MA-OpenDSS User Manual

(Version 1.2)

Sep. 16, 2018

This document describes how to do simple scripting of dynamic simulations by MA-OpenDSS. There are two newly developed models to achieve the multi-agent control and optimization: Fmonitor and Generic5.

Generic5

Generic5 is a generic model for inverter based DG, which has an open form of control feedback and can be control either locally or from network. An example model is as bellow:

$$\begin{cases} P_{DG_i} = V_{DG_i}(t) I_{d_i} \\ \dot{I}_{p_i} = v_{i_1} \end{cases} \qquad \begin{cases} Q_{DG_i} = V_{DG_i}(t) I_{q_i} \\ \dot{I}_{q_i} = v_{i_2} \end{cases}$$

Property	Description
Bus1	Bus to which the Induction Machine is connected. May include specific node specification.
Ctrl_mode	Defien the contrl modes. For example: (1) ctrl_mode =0: Three phase DG sequence control; ctrl_mode =1: Single phase DG, control is on Phase A; (2) ctrl_mode =2: Single phase DG, control is on Phase B; (3) ctrl_mode =3: Single phase DG, control is on Phase C; (4) ctrl_mode =4: Three phase DG, control is on Phase C;
kcd	The local control gain on real power.
kcq	The local control gain on reactive power.
kv	Nominal rated (1.0 per unit) voltage, kV. For 2- and 3-phase machines, specify phase-phase kV. Otherwise, specify actual kV across each branch of the machine. If wye (star), specify phase-neutral kV. If delta or phase-phase connected, specify phase-phase kV.
kW	Shaft Power, kW. Output limit of a DG
P_refkW	Ref P Value (kW). P_ref has prority to kW which is nomimal

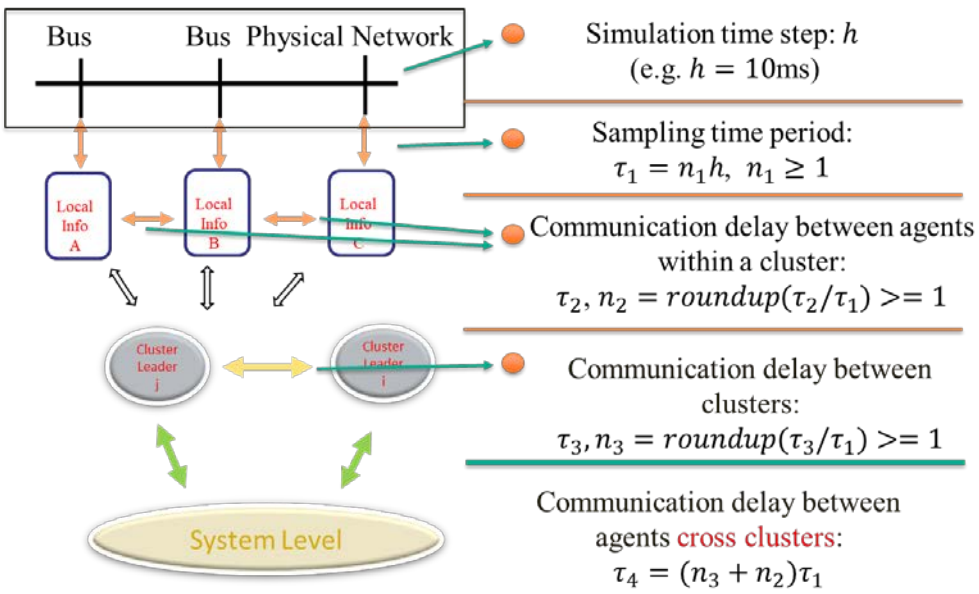
	value. (Incide variable P_ref is W)
V_refkVLN	Reference Voltage. V_ref (Unit kV, L-N value) work only when QV_flag=1
Volt_Trhd	Threshhold for voltage control. 0.~0.05. 0 means v has to follow v_ref
Q_refkVAr	Reference Q Value: work only when QV_flag=0
QV_flag	QV_flag : 0-Q_ref mode; 1- V_ref mode
CC_Switch	CC_Switch = true: network level control is on; CC_Switch = false: network level control is off.

