



Visually Interactive Package for the Teaching of Electrical Network in Buildings

By: Ir. Teo Cheng Yu

1. INTRODUCTION

An innovative approach using computer aided design tools to support the teaching of electrical installation through hands-on design exercises is described. It is implemented by an integrated package known as VipTein, which guide students step by step to complete the design of sizeable electrical installations. Supported by all the built-in facilities, the dedicated database structure enables

students to get direct access to the building information, details of each type of load and the technical parameters of all the electrical parts required for the design exercise. The built-in dynamic test specification eliminates routine and repetitive design studies and also accelerates the design and learning process. Each error made by each student is prompted on the spot and after each second attempt, the right answer and the

student's wrong answer are shown for comparison. The performance of each student is evaluated automatically through error logs and is summarised by showing the total number of demerit points, which is then converted to a grade of A, B, C, D or E. VipTein is structured for three main student groups, namely technical college, polytechnic and university as illustrated in Figure 1.

2. TRAINING SCOPE

The integrated package VipTein is designed to familiarise students with the criteria and procedure for the design of electrical installations in buildings. It guides the student to complete the whole design process. By displaying the floor plan and the connected loads, the student can practise on the estimation of maximum demand based on an assumed demand factor or coincidence factor, and the determination of the design current for various circuits including the incoming circuit. The student can also practise on the selection of appropriate types of breakers, current ratings and the category of duty against overcurrent, fault current and electric shock. It is then followed by the choice of conductor material, type of insulation, installation method and the determination of conductor size. Correction factors to cater for circuit grouping, ambient temperature and thermal insulation as well as voltage drop and motor-starting conditions will be included. Various methods to determine the size of protective conductor, and the requirements for individual main incoming circuit including current transformers (CTs) for protection and for measurement will be assessed. Knowledge of wiring regulations and the standard code of practice for electrical installation will be inherently acquired through the design process. A sample display of the interactive dialogue to assess a student on breaker specification for circuit no. 3 is shown in Figure 2.

