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

α, β, γ and δ - 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
Indusdustrial	0.18	6	2.6	1.6

IEEE model

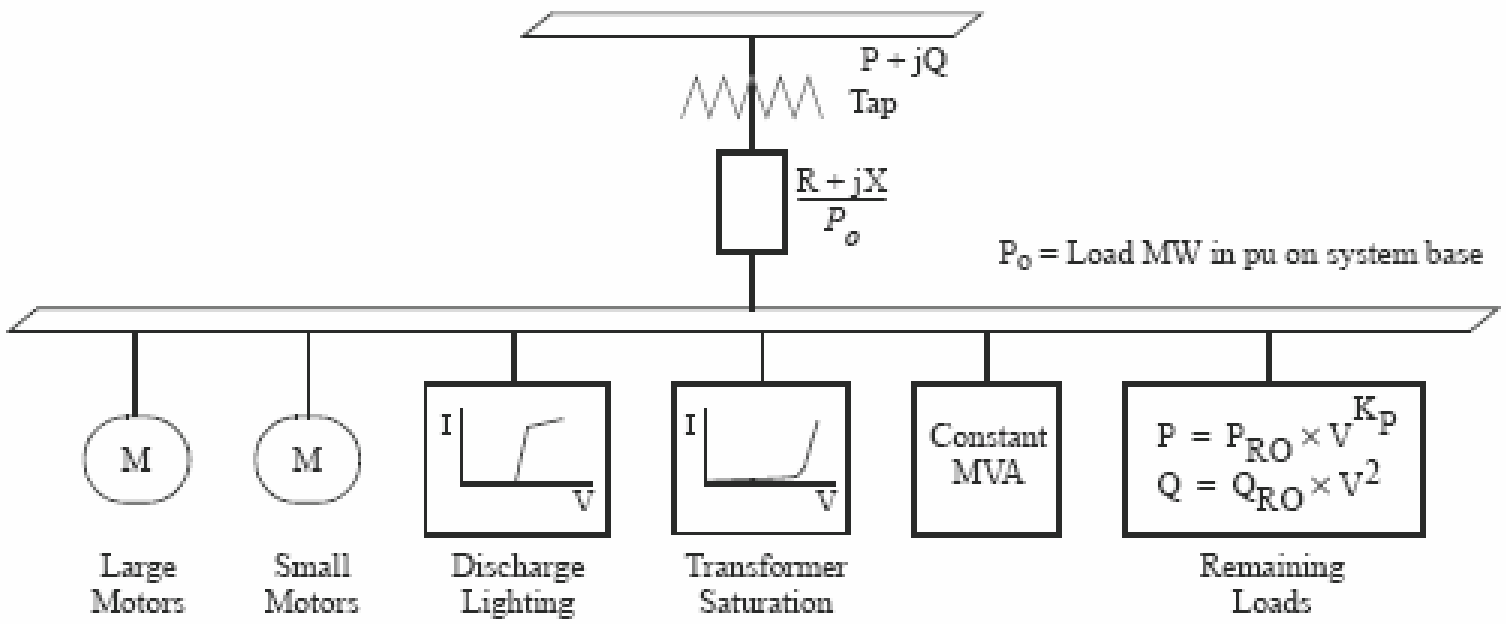
- Most commonly used
- Voltage and frequency dependency

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

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

IEELxx	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	AUXILARY	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

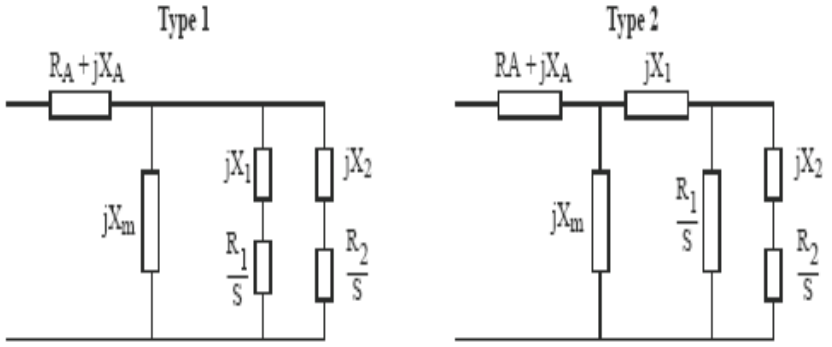
Composite load model CLOAD



- 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

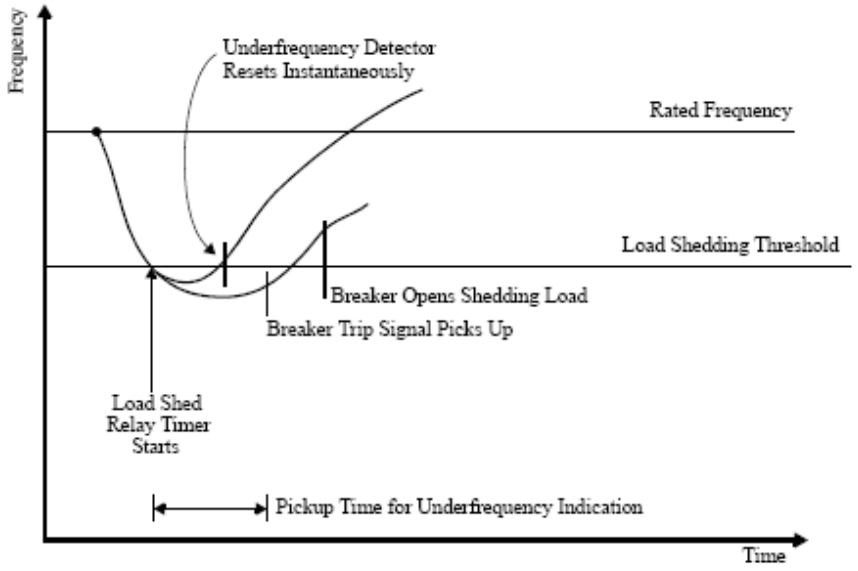
Model Notes:

1. To model single cage motor: set $R_2 = X_2 = 0$.
2. When MBASE = 0.; motor MVA base = PMULT x 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_I is the per unit voltage level below which the relay to trip the motor will begin timing. To disable relay, set $V_I = 0$.
6. T_I 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

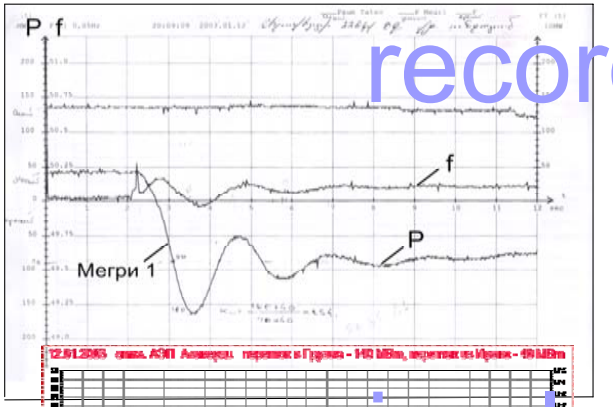
- Recommended model LHS3
- Defined for area, zone, owner or bus

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
	ttb, transfer trip breaker time (sec)

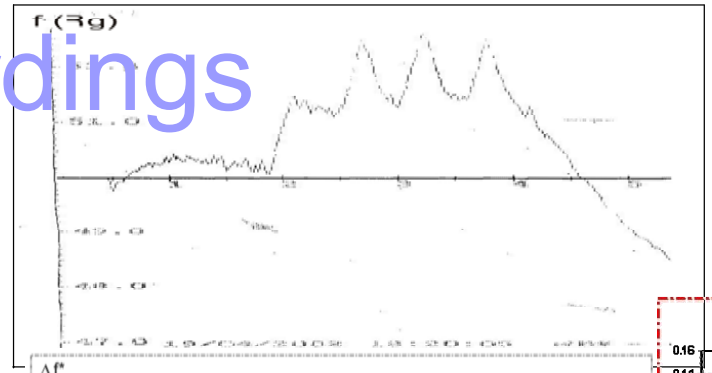


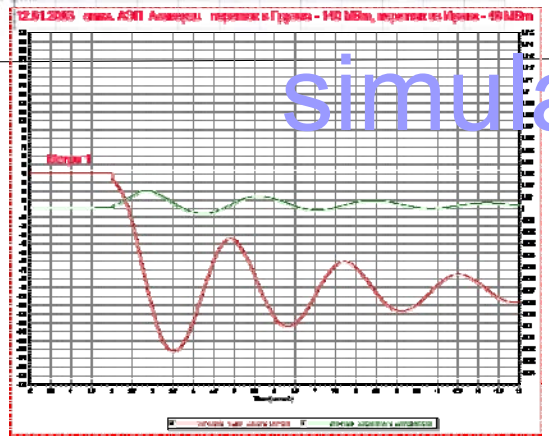
Verifying model

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

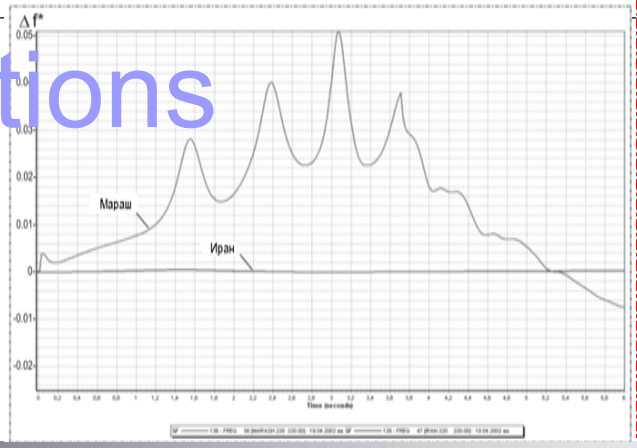


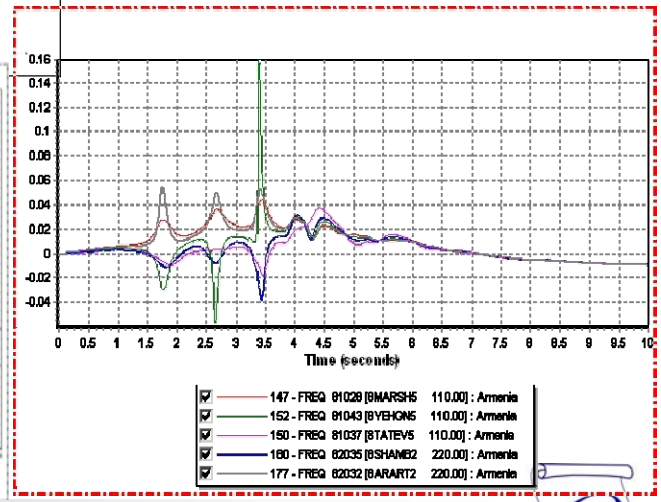
recordings





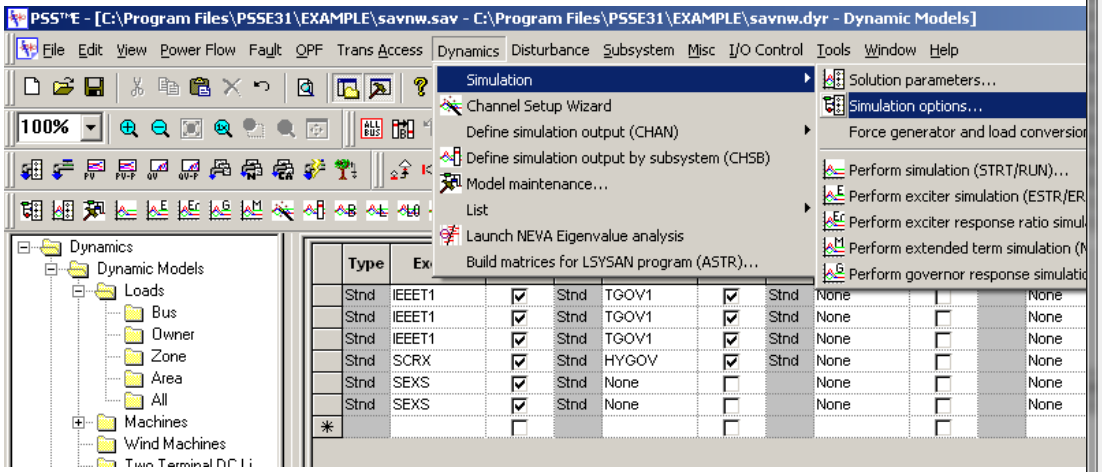
simulations

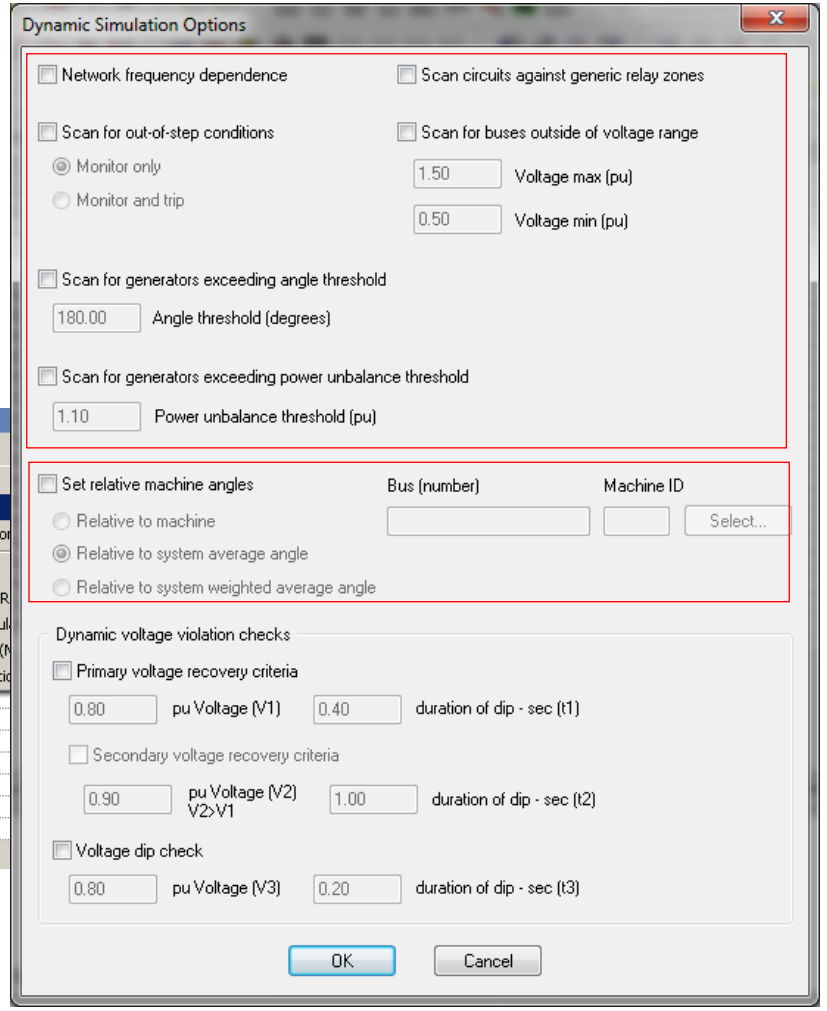




Simulation options

- Network frequency dependence
- Generic relay zones
- Out-of-step conditions
- Buses outside voltage range
- Generators exceeding angle threshold
- Generators exceeding power balance

