POWERFACTORY

PowerFactory 2021

Technical Reference

Station Controller

ElmStactrl

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

Publisher:
DIgSILENT GmbH
Heinrich-Hertz-Straße 9
72810 Gomaringen / Germany
Tel.: +49 (0) 7072-9168-0
Fax: +49 (0) 7072-9168-88
info@digsilent.de

Please visit our homepage at:
https://www.digsilent.de

December 1, 2020
PowerFactory 2021
Revision 1

Contents

1 General Description

The Station Control object (or station controller) is used in Load Flow calculations to simulate the behaviour of automatic control devices and/or operator action. It acts on sources of reactive power and, optionally, on transformers with tap changers, to achieve a target voltage at a certain bus or a target reactive power flow through a cubicle/boundary, or a target power factor at a cubicle/boundary.

The Station Control object has numerous options. For example, the user may select whether voltage control should include reactive power droop, whether the target voltage should be derived from the busbar properties by considering the switching arrangement, whether the controller may act on the tap changers of step-up transformers, and what the relative contribution of reactive power of the individual sources should be.

1.1 Definition

In order to define a station controller, multi-select the reactive power sources and the bus whose voltage is to be controlled. Valid reactive power sources include synchronous and asynchronous machines, static generators, static var systems (SVS), and PWM-Converter models with certain restrictions (see Section 2.5.2). Then enter the desired name in the Basic Data tab of the dialog.

A multi-selection is made as follows:

- Left-clicking the first element (e.g. the bus) and, while keeping the **Control** key pressed, left-click the remaining elements (e.g. the reactive power sources).
- right-click on any of the selected elements, and select ***Define*** → ***Station Control*** from the pop-up menu.

  The station controller acts on the selected machines (or static generators or SVSs). It does not act on elements that are in a separated area, or that are out of service.

2 Load Flow Analysis

2.1 Control Mode Options

Four different control modes are available:

- Voltage control
- Reactive power control
- Power factor control
- tan(phi) control.

Voltage control is done at a certain busbar/ terminal, whereas reactive power, power factor and tan(phi) control is done at a cubicle or boundary.

2.1.1 Voltage Control Mode Options

Controlled Phases
The voltage value to be controlled can be the positive sequence voltage value, the average of the three phases voltage, or a specific phase voltage value. This option has relevance only in the unbalanced load flow.

Controlled Node
This is the busbar or the terminal where the voltage will be controlled by adapting the reactive power. The busbar can either be user or automatically selected.

User Selection of Node
The user selects the controlled terminal. The controller uses the voltage set-point specified within the station controller or within the controlled terminal according the option Station Controller/ Bus target voltage.

Automatic Selection of Node
If the Automatic Selection option is selected, the controller finds the busbar at which the voltage is to be controlled, starting at the machines (or static generators of SVSs), and using the nominal voltage as a criteria. Depending on the switching arrangement of the "upstream" busbars, the controller forms one or more controlling groups. A controlling group defines the voltage set-point and the network elements that can be used to achieve the set-point. If no busbar is found at the corresponding voltage level, the station control will control the voltage of the connected terminal by using the local voltage set point of the machine.

For example, the upstream busbar may be a single busbar system with a section breaker having a group of generators connected to each of the terminals. With the option Automatic Selection enabled, the controller defines either one controlling group or two controlling groups, depending on whether the section breaker is closed or open. If the breaker is closed, the busbar section with the lowest priority determines the target voltage. If the breaker is open, each busbar section determines a target voltage.

Enable Droop
This option is only available if the controller mode is set to *Voltage Control* and the controlled busbar is user selected. A cubicle or a boundary can be selected as Q-measurement point (*pQmeas*). The voltage set point is modified depending on the reactive power flow at the Q-measurement point as follows:

$$u'_{setp} = u_{setp} + Q_{meas}/Q_{droop}$$

where:

u_{setp} Voltage set point in p.u. of the busbar
u'_{setp} Voltage set point in p.u., including the droop characteristic.
Q_{meas} Measured reactive power in Mvar
Q_{droop} Droop in Mvar/p.u.

The droop can be entered alternatively as percent value of the rated reactive power:

$$Q_{droop} = S_{rated} * 100/ddroop$$

where:

S_{rated} Rated reactive power in Mvar
$ddroop$ Droop in %

The third alternative is to enter the droop value defined by a delta(V) value:

$$Q_{droop} = S_{rated}/deltaV$$

where:

S_{rated} Rated reactive power in Mvar
$deltaV$ Droop in p.u.

If no Q-Measurement Point is selected, the measured reactive power is set to zero. The Q-flow direction of the Q-Measurement Point should be equal to the Q-flow direction of the SVS.

2.1.2 Reactive Power Control Mode Options

There are three modes of reactive power control:

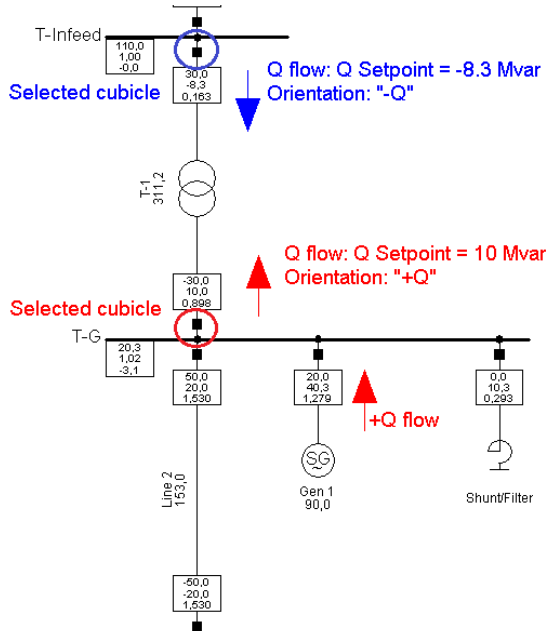
- Const. Q
- Q(V)-Characteristic
- Q(P)-Characteristic.

2.1.2.1 Const. Q

This mode controls the reactive power flow to keep it constant at the specified target value *Q Setpoint*.

Control Q at
A cubicle or a boundary can be selected, at which the reactive power flow is controlled by the station controller. The value entered at *Q Setpoint* is used as the target reactive power value.

Example:



Orientation

The parameter *Orientation* defines the orientation of the controlled cubicle or boundary interchange related to the generator in-feed. The parameter must be set to "+Q" if the "Q" flow of the controlled point is in the same direction as the Q flow of the generators (see red example). If the "Q" flow is in opposite direction the "Orientation" must be set to "-Q" (see blue example).

2.1.2.2 Q(V)-Characteristic

The Q(V)-Characteristic follows a specified characteristic as shown in the picture below.

