A Comprehensive IEEE Test Feeder

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Original 1991 IEEE Test Feeders

- 13 Node Test Feeder – provided a good test of the convergence of a program for a very unbalanced system
- 34 Node Test Feeder – a very long feeder requiring the application of voltage regulators to satisfy ANSI voltage standards

Original 1991 IEEE Test Feeders

- 37 Node Test Feeder – a three wire delta underground system
- 123 Node Test Feeder – a large system consisting of overhead and underground single phase, two phase and three phase laterals along with step voltage regulators and shunt capacitors

Why This Test Feeder?

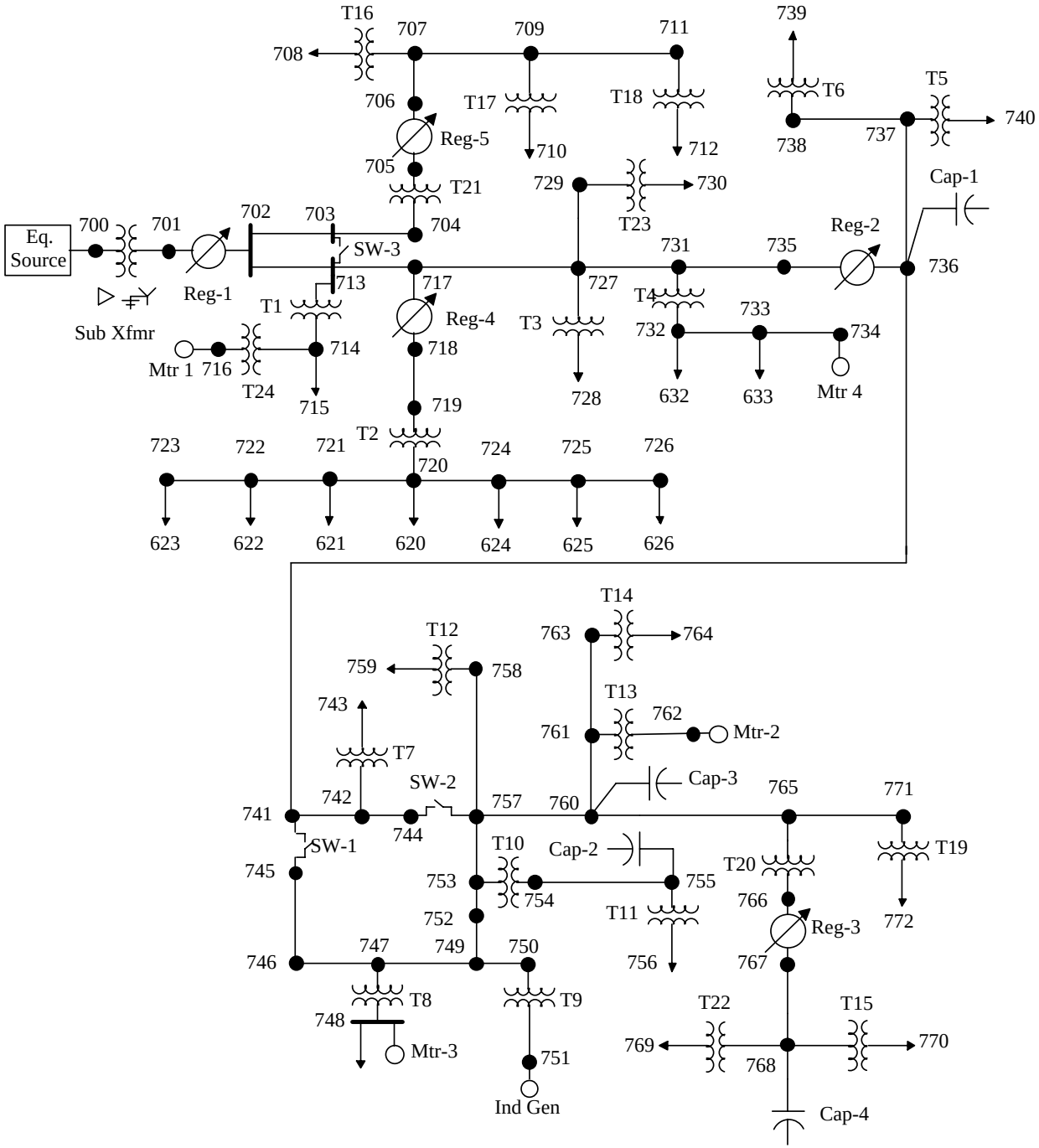
- In one feeder test the models for
  - Typical OH and UG lines
    - Single lines
    - Parallel lines (physical and electrical)
  - Typical transformer banks
    - Three-phase with and without center tap
    - Open connections with and without center tap
    - Single phase with and without center tap
  - Single phase and three phase secondaries
  - Distributed and spot load models
    - Wye and delta connected
      - Constant PQ
      - Constant Z
      - Constant I

Why This Test Feeder (cont.) ?

- Step voltage regulators with R and X specified
  - Wye connected
    - Three phase
    - Single phase
  - Delta connected
    - Closed
    - Open
- Switches
  - Open
  - Closed
- Shunt Capacitors
  - Wye connected
  - Delta connected

Why This Test Feeder (cont.) ?

