Siemens Sirius 3RW40

Figure 1. Siemens 2-phase-controlled Solid-state Soft Starter Sirius 3RW40

There are several different ways to start three-phase AC induction motors. The simplest is to connect the motor to power supply via only contactors and overload relays, and start the motor at full voltage. This method is called starting the motor across-the-line (ATL). With this type of starting, the motor will draw a high in-rush current when started at full voltage. In-rush current can be 6-10 times the full load current of a motor. Such a high current can cause voltage dips in the power supply. In a weak power supply system, lights may dim at the start of a motor. ATL also causes excessive torque in the mechanical systems driven by the motors. The excessive torque in turn can cause undesirable shocks among mechanical components, such as gears, belts, sheaves, and connections. Systems exposed to such shock will require more frequent maintenance that leads to costly down-time.

The next viable solution is using electromechanical reduced voltage starting. Choices include autotransformers and wye-delta starters. An autotransformer is simply a transformer that can be tapped to deliver 50, 65, or 80 percent of full voltage. Wye-delta starters can only be used with specially wound motors. With the wye-delta starter, the specially wound motor is first run as a wye motor so the motor windings only see 58% of full voltage. After a set period of time, the starter switches to run the motor as a delta motor and the motor windings see full voltage. By starting the motor at reduced voltage, the electromechanical starters are able to reduce in-rush current and torque to certain extent. Both autotransformers and wye-delta starters are large in size and require extra wirings. Because the voltage is reduced in limited steps, there are still sudden current change and mechanical shocks during transition.

The newer generation of starters employs solid-state technology and can provide stepless soft-starting of motors. Reduced voltage is delivered to a motor by controlling an SCR's firing angle (Figure 2). Because the SCR's firing angle can be finely controlled, solid-state starters can ramp the voltage smoothly to full rating (Figure 3). Figure 3 also shows that the in-rush current with soft starters is much lower. Therefore, both the voltage dips and the mechanical shocks can be reduced considerably with solid-state soft starters.