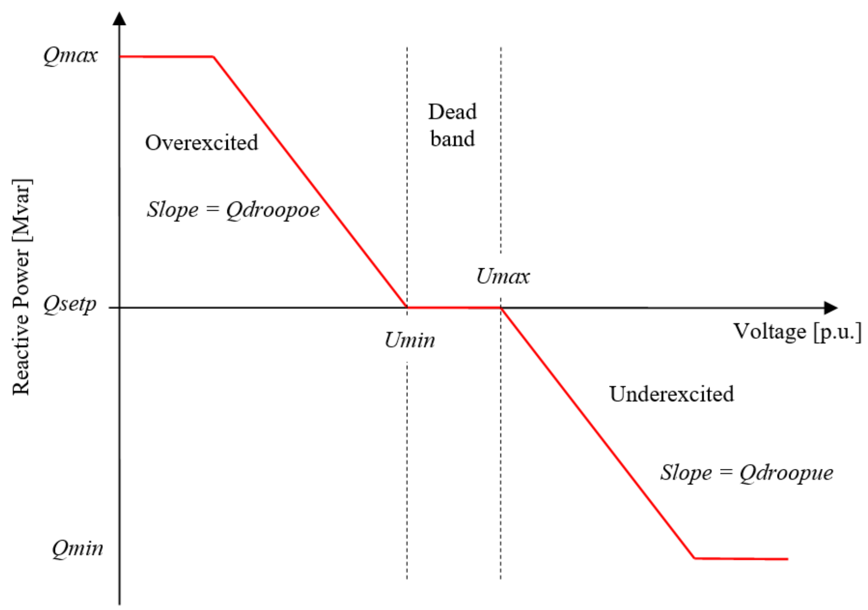


Figure 2.1: Q(V)-Characteristic

The station controller acts as a reactive power controller with a variable setpoint, *Q Setpoint*. While the reference voltage is within the dead band, the entered reactive power setpoint is kept. If the reference voltage leaves the dead band, the reactive power setpoint is adapted according to the droop entered by the user and the voltage deviation from the respective end of the dead band.

Additionally, the option Different droop values allows specifying two different droop values, one for the overexcited side ($Qdroopoe$), and another for the underexcited side ($Qdroopue$). In case when the option is not enabled then $Qdroopoe = Qdroopue = Qdroop$.

Control Q at
A cubicle or a boundary can be selected, at which the reactive power flow is controlled by the station controller.

Orientation
The parameter *Orientation* defines the orientation of the controlled cubicle or boundary interchange related to the generator in-feed. The parameter must be set to "+Q" if the "Q" flow of the controlled point is in the same direction as the Q flow of the generators. If the "Q" flow is in opposite direction the "Orientation" must be set to "-Q".

Reference Node
This is the busbar or the terminal where the voltage will be measured.

Qmin, Qmax
The lower and upper limits of the Q(V)-Characteristic.

Droop
The droop value can be entered in Mvar/p.u.

The droop can be entered alternatively as percent value of the rated reactive power:

$$Q_{droop} = S_{rated} \cdot 100/ddroop$$

where:

S_{rated} Rated reactive power in Mvar
$ddroop$ Droop in %

The third alternative is to enter the droop value defined by a delta(V) value:

$$Q_{droop} = S_{rated}/deltaV$$

where:

S_{rated} Rated reactive power in Mvar
$deltaV$ Droop in p.u.

Voltage Dead Band
The parameters *Lower Voltage Limit* (*Umin*) and *Upper Voltage Limit* (*Umax*) define the dead band.

2.1.2.3 Q(P)-Characteristic

The Q(P)-Characteristic follows the user-specified characteristic entered in the object pointed by *Q(P)-Curve*. In the characteristic, the reactive power values can be defined for positive and negative active power (useful for example for a pump storage). For points outside the defined characteristic a linear approximation of the values is used (the characteristic is not mirrored for not-defined points). The values $Qmin$ and $Qmax$ limit the minimum and maximum controllable values of the reactive power.

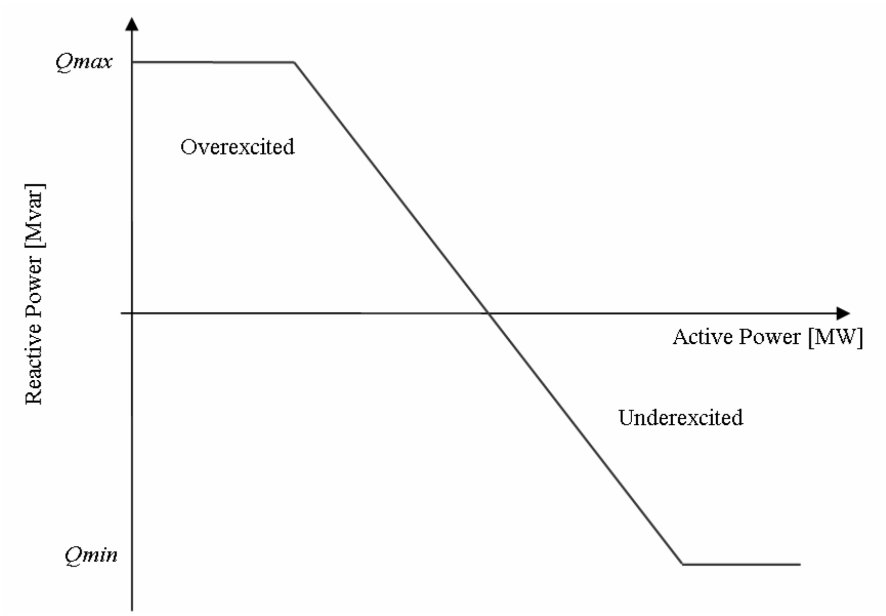


Figure 2.2: Q(P)-Characteristic: Example of user-input curve

Control Q at
A cubicle or a boundary can be selected, at which the reactive power flow is controlled by the station controller, and at which the active power is measured.

Orientation
The parameter *Orientation* defines the orientation of the controlled cubicle or boundary interchange related to the generator in-feed. The parameter must be set to “+Q” if the “Q” flow of the controlled point is in the same direction as the Q flow of the generators. If the “Q” flow is in opposite direction the “Orientation” must be set to “-Q”.

2.1.3 Power Factor Control Mode Options

There are two modes of power factor control:

- Const. PF
- cosphi(P)-Characteristic

2.1.3.1 Const. PF

This mode controls the power factor to keep it constant at the specified target value *Power Factor*.

Control Q at
A cubicle or a boundary can be selected at which the power factor is controlled by the station controller. The value entered for *Power Factor* and the option *cap./ind.* determine the target power factor.

Orientation
The parameter *Orientation* defines the orientation of the controlled cubicle or boundary interchange related to the generator in-feed. The parameter must be set to “+Q” if the “Q” flow of the controlled point is in the same direction as the Q flow of the generators. If the “Q” flow is in opposite direction the “Orientation” must be set to “-Q”.

2.1.3.2 cosphi(P)-Characteristic

The cosphi(P)-Characteristic will follow a specified characteristic as shown in the pictures below, depending on how the limits are specified.

