



Industrial System Protection

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Course Author: Velmir Lackovic

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INDUSTRIAL SYSTEM PROTECTION

Development of industrial and commercial electrical power systems has also introduced the requirements for their improved reliability. The possible outage time costs have also dramatically increased. The introduction of automation systems into industry and commerce requires application of advanced power system automation in order to enhance overall reliability and efficiency. Careful attention has to be given to the protection and control of industrial electrical supply systems. Many technologies that have been developed for EHV electrical systems may be used in lower voltage systems but usually on a reduced scale. Nevertheless, industrial electrical systems have many particular issues that need special attention and the development of custom solutions. Many industrial systems have their own generation. Sometimes it is used only in emergency situations, supplying a limited number of buses and with limited capacity. This design is frequently used to ensure safe shutdown of process plant and personnel safety. However, in some plants, processes allow generation of a substantial quantity of electricity, allowing surplus export to the grid. Industrial plants that operate power generation in parallel with the utility grid are usually referred to as cogeneration or embedded generation. Particular protection design may be needed for the point of common coupling between the private and utility grid. Industrial systems usually comprise many cable feeders and transformers and special protection arrangements may be also required for them.

BUSBAR ARRANGEMENT

The system busbar arrangement is apparently very important, and it can be quite complex for very large industrial systems. Nevertheless, in most industrial systems a single busbar divided into sections by a bus-section circuit breaker is typical. This configuration is shown in Figure 1. Main and standby drives for particular process equipment will be supplied from switchboard separate sections, or sometimes from different switchboards.

