AN INNOVATIVE PROGRAM FOR AN INTERACTIVE DESIGN, SIMULATION AND ASSESSMENT OF ELECTRICAL SYSTEM IN BUILDINGS

Reported by: Sdr. Clement Tan

Electrical installations in buildings, either as a whole or parts of it, should be properly designed to provide safety and continuity of supply. This was the first message by Ir. Assoc. Prof. C.Y. Teo, who gave a seminar on "An Innovative Program for the Interactive Design, Simulation and Assessment of Electrical Systems in Buildings" on September 8, 2003 at IEM. The seminar was well attended, with 35 participants.

Ir. Assoc. Prof. C.Y. Teo stated that overall electrical installation cost increases as a result of poor design or over design. Therefore, an engineer must always check their design before putting it into the working plan. However, engineers nowadays lack time and resources to make a complete check of all design works. The program VIPCODA (Visually Interactive Program for Consultant and Owner to Design and Access Electrical System in Buildings) was developed to provide the design, calculation, modeling and checking process that comply with safety regulations such as CP5 or the IEE Wiring Regulation.

Ir. Prof. Teo then explained the 7 types of critical tests for an electrical system, namely:-

- **Breaker and Cable Load Test**
  For each outgoing circuit in a DB, the design current (IB) and the rated circuit capacity (IZ) are calculated. For any branch, the design current (IB) can be calculated using the formula below:-

$$I_B = \frac{\sqrt{P_{eqR}^2 + Q_{eqR}^2}}{\sqrt{3}\chi V_{LL}} \quad \text{for 3-phase load} \quad \text{or}$$

$$I_B = \frac{\sqrt{P_{eqR}^2 + Q_{eqR}^2}}{3\chi\left(V_{LL}/\sqrt{3}\right)} \quad \text{for 1-phase load}$$

where Peq^R and Qeq^R are the equivalent active and reactive power connected to the branch. Based on the current rating of the protective device (I_N), the program detects whether $I_N > I_B$ and $I_Z > I_B$. Current loading (I_B/I_Z) in percentage of the rating capacity is also calculated, and if circuit loading exceeds 100%, it is considered as failed and is highlighted.

- **Overload Protection Test**
  For overload condition testing, the design current (I_B) in each circuit is increased to 145% of the rated current capacity (I_Z) and the operating time is calculated. The program detects whether $I_N < I_Z$ and whether the operating time of the protective device is less than the effective operating time of 2 hours.

- **Voltage Drop Test**
  This test will check whether the voltage drop in each circuit is within the allocated voltage drop tolerance. Voltage drop from end to end for any branch is:

$$V_{drop} = \frac{TVD_r\ \cos\theta + TVD_\chi\ \sin\theta)\ x\ I\ x\ {}_BLength}{100}$$

where cosθ is the power factor of the circuit and TVD_r and TVD_x are the tabulated voltage drop in mΩ per meter from the relevant cable table in the IEE Wiring Regulation.

- **Short Circuit Protection Test**
The 3-phase short-circuit current at the receiving end of each circuit can be calculated from the formula provided:

$$I_{EF} = \frac{\left(V_{LL}/\sqrt{3}\right)}{\sqrt{(R_{eqS} + R_C)^2 + (X_{eqS} + X_C)^2}}$$

where R_{eqS} and X_{eqS} are the source impedance at the sending end of the circuit and R_C and X_C are the impedance of the cable. A check is conducted to determine whether the braking capacity of the protection device is higher than the short-circuit at the sending end of each circuit. The operating time for the protection device is then modeled and a check is conducted to detect if the circuit will be disconnected within the critical time so that the temperature in the conductor will not exceed its thermal limit as a result of failure in insulation material.

- **Earth Fault and Circuit Protective Conductor (CPC) Test**
The earth fault current at the receiving end for a single-line-to-earth fault is:

$$I_{EF} = \frac{\left(V_{LL}/\sqrt{3}\right)}{\sqrt{(R_{eqS} + R_C + R_{cpc})^2 + (X_{eqS} + X_C + X_{cpc})^2}}$$

where R_{cpc} and X_{cpc} are the impedance of the circuit protective conductor (earth wire) of the branch. The program will be able to detect if the cable size is adequate to withstand the earth fault current.

- **Motor Starting Test**
Based on the type of motor rating and starter, direct-on-line (DOL) or wye delta, the maximum motor starting current is calculated and the protection device is modeled. The motor starting test detects if the protection device will trip during the starting period.

- **Electric Shock Protection Test**
This test determines the earth fault current and the touch voltage at the end of each circuit. Based on the IEE regulation and on the direct acting over-current protection device, it checks if the touch voltage is less than 50V and whether the disconnection time is less than 5 seconds for a TT system (where the source and the installation's earthing terminal are directly earthed through its own earthing). On the other hand, the disconnection time is less than 0.4 seconds for hand-held equipment and 5 seconds for fixed equipment for a TN system (where the installation's earthing terminal is earthed at the neutral point of the supply source through a separate protective conductor, and the source of supply is directly earthed).

If the test fails, the relevant residual protective devices such as RCCB, ELR, E/F and IDMT will be suggested. The operating time is modeled based on the specified current transformer (CT) ratio, time and current settings on the device, until the requirement on electric shock protection is met.

According to Ir. Assoc. Prof. C.Y. Teo, the automated design done by VIPCODA will ensure that the electrical system design meets all seven critical tests, through several built-in rules. He then demonstrated how the program could be used to transfer the designed system into AUTOCAD. An innovative approach of integrating design element database, network database, design methods and simulation was described. Therefore, time taken in the whole design is reduced and complete checks on each circuit are also conducted to ensure that the system meets the requirements of the relevant code and practice.

The seminar ended at 7:30 p.m. with an active question and answer session. ■

REFERENCE

1. C.Y. Teo, "An Innovation Programme for the Design and Assessment of Electrical System in Buildings", Jurutera Jan 2001, pp. 46-49.
2. C.Y. Teo, "Integrated Assessment of Electrical Systems in Building Through Simulation Tests", The Singapore Engineer May/Jun 2003, pp. 27-32.