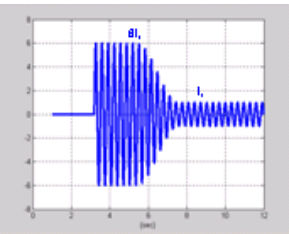
The ELSPEC EQUALIZER-ST
A NEW MOTOR START SOLUTION

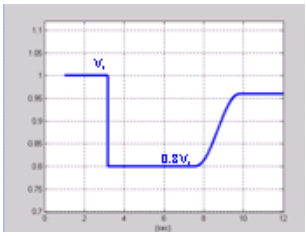
ABSTRACT

The EQUALIZER-ST is a real-time, dynamic reactive power compensation system that utilizes a proven industrial technology to provide an additional solution for the challenges related to large motor startups.

THE ELECTRICAL CHALLENGE

A motor start demands very high reactive power for a relatively short period of time. This demand creates typical reactive currents of 6-7 times the nominal current of the motor; consequently a voltage drop is developed in the local network that is usually not designed to withstand these temporary high currents. This voltage drop can create problems for other loads in the network and, if excessive, can prevent the motor from starting in some cases.





THE MECHANICAL CHALLENGE

In some cases the torque in the startup process is excessive for the system and therefore needs to be reduced.

THE SOLUTION:

Cost-effective and fast reactive power compensation

The optimal solution for the electrical challenge is to use a very fast compensation system that will supply the full amount of required reactive energy for a short period of time.

Standard contactor systems are too slow and electronic switched systems such as the Equalizer are too expensive compared to other solutions available in the market.

THE EQUALIZER-ST CONCEPT

The EQUALIZER-ST system is very similar to the Equalizer, but can cost up to 50% less than similarly sized Equalizer systems (for systems larger than 1.5MVAr). This system, however, only operates for the relatively short time period during motor startup. After operating for this short time, the device needs to be deactivated for a longer period of time. Typically, motor startup only requires a short period of time. Therefore, the EQUALIZER-ST is only designed to withstand high currents for this time period. Designing the system with this philosophy reduces the overall manufacturing costs of the device and yields a lower sell price to the end user. The typical designed duty cycle is 5%, meaning that if the EQUALIZER-ST is in operation for 20 sec, then it needs to be idle for just less than 7 min.

EQUALIZER-ST LIMITATIONS

The EQUALIZER-ST is only a solution for the *electrical challenge* when used as a standalone device. In cases where there is a need for **torque reduction,** the EQUALIZER-ST can be used in combination with a soft starter to achieve the desired dual objective of mechanical torque reduction and reactive power compensation.

AC MOTOR STARTUP

EXISTING SOLUTIONS

The primary solutions that exist in the market for AC motor startup are:

- Traditional motor starting *(low cost)*
- Star/delta
- Auto transformer
- Chokes or resistors.
- Soft starters *(medium cost)*
- Frequency inverters (VSD/VFD's) *(very high cost)*

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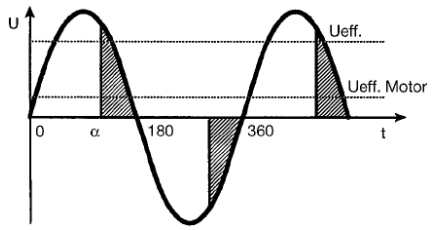
TRADITIONAL MOTOR STARTING

In order to enable the motor startup, the motor connection to the electric network is changed by using electromechanical contactors.

Advantages:

- Relatively inexpensive solution(s)
- Disadvantages:
- Extends startup time of the motor.
- Results in electrical and mechanical problems to the motor due to step changes in voltage.
- Soft starters

Electronic devices (typically thyristors) control the phase angle of the voltage applied to the motor terminals. Doing this allows the motor to start without steps. The result is an extended period of start-up time and reduction of the starting torque.

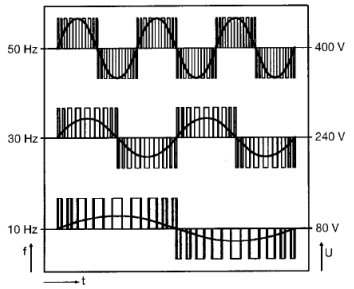


Advantages:

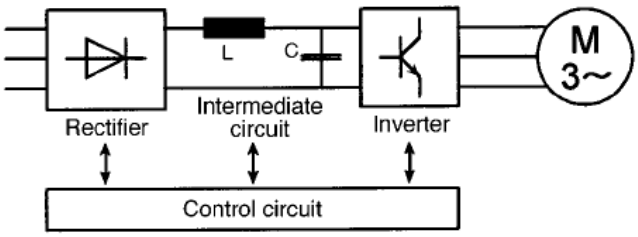
- Reduces the starting torque.
- Reduces the starting currents.
- Disadvantages:
- Extends startup time.
- Creates very high harmonics.
- Requires each motor to use a dedicated soft starter.
- Provides only a partial solution. Does not completely avoid the voltage drop and high starting current. In cases where the supply network is weak, soft starters typically cannot reduce the voltage drop enough for a successful startup.

FREQUENCY INVERTER (VSD / VFD)

Variable speed drives rectify the voltage to DC and then invert it to AC (usually using Pulse width modulation to control the torque and the speed of the motor.



Pulse width modulation



Advantages:

- Controls motor speed for process optimization.
- Controls & minimizes torque issues.
- Reduces startup current and voltage drop.
- Disadvantages:
- Very expensive solution(s).
- Introduces harmonics to the network.
- Emits radio frequencies due to high switching frequencies in many cases.
- Requires each motor to use a dedicated VSD/VFD in most cases.

THE EQUALIZER-ST SOLUTION

EQUALIZER-ST can solve the electrical problem of voltage drop and high starting current much better than soft starters. The EQUALIZER-ST does not address and cannot solve the mechanical problem of high initial torque that could potentially damage the motor.