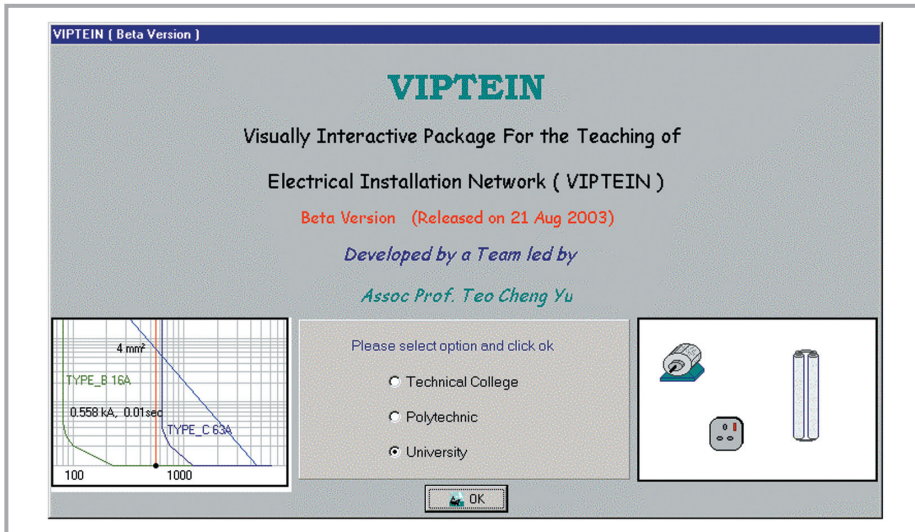


Figure 1: Dynamically tailored to technical college, polytechnic and university

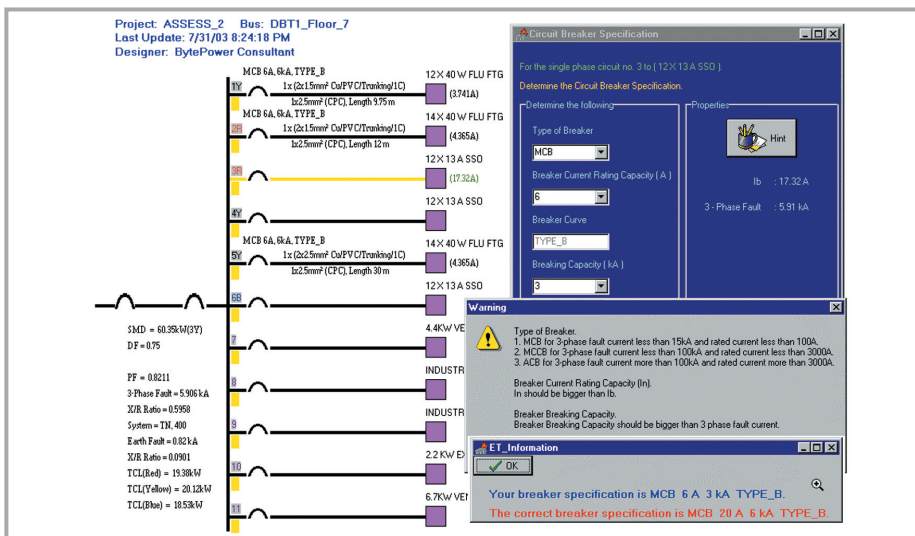


Figure 2: Interactive dialogue to assess a student on breaker specification

FEATURE

3. SIZE OF DESIGN

The main menu provides access to the two modules, i.e. assess 1 and assess 2. In assess 1, the student is given a hands-on exercise to complete the design of a TT system of a two-level building, which has two shops on each floor. Each shop has a final DB serving a floor area of 15 m x 10 m. The two final DBs on each floor are fed by a main DB, which is then connected to a cable riser. The main switchboard feeds one cable riser, a 55 kW DOL motor, an 80 kW star-delta motor and a DB with an equivalent load of 90 kW. This module allows the student to go

through the program once and to familiarise themselves with tools provided in the package as well as the method of design.

In assess 2, the student has to complete a sizeable design of 2 MVA electrical installations with two incoming busbars, one emergency busbar and one stand-by generator. A 3-D view and a typical floor plan of a seven-level flatted factory will be displayed. On each level, there are four tenant DBs, one landlord DB and one emergency DB. The floor plan and the student's connection and balancing of load for one of the final DB at floor 7 are

shown in Figure 3. As level 1 to level 7 are identical, the student only needs to complete the design for one level and the package will make identical copies for all other six levels. At the end of the design, the student will be prompted to determine breaker type and size for each incoming circuit. The student is required to verify the earth fault protection. At the end of the module, the student's performance is evaluated and given in an overall score summary.

4. VISUAL USER INTERFACE

VipTein utilises all standard Window facilities such as pull down menus, pop-up windows, symbolic icons and various visually interactive dialogue boxes, etc. It is arranged such that all the menus, icons and dialogue boxes are self-documented. At run time, the student may simply click the Hint label to view the relevant formulae or the Legend label for the relevant description. Warning and guiding messages such as cable or breaker under-sized or oversized will be displayed accordingly whenever the student makes a mistake and all the relevant data such as load description, cable specification, etc will also be listed for the student to make the right selection. For each test, in the first attempt, if the answer given by the student is wrong, the relevant formulae will be given. In the second attempt, if the answer is still wrong, VipTein will show the student's wrong answer together with the correct answer. A well-done message will always be prompted whenever the student enters the right answer. To keep the student informed on the performance and status, the student's current cumulated demerit points and the number of outstanding buses are displayed at the beginning of each section. For short circuit analysis, relevant breaker's tripping curves and cable withstand limit are graphically shown. The illustration of the short circuit protection test for DB M1_G is shown in Figure 4. Tools are provided for the student to have an enlarged view on a DB or an overview of the whole project including riser with tap-off and the incoming transformer connection.

