International Journal of Smart Grid and Clean Energy

Estimation program and load test for low-voltage main distribution board

Bancha Sreewirote[a], Chaichan Pothisarn[b]

[a]*Department of Electrical Engineering, Faculty of Engineering Thonburi University, Bangkok, Thailand*
[b]*Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand*

Abstract

There is a lot electrical equipment installed in the main distribution board (MDB) and there will be tested by electrical power. Thus, if the fault takes place during the implementation, the equipment will be damaged. As the MDB is always active and high cost, it needs to be tested before the supply of actual electrical power. In this paper, a program that helps to estimate a low voltage MDB is created, being able to operate by general estimator. The Visual Basic software is used as an interface program while the Microsoft Access is taken into consideration to be databases. After that, the load test for the MDB testing before delivering electrical power is designed, which is based on a small dimension, low cost and flexibility to use. Results indicate that the designed program can help users to easily estimate price of the MDB. Additionally, it also provides information that users can observe the overview and components of the designed MDB. The designed load test can be used in various application and provide as efficiency as a large load test.

Keywords: Load test, main distribution board, cost estimation

1. Introduction

Currently, main distribution board (MDB) manufacturing industry have been widespread in Thailand. The competition in terms of production time to deliver goods to customers in a short period. In addition, a producer lacks expertise in understanding single line diagram and wiring. As a result, the quality of the MDB is reduced. The most common problem is wrong equipment operation when power is supplied to the MDB. For instance, a digital meter shows mistake values and a ventilation system does not work according to the set temperature value.

A low voltage MDB comprises the equipment of circuit breakers, meters, controllers, protection devices, bus bars, and so on, which are housed inside an enclosure. The purpose of the MDB is to control and cut all electrical circuits connected with it; this is an important and high cost segment. In order to estimate the price for the MDB, the accuracy and reliability as well as proper price are needed for the process of estimation. Thus, the estimation is based on the knowledge and experience of an estimator. For this reason, the ability of software that are accurate, fast processing, and convenient plays an important role to assist the estimator in work effectively.

The paper [1] tests rise temperature in the elevated temperature of distribution board. The temperatures and the rise values are observed till thermal balance of the distribution board is obtained. In the paper [2], the analysis of electronic switching which has an influence on the distribution board at the bus-bar is proposed. Additionally, the measurements switching power electronic loads causing reactive power flow on the bus-bar are studied. Next, the paper [3] has an objective to estimate the risk of experiencing stability loss at a bus bar of an electrical power grid. The used technique is based on monitoring current power flow at the bus bar of the power grid. Both simulations and experiments in a real power system are

* Manuscript received November 5, 2018; revised September 7, 2019.
Corresponding author. *E-mail address*: srbancha7@gmail.com.
doi: 10.12720/sgce.8.6.740-746

used to confirm the results. There are some errors showed in watt-hour meter standards that used in a main distribution board. To reduce these errors, test procedures and equipment are presented in paper [4]. Its aim is to stabilize and eliminate all conditions which might influence on the errors.

The repair and testing of electricity meters in the MDB in order to get rid of errors are presented in [5]. For circuit breaker used in the MDB, this document [6] provides information that can be used by who design power systems and purchase, install or maintain molded case circuit breakers in industrial applications. The paper [7] presents installation and handover test of an insulated tubular bus bar in the MDB. A depth analysis all segments of the field installation approach is used to find out the possible faults during the installation.

Load testing supports user to analyse the performance of the system under heavy load or no load. There are many research articles discussing about load teasing [8-12]. In order to test uninterruptible power supply (UPS) with nonlinear load which is convenient and expand the testing range, paper [8] investigates the theory and structure of the wide range automatic adjustable nonlinear load. Next, the development and application of a software to automatically analyse and test generation for mixed signal and RF circuits on Device Interface Boards (DIB) with a low cost are presented in [9]. The software uses the data of DIBs to generate tests for components and interconnectivity on the DIB. Paper [10] presents exponential static load model as industrial and residential loads to test the effect of voltage when power system dynamic stability carried out over the power system. Paper [11] employs fuzzy algorithm and binary algorithm to regulate the dry resistor-load and explains the realization of the fuzzy and binary algorithm. The comparison of different load testing tools: Apache JMeter, HP LoadRunner, Microsoft Visual Studio, Siege based on certain criteria, is dealt with in [12] in order to fine which tool is best and more efficient.

