Optidrive Applications Support Library

Application Note	**AN-ODE-3-091**
Title	**BLDC Motor Compressor Application**
Related Products	**Optidrive E3**
Level **3**	1 – Fundamental - No previous experience necessary 2 – Basic – Some Basic drives knowledge recommended 3 – Advanced – Some Basic drives knowledge required 4 – Expert – Good experience in topic of subject matter recommended

Overview

Optidrive E3 provides a cost effective method of controlling Brushless DC (BLDC) motors which are commonly used in refrigerant compressing applications. This application note provides an overview of the parameters required to obtain correct motor control, and basic guidance on configuring the drive in this application.

Commissioning Procedure

The basic commissioning procedure is as follows :-

- Determine the correct motor data and enter into parameters
- Determine the operating parameters (Min / Max Speed, Accel / Decel) and enter into parameters
- Autotune the motor
- Select a suitable ramp time to the operating speed range
- Test Operation
- Optimise the starting performance and stability if necessary

Key Motor Parameters Required for Operation

P-07 Motor kE at Rated Speed / Frequency

This parameter must be set to the motor Back EMF at rated speed, often referred to as motor nominal voltage (UN). This is the Back EMF value which will be imposed by the motor magnets at the drive output terminals when the motor operates at rated speed.

Many motor manufacturers will provide this data in different formats, and some calculation may be required to find the actual value to be used for this parameter. The value entered must be the RMS phase to phase voltage.

In some cases, the motor manufacturer will supply a voltage constant, e.g. “48 Volts / 1000 RPM” or “45.1mV / RPM”. In this case, the voltage constant should be multiplied by the rated speed to determine the correct value, e.g. if the motor has a rated speed of 3000 Rpm, and a voltage constant of 48 Volts / 1000 Rpm, P-07 = 3000 / 1000 x 48 = 144 Volts.

P-08 Motor Rated Current

This parameter must be set to the motor continuous rated phase current in amps, often referred to as the motor nominal current (IN). This parameter is used to protect the motor and prevent damage through excessive current.

P-09 Motor Rated Frequency

This parameter must be set to the frequency required for the motor to operate at rated speed, often referred to as the motor nominal frequency (fN). If the actual frequency is not given, it may be determined from the motor pole count as follows :-

Rated Frequency = Motor Rpm x Motor Poles / 120

E.g., 8 pole motor, 3000 Rpm rated speed

Rated Frequency = 3000 x 8 / 120 = 200Hz

P-10 (Optional) Motor Rated Speed (RPM)

This parameter should be set to the rated speed of the motor, often referred to as the motor nominal speed (nN). The speed must be the speed at which the motor operates when the frequency set in P-09 is applied.

P-17 Effective Switching Frequency

For PM motor applications, it is recommended to use an effective switching frequency of at least 8kHz. Setting the drive output switching frequency is a compromise between achieving the smoothest possible operation and minimisation of drive losses (with the potential need to de-rate the drive). Some testing may be required to establish the lowest switching frequency that can be selected whilst maintaining the required level of performance. When increasing the switching frequency setting always consult the appropriate drive de-rating data and configure parameter P-08, Motor rated current, appropriately.

P-51 Motor Type Selection

This parameter allows selection of the correct motor type and control method. P-51 cannot be accessed unless advanced parameter access is enabled – set P-14 = 201.

The default setting of P-51 is 0, intended for IM motors. For BLDC Motors, setting 3 must be used.

P-52 Motor Data Auto tune

When the above parameters have been set, or if any motor related parameters are changed, an autotune must be carried out. For correct operation, accurate motor data is required, which can only be determined through the autotune.

Autotune is carried out by setting P-52 = 1. The drive will display “Auto-t” and the motor data will be measured – see later in this application not for a list of the parameters measured during the autotune.

The autotune must complete successfully, and the drive must go back to showing “Stop” on the display. If the drive trips during the autotune, refer to the drive user guide for information on the relevant fault and methods to resolve.

Once the autotune has completed, it should be possible to operate the motor. The following section then provides information on how to optimise the performance further.

Compressor Operating Parameters

Most compressors will have an operating speed range, and will also give guidance on suitable acceleration or deceleration rates for normal operation. In general, it is desirable to accelerate quickly to the minimum operating speed, and then have a more gradual acceleration and deceleration rate when operating within the normal range.

In some cases, the data may be given in RPS as opposed to RPM, which can easily be converted to RPM by multiplying by 60. The data may also be presented in Hz, and again conversion is possible based on the number of motor poles.

Example of Calculating Operating Parameters

From the compressor Data sheet, we can determine the required motor data, enter into the drive and autotune. This must be completed first. From the datasheet, we can then find values for operating speed range and suggested acceleration rates.

These may be shown as follows :-

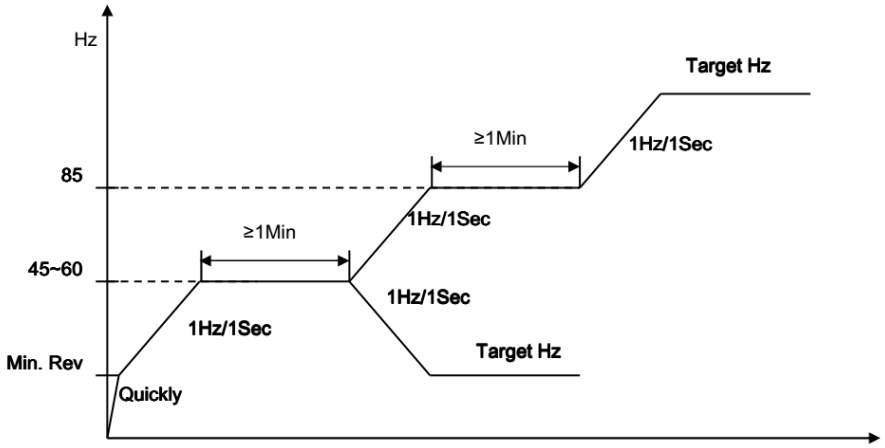
1.2 Motor

Motor Type / Starting Type	BLDC Motor
Pole / Rated Output	4 Pole / 2,030 Watts(@60Hz)