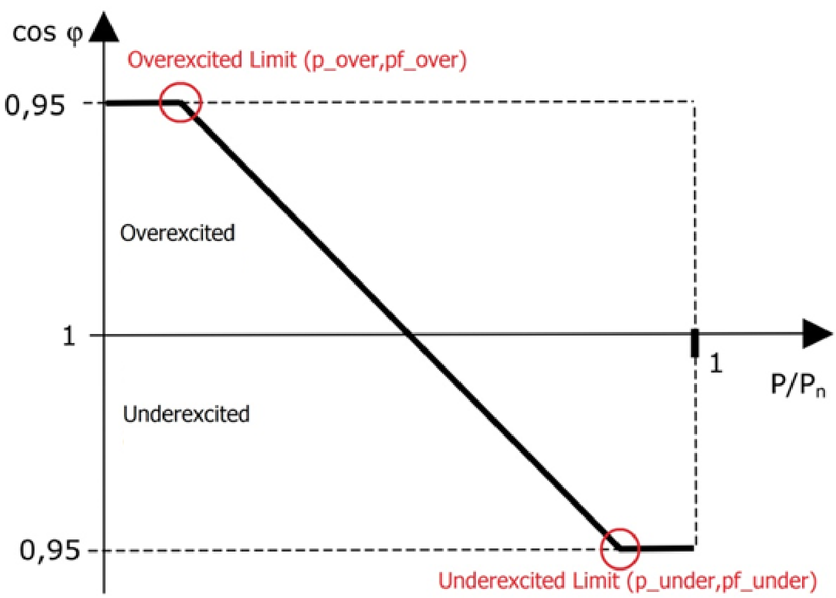


Figure 2.3: cosphi(P)-Characteristic: *pf_under* >*pf_over*

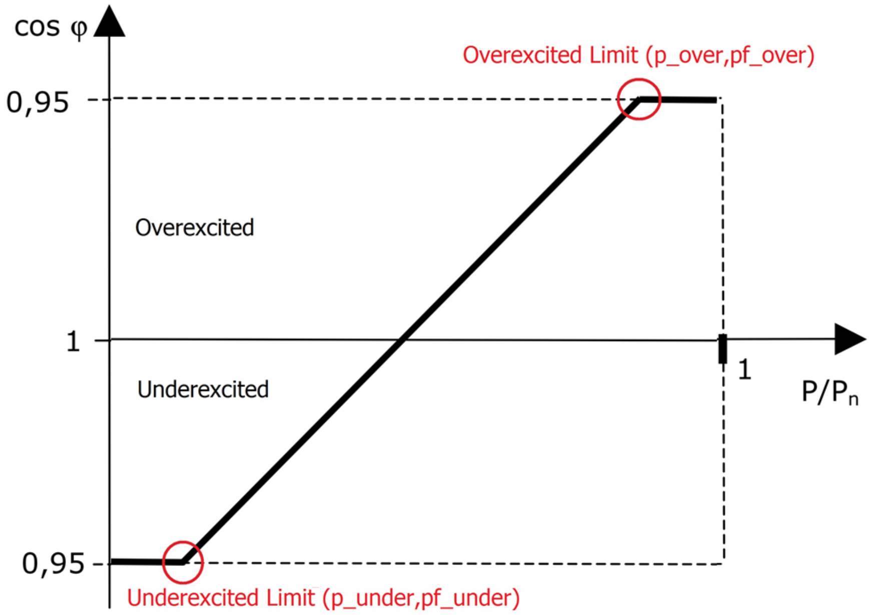


Figure 2.4: cosphi(P)-Characteristic: *pf_under* <*pf_over*

The station controller acts as a power factor controller at the control point. The controlled power factor is determined from the characteristic for a specific active power flow.

The user needs to define the cosphi(P)-Characteristic with two points (limits). The overexcited limit is defined with the parameters *p_over* and *pf_over*, and the underexcited limit is defined with the parameters *p_under* and *pf_under*. The characteristic can be defined only for positive active power. For negative active power values, the characteristic is mirrored.

2.1.3.3 cosphi(V)-Characteristic

The cosphi(V)-Characteristic will follow a specified characteristic as shown in the pictures below, depending on how the limits are specified.

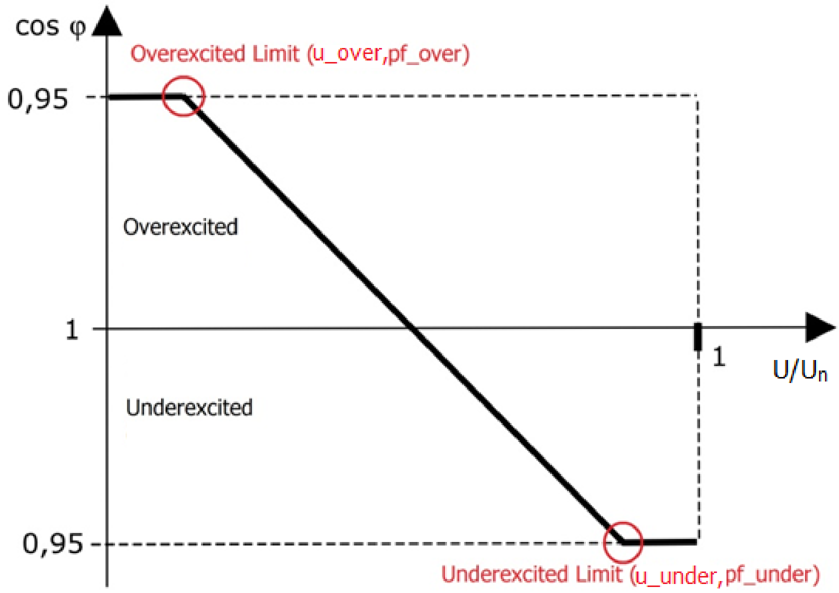


Figure 2.5: cosphi(V)-Characteristic: *pf_under* >*pf_over*

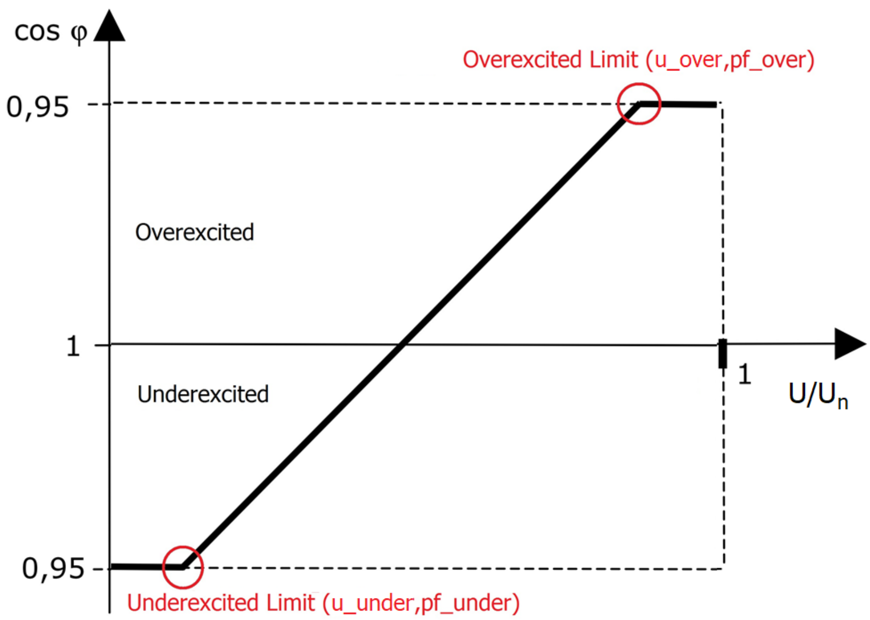


Figure 2.6: cosphi(V)-Characteristic: *pf_under* <*pf_over*

The station controller acts as a power factor controller at the control point. The controlled power factor is determined from the characteristic for a specific voltage value.

