PSCAD™

# PSCAD Initialization Tool

Written for PSCAD Version V5.0

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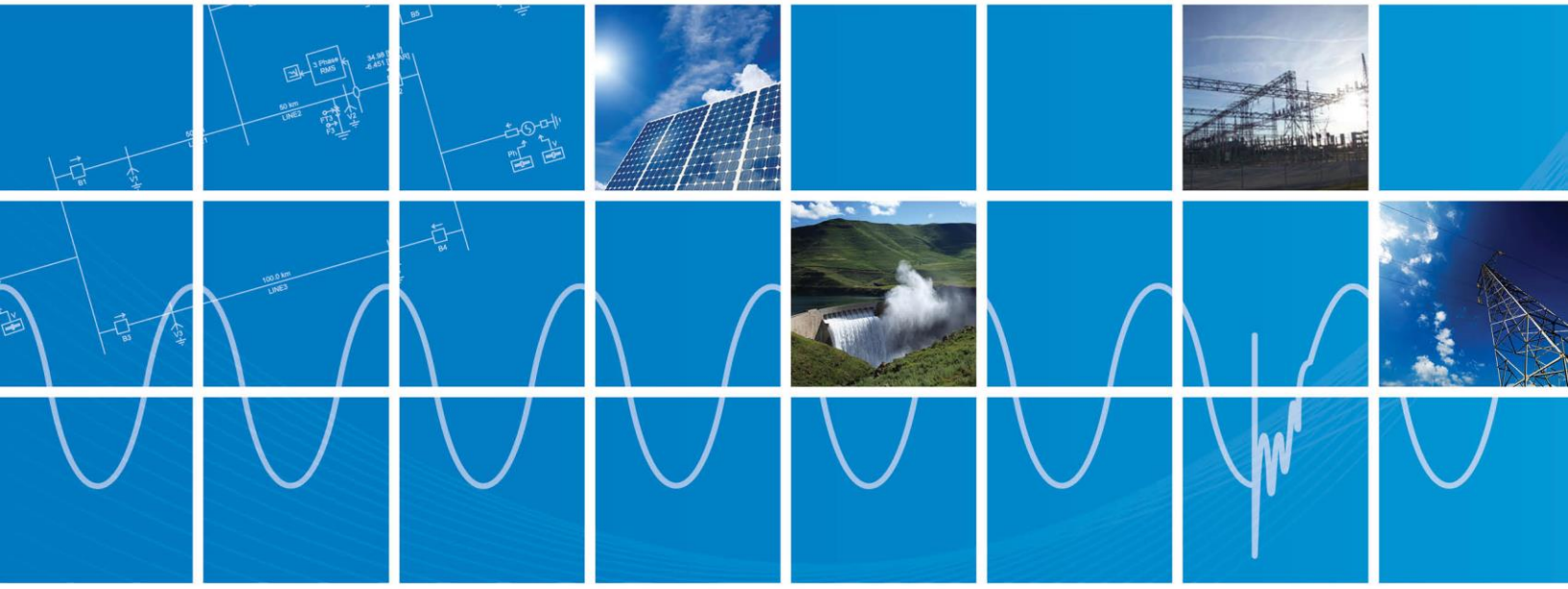
Revision 1



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## 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 (https://mycentre.hvdc.ca/).
- 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).

