CHAPTER 9

CONCLUSIONS

In this study, systematic procedures for building power system load models have been developed based on component-based method. Both steady state and dynamic characteristics are considered. The models relate the variations in active and reactive power consumption to the variations in voltage and frequency.

The models presented here are exponential and induction motor models. Static loads, which usually have very small time constants, are modelled by exponential model. Induction motor loads can be modelled by either exponential or induction motor model depend on the importance of the problems. Induction motor model may be necessary where one or more induction motors constitute a major portion of loads in power system, and/or when large disturbances are considered.

Methods for grouping individual loads to an aggregate model have been developed.

Load with represented by exponential model can be grouped together to one equivalent model by calculation the new load parameters.

A group of induction motor loads are represented by an equivalent aggregate model, of which parameters are calculated by kVA weighted average method.

When a composite load is considered, the two models can be combined together to represent a composite load model.

Simulation results obtained by aggregate models correspond fairly good with that obtained by individual representation.

Simulation results also show the differences between the proposed models and the generally used models.

In a real power system a very big number of loads have to be aggregated and connected to suitable buses in the system. Thus as preparations for a simulation of the system, the distribution systems are reduced to equivalent networks to the load elements are therefore connected series and shunt impedances representing lines and transformers etc.

From tests it has been found that a big part of the loads can be represented by the formulas of the type

$$P = P_o * (V/V_o)^{np} * (f/f_o)^{mp}$$

$$Q = Q_o * (V/V_o)^{nq} * (f/f_o)^{mq}$$

Also light loads and individual motors with small inertias can be represented in this way (see e.g. fig. A4.13-15 in Appendix 4).

When large rotating machines or special fluctuation loads are involved a more dynamic representation is necessary (e.g. large induction machines may be represented by induction motor model). Exponential model with included time function can be used. Consider the simulation results e.g. fig. A4.33-35, 39-41, the active and reactive power seem to be functions of voltage and frequency and their derivatives, thus the formulas may be modified as :

$$P = P_o * (V/V_o)^{np} * (f/f_o)^{mp} * [k1*\dot{V}(t) + k2*\dot{f}(t)]$$

$$Q = Q_0 * (V/V_0)^{nq} * (f/f_0)^{mq} * [k3*\dot{V}(t) + k4*\dot{f}(t)]$$

where $\dot{V}(t)$ and $\dot{f}(t)$ are the derivative of $V(t)$ and $f(t)$ respectively.

$\dot{V}(t)$ and $\dot{f}(t)$ can be derived if we know the voltage and frequency functions as in fig. A4.39 in Appendix 4.

LIST OF PRINCIPAL SYMBOLS

a,b,c	constants
F_{ds}	stator d-axis flux linkage
F_{qs}	stator q-axis flux linkage
F_{dr}	rotor d-axis flux linkage
F_{qr}	rotor q-axis flux linkage
f	frequency
f_o	nominal frequency
H	inertia constant
i_{ds}	stator d-axis current
i_{qs}	stator q-axis current
i_{dr}	rotor d-axis current
i_{qr}	rotor q-axis current
I_s	stator rms current
I_r	rotor rms current
I_{st}	motor starting current
Im	imaginary part
j	imaginary number
J	moment of inertia
k1, k2, k3, k4	constants
mp,mq,np,nq	load parameters
η	Motor efficiency
p	differential operator d/dt
P	active power
P_{mag}	aggregate motor parameters
P_o	nominal active power
Q	reactive power
Q_o	nominal reactive power
R_{ag}	aggregate motor rating
Re	real part
Rs	stator resistance

R_r	rotor resistance
s	motor slip
s_m	slip at maximum torque
T_e	electrical torque
T_m	mechanical torque
V_s	rms voltage
v_{ds}	stator d-axis voltage
v_{qs}	stator q-axis voltage
v_{dr}	rotor d-axis voltage
v_{qr}	rotor q-axis voltage
w_b	base electrical angular velocity
w_e	synchronous reference frame electrical angular velocity
w_r	rotor electrical angular velocity
X_m	magnetizing reactance
X_s	stator reactance
X_r	rotor reactance
Z	input impedance
Z^*	conjugate of Z