Iowa State University
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OpenDSS - Three Typical Cases

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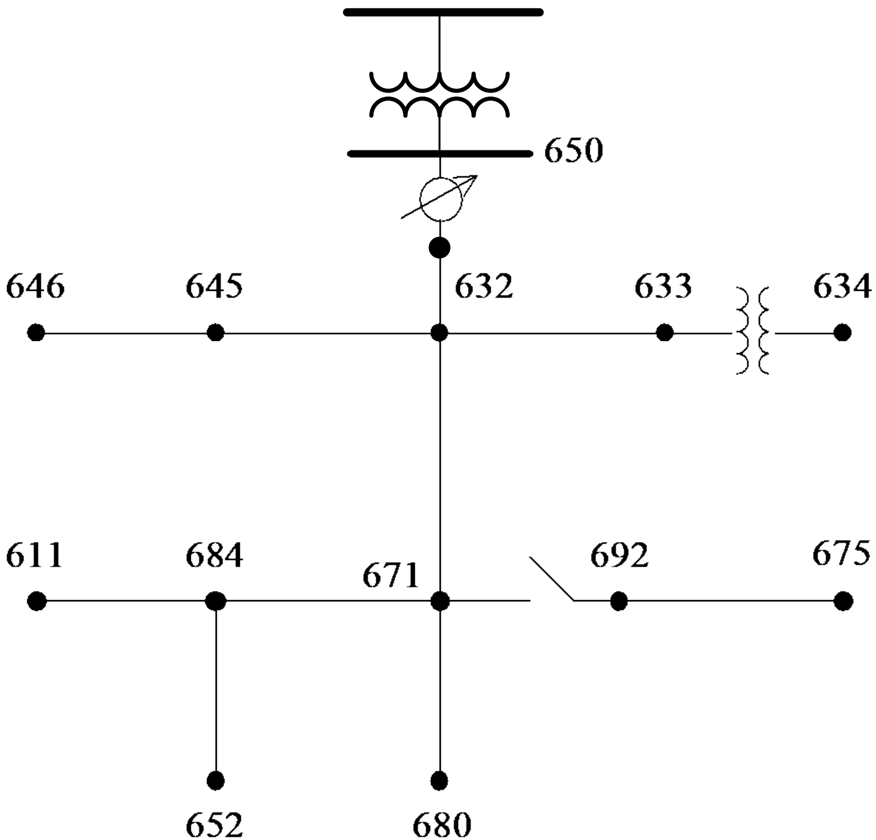
Contents

- Static Snapshot Case
- Time-series Static Case
- Fault and Dynamic Case

Case 1: IEEE 13 Bus Test Feeder

Circuit



- 1 voltage source
- 13 buses
- 2 transformers
- 1 voltage regulator
- 1 switch
- 10 lines
- 8 spot loads
- 1 capacitor bank
- 1 1-phase capacitor
- 1 bus coordinate file

Case 1: IEEE 13 Bus Test Feeder

Given Parameters

Transformer Data:

	kVA	kV-high	kV-low	R - %	X - %
Substation:	5,000	115 - D	4.16 Gr. Y	1	8
XFM -1	500	4.16 – Gr.W	0.48 – Gr.W	1.1	2

Regulator Data:

Regulator ID:	1	2	3
Connection:	1-Ph,LG	1-Ph,LG	1-Ph,LG
Monitoring Phase:	A	B	C
Bandwidth:	2.0 volts	2.0 volts	2.0 volts
PT Ratio:	20	20	20
Primary CT Rating:	700	700	700
Compensator Settings:	Ph-A	Ph-B	Ph-C
R - Setting:	3	3	3
X - Setting:	9	9	9
Volltage Level:	122	122	122

Spot Load Data:

Bus	Load	Ph-1	Ph-1	Ph-2	Ph-2	Ph-3	Ph-3
	Model	kW	kVAr	kW	kVAr	kW	kVAr
634	Y-PQ	160	110	120	90	120	90
645	Y-PQ	0	0	170	125	0	0
646	D-Z	0	0	230	132	0	0
652	Y-Z	128	86	0	0	0	0
671	D-PQ	385	220	385	220	385	220
675	Y-PQ	485	190	68	60	290	212
692	D-I	0	0	0	0	170	151
611	Y-I	0	0	0	0	170	80
	TOTAL	1158	606	973	627	1135	753

Capacitor Data:

Bus	Ph-A	Ph-B	Ph-C
	kVAr	kVAr	kVAr
675	200	200	200
611			100
Total	200	200	300

Case 1: IEEE 13 Bus Test Feeder

Given Parameters

Overhead Line Configuration Data:

Config.	Phasing	Phase	Neutral	Spacing
		ACSR	ACSR	ID
601	B A C N	556,500 26/7	4/0 6/1	500
602	C A B N	4/0 6/1	4/0 6/1	500
603	C B N	1/0	1/0	505
604	A C N	1/0	1/0	505
605	C N	1/0	1/0	510

Line Segment Data:

Bus A	Bus B	Length(ft.)	Config.	Phasing
632	645	500	603	B,C
632	633	500	602	A,B,C
633	634	0	XFM-1	A,B,C
645	646	300	603	B,C
RG60	632	2000	601	A,B,C
684	652	800	607	A
632	671	2000	601	A,B,C
671	684	300	604	A,C
671	680	1000	601	A,B,C
671	692	0	Switch	A,B,C
684	611	300	605	C
692	675	500	606	A,B,C

Underground Line Configuration Data:

Config.	Phasing	Cable	Neutral	Space ID
606	A B C N	250,000 AA, CN	None	515
607	A N	1/0 AA, TS	1/0 Cu	520

Source Data:

Base kV.	pu	Phasing	Angle	MVAsc3	MVAsc1
115	1.0001	A B C N	30	20,000	21,000

Case 1: IEEE 13 Bus Test Feeder

Given Parameters

Configuration 601:

Z (R +jX) in ohms per mile

0.3465	1.0179	0.1560	0.5017	0.1580	0.4236
		0.3375	1.0478	0.1535	0.3849
				0.3414	1.0348

Configuration 602:

Z (R +jX) in ohms per mile

0.7526	1.1814	0.1580	0.4236	0.1560	0.5017
		0.7475	1.1983	0.1535	0.3849
				0.7436	1.2112

Configuration 603:

Z (R +jX) in ohms per mile

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		1.3294	1.3471	0.2066	0.4591
				1.3238	1.3569

Configuration 604:

Z (R +jX) in ohms per mile

1.3238	1.3569	0.0000	0.0000	0.2066	0.4591
		0.0000	0.0000	0.0000	0.0000
				1.3294	1.3471

Configuration 605:

Z (R +jX) in ohms per mile

0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
		0.0000	0.0000	0.0000	0.0000
				1.3292	1.3475

Configuration 606:

Z (R +jX) in ohms per mile

0.7982	0.4463	0.3192	0.0328	0.2849	-0.0143
		0.7891	0.4041	0.3192	0.0328
				0.7982	0.4463

B in micro Siemens per mile

96.8897	0.0000	0.0000
	96.8897	0.0000
		96.8897

Configuration 607:

Z (R +jX) in ohms per mile

1.3425	0.5124	0.0000	0.0000	0.0000	0.0000
		0.0000	0.0000	0.0000	0.0000
				0.0000	0.0000

B in micro Siemens per mile

88.9912	0.0000	0.0000
	0.0000	0.0000
		0.0000

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Vsource

Source Data:

Base kV.	pu	Phasing	Angle	MVAsc3	MVAsc1
606	1.0001	A B C N	30	20,000	21,000

OpenDSS Code:

```
// define a new circuit
Clear
Set DefaultBaseFrequency=60
new circuit.IEEE13Nodeckt
~ basekv=115 pu=1.0001 phases=3 bus1=SourceBus
~ Angle=30
~ MVAsc3=20000 MVASC1=21000
```

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Vsource

OpenDSS Code:

```
// define a new circuit
Clear
Set DefaultBaseFrequency=60
new circuit.IEEE13Nodeckt
~ basekv=115 pu=1.0001 phases=3 bus1=SourceBus
~ Angle=30
~ MVAsc3=20000 MVASC1=21000
```

Explanation:

// or !

"//" or "!" indicate that this statement is a comment line.

Clear

Clears all circuit element definitions from the DSS. This statement is **recommended** at the beginning of all Master files for defining DSS circuits.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Vsource

OpenDSS Code:

```
// define a new circuit
Clear
Set DefaultBaseFrequency=60
new circuit.IEEE13Nodeckt
~ basekv=115 pu=1.0001 phases=3 bus1=SourceBus
~ Angle=30
~ MVAsc3=20000 MVASC1=21000
```

Explanation:

Set DefaultBaseFrequency

It sets Default Base Frequency, in Hz. The default value when first installed is 60 Hz. {50|60}, Hz

New circuit.IEEE13Nodeckt

It creates a new circuit object named IEEE13Nodeckt.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Vsource

OpenDSS Code:

```
// define a new circuit
Clear
Set DefaultBaseFrequency=60
new circuit.IEEE13Nodeckt
~ basekv=115 pu=1.0001 phases=3 bus1=SourceBus
~ Angle=30
~ MVAsc3=20000 MVASC1=21000
```

Explanation:

~

It is a More Command. The More command continues editing the active object. The same as M or More.

basekv (Vsource)

Sets the nominal Line-to-line kV of Vsource.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Vsource

OpenDSS Code:

```
// define a new circuit
Clear
Set DefaultBaseFrequency=60
new circuit.IEEE13Nodeckt
~ basekv=115 pu=1.0001 phases=3 bus1=SourceBus
~ Angle=30
~ MVAsc3=20000 MVASC1=21000
```

Explanation:

pu

Actual per unit at which the source is operating. It is assumed balanced for all phases. In general, the voltage range is generally ±*5%* of the nominal voltage. That means the pu is in the range of 0.95~1.05.

phases

Number of phases. Default = 3.0. {1|2|3}.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Vsource

OpenDSS Code:

```
// define a new circuit
Clear
Set DefaultBaseFrequency=60
new circuit.IEEE13Nodeckt
~ basekv=115 pu=1.0001 phases=3 bus1=SourceBus
~ Angle=30
~ MVAsc3=20000 MVASC1=21000
```

Explanation:

bus1

Name of bus to which the source's first terminal is connected.

Angle

Base angle, in degrees, of the first phase.

MVAsc3

3-phase short circuit MVA.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Vsource

OpenDSS Code:

```
// define a new circuit
Clear
Set DefaultBaseFrequency=60
new circuit.IEEE13Nodeckt
~ basekv=115 pu=1.0001 phases=3 bus1=SourceBus
~ Angle=30
~ MVAsc3=20000 MVASC1=21000
```

Explanation:

MVAsc1

1-phase short circuit MVA.

* MVAsc3 and MVAsc1 are used for determining the positive- and zero-sequence impedances, i.e., Z1=R1+jX1 and Z0=R0+jX0. In general, they are obtained from system data. Default x1/r1 is 4.0 and Default x0/r0 is 3.0.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Transformer

Transformer Data:

	kVA	kV-high	kV-low	R - %	X - %
Substation:	5,000	115 - D	4.16 Gr. Y	1	8
XFM -1	500	4.16 – Gr.W	0.48 – Gr.W	1.1	2

OpenDSS Code:

```
// Substation transformer definitions
New Transformer.Sub Phases=3 Windings=2   XHL=8
~ wdg=1 bus=SourceBus   conn=delta  kv=115  kva=5000   %r=0.5
~ wdg=2 bus=650             conn=wye   kv=4.16 kva=5000   %r=0.5
```

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Transformer

OpenDSS Code:

```
// Substation transformer definitions
New Transformer.Sub Phases=3 Windings=2   XHL=8
~ wdg=1 bus=SourceBus   conn=delta  kv=115  kva=5000   %r=0.5
~ wdg=2 bus=650         conn=wye    kv=4.16 kva=5000   %r=0.5
```

Explanation:

New Transformer.Sub

Defines a transformer object named Sub.

Phases

Number of phases. Default is 3. {1|3}

Windings

Number of windings. Default is 2. {2|3|4}

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Transformer

	kVA	kV-high	kV-low	R - %	X - %
Substation:	5,000	115 - D	4.16 Gr. Y	1	8

OpenDSS Code:

```
// Substation transformer definitions
New Transformer.Sub Phases=3 Windings=2   XHL=8
~ wdg=1 bus=SourceBus   conn=delta  kv=115  kva=5000   %r=0.5
~ wdg=2 bus=650             conn=wye   kv=4.16 kva=5000   %r=0.5
```

Explanation:

XHL (or X12)

Percent reactance high-to-low (winding1 to winding 2).

Wdg

It specifies an integer representing the winding which will become the active winding for subsequent data.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Transformer

OpenDSS Code:

```
// Substation transformer definitions
New Transformer.Sub Phases=3 Windings=2   XHL=8
~ wdg=1 bus=SourceBus   conn=delta  kv=115  kva=5000   %r=0.5
~ wdg=2 bus=650              conn=wye   kv=4.16 kva=5000   %r=0.5
```

Explanation:

bus

It specifies the name of bus to which the winding is connected.

conn

It Specifies the connection of this winding. One of {wye | ln} for wye connected banks or {delta | ll} for delta (line-line) connected banks. Default is wye.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Transformer

OpenDSS Code:

```
// Substation transformer definitions
New Transformer.Sub Phases=3 Windings=2   XHL=8
~ wdg=1 bus=SourceBus   conn=delta  kv=115  kva=5000   %r=0.5
~ wdg=2 bus=650         conn=wye   kv=4.16 kva=5000   %r=0.5
```

Explanation:

kv

It specifies the rated voltage of this winding, in kV. For transformers designated 2- or 3-phase, enter phase-to-phase kV. For all other designations, enter actual winding kV rating. Default is 12.47 kV.

kva

It specifies the base kVA rating of this winding.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Transformer

	kVA	kV-high	kV-low	R - %	X - %
Substation:	5,000	115 - D	4.16 Gr. Y	1	8

*0.5

OpenDSS Code:

```
// Substation transformer definitions
New Transformer.Sub Phases=3 Windings=2   XHL=8
~ wdg=1 bus=SourceBus   conn=delta  kv=115  kva=5000   %r=0.5
~ wdg=2 bus=650              conn=wye   kv=4.16 kva=5000   %r=0.5
```

Explanation:

%r

It specifies the percent resistance of this winding on the rated kVA base. (It equals half of total for a 2-winding transformer).

* Transformer parameters are obtained from transformer nameplate.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Regulator

Voltage Regulator Data:

Regulator ID:	1	2	3
Connection:	1-Ph,LG	1-Ph,LG	1-Ph,LG
Monitoring Phase:	A	B	C
Bandwidth:	2.0 volts	2.0 volts	2.0 volts
PT Ratio:	20	20	20
Primary CT Rating:	700	700	700
Compensator Settings:	Ph-A	Ph-B	Ph-C
R - Setting:	3	3	3
X - Setting:	9	9	9
Volltage Level:	122	122	122

OpenDSS Code:

```
// Voltage Regulator Definitions
New Transformer.Reg1 phases=1 bank=reg1 XHL=0.01 kVAs=[1666 1666]
~ Buses=[650.1 RG60.1] kVs=[2.4  2.4]
new regcontrol.Reg1  transformer=Reg1 winding=2  vreg=122  band=2  ptratio=20 ctprim=700 R=3   X=9

New Transformer.Reg2 phases=1 bank=reg1 XHL=0.01 kVAs=[1666 1666]
~ Buses=[650.2 RG60.2] kVs=[2.4  2.4]
new regcontrol.Reg2  transformer=Reg2 winding=2  vreg=122  band=2  ptratio=20 ctprim=700  R=3   X=9

New Transformer.Reg3 phases=1 bank=reg1 XHL=0.01 kVAs=[1666 1666]
~ Buses=[650.3 RG60.3] kVs=[2.4  2.4]
new regcontrol.Reg3  transformer=Reg3 winding=2  vreg=122  band=2  ptratio=20 ctprim=700  R=3   X=9
```

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Regulator

OpenDSS Code:

```
// Voltage regulator and control definitions
New Transformer.Reg1 phases=1 bank=reg1 XHL=0.01 kVAs=[1666 1666]
~ Buses=[650.1 RG60.1] kVs=[2.4  2.4]
new regcontrol.Reg1  transformer=Reg1 winding=2  vreg=122  band=2  ptratio=20 ctprim=700 R=3   X=9
```

Explanation:

Note that voltage regulator is defined using the class of transformer. Different with the transformer, additional RegControl Object should be defined for each regulator.

New Transformer.Reg1

Defines a regulator named Reg1.

phases

Specifies Number of phases.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Regulator

OpenDSS Code:

```
// Voltage regulator and control definitions
New Transformer.Reg1 phases=1 bank=reg1 XHL=0.01 kVAs=[1666 1666]
~ Buses=[650.1 RG60.1] kVs=[2.4  2.4]
new regcontrol.Reg1  transformer=Reg1 winding=2  vreg=122  band=2  ptratio=20 ctprim=700 R=3   X=9
```

Explanation:

bank

Specifies the name of the bank this regulator is part of.

XHL (or X12)

Specifies the percent reactance high-to-low (winding 1 to winding 2).

