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# Flutter Framework Implementation for Over Current Relay and Ground Fault Relay Setting Applications in 20 kV Distribution Systems

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## ABSTRACT

In the distribution system, there are several faults such as blackouts due to errors in the coordination of the protection relay. To minimize excessive damage to the electrical system, components such as over current relays (OCR) are needed to overcome inter-phase faults and ground fault relays (GFR) to overcome phase-to-ground faults. The setting process that has been carried out so far is still ineffective, so a system is needed to simplify the setting process. Flutter is a development framework from Google that can release applications in the form of Android or iOS. This study aims to simplify the OCR and GFR setting process using a mobile application. Application development uses the waterfall method. The test results consisting of blackbox alpha, beta and manual calculations show that this application is running according to the expected functionality. In addition, the results of the settings that have been done are the OCR setting current of 400 A in zone 1 and 300 A in zone 2 with a Time Multiplier Setting (TMS) value of 0.2 in zone 1 and 0.05 in zone 2. While the GFR setting current is 80 A in zone 1 and 60 A in zone 2 with a TMS value of 0.175 in zone 1 and 0.05 in zone 2. From these setting values, the OCR time difference (Δt) value is then obtained around 0.6 seconds and 0.8 seconds for GFR. This shows that the OCR and GFR are in good condition.

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## 1. INTRODUCTION

The distribution system is divided into two types, namely the primary distribution network and the secondary distribution network. The primary distribution voltage used by PLN includes 20 kV, 12 kV, and 6 kV. Currently, the primary distribution voltage that is most widely developed by PLN is 20 kV. The voltage in this primary distribution network is then lowered by the distribution substation to a low voltage of 380/220 V, which is then distributed through the low voltage network to consumers (R. Syaifuddin, et al., 2020).

In the process of distributing electricity, several abnormal events can occur that disrupt the distribution of electricity. One of the disturbances is black out (electrical system failure) in the distribution system which often occurs due to coordination errors between protection relays. This disturbance causes the distribution system to be unreliable and the entire electrical system is disrupted. Disturbances in the distribution system can be overcome by using several protection relays. One of them is the over current relay (OCR) and ground fault relay (GFR). Three- or two-phase short circuit faults can be secured using OCR and for single phase or two-phase faults to ground can use GFR (A. E. Ismail, et al., 2018). In addition, to prevent larger blackouts, protection relay coordination settings are needed. Protection settings function to minimize blackout areas (disruptions) and safeguard against temporary disturbances, temporary disturbances if not removed can cause quite extensive blackouts (Joko, et al., 2022).

Therefore, a tool or system is needed that can assist in the relay setting process. Flutter is a framework developed by Google, allowing applications to be released on Android and iOS operating systems (R. Kartadie, et al., 2023). Flutter has the advantage of a hot-reload feature in accelerating the UI development cycle, adding features, and fixing bugs (I. Husain, et al., 2023). So, this study designs and implements a mobile application using the flutter framework which is used to set over current relays and ground fault relays in a 20 kV distribution system.

## 2. METHODS

Over current relay (OCR) is a type of relay that works based on the amount of current flowing through it. This relay works when the current flowing exceeds the specified value or setting current. While the ground fault relay (GFR) is the same as OCR, only different in detecting disturbances, for GFR it detects disturbance currents between phases and ground (Y. Triono, et al., 2013).

This study uses the waterfall method, often referred to as the classic life cycle, which shows a systematic and sequential approach to software development. The stages of the waterfall method include several systematic steps consisting of requirements analysis, design, implementation, testing and maintenance (G. Metboki, et al., 2024). At the requirements analysis stage, data is collected and system requirements are analysed through interviews, surveys, and literature studies. The design stage aims to create a picture of the system to be developed, including the design of the interface display and system flow. After that, the system that has been designed is implemented using programming code with various relevant tools and programming languages. Then, the testing stage is carried out to test whether the system that has been built meets the requirements, both in terms of design, function, and performance. Finally, the maintenance stage aims for periodic system maintenance, repair, evaluation, and further software development.

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This study also uses the Flutter framework, a platform made by Google that uses the Dart programming language. Flutter allows you to build mobile applications that are compatible with Android and iOS. One of the advantages of Flutter is the use of a built-in rendering engine to present widgets, which makes the user interface (UI) display more consistent and unique (H. P. Ramadhan, et al., 2020). Because the entire UI is built with widgets so that it can embed other widgets on existing widgets, for example adding images or text to buttons. There are two types of widgets in flutter, namely Stateful Widget and Stateless Widget (R. Kartadie, et al., 2023).

