5.2 Substation & Line Re-switching Automation

Substation functions

- node in the network

  for outgoing/incoming lines
  - circuit breaker, earthing switch, ... telecontrolled from central SCC
  - protection
  - measuring equipment

- bus bar
  - connecting the lines with their load flow
  - a common voltage point
  - protection
  - circuit breaker and switches

- transformers as (±) power injection points,
  - connecting/**coupling** two or three different voltage levels
  - voltage and load flow influenced by tap changers

Line function

- transmission of energy

  risk: switched off because of
  - short circuit
  - earth fault
  - overload
  - mis-measuring

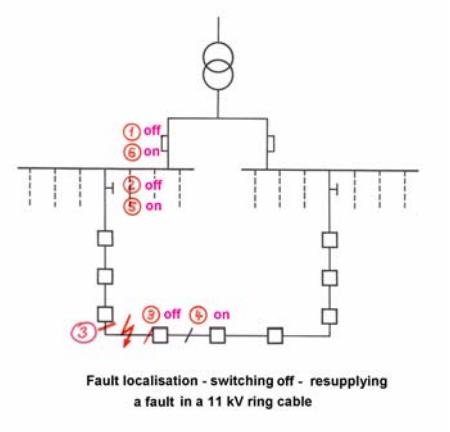
Automation potential

- changing the bus bar
- execute a fixed order of commands for single feeders
- regulating the voltage by adjusting the tap changer
- switching over transformer power injections in case of the outage of a transformer
- co-ordinated switching of load breaking switches and circuit breakers in an appropriate designed switchgear (11 kV compact substation)
- checking the synchronous conditions before switching "on"

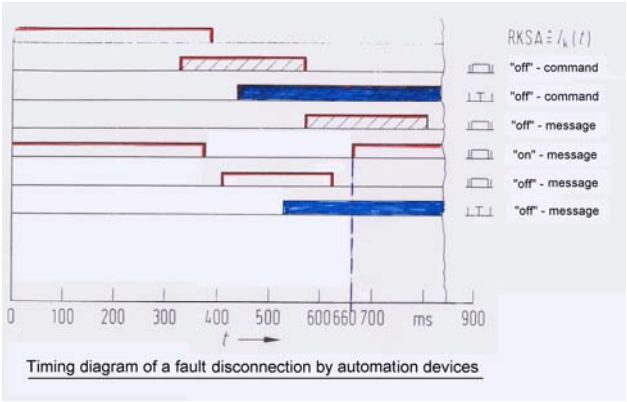
- temperature regulation of transformers by switching on and off the cooling ventilators
- co-ordinated switching in correspondence with load breaking switches of other substations (115 kV compact substations)
- fault localisation by short circuit indicators in MV networks
- fault localisation, switching **off** the faulty line part and switching **on** for full re-supply in MV networks

Technique, generally used

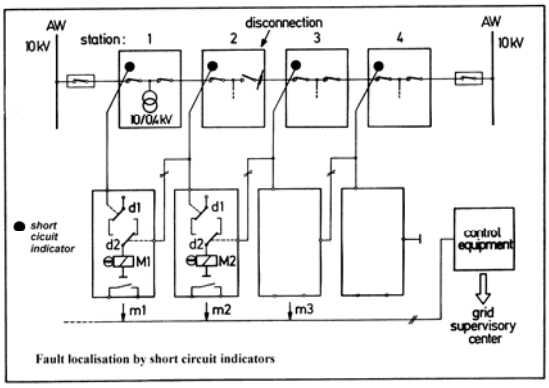
- separate µP modules with special tasks to cope with the requirements of the automation function
- special developed electronic modules working on analogue base
- electro-mechanical apparatus (relays technique), developed and installed in the 70th and 80th



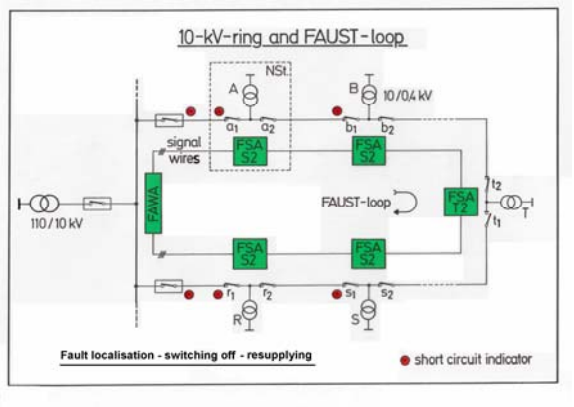
Fault localisation - switching off - resupplying a fault in a 11 kV ring cable

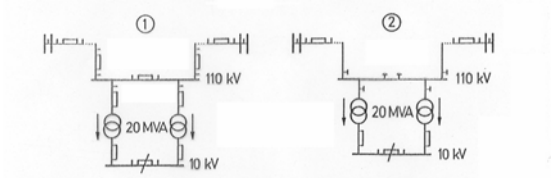


Timing diagram of a fault disconnection by automation devices



Fault localisation by short circuit indicators





switchgear conception	① power circuit-breaker	② load break switch, switching over by automatic transfer equipment	② load break switch, switching over by remote control
failure rate cable	0,036 a^{-1}	0,036 a^{-1}	0,036 a^{-1}
failure rate transformer	0,044 a^{-1}	0,044 a^{-1}	0,044 a^{-1}
interruption duration transformer fault	1 s*	1 s*	10 min
interruption duration cable fault	0,15 s	1 s	10 min
annual non-delivered power	880 kW/a	1600 kW/a	1600 kW/a
annual non-delivered energy	≈ 0 kWh/a	≈ 0 kWh/a	≈ 270 kWh/a
annual costs of supply interruptions	1760 DEM/a	3200 DEM/a	6500 DEM/a
annual costs of 110 kV switchgear	400 000 DEM/a	210 000 DEM/a	200 000 DEM/a

*in case of transformer fault : automatic transfer within 10 kV switchgear

Economical and technical comparison of alternativ solutions

HV networks – grids

- automatic switching only together with protection functions
  - automatical re-switching (200 ... 400 ms) after a short interruption because of a short circuit or a earth fault. Star point treatment has to be considered.
  - intertripping to avoid no-synchronous resupplying or for ameliorating the selectivity of distance protection

MV networks

- most faults lead to power interruptions
  - network structure has to take this into account
  - automation devices in the substation – decision is made there
  - substation as information node ➔ SCC
  - normally only load breaking switches in the transformer stations; automation means to install power storages there to make the breakers controllable; the transformer stations must be reached by telephone wires or other information transmission medium.
  - real time profit has to be checked compared with conventional method as e.g. reading the short circuit indicators in the transformer stations or the transmission to the supplying substation or to the SCC.
  - current as indicator ➔ measuring equipment has to be considered

- primary measures to avoid outages have to be checked and compared with restoring measures (surge arrester, earth wire, pruning, ...)

Line Re-switching Automation:

- more slowly than protection devices but much more quicker than switching by an operator
- checking the more complex network situation and working only under pre-selected conditions
- switching over for re-supplying (centralised – local)
- load shedding in emergency situations

Automatic disconnector