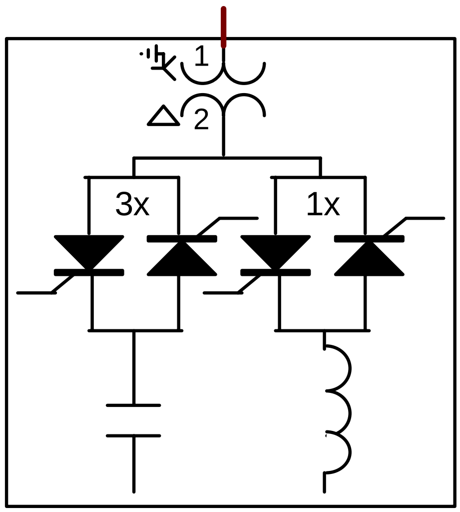
Static Var Compensator device



SVC_1

1 Description

The Static Var Compensator (SVC) is a shunt device of the Flexible AC Transmission Systems (FACTS) family using power electronics to control power flow and improve transient stability on power grids [1]. In general, the SVC can be used where continuous and fast control or reactive power is required to meet any or all of the following objectives [2]:

- Improved voltage regulation;
- Enhancement of steady state and dynamic stability;
- Reduction of over voltages;
- Reduction of voltage flicker;
- Damping of sub synchronous oscillations;
- Reduction of voltage or current unbalances.

This SVC is a generic model using three Thyristor Switched Capacitor banks (TSC) and one Thyristor Controlled Reactor (TCR).

The SVC regulates voltage at its terminals by controlling the amount of reactive power injected into or absorbed from the power system. When system voltage is low, the SVC generates reactive power (SVC capacitive). The variation of reactive power is performed by switching three-phase capacitor banks and inductor banks connected on the secondary side of a coupling transformer. Each TSC bank is switched on and off while the TCR phase-controlled.

The figure below shows the top level circuit in the SVC subcircuit.

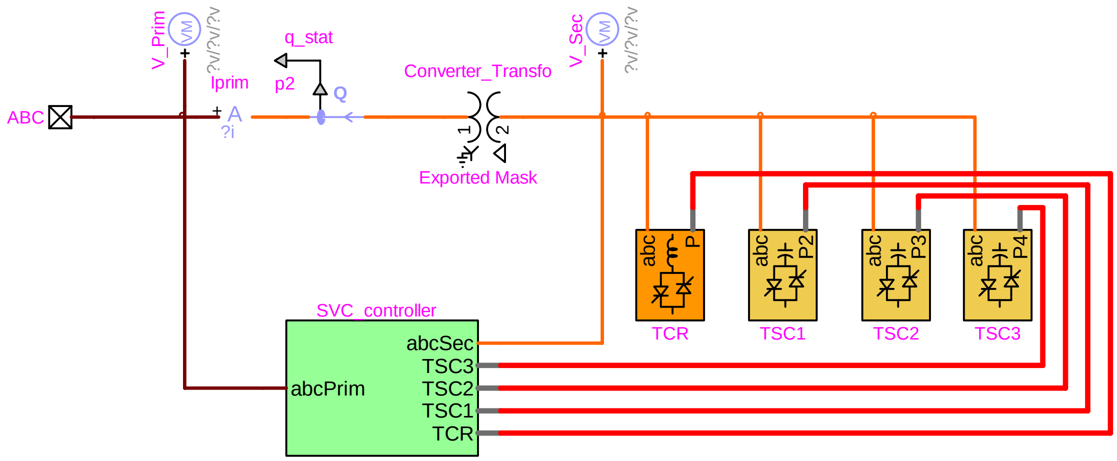


Figure 1-1 Top level of the SVC subcircuit

The control system subcircuit (shown in Figure 1-2) consists of:

- A measurement system (Measurement_System, see contents in Figure 1-3) measuring the positive-sequence voltage to be controlled. A Fourier-based measurement system using a one-cycle running average is used.
- A voltage regulator (Voltage_Regulato, see contents in Figure 1-4) that uses the voltage error (difference between the measured voltage Vmes and the reference voltage Vref) to determine the SVC susceptance B needed to keep the system voltage constant.
- A distribution unit (Distribution_Unit) that determines the TSCs that must be switched in and out, and computes the firing angle Alpha of TCRs.
- A firing unit (firing_unit) that includes a synchronizing system using a phase-locked loop (PLL) synchronized on the secondary voltages and a pulse generator that sends appropriate pulses to the thyristors.