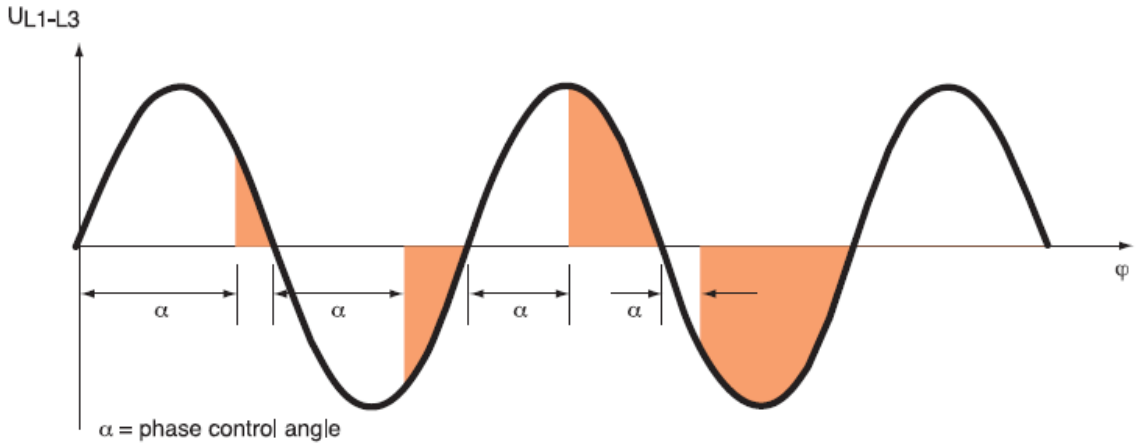

Figure 2. Smoothly Ramp up Motor Voltage by Controlling SCR's Firing Angle

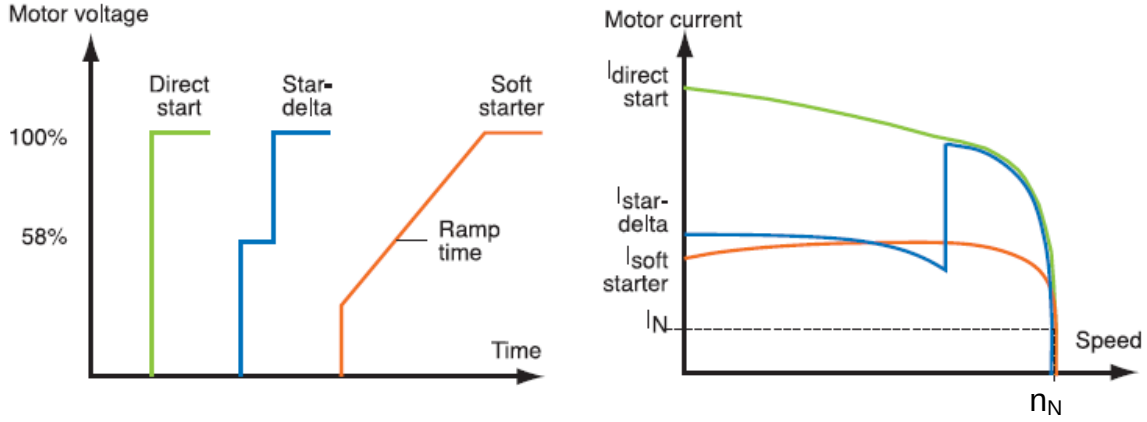

Figure 3. Sirius Soft Starters Significantly Reduce Voltage Dips and Mechanical Shocks.

There are usually 3 pairs of SCRs to control the voltage to a 3-phase AC induction motor, i.e., one pair for each phase (Figure 4). Because SCRs are power components, they generate approximately 1 watt per amp per phase of heat when they are on. The heat sink must be required to dissipate the heat. Both the SCRs and the heat sink are expensive components. Because a 3-phase motor is a three-wire system, the sum of its 3 phase currents is physically constrained to zero. If the currents to 2 of the 3 phases are reduced, the current to the third phase will be reduced as well, even when the third phase is directly connected to full line voltage. Six years ago, Siemens Engineers developed 2-phase-controlled solid-sate soft starter Sirius 3RW30. A 3RW30 uses only 2 pairs of SCRs, so it has smaller heat sink. Fewer SCRs and a smaller heat sink brought down the cost and size of the 3RW30. Compared to an electromechanical starter, a 3RW30 offers superior performance in a compact size. The cost of parts, installation, and maintenance is also considerably lower. The Sirius 3RW30 has been successfully applied in the field for over six years.

Rising from the success of Sirius 3RW30, the Siemens team is now launching the second generation of 2-phase-controlled soft starter Sirius 3RW40. The 3RW40 has bundled the latest technology inside a compact footprint and is offered at very competitive price. The impressive features of 3RW40 include:

- Patented polarity balancing control allowing the motor to start at <50% full voltage using 2-phase control up to 300HP
- Integrated AC Motor thermal protection conforming to latest IEC 60947-4-2
- Selectable motor overload trip class
- Adjustable current limiting, start time, stop time, and starting voltage
- Built in by-pass contactors

- Detection of phase failure, faulty control voltage, locked rotor, SCR overheat, and more…

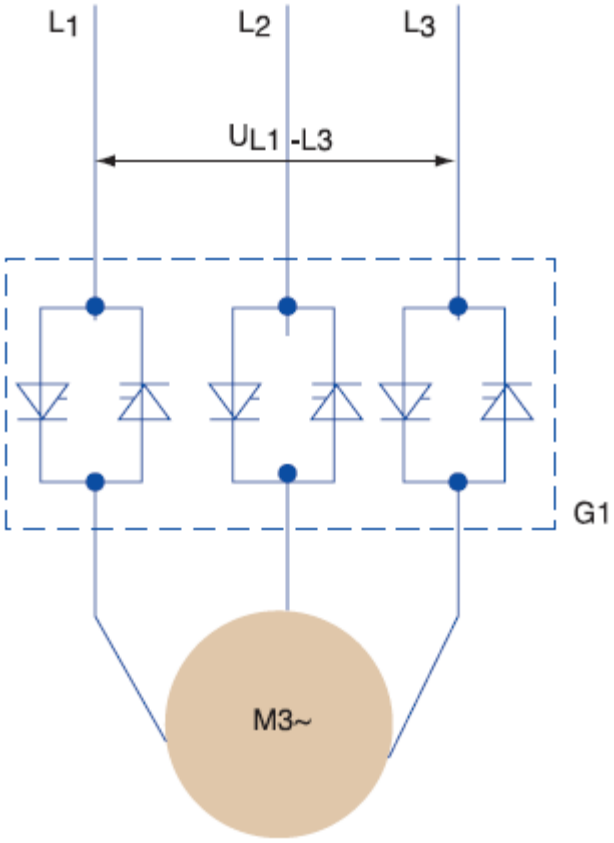

Figure 4. SCRs Control Motor Voltage

Normally a 2-phase-controlled soft starters can cause an undesirable acoustical noise oon larger motors at voltages <50%. The cause of the audible noise is relatd to the CD component in the phase current. DC components in phase currents (Figure 5) can cause additional heating. Because of shorter starting times, the heating affect in the motor is minimal. The polarity balancing control used in 3RW40, balances the current in positive half and negative half, eliminating these DC components (Figure 6). With polarity balancing motors can be started at voltages <50% of full rating and up to 300HP. This feature is especially helpful when soft starting a fan motor or pump motor at light load or no load during the start period.

