

POWER DISTRIBUTION NETWORK

BY

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Electrical distribution systems are an essential part of the electrical power system. In Nigeria, Distribution networks were designed as passive systems, which provides one-directional links between the transmission network and electricity end users. Most of the radiating feeders are radial networks and very few ring networks.

In Nigeria, Distribution Networks consist of:

- **33kV Networks**
- **11kV Networks**
- **400V Networks and Below.**

We have two types of Distribution networks:

- **Overhead Distribution Network**
- **Underground Distribution Network**

Overhead Distribution network

Overhead distribution network is an electrical network where the electrical conductors are erected on structures in the open to distribute power supply to energy consumers or users.

ROUTE SURVEY

**Produce a survey plan and profile of the route.
NESIS 5.1.1**

- What to consider during the route survey?**
- Topography, type of soil, type of settlement, type of connections etc**
- Is the construction within the Township or an Inter-township connection?**

TOWNSHIP DISTRIBUTION NETWORK (TDN)		SPAN LENGTH	
Type of Construction	Conductor Type and Size	Min (m)	Max (m)
LV (400V)	70mm ² , 100mm ² , AAC	45	50
HV/LV (33/11/0.4kV)	70mm ² , 100mm ² , 150mm ² , AAC 100mm ² , 150mm ² , ACSR	45	50
HV (11kV)	100mm ² , 150mm ² , AAC, ACSR	45	50
HV (33kV)	150mm ² , ACSR	45	50

INTER-TOWNSHIP CONNECTION (ITC)		SPAN LENGHT	
Type of Construction	Conductor Type and Size	Min (m)	Max (m)
HV (11kV)	100mm ² , 150mm ² , AAC, ACSR	50	70
HV (33kV)	150mm ² , 200mm ² , ACSR	50	70

WHAT SHOULD BE CONSIDERED WHEN DESIGNING AN OVERHEAD DISTRIBUTION LINES: NESIS 5.1

- **Materials**
- **Environmental issues**
- **Mechanical loading conditions**
- **Electrical service conditions and physical environment**
- **Prevention of unauthorized access.**

Materials:

- The components, accessories, and support structures



Environmental Issues:

- The social impact of new projects, and community concerns,
- The minimization of environmental damage, including visual impacts, tree and forestry management programmes,
- The consideration of Electromagnetic radiation.
- Erosion prone environment.

Mechanical Loading Conditions

mechanical and structural strength to withstand anticipated stresses and strains due to environmental and electrical service conditions.

Electrical Service Conditions and Physical Environment

In determining the electrical service conditions and the physical environment under which the electrical works will operate, reasonable care shall be given to the consideration of extremes that may occur, the likelihood of their occurrence and the associated risks.

Prevention of Unauthorized Access

All electrical works with exposed live parts shall be designed and constructed in such a manner as to prevent unauthorized access to any person as far as is reasonably practicable.

SUPPORTS:

- **Treated wooden poles**
- **Concrete poles**
- **Lattice steel poles**

- **Treated wooden poles:**
- **Treated wooden poles made from opepe tree are exceptionally good and strong as support structure in distribution overhead lines.**

- **Concrete poles:**
- **We have two types of concrete poles in Nigeria: Pre-stressed and Reinforced concrete poles.**

- **Lattice Poles:**
- **Poles made from galvanized steel.**

S/N	Line type	Pole height (m)	Pole Planting depth (m)
1	LV (400V)	8.54	1.2
2	LV & HV (33/11/0.4kV)	10.36	1.8
3	HV (33/11kV)	10.36 12.20	1.8 2.1
4	33kV Double circuit	12.20	2.1

Poles identification:

All poles must have a legible engraved identification mark showing its NEMSA No. Batch No, Planting depth mark. They have to be numbered.

CROSS ARMS

Cross arms can be an approved treated wood, galvanized mild steel (U-channel) or fibre that is mounted on an electric pole to hold up power lines or other electrical equipment. They are used for anchoring and supporting conductor distribution lines.