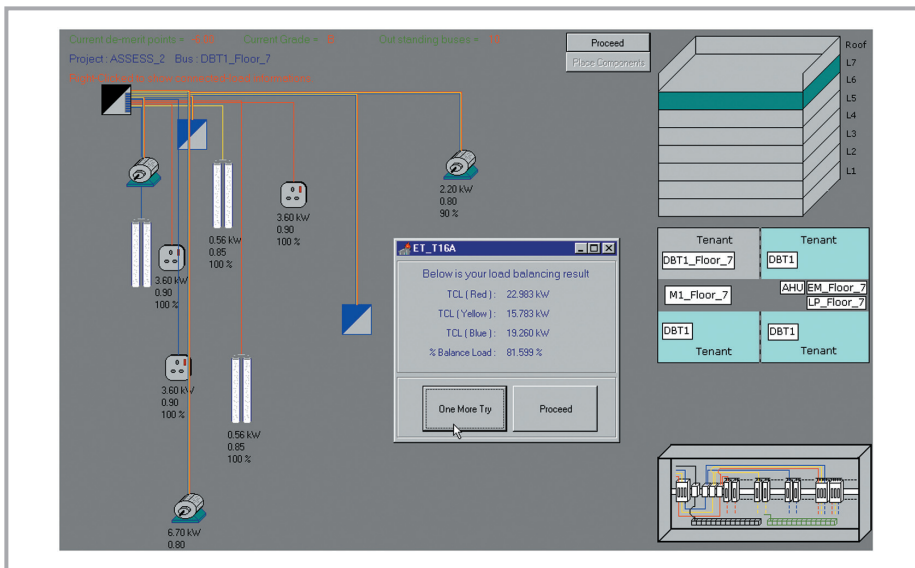


Figure 3: The first attempt of the student's connection and balancing of load

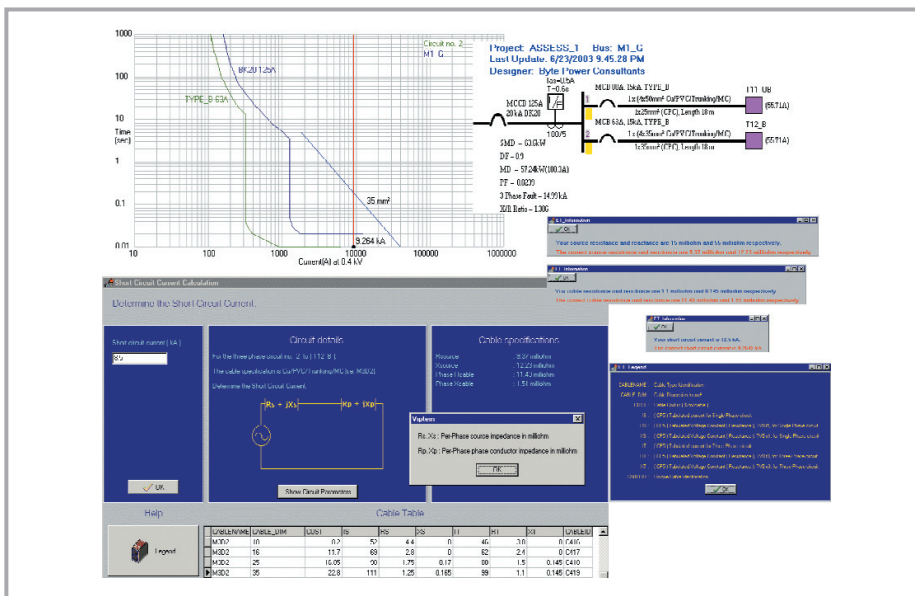


Figure 4: Interactive dialogue of short circuit protection test

FEATURE

5. ASSESSMENT CRITERIA AND GRADING

The evaluation of a trainee's performance focuses on ten categories, namely circuit breaker selection, design current calculation, cable sizing, short circuit analysis, earth fault analysis, motor starting, voltage drop calculation, load connection and load balance. All errors made by the student are logged and evaluated automatically by demerit points. The instructor may adjust the number of demerit points for each type of error and the conversion from the total demerit points to an appropriate grade. The overall score summary is shown in Figure 5 and the illustration of part of the details of each test is shown in Figure 6.

