

Determination of Bank Capacitor Size as Power Factor Improvement in Inductive Loads Using Lab View Interface

Donny Dupang Sitorus, A. Tossin Alamsyah and Asrizal Tatang
Electrical Engineering Department State Polytechnic of Jakarta Jakarta, Indonesia

Keywords: Labview, Capacitor Bank, KHA, MCCB.

Abstract: The development of the housing, hotel, and mall sectors has resulted in an ever-increasing demand for electrical energy. Therefore, the electrical energy distribution is fast, precise, and accurate. Calculating the quality of the power factor, conductors, and safety is necessary. This is because it involves the reliability of the system. The quality of the power factor must be maintained by the standards given by PLN to reduce the cost of electric power used, increase system capacity, increase voltage, and reduce losses to the system. Calculating the KHA is also essential to make it easier to determine the cross-sectional area of the cable that will be used correctly, safely, and by predetermined standards. At the same time, calculating the magnitude of the breaker capacity is essential for safety and the current breaker when there is a short circuit (short circuit) or overload (overload), which can cause damage to the electric motor and fire due to sparks. In this study, we will design and calculate the value of the capacitor bank, the calculation of the value of the cable KHA, and the capacity of the MCC breaker using the LabVIEW interface so that it can make it easier for the industry to do calculations quickly just by entering load data.

1 INTRODUCTION

Electrical energy is one of the most vital energy roles in everyday life. This fact triggers the demand for electrical energy from year to year to increase with the development of the housing sector, hotels, malls, and so on. This increase must be followed by a good and efficient distribution of electrical energy to obtain electrical energy with high continuity of supply (E. Ridwan, M. I. Arsyad, A. Razikin, 2018).

In Indonesia, electric power consumers comprise various groups ranging from households to businesses to industries. This load variation causes fluctuations in the power quality of distribution network buses. Power quality is determined by the bus's high and low power factors. The decrease in the value of the PF power factor ($\cos\phi$) is a problem that must be minimized. Because with a decrease in PF, consumers and suppliers of electrical energy will experience losses (B. S. Fauzan, F. Danang Wijaya,). For consumers, the disadvantages include decreased system voltage, and the electric power supply cannot be maximized. The factor that affects the decrease in PF is the use of inductive loads. The problem is the low power quality caused by inductive loads (Lisiani, A. Razikin, and Syaifurrahman, 2020). The inductive

load is a type of load with a wire wound element. An increase in inductive load results in an increase in the use of reactive power, which affects the quality of electric power, especially the power factor. The comparison between active power (W) and visible power (VA) will result in a low PF power factor ($\cos\phi$) as a result of the use of inductive loads (A. Dani and M. Hasanuddin, (2014)).

One of the efforts made to reduce reactive power due to using inductive loads is to compensate for reactive power (V.B.Rizqiya, (2019)). The reactive power compensation will reduce the inductive load's reactive power (S. T. Listrik,). Bank capacitors are capacitive loads that can reduce reactive power in inductive loads (A. B. Ar Rahman, (2017)). So the use of capacitor banks as reactive power compensators can correct poor power factors in the load so that the use of electrical power to the needs of the load is more appropriate.

The correct cable selection also needs to be considered because it functions to see the smooth distribution of electrical energy from the source to the load, (S. A. Gunawan (2000)). To ensure the system is safe, a breaker is also required. Breakers such as MCCB function as safety and current breaker when

there is a short circuit (short circuit) or overload (overload), (W. P. Azhari, 2019).

Therefore, the calculation of capacitor banks, cable calculations, and efficient safety are needed to maintain the quality of the power produced for consumers. This research will focus on developing an interface using LabView for this calculation so that it will make it easier for developers to perform calculations for the needs of the power system system.

2 METHODS

2.1 Capacitor Bank

Capacitor banks are used to improve the power factor in a system by entering reactive power into the system (V. B. Rizqiya, 2019). The capacity of the capacitor entered into the system depends on the VAR requirement. Calculation of the need for compensation VAR can be calculated using the formula (P. Kebutuhan and K. Daya, 2006)

$$Q_1 = P. (\tan(\cos^{-1} x_1) - \tan(\cos^{-1} x_2)) \quad (1)$$

Keterangan:

P = Active power

X₁ = initial power factor value

X₂ = target power factor value

At this stage, several steps must be taken to determine the value of the capacitor bank to improve the PF value. Before looking for the PF value, the first thing to do is to record or measure the existing PF of a plan. After knowing the PF value and power, determine how much new PF you want so that the system is much better than before. Several inputs must be known so the system can work automatically for the desired PF repair. We can see in the LabVIEW display in Figure 2 below.