The MDB comprises many parts of electric devices, which are used electrical power to test them. If there is fault occurrence in the system, the equipment inside the MDB will be damaged. Furthermore, most of the equipment in the MDB is always active. Thus, it necessaries to be test before actual operation. However, the most of MDB tests in factory is conducted by only suppling voltage and the three-phase current generation is large and expensive. This paper proposes a program used to estimate price of the low voltage MDB for users and designs a load test for examining the MDB operation before it is supplied by actual electrical power. The proposed load test is designing to be a small dimension, cheap, and convenient movement for the most efficient utilization. The paper is organized as follows. Section 2 discusses the main distribution board estimation. Then, the experiment of load test is proposed in Section 3. Section 4 concludes the paper.

2. The Main Distribution Board Estimation

A software used to develop the price estimation of a low voltage MDB is divided into two parts: the program and database. The Visual Basic is carried out to be the program's interface. The Microsoft access software is used to write the database, i.e. bus-bars, circuit breakers, meters as well as steel sheets used to make cabinets, by using basic language to process, because it is easy to record data and present a report. The data in database is consisted of text and number. The former is the data that not use to calculate such as a brand and a rated device, while the latter is the data used to calculate such as a price.

The database of this program contains the following information.

1. Assembly: the number of steel sheets used to make a cabinet including the size of them.
2. ATS: databases and cost of switches and controller.
3. Cap: databases of all capacitor equipment in the capacitor cabinet.
    - 3.1 Cap: data and prices of capacitors.
    - 3.2 Mag: data and prices of magnetic contactors.
    - 3.3 Hrc: data and prices of HRC fuses.
    - 3.4 Pfcontroller: data and prices of power factor controllers.
4. Circuit Breaker: data and prices of circuit breakers.
5. CT: data and prices of current transformers.

6. Metering: data and prices of meters.

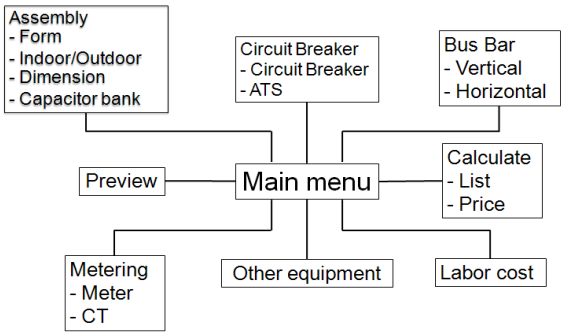


Fig. 1. The diagram of databases within the designed program.

Fig. 2. The Main menu of the designed program.

Fig. 1 shows the diagram of databases within the designed program. It can be found that all parts of the designed program will be connected to the Main menu which has the interface icon as displayed in Fig. 2.

In Fig. 2, the main menu consists of eight sub-icons, which are links to the designed program.

- Assembly is linked to the section of cabinet and capacitor cabinet.
- Circuit breaker is linked to the section of circuit breakers, transfer switches, and controllers.
- Metering is linked to the section of meters and current transformers.
- Busbar is linked to the calculation section of copper bars.
- Other is linked to the prices of devices that do not contain within the application.
- Labour cost is linked to the section of wages.
- Preview is linked to the section of the cabinet preview.
- Calculate price is linked to the estimated price of the cabinet, and display the lists of selected items.

Fig. 3 shows all selected equipment to design the MDB. The details of each equipment used to build the MDB including size and quantity are also illustrated. The Solidwork software is used to create the switchboard's 3D models including all equipment in database that users can observe the overview and components of the designed MDB. The main components used in the MDB such as enclosures, bus bars, circuit breakers, meters, and so on are displayed in the Preview section as shown Fig. 4.

