Calculation of Swing Curve

Example

A 25MVA, 50Hz generator delivers 20MW over a double circuit transmission line to an infinite bus. The generator, together with its prime-mover, has an inertia constant of 64×10^{-4} $Js^2/°$elec. A 3-phase short-circuit which occurs at the middle of one of the transmission lines is cleared in 0.4s by the simultaneous opening of the circuit breakers at both ends of the line. Calculate and plot the swing curve of the generator over a time period of 1s, using time intervals of 0.05s.
Prior to the fault the electrical power transfer from the generator is given by $P_e = 64.5 \sin\delta$. This changes to $P_e = 23.4 \sin\delta$ during the fault, and $P_e = 51.5 \sin\delta$ after the fault has been cleared.

Solution

Select a 25MVA base and convert the data to per-unit:

$$M = \frac{64 \times 10^{-4}}{25} = 2.56 \times 10^{-4} \text{ pu}$$

Prior to the fault:

$$P_e = \frac{64.5}{25}\sin\delta = 2.58 \sin\delta \text{ pu}$$

During the fault:

$$P_e = \frac{23.4}{25}\sin\delta = 0.936 \sin\delta \text{ pu}$$

After the fault:

$$P_e = \frac{51.5}{25}\sin\delta = 2.06 \sin\delta \text{ pu}$$

Prefault:

$$P_m = \frac{20}{25} = 0.8 \text{ pu}$$

and the initial load angle is therefore found from:

$$P_m = P_e = 0.8 = 2.58 \sin\delta_0$$

so

$$\sin\delta_0 = \frac{0.8}{2.58}$$

therefore:

$$\boldsymbol{\delta_0 = 18.1°}$$

Step by step calculation of the swing curve:

Using the equation:

$$\Delta\delta_n = \Delta\delta_{n-1} + \frac{(\Delta t)^2 P_{a(n-1)}}{M}$$

Selecting a time interval of 0.05s and substituting the value for M gives:

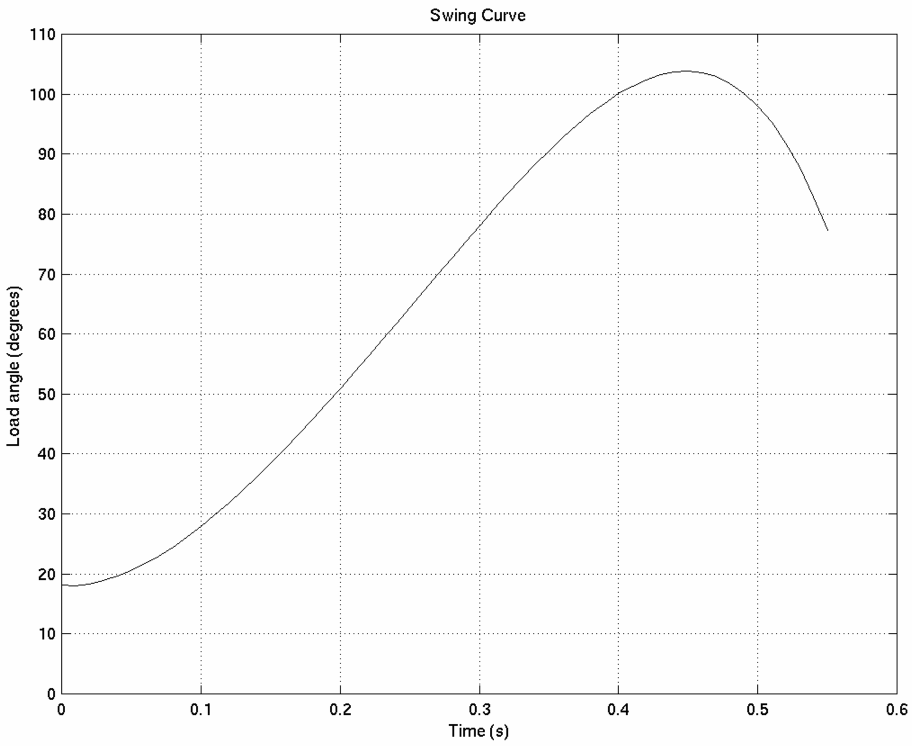
$$\Delta\delta_n = \Delta\delta_{n-1} + 9.76 P_{a(n-1)}$$

and:

$P_e = C \sin\delta$

C = 2.58 prior to fault
C = 0.936 during the fault
C= 2.06 after the fault

time (s)	C	Sin δ	P_e	P_a	9.76 P_a	$\Delta\delta$	δ
0–	2.58	0.310	0.8	0			18.1
0+	0.936	0.310	0.29	0.51			18.1
0av				0.2505	2.5		18.1
						2.5	
0.05	0.936	0.352	0.330	0.47	4.6		20.6
						7.1	
0.1	0.936	0.465	0.435	0.365	3.6		27.7
						10.7	
0.15	0.936	0.621	0.581	0.219	2.1		38.4
						12.8	
0.2	0.936	0.779	0.729	0.07	0.69		51.2
						13.5	
0.25	0.936	0.904	0.846	-0.046	-0.45		64.7
						13.1	
0.3	0.936	0.977	0.914	-0.114	-1.11		77.8
						12.0	
0.35	0.936	1.0	0.936	-0.136	-1.33		89.8
						10.7	
0.4–	0.936	0.983	0.920	-0.12			100.5
0.4+	2.06	0.983	2.025	-1.225			
0.4av				-0.672	-6.56		
						4.1	
0.45	2.06	0.968	1.994	-1.194	-11.65		104.6
						-7.5	
0.5	2.06	0.992	2.04	-1.24	-12.1		97.1
						-19.6	
							77.5



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