- Induction machines
  - Detailed motor models
    - Specify input kW
    - Specify input slip
  - Detailed generator model
    - Specify output kW
  - Simple model
    - Specify input kW and power factor


Eq. Source
Sub Xfmr
Reg-1
Reg-2
Reg-3
Reg-4
Reg-5
SW-1
SW-2
SW-3
Cap-1
Cap-2
Cap-3
Cap-4
Mtr 1
Mtr 4
Mtr-2
Mtr-3
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Source Data

- Balanced 115 kV input to substation transformer
  - V AB = 115,000 at 30 degrees
  - Positive and zero sequence equivalent system impedances
- Substation transformer
  - kVA rating
  - 115 kV Delta – 24.9 kV grounded Wye
  - Transformer impedance

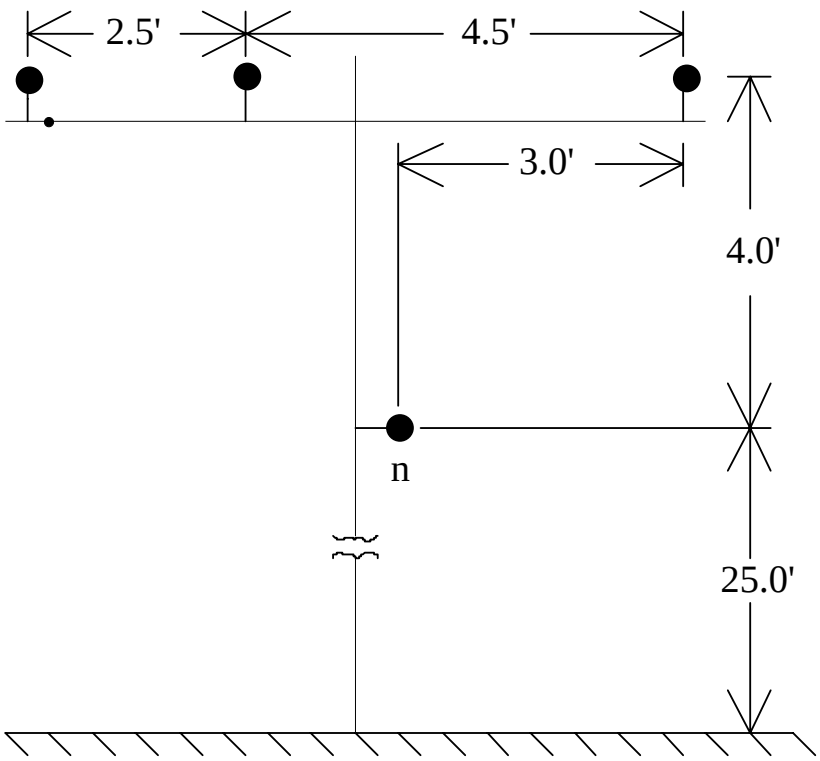
Conductor Data

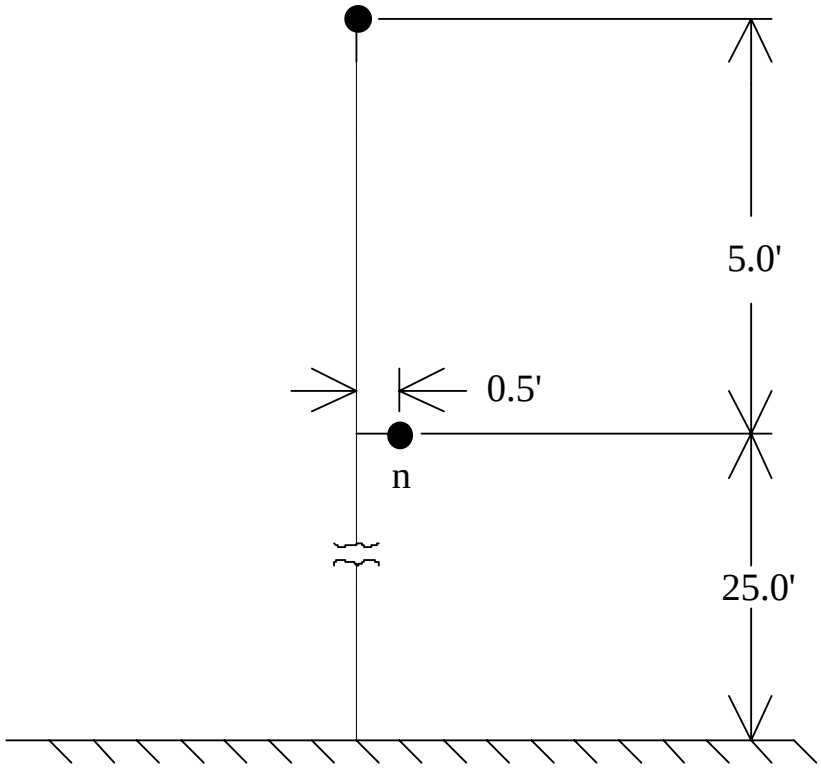
Conductor	Type	Res. Ohms/mi	Dia. Inch	GMR Ft.	Rating Amps
1,000,000 CM	AA	0.105	1.150	0.0368	698
556,500 CM	ACSR	0.186	0.927	0.0311	730
500,000 CM	AA	0.206	0.813	0.0260	483
336,400 CM	ACSR	0.306	0.721	0.0244	530
#4/0	ACSR	0.592	0.563	0.0081	340
#2/0	AA	0.769	0.414	0.0125	230
#1/0	ACSR	1.120	0.398	0.0045	230
#1/0	CU	0.607	0.368	0.0111	310
#2	AA	1.540	0.292	0.0088	156
#2	ACSR	1.690	0.316	0.0042	180
#4	ACSR	2.550	0.257	0.0045	140
#10	CU	5.903	0.102	0.0033	80
#12	CU	9.375	0.081	0.0026	75
#14	CU	14.872	0.064	0.0021	20

Examples of Overhead Lines

Type	Node A	Node B
Three-phase 4 wire	717	727
Three-phase 3 wire	765	771
Two-phase 3 wire	736	737
Single-phase 2 wire	757	758
Single-phase triplex	720	721
Three-phase quadraplex	732	733

