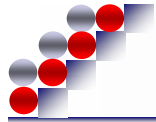


# Power system analyses (Dynamic modeling)

Using PSS/E for power system analyses  
- Load modeling and others -

Istanbul, May 2011





# Load characteristics

- Load characteristic is described by load parameters according to following equations:

$$P = P_0 (\Delta V/V_0)^\alpha (\Delta f/f_0)^\gamma$$

$$Q = Q_0 (\Delta V/V_0)^\beta (\Delta f/f_0)^\delta$$

P0

- nominal active power of load,

Q0

- nominal reactive power of load,

V0

- nominal bus voltage,

f0

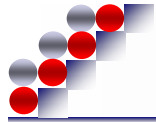
- nominal frequency

$\alpha$ ,  $\beta$ ,  $\gamma$  and  $\delta$

- coefficients that describe voltage and frequency dependences

	kpv	kqv	kpf	kqf
	dP/dV	dQ/dV	dP/df	dQ/df
	alpha	beta	gamma	delta
Public Lighting	0.96	7.4	1	-2.8
Residential	1.5	2.9	0.6	-2.2
Commercial	0.99	3.5	1.2	-1.6
Industrial	0.18	6	2.6	1.6





# IEEE model

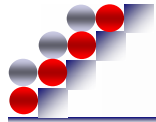
- Most commonly used
- Voltage and frequency dependency

$$P = P_{load} (a_1 v^{n_1} + a_2 v^{n_2} + a_3 v^{n_3}) (1 + a_7 \Delta f)$$

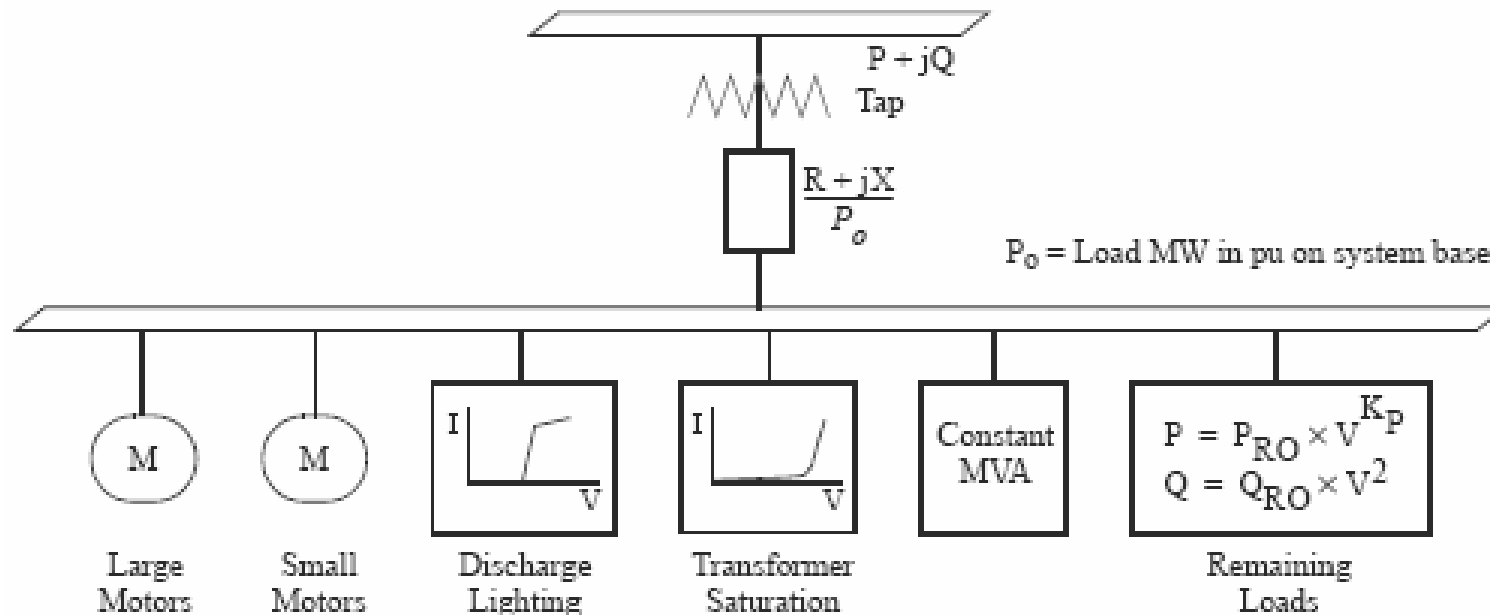
$$Q = Q_{load} (a_4 v^{n_4} + a_5 v^{n_5} + a_6 v^{n_6}) (1 + a_8 \Delta f)$$