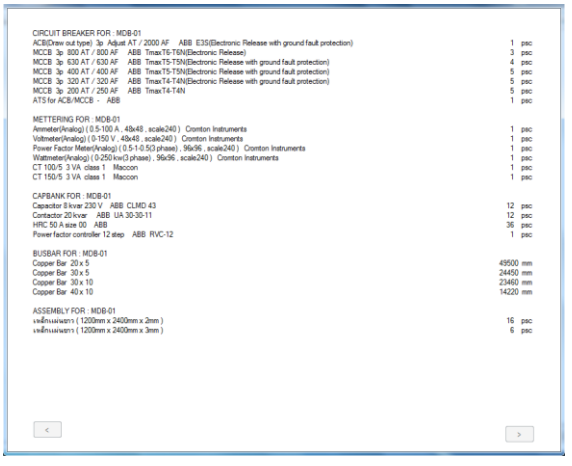


Fig. 3. The final list of the designed program.

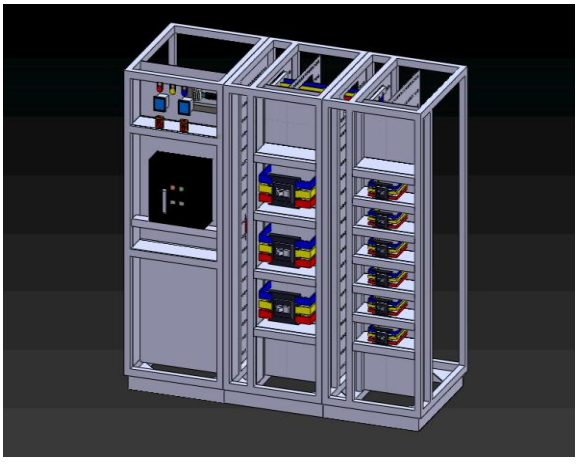


Fig. 4. The Preview in the calculation price section of a designed MDB.

3. The Experiment of Load Test

The load test is designed for the size of three phases, 70 A as shown in Fig. 5. The motor of 1,500 W is used to be a ventilation system in the switchboard cabinet when the temperature value observed by the thermostat is higher than the default value. The heater of 3,500 w is selected to be the load of the load test. In the design, we use five heater sets. Thus, the load test is divided into five levels by using selector switch to energize the heater load in each step. The components of the load test consist of a digital meter, bus bars, a thermostat, pilot LED lamps, current transformers, and selector switch as shown the detail in Table 1.

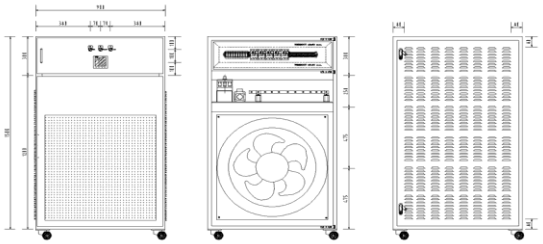
Table 1. The equipment of the proposed load test.

Equipment	**Description**
Digital meter 	The basic instrument used is a voltmeter and an ammeter which are connected to a selector switch to measure voltage or current in each phase.
Bus bar 	The bus bar of 15 x 7 mm. is used to conduct electricity within the load test. It allows heat to be released quickly because of its relatively large surface area.
Thermostat 	Thermostat is a high temperature protection device, which uses to cut off all operating systems to prevent fire.
Pilot LED lamp 	Pilot LED lamp of 220 V is used to display the status of the load test.
Current transformer 	Current transformer (CT) of 600/6 A is used to measure current with a digital meter. It produces a current in its secondary which is proportional to the current in its primary.

Selector switch 	Selector switch is used with CT and a panel ammeter to measure the current. The voltmeter selector switch is used with a panel voltmeter to measure the voltage.

In order to test the MDB, the wire of the designed test load is connected to the bus bars of the MDB. After that, the electrical power is supplying to check electrical parameters: current, voltage, and active power during the MDP operated.