Furthermore, this research was carried out by calculating impedance, calculating short circuit current, and calculating Setting Over current relay and Ground fault relay.

### 2.1. Usecase Diagram

Usecase diagram is a visual tool used to describe the interaction between a system and its users. This diagram shows the actors/users and usecases (functions provided by the system) and the relationships between them. Figure 1 is a Usecase diagram of the over current relay (OCR) and ground fault relay (GFR) setting application. After logging in, the user will enter the home page which displays the substation and feeder data, when pressed there are 3 main menus, namely the data menu, the setting menu along with the OCR & GFR simulation.

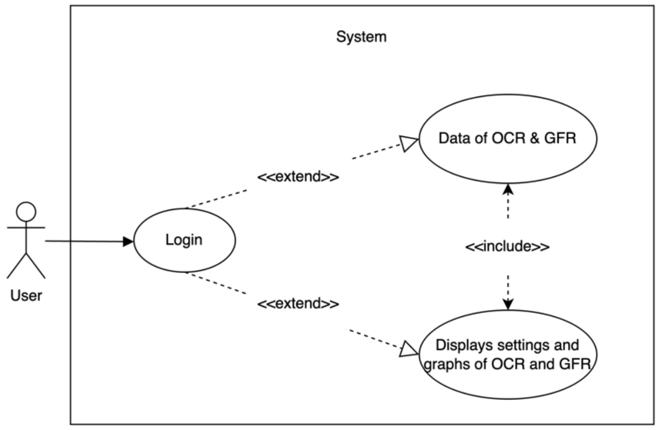


**Figure 1.** Usecase diagram.

### 2.2. Class Diagram

Class diagram is a static diagram in Unified Modelling Language (UML) that shows the structure of a system by displaying classes, attributes, methods, and relationships between classes. The following is a class diagram in the OCR and GFR setting application as shown in Figure 2.

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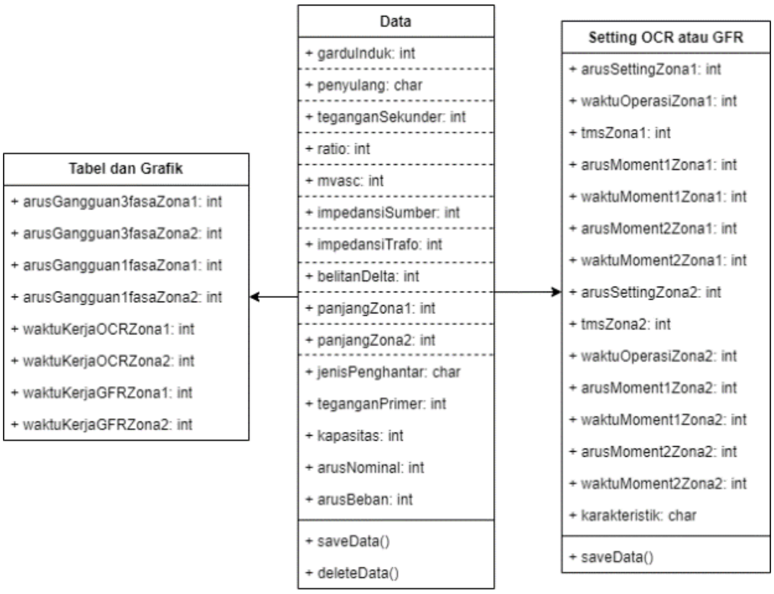


**Figure 2.** Class diagram.

### 2.3. Impedance Calculation

Impedance calculations include several impedance calculations such as source impedance, transformer impedance and line or feeder impedance (positive, negative and zero sequence). The calculation of source impedance and transformer impedance is calculated using Equations 1 and 2 (W. Wijana, et al., 2018):

$$Z_s = \frac{E_{TM}^2}{MVA_{sc}} \quad (1)$$

$$X_{TR} = \%X_T \times \frac{E_{TM}^2}{MVA_{sc}} \quad (2)$$

The impedance calculation on the feeder depends on the magnitude of the impedance per km of the feeder to be calculated. For example, the magnitude of the feeder impedance value can be determined using Equations 3 and 4 (L. Maisyarah, 2019):

$$Z1 = Z2 = \text{percentage } (\%) \times \text{feeder length (km)} \times Z1/Z2\ (\Omega) \quad (3)$$

$$Z0 = \text{persentase } (\%) \times \text{feeder length (km)} \times Z0\ (\Omega) \quad (4)$$