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Regulator

OpenDSS Code:

```
// Voltage regulator and control definitions
New Transformer.Reg1 phases=1 bank=reg1 XHL=0.01 kVAs=[1666 1666]
~ Buses=[650.1 RG60.1] kVs=[2.4  2.4]
new regcontrol.Reg1  transformer=Reg1 winding=2  vreg=122  band=2  ptratio=20 ctprim=700 R=3   X=9
```

Explanation:

kVAs=[1666 1666]

Specifies an array of base kVA ratings for windings [1, 2]. The kVA rating of winding 1 is 1666kVA, the kVA rating of winding 2 is 1666 kVA.
* Note that compared with the aforementioned way of defining the properties of transformer windings, i.e., specifying the properties for each winding, individually, this is another way of defining the winding properties, i.e., using property arrays.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Regulator

OpenDSS Code:

```
// Voltage regulator and control definitions
New Transformer.Reg1 phases=1 bank=reg1 XHL=0.01 kVAs=[1666 1666]
~ Buses=[650.1 RG60.1] kVs=[2.4  2.4]
new regcontrol.Reg1  transformer=Reg1 winding=2  vreg=122  band=2  ptratio=20 ctprim=700 R=3   X=9
```

Explanation:

Buses=[650.1 RG60.1]

Specifies an array of the names of buses to which the windings [1, 2] are connected. Winding 1 is connected to Bus 650, winding 2 is connected to Bus RG60.

kVs=[2.4 2.4]

Specifies an array of kV ratings for windings [1,2]. The kV rating of winding 1 is 2.4 kV, the kV rating of winding 2 is 2.4 kV.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Regulator

OpenDSS Code:

```
// Voltage regulator and control definitions
New Transformer.Reg1 phases=1 bank=reg1 XHL=0.01 kVAs=[1666 1666]
~ Buses=[650.1 RG60.1] kVs=[2.4  2.4]
new regcontrol.Reg1  transformer=Reg1 winding=2  vreg=122  band=2  ptratio=20 ctprim=700 R=3   X=9
```

Explanation:

new regcontrol.Reg1

Defines a regulator control object named Reg1.

transformer

Specifies the name of transformer to which the RegControl is connected.

winding

Specifies the number of transformer winding that the RegControl is monitoring. 1 or 2, typically.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Regulator

OpenDSS Code:

```
// Voltage regulator and control definitions
New Transformer.Reg1 phases=1 bank=reg1 XHL=0.01 kVAs=[1666 1666]
~ Buses=[650.1 RG60.1] kVs=[2.4  2.4]
new regcontrol.Reg1  transformer=Reg1 winding=2  vreg=122  band=2  ptratio=20 ctprim=700 R=3   X=9
```

Explanation:

vreg

Specifies the voltage regulator setting, in volts, for the winding being controlled.

band

Specifies the bandwidth, in volts, for the controlled bus. Default is 3.0.

ptratio

Specifies the ratio of the PT that converts the controlled winding voltage to the regulator voltage. Default is 60. If the winding is Wye, the line-to-neutral voltage is used. Else, the line-to-line voltage is used.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model -- Regulator

OpenDSS Code:

```
// Voltage regulator and control definitions
New Transformer.Reg1 phases=1 bank=reg1 XHL=0.01 kVAs=[1666 1666]
~ Buses=[650.1 RG60.1] kVs=[2.4  2.4]
new regcontrol.Reg1  transformer=Reg1 winding=2  vreg=122  band=2  ptratio=20 ctprim=700 R=3   X=9
```

Explanation:

ctprim

Specifies the rating, in Amperes, of the primary CT rating for converting the line amps to control amps. The typical default secondary ampere rating is 0.2 Amps.

R

Specifies the R setting on the line drop compensator in the regulator, in VOLTS.

X

Specifies the X setting on the line drop compensator in the regulator, in VOLTS.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Line Configuration

Line Configuration Data:

Configuration 606:

```
           Z (R +jX) in ohms per mile
0.7982  0.4463    0.3192  0.0328    0.2849 -0.0143
                  0.7891  0.4041    0.3192  0.0328
                                    0.7982  0.4463
          B in micro Siemens per mile
           96.8897     0.0000     0.0000
                      96.8897     0.0000
                                 96.8897
```

Configuration 607:

```
           Z (R +jX) in ohms per mile
1.3425  0.5124    0.0000  0.0000    0.0000  0.0000
                  0.0000  0.0000    0.0000  0.0000
                                    0.0000  0.0000
          B in micro Siemens per mile
           88.9912     0.0000     0.0000
                       0.0000     0.0000
                                  0.0000
```

OpenDSS Code:

```
// Linecode definitions
New Linecode.mtx606 nphases=3  Units=mi
~ Rmatrix=[0.7982  |0.3192  0.7891  |0.2849  0.3192  0.7982  ]
~ Xmatrix=[0.4463  |0.0328  0.4041  |-0.0143  0.0328  0.4463  ]
~ Cmatrix=[257.01  |0  257.01  |0  0  257.01  ]
~ units=mi

New linecode.mtx607 nphases=1 BaseFreq=60
~ rmatrix = (1.3425 )
~ xmatrix = (0.5124 )
~ cmatrix = [236.06]
~ units=mi
```

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Line configuration

OpenDSS Code:

```
// Linecode definitions
New Linecode.mtx606 nphases=3  BaseFreq=60
~ Rmatrix=[0.7982  |0.3192  0.7891  |0.2849  0.3192  0.7982  ]
~ Xmatrix=[0.4463  |0.0328  0.4041  |-0.0143  0.0328  0.4463  ]
~ Cmatrix=[257.01  |0  257.01  |0  0  257.01  ]
~ units=mi
```

Explanation:

New linecode.mtx606

Defines a linecode object named mtx606.

nphases

Specifies the number of phases. Default = 3.

BaseFreq

Specifies the Base Frequency at which the impedance values are specified. {50 | 60}, Hz, Default = 60.0 Hz.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Line configuration

OpenDSS Code:

```
// Linecode definitions
New Linecode.mtx606 nphases=3  BaseFreq=60
~ Rmatrix=[0.7982  |0.3192  0.7891  |0.2849  0.3192  0.7982  ]
~ Xmatrix=[0.4463  |0.0328  0.4041  |-0.0143  0.0328  0.4463  ]
~ Cmatrix=[257.01  |0  257.01  |0  0  257.01  ]
~ units=mi
```

Explanation:

Rmatrix

Defines the series resistance matrix, in ohms per unit length. The order of matrices expected is the number of phases. The matrices may be entered in lower triangle form or full matrix. The result is always symmetrical.

The "|" separates rows.

Xmatrix

Similar with Rmatrix, Xmatrix is a series reactance matrix, in ohms per unit length.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Line configuration

OpenDSS Code:

```
// Linecode definitions
New Linecode.mtx606 nphases=3  BaseFreq=60
~ Rmatrix=[0.7982  |0.3192  0.7891  |0.2849  0.3192  0.7982  ]
~ Xmatrix=[0.4463  |0.0328  0.4041  |-0.0143  0.0328  0.4463  ]
~ Cmatrix=[257.01  |0  257.01  |0  0  257.01  ]
~ units=mi
```

Explanation:

Cmatrix

Defines the shunt nodal capacitance matrix, in nanofarads per unit length. The order of matrices expected is the number of phases. The matrices may be entered in lower triangle form or full matrix. The result is always symmetrical.
The "|" separates rows.

Units

Specifies the length units of linecode. If not specified, it is assumed that the units correspond to the length being used in the Line models. {mi|kft|km|m|Ft|in|cm}.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Line

Line Segment Data:

Node A	Node B	Length(ft.)	Config.	Phasing
632	645	500	603	B,C
632	633	500	602	A,B,C
645	646	300	603	B,C
RG60	632	2000	601	A,B,C
684	652	800	607	A
632	671	2000	601	A,B,C
671	684	300	604	A,C
671	680	1000	601	A,B,C
684	611	300	605	C
692	675	500	606	A,B,C

OpenDSS Code:

```
// Line definitions
New Line.632645   Phases=2 Bus1=632.3.2     Bus2=645.3.2    LineCode=mtx603 Length=500  units=ft
New Line.632633   Phases=3 Bus1=632.1.2.3   Bus2=633.1.2.3  LineCode=mtx602 Length=500  units=ft
New Line.645646   Phases=2 Bus1=645.3.2     Bus2=646.3.2    LineCode=mtx603 Length=300  units=ft
New Line.RG60632  Phases=3 Bus1=RG60.1.2.3  Bus2=632.1.2.3  LineCode=mtx601 Length=2000 units=ft
New Line.684652   Phases=1 Bus1=684.1       Bus2=652.1      LineCode=mtx607 Length=800  units=ft
New Line.632671   Phases=3 Bus1=632.1.2.3   Bus2=671.1.2.3  LineCode=mtx601 Length=2000 units=ft
New Line.671684   Phases=2 Bus1=671.1.3     Bus2=684.1.3    LineCode=mtx604 Length=300  units=ft
New Line.671680   Phases=3 Bus1=671.1.2.3   Bus2=680.1.2.3  LineCode=mtx601 Length=1000 units=ft
New Line.684611   Phases=1 Bus1=684.3       Bus2=611.3      LineCode=mtx605 Length=300  units=ft
New Line.692675   Phases=3 Bus1=692.1.2.3   Bus2=675.1.2.3  LineCode=mtx606 Length=500  units=ft
```

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Line

OpenDSS Code:

```
// Line definitions
New Line.632645    Phases=2 Bus1=632.3.2     Bus2=645.3.2    LineCode=mtx603 Length=500  units=ft
```

Explanation:

New Line.650632

Defines a line object named 650632.

Phases

Specifies the number of phases. Default = 3.

Bus1

Specifies the name of bus for terminal 1.

Bus2

Specifies the name of bus for terminal 2.

LineCode

Specifies the name of an existing LineCode object containing impedance definitions.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Line

OpenDSS Code:

```
// Line definitions
New Line.632645    Phases=2 Bus1=632.3.2     Bus2=645.3.2    LineCode=mtx603 Length=500  units=ft
```

Explanation:

Length

Specifies a length multiplier to be applied to the impedance data.

Units

Specifies the length Units = {none | mi | kft | km | m | Ft | in | cm}.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Load

Spot Load Data:

Node	Load Model	Ph-1 kW	Ph-1 kVAr	Ph-2 kW	Ph-2 kVAr	Ph-3 kW	Ph-3 kVAr
634	Y-PQ	160	110	120	90	120	90
645	Y-PQ	0	0	170	125	0	0
646	D-Z	0	0	230	132	0	0
652	Y-Z	128	86	0	0	0	0
671	D-PQ	385	220	385	220	385	220
675	Y-PQ	485	190	68	60	290	212
692	D-I	0	0	0	0	170	151
611	Y-I	0	0	0	0	170	80

OpenDSS Code:

```
// Load definitions
New Load.634a Bus1=634.1     Phases=1 Conn=Wye  Model=1 kV=0.277  kW=160   kvar=110
New Load.634b Bus1=634.2     Phases=1 Conn=Wye  Model=1 kV=0.277  kW=120   kvar=90
New Load.634c Bus1=634.3     Phases=1 Conn=Wye  Model=1 kV=0.277  kW=120   kvar=90
New Load.645 Bus1=645.2      Phases=1 Conn=Wye  Model=1 kV=2.4      kW=170   kvar=125
New Load.646 Bus1=646.2.3   Phases=1 Conn=Delta Model=2 kV=4.16     kW=230   kvar=132
New Load.652 Bus1=652.1      Phases=1 Conn=Wye  Model=2 kV=2.4  kW=128   kvar=86
New Load.671 Bus1=671.1.2.3  Phases=3 Conn=Delta Model=1 kV=4.16   kW=1155 kvar=660
New Load.675a Bus1=675.1    Phases=1 Conn=Wye  Model=1 kV=2.4  kW=485   kvar=190
New Load.675b Bus1=675.2    Phases=1 Conn=Wye  Model=1 kV=2.4  kW=68   kvar=60
New Load.675c Bus1=675.3    Phases=1 Conn=Wye  Model=1 kV=2.4  kW=290   kvar=212
New Load.692 Bus1=692.3.1    Phases=1 Conn=Delta Model=5 kV=4.16    kW=170   kvar=151
New Load.611 Bus1=611.3      Phases=1 Conn=Wye  Model=5 kV=2.4  kW=170   kvar=80
```

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Load

OpenDSS Code:

```
// Load definitions
New Load.634a Bus1=634.1     Phases=1 Conn=Wye  Model=1 kV=0.277  kW=160   kvar=110
```

Explanation:

New Load.634a

Defines a load object named 634a.

Bus1

Specifies the name of bus to which the load is connected.

Phases

Specifies the number of phases of this load.

Conn

{wye | y | LN} for Wye (Line-Neutral) connection; {delta | LL} for Delta (Line-Line) connection. Default = wye.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Load

OpenDSS Code:

```
// Load definitions
New Load.634a Bus1=634.1    Phases=1 Conn=Wye  Model=1 kV=0.277  kW=160   kvar=110
```

Explanation:

Model

An integer defining how the load will vary with voltage. The load models currently implemented are:

1: Constant P and constant Q (Default): Commonly used for power flow studies,

2: Constant Z (or constant impedance),

3: Constant P and quadratic Q ($Q/_{Q0} = (V/_{V0})^2$),

4: Exponential: $P/_{P0} = (V/_{V0})^{CVRwatts}$ and $Q/_{Q0} = (V/_{V0})^{CVRvars}$

5: Constant I (or constant current magnitude),

6: Constant P and fixed Q (at the nominal value)

7: Constant P and quadratic Q (i.e., fixed reactance),

8: ZIP

…

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Load

OpenDSS Code:

```
// Load definitions
New Load.634a Bus1=634.1    Phases=1 Conn=Wye  Model=1 kV=0.277  kW=160   kvar=110
```

Explanation:

Model

…

"Constant" power value (either P or Q) may be modified by loadshape multipliers. "Fixed" power values are always the same.

- ZIP model:

$$P = P_0\left[a_1\left(\frac{V}{V_0}\right)^2 + a_2\left(\frac{V}{V_0}\right) + a_3\right]$$

$$Q = Q_0\left[a_4\left(\frac{V}{V_0}\right)^2 + a_5\left(\frac{V}{V_0}\right) + a_6\right]$$

kV

Specifies the Base voltage for load. For 2- or 3-phase loads, it is specified in phase-to-phase kV.

For all other loads, it is specified in the actual kV across the load branch. If the load is wye (star) connected, then specify phase-to-neutral (L-N) kV. If the load is delta or phase-to-phase connected, specify the phase-to-phase (L-L) kV.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Load

OpenDSS Code:

```
// Load definitions
New Load.634a Bus1=634.1    Phases=1 Conn=Wye  Model=1 kV=0.277  kW=160   kvar=110
```

Explanation:

kW

Specifies the nominal active power, in kW, for the load. Total of all phases.

kVar

Specifies the nominal reactive power, in kVar, for the load. Total of all phases.

*** If there is no specification, the kW and kVar are divided evenly in each phase. If the load is unbalanced, the load should be defined for each phase.**

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Capacitor

Capacitor Data:

Node	Ph-A	Ph-B	Ph-C
	kVAr	kVAr	kVAr
675	200	200	200
611			100

OpenDSS Code:

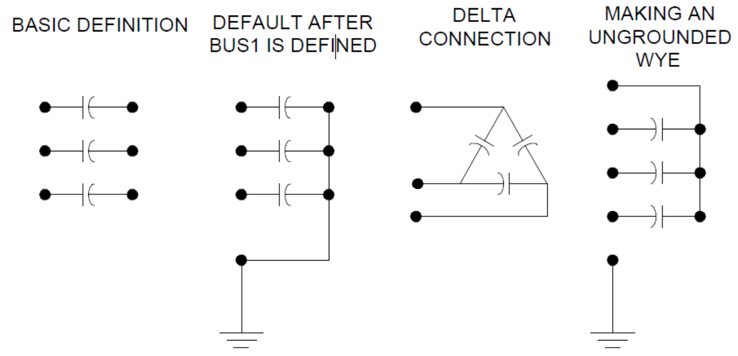
```
// Capacitor definitions
New Capacitor.Cap1 Bus1=675     phases=3 kVAR=600 kV=4.16
New Capacitor.Cap2 Bus1=611.3  phases=1 kVAR=100 kV=2.4
```

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Capacitor

OpenDSS Code:

```
// Capacitor definitions
New Capacitor.Cap1 Bus1=675    phases=3 kVAR=600 kV=4.16
New Capacitor.Cap2 Bus1=611.3 phases=1 kVAR=100 kV=2.4
```



Explanation:

New Capacitor.Cap1

Define a capacitor object named Cap1.

Bus1

Specifies the name of the first bus to which the capacitor is connected.

phases

Specifies the number of phases.

kVAR

Specifies the rated kvar at rated kV, total of all phases. Each phase is assumed equal.

kV

For 2- or 3-phase, enter line-to-line rated voltage. For 1-phase, enter line-to-ground rated voltage. (For Delta connection this is always line-to-line rated voltage).

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Switch

Switch Data:

Node A	Node B	Length(ft.)	Config.	Phasing
671	692	0	Switch	A,B,C

OpenDSS Code:

```
// Switch definitions
New Line.671692    Phases=3 Bus1=671   Bus2=692  Switch=y  r1=1e-4 r0=1e-4 x1=0.000 x0=0.000 c1=0.000 c0=0.000
```

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Switch

OpenDSS Code:

```
// Switch definitions
New Line.671692    Phases=3 Bus1=671   Bus2=692  Switch=y  r1=1e-4 r0=1e-4 x1=0.000 x0=0.000 c1=0.000 c0=0.000
```

Explanation:

New Line.671692

Defines a line object named 671692.