IEELxx	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	AUXILIARY	CONST POWER	CONST CURRENT	CONST IMPED
a1	1	1	1	1	1	1	1
a2	0	0	0	0	0	0	0
a3	0	0	0	0	0	0	0
a4	1	1	1	1	1	1	1
a5	0	0	0	0	0	0	0
a6	0	0	0	0	0	0	0
a7	0.9	1.5	2.6	2.9	0	0	0
a8	-2	-1	1.6	1.8	0	0	0
n1	1.3	0.7	0.2	0.1	0	1	2
n2	0	0	0	0	0	0	0
n3	0	0	0	0	0	0	0
n4	2.8	2.4	6	1.6	0	1	2
n5	0	0	0	0	0	0	0
n6/	0	0	0	0	0	0	0



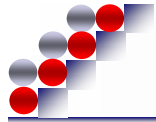


# Composite load model CLOAD



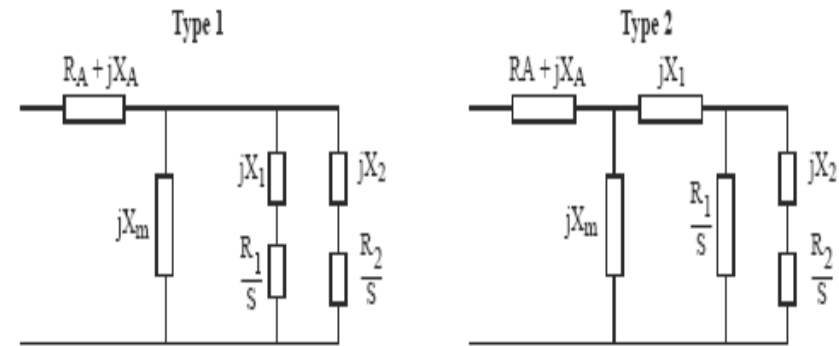
- Advantage: entering demand by participation
- Influence of distribution transformers





# Induction (asynchronous) motor model

- Only for large units
- Integration step has to be small ( $<0.005$ )

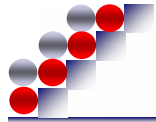


Impedances on Motor MVA Base

## Model Notes:

1. To model single cage motor: set  $R_2 = X_2 = 0$ .
2. When  $MBASE = 0$ .; motor MVA base =  $PMULT \times MW$  load. When  $MBASE > 0$ .; motor MVA base =  $MBASE$ .
3. Load torque,  $T_L = T (A\omega^2 + B\omega + C_0 + D\omega^E)$
4. For motor starting,  $T = T_{nom}$  is specified by the user in CON (J+22). For motor on-line studies,  $T = T_0$  is calculated in the code during initialization and stored in VAR (L+4).
5.  $V_T$  is the per unit voltage level below which the relay to trip the motor will begin timing. To disable relay, set  $V_T = 0$ .
6.  $T_T$  is the time in cycles for which the voltage must remain below the threshold for the relay to trip.  $T_B$  is the breaker delay time cycles.