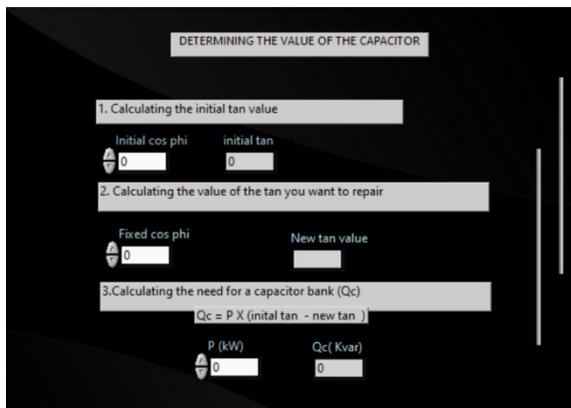


Figure 1: Interface image of the stages of determining the value of the capacitor.

From Figure 1 above, we can understand that several output options are presented to calculate the value of the capacitor bank and how many sizes of capacitor capacity are needed to meet the installed capacitor bank.

2.2 Determining the Cable Size

In determining the cable type, you must first consider the current-carrying strength (KHA) that will pass through the cable. After the KHA value has been determined, it will be compared with the PUIL 2000 standard to determine the required cross-sectional area. The following is the calculation of CRC based on the rules in PUIL 2000:

$$KHA = 125\% \times FLA \quad (2)$$

where:

KHA: Strong Current Conduct

FLA: Full Load Ampere

Moreover, the calculation of the correction factor on the attached cable is as follows:

$$Ib = \frac{ib}{(k1 \times k2)} \quad (3)$$

Ib = Load current (A)

K1 = Room temperature correction factor

K2 = Group reduction correction factor

At this stage, the interface is made for calculating the cable size in LabVIEW. Input in power and voltage, power factor, and current. The LabVIEW program will perform calculations automatically based on the input so that the value of KHA is obtained. After obtaining the KHA value, the cable size selection is based on the datasheet available in LabVIEW.

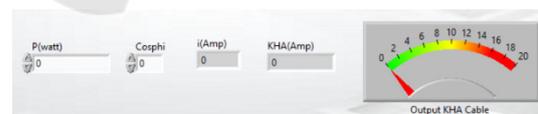


Figure 2: Initial Interface Image Determination of Cable Size.

2.3 Determining MCCB

In determining the capacity of the circuit breaker, it must first consider the maximum setting of the short circuit protection device on the circuit breaker. The calculation is based on the applicable standard, PUIL 2000, where the maximum setting of the short circuit protection device on the cage motor circuit breaker does not exceed 250% of the total load current of the

motor. The following is the calculation of the maximum setting of the protective device.

$$\text{Maximum protective device} = 250\% \times \text{FLA}$$

where:

FLA: Full load ampere

At this stage, the interface is made for calculating the cable size in the LabVIEW software. The inputs are load power, source voltage, and cos phi. The LabVIEW program will automatically calculate the nominal value and the installed MCCB capacity. By determining the correct MCCB value, the system is expected to be able to overcome any sudden disturbances.

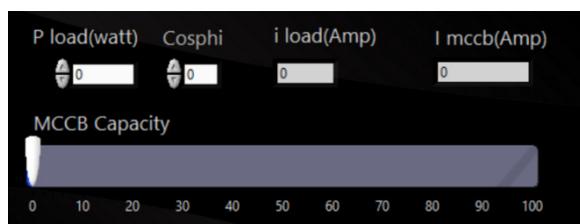


Figure 3: Initial Interface Image Determination of MCCB.

