Power System Protection

EE454

Lecture ppt. # 2

- **Note:**

  The materials in this presentation are only for the use of students enrolled in this course in the specific campus; these materials are for purposes associated with this course and may not be further disseminated or retained after expiry of the course.

Some of the Contents
Lect. File 2 – **Chapter 2** of PS Relaying
Detection of Faults – different methodologies, Fuses (just brief), Electromechanical Relays, Computer relays


بسم الله الرحمن الرحيم

2

Relay operating principles

The fundamental problem in power system protection is to define the quantities that can differentiate between normal and abnormal conditions. This problem of being able to distinguish between normal and abnormal conditions is compounded by the fact that 'normal' in the present sense means that the disturbance is outside the zone of protection.

If one were to use the magnitude of a fault current to determine whether some action should be taken, it is clear that a fault on the inside (fault F_1), or on the outside (fault F_2), of the zone of protection is electrically the same fault, and it would be impossible to tell the two faults apart based upon the current magnitude alone.

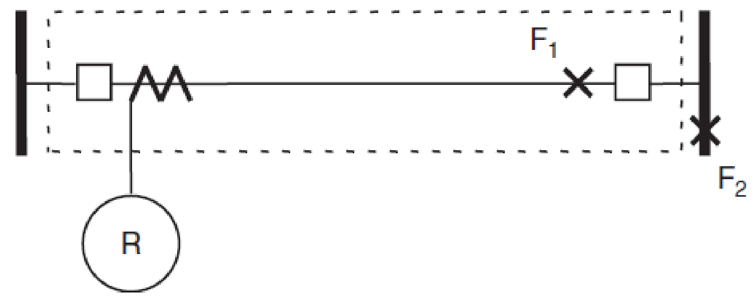


Figure 2.1 Problem of relay selectivity for faults at a zone boundary

The field of relaying is almost 100 years old. Ideas on how relaying should be done have evolved over this long period, and the limitations of the relaying process are well understood.

relays began as electromechanical devices, then progressed to solid-state hardware in the late 1950s and more recently they are being implemented on microcomputers. We will now examine – in general terms – the functional operating principles of relays and certain of their design aspects.

2.2 Detection of faults

2.2.1 Level detection

motor connected to a 4 kV power system as shown in Figure 2.2. The full load current for the motor is 245 A. Allowing for an emergency overload capability of 25 %, a current of $1.25 \times 245 = 306$ A or lower should correspond to normal operation.

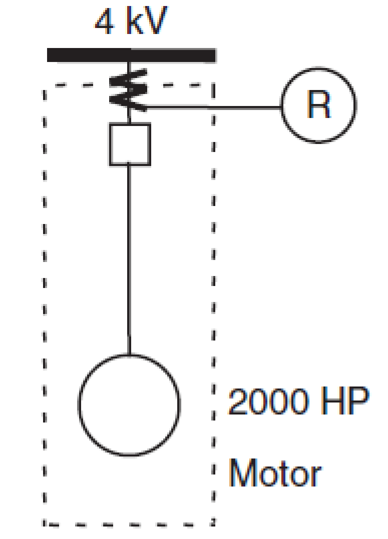


Figure 2.2 Overcurrent protection of a motor

So detect motor current going beyond the level of 306A – This is a fault or any other abnormal condition.

Level above which relay operates is known as pickup setting of relay.

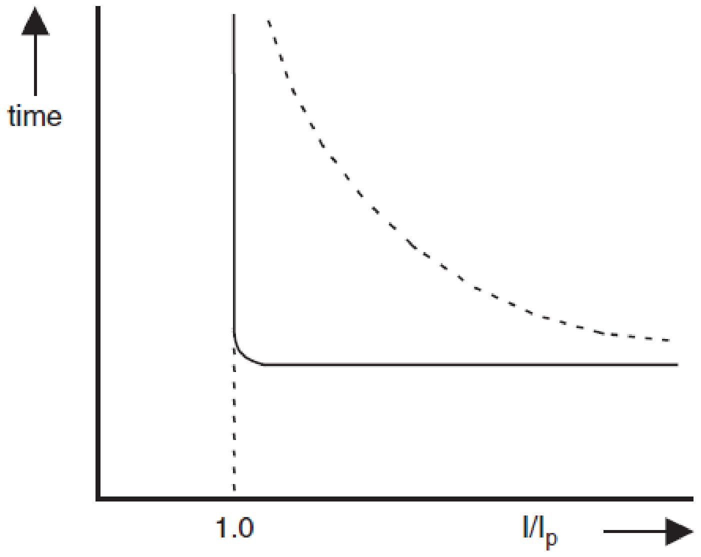


Figure 2.3 Characteristic of a level detector relay

2.2.2 Magnitude comparison

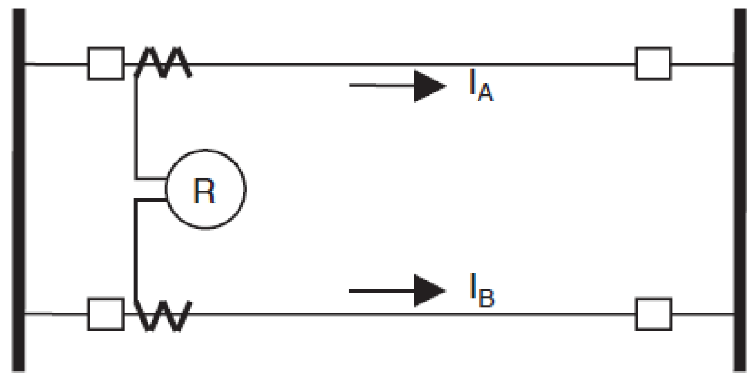


Figure 2.4 Magnitude comparison relaying for two parallel transmission lines

Assume that normally IA and IB are equal (or proportionate)

The relay will operate when the current division in the two circuits varies by a given tolerance.

2.2.3 Differential comparison

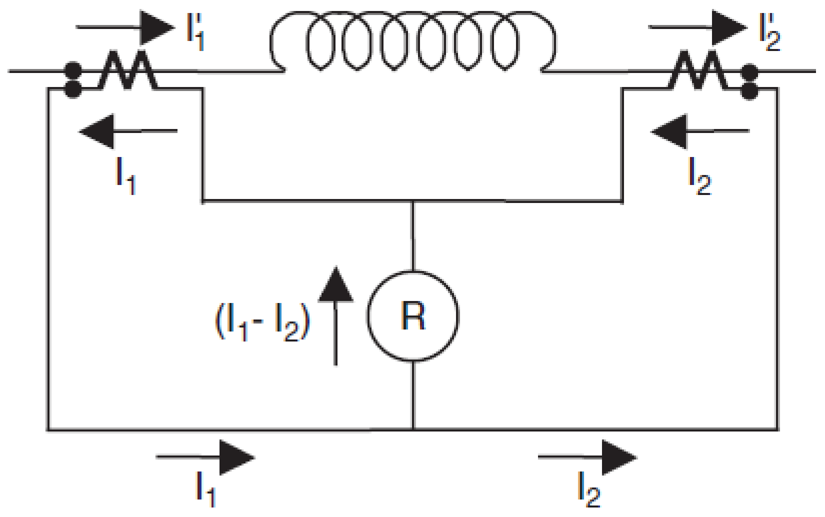


Figure 2.5 Differential comparison principle applied to a generator winding

Very sensitive – gives sharp zone boundaries
But is limited to PS apparatus (for non-pilot protection)

2.2.4 *Phase angle comparison*

Phase angle comparison is commonly used to determine the direction of a current with respect to a reference quantity.

for a fault in the forward or reverse direction, the phase angle of the current with respect to the voltage will be $-\varphi$ and $(180° - \varphi)$ respectively, where φ, the impedance angle of the fault circuit, is close to 90° for power transmission networks.

