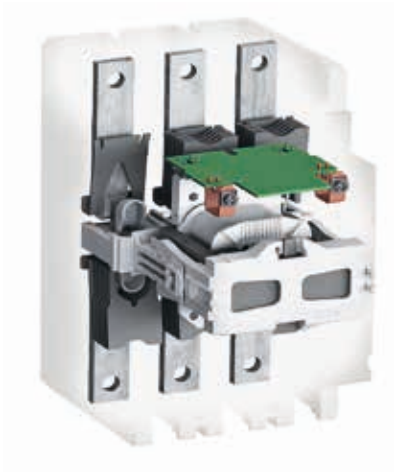
Clean contact

Contactor technology for power switching and motor control

GUNNAR JOHANSSON – Electric contactors are nearly as old as electrotechnology itself – a fact ABB can attest to, having produced low-voltage equipment for over 100 years. Now, however, innovation and new technology are breathing new life into contactors and are eliminating many of the problems that traditionally dogged this workhorse of the electrical switching world. ABB's new-generation AF contactors are paving the way.

1 Contactor schematic



ABB's new contactors utilize software and an electronic circuit in combination with a specially designed magnet to quickly build up a high contact force.

A contactor is an electrically controlled switching device that works much like a relay, but for higher currents. Unlike the circuit breaker, which is another type of switching device, the contactor cannot break short-circuit currents, though it can perform many more operations. Traditionally, contactors are for starting and stopping electrical machinery. The most common contactor type is the three-pole contactor, used to make, conduct and break the current in a three-phase system.

Contactors are built around a contact system that connects to the main circuit. Adjacent to this contact system is a breaking chamber containing various devices that improve breaking performance. The moving contacts are operated by a contact bridge with springs that provide contact force in the closed position. The movement is accomplished by an electromagnet that is enclosed by a coil ➔ 1.

A rear-mounted circuit facilitates combination with other switching devices and prevents the main circuit cables blocking access.

Simple product concept

Large contactors from ABB differ significantly from competitors' by having the main circuit located at the rear. Launched about 10 years ago, this approach has now been proven in the field. This configuration facilitates combination with other switching devices, primarily circuit breakers, and prevents the main circuit cables, which are thick and rather stiff, from blocking access ➔ 2.

The cost of the electronics has been brought down to a level that makes these electronically controlled contactors comparable in price to conventional ones. Assembly costs are low as the electronic module easily snaps into the contactor.

Less raw material

When contactors make or break large currents, arcs are generated. These

Title picture

Ever since electrotechnology was first introduced into the world of industry, contactors have played a vital role. New ideas have now overcome traditional drawbacks, allowing a new generation of contactors to be launched.

2 Placement of circuit at the rear eases access

2a Older contactor with main circuit in the front

2b New contactor with main circuit in the rear

The cost of these electronically controlled contactors is comparable to that of conventional devices.

erode the contact material and this erosion determines the contactor life. A high-grade silver alloy is usually the principal contact constituent. As silver is expensive, increasing the contact bulk to increase contact life is impractical, so ABB has devoted much research to finding other ways to extend contact life.

Several approaches have emerged:
- Improving contactor movements by using an electronic control circuit
- Using software solutions that reduce contact wear
- Designing new magnets that allow higher contact forces
- Introducing new breaking chambers that better remove and quench arcs
- Tuning the contact material manufacture and composition to give high durability

Closing contacts

When switches close, small, short bounces sometimes occur before the contacts settle in the closed position. This so-called contact bounce causes minor, erosive arcs to form. As the current at this point is low, contact bounce is not so important. Far more important is contact lift.

Contact lift happens a little later, when the current is high ➔ 3. The contacts are then usually in the correct position but there are factors, for example, the high switching current, that can separate them, causing arcs. As high currents are flowing, erosion is severe ➔ 4. Also, vibrations, which arise from the closing contactor magnet, can interact with the separation forces to cause contact lift. Therefore, contacts must be held tightly closed so as to resist any possible separation forces. To do this, ABB's new contactors utilize software and an electronic circuit in combination with a specially designed magnet to quickly build up a high contact force. The circuit also provides a measured and controlled movement that minimizes vibrations. Contact lift is rare and erosion on making is thus minimized.

