State-Space Model of Modified IEEE-Second Benchmark (M-IEEE-SBM):

For a power system with N synchronous machines equipped with PSS and excitation systems, along with the mechanical section of the shaft-turbine model, the state variables of i^{th} synchronous machine can be defined as follows:

$$x_i(t) = [\Delta E'_{qi} \quad \Delta E_{fdi} \quad \Delta y_{pss\_i} \quad \Delta\delta_i \quad \Delta\omega_{Gi} \quad \Delta\delta_{LPi} \quad \Delta\omega_{LPi} \quad \Delta\delta_{HPi} \quad \Delta\omega_{HPi}]^T$$

$$A = \begin{bmatrix} \frac{-1}{k_{3\_ii}T'_{doi}} & \frac{1}{T'_{doi}} & 0 & \frac{-k_{4\_ii}}{T'_{do}} & 0 & 0 & 0 & 0 & 0 \\ \frac{-K_{ai}}{T_{ai}}k_{6\_ii} & \frac{-1}{T_{ai}} & \frac{K_{ai}}{T_{ai}} & \frac{-K_{ai}}{T_{ai}}k_{5\_ii} & 0 & 0 & 0 & 0 & 0 \\ \frac{-k_{ii\_2}T_{1i}K_{Pi}}{2H_iT_{2i}} & 0 & \frac{-1}{T_{2i}} & \frac{-T_{1i}K_{Pi}}{2H_iT_{2i}}(k_{ii\_1}+K_{GLi}) & \frac{K_{pi}}{T_{2i}}(1-\frac{D_iT_{1i}}{2H_i}) & \frac{-T_{1i}K_{Pi}}{2H_iT_{2i}}K_{GLi} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \omega_s & 0 & 0 & 0 & 0 \\ \frac{-k_{2\_ii}}{2H_i} & 0 & 0 & -\frac{(k_{1\_ii}+K_{GLi})}{2H_i} & \frac{-D_i}{2H_i} & \frac{K_{GLi}}{2H_i} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \omega_s & 0 & 0 \\ 0 & 0 & 0 & \frac{K_{GLi}}{2H_{LPi}} & 0 & -\frac{(K_{LHi}+K_{GLi})}{2H_{LPi}} & \frac{-D_{LP}}{2H_{LPi}} & \frac{K_{LH}}{2H_{LPi}} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \omega_s \\ 0 & 0 & 0 & 0 & 0 & \frac{K_{LH}}{2H_{HP}} & 0 & \frac{-K_{LH}}{2H_{HP}} & \frac{-D_{HP}}{2H_{HP}} \end{bmatrix}$$

$$B = [0 \quad \frac{K_{ai}}{T_{ai}} \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0 \quad 0]^T$$

$$C = [0 \quad 0 \quad 0 \quad 0 \quad 1 \quad 0 \quad 0 \quad 0 \quad 0]$$

$$R_a = [0 \quad 0 \quad \frac{-K_{Pi}T_{1i}}{2H_iT_{2i}} \quad 0 \quad -\frac{1}{2H_i} \quad 0 \quad 0 \quad 0 \quad 0]^T$$

If the developed power grid consists of more synchronous machines, all the mentioned state variables in $x_i(t)$ must be rewritten for new machines and combined together to generate a consolidated state matric A. Moreover, the interconnection between i^{th} and j^{th} synchronous machines <u>must be also considered</u> to obtain the comprehensive state variable vector of the system and complete the state matrix A.