# DOME

A Python package for power system analysis
Documentation for DOME version 2013.03.05, March 5, 2013

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# Contents

# Chapter 1

# Introduction

## 1.1 Why Dome?

Dome is a modular Python package that takes deeply advantage of the features of this modern scripting language, such as inheritance, introspection, and polymorphism, for power system analysis. Dome can solve power flow, continuation power flow, optimal power flow, small signal analysis and transient analysis. The main goals of the Dome project are:

1. To develop parallel software tools (e.g., multicore, cluster, GPUs, etc.) for power system analysis.

2. To implement novel algorithms and routines for power system analysis.

3. To model any existing devices and controllers used in power systems.

4. To provide a "canonical model", e.g., a universal format converter, for power system analysis.

## 1.2 A Word of Caution

Currently Dome is distributed as a "demo" package. This means that simulations are limited to networks with a reduced number of buses.

The reason for distributing a constrained version of Dome is mainly to force researchers interested in getting Dome to contact me. In order to get Dome sources, one has to agree in actively participate to the development and/or to the debugging of Dome. Conditions to be eligible to develop Dome will be stated in an *ad-hoc* license that has to be agreed by the parts.

Anyway, what said above is in no way not intended to discourage you to ask for Dome sources. Any question and suggestion is welcome. Please contact me at the following e-mail address:

`Federico.Milano@uclm.es`

## 1.3 Notation

The notation used throughout this documentation is as follows.

Sans Serif Font is used for indicating Python libraries, packages and modules.

`Courier Font` is used for indicating file and folder names and commands at the terminal prompt and at the Python interactive session. The user terminal prompt is indicated with `$`, the root terminal prompt is indicated with `#`, and the Python prompt is indicated with `>>>`.

# Chapter 2

# Installation

## 2.1 Python Version

Dome runs on both Python 2.6.x, 2.7.x and Python 3.x, the latter through the `2to3` utility. Older version of Python are not supported. Dome is develped and designed for Unix-like 64-bit platforms (e.g., Linux and Mac OS X), but a minimal working version can be compiled on 32-bit platforms as well as on Windows.[1]

## 2.2 Installing the Dome RPM

Currently, the demo version of Dome is distributed only as an RPM file and can be intalled only on 64-bit architectures running Fedora Core 15. Other platforms that support the RPM system can be used, but the Dome RPM distribution file is tested only on Fedora.

The installation can be easily accomplished using `yum` bu running as root:

```
# yum install dome-2011[month][day]-[build].fc15.x86_64.rpm
```

where `month`, `day` and `build` has to be substituted with current release values without square brackets. For example:

```
# yum install dome-20110722-1.fc15.x86_64.rpm
```

The RPM file contains information on all dependencies and should install missing ones.

## 2.3 Running Dome from a Remote Terminal

Compiling and installing the full and most recent version of Dome can be a complex and time-consuming operation.

[1]The installation on Windows depends on the avilability of binaries of GNU/Octave for Windows.

Since DOME has been designed to be a server application, the easiest way to run DOME is by getting an account on the serer where it is currently maintained. The current locations where DOME is installed are the following Linux servers of the University of Castilla-La Mancha:

- `tesla.uclm.es`, address 161.67.138.21
- `faraday.uclm.es`, address 161.67.140.142

If you are interested in testing DOME, please contact me.

## 2.4 Dependencies

If the RPM file is installed using rpm (which is not recommended), one will have to manually take care of all dependencies. Required mathematical libraries and Python modules, as follows:

Mathematical Libraries: blas, lapack, SuiteSparse, and gsl.

Python Modules: python-setuptools, Numpy, python-matplotlib, and sympy.

The naming convention is the one used in the Fedora 15 database (it may change on other platforms that supports RPM packages).

Optional, but strongly recommended packages are arpack, fftw3, python-lxml, python-cvxopt, python-blist, python-networkx, Mayavi, python-xlwt, python-xlrd, and python-progressbar.

Finally, a package that is not currently used but can be needed in future versions is python-scipy.

**Note 1:** only the source code of the SuiteSparse package is needed. It is recommended to download and expand the latest SuiteSparse tarball in the same folder as DOME. SuiteSparse is available at:

`http://www.cise.ufl.edu/research/sparse/SuiteSparse/`

**Note 2:** packages Numpy, python-matplotlib, and sympy are required only for plotting results through `domeplot`.

**Note 3**: all packages above should be installed using the latest version available in the Fedora repositories.

## 2.5 External Libraries

SuiteSparse provides state-of-the-art libraries for sparse matrix factorization. In particular, DOME supports KLU (default), UMFPACK, CXSPARSE and CHOLMOD packages.

With the aim of taking advantage of any cutting-edge mathematical packages, DOME is statically linked to some external libraries that are not currently included in the Fedora repositories. These external libraries are statically included into DOME C extensions.

Currently, the libraries that can be linked to DOME are:

PETSc Library for parallel Krylov subspace factorization of sparse matrices. PETSc is available at:

`www.mcs.anl.gov/petsc/petsc-as/`

SLEPc Library for parallel computing the eigenvalues of sparse matrices (based on PETSc). SLEPc is available at:

`www.grycap.upv.es/slepc/`

SuperLU Library for LU factorization of parse matrices. SuperLU is available at:

`http://crd.lbl.gov/~xiaoye/SuperLU/`

SuperLU_MT Library for distributed LU factorization of parse matrices using a multi-threading approach. SuperLU_MT is available at:

`http://crd.lbl.gov/~xiaoye/SuperLU/`

LUSOL Library written in FORTRAN for LU factorization developed by the Stanford University. LUSOL is available at:

`http://www.stanford.edu/group/SOL/software/lusol.html`

TAUCS Library for large (possibly out-of-core) sparse matrix factorization of symmetric matrices. TAUCS is available at:

`http://www.tau.ac.il/~stoledo/taucs/`

Y12M Library written in FORTRAN for sparse matrix factorization of symmetric matrices. Y12M is available at:

`http://www.netlib.org/y12m/`

MAGMA Library that provides an implementation of LAPACK routines for heterogeneous "Multicore + GPUs" architectures. MAGMA is available at:

`http://icl.cs.utk.edu/magma/`

# Chapter 3

# Compiling Dome

While installing Dome through the rpm is the recommended way to have a end-user working version on Fedora Linux, the development of Dome requires the ability of compiling sources and extensions. This section describes how to create a development verion of Dome on various platforms.

## 3.1 Unix-like Operating Systems

These include Linux and Mac OS X with MacPort. As said above, compiling the full cutting-edge version of Dome can be a quite time-consuming task. The procedure to proeprly compile and link each external library is described in the C extension file. However, to run a minimal but fully functional version of Dome only the SuiteSparse source files are required along with BLAS, LAPACK and GSL libraries.

To compile Dome simply execute as root:

```
# python setup.py install
```

or

```
# python setup.py develop
```

from within the Dome folder. Before being able to compile Dome, it is **necessary** to properly edit the file `setup.py` to point to the correct libraries and library paths. The `setup.py` script contains some heuristics to check if certain libraries are not installed on the system. Libraries that are not found will be ignored.

Observe that, on 32-bit platforms, only a minimal Dome version can be compiled.

## 3.2 Windows

The procedure described in this section has been tested for Windows 7, 32 bit. On Windows 64-bit, the procedure is likely the same but, at the moment ,some

Python packages required by DOME are not avialable for the 64-bit architecture. The procedure should work on any recent version of Windows, but only Windows 7 has been tested.

The first step is to install Python 2.7.2 and all DOME Python dependencies. If both the 64 bit or the 32 bit version are avaiable for a package, always choose the 32 bit version of the package, even if you are working on a Windows 64 bit platform. For most of the DOME Python dependencies htere exists either a Windows precompiled installer or a Python egg. Both methods are fine as long as all DOME dependencies are properly installed

Then install the latest versions of MinGW and GNU Octave. MinGW is the GNU compiler for the Windows system. GNU Octave is a free clone of Matlab. GNU Octave *per se* is not needed by DOME, but since GNU Octave comes with most mathematical libraries precompiled using MinGW, installing GNU Octave is the fastest and safest way to get BLAS, LAPACK, GSL, and ARPACK without the need of compiling them from scratch.

It is highly recommended to install Python, MinGW and GNU Octave in the main C folder. In this way, no changes will be needed in the DOME `setup.py` script. In any case, avoid folders that contains space or non alphanumeric characters that may create issues to the MinGW compiler.

Once the installation of all the packages listed above is completed, there are still a few step to complete before DOME can be compiled. These are:

1. Add to the Windows `PATH` environment variable the location of the `Python27` folder as well as the `Python27/Scripts` folder.
2. Create in the `Python/Lib/distutils` folder a file `distutils.cfg` as follows:

   ```
   [build]
   compiler=mingw32
   ```

3. Uncompress the DOME source files in a folder with reading and writing permissions. It is importatn to note that this folder will be the working folder of DOME, so that this has to be accessible to anyone allowed to make changes to DOME sources.
4. In the same folder as DOME, download and uncompress the latest version of SuiteSparse.

Open a Windows command prompt or a PowerShell window, move to the DOME main folder and run:

```
>> python setup.py develop
```

If everything has been properly installed and the Windows `PATH` has been properly customized, the command should compile all DOME C extensions and produce a working developing version of DOME that can be launched from any terminal.

Any changes to the Python sources in the DOME folders will be automatically available at the next execution of DOME. Changes to DOME C extensions requires re-running the `python setup.py develop` command.

# Chapter 4

# Command Line Options

Once the installation is complete, two commands are available: `dome` that allows solving simulations, and `domeplot` that allows plotting results.

As any Unix-like command both `dome` and `domeplot` provide a variety of command line options that allow adjusting the behavior to user's needs. This chapter describes in details all command line options.

## 4.1 Generalities

The general `dome` syntax is as follows:

```
$ dome [[--opt_name1=opt_value] [--opt_name2] ...] [data_file_name]
```

where, following the usual Unix notation, square brackets indicates optional syntax. The command line accepts any number of options. However, some options interrupt the execution of the program (e.g., `--help`) and hence make following options idle.

For frequently used options a shortcut is provided. For example:

```
$ dome --help
$ dome -h
```

do the same.

## 4.2 `dome` Options

In this section, the command line options are divided into four groups: (i) general options, (ii) IO data file options, (iii) solver options, and (iv) device options. The abbreviated option notation is indicated after the long one. Options arguments are printed in upper case.

### 4.2.1 General Options

`--clean, -c` Clean DOME output files and exit.

`--dontoverwrite, -z` Do not overwrite logging and report files. If this option is not enforced, output files are assigned default names and overwritten at each execution of DOME.

`--dump=DUMP, -d DUMP` Specify the name of the output file to which dumping simulation results.

`--exit, -x` Parse data file and exit without solving the power flow. This option is useful in case one wants to use dome as a data file converter. With this aim, one has to specify the input data and the output format.

`--get_dome` Get the latest DOME tarball and exit (Unix and Unix-like only).

`--help, -h` Print the list as well as a brief desciption of all available options and exit.

`--license` Retrieve and print the GNU GPLv3.

`--log=LOG, -l LOG` Explicitly assign a name for the output log file. By default, `dome_log_file.out` is used.

`--no_output, -n` Force not to write any output file. This may help save some time in case of large simulations.

`--param_help=PAR_HELP, -B PAR_HELP` Print a quick help on specific DOME setting parameter.

`--password=PASSWORD, -Z PASSWORD` Password of the SMTP server account. This option only has effect if the users specifies in the setting file an e-mail account to which sending simulation results ans log files (See general settings in Chapter 5).

`--retrieve, -R` Same as update, but without the installation step. Hence, it does not requires the root password.

`--settings=SETTINGS, -s SETTINGS` File name for custom settings (must be in the local path). On Unix and Unix-like, DOME looks also for the file `.domerc` in the user home folder. Otherwise, default settings are used. The custom setting files overwrites the `.domerc` settings.

`--settings_help=SET_HELP, -A SET_HELP` Print a quick help on DOME settings (use `All` for listing all classes).

`--smp=NCPUS, -M NCPUS` Run `NCPUS` parallel processes using the file list. If only one file is given, then `NCPUS` simulation are run in parallel using the same input data file. This option makes sense only if the data file contains stochastic processes and the computer has multiple CPUs.

`--update, -U` Check for DOME update and download and install it if needed. The installation requires the root password.

`--verbose=VERBOSE, -v VERBOSE` Logging verbose level. The verbosity level is measured by an integer number from 1 to 5. The level correspondence is: TODO = 0, DEBUG = 1, INFO = 2, WARNING = 3, ERROR = 4, and CRITICAL = 5. For example, the level 0 displays everthing while the level 5 displays only critical errors. The default logging level is 2

`--version, -V` Print DOME current version and exit. The operating system name and the Python version are also shown.

`--warranty, -w` Print the warranty disclaimer and the limitations of liability.

`--profile, -9` run the Python profiler on top of the current DOME call. Once the simulation completed, the profiler displays on the terminal the most time consuming DOME functions (5% of the full profiler log). The profiler sligthly slows down the simulation.

### 4.2.2 IO Options

`--addfile=ADDFILE, -a ADDFILE` Additional data file needed by some formats (see also Chapter 8).

`--gis=GIS, -J GIS` GIS file (JML format). This file specifies through an XML scheme, topological information (see also Chapter 8).

`--input=INPUT_FORMAT, -i INPUT_FORMAT` Format of the input data file. Accepted formats are: `cepel`, `cfins`, `chapman`, `cim`, `cyme`, `digsilent`, `dome`, `epri`, `eurostag`, `flowdemo`, `fluprog`, `ge`, `ieee`, `inptc1`, `interpss`, `ipssdat`, `jml`, `m3`, `matpower`, `odm`, `pcflo`, `pndm`, `powerworld`, `psap`, `psat`, `psse`, `pst`, `reds`, `sepe`, `simpow`, `simulink`, `tsinghua`, `ucte`, `vst`, `webflow`, and `wood`. See also Chapter 8. Observe that specifying the input format is not mandatory. If no format is specified, DOME attempts to recognize the input data format using heuristic rules. However, to avoid issues and save time, it is recommended to specify the input data format.

`--cleanall, -K` clean all DOME output and auxiliary files in the current path.

`--map, -m` plot map of power flow results. This option has an effect only if the input data includes topological information or if used in conjunction with option `--gis` (see above). See the settings `Plot` for details on customizable options.

`--output=OUTPUT, -O OUTPUT` Custom output file name. The default is the same input data file name with an adequate suffix and extension. The extension depnds on the output format selceted by the user. By default, the output format is a plain ASCII text (extension `.txt`).

`--output_format=OUTPUT_FORMAT, -o OUTPUT_FORMAT` Format of the output data file. Accepted formats are: `dome`, `ieee`, `latex`, `psat`, `sepe` and `sostools`. See also Chapter 8.

`--path=PATH, -p PATH` Path to the input data file. It can be a relative or an absolute path.

`--raw_format, -e` Dump DOME raw input data format. By default, format syntax and rules are saved in the file `dome_raw_format.txt`. While new rules and syntax keywords can be added in the future to the DOME data format, backward compatibility is always guarranteed.

`--summary, -Y` Write a brief summary of the data file. The data file is parsed and relvant information about devices included in the file is printed out. This option can be used in conjunction with option `--exit` if the power lfow analysis is not required.

### 4.2.3 Solver Options

`--cuda=CUDA, -D CUDA` Enable the support of the Cuda libraries and hardware for array calculus. ANy array bigger than the threshold `CUDA` is handled using available GPUs rather than CPUs. Both 32- and 64-bit Nvidia GPU platforms are supported. This options requires that DOME extensions have been compiled with Cuda libraries support. If not, this options is neglected.

`--checkjacs, -j` Check analytical Jacobian matrices using numerical differentiation. This option is useful when developing new devices. Of course, this options does not state whether the device equations are consistent, just checks whether the analytical Jacobian elements coincides with the numerical differentiation of device equations. Hence, this option allows checking if the analytical Jacobian corresponds to the device equations. Observe that the numerical differentiation fails whenever a hard limit is binding.

`--force, -F` Force continuing the execution even if the power flow routine does not converge. By default, is the power flow has convergence issues, DOME exit with an error message. However, during the development of new devices, it may be useful to check analytical Jacobian matrix elements since these are often the cause of the convergence failure (see option `--checkjacs` above). With this aim, it may be useful to reduce the maximum number of power flow iterations to 1 or 2. In fact, when the power flow does not converge, variable values often increase more than quadratically and even get the not-a-number (`NaN`) value. The numerical differentiation is more informative if variable values are close to nominal ones.

`--only_check_jacobian, -O` Check analytical Jacobian matrices using numerical differentiation. This option is similar to `checkjacs` but does not attempt to solve the power flow analysis. This option can be useful during the debugging phase of a new device model in case the Jacobian matrix is singular.

`--routine=ROUTINE, -r ROUTINE` Set the routine to be solved after power flow analysis. Available solvers are:

`CPF` continuation power flow analysis;

`EIG` eigenvalue analysis;

`OPF` optimal power flow analysis;

`TDS` time domain integration.

Abbreviations `C`, `E`, `O` and `T` are and lower cases are also recognized. Only one solver per run is allowed. Although each solver performs some basic control over the input data, the user should always do a careful check of the data file to be sure that these are conssitent with the solver. The user should also carefully study the default values assumed by the solvers in case no explicit setting is provided. Solver settings are detalied in Chapter 5.

### 4.2.4 Device Options

`-categories=DEVICECATEGORY, -C DEVICECATEGORY` Dumps all devices belonging to the given category. Categories are used for appying certain common operations to devices beloging to the same category. A device can belong ot several categories. If `DEVICECATEGORY` is `All`, then the command dumps all DOME devices ordered by categories.

`--dev_format, -f` This option produces a print out of the format of all devices. Devices are printed in alphabetical order. The format includes a brief description of the device and the list of input data names also in alphabetical order. Data names are case sensitive. Each data is briefly described. An asterisk `*` indicates that the data is mandatory and a bound mark `#` indicates that the data cannot be zero. Finally, the default value as well as the unit of the data are reported. All pu values refers to the bases of the device nominal rates.

`--device_list, -L` Print the list of all devices in alphabetical order. The default output file name is `dome_dev_list.txt`.

`--device_variables=DEVICENAME, -W DEVICENAME` Print a list of the variables of given device as well as a brief description and variable units used in the device model.

`--groups=DEVICEGROUP, -G DEVICEGROUP` Dumps all devices belonging to the given group. Device groups are important because the IDs of devices belonging to the same group have to be different. A device can belong only to one group. If `DEVICEGROUP` is `All`, then the command dumps all DOME devices ordered by groups.

`--quick_help=DEVICENAME, -q DEVICENAME` Print specific device data format. The format is the same as that used for print the format of all devices (see option `--dev_format`).

`--search=EXPRESSION, -S EXPRESSION` Search devices that begin with a given expression. The searching method is based on regular expressions, hence, any regular expression enclosed in `"` will work.

## 4.3 *Examples*

Running the power flow with implicit format assumption:

```
$ dome foo.txt
```

Running the power flow with explicit format specification:

```
$ dome -i ieee foo.txt
```

Running the power flow using a relative path:

```
$ dome -p foopath1/foopath2 foo.txt
```

Runnig the power flow using an absolute path:

```
$ dome -p "/home/user name/foopath" foo.txt
```

Solving a time domain simulation:

```
$ dome -r TDS foo.txt
```

Solving the CPF analysis and check the consistency of analytical Jacobian matrices:

```
$ dome -r CPF -j foo.txt
```

Forcing the check of the consistency of analytical Jacobian matrices in case the power flow analysis does not converge:

```
$ dome -j --force foo.txt
```

Converting a file in IEEE CDF into DOME format without solving the power flow:[1]

```
$ dome -i ieee -o dome -x foo.txt
```

Getting the summary of a data file without solving the power flow:

```
$ dome --summary -x foo.txt
```

Looking for help on the device `Line`:

```
$ dome -q Line
```

Looking for all devices whose name starts with `T`:

```
$ dome --search T
```

Looking for all devices whose name contains the token `Line`:

```
$ dome --search "\w*Line"
```

Printing all options of the settings for CPF analysis:

```
$ dome -A CPF
```

[1]Forcing DOME to exit before solving the power flow can be inconsistent if the parser requires the power flow solution to create the output file.

# Chapter 5

# Settings

## 5.1 Available Settings

Apart from command line options, the behavior of DOME and of each solver can be finely adjusted through a set of settings. DOME assigns default values to all settings. Such defualt values can be customized in two ways, as explained in the following subsection.

Settings are divided into groups. Group names and a brief description of each option of each group can be retrieved using the command:

```
$ dome -A All
```

Currently defined setting groups are: `Settings`, `Plot`, `PF`, `TDS`, `CPF`, `OPF`, `SSSA`, `EQUIV`, `SOS`, and `SMTP`. Each group as a set of options. All options displayed using the previous command can be customized by the user. One can also retrieve the options of a single group:

```
$ dome -A CPF
```

The user can also retrive information on a single option of a certain group, for example:

```
$ dome -B CPF.method
```

## 5.2 Customizing DOME Behavior

There are currently two ways for customizing DOME behavior. The first way is to place a file called `.domerc` in the user home folder, the second one is to place a setting file in the current folder and call it at execution time.[1] The two methods can be used together. The settings in the `.domerc` file overwrite DOME default

[1]On Unix-like systems, a file preceeded by a dot is an hidden file. DOME recognizes the file `.domerc` only on Unix-like systems.

settings, while the custom setting file overwrite both `.domerc` settings and default ones.

Both the `.domerc` and custom setting files have same syntax, which is inherited from typical Unix-command setting files. Each line assigns a value to one DOME variable. The syntax is as follows:

```
class_name.attribute_name = attribute_value
```

where `class_name` is one of the following:

| | |
|---|---|
| `CPF` | Continuation power flow settings. |
| `EQUIV` | Equivalencing procedure settings. |
| `PF` | Power flow settings. |
| `OPF` | Optimal power flow settings. |
| `Settings` | General settings. |
| `SMTP` | SMTP settings for sending DOME results by e-mail. |
| `SOS` | Polynomial (sum of squares) settings. |
| `SSSA` | Small-signal stability settings. |
| `TDS` | Time domain simulation settings. |

The `attribute_value` can be any number, a Python Boolean (i.e., `True` or `False`) or a string. Strings have to be included in `'` or `"`. Any line starting with `#` is a comment and is simply ignored. Blank lines are aslo ignored.

The following is an example of setting file.

```
Settings.freq = 60.0
Settings.distrsw = False
Settings.export = 'txt'
Settings.forcepq = False
Settings.library = 'SUPERLU'
Settings.coi = True
Settings.connectivity = True
Settings.pvdir = False
Settings.seed = False
Settings.write_bus_names = False

PF.solver = 'NR'
PF.report = 'default'
PF.pv2pq = False
PF.violations = False
PF.maxit = 100
PF.sortbuses = 'data'

TDS.pq2z = True
TDS.tf = 30
TDS.resetangles = True
TDS.fixt = True
TDS.tstep = 0.01

# SMTP settings
```

```
SMTP.email = False
SMTP.server = 'smtp.mail.uclm.es'
SMTP.username = 'Federico.Milano'
SMTP.address = 'Federico.Milano@uclm.es'
SMTP.password = ''
SMTP.port = 587

# CPF.ending = 'all solutions'
CPF.method = 'perpendicular intersection'
CPF.single_slack = False
CPF.reactive_limits = False
CPF.nump = 100
CPF.mu_init = 1.0
CPF.step = 0.5
CPF.hopf = True

EQUIV.bus_selec = 'area'
EQUIV.area = 5
EQUIV.method = 'REI'
EQUIV.lossless = True
```

## 5.3 Detailed List of Available Settings

The output of the command `dome -A All` is given below.

```
DOME 2012.11.27(04)

Copyright (C) 2010-2012 Federico Milano
DOME comes with ABSOLUTELY NO WARRANTY

Interpreter:  python 2.7.3
Platform:     darwin
BLAS library: NFS BLAS
Usage:        command line
Session:      Wed Nov 28 09:22:48 2012
Mode:         single process

System structure populated in 0.03195 s
Parsing input file <.domerc>
DOME settings


Class <Settings>

---------------------------------------------------------------------------
 Parameter         | Description                                | Default
---------------------------------------------------------------------------
```

```
coi               | use the center of intertia in          | True
                  | synchronous machine models             |
connectivity      | check the connectivity of the network  | True
                  | before solving the power flow          |
default_names     | force the use of default device names  | False
disable_antiwindup | neglect time derivative signs in      | False
                  | antiwindup limiters (needed for QSS    |
                  | and CPF)                               |
discrete_ultc     | use discrete ULTC models when          | False
                  | converting data files from external    |
                  | formats                                |
distrsw           | use distributed slack bus              | False
export            | format of the output files (such as    | txt
                  | the power flow report). Alternatives:  |
                  | [txt, htm, tex, rst, xls]              |
forcepq           | force the use of constant PQ loads     | False
                  | (disable any other setting)            |
freq              | system frequency rate in Hz (it is     | 60.0
                  | linked to <rad>)                       |
idc               | system current base in kA for dc       | 10.0
                  | devices                                |
isga              | enable the computation of the ISGA     | False
                  | index                                  |
library           | library used for solving sparse        | KLU
                  | linear systems. Alternatives: [KLU,    |
                  | UMFPACK, SUPERLU, PETSC, SLUDIST,      |
                  | MUMPS, CHOLMOD, CXSPARSE, SUPERMT,     |
                  | LUSOL]                                 |
mva               | system power base in MVA for ac        | 100
                  | devices                                |
pvdir             | use power directions of PV devices     | False
rad               | system frequency rate in rad/s (it is  | 376.991118431
                  | linked to <freq>)                      |
seed              | set to <False> for "reproducible"      | False
                  | random results                         |
seedval           | custom value of the seed passed to     | None
                  | the random number generator            |
similarity        | guess device names using string        | True
                  | similarity when parsing Dome data      |
                  | files                                  |
tol               | tolerance for convergence test         | 1e-05
useibase          | use system dc current base rather      | False
                  | than the current base defined at each  |
                  | dc node                                |
usepbase          | use system ac power base rather than   | False
                  | the power base defined at each ac bus  |
verrmax           | maximum allowable difference between   | 15
                  | device rate voltage and base in %      |
vstab             | compute voltage stability indices      | False
write_bus_names   | write bus names and indexes to a file  | False
```

```
---------------------------------------------------------------------------

Class <Plot>

---------------------------------------------------------------------------
 Parameter          | Description                            | Default
---------------------------------------------------------------------------
 bus_names          | plot bus names in temperature maps     | True
 colormap           | color map used for plotting            | jet
                    | temperature maps. Alternatives: [jet,  |
                    | autumn, bone, cool, copper, flag,      |
                    | gray, hsv, hot, pink, prism, spring,   |
                    | summer, winter, spectral]              |
 dim                | dimension of the drawing.              | 2D
                    | Alternatives: [2D, 3D]                 |
 drawing            | type of the drawing to display         | network
                    | results. Alternatives: [temperature,   |
                    | congestion, network]                   |
 format             | format of the drawing file.            | eps
                    | Alternatives: [eps, png, tiff, gif,    |
                    | jpg]                                   |
 hidden             | if true, do not show the drawing in a  | True
                    | separate window                        |
 layout             | Graphviz layout type. Alternatives:    | neato
                    | [neato, dot, fdp, twopi, circo]        |
 symbols            | plot device symbols in temperature     | False
                    | maps                                   |
 var                | variables considered to create the     | flows
                    | drawing. Alternatives: [voltages,      |
                    | flows]                                 |
---------------------------------------------------------------------------

Class <PF>

---------------------------------------------------------------------------
 Parameter          | Description                            | Default
---------------------------------------------------------------------------
 flatstart          | use flat start for solving power flow  | False
                    | analysis                               |
 inpvpq             | iteration number at which PV-PQ        | 2
                    | switching begins (for power flow       |
                    | analysis)                              |
 maxit              | maximum number of iteration of the     | 100
                    | power flow analysis                    |
 pv2pq              | switch PV to PQ in case of reactive    | False
                    | power limit violation during power     |
                    | flow analysis                          |
 report             | power flow report type. Alternatives:  | default
                    | [default, extended]                    |
 show               | show iteration status during power     | True
```

```
                  | flow analysis                        |
 solver           | power flow solver method.            | NR
                  | Alternatives:                        |
                  | <NR>: standard Newton-Raphson        |
                  | <XB>: fast decoupled power flow      |
                  | <BX>: fast decoupled power flow      |
                  | <DC>: dc power flow                  |
                  | <RK4>: Runge-Kutta's order 4 formula |
                  | <RK6>: Runge-Kutta's order 6 formula |
                  | <Braz>: robust Braz-Castro's method  |
                  | <Robust>: robust Newton-Raphson      |
                  | <Gauss>: Gauss-Seidel's method       |
                  | <Jacobi>: Jacobi's method            |
                  | <Dishonest>: dishonest Newton-Raphson |
                  | <BFS>: back-forward sweep            |
 sortbuses        | criterion used to sort buses in power | data
                  | flow report. Alternatives: [id, name, |
                  | data]                                |
 static           | discard dynamic devices (if the are  | False
                  | initialized after power flow)        |
 switch1pv        | switch only one PV to PV per         | True
                  | iteration during power flow analysis |
 switch2nr        | allow switching to Newton-Raphson    | False
                  | method if the power flow convergence |
                  | error is sufficiently small          |
 units            | units used in the power flow report. | pu
                  | Alternatives: [pu, MVA, kVA, VA]     |
 usedegree        | use degree instead of rad in power   | False
                  | flow report                          |
 violations       | include limit violations in the power | True
                  | flow report                          |
---------------------------------------------------------------------------

Class <TDS>

---------------------------------------------------------------------------
 Parameter        | Description                          | Default
---------------------------------------------------------------------------
 checkdelta       | check maximum difference of          | False
                  | consecutive rotor angles during TDS  |
 deltadelta       | the maximum allowed difference of    | 180.0
                  | consecutive rotor angles during TDS  |
 deltat           | time step used during TDS (used for  | 1e-05
                  | fixed time step)                     |
 deltatmax        | maximum time step used during TDS    | 0.001
                  | (adaptive time step)                 |
 deltatmin        | minimum time step used during TDS    | 1e-05
                  | (adaptive time step)                 |
 fixt             | use fixed time step for time domain  | True
                  | simulations                          |
```

| | | |
|---|---|---|
| locksnap | lock snapshots (used in time domain analysis) | False |
| maxit | maximum number of iterations per step of the inner NR loop of TDS | 20 |
| method | integration method for time domain simulation. Alternatives: <trapezoidal>: implicit trapezoidal formula <euler>: implicit backward Euler’s formula <qss>: quasi-static simulation <bdf2>: 2nd order backward differentiation formula | trapezoidal |
| method_sdae | integration method for the diffusion term of SDAEs. Alternatives: <euler>: explicit forward Euler’s formula <milstein>: Milstein’s formula | euler |
| perturbation | apply given perturbation during time domain simulations | False |
| pq2z | switch constant PQ loads to constant impedances for time domain simulations | False |
| progressbar | use the progress bar during time domain simulations (can be slow) | True |
| resetangles | reset bus angles to pre-fault values after clearing faults | True |
| solver | type of solver for each time step. Alternatives: <DH>: dishonest Newton-Raphson <NR>: Newton-Rapshon | DH |
| t0 | initial simulation time | 0.0 |
| tf | final simulation time | 15 |
| tstep | fixed time step for time domain simulation | 0.01 |

Class <SSSA>

| Parameter | Description | Default |
|---|---|---|
| cheb | number of points of the Chebyshev differentiation matrix (only for DDAE) | 10 |
| color | color platte used in the root loci figure. Alternatives: [color, black] | black |
| dde_method | the method of the spectrum analysis in case of DDAE. Alternatives: [Bellen, Breda] | Bellen |

```
debug            | ARPACK debugging info: 0 no          | 0
                 | information -> 6 maximum information |
                 | (used only if <solver> is not <la>)  |
display          | show root loci figure when the small | False
                 | sinagl analysis is completed         |
markup           | the format of text in the root loci  | latex
                 | figure. Alternatives: [latex,        |
                 | unformatted]                         |
matrix           | matrix type used to solve the        | As
                 | eigenvalue analysis. Alternatives:   |
                 | [As, Jlf]                            |
maxit            | maximum number of iterations allowed | 100
                 | for iterative solvers                |
mineig           | eigenvalue threshold used in for     | -6.0
                 | plotting the root loci               |
mpd              | maximum projected dimension. If None,| None
                 | an optimal value is used (used only  |
                 | if <solver> is not <la>)             |
ncv              | number of basisvectors. If None, an  | None
                 | optimal value is used (used only if  |
                 | <solver> is not <la>)                |
nev              | number of eigenvalues to be computed | 6
                 | (used only if <solver> is not <la>)  |
plane            | the type of plane used to solve the  | splane
                 | eigenvalue analysis. Alternatives:   |
                 | [zplane, splane, map]                |
plot             | if true, the SSSA routine creates a  | False
                 | figure with the resulting eigenvalue |
                 | loci                                 |
pq2z             | convert PQ loads to constant         | False
                 | impedance before running the         |
                 | eigenvalue analysis                  |
sigma            | eigenvalue spectral shift real value | -0.6
                 | (used only if <solver> is not <la>)  |
solver           | the solver used to solve the         | la
                 | eigensystem. Alternatives:           |
                 | <la>: Shur method (LAPACK)           |
                 | <ak>: Arnoldi iteration (ARPACK)     |
                 | <ar>: Arnoldi iteration (SLEPc)      |
                 | <ks>: Krylov-Shur method (SLEPc)     |
                 | <lz>: Lanczos method (SLEPc)         |
                 | <gd>: General Davidson method (SLEPc)|
                 | <jd>: Jacobi-Davidson method (SLEPc) |
                 | <ma>: GPU-based Shur method (MAGMA)  |
spectrum         | the kind of eigenvalues to be        | All
                 | computed. Alternatives:              |
                 | <All>: complete spectrum             |
                 | <LM>: largest magnitude              |
                 | <SM>: smallest magnitude             |
                 | <LR>: largest real value             |
```

```
                    | <SR>: smallest real value             |
                    | <LI>: largest imaginary value         |
                    | <SI>: smallest imaginary value        |
 tol                | numerical tolerance (used only if     | 1e-14
                    | <solver> is not <la>)                 |
 zeta               | damping value in pu used to plot a    | 0.05
                    | line in the root loci                 |
---------------------------------------------------------------------------

Class <CPF>

---------------------------------------------------------------------------
 Parameter          | Description                           | Default
---------------------------------------------------------------------------
 areagrowth         | enforce using area annual growth      | False
 corrector          | method used for the corrector step.   | LP
                    | Alternatives:                         |
                    | <LP>: local parametrization           |
                    | <PI>: perpendicolar intersection      |
                    | <GP>: geometric parametrization       |
 ending             | CPF stopping criterion. Alternatives: | nose
                    | <nose>: conventional nose curve       |
                    | <1stbif>: first bif. encountered      |
                    | <1stlim>: first limit encountered     |
                    | <allsol>: all solutions               |
 flow               | flow type for branch limits.          | I
                    | Alternatives:                         |
                    | <I>: currents                         |
                    | <P>: active powers                    |
                    | <S>: apparent powers                  |
 flow_limits        | enforce checking branch flow limits   | False
 hopf               | enforce checking Hopf bifurcations    | False
 index              | index of the algebraic variable to be | None
                    | plotted for the <allsol> case         |
 maxit              | maximum number of iterations for the  | 20
                    | corrector step                        |
 msv                | compute the minimum singular value    | False
 mu_init            | initial continuation parameter        | 1.0
 negload            | allow using negative load as power    | False
                    | directions                            |
 norm               | threshold value of the tangent        | 20.0
                    | Euclidean norm used to identify SNBs  |
 onlynegload        | force using only negative loads as    | False
                    | power directions                      |
 onlypqgen          | force using only PQ generators as     | False
                    | power directions                      |
 points             | number of points of the homotopy      | 100
                    | technique                             |
 predictor          | method used for the predictor step.   | tan
                    | Alternatives:                         |
```

```
                   | <tan>: tangent vector                 |
                   | <sec>: secant vector                  |
 reactive_limits   | enforce checking generator reactive   | True
                   | power limits                          |
 regngrowth        | enforce using region annual growth    | False
 show              | enforce displaying CPF results        | True
 single_slack      | if True, the single slack bus is used | False
 step              | step size of the tangent vector       | 0.1
 stepcut           | enforce step cutting                  | True
 tolc              | tolerance of the corrector step       | 1e-05
 tolf              | tolerance of the flow limit           | 0.01
                   | violations                            |
 tolv              | tolerance of the voltage limit        | 0.005
                   | violations                            |
 transcritical     | threshold for transcritical and       | 35.0
                   | pitchfork bifurcations                |
 voltage_limits    | enforce checking bus voltage limits   | False
---------------------------------------------------------------------------
```

Class <OPF>

```
---------------------------------------------------------------------------
 Parameter         | Description                           | Default
---------------------------------------------------------------------------
 basepg            | include base power generation         | True
 basepl            | include base power consumption        | True
 deltat            | time period used for multiperiod OPF  | 30.0
 enflow            | enforce branch flow contraints        | True
 enreac            | enforce reactive power constraints    | True
 envolt            | enforce voltage constraints           | True
 eps1              | tolerance of equality constraints     | 0.0001
 eps2              | tolerance of variable increments      | 0.005
 eps_mu            | tolerance of the barrier parameter    | 1e-10
 flatstart         | use flat start as initial guess of    | True
                   | the OPF problem                       |
 flow              | type of flow constraints.             | currents
                   | Alternatives: [currents, active,      |
                   | apparent]                             |
 gamma             | safety factor fo the IPM              | 0.95
 line              | index of the line with contingency    | None
 method            | optimal power flow NLP solver.        | Mehrotra
                   | Alternatives: [Mehrotra, Newton]      |
 mit               | maximum number of iterations          | 50
 model             | optimal power flow model. Currently   | single
                   | only <single> is available.           |
                   | Alternatives: [single, pareto,        |
                   | dailyatc_cpf, atc_sens]               |
 mu_max            | maximum loading parameter for the     | 0.8
                   | Pareto set                            |
 mu_min            | minimum loading paramter for the      | 0.1
```

```
                   | Pareto set                            |
 show              | display OPf iterations                | True
 sigma             | centering parameter of the IPM        | 0.2
 tiebreak          | include penalty funcitons for tie     | False
                   | breaks                                |
---------------------------------------------------------------------------

Class <SOS>

---------------------------------------------------------------------------
 Parameter         | Description                           | Default
---------------------------------------------------------------------------
 check             | check recast system by evaluating it  | True
                   | at the e.p.                           |
 digits            | number of digits used for printing    | 6
                   | polynomial coefficients               |
 jacobian          | include Jacobian matrix equations     | True
 rm_error          | remove numerical error from shifted   | True
                   | equations (implies "shift")           |
 rm_orphans        | remove unused algebraic variables     | True
                   | from recast system                    |
 shift             | shift variables so that 0 is the e.p. | False
 simplify          | rewrite equations to pack polynomial  | True
                   | coefficients                          |
 subdev            | substitute non-polynomial functions   | True
                   | for a polynomial approximation        |
---------------------------------------------------------------------------

Class <EQUIV>

---------------------------------------------------------------------------
 Parameter         | Description                           | Default
---------------------------------------------------------------------------
 Vn                | voltage level in kV that defines the  | 220.0
                   | study system  (used only if           |
                   | "bus_selec" is "level" or             |
                   | "threshold")                          |
 add_loads         | enforce adding equivalent load at     | True
                   | boundary buses                        |
 area              | area code that defines the study      | 5
                   | system (used only if "bus_selec" is   |
                   | "area")                               |
 bus_depth         | the level of the connection degree to | 0
                   | boundary buses of the buses of the    |
                   | external system that have to be       |
                   | included in the study system (0 means |
                   | that no external buses are included   |
                   | in the study system)                  |
 bus_selec         | criterion used to define tha study    | area
                   | system. Alternatives: [level, area,   |
```

| | | |
|---|---|---|
| | region, threshold, custom] | |
| custom_file | file containing the bus indexes of the study system (used only if "bus_selec" is "custom") | |
| custom_path | absolute or relative path of the custom file | |
| flatstart | do not include power flow solution voltage values of the original system in the data file of the resulting equivalent system | True |
| gen_model | the static generator model for equivalent and boundary buses. Alternatives: [PVgen, PQgen] | PVgen |
| load_model | the static load model for equivalent and boundary buses. Alternatives: [PQ, Shunt] | PQ |
| lossless | neglect the resistance of equivalent branches | True |
| method | equivalencing procedure. Alternatives: [Thevenin, REI, GREI, Ward, SSpace] | REI |
| omega_file | name of the file containing the bus groups for the "GREI" methods. Each group has to be identified by a tag with the format: "# code" | None |
| output | format of the out data file containing the resulting equivalent system | dome |
| region | region code that defines the study system (used only if "bus_selec" is "region") | 1 |
| stop_island | stop the equivalencing procedure if the study system is not interconnected | False |
| ymin | equivalent branches with series admittance lower than "ymin" are neglected (used only if "method" is "GREI" or "Ward") | 0.1 |

Class <SMTP>

| Parameter | Description | Default |
|---|---|---|
| address | e-mail address used for sending simulation results | None |
| attach | send simulation results as attachments | False |
| email | send simulation results by e-mail | False |

```
 password           | password of the e-mail account used   |
                    | for sending simulation results        |
 port               | port of the e-mail account used for   | 22
                    | sending simulation results            |
 server             | IP of the e-mail server used for      | None
                    | sending simulation results            |
 username           | username of the e-mail account used   | None
                    | for sending simulation results        |
---------------------------------------------------------------------------

Class <ACS>

---------------------------------------------------------------------------
 Parameter          | Description                           | Default
---------------------------------------------------------------------------
 gamma              | threshold of load reduction in % for  | 25.0
                    | the fair admission rule               |
 maxit              | maximum number of iterations for the  | 20
                    | power flow solver                     |
 maxit_qp           | maximum number of iterations for the  | 30
                    | quadratic programming solver          |
 method             | numerical method to solve power flow  | BFS
                    | analysis. Alternatives: [NR, BFS]     |
 nadm               | number of new admissions to wait      | 10
                    | before updating load sensitivities.   |
                    | If nadm <= 0, sensitivities are       |
                    | updated at each time step             |
 nofair             | do not apply fair ACS rules           | False
 nolimits           | do not enforce any limit check        | False
                    | (implies <nofair = True>)             |
 plevelmax          | maximum priority level for loads. All | 10
                    | loads with a priority level equal to  |
                    | or greater than the maximum one,      |
                    | cannot be modified by the fair        |
                    | admission rule                        |
 progressbar        | use the progress bar during time      | True
                    | domain simulations                    |
 reqthres           | threshold that activates the          | 1.0
                    | reformulation of load request ( >=    |
                    | 1.0)                                  |
 rplevel            | assign a random priority level to     | False
                    | load rather using the value defined   |
                    | in load data                          |
 sens               | method used for computing             | tree
                    | sensitivities of limit with respect   |
                    | to technical limits. Alternatives:    |
                    | [none, tree, all]                     |
 smargin            | security margin in % used for         | 10.0
                    | reducing technical limits when        |
                    | evaluating the feasibility of         |
```

```
                  | distributed generation power offers   |
 t0               | initial time [s]                      | 0
 tf               | final time [s]                        | 86400
 tstep            | time step every which load requests   | 60
                  | are updated [s]                       |
 updatereq        | if enforced, admitted loads that have | False
                  | been rescheduled attempt to           |
                  | reformulate their requests            |
 viewbind         | print out binding constraints during  | True
                  | ACS simulation                        |
 viewsens         | print out sensitivities during ACS    | False
                  | simulation                            |
 vmax             | maximum allowable bus voltage [pu]    | 1.2
 vmin             | minimum allowable bus voltage [pu]    | 0.8
---------------------------------------------------------------------------

Class <SCA>

---------------------------------------------------------------------------
 Parameter        | Description                           | Default
---------------------------------------------------------------------------
 build_neg        | if True, build the negative-sequence  | False
                  | admittance matrix, otherwise assume   |
                  | the the negative sequence is the      |
                  | equal to the positive one             |
 fault            | fault type to be applied and solved.  | 3P
                  | Alternatives:                         |
                  | <3P>: symmetrical three-phase fault   |
                  | <LL>: line-to-line fault              |
                  | <DLG>: double line to ground fault    |
                  | <SLG>: single line to ground fault    |
 flat             | if True, use flat voltage profile;    | False
                  | otherwise use power flow solution     |
 iload            | if True, compute total short-circuit  | False
                  | currents including pre-fault load     |
                  | currents                              |
 k0               | the factor used multiply positive-    | 3.0
                  | sequence imepdances to compute zero-  |
                  | sequence ones in case zero-sequence   |
                  | values are not provided               |
 loads            | if True, include load current         | False
                  | consumptions                          |
 method           | method to solve the short circuit     | Ybus
                  | analysis. Alternatives:               |
                  | <Ybus>: admittance matrix             |
                  | <Zbus>: impedance matrix              |
 timeframe        | time frame used for defining          | SY
                  | generator internal impedances.        |
                  | Alternatives:                         |
                  | <SY>: synchronous                     |
```

```
                   | <TR>: transient                     |
                   | <ST>: subtransient                  |
 transf            | type of symmetrical component       | FT
                   | transformation. Alternatives:       |
                   | <FT>: Fortescue transformation      |
                   | <PI>: power invariant transformation |
 usefault          | if True, use impedances of <Fault>  | True
                   | devices to define short-circuit     |
                   | currents                            |
---------------------------------------------------------------------------

Static report saved in file <setting_help.txt>
```

# Chapter 6

# Device Groups

DOME internally organized devices into groups. When defining DOME data files, it is important to remmeber that devices pertaining to the same group **must** have different id. Failing to do so can lead to unconsistent results. This rule is certainly satisfied if the input data are in any format other than the internal DOME format.

The output of the command `dome -G All` is given below.

```
DOME device groups

Group <AC/DC> (6 devices)
-------------------------------------------------------------------------
Inverter     Rectifier    VSC1         VSC2
VSC_static1  VSC_static2

Group <AGC> (1 devices)
-------------------------------------------------------------------------
AGC

Group <AVR> (10 devices)
-------------------------------------------------------------------------
Avr1         Avr1d        Avr1p        Avr2
Avr2p        Avr3         Avr4         Avr5
Avr5p        Avr6

Group <DC> (18 devices)
-------------------------------------------------------------------------
CG           CompACMac    CompBCMac    DCFilter1
DCFilter2    Dynamo       GLC          Ground
ICG          ISwitch      IVG          R
RC           RL           RLC          SepMac
SeriesMac    ShuntMac

Group <DC/DC> (3 devices)
-------------------------------------------------------------------------
```

```
Boost        Buck         Chopper

Group <DER> (4 devices)
------------------------------------------------------------------------
DER          DERf         DERv         DERvf

Group <Direction> (2 devices)
------------------------------------------------------------------------
PQdir        PVdir

Group <FuelCell> (4 devices)
------------------------------------------------------------------------
Electrolyzer Fuel_control1 Fuel_control2 Sofc

Group <Graphic> (1 devices)
------------------------------------------------------------------------
Display

Group <HVDC> (2 devices)
------------------------------------------------------------------------
HVDC_control HVDC_static

Group <Induction> (3 devices)
------------------------------------------------------------------------
Ind1         Ind3         Ind5

Group <Load> (58 devices)
------------------------------------------------------------------------
Aluminium    CFlamp       CRTTV        ERLoad
EVcharger    FDL          FDLS         FLMotor
Flamp        Fluorescent  Furnace      HIDlamp
HLMotor      Heater       Hglamp       Incandescent
Indcooker    Jimma        LCDTV        MHlamp
Microwave    Mixed        Notebook     PQ
PQD          PQdyn        PQdynmr      PQmr
PQprb        PQstc        PQw          ParkLoad1
ParkLoad2    ParkShunt    Pcosphi      PphiD
RLoad        RLoadmr      RLoadstc     Sodium
Tap1         Tap2         Thl          ThlBus
ThlCoi       VDL1         VDL2         VDL2ph
VDLD         VDLcycle     VDLdyn       VDLmr
VDLstc       Vphi         ZIP1         ZIP2
ZIP2ph       ZIPD

Group <MPPT> (3 devices)
------------------------------------------------------------------------
Mppt1        Mppt2        Mppt3

Group <Market> (4 devices)
------------------------------------------------------------------------
```

```
Demand       Genbid       Reserve      Supply

Group <Measure> (2 devices)
------------------------------------------------------------------------
BusFreq      Pmu

Group <OEL> (2 devices)
------------------------------------------------------------------------
Oel1         Oel2

Group <Other> (22 devices)
------------------------------------------------------------------------
ACSDisp      BusLine      COI          COILine
Custom       FortDisp     GenDisp      ISGA
LineDisp     LoadDisp     MSV          Output
Prototype    Reference    Routine      SSpace
Shaft        ShuntD       TreeDisp     Tuning
XControl     YControl

Group <POD> (4 devices)
------------------------------------------------------------------------
POD_p_svc    POD_p_upfc   POD_v_svc    POD_v_upfc

Group <PSS> (7 devices)
------------------------------------------------------------------------
Pss0         Pss1         Pss2         Pss2d
Pss3         Pss4         Pss5

Group <PVCell> (5 devices)
------------------------------------------------------------------------
PVCell1      PVCell2      PVCell3      PVCell4
PVCell5

Group <Perturbation> (3 devices)
------------------------------------------------------------------------
StcBus       StcPer       StcPower

Group <SSSC> (1 devices)
------------------------------------------------------------------------
SSSC_control

Group <STATCOM> (2 devices)
------------------------------------------------------------------------
Statcom      Statcom_control

Group <SVC> (4 devices)
------------------------------------------------------------------------
Svc1         Svc2         Svc3         Svc4

Group <Sequence> (7 devices)
```

```
-------------------------------------------------------------------------
FltSeq      GenSeq      LineSeq     LoadSeq
MotSeq      Mutual      Petersen

Group <Series> (17 devices)
-------------------------------------------------------------------------
AltLine     AreaCoup    CompLine    Coupling
CouplingD   Fortescue   Line        LineD
ParkLine    ParkRL      ParkRLC     StcLine
TieLine     TransfCoup  Trasf3a     Trasf3b
TrasfD

Group <Shunt> (3 devices)
-------------------------------------------------------------------------
Shunt       SwShunt1    SwShunt2

Group <StaticGen> (7 devices)
-------------------------------------------------------------------------
DERD        FeederD     PQgen       PVD
PVgen       PVncp       Slack

Group <Storage> (15 devices)
-------------------------------------------------------------------------
Battery1    Battery2    Bess1       Bess1_control
Bess2       Bess2_control Caes       Caes_control
Fess1       Fess2       Fess_control Sces
Sces_control Smes       Smes_control

Group <Sun> (2 devices)
-------------------------------------------------------------------------
Sun1        Sun2

Group <Switch> (3 devices)
-------------------------------------------------------------------------
Breaker     Fault       Switch

Group <Synchronous> (14 devices)
-------------------------------------------------------------------------
Syn2        Syn3        Syn4        Syn5a
Syn5b       Syn5c       Syn5d       Syn6a
Syn6aw      Syn6b       Syn6bw      Syn8a
Syn8b       Synem

Group <TCSC> (3 devices)
-------------------------------------------------------------------------
Tcsc1       Tcsc2       TcscLine

Group <TReg> (8 devices)
-------------------------------------------------------------------------
Phs         Ultc1       Ultc2       Ultc3
```

```
Ultc3a       Ultc4        UltcPhs1     UltcPhs2

Group <Topology> (7 devices)
-----------------------------------------------------------------------
Area         Border       Bus          Network
Node         Region       Tree

Group <Turbine> (7 devices)
-----------------------------------------------------------------------
Expander     Htg1         Htg2         Htg3
Htg4         Tg1          Tg2

Group <UEL> (2 devices)
-----------------------------------------------------------------------
Uel1         Uel2

Group <UPFC> (8 devices)
-----------------------------------------------------------------------
GUPFC_control Gupfc        IPFC1_control IPFC2_control
Ipfc1        Ipfc2        UPFC_control Upfc

Group <Wind> (7 devices)
-----------------------------------------------------------------------
WindSDE1     WindSDE2a    WindSDE2b    Wind_compost
Wind_measure Wind_mexican Wind_weibull

Group <WindTurbine> (14 devices)
-----------------------------------------------------------------------
Cswt1        Cswt2        Ddsg1        Ddsg2
Ddsg3        Ddsg4        Ddsg5        Ddsg6
Ddsg7        Ddsg8        Ddsg9        Dfig1
Dfig2        Dfig3
```

# Chapter 7

# Device Categories

Besides groups, DOME also internally organized devices into categories. Categories are weaker than groups. A device can belong to several categories but only to one group. Categories are useful to define certain common behaviors of device sets.

