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Lightning protection of the dedicated transformer for radio base station

Recommendation ITU-T K.110

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Summary

Recommendation ITU-T K.110 addresses lightning protection of the dedicated transformer for a radio base station (RBS).

RBSs are usually powered by the local power utility with a dedicated power line operating at medium voltage (e.g., from 10 kV to 20 kV). A dedicated transformer is installed at the RBS for transforming the medium voltage (MV) to low voltage (LV) (e.g., 380 V or 240 V), which is then used to power the RBS.

Frequently, the dedicated transformer is installed on a pole, and thus the associated overhead lines (medium and low voltage) have poor earthing conditions. Therefore, these transformers are exposed to lightning effects and, consequently, the power interruptions caused by lightning flashes can severely affect normal operations of the RBS.

The main objective of this Recommendation is to reduce the risk of damage to an RBS dedicated transformer due to lightning flashes, which will improve the safety and reliability of the RBS itself and its related equipment.

This Recommendation includes the following features:

- 1) need of protection for dedicated transformer;
- 2) earthing and bonding of transformer and RBS;
- 3) direct lightning protection for transformers;
- 4) transformer insulation requirements;
- 5) MV/LV arresters and LV surge protective devices (SPDs);
- 6) protection of ancillary facilities.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Recommendation ITU-T K.110

Lightning protection of the dedicated transformer for radio base station

1 Scope

This Recommendation addresses the lightning protection of dedicated transformers used to provide electrical power for radio base stations (RBSs). It contains procedures for earthing, bonding and direct lightning protection of the dedicated transformer, including protection methods for the associated power lines, requirements for surge arresters (medium voltage (MV) and low voltage (LV) arresters), and protection procedures for ancillary facilities.

Transformers used for powering an RBS and other components (i.e., shared transformers) are not covered in this Recommendation. The lightning protection of these shared transformers is contained in [b-ITU-T K.111].

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- [ITU-T K.56] Recommendation ITU-T K.56 (2010), *Protection of radio base stations against lightning discharges*.
- [ITU-T K.97] Recommendation ITU-T K.97 (2014), *Lightning protection of distributed base stations*.
- [ITU-T K.112] Recommendation ITU-T K.112 (2015), *Lightning protection, earthing and bonding: Practical procedures for radio base station sites*.
- [IEC 60076-3] IEC 60076-3 (2013), *Power transformers – Part 3: Insulation levels, dielectric tests and external clearances in air*.
- [IEC 60076-4] IEC 60076-4 (2002), *Power transformers – Part 4: Guide to the lightning impulse and switching impulse testing – Power transformers and reactors*.
- [IEC 60099-4] IEC 60099-4 (2014), *Surge arresters – Part 4: Metal-oxide surge arresters without gaps for a.c. systems*.
- [IEC 61643-11] IEC 61643-11 (2011), *Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods*.
- [IEC 62305-1] IEC 62305-1 (2010), *Protection against lightning – Part 1: General principles*.
- [IEC 62305-2] IEC 62305-2 (2010), *Protection against lightning – Part 2: Risk management*.
- [IEC 62305-3] IEC 62305-3, (2010), *Protection against lightning – Part 3: Physical damage to structures and life hazard*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 continuous operating voltage of an arrester (U_c) [IEC 60099-4]: Designated permissible r.m.s. value of power-frequency voltage that may be applied continuously between the arrester terminals in accordance with U_r .

3.1.2 non-solidly earthed power distribution systems [b-IEC 60050-601]: System generally refers to neutral point ungrounded via arc suppression coil or high-impedance to ground. When short-current fault occurs, the system can not constitute a current loop, the fault current is very small, also known as small current grounding system.

3.1.3 rated voltage of an arrester (U_r) [IEC 60099-4]: Maximum permissible RMS. value of power-frequency voltage between its terminals at which is designed to operate correctly under temporary overvoltage conditions as established in operating duty tests.