Overhead Construction



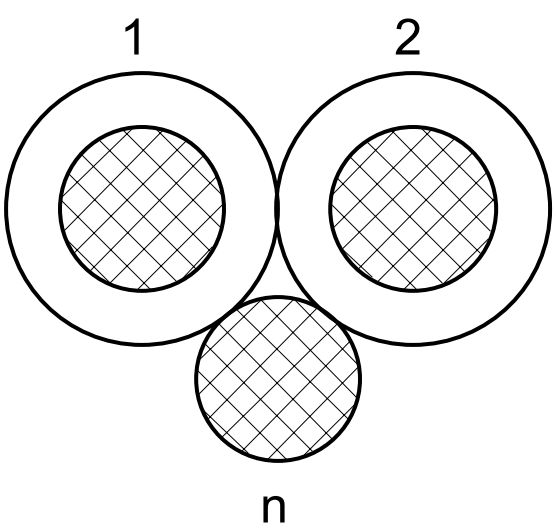


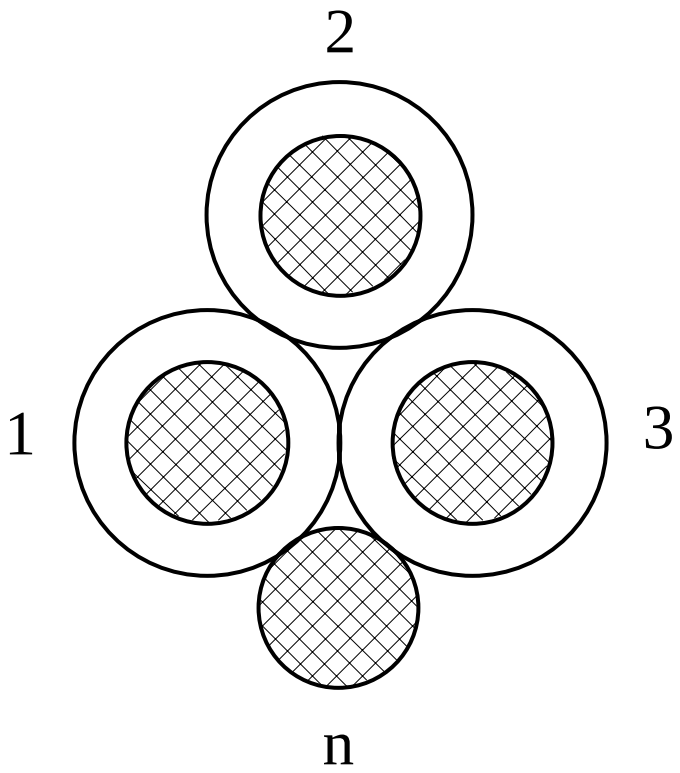
Line Construction Codes

- Code number
- X and Y coordinates for each phase and neutral position
- Example

Code	Position 1 ft.		Position 2 ft.		Position 2 ft.		Neutral ft.	
	X	Y	X	Y	X	Y	X	Y
500	0	29	2.5	29	7.0	29	4.0	25