Category	Type of Error	Nos of 1st Attempt	Nos of 2nd Attempt	Demerit Points
1	Circuit Breaker	4	4	-16.00
2	Design Current	5	5	-20.00
3	Cable Sizing	3	3	-12.00
4	Short Circuit Analysis	5	4	-17.00
5	Earth Fault Analysis	6	5	-21.00
6	Motor Starting	3	2	-9.00
7	Voltage Drop	4	2	-10.00
8	Load Connection	10	0	-10.00

Student Name : Zhang Sun
Li Si
Supervisor : A/Prof Teo Cheng Yu
Class / Group : EIS/05

Number of Bonus : 0
Bonus Points : 0
Total Demerit Points : -115.00
Overall Grade : E

Start Date / Time : 8/18/03 10:44:33 AM
End Date / Time : 8/18/03 10:46:55 AM

Figure 5: Overall score summary

Category	Test Level	Error Descriptions	No. of 1st Attempts	No. of 2nd Attempts	Demerit Points
2	T1_1	Design Current	4 (-1)	4 (-3)	-16.00
1	T2_1	Circuit Breaker Specification	3 (-1)	3 (-3)	-12.00
3	T3_1	Tabulated Current, I _{tmin}	1 (-1)	1 (-3)	-4.00
3	T3_2	Cable Sizing	1 (-1)	1 (-3)	-4.00
7	T4_1	Voltage Drop Calculation	2 (-1)	2 (-3)	-8.00
7	T4_2	Voltage Drop Tolerance	2 (-1)	0 (-3)	-2.00
3	T4M_1	Cable Sizing	1 (-1)	1 (-3)	-4.00
4	T5_1	Source Impedance	0 (-1)	0 (-3)	0.00
4	T5_2	Phase Cable Impedance	0 (-1)	0 (-3)	0.00
4	T5_3	Short Circuit Current Calculation	1 (-1)	1 (-3)	-4.00
4	T6_1	Phase Cable Thermal Limit	1 (-1)	1 (-3)	-4.00
4	T6_2	Phase Cable Thermal Limit Tolerance	1 (-1)	0 (-3)	-1.00

Figure 6: Illustration of part of the details of each test

Table 1: Summary of student performance

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Grade	Points	GA	GB	GC	Total
Dist	4	2	8	0	10
A	1 to 3	7	6	8	21
B	0, -1 to -3	5	4	10	19
C	-4 to -8	5	4	4	13
D	-9 to -18	6	2	4	12
E	-19 to -36	2	0	0	2
	27	24	26	77	

6. DYNAMIC INSTRUCTOR CONTROL

VipTein provides built-in features for the instructor to specify a total of 28 tests grouped under 10 categories in a test specification database file. It is also structured according to three main options, namely technical college, polytechnic and university. In each option, the instructor may specify the number and identification of each DB in assess 1 and in assess 2. For each DB, the instructor may specify the desired types of test according to the students' capability. In general, the test file for technical college will be easier and that for university will be more difficult and each could be focused on different categories. To eliminate repetitive

calculation, for some tests that involve a number of steps, the instructor can specify a step number in the test and the system will give the relevant answer of the previous step and jump to the specified steps to test a student. In this way, although the type of building is identical, the scope, duration and depth of study can be dynamically adjusted.

6. CONCLUSION

By using the integrated package VipTein for design exercise, the time taken by the students in the learning and design process is substantially reduced. The built-in dynamic instructor control enables the combination of full design, selective design and automatic design. Thus, it eliminates routine and repetitive design exercises and also accelerates the design and learning process. The built-in automatic marking mechanism is not only effective and fair but enables the students to know exactly the mistakes made. At NTU, VipCoda and VipTein are used to support a final year design class and the summary of student performance of a total of 77 students divided to three batches is shown in Table 1. ■

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