The output of the command `dome -C All` is given below.

```
DOME device categories

Category <Circuit> (41 devices)
------------------------------------------------------------------------
Battery1     Battery2     Bess1        Bess2
Boost        Buck         CG           Caes
Chopper      CompACMac    CompBCMac    DCFilter1
DCFilter2    Dynamo       Electrolyzer Fess1
Fess2        GLC          Ground       ICG
ISwitch      IVG          Inverter     Node
PVCell1      PVCell2      PVCell3      PVCell4
PVCell5      R            RC           RL
RLC          Rectifier    Sces         SepMac
SeriesMac    ShuntMac     Smes         VSC1
VSC2

Category <Consumption> (62 devices)
------------------------------------------------------------------------
Aluminium    CFlamp       CRTTV        ERLoad
EVcharger    FDL          FDLS         FLMotor
Flamp        Fluorescent  Furnace      HIDlamp
HLMotor      Heater       Hglamp       Incandescent
Indcooker    Jimma        LCDTV        LoadSeq
MHlamp       Microwave    Mixed        Notebook
PQ           PQD          PQdir        PQdyn
PQdynmr      PQmr         PQprb        PQstc
PQw          ParkLoad1    ParkLoad2    ParkShunt
Pcosphi      PphiD        RLoad        RLoadmr
```

```
RLoadstc     Shunt        ShuntD       Sodium
Tap1         Tap2         Thl          ThlBus
ThlCoi       VDL1         VDL2         VDL2ph
VDLD         VDLcycle     VDLdyn       VDLmr
VDLstc       Vphi         ZIP1         ZIP2
ZIP2ph       ZIPD

Category <Converter> (7 devices)
-----------------------------------------------------------------------
Boost        Buck         Chopper      Inverter
Rectifier    VSC1         VSC2

Category <Cover> (11 devices)
-----------------------------------------------------------------------
CouplingD    DERD         FeederD      LineD
PQD          PVD          Pcosphi      PphiD
Trasf3a      Trasf3b      TrasfD

Category <Delay> (2 devices)
-----------------------------------------------------------------------
Avr1d        Pss2d

Category <Distributed> (44 devices)
-----------------------------------------------------------------------
Bess1        Bess2        Caes         Cswt1
Cswt2        Ddsg1        Ddsg2        Ddsg3
Ddsg4        Ddsg5        Ddsg6        Ddsg7
Ddsg8        Ddsg9        Dfig1        Dfig2
Dfig3        Electrolyzer Expander     Fess1
Fess2        Fuel_control1 Fuel_control2 Mppt1
Mppt2        Mppt3        PVCell1      PVCell2
PVCell3      PVCell4      PVCell5      Sces
Sces_control Smes         Sofc         Sun1
Sun2         WindSDE1     WindSDE2a    WindSDE2b
Wind_compost Wind_measure Wind_mexican Wind_weibull

Category <Distribution> (29 devices)
-----------------------------------------------------------------------
Aluminium    CRTTV        CouplingD    DERD
EVcharger    FLMotor      FeederD      Fluorescent
Fortescue    Furnace      HLMotor      Heater
Incandescent Indcooker    LCDTV        LineD
Microwave    Notebook     PQD          PVD
PphiD        ShuntD       Sodium       TrasfD
Tree         VDL2ph       VDLD         ZIP2ph
ZIPD

Category <Event> (6 devices)
-----------------------------------------------------------------------
Breaker      Fault        ICG          ISwitch
```

```
IVG          Switch

Category <Facts> (32 devices)
-----------------------------------------------------------------------
GUPFC_control Gupfc        HVDC_control HVDC_static
IPFC1_control IPFC2_control Ipfc1        Ipfc2
Phs          SSSC_control Statcom      Statcom_control
Svc1         Svc2         Svc3         Svc4
SwShunt1     SwShunt2     Tcsc1        Tcsc2
TcscLine     UPFC_control Ultc1        Ultc2
Ultc3        Ultc3a       Ultc4        UltcPhs1
UltcPhs2     Upfc         VSC_static1  VSC_static2

Category <Fortescue> (8 devices)
-----------------------------------------------------------------------
FltSeq       Fortescue    GenSeq       LineSeq
LoadSeq      MotSeq       Mutual       Petersen

Category <Fuel> (4 devices)
-----------------------------------------------------------------------
Electrolyzer Fuel_control1 Fuel_control2 Sofc

Category <Generation> (49 devices)
-----------------------------------------------------------------------
Cswt1        Cswt2        DER          DERD
DERf         DERv         DERvf        Ddsg1
Ddsg2        Ddsg3        Ddsg4        Ddsg5
Ddsg6        Ddsg7        Ddsg8        Ddsg9
Dfig1        Dfig2        Dfig3        Expander
FeederD      GenSeq       MotSeq       PQgen
PVCell1      PVCell2      PVCell3      PVCell4
PVCell5      PVD          PVdir        PVgen
PVncp        Slack        Sofc         Syn2
Syn3         Syn4         Syn5a        Syn5b
Syn5c        Syn5d        Syn6a        Syn6aw
Syn6b        Syn6bw       Syn8a        Syn8b
Synem

Category <Interface> (2 devices)
-----------------------------------------------------------------------
AreaCoup     TransfCoup

Category <Machine> (42 devices)
-----------------------------------------------------------------------
Caes         CompACMac    CompBCMac    Cswt1
Cswt2        Ddsg1        Ddsg2        Ddsg3
Ddsg4        Ddsg5        Ddsg6        Ddsg7
Ddsg8        Ddsg9        Dfig1        Dfig2
Dfig3        Dynamo       Expander     Fess1
Fess2        Ind1         Ind3         Ind5
```

```
SepMac       SeriesMac    Shaft        ShuntMac
Syn2         Syn3         Syn4         Syn5a
Syn5b        Syn5c        Syn5d        Syn6a
Syn6aw       Syn6b        Syn6bw       Syn8a
Syn8b        Synem

Category <MetaDevice> (4 devices)
------------------------------------------------------------------------
Custom       Prototype    Routine      Tuning

Category <Other> (13 devices)
------------------------------------------------------------------------
ACSDisp      BusLine      COILine      Display
FortDisp     GenDisp      LineDisp     LoadDisp
MSV          Output       Reference    SSpace
TreeDisp

Category <Park> (6 devices)
------------------------------------------------------------------------
ParkLine     ParkLoad1    ParkLoad2    ParkRL
ParkRLC      ParkShunt

Category <PowerElectronics> (33 devices)
------------------------------------------------------------------------
Bess1        Bess2        Boost        Buck
Caes         Chopper      Ddsg1        Ddsg2
Ddsg3        Ddsg4        Ddsg5        Ddsg6
Ddsg7        Ddsg8        Ddsg9        Dfig1
Dfig2        Dfig3        Fess1        Fess2
Inverter     Rectifier    Sces         Smes
Statcom      Svc1         Svc2         Svc3
Svc4         Tcsc1        Tcsc2        VSC1
VSC2

Category <Protection> (4 devices)
------------------------------------------------------------------------
Breaker      BusFreq      Pmu          Switch

Category <Regulation> (76 devices)
------------------------------------------------------------------------
AGC          Avr1         Avr1d        Avr1p
Avr2         Avr2p        Avr3         Avr4
Avr5         Avr5p        Avr6         Bess1_control
Bess2_control Caes_control CompLine     Expander
Fess_control Fuel_control1 Fuel_control2 GUPFC_control
HVDC_control HVDC_static  Htg1         Htg2
Htg3         Htg4         IPFC1_control IPFC2_control
Mppt1        Mppt2        Mppt3        Oel1
Oel2         POD_p_svc    POD_p_upfc   POD_v_svc
POD_v_upfc   Phs          Pss0         Pss1
```

```
Pss2        Pss2d       Pss3        Pss4
Pss5        SSSC_control Sces_control Smes_control
Statcom     Statcom_control Svc1       Svc2
Svc3        Svc4        SwShunt1    SwShunt2
Tcsc1       Tcsc2       TcscLine    Tg1
Tg2         TieLine     UPFC_control Uel1
Uel2        Ultc1       Ultc2       Ultc3
Ultc3a      Ultc4       UltcPhs1    UltcPhs2
VSC_static1 VSC_static2 XControl    YControl

Category <Renewable> (31 devices)
-----------------------------------------------------------------------
Cswt1       Cswt2       Ddsg1       Ddsg2
Ddsg3       Ddsg4       Ddsg5       Ddsg6
Ddsg7       Ddsg8       Ddsg9       Dfig1
Dfig2       Dfig3       Mppt1       Mppt2
Mppt3       PVCell1     PVCell2     PVCell3
PVCell4     PVCell5     Sun1        Sun2
WindSDE1    WindSDE2a   WindSDE2b   Wind_compost
Wind_measure Wind_mexican Wind_weibull

Category <Series> (30 devices)
-----------------------------------------------------------------------
AltLine     AreaCoup    CompLine    Coupling
CouplingD   Fortescue   Line        LineD
LineSeq     Mutual      ParkLine    ParkRL
ParkRLC     Phs         StcLine     Tcsc1
Tcsc2       TcscLine    TieLine     TransfCoup
Trasf3a     Trasf3b     TrasfD      Ultc1
Ultc2       Ultc3       Ultc3a      Ultc4
UltcPhs1    UltcPhs2

Category <ShortCircuit> (8 devices)
-----------------------------------------------------------------------
Fault       FltSeq      GenSeq      LineSeq
LoadSeq     MotSeq      Mutual      Petersen

Category <Solar> (7 devices)
-----------------------------------------------------------------------
PVCell1     PVCell2     PVCell3     PVCell4
PVCell5     Sun1        Sun2

Category <Source> (9 devices)
-----------------------------------------------------------------------
Sun1        Sun2        WindSDE1    WindSDE2a
WindSDE2b   Wind_compost Wind_measure Wind_mexican
Wind_weibull

Category <Stochastic> (13 devices)
-----------------------------------------------------------------------
```

```
PQdynmr      PQmr         PQprb        PQstc
PQw          RLoadmr      RLoadstc     StcBus
StcLine      StcPer       StcPower     VDLmr
VDLstc

Category <Storage> (15 devices)
-------------------------------------------------------------------------
Battery1     Battery2     Bess1        Bess1_control
Bess2        Bess2_control Caes         Caes_control
Fess1        Fess2        Fess_control Sces
Sces_control Smes         Smes_control

Category <Topology> (7 devices)
-------------------------------------------------------------------------
Area         Border       Bus          Network
Node         Region       Tree

Category <Transmission> (113 devices)
-------------------------------------------------------------------------
AltLine      Area         AreaCoup     Border
Bus          CFlamp       COI          CompLine
Coupling     DER          DERf         DERv
DERvf        Demand       ERLoad       FDL
FDLS         Flamp        Fortescue    Genbid
Gupfc        HIDlamp      Hglamp       ISGA
Ind1         Ind3         Ind5         Inverter
Ipfc1        Ipfc2        Jimma        Line
MHlamp       Mixed        Network      PQ
PQdir        PQdyn        PQdynmr      PQgen
PQmr         PQprb        PQstc        PQw
PVdir        PVgen        PVncp        Pcosphi
Phs          RLoad        RLoadmr      RLoadstc
Rectifier    Region       Reserve      Shunt
Slack        Statcom      StcBus       StcLine
StcPower     Supply       Svc1         Svc2
Svc3         Svc4         SwShunt1     SwShunt2
Syn2         Syn3         Syn4         Syn5a
Syn5b        Syn5c        Syn5d        Syn6a
Syn6aw       Syn6b        Syn6bw       Syn8a
Syn8b        Synem        Tap1         Tap2
Tcsc1        Tcsc2        TcscLine     Thl
ThlBus       ThlCoi       TieLine      TransfCoup
Trasf3a      Trasf3b      Ultc1        Ultc2
Ultc3        Ultc3a       Ultc4        UltcPhs1
UltcPhs2     Upfc         VDL1         VDL2
VDLcycle     VDLdyn       VDLmr        VDLstc
VSC1         VSC2         Vphi         ZIP1
ZIP2

Category <Wind> (21 devices)
```

```
-------------------------------------------------------------------------
Cswt1        Cswt2        Ddsg1        Ddsg2
Ddsg3        Ddsg4        Ddsg5        Ddsg6
Ddsg7        Ddsg8        Ddsg9        Dfig1
Dfig2        Dfig3        WindSDE1     WindSDE2a
WindSDE2b    Wind_compost Wind_measure Wind_mexican
Wind_weibull
```

# Chapter 8

# Data Formats

The output of the command `dome -f` is given below.

```
  1. Device <ACSDisp>

This device defines some global indicators and quantities
useful to evaluate the 'quality' of the admission control strategy

------------------------------------------------------------------------
   Parameter  | Description                      | Default    | Units
--------------+----------------------------------+------------+-----------
   u          | Connection status                | 1.0        | bool
------------------------------------------------------------------------

  2. Device <AGC>

Automatic Generation Control class

------------------------------------------------------------------------
   Parameter  | Description                      | Default    | Units
--------------+----------------------------------+------------+-----------
   coi        | Coi id                           | 1          | -
   k0         | Gain of the agc integrator       | 0.05       | -
   u          | Connection status                | 1.0        | bool
   wref0      | Reference speed                  | 1.0        | pu(Hz)
------------------------------------------------------------------------

  3. Device <AltLine>

Base transmission line class (not included in the admittance matrix)

------------------------------------------------------------------------
   Parameter  | Description                      | Default    | Units
--------------+----------------------------------+------------+-----------
```

| | | | |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| b | Total shunt susceptance | 0.0 | pu(1/Ohm) |
| b1 | From bus shunt susceptance | 0.0 | pu(1/Ohm) |
| b2 | To bus shunt susceptance | 0.0 | pu(1/Ohm) |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| g | Total shunt conductance | 0.0 | pu(1/Ohm) |
| g1 | From bus shunt conductance | 0.0 | pu(1/Ohm) |
| g2 | To bus shunt conductance | 0.0 | pu(1/Ohm) |
| imax | Maximum current | 999.9 | pu(kA) |
| phases | Number of phases (1 or 3) | 3 | int |
| pmax | Maximum active power | 999.9 | pu(MW) |
| r | Series resistance | 0.0 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| # x | Series reactance | 1e-05 | pu(Ohm) |

4. Device <Aluminium>

Aluminium plant

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power at nominal voltage | 80.0 | kW |
| # Vn | Voltage rate | 0.4 | kV |
| * bus | Bus id | - | - |
| pf | Nominal power factor (negative for capacitive loads) | 0.9 | - |
| plevel | Priority level (for the acs routine) | 4 | int |
| u | Connection status | 1.0 | bool |

5. Device <Area>

Define topological zones, areas, regions, etc.

| Parameter | Description | Default | Units |
|---|---|---|---|
| Pex | Active power exchange | 0 | pu(MW) |
| Pnet | Actual p net exchange | 0 | pu(MW) |
| Ptol | Active power tolerance | 0 | pu(MW) |
| Qnet | Actual q net exchange | 0 | pu(MVAr) |

| | | | |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| bus | Array of zone bus ids | [] | - |
| deltaP | Annual growth rate | 0 | %(MW) |
| slack | Zone slack bus id | - | - |
| u | Connection status | 1.0 | bool |

6. Device <AreaCoup>

Device that allows coupling areas having different power bases. The power bases of the primary and secondary windings are grabbed from bus data.

| Parameter | Description | Default | Units |
|---|---|---|---|
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| imax | Maximum current | 999.9 | pu(kA) |
| phases | Number of phases (1 or 3) | 3 | int |
| pmax | Maximum active power | 999.9 | pu(MW) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |

7. Device <Avr1>

Simplified AVR IEEE type DC-1

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ae | 1st ceiling coefficient | 0.0006 | - |
| Be | 2nd ceiling coefficient | 0.9 | - |
| * Ka | Amplifier gain | 20 | - |
| Ke | Field integral deviation | 1.0 | - |
| * Kf | Stabilizer gain | 0.063 | - |
| * Ta | Amplifier time constant | 0.2 | s |
| # Te | Field circuit time constant | 1.0 | s |
| * Tf | Stabilizer time constant | 0.35 | s |
| # Tr | Voltage measure time constant | 0.001 | s |
| bus | Regulated bus id | - | - |
| rc | Load compensation resistance | 0.0 | pu(Ohm) |
| * syn | Synchronous machine id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum regulator voltage | 5.0 | pu(kV) |
| vmin | Minimum regulator voltage | -5.0 | pu(kV) |
| xc | Load compensation reactance | 0.0 | pu(Ohm) |

8. Device <Avr1d>

Simplified AVR IEEE type DC-1 with constant delay in the voltage measure

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ae | 1st ceiling coefficient | 0.0006 | - |
| Be | 2nd ceiling coefficient | 0.9 | - |
| * Ka | Amplifier gain | 20 | - |
| Ke | Field integral deviation | 1.0 | - |
| * Kf | Stabilizer gain | 0.063 | - |
| * Ta | Amplifier time constant | 0.2 | s |
| # Te | Field circuit time constant | 1.0 | s |
| * Tf | Stabilizer time constant | 0.35 | s |
| # Tr | Voltage measure time constant | 0.001 | s |
| bus | Regulated bus id | - | - |
| rc | Load compensation resistance | 0.0 | pu(Ohm) |
| * syn | Synchronous machine id | - | - |
| # tau | Constant time delay | 0.005 | s |
| u | Connection status | 1.0 | bool |
| vmax | Maximum regulator voltage | 5.0 | pu(kV) |
| vmin | Minimum regulator voltage | -5.0 | pu(kV) |
| xc | Load compensation reactance | 0.0 | pu(Ohm) |

9. Device <Avr1p>

Simplified AVR IEEE type DC-1 with polynomial ceiling

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ae | 1st ceiling coefficient | 0.0006 | - |
| Be | 2nd ceiling coefficient | 0.9 | - |
| * Ka | Amplifier gain | 20 | - |
| Ke | Field integral deviation | 1.0 | - |
| * Kf | Stabilizer gain | 0.063 | - |
| * Ta | Amplifier time constant | 0.2 | s |
| # Te | Field circuit time constant | 1.0 | s |
| * Tf | Stabilizer time constant | 0.35 | s |
| # Tr | Voltage measure time constant | 0.001 | s |
| bus | Regulated bus id | - | - |
| rc | Load compensation resistance | 0.0 | pu(Ohm) |
| * syn | Synchronous machine id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum regulator voltage | 5.0 | pu(kV) |
| vmin | Minimum regulator voltage | -5.0 | pu(kV) |
| xc | Load compensation reactance | 0.0 | pu(Ohm) |

---

10. Device <Avr2>

AVR IEEE type 2 with static excitation

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ae | 1st ceiling coefficient | 0.0006 | - |
| Be | 2nd ceiling coefficient | 0.9 | - |
| # T1 | 1st regulator pole | 0.01 | s |
| T2 | 1st regulator zero | 0.1 | s |
| # T3 | 2nd regulator pole | 0.05 | s |
| T4 | 2nd regulator zero | 1.0 | s |
| # Te | Field circuit time constant | 1.0 | s |
| # Tr | Voltage measure time constant | 0.001 | s |
| bus | Regulated bus id | - | - |
| # m0 | Regulator gain | 200 | - |
| rc | Load compensation resistance | 0.0 | pu(Ohm) |
| * syn | Synchronous machine id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum regulator voltage | 5.0 | pu(kV) |
| vmin | Minimum regulator voltage | -5.0 | pu(kV) |
| xc | Load compensation reactance | 0.0 | pu(Ohm) |

11. Device <Avr2p>

AVR IEEE type 2 with static excitation and polynomial ceiling function

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ae | 1st ceiling coefficient | 0.0006 | - |
| Be | 2nd ceiling coefficient | 0.9 | - |
| # T1 | 1st regulator pole | 0.01 | s |
| T2 | 1st regulator zero | 0.1 | s |
| # T3 | 2nd regulator pole | 0.05 | s |
| T4 | 2nd regulator zero | 1.0 | s |
| # Te | Field circuit time constant | 1.0 | s |
| # Tr | Voltage measure time constant | 0.001 | s |
| bus | Regulated bus id | - | - |
| # m0 | Regulator gain | 200 | - |
| rc | Load compensation resistance | 0.0 | pu(Ohm) |
| * syn | Synchronous machine id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum regulator voltage | 5.0 | pu(kV) |
| vmin | Minimum regulator voltage | -5.0 | pu(kV) |
| xc | Load compensation reactance | 0.0 | pu(Ohm) |

---

12. Device <Avr3>

Simple lead-lag regulator model

| Parameter | Description | Default | Units |
|---|---|---|---|
| T1 | Regulator zero | 0.01 | s |
| # T2 | Regulator pole | 0.1 | s |
| # Te | Field circuit time constant | 1.0 | s |
| # Tr | Voltage measure time constant | 0.001 | s |
| bus | Regulated bus id | - | - |
| m0 | Regulator gain | 20 | - |
| rc | Load compensation resistance | 0.0 | pu(Ohm) |
| s0 | V0 signal | True | bool |
| * syn | Synchronous machine id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum field voltage | 5.0 | pu(kV) |
| vmin | Minimum field voltage | -5.0 | pu(kV) |
| xc | Load compensation reactance | 0.0 | pu(Ohm) |

13. Device <Avr4>

AVR IEEE Type AC4 (Vr limits do not include Ifd)

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Ka | Field voltage gain | 20 | - |
| # Ta | Field voltage pole | 0.01 | s |
| # Tb | Regulator pole | 0.1 | s |
| Tc | Regulator zero | 0.05 | s |
| # Tr | Voltage measure time constant | 0.001 | s |
| bus | Regulated bus id | - | - |
| rc | Load compensation resistance | 0.0 | pu(Ohm) |
| * syn | Synchronous machine id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum field voltage | 5.0 | pu(kV) |
| vmin | Minimum field voltage | -5.0 | pu(kV) |
| xc | Load compensation reactance | 0.0 | pu(Ohm) |

14. Device <Avr5>

Full AVR IEEE type DC-1

---

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ae | 1st ceiling coefficient | 0.0006 | - |
| Be | 2nd ceiling coefficient | 0.9 | - |
| * Ka | Amplifier gain | 20 | - |
| Ke | Field integral deviation | 1.0 | - |
| * Kf | Stabilizer gain | 0.063 | - |
| * Ta | Amplifier time constant | 0.2 | s |
| # Tb | Time constant | 1.0 | s |
| Tc | Time constant | 1.0 | s |
| # Te | Field circuit time constant | 1.0 | s |
| * Tf | Stabilizer time constant | 0.35 | s |
| # Tr | Voltage measure time constant | 0.001 | s |
| bus | Regulated bus id | - | - |
| rc | Load compensation resistance | 0.0 | pu(Ohm) |
| * syn | Synchronous machine id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum regulator voltage | 5.0 | pu(kV) |
| vmin | Minimum regulator voltage | -5.0 | pu(kV) |
| xc | Load compensation reactance | 0.0 | pu(Ohm) |

15. Device <Avr5p>

Full AVR IEEE type DC-1 with polynomial ceiling function

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ae | 1st ceiling coefficient | 0.0006 | - |
| Be | 2nd ceiling coefficient | 0.9 | - |
| * Ka | Amplifier gain | 20 | - |
| Ke | Field integral deviation | 1.0 | - |
| * Kf | Stabilizer gain | 0.063 | - |
| * Ta | Amplifier time constant | 0.2 | s |
| # Tb | Time constant | 1.0 | s |
| Tc | Time constant | 1.0 | s |
| # Te | Field circuit time constant | 1.0 | s |
| * Tf | Stabilizer time constant | 0.35 | s |
| # Tr | Voltage measure time constant | 0.001 | s |
| bus | Regulated bus id | - | - |
| rc | Load compensation resistance | 0.0 | pu(Ohm) |
| * syn | Synchronous machine id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum regulator voltage | 5.0 | pu(kV) |
| vmin | Minimum regulator voltage | -5.0 | pu(kV) |
| xc | Load compensation reactance | 0.0 | pu(Ohm) |

16. Device <Avr6>

AVR simplified IEEE Type AC4 (no lead-lag block and Vr limits do not include Ifd)

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Ka | Field voltage gain | 20 | - |
| # Ta | Field voltage pole | 0.01 | s |
| # Tr | Voltage measure time constant | 0.001 | s |
| bus | Regulated bus id | - | - |
| rc | Load compensation resistance | 0.0 | pu(Ohm) |
| * syn | Synchronous machine id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum field voltage | 5.0 | pu(kV) |
| vmin | Minimum field voltage | -5.0 | pu(kV) |
| xc | Load compensation reactance | 0.0 | pu(Ohm) |

17. Device <Battery1>

Power battery device

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Idcn | Nominal discharge current | 0.0013 | kA |
| Qn | Rated charge | 6.5 | Ah |
| Ri | Internal resistance | 0.002 | Ohm |
| Rp | Polarizarion resistance | 0.015 | Ohm |
| # Tm | Time constant of the i_dc low-pass filter | 2.0 | s |
| # Vdcn | Dc voltage rate | 0.2 | kV |
| be | Exponential capacity coeff. | 0.001 | 1/Ah |
| i0 | Initial currrent | 0.0 | pu(kA) |
| kp | Polarization constant | 0.015 | - |
| * node1 | Input dc node 1 | - | - |
| * node2 | Input dc node 2 | - | - |
| np | Number of batteries in parallel | 20 | - |
| ns | Number of batteries in series | 20 | - |
| qe0 | Initial charge | 0.2 | pu(kC) |
| smax | Maximum state of charge | 0.95 | - |
| smin | Minimum state of charge | 0.2 | - |
| u | Connection status | 1.0 | bool |
| ve | Exponential voltage | 0.2 | pu(kV) |
| voc | Open circuit potencial | 1.05 | pu(kV) |

18. Device <Battery2>

Power battery device with internal resistance dependent on the temperature

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ac | Cell effective convection area | 1.0 | m^2 |
| Ar | Cell effective radiaton area | 1.0 | m^2 |
| Ep | Average discharge losses | 1.0 | W/A |
| # Idcn | Nominal discharge current | 0.0013 | kA |
| Qn | Rated charge | 6.5 | Ah |
| Rp | Polarizarion resistance | 0.015 | Ohm |
| Ta | Ambient temperature | 293.0 | K |
| # Tm | Time constant of the i_dc low-pass filter | 2.0 | s |
| # Vdcn | Dc voltage rate | 0.2 | kV |
| a0 | Internal resistance coeff. | 0.0111 | Ohm/K^2 |
| a1 | Internal resistance coeff. | -0.0147 | Ohm/pu/K^2 |
| a2 | Internal resistance coeff. | 0.0081 | Ohm/pu^2/K^2 |
| b0 | Internal resistance coeff. | -0.2896 | Ohm/K |
| b1 | Internal resistance coeff. | 0.1207 | Ohm/pu/K |
| b2 | Internal resistance coeff. | 0.0 | Ohm/pu^2/K |
| be | Exponential capacity coeff. | 0.001 | 1/Ah |
| c0 | Internal resistance coeff. | 23.2637 | Ohm |
| c1 | Internal resistance coeff. | -9.5 | Ohm/pu |
| c2 | Internal resistance coeff. | 0.0 | Ohm/pu^2 |
| # cp | Average battery specific heat | 1.0 | J/kg/K |
| e | Emittance | 1.0 | - |
| eta | Efficiency factor on discharge | 0.9 | - |
| h | Convection-cooling coeff. | 10.0 | W/K/m^2 |
| i0 | Initial currrent | 0.0 | pu(kA) |
| kp | Polarization constant | 0.015 | - |
| # mg | Battery mass | 1.0 | kg |
| * node1 | Input dc node 1 | - | - |
| * node2 | Input dc node 2 | - | - |
| np | Number of batteries in parallel | 20 | - |
| ns | Number of batteries in series | 20 | - |
| qe0 | Initial charge | 0.2 | pu(kC) |
| smax | Maximum state of charge | 0.95 | - |
| smin | Minimum state of charge | 0.2 | - |
| u | Connection status | 1.0 | bool |
| ve | Exponential voltage | 0.2 | pu(kV) |
| voc | Open circuit potencial | 1.05 | pu(kV) |

19. Device <Bess1>

Battery energy storage system (BESS). It includes a dc/dc converter to regulate the battery terminal voltage.

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Idcn | Nominal discharge current | 0.0013 | kA |
| Qn | Rated charge | 6.5 | Ah |
| Ri | Internal resistance | 0.002 | Ohm |
| Rp | Polarizarion resistance | 0.015 | Ohm |
| # Tm | Time constant of the i_dc low-pass filter | 2.0 | s |
| # Vdcn | Dc voltage rate | 0.2 | kV |
| be | Exponential capacity coeff. | 0.001 | 1/Ah |
| i0 | Initial currrent | 0.0 | pu(kA) |
| kp | Polarization constant | 0.015 | - |
| * node1 | Input dc node 1 | - | - |
| * node2 | Input dc node 2 | - | - |
| np | Number of batteries in parallel | 20 | - |
| ns | Number of batteries in series | 20 | - |
| qe0 | Initial charge | 0.2 | pu(kC) |
| smax | Maximum state of charge | 0.95 | - |
| smin | Minimum state of charge | 0.2 | - |
| u | Connection status | 1.0 | bool |
| ve | Exponential voltage | 0.2 | pu(kV) |
| voc | Open circuit potencial | 1.05 | pu(kV) |

20. Device <Bess1_control>

Controller of Bess1 devices

| Parameter | Description | Default | Units |
|---|---|---|---|
| # K | Gain of modulation control | 10.0 | - |
| Kd | Integral deviation of mod. control | 0.0 | - |
| Kddc | Derivative gain of dc signal | 5.0 | - |
| Ki | Integral gain of angle control | 5.0 | - |
| Kidc | Integral gain of dc signal | 10.0 | - |
| Kmac | Gain of ac measure | 1.0 | - |
| Kmdc | Gain of dc measure | 1.0 | - |
| Kp | Proportional gain of angle control | 10.0 | - |
| Kpdc | Proportional gain of dc signal | 1.0 | - |
| Pref | Reference active power | 1.0 | pu(MW) |
| # T1 | Lead of modulation control | 0.1 | s |
| T2 | Lag of modulation control | 0.05 | s |
| # Tf | Low-pass filter time constant | 0.001 | s |
| # Tmac | Lag of ac measure | 0.01 | s |
| # Tmdc | Lag of dc measure | 0.01 | s |

| | | | |
|---|---|---|---|
| amax | Maximum firing angle | 360.0 | deg |
| amin | Minimum firing angle | -360.0 | deg |
| * bess | Bess id | - | - |
| db | Dead band of the power measure | 0 | - |
| dcmax | Maximum duty cycle | 0.9 | - |
| dcmin | Minimum duty cycle | 0.0 | - |
| * line | Transmission line id | - | - |
| mmax | Maximum modulation | 3.0 | - |
| mmin | Minimum modulation | 0.5 | - |
| trig | Factor to relax pref signal (0, 1] | 0.05 | - |
| u | Connection status | 1.0 | bool |
| * vsc | Vsc id | - | - |
| * vsc_static | Static vsc control id | - | - |

21. Device <Bess2>

Battery energy storage system (BESS). It includes a secondary control loop that varies the VSC dc voltage reference to regulate the battery terminal voltage.

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Idcn | Nominal discharge current | 0.0013 | kA |
| Qn | Rated charge | 6.5 | Ah |
| Ri | Internal resistance | 0.002 | Ohm |
| Rp | Polarizarion resistance | 0.015 | Ohm |
| # Tm | Time constant of the i_dc low-pass filter | 2.0 | s |
| # Vdcn | Dc voltage rate | 0.2 | kV |
| be | Exponential capacity coeff. | 0.001 | 1/Ah |
| i0 | Initial currrent | 0.0 | pu(kA) |
| kp | Polarization constant | 0.015 | - |
| * node1 | Input dc node 1 | - | - |
| * node2 | Input dc node 2 | - | - |
| np | Number of batteries in parallel | 20 | - |
| ns | Number of batteries in series | 20 | - |
| qe0 | Initial charge | 0.2 | pu(kC) |
| smax | Maximum state of charge | 0.95 | - |
| smin | Minimum state of charge | 0.2 | - |
| u | Connection status | 1.0 | bool |
| ve | Exponential voltage | 0.2 | pu(kV) |
| voc | Open circuit potencial | 1.05 | pu(kV) |
| * vsc | Index of the vsc connected to the bess | - | - |

22. Device <Bess2_control>

Controller of Bess2 devices

| Parameter | Description | Default | Units |
|---|---|---|---|
| # K | Gain of modulation control | 10.0 | - |
| Kd | Integral deviation of mod. control | 0.0 | - |
| Kddc | Derivative gain of dc signal | 5.0 | - |
| Ki | Integral gain of angle control | 5.0 | - |
| Kidc | Integral gain of dc signal | 10.0 | - |
| Kmac | Gain of ac measure | 1.0 | - |
| Kmdc | Gain of dc measure | 1.0 | - |
| Kp | Proportional gain of angle control | 10.0 | - |
| Kpdc | Proportional gain of dc signal | 1.0 | - |
| Pref | Reference active power | 1.0 | pu(MW) |
| # T1 | Lead of modulation control | 0.1 | s |
| T2 | Lag of modulation control | 0.05 | s |
| # Tf | Low-pass filter time constant | 0.001 | s |
| # Tmac | Lag of ac measure | 0.01 | s |
| # Tmdc | Lag of dc measure | 0.01 | s |
| amax | Maximum firing angle | 360.0 | deg |
| amin | Minimum firing angle | -360.0 | deg |
| * bess | Bess id | - | - |
| db | Dead band of the power measure | 0 | - |
| * line | Transmission line id | - | - |
| mmax | Maximum modulation | 3.0 | - |
| mmin | Minimum modulation | 0.5 | - |
| trig | Factor to relax pref signal (0, 1] | 0.05 | - |
| u | Connection status | 1.0 | bool |
| vdcmax | Maximum dc voltage | 1.5 | pu(kV) |
| vdcmin | Minimum dc voltage | 0.5 | pu(kV) |
| * vsc | Vsc id | - | - |
| * vsc_static | Static vsc control id | - | - |

23. Device <Boost>

Boost dc/dc converter

| Parameter | Description | Default | Units |
|---|---|---|---|
| Cdd | Capacitance | 0.0025 | Farad |
| Gdd | Conductance | 1e-05 | 1/Ohm |
| # Idcn | Input dc current rate | 10.0 | kA |

| | | | |
|---|---|---|---|
| # Idcn_out | Output dc current rate | 10.0 | kA |
| Ki | Pi contr. integral gain | 10.0 | - |
| Kp | Pi contr. proportional gain | 0.1 | - |
| Ldd | Inductance | 0.12 | Henry |
| Rdd | Resistance | 0.001 | Ohm |
| # Vdcn | Input dc voltage rate | 100.0 | kV |
| # Vdcn_out | Output dc voltage rate | 100.0 | kV |
| # Vtri | Saw-tooth waveform amplitude | 480.0 | V |
| d0 | Initial duty cycle value | 0.5 | - |
| dcmax | Maximum duty cycle | 0.84 | - |
| dcmin | Minimum duty cycle | 0.0 | - |
| lock | Lock duty cycle control | 0 | bool |
| * node1i | Input dc node 1 | - | - |
| * node1o | Output dc node 1 | - | - |
| * node2i | Input dc node 2 | - | - |
| * node2o | Output dc node 2 | - | - |
| u | Connection status | 1.0 | bool |
| vref | Reference output voltage | 1.01 | pu(kV) |

24. Device <Border>

Define a void device for graphical output. Only coordinates and graphical attributes are defined. Also used for defining Network elements. Networks should be used for 'closed' borders, but it is not mandatory.

| Parameter | Description | Default | Units |
|---|---|---|---|
| u | Connection status | 1.0 | bool |

25. Device <Breaker>

Breaker for transmission lines and transformers

| Parameter | Description | Default | Units |
|---|---|---|---|
| * bus | Bus id | - | - |
| * line | Line id | - | - |
| t1 | 1st switch time | 0.0 | s |
| t2 | 2nd switch time | 0.0 | s |
| t3 | 3rd switch time | 0.0 | s |
| t4 | 4th switch time | 0.0 | s |
| u | Connection status | 1.0 | bool |
| u1 | Apply 1st switch | False | bool |
| u2 | Apply 2nd switch | False | bool |
| u3 | Apply 3nd switch | False | bool |

| | | | |
|---|---|---|---|
| u4 | Apply 4nd switch | False | bool |

26. Device <Buck>

Buck dc/dc converter (average dynamic model)

| Parameter | Description | Default | Units |
|---|---|---|---|
| Cdd | Capacitance | 0.0025 | Farad |
| Gdd | Conductance | 1e-05 | 1/Ohm |
| # Idcn | Input dc current rate | 10.0 | kA |
| # Idcn_out | Output dc current rate | 10.0 | kA |
| Ki | Pi contr. integral gain | 10.0 | - |
| Kp | Pi contr. proportional gain | 0.1 | - |
| Ldd | Inductance | 0.12 | Henry |
| Rdd | Resistance | 0.001 | Ohm |
| # Vdcn | Input dc voltage rate | 100.0 | kV |
| # Vdcn_out | Output dc voltage rate | 100.0 | kV |
| # Vtri | Saw-tooth waveform amplitude | 480.0 | V |
| d0 | Initial duty cycle value | 0.5 | - |
| dcmax | Maximum duty cycle | 0.84 | - |
| dcmin | Minimum duty cycle | 0.0 | - |
| lock | Lock duty cycle control | 0 | bool |
| * node1i | Input dc node 1 | - | - |
| * node1o | Output dc node 1 | - | - |
| * node2i | Input dc node 2 | - | - |
| * node2o | Output dc node 2 | - | - |
| u | Connection status | 1.0 | bool |
| vref | Reference output voltage | 1.01 | pu(kV) |

27. Device <Bus>

Ac bus

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| * Vn | Voltage rate | 220.0 | kV |
| angle | Bus angle | 0 | rad |
| area | Area id | 1 | - |
| network | Network id | 1 | - |
| phase | Bus phase [a, b, c, 0, 1, 2] | 1 | - |
| region | Region id | 1 | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum voltage | 1.1 | pu(kV) |
| vmin | Minimum voltage | 0.9 | pu(kV) |

| | | | |
|---|---|---|---|
| voltage | Bus voltage | 1 | pu(kV) |

28. Device <BusFreq>

Bus frequency measurement class

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| Tf | Low-pass filter time constant | 0.1 | s |
| Tw | Washout time constant | 1.0 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| u | Connection status | 1.0 | bool |

29. Device <BusLine>

Transmission line with depedence on bus frequency

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * busf | <busfreq> device id | - | - |
| * line | Line id | - | - |
| u | Connection status | 1.0 | bool |

30. Device <CFlamp>

Compact fluorescent lamp (Philips PL-C 26W)

| Parameter | Description | Default | Units |
|---|---|---|---|
| L | Ballast inductance | 1.18 | H |
| # Sn | Power rate | 2.6e-05 | MVA |
| Theta0 | Gas temperature | 350.0 | K |
| # Vn | Voltage rate | 0.23 | kV |
| * bus | Bus id | - | - |
| c1 | Coefficient of the lamp model | 50596.2 | K/J |
| c2 | Coefficient of the lamp model | 174800.0 | W |
| c3 | Coefficient of the lamp model | 1.07 | J/C |
| c4 | Coefficient of the lamp model | 0.06 | W/K |
| c5 | Coefficient of the lamp model | 3966.03 | Ohm*K^0.75 |
| c6 | Coefficient of the lamp model | 0.33 | J/C |

| | | | |
|---|---|---|---|
| c7 | Factor of the lamp model | 0.67 | - |
| r | Ballast resistance | 0.0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| ve | Electrode voltage drop | 11.0 | V |

31. Device <CG>

CG parallel for EMT circuits

| Parameter | Description | Default | Units |
|---|---|---|---|
| # C | Capacity | 1.0 | Farad |
| G | Conductance | 0.0 | 1/Ohm |
| # Idcn | Dc current rate | 10.0 | kA |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| * node1 | 1st node id | - | - |
| * node2 | 2nd node id | - | - |
| u | Connection status | 1.0 | bool |
| v0 | Initial voltage | 0.0 | pu(kV) |

32. Device <COILine>

Transmission line with depedence on COI frequency

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| coi | Coi id | 1 | - |
| * line | Line id | - | - |
| u | Connection status | 1.0 | bool |

33. Device <CRTTV>

CRT computer display

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power at nominal voltage | 0.11 | kW |
| # Vn | Voltage rate | 0.4 | kV |
| * bus | Bus id | - | - |
| pf | Nominal power factor (negative for capacitive loads) | 0.02 | - |

| | | | |
|---|---|---|---|
| plevel | Priority level (for the acs routine) | 1 | int |
| u | Connection status | 1.0 | bool |

34. Device <Caes>

Compressed Air Energy Storage (CAES)

| Parameter | Description | Default | Units |
|---|---|---|---|
| # D | Turbine/compressor rotor damping | 0.01 | kW/kVA |
| # H | Turbine/compressor inertia constant | 1.0 | kWs/kVA |
| # Idcn | Dc current rate | 10.0 | kA |
| Kv | Voltage regulator proportional constant | 10.0 | - |
| # Patm | Atmospheric pressure | 1.0 | bar |
| Pmax | Maximum allowable tank pressure | 100.0 | bar |
| Pmin | Minimum allowable tank pressure | 2.0 | bar |
| Pref | Initial internal tank pressure | 20 | bar |
| Sn | Machine power rate | 5.0 | MVA |
| Theta | Tank temperature | 298.0 | K |
| # Tv | Voltage regulator time constant | 1.0 | s |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| Vn | Turbine/compressor nominal voltage | 1.0 | kV |
| # Vol | Tank volume | 50.0 | m3 |
| Wn | Turbine/compressor nominal frecuency | 314.16 | rad/s |
| eta | Compressor mechanic performance | 0.95 | - |
| gamma | Specific heat ratio (cp/cv) | 1.3 | - |
| mmax | Maximum modulation amplitude | 2.0 | - |
| mmin | Minimum modulation amplitude | 0.5 | - |
| * node1 | Input dc node 1 | - | - |
| * node2 | Input dc node 2 | - | - |
| pim | Air molecular weight | 1.0 | kg/kmol |
| rho | Air density | 1.0 | kg/m3 |
| rr | Rotor resistance | 0.01 | pu(Ohm) |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| vref | Ac reference voltage | 1.0 | pu(kV) |
| xm | Mutual inductance | 1.9 | pu(Ohm) |
| xr | Rotor leakage inductance | 2.0 | pu(Ohm) |

| | | | |
|---|---|---|---|
| xs | Stator leakage inductance | 2.0 | pu(Ohm) |

35. Device <Caes_control>

Controller of CAES devices

| Parameter | Description | Default | Units |
|---|---|---|---|
| # K | Gain of modulation control | 10.0 | - |
| Kd | Integral deviation of mod. control | 0.0 | - |
| Kddc | Derivative gain of dc signal | 0.0 | - |
| Ki | Integral gain of angle control | 5.0 | - |
| Kidc | Integral gain of dc signal | 10.0 | - |
| Kmac | Gain of ac measure | 1.0 | - |
| Kmdc | Gain of dc measure | 1.0 | - |
| Kp | Proportional gain of angle control | 10.0 | - |
| Kpdc | Proportional gain of dc signal | 1.0 | - |
| Qmax | Maximum caudal | 2.0 | - |
| Qmin | Minimum caudal | -2.0 | - |
| # T1 | Lead of modulation control | 0.1 | s |
| T2 | Lag of modulation control | 0.05 | s |
| # Tf | Low-pass filter time constant | 0.01 | s |
| # Tmac | Lag of ac measure | 0.01 | s |
| # Tmdc | Lag of dc measure | 0.01 | s |
| amax | Maximum firing angle | 360.0 | deg |
| amin | Minimum firing angle | -360.0 | deg |
| * caes | Caes id | - | - |
| db | Dead band of the power measure | 0 | - |
| * line | Transmission line id | - | - |
| mmax | Maximum modulation | 3.0 | - |
| mmin | Minimum modulation | 0.5 | - |
| trig | Coefficient to relax pref signal (0, 1] | 0.05 | - |
| u | Connection status | 1.0 | bool |
| * vsc | Vsc id | - | - |
| * vsc_static | Static vsc control id | - | - |

36. Device <Chopper>

Ideal dc/dc converter

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Idcn | Input dc current rate | 10.0 | kA |

| | | | |
|---|---|---|---|
| # Idcn_out | Output dc current rate | 10.0 | kA |
| Ki | Pi contr. integral gain | 10.0 | - |
| Kp | Pi contr. proportional gain | 0.1 | - |
| # Vdcn | Input dc voltage rate | 100.0 | kV |
| # Vdcn_out | Output dc voltage rate | 100.0 | kV |
| # Vtri | Saw-tooth waveform amplitude | 480.0 | V |
| d0 | Initial duty cycle value | 0.5 | - |
| dcmax | Maximum duty cycle | 0.84 | - |
| dcmin | Minimum duty cycle | 0.0 | - |
| lock | Lock duty cycle control | 0 | bool |
| * node1i | Input dc node 1 | - | - |
| * node1o | Output dc node 1 | - | - |
| * node2i | Input dc node 2 | - | - |
| * node2o | Output dc node 2 | - | - |
| u | Connection status | 1.0 | bool |
| vref | Reference output voltage | 1.01 | pu(kV) |

37. Device <CompACMac>

compound-connected dc machine (ahead connection)

| Parameter | Description | Default | Units |
|---|---|---|---|
| D | Rotor damping | 0.01 | kW/kVA |
| H | Inertia constant | 2.0 | kWs/kVA |
| # Idcn | Dc current rate | 10.0 | kA |
| # Laa | Autoinductance of the armature winding | 0.5 | H |
| Laf | Mutual inductance of the armature and the shunt-connected field windings | 1.0 | H |
| Las | Mutual inductance of the armature and the series-connected field windings | 1.0 | H |
| # Lff | Autoinductance of the shunt-connected field winding | 0.5 | H |
| Lfs | Mutual inductance of the series- and shunt-connected field windings | 1.0 | H |
| # Lss | Autoinductance of the series-connected field winding | 0.5 | H |
| Ra | Armature winding resistance | 0.05 | Ohm |
| Rf | Shunt-connected field winding resistance | 0.0 | Ohm |
| Rs | Series-connected field winding resistance | 0.0 | Ohm |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| con | Type ot the series connection | S | - |

```
             | ("s" for series and "c" for    |            |
             | cumulative)                    |            |
 * node1     | Input dc node 1                | -          | -
 * node2     | Input dc node 2                | -          | -
   rpm       | Nominal revolution per minute  | 1500       | -
   tm0       | Constant mechanical torque     | 1.0        | MNm
             | (use tm0 < 0 for generators)   |            |
   u         | Connection status              | 1.0        | bool
-----------------------------------------------------------------------

 38. Device <CompBCMac>

compound-connected dc machine (behind connection)

-----------------------------------------------------------------------
   Parameter | Description                    | Default    | Units
-------------+--------------------------------+------------+-----------
   D         | Rotor damping                  | 0.01       | kW/kVA
   H         | Inertia constant               | 2.0        | kWs/kVA
 # Idcn      | Dc current rate                | 10.0       | kA
 # Laa       | Autoinductance of the armature | 0.5        | H
             | winding                        |            |
   Laf       | Mutual inductance of the       | 1.0        | H
             | armature and the shunt-        |            |
             | connected field windings       |            |
   Las       | Mutual inductance of the       | 1.0        | H
             | armature and the series-       |            |
             | connected field windings       |            |
 # Lff       | Autoinductance of the shunt-   | 0.5        | H
             | connected field winding        |            |
   Lfs       | Mutual inductance of the       | 1.0        | H
             | series- and shunt-connected    |            |
             | field windings                 |            |
 # Lss       | Autoinductance of the series-  | 0.5        | H
             | connected field winding        |            |
   Ra        | Armature winding resistance    | 0.05       | Ohm
   Rf        | Shunt-connected field winding  | 0.0        | Ohm
             | resistance                     |            |
   Rs        | Series-connected field winding | 0.0        | Ohm
             | resistance                     |            |
 # Vdcn      | Dc voltage rate                | 100.0      | kV
   con       | Type ot the series connection  | S          | -
             | ("s" for series and "c" for    |            |
             | cumulative)                    |            |
 * node1     | Input dc node 1                | -          | -
 * node2     | Input dc node 2                | -          | -
   rpm       | Nominal revolution per minute  | 1500       | -
   tm0       | Constant mechanical torque     | 1.0        | MNm
             | (use tm0 < 0 for generators)   |            |
   u         | Connection status              | 1.0        | bool
```