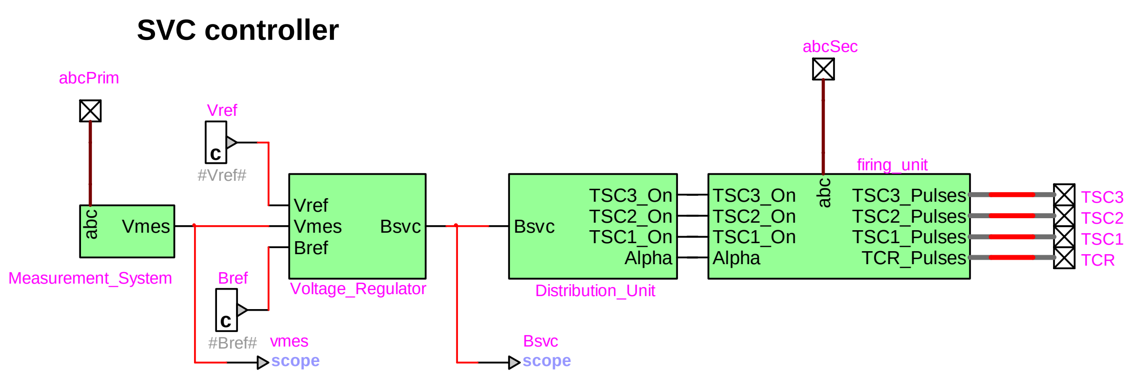


Figure 1-2 SVC controller

Measurement system

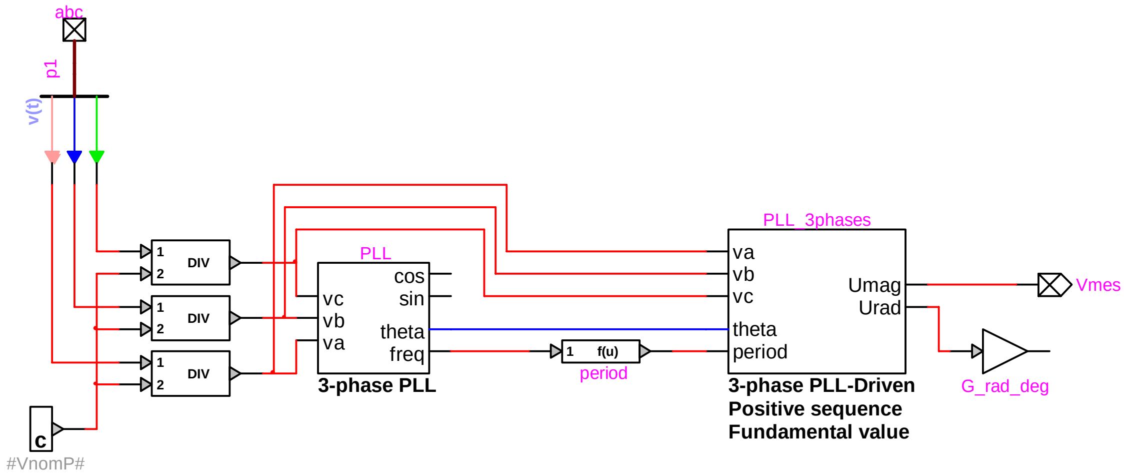


Figure 1-3 Measurement system subcircuit

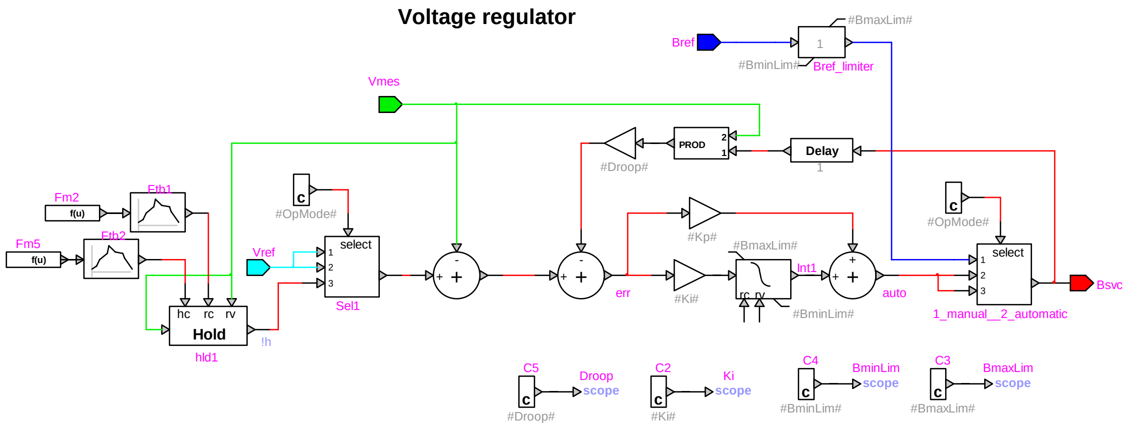


Figure 1-4 Voltage regulator block

2 Parameters

2.1 User defined Initial values

This device is using a scripted mask. Detailed information on scripted masks can be found by selecting the index Masking in “Help Docs>Using EMTP – Tutorials and Reference” and the documentation on “Mask Scripts”.

The user can enter data in the “Initial values” section. More advanced usage may require editing the “Rules” section. The “Rules” section is providing data preprocessing based on initial values. Help on enabling and disabling the Rules section can be found in the Masking documentation.

This device is using several subcircuit levels. Some subcircuit based devices are taken from existing (built-in) EMTPWorks libraries. All contents (subcircuits) are unique and cannot be altered by modifying similar devices taken from built-in libraries and appearing within a design where this SVC is located. If it is needed to make separate changes in the subcircuit of one SVC without affecting other SVC circuits in the same design, then the SVC must be first made unique using the “Make Unique Type” command under the menu Options>Part Type. User changes will only affect the design contents and not the original library version of the device.

The following parameters are defined in the mask:

Symbol	Description	Units
Freq	The nominal Frequency	Hz
VnomPri	Nominal SVC voltage, line-to-line, RMS.	VRMSLL
VnomSec	Secondary nominal voltage magnitude, line-to-line, RMS.	VRMSLL
Xf_xfo	Transformer total leakage reactance.	pu on Pnom_xfo
Rf_xfo	Transformer total resistance.	pu on Pnom_xfo