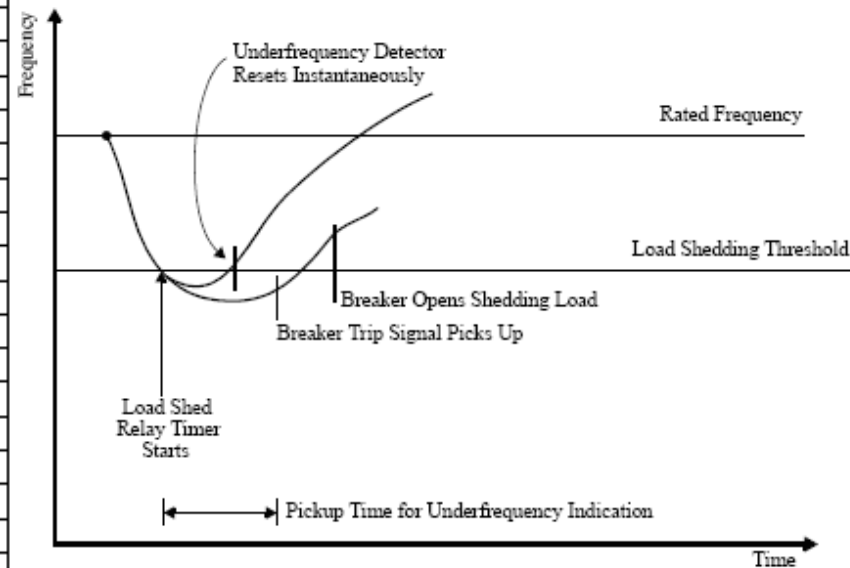


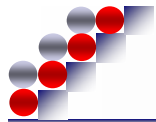


# Load shedding model

- Recommended model LHS3
- Defined for area, zone, owner or bus

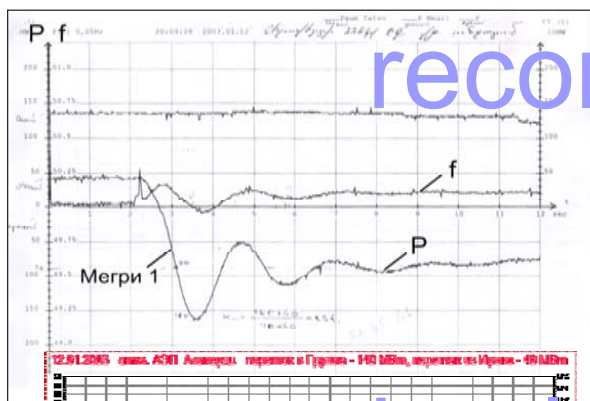
Value	Description
$f_1$	first load shedding point (Hz)
$t_1$	first point pickup time (sec)
$tb_1$	first breaker time (sec)
$frac_1$	first fraction of load to be shed
$f_2$	second load shedding point (Hz)
$t_2$	second point pickup time (sec)
$tb_2$	second breaker time (sec)
$frac_2$	second fraction of load to be shed
$f_3$	third load shedding point (Hz)
$t_3$	third point pickup time (sec)
$tb_3$	third breaker time (sec)
$frac_3$	third fraction of load to be shed
$f_4$	fourth load shedding point (Hz)
$t_4$	fourth point pickup time (sec)
$tb_4$	fourth breaker time (sec)
$frac_4$	fourth fraction of load to be shed
$f_5$	fifth load shedding point (Hz)
$t_5$	fifth point pickup time (sec)
$tb_5$	fifth breaker time (sec)
$frac_5$	fifth fraction of load to be shed
$t_{tb}$	transfer trip breaker time (sec)