---

39. Device <CompLine>

Static device for imposing a given compensation to the series impedance

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| b | Total shunt susceptance | 0.0 | pu(1/Ohm) |
| b1 | From bus shunt susceptance | 0.0 | pu(1/Ohm) |
| b2 | To bus shunt susceptance | 0.0 | pu(1/Ohm) |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| cp | Compensation level | 0.0 | %(Ohm) |
| g | Total shunt conductance | 0.0 | pu(1/Ohm) |
| g1 | From bus shunt conductance | 0.0 | pu(1/Ohm) |
| g2 | To bus shunt conductance | 0.0 | pu(1/Ohm) |
| imax | Maximum current | 999.9 | pu(kA) |
| phases | Number of phases (1 or 3) | 3 | int |
| pmax | Maximum active power | 999.9 | pu(MW) |
| r | Series resistance | 0.0 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| # x | Series reactance | 1e-05 | pu(Ohm) |

40. Device <Coupling>

coupling device (zero-impedance connection)

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| imax | Maximum current | 999.9 | pu(kA) |
| kp | Active power droop | 1e-08 | - |
| kq | Reactive power droop | 1e-08 | - |
| phases | Number of phases (1 or 3) | 3 | int |
| pmax | Maximum active power | 999.9 | pu(MW) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |

| | | | |
|---|---|---|---|
| u | Connection status | 1.0 | bool |

41. Device <CouplingD>

Distribution line

| Parameter | Description | Default | Units |
|---|---|---|---|
| Imax | Maximum current limit (=in, if it is not defined) | - | A |
| * In | Current rate | 10.0 | A |
| # Vn | Voltage rate | 20.0 | kV |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number | 1 | int |
| phases | Number of phases (1 or 3) | 3 | int |
| u | Connection status | 1.0 | bool |

42. Device <Cswt1>

Constant speed wind turbine with 5th-order squirrel-cage induction generator model, turbine model 1, static shaft model, and static capacitor bank

| Parameter | Description | Default | Units |
|---|---|---|---|
| # D | Rotor damping | 0.01 | kW/kVA |
| # H | Machine inertia constant | 2.0 | kWs/kVA |
| R | Rotor radius | 35.0 | m |
| # Sn | Machine power rate | 5.0 | MVA |
| # Vn | Machine nominal voltage | 1.0 | kV |
| Wn | Machine nominal frecuency | 376.99112 | rad/s |
| * bus | Bus id | - | - |
| etaGB | Gear box ratio | 0.01124 | - |
| * gen | Static generator id | - | - |
| # nb | Number of blades | 3 | int |
| # ng | Number of machines | 40 | int |
| # np | Number of poles | 4 | int |
| rr | Rotor resistance | 0.01 | pu(Ohm) |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| * wind | Wind speed id | - | - |
| xm | Mutual inductance | 1.9 | pu(Ohm) |
| xr | Rotor leakage inductance | 2.0 | pu(Ohm) |
| xs | Stator leakage inductance | 2.0 | pu(Ohm) |

43. Device <Cswt2>

Constant speed wind turbine with 5th-order squirrel-cage induction generator model, turbine model 1, dynamic shaft model with tower-shadow effect, and static capacitor bank

| Parameter | Description | Default | Units |
|---|---|---|---|
| Bs | Shaft viscous friction | 0.0 | pu |
| # D | Rotor damping | 0.01 | kW/kVA |
| # H | Machine inertia constant | 2.0 | kWs/kVA |
| # Ht | Wind turbine inertia | 0.5 | kWs/kVA |
| # Ks | Shaft stiffness | 0.3 | pu |
| R | Rotor radius | 35.0 | m |
| # Sn | Machine power rate | 5.0 | MVA |
| # Vn | Machine nominal voltage | 1.0 | kV |
| Wn | Machine nominal frecuency | 376.99112 | rad/s |
| * bus | Bus id | - | - |
| etaGB | Gear box ratio | 0.01124 | - |
| * gen | Static generator id | - | - |
| # nb | Number of blades | 3 | int |
| # ng | Number of machines | 40 | int |
| # np | Number of poles | 4 | int |
| rr | Rotor resistance | 0.01 | pu(Ohm) |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| * wind | Wind speed id | - | - |
| xm | Mutual inductance | 1.9 | pu(Ohm) |
| xr | Rotor leakage inductance | 2.0 | pu(Ohm) |
| xs | Stator leakage inductance | 2.0 | pu(Ohm) |

44. Device <Custom>

Class for importing on-the-fly user defined devices from a Python module passed to Dome as input data. The device itself is empty and does not define anything. It is just an interface for the user defined device class.

| Parameter | Description | Default | Units |
|---|---|---|---|
| * device | Name of user defined class where the device is defined | - | - |
| instance | Name of the instance of the device class | - | - |
| * module | Name of the module where the device is defined | - | - |

| | | | |
|---|---|---|---|
| path | Absolute or relative path where the module is placed | - | - |
| u | Connection status | 1.0 | bool |

45. Device <DCFilter1>

dc filter type 1

| Parameter | Description | Default | Units |
|---|---|---|---|
| # C | Capacity | 0.0 | Farad |
| # Idcn | Dc current rate | 10.0 | kA |
| # L | Inductance | 0.0 | Henry |
| R1 | Series resistance | 0.0 | Ohm |
| # R2 | Paralel resistance | 1e+15 | Ohm |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| i0 | Initial inductance current | 0.0 | pu(kA) |
| * node1 | 1st node id | - | - |
| * node2 | 2nd node id | - | - |
| u | Connection status | 1.0 | bool |
| v0 | Initial voltage | 0.0 | pu(kV) |

46. Device <DCFilter2>

dc filter type 2

| Parameter | Description | Default | Units |
|---|---|---|---|
| # C1 | Parallel capacity | 0.0 | Farad |
| # C2 | Series capacity | 0.0 | Farad |
| # Idcn | Dc current rate | 10.0 | kA |
| # L | Inductance | 0.0 | Henry |
| R1 | Series resistance | 0.0 | Ohm |
| # R2 | Parallel resistance | 1e+15 | Ohm |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| i0 | Initial inductance current | 0.0 | pu(kA) |
| * node1 | 1st node id | - | - |
| * node2 | 2nd node id | - | - |
| u | Connection status | 1.0 | bool |
| v10 | Initial voltage of c1 | 0.0 | pu(kV) |
| v20 | Initial voltage of c2 | 0.0 | pu(kV) |

47. Device <DER>

Distributed energy source with constant P and Q orders

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Td | Time constant of the d-axis current control | 1.0 | s |
| # Tq | Time constant of the q-axis current control | 1.0 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| * gen | Index of the static generator | - | - |
| u | Connection status | 1.0 | bool |

48. Device <DERD>

Distributed Energy Resource (DER) for distribution systems

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Generated active power | 0.0 | kW |
| # Vn | Voltage rate | 20.0 | kV |
| bus | Bus id | - | - |
| pf | Power factor | 1.0 | [0, 1] |
| plevel | Priority level (for the acs routine) | 1 | int |
| u | Connection status | 1.0 | bool |

49. Device <DERf>

Distributed energy source with constant Q and frequency droop control

| Parameter | Description | Default | Units |
|---|---|---|---|
| # R | Frequency control droop | 20.0 | pu |
| # Sn | Power rate | 100.0 | MVA |
| # Td | Time constant of the d-axis current control | 1.0 | s |
| # Tf | Time constant of the frequency control | 2.0 | s |
| # Tq | Time constant of the q-axis current control | 1.0 | s |
| # Tw | Washout time constant | 1.0 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| dt | Refreshing interval of bus | 0.01 | s |

| Parameter | Description | Default | Units |
|---|---|---|---|
| | angle | | |
| * gen | Index of the static generator | - | - |
| u | Connection status | 1.0 | bool |

50. Device <DERv>

Distributed energy source with constant P and voltage PI control

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ki | Integral gain of the voltage controller | 5.0 | pu |
| Kp | Proportional gain of the voltage controller | 10.0 | pu |
| # Sn | Power rate | 100.0 | MVA |
| # Td | Time constant of the d-axis current control | 1.0 | s |
| # Tq | Time constant of the q-axis current control | 1.0 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| * gen | Index of the static generator | - | - |
| u | Connection status | 1.0 | bool |

51. Device <DERvf>

Distributed energy source with voltage PI and frequency droop controls

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ki | Integral gain of the voltage controller | 5.0 | pu |
| Kp | Proportional gain of the voltage controller | 10.0 | pu |
| # R | Frequency control droop | 20.0 | pu |
| # Sn | Power rate | 100.0 | MVA |
| # Td | Time constant of the d-axis current control | 1.0 | s |
| # Tf | Time constant of the frequency control | 2.0 | s |
| # Tq | Time constant of the q-axis current control | 1.0 | s |
| # Tw | Washout time constant | 1.0 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| dt | Refreshing interval of bus | 0.01 | s |

| | | | |
|---|---|---|---|
| | angle | | |
| * gen | Index of the static generator | - | - |
| u | Connection status | 1.0 | bool |

52. Device <Ddsg1>

Direct-drive wind turbine with 3th-order synchronous generator model, static shaft model, turbine model 2, pitch control, converter static model, cubic MPPT approximation, AVR with lag model and static governor model

| Parameter | Description | Default | Units |
|---|---|---|---|
| # D | Rotor damping | 0.01 | kW/kVA |
| # H | Machine inertia constant | 2.0 | kWs/kVA |
| Kp | Pitch control gain | 10.0 | pu |
| Kv | Voltage control gain | 10.0 | pu |
| R | Rotor radius | 35.0 | m |
| # Sn | Machine power rate | 5.0 | MVA |
| # Tp | Pitch control time constant | 3.0 | s |
| # Tv | Voltage control time constant | 0.01 | s |
| # Vn | Machine nominal voltage | 1.0 | kV |
| Wn | Machine nominal frecuency | 376.99112 | rad/s |
| * bus | Bus id | - | - |
| etaGB | Gear box ratio | 0.01124 | - |
| * gen | Static generator id | - | - |
| # nb | Number of blades | 3 | int |
| # ng | Number of machines | 40 | int |
| # np | Number of poles | 4 | int |
| ploss | Losses of power electronic bridges | 0.01 | pu |
| pmax | Maximum active power | 1.2 | pu |
| pmin | Minimum active power | 0.0 | pu |
| psip | Permanent magnet field flux | 1.0 | pu(kWb) |
| qmax | Maximum reactive power | 1.0 | pu |
| qmin | Minimum reactive power | -1.0 | pu |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| tpmax | Maximum pitch angle | 90.0 | deg |
| u | Connection status | 1.0 | bool |
| * wind | Wind speed id | - | - |
| wmax | Maximum allowable rotor speed | 1.0 | pu(Hz) |
| wmin | Minimum allowable rotor speed | 0.5 | pu(Hz) |
| wthr | Rotor speed threshold for linear approximation | 1.1 | - |
| xd | Direct stator reactance | 1.9 | pu(Ohm) |
| xq | Inverse stator reactance | 2.0 | pu(Ohm) |

53. Device <Ddsg2>

Direct-drive wind turbine with 3th-order synchronous generator model, static shaft model, turbine model 2, pitch control, converter static model, cubic MPPT approximation, AVR with lag model and integral governor model

| Parameter | Description | Default | Units |
|---|---|---|---|
| # D | Rotor damping | 0.01 | kW/kVA |
| # H | Machine inertia constant | 2.0 | kWs/kVA |
| Kp | Pitch control gain | 10.0 | pu |
| Kv | Voltage control gain | 10.0 | pu |
| R | Rotor radius | 35.0 | m |
| # Sn | Machine power rate | 5.0 | MVA |
| # Tp | Pitch control time constant | 3.0 | s |
| # Ts | Speed control time constant | 0.01 | s |
| # Tv | Voltage control time constant | 0.01 | s |
| # Vn | Machine nominal voltage | 1.0 | kV |
| Wn | Machine nominal frecuency | 376.99112 | rad/s |
| * bus | Bus id | - | - |
| etaGB | Gear box ratio | 0.01124 | - |
| * gen | Static generator id | - | - |
| # nb | Number of blades | 3 | int |
| # ng | Number of machines | 40 | int |
| # np | Number of poles | 4 | int |
| ploss | Losses of power electronic bridges | 0.01 | pu |
| pmax | Maximum active power | 1.2 | pu |
| pmin | Minimum active power | 0.0 | pu |
| psip | Permanent magnet field flux | 1.0 | pu(kWb) |
| qmax | Maximum reactive power | 1.0 | pu |
| qmin | Minimum reactive power | -1.0 | pu |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| tpmax | Maximum pitch angle | 90.0 | deg |
| u | Connection status | 1.0 | bool |
| * wind | Wind speed id | - | - |
| wmax | Maximum allowable rotor speed | 1.0 | pu(Hz) |
| wmin | Minimum allowable rotor speed | 0.5 | pu(Hz) |
| wthr | Rotor speed threshold for linear approximation | 1.1 | - |
| xd | Direct stator reactance | 1.9 | pu(Ohm) |
| xq | Inverse stator reactance | 2.0 | pu(Ohm) |

54. Device <Ddsg3>

Direct-drive wind turbine with 3th-order synchronous generator model, static shaft model, turbine model 2, pitch control, converter dynamic model with PI power control and condenser dynamic, cubic MPPT approximation, AVR with lag model and static governor model

| Parameter | Description | Default | Units |
|---|---|---|---|
| # C | Converter compensating capacitor | 0.01 | pu |
| # D | Rotor damping | 0.01 | kW/kVA |
| G | Conductance of the converter dc circuit | 0.001 | pu |
| # H | Machine inertia constant | 2.0 | kWs/kVA |
| Kic | Integral gain of the converter power control | 5.0 | pu |
| Kp | Pitch control gain | 10.0 | pu |
| Kpc | Proportional gain of the converter power control | 10.0 | pu |
| Kv | Voltage control gain | 10.0 | pu |
| R | Rotor radius | 35.0 | m |
| # Sn | Machine power rate | 5.0 | MVA |
| # Tp | Pitch control time constant | 3.0 | s |
| # Tv | Voltage control time constant | 0.01 | s |
| # Vn | Machine nominal voltage | 1.0 | kV |
| Wn | Machine nominal frecuency | 376.99112 | rad/s |
| * bus | Bus id | - | - |
| etaGB | Gear box ratio | 0.01124 | - |
| * gen | Static generator id | - | - |
| # nb | Number of blades | 3 | int |
| # ng | Number of machines | 40 | int |
| # np | Number of poles | 4 | int |
| ploss | Losses of power electronic bridges | 0.01 | pu |
| pmax | Maximum active power | 1.2 | pu |
| pmin | Minimum active power | 0.0 | pu |
| psip | Permanent magnet field flux | 1.0 | pu(kWb) |
| qmax | Maximum reactive power | 1.0 | pu |
| qmin | Minimum reactive power | -1.0 | pu |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| tpmax | Maximum pitch angle | 90.0 | deg |
| u | Connection status | 1.0 | bool |
| vdref | Reference converter dc voltage | 1.25 | pu |
| * wind | Wind speed id | - | - |
| wmax | Maximum allowable rotor speed | 1.0 | pu(Hz) |
| wmin | Minimum allowable rotor speed | 0.5 | pu(Hz) |
| wthr | Rotor speed threshold for linear approximation | 1.1 | - |
| xd | Direct stator reactance | 1.9 | pu(Ohm) |
| xq | Inverse stator reactance | 2.0 | pu(Ohm) |

55. Device <Ddsg4>

Direct-drive wind turbine with 3th-order synchronous generator model, static shaft model, turbine model 2, pitch control, converter dynamic model with PI power control, condenser dynamic and connection reactance, cubic MPPT approximation, AVR with lag model and static governor model

| Parameter | Description | Default | Units |
|---|---|---|---|
| # C | Converter compensating capacitor | 0.01 | pu |
| # D | Rotor damping | 0.01 | kW/kVA |
| G | Conductance of the converter dc circuit | 0.001 | pu |
| # H | Machine inertia constant | 2.0 | kWs/kVA |
| Kic | Integral gain of the converter power control | 5.0 | pu |
| Kp | Pitch control gain | 10.0 | pu |
| Kpc | Proportional gain of the converter power control | 10.0 | pu |
| Kv | Voltage control gain | 10.0 | pu |
| R | Rotor radius | 35.0 | m |
| # Sn | Machine power rate | 5.0 | MVA |
| # Tp | Pitch control time constant | 3.0 | s |
| # Tv | Voltage control time constant | 0.01 | s |
| # Vn | Machine nominal voltage | 1.0 | kV |
| Wn | Machine nominal frecuency | 376.99112 | rad/s |
| * bus | Bus id | - | - |
| etaGB | Gear box ratio | 0.01124 | - |
| * gen | Static generator id | - | - |
| # nb | Number of blades | 3 | int |
| # ng | Number of machines | 40 | int |
| # np | Number of poles | 4 | int |
| ploss | Losses of power electronic bridges | 0.01 | pu |
| pmax | Maximum active power | 1.2 | pu |
| pmin | Minimum active power | 0.0 | pu |
| psip | Permanent magnet field flux | 1.0 | pu(kWb) |
| qmax | Maximum reactive power | 1.0 | pu |
| qmin | Minimum reactive power | -1.0 | pu |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| tpmax | Maximum pitch angle | 90.0 | deg |
| u | Connection status | 1.0 | bool |
| vdref | Reference converter dc voltage | 1.25 | pu |
| * wind | Wind speed id | - | - |
| wmax | Maximum allowable rotor speed | 1.0 | pu(Hz) |
| wmin | Minimum allowable rotor speed | 0.5 | pu(Hz) |
| wthr | Rotor speed threshold for | 1.1 | - |

| | | | |
|---|---|---|---|
| | linear approximation | | |
| xc | Converter series reactor | 0.1 | pu |
| xd | Direct stator reactance | 1.9 | pu(Ohm) |
| xq | Inverse stator reactance | 2.0 | pu(Ohm) |

56. Device <Ddsg5>

Direct-drive wind turbine with 3th-order synchronous generator model, static shaft model, turbine model 2, pitch control, converter static model with lag power control, cubic MPPT approximation, AVR with lag model and static governor model

| Parameter | Description | Default | Units |
|---|---|---|---|
| # D | Rotor damping | 0.01 | kW/kVA |
| # H | Machine inertia constant | 2.0 | kWs/kVA |
| # Kc | Gain of the converter power control | 10.0 | pu |
| Kp | Pitch control gain | 10.0 | pu |
| Kv | Voltage control gain | 10.0 | pu |
| R | Rotor radius | 35.0 | m |
| # Sn | Machine power rate | 5.0 | MVA |
| # Tc | Time constant of the converter power control | 5.0 | s |
| # Tp | Pitch control time constant | 3.0 | s |
| # Tv | Voltage control time constant | 0.01 | s |
| # Vn | Machine nominal voltage | 1.0 | kV |
| Wn | Machine nominal frecuency | 376.99112 | rad/s |
| * bus | Bus id | - | - |
| etaGB | Gear box ratio | 0.01124 | - |
| * gen | Static generator id | - | - |
| # nb | Number of blades | 3 | int |
| # ng | Number of machines | 40 | int |
| # np | Number of poles | 4 | int |
| ploss | Losses of power electronic bridges | 0.01 | pu |
| pmax | Maximum active power | 1.2 | pu |
| pmin | Minimum active power | 0.0 | pu |
| psip | Permanent magnet field flux | 1.0 | pu(kWb) |
| qmax | Maximum reactive power | 1.0 | pu |
| qmin | Minimum reactive power | -1.0 | pu |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| tpmax | Maximum pitch angle | 90.0 | deg |
| u | Connection status | 1.0 | bool |
| * wind | Wind speed id | - | - |
| wmax | Maximum allowable rotor speed | 1.0 | pu(Hz) |
| wmin | Minimum allowable rotor speed | 0.5 | pu(Hz) |
| wthr | Rotor speed threshold for | 1.1 | - |

| | | | |
|---|---|---|---|
| | linear approximation | | |
| xd | Direct stator reactance | 1.9 | pu(Ohm) |
| xq | Inverse stator reactance | 2.0 | pu(Ohm) |

57. Device <Ddsg6>

Direct-drive wind turbine with 3th-order synchronous generator model, static shaft model, turbine model 2, pitch control, converter static model with PI power control and series reactance, cubic MPPT approximation, AVR with PI controller and governor with PI controller. Controllers are based on Zhang's DDSG model, University of Birmingham.

| Parameter | Description | Default | Units |
|---|---|---|---|
| # C | Converter compensating capacitor | 0.01 | pu |
| # D | Rotor damping | 0.01 | kW/kVA |
| G | Conductance of the converter dc circuit | 0.001 | pu |
| # H | Machine inertia constant | 2.0 | kWs/kVA |
| Kic | Integral gain of the converter power control | 5.0 | pu |
| Kig | Integral gain of the governor controller | 5.0 | pu |
| Kiv | Integral gain of the voltage controller | 5.0 | pu |
| Kp | Pitch control gain | 10.0 | pu |
| Kpc | Proportional gain of the converter power control | 10.0 | pu |
| Kpg | Proportional gain of the governor controller | 10.0 | pu |
| Kpv | Proportional gain of the voltage controller | 10.0 | pu |
| R | Rotor radius | 35.0 | m |
| # Sn | Machine power rate | 5.0 | MVA |
| # Tp | Pitch control time constant | 3.0 | s |
| # Vn | Machine nominal voltage | 1.0 | kV |
| Wn | Machine nominal frecuency | 376.99112 | rad/s |
| * bus | Bus id | - | - |
| etaGB | Gear box ratio | 0.01124 | - |
| * gen | Static generator id | - | - |
| # nb | Number of blades | 3 | int |
| # ng | Number of machines | 40 | int |
| # np | Number of poles | 4 | int |
| ploss | Losses of power electronic bridges | 0.01 | pu |
| pmax | Maximum active power | 1.2 | pu |
| pmin | Minimum active power | 0.0 | pu |

| | | | |
|---|---|---|---|
| psip | Permanent magnet field flux | 1.0 | pu(kWb) |
| qmax | Maximum reactive power | 1.0 | pu |
| qmin | Minimum reactive power | -1.0 | pu |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| tpmax | Maximum pitch angle | 90.0 | deg |
| u | Connection status | 1.0 | bool |
| vdref | Reference converter dc voltage | 1.25 | pu |
| * wind | Wind speed id | - | - |
| wmax | Maximum allowable rotor speed | 1.0 | pu(Hz) |
| wmin | Minimum allowable rotor speed | 0.5 | pu(Hz) |
| wthr | Rotor speed threshold for linear approximation | 1.1 | - |
| xc | Converter series reactor | 0.1 | pu |
| xd | Direct stator reactance | 1.9 | pu(Ohm) |
| xq | Inverse stator reactance | 2.0 | pu(Ohm) |

58. Device <Ddsg7>

Direct-drive wind turbine with 3th-order synchronous generator model, static shaft model, turbine model 2, pitch control, converter static model with PI power control and series reactance, cubic MPPT approximation, AVR with PI controller and governor with PI controller. Controllers are based on DigSILENT model

| Parameter | Description | Default | Units |
|---|---|---|---|
| # C | Converter compensating capacitor | 0.01 | pu |
| # D | Rotor damping | 0.01 | kW/kVA |
| G | Conductance of the converter dc circuit | 0.001 | pu |
| # H | Machine inertia constant | 2.0 | kWs/kVA |
| Ki1dc | Int. gain of active power control | 5.0 | pu |
| Ki1ds | Int. gain of dc voltage control | 5.0 | pu |
| Ki1qc | Int. gain of bus voltage control | 5.0 | pu |
| Ki1qs | Int. gain of generator voltage control | 10.0 | pu |
| Ki2dc | Int. gain of of idc control | 5.0 | pu |
| Ki2ds | Int. gain of of ids control | 5.0 | pu |
| Ki2qc | Int. gain of of iqc control | 5.0 | pu |
| Ki2qs | Int. gain of of iqs control | 5.0 | pu |
| Kp | Pitch control gain | 10.0 | pu |
| Kp1dc | Prop. gain of active power control | 10.0 | pu |
| Kp1ds | Prop. gain of dc voltage | 10.0 | pu |

```
             | control                        |            |
  Kp1qc      | Prop. gain of bus voltage      | 10.0       | pu
             | control                        |            |
  Kp1qs      | Prop. gain of generator        | 0.01       | pu
             | voltage control                |            |
  Kp2dc      | Prop. gain of idc control      | 10.0       | pu
  Kp2ds      | Prop. gain of ids control      | 10.0       | pu
  Kp2qc      | Prop. gain of iqc control      | 10.0       | pu
  Kp2qs      | Prop. gain of iqs control      | 10.0       | pu
  R          | Rotor radius                   | 35.0       | m
# Sn         | Machine power rate             | 5.0        | MVA
# Tp         | Pitch control time constant    | 3.0        | s
# Vn         | Machine nominal voltage        | 1.0        | kV
  Wn         | Machine nominal frecuency      | 376.99112  | rad/s
* bus        | Bus id                         | -          | -
  etaGB      | Gear box ratio                 | 0.01124    | -
* gen        | Static generator id            | -          | -
  idcmax     | Maximum idc current            | 1.5        | pu(kA)
  idcmin     | Minimum idc current            | -1.5       | pu(kA)
  idsmax     | Maximum ids current            | 1.5        | pu(kA)
  idsmin     | Minimum ids current            | -1.5       | pu(kA)
  iqcmax     | Maximum iqc current            | 1.5        | pu(kA)
  iqcmin     | Minimum iqc current            | -1.5       | pu(kA)
  iqsmax     | Maximum iqs current            | 1.5        | pu(kA)
  iqsmin     | Minimum iqs current            | -1.5       | pu(kA)
  mdcmax     | Maximum mdc modulation         | 1.5        | pu/pu
  mdcmin     | Minimum mdc modulation         | -1.5       | pu/pu
  mdsmax     | Maximum mds modulation         | 1.5        | pu/pu
  mdsmin     | Minimum mds modulation         | -1.5       | pu/pu
  mqcmax     | Maximum mqc modulation         | 1.5        | pu/pu
  mqcmin     | Minimum mqc modulation         | -1.5       | pu/pu
  mqsmax     | Maximum mqs modulation         | 1.5        | pu/pu
  mqsmin     | Minimum mqs modulation         | -1.5       | pu/pu
# nb         | Number of blades               | 3          | int
# ng         | Number of machines             | 40         | int
# np         | Number of poles                | 4          | int
  ploss      | Losses of power electronic     | 0.01       | pu
             | bridges                        |            |
  psip       | Permanent magnet field flux    | 1.0        | pu(kWb)
  rs         | Stator resistance              | 0.01       | pu(Ohm)
  tpmax      | Maximum pitch angle            | 90.0       | deg
  u          | Connection status              | 1.0        | bool
  vdref      | Reference converter dc voltage | 1.25       | pu
* wind       | Wind speed id                  | -          | -
  wmax       | Maximum allowable rotor speed  | 1.0        | pu(Hz)
  wmin       | Minimum allowable rotor speed  | 0.5        | pu(Hz)
  wthr       | Rotor speed threshold for      | 1.1        | -
             | linear approximation           |            |
  xc         | Converter series reactor       | 0.1        | pu
  xd         | Direct stator reactance        | 1.9        | pu(Ohm)
```

| | | | |
|---|---|---|---|
| xq | Inverse stator reactance | 2.0 | pu(Ohm) |

59. Device <Ddsg8>

Direct-drive wind turbine with 3th-order synchronous generator model, static shaft model, turbine model 2, pitch control, converter static model with PI power control and series reactance, cubic MPPT approximation, reactive power control with PI controller and governor with PI controller. Controllers are based on DigSILENT model

| Parameter | Description | Default | Units |
|---|---|---|---|
| # C | Converter compensating capacitor | 0.01 | pu |
| # D | Rotor damping | 0.01 | kW/kVA |
| G | Conductance of the converter dc circuit | 0.001 | pu |
| # H | Machine inertia constant | 2.0 | kWs/kVA |
| Ki1dc | Int. gain of active power control | 5.0 | pu |
| Ki1ds | Int. gain of dc voltage control | 5.0 | pu |
| Ki1qc | Int. gain of bus voltage control | 5.0 | pu |
| Ki1qs | Int. gain of generator voltage control | 10.0 | pu |
| Ki2dc | Int. gain of of idc control | 5.0 | pu |
| Ki2ds | Int. gain of of ids control | 5.0 | pu |
| Ki2qc | Int. gain of of iqc control | 5.0 | pu |
| Ki2qs | Int. gain of of iqs control | 5.0 | pu |
| Kp | Pitch control gain | 10.0 | pu |
| Kp1dc | Prop. gain of active power control | 10.0 | pu |
| Kp1ds | Prop. gain of dc voltage control | 10.0 | pu |
| Kp1qc | Prop. gain of bus voltage control | 10.0 | pu |
| Kp1qs | Prop. gain of generator voltage control | 0.01 | pu |
| Kp2dc | Prop. gain of idc control | 10.0 | pu |
| Kp2ds | Prop. gain of ids control | 10.0 | pu |
| Kp2qc | Prop. gain of iqc control | 10.0 | pu |
| Kp2qs | Prop. gain of iqs control | 10.0 | pu |
| R | Rotor radius | 35.0 | m |
| # Sn | Machine power rate | 5.0 | MVA |
| # Tp | Pitch control time constant | 3.0 | s |
| # Vn | Machine nominal voltage | 1.0 | kV |
| Wn | Machine nominal frecuency | 376.99112 | rad/s |

| | | | |
|---|---|---|---|
| * bus | Bus id | - | - |
| etaGB | Gear box ratio | 0.01124 | - |
| * gen | Static generator id | - | - |
| idcmax | Maximum idc current | 1.5 | pu(kA) |
| idcmin | Minimum idc current | -1.5 | pu(kA) |
| idsmax | Maximum ids current | 1.5 | pu(kA) |
| idsmin | Minimum ids current | -1.5 | pu(kA) |
| iqcmax | Maximum iqc current | 1.5 | pu(kA) |
| iqcmin | Minimum iqc current | -1.5 | pu(kA) |
| iqsmax | Maximum iqs current | 1.5 | pu(kA) |
| iqsmin | Minimum iqs current | -1.5 | pu(kA) |
| mdcmax | Maximum mdc modulation | 1.5 | pu/pu |
| mdcmin | Minimum mdc modulation | -1.5 | pu/pu |
| mdsmax | Maximum mds modulation | 1.5 | pu/pu |
| mdsmin | Minimum mds modulation | -1.5 | pu/pu |
| mqcmax | Maximum mqc modulation | 1.5 | pu/pu |
| mqcmin | Minimum mqc modulation | -1.5 | pu/pu |
| mqsmax | Maximum mqs modulation | 1.5 | pu/pu |
| mqsmin | Minimum mqs modulation | -1.5 | pu/pu |
| # nb | Number of blades | 3 | int |
| # ng | Number of machines | 40 | int |
| # np | Number of poles | 4 | int |
| ploss | Losses of power electronic bridges | 0.01 | pu |
| psip | Permanent magnet field flux | 1.0 | pu(kWb) |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| tpmax | Maximum pitch angle | 90.0 | deg |
| u | Connection status | 1.0 | bool |
| vdref | Reference converter dc voltage | 1.25 | pu |
| * wind | Wind speed id | - | - |
| wmax | Maximum allowable rotor speed | 1.0 | pu(Hz) |
| wmin | Minimum allowable rotor speed | 0.5 | pu(Hz) |
| wthr | Rotor speed threshold for linear approximation | 1.1 | - |
| xc | Converter series reactor | 0.1 | pu |
| xd | Direct stator reactance | 1.9 | pu(Ohm) |
| xq | Inverse stator reactance | 2.0 | pu(Ohm) |

60. Device <Ddsg9>

Direct-drive wind turbine with 3th-order synchronous generator model, dynamic shaft model with tower-shadow effect, turbine model 2, pitch control, converter static model with PI power control and series reactance, cubic MPPT approximation, AVR with PI controller and governor with PI controller. Controllers are based on DigSILENT model

| Parameter | Description | Default | Units |
|---|---|---|---|

```
  Bs         | Shaft viscous friction         | 0.0       | pu
# C          | Converter compensating         | 0.01      | pu
             | capacitor                      |           |
# D          | Rotor damping                  | 0.01      | kW/kVA
  G          | Conductance of the converter   | 0.001     | pu
             | dc circuit                     |           |
# H          | Machine inertia constant       | 2.0       | kWs/kVA
# Ht         | Wind turbine inertia           | 0.5       | kWs/kVA
  Ki1dc      | Int. gain of active power      | 5.0       | pu
             | control                        |           |
  Ki1ds      | Int. gain of dc voltage        | 5.0       | pu
             | control                        |           |
  Ki1qc      | Int. gain of bus voltage       | 5.0       | pu
             | control                        |           |
  Ki1qs      | Int. gain of generator voltage | 10.0      | pu
             | control                        |           |
  Ki2dc      | Int. gain of of idc control    | 5.0       | pu
  Ki2ds      | Int. gain of of ids control    | 5.0       | pu
  Ki2qc      | Int. gain of of iqc control    | 5.0       | pu
  Ki2qs      | Int. gain of of iqs control    | 5.0       | pu
  Kp         | Pitch control gain             | 10.0      | pu
  Kp1dc      | Prop. gain of active power     | 10.0      | pu
             | control                        |           |
  Kp1ds      | Prop. gain of dc voltage       | 10.0      | pu
             | control                        |           |
  Kp1qc      | Prop. gain of bus voltage      | 10.0      | pu
             | control                        |           |
  Kp1qs      | Prop. gain of generator        | 0.01      | pu
             | voltage control                |           |
  Kp2dc      | Prop. gain of idc control      | 10.0      | pu
  Kp2ds      | Prop. gain of ids control      | 10.0      | pu
  Kp2qc      | Prop. gain of iqc control      | 10.0      | pu
  Kp2qs      | Prop. gain of iqs control      | 10.0      | pu
# Ks         | Shaft stiffness                | 0.3       | pu
  R          | Rotor radius                   | 35.0      | m
# Sn         | Machine power rate             | 5.0       | MVA
# Tp         | Pitch control time constant    | 3.0       | s
# Vn         | Machine nominal voltage        | 1.0       | kV
  Wn         | Machine nominal frecuency      | 376.99112 | rad/s
* bus        | Bus id                         | -         | -
  etaGB      | Gear box ratio                 | 0.01124   | -
* gen        | Static generator id            | -         | -
  idcmax     | Maximum idc current            | 1.5       | pu(kA)
  idcmin     | Minimum idc current            | -1.5      | pu(kA)
  idsmax     | Maximum ids current            | 1.5       | pu(kA)
  idsmin     | Minimum ids current            | -1.5      | pu(kA)
  iqcmax     | Maximum iqc current            | 1.5       | pu(kA)
  iqcmin     | Minimum iqc current            | -1.5      | pu(kA)
  iqsmax     | Maximum iqs current            | 1.5       | pu(kA)
  iqsmin     | Minimum iqs current            | -1.5      | pu(kA)
```

| | | | |
|---|---|---|---|
| mdcmax | Maximum mdc modulation | 1.5 | pu/pu |
| mdcmin | Minimum mdc modulation | -1.5 | pu/pu |
| mdsmax | Maximum mds modulation | 1.5 | pu/pu |
| mdsmin | Minimum mds modulation | -1.5 | pu/pu |
| mqcmax | Maximum mqc modulation | 1.5 | pu/pu |
| mqcmin | Minimum mqc modulation | -1.5 | pu/pu |
| mqsmax | Maximum mqs modulation | 1.5 | pu/pu |
| mqsmin | Minimum mqs modulation | -1.5 | pu/pu |
| # nb | Number of blades | 3 | int |
| # ng | Number of machines | 40 | int |
| # np | Number of poles | 4 | int |
| ploss | Losses of power electronic bridges | 0.01 | pu |
| psip | Permanent magnet field flux | 1.0 | pu(kWb) |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| tpmax | Maximum pitch angle | 90.0 | deg |
| u | Connection status | 1.0 | bool |
| vdref | Reference converter dc voltage | 1.25 | pu |
| * wind | Wind speed id | - | - |
| wmax | Maximum allowable rotor speed | 1.0 | pu(Hz) |
| wmin | Minimum allowable rotor speed | 0.5 | pu(Hz) |
| wthr | Rotor speed threshold for linear approximation | 1.1 | - |
| xc | Converter series reactor | 0.1 | pu |
| xd | Direct stator reactance | 1.9 | pu(Ohm) |
| xq | Inverse stator reactance | 2.0 | pu(Ohm) |

61. Device <Demand>

Demand bids

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| * bus | Bus id | - | - |
| cosphi | Power factor | 1.0 | - |
| cp0 | Active power c0 bid | 0.0 | $/h |
| cp1 | Active power c1 bid | 0.0 | $/MWh |
| cp2 | Active power c2 bid | 0.0 | $/MW^2h |
| cq0 | Reactive power c0 bid | 0.0 | $/h |
| cq1 | Reactive power c1 bid | 0.0 | $/MVArh |
| cq2 | Reactive power c2 bid | 0.0 | $/MVAr^2h |
| pmax | Maximum active power | 0.0 | pu(MW) |
| pmin | Minimum active power | 0.0 | pu(MVAr) |
| tie | Tie-break cost | 0.0 | $/MWh |
| u | Connection status | 1.0 | bool |

62. Device <Dfig1>

Variable-speed wind turbine with 5th-order doubly-fed induction generator model, static shaft model, turbine model 2, pitch control, linear MPPT approximation, avr model 1 and speed control model 2

| Parameter | Description | Default | Units |
|---|---|---|---|
| # D | Rotor damping | 0.01 | kW/kVA |
| # H | Machine inertia constant | 2.0 | kWs/kVA |
| Kp | Pitch control gain | 10.0 | pu |
| Kv | Voltage control gain | 10.0 | pu |
| R | Rotor radius | 35.0 | m |
| # Sn | Machine power rate | 5.0 | MVA |
| # Tp | Pitch control time constant | 3.0 | s |
| # Vn | Machine nominal voltage | 1.0 | kV |
| Wn | Machine nominal frecuency | 376.99112 | rad/s |
| * bus | Bus id | - | - |
| etaGB | Gear box ratio | 0.01124 | - |
| * gen | Static generator id | - | - |
| # nb | Number of blades | 3 | int |
| # ng | Number of machines | 40 | int |
| # np | Number of poles | 4 | int |
| pmax | Maximum active power | 1.2 | pu(MW) |
| pmin | Minimum active power | 0.0 | pu(MW) |
| qmax | Maximum reactive power | 1.2 | pu(MVAr) |
| qmin | Minimum reactive power | -1.2 | pu(MVAr) |
| rr | Rotor resistance | 0.01 | pu(Ohm) |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| tpmax | Maximum pitch angle | 90.0 | deg |
| u | Connection status | 1.0 | bool |
| * wind | Wind speed id | - | - |
| wmax | Maximum allowable rotor speed | 1.0 | pu(Hz) |
| wmin | Minimum allowable rotor speed | 0.5 | pu(Hz) |
| xm | Mutual inductance | 1.9 | pu(Ohm) |
| xr | Rotor leakage inductance | 2.0 | pu(Ohm) |
| xs | Stator leakage inductance | 2.0 | pu(Ohm) |

63. Device <Dfig2>

Variable-speed wind turbine with 5th-order doubly-fed induction generator model, static shaft model, turbine model 2, pitch control, cubic MPPT approximation, avr model 1 and speed control model 2

| Parameter | Description | Default | Units |
|---|---|---|---|
| # D | Rotor damping | 0.01 | kW/kVA |

| | | | |
|---|---|---|---|
| # H | Machine inertia constant | 2.0 | kWs/kVA |
| Kp | Pitch control gain | 10.0 | pu |
| Kv | Voltage control gain | 10.0 | pu |
| R | Rotor radius | 35.0 | m |
| # Sn | Machine power rate | 5.0 | MVA |
| # Tp | Pitch control time constant | 3.0 | s |
| # Vn | Machine nominal voltage | 1.0 | kV |
| Wn | Machine nominal frecuency | 376.99112 | rad/s |
| * bus | Bus id | - | - |
| etaGB | Gear box ratio | 0.01124 | - |
| * gen | Static generator id | - | - |
| # nb | Number of blades | 3 | int |
| # ng | Number of machines | 40 | int |
| # np | Number of poles | 4 | int |
| pmax | Maximum active power | 1.2 | pu(MW) |
| pmin | Minimum active power | 0.0 | pu(MW) |
| qmax | Maximum reactive power | 1.2 | pu(MVAr) |
| qmin | Minimum reactive power | -1.2 | pu(MVAr) |
| rr | Rotor resistance | 0.01 | pu(Ohm) |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| tpmax | Maximum pitch angle | 90.0 | deg |
| u | Connection status | 1.0 | bool |
| * wind | Wind speed id | - | - |
| wmax | Maximum allowable rotor speed | 1.0 | pu(Hz) |
| wmin | Minimum allowable rotor speed | 0.5 | pu(Hz) |
| wthr | Rotor speed threshold for linear approximation | 1.1 | - |
| xm | Mutual inductance | 1.9 | pu(Ohm) |
| xr | Rotor leakage inductance | 2.0 | pu(Ohm) |
| xs | Stator leakage inductance | 2.0 | pu(Ohm) |

64. Device <Dfig3>

Variable-speed wind turbine with 5th-order doubly-fed induction generator model, dynamic shaft model with tower-shadow effect, double-mass shaft model, turbine model 2, pitch control, cubic MPPT approximation, avr model 1 and speed control model 2

| Parameter | Description | Default | Units |
|---|---|---|---|
| Bs | Shaft viscous friction | 0.0 | pu |
| # D | Rotor damping | 0.01 | kW/kVA |
| # H | Machine inertia constant | 2.0 | kWs/kVA |
| # Ht | Wind turbine inertia | 0.5 | kWs/kVA |
| Kp | Pitch control gain | 10.0 | pu |
| # Ks | Shaft stiffness | 0.3 | pu |
| Kv | Voltage control gain | 10.0 | pu |
| R | Rotor radius | 35.0 | m |

| | | | |
|---|---|---|---|
| # Sn | Machine power rate | 5.0 | MVA |
| # Tp | Pitch control time constant | 3.0 | s |
| # Vn | Machine nominal voltage | 1.0 | kV |
| Wn | Machine nominal frecuency | 376.99112 | rad/s |
| * bus | Bus id | - | - |
| etaGB | Gear box ratio | 0.01124 | - |
| * gen | Static generator id | - | - |
| # nb | Number of blades | 3 | int |
| # ng | Number of machines | 40 | int |
| # np | Number of poles | 4 | int |
| pmax | Maximum active power | 1.2 | pu(MW) |
| pmin | Minimum active power | 0.0 | pu(MW) |
| qmax | Maximum reactive power | 1.2 | pu(MVAr) |
| qmin | Minimum reactive power | -1.2 | pu(MVAr) |
| rr | Rotor resistance | 0.01 | pu(Ohm) |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| tpmax | Maximum pitch angle | 90.0 | deg |
| u | Connection status | 1.0 | bool |
| * wind | Wind speed id | - | - |
| wmax | Maximum allowable rotor speed | 1.0 | pu(Hz) |
| wmin | Minimum allowable rotor speed | 0.5 | pu(Hz) |
| wthr | Rotor speed threshold for linear approximation | 1.1 | - |
| xm | Mutual inductance | 1.9 | pu(Ohm) |
| xr | Rotor leakage inductance | 2.0 | pu(Ohm) |
| xs | Stator leakage inductance | 2.0 | pu(Ohm) |

65. Device <Display>

Basic display class

| Parameter | Description | Default | Units |
|---|---|---|---|
| bus | Associated bus index (if any) | - | - |
| closed | Closed line | False | bool |
| color | Line color | b | - |
| * devID | Index of associated device | - | - |
| * devName | Name of associated device | - | - |
| glyph | Glyph name for 3d maps | sphere | str |
| marker | Device marker | | str |
| mcolor | Marker color | b | - |
| resol | Number of faces of glyphes | 15 | int |
| sfactor | Glyph scale factor | 0.15 | double |
| style | Line style | - | str |
| thick | Line thickness | 0.5 | double |
| u | Connection status | 1.0 | bool |
| xcoord | X axis topological coordinates | [] | double array |
| ycoord | Y axis topological coordinates | [] | double array |

| | | | |
|---|---|---|---|
| zorder | Z order of the graphical object | 1 | int |

66. Device <Dynamo>

dc machine with permanent magnet on the rotor (dynamo)

| Parameter | Description | Default | Units |
|---|---|---|---|
| D | Rotor damping | 0.01 | kW/kVA |
| H | Inertia constant | 2.0 | kWs/kVA |
| # Idcn | Dc current rate | 10.0 | kA |
| # Laa | Autoinductance of the armature winding | 0.5 | H |
| Ra | Armature winding resistance | 0.05 | Ohm |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| * node1 | Input dc node 1 | - | - |
| * node2 | Input dc node 2 | - | - |
| psif | Flux of the rotor permanent magnet | 1.0 | pu(kWb) |
| rpm | Nominal revolution per minute | 1500 | - |
| tm0 | Constant mechanical torque (use tm0 < 0 for generators) | 1.0 | MNm |
| u | Connection status | 1.0 | bool |

67. Device <ERLoad>

Exponential recovery load

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| * Tp | P time constant | 5.0 | s |
| * Tq | Q time constant | 5.0 | s |
| alfas | Static p exponent | 0.0 | - |
| alfat | Dynamic p exponent | 0.0 | - |
| betas | Static q exponent | 0.0 | - |
| betat | Dynamic q exponent | 0.0 | - |
| * bus | Bus id | - | - |
| * kp | Active power percentage | 0.0 | %(MW) |
| * kq | Reactive power percentage | 0.0 | %(MVAr) |
| * pqid | Pq load id | - | - |
| u | Connection status | 1.0 | bool |

68. Device <EVcharger>

Simplified electric vehicle charger model

| Parameter | Description | Default | Units |
|---|---|---|---|
| I0 | Nominal current | 15.0 | A |
| # Vn | Voltage rate | 0.4 | kV |
| * bus | Bus id | - | - |
| phases | Number of phases (1 or 3) | 3 | int |
| plevel | Priority level (for the acs routine) | 0 | int |
| u | Connection status | 1.0 | bool |

69. Device <Electrolyzer>

Electrolyzer with electrical, chemical and thermodynamic model

| Parameter | Description | Default | Units |
|---|---|---|---|
| # A | Area of the cell | 0.25 | m^2 |
| # Cpcm | Total heat capacity of the cooling medium | 697.67 | W/K |
| # Cpel | Total heat capacity of the electrolyzer stack | 625200.0 | J/K |
| # Idcn | Dc current rate | 10.0 | kA |
| # Rtel | Equivalent thermal resistance | 0.167 | K/W |
| Ta | Ambient temperature | 298.15 | K |
| Tcmi | Inlet temperature of the cooling medium | 298.15 | K |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| Vrev0 | Reversible cell voltage at standard conditions | 1.229 | V |
| Vth | Thermoneutral cell voltage | 1.482 | V |
| hcond | Conductive heat coefficient | 7.0 | W/K |
| hconv | Convective heat coefficient | 0.02 | W/KA |
| kel | Cell overvoltage coefficient | 0.185 | V |
| kf1 | 1st empirical constant for parasitic losses | 25000.0 | A/m^2 |
| kf2 | 2nd empirical constant for parasitic losses | 0.96 | - |
| krev | Empirical temperature coeff. of reversible voltage | 0.00193 | V/K |
| kt1 | 1st overvoltage parameter | 1.599 | m^2/A |
| kt2 | 2nd overvoltage parameter | -1.302 | m^2 K/A |
| kt3 | 3rd overvoltage parameter | 421.3 | m^2 K^2/A |
| * node1 | Input dc node 1 | - | - |
| * node2 | Input dc node 2 | - | - |

| | | | |
|---|---|---|---|
| ns | Number of cells in series | 40 | int |
| r1 | 1st param. of the cell resist. | 8.05e-05 | Ohm m^2 |
| r2 | 2nd param. of the cell resist. | -2.5e-07 | Ohm m^2/K |
| u | Connection status | 1.0 | bool |

70. Device <Expander>

Turbo-expander with controlled nozzle and gearbox coupled to a induction generator. The default gas is methane.