After getting some impedance values, the calculation of the equivalent impedance of the network is continued, which is used for calculating the short circuit fault current. Thus, the positive, negative and zero sequence equivalent impedances can be calculated using Equations 5 and 6 (L. Maisyarah, 2019):

$$Z1_{eq} = Z2_{eq} = Zs_1 + Zt_1 + Z_1 \text{ feeder} \quad (5)$$

$$Z0eq = Zt0 + 3RN + Z0 \text{ feeder} \quad (6)$$

### 2.4. Short Circuit Current Calculation

Analysis of the impact of short circuits on the electric power system is done by calculating the current flowing when the disturbance occurs. This calculation is done to find or identify changes that occur in electrical parameters due to short circuit disturbances. Calculation of the current flowing when three electrical cables touch (three-phase disturbance), can use the Equation 7 (S. Thaha, 2022):

$$I_{3\emptyset} = \frac{\frac{V_f}{\sqrt{3}}}{\sqrt{{R_{1eq}}^2 + j{x_{1eq}}^2}} \tag{7}$$

Next, calculate the 2-phase short circuit current fault using Equation 8:

$$I_{2\emptyset} = \frac{\sqrt{3}}{2} \times I_{3\emptyset} \tag{8}$$

Finally, the calculation of single-phase short circuit current to ground can be found using Equation 9:

$$I_{1\emptyset} = \frac{3 \times \frac{V_f}{\sqrt{3}}}{\sqrt{(2 \times ({R_{1eq}}^2 + j{x_{1eq}}^2)) + {R_{0eq}}^2 + j{x_{0eq}}^2}} \tag{9}$$

### 2.5. Calculation of Over current relay and Ground fault relay settings

The calculation of over current relay (OCR) and ground fault relay (GFR) settings can be found by calculating the setting current value first and then calculating the time multiple setting (TMS). For the calculation of the OCR setting current in Equation 10, the calculation of the GFR setting current in Equation 11 and the calculation of the secondary setting current of OCR or GFR in Equation 12 (Baddarudin and B. Wirawan, 2014), (E. Dermawan and D. Nugroho, 2017):

$$I_{setOCR} = 1{,}2 \times I_n \tag{10}$$

$$I_{setGFR} = (0{,}2 - 0{,}3) \times I_n \tag{11}$$

$$I_{sekunder} = I_{set} \times \frac{1}{Ratio\ CT} \tag{12}$$

To calculate the TMS time setting for both ground fault relays and over current relays, use the same method as in Equation 13 (W. Wijana, 2018):

$$t = TMS \times \frac{\beta}{\left[\left[\frac{I_{Fault}}{I_{set}}\right]^{\alpha} - 1\right]} \tag{13}$$

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The following values of the constants α and β depend on the characteristic curves in Table 1 (W. Wijana, 2018):

**Table 1.** Constants of α and β.

| No | Curve | α | β |
|---|---|---|---|
| 1 | *Definite time* | - | - |
| 2 | *Standart inverse* | 0,02 | 0,14 |
| 3 | *Very inverse* | 1 | 13,2 |
| 4 | *Extremely inverse* | 2 | 80 |
| 5 | *Long time inverse* | 1 | 120 |

## 3. RESULTS AND DISCUSSION

### 3.1. Mobile Application

The implementation results of the application created consist of 4 pages, namely the login page, home page, data page and relay setting page as shown in Figure 3-7.

