# A motor's best friend

Narrowing the gap between softstarters and drives

CARL THORSTENSSON, JOAKIM X. JANSSON – ABB has been at the forefront of the development of electrical motors for more than 100 years. Wherever there is a motor, there is the challenge of starting it without being too harsh on both the electrical supply and the mechanical load. It is thus hardly surprising that ABB has been supplying motor-starting solutions for as long as the company has been making motors. In the early days, these focused on different approaches to making direct starts and stops using such devices as disconnectors and contactors. Later the variable-speed drive was introduced, making it possible to

control the speed of the motor. In the 1980s the softstarter was introduced as a compromise between the soft start and stop that a drive can provide and the compact size and lower cost of the direct online connection (a softstarter is a solid-state device rather like a drive but that is normally bypassed once the motor is at speed). Since then ABB has developed several generations of softstarters. When the company asked customers how they wanted to see softstarters improved further, the feedback was for the gap between softstarters and drives needed to be narrowed. ABB's answer is the PSTX softstarter.

1 The PSTX softstarter requires significantly less space than the equivalent drive.

Drive

H = 0.88 m

D = 0.40 m

W = 0.30 m

PSTX frame C

H = 0.47 m

D = 0.28 m

W = 0.26 m
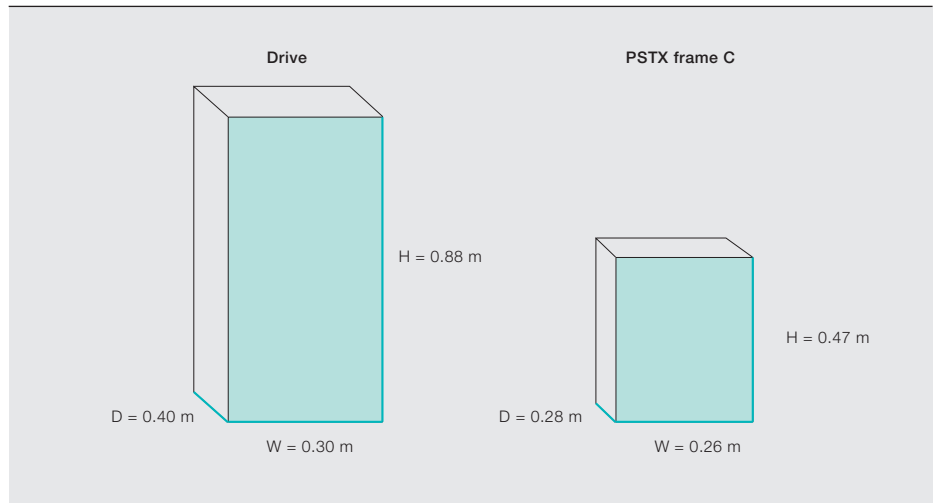
To narrow the gap between soft-starters and drives, ABB has equipped the PSTX with many features for full-speed applications that were previously only available in the drive – and achieved this without transgressing the softstarter's core strengths of compact size ➔ 1, lower heat generation and lower cost. The PSTX features, for example, over- and under-voltage protection, limp mode, motor brake and motor heating. One of the most innovative features is the slow-speed jog. Slow-speed jog is a function bridging the gap to the drive by allowing the motor to run at reduced speed.

Value of function
By using PSTX softstarters, it is possible to speed regulate a motor without using a drive. With slow-speed jog, the motor can be run at three different reduced speeds, both forward and backward. By reducing the output frequency of the softstarter, the speed of the motor can be reduced due to the proportionality between the frequency and motor speed.

It is then possible to temporarily speed-control a motor without a large and expensive drive.

A reoccurring problem in pumping applications can be clogged pipes or jammed pumps. By combining the backward jog with the kickstart function

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the PSTX provides a solution for pump cleaning. However, the jog can be applied in many other situations, eg, positioning of conveyor belts, simplifying maintenance inspections of machinery and ensuring full functionality of an application during commissioning.

Technical explanation
There is a fundamental relationship between the motor speed and the frequency:

$$n = \frac{2 \times f \times 60}{p} \Rightarrow n \, \alpha \, f$$

where n is the number of revolutions per minute of the motor, f is the frequency and p is the number of poles of the motor. If the frequency from the softstarter is reduced, the speed drops accordingly:
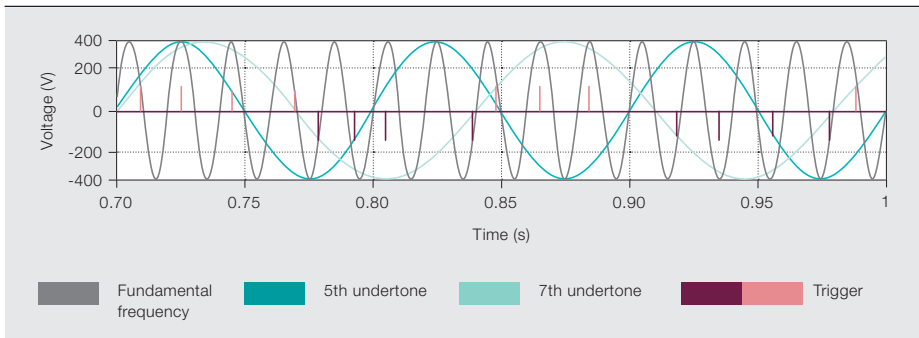
$$f \downarrow n \Rightarrow n \downarrow$$