Phases

Specifies the number of phases.

Bus1

Specifies the name of bus for terminal 1.

Bus2

Specifies the name of bus for terminal 2.

Switch

Specifies whether this line is a switch or not. {y/n | T/F}. Default= no/false.

y or T: Designates this line as a switch; n or F: Does not designate this line as a switch.

*** In OpenDss, a switch object is defined as a special line object.**

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Switch

OpenDSS Code:

```
// Switch definitions
New Line.671692    Phases=3 Bus1=671   Bus2=692  Switch=y  r1=1e-4 r0=1e-4 x1=0.000 x0=0.000 c1=0.000 c0=0.000
```

Explanation:

r1

Specifies the positive-sequence resistance, in ohms per unit length.

r0

Specifies the zero-sequence resistance, in ohms per unit length.

x1

Specifies the positive-sequence reactance, in ohms per unit length.

x0

Specifies the zero-sequence reactance, in ohms per unit length.

c1

Specifies the positive-sequence capacitance, in nanofarads per unit length.

c0

Specifies the zero-sequence capacitance, in nanofarads per unit length.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Solve

OpenDSS Code:

```
// Solve
Set Voltagebases=[115, 4.16, .48]
calcv
Set mode=snap
Set algorithm=normal
Solve
BusCoords IEEE13Node_BusXY.csv
```

Explanation:

Set Voltagebases

Defines the bus voltage bases for the defined circuit. You can enter an array of the legal voltage bases, in phase-to-phase voltages.

- The voltage level can be selected from the following values: .208, .480, 12.47, 24.9, 34.5, 115.0, 230.0

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Solve

OpenDSS Code:

```
// Solve
Set Voltagebases=[115, 4.16, .48]
calcv
Set mode=snap
Set algorithm=normal
Solve
BusCoords IEEE13Node_BusXY.csv
```

Explanation:

calcv

Also called CalcVoltageBases.
Estimates the voltage base for each bus based on the array of voltage bases defined with a "Set Voltagebases=..." command. The voltage base for each bus is then set to the nearest voltage base specified in the voltage base array.

Set mode=snap

Specifies the solution mode for the active circuit.
Snap = Solve a single snapshot power flow for the present conditions.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Solve

OpenDSS Code:

```
// Solve
Set Voltagebases=[115, 4.16, .48]
calcv
Set mode=snap
Set algorithm=normal
Solve
BusCoords IEEE13Node_BusXY.csv
```

Bus Name	X	Y
SourceBus	200	400
650	200	350
RG60	200	300
646	0	250
645	100	250
632	200	250
633	350	250
634	400	250
611	0	100
684	100	100
671	200	100
692	250	100
675	400	100
652	100	0
680	200	0

Explanation:

Set algorithm=normal

Specifies the solution algorithm type. {Normal | Newton}

Solve

Solves the circuit. Default mode is snapshot.

Buscoords

Defines x,y coordinates for buses via reading coordinates from a CSV file.
It executes after the Solve command is executed, so that bus lists are defined.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Show

OpenDSS Code:

```
// Show
Show Voltages LN Nodes
Show Currents Elem
Show Powers kVA Elem
Show Losses
Show Taps
```

Explanation:

The Show command generally writes a text file report of the specified quantity for the most recent solution, and opens a viewer (the default Editor -- e.g., Notepad or some other editor) to display the file.

Show Voltages LN Nodes

Shows the line-to-ground voltages by node. (Report)

Show Currents Elem

Shows currents of circuit elements. (Report)

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Show

OpenDSS Code:

```
// Show
Show Voltages LN Nodes
Show Currents Elem
Show Powers kVA Elem
Show Losses
Show Taps
```

Explanation:

Show Powers kVA Elem

Shows powers of circuit elements in kVA. (Report)

Show Losses

Shows losses of power delivery elements. (Report)

Show Taps

Shows the controlled transformer's tap positions. (Report)

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Visualization

OpenDSS Code:

```
// Visualization
Visualize what=currents  element=Line.632633
Visualize what=voltages  element=Line.632633
```

Explanation:

Shows the currents, voltages, or powers for selected element on a drawing in phasor quantities.

What=currents

Specifies that currents of circuit elements are visualized, in amps.

element=Line.632633

Specifies which element are visualized.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Plot

OpenDSS Code:

```
// Plot
Set markCapacitors=yes  CapMarkersize=3
Set markRegulators=yes  RegMarkersize=5
AddBusMarker Bus=632 code=34 color=Red  size=3
Plot Circuit Power Max=2000 dots=y labels=n  C1=Blue  1ph=3
Plot circuit Losses Max=0.02 dots=y labels=n subs=n C1=Blue
ClearBusMarkers
```

Explanation:

Set markCapacitors=yes

Marks Capacitor object locations with a symbol. {YES/TRUE | NO/FALSE} Default is NO.

Set CapMarkersize=3

Specifies the size of Capacitor marker on the plot. Default is 3.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Plot

OpenDSS Code:

```
// Plot
Set markCapacitors=yes  CapMarkersize=3
Set markRegulators=yes  RegMarkersize=5
AddBusMarker Bus=632 code=34 color=Red  size=3
Plot Circuit Power Max=2000 dots=y labels=n  C1=Blue  1ph=3
Plot circuit Losses Max=0.02 dots=y labels=n subs=n C1=Blue
ClearBusMarkers
```

Explanation:

AddBusMarker

Adds a marker to a bus in a circuit plot before issuing the Plot command.

Bus=632

Specifies the bus to which the marker is added.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Plot

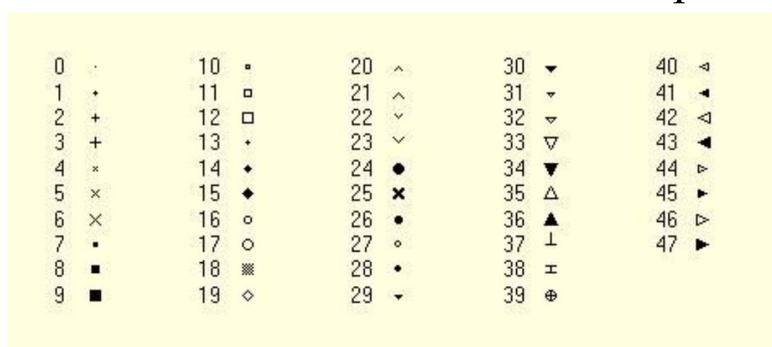
OpenDSS Code:

```
// Plot
Set markCapacitors=yes  CapMarkersize=3
Set markRegulators=yes  RegMarkersize=5
AddBusMarker Bus=632 code=34 color=Red  size=3
Plot Circuit Power Max=2000 dots=y labels=n  C1=Blue  1ph=3
Plot circuit Losses Max=0.02 dots=y labels=n subs=n C1=Blue
ClearBusMarkers
```

Explanation:

Code=34

Specifies the Number code for bus marker on circuit plots. Marker codes are:



Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Plot

OpenDSS Code:

```
// Plot
Set markCapacitors=yes  CapMarkersize=3
Set markRegulators=yes  RegMarkersize=5
AddBusMarker Bus=632 code=34 color=Red  size=3
Plot Circuit Power Max=2000 dots=y labels=n  C1=Blue  1ph=3
Plot circuit Losses Max=0.02 dots=y labels=n subs=n C1=Blue
ClearBusMarkers
```

Explanation:

color=red

Specifies the color of the bus marker on circuit plots.

size=3

Specifies the size of the bus marker on circuit plots.

plot

Displays a variety of results in a variety of manners on graphs.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Plot

OpenDSS Code:

```
// Plot
Set markCapacitors=yes  CapMarkersize=3
Set markRegulators=yes  RegMarkersize=5
AddBusMarker Bus=632 code=34 color=Red  size=3
Plot Circuit Power Max=2000 dots=y labels=n  C1=Blue  1ph=3
Plot circuit Losses Max=0.02 dots=y labels=n subs=n C1=Blue
ClearBusMarkers
```

Explanation:

Circuit

Creates displays on which the thicknesses of LINE are varied according to: Power, Current, Voltage or Losses.

Max=2000

Specifies the value corresponding to max scale or line thickness on the circuit plots. Power and Losses in kW.

dots=y

Specifies whether to show buses as dots or not. {y | n}

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Plot

OpenDSS Code:

```
// Plot
Set markCapacitors=yes  CapMarkersize=3
Set markRegulators=yes  RegMarkersize=5
AddBusMarker Bus=632 code=34 color=Red  size=3
Plot Circuit Power Max=2000 dots=y labels=n  C1=Blue  1ph=3
Plot circuit Losses Max=0.02 dots=y labels=n subs=n C1=Blue
ClearBusMarkers
```

Explanation:

labels=n

Specifies whether to show bus names or not. {y | n}

C1=Bule

Specifies the unicolor on circuit plots. Colors may be specified by their RGB color number or standard color names.

1ph=3

Specifies the Line style for drawing 1-phase lines. It is a number in the range of [1..7]. Default is 1 (solid). Use 3 for dotted; 2 for dashed.

Case 1: IEEE 13 Bus Test Feeder

Build OpenDSS Model – Plot

OpenDSS Code:

```
// Plot
Set markCapacitors=yes  CapMarkersize=3
Set markRegulators=yes  RegMarkersize=5
AddBusMarker Bus=632 code=34 color=Red  size=3
Plot Circuit Power Max=2000 dots=y labels=n  C1=Blue  1ph=3
Plot circuit Losses Max=0.02 dots=y labels=n subs=n C1=Blue
ClearBusMarkers
```

Explanation:

subs=n

Specifies whether to display a marker at each transformer declared to be a substation. At least one bus coordinate must be defined for the transformer. {Yes | No*}

ClearBusMarkers

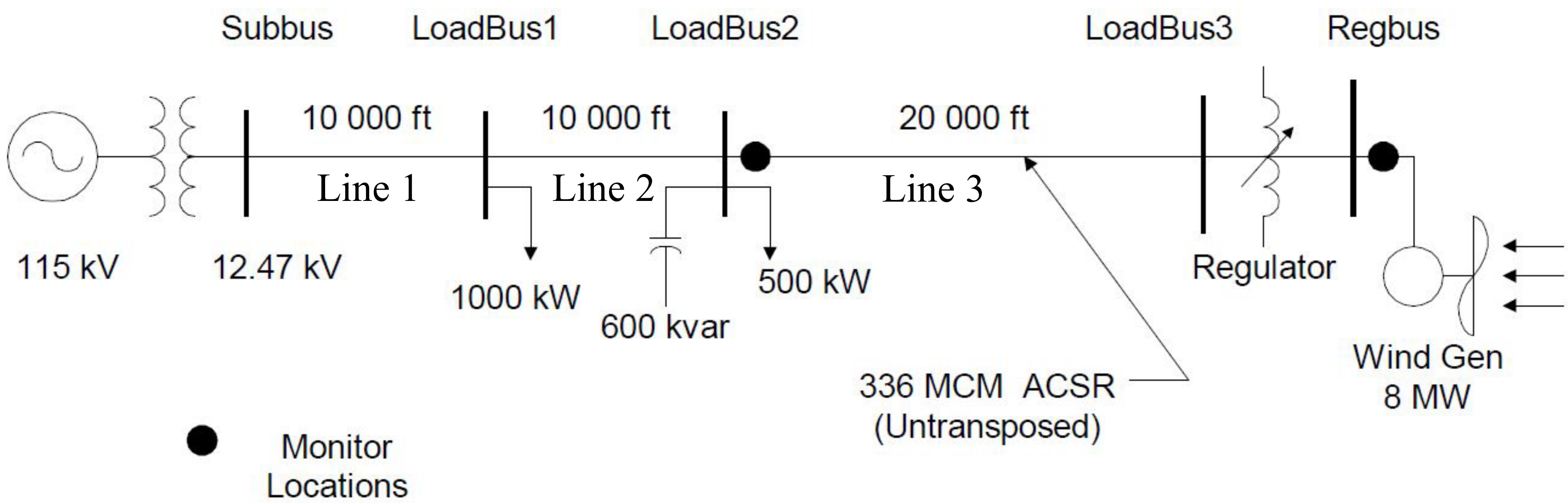
Clears the present definitions of bus markers.

Contents

- Static Snapshot Case
- Time-series Static Case
- Fault and Dynamic Case

Case II: Time-series Power Flow

Circuit



- 1 voltage source
- 1 substation transformer
- 3 line segments
- 2 time-series spot loads
- 1 capacitor with control
- 1 regulator with control
- 1 wind generator
- 4 monitors

* Time range : 1 day, Time resolution: 1 second (86,400 snapshots)

Case II: Time-series Power Flow

Build OpenDSS Model – Circuit, Vsource

OpenDSS Code:

```
clear
New object=circuit.ExampleCircuit
~ basekv=115 1.00 0.0 60.0 3 20000 21000 4.0 3.0
```

Explanation:

Clear

Clears all circuit element definitions from the DSS. This statement is **recommended** at the beginning of all Master files for defining DSS circuits.

New object=circuit.ExampleCircuit

Defines a new circuit named ExampleCircuit.

~

More Command. The More command continues editing the active object. The same as M or More.

Case II: Time-series Power Flow

Build OpenDSS Model – Circuit, Vsource

OpenDSS Code:

```
clear
New object=circuit.ExampleCircuit
~ basekv=115 1.00 0.0 60.0 3 20000 21000 4.0 3.0
```

Explanation:

basekv=115 1.00 0.0 60.0 3 20000 21000 4.0 3.0

There are ***two*** ways of setting property values of DSS circuit elements.

1. Simply specify the setting using complete element and property name, "=", and a value. For example,

```
New Line.line1.R1=.05 X1=.12 R0=.1 X0=.4
```

2. Positional property rule. For example, we can use

```
New Line.line1.R1=.05 .12 .1 .4
```

to set the R1, X1, R0, X0 properties of Line.line1 in sequence, which is equivalent to the code using 1st way. In this case, the 2nd way is adopted.

Case II: Time-series Power Flow

Build OpenDSS Model – Circuit, Vsource

OpenDSS Code:

```
clear
New object=circuit.ExampleCircuit
~ basekv=115 1.00 0.0 60.0 3 20000 21000 4.0 3.0
```

Explanation:

basekv=115 1.00 0.0 60.0 3 20000 21000 4.0 3.0

The above code equals: basekv=115 pu=1.00 Angle=0.0 Frequency=60.0 Phases=3 Mvasc3=20000 Mvasc1=21000 x1r1=4.0 x0r0=3.0

basekv: Specifies the voltage Base or rated Line-to-line kV of Vsource.

pu: Specifies the actual per unit at which the source is operating. It is assumed balanced for all phases.

Angle: Specifies the Base angle, in degrees, of the first phase.

Frequency: Specifies the frequency of the source.

…

Case II: Time-series Power Flow

Build OpenDSS Model – Circuit, Vsource

OpenDSS Code:

```
clear
New object=circuit.ExampleCircuit
~ basekv=115 1.00 0.0 60.0 3 20000 21000 4.0 3.0
```

Explanation:

basekv=115 1.00 0.0 60.0 3 20000 21000 4.0 3.0

This above code equals: basekv=115 pu=1.00 Angle=0.0 Frequency=60.0 Phases=3 Mvasc3=20000 Mvasc1=21000 x1r1=4.0 x0r0=3.0

phases: Specifies the number of phases. Default = 3.0.
MVAsc3: Specifies the 3-phase short circuit MVA.
MVAsc1: Specifies the1-phase short circuit MVA.
x1r1: Specifies the ratio of X1/R1. Default = 4.0.
x0r0: Specifies the ratio of X0/R0. Default = 3.0.

Case II: Time-series Power Flow

Build OpenDSS Model – Substation transformer

OpenDSS Code:

```
// Define Substation transformer
New transformer.subxfrm phases=3 windings=2 buses=(SourceBus subbus)
~ conns='delta wye' kvs=(115 12.47) kvas=(20000 20000) XHL=7
```

Explanation:

New transformer.subxfrm

Defines a transformer object named subxfrm.

phases

Specifies the number of phases. Default is 3.

windings

Specifies the total number of windings. Default is 2.

Case II: Time-series Power Flow

Build OpenDSS Model – Substation transformer

OpenDSS Code:

```
// Define Substation transformer
New transformer.subxfrm phases=3 windings=2 buses=(SourceBus subbus)
~ conns='delta wye' kvs=(115 12.47) kvas=(20000 20000) XHL=7
```

Explanation:

buses=(SourceBus subbus)

The above command equals: bus1=SourceBus bus2=subbus

bus1: Specifies the name of bus for terminal 1.

bus2: Specifies the name of bus for terminal 2.

conns='delta wye'

Specify that the connection of winding1 is ‘delta’, the connection of winding2 is ‘wye’.

Case II: Time-series Power Flow

Build OpenDSS Model – Substation transformer

OpenDSS Code:

```
// Define Substation transformer
New transformer.subxfrm phases=3 windings=2 buses=(SourceBus subbus)
~ conns='delta wye' kvs=(115 12.47) kvas=(20000 20000) XHL=7
```

Explanation:

kvs=(115 12.47)

Specify that the rated voltage of winding 1 is 115 kV. The rated voltage of winding 2 is 12.47kV.

kvas=(20000 20000)

Specify that the base kVA rating of winding1 is 20000 kVA. The base kVA rating of winding2 is 20000kVA.