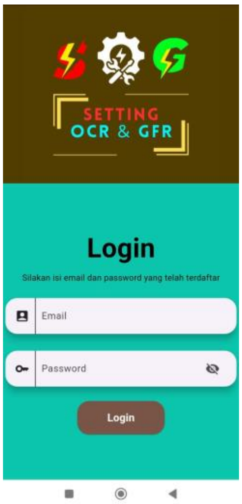


**Figure 3.** Login page.


**Figure 4.** Home page.

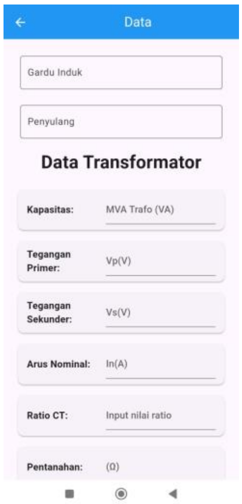


**Figure 5.** Home page.


**Figure 6.** OCR setting page.


**Figure 7.** OCR setting page.

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### 3.2. Alpha Testing

Alpha testing is a software testing method that checks the functionality of an application without looking at its internal structure or source code. This method focuses on the input and output of the application, ensuring that the application works according to the specifications and requirements set. In alpha testing, the tester provides various inputs and observes the resulting output to ensure that it is as expected. In the application of setting over current relay (OCR) and ground fault relay (GFR), this test is conducted to assess the performance of input and output, as well as assist in application development. The results of alpha testing of the OCR and GFR applications are shown in Table 2.

**Table 2.** Aplha testing result.

| Page | Procedure | Output | Result |
|---|---|---|---|
| *Login* | Enter the correct email and password, then press the Login button | Show the home page | Valid |
| | Enter the wrong email and password, then pressing the Login button | Display a pop up that the email or password entered is incorrect. | Valid |
| Home | Press the data menu | Display data menu | Valid |
| | Press the OCR or GFR setting menu | Display the OCR or GFR settings menu | Valid |
| Data | 1. Press existing data<br>2. Select general data options<br>3. Change data content<br>4. Press save data | Save data that has been changed | Valid |
| | 1. Press existing data<br>2. Select general data options<br>3. Press delete data | Delete selected data | Valid |
| | Press the add button and fill in the existing data, then press save. | Save added data | Valid |
| *Setting* OCR | 1. Press the OCR setting menu<br>2. Select the main substation and feeder<br>3. Fill in Im1 to tm2 and select the characteristics<br>4. Press calculate then press display<br>5. 5. Press save | Display calculations, tables, graphs and store data | Valid |
| *Setting* GFR | 1. Press the GFR setting menu<br>2. Select the main substation and feeder<br>3. Fill in Im1 to tm2 and select the characteristics<br>4. Press calculate then press display<br>5. Press save | Display calculations, tables, graphs and store data | Valid |

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### 3.3. Beta Testing

Next, in Blackbox testing, there is beta testing which is a direct application test by the user to validate the usability, compatibility and reliability test of the application that has been created. This beta testing is carried out using a questionnaire containing 5 questions related to the application of setting over current relay and ground fault relay with the lowest score of 1 (strongly disagree) and the highest 5 (strongly agree) which will later be filled in by the user. The results of the questionnaire are presented in Table 3.

**Table 3.** Beta testing result.

| No | Questions | SA | A | E | DS | SD | Total score |
|---|---|---|---|---|---|---|---|
| 1 | Is the application for setting over current relay and ground fault relay easy to use? | 0% | 60% | 15% | 0% | 0% | 75% |
| 2 | Do the appearance and features of the application work as intended? | 0% | 80% | 0% | 0% | 0% | 80% |
| 3 | Does the OCR and GFR setting application relay coordination simulation work properly? | 0% | 60% | 15% | 0% | 0% | 75% |
| 4 | Does the setting application make it easier to calculate settings and save setting data? | 0% | 80% | 0% | 0% | 0% | 80% |
| 5 | Is further application development necessary for further research? | 0% | 80% | 0% | 0% | 0% | 80% |

Note:
SA : Strongly agree
A : Agree
E : Enough
D : Disagree
SD : Strongly Disagree

### 3.4. Manual Calculation

#### 3.4.1 Setting Calculation

This setting calculation contains several parameters to be calculated such as source impedance (Zs), transformer impedance (Zt), OCR and GFR setting current, and the time value of OCR and GFR. These parameters are calculated based on the equations in the basic theory. Table 4 shows the calculation results of the OCR and GFR setting application compared to manual calculations.

