(\frac{-1}{25}\right)(2.5\ pu) = -.1\ p.u.$

$\Delta f_{HZ} = (-.1\ pu)(60) = -6\ HZ$

12.14 $400 = -(\beta_1 + \beta_2)\Delta f$

$\Delta f = \frac{400\ MW}{-(1000\ MW/HZ)} = -.4\ HZ$

$\Delta P_{m,1} = -\beta_1 \Delta f = -(400\ MW/HZ)(-.4\ HZ) = 160\ MW$

$\Delta P_{m,2} = -\beta_2 \Delta f = -(600\ MW/HZ)(-.4\ HZ) = 240\ MW$

Area 1 increases in 160 MW & Area 2 increases in 240 MW in terms of generation in responce to the increase in load in Area 1.

$\Delta P_{tie,2} = +240\ MW$

$\Delta P_{tie,1} = -240\ MW$

12.15 $ACE_2 = \Delta P_{tie,2} + B_{f_2}\Delta f_2$; $\Delta P_{tie,1} = -\beta_1 \Delta f$

$\Delta f = -.4\ HZ = \Delta f_2$ (Because of steady state)

$ACE_2 = 0$ (since we are in steady state)

$$\boxed{\begin{aligned}\Delta P_{tie,2} &= -\beta_{f_2}\Delta f = -(600\ MW/HZ)(-.4HZ) = 240\ MW \\ \Delta P_{tie,1} &= -\Delta P_{tie,2} = -240\ MW\end{aligned}}$$

12.17 $ACE_2 = \Delta P_{tie,2} + B_{f_2} \Delta f$

At steady state:

$ACE_2 = 0$, $\Delta P_{tie,2} = -B_{f_2} \Delta f$

$\Delta P_{tie,2} = \Delta P_{m,2}$

$\Delta P_{m,1} = \Delta P_{ref} - \beta_1 \Delta f$

$\Delta P_{ref} = 0$; $\Delta P_{m,1} = -\beta_1 \Delta f$

$\Delta P_{m,1} + \Delta P_{m,2} = -300\ MW$

$-300\ MW = -\beta_1 \Delta f - B_{f_2} \Delta f$

$-300\ MW = (-400 - 600)\Delta f$

$-300\ MW = -1000 \frac{MW}{HZ} \Delta f$

$\Delta f = .3000\ HZ$

At steady state:

$\Delta P_{tie,1} = -\beta_1 \Delta f$

$\Delta P_{tie,1} = -400 \frac{MW}{HZ}(.3\ HZ)$

$\Delta P_{tie,1} = -120\ MW$

$\Delta P_{tie,2} = -\Delta P_{tie,2} = 120\ MW$

WECC

Frequency response obligation is determined based on the total power generated by the balancing authority + total power load by the balancing authority to the frequency response needed for interconnection.

Fun with CAISO DATA

· Screen shot taken on 11/29/2018

a) Day Ahead forecast: 28,650 MW ; Hour Ahead: 29,071 MW

b) At 7 am: Demand = 24,923 MW

Day Ahead Forecast = 23,851 MW ; Hour Ahead: 24,499 MW

Discrepency: 1072 MW

c) Yesterday's: 29,126 MW

Today's : 28,650 MW

Tomorrow's : 27,509 MW

Tomorrow is Friday, the beginning of the weekend. Most people go out, so there is less electricity being used in homes.

d) I imagine it would be hardest to maintain frequency at the peak values because if our guess is wrong, then the power generated (at the peak value) will be below than the required by the load. The frequency will decrease.

Scanned with CamScanner