XHL

Specify the percent reactance high-to-low (winding 1 to winding 2).

Case II: Time-series Power Flow

Build OpenDSS Model – Linecode

OpenDSS Code:

```
// Define a linecode for the lines - unbalanced 336 MCM ACSR connection
New linecode.336matrix nphases=3
~ rmatrix=(0.0868455 | 0.0298305 0.0887966 | 0.0288883 0.0298305 0.0868455)
~ xmatrix=(0.2025449 | 0.0847210 0.1961452 | 0.0719161 0.0847210 0.2025449)
~ cmatrix=(2.74 | -0.70 2.96| -0.34 -0.71 2.74)
~ Normamps = 400  Emergamps=600
```

Explanation:

New linecode.336matrix

Defines a linecode object named 336matrix.

nphases

Specifies the number of phases. Default = 3.

Case II: Time-series Power Flow

Build OpenDSS Model – Linecode

OpenDSS Code:

```
// Define a linecode for the lines - unbalanced 336 MCM ACSR connection
New linecode.336matrix nphases=3
~ rmatrix=(0.0868455 | 0.0298305 0.0887966 | 0.0288883 0.0298305 0.0868455)
~ xmatrix=(0.2025449 | 0.0847210 0.1961452 | 0.0719161 0.0847210 0.2025449)
~ cmatrix=(2.74 | -0.70 2.96| -0.34 -0.71 2.74)
~ Normamps = 400  Emergamps=600
```

Explanation:

rmatrix

Series resistance matrix, in ohms per unit length. The order of matrices expected is the number of phases. The matrices may be entered in lower triangle form or full matrix. The result is always symmetrical.
The "|" separates rows.

xmatrix

Series reactance matrix, in ohms per unit length. Similar with rmatrix.

Case II: Time-series Power Flow

Build OpenDSS Model – Linecode

OpenDSS Code:

```
// Define a linecode for the lines - unbalanced 336 MCM ACSR connection
New linecode.336matrix nphases=3
~ rmatrix=(0.0868455 | 0.0298305 0.0887966 | 0.0288883 0.0298305 0.0868455)
~ xmatrix=(0.2025449 | 0.0847210 0.1961452 | 0.0719161 0.0847210 0.2025449)
~ cmatrix=(2.74 | -0.70 2.96| -0.34 -0.71 2.74)
~ Normamps = 400  Emergamps=600
```

Explanation:

cmatrix

Shunt nodal capacitance matrix, in nanofarads per unit length. The order of matrices expected is the number of phases. The matrices may be entered in lower triangle form or full matrix. The result is always symmetrical.
The "|" separates rows.

Case II: Time-series Power Flow

Build OpenDSS Model – Linecode

OpenDSS Code:

```
// Define a linecode for the lines - unbalanced 336 MCM ACSR connection
New linecode.336matrix nphases=3
~ rmatrix=(0.0868455 | 0.0298305 0.0887966 | 0.0288883 0.0298305 0.0868455)
~ xmatrix=(0.2025449 | 0.0847210 0.1961452 | 0.0719161 0.0847210 0.2025449)
~ cmatrix=(2.74 | -0.70 2.96| -0.34 -0.71 2.74)
~ Normamps = 400  Emergamps=600
```

Explanation:

Normamps

Specifies the normal ampacity, in amperes.

Emergamps

Specifies the emergency ampacity, in amperes.

Case II: Time-series Power Flow

Build OpenDSS Model – Line

OpenDSS Code:

```
// Define the lines
New line.line1 bus1=subbus bus2=loadbus1 linecode=336matrix length=10 units=kft
New line.line2 loadbus1 loadbus2 336matrix 10
New line.line3 Loadbus2 loadbus3 336matrix 20
```

Explanation:

New line.l1

Defines a line object named l1.

Bus1

Specifies the name of bus for terminal 1.

Bus2

Specifies the name of bus for terminal 2.

Case II: Time-series Power Flow

Build OpenDSS Model – Line

OpenDSS Code:

```
// Define the lines
New line.line1 bus1=subbus bus2=loadbus1 linecode=336matrix length=10 units=kft
New line.line2 loadbus1 loadbus2 336matrix 10
New line.line3 Loadbus2 loadbus3 336matrix 20
```

Explanation:

LineCode

Specifies the name of an existing LineCode object containing impedance definitions.

Length

Specifies a length multiplier to be applied to the impedance data.

units

Specifies the length Units.
{none | mi | kft | km | m | Ft | in | cm }

Case II: Time-series Power Flow

Build OpenDSS Model – Loadshape

OpenDSS Code:

```
// Define some load shapes for the loads and wind
New loadshape.day 8 3.0
~ mult=(.3 .36 .48 .62 .87 .95 .94 .60)
New loadshape.wind 2400 {1 24 /}
~ mult=(file=zavwind.csv) action=normalize
```

Explanation:

A Loadshape object is very important for all types of **sequential** power flow solutions. It consists of a series of **multipliers**, typically ranging from 0.0 to 1.0 which are applied to the base kW values of the load, to represent variation of the load over some time period.

New loadshape.day 8 3.0

Defines a loadshape object named day.
The above code equals: New loadshape.day Npts=8 Interval=3.0.

Case II: Time-series Power Flow

Build OpenDSS Model – Loadshape

OpenDSS Code:

```
// Define some load shapes for the loads and wind
New loadshape.day 8 3.0
~ mult=(.3 .36 .48 .62 .87 .95 .94 .60)
New loadshape.wind 2400 {1 24 /}
~ mult=(file=zavwind.csv) action=normalize
```

Explanation:

New loadshape.day 8 3.0

New loadshape.day Npts=8 Interval=3.0.

Npts: Specifies the number of points to expect when defining the curve.

Interval: Specifies the time interval of the data, in Hr. Default=1.0. If the load shape has non-uniformly spaced points, specify the interval as 0.0.

Note:

1. In defaults: the loadshape is constant during each 3-hr interval. 8*3=24 hrs.
2. For the loadshape named wind, 2400*1/24=100 hrs. Considering the simulation time range is 24 hours (specified later), the remaining 76 points are clipped.

Case II: Time-series Power Flow

Build OpenDSS Model – Loadshape

OpenDSS Code:

```
// Define some load shapes for the loads and wind
New loadshape.day 8 3.0
~ mult=(.3 .36 .48 .62 .87 .95 .94 .60)
New loadshape.wind 2400 {1 24 /}
~ mult=(file=zavwind.csv) action=normalize
```

Explanation:

Mult

Specifies an array of multiplier values. It looks for Npts values. Omitted values are assumed to be zero, and **extra values are ignored.**

You may also use the syntax:

```
Mult=[file=myfile.txt],
Mult=[file=myfile.csv]
Mult=[dblfile=myfile.dbl],
Mult=[sngfile=myfile.sng]
```

Case II: Time-series Power Flow

Build OpenDSS Model – Loadshape

OpenDSS Code:

```
// Define some load shapes for the loads and wind
New loadshape.day 8 3.0
~ mult=(.3 .36 .48 .62 .87 .95 .94 .60)
New loadshape.wind 2400 {1 24 /}
~ mult=(file=zavwind.csv) action=normalize
```

Explanation:

action

After defining the load curve data, setting **action=normalize** will modify the multipliers so that the peak is 1.0. The mean and std deviation are recomputed.

Case II: Time-series Power Flow

Build OpenDSS Model – Load

OpenDSS Code:

```
// Define the loads
New load.load1 bus1=loadbus1 phases=3 kv=12.47 kw=1000.0 pf=0.88 model=1
~ class=1 duty=day
New load.load2 bus1=loadbus2 phases=3 kv=12.47 kw=500.0 pf=0.88 model=1
~ class=1 duty=day conn=delta
```

Explanation:

New Load.load1

Defines a load object named load1.

bus1

Specifies the name of bus to which the load is connected.

phases

Specifies the number of phases of this load.

Case II: Time-series Power Flow

Build OpenDSS Model – Load

OpenDSS Code:

```
// Define the loads
New load.load1 bus1=loadbus1 phases=3 kv=12.47 kw=1000.0 pf=0.88 model=1
~ class=1 duty=day
New load.load2 bus1=loadbus2 phases=3 kv=12.47 kw=500.0 pf=0.88 model=1
~ class=1 duty=day conn=delta
```

Explanation:

kv

Specifies the Base voltage for load. For 2- or 3-phase loads, it is specified in phase-to-phase kV.
For all other loads, it is specified in the actual kV across the load branch. If the load is wye (star) connected, then specify phase-to-neutral (L-N) kV. If the load is delta or phase-to-phase connected, specify the phase-to-phase (L-L) kV.

kw

Specifies the nominal active power, in kW, for the load. Total of all phases.

Case II: Time-series Power Flow

Build OpenDSS Model – Load

OpenDSS Code:

```
// Define the loads
New load.load1 bus1=loadbus1 phases=3 kv=12.47 kw=1000.0 pf=0.88 model=1
~ class=1 duty=day
New load.load2 bus1=loadbus2 phases=3 kv=12.47 kw=500.0 pf=0.88 model=1
~ class=1 duty=day conn=delta
```

Explanation:

pf

Specifies the nominal power factor for load. Negative PF is leading. Specify either PF or kvar. If both are specified, the last one specified takes precedence.

Model

An integer defining how the load will vary with voltage. The load models currently implemented are:

1: Constant P and constant Q (Default): Commonly used for power flow studies,

…

Case II: Time-series Power Flow

Build OpenDSS Model – Load

OpenDSS Code:

```
// Define the loads
New load.load1 bus1=loadbus1 phases=3 kv=12.47 kw=1000.0 pf=0.88 model=1
~ class=1 duty=day
New load.load2 bus1=loadbus2 phases=3 kv=12.47 kw=500.0 pf=0.88 model=1
~ class=1 duty=day conn=delta
```

Explanation:

Model

…
2: Constant Z (or constant impedance),
3: Constant P and quadratic Q ($Q/Q0=(V/V0)$^2),
4: Exponential: $P/P0=(V/V0)^{CVRwatts}$ and $Q/Q0=(V/V0)^{CVRvars}$
5: Constant I (or constant current magnitude),
6: Constant P and fixed Q (at the nominal value)
7: Constant P and quadratic Q (i.e., fixed reactance),
…

Case II: Time-series Power Flow

Build OpenDSS Model – Load

OpenDSS Code:

```
// Define the loads
New load.load1 bus1=loadbus1 phases=3 kv=12.47 kw=1000.0 pf=0.88 model=1
~ class=1 duty=day
New load.load2 bus1=loadbus2 phases=3 kv=12.47 kw=500.0 pf=0.88 model=1
~ class=1 duty=day conn=delta
```

Explanation:

Model

…

8: ZIP

"Constant" power value (either P or Q) may be modified by loadshape multipliers. "Fixed" power values are always the same.

- ZIP model:

$$P = P_0\left[a_1\left(\frac{V}{V_0}\right)^2 + a_2\left(\frac{V}{V_0}\right) + a_3\right]$$

$$Q = Q_0\left[a_4\left(\frac{V}{V_0}\right)^2 + a_5\left(\frac{V}{V_0}\right) + a_6\right]$$

Case II: Time-series Power Flow

Build OpenDSS Model – Load

OpenDSS Code:

```
// Define the loads
New load.load1 bus1=loadbus1 phases=3 kv=12.47 kw=1000.0 pf=0.88 model=1
~ class=1 duty=day
New load.load2 bus1=loadbus2 phases=3 kv=12.47 kw=500.0 pf=0.88 model=1
~ class=1 duty=day conn=delta
```

Explanation:

class

An integer number segregating the load according to a particular class.

duty

Specifies the name of duty cycle load shape. Defaults to Daily load shape if not defined.

conn

Specifies the winding connection. {wye | y | LN} for Wye (Line-Neutral) connection; {delta | LL} for Delta (Line-Line) connection. Default = wye.

Case II: Time-series Power Flow

Build OpenDSS Model – Capacitor

OpenDSS Code:

```
// Capacitor with control
New capacitor.Cap1 bus1=loadbus2 phases=3 kvar=600 kv=12.47
New capcontrol.Cap1Ctrl element=line.line3 terminal=1 capacitor=Cap1
~ type=current ctratio=1 ONsetting=60 OFFsetting=55 delay=2
```

Explanation:

New Capacitor.Cap1

Defines a capacitor object named Cap1.

Bus1

Specifies the name of the first bus to which the capacitor is connected.

phases

Specifies the number of phases.

kvar

Specifies the rated kvar at rated kV, total of all phases. Each phase is assumed equal.

Case II: Time-series Power Flow

Build OpenDSS Model – Capacitor

OpenDSS Code:

```
// Capacitor with control
New capacitor.Cap1 bus1=loadbus2 phases=3 kvar=600 kv=12.47
New capcontrol.Cap1Ctrl element=line.line3 terminal=1 capacitor=Cap1
~ type=current ctratio=1 ONsetting=60 OFFsetting=55 delay=2
```

Explanation:

kv

Specifies the kV rating of capacitor. For Phases=2 or Phases=3, enter line-to-line (phase-to-phase) rated voltage. For all other numbers of phases, enter actual can rating. (For Delta connection this is always line-to-line rated voltage).

New capcontrol.Cap1Ctrl

Defines a capacitor control object named Cap1Ctrl.

* The capacitor control monitors the voltage and current at a terminal of a PDelement or a PCelement and sends switching messages to a Capacitor object.

Case II: Time-series Power Flow

Build OpenDSS Model – Capacitor

OpenDSS Code:

```
// Capacitor with control
New capacitor.Cap1 bus1=loadbus2 phases=3 kvar=600 kv=12.47
New capcontrol.Cap1Ctrl element=line.line3 terminal=1 capacitor=Cap1
~ type=current ctratio=1 ONsetting=60 OFFsetting=55 delay=2
```

Explanation:

element

Specifies the full object name of the circuit element, typically a line or transformer, to which the capacitor control's PT and/or CT are connected. There is no default; must be specified.

terminal

Specifies the number of terminal of the circuit element to which the CapControl is connected. 1 or 2, typically. Default is 1.

Case II: Time-series Power Flow

Build OpenDSS Model – Capacitor

OpenDSS Code:

```
// Capacitor with control
New capacitor.Cap1 bus1=loadbus2 phases=3 kvar=600 kv=12.47
New capcontrol.Cap1Ctrl element=line.line3 terminal=1 capacitor=Cap1
~ type=current ctratio=1 ONsetting=60 OFFsetting=55 delay=2
```

Explanation:

capacitor

Specifies the name of Capacitor which the CapControl controls. No Default; Must be specified.

type

Specifies the Control type. {Current | voltage | kvar | PF | time }.

ctratio

Specifies the ratio of the CT from line amps to control ampere setting for current and kvar control types.

Case II: Time-series Power Flow

Build OpenDSS Model – Capacitor

OpenDSS Code:

```
// Capacitor with control
New capacitor.Cap1 bus1=loadbus2 phases=3 kvar=600 kv=12.47
New capcontrol.Cap1Ctrl element=line.line3 terminal=1 capacitor=Cap1
~ type=current ctratio=1 ONsetting=60 OFFsetting=55 delay=2
```

Explanation:

onsetting

Specifies the value at which the control arms to switch the capacitor ON. For different types of control, the value is calculated by:

- Current: Line Amps / CTratio
- Voltage: Line-Neutral (or Line-Line for delta) Volts / PTratio
- kvar: Total kvar, all phases. This is directional.
- PF: Power Factor, Total power in monitored terminal.
- Time: Hrs from Midnight as a floating point number (decimal). 7:30am would be entered as 7.5.

Case II: Time-series Power Flow

Build OpenDSS Model – Capacitor

OpenDSS Code:

```
// Capacitor with control
New capacitor.Cap1 bus1=loadbus2 phases=3 kvar=600 kv=12.47
New capcontrol.Cap1Ctrl element=line.line3 terminal=1 capacitor=Cap1
~ type=current ctratio=1 ONsetting=60 OFFsetting=55 delay=2
```

Explanation:

offsetting

Specifies the value at which the control arms to switch the capacitor OFF. For different types of control, the value is calculated by:

- Current: Line Amps / CTratio
- Voltage: Line-Neutral (or Line-Line for delta) Volts / PTratio
- kvar: Total kvar, all phases. This is directional.
- PF: Power Factor, Total power in monitored terminal.
- Time: Hrs from Midnight as a floating point number (decimal). 7:30am would be entered as 7.5.

Case II: Time-series Power Flow

Build OpenDSS Model – Capacitor

OpenDSS Code:

```
// Capacitor with control
New capacitor.Cap1 bus1=loadbus2 phases=3 kvar=600 kv=12.47
New capcontrol.Cap1Ctrl element=line.line3 terminal=1 capacitor=Cap1
~ type=current ctratio=1 ONsetting=60 OFFsetting=55 delay=2
```

Explanation:

delay

Specifies the time delay, in seconds, from when the control is armed before it sends out the switching command to turn the capacitor ON.