SPECIFIC EQUALIZER-ST APPLICATIONS

STANDALONE SOLUTION

In any case that a direct motor start is possible without the possibility of creating mechanical damage, EQUALIZER-ST can be a very efficient and cost-effective solution. The EQUALIZER-ST advantage is even greater in a location where there are many motors, since it is a *central compensation solution*. Whereas soft starters

and VSD/VFD's create harmonics and therefore power quality problems, the EQUALIZER-ST helps to improve the power quality of the electrical network. A large portion of the motor starting applications do not have issues of potential mechanical damage caused by excessive starting torque.

COMBINATION SOLUTION

- In cases that there is a need to reduce the starting torque as well, EQUALIZER-ST is not used a standalone solution, but rather is combined with a soft starter to provide for the complete requirements of the motor:
- In areas with weak electrical networks, a soft starter may not reduce the voltage drop enough for the motor to start each time. In this case, a EQUALIZER-ST can be used as a considerably less expensive substitute than a VSD/VFD if speed control is not necessary for a manufacturing process.
- In cases that there are Power Quality problems during the motor start, EQUALIZER-ST can improve the power quality

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EQUALIZER-ST - OVERVIEW MOTOR STARTING TECHNOLOGIES

This case study simulation analysis demonstrates the results of a 5MW motor supplied by a 11.5kV electrical network supported by a 15MVA transformer. The chart below highlights the following starting scenarios:

- Direct Online Connection
- Soft Starter
- 32MVAr EQUALIZER-ST - Sized for Maximum 2.5% Voltage Drop
- 25MVAr EQUALIZER-ST – Sized for Maximum 6.0% Voltage Drop
- Combination Soft Starter with 12MVAr EQUALIZER-ST
- 12MVAr EQUALIZER-ST – Sized for Maximum 10.0% Voltage Drop

SYSTEM COMPARISON

The table below describes the parameters and results from each possible solution. The graphical reference to each solution is at the bottom of each column.

	Direct Online	Soft Starter	EQUALIZER-ST 32MVAr	EQUALIZER-ST 25MVAr	Soft Starter + EQUALIZER-ST 12MVAr	EQUALIZER-ST 12MVAr
Startup time	6.9 sec	11.1 sec	5.1 sec	5.6 sec	9.5 sec	6.2 sec
Voltage Drop	-14.5%	-12.0%	-2.5%	-6.0%	-6%	-10.0%
THD v	< 2%	10%	< 1%	< 1%	6%	< 1%
THD i	< 2%	19%	< 1%	< 1%	20%	< 1%
Reference	*Fig 1, 2, 13*	*Fig 3, 4, 14*	*Fig 5, 6, 15*	*Fig 7, 8*	*Fig 9, 10, 16*	*Fig 11, 12*

CONCLUSIONS

- The EQUALIZER-ST does not increase the harmonic level for the voltage and the current (in most cases, the harmonics levels are improved).
- The voltage drop caused by reactive energy demand could be completely eliminated using EQUALIZER-ST, however due to cost considerations, a compromise should be considered.
- The startup period is minimized using the EQUALIZER-ST solution, thus avoiding unnecessary wear to the motor and increasing the motor's life expectancy.
- The lowest levels of starting current occur when employing the EQUALIZER-ST solution.
- During startup, the cleanest sinusoidal waveforms are achieved via use of the EQUALIZER-ST solution.
- The complete cost of the EQUALIZER-ST in Medium Voltage applications, including the additional transformer and protection accessories, is less expensive than a soft starter solution in many operating scenarios (especially when more than one motor is used).

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Figure 1: Direct Online Motor Start

Network Voltage, Motor Current, kVAr (Motor, Equalizer-st, Mains)

