APPLICATION EDGE
VOLUME 1, ISSUE 3

SELECTING THE RIGHT STRATEGY FOR STARTING LARGE MOTORS

This article aids in selecting an appropriate large motor starting method that meets the requirements of the utility provider and user process.

Overview

There is a growing need for installing large-capacity motors on pumps and compressors in various industries. Motor power ratings are commonly over 1000 hp and sometimes as high as 60,000 hp. Starting these motors and their connected loads is often a major challenge, since motor starting currents are typically 600–650% of their rated full load current. This "motor inrush current" can produce large voltage drops that are not acceptable to the utility providers and disrupt the rest of the plant power system. Selecting the best starting strategy at the early stages of a project is very important. This selection will impact the integrity of the system, initial capital investment, operating costs and long- term reliability.

The most commonly used motor starting methods fall into two major groups, and subgroups:

1. **Fixed frequency (50Hz or 60Hz) utility voltage**
   - Full Voltage Direct on Line (DOL)
   - Reduced Voltage DOL
2. **Variable Frequency Drive (VFD) fed**
   - For loads requiring continuously variable speed
   - For loads started by VFD and then connected to the utility

Direct On Line (DOL) Starting

A standard DOL motor draws 600–650% of motor full load current. However, by modifying the rotor design the inrush can be reduced to 500% or even 300%. Figure 1a shows an electrical one-line of the low inrush motor starting scheme, and Figure 1b shows the speed-torque/current profile for DOL starting.

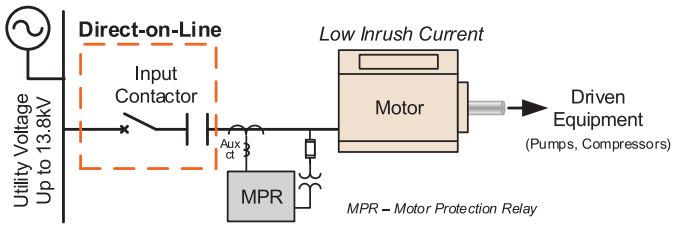

Figure 1a. Motor Starting One-line

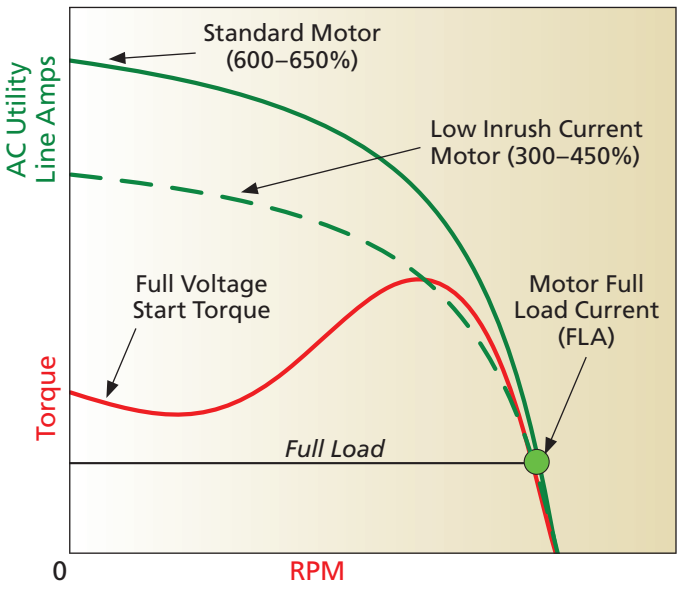

Figure 1b. Speed Torque/Current Profile for DOL Starting

Solid State Reduced Voltage (SSRV) Starter

A soft starter is a thyristor voltage controller to smoothly ramp up the voltage at the motor terminals. Soft starters use a controller that allows a timed ramp of output voltage and current limit. When the soft starter reaches full voltage, the bypass contactor closes. The available motor torque, is proportional to the square of the voltage. For example, a 20% reduction in voltage results in only 64% torque so it is important to determine the lowest acceptable inrush current to start the load. Figure 2a shows an SSRV one-line soft starter. Figure 2b shows the speed-torque/current profile. Typical applications include pumps, fans, compressors, and blowers.