3 RESULTS AND DISCUSSION

In this sub-chapter, we will discuss the results of the simulation of the operation of the LabVIEW

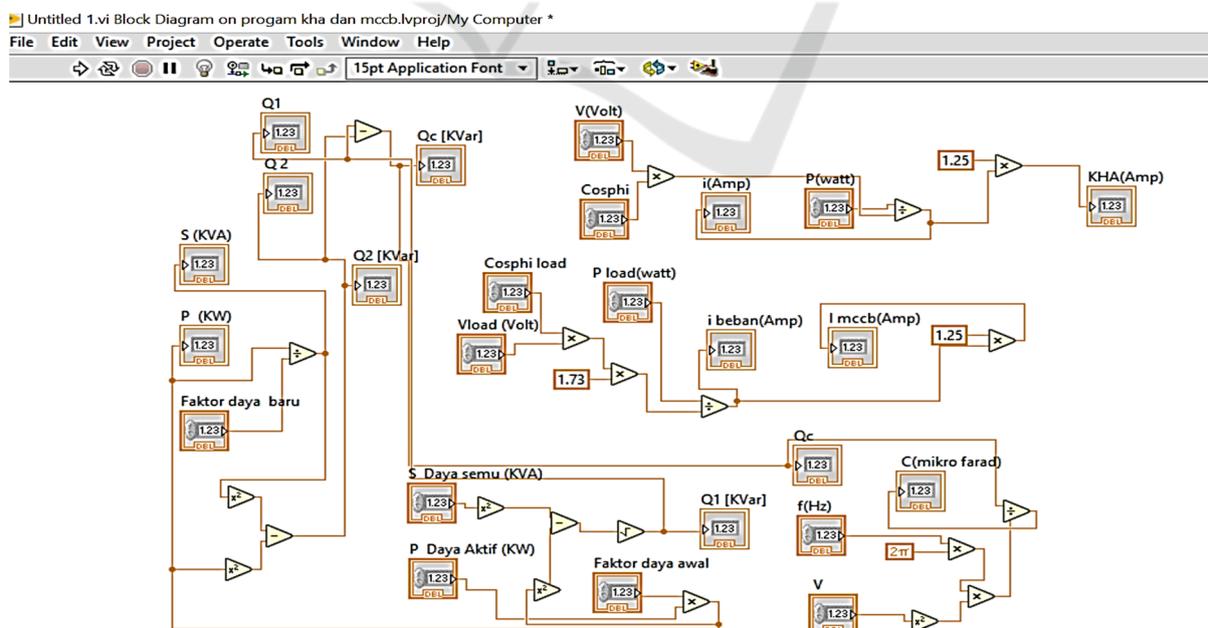


Figure 4: Overall block diagram drawing of the simulator.

that has been made to find the KHA value of a cable, the MCCB value, and the capacitor value for a better PF change from the existing system of a plan.

3.1 Identify the Crc Value Search Process Using the Labview Interface

In this research, several input and output components are needed in the initial process series related to each other. Figure 5 above is a block diagram that will be run to determine the three values, namely the cable KHA, the MCCB quantity, and the capacitor value. The front panel has been arranged as described in chapter 3.

Each simulation process will be run together. Before the simulation is run, the block diagram will check the wire connections between the indicators and whether they are connected correctly or not. If there is a wired connection, there is an incorrect block diagram, the program automatically cannot be run, and a cross appears on the error section. For the start or stop button, only one control can start and stop the calculation of the three components. Figure 5 is an image of the button for simulating the three calculations.

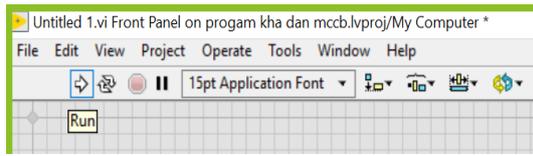


Figure 5: Image of the running and stop buttons on the simulator.

The simulation results are in the form of numbers according to the desired output. The search for the KHA value is in the form of amperes and has been carried out several times by trial and error. The simulation results have been confirmed to be the same as the results of manual calculations. To prove whether the simulator can be used, a case study is taken with the following input values: Power Capacity, Source Voltage, and Power Factor

The following is a Table of the results of the calculation of KHA using LabView simulation:

Table 1: The results of the calculation of the CRC value using the LabVIEW simulator.

No	Active Power (Watt)	Cos Phi	I (A)	CRC Labview (A)
1	25560	0.786	49,4662	61,8328
2	25850	0.793	49,5858	61,9823
3	23590	0.773	46,4215	58,0268
4	24950	0.786	48,2857	60,3571
5	21630	0.786	41,8605	52,3256

From Table 1 above can be seen the results of the simulation of the first experiment onwards.

To compare the LabVIEW simulation results, manual calculation data is needed with direct measurement data in the field. The input data used in the manual calculations are compared to the case studies for the simulation. The results of manual calculations can be seen in Table 2.

