NHP

# TECHNICAL NEWS

Issue 2

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

IN THIS ISSUE



# NON-STANDARD CONTACTOR APPLICATIONS

## Parallel wiring increases thermal capacity

Parallel connections of current paths in switchgear increase their thermal load ratings. It should be noted, however, that the resistances of the individual current paths may vary due to contact burn, contamination, etc. The current is therefore not uniformly distributed among the parallel paths, but in proportion to their resistance.

To avoid overloading of a contact point, the product of the rated current $I_e$ x number of current paths should be replaced by the following factors to obtain the permissible total current:
For 3 parallel current paths: 2.5 x $I_e$
For 2 parallel current paths: 1.7 x $I_e$

Contactor current paths may only be wired in parallel for switching active loads (utilisation category AC 1). The limited switching capacity and short circuit resistance of the contactor makes it inadvisable to use this scheme for switching motors with greater rated currents than those for which the contactor has been designed.

Compared with the standard application, the making and breaking capacities in parallel connections remain unchanged because in many cases, one contact is closed or opened first and thus assumes the major part of the switching load.

Wherever possible, contactor current paths should be connected in parallel with copper bars with central current routing. This will result in good heat dissipation and current distribution.

Such connecting bridges are available for the smaller contactors.

Permissible back-up fuses:

For 3 parallel paths:
2 rating steps higher
For 2 parallel paths:
1 rating step higher

**Contact reliability**
In auxiliary circuits, parallel connection of current paths multiplies contact reliability.

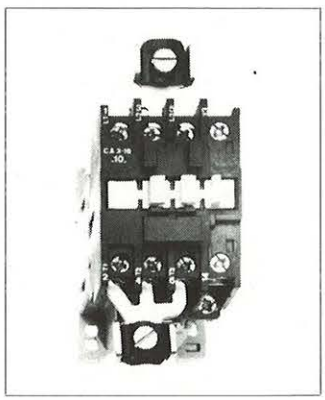


*Fig. 1.*
***Contactor having two connecting bridges for switching single-phase active loads.***

## Series wiring

A series connection of two or three current paths of standard three phase switchgear offers considerable advantages.

For example -
- increased dielectric strength
- improved switching capacity
- greater contact life

The permissible current load of series connected main current paths is the same as for the individual current path.

The effect of a series wiring approach when switching DC loads will be described in detail in a later issue.

**Operation with 50 or 60Hz three phase current**

**With a 660V three phase current** and standard double point configuration per pole, the permissible rated operational current of some contactor types is reduced in comparison to lower voltages. By connecting two main current paths per pole in series according to Fig. 2, the permissible rated operational current for 415V can be attained for 660V as well.

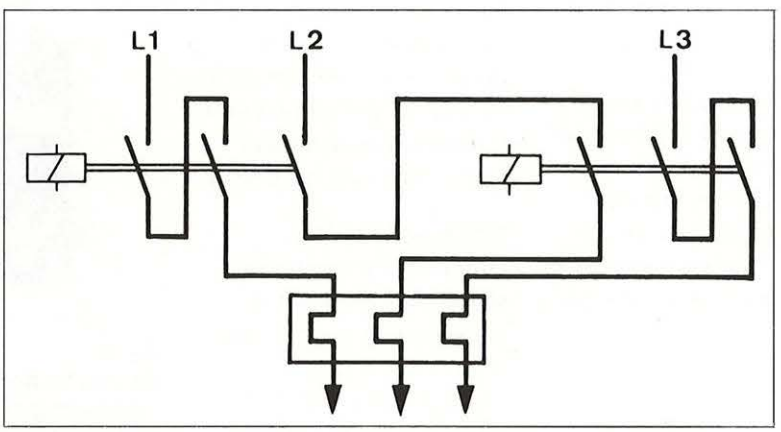



*Fig. 2. Combined arrangement of two identical contactors. Thermal overload relay, if used, to be mounted separately.*