- Types of cross arms:
- Treated wooden cross arm
- Galvanized cross arm (U-Channel and Angle galvanized steel)
- Fiber Cross arm.

Types of cross arms:

- **Treated wooden cross arm**
- **Galvanized cross arm (U-Channel and Angle galvanized steel)**
- **Fiber Cross arm.**

Voltage level (kV)	Length (mm)
11	1800
33	2700

INSULATORS FOR OVERHEAD LINES

Electrical insulators are materials that have tightly bound electrons whose internal electric charges do not flow freely; little electric current will flow through it under the influence of an electric field.

Types of insulators:

- Shackles insulators – 400V
- Coach Screw service Insulators – 400V
- Pin Insulator – 11kV or 33kV
- String Insulator – 11kV or 33kV



Types of insulators materials:

- Porcelain
- Glass
- Silicon



- Tie Straps.



- Spindle

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- Ball ended hook

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- Ball clevis

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- Socket clevis



Conductors:

- **Conductors are the materials or substances which allow electricity to flow through them. They conduct electricity because they allow electrons to flow easily inside them from atom to atom.**
- **Conductors approved for sub-transmission primary lines (33kV) is Aluminum Conductor Steel Reinforced**

S/N	Type of Construction	HV Conductor		LV Conductor		Current Carrying Capacity (A)
1	Combine 11kV and LV Circuits on concrete poles	HD AL, AAC	100 150	HD AL, AAC	50 100 150	180 270 345
2	11kV Single Circuit on Concrete Poles	ACSR, AAC	100 150	N/A	N/A	270 345
3	33kV Single Circuit on concrete poles	ACSR	100** 150 200	N/A	N/A	270 345 420
4	33kV Double circuit on Concrete poles	ACSR	150 200	N/A	N/A	345 420

- HD Al- Hard Drawn Aluminum
- AAC – All Aluminum Conductor
- ACSR – Aluminum Conductor Steel Reinforced
- N/A – Not applicable

- **Allowable Voltages in distribution network: NESIS**
- **5.1.6.i Standard AC Voltages**
- **Primary distribution: 33000 $\pm 6\%$**
- **Secondary distribution: 11000 $\pm 6\%$**
- **Low Voltage: 400 $\pm 6\%$**

Nigerian Distribution Code (NDC). V2.

NDC 4.3: Voltage Levels

- **4.3.1. Nominal and Operational Voltages on the Distribution System are shown in the following Table.**

Nominal Voltage	Operating Voltage	
	Minimum kV	Maximum kV
33kV	31 (0.94)	34.98 (1.06)
11kV	10.48 (0.95)	11.55 (1.05)
400V	376 (0.94)	424 (1.06)
230V	216.2 (0.94)	243.8 (1.06)

How to determine the length of feeder based on size and current carrying capacity of conductor.

What is the length of line to a deliver 15MW power on a 33kV overhead line using 150mm² ACSR. ensure the voltage is within the regulations minimum accepted limit.

- **Nominal voltage: 33,000v**
- **ACSR 150mm² (Wolf)**
- **Current Capacity of 150mm² ACSR Conductor at 75°C = 405Amp,**
- **Resistance = 0.1871Ω/km and Reactance = 0 Ω,**
- **Power Factor: 0.85 (NDC: 4.12)**
- **Permissible limit of % Voltage Regulation ±6%.**
- **Power to be delivered = 15MW**
- **Length of line = L**

- **Voltage drop = 33,000 – 31,020 = 1,980**
- **Load Current = KW / 1.732 x Volt x P.F**
- **Load current (I) = 15,000kW / 1.732 x 33000 x 0.85**
- **Load Current (I) = 15,000,000 / 48,582.6**
- **Load Current (I) = 308.75A**

- **Required No of conductor / Phase = $308.75 / 405 = 0.76$
Amp = 1 No**
- **Voltage Drop = $((\sqrt{3} \times (R \cos \Phi + X \sin \Phi) \times I) / (\text{No of Conductor/Phase} \times 1000)) \times \text{Length of Line}$**
- **$1,980 = ((1.732 \times (0.1871 \times 0.85 + 0 \times 0.6) \times 308.75) / (1 \times 1000)) \times L$**
- **$1,980 = (85 / 1 \times 1000) \times L$**
- **$L = 1,980 / 0.085 = 23, 294\text{m}$**
- **$L = 23.29\text{KM.}$**

NESIS 5.3: Minimum height of conductors

The minimum height of conductors should be considered in design of an overhead distribution line.