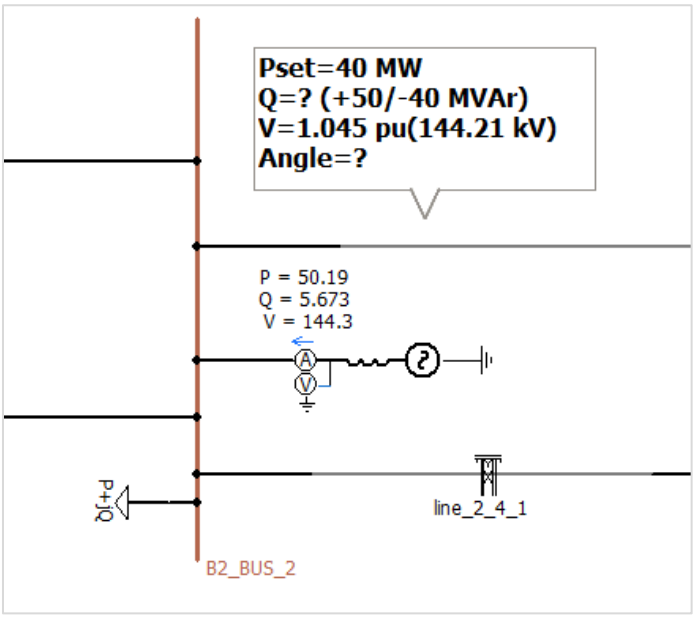


Figure 1 - Generator at B2 BUS 2

- 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").

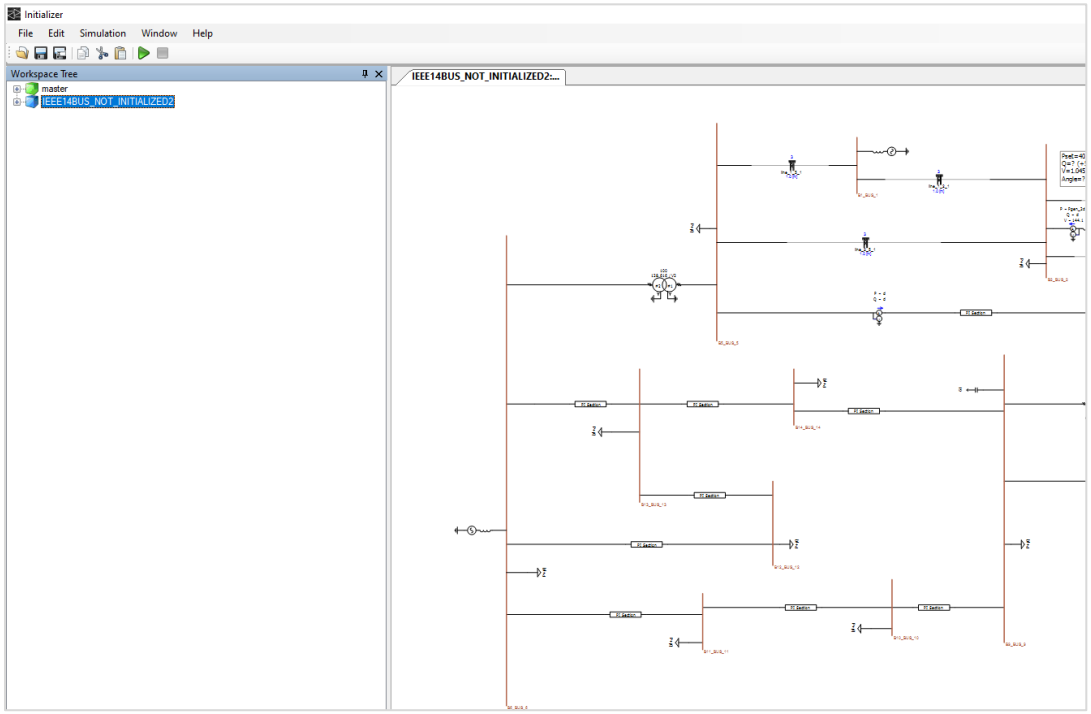


Figure 2 - IEEE 14 bus system in the PSCAD Initializer

- 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).

