NHP

TECHNICAL NEWS

Issue 10

Please circulate to

Quarterly Technical Newsletter of Australia's leading supplier of low-voltage motor control and switchgear.

IN THIS ISSUE

AC VARIABLE FREQUENCY DRIVES AND BRAKING

When an AC motor is controlled by an AC variable frequency drive (V.F. drive) there is a significant difference in the way the installation responds to overhauling loads compared with the motor being connected directly to the mains. The article will analyse the difference in performance and the strategy used by V.F. drives to absorb regenerative energy - namely, dynamic braking. Also discussed will be DC injection braking and the difference between these methods of braking will become apparent.

The AC induction motor operates on the same principle as all three phase AC motors - that is, interaction of two magnetic fields. A rotating magnetic field is set up by the stator when it is connected to the supply. The speed of rotation of this field is directly proportional to the supply frequency.

This field induces current in the rotor conductors and the magnetic field associated with these currents imparts a torque which accelerates the rotor in the direction of the rotating field. The rotor will try to match the speed of the rotating magnetic field, but due to bearing and other losses cannot run synchronously with it. The difference between the rotor speed and the synchronous speed is called "slip".

The rotor will try to match the speed of the rotating magnetic field, but due to bearing and other losses cannot run synchronously with it.

Adjustable frequency AC motor drives

AC variable frequency drives and braking (continued from page 1)

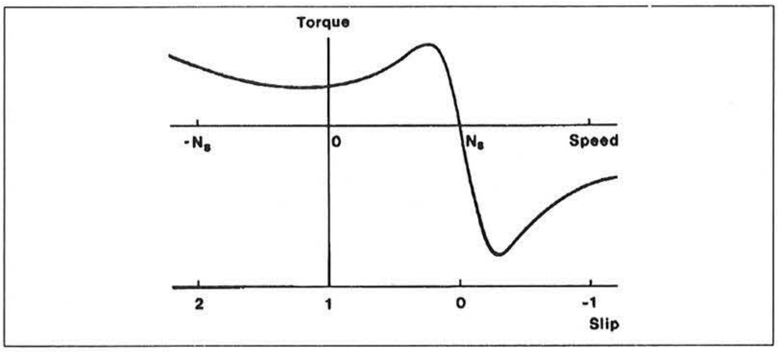

Figure 1

A V.F. drive alters the speed of the motor by changing the speed of the rotating magnetic field. The AC supply is rectified, the DC voltage is filtered by a capacitor and transistors are switched at high speed using a Pulse Width Modulation (PWM) technique to supply the motor with a variable voltage and variable frequency supply. This provides control of the speed of the rotating magnetic field and hence motor speed.

Field strength is maintained constant providing minimal reduction in motor torque at speeds up to base frequency.

A typical torque speed curve for an induction motor covering the full speed range which is likely to be encountered in practice is shown in **Figure 1**. (Ns is synchronous speed).

It can be seen that the decisive factor as far as the direction of torque is concerned is slip rather than speed.

It can be seen that the decisive factor as far as the direction of torque is concerned is slip rather than speed. When slip is positive the torque is positive and vice versa. The torque therefore always acts so as to urge the rotor to run at zero slip - that is, synchronous speed.

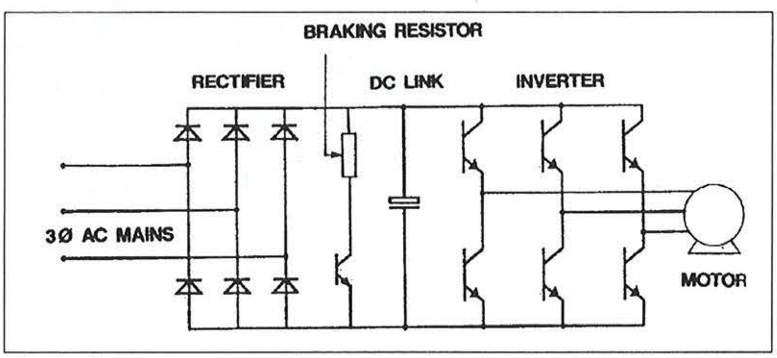

Figure 2

Generating region - overhauling loads

For negative slips - that is, when the rotor is turning in the same direction but at a higher speed than the travelling field, the "motor" torque is in fact negative. The machine develops a torque which opposes the rotation and acts as an induction "generator", converting mechanical power from the shaft into electrical energy.