Opening contacts

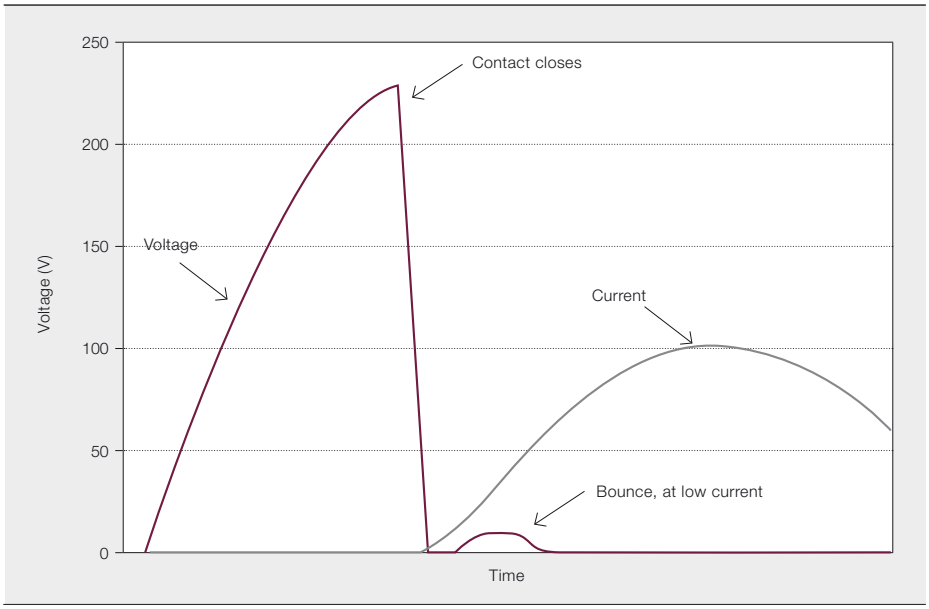
When breaking high currents (over 100 A), the arc has to be moved away quickly from the silver contact material in order to limit erosion. The erosion also has to be distributed as evenly as possible between the different phases.

In order to move the arc away from the contacts, conventional technology is used. A steel plate encloses the contact and draws the arc away. Designs are now carefully calculated and optimized by using simulation tools. Some old truths have been questioned and disproved while others have been exploited to their full potential.

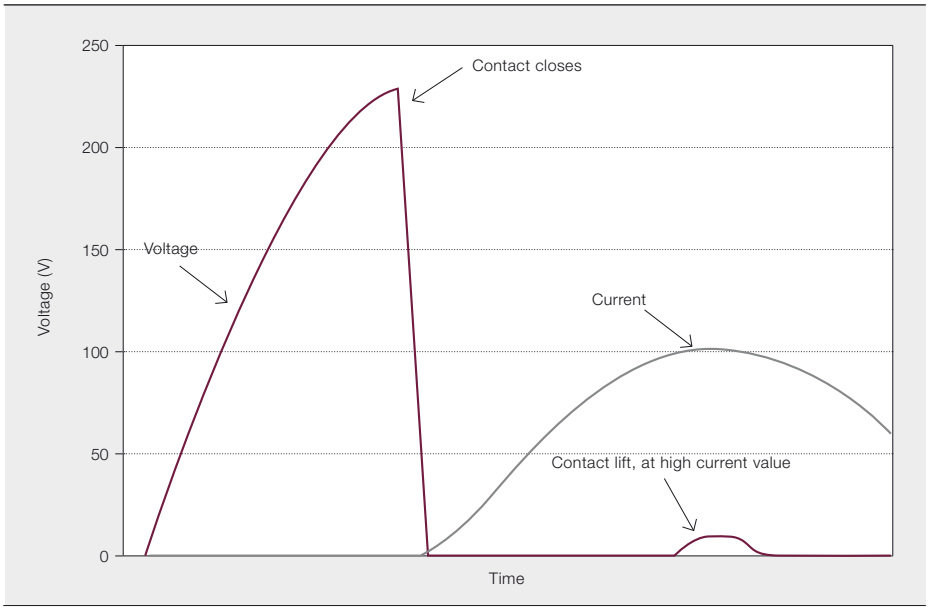
The control circuit, together with the coil and magnet, can, unfortunately, cause the contactor phases to be loaded unevenly as the voltage at the control circuit is often related to the main circuit and a certain amount of synchronization can occur between the moment of switching and the voltage phase. The load will then not be evenly distributed between the contactor's phases and the

