### Port-Sudan Substation and Transmission Line Data

<table>
<thead>
<tr>
<th>Description</th>
<th>Value/Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Power</td>
<td>130 MVA</td>
</tr>
<tr>
<td>Active power ( P )</td>
<td>100 MW</td>
</tr>
<tr>
<td>Reactive power ( Q )</td>
<td>80 MVAR</td>
</tr>
<tr>
<td>Line current ( I_L )</td>
<td>850 A</td>
</tr>
<tr>
<td>Line Voltage ( V_L )</td>
<td>220 kV</td>
</tr>
<tr>
<td>Diameter ( D )</td>
<td>17.9 mm</td>
</tr>
<tr>
<td>Length ( L )</td>
<td>450 km</td>
</tr>
<tr>
<td>Frequency ( F )</td>
<td>50 Hz</td>
</tr>
</tbody>
</table>

**Distance among phases**
- \( D_{RY} = 6.7 \) m
- \( D_{YB} = 11.8 \) m
- \( D_{RB} = 13.6 \) m

**Transformers**
- \( 30 \) /100/100 \* 2

**Type of towers**
- Single circuit

**Reactors in the line**
- 37.2 MVA in the sending-eng \* 3

**Reactors in the substation**
- MVA in tertiary winding \( 15 \) \* 2

**Conductor type**
- Zebra

**Insulator type**
- Porcelain Atbara & silicon
- Rubber Port Sudan terminal
- Porcelain 834)
- (tower silicon Rubber 400

**Number of towers**
- 1234
## (Appendix (B
Port-Sudan Feeder line (a) Data from NEC

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Power MVA</td>
<td>6.5</td>
</tr>
<tr>
<td>Active power MW</td>
<td>5.1</td>
</tr>
<tr>
<td>Reactive power MVAr</td>
<td>3.8</td>
</tr>
<tr>
<td>Line current A</td>
<td>113.11</td>
</tr>
<tr>
<td>Line Voltage kV</td>
<td>33</td>
</tr>
<tr>
<td>Diameter mm</td>
<td>185</td>
</tr>
<tr>
<td>Length km</td>
<td>16</td>
</tr>
<tr>
<td>Frequency Hz</td>
<td>50</td>
</tr>
<tr>
<td>Distance among phases</td>
<td></td>
</tr>
<tr>
<td>( D_{RV} )</td>
<td>0.943 m</td>
</tr>
<tr>
<td>( D_{YB} )</td>
<td>0.943 m</td>
</tr>
<tr>
<td>( D_{RB} )</td>
<td>1.6 m</td>
</tr>
<tr>
<td>Type of poles</td>
<td>Single circuit</td>
</tr>
<tr>
<td>( P_f )</td>
<td>0.807</td>
</tr>
</tbody>
</table>
(Appendix (C

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

```matlab
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)

```matlab
clc
clear all

a=484.5e-6
w=2*pi*50;
v=220000;
dry=6.700; %meter
dlen=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
len=450000
dby=11.800
drb=13.570
p=48e6
p=[20e6 30e6 40e6 50e6 60e6 70e6 80e6 90e6 100e6]
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
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


(Appendix (F
\[ v(j) = \sqrt{q_c(j) \times \frac{x}{\cos(\delta) - \cos(\beta \times \text{len})}} \]

```
end

figure

plot(qc, v)

;table(:, i) = qc' / 1e6

hold on

title(['Voltage Vs Reactive Power, 

\[ \text{Real Power} = ', num2str(p(i)), '\]

ylabel('Voltage

xlabel('Reactive Power

end
```
## Limiting load & distance

- **MVA, 3 km and below**: 5
- **MVA, 3-10 km and for lower load levels**: 5
- **MVA, 10-30 km**: 5
- **MVA, up to 25 km**: 10
- **MVA, above 25 km**: 10
- **MVA, up to 30 km**: 20
- **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
# Conductor Designations

