**Question:**

A 50 MVA, 50 Hz generator delivers 50 MW over a double circuit line to an infinite bus. The generator has an inertia constant H = 10 / MJ/MVA. The generator has transient reactance $X_d' =$ 0.3 pu. Each transmission line has a reactance of 0.5 pu on 50 MVA base. | E | = 1.4 pu and V = 1.0 $\underline{/0^o}$ pu. A solid three-phase fault to ground occurs on line 2. Plot the swing curve for a sustained fault upto a time of 0.7.

$\delta_o = 23.95$

Pe1 = 2.463 sin $\delta$

Pe2 = 0.915 sin $\delta$

Pe3 = 2.135 sin $\delta$

To plot the swing curve, we use the following relations:

$$P_{a\,(n-1)} = P_S - P_{max} \sin \delta_{(n-1)}$$

$$(\Delta\,\delta)_n = (\Delta\,\delta)_n + \frac{P_{a\,(n-1)}}{M} (\Delta\,t)^2$$

$$\delta_n = \delta_{n-1} + (\Delta\,\delta)_n$$

50 MVA , $f = 50$ Hz , $H = 10$ MJ / MVA

$\delta_0 = 23.95$ up to 0.7 sec

$P_{e1} = 2.463 \sin\delta$

$P_{e2} = 0.915 \sin\delta$

$P_{e3} = 2.135 \sin\delta$

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Let us take base MVA = 50 , $S = 1$ p.u

$$M = \frac{HS}{180f} = \frac{10*1}{180*50} = 11.11*10^{-4} \text{ MJs / elec. deg}$$

Since there is a discontinuity at $t = 0$

so the average value of $P_a$ is to be used

At $t = 0-$

$P_{max} = 2.463$ , $P_a = 0$

At $t = 0+$

$P_{max} = 0.915$

$$P_a = P_s - P_{e2} = P_s - P_{max2} \sin\delta_0$$
$$= 1 - 0.915 \sin(23.95) = 0.6286$$

$$P_{a(avg)} = \frac{1}{2}(0 + 0.6286) = 0.3143$$

Let us take an interval $\Delta t = 0.1$ S

$$\frac{(\Delta t)^2}{M} P_{a(n-1)} = \frac{(0.1)^2}{11.11*10^{-4}} P_{a(n-1)} = 9 \, P_{a(n-1)}$$