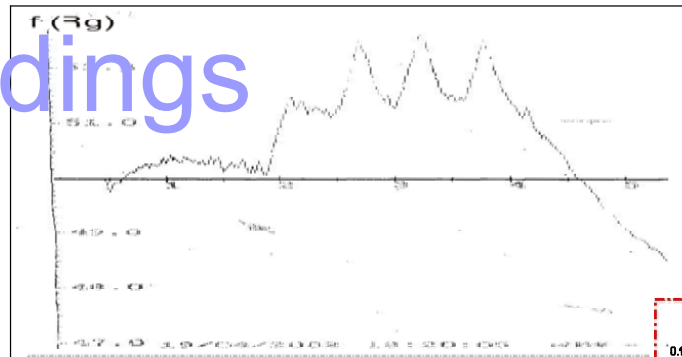


# Verifying model

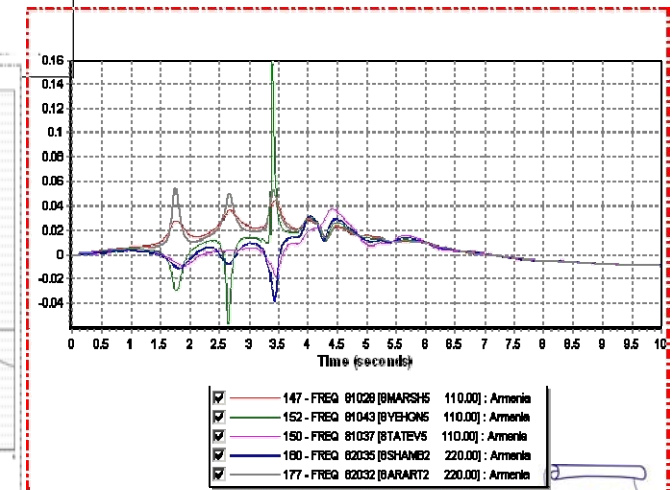
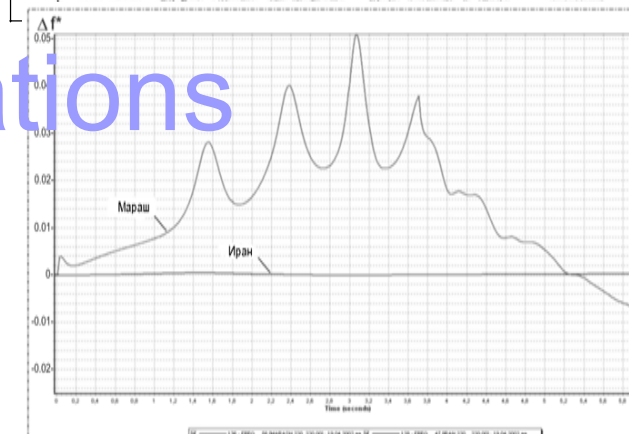
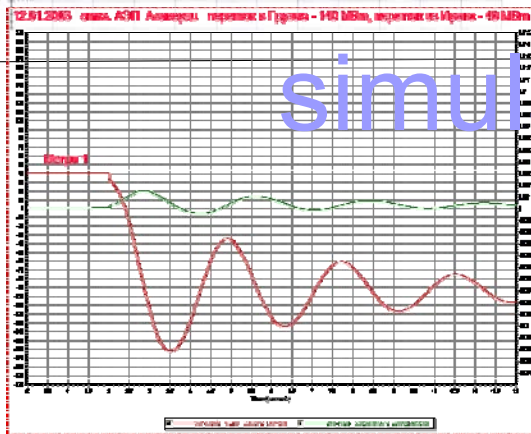
- Model is verified by comparing with real system behavior
  - Snapshot build up (based on recorded data) of disturbance
  - Simulation run according to disturbance scenario



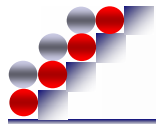
recordings



simulations







# Solution parameters

- Iterations (per each integration step)
- Acceleration (acceleration coefficient)
- Tolerance
- Delta (integration step)
- Frequency filter

The screenshot shows the 'Dynamic Solution Parameters' dialog box in the PSS/E 32 software. The dialog is divided into several sections:

- Network solution:** Iterations (25), Acceleration (1.000000), Tolerance (0.000100).
- Island frequency:** Acceleration (1.000000), Tolerance (0.000500).
- Simulation parameters:** # Channels (0), # States (0), Delta (0.010000), Freq. filter (0.040000).
- Delta threshold:** Intermediate (0.060000), Island freq. (0.140000).
- Channel output file:** (Empty text field)
- Next available addresses:** Next CON (199), Next STATE (72), Next VAR (12), Next ICON (3), Next Channel (1).

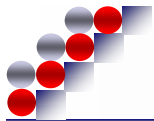
The background shows the main application window with a 'Simulation' menu open, listing options like 'Channel Setup Wizard', 'Define simulation output (CHAN)', 'Define simulation output by subsystem (CHSB)', 'Model maintenance...', 'List', 'Launch NEVA Eigenvalue analysis', and 'Build matrices for LSYSAN program (ASTR)...'. A table of network data is visible at the bottom of the application window.

