

PSCAD™

PSCAD Initialization Tool

Written for PSCAD Version V5.0

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CONTENTS

1.1.	WHAT IS PSCAD INITIALIZER	1
1.2.	How to Setup the PSCAD Initializer	2
1.3.	ILLUSTRATIVE EXAMPLE: INITIALIZATION OF THE IEEE 14 BUS SYSTEM EXAMPLE	3
1.4.	How Initializer works	7
1.5.	Power Flow Solution	8
1.6.	Power Flow Engine Parameter Settings	9
1.7.	Additional Initializer Component Parameters	11
1.8.	SETTING UP PSCAD CASE FOR INITIALIZATION	14
1.9.	Modelling Guidelines and Limitations	15
1.10.	Dynamic Component Modelling	16



1.1. What is PSCAD Initializer

An Electro Magnetic Transient (EMT) program such as PSCAD simulates a behaviour of a power system network after a disturbance, such as fault or circuit breaker operation. During this short period, the system gradually changes from one steady state behaviour to another.

The purpose of the PSCAD Initializer is to set up the proper power flow conditions (e.g. correct voltage and angles at buses, active, reactive power flows between buses, etc.) prior to the disturbance. This involves solution to the power flow equations and setting up the correct parameters of generators, sources in PSCAD, etc.



1.2. How to Setup the PSCAD Initializer

- Install and open "PSCAD Initializer" through MyUpdater utility (<u>https://mycentre.hvdc.ca/</u>).
- Select the power flow engine (go to Simulation > Compilers) to be used for the load flow solution.

The purpose of the power flow engine is to solve the power flow of the network as required by the PSCAD Initializer. The Power Flow Light is the default power flow solver developed by Manitoba Hydro International. Alternatively SIEMENS PSS[®]E software is also supported.

• Select the Compiler Settings (go to Simulation > Compiler Settings) and set the path for the PowerFlow executable

(e.g. Path to PSCAD Power Flow Light executable C:\....\ PFlightv0_1_4.exe or path to PSS[®]E executable C:\....\PTI\PSSE33\PSSBIN\pssecmd33.exe)

Note that in case of PSS[®]E engine, the command-line executable should be selected (e.g. pssecmd*.exe). For further details of Compiler Settings, see Power flow engine parameter settings.



1.3. Illustrative Example: Initialization of the IEEE 14 Bus System Example

- Open the example IEEE14BUS_NOT_INITIALIZED.pscx PSCAD case in PSCAD software and run the case. As Initializer requires the transmission line solutions, the un-initialized PSCAD case should be 'Build or Run' before the initializer tool can extract necessary network data from the PSCAD case. The 'uninitialized' case will not converge to the expected power flow conditions.
 - For example, the generator at bus BU_BUS_2, is set to generate 40 MW of active power and the bus voltage to be controlled to 144.21 kV. However, the measured active power and voltage do not match the expected values (see Figure 1).



Figure 1 - Generator at B2 BUS 2

- The PSCAD initializer tool can be used to properly initialize the PSCAD case and once initialized, the simulation will converge to the expected network steady state power flow conditions. The steps involved are the following.
 - Open "PSCAD Initializer" through MyUpdater utility.
 - Open the PSCAD example case (File > Open and select the PSCAD case "IEEE14BUS_NOT_INITIALIZED.pscx").





Figure 2 - IEEE 14 bus system in the PSCAD Initializer

Double-click on the main canvas (or double-click on any bus). This will open a new window (see Figure 3). From the list of buses, select the bus that you want to set as a swing bus/slack (there should be a voltage source associated with the swing bus to supply required active and reactive power, e.g. bus B6_BUS_6). Change the 'Type of Bus' to 'Swing bus' (by default all buses are defined as Auto Detect).