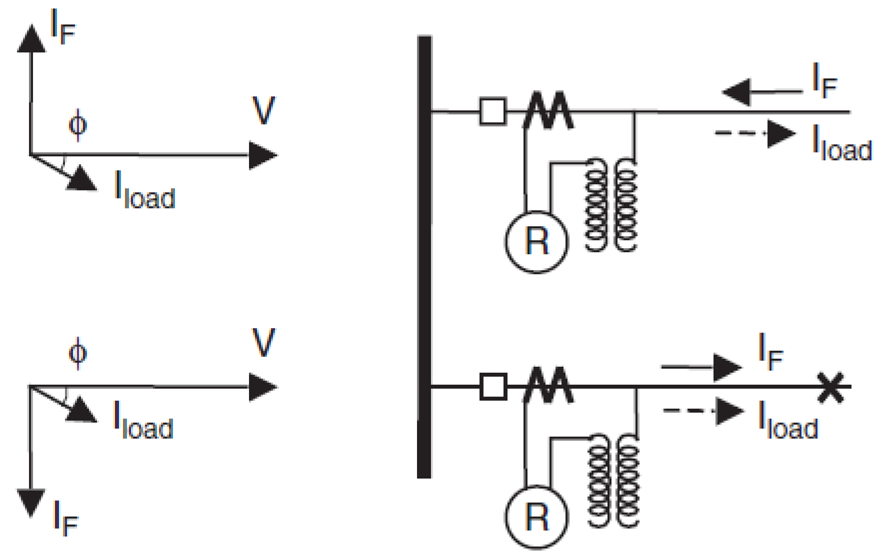


Figure 2.6 Phase angle comparison for a fault on a transmission line

2.2.6 *Pilot relaying*

Certain relaying principles are based upon information obtained by the relay from a remote location.

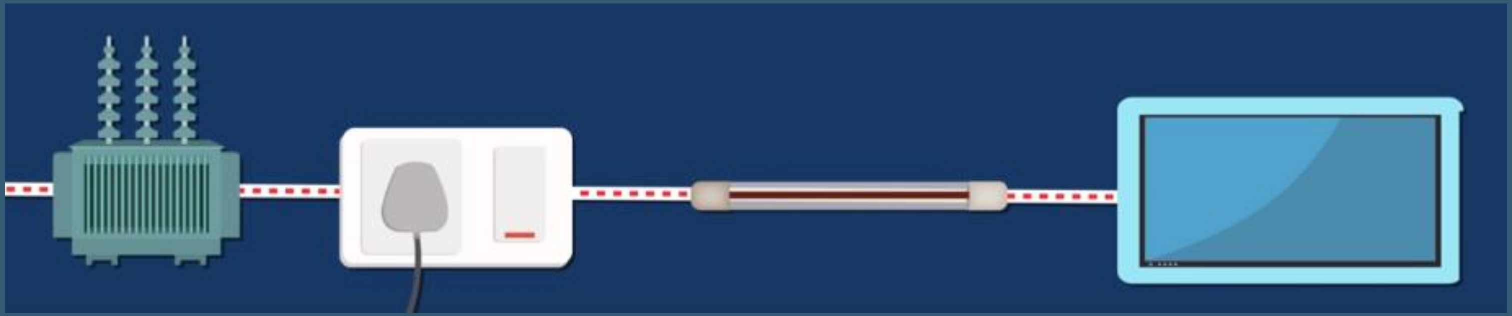
2.2.7 *Harmonic content*

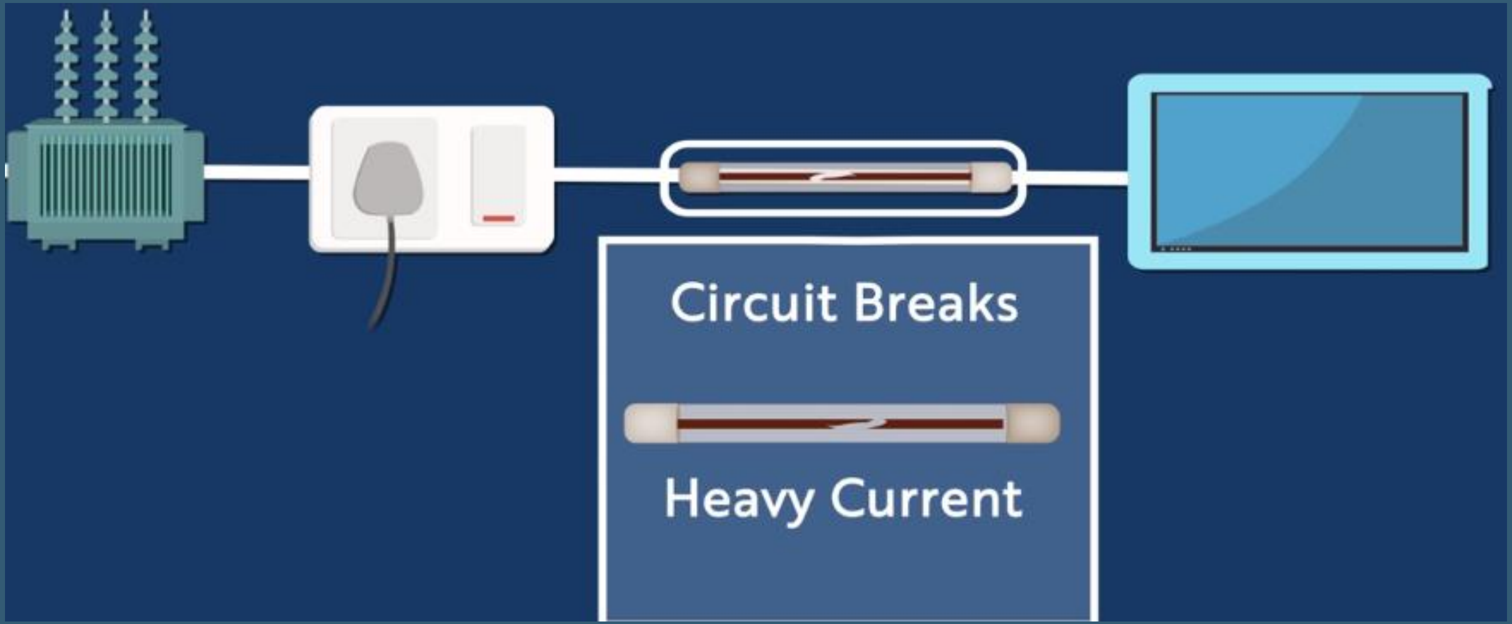
Harmonic content, obtained through filtering, may be used by the protection system.