Case II: Time-series Power Flow

Build OpenDSS Model – Regulator

OpenDSS Code:

```
// Regulator for DG
New transformer.reg1 phases=3 windings=2
~ buses=(loadbus3 regbus)   conns='wye wye'  kvs=(12.47 12.47)  kvas=(8000 8000)   XHL=1
// Regulator Control definitions
New regcontrol.subxfrmCtrl transformer=subxfrm winding=2 vreg=125
~ band=3 ptratio=60 delay=10
New regcontrol.reg1Ctrl transformer=reg1 winding=2 vreg=122 band=3
~ ptratio=60 delay=15
```

Explanation:

New Transformer.reg1

Defines a transformer named reg1.

phases

Specifies the number of phases.

windings

Specifies the number of windings.

Case II: Time-series Power Flow

Build OpenDSS Model – Regulator

OpenDSS Code:

```
// Regulator for DG
New transformer.reg1 phases=3 windings=2
~ buses=(loadbus3 regbus)   conns='wye wye'  kvs=(12.47 12.47)  kvas=(8000 8000)   XHL=1
// Regulator Control definitions
New regcontrol.subxfrmCtrl transformer=subxfrm winding=2 vreg=125
~ band=3 ptratio=60 delay=10
New regcontrol.reg1Ctrl transformer=reg1 winding=2 vreg=122 band=3
~ ptratio=60 delay=15
```

Explanation:

buses=(loadbus3 regbus)

An array specifying the names of buses to which the windings are connected. Winding1 of transformer is connected to loadbus3, winding2 is connected to regubus.

conns='wye wye'

Specifies an array of connections for winding1 and winding2.

kvs=(12.47 12.47)

Specifies an array of kV ratings for winding1 and winding2.

Case II: Time-series Power Flow

Build OpenDSS Model – Regulator

OpenDSS Code:

```
// Regulator for DG
New transformer.reg1 phases=3 windings=2
~ buses=(loadbus3 regbus)   conns='wye wye'  kvs=(12.47 12.47)  kvas=(8000 8000)   XHL=1
// Regulator Control definitions
New regcontrol.subxfrmCtrl transformer=subxfrm winding=2 vreg=125
~ band=3 ptratio=60 delay=10
New regcontrol.reg1Ctrl transformer=reg1 winding=2 vreg=122 band=3
~ ptratio=60 delay=15
```

Explanation:

kvas=(8000 8000)

Specifies an array of base kVA rating for winding1 and winding2.

XHL (or X12)

Specifies the percent reactance high-to-low (winding 1 to winding 2).

Case II: Time-series Power Flow

Build OpenDSS Model – Regulator

OpenDSS Code:

```
// Regulator for DG
New transformer.reg1 phases=3 windings=2
~ buses=(loadbus3 regbus)   conns='wye wye'  kvs=(12.47 12.47)  kvas=(8000 8000)   XHL=1
// Regulator Control definitions
New regcontrol.subxfrmCtrl transformer=subxfrm winding=2 vreg=125
~ band=3 ptratio=60 delay=10
New regcontrol.reg1Ctrl transformer=reg1 winding=2 vreg=122 band=3
~ ptratio=60 delay=15
```

Explanation:

New regcontrol.subxfrmCtrl

Defines a regulator control object named subxfrmCtrl.

transformer

Specifies the name of transformer to which the RegControl is connected.

winding

Specifies the number of the winding of the transformer that the RegControl is monitoring. 1 or 2, typically.

Case II: Time-series Power Flow

Build OpenDSS Model – Regulator

OpenDSS Code:

```
// Regulator for DG
New transformer.reg1 phases=3 windings=2
~ buses=(loadbus3 regbus)   conns='wye wye'  kvs=(12.47 12.47)  kvas=(8000 8000)   XHL=1
// Regulator Control definitions
New regcontrol.subxfrmCtrl transformer=subxfrm winding=2 vreg=125
~ band=3 ptratio=60 delay=10
New regcontrol.reg1Ctrl transformer=reg1 winding=2 vreg=122 band=3
~ ptratio=60 delay=15
```

Explanation:

vreg

Specifies the voltage regulator setting, in VOLTS, for the winding being controlled.

band

Specifies the bandwidth, in VOLTS, for the controlled bus. Default is 3.0

Case II: Time-series Power Flow

Build OpenDSS Model – Regulator

OpenDSS Code:

```
// Regulator for DG
New transformer.reg1 phases=3 windings=2
~ buses=(loadbus3 regbus)   conns='wye wye'  kvs=(12.47 12.47)  kvas=(8000 8000)   XHL=1
// Regulator Control definitions
New regcontrol.subxfrmCtrl transformer=subxfrm winding=2 vreg=125
~ band=3 ptratio=60 delay=10
New regcontrol.reg1Ctrl transformer=reg1 winding=2 vreg=122 band=3
~ ptratio=60 delay=15
```

Explanation:

ptratio

Specifies the ratio of the PT that converts the controlled winding voltage to the regulator voltage. Default is 60. If the winding is Wye, the line-to-neutral voltage is used. Else, the line-to-line voltage is used.

delay

Specifies the time delay, in seconds, from when the voltage goes out of band to when the tap changing begins. This is used to determine which regulator control will act first. Default is 15.

Case II: Time-series Power Flow

Build OpenDSS Model – Wind generator

OpenDSS Code:

```
// Define a wind generator of 8MW
New generator.gen1 bus1=regbus kV=12.47 kW=8000 pf=1 conn=delta
~ duty=wind Model=1
```

Explanation:

A Generator is a Power Conversion element similar to a Load object. Its rating is basically defined by its nominal kW and PF or its kW and kvar. Then it may be modified by a number of multipliers, including the global circuit load multiplier, yearly load shape, daily load shape, and a dutycycle load shape.

New generator.gen1

Defines a generator object named gen1.

bus1

Specifies the name of bus to which the generator is connected.

Case II: Time-series Power Flow

Build OpenDSS Model – Wind generator

OpenDSS Code:

```
// Define a wind generator of 8MW
New generator.gen1 bus1=regbus kV=12.47 kW=8000 pf=1 conn=delta
~ duty=wind Model=1
```

Explanation:

kV

Specifies the Base voltage for generator. For 2- or 3-phase generators, it is specified in phase-to-phase kV.
For all other generators, it is specified in the actual kV across the generator branch. If the generator is wye (star) connected, specify the phase-to-neutral (L-N) kV. If the generator is delta or phase-to-phase connected, specify the phase-to-phase (L-L) kV.

kW

Specifies the nominal kW for generator. Total of all phases.

pf

Specifies the nominal power factor for generator.

Case II: Time-series Power Flow

Build OpenDSS Model – Wind generator

OpenDSS Code:

```
// Define a wind generator of 8MW
New generator.gen1 bus1=regbus kV=12.47 kW=8000 pf=1 conn=delta
~ duty=wind Model=1
```

Explanation:

conn

Specifies the winding connection of the generator. {wye | y | LN} for Wye (Line-Neutral) connection; {delta | LL} for Delta (Line-Line) connection. Default = wye.

duty

Specifies the name of Duty cycle load shape. Defaults to Daily load shape if not defined.

Model

An integer defining how the generator will vary with voltage. Presently defined models are:

…

Case II: Time-series Power Flow

Build OpenDSS Model – Wind generator

OpenDSS Code:

```
// Define a wind generator of 8MW
New generator.gen1 bus1=regbus kV=12.47 kW=8000 pf=1 conn=delta
~ duty=wind Model=1
```

Explanation:

Model

…
1: Generator injects a constant kW at specified power factor.
2: Generator is modeled as a constant admittance.
3: Const kW, constant kV. Somewhat like a conventional transmission power flow P-V generator.
4: Const kW, Fixed Q (Q never varies).
5: Const kW, Fixed Q(as a constant reactance).
6: Compute load injection from User-written Model.
7: Constant kW, kvar, but current is limited when voltage is below Vminpu.

Case II: Time-series Power Flow

Build OpenDSS Model – Monitor

OpenDSS Code:

```
// Define some monitors so we can see what's happening
New Monitor.gen1 element=generator.gen1 terminal=1 mode=1
New Monitor.loadbus2 load.load2 1 mode=0
New Monitor.line3 line.line3 1 mode=48
New Energymeter.em1 line.line1
```

Explanation:

A monitor is a circuit element that is connected to a terminal of another circuit element. It takes a sample when instructed, recording the time and the complex values of voltage and current, or power, at all phases.

New Monitor.gen1

Defines a monitor object named gen1.

element

Specify the name of an existing circuit element to which the monitor is connected.

Case II: Time-series Power Flow

Build OpenDSS Model – Monitor

OpenDSS Code:

```
// Define some monitors so we can see what's happening
New Monitor.gen1 element=generator.gen1 terminal=1 mode=1
New Monitor.loadbus2 load.load2 1 mode=0
New Monitor.line3 line.line3 1 mode=48
New Energymeter.em1 line.line1
```

Explanation:

terminal

Specifies the number of the terminal to which the monitor is connected.

mode

An integer bitmask code to describe what the monitor will save. Monitors can save two basic types of quantities: 1) Voltage and current; 2) Power. The Mode codes are defined as follows:

0: Standard mode - V and I, each phase, complex

1: Power each phase, complex (kw and kvars)

…

Case II: Time-series Power Flow

Build OpenDSS Model – Monitor

OpenDSS Code:

```
// Define some monitors so we can see what's happening
New Monitor.gen1 element=generator.gen1 terminal=1 mode=1
New Monitor.loadbus2 load.load2 1 mode=0
New Monitor.line3 line.line3 1 mode=48
New Energymeter.em1 line.line1
```

Explanation:

mode

…

2: Transformer taps (connect Monitor to a transformer winding)

3: State variables (connect Monitor to a Power conversion Element)

4: Flicker level and severity index (Pst) for voltages.

5: Solution variables (Iterations, etc). Normally, these would be actual phasor quantities from solution.

6: Capacitor Switching

…

Case II: Time-series Power Flow

Build OpenDSS Model – Monitor

OpenDSS Code:

```
// Define some monitors so we can see what's happening
New Monitor.gen1 element=generator.gen1 terminal=1 mode=1
New Monitor.loadbus2 load.load2 1 mode=0
New Monitor.line3 line.line3 1 mode=48
New Energymeter.em1 line.line1
```

Explanation:

mode

…

+16: Sequence components: V012, I012

+32: Magnitude only

+64: Positive Sequence only or Average of phases, if not 3 phases.

For example, Mode=33 (33=1+32) will save the magnitude of the power (kVA) only in each phase. Mode=112 (112=0+16+32+64) saves Positive sequence voltages and currents, magnitudes only.

Case II: Time-series Power Flow

Build OpenDSS Model – Energymeter

OpenDSS Code:

```
// Define some monitors so we can see what's happening
New Monitor.gen1 element=generator.gen1 terminal=1 mode=1
New Monitor.loadbus2 load.load2 1 mode=0
New Monitor.line3 line.line3 1 mode=48
New Energymeter.em1 line.line1
```

Explanation:

* An EnergyMeter object is an intelligent meter connected to a terminal of a circuit element. It simulates the behavior of an actual energy meter.

New Energymeter.em1

Defines an energymeter object named em1.

line.line1

The above code is the same as: Element=line.line1
It designates the name of an existing circuit element to which the Enegymeter is connected.

Case II: Time-series Power Flow

Build OpenDSS Model – Solve

OpenDSS Code:

```
Set voltagebases=(115 12.47 .48)
Calcvoltagebases
Set controlmode=time
Set mode=dutycycle number=86400 hour=0 stepsize=1 sec=0
Solve
```

Explanation:

Set voltagebases=(115 12.47 .48)

Defines legal bus voltage bases for this circuit. Enter an array of the legal voltage bases, in phase-to-phase voltages. In this case, three voltage bases are defined, 115kV, 12.47kV and 0.48kV.

- The voltage level can be selected from the following values: .208, .480, 12.47, 24.9, 34.5, 115.0, 230.0

Case II: Time-series Power Flow

Build OpenDSS Model – Solve

OpenDSS Code:

```
Set voltagebases=(115 12.47 .48)
Calcvoltagebases
Set controlmode=time
Set mode=dutycycle number=86400 hour=0 stepsize=1 sec=0
Solve
```

Explanation:

Calcvoltagebases

Estimates the voltage base for each bus based on the array of voltage bases defined with a "Set Voltagebases=..." command. The voltage base for each bus is then set to the nearest voltage base specified in the voltage base array.

ControlMode

Specifies the Control mode for the solution. {OFF | STATIC |EVENT | TIME}, Default is "STATIC".
The detailed meanings are as follows:
…

Case II: Time-series Power Flow

Build OpenDSS Model – Solve

OpenDSS Code:

```
Set voltagebases=(115 12.47 .48)
Calcvoltagebases
Set controlmode=time
Set mode=dutycycle number=86400 hour=0 stepsize=1 sec=0
Solve
```

Explanation:

ControlMode

…

STATIC = Time does not advance. Control actions are executed in order of shortest time to act until all actions are cleared from the control queue.

EVENT = solution is event driven. Only the control actions nearest in time are executed and the time is advanced automatically to the time of the event.

TIME = solution is time driven. Control actions are executed when the time for the pending action is reached or surpassed.

Case II: Time-series Power Flow

Build OpenDSS Model – Solve

OpenDSS Code:

```
Set voltagebases=(115 12.47 .48)
Calcvoltagebases
Set controlmode=time
Set mode=dutycycle number=86400 hour=0 stepsize=1 sec=0
Solve
```

Explanation:

Mode

Specifies the solution mode for the active circuit. Mode can be one of snap, daily, direct, dutycycle, dynamics, faultstudy, harmonics, or yearly.

Mode=Snap:

Solve a single snapshot power flow for the present conditions. Loads are modified only by the global load multiplier (LoadMult) and the growth factor for the present year (Year).

…

Case II: Time-series Power Flow

Build OpenDSS Model – Solve

OpenDSS Code:

```
Set voltagebases=(115 12.47 .48)
Calcvoltagebases
Set controlmode=time
Set mode=dutycycle number=86400 hour=0 stepsize=1 sec=0
Solve
```

Explanation:

Mode

…

Mode=Daily:

Do a series of solutions following the daily load curves. The Stepsize defaults to 3600 sec (1 hr).

Mode=Direct:

Solve a single snapshot solution using an admittance model of all loads. This is noniterative; just a direct solution using the currently specified voltage and current sources.

…

Case II: Time-series Power Flow

Build OpenDSS Model – Solve

OpenDSS Code:

```
Set voltagebases=(115 12.47 .48)
Calcvoltagebases
Set controlmode=time
Set mode=dutycycle number=86400 hour=0 stepsize=1 sec=0
Solve
```

Explanation:

Mode

…

Mode=Dutycycle:
The solver follows the duty cycle curves with the time increment specified.

Mode=Dynamics:
Sets the solution mode for a dynamics solution. Must be preceded by a successful power flow solution so that the machines can be initialized.

…

Case II: Time-series Power Flow

Build OpenDSS Model – Solve

OpenDSS Code:

```
Set voltagebases=(115 12.47 .48)
Calcvoltagebases
Set controlmode=time
Set mode=dutycycle number=86400 hour=0 stepsize=1 sec=0
Solve
```

Explanation:

Mode

…

Mode=FaultStudy:

Do a full fault study solution, determining the Thevenin equivalents for each bus in the active circuit. Prepares all the data required to produce fault study report under the Show Fault command.

Mode=Harmonics:

Sets the solution mode for a Harmonics solution. Must be preceded by a successful power flow solution so that the machines and harmonics sources can be initialized.

Loads are converted to harmonic current sources and initialized based on the power flow solution according to the Spectrum object associated with each Load.

…

Case II: Time-series Power Flow

Build OpenDSS Model – Solve

OpenDSS Code:

```
Set voltagebases=(115 12.47 .48)
Calcvoltagebases
Set controlmode=time
Set mode=dutycycle number=86400 hour=0 stepsize=1 sec=0
Solve
```

Explanation:

Mode

…

Mode=Yearly:

Do a solution following the yearly load curves. The solution is repeated as many times as the specified by the Number=option. Each load then follows its yearly load curve. Load is determined solely by the yearly load curve and the growth multiplier.

Case II: Time-series Power Flow

Build OpenDSS Model – Solve

OpenDSS Code:

```
Set voltagebases=(115 12.47 .48)
Calcvoltagebases
Set controlmode=time
Set mode=dutycycle number=86400 hour=0 stepsize=1 sec=0
Solve
```

Explanation:

number

Specifies the number of time steps or solutions to run.

hour

Sets the hour to be used for the start time of the solution of the active circuit.

stepsize

Sets the time step size for the solution of the active circuit. Default unit is sec.

sec

Sets the seconds from the hour for the start time for the solution of the active circuit.

Case II: Time-series Power Flow

Build OpenDSS Model – Solve

OpenDSS Code:

```
// Show some results
Plot monitor, object=loadbus2
Visualize element=Line.line1 what=powers
Plot profile
```

Explanation:

plot

Displays a variety of results in a variety of manners on graphs.

monitor

Specifies that the type to be plotted is monitor. The Monitor plot plots one or more channels from a Monitor element.

object

Specifies what object to plot.
[metername for Zone plot | Monitor name | File Name for General bus data or Circuit branch data].

Case II: Time-series Power Flow

Build OpenDSS Model – Solve

OpenDSS Code:

```
// Show some results
Plot monitor, object=loadbus2
Visualize element=Line.line1 what=powers
Plot profile
```

Explanation:

channel

Specifies an array of channel numbers for monitor plot. More than one monitor channel can be plotted on the same graph. Example: Channels=[1, 3, 5]

visiualize

Shows the currents, voltages, or powers for selected element on a drawing in phasor quantities.