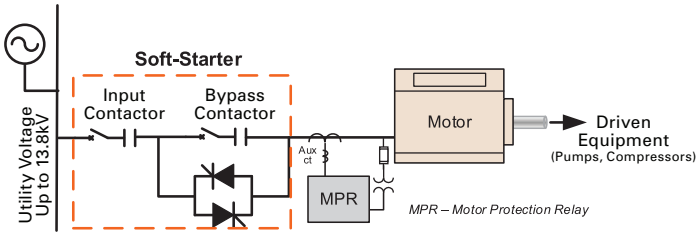

Figure 2a. Motor with Soft Starter

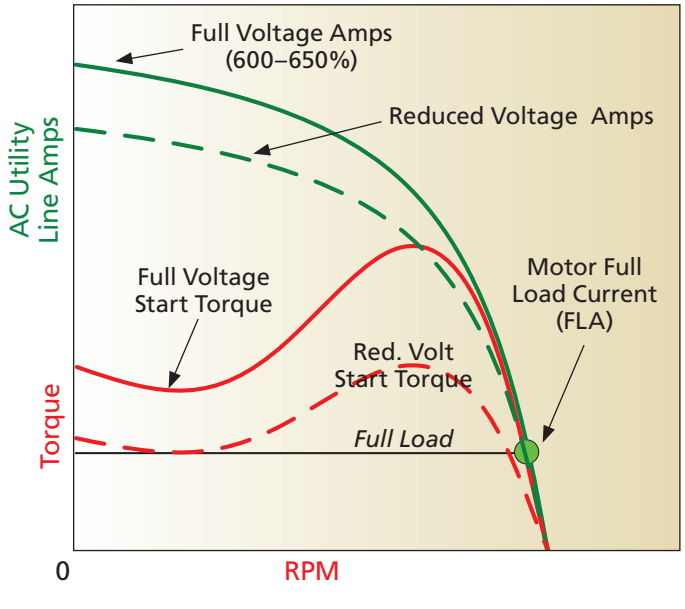

Figure 2b. Speed Torque/Current Profile for SSRV Starting

Variable Frequency Drives (VFD)

VFDs are a type of power conversion equipment that converts utility supply into variable voltage and frequency (speed). One of the benefits of a VFD is that the inrush current never exceeds the motor FLC. Figure 3a shows a VFD and bypass arrangement. Figure 3b shows the speed-torque/current profile. When a VFD is employed for starting, a smaller drive can be used. A VFD scheme can be used to start two or more motors sequentially and synchronize them to the line. Unlimited number of starts per hour are allowed.

