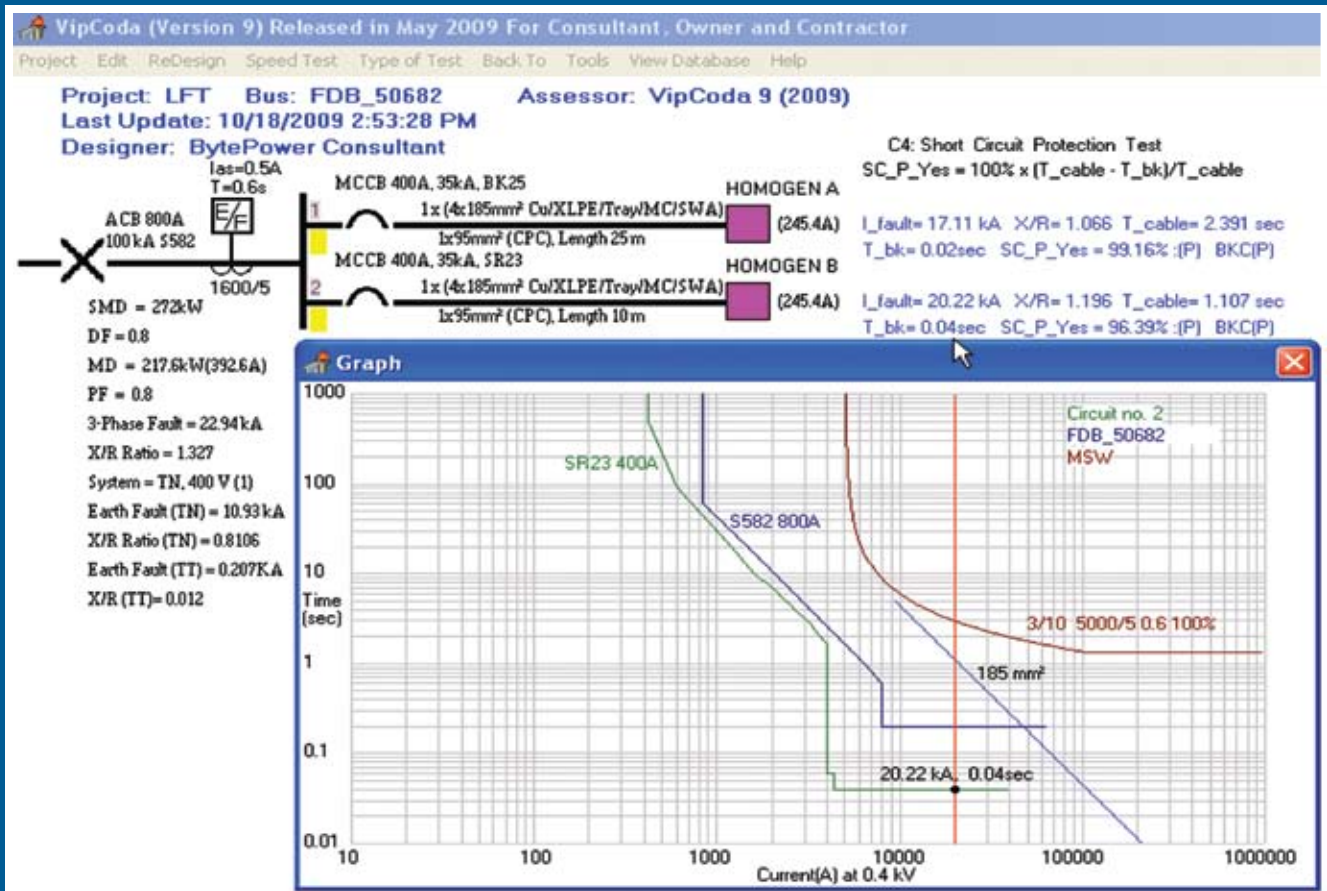
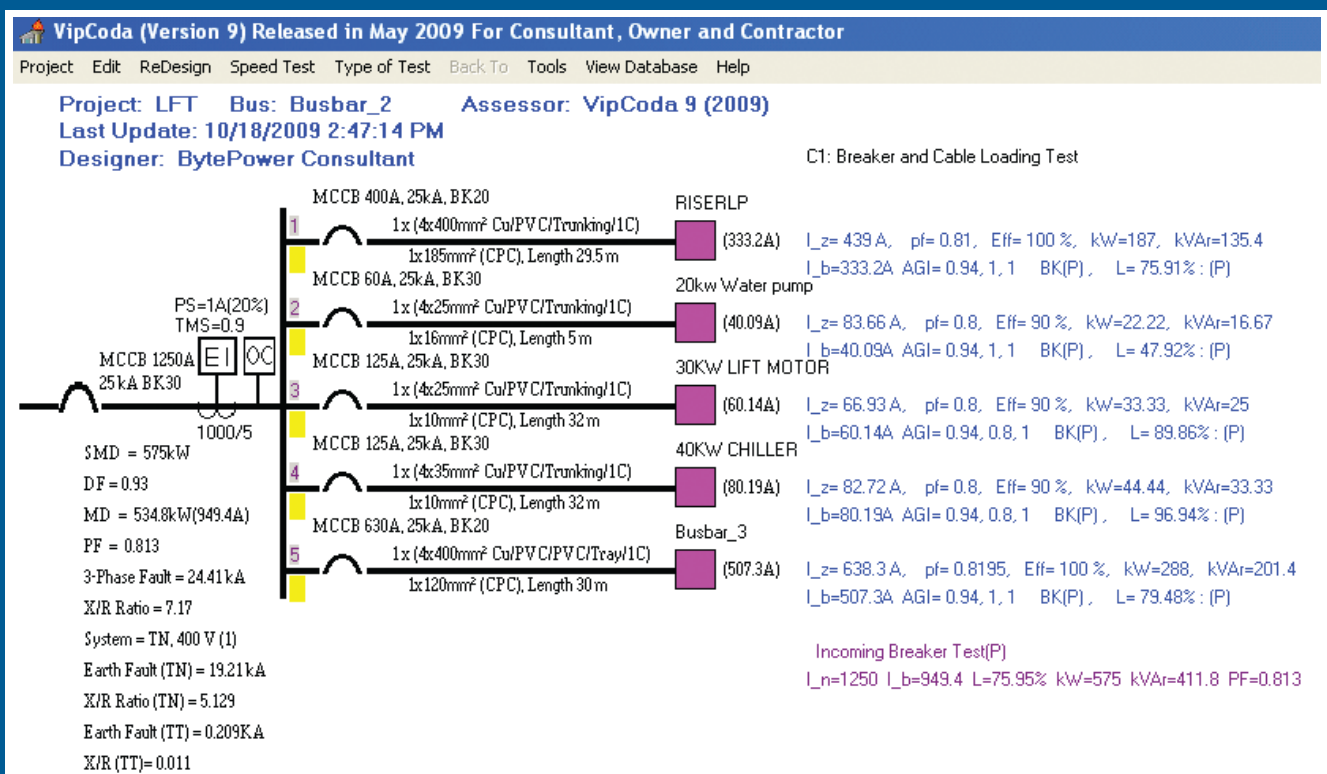