Secondary Lines



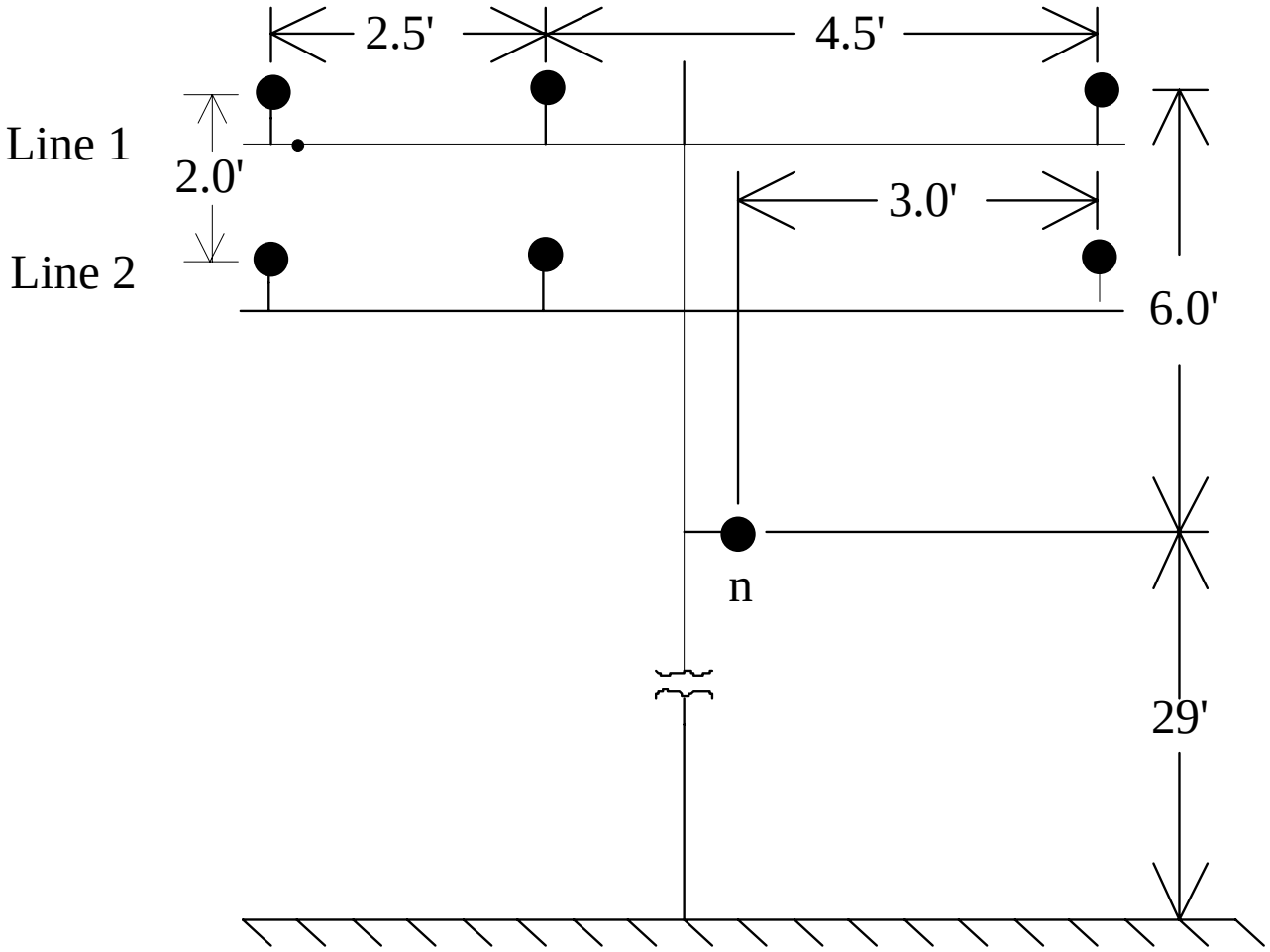


Secondary Construction Codes

- Triplex and quadraplex
- Quadraplex example

Code	Position 1 in.		Position 2 in.		Position 2 in.		Neutral in.	
	X	Y	X	Y	X	Y	X	Y
560	0	0	0.267	0.4625	0.534	0	0.267	-0.4115

Parallel Overhead Line



Overhead Construction Codes

Code	Position 1 ft.		Position 2 ft.		Position 2 ft.		Neutral ft.	
	X	Y	X	Y	X	Y	X	Y
565	0	33	2.5	33	7	33	4	25
570	0	29	2.5	29	7	29		

Overhead Line Data

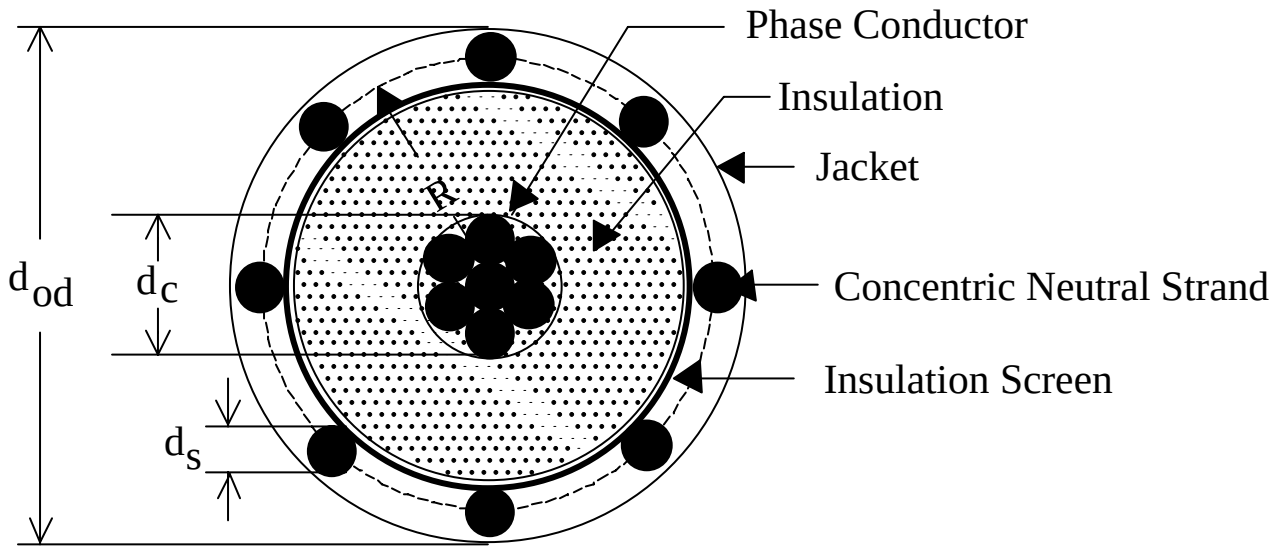
- Line name
- From node – To node
- Length (ft.)
- Phasing
  - b-c-a means position 1-2-3 on construction code
- Phase conductor
- Neutral conductor
- Construction Code
- Example

Name	From	To	Length	Phases	Phase Cond	Neut. Cond.	Code
OH-6	717	727	20,000	b-c-a	1/0 ACSR 6/1	1/0 ACSR 6/1	500