Workspace Tree	# X IEEE14BUS_NOT_I		14BUS_NOT_INITIALIZED2:	
master initialized2	System MVA 100	System Frequen	cy 60	22 21 21
	Bus Name		_ Туре	∧ ∨ Attributes
	B1_BUS_1		Auto Detect	ID 119624
	B10_BUS_10		Auto Detect	Name B6 BU
	B11_BUS_11		Auto Detect	✓ Inputs
	B12 BUS 12		Auto Detect	Base Votage (kV) 138
	B13 BUS 13		Auto Detect	Type Swing
	B14. BUS 14		Auto Detect	✓ Outputs
	B2 BUS 2		Auto Detect	Phase Angle 0
	B3 BUS 3		Auto Detect	Properties
	B4 BUS 4		Auto Detect	RMS Voltage 0
	B5 BUS 5		Auto Detect	
	B6 BUS 6		Swine Bus	
	B7 BUS 7		Auto Detect	
	B& BUS &		Auto Detect	v .
	Component ID	Name	Definition Name	
	1994636021	source 1 1	master source 3	
	1561797661	source 2.1	master source 3	
	1388978276	source 3.1	matersource 3	
	1363557341	anama 6 1	materia inc.	
	93521993		materia active_s	
	622521652	source_6_1	master source_s	

Figure 3 - Bus details and additional parameters windows



- Optional: Set additional load flow parameters, if required (see section <u>1.7</u> for more details).
- Run the case (Simulation > Run) and check if load flow is properly converged and solved from the output window (bottom left) as shown in Figure 4.

Output	
43 > PowerFlow Message >	
44 > PowerFlow Message >	*************
45 > PowerFlow Message >	Reading raw data successfully completed
46 > PowerFlow Message >	**********
47 > PowerFlow Message >	
48 > PowerFlow Message >	*************
49 > PowerFlow Message >	STARTING POWERFLOW
50 > PowerFlow Message >	*************
51 > PowerFlow Message >	
52 > PowerFlow Message >	***********
53 > PowerFlow Message >	ASSEMBLING ADMITTANCE MATRIX
54 > PowerFlow Message >	****************
55 > PowerFlow Message >	
56 > PowerFlow Message >	******************
57 > PowerFlow Message >	ADMITTANCE MATRIX ASSEMBLED
58 > PowerFlow Message >	*******************
59 > PowerFlow Message >	
60 > PowerFlow Message >	ITER DELTA_P DELTA_Q
61 > PowerFlow Message >	
62 > PowerFlow Message >	1 9.2194E-01 6.1850E-01
63 > PowerFlow Message >	2 4.9537E-02 1.6803E-01
64 > PowerFlow Message >	3 6.3796E-04 1.5065E-03
65 > PowerFlow Message >	4 1.3836E-07 1.9243E-07
66 > PowerFlow Message >	
67 > PowerFlow Message >	***************************************
68 > PowerFlow Message >	Power Flow successfully completed
69 > PowerFlow Message >	***************************************

Figure 4 - Power flow solution

- Save the case. You may want to give a diffent name to PSCAD case to preserve the settings in the original case (e.g. "IEEE14BUS_ INITIALIZED.pscx").
- Open the saved PSCAD case (PSCAIEEE14BUS_INITIALIZED.pscx) in PSCAD and run the case. Verify the steady state values, such as bus voltages, active and reactive power flow through branches. The active power and voltages are as expected as shown in Figure 5.





Figure 5 - Bus B2_BUS_2 in solved PSCAD case



1.4. How Initializer works

The initializer generates a power flow network data file ("input.netdata") from a PSCAD case. The "input.netdata" is solved by a power flow engine and generates an output data file "output.netdata." The Initializer uses the information in the solved "output.netdata" file to update necessray fields of the PSCAD case (see Figure 6).



Figure 6 - Initializer block diagram



1.5. Power Flow Solution

The objective of power flow solution is to determine bus voltages and angles, active and reactive power through branches, generator and loads for steady state condition. This is a constrained optimization problem.

There are four variables associated with each bus:

- Voltage |V|
- Phase angle $|\delta|$
- Active or real power |P|
- Reactive power |Q|

	Р	Q	V	δ
P-Q bus	known	known	unknown	unknown
P-V bus	known	unknown	known	unknown
Slack bus/swing bus	unknown	unknown	known	known

The power flow solution calculates the P, Q for swing/slack bus, Q, δ for PV buses and V, δ for PQ buses.