**Table 4.** Setting calculation.

| Location | Parameter | Manual calculation | Application calculation | Error |
|---|---|---|---|---|
| Cianjur Main Substation, Sukaluyu Feeder (SKLY) | Zs | 0,8 Ω | 0,8 Ω | 0 |
| | Zt | 0,67 Ω | 0,67 Ω | 0 |

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| Location | Parameter | Manual calculation | Application calculation | Error |
|---|---|---|---|---|
| | I set OCR | 400 A | 400 A | 0 |
| | I set GFR | 80 A | A | 0 |

### 3.4.2 Simulation Parameter calculation

This simulation calculation is used to see the coordination between the over current relay (OCR) and the ground fault relay (GFR). The values displayed on the graph come from the table in the application. Some important parameters in the OCR simulation include the length (L), 3-phase fault current (if3), and time (t) that apply in zone 1 and zone 2. The percentage value of the length of zone 1 (L Z1) is multiplied by a percentage in sequence from 5% to 100%, and the result is used to calculate the 3-phase fault current in zone 1 (if3 Z1). Likewise, the calculation of time in zone 1 is based on the fault current in zone 1 (t Z1 at if3 Z1) and the fault current in zone 2 (t Z1 at if3 Z2). Meanwhile, the length of zone 2 (L Z2) is used to calculate the 3-phase fault current in zone 2 (if3 Z2) and the time in zone 2 (t Z2). All of these parameters can be found in Table 5.

**Table 5.** OCR Simulation parameter.

| Location | Percentage | L Z1 (km) | L Z2 (km) | If3 Z1 (A) | If3 Z2 (A) | t Z1 at If3 Z1 (sec) | t Z1 at If3 Z2 (sec) | t Z2 (sec) |
|---|---|---|---|---|---|---|---|---|
| Cianjur Main Substation, Sukaluyu Feeder (SKLY) | 100% | 10 | 14 | 3.697 | 1.451 | 0.6156 | 1.0727 | 0.2186 |
| | 95% | 9.5 | 13.3 | 3.811 | 1.496 | 0.6072 | 1.0472 | 0.2143 |
| | 90% | 9 | 12.6 | 3.931 | 1.545 | 0.5987 | 1.0221 | 0.2102 |
| | 85% | 8.5 | 11.9 | 4.508 | 1.597 | 0.5903 | 0.9975 | 0.2059 |
| | 80% | 8 | 11.2 | 4.193 | 1.652 | 0.5819 | 0.9731 | 0.2017 |
| | 75% | 7.5 | 10.5 | 4.336 | 1.711 | 0.5736 | 0.9492 | 0.1975 |
| | 70% | 7 | 9.8 | 4.487 | 1.775 | 0.5652 | 0.9256 | 0.1934 |
| | 65% | 6.5 | 9.1 | 4.648 | 1.844 | 0.5569 | 0.9022 | 0.1893 |
| | 60% | 6 | 8.4 | 4.819 | 1.918 | 0.5486 | 0.8792 | 0.1853 |
| | 55% | 5.5 | 7.7 | 5.001 | 1.998 | 0.5404 | 0.8564 | 0.1811 |
| | 50% | 5 | 7 | 5.195 | 2.086 | 0.5322 | 0.8339 | 0.1770 |
| | 45% | 4.5 | 6.3 | 5.401 | 2.181 | 0.5240 | 0.8115 | 0.1730 |
| | 40% | 4 | 5.6 | 5.619 | 2.285 | 0.5159 | 0.7894 | 0.1689 |
| | 35% | 3.5 | 4.9 | 5.852 | 2.400 | 0.5079 | 0.7674 | 0.1648 |
| | 30% | 3 | 4.2 | 6.098 | 2.527 | 0.5000 | 0.7456 | 0.1608 |
| | 25% | 2.5 | 3.5 | 6.359 | 2.668 | 0.4922 | 0.7238 | 0.1567 |

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| Location | Percentage | L Z1 (km) | L Z2 (km) | If3 Z1 (A) | If3 Z2 (A) | t Z1 at If3 Z1 (sec) | t Z1 at If3 Z2 (sec) | t Z2 (sec) |
|---|---|---|---|---|---|---|---|---|
| | 20% | 2 | 2.8 | 6.635 | 2.826 | 0.4846 | 0.7022 | 0.1526 |
| | 15% | 1.5 | 2.1 | 6.924 | 3.003 | 0.4772 | 0.6806 | 0.1485 |
| | 10% | 1 | 1.4 | 7.225 | 3.204 | 0.4699 | 0.6590 | 0.1443 |
| | 5% | 0.5 | 0.7 | 7.537 | 3.433 | 0.4630 | 0.6373 | 0.1401 |

The GFR simulation parameters include length (P), single-phase fault current (if1), and time (t) applicable in zone 1 and zone 2. The percentage of zone 1 length (L Z1) is multiplied from 5% to 100%, then the result is used to calculate the single-phase fault current in zone 1 (if1 Z1). Likewise, the time in zone 1 is calculated based on the fault current in zone 1 (t Z1 in if1 Z1) and the fault current in zone 2 (t Z1 in if1 Z2). For zone 2, the length of zone 2 (L Z2) is used to calculate the single-phase fault current in zone 2 (if1 Z2) and the time in zone 2 (t Z2). All these parameters can be found in Table 6.