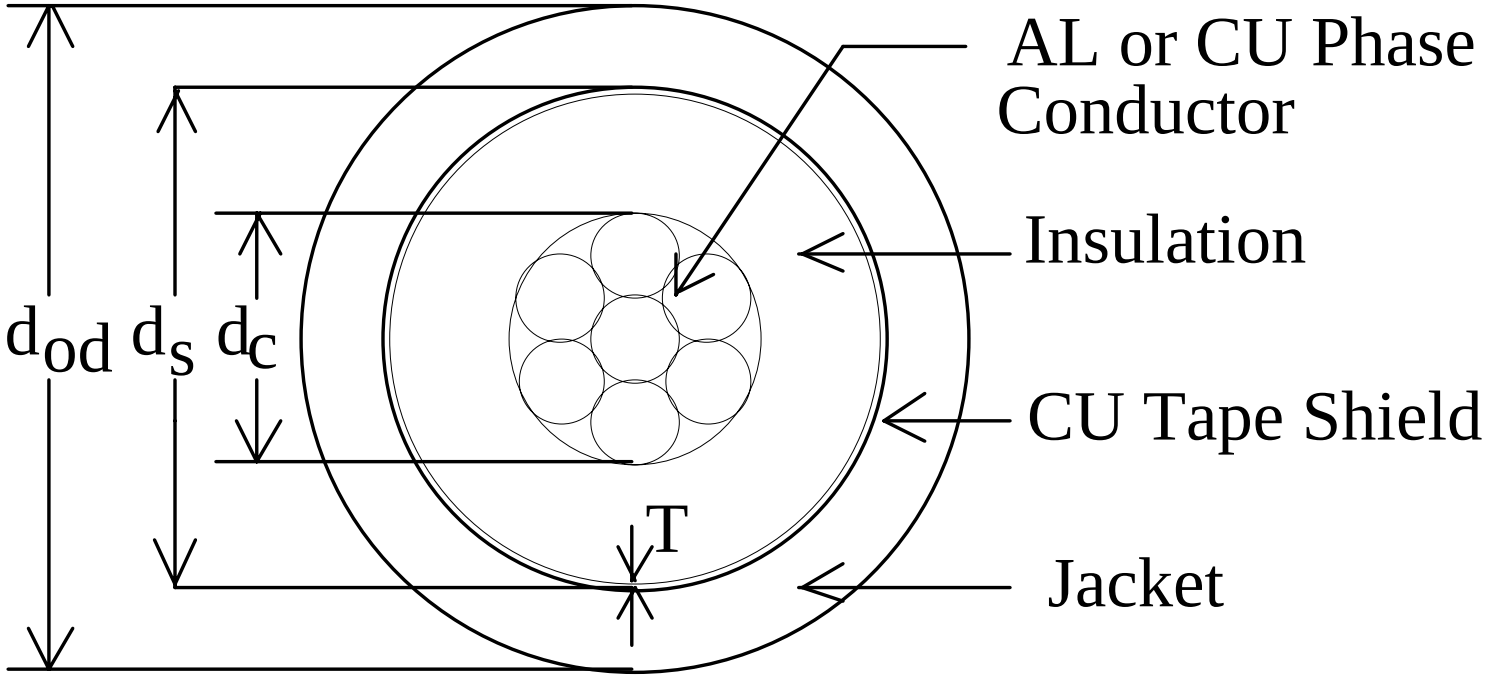
Examples of Underground Cable Lines

Type	Node A	Node B
Three concentric 1/3 neutrals + 1	760	761
Three concentric 1/3 neutrals	706	707
Two concentric full neutrals	707	709
Two tape shielded cables + 1	737	738
One full concentric neutral	718	719