1.6. Power Flow Engine Parameter Settings

The Power flow engine parameers are shown in Figure 7 and described in Table 1.

	ttings		X
•	↠🖻		
×	Settings		
	Compile Folder	\$(Output Dir)	
	Overwrite Input File	False	
	PowerFlow Executable	alizer_package\Pflight\	PFlightv0_1_4.ex
×	Solution Options		
	Acceleration Factor	1	
	Flat Start	True	
	PowerFlow Solution Tolerance	1E-05	
	Q Iteration	20	
	Reactive Power Limits	Ignore	
	The number of iterations.	20	
	Zero Impedance Threshold	0.0001	

Figure 7 - Initializer settings dialog



Option	Value	Description
Compile folder	\$(OutputDir) This macro is the default location for output files. The default macro resolves to: FilePath\CaseName.init e.g. C:\Folder\Case.pscx Has a \$(OutputDir) C:\Folder\Case.init\	This option provides the location for all temporary files that are generated when compiling.
Overwrite input file	Logical (True or False)	The "input.raw" is the unsolved load flow file created from the PSCAD case. If True, the "input.raw" data file is updated with load flow solved data, otherwise it is written to a new file "output.raw". False is recommended as the two files (before and after solution) can be compared manually if needed.
PowerFlow Executable	 (a) PSCAD power flow light engine e.g. C:\\ PFlightv0_1_4.exe or (b) PSSE engine usually located in C:\Program Files (x86)\PTI\PSSE##\PSSBIN\pssecmd##.exe e.g. C:\Program Files (x86)\PTI\PSSE33\PSSBIN\pssecmd33.exe 	Path to power flow solution engine. In case of PSSE engine, the command-line execute should be selected (e.g. pssecmd*.exe).
Solution Options		
Acceleration Factor	Real	Acceleration Factor for power flow solution algorithm
Flat Start	Logical (True or False)	If True, the bus voltages are set to 1.0 and angle to 0.0 as initial condition for power follow solution. If False, previous power flow values are used as seed values.
Power Flow solution tolerance	Real	This is Power Flow convergence tolerance
Q iteration	Real	Maximum number of iterations for relative power limits
Reactive Power Limits	Choice (Ignore/Iterations/Auto)	This is how to treat reactive power limits. If "ignore", reactive power limits are neglected.
The Number of Iterations	Integer	Maximum number of iterations for convergence
Zero Impedance Threshold	Real	This is the tolerance/threshold to identify zero impedance lines

Table 1: Power flow parameter settings



1.7. Additional Initializer Component Parameters

The Initializer uses relevant parameters of PSCAD master library components for initialization. However in some components, additional parameters may be required to define. These parameters can be seen from the extended properties window in the Initializer.

• Bus parameters

Select the bus to see the bus parameters.

System MVA 100	System Frequency	60		
Bus Name			Туре	^
B1_BUS_1			Auto Detect	
B10_BUS_10			Auto Detect	
B11_BUS_11			Auto Detect	
B12_BUS_12			Auto Detect	
B13_BUS_13			Auto Detect	
B14_BUS_14			Auto Detect	
B2_BUS_2			Auto Detect	
B3_BUS_3			Auto Detect	
B4_BUS_4			Auto Detect	
B5_BUS_5			Auto Detect	
B6_BUS_6			Swing Bus	
B7_BUS_7			Auto Detect	
B9 BUS 9			Auto Detect	۷.