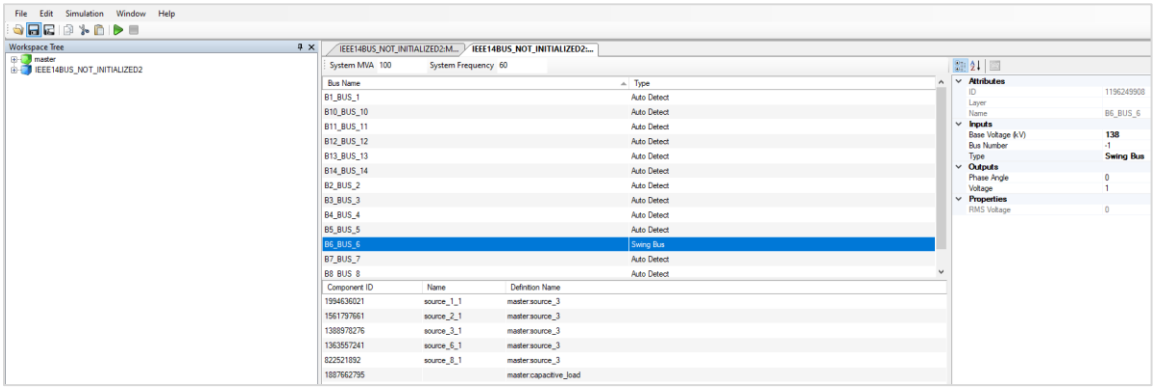


Figure 3 - Bus details and additional parameters windows

- Optional: Set additional load flow parameters, if required (see section 1.7 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.

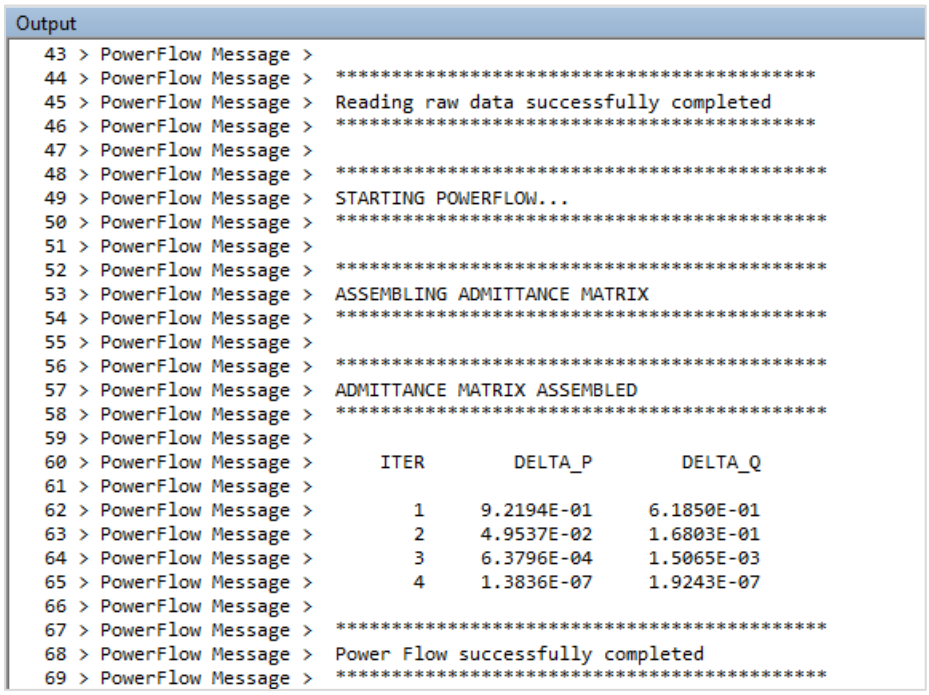


Figure 4 - Power flow solution

- 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.

