NHP

TECHNICAL NEWS

Issue 6

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

IN THIS ISSUE

CONTACTOR OPERATING SPEED

Introduction

The basic contactor has been around for a long time. Most people in the electrical industry take them for granted and do not appreciate that in some applications the speed of operation can be critical. Between different contactor designs and control circuits there can be significant differences in the closing and opening times. In some cases the delay on opening times can be as high as several seconds.

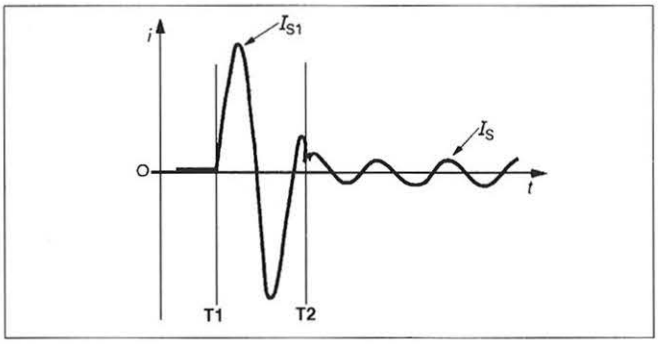

***Fig. 1** Coil current during closing operation of a contactor AC magnet*

I_S Rated coil current

I_{S1} Closing current of coil (6...25 I_S depending on contactor)

T_1 Closing command (coil closed)

T_2 Magnet closed

AC types

Switching on -

The operation of contactors on AC is generally faster than DC. When switching on there is a starting current inrush created by the build up of the magnetic field and the initially low inductance with the core of the magnet still open. The low initial inductance allows the magnet system to develop sufficient power to rapidly close. The time from the closing command to the magnetic system closing is typically in the order of 20mSec. This will vary by about ± 5mSec., depending on the actual point on the wave that the closing command is made. (Fig. 1).

Switching off -

When switching off the control contacts interrupt the coil current and an electric arc is produced. The arcing is enhanced by the highly inductive nature of the magnet system and high voltage spikes can be produced. The arcing is normally extinguished in the first zero passage of the current. (Fig. 2).

The fastest opening operation is obtained when no suppression devices are fitted to the coil. The use of sensitive electronic equipment in the vicinity of the contactor control circuit requires suppression of the voltage transient. The

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most common form is a simple RC network connected across the coil and this has the advantage of only slightly increasing the contactor switching time. At this point it is usually assumed that AC magnet systems will always open rapidly, but the circuit is not always simple. If the coil is connected in parallel with other loads (Figure 3) this greatly effects the time constant of the circuit and with some contactors, drop out delays exceeding 100mSec. can arise.

DC control

Switching on -

Unlike the AC magnet which limits the closed current drawn by the coil inductance, the final current in a DC system is limited by the coil resistance.

The closing operation for DC is slower as the current profile is the reverse of an AC system.

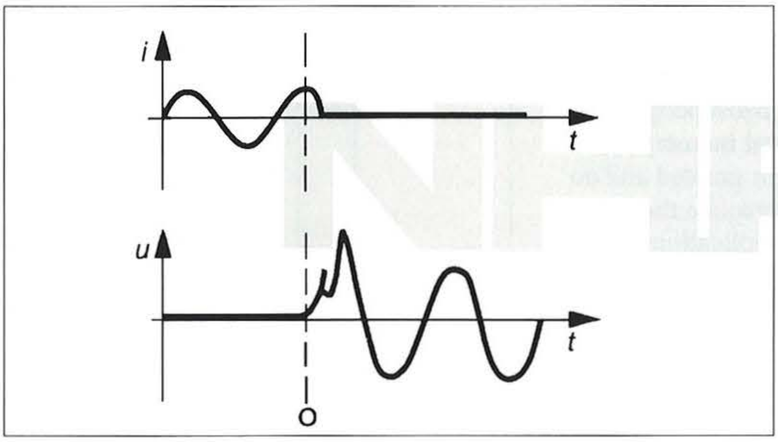
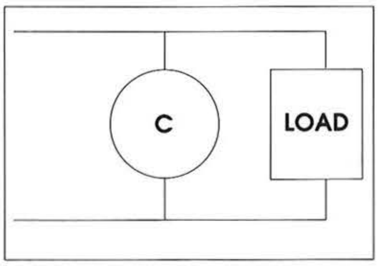
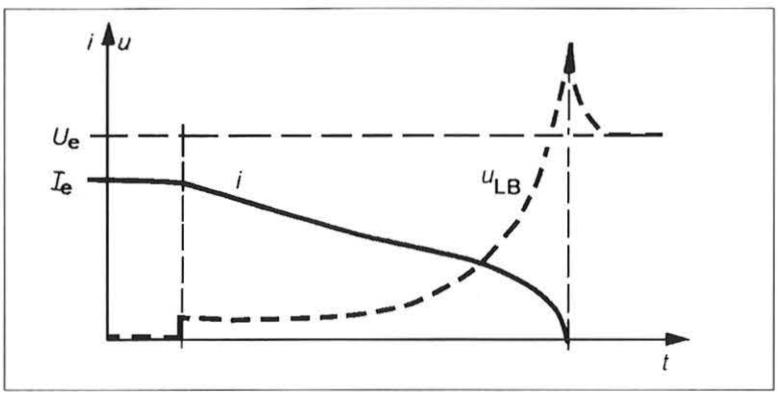


