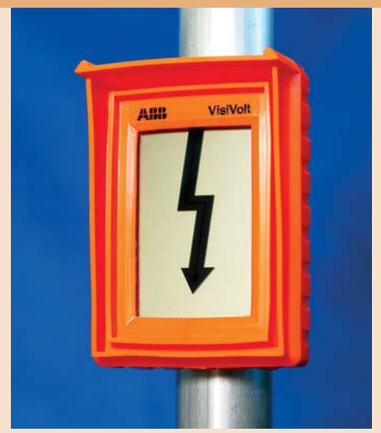
A New Technology for Indicating Presence of Voltage

Safety is one of key aspects in the operation of any distribution system. This is because MV systems, with their comparatively easy accessibility to live components, are usually the most involved in electrical accidents. These often arise from the mistaken belief that no voltage was present due to improper communication, equipment malfunction or inadequate testing.

Such incidents could be avoided, however, if the presence of voltage could somehow easily be visualized on the conductors. Developing a system to allow for such visualization was the major goal of a project recently conducted at ABB Corporate Research.

INMR reports on this project which resulted in the development of a new technology for voltage indication. This technology is based on liquid crystal displays (LCD) and particularly on a special internal structure which imparts to them a very high sensitivity to AC electric fields.

New passive voltage indicator developed at ABB.



Systems indicating the presence of voltage and which can be installed permanently on MV distribution installations are vital to ensuring the safety of operational staff. Such indicators would provide rapid information on the voltage status of each panel, help track faults and also warn workers about the presence of voltage. Approved types could also be used to verify the absence of voltage prior to grounding and entering a system to conduct any required maintenance. Indeed, among all the functional aspects of voltage indication, safety is by far the most important.

The possible causes of disastrous electrical accidents can be many. For example, the momentary distraction of a worker combined with equipment malfunction. Or, poor communication between the various service personnel. These types of situation could, for example, lead to someone approaching a distribution panel which, while thought to be disconnected from voltage, is in fact live. Generally-speaking, all such potentially serious accidents arise from the mistaken belief that no voltage was present.

It is perhaps impossible to fully avoid all such dangerous incidents. That is why service personnel would probably prefer to have an additional and *independent* source of information about voltage status, apart from the portable indicators they are required to use before entering a system for work.

Permanently-installed indicators could provide such information. Although most of these are not necessarily approved for verifying the absence of voltage, they can substantially increase the safety of a system by warning personnel about any unexpected emergence of voltage.

There are a huge number of locations on a distribution system where voltage indication would be desirable. Typical examples include outdoor and indoor distribution transformer connections, open indoor distribution switchgear, outdoor cable ends which feed overhead systems and the terminals of outdoor switch-disconnecting units.

Unfortunately, one typically does not find voltage indicators at such locations due to the additional complexity these would entail (i.e. the need for expensive outdoor-compatible systems, lack of primary impedance, etc.). In all cases, this has been due to the lack of a simple, economic and robust technology for voltage indication which could be broadly-employed, especially in outdoor systems.

Aiming to satisfy this perceived need in the marketplace, ABB Corporate Research, in cooperation with Business Unit MV Products, recently developed a passive voltage indicator which it says can be attached directly to busbars or conductors of any unscreened indoor or outdoor MV systems from 3 to 36 kV. The presence of voltage in this product is indicated by the prominent display of a large lightning arrow.

According to Project Leader, Dr. Jan Czyzewski, the threshold for this warning indicator has been adapted to meet current IEC standards, i.e., signaling the presence of AC voltage when it exceeds 45 percent of the nominal phase-to-phase voltage (DC voltage is not indicated). As with other types of busbar mounted indicators, the unit is sensitive to the presence of both phase-to-ground and phase-to-phase voltages.

Pilot installations (from left): operating during a heavy rain at utility in Poland; at a test station on the west coast of Sweden; and at a 6 kV system at a Polish hydropower plant.

Since each live conductor generates an electric field close to its surface, the particular goal of the project, says Czyzewski, was to develop a material or structure which changes its appearance in the presence of an AC electric field of required magnitude. This could be achieved by exploring various display technologies.

A typical display device converts electric field into information which is visible to the human eye. The problem, explains Czyzewski, is that the electric field around a conductor of a typical air-insulated distribution system ranges from a fraction to only a few kV per centimeter - which is quite a low value in terms of electro-optical materials. No standard display material is therefore able to respond directly to such low electric fields.

Moreover, sensitivity to electric field is apparently not the only criterion required to apply this technology to power equipment. The system, particularly in an outdoor application, must be able to withstand demanding environmental conditions such as wide fluctuations in temperature and humidity as well as rain and direct exposure to sunlight. Additionally, once installed, it must remain operational for many years without the need for maintenance. Says Czyzewski, "not many display technologies are able to withstand such difficult conditions."

This is why, even though it successfully completed an initial prototype based on fragile electronic paper technology, the project team ultimately directed its research towards the more mature and robust technology of liquid crystal displays (LCD). The key development step, emphasizes Czyzewski, was inventing a novel structure of internal electrodes in the unit's display panel. This would then permit the capacitive current generated by an AC electric field to be most effectively collected into the sign display area of the panel.

According to Czyzewski, LCD technology has the advantage of being able to operate at a very broad temperature range (-40° C to +85° C in the case of this product) and continuous service lifetimes measured in tens of years. He states in order to confirm the performance level expected, a number of tests were performed during the prototyping stage including voltage threshold testing across the full temperature range, xenon arc lamp tests simulating extreme sunlight and accelerated ageing tests.

Any busbar-mounted indicator is a high impedance device and its internal components therefore require a high level of insulation. That is why a silicone enclosure was selected in which to permanently seal all internal components, much as one finds in polymeric-housed surge arresters. This was done to ensure that any current leakage inside or over the surface of the enclosure would be minimal and not disturb the normal functioning of the indicator.

Employing a flat panel LCD, which is inherently sensitive to any electric field, allows for simple construction of the indicator unit without application of any electronic circuitry. Czyzewski explains that the main components are an electrically-conductive back plate, the LCD, a protective window and the insulating enclosure.

This, he points out, results in a very compact design of the unit, which is especially important for installation directly onto busbars. As a result, after installation, the indicator hardly changes the geometry of the current track and does not influence the insulation properties of the distribution system.

As with most product development in this field, there was a need to test the final unit in a real service environment. A prototype having a gray enclosure was developed in 2005 and a number of pilot installations have since been arranged. Says Czyzewski "all installations, including one at a test station on the west coast of Sweden which is exposed to particularly difficult operating conditions, have been running successfully now for more than a year." This, he notes, is not surprising since the type tests for the unit included moisture ingress testing adapted directly from IEC 60994 for polymeric arresters (i.e. ensuring that the functionality of the indicators does not change even after 52 hours of immersion in a saline solution of 1g/dm^3 at 80° C). Basically, this served to verify the quality of sealing of the internal parts within the silicone enclosure.

With its outdoor compatibility, compact construction and simple fitting system, Czyzewski says that this innovative indicating technology represents an attractive solution to broadly introduce indicators with an active warning in regard to the presence of voltage into systems where they have not been available up to now. This, he feels, will contribute greatly to reducing the incidence of serious accidents. ☒