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ad | Diaphragm area | 10 | m^2 |
| # D | Rotor damping | 0.01 | kW/kVA |
| Dd | Damping coefficient of the diaphragm position | 19.0 | kg/s |
| Dhl | Turbine - high speed gearbox damping | 0.8 | kNms/rad |
| Dlr | Low speed gearbox - machine rotor damping | 0.5 | kNms/rad |
| # H | Machine inertia constant | 2.0 | kWs/kVA |
| Jh | High speed gearbox inertia | 4.0 | kg m^2 |
| Jt | Turbine inertia | 15.0 | kg m^2 |
| Kd | Elastic constant of the nozzle spring | 10.2 | kg/s^2 |
| Khl | Turbine - low speed gearbox torsional elastic constant | 0.003 | kNm/rad |
| Ki | Integral gain of the nozzle controller | 5.0 | - |
| Klr | Low speed gearbox - machine rotor torsional elastic constant | 0.002 | kNm/rad |
| Kp | Proportinal gain of the nozzle controller | 10.0 | - |
| Kt | Mass flow rate vs. nozzle position coefficient | 30.0 | m/(sK^.5rad) |
| Md | Mass of the diaphragm | 50.0 | kg |
| Pin | Turbine input pressure | 19.0 | bar |
| Prate | Turbine input pressure rate | 19.0 | bar |
| Pref | Reference output pressure | 15.2 | bar |
| Qrate | Turbine mass flow rate | 100.0 | kg/s |
| # Sn | Machine power rate | 0.01 | MVA |
| Tin | Turbine input temperature | 341.0 | K |
| # Vn | Machine nominal voltage | 1.0 | kV |
| Wn | Machine nominal frecuency | 376.99112 | rad/s |
| * bus | Bus id | - | - |
| cp | Specific heat capacity at constant pressure | 2.22 | kJ/(kg K) |

| | | | |
|---|---|---|---|
| cv | Specific heat capacity at constant volume | 1.7 | kJ/(kg K) |
| etalb | Lower bound of the turbine efficiency | 70.0 | % |
| etaub | Upper bound of the turbine efficiency | 85.0 | % |
| k0 | Coefficient relating the nozzle pressure with angular error | 70.0 | bar/rad |
| k1 | Nozzle-diaphragm linear coefficient | 7.5 | rad/m |
| k2 | Nozzle-diaphragm constant coefficient | -261.0 | rad |
| ng | Gearbox ratio | 15.6 | - |
| rr | Rotor resistance | 0.01 | pu(Ohm) |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| tref | Reference nozzle angular position | 0.5 | rad |
| u | Connection status | 1.0 | bool |
| xm | Mutual inductance | 1.9 | pu(Ohm) |
| xr | Rotor leakage inductance | 2.0 | pu(Ohm) |
| xs | Stator leakage inductance | 2.0 | pu(Ohm) |

71. Device <FDL>

Frequency dependent load

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| * Tf | Filter time constant | 0.01 | s |
| # Vn | Voltage rate | 220.0 | kV |
| ap | P voltage exponent | 2.0 | - |
| aq | Q voltage exponent | 2.0 | - |
| bp | P frequency exponent | 0.0 | - |
| bq | Q frequency exponent | 0.0 | - |
| * bus | Bus id | - | - |
| # dt | Refreshing interval of bus angle | 0.01 | s |
| * kp | Active power percentage | 0.0 | %(MW) |
| * kq | Reactive power percentage | 0.0 | %(MVAr) |
| * pqid | Pq load id | - | - |
| u | Connection status | 1.0 | bool |

72. Device <FDLS>

Frequency dependent load (with synchronous machine frequency signal)

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| ap | P voltage exponent | 2.0 | - |
| aq | Q voltage exponent | 2.0 | - |
| bp | P frequency exponent | 0.0 | - |
| bq | Q frequency exponent | 0.0 | - |
| * bus | Bus id | - | - |
| * kp | Active power percentage | 0.0 | %(MW) |
| * kq | Reactive power percentage | 0.0 | %(MVAr) |
| * pqid | Pq load id | - | - |
| * syn | Synchronous machine signal | - | - |
| u | Connection status | 1.0 | bool |

73. Device <FLMotor>

Full-load induction motor

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power at nominal voltage | 10.0 | kW |
| # Vn | Voltage rate | 0.4 | kV |
| * bus | Bus id | - | - |
| pf | Nominal power factor (negative for capacitive loads) | 0.85 | - |
| plevel | Priority level (for the acs routine) | 3 | int |
| u | Connection status | 1.0 | bool |

74. Device <Fault>

Three-phase fault for time-domain analysis. The fault impedance can be also used for short-circuit analysis an has the same usage as zf for the <FltSeq> device.

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| rf | Fault resistance | 0.0 | pu(Ohm) |
| tc | Time of fault clearance | 0.0 | s |

| | | | |
|---|---|---|---|
| tf | Time of fault occurrence | 0.0 | s |
| u | Connection status | 0.0 | bool |
| xf | Fault reactance | 1e-05 | pu(Ohm) |

75. Device <FeederD>

Distribution network feeder

| Parameter | Description | Default | Units |
|---|---|---|---|
| * V0 | Feeder voltage magnitude | 20.0 | kV |
| # Vn | Voltage rate | 20.0 | kV |
| * bus | Bus id | - | - |
| u | Connection status | 1.0 | bool |

76. Device <Fess1>

Flywheel energy storage system (FESS) based on induction machine

| Parameter | Description | Default | Units |
|---|---|---|---|
| # D | Rotor damping | 0.01 | kW/kVA |
| # H | Machine inertia constant | 2.0 | kWs/kVA |
| # Idcn | Dc current rate | 10.0 | kA |
| Ki | Voltage regulator integral gain | 1.0 | - |
| Kp | Voltage regulator proportional gain | 5.0 | - |
| Sn | Machine power rate | 5.0 | MVA |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| Vn | Machine nominal voltage | 1.0 | kV |
| Wn | Machine nominal frecuency | 376.99112 | rad/s |
| idcmax | Maximum allowable dc current | 1.2 | pu(kA) |
| idcmin | Minimum allowable dc current | -1.2 | pu(kA) |
| mmax | Maximum allowable modulation amplitude | 2.0 | - |
| mmin | Minimum allowable modulation amplitude | -2.0 | - |
| * node1 | Input dc node 1 | - | - |
| * node2 | Input dc node 2 | - | - |
| rr | Rotor resistance | 0.01 | pu(Ohm) |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| tref | Reference torque | 0.001 | pu(MNm) |
| u | Connection status | 1.0 | bool |
| vref | Reference voltage | 1.0 | pu(kV) |
| wmax | Maximum allowable rotor speed | 1.5 | pu(Hz) |

| | | | |
|---|---|---|---|
| wmin | Minimum allowable rotor speed | 0.5 | pu(Hz) |
| wref | Reference stator speed | 1.0 | pu(Hz) |
| xm | Mutual inductance | 1.9 | pu(Ohm) |
| xr | Rotor leakage inductance | 2.0 | pu(Ohm) |
| xs | Stator leakage inductance | 2.0 | pu(Ohm) |

77. Device <Fess2>

Flywheel energy storage system (FESS) based on permament magnet synchronous machine

| Parameter | Description | Default | Units |
|---|---|---|---|
| # D | Rotor damping | 0.01 | kW/kVA |
| # H | Machine inertia constant | 2.0 | kWs/kVA |
| # Idcn | Dc current rate | 10.0 | kA |
| Kid | Direct axis regulator integral gain | 1.0 | - |
| Kiq | Inverse axis regulator integral gain | 1.0 | - |
| Kiw | Speed regulator integral gain | 1.0 | - |
| Kpd | Direct axis regulator proportional gain | 5.0 | - |
| Kpq | Inverse axis regulator proportional gain | 5.0 | - |
| Kpw | Speed regulator proportional gain | 5.0 | - |
| Sn | Machine power rate | 5.0 | MVA |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| Vn | Machine nominal voltage | 1.0 | kV |
| Wn | Machine nominal frecuency | 376.99112 | rad/s |
| idcmax | Maximum allowable dc current | 1.2 | pu(kA) |
| idcmin | Minimum allowable dc current | -1.2 | pu(kA) |
| imax | Maximum allowable stator current | 2.0 | pu(kA) |
| imin | Minimum allowable stator current | -2.0 | pu(kA) |
| * node1 | Input dc node 1 | - | - |
| * node2 | Input dc node 2 | - | - |
| psip | Permanent magnet field flux | 1.0 | pu(kWb) |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| tmax | Maximum allowable torque | 2.0 | pu(MNm) |
| tmin | Minimum allowable torque | -2.0 | pu(MNm) |
| u | Connection status | 1.0 | bool |
| wmax | Maximum allowable rotor speed | 1.5 | pu(Hz) |
| wmin | Minimum allowable rotor speed | 0.5 | pu(Hz) |
| wref | Reference rotor speed | 1.0 | pu(Hz) |
| xd | Direct stator reactance | 1.9 | pu(Ohm) |
| xq | Inverse stator reactance | 2.0 | pu(Ohm) |

78. Device <Fess_control>

Controller of flywheel energy storage devices

| Parameter | Description | Default | Units |
|---|---|---|---|
| # K | Gain of modulation control | 10.0 | - |
| Kd | Integral deviation of mod. control | 0.0 | - |
| Kddc | Derivative gain of dc signal | 5.0 | - |
| Ki | Integral gain of angle control | 5.0 | - |
| Kidc | Integral gain of dc signal | 10.0 | - |
| Kmac | Gain of ac measure | 1.0 | - |
| Kmdc | Gain of dc measure | 1.0 | - |
| Kp | Proportional gain of angle control | 10.0 | - |
| Kpdc | Proportional gain of dc signal | 1.0 | - |
| Pref | Reference active power | 1.0 | pu(MW) |
| # T1 | Lead of modulation control | 0.1 | s |
| T2 | Lag of modulation control | 0.05 | s |
| # Tf | Low-pass filter time constant | 0.001 | s |
| # Tmac | Lag of ac measure | 0.01 | s |
| # Tmdc | Lag of dc measure | 0.01 | s |
| amax | Maximum firing angle | 360.0 | deg |
| amin | Minimum firing angle | -360.0 | deg |
| db | Dead band of the power measure | 0 | - |
| * fess | Flywheel id | - | - |
| * line | Transmission line id | - | - |
| mmax | Maximum modulation | 3.0 | - |
| mmin | Minimum modulation | 0.5 | - |
| trig | Coefficient to relax pref signal (0, 1] | 0.05 | - |
| u | Connection status | 1.0 | bool |
| * vsc | Vsc id | - | - |
| * vsc_static | Static vsc control id | - | - |

79. Device <Flamp>

Fluorescent lamp (Osram L36W)

| Parameter | Description | Default | Units |
|---|---|---|---|
| L | Ballast inductance | 1.18 | H |
| # Sn | Power rate | 3.6e-05 | MVA |
| Theta0 | Gas temperature | 350.0 | K |

```
 # Vn         | Voltage rate                    | 0.23       | kV
 * bus        | Bus id                          | -          | -
   c1         | Coefficient of the lamp model   | 38019.3    | K/J
   c2         | Coefficient of the lamp model   | 829000.0   | W
   c3         | Coefficient of the lamp model   | 6.45       | J/C
   c4         | Coefficient of the lamp model   | 0.055      | W/K
   c5         | Coefficient of the lamp model   | 8828.31    | Ohm*K^0.75
   c6         | Coefficient of the lamp model   | 0.23       | J/C
   c7         | Factor of the lamp model        | 0.8        | -
   r          | Ballast resistance              | 0.0        | pu(Ohm)
   u          | Connection status               | 1.0        | bool
   ve         | Electrode voltage drop          | 11.0       | V
-------------------------------------------------------------------------

 80. Device <FltSeq>

Fault and line-to-ground impedances for short-circuit analysis.
The impedances are used as follows:

1. For symmetrical three-phase (3P) faults, zf is the fault impedance
   per phase; since the pre-fault system condition is assumed
   balanced, zg is immaterial.

   a o---[zf]---
             |
   b o---[zf]------[zg]--
             |        |
   c o---[zf]---      |
                      +

2. For line-to-line (LL) faults, zf is the total fault impedance
   connecting two phases; since the pre-fault system condition is
   assumed balanced, zg is not used.

   a o---o

   b o---[zf]---
             |
   c o----------

3. For double-line to ground (DLG) faults to ground, zf is the fault
   impedance per phase, while zg is the impedance to ground.

   a o---o

   b o---[zf]---
             |---[zg]--
   c o---[zf]---      |
                      +
```

4. For single line to ground (SLG) faults, zg is the line-to-ground impedance; zf is not used.

```
a o---[zg]---
            |
b o---o     |
            |
c o---o     |
            +
```

5. For single line to ground plus line-to-line faults, zg is the line-toground impedance, while zf is the total fault impedance connecting the other two phases.

```
a o---[zg]-------
                |
b o---[zf]---   |
            |   |
c o----------   |
                +
```

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| rf | Fault resistance | 0 | pu(Ohm) |
| rg | Line-to-ground resistance | 0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| xf | Fault impedance | 0 | pu(Ohm) |
| xg | Line-to-ground impedance | 0 | pu(Ohm) |

81. Device <Fluorescent>

Fluorescent lamp

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power at nominal voltage | 0.088 | kW |
| # Vn | Voltage rate | 0.4 | kV |
| * bus | Bus id | - | - |
| pf | Nominal power factor (negative for capacitive loads) | -0.0036 | - |
| plevel | Priority level (for the acs routine) | 3 | int |

| | | | |
|---|---|---|---|
| u | Connection status | 1.0 | bool |

82. Device <FortDisp>

This device defines the unbalanced level of the Fortescue device and is useful to evaluate the 'quality' of the admission control strategy

| Parameter | Description | Default | Units |
|---|---|---|---|
| * fort | Fortescue device id | - | - |
| u | Connection status | 1.0 | bool |

83. Device <Fortescue>

Three-phase to single-phase interface based on the Fortescue's symmetrical component theory

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| b0 | Seq 0 equivalent shunt susceptance | 0.0 | pu(1/Ohm) |
| b1 | Seq + shunt susceptance | 0.0 | pu(1/Ohm) |
| b2 | Seq - equivalent shunt susceptance | 0.0 | pu(1/Ohm) |
| * bus1 | Index of the single-phase bus (positive sequence) | - | - |
| * busa | Index of the phase <a> bus | - | - |
| * busb | Index of the phase <b> bus | - | - |
| * busc | Index of the phase <c> bus | - | - |
| g0 | Seq 0 equivalent shunt conductance | 0.0 | pu(1/Ohm) |
| g1 | Seq + shunt conductance | 0.0 | pu(1/Ohm) |
| g2 | Seq - equivalent shunt conductance | 0.0 | pu(1/Ohm) |
| imax | Maximum current | 999.9 | pu(kA) |
| pmax | Maximum active power | 999.9 | pu(MW) |
| r1 | Seq + series resistance | 0.0 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| x1 | Seq + series reactance | 0.01 | pu(Ohm) |

84. Device <Fuel_control1>

Constant current regulator with PI controller for fuel cells

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ki | Integral gain of the fuel pi controller | 10.0 | - |
| Kp | Proportional gain of the fuel pi controller | 100.0 | - |
| # Tf | Fuel processor response time | 1.0 | s |
| Umax | Maximum fuel utilization | 1.0 | - |
| Umin | Minimum fuel utilization | 0.0 | - |
| * cell | Fuel cell id | - | - |
| iref | Single cell reference current | 0.6 | A |
| u | Connection status | 1.0 | bool |

85. Device <Fuel_control2>

Solid Oxide Fuel Cell (SOFC) with constant power control

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ki | Integral gain of the fuel pi controller | 0.001 | - |
| Kp | Proportional gain of the fuel pi controller | 0 | - |
| # Tf | Fuel processor response time | 1.0 | s |
| Umax | Maximum fuel utilization | 1.0 | - |
| Umin | Minimum fuel utilization | 0.0 | - |
| * cell | Fuel cell id | - | - |
| pref | Single cell reference power | 1.0 | W |
| u | Connection status | 1.0 | bool |

86. Device <Furnace>

Reduction furnace

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power at nominal voltage | 80.0 | kW |
| # Vn | Voltage rate | 0.4 | kV |
| * bus | Bus id | - | - |
| pf | Nominal power factor (negative for capacitive loads) | 0.9 | - |

| | | | |
|---|---|---|---|
| plevel | Priority level (for the acs routine) | 4 | int |
| u | Connection status | 1.0 | bool |

87. Device <GLC>

GLC parallel for EMT circuits

| Parameter | Description | Default | Units |
|---|---|---|---|
| # C | Capacity | 1.0 | Farad |
| G | Conductance | 0.0 | Siemens |
| # Idcn | Dc current rate | 10.0 | kA |
| # L | Inductance | 0.0 | Henry |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| i0 | Initial inductance current | 0.0 | pu(kA) |
| * node1 | 1st node id | - | - |
| * node2 | 2nd node id | - | - |
| u | Connection status | 1.0 | bool |
| v0 | Initial voltage | 0.0 | pu(kV) |

88. Device <GUPFC_control>

Dynamic Generalized UPFC controller

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kmi | Voltage control gain | 10.0 | - |
| Kp1 | Proportional gain of the pi controller of vpj | 10.0 | - |
| Kp2 | Proportional gain of the pi controller of vqj | 10.0 | - |
| Kp3 | Proportional gain of the pi controller of vpk | 10.0 | - |
| Kp4 | Proportional gain of the pi controller of vqk | 10.0 | - |
| # Ti1 | Time constant of the pi controller of vpj | 0.01 | s |
| # Ti2 | Time constant of the pi controller of vqj | 0.01 | s |
| # Ti3 | Time constant of the pi controller of vpk | 0.01 | s |
| # Ti4 | Time constant of the pi controller of vqk | 0.01 | s |
| # Tm1 | Lag time constant of the vpj controller | 0.01 | s |

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Tm2 | Lag time constant of the vqj controller | 0.01 | s |
| # Tm3 | Lag time constant of the vpk controller | 0.01 | s |
| # Tm4 | Lag time constant of the vqk controller | 0.01 | s |
| # Tmi | Voltage control time constant | 0.01 | s |
| * gupfc | Gupfc id | - | - |
| u | Connection status | 1.0 | bool |

89. Device <GenDisp>

This device defines some indicators of generator devices and can be useful to evaluate the 'quality' of the admission control strategy

| Parameter | Description | Default | Units |
|---|---|---|---|
| * gen | Generator device id | - | - |
| u | Connection status | 1.0 | bool |

90. Device <GenSeq>

Auxiliary device that allows defining positive, negative and zero sequence parameters for generators. If negative sequence values are not provided, positive sequence values are used.

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| con | Connection type ('d', 'y' ot 'yn') | D | - |
| r0 | Synchronous seq 0 resistance | 0 | pu(Ohm) |
| r0s | Subtransient seq 0 resistance | 0 | pu(Ohm) |
| r0t | Transient seq 0 resistance | 0 | pu(Ohm) |
| r1 | Synchronous seq + resistance | 0 | pu(Ohm) |
| r1s | Subtransient seq + resistance | 0 | pu(Ohm) |
| r1t | Transient seq + resistance | 0 | pu(Ohm) |
| r2 | Synchronous seq - resistance | 0 | pu(Ohm) |
| r2s | Subtransient seq - resistance | 0 | pu(Ohm) |
| r2t | Transient seq - resistance | 0 | pu(Ohm) |
| rg | Neutral-to-ground resistance (only for yn connection) | 0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |

| | | | |
|---|---|---|---|
| x0 | Synchronous seq 0 reactance | 0 | pu(Ohm) |
| x0s | Subtransient seq 0 reactance | 0 | pu(Ohm) |
| x0t | Transient seq 0 reactance | 0 | pu(Ohm) |
| x1 | Synchronous seq + reactance | 0 | pu(Ohm) |
| x1s | Subtransient seq + reactance | 0 | pu(Ohm) |
| x1t | Transient seq + reactance | 0 | pu(Ohm) |
| x2 | Synchronous seq - reactance | 0 | pu(Ohm) |
| x2s | Subtransient seq - reactance | 0 | pu(Ohm) |
| x2t | Transient seq - reactance | 0 | pu(Ohm) |
| xg | Neutral-to-ground impedance (only for yn connection) | 0 | pu(Ohm) |

91. Device <Genbid>

Supply bids. P and Q limits are inherited from a static generator

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| * bus | Bus id | - | - |
| cp0 | Active power c0 bid | 0.0 | $/h |
| cp1 | Active power c1 bid | 0.0 | $/MWh |
| cp2 | Active power c2 bid | 0.0 | $/MW^2h |
| cq0 | Reactive power c0 bid | 0.0 | $/h |
| cq1 | Reactive power c1 bid | 0.0 | $/MVArh |
| cq2 | Reactive power c2 bid | 0.0 | $/MVAr^2h |
| * gen | Static generator id | - | - |
| tie | Tie-break cost | 0.0 | $/MWh |
| u | Connection status | 1.0 | bool |

92. Device <Ground>

Ground node for dc circuits

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Idcn | Dc current rate | 10.0 | kA |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| * node | Dc node id | - | - |
| u | Connection status | 1.0 | bool |
| v0 | Ground voltage value | 0.0 | pu(kV) |

93. Device <Gupfc>

Static Generalized UPFC

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus1 | Bus i id | - | - |
| * bus2 | Bus j id | - | - |
| * bus3 | Bus k id | - | - |
| imax | Maximum current | 999.9 | pu(kA) |
| iqimax | Maximum shunt current | 0.2 | pu(kA) |
| iqimin | Minimum shunt current | -0.2 | pu(kA) |
| pmax | Maximum active power | 999.9 | pu(MW) |
| * prefj | Reference active power injected at bus j | 0.0 | pu(MW) |
| * prefk | Reference active power injected at bus k | 0.0 | pu(MW) |
| * qrefj | Reference reactive power injected at bus j | 0.0 | pu(MVAr) |
| * qrefk | Reference reactive power injected at bus k | 0.0 | pu(MVAr) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| vpjmax | Maximum quadrature voltage for the series compensation of branch i-j | 0.1 | pu(kV) |
| vpjmin | Minimum quadrature voltage for the series compensation of branch i-j | -0.1 | pu(kV) |
| vpkmax | Maximum quadrature voltage for the series compensation of branch i-k | 0.1 | pu(kV) |
| vpkmin | Minimum quadrature voltage for the series compensation of branch i-k | -0.1 | pu(kV) |
| vqjmax | Maximum direct voltage for the series compensation of branch i-j | 0.1 | pu(kV) |
| vqjmin | Minimum direct voltage for the series compensation of branch i-j | -0.1 | pu(kV) |
| vqkmax | Maximum direct voltage for the series compensation of branch i-k | 0.1 | pu(kV) |
| vqkmin | Minimum direct voltage for the series compensation of branch i-k | -0.1 | pu(kV) |
| vrefi | Reference voltage of the shunt control | 1.0 | pu(kV) |
| # xij | Series reactance of the branch | 0.01 | pu(Ohm) |

| | | | |
|---|---|---|---|
| | i-j | | |
| # xik | Series reactance of the branch i-k | 0.01 | pu(Ohm) |

94. Device <HIDlamp>

High-intensity discharge (HID) lamp (Philips TL40W)

| Parameter | Description | Default | Units |
|---|---|---|---|
| L | Ballast inductance | 1.04 | H |
| # Sn | Power rate | 0.0001 | MVA |
| Theta0 | Arc tube wall temperature | 350.0 | K |
| # Vn | Voltage rate | 0.23 | kV |
| * bus | Bus id | - | - |
| c1 | Coefficient of the lamp model | 10587.0 | K/J |
| c2 | Coefficient of the lamp model | 525.9 | W |
| c3 | Coefficient of the lamp model | 0.11 | J/C |
| c4 | Coefficient of the lamp model | 0.011 | W/K |
| c5 | Coefficient of the lamp model | 825.6 | Ohm*K^0.75 |
| c6 | Coefficient of the lamp model | 0.3 | J/C |
| c7 | Factor of the lamp model | 1.0 | - |
| r | Ballast resistance | 0.0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| ve | Electrode voltage drop | 11.0 | V |

95. Device <HLMotor>

Half-load induction motor

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power at nominal voltage | 5.0 | kW |
| # Vn | Voltage rate | 0.4 | kV |
| * bus | Bus id | - | - |
| pf | Nominal power factor (negative for capacitive loads) | 0.9 | - |
| plevel | Priority level (for the acs routine) | 3 | int |
| u | Connection status | 1.0 | bool |

96. Device <HVDC_control>

HVDC controllers

| Parameter | Description | Default | Units |
|---|---|---|---|
| Idcn | Dc current rate | 10.0 | kA |
| Ki | Integral gain | 10.0 | - |
| Kp | Proportional gain | 50.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| # Ti | Inverter time constant | 5.0 | s |
| # Tr | Rectifier time constant | 5.0 | s |
| Vdcn | Dc voltage rate | 350.0 | kV |
| # Vn | Voltage rate | 220.0 | kV |
| aref | Reference firing angle | 15.0 | deg |
| gref | Reference extinction angle | 15.0 | deg |
| idcmin | Minimum dc current | 0.1 | pu(kA) |
| im | Current margin | 0.125 | pu(kA) |
| * inverter | Inverter index | - | - |
| * node | Id of the dc node used for power control | - | - |
| pref | Reference active power | 15.0 | pu(MW) |
| * rectifier | Rectifier index | - | - |
| u | Connection status | 1.0 | bool |
| vacref | Reference ac voltage | 1.0 | pu(kV) |
| vdcmax | Maximum dc voltage | 0.7 | pu(kV) |
| vdcmin | Minimum dc voltage | 0.3 | pu(kV) |
| # vdcref | Reference dc voltage | 1.0 | pu(kV) |

97. Device <HVDC_static>

Static model of HVDC devices

| Parameter | Description | Default | Units |
|---|---|---|---|
| Idcn | Dc current rate | 10.0 | kA |
| # Sn | Power rate | 100.0 | MVA |
| Vdcn | Dc voltage rate | 350.0 | kV |
| # Vn | Voltage rate | 220.0 | kV |
| gref | Reference extinction angle | 15.0 | deg |
| * inverter | Inverter index | - | - |
| * node | Id of the dc node used for power control | - | - |
| pref | Reference active power | 15.0 | pu(MW) |
| * rectifier | Rectifier index | - | - |
| u | Connection status | 1.0 | bool |
| vacref | Reference ac voltage | 1.0 | pu(kV) |
| vdcref | Reference dc voltage | 1.0 | pu(kV) |

98. Device <Heater>

Heater

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power at nominal voltage | 10.0 | kW |
| # Vn | Voltage rate | 0.4 | kV |
| * bus | Bus id | - | - |
| plevel | Priority level (for the acs routine) | 2 | int |
| u | Connection status | 1.0 | bool |

99. Device <Hglamp>

Mercury (Hg) lamp

| Parameter | Description | Default | Units |
|---|---|---|---|
| L | Ballast inductance | 1.04 | H |
| # Sn | Power rate | 5e-05 | MVA |
| Theta0 | Arc tube wall temperature | 1000.0 | K |
| # Vn | Voltage rate | 0.23 | kV |
| * bus | Bus id | - | - |
| c1 | Coefficient of the lamp model | 19948.62 | K/J |
| c2 | Coefficient of the lamp model | 8490.1979 | W |
| c3 | Coefficient of the lamp model | 1.9104 | J/C |
| c4 | Coefficient of the lamp model | 0.00133 | W/K |
| c5 | Coefficient of the lamp model | 739.9454 | Ohm*K^0.75 |
| c6 | Coefficient of the lamp model | 3.34337 | J/C |
| c7 | Factor of the lamp model | 1.0 | - |
| r | Ballast resistance | 0.0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| ve | Electrode voltage drop | 11.0 | V |

100. Device <Htg1>

Hydro turbine and governor (HTG) type 1

| Parameter | Description | Default | Units |
|---|---|---|---|
| # R | Pilot valve droop | 0.2 | pu(MW) |
| # Tp | Pilot valve time constant | 0.04 | s |
| # Tr | Dashpot time constant | 5.0 | s |

| | | | |
|---|---|---|---|
| # Tw | Water starting time | 1.0 | s |
| # a11 | Derivative of turbine flow | 0.5 | - |
| | rate with respect to turbine | | |
| | head | | |
| a13 | Derivative of turbine flow | 1.0 | - |
| | rate with respect to gate | | |
| | position | | |
| a21 | Derivative of turbine torque | 1.5 | - |
| | with respect to turbine head | | |
| # a23 | Derivative of turbine torque | 1.0 | - |
| | with respect to gate position | | |
| agc | Automatic generator control id | - | - |
| delta | Transient speed droop | 0.3 | - |
| pmax | Maximum gate opening | 1.0 | pu(MW) |
| pmin | Minimum gate opening | 0.0 | pu(MW) |
| sigma | Permanent speed droop | 0.04 | - |
| * syn | Synchronous machine id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum gate opening rate | 0.1 | pu(MW)/s |
| vmin | Minimum gate opening rate | -0.1 | pu(MW)/s |
| wref0 | Refrence rotor speed | 1.0 | pu(Hz) |

101. Device <Htg2>

Hydro turbine and governor (HTG) type 2

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ki | Integral droop | 0.105 | - |
| Kp | Proportional droop | 1.163 | - |
| # R | Pilot valve droop | 0.2 | pu(MW) |
| # Tp | Pilot valve time constant | 0.04 | s |
| # Tr | Dashpot time constant | 5.0 | s |
| # Tw | Water starting time | 1.0 | s |
| # a11 | Derivative of turbine flow | 0.5 | - |
| | rate with respect to turbine | | |
| | head | | |
| a13 | Derivative of turbine flow | 1.0 | - |
| | rate with respect to gate | | |
| | position | | |
| a21 | Derivative of turbine torque | 1.5 | - |
| | with respect to turbine head | | |
| # a23 | Derivative of turbine torque | 1.0 | - |
| | with respect to gate position | | |
| agc | Automatic generator control id | - | - |
| delta | Transient speed droop | 0.3 | - |
| pmax | Maximum gate opening | 1.0 | pu(MW) |
| pmin | Minimum gate opening | 0.0 | pu(MW) |

| | | | |
|---|---|---|---|
| sigma | Permanent speed droop | 0.04 | - |
| * syn | Synchronous machine id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum gate opening rate | 0.1 | pu(MW)/s |
| vmin | Minimum gate opening rate | -0.1 | pu(MW)/s |
| wref0 | Refrence rotor speed | 1.0 | pu(Hz) |

102. Device <Htg3>

Hydro turbine and governor (HTG) type 3

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ki | Integral droop | 0.5 | - |
| Kp | Proportional droop | 3.0 | - |
| # R | Pilot valve droop | 0.2 | pu(MW) |
| # Tp | Pilot valve time constant | 0.05 | s |
| # Tw | Water starting time | 1.0 | s |
| agc | Automatic generator control id | - | - |
| pmax | Maximum gate opening | 1.0 | pu(MW) |
| pmin | Minimum gate opening | 0.0 | pu(MW) |
| sigma | Permanent speed droop | 0.04 | - |
| * syn | Synchronous machine id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum gate opening rate | 0.1 | pu(MW)/s |
| vmin | Minimum gate opening rate | -0.1 | pu(MW)/s |
| wref0 | Refrence rotor speed | 1.0 | pu(Hz) |

103. Device <Htg4>

Hydro turbine and governor (HTG) type 4

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ka | Servomotor gain | 3.33333 | - |
| Kd | Derivative droop | 0.0 | - |
| Ki | Integral droop | 0.105 | - |
| Kp | Proportional droop | 1.163 | - |
| # R | Rotor speed permanent droop | 1.0 | pu(MW) |
| Rp | Power permanent droop | 25.0 | - |
| # Ta | Pilot valve time constant | 0.07 | s |
| # Td | Derivative droop time constant | 0.01 | s |
| # Tw | Water starting time | 2.67 | s |
| agc | Automatic generator control id | - | - |
| beta | Transient speed droop | 0.0 | - |
| pmax | Maximum gate opening | 0.97518 | pu(MW) |

| | | | |
|---|---|---|---|
| pmin | Minimum gate opening | 0.01 | pu(MW) |
| * syn | Synchronous machine id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum gate opening rate | 0.1 | pu(MW)/s |
| vmin | Minimum gate opening rate | -0.1 | pu(MW)/s |
| wref0 | Refrence rotor speed | 1.0 | pu(Hz) |

104. Device <ICG>

Independent current generator for dc circuits

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Idcn | Dc current rate | 10.0 | kA |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| f | Frequency of ac voltage | 50.0 | Hz |
| iac | Rms of ac current | 0.0 | pu(kA) |
| idc | Constant dc current | 0.0 | pu(kA) |
| * node1 | 1st node id | - | - |
| * node2 | 2nd node id | - | - |
| phi | Ac voltage phase angle | 0.0 | deg |
| tof | Switch off time | - | s |
| ton | Switch on time | - | s |
| u | Connection status | 1.0 | bool |

105. Device <IPFC1_control>

Dynamic IPFC controller with controls over pj, qj and pk

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kp1 | Proportional gain of the pi controller of vpj | 10.0 | - |
| Kp2 | Proportional gain of the pi controller of vqj | 10.0 | - |
| Kp3 | Proportional gain of the pi controller of vpk | 10.0 | - |
| # Ti1 | Time constant of the pi controller of vpj | 0.01 | s |
| # Ti2 | Time constant of the pi controller of vqj | 0.01 | s |
| # Ti3 | Time constant of the pi controller of vpk | 0.01 | s |
| # Tm1 | Lag time constant of the vpj controller | 0.01 | s |
| # Tm2 | Lag time constant of the vqj | 0.01 | s |

| Parameter | Description | Default | Units |
|---|---|---|---|
| | controller | | |
| # Tm3 | Lag time constant of the vpk controller | 0.01 | s |
| * ipfc | Ipfc id | - | - |
| u | Connection status | 1.0 | bool |

106. Device <IPFC2_control>

Dynamic IPFC controller with controls over pj, qj and qk

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kp3 | Proportional gain of the pi controller of vqk | 10.0 | - |
| # Ti3 | Time constant of the pi controller of vqk | 0.01 | s |
| # Tm3 | Lag time constant of the vqk controller | 0.01 | s |
| * ipfc | Ipfc id | - | - |
| u | Connection status | 1.0 | bool |

107. Device <ISwitch>

Switch for dc circuits

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Idcn | Dc current rate | 10.0 | kA |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| * node1 | 1st node id | - | - |
| * node2 | 2nd node id | - | - |
| tof | Switch off time | - | s |
| ton | Switch on time | - | s |
| u | Connection status | 1.0 | bool |

108. Device <IVG>

Independent voltage generator for dc circuits

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Idcn | Dc current rate | 10.0 | kA |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| f | Frequency of ac voltage | 50.0 | Hz |

| | | | |
|---|---|---|---|
| * node1 | 1st node id | - | - |
| * node2 | 2nd node id | - | - |
| phi | Ac voltage phase angle | 0.0 | deg |
| tof | Switch off time | - | s |
| ton | Switch on time | - | s |
| u | Connection status | 1.0 | bool |
| vac | Rms of ac voltage | 0.0 | pu(kV) |
| vdc | Constant dc voltage | 0.0 | pu(kV) |

109. Device <Incandescent>

Incandescent lamp

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power at nominal voltage | 0.21 | kW |
| # Vn | Voltage rate | 0.4 | kV |
| * bus | Bus id | - | - |
| plevel | Priority level (for the acs routine) | 3 | int |
| u | Connection status | 1.0 | bool |

110. Device <Ind1>

First order induction machine class

| Parameter | Description | Default | Units |
|---|---|---|---|
| H | Inertia | 3.0 | kWs/kVA |
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| alpha | Constant mechanical torque | 0.0 | pu(kNm) |
| beta | Linear mechanical torque | 0.0 | pu(kNm/Hz) |
| brake | Allow working as brake | False | bool |
| * bus | Bus id | - | - |
| gamma | Quadratic mechanical torque | 0.0 | pu(kNm/Hz^2) |
| rr | Rotor resistance | 0.01 | pu(Ohm) |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| startup | Force start up | False | bool |
| tup | Start up time | 0.0 | s |
| u | Connection status | 1.0 | bool |
| # xm | Magnetization reactance | 5.0 | pu(Ohm) |
| xr | Rotor reactance | 0.1 | pu(Ohm) |
| xs | Stator reactance | 0.1 | pu(Ohm) |

111. Device <Ind3>

Third order induction machine class

| Parameter | Description | Default | Units |
|---|---|---|---|
| H | Inertia | 3.0 | kWs/kVA |
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| alpha | Constant mechanical torque | 0.0 | pu(kNm) |
| beta | Linear mechanical torque | 0.0 | pu(kNm/Hz) |
| brake | Allow working as brake | False | bool |
| * bus | Bus id | - | - |
| gamma | Quadratic mechanical torque | 0.0 | pu(kNm/Hz^2) |
| rr | Rotor resistance | 0.01 | pu(Ohm) |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| startup | Force start up | False | bool |
| tup | Start up time | 0.0 | s |
| u | Connection status | 1.0 | bool |
| # xm | Magnetization reactance | 5.0 | pu(Ohm) |
| xr | Rotor reactance | 0.1 | pu(Ohm) |
| xs | Stator reactance | 0.1 | pu(Ohm) |

112. Device <Ind5>

Fifth order induction machine class

| Parameter | Description | Default | Units |
|---|---|---|---|
| H | Inertia | 3.0 | kWs/kVA |
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| alpha | Constant mechanical torque | 0.0 | pu(kNm) |
| beta | Linear mechanical torque | 0.0 | pu(kNm/Hz) |
| brake | Allow working as brake | False | bool |
| * bus | Bus id | - | - |
| gamma | Quadratic mechanical torque | 0.0 | pu(kNm/Hz^2) |
| rr | Rotor resistance | 0.01 | pu(Ohm) |
| rr2 | Second cage reactance | 0.01 | pu(Ohm) |
| rs | Stator resistance | 0.01 | pu(Ohm) |
| startup | Force start up | False | bool |
| tup | Start up time | 0.0 | s |
| u | Connection status | 1.0 | bool |
| # xm | Magnetization reactance | 5.0 | pu(Ohm) |
| xr | Rotor reactance | 0.1 | pu(Ohm) |
| xr2 | Second cage resistance | 0.1 | pu(Ohm) |

| Parameter | Description | Default | Units |
|---|---|---|---|
| xs | Stator reactance | 0.1 | pu(Ohm) |

113. Device <Indcooker>

Induction cooker model

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power at nominal voltage | 1.677 | kW |
| # Vn | Voltage rate | 0.4 | kV |
| * bus | Bus id | - | - |
| pf | Nominal power factor (negative for capacitive loads) | -0.079 | - |
| plevel | Priority level (for the acs routine) | 1 | int |
| u | Connection status | 1.0 | bool |

114. Device <Inverter>

12-pulse thyristor controlled inverter

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Idcn | Dc current rate | 20 | kA |
| # Sn | Power rate | 100.0 | MVA |
| # Vdcn | Dc voltage rate | 750 | kV |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Ac bus id | - | - |
| gmax | Maximum extinction angle | 90.0 | deg |
| gmin | Minimum extinction angle | 10.0 | deg |
| mmax | Maximum tap ratio | 1.2 | - |
| mmin | Minimum tap ratio | 0.7 | - |
| * node1 | 1st dc node | - | - |
| * node2 | 2nd dc node | - | - |
| u | Connection status | 1.0 | bool |
| xt | Transformer reactance | 0.1 | pu(Ohm) |

115. Device <Ipfc1>

Static Interline Power Flow Controller (IPFC) with controls over pj, qj and pk

| Parameter | Description | Default | Units |
|---|---|---|---|

```
 # Sn          | Power rate                       | 100.0      | MVA
 # Vn          | Voltage rate                     | 220.0      | kV
 * bus1        | Bus i id                         | -          | -
 * bus2        | Bus j id                         | -          | -
 * bus3        | Bus k id                         | -          | -
   imax        | Maximum current                  | 999.9      | pu(kA)
   pmax        | Maximum active power             | 999.9      | pu(MW)
 * prefj       | Reference active power           | 0.0        | pu(MW)
               | injected at bus j                |            |
 * prefk       | Reference active power           | 0.0        | pu(MW)
               | injected at bus k                |            |
 * qrefj       | Reference reactive power         | 0.0        | pu(MVAr)
               | injected at bus j                |            |
   smax        | Maximum apparent power           | 999.9      | pu(MVA)
   u           | Connection status                | 1.0        | bool
   vpjmax      | Maximum quadrature voltage for   | 0.1        | pu(kV)
               | the series compensation of       |            |
               | branch i-j                       |            |
   vpjmin      | Minimum quadrature voltage for   | -0.1       | pu(kV)
               | the series compensation of       |            |
               | branch i-j                       |            |
   vpkmax      | Maximum quadrature voltage for   | 0.1        | pu(kV)
               | the series compensation of       |            |
               | branch i-k                       |            |
   vpkmin      | Minimum quadrature voltage for   | -0.1       | pu(kV)
               | the series compensation of       |            |
               | branch i-k                       |            |
   vqjmax      | Maximum direct voltage for the   | 0.1        | pu(kV)
               | series compensation of branch    |            |
               | i-j                              |            |
   vqjmin      | Minimum direct voltage for the   | -0.1       | pu(kV)
               | series compensation of branch    |            |
               | i-j                              |            |
   vqkmax      | Maximum direct voltage for the   | 0.1        | pu(kV)
               | series compensation of branch    |            |
               | i-k                              |            |
   vqkmin      | Minimum direct voltage for the   | -0.1       | pu(kV)
               | series compensation of branch    |            |
               | i-k                              |            |
 # xij         | Series reactance of the branch   | 0.01       | pu(Ohm)
               | i-j                              |            |
 # xik         | Series reactance of the branch   | 0.01       | pu(Ohm)
               | i-k                              |            |
------------------------------------------------------------------------

116. Device <Ipfc2>

Static Interline Power Flow Controller (IPFC) with controls over pj, qj and qk

------------------------------------------------------------------------
```

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus1 | Bus i id | - | - |
| * bus2 | Bus j id | - | - |
| * bus3 | Bus k id | - | - |
| imax | Maximum current | 999.9 | pu(kA) |
| pmax | Maximum active power | 999.9 | pu(MW) |
| * prefj | Reference active power injected at bus j | 0.0 | pu(MW) |
| * qrefj | Reference reactive power injected at bus j | 0.0 | pu(MVAr) |
| * qrefk | Reference reactive power injected at bus k | 0.0 | pu(MVAr) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| vpjmax | Maximum quadrature voltage for the series compensation of branch i-j | 0.1 | pu(kV) |
| vpjmin | Minimum quadrature voltage for the series compensation of branch i-j | -0.1 | pu(kV) |
| vpkmax | Maximum quadrature voltage for the series compensation of branch i-k | 0.1 | pu(kV) |
| vpkmin | Minimum quadrature voltage for the series compensation of branch i-k | -0.1 | pu(kV) |
| vqjmax | Maximum direct voltage for the series compensation of branch i-j | 0.1 | pu(kV) |
| vqjmin | Minimum direct voltage for the series compensation of branch i-j | -0.1 | pu(kV) |
| vqkmax | Maximum direct voltage for the series compensation of branch i-k | 0.1 | pu(kV) |
| vqkmin | Minimum direct voltage for the series compensation of branch i-k | -0.1 | pu(kV) |
| # xij | Series reactance of the branch i-j | 0.01 | pu(Ohm) |
| # xik | Series reactance of the branch i-k | 0.01 | pu(Ohm) |

117. Device <Jimma>

Jimma load - Voltage dependent (polynomial) load class

This component is initialized after power flow analysis

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kv | Voltage derivative coeficient | 0.01 | 1/s |
| # Sn | Power rate | 100.0 | MVA |
| # Tf | High-pass time constant | 0.1 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| kb | Susceptance rate | 0.0 | %(1/Ohm) |
| kg | Conductance rate | 0.0 | %(1/Ohm) |
| kip | Active current rate | 0.0 | %(kA) |
| kiq | Reactive current rate | 0.0 | %(kA) |
| kp | Active power rate | 0.0 | %(MW) |
| kq | Reactive power rate | 0.0 | %(MVAr) |
| * pqid | Pq load id | - | - |
| u | Connection status | 1.0 | bool |

118. Device <LCDTV>

LCD TV display

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power at nominal voltage | 0.14 | kW |
| # Vn | Voltage rate | 0.4 | kV |
| * bus | Bus id | - | - |
| pf | Nominal power factor (negative for capacitive loads) | -0.024 | - |
| plevel | Priority level (for the acs routine) | 1 | int |
| u | Connection status | 1.0 | bool |

119. Device <Line>

Transmission line and static transformer

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| b | Shunt susceptance | 0.0 | pu(Ohm) or uS/km |
| b1 | From bus shunt susceptance | 0.0 | pu(1/Ohm) or uS/km |

| | | | |
|---|---|---|---|
| b2 | To bus shunt susceptance | 0.0 | pu(1/Ohm) or uS/km |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| g | Shunt conductance | 0.0 | pu(1/Ohm) or uS/km |
| g1 | From bus shunt conductance | 0.0 | pu(1/Ohm) or uS/km |
| g2 | To bus shunt conductance | 0.0 | pu(1/Ohm) or uS/km |
| imax | Maximum current | 999.9 | pu(kA) |
| length | Line length | 0.0 | km |
| phases | Number of phases (1 or 3) | 3 | int |
| phi | Phase shift | 0.0 | deg |
| pmax | Maximum active power | 999.9 | pu(MW) |
| r | Series resistance | 0.0 | pu(Ohm) or Ohm/km |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| tap | Tap ratio | 1.0 | - |
| trasf | True if transformer | False | bool |
| u | Connection status | 1.0 | bool |
| x | Series reactance | 1e-05 | pu(Ohm) or Ohm/km |

120. Device <LineD>

Distribution line

| Parameter | Description | Default | Units |
|---|---|---|---|
| Imax | Maximum current limit (=in, if it is not defined) | - | A |
| * In | Current rate | 10.0 | A |
| # Vn | Voltage rate | 20.0 | kV |
| XR | X/r ratio | 0.0 | - |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number | 1 | int |
| dU | Nominal voltage drop | 2.5 | % |
| length | Line length (not used) | 0.0 | m |
| pf | Nominal power factor [0, 1] | 0.9 | - |
| phases | Number of phases (1 or 3) | 3 | int |
| u | Connection status | 1.0 | bool |

121. Device <LineDisp>

This device defines some line and transformer quantities useful
to evaluate the 'quality' of the admission control strategy

| Parameter | Description | Default | Units |
|---|---|---|---|

| | | | |
|---|---|---|---|
| * line | Line or transformer id | - | - |
| u | Connection status | 1.0 | bool |

122. Device <LineSeq>

Auxiliary device that allows defining negative and zero sequence parameters for transmission lines and transformers. The parameters of the original line or transformer are assumed to define the positive sequence. If negative sequence values are not provided, positive sequence values are used.

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| b0 | Seq 0 shunt susceptance | 0 | pu(1/Ohm) |
| b10 | Sending-end seq 0 shunt susceptance | 0 | pu(1/Ohm) |
| b12 | Sending-end seq - shunt susceptance | 0 | pu(1/Ohm) |
| b2 | Seq - shunt susceptance | 0 | pu(1/Ohm) |
| b20 | Receiving-end seq 0 shunt susceptance | 0 | pu(1/Ohm) |
| b22 | Receiving-end seq - shunt susceptance | 0 | pu(1/Ohm) |
| * dev | Static line or transformer id | - | - |
| g0 | Seq 0 shunt conductance | 0 | pu(1/Ohm) |
| g10 | Sending-end seq 0 shunt conductance | 0 | pu(1/Ohm) |
| g12 | Sending-end seq - shunt conductance | 0 | pu(1/Ohm) |
| g2 | Seq - shunt conductance | 0 | pu(1/Ohm) |
| g20 | Receiving-end seq 0 shunt conductance | 0 | pu(1/Ohm) |
| g22 | Receiving-end seq - shunt conductance | 0 | pu(1/Ohm) |
| group | Transformer group and hour indicator | Yy0 | - |
| r0 | Seq 0 series resistance | 0 | pu(Ohm) |
| r1d | Sending-end triangle resistance | 0 | pu(Ohm) |
| r1g | Sending-end neutral-to-ground resistance | 0 | pu(Ohm) |
| r2 | Seq - series resistance | 0 | pu(Ohm) |
| r2d | Receiving-end triangle resistance | 0 | pu(Ohm) |
| r2g | Receiving-end neutral-to-ground resistance | 0 | pu(Ohm) |

| | | | |
|---|---|---|---|
| u | Connection status | 1.0 | bool |
| x0 | Seq 0 series impedance | 0 | pu(Ohm) |
| x1d | Sending-end triangle impedance | 0 | pu(Ohm) |
| x1g | Sending-end neutral-to-ground impedance | 0 | pu(Ohm) |
| x2 | Seq - series impedance | 0 | pu(Ohm) |
| x2d | Receiving-end triangle impedance | 0 | pu(Ohm) |
| x2g | Receiving-end neutral-to-ground impedance | 0 | pu(Ohm) |

123. Device <LoadDisp>

This device defines some indicators of load devices and can be useful to evaluate the 'quality' of the admission control strategy

| Parameter | Description | Default | Units |
|---|---|---|---|
| * load | Load device id | - | - |
| u | Connection status | 1.0 | bool |

124. Device <LoadSeq>

Auxiliary device that allows defining the negative- and zero-sequence impedances of loads. If the negative- or zero-sequence are not defined, the positive-sequence load impedance is used and mltiplied by an adjusting factor.