Fig. 2 Current and voltage curves across the contact on switching off alternating current magnet drives



◀ ***Fig 3. Contactor coil connected in parallel with load circuit alters opening time.***

Fig. 4 Current curve on switching on a pure direct current magnet drive.
A: Influence of the armature reaction. ▼



While the coil inductance has no effect on the final current, it does slow the rate of rise in current and there is a delay before sufficient force is developed to start the system moving. (Fig. 4).

Switching off -

With a DC system the current required to hold the magnet system closed can be very small and therefore on switching off the coil current has to decay to a very low value. (Fig. 5) The fastest drop out is achieved when the coil is switched directly, but this can produce high voltage transients. A diode connected across the coil will provide a discharge path for the energy in the coil, but will delay the drop out. With some larger contactors this delay can be in the order of 1 second.

It is common with contactors over about 500 amp rating to use only DC magnet systems. For AC control a diode bridge is incorporated into the design. If control of the coil is on the AC side, drop out of the contactor will be slow. For fast operation the switching element needs to be connected on the DC side of the diode bridge.

Case studies

Case study No 1.

A large bar contactor was used to provide changeover to an alternate supply when failure of the normal supply occurred. The contactor was fitted with changeover contacts to provide the change with only one contactor.

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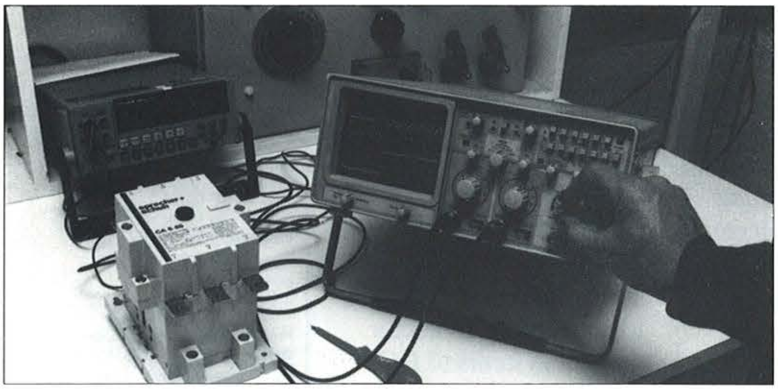

Bench testing for contactor operating times.

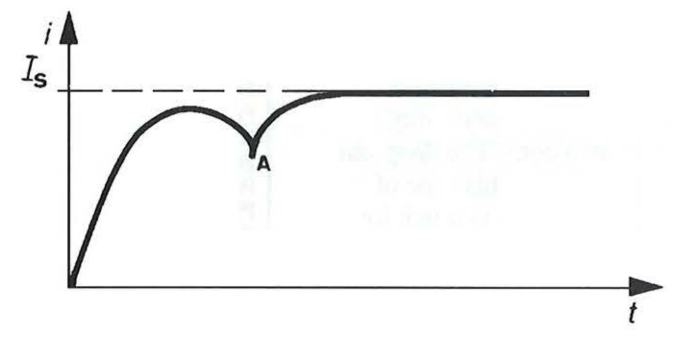

Fig. 5 Current and voltage curves on switching off direct current magnet drives

I_e	***Nominal operational current***
i	***Current curve on switching off***
U_e	***Nominal operational voltage***
u_{LB}	***Arc voltage***
u	***Voltage across control contact***

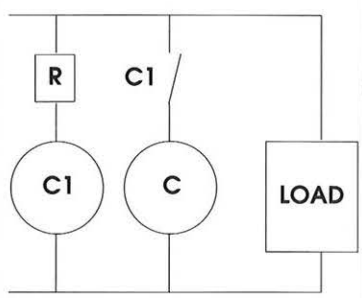

Fig 6. Interposing relay with series resistance to improve opening time.

