# Optidrive Applications Support Library

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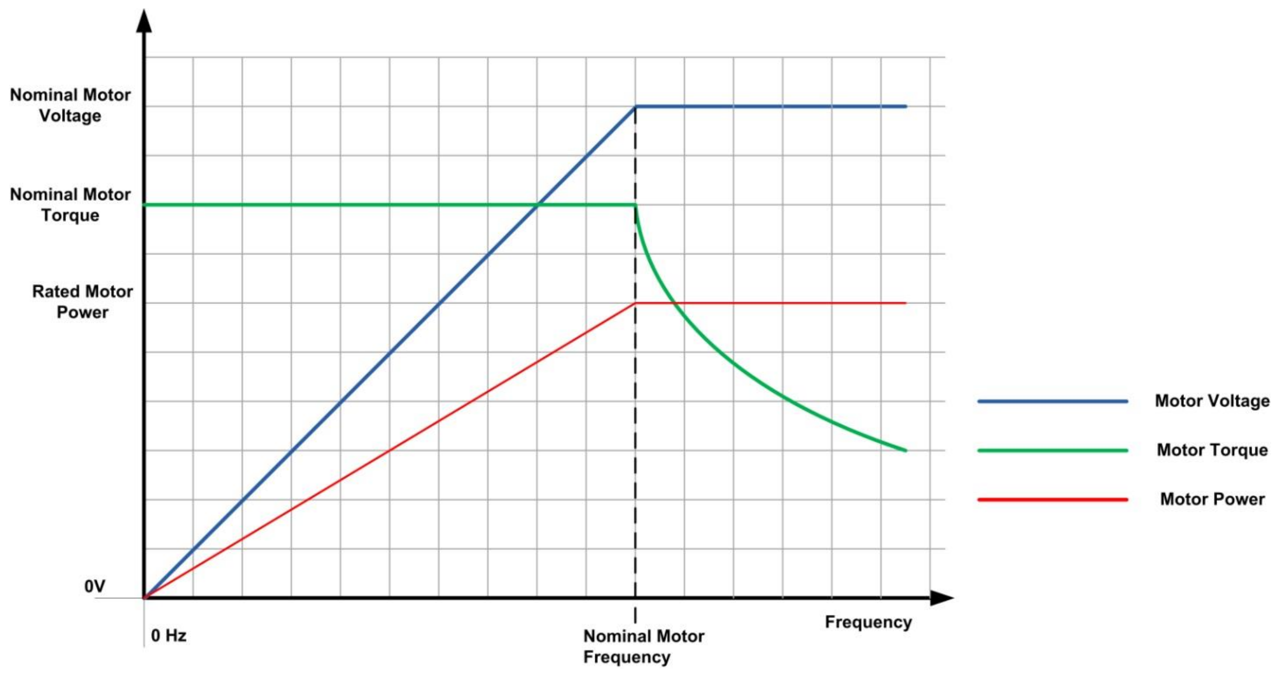
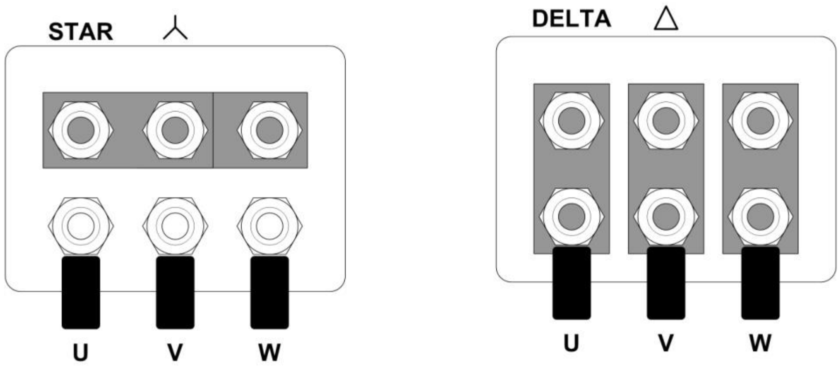
| **Application Note** | **AN-ODE-2-061** |
| **Title** | **87Hz(104Hz) Operation of Standard Induction Motors** |
| **Related Products** | **Optidrive E2** |
| **Level**<br>**1** | 1 – Fundamental - No previous experience necessary<br>2 – Basic – Some Basic drives knowledge recommended<br>3 – Advanced – Some Basic drives knowledge required<br>4 – Expert – Good experience in topic of subject matter recommended |

### Overview

When operating up to the nominal motor frequency the drive is able to modify the output voltage in relation to frequency giving a fixed ratio of voltage and frequency through the range and resulting in constant torque in the motor. When the drive output reaches nominal frequency the output voltage from the drive is typically at its maximum and cannot increase further as the frequency is increased. As a result the power out from the drive remains a constant and the torque output is reduced as the speed increases (Tq = Pshaft/ ωm). This is shown in the graph below (graph shows ideal characteristics, ignoring any losses).



