3.2.1.2 Off-load switching

The term off-load switching is understood to mean the opening or closing of a circuit, in which either no current is flowing before and after the switching operation, or only a very small current (e.g. owing to line capacitance) flows through the contacts at the moment of opening.

The use of off-load switches pre-supposes that accidental switching under load, e.g. under fault conditions, is always prevented by other measures. If this were not the case, damage to the item of switchgear and therefore to the plant could result, but above all, operating personnel could be exposed to the dangers of switching arcs. For this reason, off-load switches are only rarely used nowadays, and only in special applications e.g. in heavy current installations. In all other cases, on-load disconnectors are selected as a minimum.

3.2.1.3 On-load switching

On-load switch-disconnectors are capable of switching the rated current of equipment or sections of an electrical installation under fault-free conditions. By definition, on-load switch-disconnectors can also make and break overload currents.

In terms of DIN VDE 0660, their switching capacity lies between 1.5 to $10 \cdot I_e$. More specifically,

AC-21: $1.5 \cdot$ rated operating current I_e,
AC-22: $3 \cdot$ rated operating current I_e,
AC-23: 6 to $10 \cdot$ rated operating current I_e.

The switching capacity of on-load switch-disconnectors and fuse switch disconnectors is given in the relevant Siemens l.v. switchgear catalogue. It is stated as a multiple of the rated current. In addition, since the Siemens switch-disconnectors feature a very high making capacity, no danger to personnel will result from the unintentional closing onto an existing short-circuit (also refer to Section 3.3.4.2, page 119).

3.2.1.4 Motor switching

Motor switches are items of switchgear specifically designed for the switching of motors. Their switching capacity meets the demands made by the various types of motors and operating duty types e.g. inching and plugging (see Section 3.2.2.1, page 111).

Although on-load switch-disconnectors and fuse switch disconnectors, as well as switch-disconnectors with fuses (fuse-combination units, combined fuse switches or c.f.s. units) do have motor-switching capacity, they are not intended for the operational switching of motors. Contactors and motor control switches with AC-3 switching capacity are more suitable for this application.

Like circuit-breakers, fuse switch disconnectors and switch-disconnectors with fuses also possess a short-circuit making capacity.

3.2.1.5 Power switching, switching of short-circuits

Circuit-breakers are items of switchgear, which can be used to switch not only load, motor and overload currents, but also for the interruption of short-circuit currents.

In terms of the arc quenching technique employed, one can distinguish between two basic types or designs of circuit-breakers:

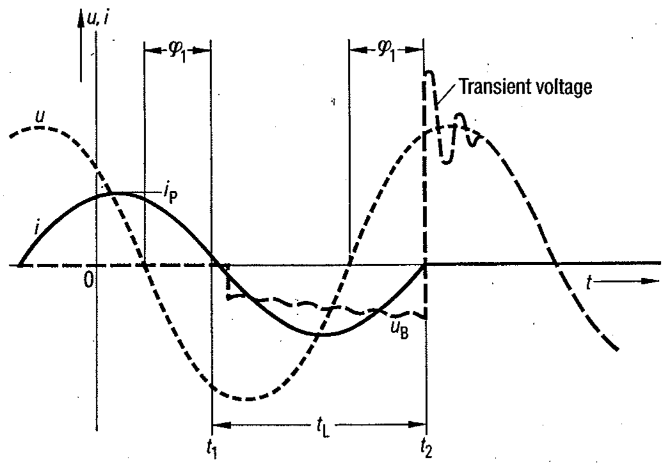
▷ zero-point quenching circuit-breakers,

▷ current-limiting circuit-breakers.

Zero-point quenching circuit-breakers

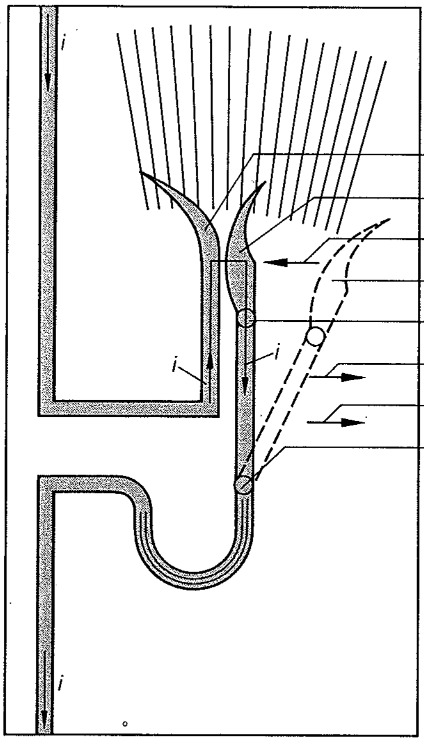
In circuit-breakers of this type, the arc drawn between the circuit-breaker contacts during opening is extinguished when the alternating current passes through the zero point (Fig. 3.2).