Concentric Neutral Cable



Tape Shielded Cable

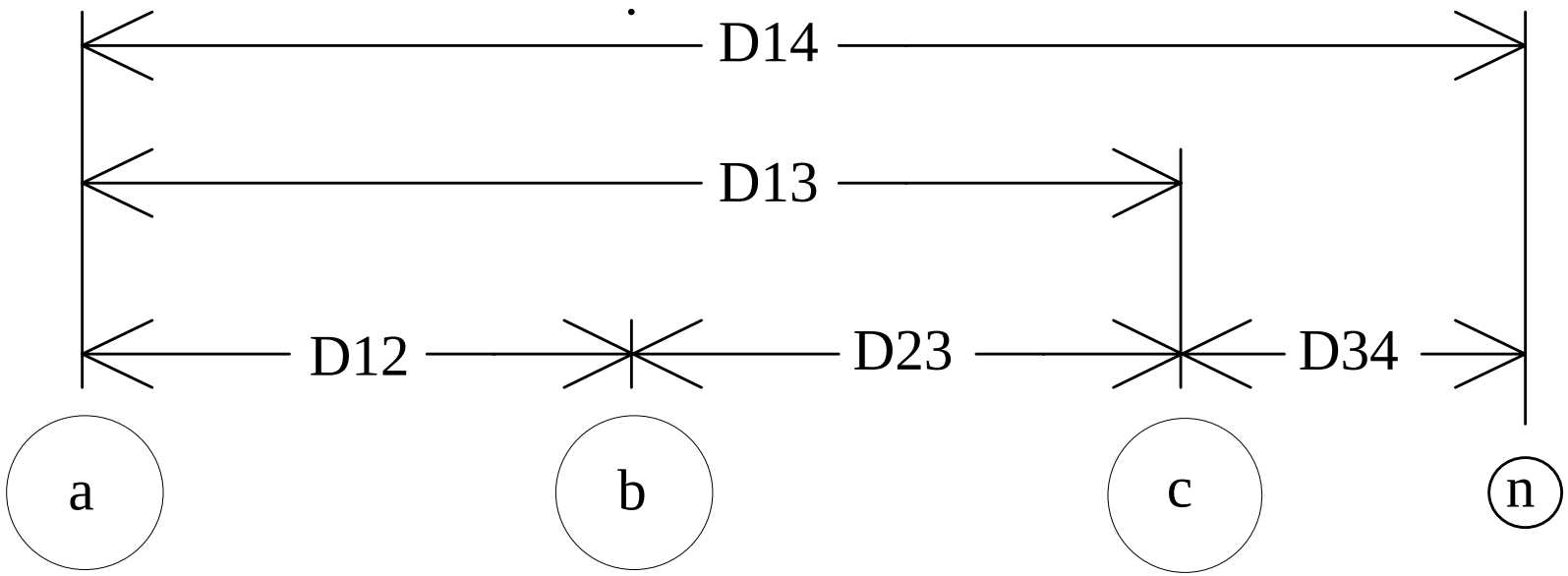


Cable Data

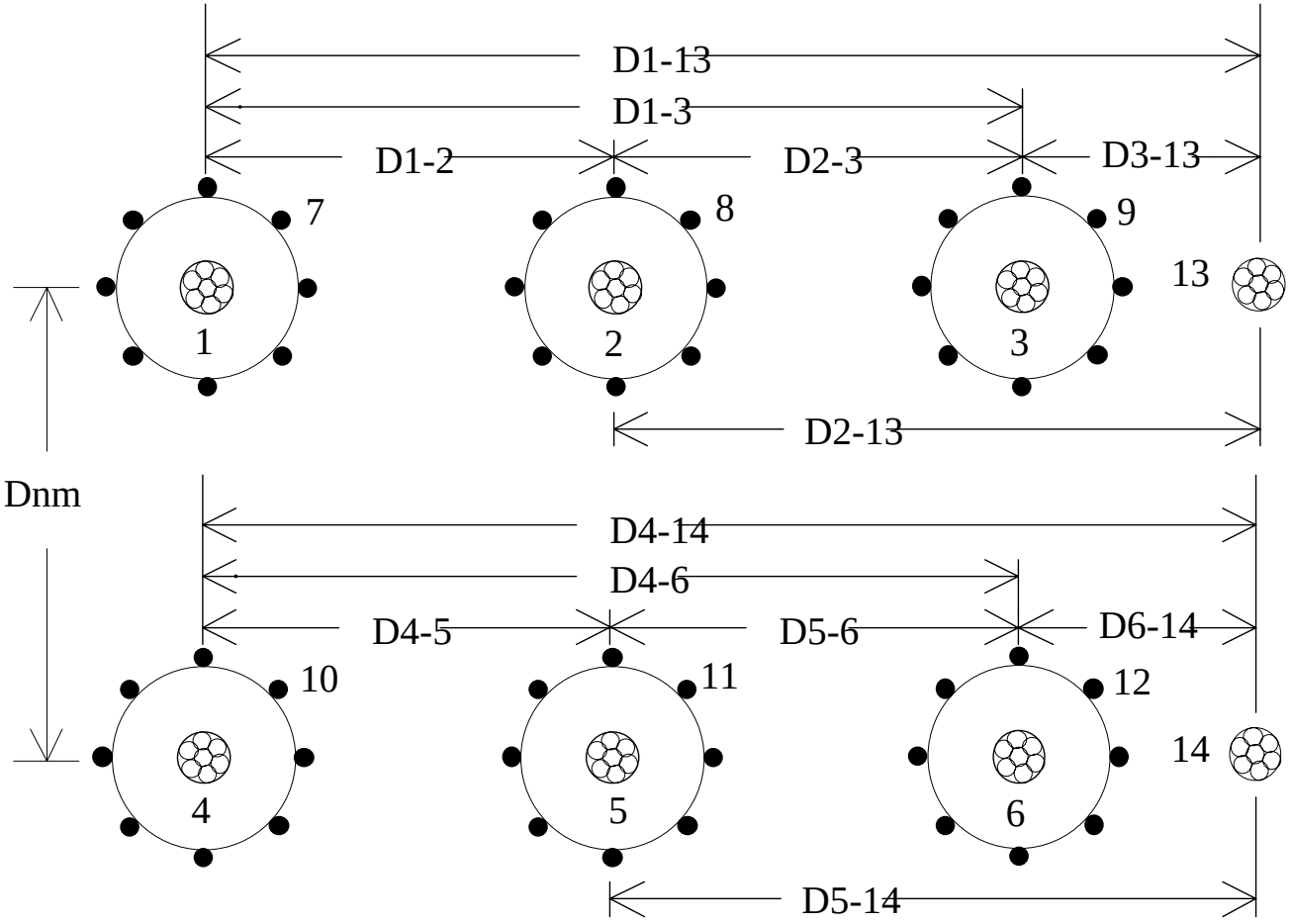
Type	Phase Cond.	Neutral	Outside Diameter
CN	1,000,000 AA	20 - #10 CU	1.999 Inch
CN	500,000 AA	16 - #12 CU	1.582 Inch
CN	250,000 AA	13 - #14 CU	1.318 Inch
CN	2/0 AA	13 - #12 CU	1.147 Inch
CN	1/0 CU	9 - #14 CU	1.068 Inch
CN	#2 AA	10 - #14 CU	0.993 Inch