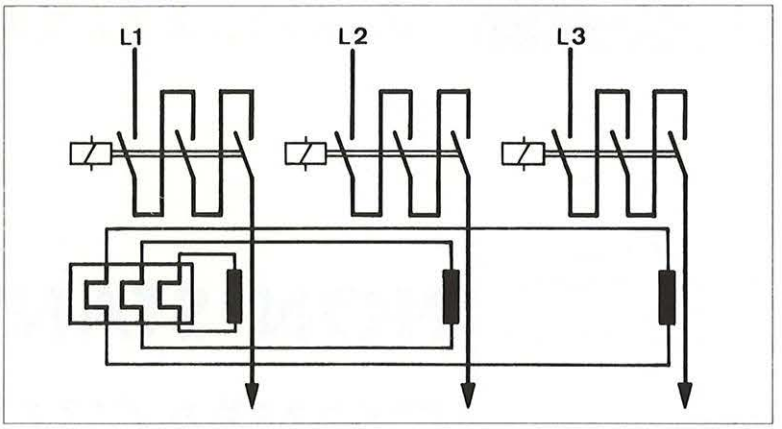



*Fig. 3. Combined arrangement of three identical contactors mounted separately. A thermal overload relay would have to be wired to three single-phase current transformers, $U_n$ = 1000V, class ≤ 0.5.*

**With a 1000V three phase current** all three main current paths of a contactor should be connected in series (according to Fig. 3). The permissible rated operational current is the same as for 415V.

The three contacts must be insulated on post or panel insulators.
The distance between the units and against ground must correspond to the applicable electrical standards.

**Note:** In thermal overload relays it is always necessary to load each of the three current paths so that the simulation of a phase failure cannot occur. ■

## Switching deviating line frequencies

Low voltage switchgear is generally designed for a line frequency of 50 to 60Hz. If the corresponding reduction factors are introduced, the main current paths of the contactors can be used at any line frequency up to about 3kHz.

Basically, this also applies to thermal overload relays, but not to solenoid actuators in contactors.

With respect to the main contactor current paths, the effects of deviating line frequencies on the permissible load and the switching capacity must be taken into consideration.

Between 50..400Hz electrical life of a device is practically not affected. At higher frequencies it will be reduced. The same applies to lower frequencies, especially in the case of small contactors without special quenching devices. ■

## Effect of line frequency on permissible load

The skin effect produces an increased resistance of the current path with increasing frequency. In addition, magnetic induction in adjacent metal parts will cause increased hysteresis and eddy-current losses. Steel plates (quenching devices, screws, magnets, base plates) may be heated to levels in excess of permissible temperatures.

Since the cross section of the current path, as well as the type and distance of adjacent metal parts can vary, the total heat generation and the local over-temperatures depend on the contactor type.

For higher frequencies the following guidelines should be observed.

The connected conductors should be selected according to the higher frequency (flat cable or tubular conductors).

Loop-type cable clamps must not be used.

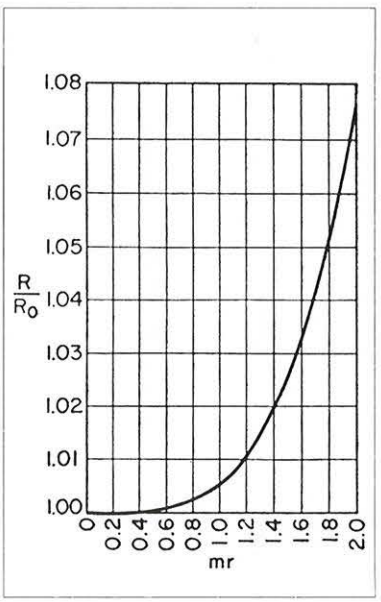
For a single phase load above 400Hz the two external poles should be connected parallel for the outgoing path, and the centre pole used for the returning path. (This will partly compensate for magnetic induction.)