Bus Number	Bus Name																			
101	NUC-A																			
102	NUC-B	21.5	1	FLAPCO	77	PLANT														
151	NUCPANT	500.0	1	FLAPCO	1	FRST														
152	MID500	500.0	1	FLAPCO	1	FRST														
153	MID230	230.0	1	FLAPCO	1	FRST														
154	DOWNTN	230.0	1	FLAPCO	1	FRST														
201	HYDRO	500.0	2	LIGHTCO	2	SECOND														
202	EAST500	500.0	2	LIGHTCO	2	SECOND														
203	EAST230	230.0	2	LIGHTCO	2	SECOND														
204	SUB500	500.0	2	LIGHTCO	2	SECOND														
205	SUB230	230.0	2	LIGHTCO	2	SECOND														

- Double check time constants and integration step (PSSE sensitive and might crash if data not correct)
  - Integration step < smallest time constant







# Running simulations

PSS@E 32 - C:\Program Files\PTI\PSSE32\EXAMPLE\savnw.sav - C:\Program Files\PTI\PSSE32\EXAMPLE\savnw.dyr - [Network data]

File Edit View Diagram Power Flow Fault OPF Trans Access Dynamics Disturbance Subsystem Misc I/O Control Tools Window Help

Simulation

- Solution parameters...
- Simulation options...
- Force generator and load conversion for simulations
- Update active Plot Book during simulation
- Update active Diagram during simulation
- Perform simulation (STRT/RUN)...**
- Perform exciter simulation (ESTR/ERUN)...
- Perform exciter response ratio simulation (ESTR/ERUN)...
- Perform extended term simulation (MSTR/MRUN)...
- Perform governor response simulation (GSTR/GRUN)...

Bus Number	Bus Name											leg (pu)	G-Zer Load (	
101	NUC-A											0.0000	0.00	
102	NUC-B	21.6	1	FLAPCO	77	PLANT						0.0000	0.00	
		500.0	1	FLAPCO	1	FIRST						0.0000	0.00	
			1	FLAPCO	1	FIRST						0.0000	0.00	
			1	FLAPCO	1	FIRST	1	TRAN 1	1	0.9930	-3.24	0.00000	0.00000	0.00
			1	FLAPCO	1	FIRST	1	TRAN 1	1	0.9389	-9.89	0.00000	0.00000	0.00
			2	LIGHTCO	22	GEN 2	1		1	1.0400	6.16	0.00000	0.00000	0.00
			2	LIGHTCO	2	SFCOND	2	TRAN 2	1	1.0088	-1.32	0.00000	0.00000	0.00

**Convert Generators and Load Representation**

Generators are not "converted". "OK" to convert and continue, "Cancel" to abort simulation initialization.

Loads

Convert existing load representation?

Operation: Convert constant MVA loads

Active Power: % Constant current 100.000, % Constant admittance 0.000, % Constant power 0.0

Reactive Power: 0.000, 100.000, 0.0

Select:  All buses

**Perform Dynamic Simulation**

Initialization options

Channel output file: C:\Program Files\PTI\PSSE32\EXAMPLE\1.out

Simulation options

Run to: -0.0200 0.0100 secs

Print every: 0 time steps

Write every: 5 time steps

Plot every: 5 time steps

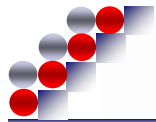
Display network convergence monitor

Run Close **Initialize**

```

ONLY PSS/E SUPPLIED MODELS IN CASE. COMPILATION NOT REQUIRED
GENERATOR CONVERSION COMPLETED
8 LOADS CONVERTED DURING THIS STEP
8 OF 8 LOADS CONVERTED
ORDERING NETWORK
DIAGONALS = 23 OFF-DIAGONALS = 41 MAX SIZE = 60
23 DIAGONAL AND 41 OFF-DIAGONAL ELEMENTS
PTI INTERACTIVE POWER SYSTEM SIMULATOR--PSS@E TUE, SEP 21 2010 10:19
PSS(R)E PROGRAM APPLICATION GUIDE EXAMPLE
BASE CASE INCLUDING SEQUENCE DATA
INITIAL CONDITION LOAD FLOW USED 1 ITERATIONS
-----
BUS# X-- NAME --Y BASKV ID MACHINE INITIAL CONDITIONS -----
101 NUC-A 21.600 1 1.0200 2.0563 750.00 81.20 0.9942 63.47 0.6571 0.4934
102 NUC-B 21.600 1 1.0200 2.0563 750.00 81.20 0.9942 63.47 0.6571 0.4934
206 URBGEN 18.000 1 1.0236 2.5618 800.00 600.00 0.8000 23.53 0.8733 0.4380
211 HYDRO_G 20.000 1 1.0404 1.6150 600.00 17.74 0.9996 42.14 0.4089 0.6827
3011 MINE_G 13.800 1 1.0400 1.4655 258.66 104.04 0.9278 16.02 0.1648 0.2114
3018 CATDOG_G 13.800 1 1.0218 2.9374 100.00 80.00 0.7809 22.53 0.8757 0.4033
-----
INITIAL CONDITIONS CHECK O.K.
CHANNEL OUTPUT FILE IS C:\Program Files\PTI\PSSE32\EXAMPLE\1.out
  