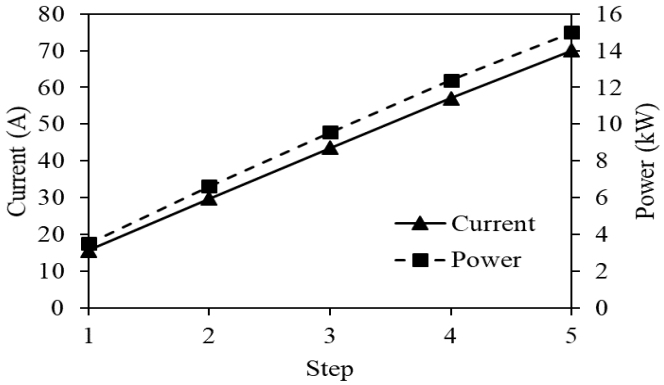
(a) hardware



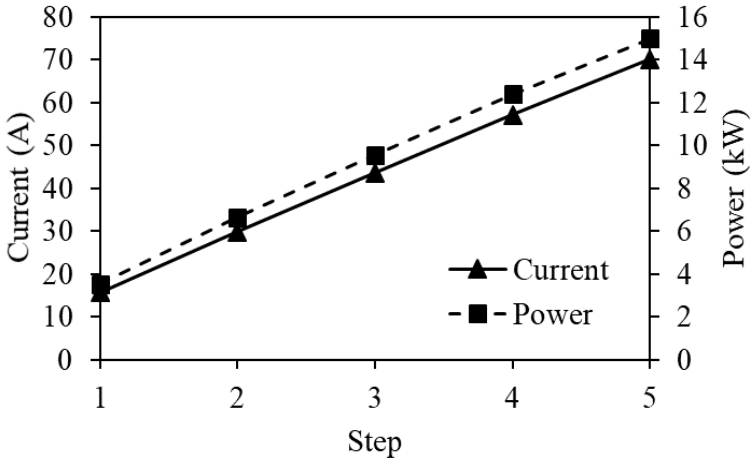
(b) layout

Fig. 5. The designed load test.

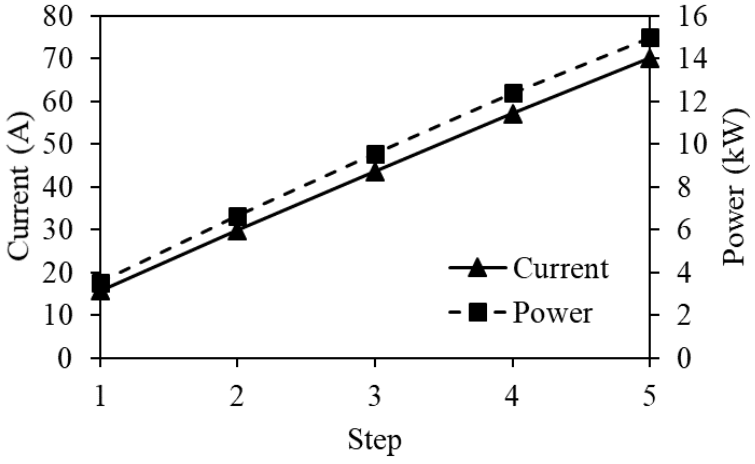
Experimental results of the load test with actual MDB are implemented with different load conditions. The purpose is to develop and test the load test before the actual power supply. In order to test the designed load test operation, three MDB which are the MDB of 1,600 A, the MDB of 800 A, and the MDB of 630 A, are selected. In addition, this process is carried out by the voltage of 220 V. The test load is adjusted to be five steps: 3.5 kW, 6.5 kW, 9.5 kW, 12.5 kW, and 15 kW respectively, to test the system operation. Test results of current and active power in each a step of the load test operation are shown in Fig. 6. The results show that the load test can work effectively, providing accurate the parameter values of voltage, current, and active power in each step. The load test can apply to various MDB sizes with high efficiency; it can use for 70 A maximum current with the test reactive power of 15 kW. However, the measurement from the digital meter may have slightly error, taking place from measurement error.