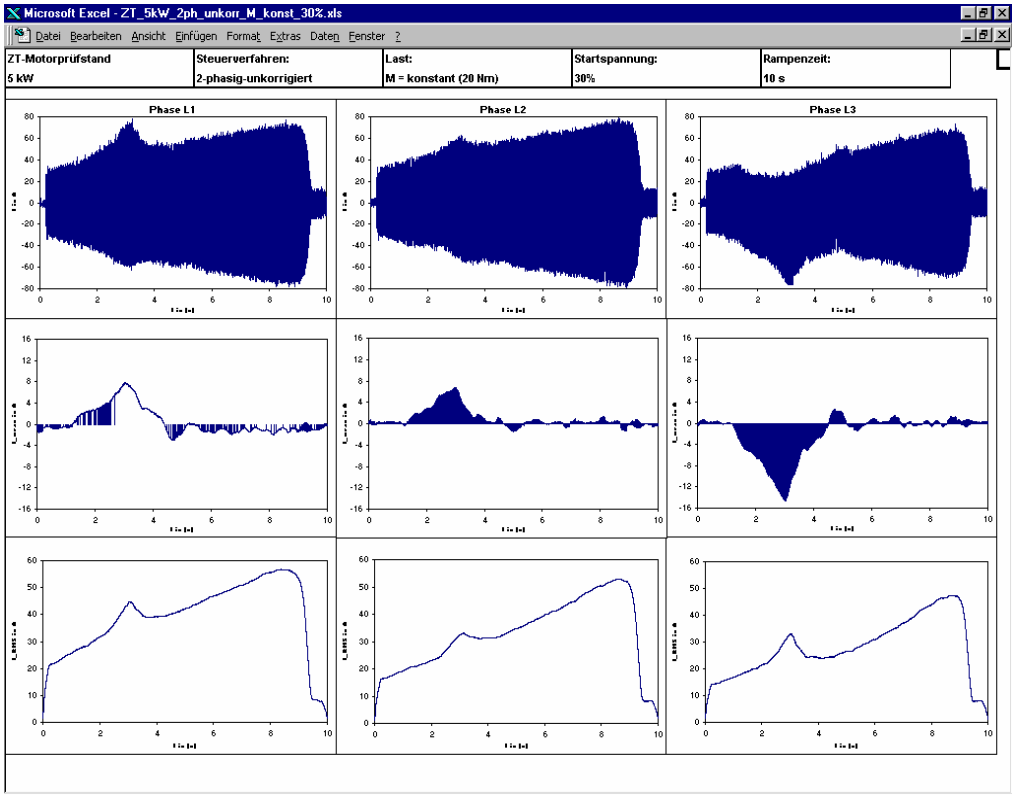

Figure 5. 2-phase-controlled Starting without Polarity Balancing. The 3 top graphs show the 3 instantaneous line currents. The 3 middle graphs show the DC components in the 3 currents. The 3 bottom graphs show RMS value of the 3 currents.