Table 2: The results of calculating the CRC value using manual field measurement.

No	Active Power (W)	Cos Phi	I (A)	CRC Labview (A)
1	25560	0.786	49,46	61,82
2	25850	0.793	49,57	61,96
3	23590	0.773	46,41	58,01
4	25950	0.786	48,28	60,35
5	21630	0.786	41,85	52,32

Table 2 above shows the results of the calculation of the first experiment onwards.

Table 3: Comparison of manual field measurement determining the value of CRC and the LabView simulator.

Trial and error simulation data retrieval	LabVIEW simulation results	Field Measurements
1	61,8328	61,82
2	61,9823	61,96
3	58,0268	58,01
4	62,7762	60,35
5	52,3256	52,32

From the results of Table 3 above, it can be seen the results of the simulation of the first experiment onwards. There is no significant change in value between LabVIEW simulation and manual calculation. The difference in the simulation results with manual calculations only lies in the value of the number behind the comma. As we can see in data retrieval 1, the LabVIEW simulation results are 61,8328, while the field measurements is 61,82. It can be concluded that there is no difference in the central values between the simulation results and the manual.

3.2 Identification of the Mccb Value Search Process Using the Labview Interface

To change the power factor value that is better than the existing system. Similarly, after coding the block diagram for finding the MCCB value is complete, the simulation can be done by pressing the running button on the control bar icon. At this stage of finding the value of the capacitor, many inputs and outputs are described. The simulation results that have been carried out several times can be interpreted as the resulting value following the calculation. In Table 4.4 below are the record results from the final simulation results using LabVIEW. To prove whether the simulator can be used, a case study is taken with the input values for the mccb of a motor as follows:

The following is a Table of the results of the calculation of MCCB value using LabView simulation:

Table 4: The results of the calculation of the MCCB value using the LabVIEW simulator.

No	Active Power (Watt)	Cos Phi	MCCB Value simulation results on LabVIEW
1	84720	0,77	209,207
2	88570	0,793	212,37
3	84940	0,773	208,936
4	91660	0,794	219,503
5	87910	0,799	209,205

From Table 4. above, the simulation results of the first experiment onwards can be seen. To compare the LabVIEW simulation results, manual calculation data is needed with direct measurement data in the field. The input data used in the manual calculations are compared to the case studies for the simulation. The results of manual calculations can be seen in Table 5.

Table 5: The results of calculating the MCCB value using field measurement.

No	Active Power (Watt)	Cos Phi	Field Measurement of MCCB value results (A)
1	84720	0,77	209,16
2	88570	0,793	212,31
3	84940	0,773	208,87
4	91660	0,794	219,46
5	87910	0,799	209,16

From table 5. above, the results of the calculation of the first experiment onwards can be seen.

Table 6: Comparison of calculations to determine the MCCB value with the LabVIEW simulator and manual calculations.

Trial and error simulation data retrieval	LabVIEW simulation results	MCCB value field measurement (A)
1	209,207	209,16
2	212,37	212,31
3	208,936	208,87
4	219,503	219,46
5	209,205	209,16

From the results of table 6 above, it can be seen the results of the simulation of the first experiment onwards. There is no significant change in value between LabVIEW simulation and manual calculation. The difference in the simulation results with field measurement only lies in the value of the number behind the comma. As we can see in data retrieval 1, the LabVIEW simulation result is 209,207 A, while the field measurement is 209,16 A. It can be concluded that there is no difference in the central values between the simulation results and field measurement.

3.3 Interface Labview Identify the Process of Finding the Capacitor Bank Value for Power Factor Improvement Using the Labview Interface

After the coding of the block diagram for finding the capacitor value has been completed, the simulation

can be done by pressing the running button on the control bar icon. At this stage of finding the value of the capacitor, many inputs and outputs are described. To change the power factor value that is better than the existing system. The simulation results that have been carried out several times can be interpreted as the resulting value by the calculation. In Table 7 below are the recorded results of the final simulation results using LabVIEW To prove whether the simulator can be used, a case study is taken with the following input: Active Power, Cos Phi before PF repair, and target Cos Phi

The following is a table of the results of the calculation of Capacitor needed value using LabVIEW simulation:

Table 7: Capacitor needed value calculation results using the LabVIEW simulator.