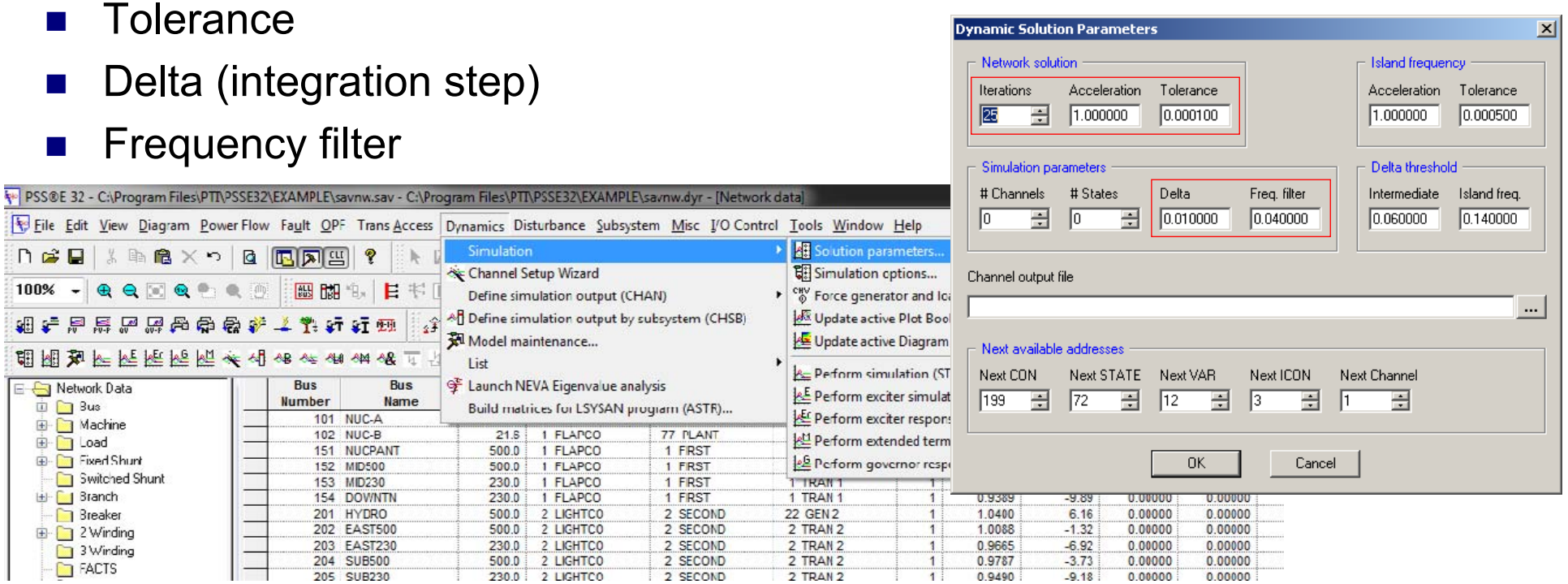




- Relative machine angles
  - Relative to machine
  - Relative to system average angle
  - Relative to system weighted average angle

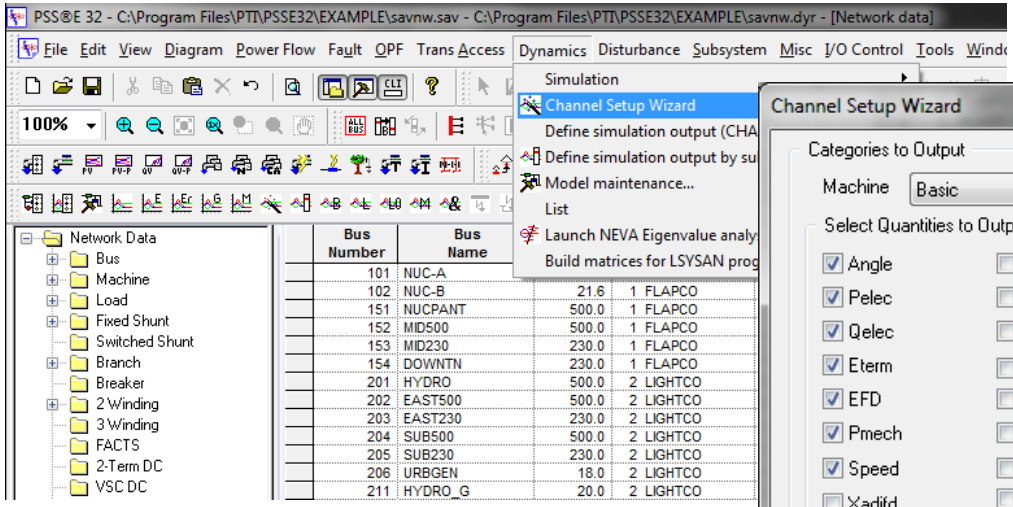
Solution parameters

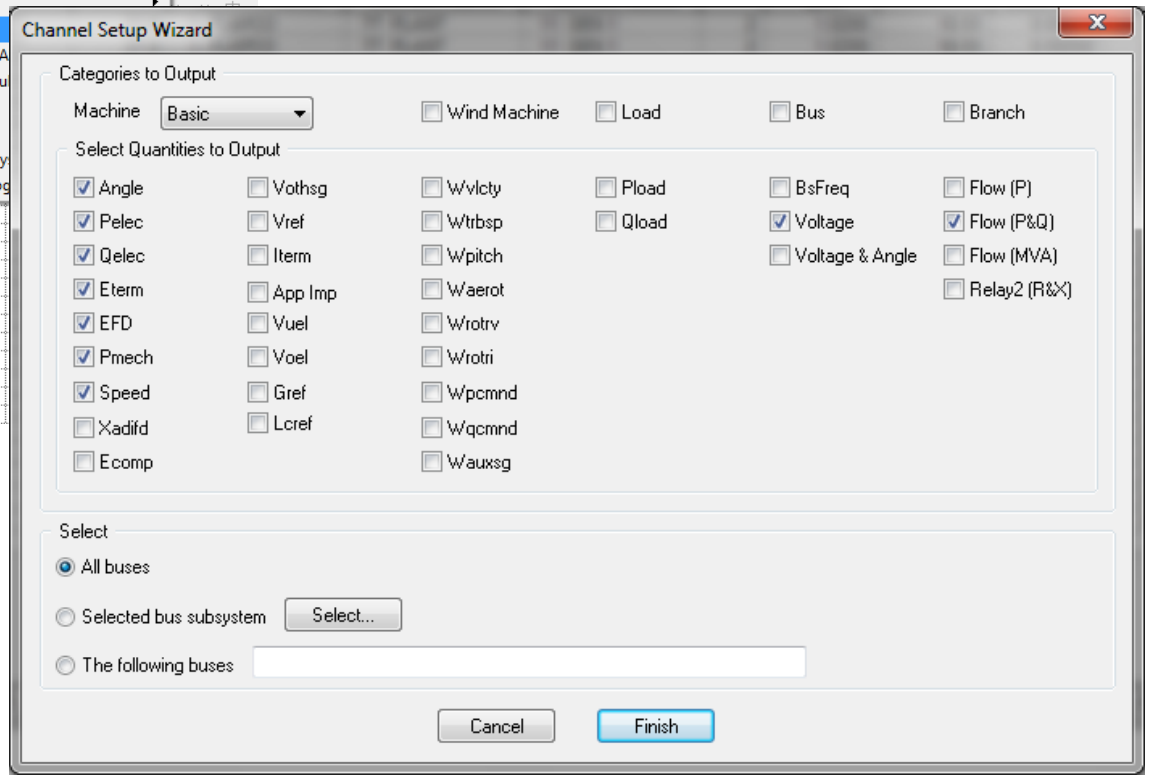
- Iterations (per each integration step)
- Acceleration (acceleration coeficient)
- Tolerance
- Delta (integration step)
- Frequency filter