# VipCoda

## Visually Interactive Program for Consultant and Owner to Design and Assess Electrical Systems in Buildings



Graphical display of the short-circuit protection test showing 20 kA at circuit 2, and 1.1 sec for 185 mm<sup>2</sup> cable withstand limit with the operating times of circuit 2 at 0.04 sec and its upstream breakers at 0.2 and 3 sec.



Tabulation of design current ( $I_b$ ), circuit rating ( $I_z$ ), connected load (kW, pf, kvar), ambient, grouping and thermal correction factors (A, G, I), and circuit loading % (L) at design condition for each circuit.

By utilizing the visually interactive window programming technique and facilities on database access, VipCoda provides an user friendly, visually interactive tool to automate the design process producing a sound and reliable design which meets the code of practice of CP5 (1998) and BS 7671:1992 (IEE wiring regulations, 16th Edition). VipCoda can also be used to automatically assess and evaluate any submitted electrical network systematically within a short time. By utilizing the built-in database structure, all the design assumptions are automatically documented and stored together with the completed design network. Thus, it is also a comprehensive tool for training and upgrading engineers on how to design and assess an electrical network.

The completed design including all the technical parameters can be displayed and viewed in exactly the same presentation as reading a single-line diagram generated by AutoCAD. In addition, the calculated fault level and the cumulative voltage drops from the main incoming circuit up to each final circuit are graphically displayed. Facilities are provided to simulate the normal loading, overloading, short circuit and earth fault conditions. A result of pass or fail will be given by assessing through seven critical tests and three non-critical tests. A full explanation as to why, how and by how much the design fails will also be included.

## 1 Computer-aided Interactive Design

The user may carry out the design work in any sequence starting from a main switchboard (MSW), a main distribution board (MDB) or a final distribution board (FDB). Built-in facilities are provided for the user to link the complete network by backward chaining from FDB, MDB to MSW, or a forward chaining from MSW, MDB to FDB. For each circuit, based on the user's specification on the required type of load and power rating, type of cable, circuit length, correction factors, and fault level etc, the program automates the design process and shows the appropriate breaker and cable including CPC in a single line diagram. Through built-in rules, the automated design done by VipCoda will ensure that it meets the code of practice and passes the seven critical tests. In addition, it is a unique and minimum design that meets the specifications.