Figure 8 - List of buses in the network

•	₽↓	
~	Attributes	
	ID	1196249908
	Layer	
	Name	B6_BUS_6
~	Inputs	
	Base Voltage (kV)	138
	Bus Number	-1
	Туре	Swing Bus
~	Outputs	
	Phase Angle	0
	Voltage	1
~	Properties	
	RMS Voltage	0

Figure 9 - Bus parameters



Base Voltage	Real	Bus base voltage in kV. The default value is base kV of the PSCAD Bus component.	
Bus Number	Integer	Define unique bus number If the bus number is -1, Initializer will automatically specify the bus number	
Bus Type	Choice	 Select the Bus type from following options Auto Detect Swing bus (or Swing bus) Generator bus (or PV bus) Non-generator bus (or PQ bus) isolated bus (bus is disconnected) If Auto Detect is selected, Initializer will automatically select the bus type, however the Swing bus should be manually selected. There is at least one Swing bus in the system. 	
Phase Angle	Real	This displays the phase angle of the bus in degrees after the load flow solution	
Voltage	Real	This displays the voltage magnitude of the bus in degrees after the load flow solution	

Table 2: Bus parameters



• Generator extended parameters

Select the voltage source to see generator parameters:

Component ID	Name	Definition Name	
1994636021	source_1_1	master:source_3	
1561797661	source_2_1	master:source_3	
1388978276	source_3_1	master:source_3	
1363557241	source_6_1	master:source_3	
1887662795		master:capacitive_load	



The generator/source extended parameters are shown below:

IsQset_2	Text	True or false
		If True, the Generator reactive power limits are enforced.
Qmax	Real	Maximum Reactive power in MVar
Qmin	Real	Minimum Reactive power in Mvar
RmtBus	Integer	The bus number of the Regulated Bus. If left as 0 the Generator will regulate its own bus. 0 By Default

The load extended parameters are shown below:

IsLdMdl	Text	True or false
		If true, the load will be modeled as a standard load
		If false, the load will be modeled as a fixed shunt



1.8. Setting up PSCAD Case for Initialization

• Voltage sources to represent generator

Three Phase Voltage Source Model 2

The "Three phase voltage source Model 2" represents a generator in the initialization procedure. In the "Signal Parameters" section of the voltage source, the specified parameters are set as "At the terminal." The power flow parameters are defined in the "Terminal conditions" section.

Three Phase Voltage Source Model 1

The "Three phase voltage source Model 1" also represents a generator (or network equivalent).

In the "Configuration" section, set "Source Control" to "Fixed" and "Specified parameters" to "At the terminal." The power flow parameters can be found in "Source Values for Fixed Control" section.



1.9. Modelling Guidelines and Limitations

- If a load is represented using passive elements, such as R,L,C, the load should be replaced with PSCAD load components. Note that R,L,C are considered as ac lines.
- Transmission lines with multiple circuits are not supported.
- Transmission lines or cables with more than three conductors are not supported. (e.g. cable with sheath, etc.). Alternatively, these models can be put inside a page module and modelled as an AC or DC line (see section <u>1.10</u> for details).
- Breakers are not supported.
- PSCAD calculates certain parameters at time zero or in the first few time steps to be used for the rest of the time domain simulation. This pre-processing data is not available to the Initializer. Some parameters are defined externally as signals to the module or the components (e.g. a value of the tap changer externally connected to the transformer, signal inputs to the page modules in PSCAD).
- Some master library components may not be supported. Resister, inductor, capacitor, three-phase two winding or three-winding transformers (auto transformers not supported), all three-phase sources, transmission lines models, and coupled pi-circuit are supported.
- PSCAD cases linked with Parallel Network Interface (PNI) are not supported.



1.10. Dynamic Component Modelling

Dynamic componets, such as STATCOM, generators, and windfarms defined in page modules, can be initialized. However this requires some additional steps.

First, the power flow equivalent model to represent the PSCAD dynamic component is identified (e.g. Generator, FACTS, dc lines, etc.). Then the relevant power flow parameters are defined in the PSCAD page module. In the Initializer, the page module is identified as the relevant power flow equivalent model and finally the relationship is established between the parameters of power flow equivalent model to the parameters of the PSCAD page module.

This is demostrated using an example involving a page module contaiing a generator component with exciters, governeor, etc. This module is connected to Bus 4, as shown in Figure 11.

In this initialization process, the generator set voltage magnitude and active power is defined. The objective is to find the voltage magnitude and angle of the connected bus and reactive power of the generator from the Initializer tool. These values can be used to set initialization parameters of PSCAD generator model.