Examples

```
New Generic5.g1  bus1=76  phases=3  kVA=2100  kV= 4.16  kW=1750  P_refkW=10  V_refkVLN =2.402
Q_refkVAr=0  ctrl_mode=0  QV_flag=1  kcd=0.2  kcq=2 Volt_Trhd=0.01  cc_switch=f
New Generic5.g2  bus1=83  phases=3  kVA=2100  kV= 4.16  kW=1750  P_refkW=10  V_refkVLN =2.402
Q_refkVAr=0  ctrl_mode=0  QV_flag=1  kcd=0.2  kcq=2 Volt_Trhd=0.01  cc_switch=f
```

Fmonitor

Fmonitor is the model of communication in distribution network that follows the OpenFMB design. To enable the cooperative control scheme, a standard and scalable communication structure is implemented as an upper layer design over physical systems in this platform. A standard interface (‘Cluster’ and ‘node’) is established in this structure which can be used to simulate both distributed or centralized communication topology. The buses in power systems can be arranged with clusters and nodes. Within a cluster, each node can communicate to others which DGs might be attached to. By this approach, the communication could be an independent part of the platform. To study the response time of the cooperative control, we improved the dynamic simulation of MA-OpenDSS.



FMonitor defines the clusters of a distribution system, which the multi-agent distributed control can be implemented upon. The properties of Fmonitor are the following.

Property	Description
Cluster_num	The cluster number.
Element	Name (Full Object name) of element to which is the virtual leader of this cluster.
Terminal	Number of the terminal of the circuit element to which the virtual leader is connected. 1 or 2, typically.
Nodes	Nodes connected to this FMonitor. Example:(Nodes=33)
ElemTableLine	Define each node within this cluster. The first entry of this vector is the number of node within cluster; The second is bus name; The third is the measured element name; The forth is terminal number; The fifth is voltage base; The last the control gain of network level control.
CommVector	Define the communication vector of each node in this FMonitor. The first entry of this vector is the node number.
T_intvl_smpl	The time period that indicates the information of each agent will be sampled at each node. T_intvl_smpl is also the minimal communication time between neighbor nodes. If T_intvl_smpl=0.0, no delay for the communication is enabled in the simulation.
MaxLocalMem	The max number of local memory size of each agent. No larger than 99.

b_Curt_Ctrl	Set P curtailment on/off; b_Curt_Ctrl=True: P curtailment will be implemented according to the system voltage (default); b_Curt_Ctrl=False: P curtailment will not be implemented.
CommDelayVector	Set the time delay between agents in this FMonitor. The first entry of this vector is the number of the node. The example show node #2 can communicate to node #1 and #3 with time delay t1 and t2 seperately
up_dly	Delay time to upper level. For example: "up_dly := 0.05" It can be used to simulate the time delay between clusters
Volt_limits_pu	Define the voltage limits of this cluster, will be used on the network level control. Exmaple "Volt_limits_pu={a0,a1, a2}" a0: the phase number, 0 means pos. seq; a1: upper voltage limit of this cluster, usually 1.05; a2: upper voltage limit of this cluster, usually 0.95

Examples

New "Fmonitor.FM3" Cluster_num=3 element=Line.LN5956470-1 terminal=1 Nodes=2 t_intvl_smpl=0.0 up_dly=0.0 MaxLocalMem =60 Volt_limits_pu={the 0,1.05, 0.96}
Fmonitor.FM3.ElemTableLine={1, M1069311, Line.LN5965099-2, 2, 7.2, 1.0}
Fmonitor.FM3.ElemTableLine={2, L3159448, Line.LN5965099-9, 2, 7.2, 1.0}

Fmonitor.FM3.CommVector={1,1,1}
Fmonitor.FM3.CommVector={2,1,1}

Fmonitor.FM3.CommDelayVector={1, 0, 0.1}
Fmonitor.FM3.CommDelayVector={2, 0.1, 0

Plot monitor object= dg_g2 channels=(31) !

Simulations:

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Example of IEEE123 system

Compile (IEEE123Master.dss)

