Appendix (A)
Port-Sudan Substation and Transmission Line Data

Total Power =	130 MVA
Active power P =	100 MW
Reactive power Q =	80 MVAr
Line current I_L =	850 A
Line Voltage V_L =	220 kV
Diameter D =	17.9 mm
Length L =	450k m
Frequency F =	50 Hz
Distance among phases	D_{RY} = 6.7 m
	D_{YB} = 11.8 m
	D_{RB} = 13.6 m
Transformers(220/110/30/)	2 * (100/100/ 30) MVA
Type of towers	Single circuit
Reactors in the line	3*37.2MVA in the sending-eng
Reactors in the substation	2*15 MVA in tertiary winding
Conductor type	Zebra
Insulator type	Porcelain Atbara & silicon Rubber Port Sudan terminal
Number of towers 1234	(834 tower Porcelain & 400 tower silicon Rubber)

Appendix (B)
Port-Sudan Feeder line (a) Data from NEC

Total Power =	6.5 MVA
Active power P =	5.1 MW
Reactive power Q =	3.8 MVAr
Line current I_L =	113.11 A
Line Voltage V_L =	33 kV
Diameter D =	185 mm
Length L =	16 k m
Frequency F =	50 Hz
Distance among phases	D_{RY} = 0.943 m
	D_{YB} = 0.943 m
	D_{RB} = 1.6 m
Pf =	0.807
Type of poles	Single circuit

Appendix (C)

Program to calculate Inductive reactive power (Q_L) by Mat lap

```
clc
clear all


a=484.5e-6
w=2*pi*50
v=220000;
dry=6.700  ;%meter
len=450000
dby=11.800;
drb=13.57;


mu0=4*pi*10^(-7);
e0=8.85e-12;
d=2*sqrt((a/(2*pi)))
r=d/2;
de=(dry*dby*drb)^(1/3);
L=mu0/(8*pi)*(1+4*log(de/r))
c=2*pi*e0/(log(de/r))
zc=sqrt(L/c)
bita=w*sqrt(L*c)
x=sin(bita*len)/(1-cos(bita*len))*zc
ql=(v^2/x)
```

Appendix (D)

Program to calculate capacitance reactive power (Qc)

```
clc
clear all

a=484.5e-6
w=2*pi*50
v=220000;
dry=6.700  ;%meter
len=450000
dby=11.800;
drb=13.570;
p=100%48e6

mu0=4*pi*10^(-7);
e0=8.85e-12;
d=2*sqrt((a/(2*pi)))
r=d/2
de=(dry*dby*drb)^(1/3)
L=mu0/(8*pi)*(1+4*log(de/r))
c=2*pi*e0/log(de/r)
zc=sqrt(L/c)
bita=w*sqrt(L*c)
x=sin(bita*len)*zc
b=(p*x)/(v/1000)^2;
delta= asin(b)
%delta=real(delta)
qc=(v^2/x)*(cos(delta)-cos(bita*len))
```

Appendix (E)

program to calculate Voltage VS Reactive Power (Qc)

```
clc
clear all
close all

a=484.5e-6
w=2*pi*50
% v=220000;
v=200000:5000:245000;
dry=6.700  ;%meter
len=450000
dby=11.800;
drb=13.570;
% p=48e6
% p=[20e6 30e6 40e6 50e6 60e6 70e6 80e6 90e6 100e6
110e6];
p=10e6:10e6:100e6
v=200000:5000: 245000
for i=1:10 % power counter
    for j=1:10  % voltage counter

        mu0=4*pi*10^(-7);
        e0=8.85e-12;
        d=2*sqrt((a/(2*pi)))
        r=d/2;
        de=(dry*dby*drb)^(1/3)
        L=(mu0/(8*pi))*(1+4*log(de/r))
        c=2*pi*e0/(log(de/r))
        zc=sqrt(L/c)
        bita=w*sqrt(L*c)
        x=sin(bita*len)*zc
        b=(p(i)*x)/(v(j)/1)^2;
        delta= asin(b)
        %delta=real(delta)
        qc(j)=(v(j)^2/x)*(cos(delta)-cos(bita*len))
```

```
    end
% % % % %         figure
        plot(qc,v)
        table(:,i)=qc'/1e6;
        hold on

% % % % %         title(['Voltage Vs Reactive Power,
Real Power =',num2str(p(i))])
        ylabel('Voltage')
        xlabel('Reactive Power')
end
```

Appendix (F)