(a) The MDB of 1,600 A



(b) The MDB of 800 A



(c) The MDB of 630 A

Fig. 6. Results of the designed load test with the various MDB.

4. Conclusions

The designed program can help users to easily estimate price of the MDB. Additionally, it also provides information that users can observe the overview and components of the designed MDB. The main components used in the MDB such as enclosures, bus bars, circuit breakers, meters, and so on. After that, the program will show the price of these devices. The cost of labor, shipping, profit and taxes are combined with the device price to be the net price of the designed MDB. If the items in the designed MDB are changed, it can back to edit them easily. From using the designed estimation program, it is found that the price of the MDB is directly depend on circuit breakers and bus bars. Thus, they will determine the price of the MDB to be different.

The designed load test can be used in various application and provide as efficiency as a large load test. From experimental results, the designed load test gives accurate current and active power while it is used to test the MDB. The current and active power obtained in the experimental show similar responses to various case study, since the used load test is relatively stable.

Acknowledgements

The authors wish to gratefully acknowledge financial support for this research from Faculty of Engineering Thonburi University Research fund, Thailand.

References

[1] Viswanatha C, Vittal GP., and Babu VM. Temperature rise test effect of elevated temperature on 2500 Amps low voltage distribution board. *2014 6th IEEE Power India International Conference (PIICON)*, Delhi, 2014; 1-4.

[2] Lopes GN, Finazzi AP, Vasconsellos AB, Santilio FP, Silva RPB. and Carvalho TIR. The influence of electronic loads switching in the reactive flow of a bus bar. *2016 17th International Conference on Harmonics and Quality of Power (ICHQP)*, Belo Horizonte, 2016: 925-930.

[3] Lorenzen H, Timmerberg J, and Mylvaganam S. Risk assessment of stability loss: Experimental investigations of weak bus bars. *2016 12th IEEE International Symposium on Electronics and Telecommunications (ISETC)*, Timisoara, 2016, pp. 281-284.

[4] Levitsky FJ. A test board for watt-hour meter standards. *in Electrical Engineering*, July 1955; 74(7): 605-605.

[5] Kowol J. Technology, measuring methods and measuring equipment for the repair and testing of electricity meters at a test board of a power supply enterprise. *Sixth International Conference on Metering Apparatus and Tariffs for Electricity Supply 1990*, Manchester, 1990; 241-244.

[6] IEEE Approved Draft Recommended Practice for the Selection, Field Testing, and Life Expectancy of Molded Case Circuit Breakers for Industrial Applications," *in IEEE P1458/D8*, June 2017, vol., no., pp.1-86, Jan. 1 2017

[7] Sirui Z, Ling R, Xiang R, Wenpei L, and Bin X. Research on the defects in the field installation of insulated tubular bus-bar and its test method. *2017 20th International Conference on Electrical Machines and Systems (ICEMS)*, Sydney, NSW, 2017; 1-5.

[8] Shuming L, Bolong S. Yi, Zhen M. L., and Hailong S. Application of benchmark nonlinear load in UPS power supply testing. *2017 13th IEEE International Conference on Electronic Measurement & Instruments (ICEMI)*, Yangzhou, 2017, pp. 216-220.

[9] Kannan S and Kim BC. Automatic diagnostic tool for Analog-Mixed Signal and RF load boards. *2009 International Test Conference*, Austin, TX, 2009: 1-1.

[10] Aguero JL, Barbieri MB, and Beroqui MC. Voltage depending load models. Validation by voltage step tests. *2006 IEEE Power Engineering Society General Meeting*, Montreal, Que., 2006; 6

[11] Tang CQ, Mo YM, and Zhou W. Application of fuzzy and binary algorithm to regulation of load in locomotive load test. *2011 Second International Conference on Mechanic Automation and Control Engineering*, Hohhot, 2011; 96-99.

[12] Abbas R, Sultan Z, and Bhatti SN. Comparative analysis of automated load testing tools: Apache JMeter, Microsoft Visual Studio (TFS), LoadRunner, Siege. *2017 International Conference on Communication Technologies (ComTech)*, Rawalpindi, 2017; 39-44.