First interval $t = 0.1\,sec$

$$\Delta\delta_1 = \Delta\delta_0 + \frac{(\Delta t)^2}{M} P_{a0}$$

$$= 0 + 9 * 0.3143 = 2.82^\circ$$

$$\delta_1 = \delta_0 + \Delta\delta_1 = 23.95 + 2.83 = 26.78^\circ$$

Second interval $t = 0.2\,sec$

$$P_{a1} = P_s - P_{max_2} \sin\delta_1 = 1 - 0.915 \sin(26.78) = 0.5877$$

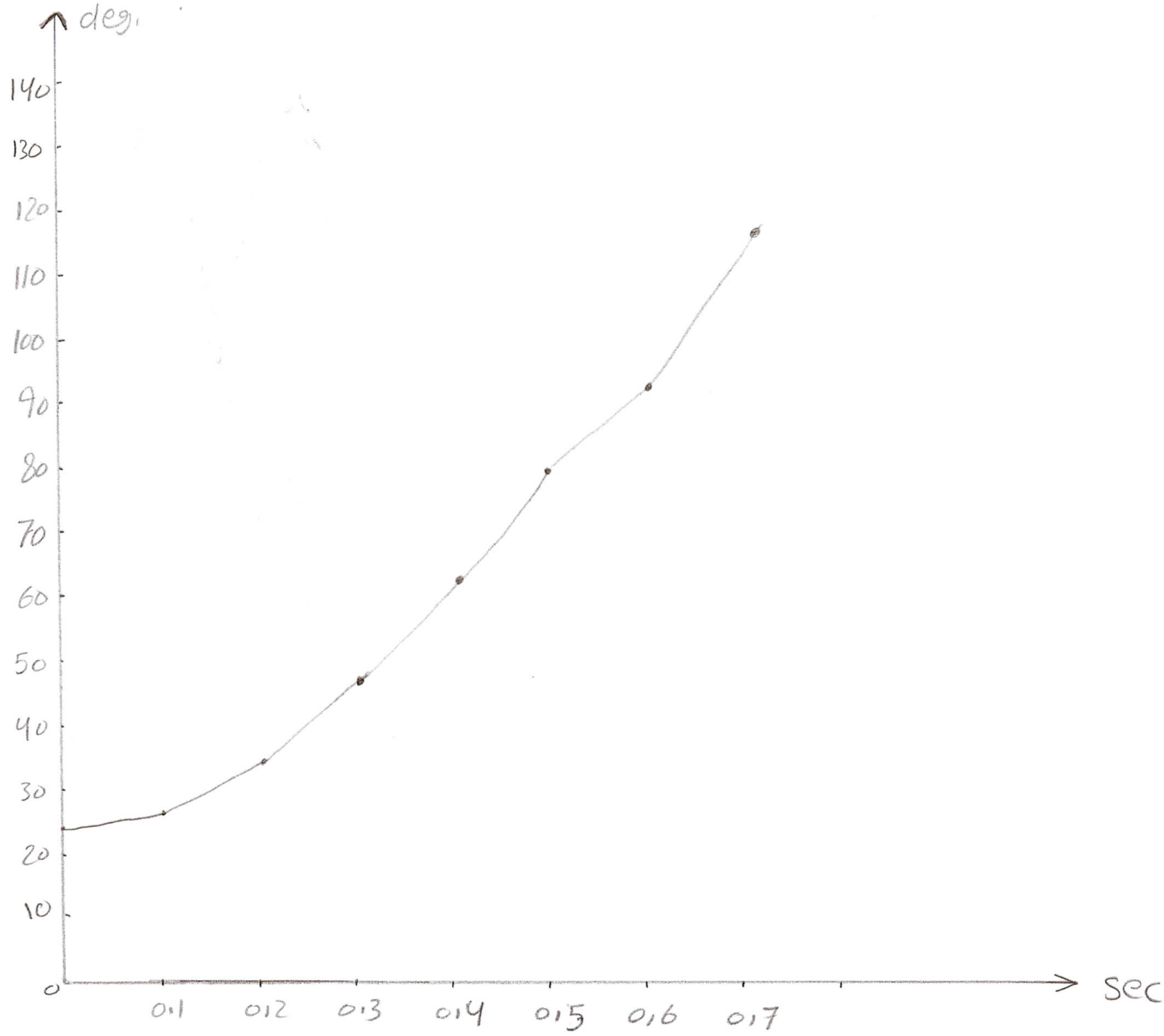
$$\Delta\delta_2 = \Delta\delta_1 + \frac{(\Delta t)^2}{M} P_{a1}$$

$$= 2.82 + 9 * 0.5877 = 8.11^\circ$$

$$\delta_2 = \delta_1 + \Delta\delta_2 = 26.78 + 8.11 = 34.9$$

**Table 1** Point-by-Point Solution of Swing Equation for Sustained Fault

| t | $P_{max}$ | $\sin\delta$ | $P_e$ | $P_a$ | $\frac{(\Delta t)^2}{M}Pa$ | $\Delta\delta$ | $\delta$ |
|---|---|---|---|---|---|---|---|
| s | pu | | pu $= 0.915\sin\delta$ | pu $(1 - P_e)$ | elec. deg. $9P_a$ | elec. deg. | elec. deg. |
| $0_-$ | 2.463 | 0.4059 | 1 | 0 | 0 | 0 | 23.95 |
| $0_+$ | 0.915 | 0.4059 | 0.3714 | 0.6286 | – | – | |
| $0_{avg}$ | | | | 0.3143 | 2.83 | 2.83 | |
| 0.1 | 0.915 | 0.4507 | 0.4123 | 0.5877 | 5.23 | 8.11 | 26.78 |
| 0.2 | 0.915 | 0.5721 | 0.5235 | 0.4765 | 4.2885 | 12.4 | 34.9 |
| 0.3 | 0.915 | 0.7349 | 0.6724 | 0.3276 | 2.9484 | 15.35 | 47.3 |
| 0.4 | 0.915 | 0.8882 | 0.8127 | 0.1873 | 1.6857 | 17.04 | 62.65 |
| 0.5 | 0.915 | 0.9839 | 0.9002 | 0.09977 | 0.8982 | 17.93 | 79.69 |
| 0.6 | 0.915 | 0.9912 | 0.9069 | 0.09308 | 0.8377 | 18.77 | 97.62 |
| 0.7 | 0.915 | 0.8958 | 0.8196 | 0.1804 | 1.6231 | 20.4 | 116.39 |



deg.
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
sec