- NESIS 5.3.1 Clearance of Pole to ground or roads:

System voltage	Ground clearance (m)		
	Over streets, road, public spaces and other vehicular traffic	Along streets, roads and places accessible to traffic	Positions inaccessible to vehicular traffic not streets or roads
400V	5.8	5.8	5.8
11000V	6.1	6.1	6.1
33000V	6.1	6.1	6.1

NESIS 5.2.12. Jointing Requirements for Overhead Distribution Conductors

Joints between conductors of overhead distribution lines shall be mechanically secure and electrically continuous under the conditions of operation.

- There shall be one (1) joint only for new connections;**
- while two (2) joints may be allowed for existing connections.**

The proximity of the Overhead distribution conductors to Railway Lines, telecommunication lines, airfields, rail tracks, radio ad telecommunication aerial .

Clearance between any overhead transmission conductor and any overhead distribution conductor

System voltage between phases	Clearance (m)
Not exceeding 400V – Insulated	0.2
Not exceeding 400V – uninsulated	0.6
Over 400V but not exceeding 33kV	1.8
Over 33kV but not exceeding 132kV	2.4

Clearance of electric lines to buildings: electric lines over or adjacent to a building NESIS: 5.3.4.1

VOLTAGE LEVEL

CLEARANCE (M)

400V to 11000V

2.4

33000V

3

Right of Way: NESIS 3.1

This is the distance of any structure from the middle of the conductors of overhead power lines of any voltage level.

Voltage level (kV)	Right of Way (m)	Middle of conductor to structure (m)
11	11	5.5
33	11	5.5

Type of Faults:

Faults on overhead lines fall into one of three categories. They are transient, semi-permanent and permanent. 80-90% of fault on any overhead line network are transient in nature. The remaining 10%-20% of faults are either semi-permanent or permanent.

- Transient fault - A transient faults are faults that are expected to be cleared automatically, and these do not require any attempt for fault rectification. It can be like a lightning strike or an insulator flash over that is cleared by tripping of circuit breaker and does not re occur when the line is energized again. E. g, momentary tree contact, bird or other animal contact, lightning strike, and conductor clashing.**

Type of Faults:

- Semi-permanent faults - are also transient in nature but they take few moments to remove. E g, A branch falling on the line. This kind of fault will not be cleared by subsequent tripping and auto-reclosing, but a time delayed trip will allow the branch to be burned out fully.
- Permanent faults – A permanent fault is one which is not cleared by tripping and reclosing. E g, Careless motor vehicle drivers, Operating error: leaving earths connected, Equipment Failure.

Challenges in Power Distribution Network:

- **Aged Distribution Network**
- **Vandalisation of Distribution lines**
- **Nonconformity with the relevant codes and standards and regulations.**
- **Poor city and town planning**
- **Inadequate technical capacity.**
- **Technical losses because of over stretched network (33, 11, & 0.4kV lines)**
- **Lack of adequate technical collaboration among stakeholders. (Location of TCN 132/33kV and DisCos 33/11kV, ...)**

Solutions

- **Technical collaboration and interface among stakeholders should be encouraged.**
- **Distribution networks should be upgraded in terms of distribution lines and transformers.**
- **Building of more injection substation to increase power reliability and sustainability.**
- **Enforcement of technical code and standards and regulations.**
- **Improve technical capacity.**

QUESTIONS AND ANSWER

- THANK YOU