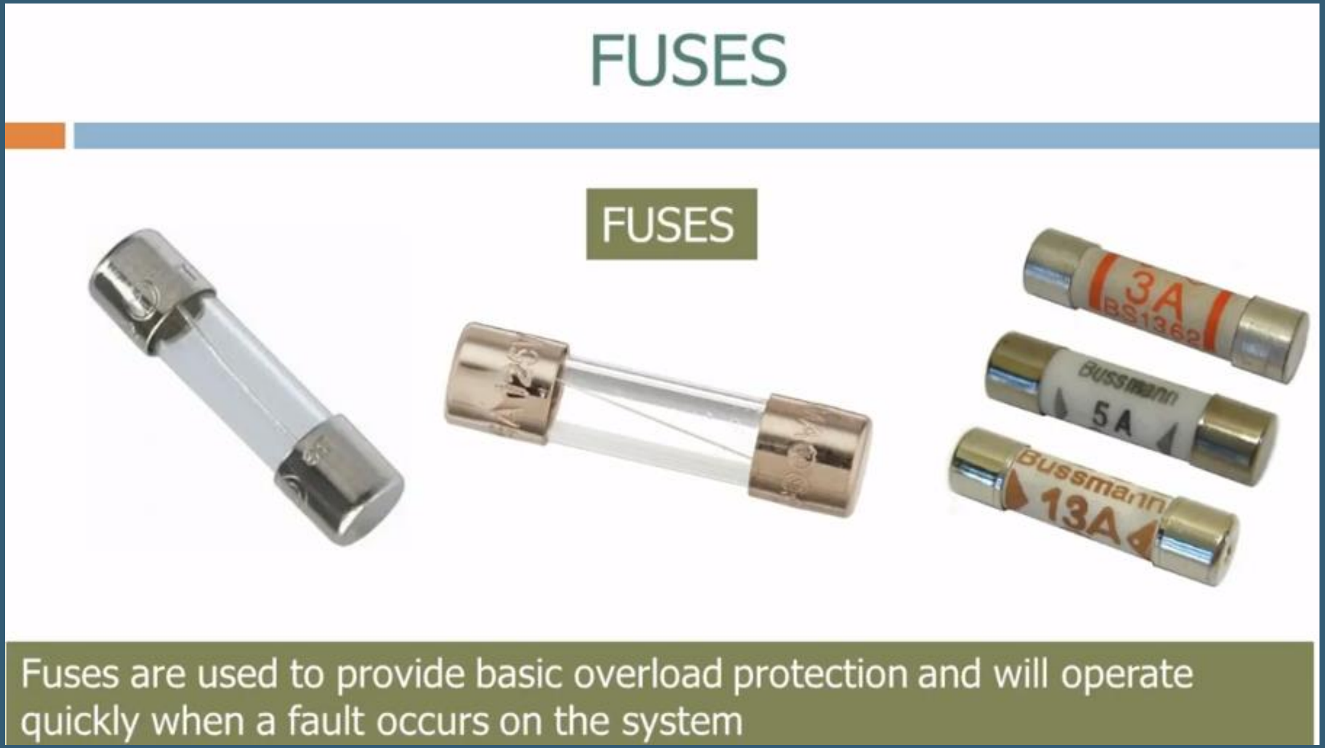
2.2.8 *Frequency sensing*

Frequency-sensing relays may be used to take corrective actions which will bring the system frequency back to normal.

2.3.1 Fuses



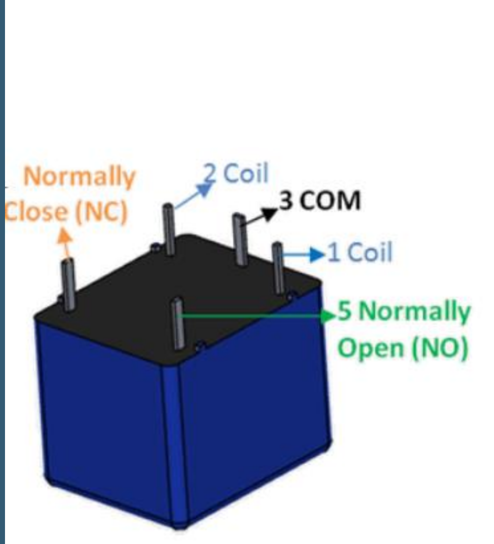




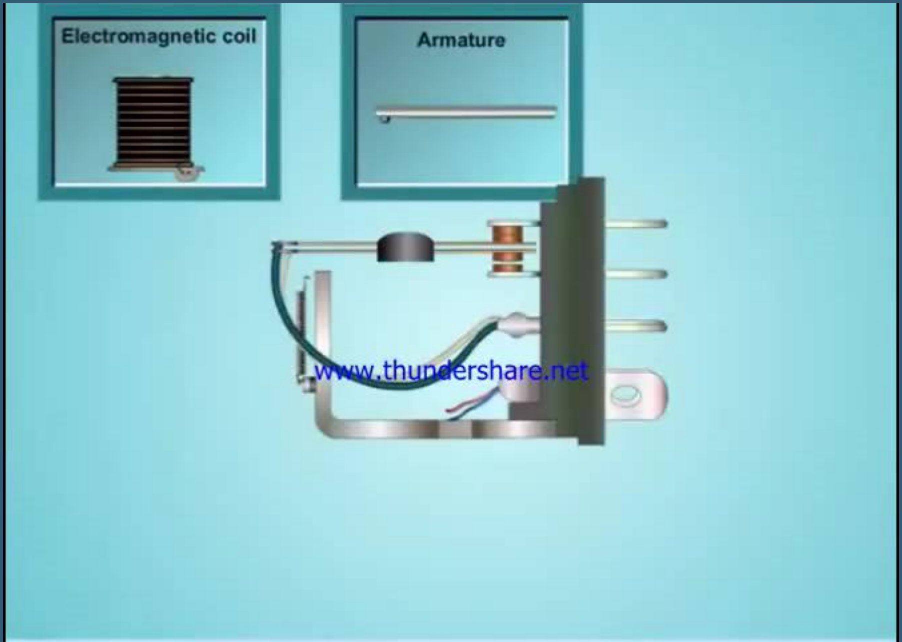
Some of the issues with fuses are:

1. Single shot feature
2. Only one phase trips – that can lead to single phasing in motors.
3. Do not have very high interrupting capacity as needed in HV power systems.

2.4 Electromechanical relays

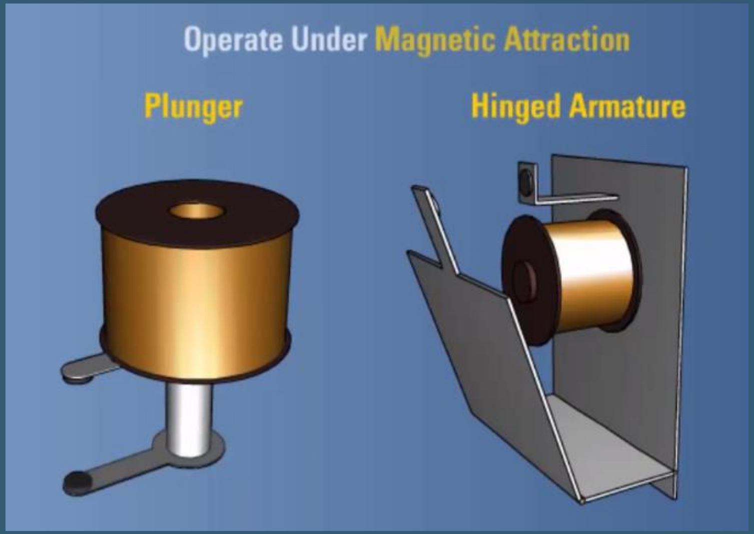


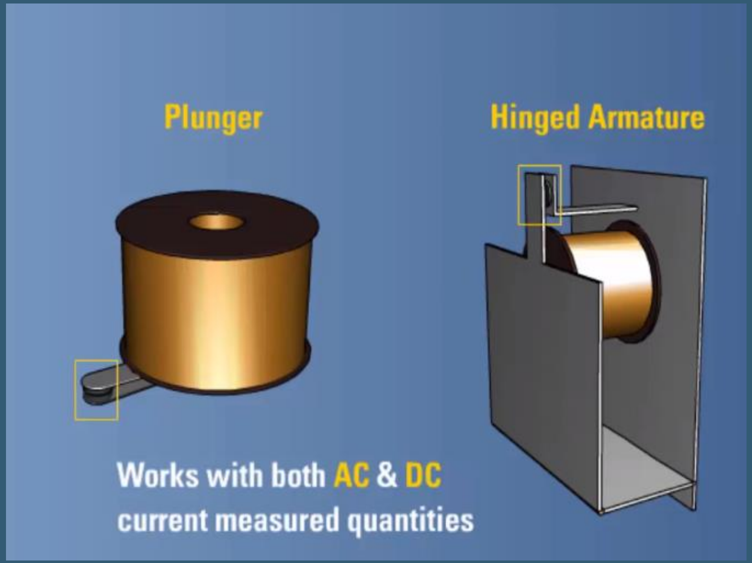
A simple relay that you might have seen/used