The high current peaks of short-circuit currents produce extremely strong forces of repulsion between



t_1 Parting of the contacts
t_2 End of the breaking process
t_L Arc duration
u_B Arc voltage

Figure 3.2
Current and voltage during a short-circuit interruption by a zero-point quenching circuit-breaker



1 Fixed contact
2 Moving contact
3 Direction of the contact pressure reinforcement
4 Moving contact, opened
5 Fulcrum of the moving contact assembly in the closed position
6 Direction of repulsive force of owing to current in parallel conductors
7 Direction of force from the contact pressure spring
8 Hinge point of the moving contact assembly during opening or closing

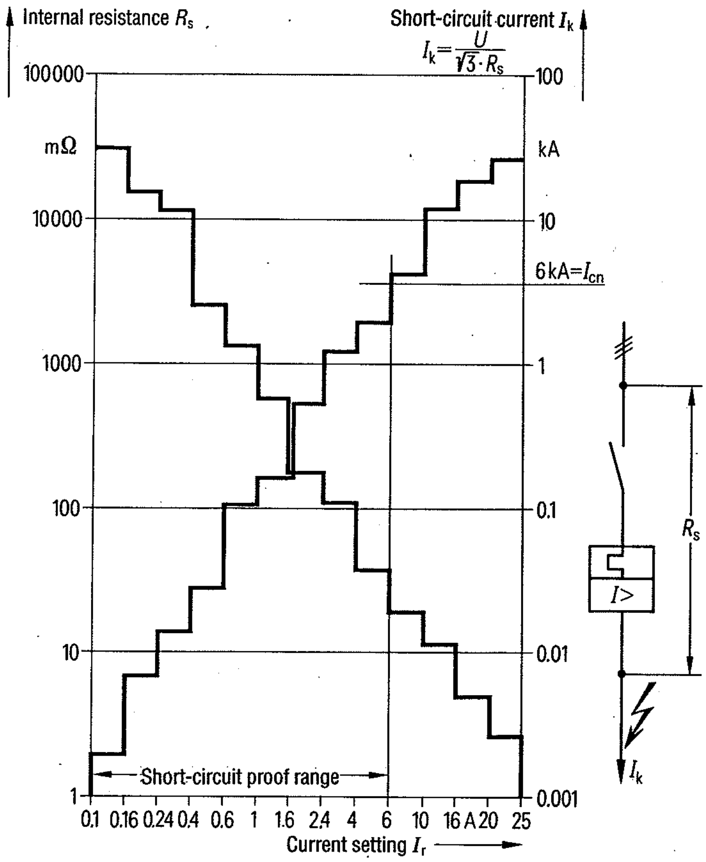
Figure 3.3
Switching elements of a discriminative zero-point quenching circuit-breaker with current rating above approx. 160 A (schematic illustration)

the contacts. The circuit-breakers therefore either have a correspondingly high mechanical contact pressure, or they employ an electrodynamic technique which reinforces the contact pressure during short-circuit conditions, to prevent parting of the contacts before the electromagnetic release has operated. The electrodynamic method for increasing the contact pressure is used particularly in discriminative type circuit-breakers with current ratings higher than 160 A, where an opening delay under short-circuit conditions is required.

Refer to Figure 3.3. As a result of the force of repulsion which is induced between two parallel conductors carrying current in opposite directions, the longer moving contact lever arm is repelled from the fixed contact assembly in the event of a short-circuit. This force of repulsion is converted into a force in the opposite direction on the shorter moving contact lever arm by the presence of a fulcrum (point of support), and causes an increase in the contact pressure. This fulcrum is released by the opening command, and the repulsive force then assists the opening movement while the current flows via the switching arc.

Current-limiting circuit-breakers

The term "current-limiting" refers to the technique by which the peak value i_p of a prospective short-circuit current, is limited to a smaller let-through or cut-off current i_D. This current-limiting can be achieved by circuit-breakers in a number of ways.