Most modern three phase induction motors are normally dual rated for both 230V and 400V operation. These motors are connected in a 'Star' or 'Delta' Configuration to accommodate the two voltage ranges.




87Hz operation exploits the possibility that the motor could be configured for low voltage 230V (Delta) operation but actually be supplied from a 400V source / drive. In effect the maximum voltage applied to the motor terminals has been increased by a factor of root (3). To avoid over fluxing the motor and to provide a constant Volts/Hz ratio the nominal motor frequency should also be increased by root (3) resulting in the 87Hz operating point.

Now when the motor speed is operated at 50Hz the voltage on the motor terminals will be 230V. When increased beyond 50Hz the drive is able to continue to increase the output voltage to the motor and to maintain the constant torque characteristic within the motor. The torque profile will remain constant now up until 87Hz where maximum voltage is again being supplied to the motor.

The increase in voltage and frequency by a factor of root (3) will result in a subsequent increase in motor output power by approximately the same root (3) factor. Effectively we are using the higher current rating (for Delta operation) in conjunction with the higher voltage rating (from Star Operation) to increase the available output power from the motor.

The same philosophy could be applied to 60HZ 277 / 480V motors. Here the 60Hz nominal frequency can be increased to 104Hz [60 * Root (3)] by employing the same technique.

**Caution: By applying 87Hz (or 104Hz) operation the power output from the motor is effectively increased by root (3) or 1.732. For example a 100kW / 50Hz motor might be configured for 173kW with 87Hz operation. As well as the advantages this brings there are also some drawbacks that should be fully understood and the suitability of the motor must always be confirmed as described below.**

## Suitability for 87Hz (104Hz)

The following factors should be checked to ensure suitability.

- Motor mechanical speed limits
  - Check the motor mechanics are rated / suitable for operation at the RPM that results from 87Hz (104Hz) operation.
- Motor Insulation
  - Check that the motor is able to cope with the additional insulation stresses caused by increased voltage on the motor terminals whilst configured for Delta operation.
- Motor Increased thermal load
  - Addition power derived from operating the motor in this way will result in additional heat generation within the motor. Forced cooling of the motor or motor over-temperature protection may be a requirement.

**Caution: Not all motors are suitable for 87Hz (104Hz) motor operation. The motor manufacturer and associated motor documentation should always be checked prior to commencing commissioning and motor suitability confirmed. The above mentioned points should be checked carefully with the motor manufacturer / motor data to ensure suitability.**

## Drive Set Up

The 87Hz (104Hz) mode of operation requires a 400V rated drive, supplied by 400V 3 phase mains supply voltage.

The following Parameters should be configured on the drive.

| Parameter | Description | Value |
|---|---|---|
| P-01 | Maximum Speed Limit | 87Hz (for a 50Hz motor) or 104Hz (for a 60Hz motor) |
| P-07 | Motor Rated Voltage | 400V (or Motor rated Voltage for Star Operation) |
| P-08 | Motor Rated Current | Motor rated Voltage for Delta Operation |
| P-09 | Motor Rated Frequency | 87Hz (for a 50Hz motor) or 104Hz (for a 60Hz motor) |