The user may simply click on the single line diagram to change a breaker or a cable in any circuit, or to enter a given design done by a contractor. The user may click the 'speed test' button to obtain summaries of those tests that have detected failure. The user may then click for a particular test to find out the cause of failure or click the 'redesign' button to carry out a redesign by VipCoda for one particular circuit, the whole DB or the entire project to automatically rectify all the design errors. Options are provided for load balancing either manually or automatically.

Facilities are provided for the user to list or print a technical summary or a cost summary of the whole project. In the technical summary, all the DBs in the specified project are tabulated together with the maximum demand, fault current, earth fault current and the cumulative voltage drop at each DB. For cost summary, the cost for each DB and the total cost of the whole project are listed with breakdown in cable and breaker costs. Tools are also provided for the user to delete or insert a circuit, copy a DB to a project or create a project

by modifying from a list of standard projects or previously completed projects. Utilities are also provided for the user to print the single-line diagram of a particular DB with or without the result of the simulation test for each circuit.

## 2 Assessment by Simulation

To assess whether the given design meets adequately the code of practice, seven types of critical tests and two types of non-critical tests are conducted for each circuit in each DB under normal loading, overloading, short-circuit and earth fault conditions.

Breaker and Cable Load Test. Compute design current ( $I_B$ ) and the rated circuit capacity ( $I_Z$ ) by considering the ambient temperature and grouping factor. Based on the current rating of the protective device ( $I_N$ ), detect whether  $I_N > I_B$  and  $I_Z > I_B$ . Compute the circuit loading in percentage of the rated capacity under the specified conditions.

Overload Protection Test. Increase the load current in each circuit to 145% of the rated circuit capacity ( $I_Z$ ) and model the operating time of the protective device. Detect whether the operating time of the protective device is less than the effective operating time of 2 hours. ( i.e.  $I_2 < 1.45 I_Z$  and  $I_N < I_Z$ ).

Voltage Drop Test. Calculate the voltage drops in volts and in percentage of the rated operating voltage. Check whether the voltage drop is within the specified voltage drop tolerance.

Short-circuit Protection Test. Calculate the 3-phase short-circuit current at the end of each circuit. Check whether the breaking capacity of the protective device is higher than the calculated short-circuit current at point of installation. Calculate the operating time of the protective device under the fault condition. Detect whether the circuit will be disconnected within the critical time, which is the maximum allowable time in seconds to ensure that the temperature in the conductor will not exceed its thermal limit resulting in a failure in insulation material.

Earth Fault and CPC Test. Calculate the earth fault current at end of each circuit. Detect whether the size of each circuit protective conductor (CPC) is adequate to withstand the earth fault current until the operation of the protective device.

Motor Starting Test. Based on the specified type of starter and the motor rating, calculate the motor starting current. Model the operating time of the protective device and detect whether the protective device will trip during the starting period. Based on the circuit impedance and the source impedance, calculate the transient voltage dips at the instant when the motor starts to ensure that the stator is stable and the motor can be started.

Electric Shock Protection Test. Calculate the earth fault current and the touch voltage at the end of each circuit. Based on the IEE regulations and solely based on the direct acting overcurrent protective device, check whether the touch voltage is less than 50 V and whether the disconnection time is less than 5 s for a TT system. For a TN system, the earth fault loop impedance is calculated and a check is made to detect whether the disconnection time is less than 0.4 s for hand-held

equipment and 5 s for fixed equipment. If the direct acting overcurrent protective device fails to provide the requirements for electric shock protection, 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 CT ratio, time and current settings of the device. The user will be prompted to specify new settings until the requirement on electric shock protection is met.

## 3 Design Element Database

All the cable tables given in the IEE wiring regulation and CP5 (1998) are structurally stored in the cable database grouped according to the conductor material, insulation material, and cable construction and installation methods. In addition, fire resistant cables and busways are also represented. Currently, eight types of cables, namely copper PVC, copper MICC, aluminum PVC, aluminum XLPE, copper XLPE, copper fire resistant, copper busway and aluminum busway are available in 970 records. The installation methods include clipped direct, conduit/trunking, cable ladder and tray for single-core non-armored, multi-core non-armored, single-core armored and multi-core-armored cables. All the cables can be interactively selected from a number of simple dialogue boxes and built-in facilities are provided for the user to have a speed search for all CP5/IEE cable tables.