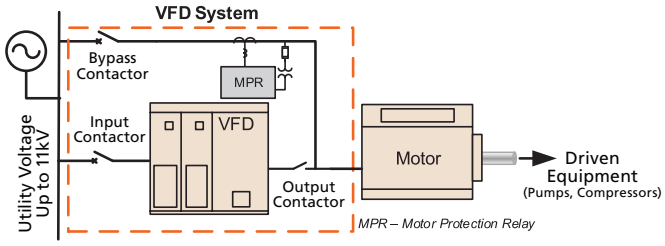

Figure 3a. Starting Using a VFD

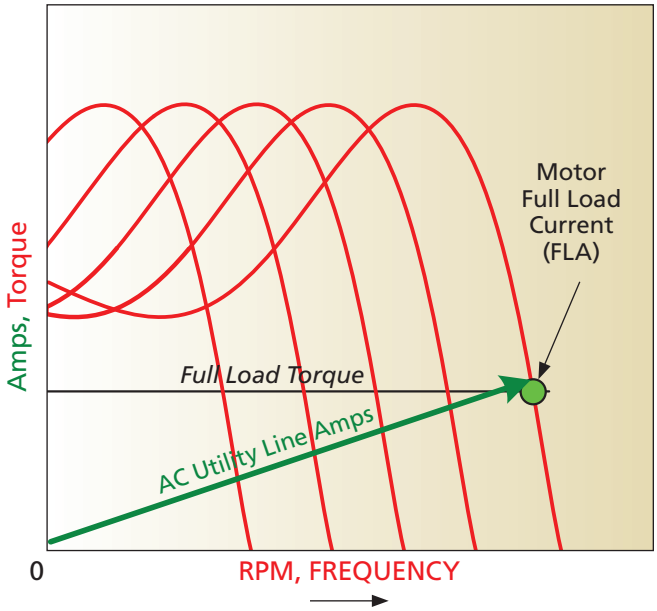

Figure 3b. Speed Torque/Current Profile for VFD Starting

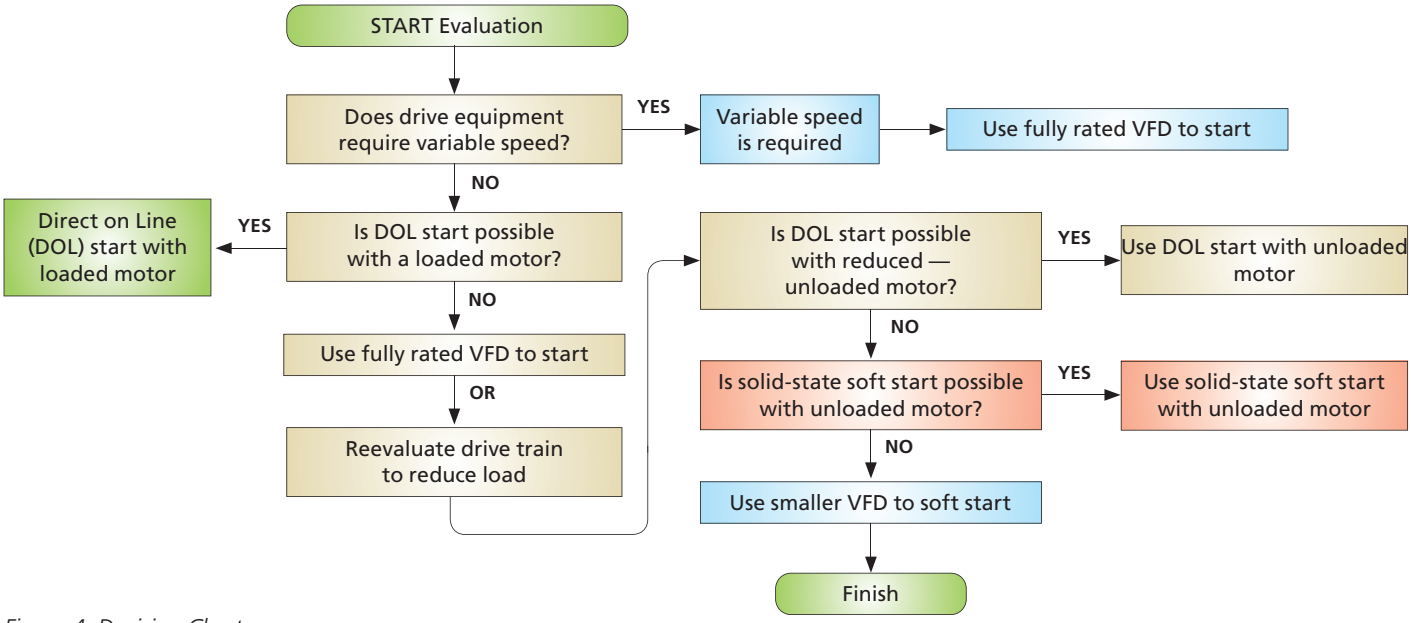

Figure 4. Decision Chart

How to Select a Starting Strategy

Figure 4 is a flow chart that provides a guide to decision-making factors that are needed to evaluate a starting strategy.

Overall Evaluation of Different Starting Options

Most decisions relating to a choice of technology require the evaluator to assess the technical and economic benefits, commonly known as the techno-economic evaluation. Table 1 provides a techno-economic comparison of various starting methods. Cost factors are weighted against the DOL starting method.

	Starting Method	*Stiff Network*	*Weak Network*	*Starting under Full Load or Partial Load*	*Relative Cost*
1	Direct on Line (DOL)	Preferable; if voltage drop is excessive, evaluate 2–4	Results in unacceptable voltage drop	Preferable; otherwise use 4	100%
2	Low Inrush Current DOL	Preferable; if voltage drop is excessive, evaluate 2–4	Evaluate power system capabilities; if not, use 4	Not recommended	120%–180%
3	Solid State Reduced Voltage (SSRV) Starter	Only if DOL is unacceptable and no harmonic concern	Evaluate power system capabilities; if not, use 4	Not recommended	160%
4	Variable Frequency Drive (VFD)	If soft start or variable speed required	Guaranteed to work	Can start under full load	250%

Table 1. Techno-economic comparison of different starting strategies. Relative costs include both motor and starting equipment and/or VFD.

Conclusion

This article presents the options that are available to an end user for starting large electric motors. The correct starting strategy will depend on meeting each installation's unique trade-off challenges, cost-benefit analysis, and evaluating trade-offs. TMEIC is experienced in performing these trade-offs.

For specifications not mentioned here, contact TMEIC

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I-5008-103-A July 2020