Figure 11 - PSCAD main page



Figure 12 - Generator details inside page module of Sync



a. Set up PSCAD case for initialization.

In the parameter section of the page module, the initialization parameters (i.e. terminal reactive power (I_Q0), terminal voltage phase (I_Pheta) and terminal voltage magnitude(I_VT)) are created as shown below:



Figure 13 - Parameters for initialization

In the synchronous machine, these parameters can be linked to the appropriate entries for initialization.

	Synchronous Machine	×		
Initial	initial Conditions			
•	24 🗃 📑 🐙 🦏			
~ G	eneral			
Т	erminal Voltage Magnitude at Time = 0-	I_VT		
Т	erminal Voltage Phase at Time = 0-	I_Pheta		
Ini ©	tial Conditions if Starting as a Machine	~		
~	General			
	Terminal Real Power at Time = 0- ; Out +	240.0		
	Terminal Reactive Power at Time = 0- ; Out +	I_Q0		
	Initial Rotor Angle ref: Stator	3.141592 [rad]		
	D-axis Armature Current; In +	0.0 [pu]		
	Q-axis Armature Current; In +	0.0 [pu]		
	Initial Field Current	0.0 [pu]		
	Initial Machine Speed	1.0 [pu]		

Figure 14 - Synchronous machine model parameters



b. Load the case in to the Initializer and define Bus 4 as a generator bus.

master:Main 4Bus_GEN_Initialized6:Main 4Bus_GEN_Initialized6:Main System MVA 100 System Frequency 60					
				Bus Name	File Ed
Bus1				Swing Bus	
Bus2				Auto Detect	
Bus3				Auto Detect	
Bus4				Generator Bus (PV Bus)	

Figure 15 - Bus parameters of the Initializer

Double click on the generator page module (Sync) and resolve it as a Generator.

master:Main	4Bus_GEN_Initialized:Main 4Bus_GEN_Initialized:SYNC 4Bus_GEN_Initialized:SYNC			
Resolve Schematic Generator -				
Туре 🔺	Condition			
Generator t	ine			

