Soft Starter Training

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Soft Starter Theory of Operation
Main Methods for Starting Induction Motors:

- Direct on-line starter
- Star-delta starter
- Auto-transformer starter
- Soft Starter

A soft starter offers nearly the best starting characteristics, reduced current, and a controlled ramp.
Soft-Starter Applications

Typical soft-starter applications include the following:

- Pumps
- Fans
- Conveyors
- Compressors
Soft-Starter Advantages

- Smooth starting ramp
- Reduced peak currents
- Precise current limit during starting
- Reduced mechanical stress (shock on the load)
- Reduced water hammer
- No moving parts to wear out
- Fault detection

Soft-Starter Method of Operation

Soft-starters use SCRs (Thyristors) to regulate the amount of voltage applied to the motor. When correctly set it provides the minimum amount of voltage necessary to develop the required starting torque.

The voltage is then increased via a programmable ramp thereby providing the motor with a smooth starting torque and step less ramp to full speed.
Soft Starter Simplified Diagram

Soft Starter Triggering (resistive load)
SCR Triggering (Inductive load)
Model Number Identification
Control Mode

- **Voltage ramp**
  Voltage increases according to a preset ramp time and starting current is a function of ramp time and type of load.

- **Current Limit**
  Voltage is applied in order to maintain a preset current level according to the application.

- **Current Ramp**
  Maximum current level is also limited during start-up however higher or lower start-up current limits can be set.

- **Pump Control**
  Optimized control method providing the required torque to start/stop Hydraulic centrifugal pumps smoothly.

- **Torque Control**
  This method allows a torque control with 1 up to 3 setting points.
Starting by Voltage Ramp (P202=0)

1) Set initial voltage, P101. Set initially to a low value;
2) When load is applied to the motor, set P101 to a value that allows motor running smoothly since the begin of its enabled;
3) Set P102 to the time required for the motor start. Set firstly short time, 10 to 15 seconds, after try to find the most suitable starting condition for your load.

Starting by Current Limit (P202=1)

1) To start the motor with a current limit you must apply a load to the motor. No-load tests can be done by voltage ramp;
2) Set P102 to the time required for the load start. At first set short times, 20 to 25s. This time will be used as the locked rotor time, when the motor is unable to start;
3) Set P110 with Current Limit by considering its electrical installation and ensuring sufficient torque for the motor start. Initially you can set firstly 2x to 3x the rated motor current (I_n of the motor).
Starting by Current Ramp (P202=4)

1) To start the motor with current ramp you must apply load on the motor. No-load tests can be done by voltage ramp.
2) Use this function to help starting loads that require a lower initial torque, as fans and blowers.
3) When such a load is started with fixed current limit, you can note that the motor starts the load and then it speeds up;
4) As soon we recommend setting a lower initial current to only run the load and the increase the current limit gradually until the end of the start. In this way you will certainly ensure a smooth start;
5) Set P111 to the current value required to start the motor in movement only;
6) Set P112 initially to 75% of P102(20s) = 15s and then increase it gradually;
7) The motor must run as soon as it is enabled;
8) Set P110 with current limit that maintains the motor accelerating;
9) The motor must accelerate till the start end.

Starting with Pump Control (P202=2)

1) To start with pump control a load is necessary. Tests without a load can be done with voltage ramp;
2) The parameter setting depends mainly on the types of hydraulic installations. Thus we recommend to optimizing factory settings, if possible;
3) Check if the motor rotation direction is an indicated on the pump frame. If not, connect the phase sequence as indicated at P620;
4) Set the initial voltage - P101 – so the motor starts smoothly as soon as it is enabled;
5) Set the acceleration time according to its application (i), and that the motor is able to start the load smoothly, but the required acceleration is not exceeded. If acceleration times are set too long, this may result in vibration of harmful motor overheating;
6) To check the correct starting process, always use a manometer in the hydraulic installation. Pressure increase should not result in sudden oscillations. Thus the pressure increase should be as linear as possible;
9) Generally, the current increases at the end of the deceleration ramp and in this case the motor requires more torque to achieve a smooth water flow stop. When the motor has already stopped, but is still enabled, the current will increase too much. To prevent this condition, set P105 to a value that as soon it stoops it is also disabled.

10) Set P610 and P611 to current and line levels that prevent the hydraulic pump from running without a load.

11) The torque control of the Soft-Starter SSM-06 demonstrates excellent performance during motor and load starts.
12) This control is available in a form to provide and to adjust the type of control to the type of load.
13) See below some recommendations on how to program and set this type of control.