Ratio_xfo	Winding impedance on winding 1.	
C_TSC_MVAR	TSC branch total MVARs. This is used also in the calculation of the nominal power for the transformer.	MVAR
OpMode	Operation mode: 1 is for manual mode (VAR control) 2 is for automatic mode (voltage control) with Vref 3 is for automatic mode with Vref=Vmes Vmes is the measured voltage. If manual: set the variable Bref If automatic: set the variable Vref See the subcircuit Voltage_Regulator	
Bref	Reference susceptance when the SVC is operating in manual mode (VAR control). A positive value indicates that the SVC is capacitive. See SVC_controller subcircuit.	pu on 100MVA
Vref	Reference voltage used by the voltage regulator when the SVC is operating in the automatic mode. See SVC_controller subcircuit.	pu
timeVref	Time at which Vref is set to Vmes. See Voltage_Regulator.	s
Time_Cst	Droop time-constant (use for finding Ki in Voltage_Regulator).	s
v_reg_level	Voltage at which the SVC is fully capacitive. Used in the calculation of Droop gain in Voltage_Regulator.	pu
Kp	Voltage regulator Proportional gain.	
K_share	Used in the Rule of L_TCR_MVAR: L_TCR_MVAR=C_TCS_MVAR*1.15/K_share Use K_share=1 if positive MVARs are equal to negative MVARs.	
Q	Quality factor of L_TCR (TCR inductance).	
L_TSC	TSC branch inductance.	H
Rseries	Series resistance of TSC	Ohm
Rparallel	Parallel resistance of TSC	Ohm
Rsnb	Thyristor snubber resistance	Ohm
Csnb	Thyristor snubber capacitance	F
Vf	Thyristor forward voltage drop	V
hyst_svc	Hysteresis for TSC switching (Distribution unit)	pu on 100MVA
Firing_Mode	Firing mode of the capacitive branch in the firing unit: 0 is for synchronized (harmonics damp more quickly) 1 is for continuous	
Nstep	Total delay in the number of time steps to be compensated in the firing unit.	