	Phase Cond.	Tape Thickness	Diameter Over Screen
TS	1/0 CU	5 Mils	.85 Inch

Underground Construction



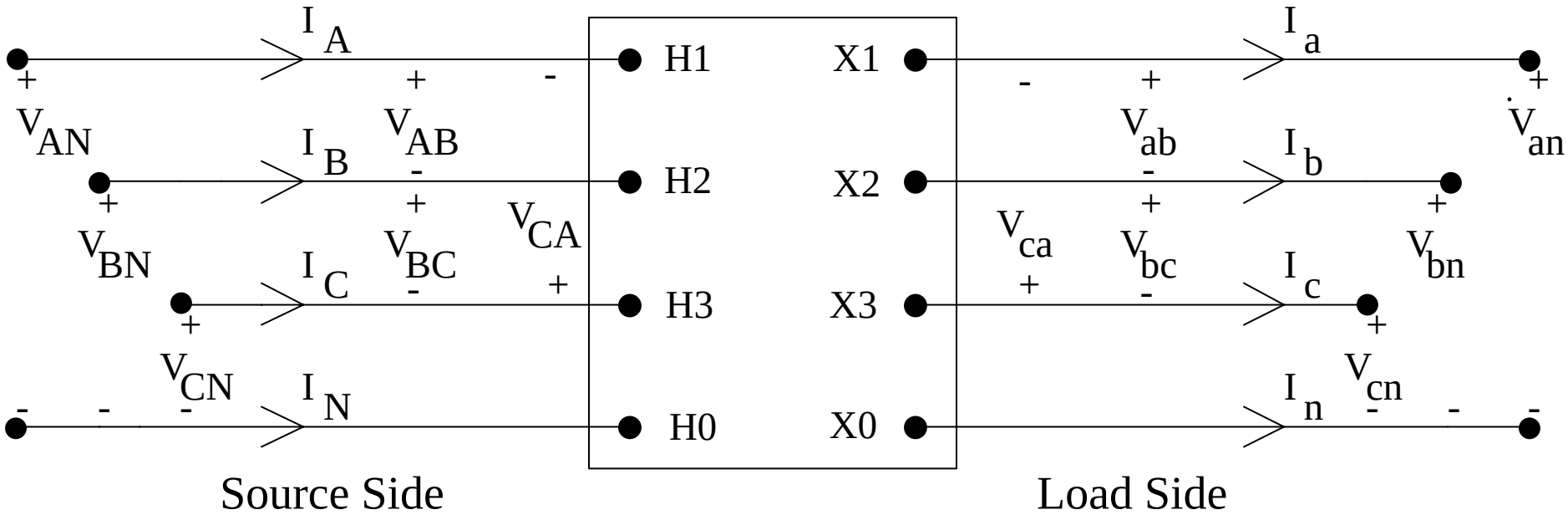
Parallel UG Construction



Transformer Connections

Xfm Num.	Node	Connection	Transformers
T1	717	Grd. Y – Grd. Y	3 – Single Phase
T10	753	D-Y Grd. thru R	1 – Three Phase
T3	727	Grd. Y – D	3 – Single Phase
T7	742	Ungrd. Y – D	3 – Single Phase
T5	737	Open Grd. Y – D	2 – Single Phase
T12	758	One Grd. Y – D	1 – Single Phase
T11	755	D – Grd. Y	3 – Single Phase
T19	771	Open D – Grd. Y	2 – Single Phase
T17	709	One D – Grd. Y	1 – Single Phase
T9	750	D – D	1 – Three Phase
T13	761	Open D – D	2 – Single Phase
T16	707	One D – D	1 – Single Phase