The user needs to define the cosphi(V)-Characteristic with two points (limits). The overexcited limit is defined with the parameters *u_over* and *pf_over*, and the underexcited limit is defined with the parameters *u_under* and *pf_under*.

2.1.4 tan(phi) Control Mode Options

The tan(phi) control mode is nearly identical to the “Power Factor” control mode. The internal reactive power set-point is the product of the tan(phi) value and the measured active power:

$$setq = tansetp * pctrl$$

Control Q at
A cubicle or a boundary can be selected at which the tan(phi) value is controlled by the station controller.

Orientation
The parameter *Orientation* defines the orientation of the controlled cubicle or boundary interchange related to the generator in-feed. The parameter must be set to “+Q” if the “Q” flow of the controlled point is in the same direction as the Q flow of the generators. If the “Q” flow is in opposite direction the “Orientation” must be set to “-Q”.

2.2 Reactive Power Distribution

Contribution of the different reactive power sources to the control of the voltage is specified in this part of the dialog.

Every source is assigned a contribution factor (K_p) that indicates the percentage to feed an actual value, in addition to its set point. This factor is calculated according to five different options:

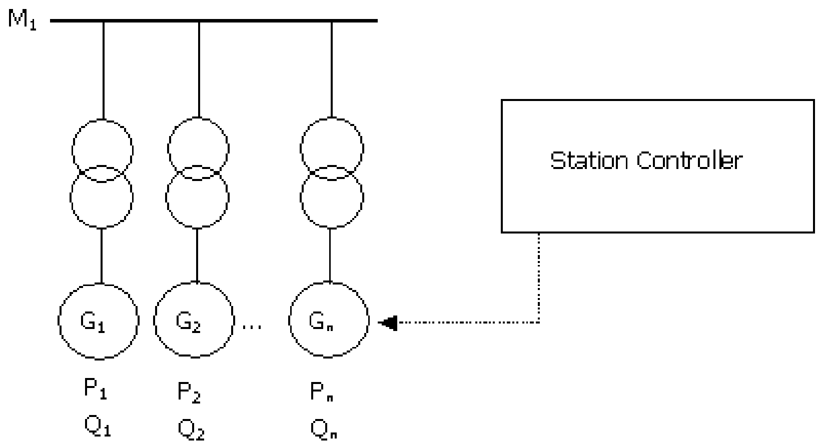
- Dispatched Active Power
  The contribution K_p factor is proportional to the dispatch active power specified for the source. In this case, the higher the active power infeed of a source, the higher will be its contribution in controlling the reactive power.
- Rated Power
  The contribution K_p factor is proportional to the rated apparent power (MVA) of the device.
- Individual Reactive Power
  The percentage of each contribution can be set individually. The K_p factors for each source will be normalized, so that their sum always will be 100%.
- Maximise Reactive Reserve
  The contribution K_p factor is calculated to optimize the reactive power reserve of the sources.
- Voltage Setpoint Adaptation
  The reactive power will be automatically distributed by modifying the local voltage setpoint of each generator.

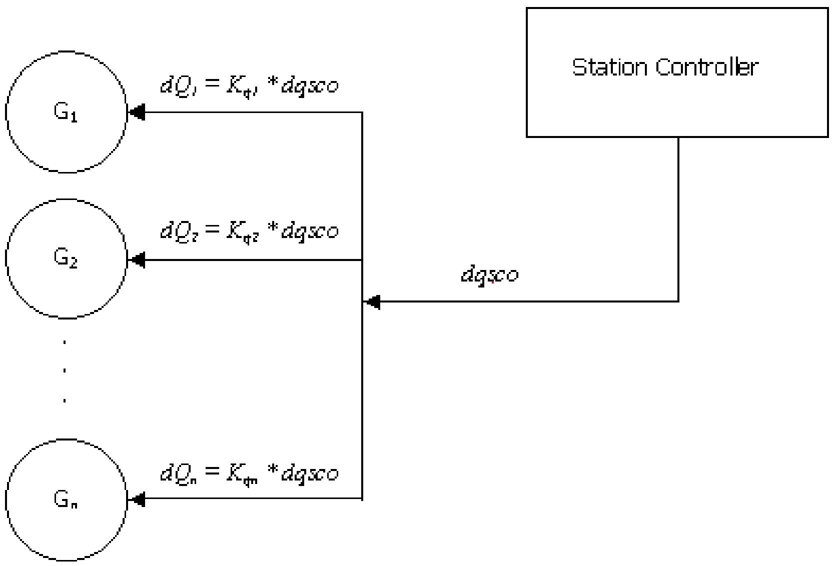
2.2.1 Calculation of Contributions (Dispatched Active Power, Rated Power and Individual Reactive Power)

The relationships between the station controller and the belonging sources are as follows:

Selection of Controlled Busbar: User Selection

One single busbar example:





The actual reactive power of each source is given by:

- If option *Consider reactive power dispatch* is enabled:

$$Q_i = Q_{dispatch\_i} + dQ_i$$

- if disabled:

$$Q_i = dQ_i$$

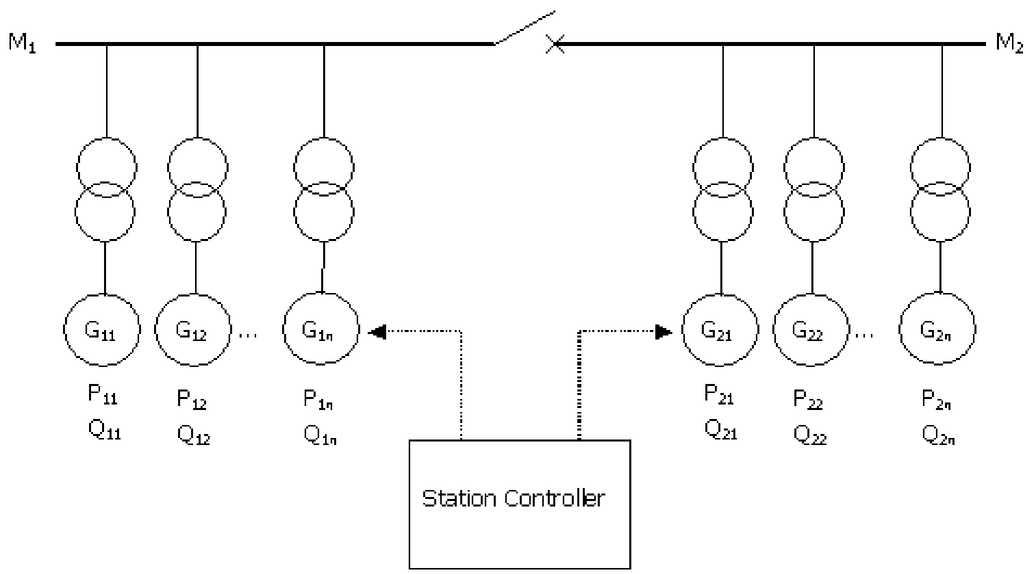
where:

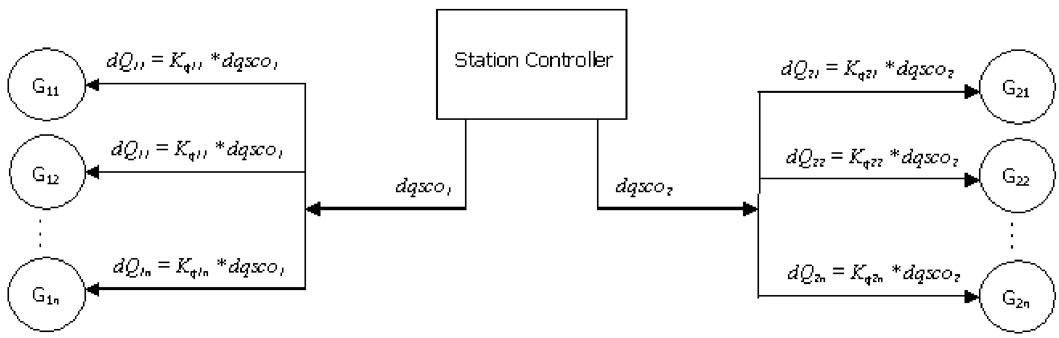
$$dQ_i = K_{qi} \cdot dqsco$$

Q_i is the source actual reactive power output
$Q_{dispatch\_i}$ is the specified dispatch reactive power for the source
dQ is the change of reactive power of the source
K_{qi} is the factor assigned for the source
$dqsco$ is the additional reactive power needed to keep the voltage at the specified setpoint of the controlled node

Selection of Controlled Busbar: Automatic Selection

One single busbar system with a section breaker example:





The actual reactive power of each source is given by:

- If option *Consider reactive power dispatch* is enabled:

$$Q_{ij} = Q_{dispatch\_ij} + dQ_{ij}$$

- if disabled:

$$Q_{ij} = dQ_{ij}$$

where:

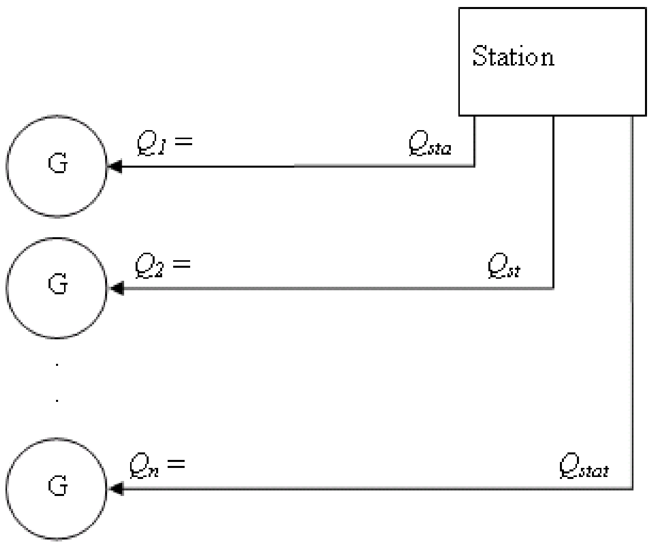
$$dQ_{ij} = K_{qij} \cdot dqsco_i$$

Q_{ij} is the source actual reactive power output
$Q_{dispatch\_ij}$ is the specified dispatch reactive power for the source
dQ is the change of reactive power of the source
K_{qij} is the factor assigned for the source. This factor is normalized for the controlling group of sources
$dqsco_i$ is the additional reactive power needed to keep the voltage at the specified setpoint of the controlled node

2.2.2 Calculation of Contributions (Maximise Reactive Reserves)

The relationships between the station controller and the belonging sources are as follows:

For both *User Selection and Automatic Selection*:



The actual reactive power of each source is given by:

$$Q_i = Q_{stati}$$

where:

Q_i is the actual reactive power output of the source
Q_{stat} i is the reactive power of the source calculated by the station controller

If the load flow option *Consider Reactive Power Limits* is enabled and a machine runs in his limits (Qmin,Qmax), the machine is ignored for the reactive power participation calculation.

2.2.3 Calculation of Contributions (Voltage Setpoint Adaptation)

With this option, the reactive power is automatically distributed by modifying the local voltage setpoint of each generator. For each generator local terminal voltage will be controlled by the generators using the local voltage setpoint $(usetp)$ and the delta u signal (du) of the station controller.

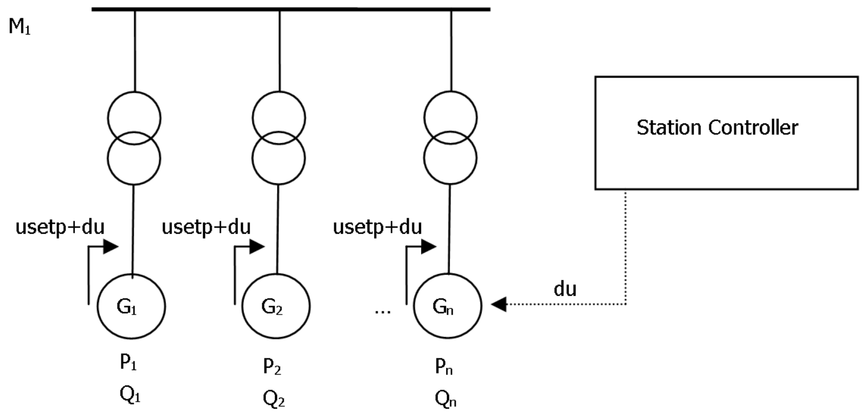


Figure 2.7: Voltage Setpoint Adaptation

Limitations:

- Only possible for one generator per local terminal (fails if more than one generator controls the same local voltage)
- Not supported for SVS (error message is printed)

Generator limits:

- Generator check if the actual voltage setpoint $(usetp + du)$ is within the voltage control limits (*usp_min*, *usp_max*), if not the parameter *i_ulim* is set and the voltage is kept fixed $(usetp + usp_{min}$ or $usetp + usp_{max})$.
- In addition the generator checks if the actual Q is within the reactive power limits (*Qmin*, *Qmax*)

2.3 Topology Methods

2.3.1 Voltage Level Busbar Detection

The search routine starts from the terminal of the machines and stops at the following criteria:

- Open switch (breakers, isolators, fuses)
- Transformers (step-down, e.g. from MV or LV voltage level)
- After first voltage level terminal was passed (nominal voltage of terminal $>=$ "Busbar Search Criteria $>=$"), the automatic "Busbar detection" is used to find the next busbar with the lowest voltage priority (see chapter 2.3.2).