Case II: Time-series Power Flow

Build OpenDSS Model – Solve

OpenDSS Code:

```
// Show some results
Plot monitor, object=loadbus2
Visualize element=Line.line1 what=powers
Plot profile
```

Explanation:

element

Specifies the names of elements to be visualized. It should follow the following format:

element=full_element_name (i.e., class.name).

what

Specifies the what quantity to be visualized.
It can be the following item: currents, voltages, powers.

plot profile

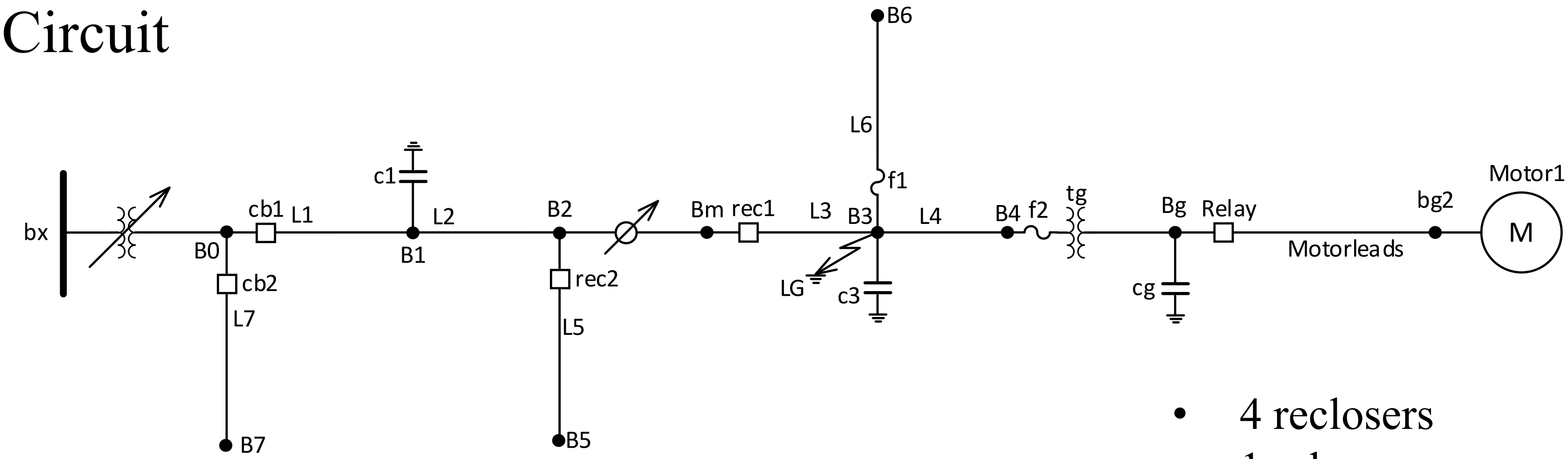
Plot voltage profiles.

Contents

- Static Snapshot Case
- Time-series Static Case
- Fault and Dynamic Case

Case III: Fault and Dynamic

Circuit



- 12 buses
- 1 voltage source
- 2 transformers
- 1 voltage regulator bank with control
- 3 capacitor banks
- 7 line segments
- 4 reclosers
- 1 relay
- 2 fuses
- 1 induction motor
- 7 loads

- From 0 to 0.3 second, the circuit is in a normal status (no fault).
- At t=0.3 second, a 0.21-second temporary SLG (Phase A) fault occurs at Bus **B3**.
- Sensing the undervoltages and overcurrents, the Relay operates 0.1 s later (at t=0.4 second), isolating the induction motor.
- Since the time duration of the fault is 0.21 s, the fault still exists. Therefore, the recloser rec1 disconnects line **L3** 0.11s later (at t=0.51 second). Also, almost at the same time, the temporary fault disappears.
- After 0.5 seconds (at t=1.01 second), the recloser reconnects line **L3**.

Case III: Fault and Dynamic

OpenDSS files

17 files

Capacitor.dss	Define capacitor banks
Fault.dss	Define fault
Fuse.dss	Define fuse
IndMach012.dss	Define induction motor
line.dss	Define line segment
LineCode.dss	Define line configuration
Load.dss	Define load
LoadShape.dss	Define loadshape
Master.DSS	Define Master file
Monitor.dss	Define monitors
Recloser.dss	Define reclosers
RegControl.dss	Define regulator control
Relay.dss	Define relay
Run.dss	Define a file to perform dynamic analysis
TCC_Curve.dss	Define operating curves for relay, recloser and fuses
Transformer.dss	Define transformers
Vsource.dss	Define voltage source

Case III: Fault and Dynamic

- Run.dss file

It is the main file which is defined to perform dynamic analysis.

Two steps to perform dynamic analysis:

1. Run static power flow to obtain the initialization for dynamic simulation
2. Perform the dynamic simulation

OpenDSS Code (Initialization):

```
Redirect "Master.DSS"  !Compile
New Monitor.Mtime Vsource.source  mode=5   ! solution time monitor
Set Maxcontroliter=20
Set maxiterations=20
solve
```

Explanation:

Redirect

Resets the current directory to Master.DSS file.

Case III: Fault and Dynamic

- Run.dss file

OpenDSS Code (Initialization):

```
Redirect "Master.DSS"  !Compile
New Monitor.Mtime Vsource.source  mode=5   ! solution time monitor
Set Maxcontroliter=20
Set maxiterations=20
solve
```

Explanation:

New Monitor.Mtime

Defines a monitor object named Mtime, which is used for collecting time information for plotting.

Vsource.source

It is equivalent with Element=Vsource.source
It specifies the Name of an existing circuit element to which the monitor is to be connected.

Case III: Fault and Dynamic

- Run.dss file

OpenDSS Code (Initialization):

```
Redirect "Master.DSS"  !Compile
New Monitor.Mtime Vsource.source  mode=5   ! solution time monitor
Set Maxcontroliter=20
Set maxiterations=20
solve
```

Explanation:

mode

Mode is an integer bitmask code to describe what the monitor will save. Monitors can save two basic types of quantities: 1) Voltage and current; 2) Power.

The Mode codes are defined as follows:

0: Standard mode - V and I, each phase, complex
1: Power each phase, complex (kw and kvars)
2: Transformer taps (connect Monitor to a transformer winding)
3: State variables (connect Monitor to a PCelement)

…

Case III: Fault and Dynamic

- Run.dss file

OpenDSS Code (Initialization):

```
Redirect "Master.DSS"  !Compile
New Monitor.Mtime Vsource.source  mode=5   ! solution time monitor
Set Maxcontroliter=20
Set maxiterations=20
solve
```

Explanation:

mode

…

4: Flicker level and severity index (Pst) for voltages.

5: Solution variables (Iterations, etc). Normally, these would be actual phasor quantities from solution.

6: Capacitor Switching

+16: Sequence components: V012, I012

+32: Magnitude only

+64: Positive Sequence only or Average of phases, if not 3 phases.

For example, Mode=33 (33=1+32) will save the magnitude of the power (kVA) only in each phase.

Case III: Fault and Dynamic

- Run.dss file

OpenDSS Code (Initialization):

```
Redirect "Master.DSS"  !Compile
New Monitor.Mtime Vsource.source  mode=5   ! solution time monitor
Set Maxcontroliter=20
Set maxiterations=20
solve
```

Explanation:

Maxcontroliter

Sets the maximum control iterations per solution. Default is 10.

maxiterations

Also called Maxiter. Sets the maximum allowable iterations for power flow solutions. Default is 15.

Solve

Solves the circuit. Default mode is snapshot.

Case III: Fault and Dynamic

- Run.dss file

OpenDSS Code (Perform Dynamic Simulation):

```
Set mode=dynamics number=1 h=0.000166667
solve
Solve number= 10000
get time
get number
```

Explanation:

Mode

Specifies the solution mode for the active circuit. Mode can be one of snap, daily, direct, dutycycle, dynamics, faultstudy, harmonics, yearly.

Mode=Snap:
Solve a single snapshot power flow for the present conditions. Loads are modified only by the global load multiplier (LoadMult) and the growth factor for the present year (Year).

…

Case III: Fault and Dynamic

- Run.dss file

OpenDSS Code (Perform Dynamic Simulation):

```
Set mode=dynamics number=1 h=0.000166667
solve
Solve number= 10000
get time
get number
```

Explanation:

Mode

…

Mode=Daily:

Do a series of solutions following the daily load curves. The stepsize defaults to 3600 sec (1 hr).

Mode=Direct:

Solves a single snapshot solution using an admittance model of all loads. This is noniterative; just a direct solution using the currently specified voltage and current sources.

…

Case III: Fault and Dynamic

- Run.dss file

OpenDSS Code (Perform Dynamic Simulation):

```
Set mode=dynamics number=1 h=0.000166667
solve
Solve number= 10000
get time
get number
```

Explanation:

Mode

…

Mode=Dutycycle:
Follows the duty cycle curves with the time increment specified.

Mode=Dynamics:
Sets the solution mode for a dynamics solution. Must be preceded by a successful power flow solution so that the machines can be initialized.

…

Case III: Fault and Dynamic

- Run.dss file

OpenDSS Code (Perform Dynamic Simulation):

```
Set mode=dynamics number=1 h=0.000166667
solve
Solve number= 10000
get time
get number
```

Explanation:

Mode

…

Mode=FaultStudy:

Do a full fault study solution, determining the Thevenin equivalents for each bus in the active circuit. Prepares all the data required to produce fault study report under the Show Fault command.

…

Case III: Fault and Dynamic

- Run.dss file

OpenDSS Code (Perform Dynamic Simulation):

```
Set mode=dynamics number=1 h=0.000166667
solve
Solve number= 10000
get time
get number
```

Explanation:

Mode

…

Mode=Harmonics:

Sets the solution mode for a Harmonics solution. Must be preceded by a successful power flow solution, so that the machines and harmonics sources can be initialized. Loads are converted to harmonic current sources and initialized based on the power flow solution, according to the Spectrum object associated with each Load.

…

Case III: Fault and Dynamic

- Run.dss file

OpenDSS Code (Perform Dynamic Simulation):

```
Set mode=dynamics number=1 h=0.000166667
solve
Solve number= 10000
get time
get number
```

Explanation:

Mode

…

Mode=Yearly:

Do a solution following the yearly load curves. The solution is repeated as many times as the specified by the Number=option. Each load then follows its yearly load curve. Load is determined solely by the yearly load curve and the growth multiplier.

number

Specifies the number of time steps in each solution.

Case III: Fault and Dynamic

- Run.dss file

OpenDSS Code (Perform Dynamic Simulation):

```
Set mode=dynamics number=1 h=0.000166667
solve
Solve number= 10000
get time
get number
```

Explanation:

h

Also called stepsize. It sets the time step size for the solution of the active circuit. Default unit is second. Normally, this is specified for dynamic solution.

Solve

Solves the circuit.

Solve number= 10000

Specifies the number of solutions in dynamic simulation to run.

Case III: Fault and Dynamic

- Run.dss file

OpenDSS Code (Perform Dynamic Simulation):

```
Set mode=dynamics number=1 h=0.000166667
solve
Solve number= 10000
get time
get number
```

Explanation:

get time

Obtains time values of solutions in dynamic simulation.

get number

Obtains number values of solutions in dynamic simulation.

Case III: Fault and Dynamic

- Run.dss file

OpenDSS Code (Plot Results):

```
Plot monitor object= cb1 channels=(1, 3, 5)
Plot monitor object= cb1 channels=(7, 9, 11)
Plot monitor object= rec1 channels=(1, 3, 5)
Plot monitor object= F1 channels=(1, 3, 5)
```

Explanation:

plot

Displays a variety of results in a variety of manners on graphs.

monitor

Specifies that the type to be plotted is monitor. The Monitor plot plots one or more channels from a Monitor element.

object

Specifies what object to plot.
[metername for Zone plot | Monitor name | File Name for General bus data or Circuit branch data].

Case III: Fault and Dynamic

- Run.dss file

OpenDSS Code (Plot Results):

```
Plot monitor object= cb1 channels=(1, 3, 5)
Plot monitor object= cb1 channels=(7, 9, 11)
Plot monitor object= rec1 channels=(1, 3, 5)
Plot monitor object= F1 channels=(1, 3, 5)
```

Explanation:

channel

Specifies the array of channel numbers for monitor plot. More than one monitor channel can be plotted on the same graph. Example: Channels=[1, 3, 5]

Case III: Fault and Dynamic

- Master.dss file

OpenDSS Code:

```
Clear
New Circuit.NewModel
Redirect Vsource.dss
Redirect LineCode.dss
Redirect LoadShape.dss
Redirect TCC_Curve.dss
Redirect line.dss
Redirect Load.dss
Redirect Transformer.dss
Redirect RegControl.dss
Redirect Capacitor.dss
Redirect Fault.dss
Redirect IndMach012.dss
Redirect Relay.dss
Redirect Recloser.dss
Redirect Fuse.dss
Redirect Monitor.dss
Buscoords buscoords.dat

set voltagebases=(115 12.47 .48)
calcv
```

Case III: Fault and Dynamic

- Vsource.dss file

OpenDSS Code:

```
Edit "Vsource.source" bus1=Bx basekv=115 pu=1.0475 angle=0 frequency=60
phases=3 MVAsc3=20000 MVAsc1=21000 x1r1=4 x0r0=3
```

Explanation:

Edit

Edits the object specified. In this case, the Vsource object named source is edited.

bus1

Specifies the bus to which Vsource is connected.

basekv

Specifies Base or rated Line-to-line kV of Vsource.

pu

Specifies the actual per unit at which the source is operating. It is assumed balanced for all phases.

Angle

Specifies Base angle, in degrees, of the first phase.

Case III: Fault and Dynamic

- Vsource.dss file

OpenDSS Code:

```
Edit "Vsource.source" bus1=Bx basekv=115 pu=1.0475 angle=0 frequency=60
phases=3 MVAsc3=20000 MVAsc1=21000 x1r1=4 x0r0=3
```

Explanation:

frequency

Specifies the frequency of the source.

phases

Specifies the number of phases. Default = 3.0.

MVAsc3

Specifies the 3-phase short circuit MVA.

MVAsc1

Specifies the 1-phase short circuit MVA.

x1r1

Specifies the ratio of X1/R1. Default = 4.0.

x0r0

Specifies the ratio of X0/R0. Default = 3.0.

Case III: Fault and Dynamic

- Linecode.dss file

OpenDSS Code:

```
New "LineCode.3x_336aa_1/0asn" nphases=3 baseFreq=60 normamps=396 emergamps=495
r1=0.05284 x1=0.12447 r0=0.14504 x0=0.41903 c1=3.30053 c0=1.43804 units=kft
…
```

Explanation:

LineCode.3x_336aa_1/0asn

Defines a linecode object named 3x_336aa_1/0asn.

nphases

Specifies the number of phases. Default = 3.

BaseFreq

Specifies the Base Frequency at which the impedance values are specified. Default = 60.0 Hz.

Normamps

Specifies the normal ampacity, in amps.

emergamps

Specifies the emergency ampacity, in amps.

Case III: Fault and Dynamic

- Linecode.dss file

OpenDSS Code:

```
New "LineCode.3x_336aa_1/0asn" nphases=3 baseFreq=60 normamps=396 emergamps=495
r1=0.05284 x1=0.12447 r0=0.14504 x0=0.41903 c1=3.30053 c0=1.43804 units=kft
…
```

Explanation:

r1

Specifies the positive-sequence resistance, in ohms per unit length.

x1

Specifies the positive-sequence reactance, in ohms per unit length.

r0

Specifies the zero-sequence resistance, in ohms per unit length.

x0

Specifies the zero-sequence reactance, in ohms per unit length.

Case III: Fault and Dynamic

- Linecode.dss file

OpenDSS Code:

```
New "LineCode.3x_336aa_1/0asn" nphases=3 baseFreq=60 normamps=396 emergamps=495
r1=0.05284 x1=0.12447 r0=0.14504 x0=0.41903 c1=3.30053 c0=1.43804 units=kft
…
```

Explanation:

c1

Specifies the positive-sequence capacitance, in nanofarads per unit length.

c0

Specifies the zero-sequence capacitance, in nanofarads per unit length.

units

Specifies the length units. If not specified, it is assumed that the units correspond to the length being used in the Line models.
{mi | km | kft | m | ft | in | cm}.

Case III: Fault and Dynamic

- Lodeshape.dss file

OpenDSS Code:

```
New "LoadShape.wind2400" npts=2501 interval=0.000277778 csvfile=WPWind2400.csv
action=normalize
```

Explanation:

New "LoadShape.wind2400"

Defines a loadshape object named wind2400.

Npts

Specifies the number of points to expect when defining the curve.

interval

Specifies the time interval of the data, in Hr. Default=1.0. If the load shape has non-uniformly spaced points, specify the interval as 0.0.

csvfile

Specifies the name of a CSV file containing active power load shape data, one interval to a line.

Case III: Fault and Dynamic

- Lodeshape.dss file

OpenDSS Code:

```
New "LoadShape.wind2400" npts=2501 interval=0.000277778 csvfile=WPWind2400.csv
action=normalize
```

Explanation:

action

{**Normalize** | **DblSave** | **SngSave**} After defining load curve data, setting **action=normalize** will modify the multipliers, so that the peak is 1.0. The mean and std deviation are recomputed.

mean

Specifies the mean of the multiplier array.

stddev

Specifies the standard deviation of the multiplier array.