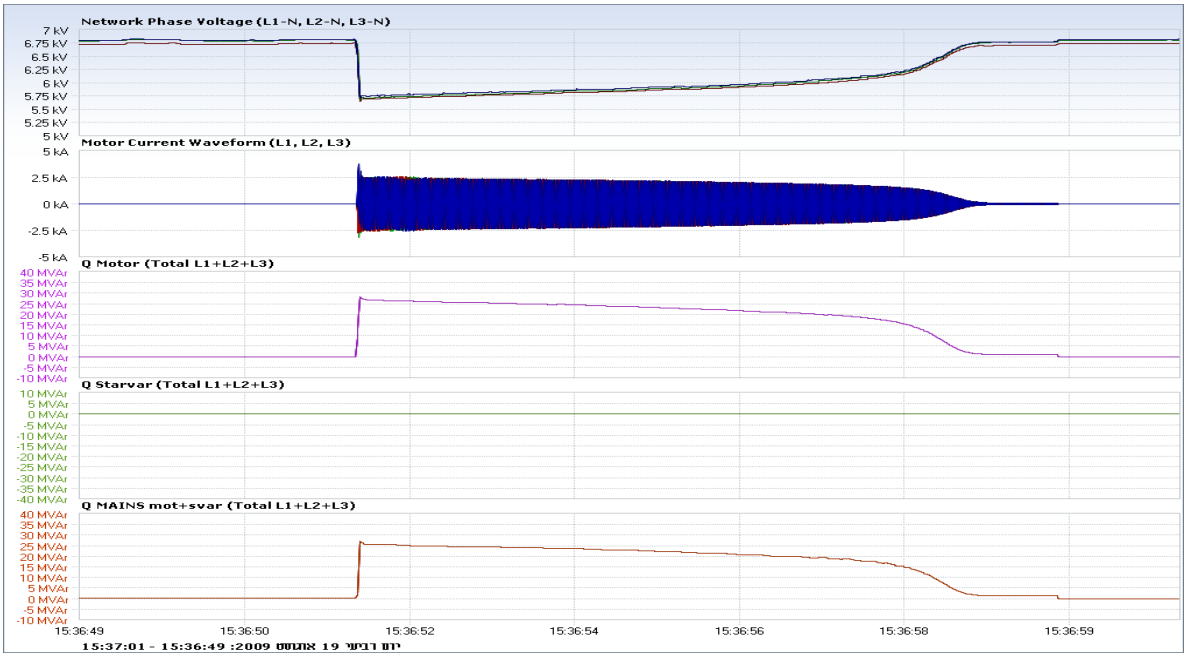

Figure 2: Direct Online Motor Start

Network Voltage Drop, Motor Current, THDv, THDi

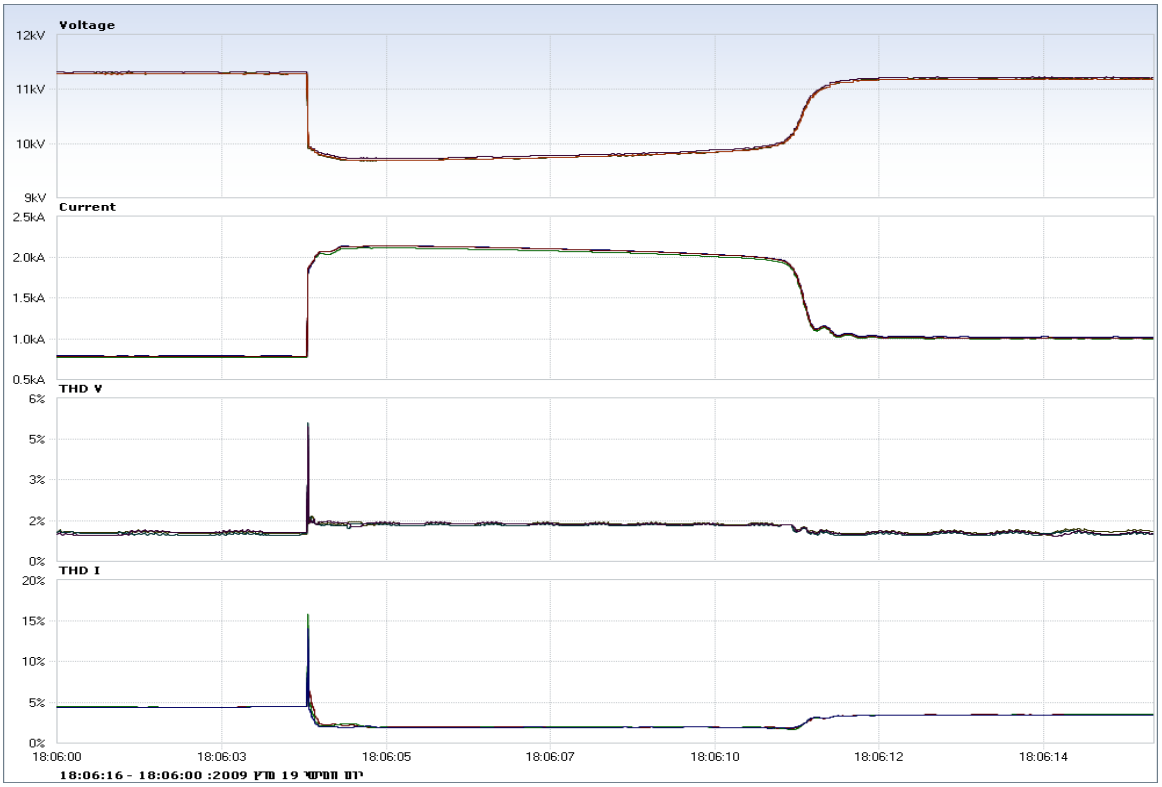

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Figure 3: Soft Starter *(simulated)*

Network Voltage, Motor Current, kVAr (Motor, Equalizer-st, Mains)

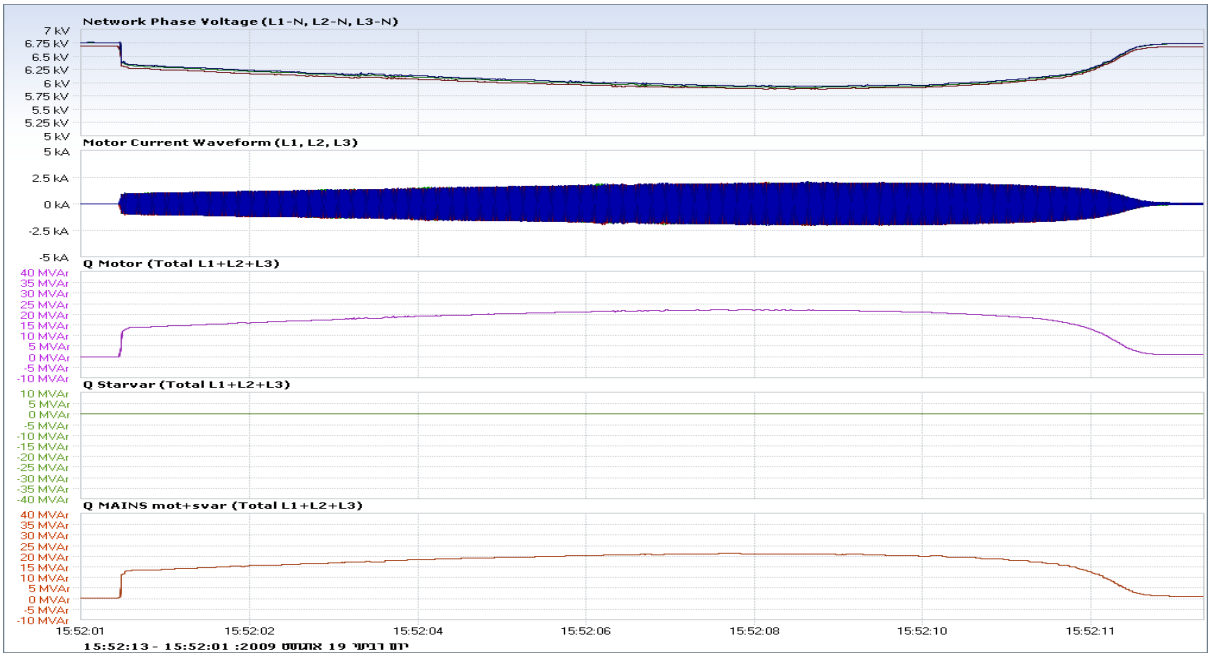

Figure 4: Soft Starter *(simulated)*

Network Voltage Drop, Motor Current, THDv, THDi

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Figure 5: 32MVAr EQUALIZER-ST *(simulated)*

Network Voltage, Motor Current, kVAr (Motor, Equalizer-st, Mains)