**Table 6.** GFR Simulation parameter.

| Location | Percentage | L Z1 (km) | L Z2 (km) | If1 Z1 (A) | If1 Z2 (A) | t Z1 at If1 Z1 (sec) | t Z1 at If1 Z2 (sec) | t Z2 (sec) |
|---|---|---|---|---|---|---|---|---|
| Cianjur Main Substation, Sukaluyu Feeder (SKLY) | 100% | 10 | 14 | 271 | 254 | 0.9914 | 1.0490 | 0.2392 |
| | 95% | 9.5 | 13.3 | 272 | 255 | 0.9889 | 1.0436 | 0.2382 |
| | 90% | 9 | 12.6 | 273 | 257 | 0.9864 | 1.0383 | 0.2372 |
| | 85% | 8.5 | 11.9 | 274 | 258 | 0.9839 | 1.0331 | 0.2363 |
| | 80% | 8 | 11.2 | 274 | 260 | 0.9815 | 1.0281 | 0.2354 |
| | 75% | 7.5 | 10.5 | 275 | 261 | 0.9790 | 1.0231 | 0.2345 |
| | 70% | 7 | 9.8 | 276 | 263 | 0.9766 | 1.0183 | 0.2336 |
| | 65% | 6.5 | 9.1 | 277 | 264 | 0.9741 | 1.0137 | 0.2327 |
| | 60% | 6 | 8.4 | 278 | 265 | 0.9717 | 1.0091 | 0.2319 |
| | 55% | 5.5 | 7.7 | 279 | 267 | 0.9692 | 1.0047 | 0.2310 |
| | 50% | 5 | 7 | 280 | 268 | 0.9668 | 1.0003 | 0.2302 |
| | 45% | 4.5 | 6.3 | 280 | 270 | 0.9644 | 0.9961 | 0.2295 |
| | 40% | 4 | 5.6 | 281 | 271 | 0.9620 | 0.9921 | 0.2287 |
| | 35% | 3.5 | 4.9 | 282 | 272 | 0.9596 | 0.9881 | 0.2280 |
| | 30% | 3 | 4.2 | 283 | 274 | 0.9572 | 0.9843 | 0.2272 |
| | 25% | 2.5 | 3.5 | 284 | 275 | 0.9548 | 0.9806 | 0.2265 |
| | 20% | 2 | 2.8 | 285 | 276 | 0.9525 | 0.9770 | 0.2259 |

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| Location | Percentage | L Z1 (km) | L Z2 (km) | If1 Z1 (A) | If1 Z2 (A) | t Z1 at If1 Z1 (sec) | t Z1 at If1 Z2 (sec) | t Z2 (sec) |
|---|---|---|---|---|---|---|---|---|
| | 15% | 1.5 | 2.1 | 286 | 277 | 0.9501 | 0.9736 | 0.2252 |
| | 10% | 1 | 1.4 | 287 | 278 | 0.9477 | 0.9703 | 0.2246 |
| | 5% | 0.5 | 0.7 | 288 | 279 | 0.9454 | 0.9671 | 0.2240 |

### 3.5. Coordination Simulation Testing

In this test, a coordination simulation between the over current relay (OCR) and ground fault relay (GFR) was performed using the OCR and GFR setting application. The results of this simulation were then compared with the simulation performed using ETAP software. Testing was carried out to ensure the suitability between the simulation results in the application and ETAP software, which is software that is often used in protection system analysis.

Figure 8 shows the results of the coordination simulation between the OCR relay in zone 1 and zone 2 carried out using ETAP software. The setting values used in this simulation refer to the calculation results and OCR specification data listed in Table 5. The graph shown illustrates the relationship between the 3-phase fault current value and the OCR relay working time in both zones. This simulation provides information on the condition of the OCR as seen from the difference in OCR time between zone 1 and zone 2.