Standard 30 Degree Connection
Wye-Delta and Delta-Wye



Step - Down Connection

V_{AB} leads V_{ab} by 30 degrees

I_A leads I_a by 30 degrees

Step - Up Connection

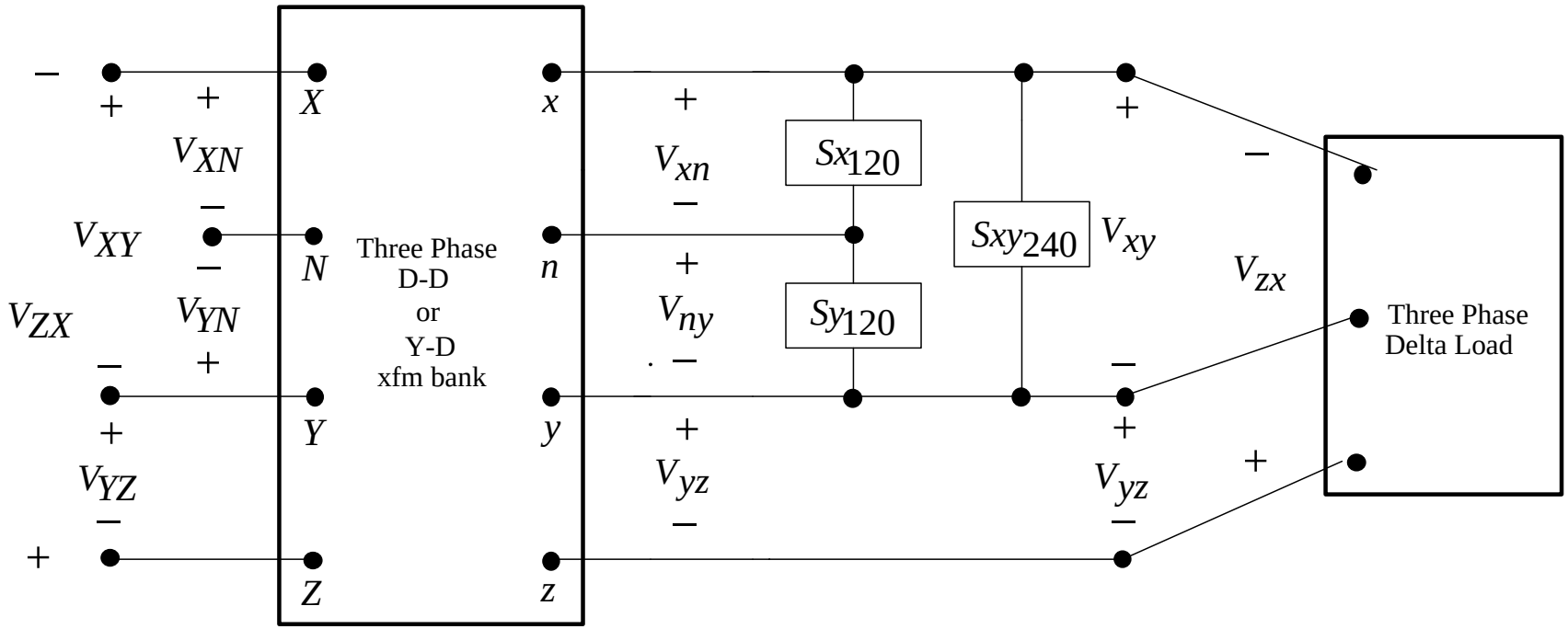
V_{ab} leads V_{AB} by 30 degrees

I_a leads I_A by 30 degrees

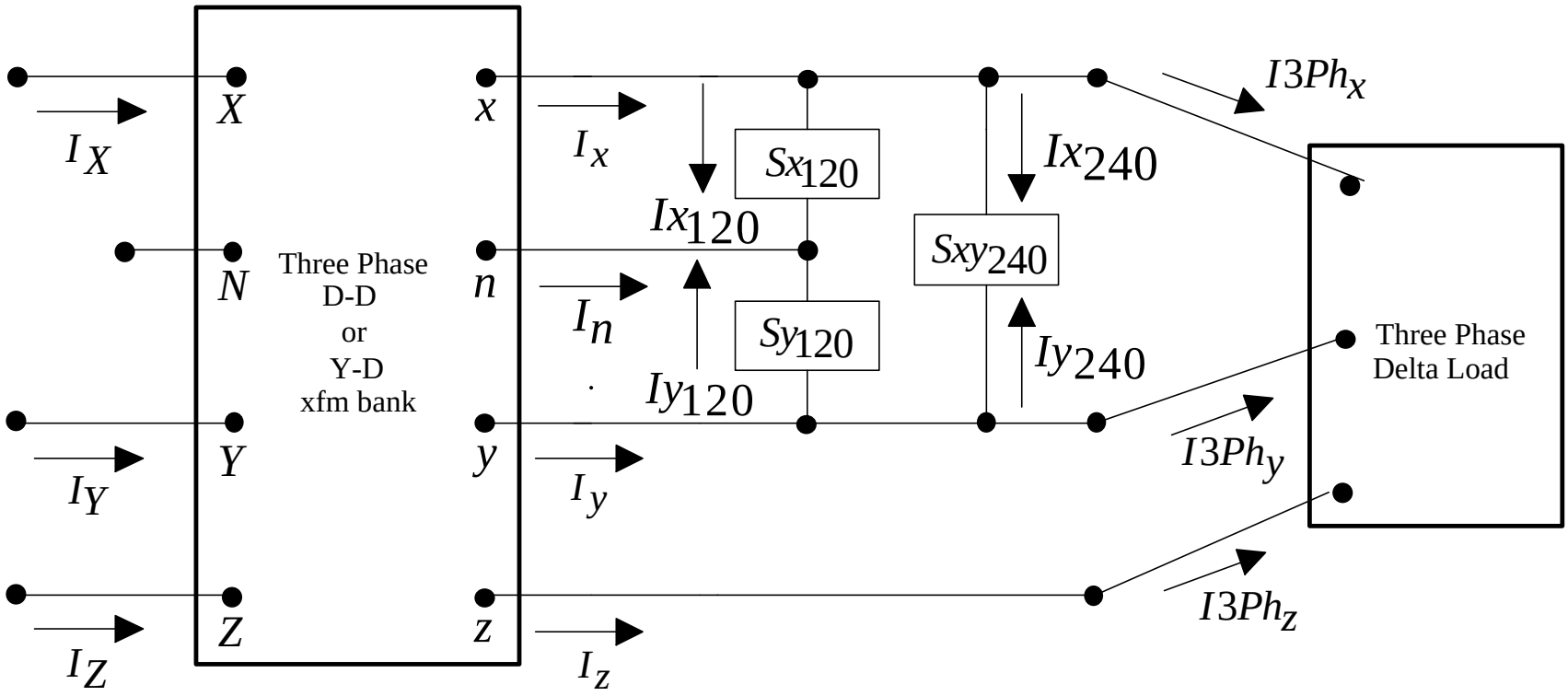
Center Tapped Transformers

Xfm Num.	Node	Connection	Transformers
T4	731	Grd. Y – D	3 – Single Phase
T8	747	UnGrd. Y – D	3 – Single Phase
T6	738	Open Grd. Y – D	2 – Single Phase
T2	719	One Grd. Y – D	1 – Single Phase
T22	769	D – D	3 – Single Phase
T14	763	Open D – D	2 – Single Phase
T18	711	One D – D	1 – Single Phase

Center Tap Transformer Voltages



Center Tap Transformer Currents



Spot and Distributed Load Models

- Wye Connected
  - Constant P and Q (Y-PQ)
  - Constant Z (Y-Z)
  - Constant I (Y-I)
- Delta Connected
  - Constant P and Q (D-PQ)
  - Constant Z (D-Z)
  - Constant I (D-I)
- All data given in kW and kvar per phase

Step Voltage Regulators

Reg. Num	Node	Connection	Regulators
Reg – 1	701	Grd. Y – Grd. Y	3 – Single Phase
Reg – 2	735	Grd. Y – Grd. Y	3 – Single Phase
Reg – 3	766	D – D	3 – Single Phase
Reg – 4	717	Grd. Y	1 – Single Phase
Reg – 5	705	Open D – Open D	2 – Single Phase

Step Voltage Regulators

Voltage Regulators

	32 Step	Step Size	No. of Steps	Bandwidth
All Regulators	±10 %	5/8 %	16	2

Reg. Number	Connection	Regulator type	Phases	CT Rating	Set V Level Volgs	Comp R Volts	Set Comp X Volts
Reg 1	Y-Y	3 single phase	a-b-c	200	123	4.7	3.4
Reg 2	Y-Y	3 single phase	a-b-c	100	124	3.6	2.8
Reg 3	D-D	3 single phase	ab-bc-ca	50	122	0	0
Reg 4	Y	1 single phase	a	100	125	1.3	0.5
Reg 5	Open D-D	2 singel phase	ab	50	120	0	0.6
			bc	50	120	0.7	0.1

Machine Data

Machines

Machine ID	kVA Rating	Rated Voltage	Stator R (Ω)	Stator X (Ω)	Rotor R (Ω)	Rotor X (Ω)	Mag. X (Ω)	Operating Spec
Motor 1	25	480	0.3096	0.7372	0.3632	0.7372	19.3536	slip = 3.5
Motor 2	50	480	0.322	0.675	0.196	0.51	12.5	kW input = 45
Motor 3	50	240						kW in = 45, PF = 85
Motor 4	25	240	0.0774	0.1843	.0.0908	0.1843	4.8384	slip = 3.5
Ind Gen	150	480	0.1	0.25	0.085	0.175	6.25	kW = 150

Switches

Switch #	From	To	Normal
1	741	745	Closed
2	744	757	Open
3	703	713	Closed

Switches 1 and 2 are used for creating a loop with both switches closed or to change system configuration.

Switch 3 is used to create an electrical parallel for the UG lines when closed or for the UG lines to be physically parallel with the switch open.

Final Comments

- Test feeder was created to model most common devices on a distribution feeder
- Purpose to provide developers of distribution analysis programs one feeder to test all models and compare to published results
- Data and results will soon be on the IEEE Test Feeder website