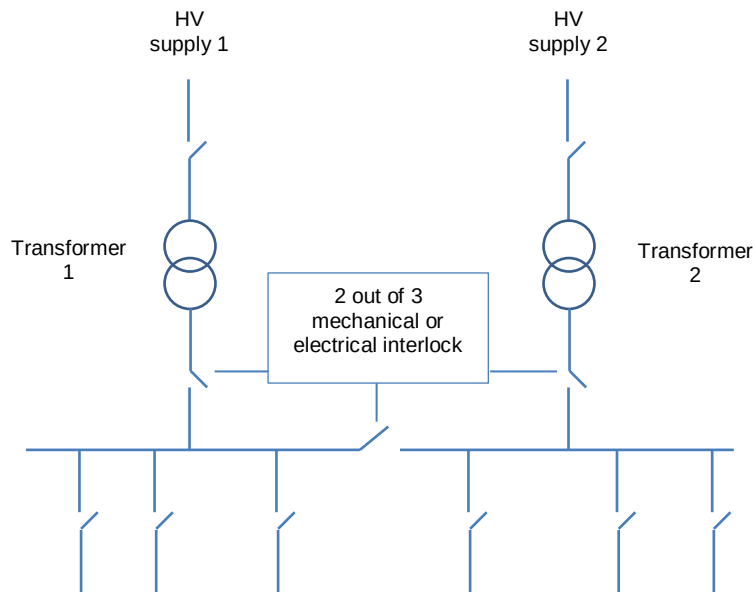
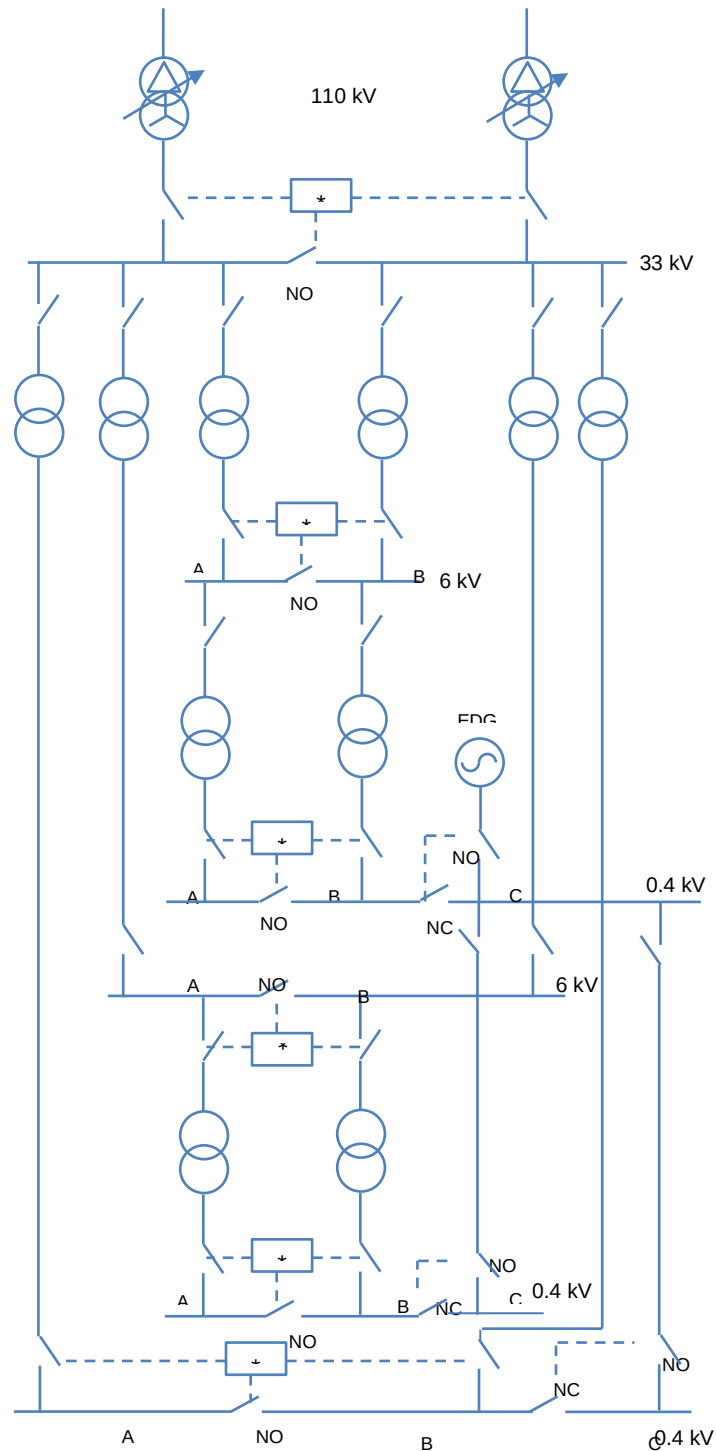


Figure 1. Common switchboard arrangement for an industrial plant

The main system design condition is that electrical network single outages within the plant will not cause simultaneous loss of both the main and standby drives. Analyzing a medium sized industrial supply system, presented in Figure 2 it will be noted that not only duplicate supplies and transformers are used, but also few important loads are separated and supplied from 'Essential Services Board(s)' (usually known as 'Emergency' boards). This allows maximum utilization of the standby generator equipment. A standby generator is typically of the turbocharged diesel-driven type. On loss of incoming supply detection at any switchboard with an emergency section, the generator is automatically started. The adequate circuit breakers will close once the generator is up to speed and rated voltage to recover supply to the Essential Services affected switchboard sections. For a common diesel generator set, the emergency supply would be available within 10-20 seconds from the start sequence command being released.



Bus section C – Essential supplies
 EDG – Emergency generator
 * - Two out of three interlock

Figure 2. Common industrial power system

The Essential Services Boards are installed to supply equipment that is essential for the secure shut down, limited operation or plant preservation and for the staff safety. This will cover process drives that are needed for safe shutdown, venting systems, UPS loads supplying emergency lighting, process control computers, etc. The emergency generator may vary in size from a single unit rated 20-30kW in a small plant up to several units of 2-10MW in a large oil refinery. Big financial trading institutions may also have standby power demands of few MW to keep computer systems.