**NOTES!**
1) To start with pump control a load is necessary. Test without a load can be done with voltage ramp.
2) If the torque limits are not reached during the start, the motor will start immediately.
3) Only use the control type and torque control type you are able to set. Always select the control type that is easier to set, considering the load characteristics.
4) When heavy loads are started, always start at an easily limit. In this way you can set the energy consumption during the start by considering the power line capacity.
5) All motor parameters must be set according to the motor nameplate, P440 to P445.
6) Torque limits that are too low do not supply enough torque to start the motor.
7) Low torque limits are also very sensitive to motor temperature oscillations, for instance when load is started with cold or hot motor.
8) High torque limits are also very sensitive to load changes, for instance, oil, gases and intake valves have different resistant torques in relation to the motor start when they are not or cold.
9) Always maintain motor running after it has been started cold or hot.
10) The motor manufacturer supplies the maximum torque developed by the motor, during the starting or at full load. The Soft-Starter can only limit this data.
11) If errors are detected during the motor start, check all connections of the Soft-Starter to the power line; the motor connections, the voltage levels of the control, the cables, circuit breakers and disconnecting switches.
5 Types of control (P202)

- A soft-starter only gives a reduced voltage start-up (like a light dimmer switch)
- This reduces starting current and starting torque and therefore the mechanical stress
- What does a soft-starter do?
  It gradually ramps up the voltage in a controlled manner and thereby reduces the starting current
- No Speed control on SoftStarter

Soft Starters - Practical Considerations:

When a soft-starter and when a VSD?

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- What does a soft-starter do?
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- No Speed control on SoftStarter
Some practical soft-starter considerations:

- Reduced voltage gives reduced torque – MUCH REDUCED!
- \( T \) is proportional to \( V^2 \)
- E.g. A typical motor has a starting torque of 200%, also a typical soft-starter starting voltage is 30%. The motor starting torque would then be:
  - 18% - very soft!

Best suited for the type of applications that use reduced torque like centrifugal pumps & fans mainly.
The WEG soft-starters can deliver up to 500% current and can therefore also be used in “high torque” applications such as conveyors, crushers, screw feeders, large high inertia fans with a long run-up time etc.
Soft Starter & Motor selection
Important To Know To Size a Soft-Starter:

- Starts/Hour
- Ambient Application
- Absorbed power
- Torque characteristic
- Inertia
- Motor Current
- Motor Power
- Supply Voltage
- Number of Conditions

These values can be entered into the SDW software on the WEG website to make an accurate selection.

Pumps

Starter Method:

- Start with acceleration ramp
- Function “Pump Control”

Advantages:

- Reduction of “Water hammer”
- Reduced current
Fans

**Starter Method:**
- Start with “current limit”.

**Advantage:**
- Reduced mechanical stress and wear
- Reduced current

Compressors

**Starter Method:**
- “Kick-Start” function
- Start with voltage ramp

**Advantage:**
- Able to accelerate the inertia process of the load smoothly
Starter Method:
- Start with "current limit"

Advantage:
- Reduction of mechanical wear

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Conveyor Belt

Starter Method:
- Start with “voltage ramp”

Advantage:
- Reduction of mechanical wear
INTRODUCTION

Soft-Starters are considered to be “Industrial Electronic” items and as such should be able to withstand rough working conditions.

This is true.

However, fact is, a Soft-starter is an electronic item. The better the installation, the less problems and greater reliability the user will enjoy.
Mechanical Installation

As far as possible avoid the following:

- Direct exposure to sunlight, rain, high moisture and sea air
- Exposure to corrosive liquids or gasses
- Exposure to excessive vibration
- Conductive dust, oil or any conductive particles or materials

Environmental conditions:

- Temperature: 0…40ºC – nominal conditions
  0…55ºC - with current derating
- Relative Air Humidity: 5% to 90%, non-condensing
- Maximum Altitude: 1000m – nominal conditions.
  1000 - 4000m – with 1% current derating for each
  100m above 1000m.
Cooling Airflow

1. Always ensure sufficient room and ventilation for cooling air flow.
2. Sufficient space – top, bottom and sides.
3. Avoid direct sunlight.

Hints:
1. Use panel fans if in doubt.
2. Remember that trunking impedes air flow.
3. Rather allow more flow and space than the minimum requirements.
4. Allow for heating from other components within the VSD panel.
5. A sealed, clean air conditioned environment is best.