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| con | Connection type ('d', 'y' ot 'yn') | D | - |
| k0 | Zero-sequence factor | 3.0 | - |
| k2 | Negative-sequence factor | 1.0 | - |
| * load | Load id | - | - |
| r0 | Zero-sequence resistance | 0 | pu(Ohm) |
| r2 | Negative-sequence resistance | 0 | pu(Ohm) |
| rg | Neutral-to-ground resistance (only for yn connection) | 0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| x0 | Zero-sequence impedance | 0 | pu(Ohm) |
| x2 | Negative-sequence impedance | 0 | pu(Ohm) |
| xg | Neutral-to-ground impedance (only for yn connection) | 0 | pu(Ohm) |

125. Device <MHlamp>

Metal-halide (MH) lamp

| Parameter | Description | Default | Units |
|---|---|---|---|
| L | Ballast inductance | 1.199 | H |
| # Sn | Power rate | 3.5e-05 | MVA |
| Theta0 | Arc tube wall temperature | 1000.0 | K |
| # Vn | Voltage rate | 0.23 | kV |
| * bus | Bus id | - | - |
| c1 | Coefficient of the lamp model | 34827.66 | K/J |
| c2 | Coefficient of the lamp model | 12804.93 | W |
| c3 | Coefficient of the lamp model | 1.6148 | J/C |
| c4 | Coefficient of the lamp model | 0.001 | W/K |
| c5 | Coefficient of the lamp model | 33.34 | Ohm*K^0.75 |
| c6 | Coefficient of the lamp model | 4.099 | J/C |
| c7 | Factor of the lamp model | 1.0 | - |
| r | Ballast resistance | 0.0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| ve | Electrode voltage drop | 11.0 | V |

126. Device <MSV>

Minimum Singular Value class

| Parameter | Description | Default | Units |
|---|---|---|---|
| u | Connection status | 1.0 | bool |

127. Device <Microwave>

Microwave oven model

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power at nominal voltage | 1.337 | kW |
| # Vn | Voltage rate | 0.4 | kV |
| * bus | Bus id | - | - |
| pf | Nominal power factor (negative for capacitive loads) | 0.338 | - |
| plevel | Priority level (for the acs | 2 | int |

| Parameter | Description | Default | Units |
|---|---|---|---|
| | routine) | | |
| u | Connection status | 1.0 | bool |

128. Device <Mixed>

Mixed load class

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kpf | P frequency rate | 0.1 | pu(MW/Hz) |
| Kqf | Q frequency rate | 0.1 | pu(MW/Hz) |
| # Sn | Power rate | 100.0 | MVA |
| # Tfa | V angle filter time constant | 0.1 | s |
| # Tfv | V module filter time constant | 0.1 | s |
| Tpv | P time constant | 0.01 | s |
| Tqv | Q time constant | 0.01 | s |
| # Vn | Voltage rate | 220.0 | kV |
| ap | Active power exponent | 2.0 | - |
| aq | Reactive power exponent | 2.0 | - |
| * bus | Bus id | - | - |
| kp | Active power rate | 0.0 | %(MW) |
| kq | Reactive power rate | 0.0 | %(MVAr) |
| * pqid | Pq load id | - | - |
| u | Connection status | 1.0 | bool |

129. Device <MotSeq>

Auxiliary device that allows defining positive, negative and zero sequence parameters for asynchronous motors. If negative sequence values are not provided, positive sequence values are used. Asynchronous motors only modify sequence admittance matrices for subtransient time frames.

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| con | Connection type ('d', 'y' ot 'yn') | D | - |
| r0s | Subtransient seq 0 resistance | 0 | pu(Ohm) |
| r1s | Subtransient seq + resistance | 0 | pu(Ohm) |
| r2s | Subtransient seq - resistance | 0 | pu(Ohm) |
| rg | Neutral-to-ground resistance (only for yn connection) | 0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |

| | | | |
|---|---|---|---|
| x0s | Subtransient seq 0 reactance | 0 | pu(Ohm) |
| x1s | Subtransient seq + reactance | 0 | pu(Ohm) |
| x2s | Subtransient seq - reactance | 0 | pu(Ohm) |
| xg | Neutral-to-ground impedance (only for yn connection) | 0 | pu(Ohm) |

130. Device <Mppt1>

Simple MPPT model Voc Control

| Parameter | Description | Default | Units |
|---|---|---|---|
| NOCT | Nominal operation condition temperature | 318.15 | K |
| Voc0 | Standard condition open-circuit voltage | 0.57 | V |
| beta | Voltage variation over temperature | 0.2 | V/K |
| * dcdc | Dc/dc converter id | - | - |
| k1 | Voc proportionality factor | 0.8 | [0.71, 0.78] |
| * pvcell | Pv cell id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum voltage reference | 1.2 | V |
| vmin | Minimum voltage reference | 0.8 | V |

131. Device <Mppt2>

Simple MPPT model Isc Control

| Parameter | Description | Default | Units |
|---|---|---|---|
| ALPHAjsc | Short circuit current density variation over temperature factor | 3e-05 | A/(K*cm^2) |
| Area | Solar cell area | 0.01563 | cm^2 |
| Jsc | Short circuit current density | 0.02816 | A/cm^2 |
| NOCT | Nominal operation condition temperature | 318.15 | K |
| * dcdc | Dc/dc converter id | - | - |
| k2 | Short circuit current proportionality factor | 0.85 | [0.78, 0.92] |
| * pvcell | Pv cell id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum voltage reference | 1.2 | V |
| vmin | Minimum voltage reference | 0.8 | V |

132. Device <Mppt3>

Analytic MPPT model (fill factor)

| Parameter | Description | Default | Units |
|---|---|---|---|
| NOCT | Nominal operation condition temperature | 318.15 | K |
| * dcdc | Dc/dc converter id | - | - |
| * pvcell | Pv cell id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum voltage reference | 1.2 | V |
| vmin | Minimum voltage reference | 0.8 | V |

133. Device <Mutual>

Auxiliary device that allows defining the zero-sequence between two mutually coupled transmission line elements. The coupling only applies to transmission lines or to transformers with nominal tap ratio and zero phase shift. If the mutual coupling impedance is zero, the device has no effect on the resulting zero-sequence admittance matrix.

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| rm | Mutual coupling zero-sequence resistance | 0 | pu(Ohm) |
| * seq1 | 1st mutually coupled line sequence id | - | - |
| * seq2 | 2nd mutually coupled line sequence id | - | - |
| u | Connection status | 1.0 | bool |
| xm | Mutual coupling zero-sequence reactance | 0 | pu(Ohm) |

134. Device <Network>

Define a void device for graphical output. Only coordinates and graphical attributes are defined. Also used for defining Network elements. Networks should be used for 'closed' borders, but it is not mandatory.

---

| Parameter | Description | Default | Units |
|---|---|---|---|
| u | Connection status | 1.0 | bool |

135. Device <Node>

EMT node

| Parameter | Description | Default | Units |
|---|---|---|---|
| Idcn | Dc current rate | 10.0 | kA |
| * Vdcn | Dc voltage rate | 10.0 | kV |
| area | Area id | 1 | - |
| network | Network id | 1 | - |
| region | Region id | 1 | - |
| u | Connection status | 1.0 | bool |
| voltage | Initial guess voltage | 0.0 | pu(kV) |

136. Device <Notebook>

Notebook computer model

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power at nominal voltage | 0.055 | kW |
| # Vn | Voltage rate | 0.4 | kV |
| * bus | Bus id | - | - |
| pf | Nominal power factor (negative for capacitive loads) | -0.022 | - |
| plevel | Priority level (for the acs routine) | 1 | int |
| u | Connection status | 1.0 | bool |

137. Device <Oel1>

Over-excitation limiter for synchronous machines.
Estimated d- and q-axis reactances are on machine bases.

| Parameter | Description | Default | Units |
|---|---|---|---|
| # T0 | Integrator time constant | 0.05 | s |
| * avr | Avr id | - | - |
| imax | Field current thermal limit | 2.7 | pu(kA) |

| | | | |
|---|---|---|---|
| u | Connection status | 1.0 | bool |
| vmax | Maximum output signal | 0.3 | pu(kV) |
| xd | Estimated d-axis reactance | 2.0 | pu(Ohm) |
| xq | Estimated q-axis reactance | 1.8 | pu(Ohm) |

138. Device <Oel2>

Over-excitation limiter for synchronous machines.
d- and q-axis reactances are grabbed from machine parameters.

| Parameter | Description | Default | Units |
|---|---|---|---|
| # T0 | Integrator time constant | 0.05 | s |
| * avr | Avr id | - | - |
| imax | Field current thermal limit | 2.7 | pu(kA) |
| u | Connection status | 1.0 | bool |
| vmax | Maximum output signal | 0.3 | pu(kV) |

139. Device <Output>

Class for selecting output variables.

To select a device variable, use the name of such variable. The list of device variable names can be obtained using the command:

```
>> dome -C
```

To select ac bus voltages, set <devName = Bus> and for <var> use:

```
"a": voltage phase angle
"v": voltage magnitude
```

To select dc node voltages, set <devName = node> and for <var> use:

```
"v": voltage magnitude
```

To select flows of series devices, reserved words for <var> are:

```
"pij": from-to active power flow
"pji": to-from active power flow
"qij": from-to reactive power flow
"qji": to-from reactive power flow
"iij": from-to current flow
"iji": to-from current flow
"sij": from-to apparent power flow
"sji": to-from apparent power flow
```

Macros:

```
"x":     all state variables
"y":     all algebraic variables
"v":     all ac bus voltage magnitudes
"theta": all ac bus voltage phase angles
"delta": all synchronous machines rotor angles
"omega": all synchronous machines rotor speeds
"p":     all active power injections at buses
"q":     all reactive power injections at buses
"pij":   all from-to active power flows
"pji":   all to-from active power flows
"qij":   all from-to reactive power flows
"qji":   all to-from reactive power flows
"iij":   all from-to current flows
"iji":   all to-from current flows
"sij":   all from-to apparent power flows
"sji":   all to-from apparent power flows
```

If the user defines a macro, <devName> and <devID> are ignored.

Wild cards for <devName>, <devID> and <macro> are accepted. Examples:

```
devName = "*"    matches all devices
devID = "*"      matches all variables of a devices
devName = "S*"   matches all devices beginning with "S"
devName = "S?n"  matches "Syn" and "Sun", but not "Syn4"
macro = "d*"     matches all state or algebriac variables
                 whose name starts with "d"
```

If wild cards are used for <devName>, then <devID> should also contain wild cards in order to lead to some matches. In this case devID = None is considered a synonym of "*".

| Parameter | Description | Default | Units |
|---|---|---|---|
| devID | Index of associated device | - | - |
| devName | Name of associated device | - | - |
| macro | Macro for selecting a set of variables | - | - |
| u | Connection status | 1.0 | bool |
| var | List of variable names | [] | - |

140. Device <POD_p_svc>

POD for SVC device (active power signal)

---

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kw | Regulator gain | 10.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| T1 | 1st zero of pod regulator | 0.01 | s |
| # T2 | 1st pole of pod regulator | 0.1 | s |
| T3 | 2nd zero of pod regulator | 0.05 | s |
| # T4 | 2nd pole of pod regulator | 1.0 | s |
| # Tw | Wash-out time constant | 0.05 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| * line | Line or transformer id | - | - |
| * svc | Parameter | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum output signal | 0.2 | pu(kV) |
| vmin | Minimum output signal | -0.2 | pu(kV) |

141. Device <POD_p_upfc>

POD for several kinds of unified power flow controller devices (active power signal). The input signal is a line active power flow. The POD adds a control signal to a given reference signal of the controller. The devices that can be connected to this POD are: UPFC_control, IPFC1_control, IPFC2_control, and GUPFC_control.

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kw | Regulator gain | 10.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| T1 | 1st zero of pod regulator | 0.01 | s |
| # T2 | 1st pole of pod regulator | 0.1 | s |
| T3 | 2nd zero of pod regulator | 0.05 | s |
| # T4 | 2nd pole of pod regulator | 1.0 | s |
| Ti | Name of the time constant of the facts lag controller | Tm1 | - |
| # Tw | Wash-out time constant | 0.05 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| * dev | Controller type (upfc, ipfc1, ipfc2, or gupfc) | upfc | - |
| * devid | Controller id | - | - |
| * line | Line or transformer id | - | - |
| u | Connection status | 1.0 | bool |
| var | Name of the state variable of the facts lag controller | xpj | - |
| vmax | Maximum output signal | 0.2 | pu(kV) |
| vmin | Minimum output signal | -0.2 | pu(kV) |

142. Device <POD_v_svc>

POD for SVC device (voltage signal)

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kw | Regulator gain | 10.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| T1 | 1st zero of pod regulator | 0.01 | s |
| # T2 | 1st pole of pod regulator | 0.1 | s |
| T3 | 2nd zero of pod regulator | 0.05 | s |
| # T4 | 2nd pole of pod regulator | 1.0 | s |
| # Tw | Wash-out time constant | 0.05 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| * svc | Parameter | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum output signal | 0.2 | pu(kV) |
| vmin | Minimum output signal | -0.2 | pu(kV) |

143. Device <POD_v_upfc>

POD for several kinds of unified power flow controller devices (active power signal). The input signal is a bus voltage magnitude. The POD adds a control signal to a given reference signal of the controller. The devices that can be connected to this POD are: UPFC_control, IPFC1_control, IPFC2_control, and GUPFC_control.

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kw | Regulator gain | 10.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| T1 | 1st zero of pod regulator | 0.01 | s |
| # T2 | 1st pole of pod regulator | 0.1 | s |
| T3 | 2nd zero of pod regulator | 0.05 | s |
| # T4 | 2nd pole of pod regulator | 1.0 | s |
| Ti | Name of the time constant of | Tm1 | - |
| | the facts lag controller | | |
| # Tw | Wash-out time constant | 0.05 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| * dev | Controller type (upfc, ipfc1, | upfc | - |
| | ipfc2, or gupfc) | | |
| * devid | Controller id | - | - |
| u | Connection status | 1.0 | bool |
| var | Name of the state variable of | xpj | - |

| | | | |
|---|---|---|---|
| | the facts lag controller | | |
| vmax | Maximum output signal | 0.2 | pu(kV) |
| vmin | Minimum output signal | -0.2 | pu(kV) |

144. Device <PQ>

Constant PQ load

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| p | Active power | 0.0 | pu(MW) |
| q | Reactive power | 0.0 | pu(MVAr) |
| u | Connection status | 1.0 | bool |
| vmax | Maximum voltage | 1.1 | pu(kV) |
| vmin | Minimum voltage | 0.9 | pu(kV) |
| z | Allow converting to impedance | True | bool |

145. Device <PQD>

Distribution constant PQ load

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power | 0.0 | kW |
| Q0 | Reactive power | 0.0 | kVAr |
| # Vn | Voltage rate | 20.0 | kV |
| bus | Bus id | - | - |
| plevel | Priority level (for the acs routine) | 1 | int |
| u | Connection status | 1.0 | bool |

146. Device <PQdir>

PQ direction class

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| * bus | Bus id | - | - |
| p0 | Active power direction | 0.0 | pu(MW) |
| q0 | Reactive power direction | 0.0 | pu(MVAr) |

| | | | |
|---|---|---|---|
| u | Connection status | 1.0 | bool |

147. Device <PQdyn>

Dynamic PQ load class

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| dt | Discrete time step | 0.0 | s |
| * pqid | Pq load id | - | - |
| ramp | Power ramp per second | 0.0005 | pu/s |
| u | Connection status | 1.0 | bool |

148. Device <PQdynmr>

Stochastic PQ load ramp with mean reversion

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| dt | Time step of the discrete load ramp (0 for continuous ramp) | 0.0 | s |
| h | Time step to generate the normal distribution | 1e-05 | s |
| * pqid | Pq load id | - | - |
| ramp | Power ramp per second | 0.0005 | pu/s |
| spp | Auto-correlation of the active power | 1.0 | % |
| spq | Correlation of active and reactive powers | 0.0 | % |
| sqq | Auto-correlation of the reactive power | 1.0 | % |
| u | Connection status | 1.0 | bool |
| vp | Speed of the active power mean-reversion | 0.1 | pu/s |
| vq | Speed of the reactive power mean-reversion | 0.1 | pu/s |

149. Device <PQgen>

PQ generator class

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| p | Active power | 0.0 | pu(MW) |
| pg | Active power (overwrites <p>) | 0.0 | pu(MW) |
| pmax | Maximum active power | 999.9 | pu(MW) |
| pmin | Minimum active power | -999.9 | pu(MW) |
| q | Reactive power | 0.0 | pu(MVAr) |
| qg | Reactive power (overwrites <q>) | 0.0 | pu(MVAr) |
| qmax | Maximum reactive power | 999.9 | pu(MVAr) |
| qmin | Minimum reactive power | -999.9 | pu(MVAr) |
| tech | Generator technology [h, n, l, c, g, o, w, p, f, oc, cc] | - | - |
| u | Connection status | 1.0 | bool |
| v0 | Desired voltage | 1.0 | pu(kV) |
| vmax | Maximum voltage | 1.1 | pu(kV) |
| vmin | Minimum voltage | 0.9 | pu(kV) |
| z | Allow converting to impedance | True | bool |

150. Device <PQmr>

Stochastic PQ load with mean reversion

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| h | Time step to generate the normal distribution | 1e-05 | s |
| pf | Mean value of the final active power | 0 | pu |
| * pqid | Pq load id | - | - |
| qf | Mean value of the final reactive power | 0 | pu |
| spp | Auto-correlation of the active power | 1.0 | % |
| spq | Correlation of active and reactive powers | 0.0 | % |
| sqq | Auto-correlation of the reactive power | 1.0 | % |
| u | Connection status | 1.0 | bool |

| | | | |
|---|---|---|---|
| vp | Speed of the active power mean-reversion | 0 | pu/s |
| vq | Speed of the reactive power mean-reversion | 0 | pu/s |

151. Device <PQprb>

Probabilistic PQ load class

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| dt | Discrete time step | 0.0 | s |
| h | Time step to generate the normal distribution | 1e-05 | s |
| pn | Standard deviation of the active power white noise | 5.0 | % |
| * pqid | Pq load id | - | - |
| qn | Standard deviation of the reactive power white noise | 5.0 | % |
| u | Connection status | 1.0 | bool |

152. Device <PQstc>

Stochastic PQ load class

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| h | Time step to generate the normal distribution | 1e-05 | s |
| * pqid | Pq load id | - | - |
| spp | Auto-correlation of the active power | 1.0 | % |
| spq | Correlation of active and reactive powers | 0.0 | % |
| sqq | Auto-correlation of the reactive power | 1.0 | % |
| u | Connection status | 1.0 | bool |

153. Device <PQw>

Static PQ load with random noise (for power flow analysis)

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| p | Active power | 0.0 | pu(MW) |
| pw | Standard deviation of the active power white noise | 5.0 | % |
| q | Reactive power | 0.0 | pu(MVAr) |
| qw | Standard deviation of the reactive power white noise | 5.0 | % |
| u | Connection status | 1.0 | bool |
| vmax | Maximum voltage | 1.1 | pu(kV) |
| vmin | Minimum voltage | 0.9 | pu(kV) |
| z | Allow converting to impedance | True | bool |

154. Device <PVCell1>

Basis photovoltaic cell

| Parameter | Description | Default | Units |
|---|---|---|---|
| ALFAgap | Gap function parameter | 0.0 | eV/K |
| ALFAjsc | Temperature conversion rate | 3e-05 | A/Kcm^2 |
| Area | Cell surface area | 0.01563 | cm^2 |
| BETAgap | Temperature coefficient | 1108.0 | K |
| Eg0 | Energy band gap | 1.16 | eV |
| # Idcn | Dc current rate | 10.0 | kA |
| Jsc | Short-circuit current density | 0.02816 | A/cm^2 |
| Rse | Cell body series resistence | 0.0105 | Ohm |
| # Rsh | Cell body shunt resistance | 10000.0 | Ohm |
| # Ta | Ambient temperature | 300.0 | K |
| # Tc | Cell temperature | 323.1 | K |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| Voc | Open circuit voltage (at reference 0 k) | 0.57 | V |
| # m | Diode ideality factor | 1.16 | - |
| * node1 | 1st dc node id | - | - |
| * node2 | 2nd dc node id | - | - |
| # np | Number of pv cells in parallel | 1 | int |
| # ns | Number of pv cells in series | 1 | int |
| * sun | Solar irradiance id | - | - |
| u | Connection status | 1.0 | bool |

155. Device <PVCell2>

Temperature-dependent photovoltaic cell

| Parameter | Description | Default | Units |
|---|---|---|---|
| ALFAgap | Gap function parameter | 0.0 | eV/K |
| ALFAjsc | Temperature conversion rate | 3e-05 | A/Kcm^2 |
| Area | Cell surface area | 0.01563 | cm^2 |
| BETAgap | Temperature coefficient | 1108.0 | K |
| Eg0 | Energy band gap | 1.16 | eV |
| # Idcn | Dc current rate | 10.0 | kA |
| Jsc | Short-circuit current density | 0.02816 | A/cm^2 |
| NOCT | Normal operating cell temperature | 42.0 | K |
| Rse | Cell body series resistence | 0.0105 | Ohm |
| # Rsh | Cell body shunt resistance | 10000.0 | Ohm |
| # Ta | Ambient temperature | 300.0 | K |
| # Td | Thermodynamic time delay | 60.0 | s |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| Voc | Open circuit voltage (at reference 0 k) | 0.57 | V |
| # m | Diode ideality factor | 1.16 | - |
| * node1 | 1st dc node id | - | - |
| * node2 | 2nd dc node id | - | - |
| # np | Number of pv cells in parallel | 1 | int |
| # ns | Number of pv cells in series | 1 | int |
| * sun | Solar irradiance id | - | - |
| u | Connection status | 1.0 | bool |

156. Device <PVCell3>

Photovoltaic system with dependence on cell temperature

| Parameter | Description | Default | Units |
|---|---|---|---|
| ALFAgap | Gap function parameter | 0.0 | eV/K |
| ALFAjsc | Temperature conversion rate | 3e-05 | A/Kcm^2 |
| Ac | Cell effective convection area | 156.25 | cm^2 |
| Ar | Cell effective radiation area | 156.25 | cm^2 |
| Area | Cell surface area | 0.01563 | cm^2 |
| BETAgap | Temperature coefficient | 1108.0 | K |
| # Cp | Average cell specific heat | 677 | J/kg*K |
| Eg0 | Energy band gap | 1.16 | eV |
| Epv | Emissivity of the pv cell | 0.9 | - |
| # Idcn | Dc current rate | 10.0 | kA |

| | | | |
|---|---|---|---|
| Jsc | Short-circuit current density | 0.02816 | A/cm^2 |
| # Rse | Cell body series resistence | 0.0105 | Ohm |
| # Rsh | Cell body shunt resistance | 10000.0 | Ohm |
| # Ta | Ambient temperature | 300.0 | K |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| Voc | Open circuit voltage (at reference 0 k) | 0.57 | V |
| hc | Convective transfer coefficient | 0.0005 | W/cm^2*K^4 |
| # m | Diode ideality factor | 1.16 | - |
| # mp | Cell mass | 0.00819 | kg |
| * node1 | 1st dc node id | - | - |
| * node2 | 2nd dc node id | - | - |
| # np | Number of pv cells in parallel | 1 | int |
| # ns | Number of pv cells in series | 1 | int |
| rhoc | Reflection factor | 0.05 | - |
| * sun | Solar irradiance id | - | - |
| tauc | Lens transmissivity | 0.8 | - |
| u | Connection status | 1.0 | bool |
| w | Parameter | 0.01 | - |

157. Device <PVCell4>

Photovoltaic system with detailed heat transfer linear model of the PV cell wafer. Considered layers for the heat transfer process are the PV cell, the Tedlar (polyvinyl fluoride, PVF) back-plate, the glass cover and the stagnant air surrounding the PV cell cover glass

| Parameter | Description | Default | Units |
|---|---|---|---|
| ALFAgap | Gap function parameter | 0.0 | eV/K |
| ALFAjsc | Temperature conversion rate | 3e-05 | A/Kcm^2 |
| Aa | Stagnant air area | 156.25 | cm^2 |
| Ac | Cell effective convection area | 156.25 | cm^2 |
| Ag | Glass cover area | 156.25 | cm^2 |
| Alfag | Absorptance of the glass cover | 0.06 | - |
| Alfap | Absorptance of the pv cell/module | 0.95 | - |
| Alfas | Coefficient of absorptance of metallic plate | 0.9 | - |
| Alfat | Absorptance of the back-plate | 0.5 | - |
| Area | Cell surface area | 0.01563 | cm^2 |
| At | Back-plate (tedlar) area | 156.25 | cm^2 |
| BETAgap | Temperature coefficient | 1108.0 | K |
| Ca | Specific heat of the air | 1005.0 | J/kg*K |
| Cg | Specific heat of the glass cover | 500.0 | J/kg*K |
| Cp | Specific heat of the pv | 677.0 | J/kg*K |

```
           | cell/module                   |            |
  Ct       | Specific heat of the back-    | 1250.0     | J/kg*K
           | plate                         |            |
  Deltaa   | Thickness of the air          | 0.3        | cm
  Deltag   | Thickness of the glass cover  | 0.3        | cm
  Deltap   | Thickness of the pv           | 0.0225     | cm
           | cell/module                   |            |
  Deltat   | Thickness of the back-plate   | 0.01       | cm
           | (tedlar)                      |            |
  Ebp      | Emissivity of back-plate      | 0.9        | -
           | (tedlar)                      |            |
  Eg0      | Energy band gap               | 1.16       | eV
  Egc      | Emissivity of glass cover     | 0.9        | -
  Epv      | Emissivity of pv cell/module  | 0.9        | -
# Idcn     | Dc current rate               | 10.0       | kA
  Jsc      | Short-circuit current density | 0.02816    | A/cm^2
  Rse      | Cell body series resistence   | 0.0105     | Ohm
# Rsh      | Cell body shunt resistance    | 10000.0    | Ohm
# Ta       | Ambient temperature           | 300.0      | K
  Ts       | Sky temperature               | 300.0      | K
# Vdcn     | Dc voltage rate               | 100.0      | kV
  Voc      | Open circuit voltage (at      | 0.57       | V
           | reference 0 k)                |            |
  Vwind    | Wind speed                    | 0.01       | cm/s
  hcag     | Convective heat transfer      | 0.0007     | W/cm^2*K
           | coeff. from stagnant air to   |            |
           | glass cover                   |            |
  hcga     | Convective heat transfer      | 0.00247    | W/cm^2*K
           | coeff. from glass cover to    |            |
           | outside air                   |            |
  hcpa     | Convective heat transfer      | 0.0007     | W/cm^2*K
           | coeff. from pv module to      |            |
           | stagnant air                  |            |
  hrgs     | Radiative heat transfer coeff. | 0.00056   | W/cm^2*K
           | from glass cover to sky       |            |
  hrpg     | Radiative heat transfer coeff. | 0.0008    | W/cm^2*K
           | from pv module to glass cover |            |
  la       | Thermal conductivity of the   | 0.00026    | W/cm*K
           | air                           |            |
  lg       | Thermal conductivity of the   | 0.018      | W/cm*K
           | glass cover                   |            |
  lp       | Thermal conductivity of the pv | 1.48      | W/cm*K
           | cell/module                   |            |
  lt       | Thermal conductivity of the   | 0.002      | W/cm*K
           | back-plate (tedlar)           |            |
# m        | Diode ideality factor         | 1.16       | -
* node1    | 1st dc node id                | -          | -
* node2    | 2nd dc node id                | -          | -
# np       | Number of pv cells in parallel | 1         | int
# ns       | Number of pv cells in series  | 1          | int
```

| | | | |
|---|---|---|---|
| rhoa | Density of the stagnant air | 1.225e-06 | kg/cm^3 |
| rhog | Density of the glass cover | 0.003 | kg/cm^3 |
| rhop | Density of the pv cell/module | 0.00233 | kg/cm^3 |
| rhot | Density of the back-plate (tedlar) | 0.0012 | kg/cm^3 |
| * sun | Solar irradiance id | - | - |
| taug | Trasmittance of the glass cover | 0.88 | - |
| u | Connection status | 1.0 | bool |

158. Device <PVCell5>

Electrical and Thermal model for single concentrator solar cell

| Parameter | Description | Default | Units |
|---|---|---|---|
| ALFAgap | Gap function parameter | 0.0 | eV/K |
| ALFAjsc | Temperature conversion rate | 3e-05 | A/Kcm^2 |
| Ac | Cell effective convection area | 0.09 | cm^2 |
| Alfag | Absorptance of the glass cover | 0.06 | - |
| Alfap | Absorptance of the pv cell/module | 0.95 | - |
| Alfas | Absorptance of metallic plate | 0.9 | - |
| Area | Cell surface area | 0.01563 | cm^2 |
| BETAgap | Temperature coefficient | 1108.0 | K |
| Cb | Specific heat of the absorber plate (in aluminium) | 900.0 | J/kg*K |
| Cg | Specific heat of the glass cover | 840.0 | J/kg*K |
| Ci | Specific heat of insulation material | 795.0 | J/kg*K |
| Cp | Specific heat of the pv cell/module | 677.0 | J/kg*K |
| Ct | Specific heat of metallic tube | 390.0 | J/kg*K |
| Cw | Specific heat of water | 4180.0 | J/kg*K |
| Deltaa | Thickness of the air gap | 0.3 | cm |
| Deltab | Thickness of the absorber plate | 0.4 | cm |
| Deltad | Thickness of the adhesive layer | 0.00013 | cm |
| Deltag | Thickness of the glass cover | 0.3 | cm |
| Deltai | Thickness of the insulation material | 0.0005 | cm |
| Deltap | Thickness of the pv cell/module | 0.03 | cm |
| Dinn | Tube inner diameter | 0.8 | cm |
| Dout | Tube outer diameter | 1.0 | cm |
| Eg0 | Energy band gap | 1.16 | eV |

```
  Egc        | Emissivity of glass cover       | 0.9         | -
  Epv        | Emissivity of pv cell/module    | 0.9         | -
# Idcn       | Dc current rate                 | 10.0        | kA
  Jsc        | Short-circuit current density   | 0.02816     | A/cm^2
  L          | Length of pv cell/panel         | 13          | cm
  NOCT       | Normal operating cell           | 42.0        | K
             | temperature                     |             |
  Qw         | Water mass flow rate            | 0.02        | kg/s
  Rse        | Cell body series resistence     | 0.0105      | Ohm
# Rsh        | Cell body shunt resistance      | 10000.0     | Ohm
# Ta         | Ambient temperature             | 300.0       | K
# Td         | Thermodynamic time delay        | 60.0        | s
  Te         | External water temperature      | 300.0       | K
  Ts         | Sky temperature                 | 300.0       | K
# Vdcn       | Dc voltage rate                 | 100.0       | kV
  Voc        | Open circuit voltage (at        | 0.57        | V
             | reference 0 k)                  |             |
  Vwind      | Wind speed                      | 150         | cm/s
  W          | Width of pv cell/panel          | 13          | cm
  htw        | Parameter                       | 0.1         | -
  ka         | Thermal conductivity of the     | 0.00025     | W/cm*K
             | air gap                         |             |
  kb         | Thermal conductivity of the     | 2.11        | W/cm*K
             | absorber plate                  |             |
  kd         | Thermal conductivity of the     | 0.0037      | W/cm*K
             | adhesive layer                  |             |
  kg         | Thermal conductivity of the     | 0.9         | W/cm*K
             | glass cover                     |             |
  ki         | Thermal conductivity of the     | 0.00036     | W/cm*K
             | insulation material             |             |
  kp         | Thermal conductivity of the pv  | 1.48        | W/cm*K
             | cell/module                     |             |
# m          | Diode ideality factor           | 1.16        | -
* node1      | 1st dc node id                  | -           | -
* node2      | 2nd dc node id                  | -           | -
# np         | Number of pv cells in parallel  | 1           | int
# ns         | Number of pv cells in series    | 1           | int
  rhob       | Density of the absorber plate   | 0.0027      | kg/cm^3
             | (in aluminium)                  |             |
  rhog       | Density of the glass cover      | 0.003       | kg/cm^3
  rhoi       | Density of insulation material  | 1.05        | kg/cm^3
  rhop       | Density of the pv cell/module   | 0.00233     | kg/cm^3
  rhot       | Density of metallic tube(in     | 0.00895     | kg/cm^3
             | copper)                         |             |
  rhow       | Parameter                       | 0.001       | -
* sun        | Solar irradiance id             | -           | -
  taug       | Trasmittance of the glass       | 0.88        | -
             | cover                           |             |
  u          | Connection status               | 1.0         | bool
-----------------------------------------------------------------------
```

159. Device <PVD>

Distribution network PV feeder

| Parameter | Description | Default | Units |
|---|---|---|---|
| * P0 | Active power | 0.0 | kW |
| * V0 | Feeder voltage magnitude | 20.0 | kV |
| # Vn | Voltage rate | 20.0 | kV |
| * bus | Bus id | - | - |
| u | Connection status | 1.0 | bool |

160. Device <PVdir>

PV direction class

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| * bus | Bus id | - | - |
| gamma | Loss participation factor | 1.0 | - |
| p0 | Active power | 0.0 | pu(MW) |
| u | Connection status | 1.0 | bool |

161. Device <PVgen>

Standard PV generator for power flow analysis

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| busr | Remote bus id | - | - |
| gamma | Loss participation factor | 1.0 | - |
| kq | Voltage control droop | 1e-06 | - |
| pg | Active power production | 0.0 | pu(MW) |
| pmax | Maximum active power | 999.9 | pu(MW) |
| pmin | Minimum active power | -999.9 | pu(MVAr) |
| qg | Reactive power production | 0.0 | pu(MVAr) |
| qmax | Maximum reactive power | 999.9 | pu(MVAr) |
| qmin | Minimum reactive power | -999.9 | pu(MVAr) |
| tech | Generator technology [h, n, l, c, g, o, w, p, f, oc, cc] | - | - |

| | | | |
|---|---|---|---|
| u | Connection status | 1.0 | bool |
| v0 | Desired voltage | 1.0 | pu(kV) |
| vmax | Maximum voltage | 1.1 | pu(kV) |
| vmin | Minimum voltage | 0.9 | pu(kV) |

162. Device <PVncp>

Static PV generator with Fischer-Burmeister function for Q limits

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| busr | Remote bus id | - | - |
| cphi | Penalty factor of the ncp- function | 0.99 | (0, 1) |
| gamma | Loss participation factor | 1.0 | - |
| kq | Voltage control droop | 1e-06 | - |
| pg | Active power production | 0.0 | pu(MW) |
| pmax | Maximum active power | 999.9 | pu(MW) |
| pmin | Minimum active power | -999.9 | pu(MVAr) |
| qg | Reactive power production | 0.0 | pu(MVAr) |
| qmax | Maximum reactive power | 999.9 | pu(MVAr) |
| qmin | Minimum reactive power | -999.9 | pu(MVAr) |
| tech | Generator technology [h, n, l, c, g, o, w, p, f, oc, cc] | - | - |
| u | Connection status | 1.0 | bool |
| v0 | Desired voltage | 1.0 | pu(kV) |
| vmax | Maximum voltage | 1.1 | pu(kV) |
| vmin | Minimum voltage | 0.9 | pu(kV) |

163. Device <ParkLine>

dynamic Park's model of transmission lines

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| b | Shunt capacitance | 0.0 | pu(1/Ohm) |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| g | Shunt conductance | 0.0 | pu(1/Ohm) |

| | | | |
|---|---|---|---|
| imax | Maximum current | 999.9 | pu(kA) |
| phases | Number of phases (1 or 3) | 3 | int |
| pmax | Maximum active power | 999.9 | pu(MW) |
| r | Series resistance | 0.01 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| x | Series inducatance | 0.1 | pu(Ohm) |

164. Device <ParkLoad1>

dynamic Park's model of RL loads (initialized after the power flow analysis)

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| kp | Active power rate | 100.0 | %(MVAr) |
| kq | Reactive power rate | 100.0 | %(MW) |
| * pqid | Pq load id | - | - |
| u | Connection status | 1.0 | bool |

165. Device <ParkLoad2>

dynamic Park's model of RL loads (included in the power flow analysis)

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| kp | Active power rate | 100.0 | %(MVAr) |
| p | Reactive power | 0.0 | pu(MW) |
| q | Active power | 0.0 | pu(MVAr) |
| u | Connection status | 1.0 | bool |

166. Device <ParkRL>

Park's model of a series RL

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Primary voltage rate | 220.0 | kV |

| | | | |
|---|---|---|---|
| Vn2 | Secondary voltage rate | 66.0 | kV |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| imax | Maximum current | 999.9 | pu(kA) |
| phases | Number of phases (1 or 3) | 3 | int |
| pmax | Maximum active power | 999.9 | pu(MW) |
| r | Series resistance | 0.01 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| x | Series reactance (inductive) | 0.1 | pu(Ohm) |

167. Device <ParkRLC>

Park's model of a series RLC transmission line

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| # b | Series susceptance | 0.0 | pu(1/Ohm) |
| | (capacitive) | | |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| imax | Maximum current | 999.9 | pu(kA) |
| phases | Number of phases (1 or 3) | 3 | int |
| pmax | Maximum active power | 999.9 | pu(MW) |
| r | Series resistance | 0.01 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| # x | Series reactance (inductive) | 0.1 | pu(Ohm) |

168. Device <ParkShunt>

Park's model of shunt condensers

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| # b | Shunt susceptance | 0.01 | pu(1/Ohm) |
| * bus | Bus id | - | - |
| g | Shunt conductance | 0.0 | pu(1/Ohm) |
| u | Connection status | 1.0 | bool |

169. Device <Pcosphi>

P cos(phi) load class

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| # cosphi | Power factor | 1.0 | - |
| p | Active power | 0.0 | pu(MW) |
| u | Connection status | 1.0 | bool |
| vmax | Maximum voltage | 1.1 | pu(kV) |
| vmin | Minimum voltage | 0.9 | pu(kV) |
| z | Allow converting to impedance | True | bool |

170. Device <Petersen>

Petersen coil that models a neutral-to-ground resonant impedance for short-circuit analysis. This device can be used also to model neutral-to-groud resistance for distribution systems. The impedance is connected as follows:

```
a o------
       |
b o---------[zp]---
       |         |
c o------        |
                 +
```

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| rp | Petersen coil resistance | 0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| xp | Petersen coil impedance | 0 | pu(Ohm) |

171. Device <Phs>

Phase shifting transformer

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ka | Integral deviation gain | 1e-05 | - |
| Ki | Integral gain | 10 | - |
| Kp | Proportional gain | 50 | - |
| # Sn | Power rate | 100.0 | MVA |
| # Tm | Measurement time constant | 0.01 | s |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| a0 | Phase shift initial guess | 0.0 | deg |
| amax | Maximum phase angle | 180.0 | deg |
| amin | Minimum phase angle | -180.0 | deg |
| bmu | Magnetizing susceptance | 0.0 | pu(1/Ohm) |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| gfe | Iron losses (conductance) | 0.0 | pu(1/Ohm) |
| imax | Maximum current | 999.9 | pu(kA) |
| m | Tap ratio | 1.0 | - |
| phases | Number of phases (1 or 3) | 3 | int |
| pmax | Maximum active power | 999.9 | pu(MW) |
| pref | Reference active power | 1.0 | pu(kW) |
| rt | Resistance | 0.0 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| xt | Reactance | 0.1 | pu(Ohm) |

172. Device <Pmu>

Phasor measurement class

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| Ta | Bus voltage magnitude low-pass filter time constant | 0.1 | s |
| Tv | Bus voltage phase angle low-pass filter time constant | 0.1 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| u | Connection status | 1.0 | bool |

173. Device <PphiD>

Distribution constant PQ load with given power factor

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power | 0.0 | kW |
| # Vn | Voltage rate | 20.0 | kV |
| bus | Bus id | - | - |
| pf | Power factor | 1.0 | [0, 1] |
| plevel | Priority level (for the acs routine) | 1 | int |
| u | Connection status | 1.0 | bool |

174. Device <Prototype>

Class for defining prototype device data. The device itself is void and does not define anything. It is just an interface for modifying default data of existing devices. This device accepts any data name of the destination device whose default values are to be modified.

| Parameter | Description | Default | Units |
|---|---|---|---|
| * device | Name of the device to be prototyped | - | - |
| u | Status | 1.0 | bool |

175. Device <Pss0>

Minimalist PSS controller. It defines a static active power and&or rotor speed feedback to the machine field voltage. It also defines a static feeback for the machine terminal voltage. The AVR is by-passed and, thus, not required.

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kp | Gain for active power | 0.0 | - |
| Kv | Gain for bus voltage | 0.0 | - |
| Kw | Gain for rotor speed | 10.0 | - |
| * syn | Synchronous machine id | - | - |
| u | Connection status | 1.0 | bool |

176. Device <Pss1>

PSS type 1

---

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kp | Gain for active power | 0.0 | - |
| Kv | Gain for bus voltage | 0.0 | - |
| Kw | Gain for rotor speed | 10.0 | - |
| # Tw1 | Wash-out time constant | 0.05 | s |
| * avr | Avr id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum output signal | 0.2 | pu(kV) |
| vmin | Minimum output signal | -0.2 | pu(kV) |

177. Device <Pss2>

PSS type 2

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kp | Gain for active power | 0.0 | - |
| Kv | Gain for bus voltage | 0.0 | - |
| Kw | Gain for rotor speed | 10.0 | - |
| T1 | 1st zero of pss regulator | 0.01 | s |
| # T2 | 1st pole of pss regulator | 0.1 | s |
| T3 | 2nd zero of pss regulator | 0.05 | s |
| # T4 | 2nd pole of pss regulator | 1.0 | s |
| # Tw | Wash-out time constant | 0.05 | s |
| * avr | Avr id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum output signal | 0.2 | pu(kV) |
| vmin | Minimum output signal | -0.2 | pu(kV) |

178. Device <Pss2d>

PSS type 2 with delayed omega measure

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kp | Gain for active power | 0.0 | - |
| Kv | Gain for bus voltage | 0.0 | - |
| Kw | Gain for rotor speed | 10.0 | - |
| T1 | 1st zero of pss regulator | 0.01 | s |
| # T2 | 1st pole of pss regulator | 0.1 | s |
| T3 | 2nd zero of pss regulator | 0.05 | s |
| # T4 | 2nd pole of pss regulator | 1.0 | s |
| # Tw | Wash-out time constant | 0.05 | s |
| * avr | Avr id | - | - |
| # tau | Constant time delay | 0.005 | s |

| | | | |
|---|---|---|---|
| u | Connection status | 1.0 | bool |
| vmax | Maximum output signal | 0.2 | pu(kV) |
| vmin | Minimum output signal | -0.2 | pu(kV) |

179. Device <Pss3>

PSS type 3

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kp | Gain for active power | 0.0 | - |
| Kv | Gain for bus voltage | 0.0 | - |
| Kw | Gain for rotor speed | 10.0 | - |
| T1 | 1st zero of pss regulator | 0.01 | s |
| # T2 | 1st pole of pss regulator | 0.1 | s |
| T3 | 2nd zero of pss regulator | 0.05 | s |
| # T4 | 2nd pole of pss regulator | 1.0 | s |
| # Tw | Wash-out time constant | 0.05 | s |
| * avr | Avr id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum output signal | 0.2 | pu(kV) |
| vmin | Minimum output signal | -0.2 | pu(kV) |

180. Device <Pss4>

PSS type 4

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ka | Gain for va signal | 0.0 | - |
| Kp | Gain for active power | 0.0 | - |
| Kv | Gain for bus voltage | 0.0 | - |
| Kw | Gain for rotor speed | 10.0 | - |
| T1 | 1st zero of pss regulator | 0.01 | s |
| # T2 | 1st pole of pss regulator | 0.1 | s |
| T3 | 2nd zero of pss regulator | 0.05 | s |
| # T4 | 2nd pole of pss regulator | 1.0 | s |
| # Ta | Time constant for va signal | 0.1 | s |
| # Tw | Wash-out time constant | 0.05 | s |
| * avr | Avr id | - | - |
| ethr | Field voltage threshold | 0.0 | pu(kV) |
| u | Connection status | 1.0 | bool |
| vamax | Max va signal | 0.1 | pu(kV) |
| vmax | Maximum output signal | 0.2 | pu(kV) |
| vmin | Minimum output signal | -0.2 | pu(kV) |
| wthr | Rotor speed threshold | 1.0 | pu(Hz) |

181. Device <Pss5>

PSS type 5

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ka | Gain for va signal | 0.0 | - |
| Kp | Gain for active power | 0.0 | - |
| Kv | Gain for bus voltage | 0.0 | - |
| Kw | Gain for rotor speed | 10.0 | - |
| T1 | 1st zero of pss regulator | 0.01 | s |
| # T2 | 1st pole of pss regulator | 0.1 | s |
| T3 | 2nd zero of pss regulator | 0.05 | s |
| # T4 | 2nd pole of pss regulator | 1.0 | s |
| # Ta | Time constant for va signal | 0.1 | s |
| # Tw | Wash-out time constant | 0.05 | s |
| * avr | Avr id | - | - |
| ethr | Field voltage threshold | 0.0 | pu(kV) |
| u | Connection status | 1.0 | bool |
| vamax | Max va signal | 0.1 | pu(kV) |
| vmax | Maximum output signal | 0.2 | pu(kV) |
| vmin | Minimum output signal | -0.2 | pu(kV) |
| wthr | Rotor speed threshold | 1.0 | pu(Hz) |

182. Device <R>

Resistance for EMT circuits

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Idcn | Dc current rate | 10.0 | kA |
| # R | Resistance | 1.0 | Ohm |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| * node1 | 1st node id | - | - |
| * node2 | 2nd node id | - | - |
| u | Connection status | 1.0 | bool |

183. Device <RC>

RC series for EMT circuits

| Parameter | Description | Default | Units |
|---|---|---|---|

| | | | |
|---|---|---|---|
| # C | Capacity | 1.0 | Farad |
| # Idcn | Dc current rate | 10.0 | kA |
| # R | Resistance | 0.0001 | Ohm |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| * node1 | 1st node id | - | - |
| * node2 | 2nd node id | - | - |
| u | Connection status | 1.0 | bool |
| v0 | Initial voltage | 0.0 | pu(kV) |

184. Device <RL>

RL series for EMT circuits

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Idcn | Dc current rate | 10.0 | kA |
| # L | Inductance | 1.0 | Henry |
| R | Resistance | 0.0 | Ohm |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| i0 | Initial current | 0.0 | pu(kA) |
| * node1 | 1st node id | - | - |
| * node2 | 2nd node id | - | - |
| u | Connection status | 1.0 | bool |

185. Device <RLC>

RLC series for EMT circuits

| Parameter | Description | Default | Units |
|---|---|---|---|
| # C | Capacity | 0.001 | Farad |
| # Idcn | Dc current rate | 10.0 | kA |
| # L | Inductance | 1.0 | Henry |
| R | Resistance | 0.0 | Ohm |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| i0 | Initial current | 0.0 | pu(kA) |
| * node1 | 1st node id | - | - |
| * node2 | 2nd node id | - | - |
| u | Connection status | 1.0 | bool |
| v0 | Initial voltage | 0.0 | pu(kV) |

186. Device <RLoad>

Recovery load

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Tp | P time constant | 5.0 | s |
| # Tq | Q time constant | 5.0 | s |
| * bus | Bus id | - | - |
| kp | Active power percentage (used for defining ps) | 100 | %(MW) |
| kq | Reactive power percentage (used for defining qs) | 100 | %(MVAr) |
| * pqid | Pq load id | - | - |
| pt | Transient active power | 0.0 | pu(MW) |
| qt | Transient reactive power | 0.0 | pu(MVAr) |
| u | Connection status | 1.0 | bool |

187. Device <RLoadmr>

Stochastic recovery load with mean reversion

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Tp | P time constant | 5.0 | s |
| # Tq | Q time constant | 5.0 | s |
| * bus | Bus id | - | - |
| h | Time step to generate the normal distribution | 1e-05 | s |
| kp | Active power percentage (used for defining ps) | 100 | %(MW) |
| kq | Reactive power percentage (used for defining qs) | 100 | %(MVAr) |
| pf | Mean value of the final active power | 0 | pu |
| * pqid | Pq load id | - | - |
| pt | Transient active power | 0.0 | pu(MW) |
| qf | Mean value of the final reactive power | 0 | pu |
| qt | Transient reactive power | 0.0 | pu(MVAr) |
| spp | Auto-correlation of the active power | 1.0 | % |
| spq | Correlation of active and reactive powers | 0.0 | % |
| sqq | Auto-correlation of the reactive power | 1.0 | % |
| u | Connection status | 1.0 | bool |
| vp | Speed of the active power mean-reversion | 0 | pu/s |

| | | | |
|---|---|---|---|
| vq | Speed of the reactive power mean-reversion | 0 | pu/s |

188. Device <RLoadstc>

Stochastic recovery load

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Tp | P time constant | 5.0 | s |
| # Tq | Q time constant | 5.0 | s |
| * bus | Bus id | - | - |
| h | Time step to generate the normal distribution | 1e-05 | s |
| kp | Active power percentage (used for defining ps) | 100 | %(MW) |
| kq | Reactive power percentage (used for defining qs) | 100 | %(MVAr) |
| * pqid | Pq load id | - | - |
| pt | Transient active power | 0.0 | pu(MW) |
| qt | Transient reactive power | 0.0 | pu(MVAr) |
| spp | Auto-correlation of the active power | 1.0 | % |
| spq | Correlation of active and reactive powers | 0.0 | % |
| sqq | Auto-correlation of the reactive power | 1.0 | % |
| u | Connection status | 1.0 | bool |

189. Device <Rectifier>

12-pulse thyristor controlled rectifier

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Idcn | Dc current rate | 20 | kA |
| # Sn | Power rate | 100.0 | MVA |
| # Vdcn | Dc voltage rate | 750 | kV |
| # Vn | Voltage rate | 220.0 | kV |
| amax | Maximum firing angle | 90.0 | deg |
| amin | Minimum firing angle | 5.0 | deg |
| * bus | Ac bus id | - | - |
| mmax | Maximum tap ratio | 1.2 | - |
| mmin | Minimum tap ratio | 0.7 | - |
| * node1 | 1st dc node | - | - |

| | | | |
|---|---|---|---|
| * node2 | 2nd dc node | - | - |
| u | Connection status | 1.0 | bool |
| xt | Transformer reactance | 0.1 | pu(Ohm) |

190. Device <Reference>

Reference angle (basically used during the QSS)

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| * kg | Index of the slack variable | - | - |
| theta0 | Voltage phase angle | 0.0 | rad |
| u | Connection status | 1.0 | bool |

191. Device <Region>

Define topological zones, areas, regions, etc.