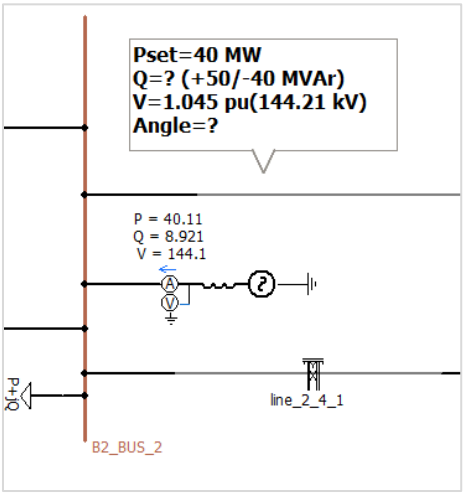


Figure 5 - Bus B2_BUS_2 in solved PSCAD case

## 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).

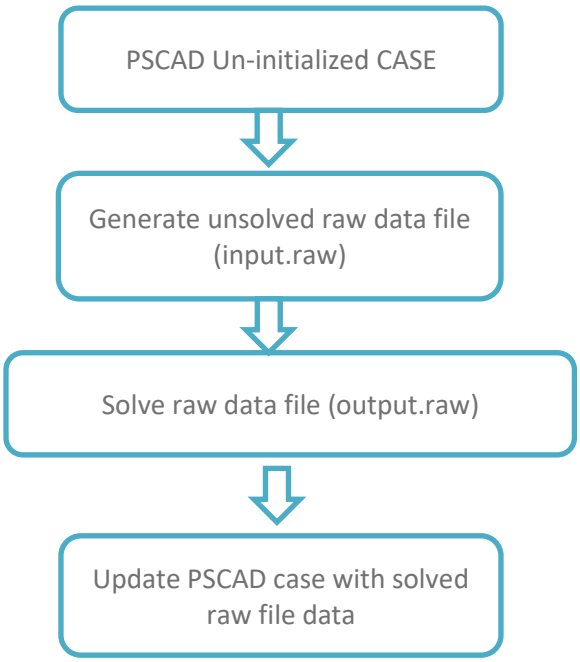


Figure 6 - Initializer block diagram

## 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 |δ|
- Active or real power |P|
- Reactive power |Q|

| | P | 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 parameeers are shown in Figure 7 and described in Table 1.

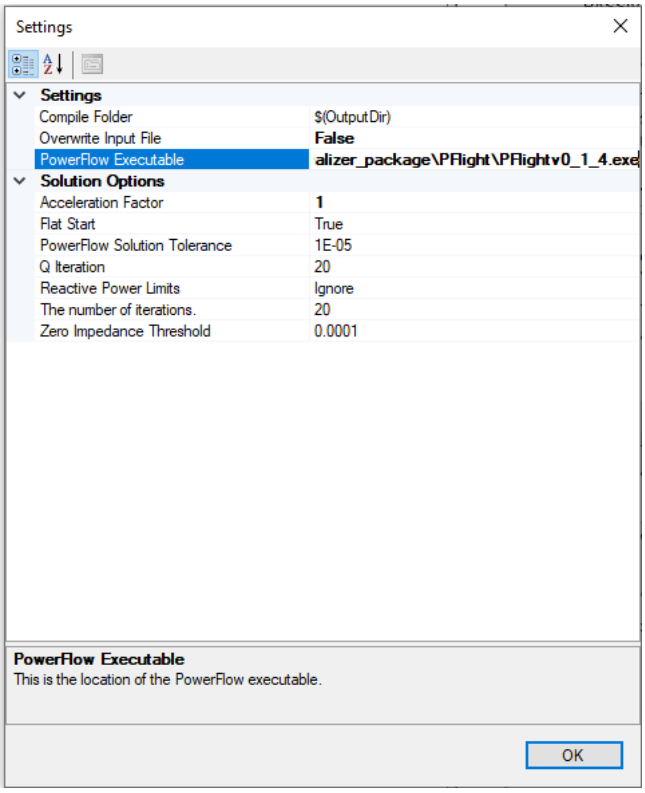


Figure 7 - Initializer settings dialog

| Option | Value | Description |
|---|---|---|
| Compile folder | $(OutputDir)<br>This macro is the default location for output files.<br>The default macro resolves to:<br>FilePath\CaseName.init<br>e.g.<br>C:\Folder\Case.pscx<br>Has a $(OutputDir)<br>C:\Folder\Case.init\ | This option provides the location for all temporary files that are generated when compiling. |
| Overwrite input file | Logical<br>(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<br>e.g. C:\....\ PFlightv0_1_4.exe<br>or<br>(b) PSSE engine usually located in C:\Program Files (x86)\PTI\PSSE##\PSSBIN\pssecmd##.exe<br>e.g.<br>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<br>(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<br>(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.