Figure 16 - Resolve Schematic in the Initializer



ConditiontrueConditiontrueCircuit NumberBothOutputI_VTVoltage ParameterI_PhetaReactive Power ParameterI_Q0Real Power ParameterI_Q0Real Power Parameter#(ignore)Phase Angle Equation#(value)*0.0174533Voltage Equation#(value)*0.0174533Voltage Equation#(value)*0.0174533Voltage Equation#(value)Reactive Power Equation#(value)Read Power Equation#(value)Phase Angle UnitradVoltage UnitpuReactive Power UnitMVARReal Power UnitMVARReal Power UnitMVARReal Power UnitNXConnecting BusNXTypeAuto DetectBase Voltage (kV)13.8Properties1.03Target Active Power (P)240.0Maximum Generator Reactive Power Outpu9999Minimum Generator Reactive Power Outpu9999Regulated Voltage Set Point1.03Bus Number to Regulate0Total MVA Base100Complex Machine Impedance (Real)0Complex Machine Impedance (Real)0Maximum Generator Active Power Output9999Minimum Generator Active Power Output9999Maximum Generator Active Power Output9990Maximum Generator Active Power Output9990Maximum Generator Active Power Output9990Maximum Generator Active Power Output9990 <th>•</th> <th>ੈz↓ 🗀</th> <th></th>	•	ੈz↓ 🗀	
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Base Voltage (kV) 13.8 Properties 240.0 Target Active Power (P) 240.0 Maximum Generator Reactive Power Output 9999 Minimum Generator Reactive Power Output 9999 Regulated Voltage Set Point 1.03 Bus Number to Regulate 0 Total MVA Base 100 Complex Machine Impedance (Real) 0 Complex Machine Impedance (Imag) 1 Maximum Generator Active Power Output 9999		Туре	Auto Detect
Properties Target Active Power (P) 240.0 Maximum Generator Reactive Power Output 9999 Minimum Generator Reactive Power Output -9999 Regulated Voltage Set Point 1.03 Bus Number to Regulate 0 Total MVA Base 100 Complex Machine Impedance (Real) 0 Complex Machine Impedance (Imag) 1 Maximum Generator Active Power Output 9999		Base Voltage (kV)	13.8
Target Active Power (P) 240.0 Maximum Generator Reactive Power Outpu 9999 Minimum Generator Reactive Power Output -9999 Regulated Voltage Set Point 1.03 Bus Number to Regulate 0 Total MVA Base 100 Complex Machine Impedance (Real) 0 Complex Machine Impedance (Imag) 1 Maximum Generator Active Power Output 9999	/	Properties	
Maximum Generator Reactive Power Outpu 9999 Minimum Generator Reactive Power Output -9999 Regulated Voltage Set Point 1.03 Bus Number to Regulate 0 Total MVA Base 100 Complex Machine Impedance (Real) 0 Complex Machine Impedance (Imag) 1 Maximum Generator Active Power Output 9999		Target Active Power (P)	240.0
Minimum Generator Reactive Power Output -9999 Regulated Voltage Set Point 1.03 Bus Number to Regulate 0 Total MVA Base 100 Complex Machine Impedance (Real) 0 Complex Machine Impedance (Imag) 1 Maximum Generator Active Power Output 9999		Maximum Generator Reactive Power Outpu	9999
Regulated Voltage Set Point 1.03 Bus Number to Regulate 0 Total MVA Base 100 Complex Machine Impedance (Real) 0 Complex Machine Impedance (Imag) 1 Maximum Generator Active Power Output 9999		Minimum Generator Reactive Power Output	-9999
Bus Number to Regulate 0 Total MVA Base 100 Complex Machine Impedance (Real) 0 Complex Machine Impedance (Imag) 1 Maximum Generator Active Power Output 9999		Regulated Voltage Set Point	1.03
Total MVA Base 100 Complex Machine Impedance (Real) 0 Complex Machine Impedance (Imag) 1 Maximum Generator Active Power Output 9999		Bus Number to Regulate	0
Complex Machine Impedance (Real) 0 Complex Machine Impedance (Imag) 1 Maximum Generator Active Power Output 9999		Total MVA Base	100
Complex Machine Impedance (Imag) 1 Maximum Generator Active Power Output 9999		Complex Machine Impedance (Real)	0
Maximum Generator Active Power Output 9999		Complex Machine Impedance (Imag)	1
Minimum Communities Antices Descent October 4 00000		Maximum Generator Active Power Output	9999
Minimum Generator Active Power Output -9999		Minimum Generator Active Power Output	-9999

The generator initialization parameter are shown below.

Figure 17 - Generator parameters for the Initializer

The generator parameters used for power flow solution is set in the properties section.

Parameter	Corresponding power flow parameter	Value
Active power (MW)	Generator active power output (MW)	240
Voltage magnitude (pu)	Regulated voltage setpoint (VS)	1.03



In the Output section, the link between PSCAD parameters and the power flow parameters is established.

Power flow parameter	Description	Corresponding PSCAD generator parameters
Reactive power parameter	Generator reactive power output (QG)	I_Q0
Phase angle parameter	Angle of bus 4 (VA)	I_Pheta
Voltage parameter	voltage magnitude of Bus 4 (VM)	I_VT

The units of PSCAD generator parameters are defined.

Parameter	PSCAD generator parameters units
Reactive power unit	MVAR
Phase angle unit	rad
Voltage unit	ри

The unit conversion from power flow parameter to PSCAD generator parameter is defined as shown below.

Note

#(value) means power flow parameter value.

Conversion	PSCAD Parameter Units	Power flow parameter units	Conversion from power flow parameters to PSCAD parameters
Reactive power equation	Mvar	Mvar	Not required
Phase angle equation	rad	Degrees	0.0174533
Voltage equation	ри	pu	?

The case can now be initialized using Initializer tool.



DOCUMENT TRACKING

Rev.	Description	Date
0	Initial	30/Mar/2020
1	Added document tracking and copyright	24/Nov/2021

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