In contrast to a drive, the PSTX generates undertones of the fundamental frequency (normal grid frequency 50 Hz or 60 Hz) by triggering the thyristors in a specific sequence.
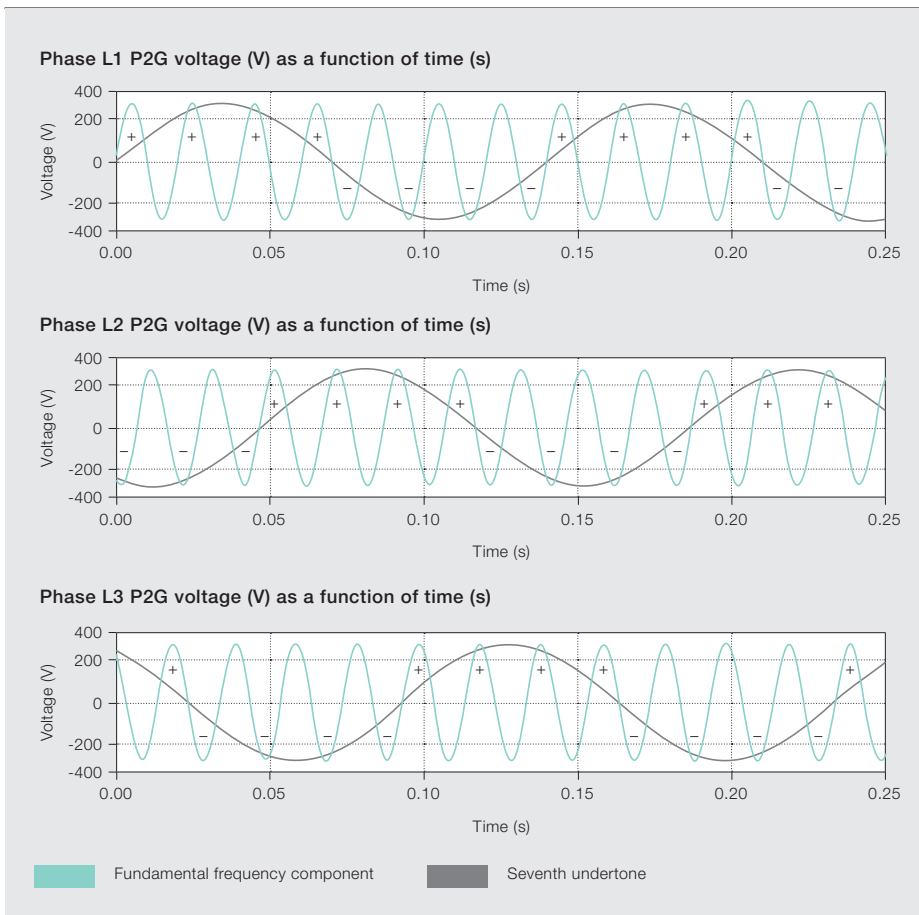
An undertone is similar to an overtone, but instead of a higher frequency the undertone has a lower frequency than the fundamental frequency. One can consider the fundamental frequency an overtone or a harmonic of the generated undertone. In order to generate the lower frequency the thyristors are triggered when the curves of the fundamental frequency and sought undertone intercept.

In ➔ 2 the broken green line is the seventh undertone and the full green line is the fifth undertone, representing two different motor speeds. The purple and red vertical markings represent the trigger signal to the positive and negative thyristor, respectively.

This approach of generating a lower frequency has many advantages over using a drive. For example, it doesn't come close to generating the amount of harmonics a drive would create in this situation because the PSTX does not chop up the incoming signal but rather uses only the necessary parts of it. The thyristors conduct parts of the half-periods to create the desired output frequency. All three phases are illustrated in ➔ 3, showing how the seventh undertone is generated.

Backward slow speed
The PSTX can run the motor at different slow speeds in the forward direction. The same method of generating lower frequencies can also be used to run the motor backwards.

2 Undertones permit slower speeds

The PSTX softstarter permits the motor to be run at three different speeds in both directions:

– Fast jog forward
  3th undertone ≈ 33.3 percent of rated RPM
– Jog forward
  7th undertone ≈ 14.3 percent of rated RPM
– Creep forward
  13th undertone ≈ 7.7 percent of rated RPM
– Creep backward
  11th undertone ≈ 9.1 percent of rated RPM
– Jog backward
  5th undertone ≈ 20.0 percent of rated RPM
– Fast jog backward
  3th undertone ≈ 33.3 percent of rated RPM

3 Generating the seventh undertone across all three phases

Phase L1 P2G voltage (V) as a function of time (s)

Phase L2 P2G voltage (V) as a function of time (s)

Phase L3 P2G voltage (V) as a function of time (s)

There is significant value in having the option of a temporarily reduced speed.

To change the direction of the motor, the magnetic field must reverse its direction of rotation. This can be achieved by changing the order in which the phases are triggered. Normally this affect would be achieved by using two contactors to swap two phases, but the PSTX provides a simpler way of obtaining the same effect.

Different speeds
The PSTX can run the motor at three different speeds forwards and backwards. This corresponds to the different undertones shown in → 4.

Always in control
With the PSTX, ABB has made the slow-speed jog basic speed control available in the compact size and lower cost of the softstarter, thereby making this functionality available for more installations and customers. There are significant advantages in having the option of a temporarily reduced speed, such as the ability to run waste water pumps backward to clean them or to position a crane or a conveyor belt. To ensure the function is easily operated, the jog can be controlled in several different ways: with the detachable keypad, with push buttons or via fieldbus communication.

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