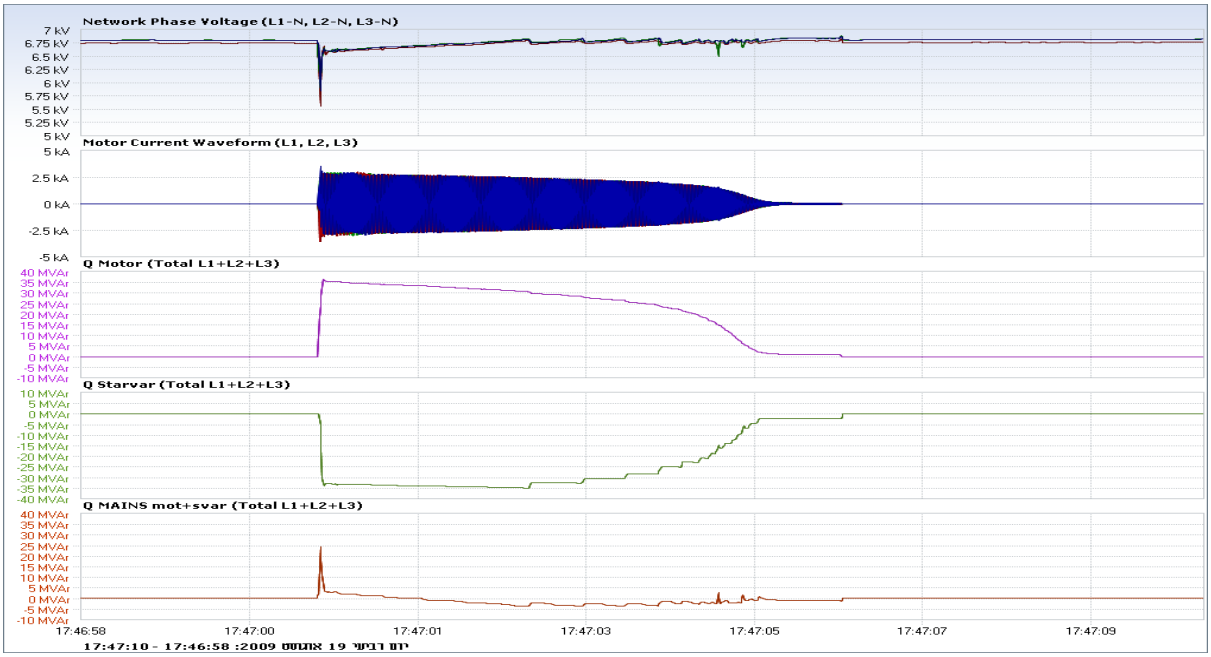

Figure 6: 32MVAr EQUALIZER-ST *(simulated)*

Network Voltage Drop, Motor Current, THDv, THDi

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Figure 7: 25MVAr EQUALIZER-ST *(simulated)*

Network Voltage, Motor Current, kVAr (Motor, Equalizer-st, Mains)

