TERMS OF REFERNCE FOR THE R&D PROJECT

1. **Title of the Project**: Calculation of thermally permissible short-circuit currents in low voltage, direct current electrical installations.

2. **Background:**

   Calculating thermally permissible short-circuit currents for conductors in electrical installations is a generally standardised process. IEC 60364-4-43 and IEC 60949, provide guidance to do so, taking into account adiabatic and non-adiabatic conditions respectively. These standards are accepted internationally and the mentioned calculations are applied almost universally for a.c. (alternating current) installations. With the introduction of low-voltage, direct current, it is foreseeable that in the near future, residential and commercial premises are likely to be supplied by either grid-independent or grid-connected low voltage d.c. (direct current), from sources such as batteries and solar photovoltaic modules. Just as in installations supplied by a.c., installations supplied by d.c. require protection against short-circuit currents. Given that there is very little research done on this subject (specifically with regards to the thermal withstand capability of conductors in short-circuit conditions), it is important to ensure that laboratory studies are conducted to come up with a standardised method to calculate thermally permissible short-circuit currents for conductors in LVDC installations.

3. **Objective:** To determine standardized method to calculate thermally permissible short-circuit currents for conductors in LVDC installations.

4. **Scope**: Scope of this research project includes –

   i. In laboratory conditions, study the effects of DC short-circuit currents on conductor temperature for conductors protected by various overcurrent protection devices [OCPDs] complying with IEC 60947-2.

   ii. Compare the findings of 3(i) with the let-through energy data [I^2t] values as given by OCPD manufacturers.

   iii. Establish, for the level of fault current generated in 3(i), maximum conductor temperature during fault conditions.

   iv. Compare, expected conductor temperature as per IEC 60364-4-43 and IEC 60949 with measured temperatures.

   v. Analyse the cause of variations in 3(iv) with respect to

- Increased resistance caused by arcs created when short-circuits are introduced in 3(i).
- Source impedance.
- Ability of source to produce high short-circuit current when faults of negligible impedance are introduced.
- Skin effect with respect to conductors carrying d.c.

   vi. Deduce a mathematical model to calculate thermally permissible short- circuit currents in low-voltage, direct current electrical installations based on calculations in IEC 60364-4-43 and IEC 60949 with specific guidance on using manufacturer quoted let-through energy values, and ‘k’ values from IEC 60949 and IEC 60364-4-43.

5. Research Methodology:

i. Literature review:

a. Studying IEC 60364-4-43, IEC 60949 and other research papers that the proposer may deem relevant.
b. Studying IEC 60947-2 to understand the importance of thermal withstand analysis, specifically with regards to quoted let-through energy (I^2t) values.
c. Studying literature published by OCPD and cable manufacturers, specifically to analyse let-through energy (I^2t) values for faults in DC installations and thermal withstand capability (k^2S^2) for DC faults respectively.
d. Documentation of takeaways from 5(i)a-5(i)c.

ii. Assessment: Meeting with BIS sectional committee members to ensure proposer and team have fully understood the context and all necessary data.Reviewing documentation takeaways from 5(i).

iii. Experimentation to gather empirical data:

a. Creation of a short-circuit conditions in a circuit of known impedance with given OCPD to measure peak temperature of conductor during circuit interruption, compared to temperature before creation of short-circuit (conductor maximum operating temperature).
b. Perform experiment for various conductor cross-sectional areas.
c. Perform experiment for various circuit lengths.
d. Perform experiment for short-circuits occurring at various points in the same circuit.
e. Perform experiment for circuits and supplies having a nominal voltage from 48V DC to 440V DC (see preferred values for DC from Table 6, IEC 60038:2009+AMD1:2021)
f. Explain mathematically, the relationship between OCPD interruption time (based on magnitude of fault current and manufacturer quoted I^2t values) and conductor temperature (with specific reference to limiting temperature).
g. *Note: Experiments have to be performed with all permutations and combinations from 5(iii)a – 5(iii)e*
h. Documentation of findings as a research paper.

iv. Meeting with BIS sectional committee members to review findings from 5(iii). Any additions or alterations will be made at this stage to create the final document.

v. Submission of final document.

6. Expected Deliverables:

a. Final project report covering all the aspects referred in the scope.
b. Questionnaire, discussion, visit reports, test reports to be appended with the final project report

7. Timeline and Method of Progress Review:

Sl. No	Stage	Time from date of award of project (cumulative)
1	Literature review (Study, Surveys, etc)	1 month
2	First draft	4 months
3	Final draft along-with report	6 months

The review will be carried out in each month along with consultation of other experts if required. The literature review after 1 month, the first draft after 4 months and the final draft along-with report at the end of 6 months.

8. Support BIS will provide:

BIS will provide access to latest editions of standards for the project.

9. Nodal person:

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