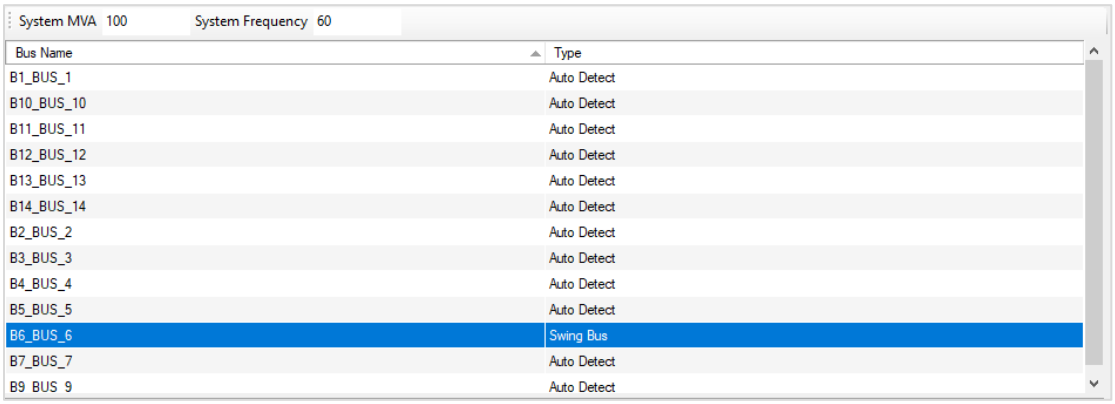


Figure 8 - List of buses in the network

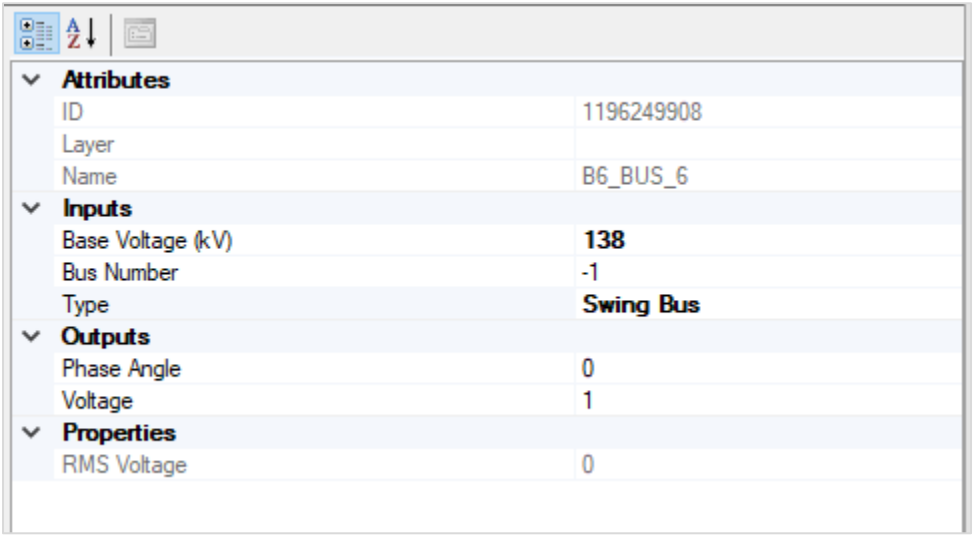


Figure 9 - Bus parameters

| | | |
|---|---|---|
| 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<br><br>If the bus number is -1, Initializer will automatically specify the bus number |
| Bus Type | Choice | Select the Bus type from following options<br>• Auto Detect<br>• Swing bus (or Swing bus)<br>• Generator bus (or PV bus)<br>• Non-generator bus (or PQ bus)<br>• isolated bus (bus is disconnected)<br><br>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 |

Figure 10 - List of sources

The generator/source extended parameters are shown below:

| | | |
|---|---|---|
| IsQset_2 | Text | True or false<br><br>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.<br><br>0 By Default |

The load extended parameters are shown below:

| | | |
|---|---|---|
| IsLdMdl | Text | True or false<br><br>If true, the load will be modeled as a standard load<br><br>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 1.10 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 contaning 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.