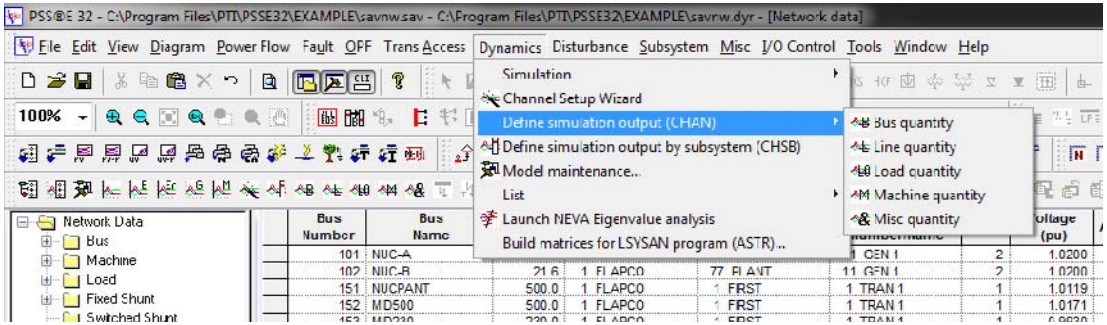
- Double check time constants and integration step (PSSE sensitive and might crash if data not correct)
  - Integration step < smallest time constant

Chanel selection

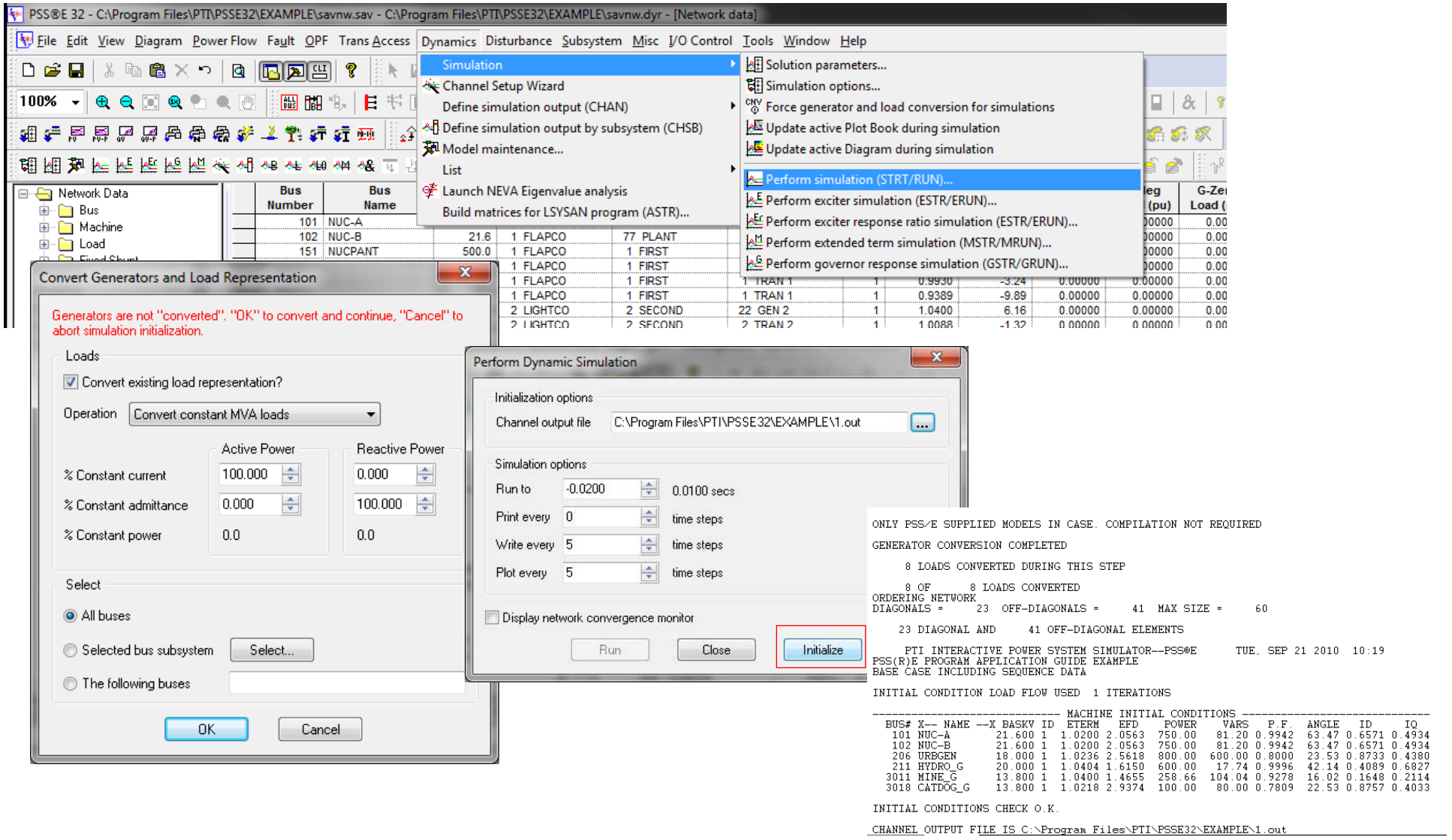




- Chanel selection wizard
  - Subsystem approach (selection)
  - Corresponds to bus related values
- Chanel selection
  - Bus quantity
  - Line quantity
  - miscellaneous