DISCRIMINATION

Protection equipment operates in conjunction with switchgear. For a common industrial system, feeders and plant will be typically protected by different circuit breakers and by fused contactors. Circuit breakers will have their overcurrent and ground fault relays. A contactor may also be installed with a protection device (e.g. motor protection), but associated fuses are supplied to break fault currents surpassing the contactor interrupting capability. The rating of fuses and selection of protection relay settings is completed to ensure that discrimination is accomplished – i.e. the ability to select and isolate only the faulty part of the system.

HRC FUSES

The protection element nearest to the actual point of power utilization is probably the fuse or a system of fuses. It is important that attention is provided to the correct fuse application. The HRC fuse is a key fault clearance device for industrial and commercial system protection. It can be installed in a distribution fuse board or as part of a contactor or fuse-switch. The second is looked at as a crucial part of LV circuit protection, combining safe circuit making and breaking with an isolating capability accomplished in conjunction with the HRC fuse reliable short circuit protection. Fuses combine the characteristics of economy and reliability. These factors are vital for industrial applications. HRC fuses stay consistent and stable in their breaking characteristics without calibration and maintenance. This is one of the major factors for keeping fault clearance discrimination. Lack of discrimination through improper fuse grading will end in unnecessary supply disconnection. However, if both the major and minor fuses are properly designed HRC devices this will not endanger staff or cables associated with the plant.

FUSE CHARACTERISTICS

The time needed for melting the fusible element is dependent on the current magnitude. This time is known as the fuse 'pre-arcing' time. Element vaporization happens on melting and there is fusion between the vapor and the filling powder resulting in quick arc extinction. Fuses have a valuable feature known as 'cut-off'. It is presented in Figure 3. When an unprotected circuit is exposed to a short circuit fault, the r.m.s. current increases towards a 'prospective' (or maximum) value. The fuse typically breaks the short circuit current before it can reach the prospective value. This happens in the first quarter to half cycle of the short circuit. The increasing current is broken by the fusible element melting, subsequently dying away to zero during the arcing period.

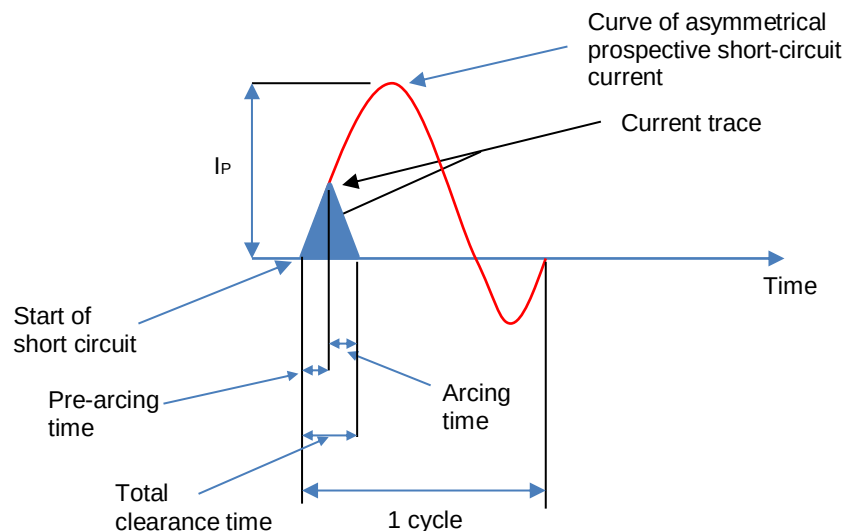


Figure 3. HRC fuse cut-off characteristic

Since the electromagnetic forces on busbars and connections conducting short circuit current are proportional to the square of the current, it will be noted that 'cut-off' significantly decreases the mechanical forces generated by the fault current and which may distort the busbars and connections if not properly rated. A common example of 'cut-off' current feature is presented in Figure 4. It is possible to use this feature during the project design stage to select equipment with a lower fault withstand rating downstream of the fuse. This may save money, but adequate documentation and maintenance controls are needed to ensure that only replacement fuses with very similar features are used throughout the plant lifetime – otherwise a safety hazard may happen.



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