APPENDIX 1

DATA FOR THE SINGLE PHASE AND TWO PHASE OPEN CONFIGURATIONS

The various investigations carried out on the single phase open configuration form part of Chapter 3, Chapter 5 and Chapter 6. The ferroresonance investigations on the two phase open configuration is presented in Chapter 5. The physical values of the parameters considered for investigations are given below (Araujo, et al 1993):

A1.1 Line data

Line capacitance to ground, C_g = 555 nF.
Line mutual capacitance, C_m = 111 nF.

A1.2 Transformer data

A 25 MVA transformer with 110/44/4 kV Y/Y/Δ windings
The coefficients of nonlinear function which represent magnetisation characteristic, $a\phi + b\phi^q$, are
a = 0.0028, b = 0.0072.
Transformer saturation index, q = 7,11.
Core loss resistance, R_m = 48.4 kΩ.
The coefficients a and b are in p.u.

A1.3 Per unit system

The base values chosen and the conversion of system parameters to per unit are given bellow:

Base values chosen are:

MVA_{base} = 25 MVA. kV_{base} = 63.5 kV.

ω_{base}= 376.99112 rad / sec.

$Z_{base} = (kV_{base})^2 / MVA_{base}$ = 161.333 Ω.

$Y_{base}= 1 / Z_{base}$= 0.00619835 Ω^{-1}.

$C_{base} = Y_{base} / \omega_{base}$ = 1.644163E-05 F.

Conversion to per unit:

$R_{pu} = R_m / Z_{base}$ = 300 p.u.

$C_{m\,pu} = C_m / C_{base}$ = 0.0072 p.u.

$\omega_{pu} = \omega / \omega_{basee}$= 1.0 p.u.

$C_{g\,pu} = C_g / C_{base}$ =0.04 p.u.

$C_{Th} = C_g + 2C_m$ = 0.047 p.u.

A1.4 Arrester parameter

The effect of arrester on the isolated subharmonic behaviour is presented in Chapter 6. The arrester parameters k and α are as follows:

k = 126681.236. α = 26.

Conversion to per unit:

$k_{pu} = k / k_{base}$. $k_{base} = V_{base} / (i_{base})^{1/\alpha}$.

k_{pu} = 2.510 p.u.

APPENDIX 2

DATA FOR 1100 kV SYSTEM OF BPA

A2.1 Line data

The data of the three phase mutually coupled transmission line is given by (Dommel et al 1983):

[C] =

20.6022	-3.55119	-3.11128
-3.55119	20.2788	-3.55119
-3.11128	-3.55119	20.6022

nF / mile

[Z] =

0.095175+j0.920867	0.0872880+j0.45328	0.089075+j0.450562
0.0872880+j0.45328	0.0915829+j0.925271	0.0872880+j0.45328
0.089075+j0.450562	0.0872880+j0.45328	0.090000+j0.920867

Ω / mile

Line length = 1.3 miles

A2.2 Transformer data

Single phase units, each rated 50MVA, 60Hz, 635.1/139.4 kV, autotransformer.

No-load test data is given in Table A2.1

Base Apparent power = 50 MVA.

Base voltage = 635.1kV.

Base current = 78.7277 A.

Base impedance = 8067.04 Ω.

The physical parameters of the circuit shown in Fig.3.7 referred to the high voltage side of the transformer are:

L_2 = 0.4032 H; R_2 = 11.3 Ω;

Linear core loss R_m = 4.49 MΩ;

Thévenin capacitance C_{Th} = 0.02616 μF;

Table A2.1 Transformer no-load test data

Voltage (V)	**Exciting current (A)**	**Excitation loss (W)**
571590	0.440875	63 129
635100	1.180916	89 794
698610	3.156983	134 394

The coefficients of the nonlinear function which represent magnetisation characteristic, $a\phi + b\phi^q$, are

For q = 7,

a = 0.000375, b = 7.3824E-24.

For q = 11,

a = 0.000375, b = 1.5648E-37.

The coefficients of the nonlinear function (Equation 3.3), which represent nonlinear core loss characteristic, are

h_0 = -3.52133E-03, h_1 = 5.78696E-07, h_2 = -1.41672E-12, h_3 = 1.21105E-18.

APPENDIX 3

DATA FOR 525 kV SYSTEM OF BPA

The physical parameters for the circuit shown in Fig.7.4 are given by Dommel (2001).

$R_A = R_B = R_C = 0.00048\ \Omega$.

$R_{mA} = R_{mB} = R_{mC} = 9.1E{+}05\ \Omega$.

$C_{gA} = 0.19792705E{-}06$ F.

$C_{gB} = 0.17922436E{-}06$ F.

$C_{gC} = 0.20128166E{-}06$ F.

$C_{mAB} = 0.0407189E{-}06$ F.

$C_{mBC} = 0.03976129E{-}06$ F.

$C_{mAC} = 0.01496137E{-}06$ F.

The current sources, which indicate the capacitive coupling, are

$I_{NA} = 0.4559836 \angle 25.01^{o}$ A.

$I_{NB} = 0.7501838 \angle 1.45^{o}$ A.

$I_{NC} = 1.8444088 \angle -18.0^{o}$ A.

The formula, which describes the magnetisation characteristic, is given by:

$$i_L = a\,\phi + b\,\phi^{q} \qquad \text{(A3.1)}$$

The coefficients a and b of Equation (A3.1) are given by:

a = 0.000375 b = 7.38244E-24.

Coefficients of the state space equations (Equations 6.5a to 6.5f) for C_g = 100 % of base case value are given below:

k_{11} = -4.4775824, k_{12} = -0.760109, k_{13} = -0.37978.
k_{14} = -4.0746E+06, k_{15} = -0.6917E+06, k_{16} = -0.3456E+06.
k_{17} = 4.0746E+06, k_{18} = 0.6917E+06, k_{19} = 0.3456E+06.
k_{21} = -0.76010989, k_{22} = -4.463516447, k_{23} = -0.73769224.
k_{24} = -0.6917E+06, k_{25} = -4.0618E+06, k_{26} = -0.6713E+06.
k_{27} = 0.6917E+06, k_{28} = 4.0618E+06, k_{29} = 0.6713E+06.

k_{31}= -0.37978, k_{32} = -0.7376923, k_{33} = -4.4293406.
k_{34} = -0.3456E+06, k_{35} = -0.6713E+06, k_{36} = -4.0307E+06.
k_{37} = 0.3456E+06, k_{38} = 0.6713E+06, k_{39} = 4.0307E+06.

k_{41} =1.0, k_{42} = -0.00048, k_{43} = -0.00048.
k_{51} =1.0, k_{52} = -0.00048, k_{53} = -0.00048.
k_{61} =1.0, k_{62} = -0.00048, k_{63} = -0.00048.