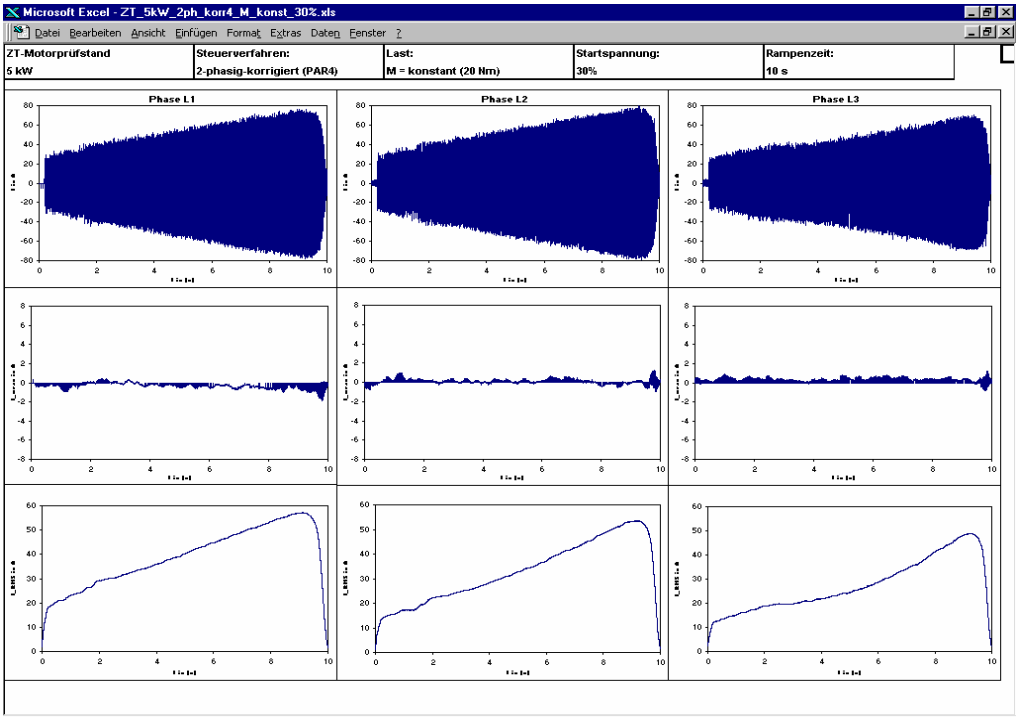

Figure 6. 2-phase-controlled Starting with Polarity Balancing. The 3 top graphs show the 3 instantaneous line currents. The 3 middle graphs show the DC components in the currents. The 3 bottom graphs show RMS value of the 3 currents.

It is worth noting that polarity balancing does not balance the currents among the 3 phases. The 3 bottom graphs in Figure 6 show that the RMS profiles of the 3 currents are not equal even with polarity balancing. The phase without SCR control will have higher current. The imbalance among the 3 phase currents is intrinsic to 2-phase control and can not be influenced. Because the imbalance among the 3 currents is generally 10-25%, it has been observed that this imbalance is not critical in most applications, where the motor load is brought to full speed quickly.

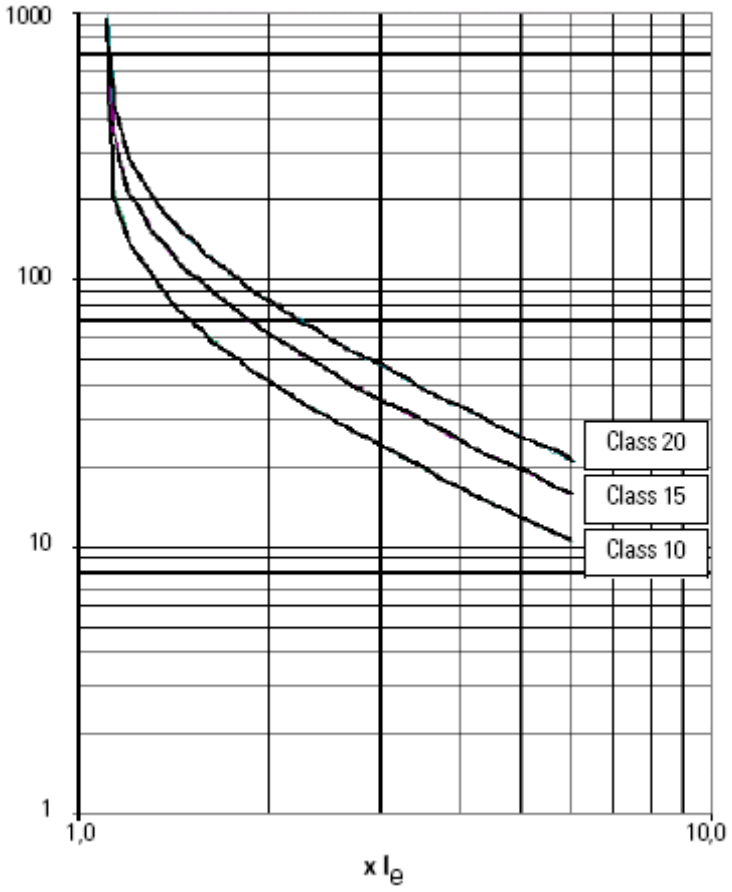

Figure 7. Trip Curves of Sirius 3RW40

3RW40 has integrated motor thermal protection into its control algorithm so no external motor overload protection is needed. The thermal protection conforms to the latest IEC 60947-4-2. Figure 7 shows the trip curves of 3RW40. The trip classes are selectable via potentiometers (Figure 8).