Panel Ventilation

A totally sealed panel circulates the Soft Starter hot air causing a steady temperature rise.
Panel design must allow for hot air to be vented.
**Important notes:**

- The AC input voltage must be compatible with the SS rated voltage.
- Capacitors for power factor correction must be disconnect at the input (R, S, T) while you are accelerating the load and they must be re-connected after the BY-PASS contactor closed.
- The SS MUST be earthed for safety purposes (resistance ≤ 10Ω).

**SSW06 Installation**

- **Fuses:**
  - *Slow Blow* installation;
  - *Ultra rapid* soft-starter

- **Contactor**
  - Maintenance;
  - Emergency;

- **Power Cabling**
  If there is any risk of EMI interference with other equipments.

- **Command Wiring**
  - Shielded cable;
  - Separated from power cables;
Main disconnect switch

For safety purposes – isolation, protection and maintenance
**Fuses**

To protect the installation input. Correctly rated ultra rapid fuses should be used for SS.

**Contactor**

If customer practice demands the use of a contactor, it may be used.
Control wiring
Keep separate from power cables
Cross power cables at 90°
Use screened cables for analogue signals
Terminal X1A Power board

<table>
<thead>
<tr>
<th>Connector X1A</th>
<th>Description</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE</td>
<td>Ground</td>
<td>110 to 230VAC (-15% to +10%) or 24 to 26VDC</td>
</tr>
<tr>
<td>Digital Inputs</td>
<td>Relay Outputs</td>
<td></td>
</tr>
</tbody>
</table>

X1B & X1C Connection

- Digital Inputs: 3, 5, 6, 7, 11, 24V
- Relay Outputs: 18, 19, 20, 21, 22, 23
Thermal Protection for Different Classes

(P640)

Soft Starter Commissioning
1. Check that all connections are correct and tight.
2. Verify that the SS is correctly rated for the motor.
3. Verify that the SS is correctly rated for the supply voltage.
4. Uncouple the load from the motor, or ensure that the load may be safely turned.
5. Check that the control voltage matches the SS unit control voltage rating – 220VAC is standard.

Thermal Protection for different classes (P640)
1. Check that the supply voltage is within acceptable range. (nominal Voltage -15% to +10%)

2. Power up the Electronics Supply

3. Check that the power up was successful.
Soft Starter Parameters

Types of Parameters

- **Read Only Parameters**: Are variables that can only be viewed on the keypad display, but not changed by the user.

- **Regulation Parameters**: Are Programmable values to be used by the SSW SSW-06 functions.

- **Configuration Parameters**: Define the SSW characteristics, the functions to be executed, as well as the Inputs and Outputs functions of the control board.

- **Motor Parameters**: Motor data that are indicated on the motor nameplate.

- **Special Function Parameters**: Included here are the stop and kick start functions.

- **Protection Parameters**: Included here are the actuation levels and actuation time of the motor protection.
Parameters Description

For ease of understanding, the parameters were grouped according to function, as follows:

- **Read Only Parameters**: P01...P99
- **Regulation Parameters**: P00 & P100 – P199
- **Configuration Parameters**: P200 – P399
- **Motor Parameters**: P400 – P499
- **Special function Parameters**: P500 – P599
- **Protection Parameters**: P600 – P699

The SSW06 HMI

It is a very simple and functional interface to operate and program the soft starter:

- Visualization and Parameter Changes
- Status Indication
- Fault Indication
- Soft starter Operation
- On/Off, Jog Function, Forward/Reverse
- Local/Remote
- Detachable
Use of the SSW06 HMI

- Liquid Crystal Display with 2 lines of 16 alphanumeric characters
- 7 segment LED Display with 4 digits
- “Program” Key
- Start Key
- Stop Key
- Local/Remote Key
- Increase Key
- Decrease Key
- FWD/REV Key
- Jog Key

Automatically guided start-up routine (P204=5)

During this start-up routine the following parameters are set:

1. P201 – Language
2. P150 – Motor connection (Inside delta)
3. P202 – Control mode
4. Parameters relevant to control mode chosen
5. Motor nameplate parameters
6. Motor protection parameter, rated thermal class
Normal Connection

**SSW-03**

3 Wire

Star Connection

**SSW-03**

3 Wire

Delta Connection

Inside Delta Connection

6 Wire

Inside Delta Connection

Soft Starter line current reduced to 0.58% Inom.

(42% reduction)

Drives and Controls
End of Course
Thank You