If no voltage level busbar was found (e.g. open breaker), the machine is controlling the local busbar voltage and the voltage set point parameter in the machine model is used as target voltage.

2.3.2 Busbar Detection / Bus Target Voltage Detection

The search routing starts from the selected terminal and stops at the following criteria:

- Open switch (breakers, isolators, fuses)
- Transformers
- If in the equipotential area of the terminal is a busbar

The busbar with the lowest voltage priority (>=0) number is used for the controlled busbar and the corresponding target voltage.

If more than one equipotential with busbars is found, the busbar detection stops and no controlling busbar is used.

For example:

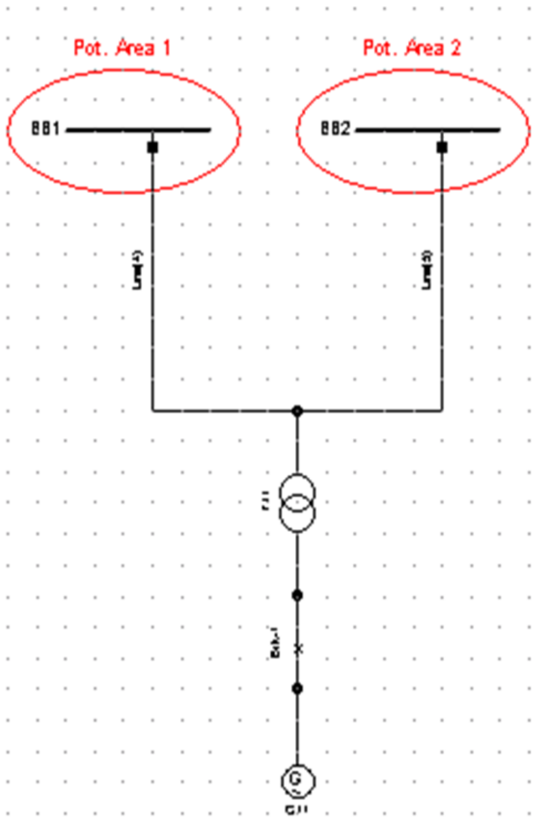


Figure 2.8: HV busbar will not be found

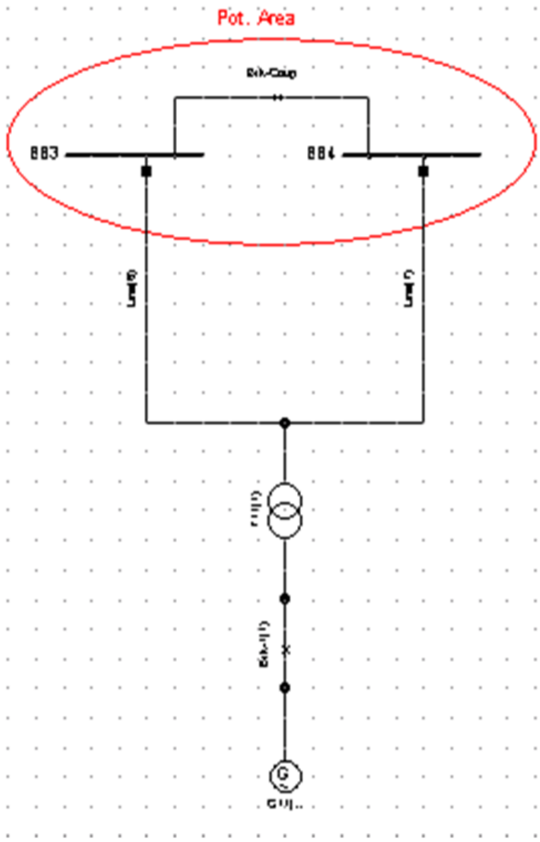


Figure 2.9: BB3 or BB4 will be found

2.3.3 Step-up Transformer Detection

The step-up transformer detection is required when the option “Step-up transformer control” is enabled. The search routine starts from all “In-service” machines/svs of the station controller. The stop criteria is the following:

- Open switches (breakers, isolators, fuses)
- Step-down transformer (from LV/MV voltage level to HV or EHV voltage level)

If no step-up transformer is found, the machines/svs controls the local busbar voltage (the voltage setpoint parameter in the machine/svs model is used as target voltage). If the option “Spinning if circuit-breaker is open” is enabled in the generator model, a warning message is printed in the output window.

2.3.4 Controlled ”HV-Node”

The search routine starts from the internal HV-node of the step-up transformer. The stop criteria is as follows:

- Open switch (breakers, isolators, fuses)
- Transformer (3-Winding, 2-Winding)
- After first busbar was passed, all elements except closed switches (switch devices) are stop criteria too.

The busbar with the lowest voltage priority ($>=0$) number is used for the controlled busbar and the corresponding target voltage. If no HV busbar was found (e.g. open HV breaker), the generator controls the local busbar voltage (the voltage setpoint parameter in the generator model is used as target voltage).

2.3.5 ”LV-Node”

The node of the connected generator is used for the controlled busbar. As target voltage the voltage setpoint parameter of the generator is used.

2.4 Step-up Transformer Control

2.4.1 HV Controlling Logic

For generators with connected step-up transformer and found HV-node, the topologically connected HV busbar is used for the voltage controlled HV node. See also chapter 2.3.4.

For generators without step-up transformer (with open breaker between generator and transformer) or open HV-circuit breaker (no HV-node found), the node of the connected generator is used for the voltage controlled node. See also chapter 2.3.5.

2.4.1.1 Flat Start Mode

The “Flat start” mode is used only if the “Automatic Tap Adjustment” in the Load Flow command is enabled and at least for one transformer is the “Automatic Tap Changing” is enabled. If the option is disabled or the “Automatic Tap Changing” is for all transformer disabled the station controllers is using directly the “Non-flat start” mode (see chapter 2.4.1.2).

The target voltage of the HV-busbar is controlled by the generators and the LV-busbar is controlled by the transformers.

If the “Automatic Tap Changing” option in the step-up transformer is enabled, the transformer is controlling the corresponding LV-busbar. The upper and lower limit of the target voltage is depending on the “Additional Voltage per Tap” parameter (*dutap* in %) of the transformer type.

$$u_{upper} = usetp + (dutap/100)$$
$$u_{lower} = usetp - (dutap/100)$$

Where $usetp$ is the voltage setpoint of generator.