```





# Running simulations

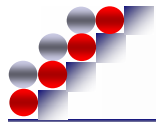
- Run simulation
- Select fault for analyses and run
- Clear fault and run simulation till end

The screenshot displays the PSS/E 32 software interface. The main window shows a menu with options like 'Bus fault...', 'Line fault...', 'Clear fault...', 'Trip line...', 'Close line...', 'Disconnect bus...', 'Disconnect machine...', 'Change Vref...', 'Change Gref...', 'Calculate and apply unbalanced bus fault...', 'Calculate and apply branch unbalance...', and 'Trigger voltage violation check'. A table of bus data is visible in the background:

Bus Number	Bus Name	Value
101	NUC-A	21.600
102	NUC-B	21.600
206	URBGEN	18.00
211	HYDRO_G	20.0
3011	MINE_G	13.800
3018	CATDOG_G	13.8

Two 'Perform Dynamic Simulation' dialog boxes are overlaid. The left dialog box shows 'Run to' set to 1 and 'Run' button highlighted. The right dialog box shows 'Run to' set to 1.10 and 'Run' button highlighted. Both dialog boxes include 'Initialization options' (Channel output file) and 'Simulation options' (Run to, Print every, Write every, Plot every) and a checkbox for 'Display network convergence monitor'.





# Viewing results

SIEMENS POWER TECHNOLOGIES INTERNATIONAL  
CHANNEL OUTPUT FILE PLOTTING PROGRAM -- PSSPLT-32.0  
INITIATED ON 08/08/2008 08:00:00

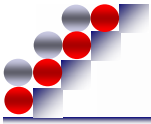
Plot Channels	Min	Max	
1 Select...	0.0000	180.0000	Adjusted
4 Select...	0.0000	180.0000	Adjusted
7 Select...	-10.0000	15.0000	Adjusted
13 Select...	0.5000	1.0000	
19 Select...	-0.0100	0.0150	
22 Select...	-0.0100	0.0150	
ANGL 101[NUC-A 21.600]1	63.465935	154.753067	Actual
ANGL 211[HYDRO_G 20.000]1	42.143284	127.728691	Actual
EFD 101[NUC-A 21.600]1	-0.273474	3.663907	
PMEC 101[NUC-A 21.600]1	0.666779	0.856190	
SPD 101[NUC-A 21.600]1	-0.000859	0.009562	
SPD 211[HYDRO_G 20.000]1	-0.000608	0.006756	

Defined Channels	Filter
11 EFD 3011 [MINE_G 13.800]1	
12 EFD 3018 [CATDOG_G 13.800]1	
13 FMEC 101 [NUC-A 21.600]1	
14 FMEC 102 [NUC-B 21.600]1	
15 FMEC 206 [URBGEN 18.000]1	
16 FMEC 211 [HYDRO_G 20.000]1	
17 FMEC 3011 [MINE_G 13.800]1	
18 FMEC 3018 [CATDOG_G 13.800]1	
19 SPD 101 [NUC-A 21.600]1	
20 SPD 102 [NUC-B 21.600]1	
21 SPD 206 [URBGEN 18.000]1	
22 SPD 211 [HYDRO_G 20.000]1	
23 SPD 3011 [MINE_G 13.800]1	
24 SPD 3018 [CATDOG_G 13.800]1	

