POWERFACTORY

PowerFactory 2021

Technical Reference

Softstarter

ElmVar

PF2021

POWER SYSTEM SOLUTIONS

MADE IN GERMANY

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1 General Description

During the start-up of induction motors the starting currents can reach values as large as six to eight times the rated current of the motor during full-load conditions. Especially when operating large motors or motors at weak grids, this can cause problems in the connected network or during the start-up procedure of the motor.

To reduce these large starting currents, the voltage at the motor terminals can be reduced during the start-up by using a softstarter device. The softstarter model in *PowerFactory*, shown in Figure 1.1, represents a device connected in series between an induction motor and the grid.

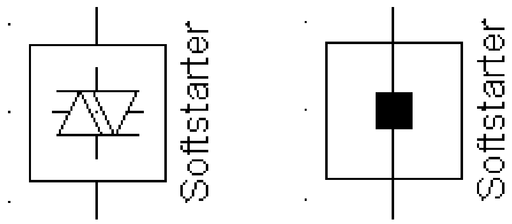

Figure 1.1: Softstarter representation when active (left) and when bypassed (right)

The softstarter can continuously control the motor side voltage dependent on the actual value of the voltage at the connection point to the grid. Subsequent to the switch-on of the input voltage to the softstarter, the soft-start is then increasing the duty ratio and hence the output voltage at the motor slowly.

Provided the torque developed under these low voltage conditions is sufficient to overcome the load torque, the motor will start to accelerate and the motor current will decrease. The voltage can then be increased linearly and the motor will reach its nominal speed.

The detailed circuit represented by the softstarter model is shown in Figure 1.2.

During steady-state operation when input voltage and terminal voltage of the motor are equal, each thyristor is conducting for a complete half-cycle. In this operation the thyristors can be bypassed by contactors in parallel to the valves to reduce the stress of the valves and to eliminate the power losses.

An advantage of this device compared to other constant speed start-up procedures, like electromechanical star-delta starters or the usage of transformer tap-changers, is the reduction of starting currents without the impact of switching transients during the tapping or switching.

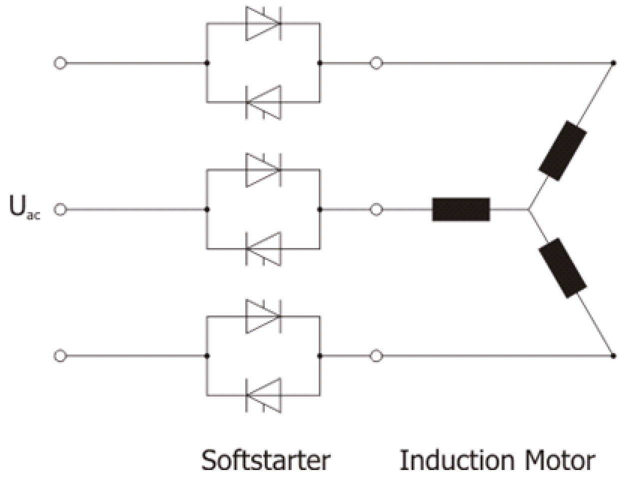

Figure 1.2: Detailed representation of the Softstarter model including induction motor

1.1 Basic Data

In the basic data page of the softstarter, there can be entered the two main parameters of the element:

- Nominal Voltage 'Unom'
- Nominal Current 'Inom'