| Parameter | Description | Default | Units |
|---|---|---|---|
| Pex | Active power exchange | 0 | pu(MW) |
| Pnet | Actual p net exchange | 0 | pu(MW) |
| Ptol | Active power tolerance | 0 | pu(MW) |
| Qnet | Actual q net exchange | 0 | pu(MVAr) |
| # Sn | Power rate | 100.0 | MVA |
| bus | Array of zone bus ids | [] | - |
| deltaP | Annual growth rate | 0 | %(MW) |
| slack | Zone slack bus id | - | - |
| u | Connection status | 1.0 | bool |

192. Device <Reserve>

Supply active power reserve bids

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| * bus | Bus id | - | - |
| cr | Reserve bid | 0.0 | $/MWh |
| pmax | Maximum active power | 0.0 | pu(MW) |
| pmin | Minimum active power | 0.0 | pu(MW) |

| | | | |
|---|---|---|---|
| * supply | Parameter | - | - |
| u | Connection status | 1.0 | bool |

193. Device <Routine>

Class for importing on-the-fly user defined routines from a Python module passed to Dome as input data. The device itself is empty and does not define anything. It is just an interface for the user defined routines. The user defined routine function must accept as unique argument an instance of the <system> class.

| Parameter | Description | Default | Units |
|---|---|---|---|
| * module | Name of the module where the routine is defined | - | - |
| path | Absolute or relative path where the module is placed | - | - |
| * routine | Name of user defined function where the routine is defined | - | - |
| u | Connection status | 1.0 | bool |

194. Device <SSSC_control>

Base class for SSSC (hybrid model)

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kiac | Integral gain of firing angle control | 5.0 | - |
| Kidc | Integral gain of modulation control | 5.0 | - |
| Kmac | Gain of ac measure | 1.0 | - |
| Kmdc | Gain of dc measure | 1.0 | - |
| Kpac | Proportional gain of firing angle control | 10.0 | - |
| Kpdc | Proportional gain of modulation control | 10.0 | - |
| # Tmac | Lag of ac measure | 0.01 | s |
| # Tmdc | Lag of dc measure | 0.01 | s |
| amax | Maximum firing angle | 180.0 | deg |
| amin | Minimum firing angle | -180.0 | deg |
| iacref | Ac reference current | 1.0 | pu(kA) |
| mmax | Maximum modulation | 3.0 | - |
| mmin | Minimum modulation | 0.5 | - |
| u | Connection status | 1.0 | bool |
| vdcref | Dc reference voltage | 1.0 | pu(kV) |

| | | | |
|---|---|---|---|
| * vsc | Vsc id | - | - |

195. Device <SSpace>

State-space equivalent of a system area (initialized during power flow)

| Parameter | Description | Default | Units |
|---|---|---|---|
| A | Matrix a in a column-major order array | [] | array |
| B | Matrix b in a column-major order array | [] | array |
| C | Matrix c in a column-major order array | [] | array |
| D | Matrix d in a column-major order array | [] | array |
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id or id list | - | - |
| fvars | List of state variable formatted names (optional) | - | - |
| * gen | Static generator id or id list | - | - |
| u | Connection status | 1.0 | bool |
| uvars | List of state variable unformatted names (optional) | - | - |
| x0 | List of the initial values of the state variables | [] | array |

196. Device <Sces>

Super-Capacitor (ultra-capacitor or double-layer capacitor) Energy Storage (SCES)

| Parameter | Description | Default | Units |
|---|---|---|---|
| C | Capacitance | 1.0 | Farad |
| Emax | Maximum sces capacity | 1.0 | MJ |
| Emin | Minimum sces capacity | 0.0 | MJ |
| # Idcn | Dc current rate | 10.0 | kA |
| R | Equivalent series resistance (esr) | 0.001 | Ohm |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| dcref | Parameter | 0.5 | - |
| * node1 | Input dc node 1 | - | - |
| * node2 | Input dc node 2 | - | - |

| | | | |
|---|---|---|---|
| u | Connection status | 1.0 | bool |
| vc0 | Initial capacitor voltage | 1.0 | pu(kV) |

197. Device <Sces_control>

Base class for controlling SCES devices

| Parameter | Description | Default | Units |
|---|---|---|---|
| # K | Gain of modulation control | 10.0 | - |
| Kd | Integral deviation of mod. control | 0.0 | - |
| Kddc | Derivative gain of dc signal | 5.0 | - |
| Ki | Integral gain of angle control | 5.0 | - |
| Kidc | Integral gain of dc signal | 10.0 | - |
| Kmac | Gain of ac measure | 1.0 | - |
| Kmdc | Gain of dc measure | 1.0 | - |
| Kp | Proportional gain of angle control | 10.0 | - |
| Kpdc | Proportional gain of dc signal | 1.0 | - |
| Pref | Reference active power | 1.0 | pu(MW) |
| # T1 | Lead of modulation control | 0.1 | s |
| T2 | Lag of modulation control | 0.05 | s |
| # Tf | Low-pass filter time constant | 0.001 | s |
| # Tmac | Lag of ac measure | 0.01 | s |
| # Tmdc | Lag of dc measure | 0.01 | s |
| amax | Maximum firing angle | 360.0 | deg |
| amin | Minimum firing angle | -360.0 | deg |
| db | Dead band of the power measure | 0 | - |
| dcmax | Maximum duty cycle | 1.0 | - |
| dcmin | Minimum duty cycle | 0.0 | - |
| * line | Transmission line id | - | - |
| mmax | Maximum modulation | 3.0 | - |
| mmin | Minimum modulation | 0.5 | - |
| * sces | Sces id | - | - |
| trig | Coefficient to relax pref signal (0, 1] | 0.05 | - |
| u | Connection status | 1.0 | bool |
| * vsc | Vsc id | - | - |
| * vsc_static | Static vsc control id | - | - |

198. Device <SepMac>

dc machine with separate winding connection

| Parameter | Description | Default | Units |
|---|---|---|---|

| | | | |
|---|---|---|---|
| D | Rotor damping | 0.01 | kW/kVA |
| H | Inertia constant | 2.0 | kWs/kVA |
| # Idcn | Dc current rate | 10.0 | kA |
| # Laa | Autoinductance of the armature winding | 0.5 | H |
| Laf | Mutual inductance of armature and field windings | 1.0 | H |
| # Lff | Autoinductance of the field winding | 0.5 | H |
| Ra | Armature winding resistance | 0.05 | Ohm |
| Rf | Field winding resistance | 0.0 | Ohm |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| * node1 | Input dc node 1 | - | - |
| * node1f | Node 1 of field winding | - | - |
| * node2 | Input dc node 2 | - | - |
| * node2f | Node 2 of field winding | - | - |
| rpm | Nominal revolution per minute | 1500 | - |
| tm0 | Constant mechanical torque (use tm0 < 0 for generators) | 1.0 | MNm |
| u | Connection status | 1.0 | bool |

199. Device <SeriesMac>

series-connected dc machine

| Parameter | Description | Default | Units |
|---|---|---|---|
| D | Rotor damping | 0.01 | kW/kVA |
| H | Inertia constant | 2.0 | kWs/kVA |
| # Idcn | Dc current rate | 10.0 | kA |
| # Laa | Autoinductance of the armature winding | 0.5 | H |
| Laf | Mutual inductance of armature and field windings | 1.0 | H |
| # Lff | Autoinductance of the field winding | 0.5 | H |
| Ra | Armature winding resistance | 0.05 | Ohm |
| Rf | Field winding resistance | 0.0 | Ohm |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| * node1 | Input dc node 1 | - | - |
| * node2 | Input dc node 2 | - | - |
| rpm | Nominal revolution per minute | 1500 | - |
| tm0 | Constant mechanical torque (use tm0 < 0 for generators) | 1.0 | MNm |
| u | Connection status | 1.0 | bool |

200. Device <Shaft>

Dynamic shaft class

| Parameter | Description | Default | Units |
|---|---|---|---|
| D12 | Hp-ip turbine damping | 0.0 | kW/kVA |
| D23 | Ip-lp turbine damping | 0.0 | kW/kVA |
| D34 | Lp turbine-rotor damping | 0.0 | kW/kVA |
| D45 | Rotor-exciter damping | 0.0 | kW/kVA |
| Dex | Exciter damping | 0.0 | kW/kVA |
| Dhp | Hp turbine damping | 0.0 | kW/kVA |
| Dip | Ip turbine damping | 0.0 | kW/kVA |
| Dlp | Lp turbine damping | 0.0 | kW/kVA |
| K12 | Hp-ip turbine elastic coeff. | 0.0 | kW/kVA |
| K23 | Ip-lp turbine elastic coeff. | 0.0 | kW/kVA |
| K34 | Lp turbine-rotor el. coeff. | 0.0 | kW/kVA |
| K45 | Rotor-exciter elastic coeff. | 0.0 | kW/kVA |
| # Mex | Inertia of exciter shaft | 1.0 | kWs/kVA |
| # Mhp | Inertia of hp turbine shaft | 1.0 | kWs/kVA |
| # Mip | Inertia of ip turbine shaft | 1.0 | kWs/kVA |
| # Mlp | Inertia of lp turbine shaft | 1.0 | kWs/kVA |
| * syn | Synchronous generator id | - | - |
| u | Connection status | 1.0 | bool |

201. Device <Shunt>

Fixed shunt admittance

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| b | Susceptance | 0.0 | pu(1/Ohm) |
| * bus | Bus id | - | - |
| g | Conductance | 0.0 | pu(1/Ohm) |
| u | Connection status | 1.0 | bool |

202. Device <ShuntD>

Distribution fixed shunt admittance

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power | 0.0 | kW |

| | Parameter | Description | Default | Units |
|---|---|---|---|---|
| | Q0 | Reactive power | 0.0 | kVAr |
| # | Vn | Voltage rate | 20 | kV |
| * | bus | Bus id | - | - |
| | plevel | Priority level (for the acs routine) | 1 | int |
| | u | Connection status | 1.0 | bool |

203. Device <ShuntMac>

shunt-connected dc machine

| | Parameter | Description | Default | Units |
|---|---|---|---|---|
| | D | Rotor damping | 0.01 | kW/kVA |
| | H | Inertia constant | 2.0 | kWs/kVA |
| # | Idcn | Dc current rate | 10.0 | kA |
| # | Laa | Autoinductance of the armature winding | 0.5 | H |
| | Laf | Mutual inductance of armature and field windings | 1.0 | H |
| # | Lff | Autoinductance of the field winding | 0.5 | H |
| | Ra | Armature winding resistance | 0.05 | Ohm |
| | Rf | Field winding resistance | 0.0 | Ohm |
| # | Vdcn | Dc voltage rate | 100.0 | kV |
| * | node1 | Input dc node 1 | - | - |
| * | node2 | Input dc node 2 | - | - |
| | rpm | Nominal revolution per minute | 1500 | - |
| | tm0 | Constant mechanical torque (use tm0 < 0 for generators) | 1.0 | MNm |
| | u | Connection status | 1.0 | bool |

204. Device <Slack>

Slack generator for power flow analysis

| | Parameter | Description | Default | Units |
|---|---|---|---|---|
| # | Sn | Power rate | 100.0 | MVA |
| # | Vn | Voltage rate | 220.0 | kV |
| * | bus | Bus id | - | - |
| | busr | Remote bus id | - | - |
| | gamma | Loss participation factor | 1.0 | - |
| | kq | Voltage control droop | 1e-06 | - |
| | pg | Active power production | 0.0 | pu(MW) |
| | pmax | Maximum active power | 999.9 | pu(MW) |

| | | | |
|---|---|---|---|
| pmin | Minimum active power | -999.9 | pu(MVAr) |
| qg | Reactive power production | 0.0 | pu(MVAr) |
| qmax | Maximum reactive power | 999.9 | pu(MVAr) |
| qmin | Minimum reactive power | -999.9 | pu(MVAr) |
| slack | Reference bus | True | - |
| tech | Generator technology [h, n, l, c, g, o, w, p, f, oc, cc] | - | - |
| theta0 | Voltage phase angle | 0.0 | rad |
| u | Connection status | 1.0 | bool |
| v0 | Desired voltage | 1.0 | pu(kV) |
| vmax | Maximum voltage | 1.1 | pu(kV) |
| vmin | Minimum voltage | 0.9 | pu(kV) |

205. Device <Smes>

Superconducting Magnetic Energy Storage (SMES)

| Parameter | Description | Default | Units |
|---|---|---|---|
| Emax | Maximum smes capacity | 1.0 | MJ |
| Emin | Minimum smes capacity | 0.0 | MJ |
| # Idcn | Dc current rate | 10.0 | kA |
| # L | Coil inductance | 1.0 | Henry |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| dcref | Reference duty cycle | 0.5 | - |
| ic0 | Initial coil current | 0.0 | pu(kA) |
| * node1 | 1st node id | - | - |
| * node2 | 2nd node id | - | - |
| u | Connection status | 1.0 | bool |

206. Device <Smes_control>

Base class for controlling SMES devices

| Parameter | Description | Default | Units |
|---|---|---|---|
| # K | Gain of modulation control | 10.0 | - |
| Kd | Integral deviation of mod. control | 0.0 | - |
| Kddc | Derivative gain of dc signal | 5.0 | - |
| Ki | Integral gain of angle control | 5.0 | - |
| Kidc | Integral gain of dc signal | 10.0 | - |
| Kmac | Gain of ac measure | 1.0 | - |
| Kmdc | Gain of dc measure | 1.0 | - |
| Kp | Proportional gain of angle control | 10.0 | - |

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kpdc | Proportional gain of dc signal | 1.0 | - |
| Pref | Reference active power | 1.0 | pu(MW) |
| # T1 | Lead of modulation control | 0.1 | s |
| T2 | Lag of modulation control | 0.05 | s |
| # Tf | Low-pass filter time constant | 0.001 | s |
| # Tmac | Lag of ac measure | 0.01 | s |
| # Tmdc | Lag of dc measure | 0.01 | s |
| amax | Maximum firing angle | 360.0 | deg |
| amin | Minimum firing angle | -360.0 | deg |
| db | Dead band of the power measure | 0 | - |
| dcmax | Maximum duty cycle | 0.8 | - |
| dcmin | Minimum duty cycle | 0.2 | - |
| * line | Transmission line id | - | - |
| mmax | Maximum modulation | 3.0 | - |
| mmin | Minimum modulation | 0.5 | - |
| * smes | Smes id | - | - |
| trig | Coefficient to relax pref signal (0, 1] | 0.05 | - |
| u | Connection status | 1.0 | bool |
| * vsc | Vsc id | - | - |
| * vsc_static | Static vsc control id | - | - |

207. Device <Sodium>

Sodium lamp

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power at nominal voltage | 0.57 | kW |
| # Vn | Voltage rate | 0.4 | kV |
| * bus | Bus id | - | - |
| pf | Nominal power factor (negative for capacitive loads) | 0.9876 | - |
| plevel | Priority level (for the acs routine) | 3 | int |
| u | Connection status | 1.0 | bool |

208. Device <Sofc>

Solid Oxide Fuel Cell (SOFC)

| Parameter | Description | Default | Units |
|---|---|---|---|
| E0 | Ideal standard potential | 1.18 | V |
| # Idcn | Dc current rate | 10.0 | kA |

| | | | |
|---|---|---|---|
| # KH2 | Hydrogen valve molar constant | 0.00084 | - |
| # KH2O | Water valve molar constant | 0.00028 | - |
| # KO2 | Oxygen valve molar constant | 0.00252 | - |
| Kr | Fuel/electrical charge ratio | 9.96e-07 | mol/C |
| Rdc | Ohmic losses | 0.126 | Ohm |
| # TH2 | Hydrogen flow response time | 26.1 | s |
| # TH2O | Water flow response time | 78.3 | s |
| # TO2 | Oxygen flow response time | 2.91 | s |
| Theta | Gas temperature | 1273.15 | K |
| # Vdcn | Dc voltage rate | 100.0 | kV |
| * node1 | Input dc node 1 | - | - |
| * node2 | Input dc node 2 | - | - |
| # np | Number of cells in parallel | 1 | int |
| # ns | Number of cells in series | 384 | int |
| # rHO | Ratio of hydrogen to oxygen | 1.145 | - |
| u | Connection status | 1.0 | bool |

209. Device <Statcom>

Base class for StatCom device (current injection model)

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kr | Regulator gain | 10.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| # Tr | Regulator time constant | 0.01 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Location bus id | - | - |
| busr | Controlled bus id | - | - |
| imax | Maximum current | 1.0 | pu(kA) |
| imin | Minimum current | -1.0 | pu(kA) |
| u | Connection status | 1.0 | bool |
| v0 | Desired bus voltage | 1.0 | pu(kV) |

210. Device <Statcom_control>

Base class for StatCom control (hybrid model)

| Parameter | Description | Default | Units |
|---|---|---|---|
| K | Gain of modulation control | 10.0 | - |
| Kd | Integral deviation of mod. control | 0.0 | - |
| Ki | Integral gain of angle control | 5.0 | - |
| Kmac | Gain of ac measure | 1.0 | - |
| Kmdc | Gain of dc measure | 1.0 | - |

| | | | |
|---|---|---|---|
| Kp | Proportional gain of angle control | 10.0 | - |
| # T1 | Lead of modulation control | 0.1 | s |
| T2 | Lag of modulation control | 0.05 | s |
| # Tmac | Lag of ac measure | 0.01 | s |
| # Tmdc | Lag of dc measure | 0.01 | s |
| amax | Maximum firing angle | 360.0 | deg |
| amin | Minimum firing angle | -360.0 | deg |
| mmax | Maximum modulation | 3.0 | - |
| mmin | Minimum modulation | 0.5 | - |
| u | Connection status | 1.0 | bool |
| vacref | Ac reference voltage | 1.0 | pu(kV) |
| vdcref | Dc reference voltage | 1.0 | pu(kV) |
| * vsc | Vsc id | - | - |

211. Device <StcBus>

Stochastic perturbation with mean reversion of bus voltage phasors. This device has no effect on the system if it is not used in conjunction with the LineStc device. One StcBus has to be defined per each network bus.

| Parameter | Description | Default | Units |
|---|---|---|---|
| am | Mean value of the bus voltage phase angle disturbance | 0.0 | rad |
| * bus | Bus id | - | - |
| h | Time step to generate the normal distribution | 1e-05 | s |
| sa | Auto-correlation of the bus voltage phase angle | 1.0 | - |
| sv | Auto-correlation of the bus voltage magnitude | 1.0 | - |
| u | Connection status | 1.0 | bool |
| va | Speed of the bus voltage phase angle mean-reversion | 1.0 | rad/s |
| vm | Mean value of the bus voltage magnitude disturbance | 0.0 | pu(kV) |
| vv | Speed of the bus voltage magnitude mean-reversion | 1.0 | pu(kV)/s |

212. Device <StcLine>

Stochastic perturbation of bus voltage phasors through transmission line and static transformer. This model must be used in conjunction with the BusStc device.

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| b | Shunt susceptance | 0.0 | pu(Ohm) or uS/km |
| b1 | From bus shunt susceptance | 0.0 | pu(1/Ohm) or uS/km |
| b2 | To bus shunt susceptance | 0.0 | pu(1/Ohm) or uS/km |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| g | Shunt conductance | 0.0 | pu(1/Ohm) or uS/km |
| g1 | From bus shunt conductance | 0.0 | pu(1/Ohm) or uS/km |
| g2 | To bus shunt conductance | 0.0 | pu(1/Ohm) or uS/km |
| imax | Maximum current | 999.9 | pu(kA) |
| length | Line length | 0.0 | km |
| phases | Number of phases (1 or 3) | 3 | int |
| phi | Phase shift | 0.0 | deg |
| pmax | Maximum active power | 999.9 | pu(MW) |
| r | Series resistance | 0.0 | pu(Ohm) or Ohm/km |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| tap | Tap ratio | 1.0 | - |
| trasf | True if transformer | False | bool |
| u | Connection status | 1.0 | bool |
| x | Series reactance | 1e-05 | pu(Ohm) or Ohm/km |

213. Device <StcPer>

Stochastic perturbation for algebraic or state variables

| Parameter | Description | Default | Units |
|---|---|---|---|
| * devIdx | Index of associated device | - | - |
| * devName | Name of associated device | - | - |
| * devVar | List of variable names | - | - |
| diff | Diffusion parameter | 0.01 | %pu/(s^0.5) |
| drift | Drift parameter | 0.0 | pu/s |
| h | Time step to generate the normal distribution | 1e-05 | s |
| u | Connection status | 1.0 | bool |

214. Device <StcPower>

Stochastic perturbation with mean reversion of bus power balances.

| Parameter | Description | Default | Units |
|---|---|---|---|
| am | Mean value of the bus active power balance disturbance | 0.0 | pu(MW) |
| * bus | Bus id | - | - |
| h | Time step to generate the normal distribution | 1e-05 | s |
| sa | Auto-correlation of the bus active power balance | 1.0 | - |
| sv | Auto-correlation of the bus reactive power balance | 1.0 | - |
| u | Connection status | 1.0 | bool |
| va | Speed of the bus active power balance mean-reversion | 1.0 | pu(MW)/s |
| vm | Mean value of the bus reactive power balance disturbance | 0.0 | pu(MVAr) |
| vv | Speed of the bus reactive power balance mean-reversion | 1.0 | pu(MVAr)/s |

215. Device <Sun1>

Class for simple solar irradiance model

| Parameter | Description | Default | Units |
|---|---|---|---|
| # day | Day number since january 1 | 196.0 | int |
| deg | Latitude degrees | 41.0 | deg |
| hour | Starting hour | 0.0 | h |
| min | Latitude minutes | 53.0 | min |
| sec | Latitude seconds | 35.0 | sec |
| u | Connection status | 1.0 | bool |

216. Device <Sun2>

Class for solar irradiance with surface tilt angle and ground reflexion coefficient

| Parameter | Description | Default | Units |
|---|---|---|---|
| # day | Day number since january 1 | 196.0 | int |
| deg | Latitude degrees | 41.0 | deg |
| hour | Starting hour | 0.0 | h |
| min | Latitude minutes | 53.0 | min |
| rog | Ground reflexion coefficient | 0.2 | - |
| sec | Latitude seconds | 35.0 | sec |
| tilt | Surface tilt angle | 30.0 | deg |

| u | Connection status | 1.0 | bool |
|---|---|---|---|

217. Device <Supply>

Supply bids

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| * bus | Bus id | - | - |
| cp0 | Active power c0 bid | 0.0 | $/h |
| cp1 | Active power c1 bid | 0.0 | $/MWh |
| cp2 | Active power c2 bid | 0.0 | $/MW^2h |
| cq0 | Reactive power c0 bid | 0.0 | $/h |
| cq1 | Reactive power c1 bid | 0.0 | $/MVArh |
| cq2 | Reactive power c2 bid | 0.0 | $/MVAr^2h |
| pmax | Maximum active power | 0.0 | pu(MW) |
| pmin | Minimum active power | 0.0 | pu(MVAr) |
| qmax | Maximum reactive power | 0.0 | pu(MVAr) |
| qmin | Minimum reactive power | 0.0 | pu(MVAr) |
| tie | Tie-break cost | 0.0 | $/MWh |
| u | Connection status | 1.0 | bool |

218. Device <Svc1>

SVC with susceptance model.

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kr | Regulator gain | 10.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| # Tr | Regulator time constant | 0.01 | s |
| # Vn | Voltage rate | 220.0 | kV |
| bmax | Maximum susceptance | 5.0 | pu(1/Ohm) |
| bmin | Minimum susceptance | -5.0 | pu(1/Ohm) |
| * bus | Location bus id | - | - |
| busr | Controlled bus id | - | - |
| u | Connection status | 1.0 | bool |
| v0 | Desired bus voltage | 1.0 | pu(kV) |

219. Device <Svc2>

SVC with firing angle model.

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| Parameter | Description | Default | Units |
|---|---|---|---|
| K | Regulator gain | 10.0 | - |
| Kd | Integral deviation | 0.0 | - |
| Km | Measure gain | 1.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| T1 | Transient reg. time constant | 0.01 | s |
| # T2 | Regulator time constant | 0.01 | s |
| # Tm | Measure time constant | 0.01 | s |
| # Vn | Voltage rate | 220.0 | kV |
| amax | Maximum firing angle | 3.14159 | rad |
| amin | Minimum firing angle | -3.14159 | rad |
| * bus | Location bus id | - | - |
| busr | Controlled bus id | - | - |
| u | Connection status | 1.0 | bool |
| v0 | Desired bus voltage | 1.0 | pu(kV) |
| xc | Capacitive reactance | 0.1 | pu(Ohm) |
| xl | Inductive reactance | 0.1 | pu(Ohm) |

220. Device <Svc3>

SVC with susceptance model. Included in the power flow analysis

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kr | Regulator gain | 10.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| # Tr | Regulator time constant | 0.01 | s |
| # Vn | Voltage rate | 220.0 | kV |
| bmax | Maximum susceptance | 5.0 | pu(1/Ohm) |
| bmin | Minimum susceptance | -5.0 | pu(1/Ohm) |
| * bus | Location bus id | - | - |
| busr | Controlled bus id | - | - |
| u | Connection status | 1.0 | bool |
| v0 | Desired bus voltage | 1.0 | pu(kV) |

221. Device <Svc4>

SVC with firing angle model. Included in the power flow analysis

| Parameter | Description | Default | Units |
|---|---|---|---|
| K | Regulator gain | 10.0 | - |
| Kd | Integral deviation | 0.0 | - |
| Km | Measure gain | 1.0 | - |
| # Sn | Power rate | 100.0 | MVA |

| | | | |
|---|---|---|---|
| T1 | Transient reg. time constant | 0.01 | s |
| # T2 | Regulator time constant | 0.01 | s |
| # Tm | Measure time constant | 0.01 | s |
| # Vn | Voltage rate | 220.0 | kV |
| amax | Maximum firing angle | 3.14159 | rad |
| amin | Minimum firing angle | -3.14159 | rad |
| * bus | Location bus id | - | - |
| busr | Controlled bus id | - | - |
| u | Connection status | 1.0 | bool |
| v0 | Desired bus voltage | 1.0 | pu(kV) |
| xc | Capacitive reactance | 0.1 | pu(Ohm) |
| xl | Inductive reactance | 0.1 | pu(Ohm) |

222. Device <SwShunt1>

Switched shunt admittance with voltage control

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| b | Initial susceptance | 0.0 | pu(1/Ohm) |
| bblock | Array of susceptances of each block | [] | pu(1/Ohm) |
| * bus | Bus id | - | - |
| busr | Remote bus id | - | - |
| g | Initial conductance | 0.0 | pu(1/Ohm) |
| gblock | Array of conductances of each block | [] | pu(1/Ohm) |
| nblock | Array of element number of each block | [] | int |
| tau | Time delay for switching elements | 30.0 | s |
| u | Connection status | 1.0 | bool |
| vref | Reference voltage | 1.0 | pu(kV) |
| vtol | Voltage tolerance | 0.05 | pu(kV) |

223. Device <SwShunt2>

Switched shunt admittance with voltage upper an lower bounds

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| b | Initial susceptance | 0.0 | pu(1/Ohm) |

| | | | |
|---|---|---|---|
| bblock | Array of susceptances of each block | [] | pu(1/Ohm) |
| * bus | Bus id | - | - |
| busr | Remote bus id | - | - |
| g | Initial conductance | 0.0 | pu(1/Ohm) |
| gblock | Array of conductances of each block | [] | pu(1/Ohm) |
| nblock | Array of element number of each block | [] | int |
| tau | Time delay for switching elements | 30.0 | s |
| u | Connection status | 1.0 | bool |
| vmax | Upper voltage limit | 1.1 | pu(kV) |
| vmin | Lower voltage limit | 0.9 | pu(kV) |

224. Device <Switch>

Switch for generic device

| Parameter | Description | Default | Units |
|---|---|---|---|
| * dev | Device type | - | - |
| * devid | Device id | - | - |
| t1 | 1st switch time | 0.0 | s |
| t2 | 2nd switch time | 0.0 | s |
| t3 | 3rd switch time | 0.0 | s |
| t4 | 4th switch time | 0.0 | s |
| u | Connection status | 1.0 | bool |
| u1 | Apply 1st switch | False | bool |
| u2 | Apply 2nd switch | False | bool |
| u3 | Apply 3nd switch | False | bool |
| u4 | Apply 4nd switch | False | bool |

225. Device <Syn2>

Classical electromechanical synchronous machine model

| Parameter | Description | Default | Units |
|---|---|---|---|
| D | Rotor damping | 0.0 | kW/kVA |
| # M | Mechanical starting time (=2h) | 5.0 | kWs/kVA |
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| coi | Center of inertia id | 1 | - |
| gammap | Active power ratio at node | 1.0 | [0, 1] |

| | | | |
|---|---|---|---|
| gammaq | Reactive power ratio at node | 1.0 | [0, 1] |
| * gen | Static generator id | - | - |
| ra | Armature resistance | 0.0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| * xd1 | D-axis transient reactance | 1.9 | pu(Ohm) |
| xl | Leakage reactance | 0.0 | pu(Ohm) |
| xq | Q-axis synchronous reactance | 1.7 | pu(Ohm) |

226. Device <Syn3>

3rd order (one-axes) synchronous machine model

| Parameter | Description | Default | Units |
|---|---|---|---|
| D | Rotor damping | 0.0 | kW/kVA |
| # M | Mechanical starting time (=2h) | 5.0 | kWs/kVA |
| S10 | 1st saturation factor | 0.0 | - |
| S12 | 2nd saturation factor | 0.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| * Td10 | D-axis transient time constant | 8.0 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| coi | Center of inertia id | 1 | - |
| gammap | Active power ratio at node | 1.0 | [0, 1] |
| gammaq | Reactive power ratio at node | 1.0 | [0, 1] |
| * gen | Static generator id | - | - |
| ra | Armature resistance | 0.0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| * xd | D-axis synchronous reactance | 1.9 | pu(Ohm) |
| * xd1 | D-axis transient reactance | 0.302 | pu(Ohm) |
| xl | Leakage reactance | 0.0 | pu(Ohm) |
| * xq | Q-axis synchronous reactance | 1.7 | pu(Ohm) |

227. Device <Syn4>

4th order (two-axes) synchronous machine model

| Parameter | Description | Default | Units |
|---|---|---|---|
| D | Rotor damping | 0.0 | kW/kVA |
| # M | Mechanical starting time (=2h) | 5.0 | kWs/kVA |
| S10 | 1st saturation factor | 0.0 | - |
| S12 | 2nd saturation factor | 0.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| * Td10 | D-axis transient time constant | 8.0 | s |
| * Tq10 | Q-axis transient time constant | 0.8 | s |

| | | | |
|---|---|---|---|
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| coi | Center of inertia id | 1 | - |
| gammap | Active power ratio at node | 1.0 | [0, 1] |
| gammaq | Reactive power ratio at node | 1.0 | [0, 1] |
| * gen | Static generator id | - | - |
| ra | Armature resistance | 0.0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| * xd | D-axis synchronous reactance | 1.9 | pu(Ohm) |
| * xd1 | D-axis transient reactance | 0.302 | pu(Ohm) |
| xl | Leakage reactance | 0.0 | pu(Ohm) |
| * xq | Q-axis synchronous reactance | 1.7 | pu(Ohm) |
| * xq1 | Q-axis transient reactance | 0.5 | pu(Ohm) |

228. Device <Syn5a>

5th order synchronous machine model based on Marconato's book

| Parameter | Description | Default | Units |
|---|---|---|---|
| D | Rotor damping | 0.0 | kW/kVA |
| # M | Mechanical starting time (=2h) | 5.0 | kWs/kVA |
| S10 | 1st saturation factor | 0.0 | - |
| S12 | 2nd saturation factor | 0.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| * Td10 | D-axis transient time constant | 8.0 | s |
| * Tq10 | Q-axis transient time constant | 0.8 | s |
| * Tq20 | Q-axis subtrans. time constant | 0.02 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| coi | Center of inertia id | 1 | - |
| corr | Use marconato's model | 0.0 | bool |
| gammap | Active power ratio at node | 1.0 | [0, 1] |
| gammaq | Reactive power ratio at node | 1.0 | [0, 1] |
| * gen | Static generator id | - | - |
| ra | Armature resistance | 0.0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| * xd | D-axis synchronous reactance | 1.9 | pu(Ohm) |
| * xd1 | D-axis transient reactance | 0.302 | pu(Ohm) |
| xl | Leakage reactance | 0.0 | pu(Ohm) |
| * xq | Q-axis synchronous reactance | 1.7 | pu(Ohm) |
| * xq1 | Q-axis transient reactance | 0.5 | pu(Ohm) |

229. Device <Syn5b>

Alernative 5th order synchronous machine model

| Parameter | Description | Default | Units |
|---|---|---|---|
| D | Rotor damping | 0.0 | kW/kVA |
| # M | Mechanical starting time (=2h) | 5.0 | kWs/kVA |
| S10 | 1st saturation factor | 0.0 | - |
| S12 | 2nd saturation factor | 0.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| Taa | D-axis leakage time constant | 0.0 | s |
| * Td10 | D-axis transient time constant | 8.0 | s |
| * Td20 | D-axis subtrans. time constant | 0.04 | s |
| * Tq20 | Q-axis subtrans. time constant | 0.02 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| coi | Center of inertia id | 1 | - |
| corr | Use marconato's model | 0.0 | bool |
| gammap | Active power ratio at node | 1.0 | [0, 1] |
| gammaq | Reactive power ratio at node | 1.0 | [0, 1] |
| * gen | Static generator id | - | - |
| ra | Armature resistance | 0.0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| * xd | D-axis synchronous reactance | 1.9 | pu(Ohm) |
| * xd1 | D-axis transient reactance | 0.302 | pu(Ohm) |
| * xd2 | Q-axis subtransient reactance | 0.204 | pu(Ohm) |
| xl | Leakage reactance | 0.0 | pu(Ohm) |
| * xq | Q-axis synchronous reactance | 1.7 | pu(Ohm) |
| * xq2 | D-axis subtransient reactance | 0.3 | s |

230. Device <Syn5c>

Saccomanno's 5th order synchronous machine model (3rd order + flux dynamics)

| Parameter | Description | Default | Units |
|---|---|---|---|
| D | Rotor damping | 0.0 | kW/kVA |
| # M | Mechanical starting time (=2h) | 5.0 | kWs/kVA |
| S10 | 1st saturation factor | 0.0 | - |
| S12 | 2nd saturation factor | 0.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| * Td10 | D-axis transient time constant | 8.0 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| coi | Center of inertia id | 1 | - |
| gammap | Active power ratio at node | 1.0 | [0, 1] |
| gammaq | Reactive power ratio at node | 1.0 | [0, 1] |
| * gen | Static generator id | - | - |
| ra | Armature resistance | 0.0 | pu(Ohm) |

| | | | |
|---|---|---|---|
| u | Connection status | 1.0 | bool |
| * xd | D-axis synchronous reactance | 1.9 | pu(Ohm) |
| * xd1 | D-axis transient reactance | 0.302 | pu(Ohm) |
| xl | Leakage reactance | 0.0 | pu(Ohm) |
| * xq | Q-axis synchronous reactance | 1.7 | pu(Ohm) |

231. Device <Syn5d>

Pai's 5th order synchronous machine model (T'q0 = 0.0)

| Parameter | Description | Default | Units |
|---|---|---|---|
| D | Rotor damping | 0.0 | kW/kVA |
| # M | Mechanical starting time (=2h) | 5.0 | kWs/kVA |
| S10 | 1st saturation factor | 0.0 | - |
| S12 | 2nd saturation factor | 0.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| * Td10 | D-axis transient time constant | 8.0 | s |
| * Td20 | D-axis subtrans. time constant | 0.04 | s |
| * Tq20 | Q-axis subtrans. time constant | 0.02 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| coi | Center of inertia id | 1 | - |
| gammap | Active power ratio at node | 1.0 | [0, 1] |
| gammaq | Reactive power ratio at node | 1.0 | [0, 1] |
| * gen | Static generator id | - | - |
| ra | Armature resistance | 0.0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| * xd | D-axis synchronous reactance | 1.9 | pu(Ohm) |
| * xd1 | D-axis transient reactance | 0.302 | pu(Ohm) |
| * xd2 | Q-axis subtransient reactance | 0.204 | pu(Ohm) |
| xl | Leakage reactance | 0.0 | pu(Ohm) |
| * xq | Q-axis synchronous reactance | 1.7 | pu(Ohm) |
| * xq1 | Q-axis transient reactance | 0.5 | - |
| * xq2 | D-axis subtransient reactance | 0.3 | s |

232. Device <Syn6a>

Sauer and Pai's 6th order synchronous machine model

| Parameter | Description | Default | Units |
|---|---|---|---|
| D | Rotor damping | 0.0 | kW/kVA |
| # M | Mechanical starting time (=2h) | 5.0 | kWs/kVA |
| S10 | 1st saturation factor | 0.0 | - |
| S12 | 2nd saturation factor | 0.0 | - |

| | | | |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| * Td10 | D-axis transient time constant | 8.0 | s |
| * Td20 | D-axis subtrans. time constant | 0.04 | s |
| * Tq10 | Q-axis transient time constant | 0.8 | s |
| * Tq20 | Q-axis subtrans. time constant | 0.02 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| coi | Center of inertia id | 1 | - |
| gammap | Active power ratio at node | 1.0 | [0, 1] |
| gammaq | Reactive power ratio at node | 1.0 | [0, 1] |
| * gen | Static generator id | - | - |
| ra | Armature resistance | 0.0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| * xd | D-axis synchronous reactance | 1.9 | pu(Ohm) |
| * xd1 | D-axis transient reactance | 0.302 | pu(Ohm) |
| * xd2 | Q-axis subtransient reactance | 0.204 | pu(Ohm) |
| xl | Leakage reactance | 0.0 | pu(Ohm) |
| * xq | Q-axis synchronous reactance | 1.7 | pu(Ohm) |
| * xq1 | Q-axis transient reactance | 0.5 | pu(Ohm) |
| * xq2 | D-axis subtransient reactance | 0.3 | pu(Ohm) |

233. Device <Syn6aw>

6th order synchronous machine model like <syn6a> but that takes into account the dependency on rotor speed in the flux algebraic equations

| Parameter | Description | Default | Units |
|---|---|---|---|
| D | Rotor damping | 0.0 | kW/kVA |
| # M | Mechanical starting time (=2h) | 5.0 | kWs/kVA |
| S10 | 1st saturation factor | 0.0 | - |
| S12 | 2nd saturation factor | 0.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| * Td10 | D-axis transient time constant | 8.0 | s |
| * Td20 | D-axis subtrans. time constant | 0.04 | s |
| * Tq10 | Q-axis transient time constant | 0.8 | s |
| * Tq20 | Q-axis subtrans. time constant | 0.02 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| coi | Center of inertia id | 1 | - |
| gammap | Active power ratio at node | 1.0 | [0, 1] |
| gammaq | Reactive power ratio at node | 1.0 | [0, 1] |
| * gen | Static generator id | - | - |
| ra | Armature resistance | 0.0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| * xd | D-axis synchronous reactance | 1.9 | pu(Ohm) |
| * xd1 | D-axis transient reactance | 0.302 | pu(Ohm) |

| | | | |
|---|---|---|---|
| * xd2 | Q-axis subtransient reactance | 0.204 | pu(Ohm) |
| xl | Leakage reactance | 0.0 | pu(Ohm) |
| * xq | Q-axis synchronous reactance | 1.7 | pu(Ohm) |
| * xq1 | Q-axis transient reactance | 0.5 | pu(Ohm) |
| * xq2 | D-axis subtransient reactance | 0.3 | pu(Ohm) |

234. Device <Syn6b>

Marconato's 6th order synchronous machine model

| Parameter | Description | Default | Units |
|---|---|---|---|
| D | Rotor damping | 0.0 | kW/kVA |
| # M | Mechanical starting time (=2h) | 5.0 | kWs/kVA |
| S10 | 1st saturation factor | 0.0 | - |
| S12 | 2nd saturation factor | 0.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| Taa | D-axis leakage time constant | 0.0 | s |
| * Td10 | D-axis transient time constant | 8.0 | s |
| * Td20 | D-axis subtrans. time constant | 0.04 | s |
| * Tq10 | Q-axis transient time constant | 0.8 | s |
| * Tq20 | Q-axis subtrans. time constant | 0.02 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| coi | Center of inertia id | 1 | - |
| corr | Use marconato's model | 0.0 | bool |
| gammap | Active power ratio at node | 1.0 | [0, 1] |
| gammaq | Reactive power ratio at node | 1.0 | [0, 1] |
| * gen | Static generator id | - | - |
| ra | Armature resistance | 0.0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| * xd | D-axis synchronous reactance | 1.9 | pu(Ohm) |
| * xd1 | D-axis transient reactance | 0.302 | pu(Ohm) |
| * xd2 | Q-axis subtransient reactance | 0.204 | pu(Ohm) |
| xl | Leakage reactance | 0.0 | pu(Ohm) |
| * xq | Q-axis synchronous reactance | 1.7 | pu(Ohm) |
| * xq1 | Q-axis transient reactance | 0.5 | pu(Ohm) |
| * xq2 | D-axis subtransient reactance | 0.3 | pu(Ohm) |

235. Device <Syn6bw>

6th order synchronous machine model like <syn6b> but that takes
into account the dependency on rotor speed in the flux algebraic
equations

| Parameter | Description | Default | Units |
|---|---|---|---|

| | | | |
|---|---|---|---|
| D | Rotor damping | 0.0 | kW/kVA |
| # M | Mechanical starting time (=2h) | 5.0 | kWs/kVA |
| S10 | 1st saturation factor | 0.0 | - |
| S12 | 2nd saturation factor | 0.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| Taa | D-axis leakage time constant | 0.0 | s |
| * Td10 | D-axis transient time constant | 8.0 | s |
| * Td20 | D-axis subtrans. time constant | 0.04 | s |
| * Tq10 | Q-axis transient time constant | 0.8 | s |
| * Tq20 | Q-axis subtrans. time constant | 0.02 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| coi | Center of inertia id | 1 | - |
| corr | Use marconato's model | 0.0 | bool |
| gammap | Active power ratio at node | 1.0 | [0, 1] |
| gammaq | Reactive power ratio at node | 1.0 | [0, 1] |
| * gen | Static generator id | - | - |
| ra | Armature resistance | 0.0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| * xd | D-axis synchronous reactance | 1.9 | pu(Ohm) |
| * xd1 | D-axis transient reactance | 0.302 | pu(Ohm) |
| * xd2 | Q-axis subtransient reactance | 0.204 | pu(Ohm) |
| xl | Leakage reactance | 0.0 | pu(Ohm) |
| * xq | Q-axis synchronous reactance | 1.7 | pu(Ohm) |
| * xq1 | Q-axis transient reactance | 0.5 | pu(Ohm) |
| * xq2 | D-axis subtransient reactance | 0.3 | pu(Ohm) |

236. Device <Syn8a>

Sauer and Pai's 8th order synchronous machine model (no saturations)

| Parameter | Description | Default | Units |
|---|---|---|---|
| D | Rotor damping | 0.0 | kW/kVA |
| # M | Mechanical starting time (=2h) | 5.0 | kWs/kVA |
| S10 | 1st saturation factor | 0.0 | - |
| S12 | 2nd saturation factor | 0.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| * Td10 | D-axis transient time constant | 8.0 | s |
| * Td20 | D-axis subtrans. time constant | 0.04 | s |
| * Tq10 | Q-axis transient time constant | 0.8 | s |
| * Tq20 | Q-axis subtrans. time constant | 0.02 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| coi | Center of inertia id | 1 | - |
| gammap | Active power ratio at node | 1.0 | [0, 1] |
| gammaq | Reactive power ratio at node | 1.0 | [0, 1] |

| | | | |
|---|---|---|---|
| * gen | Static generator id | - | - |
| ra | Armature resistance | 0.0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| * xd | D-axis synchronous reactance | 1.9 | pu(Ohm) |
| * xd1 | D-axis transient reactance | 0.302 | pu(Ohm) |
| * xd2 | Q-axis subtransient reactance | 0.204 | pu(Ohm) |
| xl | Leakage reactance | 0.0 | pu(Ohm) |
| * xq | Q-axis synchronous reactance | 1.7 | pu(Ohm) |
| * xq1 | Q-axis transient reactance | 0.5 | pu(Ohm) |
| * xq2 | D-axis subtransient reactance | 0.3 | pu(Ohm) |

237. Device <Syn8b>

Marconato's 8th order synchronous machine model

| Parameter | Description | Default | Units |
|---|---|---|---|
| D | Rotor damping | 0.0 | kW/kVA |
| # M | Mechanical starting time (=2h) | 5.0 | kWs/kVA |
| S10 | 1st saturation factor | 0.0 | - |
| S12 | 2nd saturation factor | 0.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| Taa | D-axis leakage time constant | 0.0 | s |
| * Td10 | D-axis transient time constant | 8.0 | s |
| * Td20 | D-axis subtrans. time constant | 0.04 | s |
| * Tq10 | Q-axis transient time constant | 0.8 | s |
| * Tq20 | Q-axis subtrans. time constant | 0.02 | s |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| coi | Center of inertia id | 1 | - |
| corr | Use marconato's model | 0.0 | bool |
| gammap | Active power ratio at node | 1.0 | [0, 1] |
| gammaq | Reactive power ratio at node | 1.0 | [0, 1] |
| * gen | Static generator id | - | - |
| ra | Armature resistance | 0.0 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| * xd | D-axis synchronous reactance | 1.9 | pu(Ohm) |
| * xd1 | D-axis transient reactance | 0.302 | pu(Ohm) |
| * xd2 | Q-axis subtransient reactance | 0.204 | pu(Ohm) |
| xl | Leakage reactance | 0.0 | pu(Ohm) |
| * xq | Q-axis synchronous reactance | 1.7 | pu(Ohm) |
| * xq1 | Q-axis transient reactance | 0.5 | pu(Ohm) |
| * xq2 | D-axis subtransient reactance | 0.3 | pu(Ohm) |

238. Device <Synem>

Compact classical model of synchronous machines

| Parameter | Description | Default | Units |
|---|---|---|---|
| D | Damping coefficient | 0.0 | kW/kVA |
| # M | Inertia constant | 5.0 | kWs/kVA |
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| fn | Frequency rate | 60.0 | Hz |
| * gen | Index of the static generator | - | - |
| u | Connection status | 1.0 | bool |
| # xd1 | Transient reactance | 2.0 | pu(Ohm) |

239. Device <Tap1>

Tap changer with embedded load.
This component is initialized during power flow analysis.

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| ap | P voltage exponent | 2.0 | - |
| aq | Q voltage exponent | 2.0 | - |
| * bus | Bus id | - | - |
| h | Integral deviation | 0.0 | pu |
| k | Inverse time constant | 0.1 | 1/s |
| mmax | Maximum tap ratio | 1.2 | pu/pu |
| mmin | Minimum tap ratio | 0.8 | pu/pu |
| p0 | Load active power | 0.0 | pu |
| q0 | Load reactive power | 0.0 | pu |
| u | Connection status | 1.0 | bool |
| # vref | Reference voltage | 1.0 | pu |

240. Device <Tap2>

Tap changer with embedded load.
This component is initialized after power flow analysis.