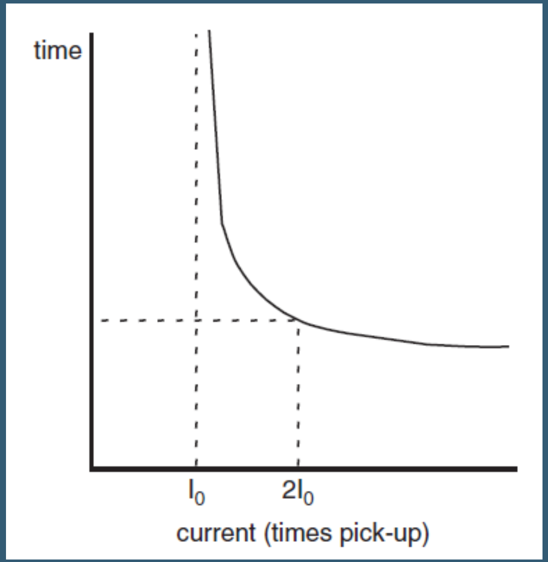


The main components of the relay are an electromagnetic coil, an armature, a spring system, a yoke and fixed and movable electrical contacts.

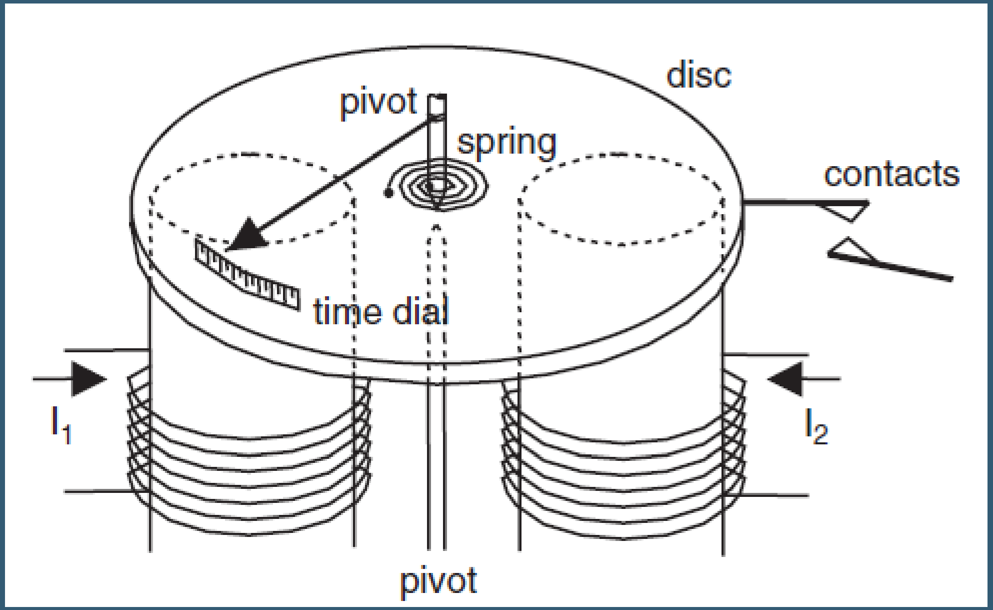
Plunger type relays

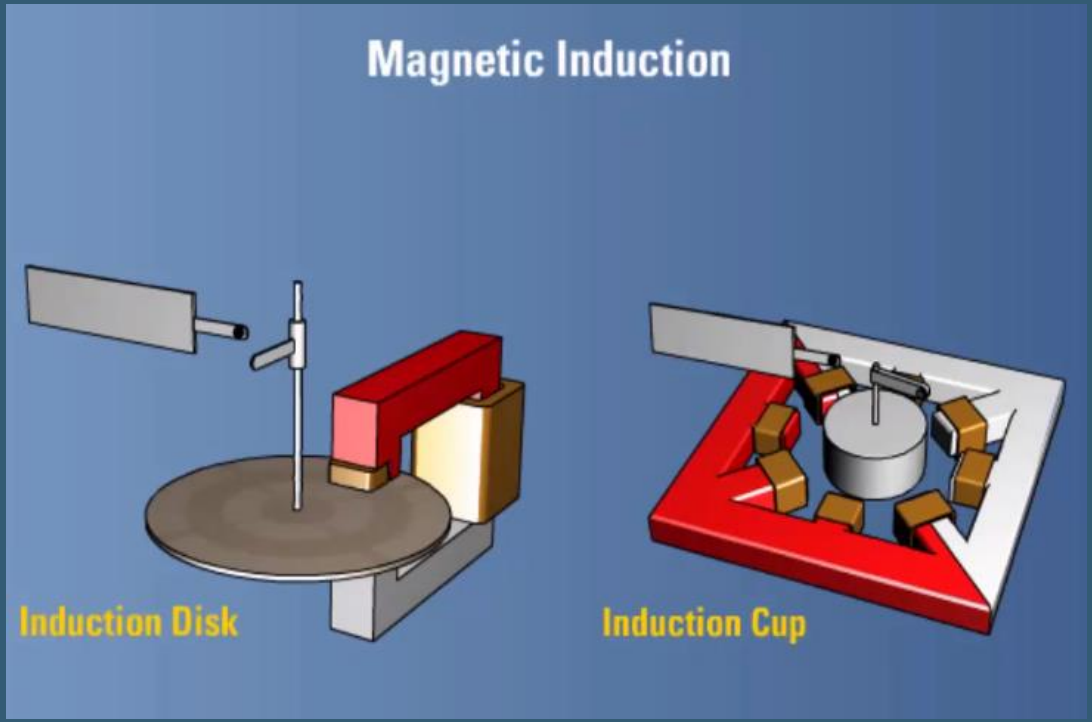






2.4.2 *Induction-type relays*





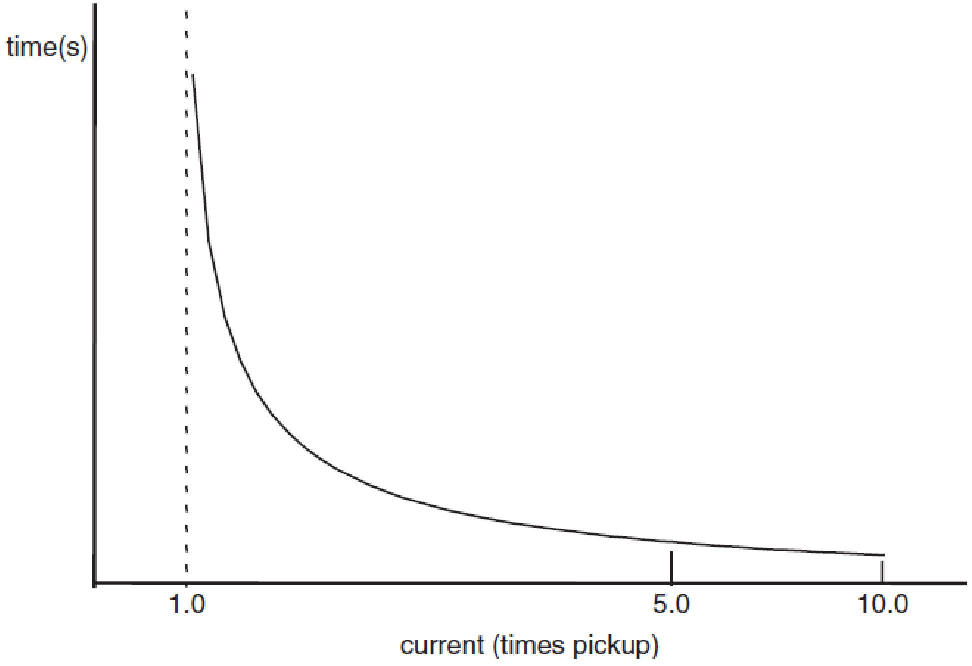
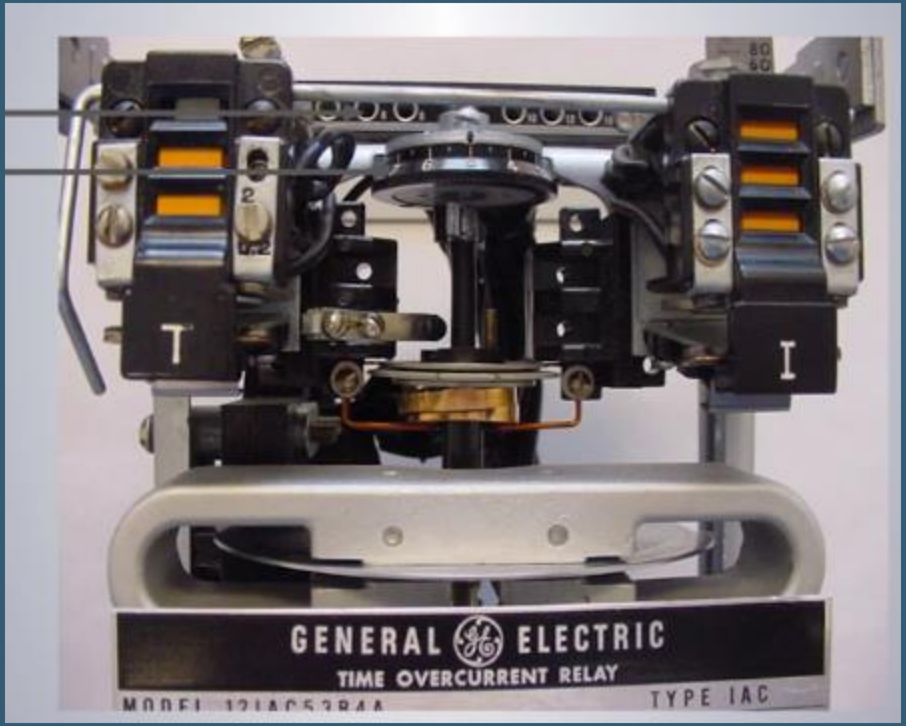


Figure 2.12 Inverse-time characteristic of an induction disc overcurrent relay