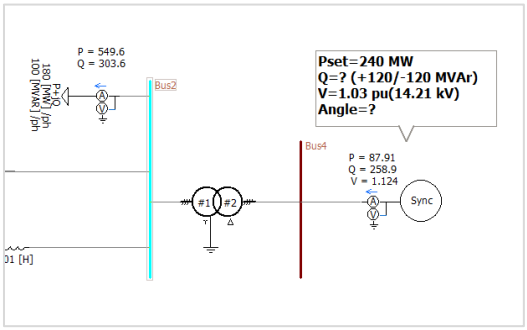


Figure 11 - PSCAD main page

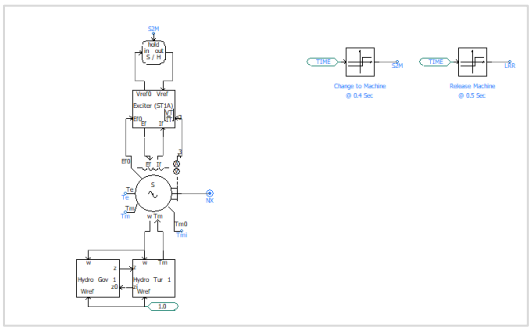

Figure 12 - Generator details inside page module of Sync

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:

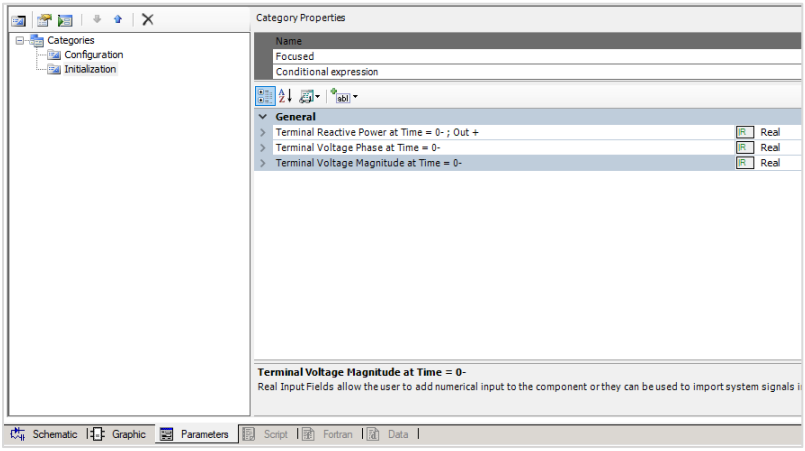


Figure 13 - Parameters for initialization

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

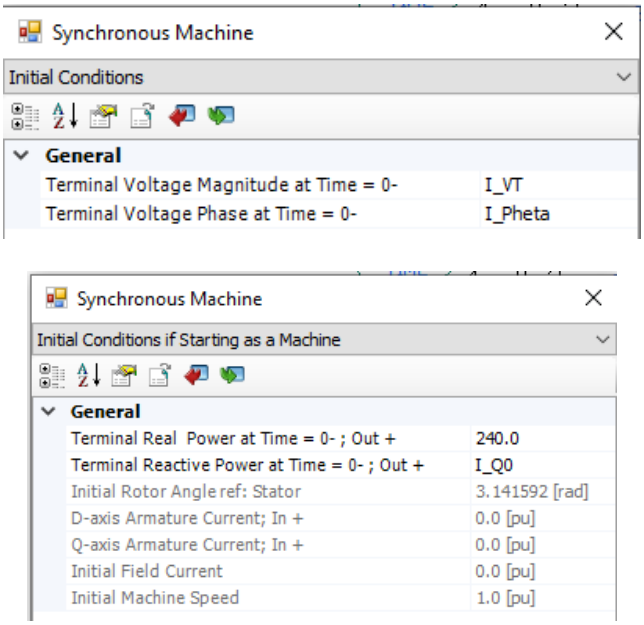


Figure 14 - Synchronous machine model parameters

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

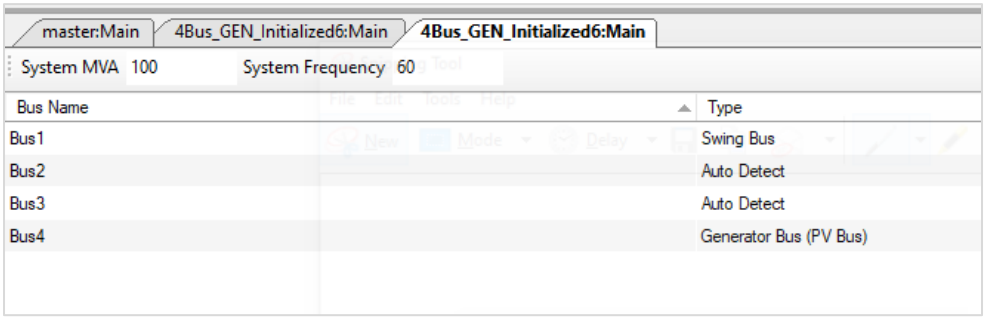