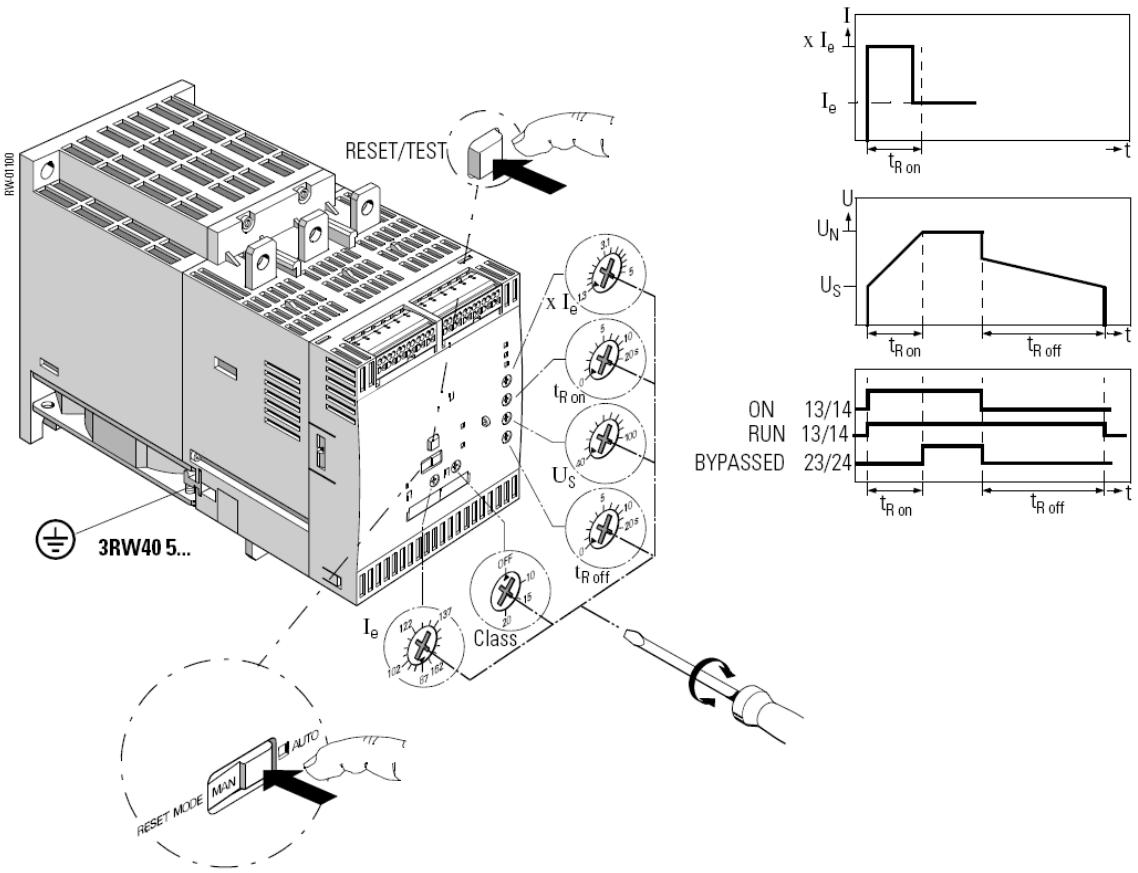

Figure 8. Commissioning 3RW40

Different applications have different requirements on starting torques. Because torque is proportional to the square of voltage, users will be able to start their motors at desired torques by selecting different starting voltage on 3RW40. Users can also limit the in-rush current to desired level. The voltage ramp-up time and ramp-down time are also adjustable. These four parameters: current limit, ramp-up time, starting voltage, and ramp-down time, are selected via the four potentiometers on 3RW40 (Figure 8).

The 3RW40 has built in by-pass contacts. Once a motor is up to speed, the SCRs are by passed and the motor is connected the line voltage.

Because SCRs are the most important components in solid-state soft starters, the SCRs in 3RW40 have built-in thermistors that will protect SCRs in case of overheating. That is very useful in preventing excessive multiple starts/stops. The 3RW40 also has control algorithms to detect phase failure, too high or too low control voltage. With these fault detection capabilities, 3RW40 can protect both the motor and itself.

In summary, the Sirius 3RW40 provides not only an economical soft start, but also protection to motors in a very compact package.