## ■ Viewing channel outputs

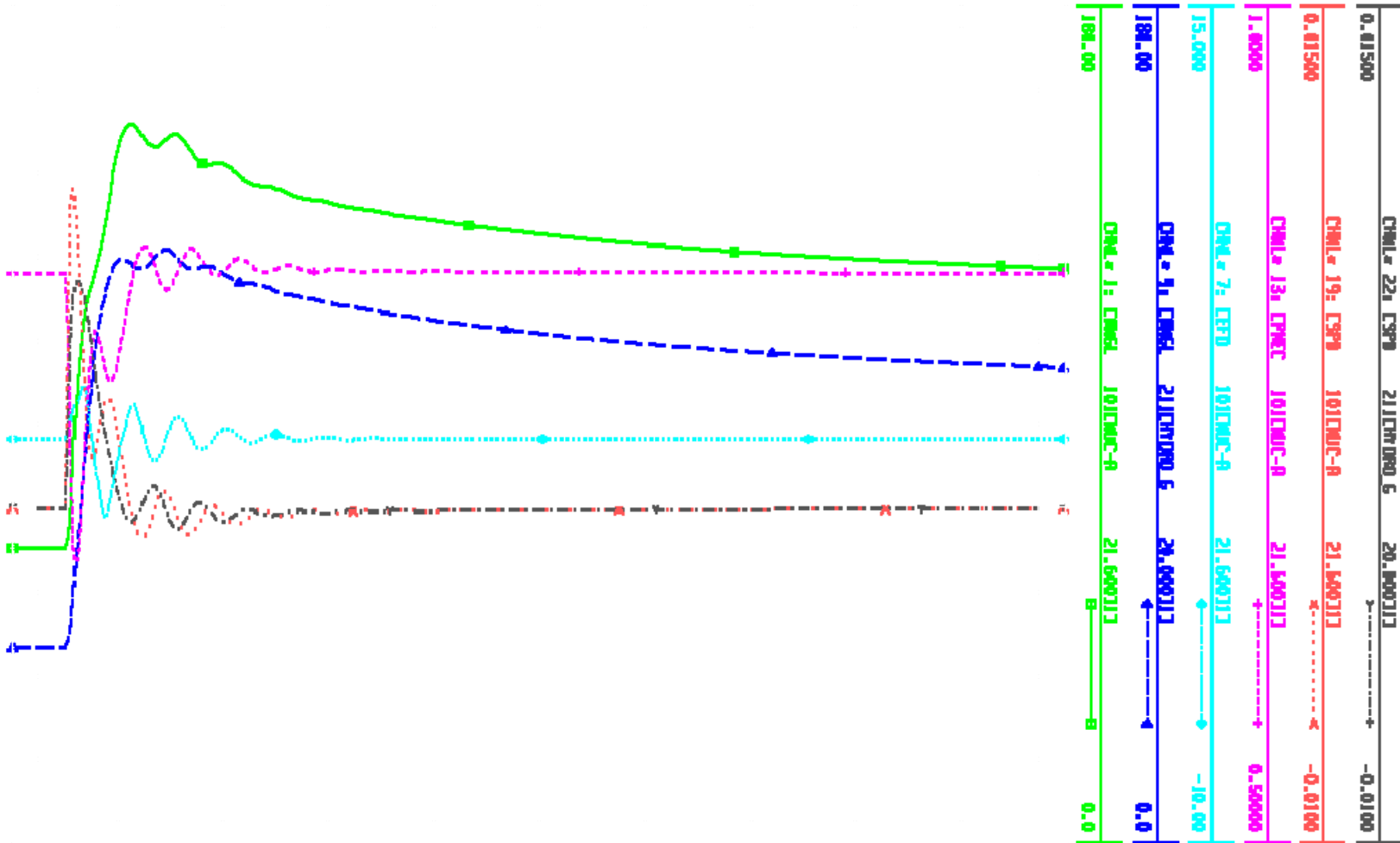
- Open PSSPLT program
- Open \*.out file
- Select channels to view (up to 6)