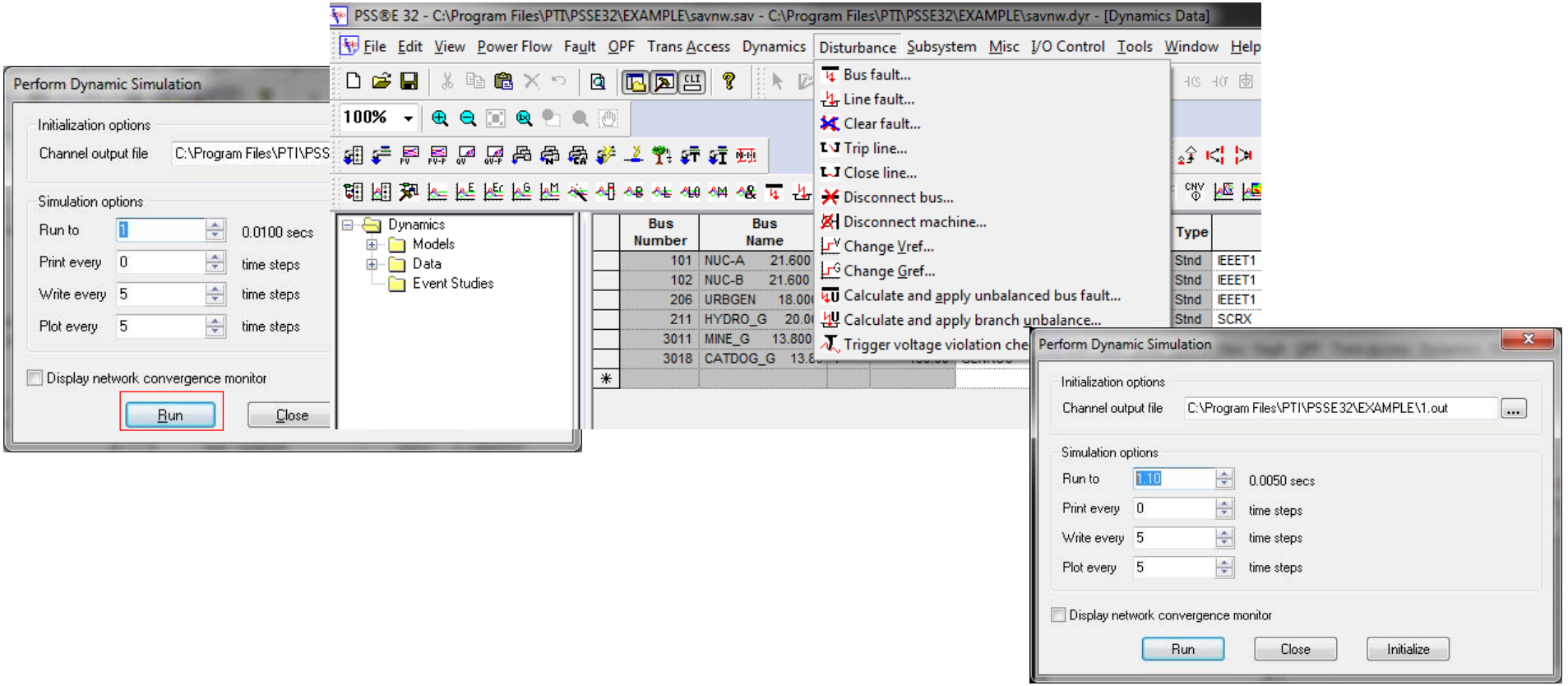


Running simulations

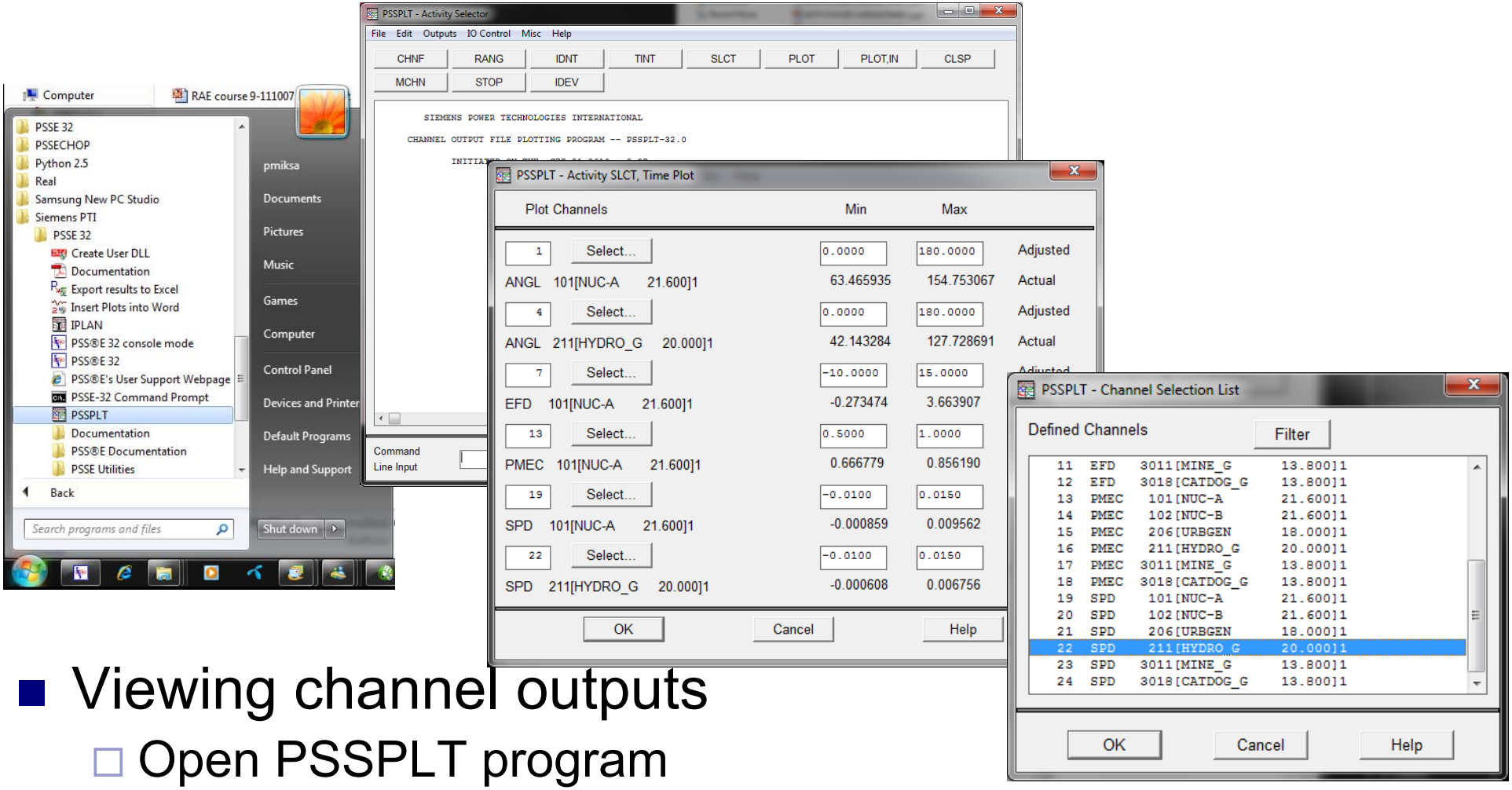


Running simulations

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