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| ap | P voltage exponent | 2.0 | - |
| aq | Q voltage exponent | 2.0 | - |

| | | | |
|---|---|---|---|
| * bus | Bus id | - | - |
| h | Integral deviation | 0.0 | pu |
| # k | Inverse time constant | 0.1 | 1/s |
| kp | Active power percentage | 0.0 | % |
| kq | Reactive power percentage | 0.0 | % |
| mmax | Maximum tap ratio | 1.2 | pu/pu |
| mmin | Minimum tap ratio | 0.8 | pu/pu |
| * pqid | Pq load id | - | - |
| u | Connection status | 1.0 | bool |

241. Device <Tcsc1>

Class for Thyristor Compensated Switched Capacitor (xc model)

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ki | Integral regulator gain | 10.0 | - |
| Kp | Proportional regulator gain | 50.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| Tr | Regulator time constant | 0.01 | s |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| b | Total shunt susceptance | 0.0 | pu(1/Ohm) |
| b1 | From bus shunt susceptance | 0.0 | pu(1/Ohm) |
| b2 | To bus shunt susceptance | 0.0 | pu(1/Ohm) |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| g | Total shunt conductance | 0.0 | pu(1/Ohm) |
| g1 | From bus shunt conductance | 0.0 | pu(1/Ohm) |
| g2 | To bus shunt conductance | 0.0 | pu(1/Ohm) |
| imax | Maximum current | 999.9 | pu(kA) |
| phases | Number of phases (1 or 3) | 3 | int |
| pmax | Maximum active power | 999.9 | pu(MW) |
| pref | Desired active power flow | 0.0 | pu(MW) |
| r | Series resistance | 0.0 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| # x | Initial reactance guess | 1e-05 | pu(Ohm) |
| xmax | Maximum compensation reactance | 0.5 | pu(Ohm) |
| xmin | Minimum compensation reactance | -0.5 | pu(Ohm) |

242. Device <Tcsc2>

Class for Thyristor Compensated Switched Capacitor (alpha model)

---

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ki | Integral regulator gain | 10.0 | - |
| Kp | Proportional regulator gain | 50.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| Tr | Regulator time constant | 0.01 | s |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| b | Total shunt susceptance | 0.0 | pu(1/Ohm) |
| b1 | From bus shunt susceptance | 0.0 | pu(1/Ohm) |
| b2 | To bus shunt susceptance | 0.0 | pu(1/Ohm) |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| g | Total shunt conductance | 0.0 | pu(1/Ohm) |
| g1 | From bus shunt conductance | 0.0 | pu(1/Ohm) |
| g2 | To bus shunt conductance | 0.0 | pu(1/Ohm) |
| imax | Maximum current | 999.9 | pu(kA) |
| phases | Number of phases (1 or 3) | 3 | int |
| pmax | Maximum active power | 999.9 | pu(MW) |
| pref | Desired active power flow | 0.0 | pu(MW) |
| r | Series resistance | 0.0 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| # x | Initial reactance guess | 1e-05 | pu(Ohm) |
| xC | Capacitive reactance | 0.04 | pu(Ohm) |
| # xL | Inductive reactance | 0.02 | pu(Ohm) |
| xmax | Maximum firing angle | 3.14159 | rad |
| xmin | Minimum firing angle | -3.14159 | rad |

243. Device <TcscLine>

Static TCSC device for imposing a desired active power
flow in a lossless transmission line

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| b | Total shunt susceptance | 0.0 | pu(1/Ohm) |
| b0 | Initial susceptance guess | 0.0 | pu(1/Ohm) |
| b1 | From bus shunt susceptance | 0.0 | pu(1/Ohm) |
| b2 | To bus shunt susceptance | 0.0 | pu(1/Ohm) |
| bmax | Maximum susceptance value | 100 | pu(1/Ohm) |
| bmin | Minimum susceptance value | -100 | pu(1/Ohm) |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |

| | | | |
|---|---|---|---|
| circuit | Circuit number or id | 1 | int |
| imax | Maximum current | 999.9 | pu(kA) |
| phases | Number of phases (1 or 3) | 3 | int |
| pmax | Maximum active power | 999.9 | pu(MW) |
| pref | Desired active power flow | 0.0 | pu(MW) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| # x | Series reactance | 1e-05 | pu(Ohm) |

244. Device <Tg1>

TG type 1

| Parameter | Description | Default | Units |
|---|---|---|---|
| # R | Droop | 0.05 | pu(MW) |
| T3 | Transient gain time constant | 0.0 | s |
| T4 | Power fraction time constant | 12.0 | s |
| * T5 | Reheat time constant | 50.0 | s |
| * Tc | Servo time constant | 0.45 | s |
| * Ts | Governor time constant | 0.1 | s |
| agc | Automatic generator control id | - | - |
| pmax | Maximum output power | 1.5 | pu(MW) |
| pmin | Minimum output power | 0.0 | pu(MW) |
| * syn | Synchronous machine id | - | - |
| u | Connection status | 1.0 | bool |
| wref0 | Refrence rotor speed | 1.0 | pu(Hz) |

245. Device <Tg2>

TG type 2

| Parameter | Description | Default | Units |
|---|---|---|---|
| # R | Droop | 0.05 | pu(MW) |
| T1 | Transient gain time constant | 0.2 | s |
| * T2 | Governor time constant | 10.0 | s |
| agc | Automatic generator control id | - | - |
| pmax | Maximum output power | 1.5 | pu(MW) |
| pmin | Minimum output power | 0.0 | pu(MW) |
| * syn | Synchronous machine id | - | - |
| u | Connection status | 1.0 | bool |
| wref0 | Refrence rotor speed | 1.0 | pu(Hz) |

246. Device <Thl>

Thermostatically controlled load. The load can model both heating and cooling systems.

| Parameter | Description | Default | Units |
|---|---|---|---|
| KL | Ceiling conductance | 2.0 | - |
| Ki | Integral gain | 25.0 | - |
| Kp | Propotional gain | 100.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| # T1 | Thermal load time constant | 1200.0 | s |
| Ta | Ambient temperature | 293.0 | K |
| # Ti | Integral time constant | 10.0 | s |
| Tref0 | Reference temperature | 293.0 | K |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| kp | Active power percentage | 0.0 | % |
| * pqid | Pq load id | - | - |
| u | Connection status | 1.0 | bool |

247. Device <ThlBus>

Thermostatically controlled load with bus frequency control. The load can model both heating and cooling systems.

| Parameter | Description | Default | Units |
|---|---|---|---|
| KL | Ceiling conductance | 2.0 | - |
| Kf | Gain of the frequency controller | 10 | - |
| Ki | Integral gain | 25.0 | - |
| Kp | Propotional gain | 100.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| # T1 | Thermal load time constant | 1200.0 | s |
| Ta | Ambient temperature | 293.0 | K |
| # Tf | Time constant of the frequency controller | 5 | s |
| # Ti | Integral time constant | 10.0 | s |
| Tmax | Maximum load temperature | 273.15 | K |
| Tmin | Minimum load temperature | 263.15 | K |
| Tref0 | Initial reference temperature | 268.15 | K |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| * busf | <busfreq> device id | - | - |
| kp | Active power percentage | 0.0 | % |
| * pqid | Pq load id | - | - |
| u | Connection status | 1.0 | bool |

248. Device <ThlCoi>

Thermostatically controlled load with COI frequency
control. The load can model both heating and cooling systems.

| Parameter | Description | Default | Units |
|---|---|---|---|
| KL | Ceiling conductance | 2.0 | - |
| Kf | Gain of the frequency controller | 10 | - |
| Ki | Integral gain | 25.0 | - |
| Kp | Propotional gain | 100.0 | - |
| # Sn | Power rate | 100.0 | MVA |
| # T1 | Thermal load time constant | 1200.0 | s |
| Ta | Ambient temperature | 293.0 | K |
| # Tf | Time constant of the frequency controller | 5 | s |
| # Ti | Integral time constant | 10.0 | s |
| Tmax | Maximum load temperature | 273.15 | K |
| Tmin | Minimum load temperature | 263.15 | K |
| Tref0 | Initial reference temperature | 268.15 | K |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| * coi | Coi id | 1 | - |
| kp | Active power percentage | 0.0 | % |
| * pqid | Pq load id | - | - |
| u | Connection status | 1.0 | bool |

249. Device <TieLine>

Static device for imposing a desired active power
flow in a transmission line

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| b | Total shunt susceptance | 0.0 | pu(1/Ohm) |
| b1 | From bus shunt susceptance | 0.0 | pu(1/Ohm) |
| b2 | To bus shunt susceptance | 0.0 | pu(1/Ohm) |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| g | Total shunt conductance | 0.0 | pu(1/Ohm) |

| | | | |
|---|---|---|---|
| g1 | From bus shunt conductance | 0.0 | pu(1/Ohm) |
| g2 | To bus shunt conductance | 0.0 | pu(1/Ohm) |
| imax | Maximum current | 999.9 | pu(kA) |
| phases | Number of phases (1 or 3) | 3 | int |
| pmax | Maximum active power | 999.9 | pu(MW) |
| pref | Desired active power flow | 0.0 | pu(MW) |
| r | Series resistance | 0.0 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| # x | Initial reactance guess | 1e-05 | pu(Ohm) |
| xmax | Maximum reactance value | 100 | pu(Ohm) |
| xmin | Minimum reactance value | -100 | pu(Ohm) |

250. Device <TransfCoup>

Transformer that allows coupling areas having different power bases. The power bases of the primary and secondary windings are grabbed from bus data.

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| b | Total shunt susceptance | 0.0 | pu(1/Ohm) |
| b1 | From bus shunt susceptance | 0.0 | pu(1/Ohm) |
| b2 | To bus shunt susceptance | 0.0 | pu(1/Ohm) |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| g | Total shunt conductance | 0.0 | pu(1/Ohm) |
| g1 | From bus shunt conductance | 0.0 | pu(1/Ohm) |
| g2 | To bus shunt conductance | 0.0 | pu(1/Ohm) |
| imax | Maximum current | 999.9 | pu(kA) |
| phases | Number of phases (1 or 3) | 3 | int |
| pmax | Maximum active power | 999.9 | pu(MW) |
| r | Series resistance | 0.0 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| # x | Series reactance | 1e-05 | pu(Ohm) |

251. Device <Trasf3a>

three-winding transformer class

| Parameter | Description | Default | Units |
|---|---|---|---|

| | | | |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | 1st winding voltage rate | 220.0 | kV |
| Vn2 | 2nd winding voltage rate | 66.0 | kV |
| Vn3 | Terziary winding voltage rate | 15.0 | kV |
| bmu | Magnetizing susceptance | 0.0 | pu(1/Ohm) |
| * bus1 | Bus of 1st winding | - | - |
| * bus2 | Bus of 2nd winding | - | - |
| * bus3 | Bus of terziary winding | - | - |
| circuit | Circuit number or id | 1 | int |
| gfe | Iron losses (conductance) | 0.0 | pu(1/Ohm) |
| imax1 | 1st winding max. current | 0.0 | pu(kA) |
| imax2 | 2nd winding max. current | 0.0 | pu(kA) |
| imax3 | 3rd winding max. current | 0.0 | pu(kA) |
| phi1 | Phase shift of 1st winding | 0.0 | deg |
| phi2 | Phase shift of 2nd winding | 0.0 | deg |
| phi3 | Phase shift of 3rd winding | 0.0 | deg |
| pmax1 | 1st winding max. active power | 0.0 | pu(MW) |
| pmax2 | 2nd winding max. active power | 0.0 | pu(MW) |
| pmax3 | 3rd winding max. active power | 0.0 | pu(MW) |
| r1 | 1st winding resistance | 0.0 | pu(Ohm) |
| r2 | 2nd winding resistance | 0.0 | pu(Ohm) |
| r3 | 3rd winding resistance | 0.0 | pu(Ohm) |
| smax1 | 1st winding max. app. power | 0.0 | pu(MVA) |
| smax2 | 2nd winding max. app. power | 0.0 | pu(MVA) |
| smax3 | 3rd winding max. app. power | 0.0 | pu(MVA) |
| tap1 | Tap ratio of 1st winding | 1.0 | - |
| tap2 | Tap ratio of 2nd winding | 1.0 | - |
| tap3 | Tap ratio of 3rd winding | 1.0 | - |
| u | Connection status | 1.0 | bool |
| x1 | 1st winding reactance | 1e-05 | pu(Ohm) |
| x2 | 2nd winding reactance | 1e-05 | pu(Ohm) |
| x3 | 3rd winding reactance | 1e-05 | pu(Ohm) |

252. Device <Trasf3b>

three-winding transformer class

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | 1st winding voltage rate | 220.0 | kV |
| Vn2 | 2nd winding voltage rate | 66.0 | kV |
| Vn3 | Terziary winding voltage rate | 15.0 | kV |
| bmu | Magnetizing susceptance | 0.0 | pu(1/Ohm) |
| * bus1 | Bus of 1st winding | - | - |
| * bus2 | Bus of 2nd winding | - | - |
| * bus3 | Bus of terziary winding | - | - |
| circuit | Circuit number or id | 1 | int |

| | | | |
|---|---|---|---|
| gfe | Iron losses (conductance) | 0.0 | pu(1/Ohm) |
| imax1 | 1st winding max. current | 0.0 | pu(kA) |
| imax2 | 2nd winding max. current | 0.0 | pu(kA) |
| imax3 | 3rd winding max. current | 0.0 | pu(kA) |
| phi1 | Phase shift of 1st winding | 0.0 | deg |
| phi2 | Phase shift of 2nd winding | 0.0 | deg |
| phi3 | Phase shift of 3rd winding | 0.0 | deg |
| pmax1 | 1st winding max. active power | 0.0 | pu(MW) |
| pmax2 | 2nd winding max. active power | 0.0 | pu(MW) |
| pmax3 | 3rd winding max. active power | 0.0 | pu(MW) |
| r12 | 1st-2nd winding resistance | 0.0 | pu(Ohm) |
| r13 | 1st-3rd winding resistance | 0.0 | pu(Ohm) |
| r23 | 2nd-3rd winding resistance | 0.0 | pu(Ohm) |
| smax1 | 1st winding max. app. power | 0.0 | pu(MVA) |
| smax2 | 2nd winding max. app. power | 0.0 | pu(MVA) |
| smax3 | 3rd winding max. app. power | 0.0 | pu(MVA) |
| tap1 | Tap ratio of 1st winding | 1.0 | - |
| tap2 | Tap ratio of 2nd winding | 1.0 | - |
| tap3 | Tap ratio of 3rd winding | 1.0 | - |
| u | Connection status | 1.0 | bool |
| x12 | 1st-2nd winding reactance | 1e-05 | pu(Ohm) |
| x13 | 1st-3rd winding reactance | 1e-05 | pu(Ohm) |
| x23 | 2nd-3rd winding reactance | 1e-05 | pu(Ohm) |

253. Device <TrasfD>

Distribution transformer

| Parameter | Description | Default | Units |
|---|---|---|---|
| Imax | Primary winding maximum current limit (=in, if it is not defined) | - | A |
| * Sn | Power rate | 50.0 | kVA |
| * Vn | Primary winding voltage rate | 20.0 | kV |
| Vn2 | Secondary winding voltage rate | 0.4 | kV |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number | 1 | int |
| phases | Number of phases (1 or 3) | 3 | int |
| u | Connection status | 1.0 | bool |
| vcc | Short circuit voltage | 7.0 | % |
| vccr | Resistive short circuit voltage | 0.0 | % |

254. Device <Tree>

A <Tree> defines a set of loads (in particular, EV chargers) pertaining to the same tree and a common feeding distribution line or transformer. This device is used in ACS routine to define a 'fair' admission control strategy that allows all loads to be admitted, possibly at a lower power rate than that initially requested.

| Parameter | Description | Default | Units |
|---|---|---|---|
| * line | Id of the line ancestor where to apply the "fair" acs rule | - | - |
| u | Connection status | 1.0 | bool |

255. Device <TreeDisp>

This device defines some tree indicators and quantities useful to evaluate the 'quality' of the admission control strategy

| Parameter | Description | Default | Units |
|---|---|---|---|
| * tree | Tree id | - | - |
| u | Connection status | 1.0 | bool |

256. Device <Tuning>

Class for customizing Dome settings through the input data file
The device itself is void and does not define anything. It is just an interface for modifying default Dome settings. This device accepts any attribute of Dome settings. Note that this device overwrites any settings passed through the -s ommand line option as well as the .domerc settings.

| Parameter | Description | Default | Units |
|---|---|---|---|
| * setting | Name of the settings class to be customized | - | - |
| u | Status | 1.0 | bool |

257. Device <UPFC_control>

Base class for the UPFC controller

| Parameter | Description | Default | Units |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Kmi | Voltage control gain | 10.0 | - |
| Kp1 | Proportional gain of the pi controller of vpj | 10.0 | - |
| Kp2 | Proportional gain of the pi controller of vqj | 10.0 | - |
| # Ti1 | Time constant of the pi controller of vpj | 0.01 | s |
| # Ti2 | Time constant of the pi controller of vqj | 0.01 | s |
| # Tm1 | Lag time constant of the vpj controller | 0.01 | s |
| # Tm2 | Lag time constant of the vqj controller | 0.01 | s |
| # Tmi | Voltage control time constant | 0.01 | s |
| u | Connection status | 1.0 | bool |
| * upfc | Upfc id | - | - |

258. Device <Uel1>

Under-excitation limiter (UEL) simple straigth line characteristic

| Parameter | Description | Default | Units |
|---|---|---|---|
| Kc | Coefficient for the actual operation point | 1.38 | - |
| Ki | Integral gain | 5.0 | - |
| Kp | Parameter | 10.0 | proportional gain |
| Kr | Coefficient for the uel boundary | 1.95 | - |
| T1 | 1st zero of uel regulator | 0.01 | s |
| # T2 | 1st pole of uel regulator | 0.1 | s |
| T3 | 2nd zero of uel regulator | 0.05 | s |
| # T4 | 2nd pole of uel regulator | 1.0 | s |
| * avr | Avr id | - | - |
| u | Connection status | 1.0 | bool |
| vmax | Maximum output signal | 0.2 | pu(kV) |
| vmin | Minimum output signal | -0.2 | pu(kV) |

259. Device <Uel2>

Under-excitation limiter (UEL) simple straight line characteristic

| Parameter | Description | Default | Units |
|---|---|---|---|
| Ki | Integral gain | 5.0 | - |
| Kp | Parameter | 10.0 | proportional gain |

| | | | |
|---|---|---|---|
| T1 | 1st zero of uel regulator | 0.01 | s |
| # T2 | 1st pole of uel regulator | 0.1 | s |
| T3 | 2nd zero of uel regulator | 0.05 | s |
| # T4 | 2nd pole of uel regulator | 1.0 | s |
| * avr | Avr id | - | - |
| beta | Slope of the uel operational region | 0.15 | - |
| q0 | Under-excitation reactive power limit | 0.4 | pu(MVAr) |
| u | Connection status | 1.0 | bool |
| vmax | Maximum output signal | 0.2 | pu(kV) |
| vmin | Minimum output signal | -0.2 | pu(kV) |

260. Device <Ultc1>

ULTC with voltage control and hybrid discrete-continuous model

| Parameter | Description | Default | Units |
|---|---|---|---|
| H | Regulator integral deviation | 0.02 | - |
| K | Inverse time constant | 0.1 | 1/s |
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| bmu | Magnetizing susceptance | 0.0 | pu(1/Ohm) |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| busr | Controlled voltage bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| d | Dead band percentage | 5 | %(kV) |
| gfe | Iron losses (conductance) | 0.0 | pu(1/Ohm) |
| imax | Maximum current | 999.9 | pu(kA) |
| m0 | Tap ratio initial guess | 1.0 | - |
| mmax | Maximum tap ratio | 1.2 | - |
| mmin | Minimum tap ratio | 0.8 | - |
| mstep | Tap ratio step | 0.0 | - |
| phases | Number of phases (1 or 3) | 3 | int |
| phi | Fixed phase shift | 0.0 | deg |
| pmax | Maximum active power | 999.9 | pu(MW) |
| rt | Transformer resistance | 0.0 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| vref | Voltage reference | 1.0 | pu(kV) |
| xt | Transform reactance | 0.1 | pu(Ohm) |

261. Device <Ultc2>

ULTC with reactive power control

| Parameter | Description | Default | Units |
|---|---|---|---|
| H | Regulator integral deviation | 0.02 | - |
| K | Inverse time constant | 0.1 | 1/s |
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| bmu | Magnetizing susceptance | 0.0 | pu(1/Ohm) |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| d | Dead band percentage | 5 | %(kV) |
| gfe | Iron losses (conductance) | 0.0 | pu(1/Ohm) |
| imax | Maximum current | 999.9 | pu(kA) |
| m0 | Tap ratio initial guess | 1.0 | - |
| mmax | Maximum tap ratio | 1.2 | - |
| mmin | Minimum tap ratio | 0.8 | - |
| mstep | Tap ratio step | 0.0 | - |
| phases | Number of phases (1 or 3) | 3 | int |
| phi | Fixed phase shift | 0.0 | deg |
| pmax | Maximum active power | 999.9 | pu(MW) |
| * qref | Reactive power reference | 1.0 | pu(MVAr) |
| rt | Transformer resistance | 0.0 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| xt | Transform reactance | 0.1 | pu(Ohm) |

262. Device <Ultc3>

Discrete under load tap changer model

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| bmu | Magnetizing susceptance | 0.0 | pu(1/Ohm) |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| busr | Controlled bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| d | Dead band percentage | 5 | %(kV) |
| gfe | Iron losses (conductance) | 0.0 | pu(1/Ohm) |
| imax | Maximum current | 999.9 | pu(kA) |
| mmax | Maximum tap ratio | 1.2 | - |

| | | | |
|---|---|---|---|
| mmin | Minimum tap ratio | 0.8 | - |
| mstep | Tap ratio step | 0.0 | - |
| phases | Number of phases (1 or 3) | 3 | int |
| phi | Fixed phase shift | 0.0 | deg |
| pmax | Maximum active power | 999.9 | pu(MW) |
| rt | Transformer resistance | 0.0 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| tau | Tap time delay | 5.0 | s |
| u | Connection status | 1.0 | bool |
| vref | Reference voltage | 1.0 | pu(kV) |
| xt | Transform reactance | 0.1 | pu(Ohm) |

263. Device <Ultc3a>

Discrete under load tap changer model with variable time delay.
The time delay depends on the dead band and the voltage error, as follows:
tau = tau0 * dz / abs(Vref - Vcon)

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| bmu | Magnetizing susceptance | 0.0 | pu(1/Ohm) |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| busr | Controlled bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| d | Dead band percentage | 5 | %(kV) |
| gfe | Iron losses (conductance) | 0.0 | pu(1/Ohm) |
| imax | Maximum current | 999.9 | pu(kA) |
| mmax | Maximum tap ratio | 1.2 | - |
| mmin | Minimum tap ratio | 0.8 | - |
| mstep | Tap ratio step | 0.0 | - |
| phases | Number of phases (1 or 3) | 3 | int |
| phi | Fixed phase shift | 0.0 | deg |
| pmax | Maximum active power | 999.9 | pu(MW) |
| rt | Transformer resistance | 0.0 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| tau | Tap time delay | 5.0 | s |
| u | Connection status | 1.0 | bool |
| vref | Reference voltage | 1.0 | pu(kV) |
| xt | Transform reactance | 0.1 | pu(Ohm) |

264. Device <Ultc4>

Discrete under load tap changer model. The voltage is kept between vmax and vmin

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| bmu | Magnetizing susceptance | 0.0 | pu(1/Ohm) |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| busr | Controlled bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| d | Dead band percentage | 5 | %(kV) |
| gfe | Iron losses (conductance) | 0.0 | pu(1/Ohm) |
| imax | Maximum current | 999.9 | pu(kA) |
| mmax | Maximum tap ratio | 1.2 | - |
| mmin | Minimum tap ratio | 0.8 | - |
| mstep | Tap ratio step | 0.0 | - |
| phases | Number of phases (1 or 3) | 3 | int |
| phi | Fixed phase shift | 0.0 | deg |
| pmax | Maximum active power | 999.9 | pu(MW) |
| rt | Transformer resistance | 0.0 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| tau | Tap time delay | 5.0 | s |
| u | Connection status | 1.0 | bool |
| vmax | Max voltage at controlled bus | 1.1 | pu(kV) |
| vmin | Min voltage at controlled bus | 0.9 | pu(kV) |
| xt | Transform reactance | 0.1 | pu(Ohm) |

265. Device <UltcPhs1>

Under load tap changer with voltage control and phase shifting transformer

| Parameter | Description | Default | Units |
|---|---|---|---|
| H | Regulator integral deviation | 0.02 | - |
| K | Inverse time constant | 0.1 | 1/s |
| Ka | Integral deviation gain | 1e-05 | - |
| Ki | Integral gain | 10 | - |
| Kp | Proportional gain | 50 | - |
| # Sn | Power rate | 100.0 | MVA |
| # Tm | Measurement time constant | 0.01 | s |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| a0 | Phase shift initial guess | 0.0 | deg |
| amax | Maximum phase angle | 180.0 | deg |
| amin | Minimum phase angle | -180.0 | deg |
| bmu | Magnetizing susceptance | 0.0 | pu(1/Ohm) |

| | | | |
|---|---|---|---|
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| busr | Controlled voltage bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| d | Dead band percentage | 5 | %(kV) |
| gfe | Iron losses (conductance) | 0.0 | pu(1/Ohm) |
| imax | Maximum current | 999.9 | pu(kA) |
| m0 | Tap ratio initial guess | 1.0 | - |
| mmax | Maximum tap ratio | 1.2 | - |
| mmin | Minimum tap ratio | 0.8 | - |
| mstep | Tap ratio step | 0.0 | - |
| phases | Number of phases (1 or 3) | 3 | int |
| phi | Fixed phase shift | 0.0 | deg |
| pmax | Maximum active power | 999.9 | pu(MW) |
| pref | Reference active power | 1.0 | pu(kW) |
| rt | Transformer resistance | 0.0 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| vref | Voltage reference | 1.0 | pu(kV) |
| xt | Transform reactance | 0.1 | pu(Ohm) |

266. Device <UltcPhs2>

Under load tap changer with reactive power control and phase shifting transformer

| Parameter | Description | Default | Units |
|---|---|---|---|
| H | Regulator integral deviation | 0.02 | - |
| K | Inverse time constant | 0.1 | 1/s |
| Ka | Integral deviation gain | 1e-05 | - |
| Ki | Integral gain | 10 | - |
| Kp | Proportional gain | 50 | - |
| # Sn | Power rate | 100.0 | MVA |
| # Tm | Measurement time constant | 0.01 | s |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| a0 | Phase shift initial guess | 0.0 | deg |
| amax | Maximum phase angle | 180.0 | deg |
| amin | Minimum phase angle | -180.0 | deg |
| bmu | Magnetizing susceptance | 0.0 | pu(1/Ohm) |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| d | Dead band percentage | 5 | %(kV) |
| gfe | Iron losses (conductance) | 0.0 | pu(1/Ohm) |
| imax | Maximum current | 999.9 | pu(kA) |
| m0 | Tap ratio initial guess | 1.0 | - |
| mmax | Maximum tap ratio | 1.2 | - |

| | | | |
|---|---|---|---|
| mmin | Minimum tap ratio | 0.8 | - |
| mstep | Tap ratio step | 0.0 | - |
| phases | Number of phases (1 or 3) | 3 | int |
| phi | Fixed phase shift | 0.0 | deg |
| pmax | Maximum active power | 999.9 | pu(MW) |
| pref | Reference active power | 1.0 | pu(kW) |
| * qref | Reactive power reference | 1.0 | pu(MVAr) |
| rt | Transformer resistance | 0.0 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| xt | Transform reactance | 0.1 | pu(Ohm) |

267. Device <Upfc>

Base class for the static UPFC

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus1 | Bus i id | - | - |
| * bus2 | Bus j id | - | - |
| imax | Maximum current | 999.9 | pu(kA) |
| iqimax | Maximum shunt current | 0.2 | pu(kA) |
| iqimin | Minimum shunt current | -0.2 | pu(kA) |
| pmax | Maximum active power | 999.9 | pu(MW) |
| * prefj | Reference active power injected at bus j | 0.0 | pu(MW) |
| * qrefj | Reference reactive power injected at bus j | 0.0 | pu(MVAr) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| vpjmax | Maximum quadrature voltage for the series compensation of branch i-j | 0.1 | pu(kV) |
| vpjmin | Minimum quadrature voltage for the series compensation of branch i-j | -0.1 | pu(kV) |
| vqjmax | Maximum direct voltage for the series compensation of branch i-j | 0.1 | pu(kV) |
| vqjmin | Minimum direct voltage for the series compensation of branch i-j | -0.1 | pu(kV) |
| vrefi | Reference voltage of the shunt control | 1.0 | pu(kV) |
| # xij | Series reactance of the branch i-j | 0.01 | pu(Ohm) |

268. Device <VDL1>

Voltage dependent (monomial) load class

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| ap | Active power exponent | 2.0 | - |
| aq | Reactive power exponent | 2.0 | - |
| * bus | Bus id | - | - |
| p0 | Active power | 0.0 | pu(MW) |
| q0 | Reactive power | 0.0 | pu(MVAr) |
| u | Connection status | 1.0 | bool |

269. Device <VDL2>

Voltage dependent (monomial) load class
This component is initialized after power flow

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| ap | Active power exponent | 2.0 | - |
| aq | Reactive power exponent | 2.0 | - |
| * bus | Bus id | - | - |
| kp | Active power rate | 0.0 | %(MW) |
| kq | Reactive power rate | 0.0 | %(MVAr) |
| * pqid | Pq load id | - | - |
| u | Connection status | 1.0 | bool |

270. Device <VDL2ph>

Two-phase voltage dependent (monomial) load

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| ap | Active power exponent | 2.0 | - |
| aq | Reactive power exponent | 2.0 | - |
| * bus1 | Terminal 1 bus id | - | - |

| Parameter | Description | Default | Units |
|---|---|---|---|
| * bus2 | Terminal 2 bus id | - | - |
| p0 | Active power | 0.0 | pu(MW) |
| q0 | Reactive power | 0.0 | pu(MVAr) |
| u | Connection status | 1.0 | bool |

271. Device <VDLD>

Distribution voltage dependent load

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power at nominal voltage | 0.0 | kW |
| # Vn | Voltage rate | 20.0 | kV |
| ap | Active power exponent | 0.0 | - |
| aq | Reactive power exponent | 0.0 | - |
| * bus | Bus id | - | - |
| pf | Nominal power factor (negative for capacitive loads) | 1.0 | - |
| plevel | Priority level (for the acs routine) | 0 | int |
| u | Connection status | 1.0 | bool |

272. Device <VDLcycle>

Voltage dependent load with cyclic sinusoidal time variation

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| ap | Active power exponent | 2.0 | - |
| aq | Reactive power exponent | 2.0 | - |
| * bus | Bus id | - | - |
| pamp | Active power cycle amplitude | 1.0 | %(MW) |
| pfre | Frequency of active power cycle | 1.0 | Hz |
| * pqid | Pq load id | - | - |
| qamp | Reactive power cycle amplitude | 1.0 | %(MVAr) |
| qfre | Frequency of reactive power cycle | 1.0 | Hz |
| u | Connection status | 1.0 | bool |

273. Device <VDLdyn>

Voltage dependent load with time ramps

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| ap | Active power exponent | 2.0 | - |
| aq | Reactive power exponent | 2.0 | - |
| * bus | Bus id | - | - |
| * pqid | Pq load id | - | - |
| rp | Active power ramp | 0.0 | %(MW) |
| rq | Reactive power ramp | 0.0 | %(MVAr) |
| t1 | Starting time of the ramp | 0.0 | s |
| t2 | Ending time of the ramp | 100.0 | s |
| u | Connection status | 1.0 | bool |

274. Device <VDLmr>

Stochastic voltage dependent load with mean reversion

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| ap | Active power exponent | 2.0 | - |
| aq | Reactive power exponent | 2.0 | - |
| * bus | Bus id | - | - |
| h | Time step to generate the normal distribution | 1e-05 | s |
| kp | Active power rate | 0.0 | %(MW) |
| kq | Reactive power rate | 0.0 | %(MVAr) |
| pf | Mean value of the final active power | 0 | pu |
| * pqid | Pq load id | - | - |
| qf | Mean value of the final reactive power | 0 | pu |
| spp | Auto-correlation of the active power | 1.0 | % |
| spq | Correlation of active and reactive powers | 0.0 | % |
| sqq | Auto-correlation of the reactive power | 1.0 | % |
| u | Connection status | 1.0 | bool |
| vp | Speed of the active power mean-reversion | 0 | pu/s |
| vq | Speed of the reactive power mean-reversion | 0 | pu/s |

275. Device <VDLstc>

Stochastic voltage dependent load

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| ap | Active power exponent | 2.0 | - |
| aq | Reactive power exponent | 2.0 | - |
| * bus | Bus id | - | - |
| h | Time step to generate the normal distribution | 1e-05 | s |
| kp | Active power rate | 0.0 | %(MW) |
| kq | Reactive power rate | 0.0 | %(MVAr) |
| * pqid | Pq load id | - | - |
| spp | Auto-correlation of the active power | 1.0 | % |
| spq | Correlation of active and reactive powers | 0.0 | % |
| sqq | Auto-correlation of the reactive power | 1.0 | % |
| u | Connection status | 1.0 | bool |

276. Device <VSC1>

Base class for shunt voltage source converter (VSC)

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Idcn | Dc current rate | 5 | kA |
| # Sn | Power rate | 100.0 | MVA |
| # Vdcn | Dc voltage rate | 10 | kV |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Ac bus id | - | - |
| ivscmax | Maximum vsc ac current | 0.0 | pu(kA) |
| ivscmin | Minimum vsc ac current | 1.0 | pu(kA) |
| * node1 | 1st dc node | - | - |
| * node2 | 2nd dc node | - | - |
| rt | Transformer resistance | 0.01 | pu(Ohm) |
| u | Connection status | 1.0 | bool |
| xt | Transformer reactance | 0.75 | pu(Ohm) |

277. Device <VSC2>

Base class for series voltage source converter (VSC)

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Idcn | Dc current rate | 5 | kA |
| # Sn | Power rate | 100.0 | MVA |
| # Vdcn | Dc voltage rate | 10 | kV |
| # Vn | Primary voltage rate | 220.0 | kV |
| Vn2 | Secondary voltage rate | 66.0 | kV |
| * bus1 | From bus id | - | - |
| * bus2 | To bus id | - | - |
| circuit | Circuit number or id | 1 | int |
| imax | Maximum current | 999.9 | pu(kA) |
| ivscmax | Maximum vsc ac current | 0.0 | pu(kA) |
| ivscmin | Minimum vsc ac current | 1.0 | pu(kA) |
| * node1 | 1st dc node | - | - |
| * node2 | 2nd dc node | - | - |
| phases | Number of phases (1 or 3) | 3 | int |
| pmax | Maximum active power | 999.9 | pu(MW) |
| rt | Transformer resistance | 0.01 | pu(Ohm) |
| smax | Maximum apparent power | 999.9 | pu(MVA) |
| u | Connection status | 1.0 | bool |
| xt | Transformer reactance | 0.75 | pu(Ohm) |

278. Device <VSC_static1>

Shunt VSC steady-state constraints for power flow analysis

| Parameter | Description | Default | Units |
|---|---|---|---|
| amax | Maximum firing angle | 360.0 | deg |
| amin | Minimum firing angle | -360.0 | deg |
| mmax | Maximum modulation | 3.0 | - |
| mmin | Minimum modulation | 0.5 | - |
| u | Connection status | 1.0 | bool |
| vacref | Ac reference voltage | 1.0 | pu(kV) |
| vdcref | Dc reference voltage | 1.0 | pu(kV) |
| * vsc | Vsc id | - | - |

279. Device <VSC_static2>

Series VSC steady-state constraints for power flow analysis

| Parameter | Description | Default | Units |
|---|---|---|---|

| | | | |
|---|---|---|---|
| amax | Maximum firing angle | 180.0 | deg |
| amin | Minimum firing angle | -180.0 | deg |
| iacref | Ac reference current | 1.0 | pu(kA) |
| mmax | Maximum modulation | 3.0 | - |
| mmin | Minimum modulation | 0.5 | - |
| u | Connection status | 1.0 | bool |
| vdcref | Dc reference voltage | 1.0 | pu(kV) |
| * vsc | Vsc id | - | - |

280. Device <Vphi>

Load for which the known quantities are the voltage magnitude
and the power factor

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| kq | Voltage droop | 1e-08 | - |
| pf | Power factor | 0.9 | - |
| u | Connection status | 1.0 | bool |
| v0 | Desired voltage | 1.0 | pu(kV) |

281. Device <WindSDE1>

Stochastic wind speed model - Autocorrelated Weibull-Distributed process

Note: Transformation from an Ornstein-Uhlenbeck process
      gvw - state variable - SDE of the Ornstein-Uhlenbeck process
      ws  - algebraic variable - Transformation to Weibull process
      vw  - state variable - Wind speed after filter

| Parameter | Description | Default | Units |
|---|---|---|---|
| Vwn | Nominal wind speed | 15.0 | m/s |
| alpha_y | Mean reversion speed of the original sde | 0.5 | - |
| c | Scale parameter of the weibull distribution | 5.0 | - |
| h | Time step to generate the normal distribution | 1e-05 | s |
| k | Shape parameter of the weibull distribution | 2.0 | - |
| rho | Air density | 1.225 | kg/m^3 |
| u | Connection status | 1.0 | bool |

| | | | |
|---|---|---|---|
| vw_init | Parameter | 0.0 | - |

282. Device <WindSDE2a>

Stochastic wind speed model - Autocorrelated Weibull process

Note: pure SDE model

| Parameter | Description | Default | Units |
|---|---|---|---|
| Vwn | Nominal wind speed | 15.0 | m/s |
| alpha_y | Mean reversion speed of the original sde | 0.5 | - |
| c | Scale parameter of the weibull distribution | 5.0 | - |
| h | Time step to generate the normal distribution | 1e-05 | s |
| k | Shape parameter of the weibull distribution | 2.0 | - |
| rho | Air density | 1.225 | kg/m^3 |
| u | Connection status | 1.0 | bool |
| vw_init | Parameter | 0.0 | - |

283. Device <WindSDE2b>

Stochastic wind speed model - Autocorrelated Weibull process

Note: One SDE + one algebraic equation model

| Parameter | Description | Default | Units |
|---|---|---|---|
| Vwn | Nominal wind speed | 15.0 | m/s |
| alpha_y | Mean reversion speed of the original sde | 0.5 | - |
| c | Scale parameter of the weibull distribution | 5.0 | - |
| h | Time step to generate the normal distribution | 1e-05 | s |
| k | Shape parameter of the weibull distribution | 2.0 | - |
| rho | Air density | 1.225 | kg/m^3 |
| u | Connection status | 1.0 | bool |
| vw_init | Parameter | 0.0 | - |

284. Device <Wind_compost>

Class for composite wind model

| Parameter | Description | Default | Units |
|---|---|---|---|
| # T | Filter time constant | 0.01 | s |
| Vwn | Nominal wind speed | 15.0 | m/s |
| df | Frequency step | 0.0 | - |
| # dt | Sampling time step | 0.1 | s |
| # h | Wind speed signal height | 80.0 | m |
| nh | Number of harmonics | 20 | - |
| rho | Air density | 1.225 | kg/m^3 |
| tge | Gust ending time | 11.0 | s |
| tgs | Gust starting time | 1.0 | s |
| tre | Ramp ending time | 11.0 | s |
| trs | Ramp starting time | 1.0 | s |
| u | Connection status | 1.0 | bool |
| vwg | Wind speed gust amplitude | 0.0 | m/s |
| vwr | Wind speed ramp amplitude | 0.0 | m/s |
| # z0 | Roughness length | 1.0 | m |

285. Device <Wind_measure>

Class for measured wind speed

| Parameter | Description | Default | Units |
|---|---|---|---|
| # T | Filter time constant | 0.01 | s |
| Vwn | Nominal wind speed | 15.0 | m/s |
| # dt | Sampling time step | 0.1 | s |
| rho | Air density | 1.225 | kg/m^3 |
| tmes | Vector of time measures | [] | s |
| u | Connection status | 1.0 | bool |
| vmes | Vector of speed measures | [] | m/s |

286. Device <Wind_mexican>

Class for Mexican hat wavelet (IEC 61400-1)

| Parameter | Description | Default | Units |
|---|---|---|---|
| # T | Filter time constant | 0.01 | s |
| Vwn | Nominal wind speed | 15.0 | m/s |
| # dt | Sampling time step | 0.1 | s |
| gust | Wind speed peak | 0.0 | m/s |

| | | | |
|---|---|---|---|
| rho | Air density | 1.225 | kg/m^3 |
| # sigma | Shape factor | 1.0 | s |
| t0 | Centering time | 0.0 | s |
| u | Connection status | 1.0 | bool |

287. Device <Wind_weibull>

Class for Weibull's distribution

| Parameter | Description | Default | Units |
|---|---|---|---|
| # T | Filter time constant | 0.01 | s |
| Vwn | Nominal wind speed | 15.0 | m/s |
| # c | Scale factor | 5.0 | - |
| # dt | Sampling time step | 0.1 | s |
| # k | Shape factor | 2.0 | - |
| rho | Air density | 1.225 | kg/m^3 |
| u | Connection status | 1.0 | bool |

288. Device <XControl>

Controller of state variables based on the Lyapunov's function

| Parameter | Description | Default | Units |
|---|---|---|---|
| Fu | Derivative df/du (must be constant) | 1.0 | - |
| K0 | Gain of the secondary control loop | 5000.0 | - |
| Kd | Deviation from the integral behavior | 0.0 | - |
| Ku | Gain of u controller | 0.01 | - |
| Kw | Gain of w*(x - x_0) controller | 5000.0 | - |
| Kx | Gain of x controller | 0.01 | - |
| T1 | Time constant of the lead control | 0.0 | s |
| # T2 | Time constant of the lag control | 1.0 | s |
| * devid | Controlled device id | - | - |
| * devname | Controlled device name | - | - |
| u | Connection status | 1.0 | bool |
| * uvar | Name of the controlled input variable | - | - |
| * xvar | Name of the controlled state variable | - | - |

289. Device <YControl>

Controller of algebraic variables based on the Lyapunov's function

| Parameter | Description | Default | Units |
|---|---|---|---|
| Gu | Derivative dg/du (must be constant) | 1.0 | - |
| K0 | Gain of the secondary control loop | 5000.0 | - |
| Kd | Deviation from the integral behavior | 0.0 | - |
| Ku | Gain of u controller | 0.01 | - |
| Kw | Gain of w*(y - y_0) controller | 5000.0 | - |
| Ky | Gain of y controller | 0.01 | - |
| T1 | Time constant of the lead control | 0.0 | s |
| # T2 | Time constant of the lag control | 1.0 | s |
| * devid | Controlled device id | - | - |
| * devname | Controlled device name | - | - |
| u | Connection status | 1.0 | bool |
| * uvar | Name of the controlled input variable | - | - |
| * yvar | Name of the controlled algebraic variable | - | - |

290. Device <ZIP1>

ZIP load - Voltage dependent (polynomial) load class

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| b0 | Susceptance | 0.0 | pu(1/Ohm) |
| * bus | Bus id | - | - |
| g0 | Conductance | 0.0 | pu(1/Ohm) |
| ip0 | Active current | 0.0 | pu(kA) |
| iq0 | Reactive current | 0.0 | pu(kA) |
| p0 | Active power | 0.0 | pu(MW) |
| q0 | Reactive power | 0.0 | pu(MVAr) |
| u | Connection status | 1.0 | bool |

291. Device <ZIP2>

ZIP load - Voltage dependent (polynomial) load.
This component is initialized after power flow analysis.

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| * bus | Bus id | - | - |
| kb | Susceptance rate | 0.0 | %(1/Ohm) |
| kg | Conductance rate | 0.0 | %(1/Ohm) |
| kip | Active current rate | 0.0 | %(kA) |
| kiq | Reactive current rate | 0.0 | %(kA) |
| kp | Active power rate | 0.0 | %(MW) |
| kq | Reactive power rate | 0.0 | %(MVAr) |
| * pqid | Pq load id | - | - |
| u | Connection status | 1.0 | bool |

292. Device <ZIP2ph>

Two-phase ZIP load

| Parameter | Description | Default | Units |
|---|---|---|---|
| # Sn | Power rate | 100.0 | MVA |
| # Vn | Voltage rate | 220.0 | kV |
| b0 | Susceptance | 0.0 | pu(1/Ohm) |
| * bus1 | Terminal 1 bus id | - | - |
| * bus2 | Terminal 2 bus id | - | - |
| g0 | Conductance | 0.0 | pu(1/Ohm) |
| ip0 | Active current | 0.0 | pu(kA) |
| iq0 | Reactive current | 0.0 | pu(kA) |
| p0 | Active power | 0.0 | pu(MW) |
| q0 | Reactive power | 0.0 | pu(MVAr) |
| u | Connection status | 1.0 | bool |

293. Device <ZIPD>

Distribution ZIP load

| Parameter | Description | Default | Units |
|---|---|---|---|
| P0 | Active power rate at nominal voltage | 0.0 | kW |
| # Vn | Voltage rate | 20.0 | kV |

```
 * bus        | Bus id                        | -          | -
   kg         | Percentage of conductance     | 0.0        | %
   kip        | Percentage of active current  | 0.0        | %
   pf         | Power factor (negative for    | 1.0        | -
              | capacitive loads)             |            |
   plevel     | Priority level (for the acs   | 0          | int
              | routine)                      |            |
   u          | Connection status             | 1.0        | bool
-----------------------------------------------------------------------

(*) Mandatory parameter.
(#) Non-zero parameter.
```

# Chapter 9

# Raw Format

The specifications of the internal Dome raw format as obtained by the command `dome -e` are given below.

```
Brief Description of the Raw DOME Data Format

The very first line must be <# DOME format version x.x>.
The second line is for the title <# Title>.
The name of the component starts in the first column.
Data follows in <Property_Name = Value> pairs, separated by commas.
Data can span multiple lines.
Data in form of strings must be delimited by "".
Data in form of arrays must be delimited by brackets [].
Each element of the array must be separated by semicolons.
Float data support simple operations (+, -, *, /).
Lines following the first one must be indented.
Comments starts with a <#> in the first column.
The extension of the file must be <.dm>.

------------
RETURN macro
------------

The file flushing can be stopped anywhere by including the macro
RETURN.  The syntax is:

RETURN

Anything coming after the RETURN macro is ignored.  The RETURN macro
applies only to the current file. If the current file has been called
through the INCLUDE command (see below), the calling file will be
parsed.

-----------
ALTER macro
-----------

Device data can be modified after being defined using the macro ALTER
The syntax of the ALTER command is as follows:
```

```
ALTER, device_name, action, filter, property, value

where:
- <device_name> is the system name of any device previously defined.
- <actions> are: MUL, DIV, SUM, SUB, POW, REP.
- <filter> is the reg-exp to be used for selecting the device (based on the name).
- <property> is any numerical property of the device.
- <value> the numerical value to be used by <action>.  Must be a float.

-----------
ALIAS macro
-----------

Device names can be replaced by aliases using the macro ALIAS, as follows:

ALIAS, device_name, alias_name

where <device_name> is the standard device name used in Dome, and
<alias_name> the new desired device name.  The alias takes effect only
'after' the occurrence of the ALIAS statement.  A new ALIAS statement
does not overwrite previous ALIAS statements for the same device.

-----------------------
INCLUDE and CARD macros
-----------------------

The format also accepts the command INCLUDE that allows nesting files
and the command CARD that allows defining custom devices.  The syntax
is:

INCLUDE, filename

where <filename> is the full or relative path to the file.

CARD, filename

where <filename> is the full or relative path to the card file.
```

## 9.1 Example

The following file is an example of DOME raw data file.

```
# DOME format version 1.0

Bus, Vn = 69.0, idx = 1, name = "Bus 1"
Bus, Vn = 69.0, idx = 2, name = "Bus 2"
Bus, Vn = 69.0, idx = 3, name = "Bus 3"
Bus, Vn = 69.0, idx = 4, name = "Bus 4"
Bus, Vn = 69.0, idx = 5, name = "Bus 5"
Bus, Vn = 13.8, idx = 6, name = "Bus 6"
Bus, Vn = 13.8, idx = 7, name = "Bus 7"
Bus, Vn = 18.0, idx = 8, name = "Bus 8"
Bus, Vn = 13.8, idx = 9, name = "Bus 9"
Bus, Vn = 13.8, idx = 10, name = "Bus 10"
Bus, Vn = 13.8, idx = 11, name = "Bus 11"
```

```
Bus, Vn = 13.8, idx = 12, name = "Bus 12"
Bus, Vn = 13.8, idx = 13, name = "Bus 13"
Bus, Vn = 13.8, idx = 14, name = "Bus 14"

Area, idx = 1, name = "14-Bus"

Region, Ptol = 9.9999, idx = 1, name = "14Bus   14", slack = 1.0

Line, Vn = 69.0, Vn2 = 69.0, b = 0.0528, bus1 = 1, bus2 = 2,
      idx = "Line_1", name = "Line 1", r = 0.01938, x = 0.05917
Line, Vn = 69.0, Vn2 = 69.0, b = 0.0492, bus1 = 1, bus2 = 5,
      idx = "Line_2", name = "Line 2", r = 0.05403, x = 0.22304
Line, Vn = 69.0, Vn2 = 69.0, b = 0.0438, bus1 = 2, bus2 = 3,
      idx = "Line_3", name = "Line 3", r = 0.04699, x = 0.19797
Line, Vn = 69.0, Vn2 = 69.0, b = 0.0374, bus1 = 2, bus2 = 4,
      idx = "Line_4", name = "Line 4", r = 0.05811, x = 0.17632
Line, Vn = 69.0, Vn2 = 69.0, b = 0.034, bus1 = 2, bus2 = 5,
      idx = "Line_5", name = "Line 5", r = 0.05695, x = 0.17388
Line, Vn = 69.0, Vn2 = 69.0, b = 0.0346, bus1 = 3, bus2 = 4,
      idx = "Line_6", name = "Line 6", r = 0.06701, x = 0.17103
Line, Vn = 69.0, Vn2 = 69.0, b = 0.0128, bus1 = 4, bus2 = 5,
      idx = "Line_7", name = "Line 7", r = 0.01335, x = 0.04211
Line, Vn = 69.0, Vn2 = 13.8, bus1 = 4, bus2 = 7, idx = "Line_8",
      name = "Line 8", tap = 0.978, trasf = True, x = 0.20912,
Line, Vn = 69.0, Vn2 = 13.8, bus1 = 4, bus2 = 9, idx = "Line_9",
      name = "Line 9", tap = 0.969, trasf = True, x = 0.55618,
Line, Vn = 69.0, Vn2 = 13.8, bus1 = 5, bus2 = 6, idx = "Line_10",
      name = "Line 10", tap = 0.932, trasf = True, x = 0.25202,
Line, Vn = 13.8, Vn2 = 13.8, bus1 = 6, bus2 = 11, idx = "Line_11",
      name = "Line 11", r = 0.09498, x = 0.19890
Line, Vn = 13.8, Vn2 = 13.8, bus1 = 6, bus2 = 12, idx = "Line_12",
      name = "Line 12", r = 0.12291, x = 0.25581
Line, Vn = 13.8, Vn2 = 13.8, bus1 = 6, bus2 = 13, idx = "Line_13",
      name = "Line 13", r = 0.06615, x = 0.13027
Line, Vn = 13.8, Vn2 = 18.0, bus1 = 7, bus2 = 8, idx = "Line_14",
      name = "Line 14", trasf = True, x = 0.17615
Line, Vn = 13.8, Vn2 = 13.8, bus1 = 7, bus2 = 9, idx = "Line_15",
      name = "Line 15", x = 0.11001
Line, Vn = 13.8, Vn2 = 13.8, bus1 = 9, bus2 = 10, idx = "Line_16",
      name = "Line 16", r = 0.03181, x = 0.08450
Line, Vn = 13.8, Vn2 = 13.8, bus1 = 9, bus2 = 14, idx = "Line_17",
      name = "Line 17", r = 0.12711, x = 0.27038
Line, Vn = 13.8, Vn2 = 13.8, bus1 = 10, bus2 = 11, idx = "Line_18",
      name = "Line 18", r = 0.08205, x = 0.19207
Line, Vn = 13.8, Vn2 = 13.8, bus1 = 12, bus2 = 13, idx = "Line_19",
      name = "Line 19", r = 0.22092, x = 0.19988
Line, Vn = 13.8, Vn2 = 13.8, bus1 = 13, bus2 = 14, idx = "Line_20",
      name = "Line 20", r = 0.17093, x = 0.34802


PQ, Vn = 69.0, bus = 2, idx = "PQ load_1", name = "PQ Bus 2", p = 0.217,
    q = 0.127
PQ, Vn = 69.0, bus = 3, idx = "PQ load_2", name = "PQ Bus 3", p = 0.942,
    q = 0.19
PQ, Vn = 69.0, bus = 4, idx = "PQ load_3", name = "PQ Bus 4", p = 0.478,
    q = -0.039
PQ, Vn = 69.0, bus = 5, idx = "PQ load_4", name = "PQ Bus 5", p = 0.076,
```

```
    q = 0.016
PQ, Vn = 13.8, bus = 6, idx = "PQ load_5", name = "PQ Bus 6", p = 0.112,
    q = 0.075
PQ, Vn = 13.8, bus = 9, idx = "PQ load_6", name = "PQ Bus 9", p = 0.295,
    q = 0.166
PQ, Vn = 13.8, bus = 10, idx = "PQ load_7", name = "PQ Bus 10", p = 0.09,
    q = 0.058
PQ, Vn = 13.8, bus = 11, idx = "PQ load_8", name = "PQ Bus 11", p = 0.035,
    q = 0.018
PQ, Vn = 13.8, bus = 12, idx = "PQ load_9", name = "PQ Bus 12", p = 0.061,
    q = 0.016
PQ, Vn = 13.8, bus = 13, idx = "PQ load_10", name = "PQ Bus 13", p = 0.135,
    q = 0.058
PQ, Vn = 13.8, bus = 14, idx = "PQ load_11", name = "PQ Bus 14", p = 0.149,
    q = 0.05

Breaker, Vn = 69.0, bus = 2, fn = 60.0, idx = 1, line = "Line_4",
         name = "Breaker 1", t1 = 1.0, t2 = 200.0, u1 = 1, u2 = 1

PV, Vn = 69.0, bus = 2, busr = 2, idx = 2, name = "PV Bus 2",
    pg = 0.4, pmax = 1.0, pmin = 0, qmax = 0.5, qmin = -0.4,
    v0 = 1.045
PV, Vn = 69.0, bus = 3, busr = 3, idx = 3, name = "PV Bus 3",
    pmax = 1.0, pmin = 0, qmax = 0.4, v0 = 1.01
PV, Vn = 13.8, bus = 6, busr = 6, idx = 6, name = "PV Bus 6",
    pmax = 1.0, pmin = 0, qmax = 0.24, qmin = -0.06, v0 = 1.07
PV, Vn = 18.0, bus = 8, busr = 8, idx = 8, name = "PV Bus 8",
    pmax = 1.0, pmin = 0, qmax = 0.24, qmin = -0.06, v0 = 1.09

Shunt, Vn = 13.8, b = 0.19, bus = 9, idx = "Shunt_1", name = "Shunt Bus 9"

SW, Vn = 69.0, bus = 1, busr = 1, idx = 1, name = "SW Bus 1",
    pg = 2.324, pmax = 999.9, pmin = -999.9, qmax = 9.9, qmin = -9.9,
    v0 = 1.06

Syn5d, D = 2.0, M = 10.296, Sn = 615.0, Td10 = 7.4, Td20 = 0.03,
       Tq20 = 0.033, Vn = 69.0, bus = 1, fn = 60.0, gen = 1,
       idx = 1, name = "Syn 1", xd = 0.8979, xd1 = 0.2995, xd2 = 0.23,
       xl = 0.2396, xq = 0.646, xq1 = 0.646, xq2 = 0.4

Shaft, syn = 1, Mhp = 0.6695, Mip = 1.4612, Mlp = 1.6307, Mex = 0.0903,
       Dhp = 0.518, Dip = 0.224, Dlp = 0.224, Dex = 0.145,
       D12 = 0.0518, D23 = 0.0224, D34 = 0.0224, D45 = 0.0145,
       K12 = 33.07, K23 = 28.59, K34 = 44.68, K45 = 21.98

Syn6a, D = 2.0, M = 13.08, Sn = 60.0, Td10 = 6.1, Td20 = 0.04,
       Tq10 = 0.3, Tq20 = 0.099, Vn = 69.0, bus = 2, fn = 60.0,
       gen = 2, idx = 2, name = "Syn 2", ra = 0.0031, xd = 1.05,
       xd1 = 0.185, xd2 = 0.13, xq = 0.98, xq1 = 0.36, xq2 = 0.13
Syn6a, D = 2.0, M = 13.08, Sn = 60.0, Td10 = 6.1, Td20 = 0.04,
       Tq10 = 0.3, Tq20 = 0.099, Vn = 69.0, bus = 3, fn = 60.0,
       gen = 3, idx = 3, name = "Syn 3", ra = 0.0031, xd = 1.05,
       xd1 = 0.185, xd2 = 0.13, xq = 0.98, xq1 = 0.36, xq2 = 0.13
Syn6a, D = 2.0, M = 10.12, Sn = 25.0, Td10 = 4.75, Td20 = 0.06,
       Tq10 = 1.5, Tq20 = 0.21, Vn = 13.8, bus = 6, fn = 60.0,
       gen = 6, idx = 4, name = "Syn 4", ra = 0.0041, xd = 1.25,
       xd1 = 0.232, xd2 = 0.12, xl = 0.134, xq = 1.22, xq1 = 0.715,
```

```
       xq2 = 0.12
Syn6a, D = 2.0, M = 10.12, Sn = 25.0, Td10 = 4.75, Td20 = 0.06,
       Tq10 = 1.5, Tq20 = 0.21, Vn = 18.0, bus = 8, fn = 60.0,
       gen = 8, idx = 5, name = "Syn 5", ra = 0.0041, xd = 1.25,
       xd1 = 0.232, xd2 = 0.12, xl = 0.134, xq = 1.22, xq1 = 0.715,
       xq2 = 0.12

Avr1, Ka = 200.0, Kf = 0.0012, Ta = 0.02, Te = 0.19, Tf = 1.0,
      bus = 1, idx = 1, name = "AVR 1", syn = 1, vmax = 9.99,
      vmin = 0.0
Avr1, Ka = 20.0, Kf = 0.001, Ta = 0.02, Te = 1.98, Tf = 1.0,
      bus = 2, idx = 2, name = "AVR 2", syn = 2, vmax = 2.05,
      vmin = 0.0
Avr1, Ka = 20.0, Kf = 0.001, Ta = 0.02, Te = 1.98, Tf = 1.0,
      bus = 3, idx = 3, name = "AVR 3", syn = 3, vmax = 1.7,
      vmin = 0.0
Avr1, Ka = 20.0, Kf = 0.001, Ta = 0.02, Te = 0.7, Tf = 1.0,
      bus = 6, idx = 4, name = "AVR 4", syn = 4, vmax = 2.2,
      vmin = 1.0
Avr1, Ka = 20.0, Kf = 0.001, Ta = 0.02, Te = 0.7, Tf = 1.0,
      bus = 8, idx = 5, name = "AVR 5", syn = 5, vmax = 2.2,
      vmin = 1.0

ALTER, PQ, MUL, *, p, 1.2
ALTER, PQ, MUL, *, q, 1.2
ALTER, PV, MUL, *, pg, 1.2
ALTER, Avr1, SUM, *, vmax, 2.0
```

# Chapter 10

# User Defined Devices

DOME supports the definition of user defined devices through *cards*. Cards have an extension `.dmc` and can be loaded *on the fly* by means for the statement `CARD` in DOME data files. Cards can be also used to create a template device module that the user can later on modify and include in DOME as any other standard module. Although quite flexible and versatile, the set up of user defined devices through cards has some limitations and should be used only for quickly test device prototypes, not as a systematic tool for implementing new models.

