THYCON

Est.1968

High Speed Electronic Fuse

HSEF 600–4000A

THYCON

Introduction

The Thycon High Speed Electronic Fuse is a fast-acting fail-safe fuse which allows the speed of a fuse to be greatly increased while avoiding the usual aging problems of fuses.

The fuse is the only truly fail-safe over-current protection system since all other interruption methods require detection and triggering; functions which, whether, electrical, electronic, thermal, magnetic, mechanical or pyrotechnic, have a non-zero probability of failure.

The fuse however has a serious limitation which is that, for it to be able to rupture quickly, it must be close to failure in normal operation or the difference between its continuous current and that of its rupture current will be too large resulting in high levels of I2t let-through, large fault currents and long clearing times. There are two techniques available for circumventing this limitation:

A. A fuse with a low current-carrying capacity is by-passed by a mechanical breaker which handles rated current and normal overloads. When a fault is detected, the mechanical breaker is blown-open by a pyrotechnic charge and the current diverted to the fuse which rapidly melts, creating an arc and limiting the current. To reset the interrupter, both the fuse and the pyrotechnic charge are replaced. This type is known as the ABB IS-limiter.

B .A fuse with a high current carrying capacity carries the rated current and normal overloads. When a fault is detected, a current pulse is added to the fuse from a discharge circuit which causes the fuse to see far more current than the fault represents at the instant of detection, thus rupturing the fuse long before the prospective current can be reached. The fuse is then replaced. This is known as the THYCON HSEF (Fig. 1).

The advantage of the THYCON HSEF is that, necessarily, a fuse is always present and in the event of a failure of the detection or trigger function, interruption will occur, albeit at a higher fault level than normal, in stark contrast to the pyrotechnic approach where there will be no fault protection in the event of a malfunction of the control system.

The use of a fuse inevitably means that both of these systems are non-resetting.

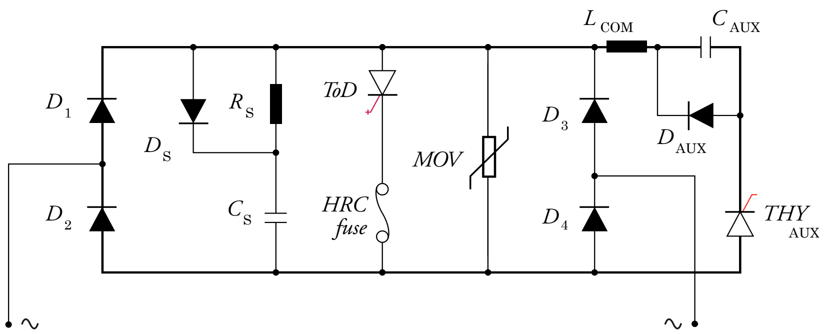

Fig. 1 – Circuit diagram of the Thycon HSEF

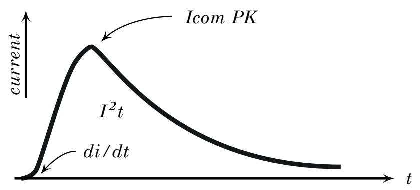

Fig. 2 – Fuse discharge pulse

Principle of Operation of the THYCON HSEF

Referring to Fig. 1, energy is stored in capacitor C_{AUX}. When the detection circuit determines that the fault should be limited, thyristor THY_{AUX} is fired. This discharges the capacitor energy into the HRC fuse via L_{COM}, D_{AUX} and THY_{AUX}. Because the thyristor has a finite di/dt capability, L_{COM} is made saturable so that the current ramps up at, say 200A/µs for a few microseconds and then at a much greater rate which causes a very large value of I^2t to be deposited in the fuse, quickly bringing it to fusion and limiting the current by the opposing arc voltage. The current waveform through the fuse is shown in Fig. 2.

The THYCON approach substitutes energy storage in a capacitor to rupture the fuse for energy storage in an explosive charge to open a switch, the detection and triggering circuits remaining essentially the same. With the THYCON limiter, only a standard fuse is replaced since no pyrotechnic charge is expended. Needless to say, this approach is also not resettable, although a resettable variant can be proposed when combined with a standard SSB [1]. This variant is shown in Fig. 3.

The SSB/HSEF of Fig. 3 in fact, offers 3 levels of protection:

1. Under normal operation, the SSB operates and limits the fault to low levels of a few thousand amps, clearing it within a few hundred microseconds; (fault detection and interruption takes about 16µs); this mode is completely resettable.
2. In the event of a failed Turn-off Device (ToD), the HSEF assesses within a few microseconds that the SSB function has failed and triggers THY_{AUX}; the fuse will have to be replaced.
3. If the detection circuit has failed, the fault current will ultimately be cleared by conventional fuse action; the fuse will have to be replaced.

A typical network example is illustrated in Fig. 4.