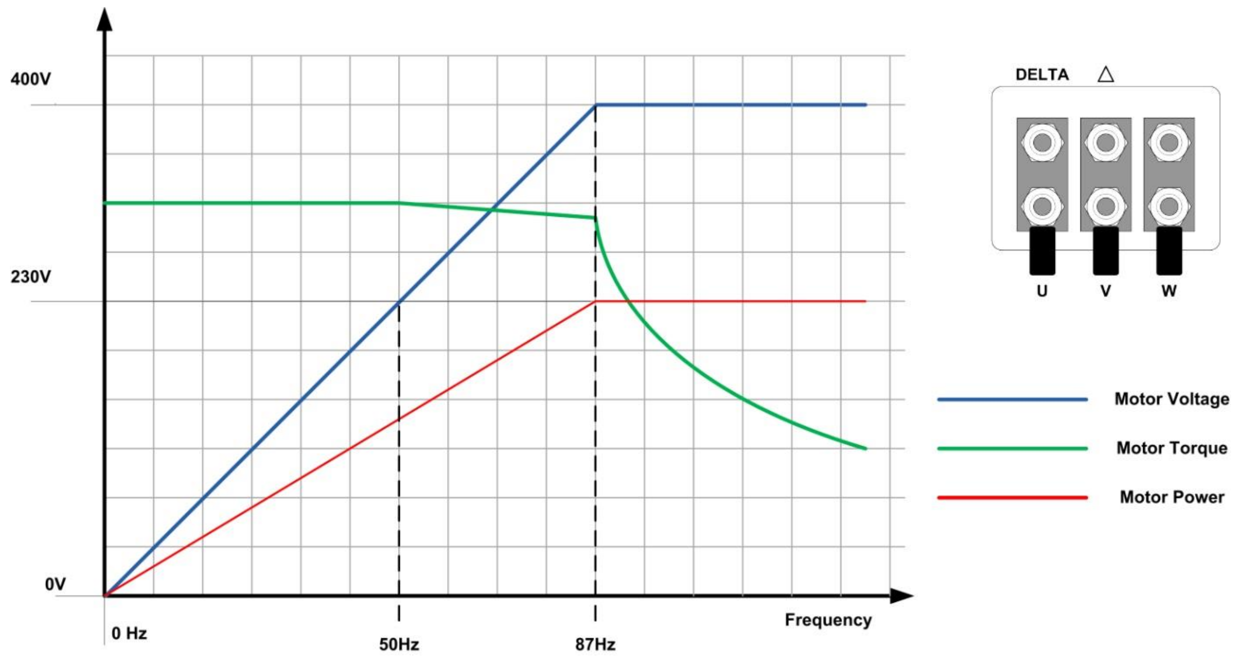
### Notes

1) Acceleration and Deceleration rates entered in P-03 and P-04 are the time taken for the drive to ramp to and from 87Hz (104Hz) in seconds.

2) If a value for Motor Rated speed (P-10) is required to be entered then the value entered will be the synchronous motor speed minus the slip at 50Hz (or 60Hz).

E.g. For a 4 pole 50Hz motor with nominal speed = 1380RPM
Motor is 230 / 400V rated and supplied by a 400V drive
Slip = 1500RPM (sync speed) – 1380 RPM = 120RPM
Synchronous speed at 87Hz = (87Hz X 60S) / Motor pole pairs (2) = 2610 RPM
P-10 = 2610 – 120 = **2490 RPM**

The drive is now configured to operate at 87Hz (or 104Hz). The Graph for 87Hz operation is shown below.




There is some Torque reduction above 50Hz caused by the increased iron losses that result from operation at a higher frequency but the net result is a significant increase in the power output from the motor.

As we are using the higher current rating for the motor it may result in a larger rated drive being required. Always check the motor rated current for Delta operation with the current rating of the drive.

## Summary of Advantages

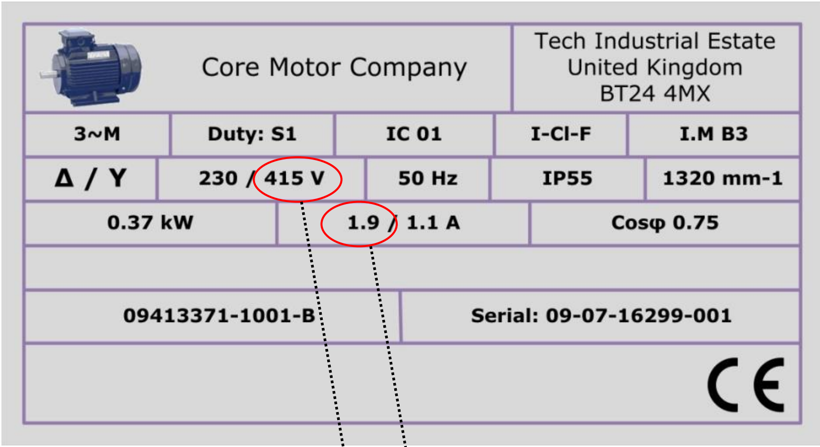
87 Hz (104Hz) operation can result in up to root (3) times more power from the same motor size as standard operation.

The advantages of this are:

- Wider Speed control range compared with standard operation (e.g. 1:87Hz instead of 1:50Hz)
- Smaller motor size in relation to the power. This might result in a smaller and cheaper motor being selected.
- When used with a gearbox, higher output torque is possible for the same gearbox speed range. (Gear ratio can be multiplied by root (3).
- As the maximum motor slip remains the same as when operating at 50Hz (or 60Hz) the motor efficiency is improved. Effectively the rated speed has increased and the slip remained the same meaning proportionally the efficiency has improved.
- The speed of an existing machine might be increased without changing the existing mechanical components.

## Example Set-Up

Take the following motor data plate:




The Optidrive E2 configuration would be as follows.

Drive required: 400V drive, rated at 0.75kW, 2.2A

P-01, Maximum Speed Limit set to **87Hz**

P-07, Motor Rated Voltage set to **415V**

P-08, Motor Rated Current set to **1.9A**

P-09, Motor Rated Frequency set to **87Hz**

We want the drive to display RPM so P-10 needs to be set.

P-10, Motor Rated Speed set to **2430RPM**

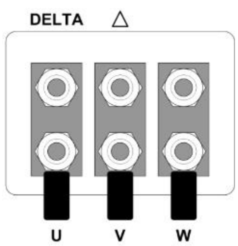
Derived from:

Synchronous speed at 87Hz = (87Hz X 60S) / Motor pole pairs = 2610

Slip = 1500RPM (sync speed) – 1320 RPM = 180RPM

P-10 = 2610 – 180 = **2430RPM**

Lastly the motor must be configured for Delta operation, typically as shown here.



## Appendix

| Revision History | | | |
|---|---|---|---|
| Issue | Comments | Author | Date |
| 01 | Document Creation | JP | 23/03/12 |
| 02 | | | |