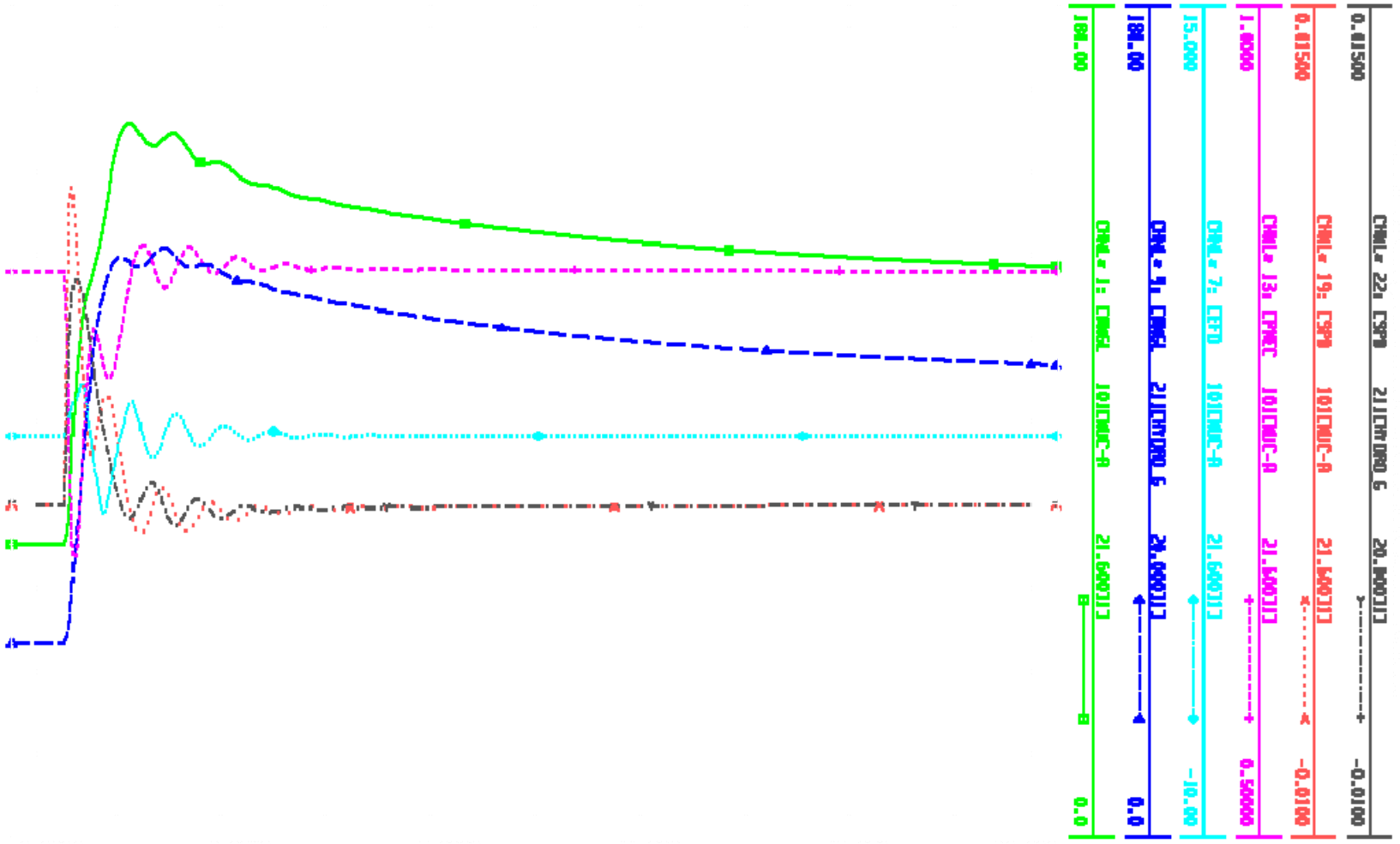
Viewing results



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

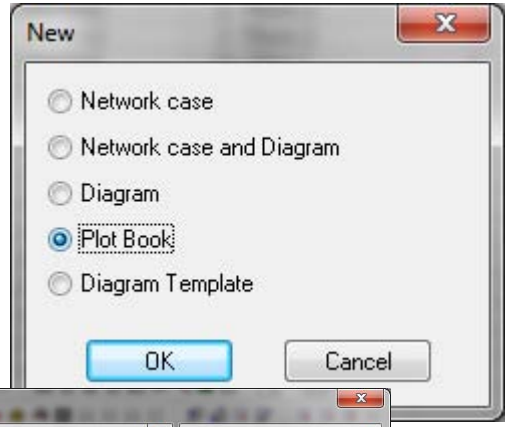
Viewing results

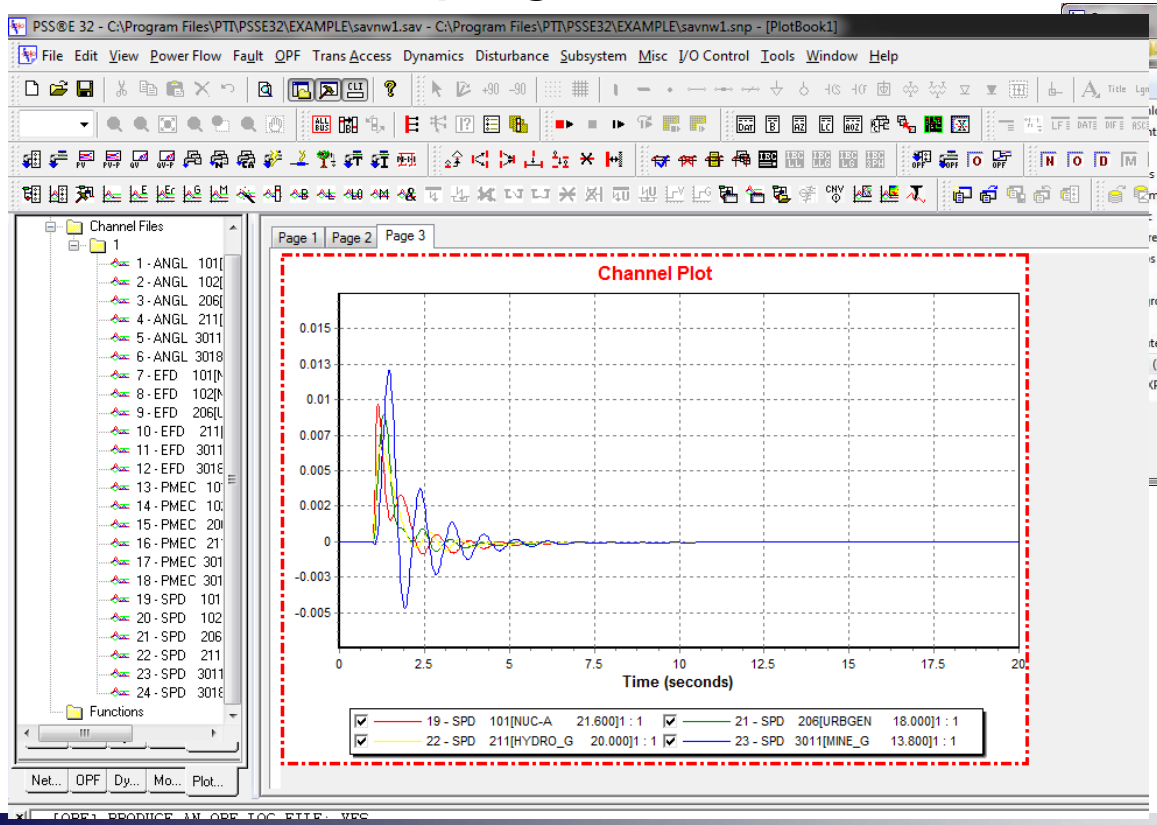
- Chanel output diagram

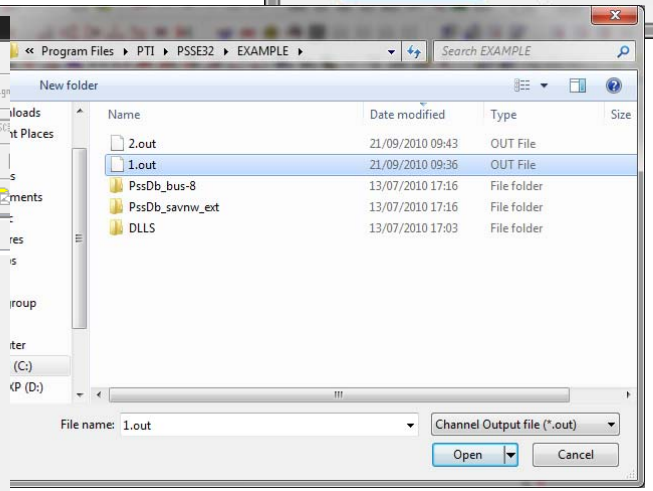


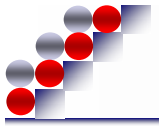
Viewing results 2

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









Thank you