kp2	1-phase PLL proportional gain (see firing_unit)	
ki2	1-phase PLL integral gain (see firing_unit)	
Tinit	Start time of SVC. No firing before Tinit.	s
kp1	3-phase PLL proportional gain (Measurement_System)	
ki1	3-phase PLL integral gain (Measurement_System)	

The transformer nominal power is found from the rule:
Pnom_xfo=C_TSC_MVAR*1.11e6;
Pnom_xfoMVA=Pnom_xfo/1e6; //transformer power in MVA

The transformer parameters entered in the SVC data mask are automatically transmitted to the transformer appearing at the top level of the SVC subcircuit (see transformer in Figure 1-1). The transformer has an Exported Mask. The connection between the SVC mask and the transformer mask is achieved in the Rules section through the function "set_converter_transfo". The transformer is located using its specific name "Converter_Transfo". The user can modify the rules by adding other options, such as changing transformer scope requests or transformer saturation data. Transformer data can be also changed manually by first eliminating the call to "set_converter_transfo" (last line in the Rules section), then clicking OK on the transformer device mask and subsequently canceling the Exported Mask status.

The user must remember that subcircuit content changes are automatically transmitted to all other subcircuits of the same type unless the modified subcircuit is first made unique using the menu Options>Part Type>Make Unique Type.
It is noticed that the last line in the Initial values section of this device is the function call:
make_me_unique();
This statement makes the top level subcircuit of the SVC unique as if the Make Unique Type command has been applied manually. After clicking OK on the SVC mask the user can modify the top level subcircuit contents, without affecting data for other SVC devices in the given design.

The make_me_unique function has two optional arguments:

- do_mychildren: set to true if the Make Unique Type command must be applied all subcircuit levels of this subcircuit. Default is false.
- my_action_message: set to false to turn off the echo message in the Console window. Default is true.

2.2 Scopes

Scope names are using the SVC subcircuit name as the root name.
The following default scopes are available for an SVC named SVC_1:

- SVC_1/V_Prima: Top voltage, primary of transformer, phase a
- SVC_1/V_Primb: Top voltage, primary of transformer, phase b
- SVC_1/V_Primc: Top voltage, primary of transformer, phase c
- SVC_1/V_Seca: Secondary voltage, phase a
- SVC_1/V_Secb: Secondary voltage, phase b
- SVC_1/V_Secc: Secondary voltage, phase c
- SVC_1/SVC_Transfo/xfmr_A/RL2: transformer secondary winding current in phase a
- SVC_1/SVC_Transfo/xfmr_B/RL2: transformer secondary winding current in phase b
- SVC_1/SVC_Transfo/xfmr_C/RL2: transformer secondary winding current in phase c
- SVC_1/SVC_controller/Voltage_Regulator/BmaxLim: see Voltage_Regulator
- SVC_1/SVC_controller/Voltage_Regulator/BminLim: see Voltage_Regulator
- SVC_1/SVC_controller/Voltage_Regulator/Droop: see Voltage_Regulator
- SVC_1/SVC_controller/Voltage_Regulator/Ki: see Voltage_Regulator
- SVC_1/SVC_controller/Distribution_Unit/alpha: firing angle
- SVC_1/SVC_controller/Distribution_Unit/tsc1: TSC1 on signal

- SVC_1/SVC_controller/Distribution_Unit/tsc2: TSC2 on signal
- SVC_1/SVC_controller/Distribution_Unit/tsc3: TSC3 on signal
- SVC_1/SVC_controller/Bsvc: Output of Voltage_Regulator
- SVC_1/SVC_controller/vmes: Measurement_System output
- SVC_1/q_stat: reactive (3-phase) power injected into the SVC bus

Scopes can be turned off by moving into the appropriate SVC subcircuit.

3 References

[1] N.G. Hingorani, L. Gyugyi, “Understanding FACTS; Concepts and Technology of Flexible AC Transmission System”, IEEE Press book, 2000

[2] The committee on static compensation, Canadian Electrical Association “STATIC COMPENSATORS for reactive power control”, Cantext Publications, Winnipeg, 1984