Program to calculate Voltage VS Reactive Power (Qc) In the City

```
clc
clear all
close all

a=185e-6;
w=2*pi*50;
% v=33000;
v=36000:-500:31500;
v'
dry=94.3  ;%meter
len=16000;
dby=94.3;
drb=94.3;
% p=10e6
p=1e6:1e6:10e6;
p'
qc= 8e6:-0.5e6:3.5e6;
qc'
for i=1:10 % Active power counter
    for j=1:10  % Reactive power counter

        mu0=4*pi*10^(-7);
        e0=8.85e-12;
        d=2*sqrt((a/(2*pi)));
        r=d/2;
        de=(dry*dby*drb)^(1/3);
        L=mu0/(8*pi)*(1+4*log(de/r));
        c=2*pi*e0/(log(de/r));
        zc=sqrt(L/c);
        bita=w*sqrt(L*c);
        x=sin(bita*len)*zc;
        b=(p(i)*x)/v(j)^2;
        delta= asin(b);
        %delta=real(delta)
        qc(j)=(v(j)^2/x)*(cos(delta)-cos(bita*len)) ;
        v(j)=sqrt(qc(j)*x/(cos(delta)-cos(bita*len)));
```

```
    end
% % % % %         figure
        plot(qc,v)
        table(:,i)=qc'/1e6;
        qc'
        v'
        hold on

% % % % %         title(['Voltage Vs Reactive Power,
Real Power =',num2str(p(i))])
        ylabel('Voltage')
        xlabel('Reactive Power')
end
```

Selection of supply voltage Appendix (G)

KV	*Limiting load & distance*
11 *22* *33* *66* *110*	*5 MVA, 3 km and below.* *5 MVA, 3-10 km and for lower load levels.* *5 MVA, 10-30 km.* *10 MVA, up to 25 km.* *10 MVA, above 25 km.* *20 MVA, up to 30 km.* *Above 20 MVA.*

Imperial Formula to select suitable supply Voltage

$$V = 5.5 \times \sqrt{(L/1.6+P/100)}$$

Where:-

V: system voltage in KV.
L: load distance in km.
P: load in KW.

Appendix (H)

Conductor Designations

The following is a list of the more commonly used aluminum conductors accompanied by their designation:

AAC	All Aluminum Conductor
	All aluminum conductor with no steel for support.
AAAC	All Aluminum Alloy Conductor
	Conductor with only aluminum alloy strands.
ACAR	Aluminum Conductor Aluminum Alloy Reinforced
	Aluminum conductor with one or more strands of aluminum alloy.
ACSR	Aluminum Conductor Steel Reinforced
	Aluminum conductor with one or more strands of steel.
ACSS	Aluminum Conductor Steel Supported
	Aluminum conductor totally supported by the strands of steel.
AW	Alumoweld Conductor made up of aluminum coated steel strands.

Appendix (I)

Table (2) Reference Values of Voltage limit in AC Network

Class	System Voltage L-L Voltage	permissible Highest Voltage L-L voltage	permissible lowest Voltage L-L Voltage
L.V (1ph)	240 Vph to n	264 V	220 V
L.V (3ph)	415 V	440 V	380 V
M.H.V	3.3 KV	3.6 KV	3KV
M.H.V	6.6 KV	7.2 KV	6 KV
N.H.V	11 KV	12 KV	10 KV
M.H.V	22 KV	24 KV	20 KV
M.H.V	33 K V	36 KV	30 KV
H.V	66 KV	72.5 KV	60 KV
H.V	132 KV	145 KV	120 KV
E.H.V	220 KV	245 KV	200 KV
E.H.V	400 KV	420 KV	380 KV
U.H.V	760 KV	800 KV	750 KV

Where

L.V = Low Voltage
M.V = Medium Voltage
H.V = High Voltage
M.H.V = medium High Voltage
E.H.V = Extra High Voltage
U.H.V = Ultra High Voltage

Appendix (J)

Table (1.1) different types of towers

Tower of Type		Applicable for	Insulator set type	Angle of deviation
AA	Suspension	plain area of the route, and for small Angles of line deviation with their extension.	Suspension	$(0 – 3)^o$
BB	Anchor / Angle	straight run of the transmission line route and Light angles of the line	Tension	$(0\text{-}5 \backslash 3\text{-}10)^o$
	Angle	Positions of less angle deviation	Tension	$(10 – 30)^o$
		Position of medium angle deviation		$(30 - 60)^o$
		Position of heavy angle deviation		$(60 - 90)^o$
FF	Terminal	the end of lines at switching stations	Tension	$(0 - 90)^o$
AAR	River Crossing	River Crossing Type $(0 - 2)^o$	Tension	$(0 - 2)^o$
AAL	Transposition (Anchor)	Anchor type and use whenever Transposition 0f conductors is required	Tension	$(25 - 60)^o$
			Tension	$(0 - 30)^o$