## 10.1 Notation

Defining custom devices consists in providing to a function (hereinafter, the *parser*) some input data that such function can parse in order to write another function that actually implements device model. Moreover, the device model requires input data. Before associating number to such data, the user defined model has to indicate what these data are.

Thus, defining custom devices requires that the user thinks in a slightly higher level than if he/she implemented the device itself.

To avoid confusion, this is the notation used in this chapter:

#### Words referring to the syntax of the user defined model

*keyword*: reserved word that are used to indicate a specific action to the parser.

*sub-keyword*: reserved word the specifies a feature of a keyword. The syntax is `keyword.sub-keyword`.

*item*: the name of an attribute of the device. The syntax is `keyword.item`. Items are internally used as attribute of a Pythonclass. Items have to be valid Python variables (e.g., cannot start with a number) and are case sensitive. Initial and trailing underscores have to be used having in mind Python conventions.

*argument*: the value to be associated to the left hand side of the statement, namely `keyword`, `keyword.sub-keyword`, or `keyword.item`. An argument can be an item, thus indicating an attribute of the device, or an actual value (a number, a string, a Boolean, a comma-separated list, etc.).

*statement*: any valid sequence of keyword, sub-keyword or item and argument. There are three statement types:

*type 1 statement*: `keyword: argument`

where `keyword` is a scalar or array attribute to which is assigned the value `argument`. `argument` can be a comma-separated ordered list. The word `None` is a valid argument for indicating that the keyword is not used by the current device. Omitting a certain keyword has the same effect as declaring:

```
keyword: None
```

Type 1 statements are "cumulative", i.e., arrays can be defined using a sequence of type 1 statements. For example:

```
keyword: arg1, arg2, arg3
```

and

```
keyword: arg1
keyword: arg2
keyword: arg3
```

do the same.

*type 2 statement*: `keyword.sub-keyword: argument`

where `keyword` is a single property with sub-property `sub-keyword` to which is assigned the value `argument`.

*type 3 statement*: `keyword.item: argument`

where the value `argument` is assigned to the property `keyword` of the device attribute `item`. Clearly, `item` has to be an existing device property defined in a previous type 1 statement.

## 10.2 Card File Format

The card is a sequence of statements with a certain order. The remainder of this chapter describes all valid keywords and sub-keywords of card files.

### 10.2.1 Version Statement

The first line of a card must be the version statement:

```
# DOME card v1.0 - user defined device
```

The text after the dash is optional and can be a brief description of the card itself. Further descriptions can be given using comment lines as explained in the next sub-section.

### 10.2.2 Comments

Apart from the very first line, any line that begins with a `#` is a comment and is neglected when parsing cards.

The keyword `comment` allows including a comment in the resulting device module. Comments to be included in the preamble of the module, use a type 1 statement syntax. For example:

```
comment: this is a comment of the module preamble!
```

Comments can be also included in any of the following methods through a type 2 statement: `init`, `setx0`, `gcall`, `fcall`, `gycall`, `fxcall`, `windup`, `params`, and `cjacs`. For example:

```
comment.gcall: this is a comment of the method <gcall>!
```

### 10.2.3 Device Name

The first statement must define the device name, through the keyword `name`:

```
name: Device_Name, type
```

The string `Device_Name` is the name used within DOME for the new device as well as the name used in DOME data file to instantiate an element of the device. The string defined by `Device_Name` is case sensitive. Following DOME conventions, the device name should start with a capitol letter. The string `type` is optional and indicates the device category. Currently, there are four types: `device`, `demand`, `series`, and `dipole`. `device` is the default value, in case `type` is not given.

`device`: this is the most general device. It is basically an empty box that can be tailored to any need. No predefined parameters are included except for `u` (device status), `Sn` (power rate) and `Vn` (ac voltage rate).

`demand`: same as `device`, but it includes some special functions for loads that are initialzed after power flow analysis and that requires a static PQ load to be properly initialized. Using this option is not strictly required but helps readability. The following properties are set to `True`: `gcall`, `shunt`, and `xinit`.

`series`: this option provides a variety of methods and parameters that define a standard series device. The predefined parameters are those of `device` plus: `bus1` (from bus index), `bus2` (to bus index), `imax` (max current flow), `pmax` (max power flow), `smax` (max apparent power flow), `Vn2` (voltage rate of the receiving-end bus), `fn` (frequency rate), and `circuit` (circuit id to distinguish parallel branches). The following properties are set to `True`: `gcall`, `gycall`, `pflow`, `series`, `flows`, and `xinit`. The indexes of the sending-end bus voltage are `afr` and `vfr` for the phase angle and the magnitude, respectively. The indexes of the receiving-end bus voltage are `ato` and `vto` for the phase angle and the magnitude, respectively. These indexes are used also as variable names within the device equations but can be overwritten using the keywords `a` and `v`.

`dipole`: this option provides a variety of methods and parameters that define an empty EMT dipole. The predefined parameters are: `node1` (from node index), `node2` (to node index), `Vdcn` (dc voltage rate), and `Idcn` (dc current rate). The following properties are set to `True`: `dcseries`, `gcall`, `pflow`, `cjacs`, and `xinit`. The indexes for the sending-end and receiving-end bus voltages are `v1` and `v2`, respectively. These indexes are used also as variable names within the device equations but can be overwritten using the keyword `v`.

### 10.2.4 Sections

While following statements can be given in a sparse order, it is highly recommended that the card is organized in six sections, with the following order:

1. Connectivity
2. Properties
3. Parameters
4. Variables
5. Equations
6. Initial conditions

A detailed description of each section follows.

### 10.2.5 Connectivity

All connectivity statements are type 1.

`buses`: a single bus name or a comma separated list of bus names. These names defines the indexes of ac buses.

`nodes`: a single node name or a comma separated list of node names. These names define the indexes of dc nodes.

`stagen`: this keyword defines the index and the bus of a static generator to which the custom device is connected, as follows:

```
stagen: gen
```

This connection implies that `property.pflow = False` and `property.xinit = True` (see next section). Moreover, the static generator is removed after initializing the custom device. If the keyword `stagen` is defined, the words `pg` and `qg` are made available for the initialization of the custom device. In particular, `pg` and `qg` are the active and reactive power injections, respectively, of the static generator after solving the power flow at the bus indicated in the statement `buses`. The device must be connected to a single ac bus and protected words `pg` and `qg` should not be redefined.

`staload`: this keyword defines the index and the bus of a static load to which the custom device is connected, as follows:

```
staload: load
```

This keyword implies that `property.pflow = False` and `property.xinit = True` (see next section). Moreover, the static load is removed after initializing the custom device. The device must be connected to a single ac bus and 4 protected words will be included in the device: `p0`, `q0`, `kp` and `kq`. The latter two are input data. The amount of initial load consumption is computed as:

$$
\begin{aligned}
p_0 &= \frac{k_p}{100} p_{s,0} \\
q_0 &= \frac{k_q}{100} q_{s,0}
\end{aligned}
\tag{10.1}
$$

where $p_{s,0}$ and $q_{s,0}$ are the active and reactive power, respectively, of the static load (typically a static PQ load) to which the user defined load is connected.

`connect`: this allows connecting a certain device to devices other than those indicated above, use the following statement:

```
connect: group_name, dev_index
```

where `group_name` is the group of the device to which the custom device has to be connected, and `dev_index` the name of the device index used in the custom device. For example, if ones wants to define an AVR, this has to be connected to synchronous machines. Hence one can define:

```
connect: Synchronous, syn
```

The group name is case sensitive. The list of all group name can be retrieved using the command `dome -G`.

### 10.2.6 Properties

Properties indicated with a † are only for advanced usage and can be ignored for the definition of the vast majority of devices.

The following is the list of valid type 1 statements.

`doc`: brief description (i.e., it must span a single line) of the device.

`type`: the group to which the device belongs. The list of existing device groups can be obtained with `dome -G All`. The default value is `Other`, but the user is strongly recommended to explicitly set a group name. `Other` should be used only in the rare circumstance in which the device substantially differs from any devices currently embedded in DOME.

`category`: a single category name or a comma-separated list of categories to which the device belongs. The list of existing device categories can be obtained with `dome -C All`. The default value is `Other`, but the user is strongly recommended to explicitly set a group name. `Other` should be used only in the rare circumstance in which the device substantially differs from any devices currently embedded in DOME.

`hidden`:† whether the device can be defined in the data file or not. It can be `True` or `False`. Default is `False`.

`avatar`:† whether the device requires the creation of an avatar when an equivalencing technique is solved. It can be `True` or `False`. Default is `False`.

The following list of type 2 statements describes the property `property` that has several sub-properties. Each sub-property can take only two values, namely `True` or `False`. The default value is always `False`, which is used in case the explicit statement is omitted. In some cases, even if the user does not set to `True` a sub-property, this is automatically enforced during compilation time. For example, if the user defines algebraic equations, `gcall` is automatically enforced. However, the user should not rely on this "smart" auto-enforcing and has to take care to carefully define each sub-property.

`property.windup`: whether the device contains algebraic equations $g$.

`property.pflow`: whether the device is used during power flow analysis.

`property.shunt`: whether the device is a shunt device, e.g., a load.

`property.series`: whether the device is a series device, e.g., a transmission line.

`property.connection`:† whether the device is a connection, e.g., a bus, an area, etc.

`property.times`:† whether the device includes some switching event that should be computed at user defined times. Enforcing this option implies that the device contains a method `get_times` that returns a Python set of the times at which switching events occur.

`property.stagen`: whether the device is a static generator, e.g., a PV generator.

`property.dyngen`: whether the device is a dynamic generator, e.g., a synchronous generator.

`property.gmcall`:† whether the device defines elements of the Jacobian matrix $\boldsymbol{g}_\mu$ used for CPF analysis.

`property.fmcall`:† whether the device defines elements of the Jacobian matrix $\boldsymbol{f}_\mu$ used for CPF analysis.

`property.dcseries`: whether the device is a dc series element.

`property.opf`: whether the device is used in OPF analysis.

`property.obj`: whether the device defines an objective function for OPF analysis.

`property.delay`: whether the device includes time delays or, which is the same, its equations are DDAE.

### 10.2.7 Parameters

The most important parameter is the property `data`, which is a type 1 statement that must precede any other property in the parameter section. The `data` statement defines the names of all attributes (except for connectivity properties) that the user can input in the data file to define the device. Then the user can define auxiliary attributes and or variables and scalar constants through `service` and `scalar`, respectively. The values given in the statements `data`, `service` and `scalar` **must** be unique.

The keywords `data` and `service` define type 1 statements:

`data`: comma-separated list of all parameter names of the device. This property must be declared before any other parameter property. All devices have three predefined data, namely, `Sn`, `Vn` and `u`, which are the power rate, the voltage rate and the device status, respectively.

`service`: comma-separated list of auxiliary parameters (i.e., computed once) or variables (i.e., updated at each iteration) of the device.

`scalar`: this keyword defines a type 3 statement where the sub-keyword is the name of the scalar constant that the user wants to define. For example:

```
scalar._pi = 3.1416
```

Then `_pi` can be used in any equation to indicate 3.1416.

`remove`: comma-separated list of data to be removed. This can be used to remove predefined data such as `Sn` and `Vn` (see also keyword `data` above). The predefined data `u` cannot be removed.

The remainder of this sub-section describes keywords that define some property of the arguments given in the `data` statement. Values of following keywords must be a subset of those defined by `data`.

`params`: comma-separated list of all parameter names that are used within device differential-algebraic equations.

`zeros`: comma-separated list of all parameter names that cannot be zero.

`powers`: comma-separated list of all parameter names that refer quantities whose physical unit is that of a power.

`voltages`: comma-separated list of all parameter names that refer quantities whose physical unit is that of an ac voltage.

`currents`: comma-separated list of all parameter names that refer quantities whose physical unit is that of an ac current.

`dcvoltages`: comma-separated list of all parameter names that refer quantities whose physical unit is that of a dc voltage.

`dccurrents`: comma-separated list of all parameter names that refer quantities whose physical unit is that of a dc current.

`impedances`: comma-separated list of all parameter names that refer quantities whose physical unit is that of an impedance.

`admittances`: comma-separated list of all parameter names that refer quantities whose physical unit is that of an admittance.

`resistances`: comma-separated list of all parameter names that refer quantities whose physical unit is that of an resistance.

`conductances`: comma-separated list of all parameter names that refer quantities whose physical unit is that of an conductance.

`times`: comma-separated list of all parameter names that refer to quantities whose physical unit is that of a time.

`mandatory`: comma-separated list of all parameters that must be defined in the data file.

Following properties can be both type 1 or type 3 statements. In case the type 1 syntax is used, the order of the arguments must be the same as that used for the `data` statement. To improve maintainability, the use of the type 3 statement syntax is highly recommended.

`defaults`: defaults values of the parameters defined by `data`.

`units`: units of the parameters defined by `data`.

`description`: brief description of the parameters defined by `data`.

To illustrate the usage of the keywords above, let consider the following example. Assume that `data` is defined as:

```
data: p0, q0, g0, b0
```

meaning that `p0` and `q0` are constant active and reactive powers, respectively, and `g0` and `b0` are constant conductance and susceptance, respectively. Then, the following are valid statements:

```
powers: p0, q0
conductances: g0, b0
defaults: 0.0, 0.0, 0.1, 0.1
units: pu, pu, pu, pu
description.p0: constant active power
description.q0: constant reactive power
description.g0: constant conductance
description.b0: constant susceptance
```

Observe that, according to the conventions described above, default values for the input data are `p0 = 0.0` and `q0 = 0.0`, `g0 = 0.1` and `b0 = 0.1`. The following statements do the same:

```
defaults.p0: 0.0
defaults.q0: 0.0
defaults.g0: 0.1
defaults.b0: 0.1
```

To retrieve data from other devices is often required (see also keyword `connect` in Subsection 10.2.5). This can be done through the following type 3 statement:

```
retrieve.dev_index: data_orig, data_dest, type
```

where `dev_index` is the device index name declared in a previous statement `connect`; `data_orig` is the original data name as defined in the device from which the data has to be retrieved; `data_dest` is the name of the data as defined in the custom device (if not declared by the statement `data`, it is automatically added to the data list); and `type` can be `matrix` or `list`, depending on whether the data is used within some equation or not, respectively. For example, if one wants to retrieve the inertia constant of a synchronous machines:

```
retrieve.syn: M, M, matrix
```

Observe that a `connect` statement must declare the connectivity index `syn` before the `retrieve` statement.

### 10.2.8 Variables

Device variables can be of three kinds, namely, algebraic, state and slack variables. Algebraic variables are further divided into two groups, those used for power flow and/or time domain analysis, and those used for OPF analysis. Observe that the names passed as arguments are used internally to indicate the *indexes* of the variables in the global algebraic and state variable vectors. Thus such names do **not** directly point to the *value* of the variable.

All, variables are defined through type 1 statements:

`y`: comma-separated list of algebraic variables used in power flow and/or time domain analysis.

`x`: comma-separated list of state variables used in power flow and/or time domain analysis.

`z`: comma-separated list of algebraic variables used for defining equality constraints in OPF analysis.

`c`: comma-separated list of slack variables used for defining disequality constraints in OPF analysis.

Each connection to the external grid has to be associated to variables, as follows:

*ac buses*: for each ac bus defined through `buses`, the keywords `v` and `a` assign the name of the voltage magnitude and phase angle, respectively. The keywords `v` and `a` are used within type 3 statements. For example, assume that:

```
buses: bus1, bus2
```

Then, one can define:

```
v.bus1: v1
a.bus1: a1
v.bus2: v2
a.bus2: a2
```

Observe that `v1`, `a1`, `v2` and `a2` are internally used as the indexes of the algebraic variables in the global algebraic variable vector.

*dc nodes*: for each dc node defined through `nodes`, the keywords `v` assigns the name of the instantaneous voltage. The keyword `v` is used within type 3 statement. For example, assume that:

```
nodes: node1, node2
```

Then, one can define:

```
v.node1: vdc1
v.node2: vdc2
```

Observe that `vdc1` and `vdc2` are internally used as the indexes of the algebraic variables in the global algebraic variable vector.

Keywords `ytex` and `xtex` can be used in both type 1 or type 3 statements. In case the type 1 syntax is used, the order of the arguments must be the same as that used for the `y` and `x` statements, respectively. To improve maintainability, the use of the type 3 statement syntax is highly recommended.

`ytex`: LaTeX-formatted name for algebraic variables defined by `y`. If `None`, the names given in `y` are used.

`xtex`: LaTeX-formatted name for state variables defined by `x`. If `None`, the names given in `x` are used.

To improve the exchange of meaningful models, a brief description as well as units can be associated to algebraic and state variables. This is obtained by keywords `algeb_doc`, `algeb_unit`, `state_doc`, and `state_unit`. These keyword can be use either as type 1 or type 3 statements. In case the type 1 syntax is used, the order of the arguments must be the same as that used for the `y` and `x` statements, respectively.

### 10.2.9 Equations

An equation has to assigned to each state and algebraic variable. Then an active and reactive power injection has to be assigned to each ac bus and a current injection has to be assigned to each dc node. This can be done through type 3 statements with the following keywords:

`g`: algebraic equations associated to each algebraic variable defined through the keyword `y`.

`f`: differential equations associated to each state variable defined through the keyword `x`.

`p`: active power injections associated to each algebraic variable defined through the keyword `buses`.

`q`: reactive power injections associated to each algebraic variable defined through the keyword `buses`.

`i`: current injections associated to each algebraic variable defined through the keyword `nodes`.

Let illustrate the usage of the keywords above through the exponential recovery load whose equations are:

$$
\begin{aligned}
p &= x_p/T_p + p_t \\
q &= x_q/T_q + q_t \\
\dot{x}_p &= -x_p/T_p + p_s - p_t \\
\dot{x}_q &= -x_q/T_q + q_s - q_t
\end{aligned} \tag{10.2}
$$

Let assume that:

```
buses: bus1
data: ps, qs, pt, qt, Tp, Tq
params: ps, qs, pt, qt, Tp, Tq
v.bus1: v1
a.bus1: a1
x: xp, xq
```

Then, the device equations are defined by:

```
p.bus1: xp/Tp + pt
q.bus1: xq/Tq + qt
f.xp: -xp/Tp + ps - pt
f.xq: -xq/Tq + qs - qt
```

The following remarks are relevant:

1. The sign of the load active and reactive powers is determined as follows: powers (and currents) are positive if *consumed* by the device, negative if *produced* by the device.

2. Differential equations are naturally associated to the first derivative of the state variable. Thus, `f.xp` is associated to $\dot{x}_p$. On the other hand, algebraic equations can be associated to any algebraic variable, as long as the number of algebraic equations is equal to the number of algebraic variables.

3. To define equations, the names of the algebraic and state variables are used explicitly. For example, `xp` is considered the state variable $x_p$. When parsing the card, DOME automatically converts `xp` to the correct syntax, e.g., `dae.x[self.xp]` where `dae.x` is the global vector of state variables and `self.xp` is the array of indexes of the variables $x_p$ defined by the device.

4. Variables `v1` and `a1` have to be defined even if they are not explicitly used in the device equations.

A special kind of functions are hard limits. There are four hard limit keywords, as follows.

`hardlimit`: hard limit for algebraic variables. This function limits an algebraic variables within given upper and lower bounds, as follows:

$$
y_i^{\min} \le y_i \le y_i^{\max} \tag{10.3}
$$

The syntax is as follows:

```
hardlimit.yvar: z, varmax, varmin, varmax_val, varmin_val
```

where `yvar` must be an algebraic variable name defined by the keyword `y`. The symbol `z` indicates the name of a Boolean variable that indicates whether the hard limit is binding or not. Moreover `yvar` is the index of $y_i$. Finally, `varmax` and `varmin` are the names of the limits $y_i^{\max}$ and $y_i^{\min}$, respectively, and `varmax_val` and `varmin_val` their default values, respectively.

`windup`: windup limit for algebraic variables. The usage of ths algebraic windup is as follows. Let assume:

$$g_i = y_i - \phi(\boldsymbol{y}, \boldsymbol{x}) \tag{10.4}$$

and:

$$y_i^{\min} \leq \phi(\boldsymbol{y}, \boldsymbol{x}) \leq y_i^{\max} \tag{10.5}$$

Equations (10.5) compares $\phi$ with the limits $y_i^{\max}$ and $y_i^{\min}$ and assigns to the algebraic variable $y_i$ the given value $\phi$ if such upper and lower bounds are not binding, otherwise assigns to the algebraic variable the binding limit. The algebraic equation $g_i$ associated with the algebraic variable $y_i$ is set to 0 if a limit is binding.

The syntax is as follows:

```
windup.yvar: z, yval, varmax, varmin, varmax_val, varmin_val
```

where `yvar` must be an algebraic variable name defined by the keyword `y`. The symbol `z` indicates the name of a Boolean variable that indicates whether the hard limit is binding or not. Moreover `yvar` is the index of $y_i$ and $g_i$, the value `yval` is defined by $\phi(\boldsymbol{y}, \boldsymbol{x})$ and is a function of everything but $y_i$. `yval` is an expression (the same as that defined in $g_i$). Finally, `varmax` and `varmin` are the names of the limits $y_i^{\max}$ and $y_i^{\min}$, respectively, and `varmax_val` and `varmin_val` their default values, respectively.

`deadband`: dead band for algebraic variables. The usage of the dead band is as follows. Let assume:

$$g_i = y_i - \phi(\boldsymbol{y}, \boldsymbol{x}) \tag{10.6}$$

and:

$$y_i = 0 \quad \text{if} \quad -db \leq \phi(\boldsymbol{y}, \boldsymbol{x}) \leq db \tag{10.7}$$

Equations (10.7) compares $\phi$ with the dead band limit $db$ and assigns to the algebraic variable $y_i$ the given value $\phi$ if $\phi$ is outside the dead band, otherwise $y_i = 0$. The algebraic equation $g_i$ associated with the algebraic variable $y_i$ is set to 0 if $\phi$ is within the dead band.

The syntax is as follows:

```
deadband.yvar: z, yval, db, db_val
```

where `yvar` must be an algebraic variable name defined by the keyword `y`. The symbol `z` indicates the name of a Boolean variable that indicates whether the dead band is binding or not. Moreover `yvar` is the index of $y_i$ and $g_i$, the value `yval` is defined by $\phi(\boldsymbol{y}, \boldsymbol{x})$ and is a function of everything but $y_i$. `yval` is an expression (the same as that defined in $g_i$). Finally, `db` is the name of the dead band $db$ and `db_val` is its default value.

`antiwindup`: antiwindup limit for state variables. This function locks the state variable and its first derivative if either the upper or the lower bound is binding, as follows.

$$\dot{x}_i = \begin{cases} 0 \quad \text{if } f_i > 0 \text{ and } x_i \geq x_i^{\max} \\ f_i(\boldsymbol{x}, \boldsymbol{y}) \quad \text{if } x_i^{\min} < x_i < x_i^{\max} \\ 0 \quad \text{if } f_i < 0 \text{ and } x_i \leq x_i^{\max} \end{cases} \tag{10.8}$$

and

$$x_i^{\min} \leq x_i \leq x_i^{\max} \tag{10.9}$$

The syntax is as follows:

```
antiwindup.xvar: z, varmax, varmin, varmax_val, varmin_val
```

where `xvar` must be a state variable name defined by the keyword `x`. The symbol `z` indicates the name of a Boolean variable that indicates whether the hard limit is binding or not. Moreover `xvar` is the index of $x_i$ and $f_i$. Finally, `varmax` and `varmin` are the names of the limits $x_i^{\max}$ and $x_i^{\min}$, respectively, and `varmax_val` and `varmin_val` their default values, respectively.

The variable `z` is internally treated as it were defined through the keyword `service`. Moreover, the parameters `varmax` and `varmin` are treated as they were defined through the keywords `data` and `params`. Hence, the names `z`, `varmax` and `varmin` **must** be unique.

### 10.2.10 Initial Conditions

If the keyword `property.xinit` is set to `True`, the user can provide initial values for the algebraic and state variables of the device. If the keyword `property.pflow` is set to `True`, the values are used as initial guesses. Valid keywords are as follows:

`y0`: the initial value of algebraic variables defined through the keyword `y`.

`x0`: the initial value of state variables defined through the keyword `x`.

`a0`: the initial value of the voltage phase angles associated to each bus defined through the keyword `buses`.

`v0`: the initial value of the voltage magnitude associated to each bus or node defined through the keywords `buses` or `nodes`, respectively.

`s0`: the initial value of the auxiliary variable defined through the keyword `service`.

Fro example, let be:

```
buses: bus1
y: y1, y2
x: x1
service: s1
```

Then initial values can be defined as follows:

```
v0.bus1: 1.0
a0.bus1: 0.0
y0.y1: 2.13
s0.s1: 3.25*y1
y0.y2: s0 + y1
x0.x1: 0.0
```

The following remarks are relevant:

1. Initial values can be expressions involving operations among variables and parameters.
2. The order in which initial values are defined in the card matters. If the initial value of `y1` is required to compute the initial value of `s1`, then the statement for `y0.y1` must precede that for `s0.s1`.

## 10.3 Example

Let consider the classical electromechanical model of the synchronous machine. Differential equations are:

$$\begin{aligned} \dot{\delta} &= \Omega_n(\omega - 1) \\ \dot{\omega} &= \frac{1}{M}\left(p_m - \frac{ev}{x'_d}\sin(\delta - \theta) - D(\omega - 1)\right) \end{aligned} \tag{10.10}$$

where $\delta$ and $\omega$ are the state variables, $v$ and $\theta$ are the voltage magnitude and phase angle, respectively, at the generator terminal bus, $M$ the inertia constant, $D$ the damping, $x'_d$ the transient direct-axis reactance and $\Omega_n$ the system frequency rate in rad/s. Auxiliary variables $p_m$ and $e$ are the mechanical power and the emf behind the reactance $x'_d$, respectively.

The power injections of the machine into the grid are:

$$
\begin{aligned}
p &= -\frac{ev}{x'_d} \sin(\delta - \theta) \\
q &= \frac{v^2}{x'_d} - \frac{ev}{x'_d} \cos(\delta - \theta)
\end{aligned}
\tag{10.11}
$$

Observe again that the sign of the powers produced by the machine are negative (because they are injected into the grid).

The machine is initialized after solving the power flow. State as well as auxiliary variables have to be initialized, as follows:

$$
\begin{aligned}
p_m &= p_0 \\
e &= \frac{x'_d}{v_0} \sqrt{p_0^2 + \left(q_0 + \frac{v_0^2}{x'_d}\right)^2} \\
\delta_0 &= \arcsin\left(\frac{x'_d}{ev_0}\right) + \theta_0 \\
\omega_0 &= 1.0
\end{aligned}
\tag{10.12}
$$

where the sub-index 0 indicates that the variables are computed at the initial time $t = 0$.

The following card file sample illustrates how to define the classical electromechanical model of the synchronous machine.

```
# DOME card v1.0 - device card test

# <name> MUST be the first declaration
# make sure that <name> is not already in use as a device name
name: SynEleMec

#### connectivity ####
buses: bus
nodes: None
stagen: gen

#### device properties ####
# device properties should be defined before variables and equations
doc: classical electro-mechanical model of the synchronous machine
type: Synchronous
category: Machine, Generation, Transmission
hidden: False
avatar: False
property.gcall: True
property.gycall: True
property.fcall: True
property.fxcall: True
property.windup: False
property.pflow: False
property.xinit: True
property.shunt: False
property.series: False
```

```
property.flows: False
property.connection: False
property.times: False
property.stagen: False
property.dyngen: True
property.gmcall: False
property.fmcall: False
property.dcseries: False
property.opf: False
property.obj: False
property.delay: False
property.cjacs: True

#### scalars ####
# add one statement for each scalar you want to define
scalar.Wn: system.Settings.rad

#### parameters ####
# <data> must be declared before any parameter properties
data: M, D, xd1
# parameters can be defined anytime
# but it is safer if they are declared before variables and equations
defaults: 5.0, 0.0, 2.0
units: kWs/kVA, pu, pu
description.xd1: transient reactance
description.M: inertia constant
description.D: damping coefficient
params: M, D, xd1
zeros: M
powers: M, D
voltages: None
currents: None
dcvoltages: None
dccurrents: None
impedances: xd1
admittances: None
resistances: None
conductances: None
times: None
service: e, pm
mandatory: bus, gen

#### variables ####
y: None
x: delta, omega
z: None
c: None
xtex: \delta, \omega
ytex: None
v.bus: v
a.bus: theta
state_descr.delta: rotor angle position
state_units.delta: rad
state_descr.omega: rotor angle speed
state_units.omega: pu(Hz)

#### equations and initial conditions ####
```

```
# equations must be defined after variables
p.bus: -e*v*sin(delta-theta)/xd1
q.bus: v*v/xd1 - e*v*cos(delta-theta)/xd1
f.delta: Wn*(omega - 1.0)
f.omega: (pm - e*v*sin(delta-theta)/xd1 - D*(omega - 1.0))/M

#### initialization ####
s0.pm: pg
s0.e: xd1*sqrt(pg**2 + (qg + v*v/xd1)**2)/v
x0.delta: asin(pg*xd1/(e*v)) + theta
x0.omega: 1.0
```

# Chapter 11

# Plotting Results

DOME provides an utility to plot results of time domain simulation continuation power flow analysis, as well as any other DOME results that produces a `.dat` and a `.lst` file. This utility is called `domeplot` and is a quite powerful and versatile tool based on Matplotlib[1] for 2D plots and Mayavi for 3D surfaces. `domeplot` also provides a simple calculator[2] and a mini-language to perform several complex operations.

## 11.1 Basic Usage

The simplest general command to plot results is:

```
>> domeplot [options] filename.dat [filename.lst] x y1 [y2 y3 ...]
```

where `filename.dat` and `filename.lst` are the output files of DOME, and `x` and `y1` are the indexes of the variables that one want to be plotted. The first variable index is used for the horizontal axis, while all remaining variable indexes are used for the vertical one. Any number of vertical axis indexes can be provided.

## 11.2 Variable List

DOME creates a default `.lst` with the same name as the `.dat` file. The default `.lst` file is used by `domeplot` if the user does not provide one explicitly. However, the user can provide a custom `.lst` file, as long as the format is the same as the `.lst` file generated by DOME, which is as follows:

- Each line must contain five values separated by colons.
- The first value is the variable index (starting from 0).
- The second value is the variable name.

[1]To obtain optimal results, Matplotlib has to be configured to enable LaTeX commands.
[2]The calculator is based on Sympy.

- The third value is the variable name formatted in LaTeX.
- The fourth value is the variable unit.
- The fifth value is the variable base (1 if it is not in pu).

The third column is used by `domeplot` for axis labels and legends. Clearly, the user can customize the text of the third column as desired. An excerpt of a typical `.lst` file is as follows:

```
 0,            Time,         $\rm Time$,        s, 1.0000
 1,     delta Syn 1,    $\delta_{Syn 1}$,     rad, 1.0000
 2,     omega Syn 1,    $\omega_{Syn 1}$,  pu(Hz), 1.0000
 3,       e1q Syn 1,      $e\'_q_{Syn 1}$,  pu(kV), 69.0000
 4,     psidl Syn 1, $\psi_{dl}_{Syn 1}$, pu(kWb), 0.1830
 5,     psiql Syn 1, $\psi_{dl}_{Syn 1}$, pu(kWb), 0.1830
 6,     delta Syn 2,    $\delta_{Syn 2}$,     rad, 1.0000
 7,     omega Syn 2,    $\omega_{Syn 2}$,  pu(Hz), 1.0000
 8,       e1q Syn 2,      $e\'_q_{Syn 2}$,  pu(kV), 69.0000
 9,     psidl Syn 2, $\psi_{dl}_{Syn 2}$, pu(kWb), 0.1830
10,       e1d Syn 2,      $e\'_d_{Syn 2}$,  pu(kV), 69.0000
11,     psiql Syn 2, $\psi_{ql}_{Syn 2}$, pu(kWb), 0.1830
...
```

To create a custom `.lst` file from scratch is rarely needed. However, it may happen that one solves a set of simulations for the same system changing only few parameters or settings. In this case, the user can customize the default `.lst` file, rename it and use such file after each simulation without the need of editing the `.lst` file several times.

## 11.3 `domeplot` Options

In this section, the command line `domeplot` options are divided into four groups: (i) general options, (ii) plotting options, (iii) special operations options, and (iv) statistical options. The abbreviated option notation is indicated after the long one. Options arguments are printed in upper case.

### 11.3.1 General Options

`-h, --help` shows the complete list of `domeplot` options and exit.

`-p PATH, --path=PATH` Path of the data file. Not needed if `filename.dat` is in the current path. Observe that `filename.lst` must be in the same path as `filename.dat`.

`-w, --display` Disable opening a window containing the plot. This option is actually not needed unless one comments out the line:

```
matplotlib.use('PS')
```

in the script `plot.py`. To allow opening front-end windows is disabled by default to allow running DOME on remote servers.

`-o OUTPUT, --output=OUTPUT` Custom output file name. If the input data file is `filename.dat`, the default output is `filename.eps`.

### 11.3.2 Plotting Options

`-l, --legend` Add legend to the plot.

`-g, --grid` Add grid to the plot.

`-s STYLE, --style=STYLE` Plot style. Allowed values for `STYLE` are:

- `c`: continuous colored lines (default).
- `b`: black lines with different styles.
- `s`: colored lines with symbols.
- `k`: black line with symbols.

`--dim=DIM` Plot dimension: ¡2D¿ or ¡3D¿. Default is 2D.

`-n NAMES, --names=NAMES` Type of names used in the legend. Allowed values for `NAMES` are:

- `f`: formatted string (typically LaTeX-style string or any string provided in the third column of the `.lst` file).
- `u`: unformatted string (or any string provided in the second column of the `.lst` file).
- `a`: anonymous string. Variables called `value` and numbered starting from 1, e.g., `value1`, `value2`, etc. This option can be useful if the user wants to process the `.eps` file in a LaTeX document using the PSfrag package.

`-k POSITION, --position=POSITION` Legend location. This option only has effect if used along with option `-l`. Allowed values for `POSITION` are:

- `0`: best position (default).
- `1`: upper right.
- `2`: upper left.
- `3`: lower left.
- `4`: lower right.
- `5`: right.
- `6`: center left.

7: center right.
8: lower center.
9: upper center.
10: center.

`-r REFERENCE, --reference=REFERENCE` Index of reference angle.

`--ylabel=YLABEL` Label for the $y$ axes.

`--xlabel=XLABEL` Label for the $x$ axes.

`--xscale=XSCALE` Scale $x$-axis by a factor.

`--yscale=YSCALE` Scale $y$-axis by a factor.

`--xoffset=XOFFSET` Offset of the $x$-axis.

`--yoffset=YOFFSET` Offset of the $y$-axis.

`--xmin=XMIN` Minimum $x$-axis value.

`--xmax=XMAX` Maximum $x$-axis value.

`--ymin=YMIN` Minimum $y$-axis value.

`--ymax=YMAX` Maximum $y$-axis value.

`--hline=HLINE` Dotted horizontal line.

`--vline=VLINE` Dotted vertical line.

`--noformat` Disable overwriting LaTeX formatting on variable labels.

`-u, --nounits` Disable including units in variable labels.

`-e, --nolegunits` Disable including units in legend entries.

### 11.3.3 Special Operations

`-i, --integral` Integrate $y$ over $x$.

`-d, --derivate` Compute $dy/dx$.

`--fftw` Discrete Fourier transform.

### 11.3.4 Statistical Options

`-m, --mean` Compute the mean value of $n$ vectors of $y$.

`-v, --std` Compute the standard deviation of $n$ vectors of $y$.

`--cdf` Compute the cdf of a variable.

`--aut` Compute autocorrelation of a series.

`--cov` Compute covariance of a series.

## 11.4 Advanced Usage

`domeplot` provides some macros to allow and/or simplify certain operations. These macros are:

- To plot some variables in a range:

  ```
  >> domeplot [options] filename.dat [filename.lst] x yi:yf
  ```

  where `yi` and `yf` are the initial and the final indexes, respectively, of the variables to be plotted. Note that `yi` < `yf` must hold. For example:

  ```
  >> domeplot filename.dat 0 1:5
  ```

  is equivalent to:

  ```
  >> domeplot filename.dat 0 1 2 3 4 5
  ```

- To plot some variables in a range with a given step:

  ```
  >> domeplot [options] filename.dat [filename.lst] x yi:ystep:yf
  ```

  where `yi` and `yf` are the initial and the final indexes, respectively, of the variables to be plotted, and `ystep` is the step used to define the series of indexes. Note that `yi` < `yf` must hold. For example:

  ```
  >> domeplot filename.dat 0 1:2:5
  ```

  is equivalent to:

  ```
  >> domeplot filename.dat 0 1 3 5
  ```

- To plot variable from different input files:

  ```
  >> domeplot [options] filename1.dat [filename1.lst] x1 y11
                        [y12 y13] filename2.dat [filename2.lst]
                        x2 y21 [y22 y23] [...]
  ```

The user can define any number of input data files. The default output file is `filename1.eps`.

- Wild cards can be used for the input file name. For example:

```
>> domeplot [options] *.dat x y
```

will plot the variable with index `y` versus the variable with index `x` of all `.dat` files in the current directory. Wild cards follows standard Unix-like shell rules.

Wild cards are particularly useful if used along with statistical options. For example:

```
>> domeplot --mean --std *.dat x y
```

will compute the mean and the standard deviation of the variable with index `y` of all `.dat` files in the current directory and create two new files with prefix `stat_` and extensions `.dat` and `.lst`, respectively. This files can be later on used to plot either the mean value or the standard deviations. To work properly, statistical options require that the indexes `x` and `y` refers to the same variables and that only one `y` is provided.

- To plot the negative of a variable:

```
>> domeplot [options] *.dat x y-
```

The minus sign indicates that `domeplot` has to plot $-y$ rather than $y$ itself.[3] This fact is also indicated in the legend if the option `-l` is used. To avoid this behavior, the option `--noformat` has to be enforced.

The minus sign is applied only to the variable at which it is assigned. So, the following command:

```
>> domeplot [options] *.dat x y1- y2 y3 y4-
```

will plot the negative of the variables with indexes `y1` and `y4` but not of those with indexes `y2` and `y3`.

- To plot the absolute value of a variable:

```
>> domeplot [options] *.dat x ya
```

[3] Observe that the minus sign has to follow the variable index because otherwise it is interpreted as an option by the Python interpreter.

The `a` letter indicates that `domeplot` has to plot $b \cdot y$ where $b$ is the base of the variable with index `y`.[4] Variable bases are the values defined in the fifth column of the `.lst` file. So, the user can modify the `.lst` file and set custom bases.

The absolute value is applied only to the variable at which it is assigned. So, the following command:

```
>> domeplot [options] *.dat x y1a y2 y3 y4a
```

will plot the absolute value of the variables with indexes `y1` and `y4` but not of those with indexes `y2` and `y3`.

The absolute value can be used in conjunction with the minus sign, in any order. For example:

```
>> domeplot [options] *.dat x y-a ya-
```

will plot the absolute value of the negative of the variable with index `y` twice.

## 11.5 Calculator

`domeplot` can be used as a calculator through a simple mini-language. All operations supported by the package Sympy are supported. The rules of the mini-language are the following:

- To distinguish between indexes and numbers, indexes must be enclosed in square brakets.
- Since spaces are used to separate variables, no space is allowed within each expression.

For example:

```
>> domeplot [options] filename.dat x [y1]+[y2] sin(2*[y3])
```

will plot the sum of the variables with indexes `y1` and `y2` and the sinus of the variable with index `y3` multiplied by 2. If enforced, the legend will show the function used to obtain each line of the plot in LaTeX format. To avoid this behavior, the option `--noformat` must be enforced.

[4] Observe that the letter `a` has to follow the variable index.

## 11.6 Note on Matplotlib

To create plots, Dome relies on the excellent Matplotlib package, which is able to provide high quality graphics. By default, Matplotlib does not enforce the support for LaTeX expressions. This fact can mess up the plots created by Dome as variables expressions are formatted using the LaTeX notation.

This behavior can be changed by properly setting up Matplotlib. With thi aim, create a the folder `.matplotlib` in the user home folder. This folder should exist if Matplotlib has been launched once. Then, create a file called `matplotlibrc` within the folder `.matplotlib`. A sample of this file can be found on the Matplotlib website at:

`http://matplotlib.org/users/customizing.html`

Then, open the file file `matplolibrc` and add or uncomment the following line:

```
text.usetex : True
```

## 11.7 Example

Figure 11.1 depicts a sample plot created using the data file shown in Section 9.1 of Chapter 9. The plot has been obtained using the following command:

```
>> domeplot -l -k 1 -s b --xmax=15 --ylabel="$\rm Rotor \; speeds$"
            ieee14.dat 0 13 7 2
```

The command above assumes that there exist the files `ieee14.lst` and `ieee14.dat` previously created by Dome by the command:

```
>> dome -r TDS ieee14.dm
```

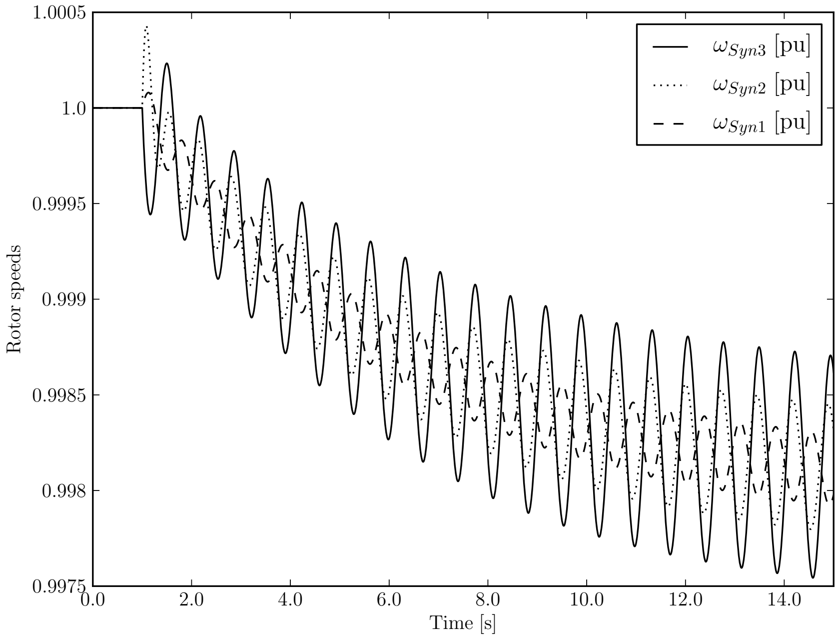


Figure 11.1: Rotor speeds of synchronous machines 1, 2 and 3 for the IEEE 14-bus system.