A silver and tin oxide mixture, with dopants, provides a good contactor material.

3 Contact bounce and contact lift



3a Contact bounce typically occurs at low current values and is not problematic.



3b Contact lift occurs at high currents and can cause severe contact erosion.

phase most used will wear soonest and, in so doing, determine the lifetime of the entire device. It is better to distribute the load evenly between the phases and equalize contact erosion. The ABB software and electronics do exactly this by eliminating synchronization. Significant improvements in longevity have resulted. The method has a patent pending.

Contact material

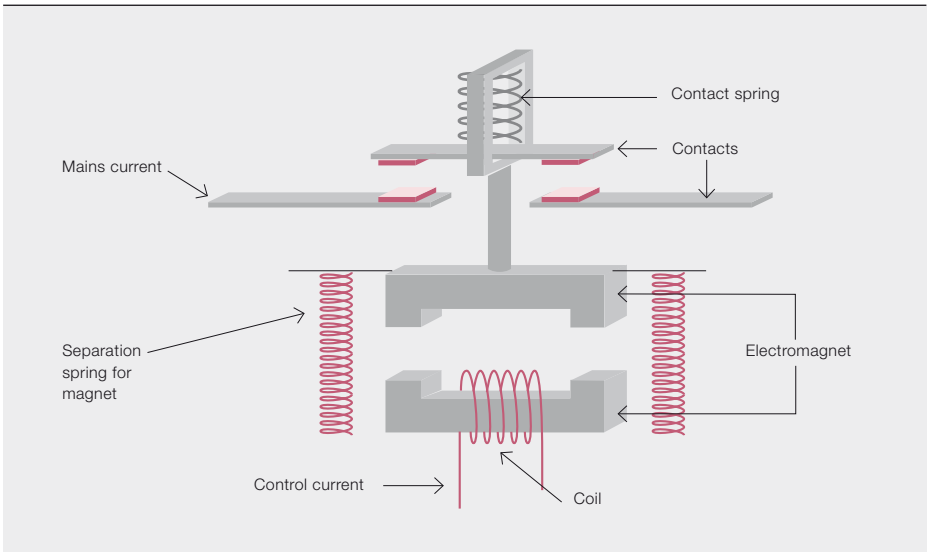
The actual contact material used and its production method have a great influence on erosion. In the past, alloys of silver and cadmium provided very good performance, but cadmium has long since been prohibited. Pure silver contacts would be excellent were it not for the fact that they weld together and rapidly erode. A silver and tin oxide mixture, with dopants, however, provides a good contactor material. As this material is so critical, ABB uses a very carefully determined mixture and the most advanced manufacturing processes to produce it.

Reliability is key

Reliability is the contactor quality most valued by customers. ABB has devoted much meticulous design work and extensive testing to realizing contactor products that meet the highest reliability requirements. The quality of the control circuit is critical.

4 Contact lift at making – snapshot from a movie. The arc consumes contactor material.

5 Conventional and well-proven control circuit



The circuit provides a measured and controlled movement that minimizes vibrations.

The control circuit

A contactor's control circuit is built around a split electromagnet that works with a spring system. The magnet is activated by a current flowing through a coil that causes the two magnet halves to attract each other. This attraction closes the magnet and, via the spring system, it also closes the contacts and provides contact force. When the magnet is deactivated, it opens – along with the contacts, interrupting the main current ➔ 5. This basic principle has been used for over 100 years and no one has yet presented a more competitive alternative. ABB and its main competitors use this simple, proven and reliable solution to make, conduct and break large currents.