1.6 Revolution Range (By standard DC Inverter)

Operating Range	15 ~ 100 rps
Rated Condition	30 ~ 90 rps
Max Load Condition	35 ~ 85 rps

***Note 1. Operating Pattern**



- From this, we can determine the motor is a 4 pole type.
- Operating Range 15 – 100RPS
  - 100 RPS = 6000RPM = 200Hz = P-01
  - 15 RPS = 900RPM = 30Hz = P-02
- The operating pattern shows an acceleration rate of 1Hz / Sec within the normal operating window
  - P-03 = P-04 = P-09 x Acceleration Rate in Hz / Second
- Below minimum revolutions, the ramp rate is shown as “Quickly”. This can be achieved using the method shown in BLDC Compressor Starting

BLDC Compressor Starting

In this application, it is desirable to have a fast acceleration up to minimum operating speed, then to have a more gradual acceleration when operating within the desired range. This can be achieved with E3 as follows :-

- Set P-26 = 0
- Set P-27 = P-02
- Set the required acceleration rate, e.g. 5.o seconds in P-24
  - P-24 is then used for both acceleration and deceleration ramp times when operating below P-02

Optimising the Motor Operation

Low Speed / Starting Boost

P-11 Low Frequency Torque Boost

In order to optimise the starting performance P-11 may be used to adjust the level of current boost applied. The motor current should be checked at starting to ensure that excessive current is not produced. If the level is too high, the drive may trip with "It.trp" (motor thermal overload) as the motor current is too high. The setting should only be high enough to ensure reliable repeat starting.

Tips & Tricks for Optimisation

There are a wide variety of different BLDC motor types now available, and the information provided by different manufacturers can be extremely variable. As such, it can be difficult and often time consuming to find the correct settings and resolve problems. This section provides some guidance on ensuring that parameters are set correctly.

Check P00-31 – Id and Iq Current Values

When basic motor parameters have been entered and an autotune completed, if it is possible to start the motor, check the value shown in P00-31 during operation. BLDC motors require no magnetising current, so when operating in a speed range approx. 50 – 70% of rated speed, the Iq value (2nd Index) should be around zero. A value of + / - 0.1A is acceptable, otherwise this often indicates that the Back EMF value entered in P-07 is incorrect – adjust the value, autotune and try again.

In general, if the magnetising current shows a positive value, P-07 is most likely too high, whereas a negative value indicates too low a value.

PM & BLDC Motor Parameters

The following sections provide a list of the parameters which are relevant to PM & BLDC motor operation. Refer to the Optidrive P2 Advanced User Guide for further information on these parameters.

Parameters Related to PM Motor Operation

Par.	Function
P-03	Acceleration ramp time
P-04	Deceleration ramp time
P-07	Nominal back emf
P-08	Motor rated current
P-09	Motor rated frequency
P-10	Motor rated speed
P-11	Low Speed Torque Boost
P-14	Extended menu access
P-17	Switching frequency
P-51	Control Mode
P-52	Motor parameter auto-tune
P-53	Vector Mode Gain
P-54	Maximum motoring Torque limit

Parameters Measured During The Autotune

The following parameters are measured during the autotune. They may be adjusted manually, however this is not recommended – the measured values will normally be extremely accurate, and should only be adjusted by users who understand the rpinciples of operation and the effect of the parameter adjustment.

Par.	Description
P-55	Motor Stator Resistance
P-56	Motor Stator D-axis Inductance
P-57	Motor Stator Q-axis Inductance

Troubleshooting

Trip codes and fault diagnostic information is provided in the standard Optidrive P2 manual. Below is further troubleshooting information specific to PM & BLDC motor control.

Symptom	Solution / Advice
Cannot access P-51	Advanced parameter access code not entered in P-14. Value '201' required.
Delay seen after drive enable	There is an in-built delay after enable to magnetise and orientate the motor shaft immediately after enable.
Auto-tune failure	See standard Optidrive E3 user guide
Poor Torque Performance at low speed	Some low speed current boost required. See Low Speed / Starting Boost
Too much current causing motor to heat up	Check parameter P-07, motor nominal voltage is set correctly Check parameter P-08, motor nominal current is set correctly If operating for sustained time period at low speed check levels of boost current applied by P-11
Motor Stalled	Check motor connection Check values entered into motor parameters (P-07 to P-10) Check Auto-tune performed Reduce the load Increase acceleration / deceleration time Increase drive / motor rating
Unstable motor speed	Check switching frequency hasn't been adjusted below recommended minimum (8 kHz) Check values entered into motor parameters (P-07 to P-10) Check Auto-tune performed Adjust the Speed loop controller value in P-54 as required
Poor motor dynamics, slow response times	Check values entered into motor parameters (P-07 to P-10) Check Auto-tune performed Check appropriate tuning of speed loop controller, increase gains as required

Appendix:

Revision History			
Issue	Comments	Author	Date
01	New Application Note Created	KB	04/12/15
02	Corrected to P-07 value is Phase – Phase RMS voltage	KB	16/9/16