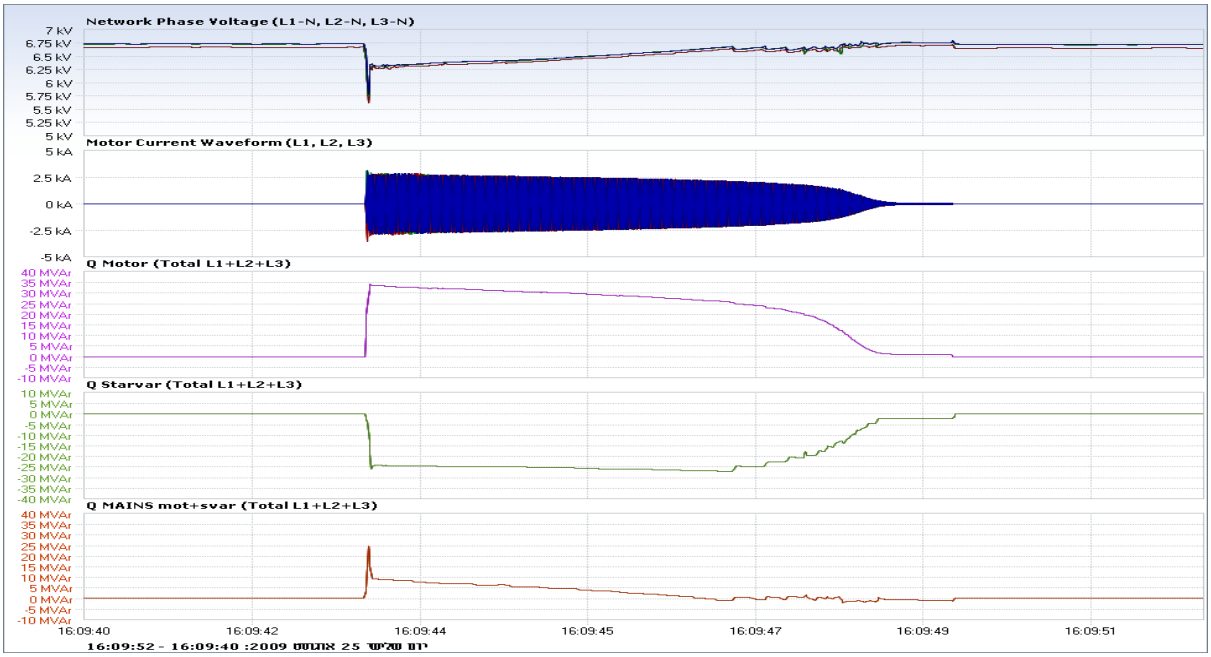

Figure 8: 25MVAr EQUALIZER-ST *(simulated)*

Network Voltage Drop, Motor Current, THDv, THDi

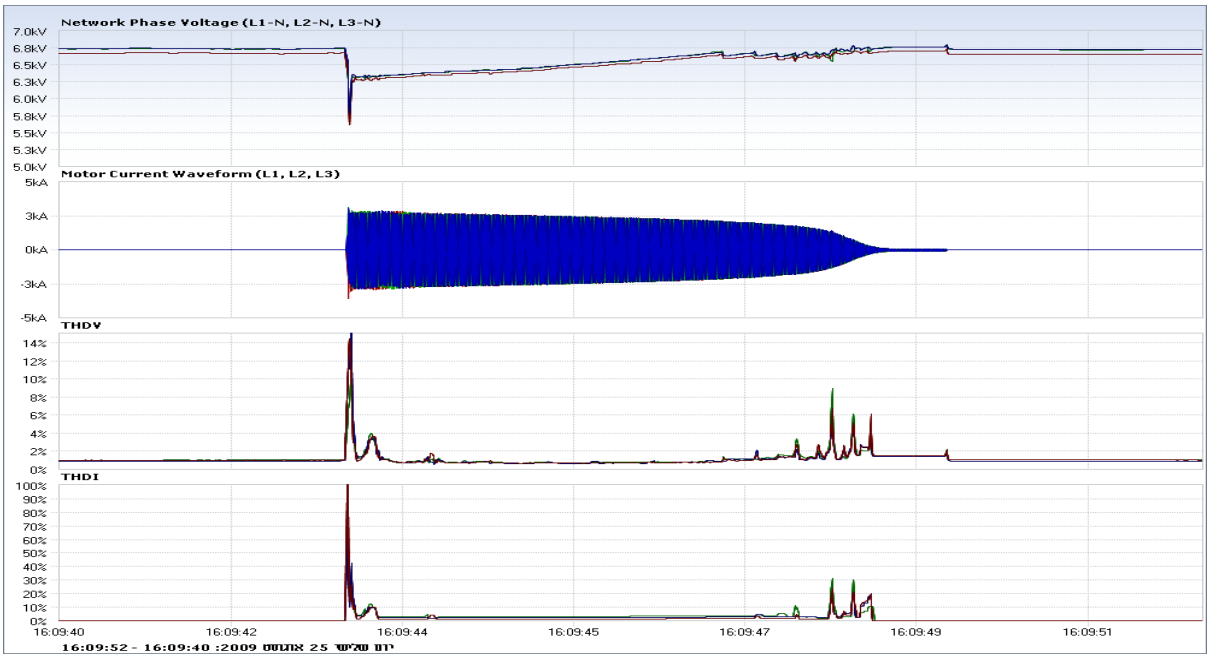

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Figure 9: Combination Soft Starter + 12MVAr EQUALIZER-ST *(simulated)*

Network Voltage, Motor Current, kVAr (Motor, Equalizer-st, Mains)