!=-=

```
New Generic5.g1  bus1=76  phases=3  kVA=2100  kV= 4.16  kW=1750  P_refkW=10  V_refkVLN =2.402
Q_refkVAr=0  ctrl_mode=0  QV_flag=1  kcd=0.2  kcq=2 droop=2  kcq_DRP2=0.06 Volt_Trhd=0.01  cc_switch=t
New Generic5.g2  bus1=83  phases=3  kVA=2100  kV= 4.16  kW=1750  P_refkW=10  V_refkVLN =2.402
Q_refkVAr=0  ctrl_mode=0  QV_flag=1  kcd=0.2  kcq=2 droop=2  kcq_DRP2=0.06 Volt_Trhd=0.01  cc_switch=t

!=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=

Set VoltageBases = [4.16, 0.48]    ! ARRAY OF VOLTAGES IN KV
CalcVoltageBases  ! PERFORMS ZERO LOAD POWER FLOW TO ESTIMATE VOLTAGE BASES

set maxiterations = 500

solve

///////////////////////////min, midmin, max, midmax
RegControl.creg1a.tapnum =4//  0   // 2  //  6  // 4
RegControl.creg2a.tapnum = 1// 0   // 1  //  0  // 1
RegControl.creg3a.tapnum = 2// 1   // 1  //  2  // 2
RegControl.creg4a.tapnum = 4 // 0  //  2  //  4  // 4
RegControl.creg3c.tapnum = 0 // 0  //  1  //  0  // 0
RegControl.creg4b.tapnum =  -1//-1  //  -1  // 1  //-1
RegControl.creg4c.tapnum =  1// 0  //  0   // -1 //1
RegControl.creg1a.maxtapchange=0  Delay=7 TapDelay=2
RegControl.creg2a.maxtapchange=0  Delay=7 TapDelay=2
RegControl.creg3a.maxtapchange=0  Delay=7 TapDelay=2
RegControl.creg4a.maxtapchange=0  Delay=7 TapDelay=2
RegControl.creg3c.maxtapchange=0  Delay=9 TapDelay=2
RegControl.creg4b.maxtapchange=0  Delay=9 TapDelay=2
RegControl.creg4c.maxtapchange=0  Delay=9 TapDelay=2

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
New "Fmonitor.FM1" element=Line.L115  terminal=1 Cluster_num=1 Nodes=2 t_intvl_smpl=0.05 MaxLocalMem
=60 b_Curt_Ctrl=f
Fmonitor.FM1.ElemTableLine={1, 76,  Line.L73,  2,  2.402,  1}
Fmonitor.FM1.ElemTableLine={2, 83,  Line.L84,  2,  2.402,  1}

Fmonitor.FM1.CommVector={1,1,1}
Fmonitor.FM1.CommVector={2,1,1}

Fmonitor.FM1.CommDelayVector={1, 0,  0.05}
Fmonitor.FM1.CommDelayVector={2, 0.05,  0 }

solve
!Show Voltages ln
show powers elem

!=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-
!--dynamic-----
New "Monitor.dg_g1" element=Generic5.g1 terminal=1 mode=3
New "Monitor.dg_g2" element=Generic5.g2 terminal=1 mode=3

Set mode=dynamics number=1 h=0.01

Solve number= 200

/* Set Fault*/
!Load.S76a.enabled = false
!Load.S48.kW =1200
!Load.S48.kW =-600
Generic5.g1.P_refkW=1650
Generic5.g2.P_refkW=1650

Generic5.g1.kcq=5
Generic5.g2.kcq=5

Solve number= 1000

Solve number= 3
```

Solve number= 4000

Plot monitor object= dg_g1 channels=(1) !
!Plot monitor object= dg_g1 channels=(2) !
Plot monitor object= dg_g2 channels=(1) !
!Plot monitor object= dg_g2 channels=(3) !

Plot monitor object= dg_g1 channels=(17)
Plot monitor object= dg_g2 channels=(17) !
Plot monitor object= dg_g1 channels=(31)
Plot monitor object= dg_g2 channels=(31) !

Example of 11k system

Compile (master.dss)

New Energymeter.m1 Line.ln5815900-1 1

Set Maxiterations=800 ! Sometimes the solution takes more than the default 15 iterations
Set maxcontroliter = 200

set Loadmult = 0.6

New Generic5.PV1 phases=3 bus1=m1027039 kV=7.2 kVA=4880 kW=2400 P_refkW=10 ctrl_mode=0 QV_flag=1 V_refkVLN = 7.2 Q_refkVAr=0 cc_switch=t Volt_Trhd=0.03 V_refkVLN = 7.2 kcd=0.5000 kcq=0.05 kqi=0.003
New Generic5.PV2 phases=3 bus1=M1027043 kV=7.2 kVA=4880 kW=2400 P_refkW=10 ctrl_mode=0 QV_flag=1 V_refkVLN = 7.2 Q_refkVAr=0 cc_switch=t Volt_Trhd=0.03 V_refkVLN = 7.2 kcd=0.5000 kcq=0.05 kqi=0.0030

New Generic5.PV3 phases=3 bus1=e203026 kV=7.2 kVA=4880 kW=2400 P_refkW=10 ctrl_mode=0 QV_flag=1 V_refkVLN = 7.2 Q_refkVAr=0 cc_switch=t Volt_Trhd=0.03 V_refkVLN = 7.2 kcd=0.5000 kcq=0.05 kqi=0.0030
New Generic5.PV4 phases=3 bus1=M1009650 kV=7.2 kVA=4880 kW=2400 P_refkW=10 ctrl_mode=0 QV_flag=1 V_refkVLN = 7.2 Q_refkVAr=0 cc_switch=t Volt_Trhd=0.03 V_refkVLN = 7.2 kcd=0.5000 kcq=0.05 kqi=0.003