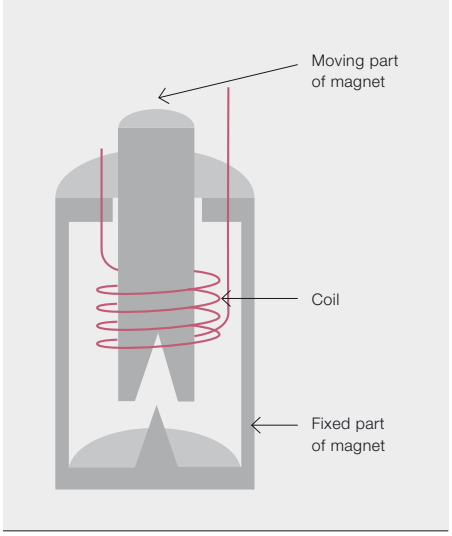
ABB's AF contactors use a patented microprocessor-controlled circuit that ensures the coil current is correct, regardless of voltage fluctuations.

The method, however, does have shortcomings:

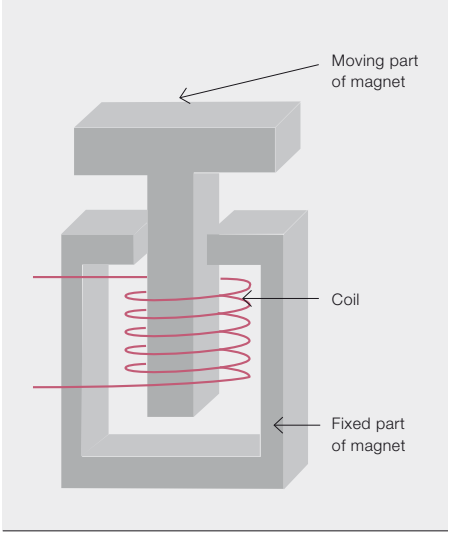
– Sensitivity to voltage variations. Variations in the supply voltage cause changes in the coil current. These have a quadratic effect on the magnetic force. In unfortunate cases, contacts can suddenly open and close, causing failure of the device.
– Most users will want to use an AC control voltage, for instance 230 V at 50 Hz. The magnet must then be both big and complicated to keep up the force at the control voltage zero crossings.
– The power consumption of the circuit is high, especially when it is supplied with an alternating voltage.
– The tolerance requirements of the surface at the magnet's poles are extremely high. During heavy use, the dimensions can change, causing a deterioration in the magnetic force.

The ABB software and electronics distribute the load evenly between the phases and equalizes contact erosion.

6 Section of cylindrical magnet



7 Magnet with T-shaped moving part



Modern technology and innovative design, however, now deal with these issues.

New in control circuits

ABB's new AF contactors use a microprocessor-controlled circuit with patented algorithms that ensure the coil current is always correct, regardless of voltage fluctuations. Thus, both the magnetic flux and the contact forces are optimized. The circuit also converts AC to DC voltage. This reduces power requirements, provides smoother magnetic force and dispenses with zero crossings. It also enables a smaller, simpler and more reliable magnet to be used. Mechanical and electrical wear are minimized.

Because zero crossings are eliminated and the coil current is controlled, old and well-proven magnet designs that otherwise would have severe limitations can be resurrected and fully exploited.

In the smallest AF contactors, a cylindrical magnet with a movable piston is used together with pole surfaces that are conical → 6. This is a very compact and low-power arrangement. It is so effective and requires so little power that the contactors can be operated with a weak power supply such as a transistor output. The larger AF contactors use a magnet whose moving and fixed parts are T-shaped and U-shaped, respectively → 7. This is also a compact and low-power solution. Both types of magnet take advantage of the fact that only DC exists in the coil.

Contactor design, though over 100 years old, has become a new and engaging field of product development – thanks to new technology and innovative thinking. Further enhancements to simplify the design, increase the reliability, improve logistics and optimize the service of this stalwart of electrical switching are in full flow.

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