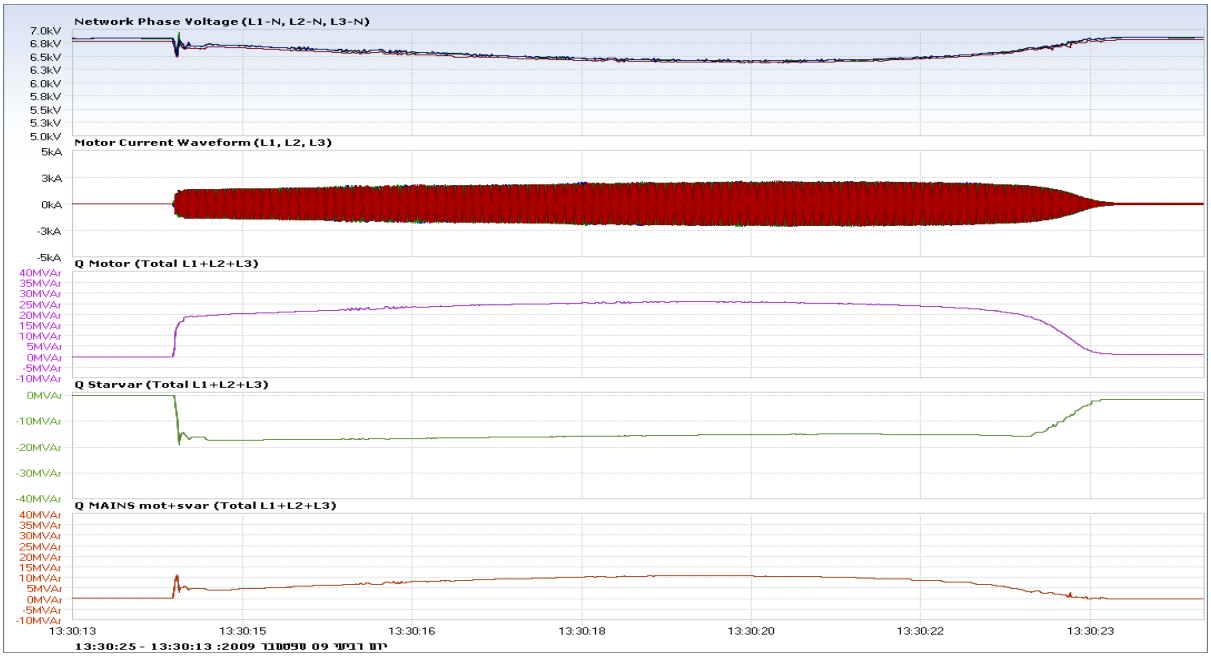

Figure 10: Combination Soft Starter + 12MVAr EQUALIZER-ST *(simulated)*

Network Voltage Drop, Motor Current, THDv, THDi

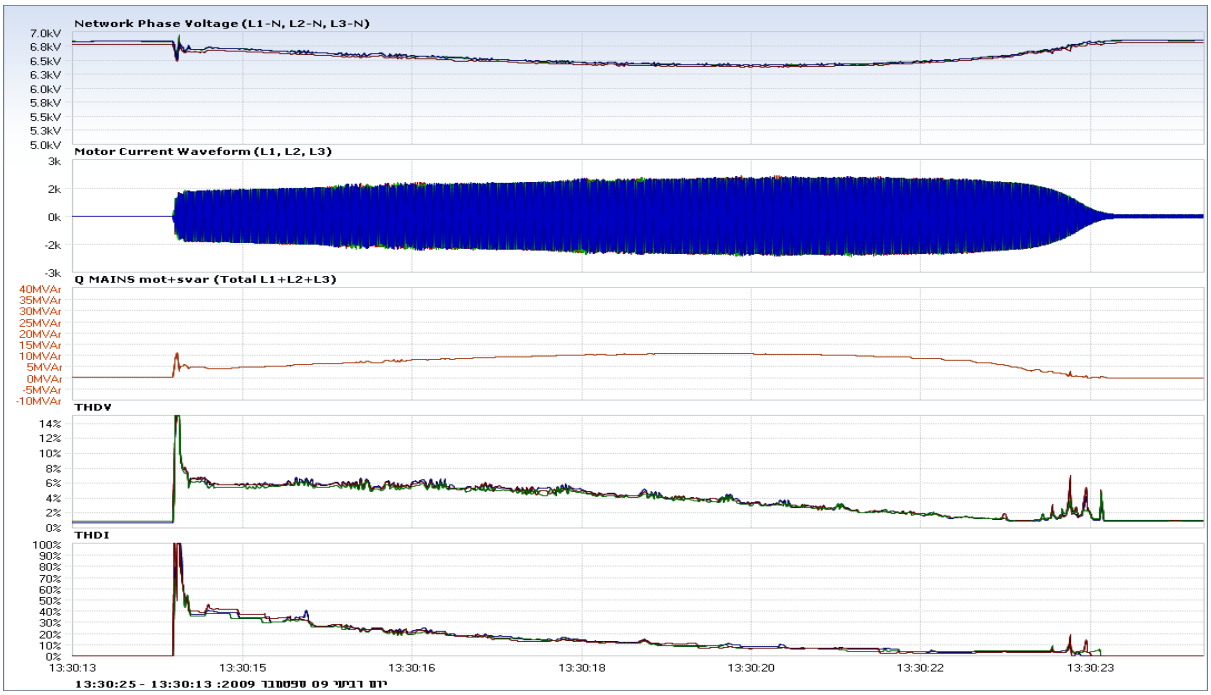

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Figure 11: 12MVAr EQUALIZER-ST *(simulated)*

Network Voltage, Motor Current, kVAr (Motor, Equalizer-st, Mains)