The taps are changed in the “outer loop” of the Load Flow calculation if the calculated voltage ($u_{LV-busbar}$) is outside the upper and lower voltage limit. The tap changes for the transformers are calculated as follows:

$$deltaTap = abs((u_{LV-busbar} - usetp)/(dutap/100))$$

Depending on if the tap is modelled on HV-side or LV-side, the tap is decreased or increased. For a transformer with a tap on the HV-Side:

- the tap is decreased by $deltaTap$: if the calculated voltage $u_{LV-busbar} < u_{lower}$
- the tap is increased by $deltaTap$: if the calculated voltage $u_{LV-busbar} > u_{upper}$

The tap position is limited according to the minimum and maximum tap position of the transformer. A “pcl” (protocol) message is printed in the *PowerFactory* output window if the tap position is reaching the minimum or maximum position.

All “Automatic Tap Changing” settings in the step-up transformer dialog are not considered, except the “Automatic Tap Changing” option.

If no step-up transformer is connected, each generator is controlling the local busbar voltage.

2.4.1.2 Non-Flat Start Mode

The non-flat start mode is used for “non flat” Load Flow calculation (e.g. contingency analysis), if the “Automatic Tap Adjustment” option in the Load Flow command is disabled or if the “Automatic Tap Changing” is for all transformer disabled and also after the “flat start” mode is successfully solved.

In the "non-flat start mode" each generator controls the local voltage (LV-busbar), the voltage setpoint in the generator model is used. For details see chapter 2.4.1.3.

Step 1:

The step-up transformers are controlling the HV-busbar voltage. If the voltage is outside the voltage band (lower and upper bound) and the corresponding generator is not reaching the reactive power limit, the new tap for the transformer is calculated as follows:

$$deltaTap = abs((u_{HV-busbar} - uset_{target})/(dutap/100))$$

Where $uset_{target}$ is the target voltage of HV-busbar.

Depending on whether the tap is modelled on HV-side or LV-side, the transformer tap is decreased or increased. For a transformer with a tap on HV-Side:

- the tap is increased by $deltaTap$: if the calculated voltage $u_{HV-busbar} < u_{lower}$, then $u_{lower} = uset_{target} + dvmin/100$
- the tap is decreased by $deltaTap$: if the calculated voltage $u_{HV-busbar} > u_{upper}$, then $u_{upper} = uset_{target} + dvmax/100$

Where $dvmin$ is the "Delta V min" of HV-busbar and $dvmax$ is the "Delta V max" of HV-busbar.

The tap position is limited according to the minimum and maximum tap position of the transformer. A "pcl" (protocol) message is printed in the *PowerFactory* output window if the tap position is reaching the minimum or maximum position.

Step 2 (only for option: "Maximise Reactive Reserve"):

If more than one transformer (generator) is in a group, the reactive power contribution of all generators not reaching the reactive power limit is controlled by the step-up transformer tap as follows:

$$K_{tot} = \frac{\sum_{i=0}^{Gen} Qm(i) - \sum_{i=0}^{Gen} Qmin(i)}{\sum_{i=0}^{Gen} Qmax(i) - \sum_{i=0}^{Gen} Qm(i)}$$

Where:

- Gen is the number of generators in the controlling logic group not reaching the reactive power limits
- $Qm(i)$ is the measured reactive power output of the generator "i".

$$K(i) = \frac{K_{tot} \cdot Qmax(i) + Qmin(i)}{1 + K_{tot}}$$

Where:

- $K(i)$ is the reactive power participation for generator "i".

To check if the reactive power participation of the generators can be modified by the step-up transformer the reactive power changes per tap is calculated for each step-up transformer:

$$dQtap(i) = \frac{dutap(i)}{100 \cdot xpu(i)}$$

Where:

- $dutap(i)$ is the additional voltage per tap (in %) for step-up transformer "i"
- $xpu(i)$ is the transformer reactance in p.u. based on 1 MVA for step-up transformer "i"

The tap is changed if the reactive power limits are not reached for the corresponding generator and:

- the tap is increased (+1) for step-up transformer "i" if $Qm(i) < K(i) - dQtap(i)/2$
- the tap is decreased (-1) for step-up transformer "i" if $Qm(i) > K(i) + dQtap(i)/2$

2.4.1.3 LV Generator control

If the generator control the local voltage and more than one generator is connected on the same LV busbar (equipotential area).

Example:

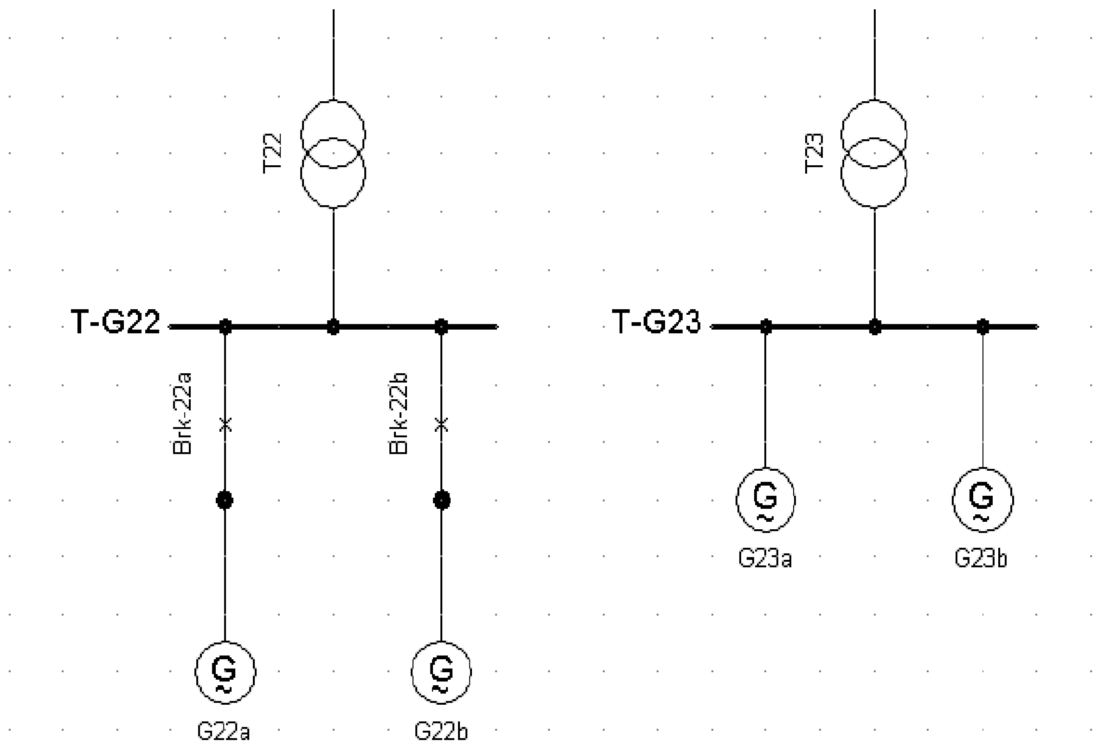


Figure 2.10: LV Generator Control

The voltage setpoint of the first listed generator (in the station controller) is used to control the LV busbar. The reactive power contribution is calculated according to the “Maximise Reactive Reserve” criteria.