1.2 Load-Flow Analysis

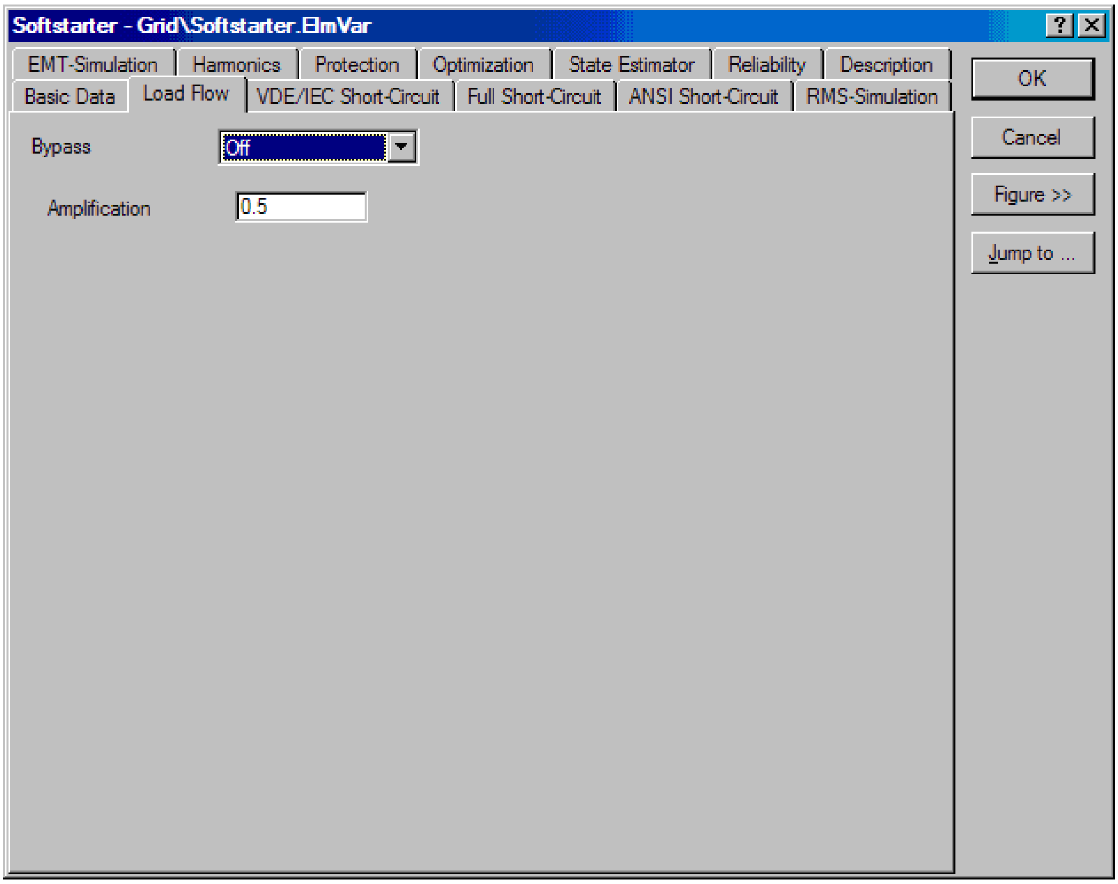

Figure 1.3: Load-Flow Set-Up of the Softstarter Element

On the load-flow page of the *ElmVar* the amplification factor of the softstarter can be set. This factor is defined by the voltages on the primary and on the secondary side of the element:

$$k_{in} = \frac{U_{sec}}{U_{prim}}$$

I.e. the duty cycle of the thyristors and hence the firing angle to the valves is set to reach the ratio between input and motor voltage. In load-flow analysis, it is easier not to specify control variables directly but to define the *controlled variables* instead. The control variable (the firing angle α) is then resulting from the load-flow calculation.

There is also the possibility to directly bypass the thyristors by setting the bypass to 'ON'. Then the amplification is not used during the calculation anymore.

1.2.1 Losses

In his model the losses of the thyristors are not implemented. During steady-state operation the valves are bypassed, thus the losses might be important only during the start-up procedure.

1.3 RMS Simulation

The stability model uses the same equations as described in section 1.2 of the load-flow analysis. There is no further information needed.

To control the start-up of the motor and hence the voltage at the motor terminals, there are two inputs available which can be accessed by parameter events or DSL models:

- i_onoff: this parameter can enable or disable the bypass of the thyristors
- Kin: the amplification factor can be set and changed continuously

1.4 EMT Simulation

The EMT model represents the softstarter by the detailed model shown in Figure 1.2. Here also two inputs available to control the start-up of the motor:

- i_onoff: this parameter can enable or disable the bypass of the thyristors
- alpha: firing angle of the thyristors to set the duty cycle of each valve and thus to control the secondary voltage

The grid frequency is estimated internally or an input ”Fmeas” can be connected to the model (for example from a PLL).

2 Input/output Definition of Dynamic Models

2.1 Stability Model (RMS)

Table 2.1: Input Definition of the RMS-Model

Parameter	**Description**	**Unit**
i_onoff	Bypass	
Kin	Voltage Ratio Vsec/Vprim	

There are no output signals available for the softstarter.

2.2 EMT-Model

Table 2.2: Input Definition of the EMT-Model

Input	**Description**	**Unit**
i_onoff	Bypass	
alpha	Firing Angle	rad
Fmeas	Frequency	Hz

There are no output signals available for the softstarter.

3 Input Parameter Definitions

3.1 *.ElmVar

Table 3.1: Input Parameter Definitions of the Softstarter Element

Parameter	Description	Unit
loc_name	Name	
Unom	Nominal Voltage	kV
Inom	Nominal Current	kA
i_onoff	Bypass	
K	Amplification Factor	

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