A GE electro-mechanical
overcurrent relay



An Alstom Relay

A protection system based on micro-processor relay

2.7 Other relay design considerations

2.7.1 Contact definition

A contact that is closed in the de-energized (on the shelf) state is Normally Closed.

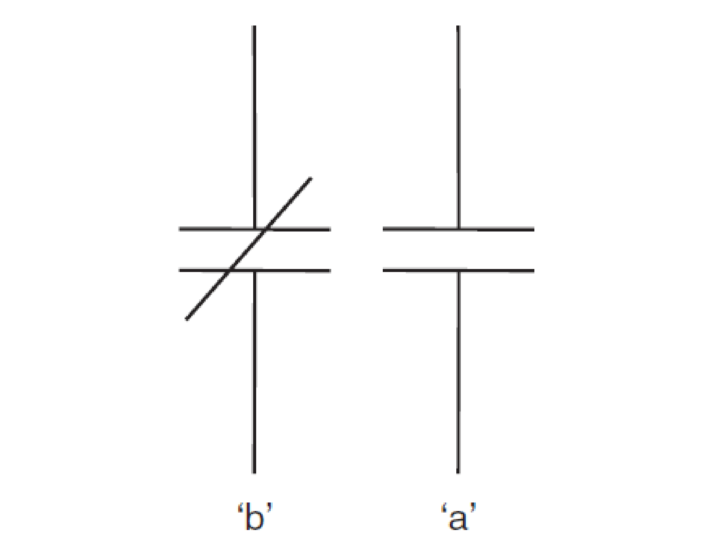
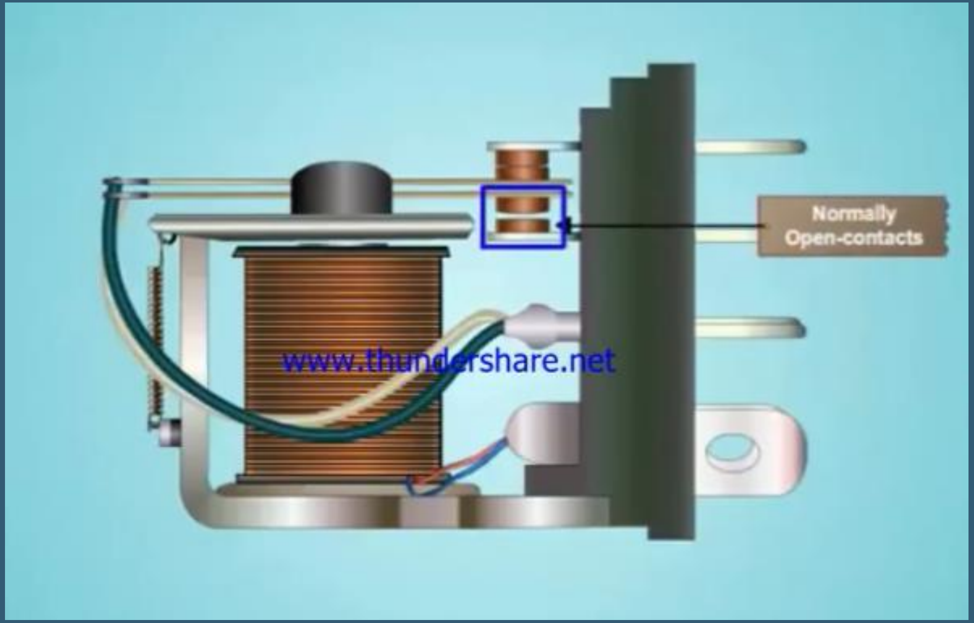


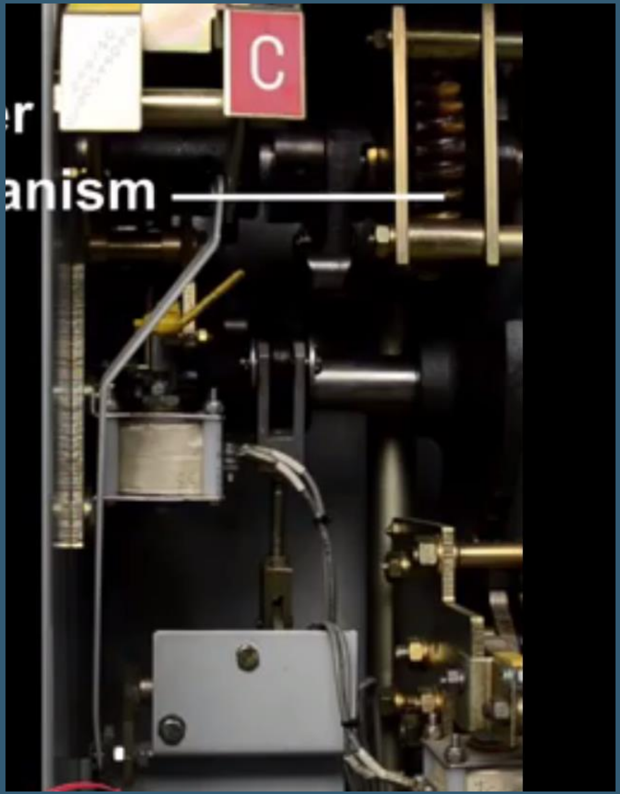
Figure 2.21 Conventions for contact status