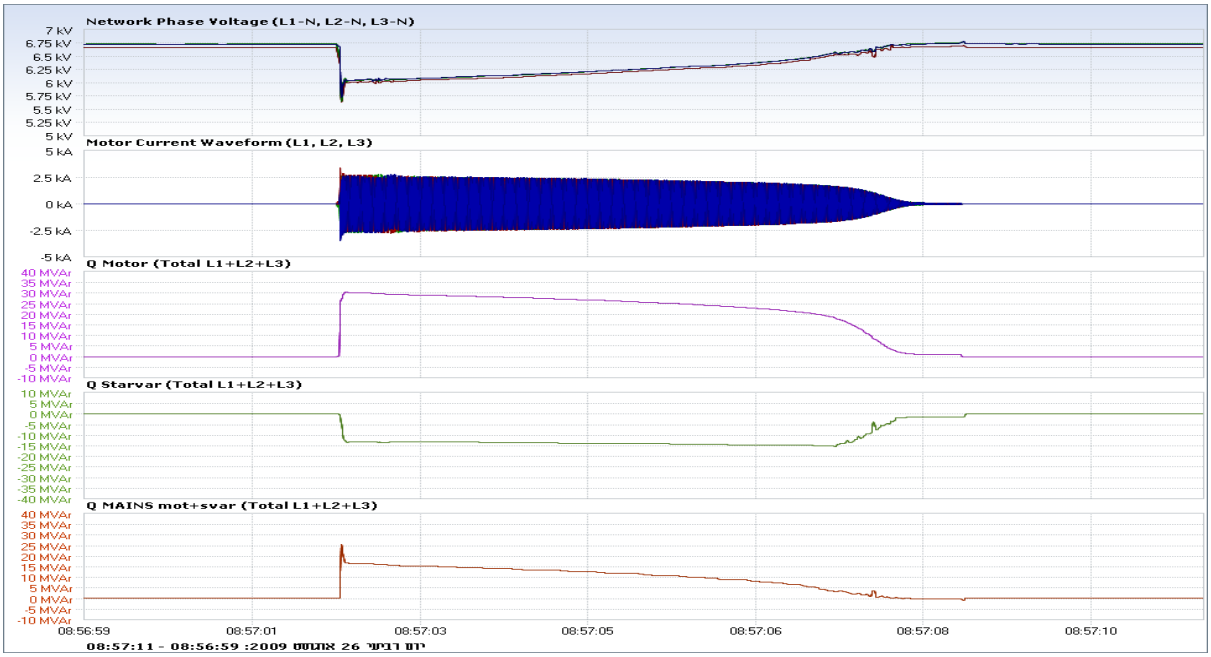

Figure 12: 12MVAr EQUALIZER-ST *(simulated)*

Network Voltage Drop, Motor Current, THDv, THDi

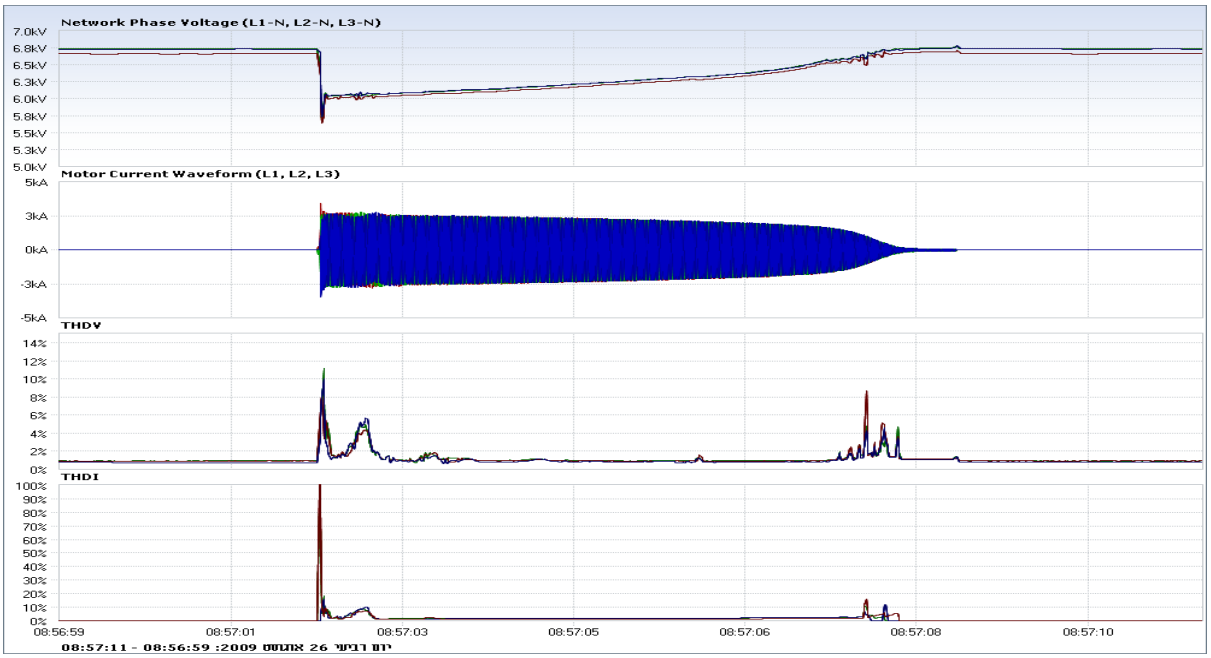

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Figure 13 – Direct Online Motor Start

Voltage & Current Waveforms during Motor Startup

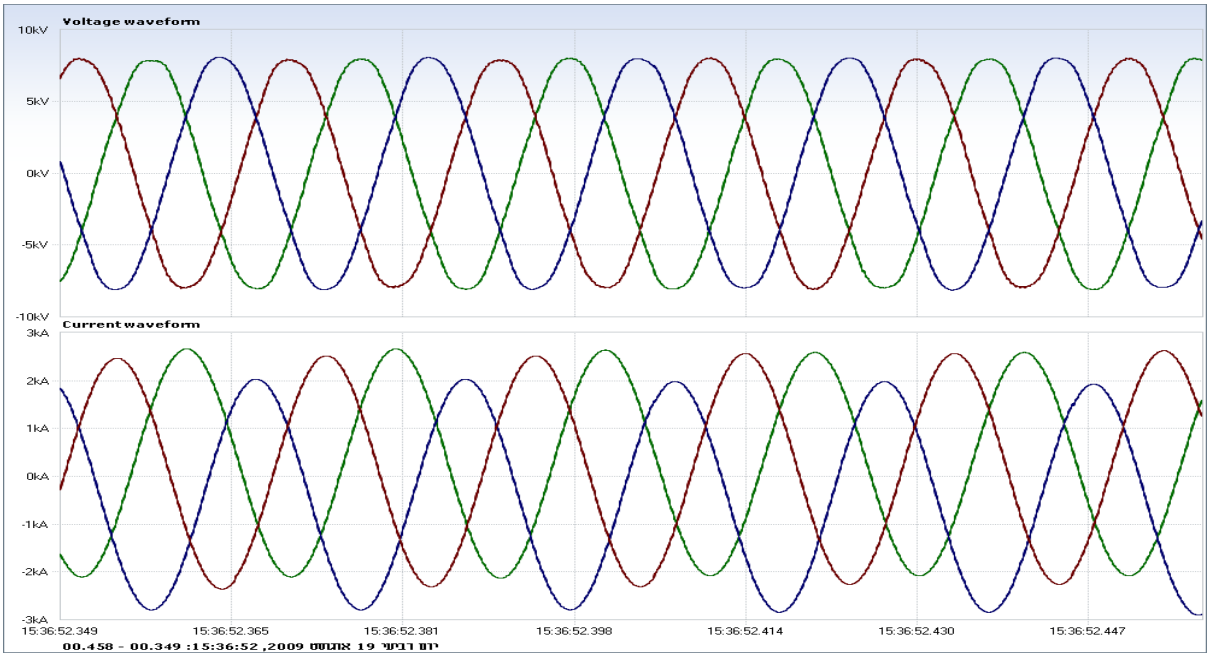

Figure 14 - Soft Starter *(simulated)*

Voltage & Current Waveforms during Motor Startup

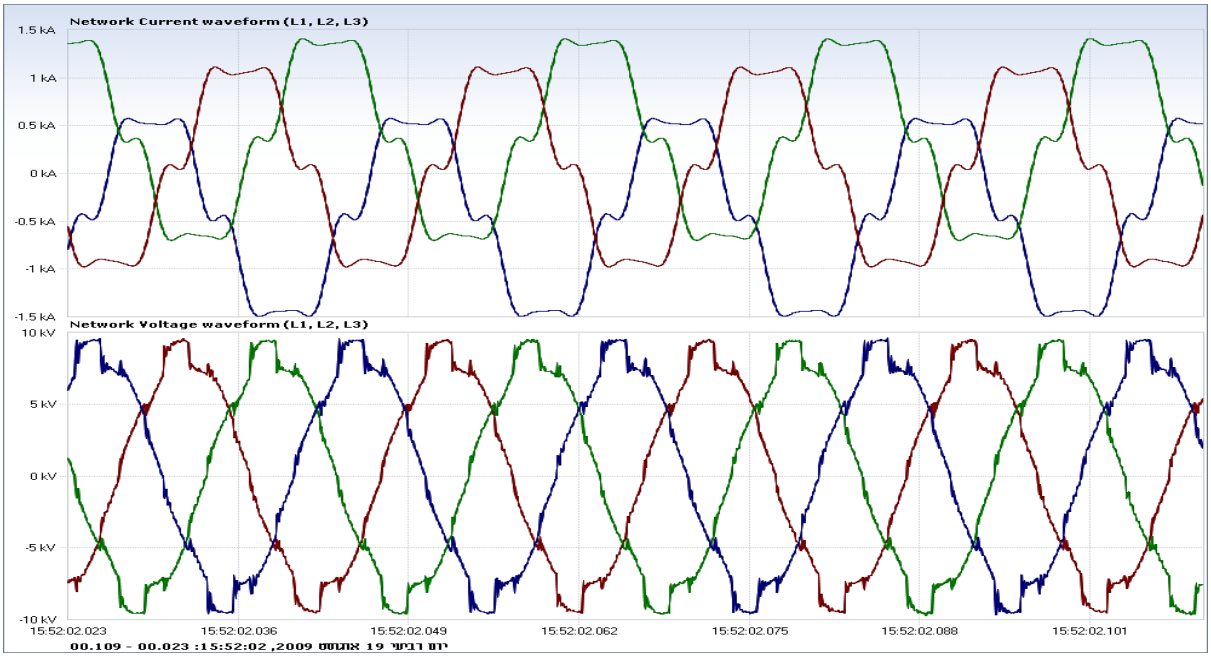

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Figure 15 – 32MVAr EQUALIZER-ST *(simulated)*