Case III: Fault and Dynamic

- TCC_Curve.dss file

OpenDSS Code:

```
New "TCC_Curve.a" npts=15 C_array=(1.1, 1.3, 1.5, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 50, 100, )
T_array=(7.1769, 2.2079, 1.234, 0.534, 0.2215, 0.134, 0.0965, 0.0769, 0.0653, 0.0578, 0.0528,
0.0492, 0.0378, 0.0346, 0.0342, )
```

Explanation:

A TCC_Curve object is defined similarly to Loadshape and Growthshape objects in that they all are defined by curves consisting of arrays of points.

New "TCC_Curve.a"

Defines a TCC_curve object named a.

Npts

Number of points to expect when defining the curve.

Case III: Fault and Dynamic

- TCC_Curve.dss file

OpenDSS Code:

```
New "TCC_Curve.a" npts=15 C_array=(1.1, 1.3, 1.5, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 50, 100, )
T_array=(7.1769, 2.2079, 1.234, 0.534, 0.2215, 0.134, 0.0965, 0.0769, 0.0653, 0.0578, 0.0528,
0.0492, 0.0378, 0.0346, 0.0342, )
```

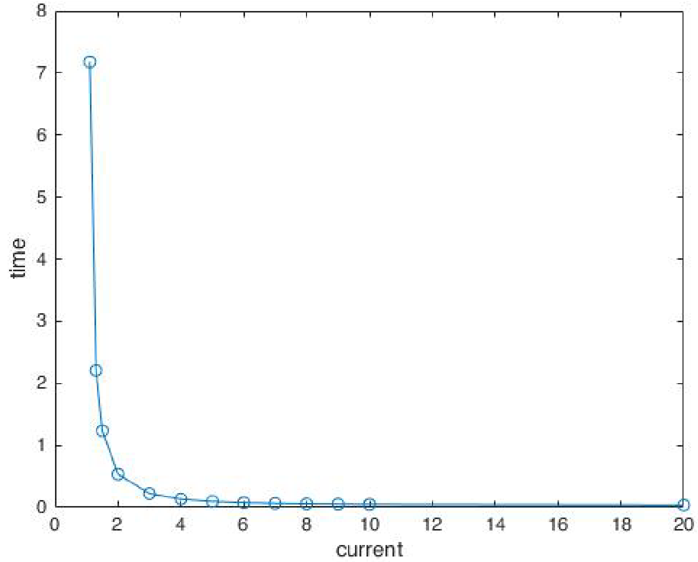
Explanation:

C_Array

Specifies an array of current (or voltage or whatever) values corresponding to time values in T_Array.

T_Array

Specifies an array of time values in seconds. Typical array syntax:
t_array = (1, 2, 3, 4, ...)



Case III: Fault and Dynamic

- Line.dss file

OpenDSS Code:

```
New "line.l1" bus1=B0 bus2=B1 linecode="Unbalanced 336 ACSR" length=10 units=kft
```

Explanation:

New Line.l1

Defines a line object named l1.

Phases

Specifies the number of phases. Default = 3.

Bus1

Specifies the name of bus for terminal 1.

Bus2

Specifies the name of bus for terminal 2.

Case III: Fault and Dynamic

- Line.dss file

OpenDSS Code:

```
New "line.l1" bus1=B0 bus2=B1 linecode="Unbalanced 336 ACSR" length=10 units=kft
```

Explanation:

LineCode

Specifies the name of an existing LineCode object containing impedance definitions.

Length

Specifies the length multiplier to be applied to the impedance data.

Units

Specifies the length units. {none | mi | kft | km | m | Ft | in | cm}.

Case III: Fault and Dynamic

- Load.dss file

OpenDSS Code:

```
New "Load.ldb0" bus1=B0 conn=wye phases=3 kW=0.1 pf=1 model=2 kV=12.47
```

Explanation:

New Load.ldb0

Defines a load object named ldb0.

bus1

Specifies the name of bus to which the load is connected.

conn

Specifies the connection of load. {wye | y | LN} for Wye (Line-Neutral) connection; {delta | LL} for Delta (Line-Line) connection. Default = wye.

phases

Specifies the number of phases of this load.

kw

Specifies the nominal active power, in kW, for the load. Total of all phases.

Case III: Fault and Dynamic

- Load.dss file

OpenDSS Code:

```
New "Load.ldb0" bus1=B0 conn=wye phases=3 kW=0.1 pf=1 model=2 kV=12.47
```

Explanation:

pf

Specifies the nominal power factor for load. Negative PF is leading. Specify either PF or kvar. If both are specified, the last one specified takes precedence.

Model

An integer defining how the load will vary with voltage. The load models currently implemented are:

1: Constant P and constant Q (Default): Commonly used for power flow studies,
2: Constant Z (or constant impedance),
3: Constant P and quadratic Q ($Q/_{Q0} = (V/_{V0})^2$),
4: Exponential: $P/_{P0} = (V/_{V0})^{CVRwatts}$ and $Q/_{Q0} = (V/_{V0})^{CVRvars}$
5: Constant I (or constant current magnitude),

…

Case III: Fault and Dynamic

- Load.dss file

OpenDSS Code:

```
New "Load.ldb0" bus1=B0 conn=wye phases=3 kW=0.1 pf=1 model=2 kV=12.47
```

Explanation:

Model

…

6: Constant P and fixed Q (at the nominal value)
7: Constant P and quadratic Q (i.e., fixed reactance),
8: ZIP
"Constant" power value (either P or Q) may be modified by loadshape multipliers. "Fixed" power values are always the same.

- ZIP model:

$$P = P_0\left[a_1\left(\frac{V}{V_0}\right)^2 + a_2\left(\frac{V}{V_0}\right) + a_3\right]$$

$$Q = Q_0\left[a_4\left(\frac{V}{V_0}\right)^2 + a_5\left(\frac{V}{V_0}\right) + a_6\right]$$

Case III: Fault and Dynamic

- Load.dss file

OpenDSS Code:

```
New "Load.ldb0" bus1=B0 conn=wye phases=3 kW=0.1 pf=1 model=2 kV=12.47
```

Explanation:

kV

Specifies the Base voltage for load. For 2- or 3-phase loads, it is specified in phase-to-phase kV.

For all other loads, it is specified in the actual kV across the load branch. If the load is wye (star) connected, then specify phase-to-neutral (L-N). If the load is delta or phase-to-phase connected, specify the phase-to-phase (L-L) kV.

Case III: Fault and Dynamic

- Transformer.dss file

OpenDSS Code:

```
New "Transformer.sub" phases=3 windings=2 buses=(bx, b0, ) conns=(delta, wye, ) kVs=(115, 12.47, ) kVAs=(20000, 20000, ) taps=(1, 1, ) Xhl=7
```

Explanation:

New "Transformer.sub"

Defines a transformer object named sub.

phases

Specifies the number of phases. Default is 3.

windings

Specifies the number of windings. Default is 2.

buses=(bx, b0,)

Specifies an array of names of buses to which the windings are connected. The above code equals: bus1=bx bus2=b0

bus1: Name of bus for terminal 1.

bus2: Name of bus for terminal 2.

Case III: Fault and Dynamic

- Transformer.dss file

OpenDSS Code:

```
New "Transformer.sub" phases=3 windings=2 buses=(bx, b0, ) conns=(delta, wye, ) kVs=(115,
12.47, ) kVAs=(20000, 20000, ) taps=(1, 1, ) Xhl=7
```

Explanation:

conns=(delta, wye,)

Specifies an array of connections for windings. The connection of winding1 is ‘delta’. The connection of winding2 is ‘wye’.

kvs=(115, 12.47,)

Specifies an array of kV ratings for windings. The rated voltage of winding1 is 115 kV. The rated voltage of winding2 is 12.47kV.

kvas=(20000, 20000,)

Specifies an array of kVA ratings for windings. The base kVA rating of winding1 is 20000 kVA. The base kVA rating of winding2 is 20000kVA.

Case III: Fault and Dynamic

- Transformer.dss file

OpenDSS Code:

```
New "Transformer.sub" phases=3 windings=2 buses=(bx, b0, ) conns=(delta, wye, ) kVs=(115, 12.47, ) kVAs=(20000, 20000, ) taps=(1, 1, ) Xhl=7
```

Explanation:

taps(1, 1,)

Specifies an array of tap positions for windings. The tap position of winding1 is 1. The tap position of winding2 is 1.

xhl

Specifies the percent reactance high-to-low (winding 1 to winding 2).

Case III: Fault and Dynamic

- RegControl.dss file

OpenDSS Code:

```
New "RegControl.reg1a" transformer=Reg1a winding=2 vreg=119.9926 band=3 ptratio=60
delay=15 tapdelay=2 reversible=yes revvreg=119.9926 revband=3 CTprim=600 R=5 X=3
revR=5 revX=3
```

Explanation:

New "RegControl.reg1a"

Defines a regulator control object named reg1a.

transformer

Specifies the name of transformer to which the RegControl is connected.

winding

Specifies the number of the winding of the transformer that the RegControl is monitoring. 1 or 2, typically.

vreg

Specifies the voltage regulator setting, in volts, for the winding being controlled. Default is 120.0

Case III: Fault and Dynamic

- RegControl.dss file

OpenDSS Code:

```
New "RegControl.reg1a" transformer=Reg1a winding=2 vreg=119.9926 band=3 ptratio=60
delay=15 tapdelay=2 reversible=yes revvreg=119.9926 revband=3 CTprim=600 R=5 X=3
revR=5 revX=3
```

Explanation:

band

Specifies the bandwidth, in volts, for the controlled bus. Default is 3.0

ptratio

Specifies the ratio of the PT that converts the controlled winding voltage to the regulator voltage. Default is 60. If the winding is Wye, the line-to-neutral voltage is used. Else, the line-to-line voltage is used.

delay

Specifies the time delay, in seconds, from when the voltage goes out of band to when the tap changing begins. This is used to determine which regulator control will act first. Default is 15.

Case III: Fault and Dynamic

- RegControl.dss file

OpenDSS Code:

```
New "RegControl.reg1a" transformer=Reg1a winding=2 vreg=119.9926 band=3 ptratio=60
delay=15 tapdelay=2 reversible=yes revvreg=119.9926 revband=3 CTprim=600 R=5 X=3
revR=5 revX=3
```

Explanation:

tapdelay

Specifies the delay, in seconds, between tap changes. Default is 2. This is how long it takes between changes after the first change.

reversible

Indicates whether or not the regulator can be switched to regulate in the reverse direction. Default is No. {Yes |No*}

revvreg

Specifies the voltage setting, in volts, for operation in the reverse direction.

Case III: Fault and Dynamic

- RegControl.dss file

OpenDSS Code:

```
New "RegControl.reg1a" transformer=Reg1a winding=2 vreg=119.9926 band=3 ptratio=60
delay=15 tapdelay=2 reversible=yes revvreg=119.9926 revband=3 CTprim=600 R=5 X=3
revR=5 revX=3
```

Explanation:

revband

Specifies the bandwidth for operating in the reverse direction.

CTprim

Specifies the rating, in Amperes, of the primary CT rating for converting the line amps to control amps. The typical default secondary ampere rating is 0.2 Amps.

R

Specifies the R setting on the line drop compensator in the regulator, in volts.

Case III: Fault and Dynamic

- RegControl.dss file

OpenDSS Code:

```
New "RegControl.reg1a" transformer=Reg1a winding=2 vreg=119.9926 band=3 ptratio=60
delay=15 tapdelay=2 reversible=yes revvreg=119.9926 revband=3 CTprim=600 R=5 X=3
revR=5 revX=3
```

Explanation:

X

Specifies the X setting on the line drop compensator in the regulator, in volts.

revR

Specifies the R line drop compensator setting for reverse direction, in volts.

revX

Specifies the X line drop compensator setting for reverse direction, in volts.

Case III: Fault and Dynamic

- Capacitor.dss file

OpenDSS Code:

```
New "Capacitor.c1" conn=wye bus1=B1 phases=3 kvar=( 600) kv=12.47
```

Explanation:

New "Capacitor.c1"

Defines a capacitor object named c1.

Bus1

Specifies the name of bus to which the first bus is connected.

conn

Specifies the connection of bank. One of {wye | ln} for wye connected banks or {delta | ll} for delta (line-line) connected banks.

phases

Specifies the number of phases.

Case III: Fault and Dynamic

- Capacitor.dss file

OpenDSS Code:

```
New "Capacitor.c1" conn=wye bus1=B1 phases=3 kvar=( 600) kv=12.47
```

Explanation:

kVAR

Specifies the rated kvar at rated kV, total of all phases. Each phase is assumed equal.

kV

Specifies the kV rating of the capacitor bank. For Phases=2 or Phases=3, enter line-to-line (phase-to-phase) rated voltage. For all other numbers of phases, enter actual can rating. (For Delta connection this is always line-to-line rated voltage).

Case III: Fault and Dynamic

- Fault.dss file

OpenDSS Code:

```
New "Fault.thefault"  bus1=B3.1 bus2=B3.0 phases=1 r=0.0001 ONtime=.3 temporary=yes
```

Explanation:

A fault object is nothing more than a resistor network with a variety of configurations.

New "Fault.thefault"

Defines a fault object named thefault.

bus1

Specifies the name of first bus the resistor is connected to.

bus2

Specifies the name of second bus the resistor is connected to.

phases

Specifies the number of phases. Default is 1.

Case III: Fault and Dynamic

- Fault.dss file

OpenDSS Code:

```
New "Fault.thefault"  bus1=B3.1 bus2=B3.0 phases=1 r=0.0001 ONtime=.3 temporary=yes
```

Explanation:

r

Specifies the resistance of each phase, in ohms. Default is 0.0001.

ontime

Specifies the time, in seconds, at which the fault is established for time varying simulations.

Temporary

Designates whether the fault is temporary or not.
{Yes | No} Default is No.

Case III: Fault and Dynamic

- IndMach012.dss file

OpenDSS Code:

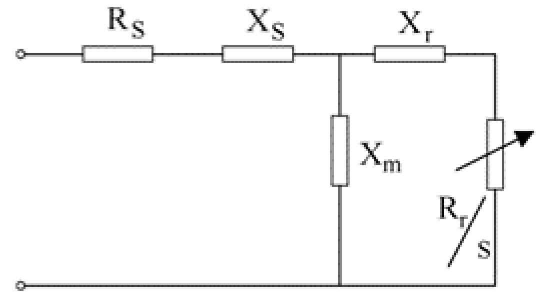
```
New "IndMach012.Motor1" bus1=Bg2 kW=1200 conn=delta kVA=1500.000 H=6
duty=Wind2400 purs=0.048 puxs=0.075 purr=0.018 puxr=0.12 puxm=3.8 slip=0.02
SlipOption=variableslip kv=0.48
```

Explanation:

INDMACH012 is an induction machine (asynchronous machine) model.

$$\begin{cases} \frac{dE'_d}{dt} = -\frac{1}{T'}\left[E'_d + (X - X')I_q\right] - (\omega - 1)E'_q \\ \frac{dE'_q}{dt} = -\frac{1}{T'}\left[E'_q + (X - X')I_d\right] + (\omega - 1)E'_d \\ \frac{d\omega}{dt} = -\frac{1}{2H}\left[(A\omega^2 + B\omega + C)T_0 - (E'_d I_d + E'_q I_q)\right] \end{cases}$$

$$\begin{cases} I_d = \frac{1}{R_s^2 + X'^2}\left[R_s\left(U_d - E'_d\right) + X'\left(U_q - E'_q\right)\right] \\ I_q = \frac{1}{R_s^2 + X'^2}\left[R_s\left(U_q - E'_q\right) - X'\left(U_d - E'_d\right)\right] \end{cases}$$



https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1626370

New "IndMach012.Motor1"

Defines an IndMach012 object named Motor1.

bus1

Specifies the name of bus to which the machine is connected.

kW

Specifies the shaft power, in kW, for the Induction Machine. A positive value denotes power for a load. Negative value denotes an induction generator. Total of all phases.

Case III: Fault and Dynamic

- IndMach012.dss file

OpenDSS Code:

```
New "IndMach012.Motor1" bus1=Bg2 kW=1200 conn=delta kVA=1500.000 H=6
duty=Wind2400 purs=0.048 puxs=0.075 purr=0.018 puxr=0.12 puxm=3.8 slip=0.02
SlipOption=variableslip kv=0.48
```

Explanation:

conn

Specifies the connection of stator: Delta or Wye. Default is Delta.

kVA

Specifies the rated kVA for the machine.

H

Specifies the per unit mass constant of the machine. In MW-sec/MVA. Default is 1.0.

duty

Specifies the load shape to use for simulations.