Figure 9 shows the simulation results of coordination between OCR relays in zone 1 and zone 2 using the application. The OCR specification data is available in Table 5, and the calculation results are a reference for the setting values used in this simulation. This graph illustrates the relationship between the 3-phase fault current value and the working time of the OCR relay in both zones. The simulation results help ensure that the relays in zone 1 and zone 2 work effectively and are well coordinated as seen from the time difference (Δt).

Likewise, Figure 10 shows the results of the GFR relay coordination simulation in zone 1 and zone 2 using ETAP software. The setting values applied in this simulation are based on the calculations and GFR relay specification data listed in Table 6. This graph illustrates the relationship between the 3-phase fault current value and the GFR relay working time in both zones. The results of this simulation aim to assess the extent to which the GFR relay functions effectively and coordinated in handling fault conditions in each zone.

Figure 11 shows the results of the GFR relay coordination simulation in zone 1 and zone 2 carried out using the application. The setting values in this simulation refer to the calculations and GFR relay specification data contained in Table 6. This graph illustrates the relationship between the 3-phase fault current value and the GFR relay working time in both zones. The results of this simulation provide insight into how the GFR relay operates and is coordinated in responding to faults in different zones, ensuring optimal system performance.

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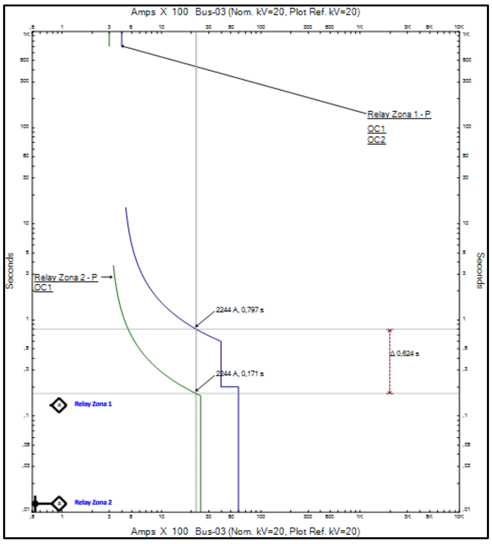


