Runge-Kutta Method

Numerical Integration methods:

- Modified Euler's method
- Runge-Kutta method

Runge-Kutta method

- Obtain a load flow solution for pre transient conditions
- Calculate the generator internal voltages behind transient reactance.
- Assume the occurrence of a fault and calculate the reduced admittance matrix
- Initialize time count K=0,J=0
- Determine the eight constants

$$K_1^k = f_1(\delta^k, \omega^k)\Delta t$$

$$l_1^k = f_2(\delta^k, \omega^k)\Delta t$$

$$K_2^k = f_1(\delta^k + \frac{K_1^k}{2}, \omega^k + \frac{l_1^k}{2})\Delta t$$

$$l_2^k = f_2(\delta^k + \frac{K_1^k}{2}, \omega^k + \frac{l_1^k}{2})\Delta t$$

$$K_3^k = f_1(\delta^k + \frac{K_2^k}{2}, \omega^k + \frac{l_2^k}{2})\Delta t$$

$$l_3^k = f_2(\delta^k + \frac{K_2^k}{2}, \omega^k + \frac{l_2^k}{2})\Delta t$$

$$K_4^k = f_1(\delta^k + \frac{K_3^k}{2}, \omega^k + \frac{l_3^k}{2})\Delta t$$

$$l_4^k = f_2(\delta^k + \frac{K_3^k}{2}, \omega^k + \frac{l_3^k}{2})\Delta t$$

$$\Delta\delta^k = \frac{\left(K_1^k + 2K_2^k + 2K_3^k + K_4^k\right)}{6}$$

$$\Delta\omega^k = \frac{\left(l_1^k + 2l_2^k + 2l_3^k + l_4^k\right)}{6}$$

- Compute the change in state vector

$$\Delta\delta^k = \frac{\left(K_1^k + 2K_2^k + 2K_3^k + K_4^k\right)}{6}$$

$$\Delta\omega^k = \frac{\left(l_1^k + 2l_2^k + 2l_3^k + l_4^k\right)}{6}$$

- Evaluate the new state vector

$$\delta^{k+1} = \delta^k + \Delta\delta^k$$

$$\omega^{k+1} = \omega^k + \Delta\omega^k$$

- Evaluate the internal voltage behind transient reactance using the relation

$$E_p^{k+1} = \left|E_p^k\right| \cos\delta_p^{k+1} + j\left|E_p^k\right| \sin\delta_p^{k+1}$$

- Check if $t<t_c$ yes K=K+1
- Check if j=0,yes modify the network data and obtain the new reduced admittance matrix and set j=j+1
- set K=K+1
- Check if K<Kmax, yes start from finding 8 constants