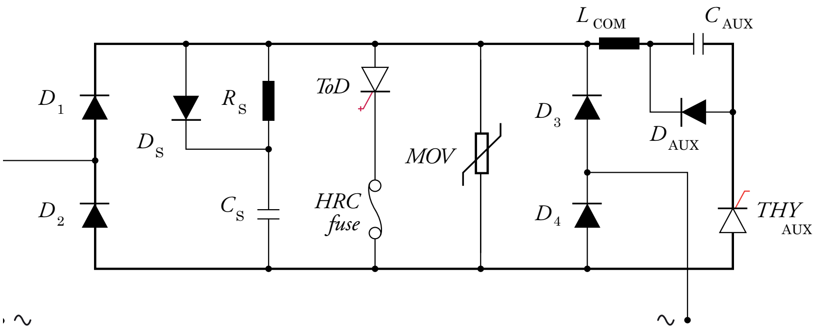

Fig. 3 – Combined THYCON SSB and HSEF

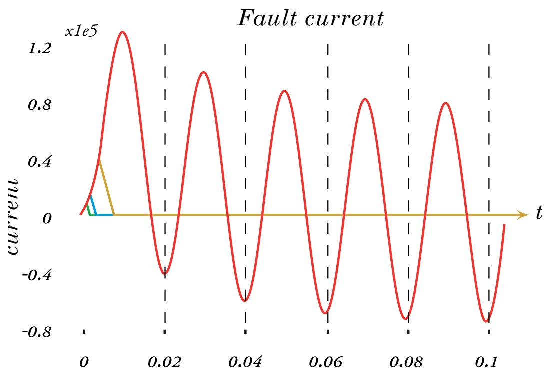

Fig. 4 – Three levels of protection afforded by the combined THYCON SSB/HSEF. Green = SSB; Blue = HSEF; Orange = Fuse alone; Red = 100ms mechanical breaker.

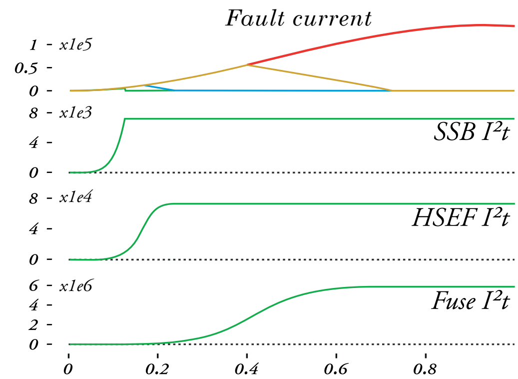

Fig. 5 – Expansion of Fig. 4 and I2t let-through values.

	I^2 t Let through (A^2 s)	
	Up to peak current	***Total Let through***
SSB	6,730	7,140
HSEF	51,580	73,650
Fuse	2,700,000	6,000,000

It should be noted that the fault current curves of Figs 4 and 5 correspond to the four protection methods operating independently. In the case of a combined SSB and HSEF combination, the blue HSEF curve would be slightly time-delayed (30 – 50µs) due to the SSB failure detection intervening after the SSB turn-off detection.

Fault Detection

The HSEF may be programmed in a variety of ways, one of which is described here for the case of the combined SSB/HSEF.

The detection system consists of a Hall-effect, closed-loop current transformer with a response time of less than 2µs.

An upper current trip-level (I_{MAX}) is set which will turn off the breaker within a time given by the inherent delays of the system, about 16µs; this will be the fastest possible (resettable) trip.

An RMS trip level (I_{RMS}), programmed in conjunction with an I^2t setting, will determine the thermal overload allowed.

This transducer feeds its output signal to a controller which calculates the RMS current. If this is exceeded, the controller starts to compute I^2t and compares this to a preset value. If both the RMS current and the I^2t limits are exceeded, then the SSB is tripped. (However, if the RMS current value falls below the trip level before the I^2t limit is reached and remains below this value for more than a preset time, the I^2t integrator is reset to zero and the transient overload is "forgotten").

The ToD of the SSB has a feed-back signal which compares the turn-off signal to the device status. If a turn-off signal is given to the ToD and its status is not confirmed within 20µs, the ToD (and hence the SSB) is assumed to be defective and the HSEF is activated by firing THY_{AUX}. The resultant pulse which is about 0.4ms long, brings the fuse to arcing within a half millisecond, thus limiting the fault and clearing it within a few milliseconds.

An additional trip criterion can be added based on di/dt measurement, i.e. measurement of the rate-of-rise of current to determine that a fault has occurred and to anticipate a trip for even faster interruption. This additional feature is however rarely needed in most line-frequency systems because SSBs, unlike mechanical breakers, can limit a fault within a few microseconds of detecting I_{MAX} and as such, di/dt measurement, can only reduce the peak interrupted current by a few hundred amperes.

Relevant Standards

All THYCON breaker and limiters are designed and perform in conformance with AS 60269.1 2005 for Low Voltage Fuses, AS 60947.1—2004 for low-voltage switchgear and control-gear, with IEC 60071-1 for dielectric tests, AC withstand voltages and lightning impulses.

Summary and Conclusions

The THYCON HSEF is specifically designed for fast failsafe protection in LV networks. Unlike the pyrotechnic types, the THYCON system has no moving parts and relies on the same fusible element for failsafe back-up. Pyrotechnology may have advantages at high voltage because of the cost of employing seriesed semiconductor stacks at many kilovolts but at LV, electronic controls are faster, more precise and more cost-effective and there is no explosive cartridge to replace after each event.

Furthermore, the THYCON HSEF has the unique advantage of being readily combined with THYCON SSB technology, allowing very fast, resettable protection with two levels of contingency.

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