Five types of overcurrent protective device, namely ACB, MCCB, MCB, RCCB and fuse are represented. The complete range of the preferred rated current and breaking capacity from the relevant BS and IEC standard are included in a total of 106 records. Four types of typical time-current characteristic curves for direct-acting breaker are modeled. In addition, overcurrent and earth fault relays by IDMT (3/10, 1.3/10, VI and EI), DTL, ELR and RCCB are all included.

## 4 Project Database

Through a number of built-in facilities, the successfully designed network of a project is automatically saved to a project database. This database contains the description of all the switchboards and DBs of the whole project in an automatically arranged structure. For each project, the design assumption, specification and the completed design database files are created and stored in a sub-folder. The name of the sub-folder is made identical to the name of project. Built-in editing facilities are provided for the user to view or edit the project database, design element database or lookup tables that contain the design rules and design assumptions.

## 5 Visual User Interface

VipCoda utilizes 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. The user may simply click a load icon to view the detailed load information, click a circuit icon to view or change the type of cable, temperature correction and grouping factor or click a breaker icon to re-specify the type of breaker or its tripping curve. Tools are provided for the user to have an enlarged

view on a DB or an overview of the whole project including incoming transformer connection, riser with tap-off units.

## 6 Benchmark Project

For verification and confirmation that the design process done by VipCoda is accurate, three benchmark projects are thus created together with all the specifications, assumption and load information. In the three benchmark projects, based on the specification and load requirements, the design is done both manually and by VipCoda. The completed design done by VipCoda represents the unique solution that meets all the given design requirements and specifications, and at the same time there is no over-design in any circuit. Thus the completed benchmark projects given by VipCoda can be used as a reference to compare a design done manually or by using any other computer aided design program.

## 7 Related Publications

- Teo C Y, "A new integrated tool for exercises on the design of electrical installations using a microcomputer", Electric Power Systems Research, Vol. 36, No. 1 PP 81-91, 1996.
- Teo C Y, "Computer aided design and simulation of low voltage electrical distribution systems", Computers in Industry, Vol. 34, No. 1, PP 87-94, 1997.
- Teo C Y, Shen Feng, "Application of artificial intelligence in the design of low voltage electrical system", Proceeding of the 2000 IEEE Winter Meeting, pp 1784-1789, Vol. 3, 2000.
- Teo C Y, "An innovative program for the design and assessment of electrical system in buildings", IEM Bulletin, pp 46-49, 2001.
- Teo C Y, "Integrated Assessment of Electrical Systems in Buildings Through Simulation Tests", The Singapore Engineers, pp 27-32, 2003.
- Teo C Y, : Visually Interactive Package for the teaching of electrical network in buildings", IEM Bulletin, pp 26-30, 2006.
- Teo Cheng Yu, "Teaching of Power Engineering through E-learning with Laboratory Automated Assessment", International Conference on Engineering and Education, March 2009.

## 8 How to Order

Send purchase order by e-mail to [cyteo@ntu.edu.sg](mailto:cyteo@ntu.edu.sg), or by call to (65) 6256 0101 for details.