When the motor is connected directly to the AC mains the regenerated energy can be fed back directly into the supply. In contrast, when the motor is supplied by a V.F. drive the regenerated energy cannot be returned to the supply. The uncontrolled bridge rectifier on the input of the V.F. drive acts as a block to the regenerated energy. This leaves all regenerated energy to be dissipated by the motor and V.F. drive.

Dynamic brake resistor

Inherent in each V.F. drive installation is the ability to dissipate 15 to 20 per cent of regenerative energy as losses within the V.F. drive and motor. Where the load inertia is large and/or rapid acceleration/deceleration occurs, regenerated energy increases substantially. This results in a rise in DC voltage and may cause damage or activate overvoltage protection to isolate the V.F. drive.

V.F. drives employ a device to dissipate excessive regenerative energy called a "Dynamic Braking Resistor". As shown in **Figure 2**, the resistor is connected across the DC bus via a transistor. When the DC voltage reaches the reference level in excess of rated capacity the transistor is turned on and the regenerative energy is dissipated in the resistor as heat.

When the speed setting of a motor connected to a V.F. drive is reduced the synchronous speed of the motor decreases. **Figure 3** below shows the effect of changing the frequency from F1 to F2 and the braking torque generated -T2.

When the synchronous speed falls below the rotor speed, slip becomes negative, thus torque generated by the motor is switched to braking torque. At speeds above base frequency braking torque is reduced - as is the positive motor torque.

Selection of the appropriate Dynamic Brake Resistor depends on the inertia of the motor and load, permissible current limit of the transistor and resistor and duty cycle of the load. Braking torque is usually expressed as a percentage of the motor torque available and can range from 30 per cent to 150 per cent of rated torque.

The situation where the load overhauls the motor can occur quite often. When the motor is connected to the AC mains this is of no consequence. However, when the motor is connected to a V.F. drive the regenerative energy must be dissipated.

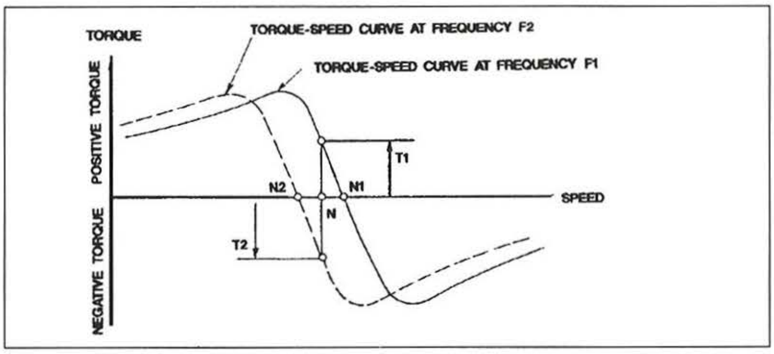

Figure 3

For this reason selection of a V.F. drive must include consideration of how the V.F. drive will respond to regenerative energy. Preferably, the V.F. drive should have dynamic braking fitted as standard and the ability to readily accept braking resistors of higher capacity to cater for varying load conditions.

DC injection braking

It was previously stated that the speed of rotation of the field in the air-gap is directly proportional to the supply frequency.

Also, the rotor always tries to run at the same speed as the air-gap field, so if the field is stationary and the rotor is not, a braking torque will be exerted.

A typical torque speed curve for DC braking an induction motor is shown in **Figure 4** below. Note the braking (negative) torque falls to zero as the rotor comes to rest, since there will only be induced currents in the rotor (and hence torque) when the rotor is cutting the flux. DC injection braking is a dissipative process and all the kinetic energy is turned into heat inside the motor. For this reason DC injection braking should not be applied for excessive periods, as motor over heating may occur.

Where DC injection braking is provided by V.F. drives several programmable parameters controlling the application of DC injection braking are provided.