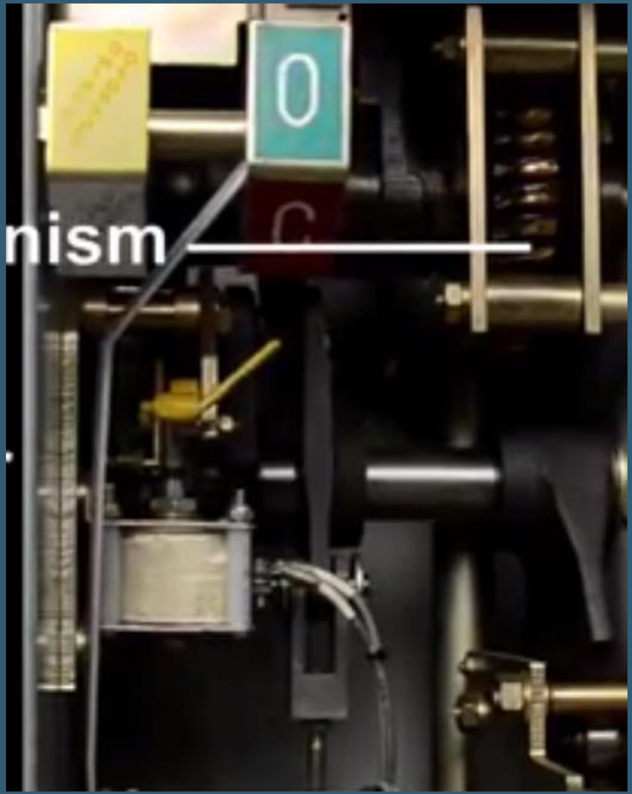


Conventionally, On-the shelf states may be shown in schematic or wiring diagrams – even if the contact status is different when it is in service. E.g. see CB aux contact in topic 2.8.

2.7.2 Targets

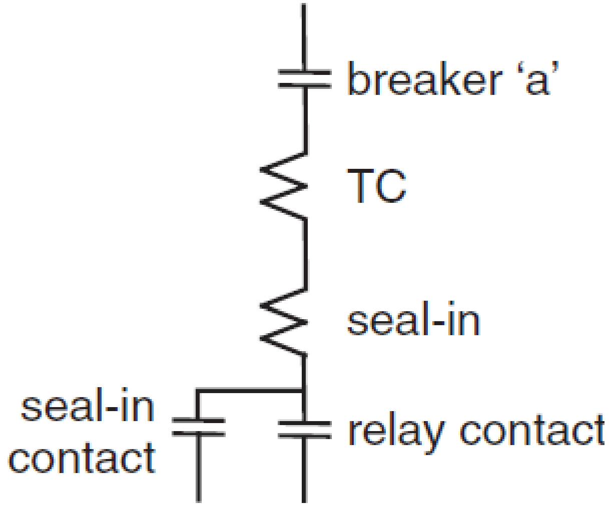
Example – GE computer relay





Example – in CBs

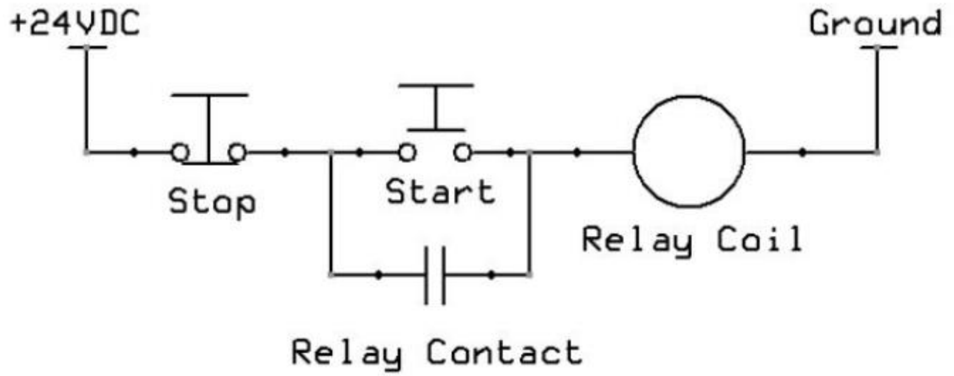
2.7.3 *Seal-in circuit*



Principle of a seal-in relay circuit (TC, trip coil)

Rough idea: This coil keeps the trip coil energized even if the relay contacts open.

When the start button is pushed it allows current to flow through the relay coil and forces the relay contact to become closed. Once the relay contact is closed there is an alternate path around the start button for current to flow so that when the button returns to its open position the current can flow through the contact and around the switch. When the stop button is pressed it interrupts current flow to the circuit and must be restarted again with the start button.



An example of the concept of seal-in being used in any DC (e.g. motor or lamp) circuit.

In topic 2.8:

the contacts of the seal-in relay bypass the tripping relay output contacts to protect it from accidental opening while carrying the trip coil current.