Case III: Fault and Dynamic

- IndMach012.dss file

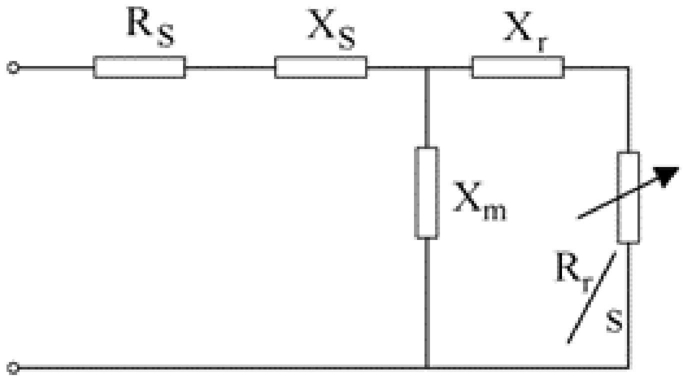
OpenDSS Code:

```
New "IndMach012.Motor1" bus1=Bg2 kW=1200 conn=delta kVA=1500.000 H=6
duty=Wind2400 purs=0.048 puxs=0.075 purr=0.018 puxr=0.12 puxm=3.8 slip=0.02
SlipOption=variableslip kv=0.48
```

Explanation:

purs

Specifies the per unit stator resistance. Default is 0.0053.



puxs

Specifies the per unit stator leakage reactance. Default is 0.106.

purr

Specifies the per unit rotor resistance. Default is 0.007.

puxr

Specifies the per unit rotor leakage reactance. Default is 0.12.

Case III: Fault and Dynamic

- IndMach012.dss file

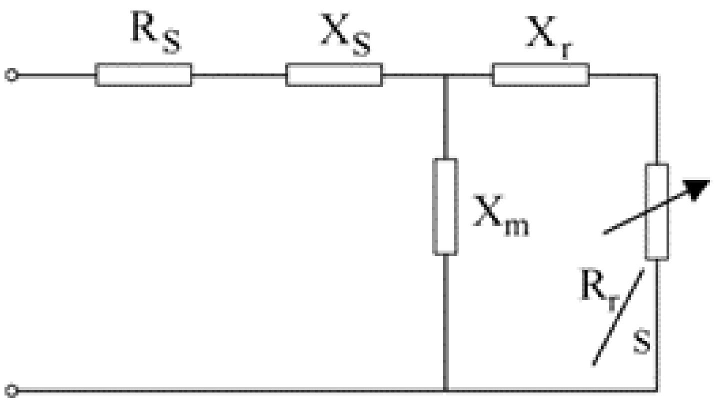
OpenDSS Code:

```
New "IndMach012.Motor1" bus1=Bg2 kW=1200 conn=delta kVA=1500.000 H=6
duty=Wind2400 purs=0.048 puxs=0.075 purr=0.018 puxr=0.12 puxm=3.8 slip=0.02
SlipOption=variableslip kv=0.48
```

Explanation:

puxm

Specifies the per unit magnetizing reactance. Default is 4.0.



slip

Specifies the initial slip value. Default is 0.007.

SlipOption

Specifies the option for slip model. One of {fixedslip | variableslip* }. Variable slip is the default and slip will be computed to satisfy the power specification. If fixed slip, kW is computed to match the slip specification.

Case III: Fault and Dynamic

- IndMach012.dss file

OpenDSS Code:

```
New "IndMach012.Motor1" bus1=Bg2 kW=1200 conn=delta kVA=1500.000 H=6
duty=Wind2400 purs=0.048 puxs=0.075 purr=0.018 puxr=0.12 puxm=3.8 slip=0.02
SlipOption=variableslip kv=0.48
```

Explanation:

kv

Specifies the Base voltage for the induction machine. For 2- or 3-phase generators, specified in phase-to-phase kV. For all other generators, the actual kV across the generator branch. If wye (star) connected, specify the phase-to-neutral (L-N) kV. If delta or phase-to-phase connected, specify the phase-to-phase (L-L) kV.

Case III: Fault and Dynamic

- Relay.dss file

OpenDSS Code:

```
New "Relay.mfrov/uv" MonitoredObj=line.MotorLeads MonitoredTerm=1 type=voltage  kvbase=0.48 Delay=0
New "Relay.mfr46" MonitoredObj=line.MotorLeads MonitoredTerm=1 type=46 46BaseAmps=1800
46%Pickup=20 46isqt=1 Delay=0.1
New "Relay.mfr47" MonitoredObj=line.MotorLeads MonitoredTerm=1 type=47 kvbase=0.48 47%Pickup=2
Delay=0.1
```

Explanation:

Relays are used to control distribution circuit breakers. The inverse time overcurrent characteristics is commonly used. An inverse time-current characteristic means that the relay will operate faster with increased current.

New "Relay.mfrov/uv"

Defines a relay object named mfrov/uv.

MonitoredObj

Specifies the full object name of the circuit element, typically a line, transformer, load, or generator, to which the relay's PT and/or CT are connected. This is the "monitored" element. There is no default; must be specified.

Case III: Fault and Dynamic

- Relay.dss file

OpenDSS Code:

```
New "Relay.mfrov/uv" MonitoredObj=line.MotorLeads MonitoredTerm=1 type=voltage  kvbase=0.48 Delay=0
New "Relay.mfr46" MonitoredObj=line.MotorLeads MonitoredTerm=1 type=46 46BaseAmps=1800
46%Pickup=20 46isqt=1 Delay=0.1
New "Relay.mfr47" MonitoredObj=line.MotorLeads MonitoredTerm=1 type=47 kvbase=0.48 47%Pickup=2
Delay=0.1
```

Explanation:

MonitoredTerm

Specifies the number of the terminal of the circuit element to which the Relay is connected. 1 or 2, typically. Default is 1.

type

Specifies the type of the relay. Voltage: undervoltage and overvoltage protection.
46: negative sequence current protection.
47: negative sequence voltage protection.

Case III: Fault and Dynamic

- Relay.dss file

OpenDSS Code:

```
New "Relay.mfrov/uv" MonitoredObj=line.MotorLeads MonitoredTerm=1 type=voltage  kvbase=0.48 Delay=0
New "Relay.mfr46" MonitoredObj=line.MotorLeads MonitoredTerm=1 type=46 46BaseAmps=1800
46%Pickup=20 46isqt=1 Delay=0.1
New "Relay.mfr47" MonitoredObj=line.MotorLeads MonitoredTerm=1 type=47 kvbase=0.48 47%Pickup=2
Delay=0.1
```

Explanation:

kvase

Specifies the voltage base (kV) for the relay. Specify line-line for 3 phase devices); line-neutral for 1-phase devices.

delay

Specifies the trip time delay, in seconds, for definite time relays.

46BaseAmps

Specifies the Base current, in amps, for 46 relay (neg seq current).

Case III: Fault and Dynamic

- Relay.dss file

OpenDSS Code:

```
New "Relay.mfrov/uv" MonitoredObj=line.MotorLeads MonitoredTerm=1 type=voltage  kvbase=0.48 Delay=0
New "Relay.mfr46" MonitoredObj=line.MotorLeads MonitoredTerm=1 type=46 46BaseAmps=1800
46%Pickup=20 46isqt=1 Delay=0.1
New "Relay.mfr47" MonitoredObj=line.MotorLeads MonitoredTerm=1 type=47 kvbase=0.48 47%Pickup=2
Delay=0.1
```

Explanation:

46%Pickup

Specifies the percent pickup current for 46 relay (neg seq current). Default is 20.0.

46isqt

Specifies the negative-sequence I-squared-t trip value for 46 relay. Default is 1 (trips in 1 sec for 1 per unit neg-seq current). Should be 1 to 99.

47%Pickup

Specifies the percent voltage pickup for 47 relay (Neg seq voltage). Default is 2.

Case III: Fault and Dynamic

- Recloser.dss file

OpenDSS Code:

```
New "Recloser.cb1" MonitoredObj=Line.L1 MonitoredTerm=1 NumFast=4 PhaseFast=Ext_Inv
PhaseDelayed=Ext_Inv PhaseTrip=800 TDPhFast=1 TDPhDelayed=1 PhaseInst=2400
GroundFast=Ext_Inv GroundDelayed=Ext_Inv GroundTrip=800 TDGrFast=1 TDGrDelayed=1
GroundInst=1200 Shots=4 RecloseIntervals=(0.5, 2, 2, )
```

A recloser is a self-controlled device for automatically ***interrupting*** and ***reclosing*** an alternating-current circuit, with a predetermined ***sequence*** of opening and reclosing followed by resetting, hold closed, or lockout.

http://c03.apogee.net/contentplayer/?coursetype=foe&utilityid=mp&id=4488

Case III: Fault and Dynamic

- Recloser.dss file

OpenDSS Code:

```
New "Recloser.cb1" MonitoredObj=Line.L1 MonitoredTerm=1 NumFast=4 PhaseFast=Ext_Inv
PhaseDelayed=Ext_Inv PhaseTrip=800 TDPhFast=1 TDPhDelayed=1 PhaseInst=2400
GroundFast=Ext_Inv GroundDelayed=Ext_Inv GroundTrip=800 TDGrFast=1 TDGrDelayed=1
GroundInst=1200 Shots=4 RecloseIntervals=(0.5, 2, 2, )
```

Explanation:

New "Recloser.cb1"

Defines a recloser object named cb1.

MonitoredObj

Specifies the full object name of the circuit element, typically a line, transformer, load, or generator, to which the Recloser's PT and/or CT are connected. This is the "monitored" element. There is no default; must be specified.

MonitoredTerm

Specifies the number of the terminal of the circuit element to which the Recloser is connected. 1 or 2, typically. Default is 1.

Case III: Fault and Dynamic

- Recloser.dss file

OpenDSS Code:

```
New "Recloser.cb1" MonitoredObj=Line.L1 MonitoredTerm=1 NumFast=4 PhaseFast=Ext_Inv
PhaseDelayed=Ext_Inv PhaseTrip=800 TDPhFast=1 TDPhDelayed=1 PhaseInst=2400
GroundFast=Ext_Inv GroundDelayed=Ext_Inv GroundTrip=800 TDGrFast=1 TDGrDelayed=1
GroundInst=1200 Shots=4 RecloseIntervals=(0.5, 2, 2, )
```

Explanation:

NumFast

Specifies the number of Fast (fuse saving) operations. Default is 1.

Fast and delayed operation: The trip operations of the recloser can be all fast, all delayed, or any combination of fast operations, followed by delayed operations up to a maximum total of four. Fast operations clear temporary faults before branch line fuses are damaged. Delayed operations allow time for fuses or other downline protective devices to clear to limit permanent faults to the smallest section of line.

phaseFast

Specifies the name of the TCC Curve object that determines the Phase Fast trip.

Case III: Fault and Dynamic

- Recloser.dss file

OpenDSS Code:

```
New "Recloser.cb1" MonitoredObj=Line.L1 MonitoredTerm=1 NumFast=4 PhaseFast=Ext_Inv
PhaseDelayed=Ext_Inv PhaseTrip=800 TDPhFast=1 TDPhDelayed=1 PhaseInst=2400
GroundFast=Ext_Inv GroundDelayed=Ext_Inv GroundTrip=800 TDGrFast=1 TDGrDelayed=1
GroundInst=1200 Shots=4 RecloseIntervals=(0.5, 2, 2, )
```

Explanation:

PhaseDelayed

Specifies the name of the TCC Curve object that determines the Phase Delayed trip.

PhaseTrip

Specifies a Multiplier or actual phase amps for the phase TCC curve. Defaults to 1.0.

TDPhFast

Specifies a time dial for Phase Fast trip curve. It is a multiplier on time axis of specified curve. Default=1.0.

TDPhDelayed

Specifies a time dial for Phase Delayed trip curve. It is a multiplier on time axis of specified curve. Default=1.0.

Case III: Fault and Dynamic

- Recloser.dss file

OpenDSS Code:

```
New "Recloser.cb1" MonitoredObj=Line.L1 MonitoredTerm=1 NumFast=4 PhaseFast=Ext_Inv
PhaseDelayed=Ext_Inv PhaseTrip=800 TDPhFast=1 TDPhDelayed=1 PhaseInst=2400
GroundFast=Ext_Inv GroundDelayed=Ext_Inv GroundTrip=800 TDGrFast=1 TDGrDelayed=1
GroundInst=1200 Shots=4 RecloseIntervals=(0.5, 2, 2, )
```

Explanation:

PhaseInst

Specifies the actual amps (Current relay) or kW (reverse power relay) for instantaneous phase trip which is assumed to happen in 0.01 sec + Delay Time. Default is 0.0, which signifies no instantaneous trip.

GroundFast

Specifies the name of the TCC Curve object that determines the Ground Fast trip.

GroundDelayed

Specifies the name of the TCC Curve object that determines the Ground Delayed trip.

Case III: Fault and Dynamic

- Recloser.dss file

OpenDSS Code:

```
New "Recloser.cb1" MonitoredObj=Line.L1 MonitoredTerm=1 NumFast=4 PhaseFast=Ext_Inv
PhaseDelayed=Ext_Inv PhaseTrip=800 TDPhFast=1 TDPhDelayed=1 PhaseInst=2400
GroundFast=Ext_Inv GroundDelayed=Ext_Inv GroundTrip=800 TDGrFast=1 TDGrDelayed=1
GroundInst=1200 Shots=4 RecloseIntervals=(0.5, 2, 2, )
```

Explanation:

GroundTrip

Specifies a multiplier or actual ground amps (3I0) for the ground TCC curve. Defaults to 1.0.

TDGrFast

Specifies the time dial for Ground Fast trip curve. It is a multiplier on time axis of specified curve. Default=1.0.

TDGrDelayed

Specifies the time dial for Ground Delayed trip curve. It is a multiplier on time axis of specified curve. Default=1.0.

Case III: Fault and Dynamic

- Recloser.dss file

OpenDSS Code:

```
New "Recloser.cb1" MonitoredObj=Line.L1 MonitoredTerm=1 NumFast=4 PhaseFast=Ext_Inv
PhaseDelayed=Ext_Inv PhaseTrip=800 TDPhFast=1 TDPhDelayed=1 PhaseInst=2400
GroundFast=Ext_Inv GroundDelayed=Ext_Inv GroundTrip=800 TDGrFast=1 TDGrDelayed=1
GroundInst=1200 Shots=4 RecloseIntervals=(0.5, 2, 2, )
```

Explanation:

GroundInst

Specifies the actual amps for instantaneous ground trip which is assumed to happen in 0.01 sec + Delay Time. Default is 0.0, which signifies no instantaneous trip.

shots

Specifies the total Number of fast and delayed shots to lockout. Default is 4. This is one more than the number of reclose intervals.

RecloseIntervals

Specifies an array of reclose intervals. Default for Recloser is (0.5, 2.0, 2.0) seconds.

Case III: Fault and Dynamic

- Fuse.dss file

OpenDSS Code:

```
New "Fuse.f1" MonitoredObj=Line.L6 MonitoredTerm=1 FuseCurve=Klink RatedCurrent=65
```

Explanation:

- Fuses have elements that melt if enough current flows through it for enough time.
- Industry standards specify two types of expulsion fuses.
  - K-type: fast fuse with speed ratio of 6-8
  - T-type: slower fuse with speed ratio of 10-13
- The speed ratio is the ratio of
  - The melting current at 0.1 second to
  - the melting current at X seconds, where X is 300 for fuse ratings below 100 amps and X is 600 for fuse ratings above 100 amps.

The current rating is the level of current the fuse can safely carry for an indefinite period of time.

Case III: Fault and Dynamic

- Fuse.dss file

OpenDSS Code:

```
New "Fuse.f1" MonitoredObj=Line.L6 MonitoredTerm=1 FuseCurve=Klink RatedCurrent=65
```

Explanation:

New "Fuse.f1"

Defines a fuse object named f1.

MonitoredObj

Specifies the full object name of the circuit element, typically a line, transformer, load, or generator, to which the Fuse is connected. This is the "monitored" element. There is no default; must be specified.

MonitoredTerm

Specifies the number of the terminal of the circuit element to which the Fuse is connected. 1 or 2, typically. Default is 1.

Case III: Fault and Dynamic

- Fuse.dss file

OpenDSS Code:

```
New "Fuse.f1" MonitoredObj=Line.L6 MonitoredTerm=1 FuseCurve=Klink RatedCurrent=65
```

Explanation:

Fusecurve

Specifies the name of the TCC Curve object that determines the fuse blowing.

RatedCurrent

Specifies a multiplier or actual phase amps for the phase TCC curve. Defaults to 1.0.

Case III: Fault and Dynamic

- Monitor.dss file

OpenDSS Code:

```
New "Monitor.cb1" element=Line.L1 terminal=1 mode=0
```

Explanation:

New "Monitor.cb1"

Defines a monitor object named cb1.

element

Specifies the name of an existing circuit element to which the monitor is to be connected.

terminal

Specifies the number of the terminal to which the monitor will be connected.

mode

An integer bitmask code to describe what the monitor will save. Monitors can save two basic types of quantities: 1) Voltage and current; 2) Power. The Mode codes are defined as follows:

0: Standard mode - V and I, each phase, complex

…

Case III: Fault and Dynamic

- Monitor.dss file

OpenDSS Code:

```
New "Monitor.cb1" element=Line.L1 terminal=1 mode=0
```

Explanation:

mode

…

1: Power each phase, complex (kw and kvars)

2: Transformer taps (connect Monitor to a transformer winding)

3: State variables (connect Montor to a PCElement)

4: Flicker level and severity index (Pst) for voltages.

5: Solution variables (Iterations, etc). Normally, these would be actual phasor quantities from solution.

6: Capacitor Switching

+16: Sequence components: V012, I012

+32: Magnitude only

+64: Positive Seqence only or Average of phases, if not 3 phases.

For example, Mode=33 (33=1+32) will save the magnitude of the power (kVA) only in each phase. Mode=112 (0+16+32+64) saves Positive sequence voltages and currents, magnitudes only.

Thank you!