**Skin-effect resistance ratio**

The ratio of the AC resistance to the DC resistance is a function of the cross-sectional shape of the conductor and its magnetic and electrical properties as well as of the frequency. For cylindrical cross sections with presumed constant values of relative permeability $\mu_r$ and resistivity $p$, the function that determines the skin-effect ratio is

$$mr = \sqrt{\frac{8\pi^2 \times 10^{-7} f \mu_r}{p}} \quad r$$

where $r$ is the radius of the conductor and $f$ is the frequency of the alternating current. The ratio of $R$, the AC resistance, to $R_0$, the DC resistance, is shown as a function of $mr$ to the right. ■




## Effect of line frequency on switching capacity

When an alternating current is switched off, the switching path must be sufficiently deionised during the zero passage to prevent re-ignition of the arc when the next half-wave appears.

At higher frequencies the regeneration of the voltage after the zero passage is usually accomplished faster. However, the duration of the arc, and thus of the ionisation phase, is shorter. This is why contactors have practically the same switching capacity at 400Hz as at 50/60Hz.

Difficulties can arise at lower frequencies as the effect of strong ionisation by the prolonged arc becomes dominant.

At lower frequencies the switching capacity is reduced, and becomes very dependent on the voltage and the induction of the load.

Switching of frequencies below 16Hz in practice corresponds to switching of direct current.

In high frequency motors the high closing currents should be considered. If a motor designed for normal frequencies is operated at higher frequencies the pick-up current will rise with the square root of the ratio between the two frequencies. Especially in large motors, the winding is modified such as to prevent extremely high pick-up currents.

Audio frequency remote control methods also have high closing currents (about 10 $I_c$) which govern the size of the contactors. ■

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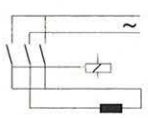
## Selection of contactors for deviating frequencies

Considering the abovementioned effects, the contactors for typical applications can be selected according to the table below.

| Application | Railroad systems | | High-frequency motors | | | Military and emergency power systems | | Inductive heating systems, welding systems | | Audio frequency remote control methods |
|---|---|---|---|---|---|---|---|---|---|---|
| Usage | 1-phase, active load, 3 poles in series | | 3-phase making and breaking | | | Mixed load 3-phase | 1-phase 3 poles in parallel | 1-phase [4] | | 3-phase, short pulses only (duty cycle less than 1%) |
| | Factors for 50/60 Hz rated operational currents | | | | | | | | | |
| Line frequency | $I_e$ AC 1 (encapsulated) $16\,^2/_3$ Hz 500V | 660V | $I_e$ AC 3 100Hz [1] | 200Hz [1] | 400Hz [1] | $I_e$ AC 1 (encapsulated) 400Hz [2] | 400Hz | $I_e$ AC 1 (encapsulated) 1kHz | 3kHz | $I_e$ AC 1 (encapsulated) 0.75...3kHz [3] |
| CA 4-5, CA 4-9 | 1 | 0.5 | 1 | 0.9 | 0.7 | 0.8 | 2 | 0.7 | 0.5 | 1.1 |
| CA 3-9...CA 3-72 | 1 | 0.5 | 1 | 0.9 | 0.7 | 0.8 | 2 | 0.7 | 0.5 | 1.1 |
| CA 6-85/105, CA 1-100 | 1 | 0.5 | 1 | 0.8 | 0.6 | 0.7 | 1.8 | 0.6 | 0.4 | 0.9 |
| CA 1-150 | 1 | 0.5 | 1 | 0.8 | 0.6 | 0.7 | 1.8 | 0.5 | 0.3 | 0.9 |
| CA 1-250 | 1 | 0.5 | 0.9 | 0.8 | 0.6 | 0.6 | 1.5 | 0.5 | 0.3 | 0.9 |
| CA 1-480 | 1 | 0.5 | 0.9 | 0.7 | 0.5 | 0.5 | 1.3 | 0.3 | 0.2 | 0.9 |

Notes: [1]) Pick-up current <12 $I_e$
[2]) Pick-up current <16 $I_e$
[3]) Making current <11 $I_e$

[4])



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