2.7.4 *Operating time*

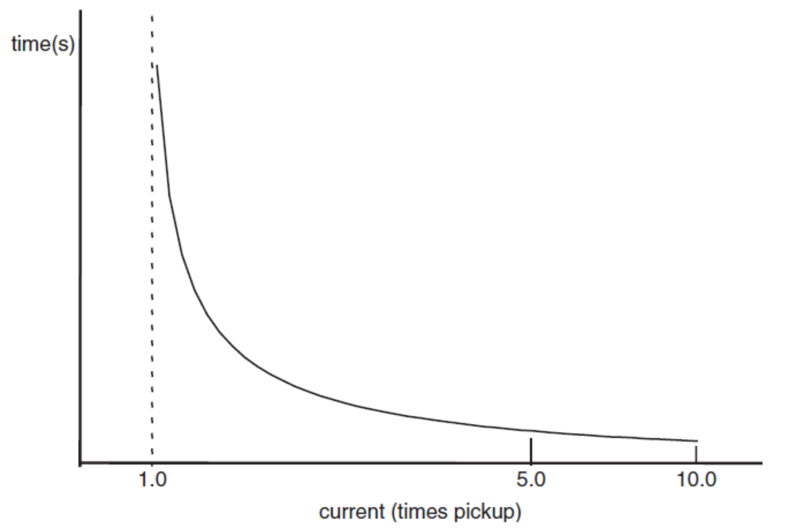
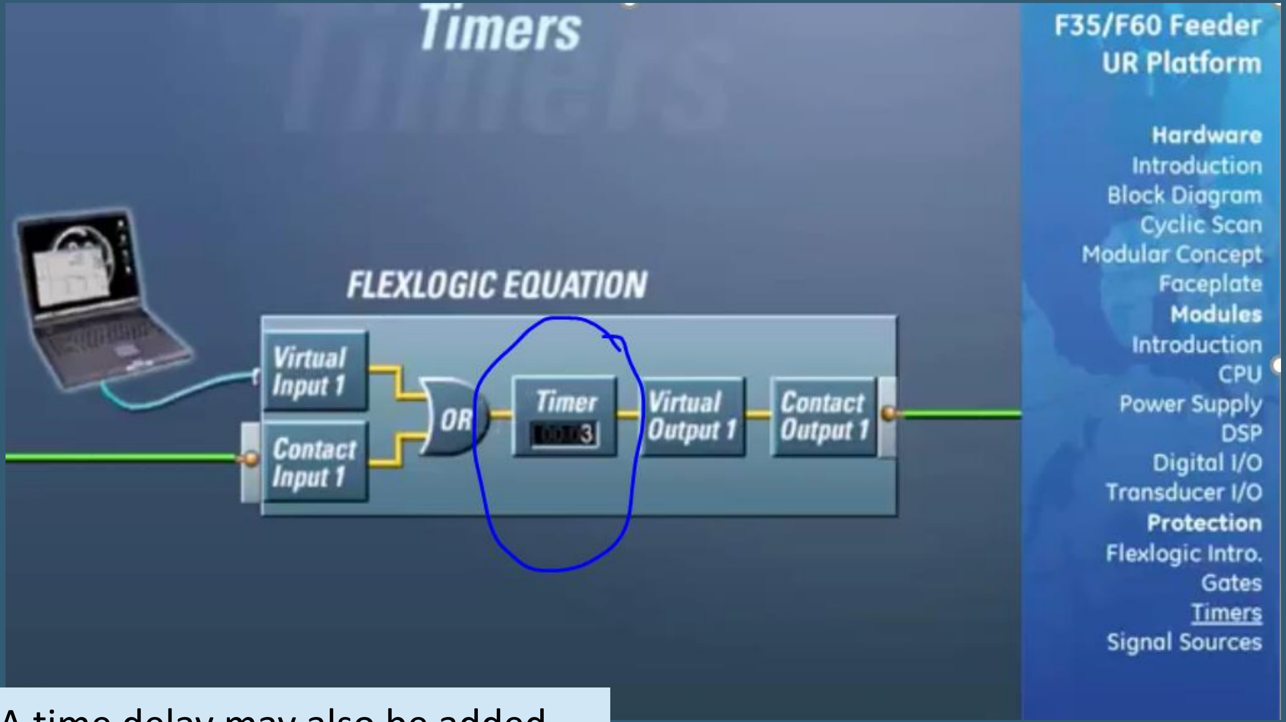
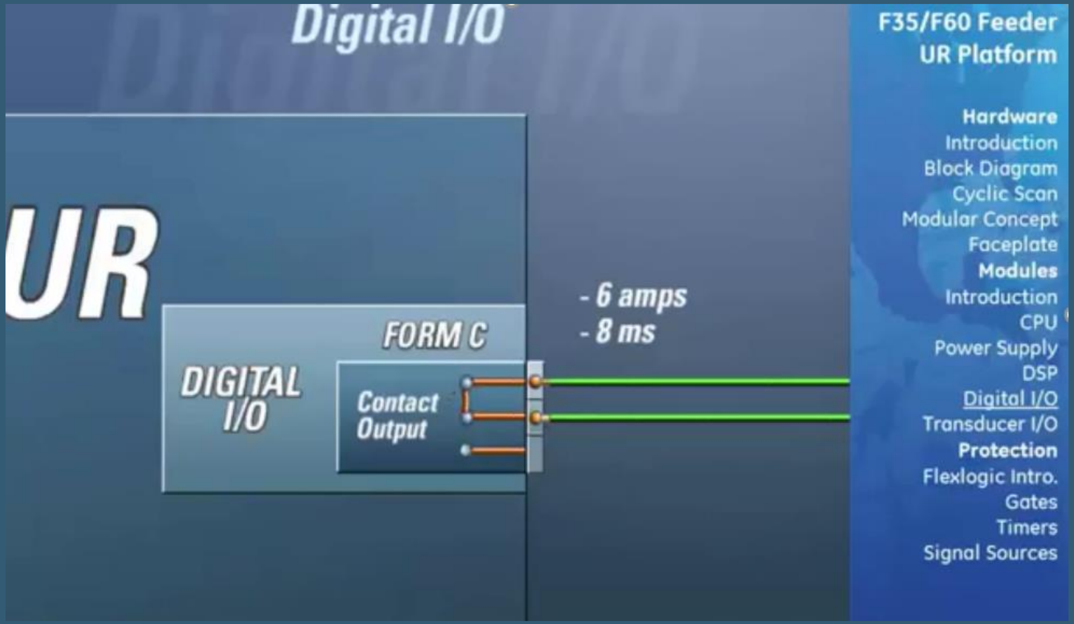


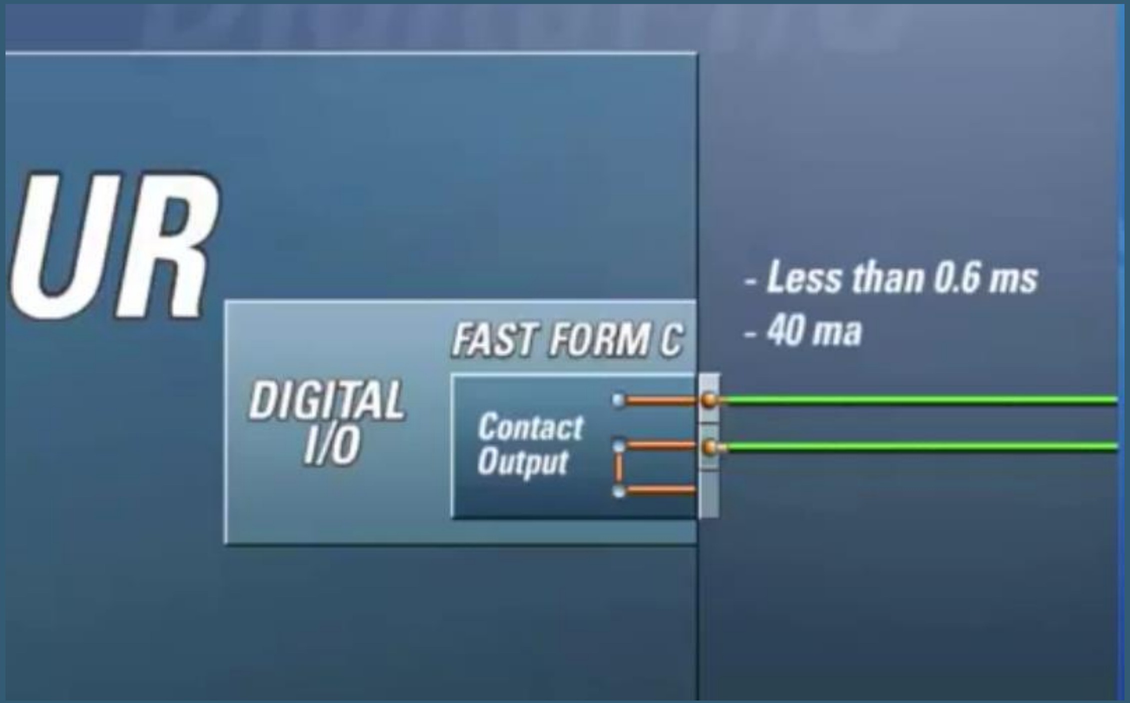
Figure 2.12 Inverse-time characteristic of an induction disc overcurrent relay

Generally an electromechanical relay may exhibit this inverse time relationship.