I_{cn} Rated short-circuit breaking capacity
I_r Current setting on the current-dependent delayed overload release

Figure 3.4
Short-circuit withstand capacity by virtue of circuit-breaker internal resistance R_S;
Example: 3VU13 circuit-breaker at 400 V

Circuit-breakers with a high internal resistance

In circuit-breakers with low overload-current settings, the combined resistance in each pole, of the bimetal heating coil and the winding of the instantaneous electromagnetic release, is relatively high. It may be so high, that every short-circuit current I_k will be limited to a value which the circuit-breaker will not only withstand, in terms of the thermal and dynamic stresses, but will also be able to interrupt. The circuit-breaker is then said to be "short-circuit proof". It may be installed at points in the network where the prospective short-circuit current level may be higher than 80 kA. The setting ranges of the thermal overload release for which the above holds true, is dependent upon the inherent breaking capacity of the circuit-breaker.

This in turn is dependent on the system voltage and the power factor, and therefore the degree to which the circuit-breaker is "short-circuit proof" will be different at various system voltages.

Figure 3.4 illustrates the short-circuit proof range of the 3VU13 circuit-breaker for a system voltage of 400 V. It can be seen that even in the event of a full short-circuit across the terminals of the circuit-breaker, the internal resistance R_s of the overload setting ranges up to 6 A, will limit the short-circuit current I_k to a value smaller than the inherent breaking capacity of 6 kA.

Circuit-breakers with extremely short opening time and high arc voltage

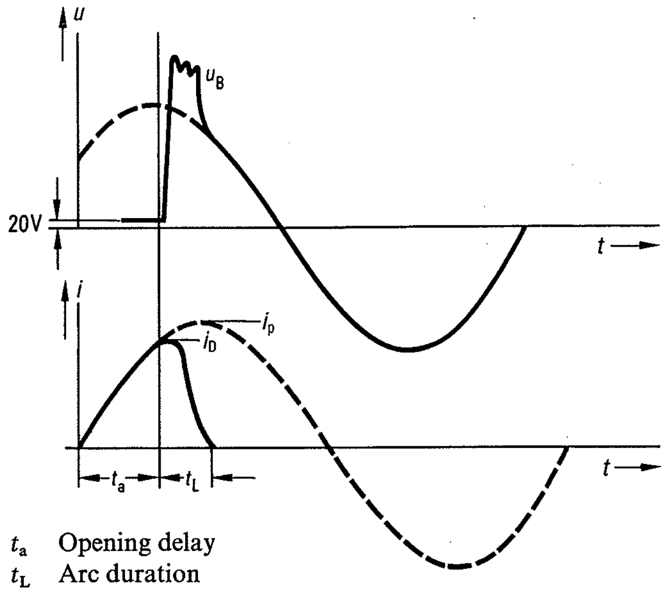
This type of current-limiting circuit-breaker incorporates a release and opening mechanism which differs fundamentally from that of the zero-point-quenching type. The opening of the contacts is not initiated by the relatively slow process of unlatching the switch mechanism.

As in the case of fuses, two conditions are met:

▷ the circuit is opened, before the peak of the prospective short-circuit current is reached, and

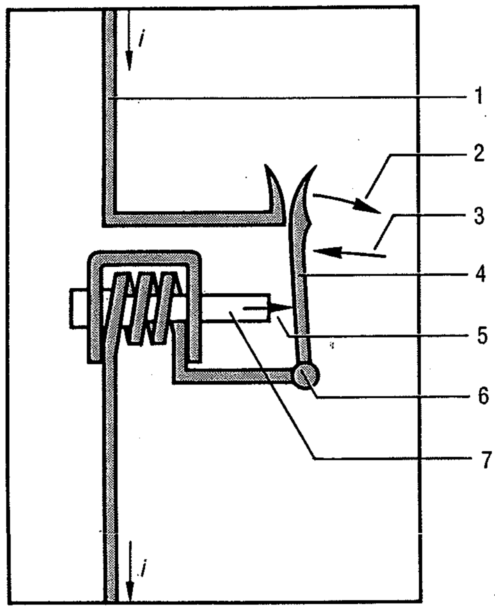
▷ a large resistance, in the form of an arc voltage, is introduced into the circuit or current path.

The rapid opening of the contacts is achieved by an arrangement, as can be seen in Figure 3.6 for smaller circuit-breakers, which causes the moving contact arm to be struck away from the fixed contact assembly by a moving armature of the electromagnetic release.



t_a Opening delay
t_L Arc duration
u_B Arc voltage
i_D Let-through current
i_p Peak of prospective short-circuit current

Figure 3.5
Current and voltage during a short-circuit interruption by a current-limiting circuit-breaker



1 Fixed contact assembly
2 Direction of repulsive force between contacts
3 Direction of force from contact pressure spring
4 Moving contact assembly
5 Direction of impact from moving armature
6 Hinge point of moving contact assembly
7 Moving armature

Figure 3.6
Switching elements of a current-limiting circuit-breaker for rated continuous currents up to approx. 63 A (schematic illustration)