Figure 15 - Bus parameters of the Initializer

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

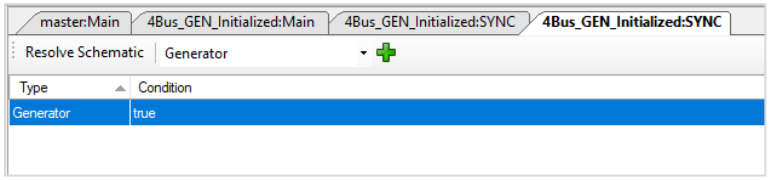


Figure 16 - Resolve Schematic in the Initializer

The generator initialization parameter are shown below.

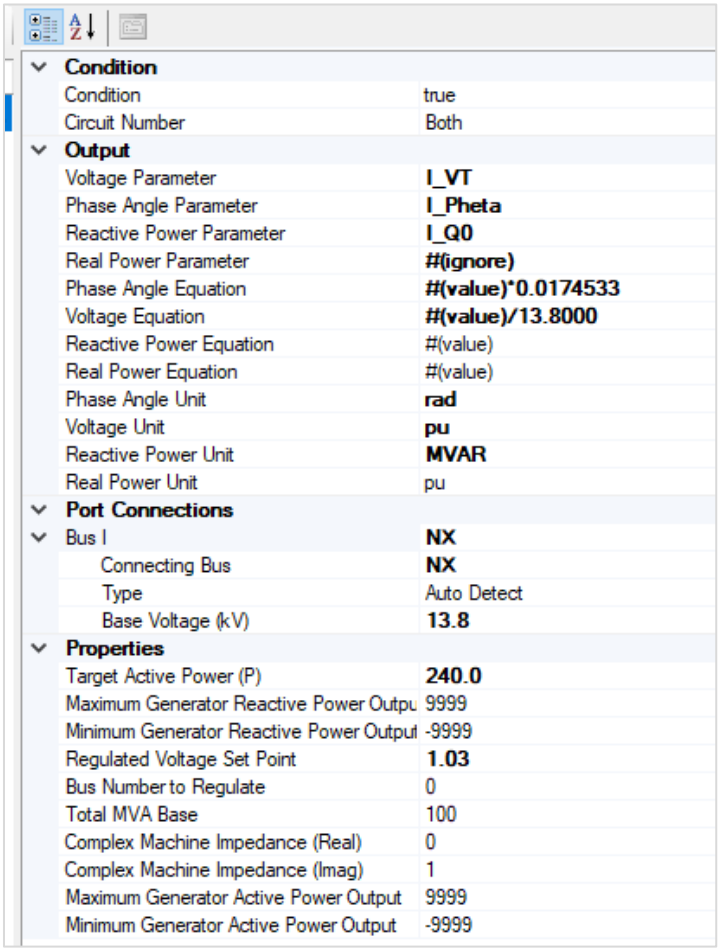


Figure 17 - Generator parameters for the Initializer

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 | pu |

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 | pu | 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 |
| | | |