No	Active Power (KW)	Q1	Q2	Capacitor needed value (Qc) simulation results (KVar) on LabView
1	542,08	0,786	0,99	349,13
2	531,38	0,793	0,99	332,515
3	482,48	0,773	0,98	298,003
4	495,22	0,786	0,99	318,949
5	512,62	0,786	0,99	330,156

Table 7 above shows the simulation results of the first experiment onwards.

To compare the LabVIEW simulation results, manual calculation data is needed with direct measurement data in the field. The input data used in the manual calculations are compared to the case studies for the simulation. The results of manual calculations can be seen in table 8.

Table 8: The results of calculating the value of the capacitor needed using manual field measurement.

No	Power Active (KW)	Q1	Q2	Qc (KVAR) measurement
1	542,08	0,786	0,99	349,13
2	531,38	0,793	0,99	332,52
3	482,48	0,773	0,99	298,00
4	495,22	0,786	0,99	318,95
5	512,62	0,786	0,99	330,16

Table 8 above shows the results of the calculation of the first experiment onwards.

Table 9: Comparison of manual field measurement capacitor needed values and LabVIEW simulator.

Trial and error simulation data retrieval	Capacitor needed simulation results (KVar) with LabView	Capacitor needed manual field measurement results (KVar)
1	349,13	349,13
2	332,515	332,52
3	298,003	298,00
4	318,949	318,95
5	330,156	330,16

From the results of table 9 above, it can be seen that the changes in the simulation result from the first experiment onwards. There is no significant change in value between LabVIEW simulation and manual field measurement. As we can see in the data retrieval of Labview simulation results, it is 349,13 KVar, and the results of manual field measurements are also 349,13 KVar. The LabView simulation results and the manual field measurement are the same.

4 CONCLUSION

Ensure that the conclusion is related to the paper's title, purpose, and contribution. The Labview application can calculate the VALUE of KHA, the value of capacitors of banks, and the value of MCCB as appropriate to automatically protect the working system of electricity flow.

REFERENCES

- E. Ridwan, M. I. Arsyad, A. Razikin,) Program, S. T. Elektro, and J. T. Elektro, "Analisis Perencanaan Pembagian Beban Dan Instalasi Listrik Pada Hotel Golden Tulip Di Kota Pontianak," pp. 1–8, 2018.
- B. S. Fauzan, F. Danang Wijaya, "Studi Perbaikan Faktor Daya Beban Induktif Dengan Kompensator Reaktif Seri Menggunakan Sakelar Pemulih Energi Magnetik," *Tek. Elektro FT UGM*, pp. 125–147.
- Lisiani, A. Razikin, and Syaifurrahman, "Identifikasi dan Analisis Jenis Beban Listrik Rumah Tangga Terhadap Faktor Daya (Cos Phi)," *J. Untan*, vol. 1, no. 3, pp. 1–9, 2020.
- A. Dani and M. Hasanuddin, "Perbaikan Faktor Daya Sebagai Kompensator Daya Reaktif (Studi Kasus STT Sinar Husni)," *Semin. Nas. R.*, vol. 998, no. September, pp. 673–678, 2018.
- V. B. Rizqiya, *Analisis Perencanaan Perbaikan Faktor Daya Sebagai Upaya Optimasi Daya Listrik Di Gedung E5 Fakultas Teknik Universitas Negeri Semarang*. 2019.
- S. T. Listrik, "Simulasi biaya penyaluran daya listrik dengan metode," *Univ. Stuttgart*, pp. 1–9.
- A. B. Ar Rahmaan, "Optimalisasi Penempatan Kapasitor Bank Untuk Memperbaiki Kualitas Daya Pada Sistem Kelistrikan Pt. Semen Indonesia Aceh Menggunakan Metode Genetic Algorithm (Ga)," *J. Tek. ITS*, vol. 5, no. 2, 2016.
- S. A. Gunawan, "Analisis Penghantar dan Pengaman Pada Gedung Admisi Universitas Muhammadiyah Yogyakarta (Analysis of Conductor and Protection on Admission Building Universitas Muhammadiyah Yogyakarta)," 2000.
- W. P. Azhari, "Tugas akhir evaluasi perencanaan kebutuhan daya pada instalasi listrik kantor pimpinan daerah muhammadiyah kota medan," *Tek. Elektro*, 2019.
- P. Kebutuhan and K. Daya, "Keywords: capasitor bank," pp. 63–72, 2006.