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

<table>
<thead>
<tr>
<th>Conductor</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Aluminum Conductor</td>
<td>AAC</td>
</tr>
<tr>
<td>All aluminum conductor with no steel for support</td>
<td>AAAC</td>
</tr>
<tr>
<td>All Aluminum Alloy Conductor</td>
<td>AAAC</td>
</tr>
<tr>
<td>Conductor with only aluminum alloy strands</td>
<td>ACAR</td>
</tr>
<tr>
<td>Aluminum Conductor Aluminum Alloy Reinforced</td>
<td>ACAR</td>
</tr>
<tr>
<td>Aluminum conductor with one or more strands of</td>
<td>ACSS</td>
</tr>
<tr>
<td>aluminum alloy</td>
<td></td>
</tr>
<tr>
<td>Aluminum Conductor Steel Reinforced</td>
<td>ACSR</td>
</tr>
<tr>
<td>Aluminum conductor with one or more strands of</td>
<td>ACSR</td>
</tr>
<tr>
<td>steel</td>
<td></td>
</tr>
<tr>
<td>Aluminum Conductor Steel Supported</td>
<td>ACSR</td>
</tr>
<tr>
<td>Aluminum conductor totally supported by the</td>
<td>ACSR</td>
</tr>
<tr>
<td>strands of steel</td>
<td></td>
</tr>
<tr>
<td>Alumoweld Conductor made up of aluminum coated</td>
<td>AW</td>
</tr>
<tr>
<td>steel strands</td>
<td></td>
</tr>
</tbody>
</table>
### (Appendix I)

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

<table>
<thead>
<tr>
<th>Class</th>
<th>L.V</th>
<th>M.H.V</th>
<th>H.V</th>
<th>M.H.V</th>
<th>E.H.V</th>
<th>U.H.V</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.V</td>
<td>V 220</td>
<td>V 380</td>
<td>3KV</td>
<td>KV 6</td>
<td>KV 10</td>
<td>KV 20</td>
</tr>
<tr>
<td>M.H.V</td>
<td>V 264</td>
<td>V 440</td>
<td>KV 3.6</td>
<td>KV 7.2</td>
<td>KV 12</td>
<td>KV 24</td>
</tr>
<tr>
<td>H.V</td>
<td>V 240</td>
<td>V 415</td>
<td>KV 3.3</td>
<td>KV 6.6</td>
<td>KV 11</td>
<td>KV 22</td>
</tr>
<tr>
<td>M.H.V</td>
<td>V 240</td>
<td>V 415</td>
<td>KV 3.3</td>
<td>KV 6.6</td>
<td>KV 11</td>
<td>KV 22</td>
</tr>
<tr>
<td>E.H.V</td>
<td>V 240</td>
<td>V 415</td>
<td>KV 3.3</td>
<td>KV 6.6</td>
<td>KV 11</td>
<td>KV 22</td>
</tr>
<tr>
<td>U.H.V</td>
<td>V 240</td>
<td>V 415</td>
<td>KV 3.3</td>
<td>KV 6.6</td>
<td>KV 11</td>
<td>KV 22</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Angle of deviation</th>
<th>Insulator set type</th>
<th>Applicable for</th>
<th>Tower of Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>°(3 – 0)</td>
<td>Suspension</td>
<td>plain area of the route, and for small Angles of line deviation with .their extension</td>
<td>Suspension</td>
</tr>
<tr>
<td>° (10- 3 \ 0-5)</td>
<td>Tension</td>
<td>straight run of the transmission line route and Light angles of the line</td>
<td>Anchor / Angle</td>
</tr>
<tr>
<td>°(30 – 10 )</td>
<td>Tension</td>
<td>Positions of less angle deviation</td>
<td>Angle</td>
</tr>
<tr>
<td>° (60 - 30 )</td>
<td></td>
<td>Position of medium angle deviation</td>
<td></td>
</tr>
<tr>
<td>°(90 - 60 )</td>
<td></td>
<td>Position of heavy angle deviation</td>
<td></td>
</tr>
<tr>
<td>°(90 - 0 )</td>
<td>Tension</td>
<td>the end of lines at switching stations</td>
<td>Terminal</td>
</tr>
<tr>
<td>°(2 - 0 )</td>
<td>Tension</td>
<td>River Crossing Type (0 - 2)°</td>
<td>River Crossing</td>
</tr>
<tr>
<td>°(60- 25 )</td>
<td>Tension</td>
<td>Anchor type and use</td>
<td>Transposition</td>
</tr>
<tr>
<td>°(30 - 0°)</td>
<td>Tension</td>
<td>Whenever transposition of conductors is required</td>
<td>n (Anchor)</td>
</tr>
<tr>
<td>-----------</td>
<td>---------</td>
<td>-----------------------------------------------</td>
<td>------------</td>
</tr>
</tbody>
</table>