Set overloadreport=true

Redirect regtaps.dss
set Loadmult = 0.6
!set Loadmult = 0.57

_Solvenocontrol

/* FM1*/
New "Fmonitor.FM1" Cluster_num=1 element=Line.LN5956470-1 terminal=1 Nodes=2 t_intvl_smpl=0.05 up_dly=1 MaxLocalMem =60 b_Curt_Ctrl=t
Fmonitor.FM1.ElemTableLine={1, M1027039, Line.LN5532750-1, 2, 7.200000, 1}
Fmonitor.FM1.ElemTableLine={2, M1027043, Line.LN5472354-1, 2, 7.200000, 1}

Fmonitor.FM1.CommVector={1,1,1}
Fmonitor.FM1.CommVector={2,1,1}

Fmonitor.FM1.CommDelayVector={1, 0, 0.1}
Fmonitor.FM1.CommDelayVector={2, 0.1, 0 }
/* FM2*/
New "Fmonitor.FM2" Cluster_num=1 element=Line.LN5956470-1 terminal=1 Nodes=2 t_intvl_smpl=0.05 up_dly=1 MaxLocalMem =60 b_Curt_Ctrl=t
Fmonitor.FM2.ElemTableLine={1, M1009650, Line.LN5800693-1, 2, 7.200000, 1}
Fmonitor.FM2.ElemTableLine={2, E203026, Line.LN6044631-1, 2, 7.200000, 1}

```
Fmonitor.FM2.CommVector={1,1,1}
Fmonitor.FM2.CommVector={2,1,1}

Fmonitor.FM2.CommDelayVector={1, 0,  0.1}
Fmonitor.FM2.CommDelayVector={2, 0.1,  0 }

/*FM3*/
New "Fmonitor.FM3" Cluster_num=3 element=Line.LN5956470-1  terminal=1  Nodes=2 t_intvl_smpl=0.05
up_dly=1  MaxLocalMem =60 Volt_limits_pu={0,1.05, 0.97}
Fmonitor.FM3.ElemTableLine={1,  M1069311,  Line.LN5965099-2,   2,  7.2,  1.0}
Fmonitor.FM3.ElemTableLine={2,  L3159448,  Line.LN5965099-9,    2,  7.2, 1.0}

Fmonitor.FM3.CommVector={1,1,1}
Fmonitor.FM3.CommVector={2,1,1}

Fmonitor.FM3.CommDelayVector={1, 0,  0.1}
Fmonitor.FM3.CommDelayVector={2, 0.1,  0

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

_Solvenocontrol


!plot profile ph=all
plot profile ph=primary
show power ln elem
show voltage ln
!show overload

New "Monitor.dg_g1" element=Generic5.PV1    terminal=1 mode=3
New "Monitor.dg_g2" element=Generic5.PV2    terminal=1 mode=3
New "Monitor.dg_g3" element=Generic5.PV3    terminal=1 mode=3
New "Monitor.dg_g4" element=Generic5.PV4    terminal=1 mode=3
New "Monitor.lwstbus" element=Line.LN5965099-2  terminal=2 mode=16

Set mode=dynamics number=1 h=0.01

Solve number= 1

Solve number= 200


/*disturbance*/
Generic5.PV1.kW=2400  ! set max p output
Generic5.PV1.P_refkW=2400
Generic5.PV2.kW=2400
Generic5.PV2.P_refkW=2400
Generic5.PV3.kW=2400 ! the max p output
Generic5.PV3.P_refkW=2400
Generic5.PV4.kW=2400 ! the max p output
Generic5.PV4.P_refkW=2400


Generic5.PV1.kcq=0.5
Generic5.PV2.kcq=0.5
Generic5.PV3.kcq=0.5
Generic5.PV4.kcq=0.5


Solve number= 1000
Solve number= 6000

Plot monitor object= dg_g1 channels=(1) !
Plot monitor object= dg_g1 channels=(2) !
Plot monitor object= dg_g3 channels=(1) !
Plot monitor object= dg_g1 channels=(3) !
Plot monitor object= dg_g3 channels=(3) !
Plot monitor object= dg_g3 channels=(1) !
Plot monitor object= dg_g3 channels=(2) !
```

Plot monitor object= dg_g3 channels=(32)
Plot monitor object= dg_g3 channels=(33)
Plot monitor object= dg_g3 channels=(31) !

Plot monitor object= dg_g1 channels=(17)
Plot monitor object= dg_g2 channels=(17) !
Plot monitor object= dg_g1 channels=(32)
Plot monitor object= dg_g1 channels=(33)
Plot monitor object= dg_g1 channels=(31) !
Plot monitor object=lwstbus channels=(3) !

Plot monitor object= dg_g3 channels=(17)
Plot monitor object= dg_g4 channels=(17) !
Plot monitor object= dg_g2 channels=(21) !
Plot monitor object= dg_g1 channels=(21) !