A 25MVA, 60Hz generator delivers 20MW over a double circuit line to an infinite bus. Under healthy conditions P_e = 2.58 Sinδ p.u. When a three phase fault occurs on one of the lines, P_e= 0.936 Sinδ p.u. After clearance of the fault by opening of the circuit breakers at the ends of the line, P_e= 2.06 Sinδ p.u. Use the equal area criterion to determine the maximum load angle excursion if fault clearance occurs at δ=100.5°.

Initial load angle δ_0 is given by:

$$\delta_0 = \sin^{-1}\frac{0.8}{2.58} = 0.314 \text{ rad}$$

Load angle at end of accelerating region δ_A is given by:

$$\delta_A = \sin^{-1}\frac{0.8}{0.936} = 1.012 \text{ rad}$$

Therefore accelerating area is equal to:

$$A_1 = \int_{0.314}^{1.012}(0.8 - 0.936\sin\delta)d\delta$$

$$A_1 = [0.8\delta + 0.936\cos\delta]_{0.314}^{1.012}$$

$$A_1 = 0.8(1.012 - 0.314) + 0.936(\cos 1.012 - \cos 0.314)$$

$$A_1 = 0.164$$

Circuit breaker clears fault at δ = 100.5° = 1.754 rad. So decelerating area up to opening of breaker A2 is given by:

$$A_2 = \int_{1.012}^{1.754}(0.936\sin\delta - 0.8)d\delta$$

$$A_2 = [-0.936\cos\delta - 0.8\delta]_{1.012}^{1.754}$$

$$A_2 = -0.936(\cos 1.754 - \cos 1.012) - 0.8(1.754 - 1.012)$$

$$A_2 = 0.0728$$

Decelerating area after opening of breaker until maximum load angle (unknown) A3 is given by:

$$A_3 = \int_{1.754}^{\delta_{\max}}(2.06\sin\delta - 0.8)d\delta$$

$$A_3 = [-2.06\cos\delta - 0.8\delta]_{1.754}^{\delta_{\max}}$$

$$A_3 = -2.06(\cos\delta_{\max} - \cos 1.754) - 0.8(\delta_{\max} - 1.754)$$

$$A_3 = -2.06\cos\delta_{\max} - 0.375 - 0.8\delta_{\max} + 1.4$$

$$A_3 = 1.025 - 2.06\cos\delta_{\max} - 0.8\delta_{\max}$$

Now for equal area criteria $A_1 = A_2 + A_3$,therefore:

$$A_3 = 1.025 - 2.06\cos\delta_{\max} - 0.8\delta_{\max} = 0.0912$$

rearranging:

$$2.06\cos\delta_{\max} + 0.8\delta_{\max} = 0.933$$

A solution to this equation is obtained by 'trial and error'

δ_{max}	$2.06\cos\delta_{max}+0.8\delta_{max}$
1.8	0.972
1.9	0.854
1.85	0.912
1.84	0.924
1.83	0.936