2.4.2 LV Controlling Logic

For generators with step-up transformer, the topologically connected HV busbar is used for the voltage controlled HV node. See also chapter 2.3.4.

For generators without step-up transformer (with open breaker between generator and transformer) or open HV-circuit breaker (no HV-node found), the node of the connected generator is used for the voltage controlled node. See also chapter 2.3.5. The transformer LV controlling logic is disabled.

The generator voltage setpoint in the generator model is used for controlling the voltage of the LV-busbar by the transformers, the HV-busbar is controlled by the generators.

If the “Automatic Tap Changing” option in the step-up transformer is enabled, the transformer is controlling the corresponding LV-busbar. The upper and lower limit of the target voltage is depending on the “Additional Voltage per Tap” parameter (*dutap* in %) of the transformer type.

$$
\begin{aligned}
u_{upper} &= usetp + (dutap/100) \\
u(lower) &= usetp - (dutap/100)
\end{aligned}
$$

Where $usetp$ is the voltage setpoint of the generator.

The taps are changed in the “outer loop” of the Load Flow calculation if the calculated voltage ($u_{LV-busbar}$) is outside the upper and lower voltage limit. The tap changes for the transformers are calculated as follows:

$$deltaTap = abs((u_{LV-busbar} - uset_{target})/(dutap/100))$$

Depending on if the tap is modelled on HV-side or LV-side the tap is decreased or increased. For a transformer with tap on HV-Side:

- the tap is decreased by $deltaTap$: if the calculated voltage $u_{LV-busbar} < u_{lower}$
- the tap is increased by $deltaTap$: if the calculated voltage $u_{LV-busbar} > u_{lower}$

The tap position is limited according to the minimum and maximum tap position of the transformer. A “pcl” (protocol) message is printed in the *PowerFactory* output window if the tap position is reaching the minimum or maximum position.

All “Automatic Tap Changing” settings in the step-up transformer dialog are not considered, except the “Automatic Tap Changing” option.

If no step-up transformer is connected, each generator is controlling the local busbar voltage.

2.4.3 3-Winding Transformer as step-up transformer

If only on the secondary or tertiary side a generator is connected, the 3-Winding transformer works like a 2-Winding transformer.

If on the secondary and tertiary side a generator is connected (see picture below), the transformer tap and the tap controller must be modelled on the HV side.

If the transformer controls the LV busbar, the voltage setpoint and the busbar of the first listed generator in the station controller is used.

Example:

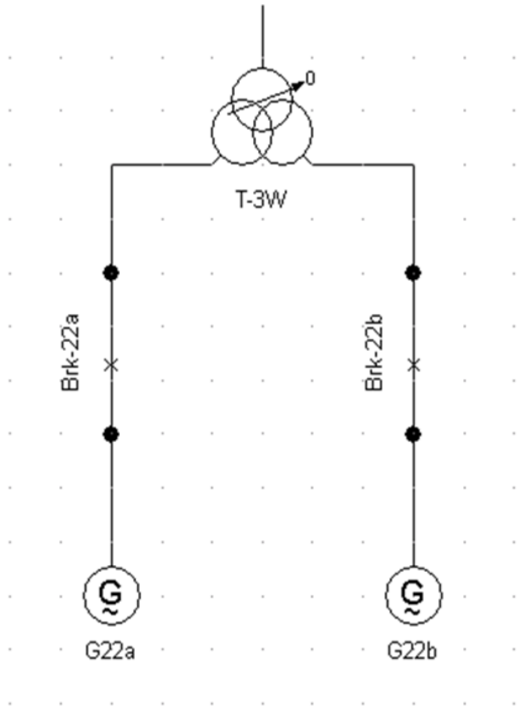


Figure 2.11: 3-Winding Transformer

2.5 Usage Hints

The station control object is not displayed graphically. However it is a specific calculation element that is also listed when selecting the icon Objects relevant for the calculation . It's icon is shown as . If you experience problems with the station control, please check that you did not define multiple station controls for the same bus, as these may result in conflicts during the calculation.

2.5.1 Individual Machines' Reactive Power Limits

It is important to mention that when the load flow is executed taking into account the reactive power limits (option *Consider Reactive Power Limits*), if the controlled machines hit their respective reactive power limits, then the station controller is switched off.

2.5.2 PWM-Converter Restrictions

PWM-Converter models (ElmVsc, ElmVscmono) can be selected for the station controller. However, the following restrictions apply:

- Control mode must not be “PWM-Phi” or “Vdc-Phi”
- Converter Modulation must not be “No Modulation”
- If the station controller contains a PWM-Converter without dispatchable active power (i.e. control mode is not “Vac-P” or “P-Q”) the reactive power contribution mode “Acc. to Dispatched Active Power” is not available

3 Input Parameter Definitions

Table 3.1: Parameter Definitions

Parameter	Description	Unit
loc_name	Name	
outserv	Out of service	
i_ctrl	Control Mode	
i_phase	Controlled Phases	
selBus	Selection of controlled busbar	
uset_mode	Selection of controlled busbar: Setpoint	
rembar	Selection of controlled busbar: Controlled Busbar	ElmTerm
cpCtrlNode	Selection of controlled busbar: Target Node	
usetp	Selection of controlled busbar: Voltage Setpoint	p.u.
selAutoUn	Selection of controlled busbar: Busbar Search Criteria >=	kV
p_cub	Control Q at	StaCubic, ElmBoundary
qsetp	Q Setpoint	Mvar
iQorient	Orientation	
pQPcurve	Selection of Q(P) curve	
Qmin	Minimum reactive power	Mvar
Qmax	Maximum reactive power	Mvar
refbar	Reference node	
udeadbup	Upper voltage limit	p.u.
udeadblow	Lower voltage limit	p.u.
pfsetp	Power Factor	
pf_recap	Option cap. or ind.	
cosphi_char	cosphi(P)-Characteristic	
pf_over	Minimum power factor (Overexcited)	
pf_under	Minimum power factor (Underexcited)	
p_over	Active Power (Overexcited)	Mvar
p_under	Active Power (Underexcited)	Mvar
i_droop	Enable Droop	
Srated	Enable Droop: Rated Reactive Power	Mvar
ddroop	Enable Droop: Droop	%
Qdroop	Enable Droop: Droop	Mvar/p.u.
deltaV	delta(V)	p.u.
pQmeas	Enable Droop: Q measured at	StaCubic, ElmBoundary
imode	Reactive Power Distribution	
iTrfCtrl	Reactive Power Distribution: Step-up Transformer Control	
Tctrl	Reactive Power Distribution: Controller Time Constant	s
Psym	ElmSym,ElmGenstat,ElmSvsMachines	
cvqq	Reactive Power Percentage	%

List of Figures

List of Tables