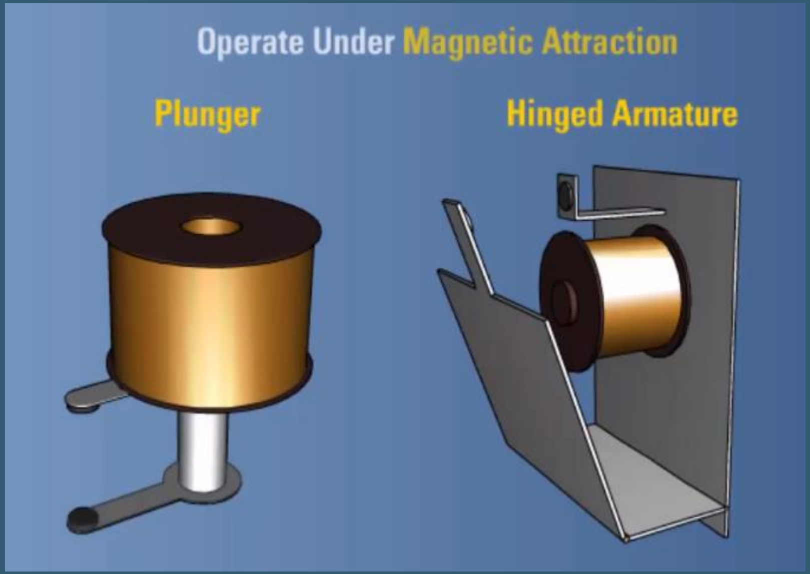


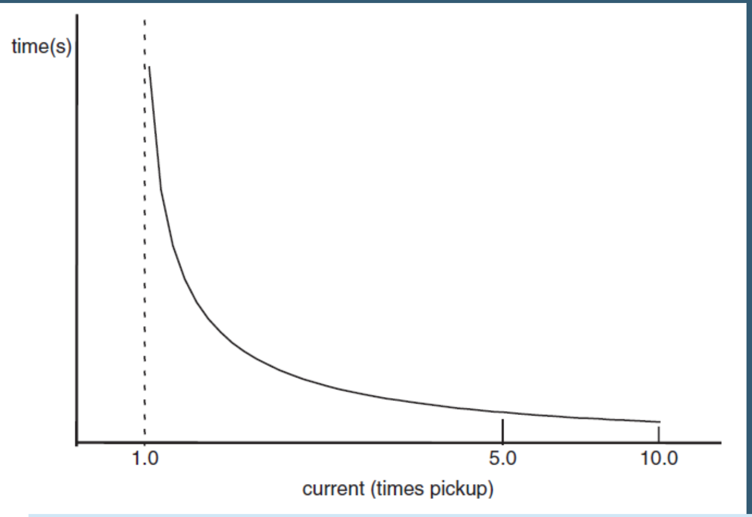
A time delay may also be added e.g. in the GE computer relay.


Digital I/O
F35/F60 Feeder
UR Platform
Hardware
Introduction
Block Diagram
Cyclic Scan
Modular Concept
Faceplate
Modules
Introduction
CPU
Power Supply
DSP
Digital I/O
Transducer I/O
Protection
Flexlogic Intro.
Gates
Timers
Signal Sources
UR
DIGITAL I/O
FORM C
Contact Output
- 6 amps
- 8 ms


UR
DIGITAL I/O
FAST FORM C
Contact Output
- Less than 0.6 ms
- 40 ma

2.7.5 *Ratio of pickup to reset*





Pick-up current is the value of coil current which makes the plunger rise and the contacts to meet e.g. 5A

Once picked-up, reducing to 4.999A might not reset the relay.

So, the energizing current needs to fall below a certain value for the relay to reset – this is dropout (reset) current.

The reset current may also be required to be carefully considered.
Let me make an example: a system undergoes an abnormal condition, the relay contacts move towards each other but do not close. Subsequently, if the system returns to normal, the relay contacts should also return to original state. However, if the drop out current is lower than the actual normal state current, the contacts may stay at their semi-picked up state and operating time may be affected in any subsequent relay operation. i.e. the relay will not follow its operating curve now.

2.8 Control circuits, a beginning

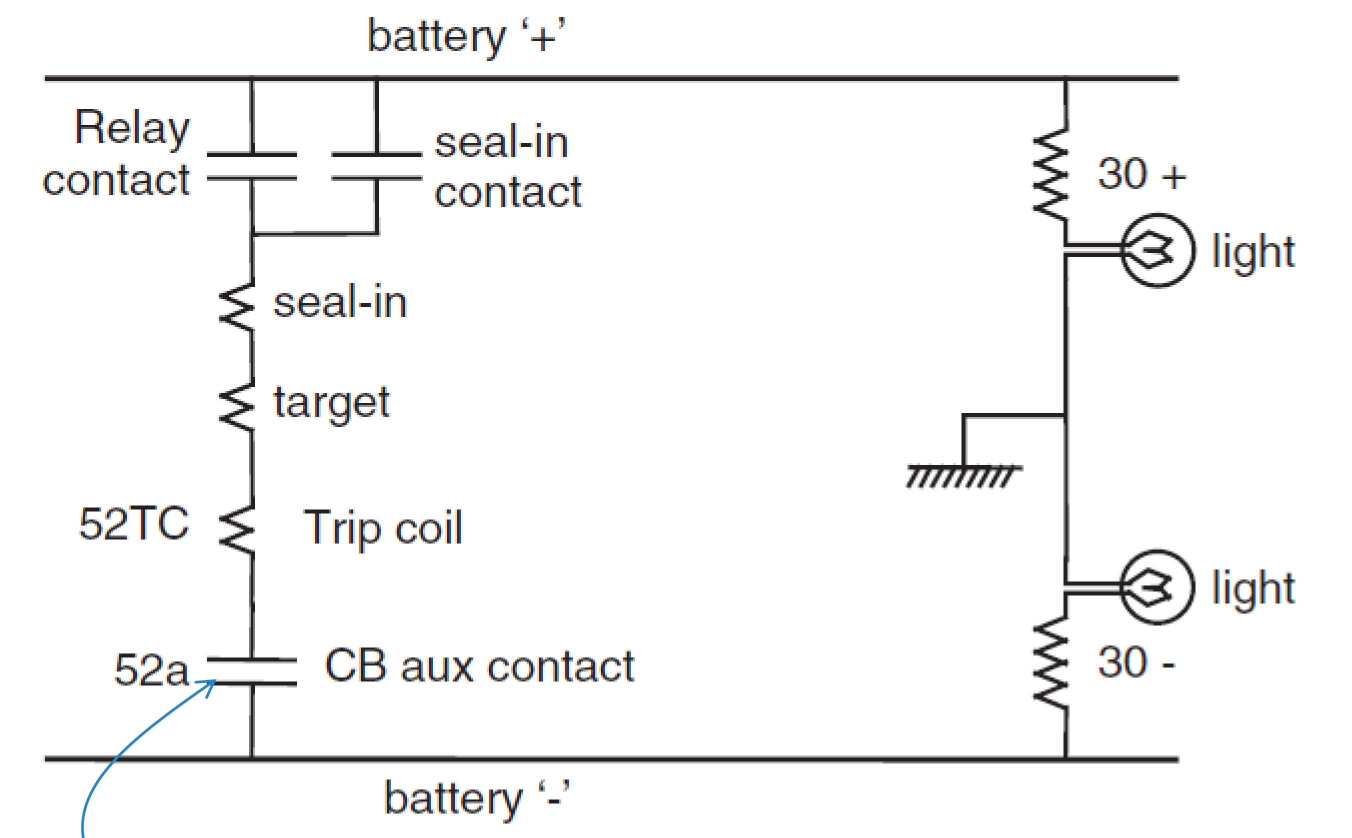


Figure 2.24 Control circuit showing various contacts and test circuit

DC cct is usually isolated from ground. The indicator bulbs light up at half brilliance, in case of a grounding of a DC bus, that lamp extinguishes while the other turns to full brilliance.

This contact will be actually closed when in service. The state shown here is 'on the shelf' state

It may be said that: the aux contact opens with the main contact. As the main contact opens the power line current, the aux contact opens the trip coil current.