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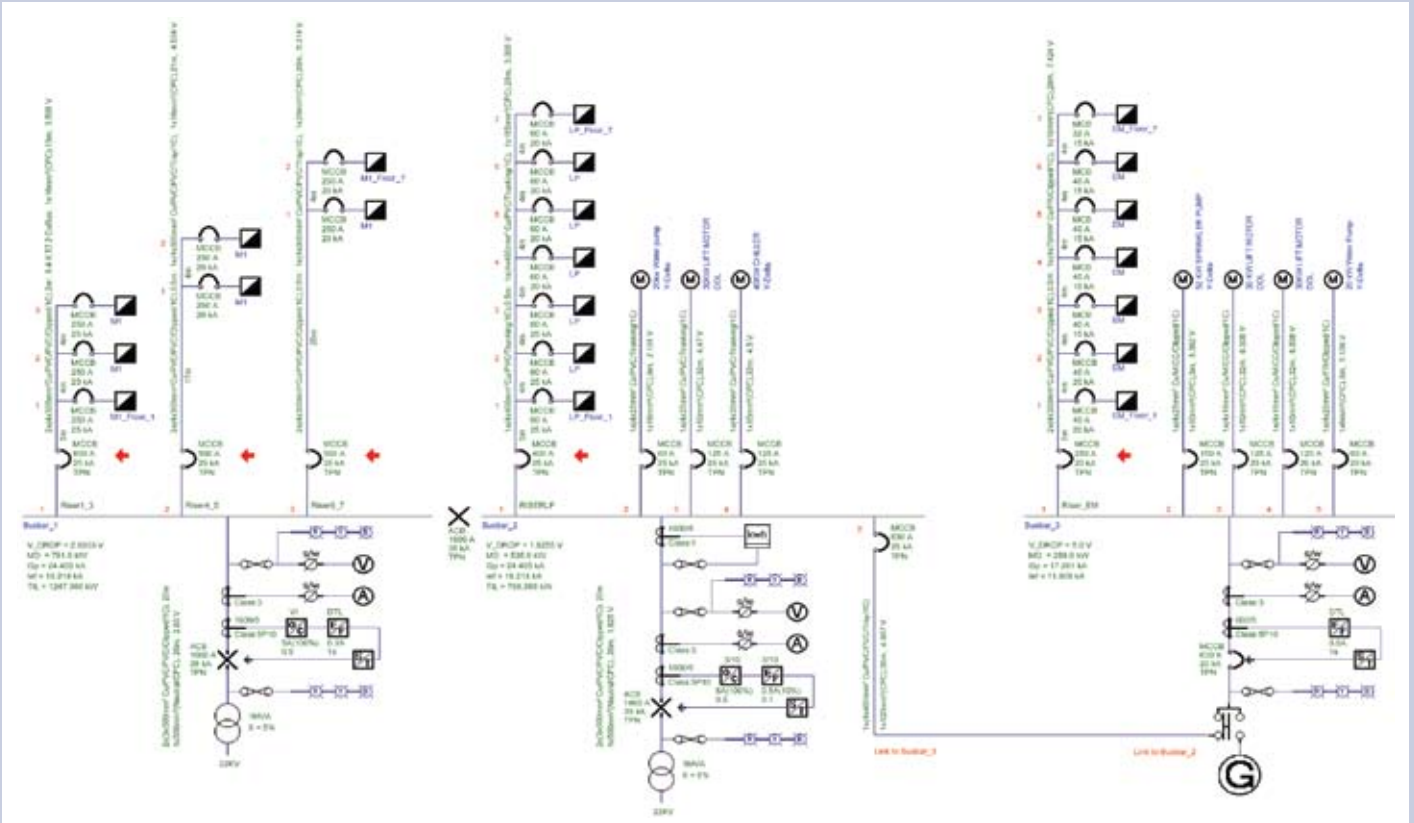
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Auto-generated overview of the completed project LFT for two HT incomings and one generator.

### Auto-Generated Technical Summary for Project LFT

BUS_ID	Max Demand (kW)	TP_Fault (kA)	E_Fault (TN) (kA)	E_Fault (TT) (kA)	Volt_Drop (V)	Volt_Drop Check	Critical Tests Check
Busbar_1	781	24.41	19.21	0.21	2.63	PASS	PASS
Busbar_2	535	24.41	19.21	0.21	1.82	PASS	FAIL*
Riser1_3	364	24.41	19.21	0.21	2.63	PASS	PASS
Busbar_3	288	17.26	11.91	0.21	4.96	PASS	FAIL
Riser4_5	238	24.41	19.21	0.21	2.63	PASS	PASS
Riser6_7	238	24.41	19.21	0.21	2.63	PASS	PASS
RISERLP	187	24.41	19.21	0.21	1.82	PASS	PASS
Riser_EM	141	17.26	11.91	0.21	4.96	PASS	PASS
M1	135	15.81	3.45	0.20	4.76	PASS	PASS
M1_Floor_7	135	15.21	3.24	0.20	6.05	PASS	PASS
M1_Floor_1	135	17.88	2.65	0.20	4.53	PASS	PASS
DBT1_Floor_7	44	5.91	0.82	0.17	9.63	PASS	PASS
DBT1_Floor_1	44	6.16	0.97	0.17	8.12	PASS	PASS
LP	32	10.94	5.85	0.20	3.63	PASS	PASS
LP_Floor_1	32	12.47	6.81	0.20	3.33	PASS	PASS
LP_Floor_7	32	10.67	5.69	0.20	4.39	PASS	PASS
EM	20	4.72	0.97	0.17	7.26	PASS	PASS
EM_Floor_1	20	7.96	1.24	0.18	6.76	PASS	PASS
EM_Floor_7	19	3.42	0.89	0.17	9.86	FAIL#	PASS

# A fail in volt\_drop check for EM\_Floor\_7 indicates that although the voltage drop to this DB is 9.86 V, there is at least one outgoing circuit that the voltage drop exceeds 4%.

\* A fail in critical tests check for Busbar\_2 indicates that this Bus\_ID fails at least one of the 7 critical tests.