3.1.4 residual voltage of an arrester (U_{res}) [IEC 60099-4]: Peak value of voltage that appears between the terminals of an arrester during the passage of discharge current.

3.1.5 solidly earthed neutral system [b-IEC 60050-601]: System whose neutral point(s) is (are) earthed directly.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 arrester disconnecter: Device for disconnecting an arrester from the system in the event of arrester failure, to prevent a persistent fault on the system and to give visible indication of the failed arrester.

NOTE – Eliminate the fault current through the arrester during disconnection generally is not a function of the device.

3.2.2 dedicated transformer: Power transformer used exclusively to provide electrical power to a radio base station.

3.2.3 drop-out fuse: Fuse used in MV power line and distribution transformers for overload and short circuit protection.

3.2.4 earthing network: The part of an earthing installation that is restricted to the earth electrodes and their interconnections.

3.2.5 heat-blast disconnecter: Device that uses the explosion of a component in order to disconnect a circuit and interrupt the current flow.

3.2.6 high current impulse of an arrester: Peak value of discharge current having a 4/10 impulse shape which is used to test the stability of the arrester on direct lightning strokes.

3.2.7 lightning protection insulator: An insulator body comprising an upper part and a lower part connected series. When subjected to a lightning overvoltage, the nonlinear resistance of the lower part decreases and the overvoltage is concentrated at the upper part, causing a flashover. After the lightning current is over, the nonlinear resistance of the lower part rapidly rises and limits the flow of power frequency current.

3.2.8 metal-oxide surge arrester without gaps: Arrester having non-linear metal-oxide resistors connected in series and/or in parallel without any integrated series or parallel spark gaps.

3.2.9 nominal discharge current of an arrester (I_n): Peak value of lightning current impulse (8/20 μ s current impulse) which is used to classify an arrester.

3.2.10 non-linear metal-oxide resistor: Part of the surge arrester which, by its non-linear voltage versus current characteristics, acts as a low resistance to overvoltage, thus limiting the voltage across the arrester terminals, and as a high resistance at normal power-frequency voltage.

3.2.11 series reactor: Device that limits the lightning current flow through a drop-out fuse, in order to avoid its undesired operation.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

EPR	Earth Potential Rise
FTO	Forward Transformation Overvoltage
ITO	Inverse Transformation Overvoltage
LV	Low Voltage
MV	Medium Voltage
RBS	Radio Base Station
SPD	Surge Protective Device

5 Conventions

None.

6 Need for protection

Power utilities usually protect distribution transformers against lightning induced surges, but not against direct lightning flashes. However, a dedicated power transformer used to provide electrical power to an RBS is installed in an environment that is very exposed to direct flashes. The main items that enhance this high exposure include the presence of a tall metallic tower for the RBS, a long overhead power distribution line (feeder) and the RBS placement on a hill. Therefore, the dedicated power transformers for RBS presents a number of aspects that need to be considered:

- earth potential rise (EPR) when lightning strikes the tower;
- induced overvoltages when lightning strikes the tower;
- low voltage (LV) and medium voltage (MV) lines nearby the transformer (within 3 km) may be struck by lightning.

This Recommendation considers two possible earthing configurations:

- 1) The transformer and the RBS share the same earthing network. This configuration is shown in Figure 1 and should be adopted when the distance between the transformer and the RBS is shorter than 30 m. When the tower is struck by lightning, the EPR may cause flashover of the line insulation at the nearest pole, and the current flowing through the MV arresters would be very high and would damage the arresters. Moreover, other components of the power system could also be damaged.
- 2) The transformer and the RBS have separated earthing network. This configuration is shown in Figure 2, where the distance between the transformer and the RBS is usually longer than 30 m. When the tower is struck by lightning, the EPR will be applied to the LV side of the transformer and may lead to the breakdown of its insulation. Moreover, if not conveniently specified, the lightning arresters may also be damaged.