Voltage & Current Waveforms during Motor Startup

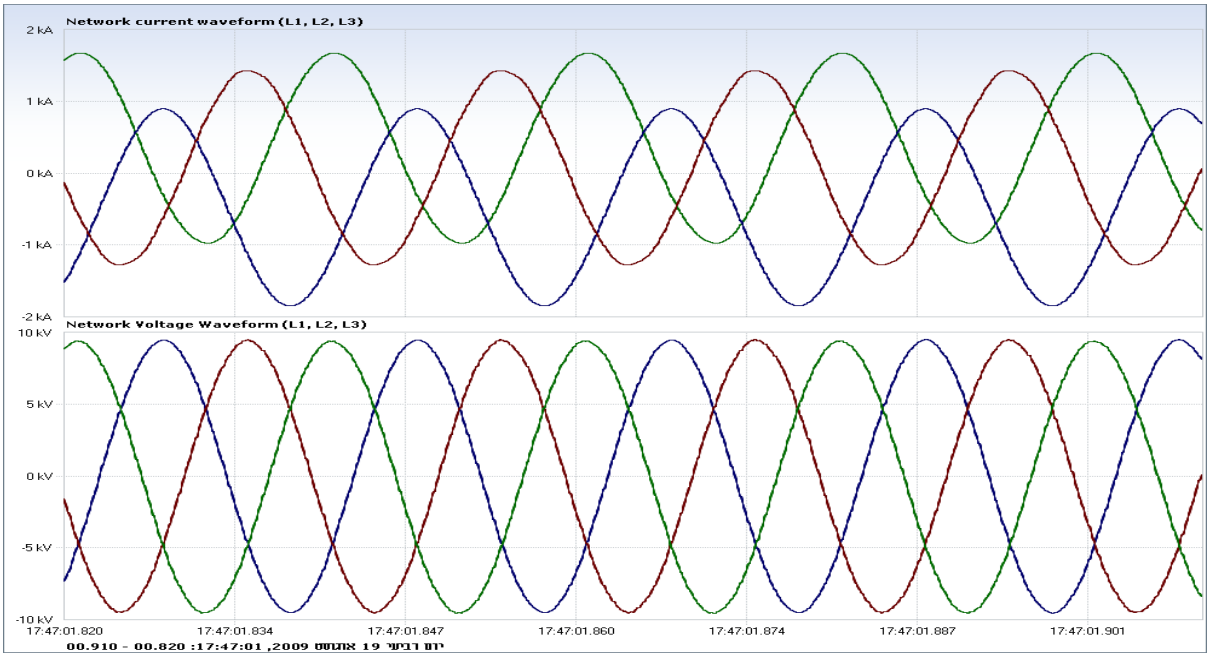
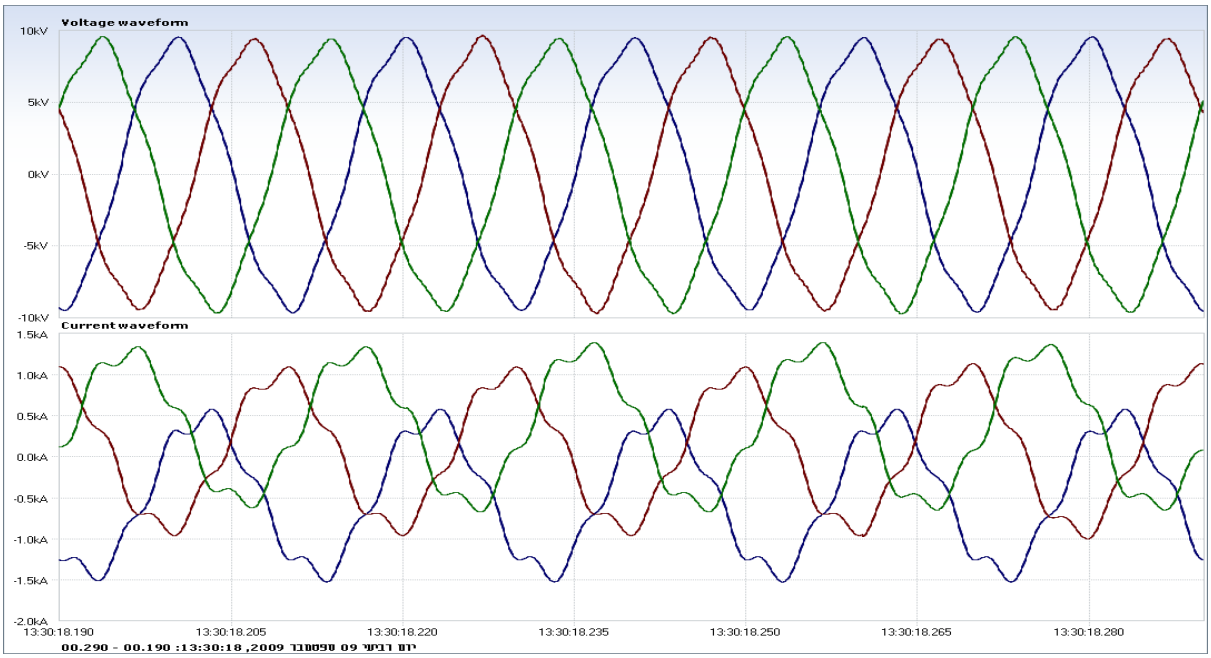


Figure 16 – Combination Soft Starter + 12MVAr STAR *(simulated)*

Voltage & Current Waveforms during Motor Startup



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