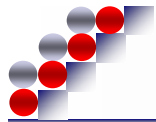




# Viewing results

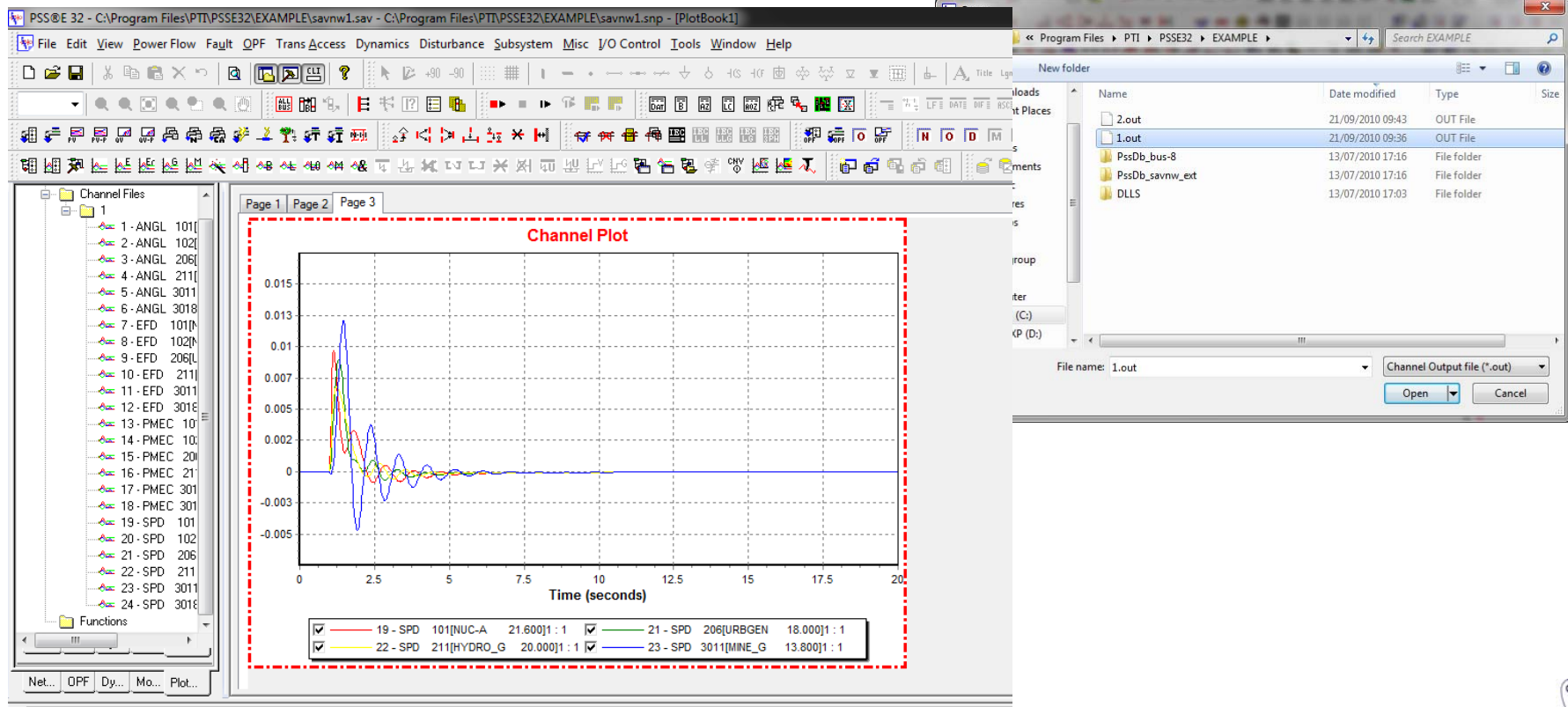
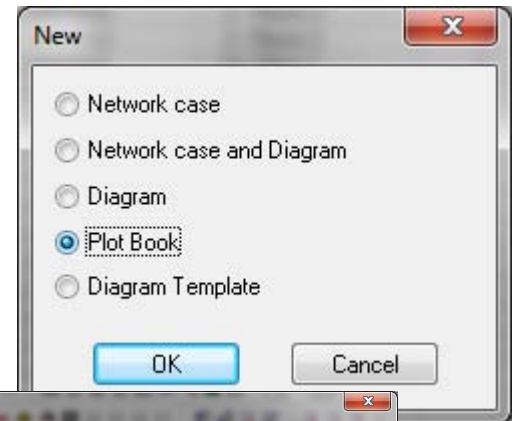
## ■ Chanel output diagram

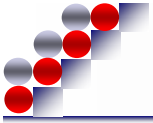




# Viewing results 2

- New plot Book
- Load \*.out channel file
- Drag and drop channel in book
- Insert new pages





*Thank you*