These parameters set the frequency (or speed) when DC injection is activated, the magnitude of DC voltage

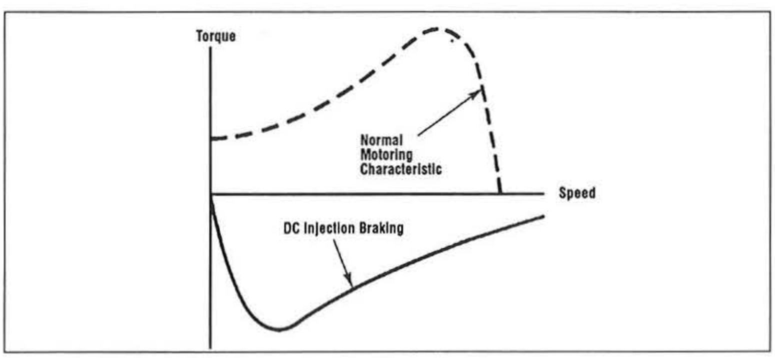

Figure 4

DC injection braking
(continued from page 3)

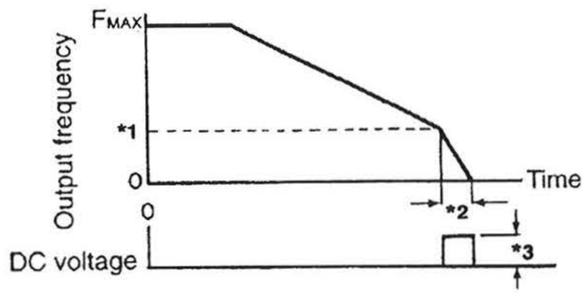

Figure 5

applied (usually as a percentage of supply voltage) and the time DC injection is applied **Figure 5**.

The above discussion has outlined the operation of a motor and V.F. drive with overhauling loads, the use of dynamic braking to dissipate regenerative energy and a method of providing positive braking torque to a motor - DC injection braking.

Dynamic braking provides improved dynamic response to speed change and overhauling loads. DC injection braking provides controlled stopping of motors for position control or elimination of over-run.

The ability of V.F. drives to provide these facilities should be considered during its selection.

Dynamic braking provides improved dynamic response to speed change and overhauling loads.

DC injection braking provides controlled stopping of motors for position control or elimination of over-run.

Editorial content: - Please address all enquiries to 'The Editor - 'NHP Technical News' PO Box 199, Richmond Victoria 3121.

NHP Electrical Engineering Products Pty Ltd A.C.N. 004 304 812
Internet http://www.nhp.com.au

MELBOURNE
43-67 River Street,
Richmond, Vic. 3121
Phone: (03) 9429 2999
Fax (03) 9429 1075

SYDNEY
30-34 Day Street North,
Silverwater, N.S.W. 2128
Phone: (02) 9748 3444
Fax: (02) 9648 4353

BRISBANE
25 Turbo Drive,
Coorparoo, Qld. 4151
Phone: (07) 3891 6008
Fax: (07) 3891 6139

ADELAIDE
50 Croydon Road,
Keswick, S.A. 5035
Phone: (08) 8297 9055
Fax: (08) 8371 0962

PERTH
38 Belmont Ave.,
Rivervale, W.A. 6103
Phone: (08) 9277 1777
Fax: (08) 9277 1700

NEWCASTLE
575 Maitland Road,
Mayfield West, N.S.W. 2304
Phone: (02) 4960 2220
Fax: (02) 4960 2203

TOWNSVILLE
62 Leyland Street,
Garbutt, Qld. 4814
Phone: (07) 4779 0700
Fax: (07) 4775 1457

ROCKHAMPTON
208 Denison Street,
Rockhampton, Qld. 4700
Phone: (07) 4927 2277
Fax: (07) 4922 2947

TOOWOOMBA
Cnr Carroll St. & Struan Crt.,
Toowoomba, Qld. 4350
Phone: (07) 4634 4799
Fax: (07) 4633 1796

CAIRNS
14/128 Lyons Street,
Bungalow, Qld. 4870
Phone: (07) 4035 6888
Fax: (07) 4035 6999

DARWIN
3 Steele Street,
Winnellie, N.T. 0820
Phone: (08) 8947 2666
Fax: (08) 8947 2049

Agents:

HOBART
199 Harrington Street,
Hobart, Tas. 7000
Phone: (03) 6234 9299
Fax: (03) 6231 1693

LAUNCESTON
59 Garfield Street,
Launceston, Tas. 7250
Phone: (03) 6344 8811
Fax: (03) 6344 4069

BURNIE
6 Wellington Street,
Burnie, Tas. 7320
Phone: (03) 6432 2588
Fax: (03) 6432 2580