It was required to make the alternate supply in under 30mSec. after failure of the main supply.

Testing of the contactor before installation proved satisfactory but, when fitted, the changeover time regularly exceeded 100mSec.

The coil of the contactor was energised directly from the normal supply. This proved to be the problem, as it meant that the circuit load was connected in parallel with the coil.

The time constant (T) of an inductive circuit is:

$$T = \frac{L}{R}$$

L = Inductance
R = Resistance

(The time constant represents the time taken for the current to reach 0.63 of its initial value.)

It can be seen from this equation that as R decreases the time constant increases. This means that the coil current takes longer to decrease to the drop out point with increasing circuit load.

To try and prevent the load circuit increasing the time constant a small interposing relay was connected in the coil circuit. Even though the interposing relay was rated for fast operation it too suffered from the same probiem as the contactor, although some improvement in the total time was achieved.

To improve the system further the voltage rating of the interposing relay was lowered and a dropping resistor used in series with the coil.

The series resistance was much larger than the connected load and allowed the time constant of the circuit to be maintained at a relatively low level.

With this arrangement the required changeover time was achieved. (Fig. 6).

Case study No 2.

A large motor drive was found to be causing problems with some contactors during start-up. The voltage drop at the point of connection was quite large and under some

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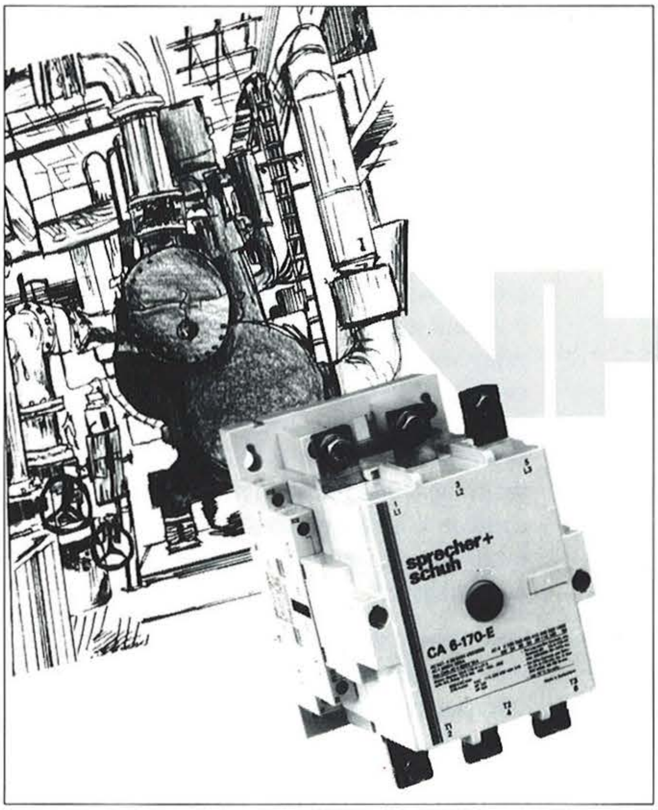
circumstances could cause contactors to chatter. To reduce the voltage drop would have meant upgrading a very long run of cable at considerable expense. Instead of doing this it was decided to try and fix the problem by modifying the contactors being affected by the voltage drop.

The first option considered was to change the contactor operating coils to a lower voltage.

This was rejected, as during normal running operation the applied voltage is close to the nominal voltage of the system. The point of chattering would have been lowered, but coil overheating would be likely.

The solution selected was to convert the contactor magnet systems to DC with continuously rated coils. This style of contactor has a large coil which is capable of continuous operation at the rated voltage without the need to switch in a limiting (economy) resistor. The drop-out point of this type of contactor is much lower than an AC style and is immune to short duration losses of control voltage when fitted with a free wheeling diode across the coil. The diode acts as a short across the coil and maintains the current flow resulting from the energy stored in the coil.

After the conversion all contactors behaved in a stable manner during the motor start cycle.



The introduction of electronic coil control has eliminated many of the problems associated with convential coils.

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