**Figure 8.** Simulation of OCR using ETAP.

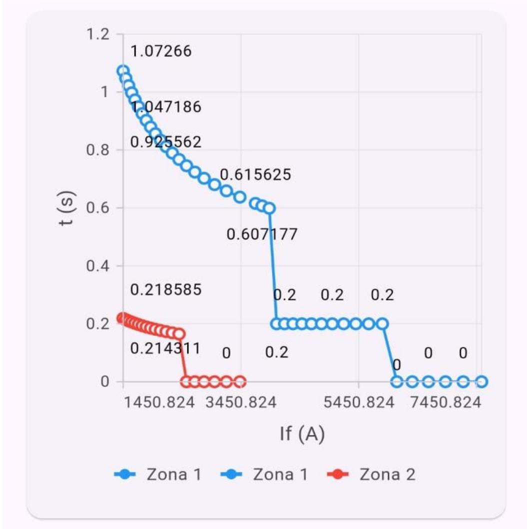


**Figure 9.** Simulation of OCR using application.

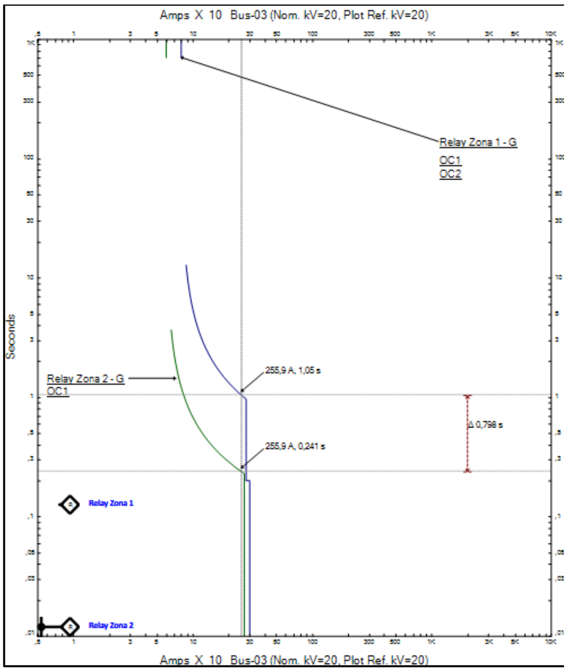


**Figure 10.** Simulation of GFR using ETAP.

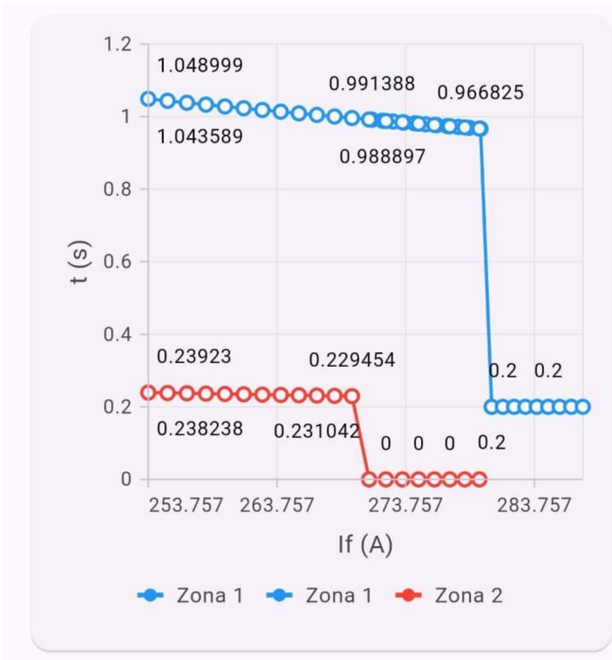


**Figure 11.** Simulation of GFR using application.

## 3.6. Discussion

The results of the application testing using the Blackbox alpha method in Table 2 show that all features in the over current relay (OCR) and ground fault relay (GFR) setting application function properly, where the input given produces, output as expected. The Blackbox beta test in Table 3 also confirms that the application makes it easier to set OCR and GFR and facilitates users in viewing coordination in zones 1 and 2.

The calculation of the setting current in Table 4 shows consistent results between the calculator and the application, with an OCR setting current of 400 A and a GFR of 80 A.

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Simulation tests of parameters such as distance, 3-phase fault current (for OCR) and 1-phase (for GFR), and operating time in zones 1 and 2 show consistent calculation results between the manual. Finally, the results of the coordination simulation from this application display the same graph as the simulation using ETAP software, showing consistency of the results.

The results of the setting calculation test in Table 5 and Table 6 are used to determine the relay working time (t) on the over current relay (OCR) and ground fault relay (GFR). This test involves three parameters: distance, three-phase fault current (If3) for OCR, and single-phase (If1) for GFR, and relay working time in zone 1 (t Z1) and zone 2 (t Z2). The fault current and the first and second moment times are used to calculate the relay working time in both zones. For OCR, zone 1 uses a setting current of 400 A with a TMS of 0.2. While zone 2 uses a setting current of 300 A with a TMS of 0.05. The fault current in zone 1 below 4000 A produces a relay working time according to the inverse time delay graph, then when the current is above 4000 A and less than 6000 A the OCR working time becomes 0.2 s (definite time delay). If the current is higher than 6000 A the working time becomes 0 seconds (instantaneous). Zone 2 follows the same principle except that there is no definite time delay, with a first moment current of 2500 A. GFR in zone 1 uses a setting current of 80 A with a TMS of 0.2. While zone 2 uses a setting current of 60 A with a TMS of 0.05. The principle of calculating working time is similar to OCR, with inverse time delay, definite time delay and instantaneous graphs for zone 1. While zone 2 only uses inverse time delay and instantaneous.

The results of the time difference (Δt) between OCR and GFR tested using the ETAP and application show very similar results. For example, at a current of 2200 A, the Δt OCR between zone 1 and zone 2 from ETAP is 0.626 seconds, while from the application it is 0.62 seconds. For GFR at a current of 256 A, the Δt from ETAP is 0.809 seconds and from the application it is 0.801 seconds. This similarity indicates that the application produces consistent results and complies with the IEC 60255 standard.

## 4. CONCLUSION

Testing of the over current relay (OCR) and ground fault relay (GFR) setting application shows that this application successfully fulfils all its functions well. Alpha and beta testing proves that all features in the application work as expected and simplify the process of setting and coordinating OCR and GFR in zones 1 and 2. The results of the calculation of the setting current and simulation parameters carried out using the application and calculator also show consistency without any differences or errors. In addition, the coordination simulation using the application displays the same graph although not as neat as the simulation results using ETAP, which confirms that this application can be relied on for setting and simulating OCR and GFR coordination.

The results of setting OCR and GFR using the OCR setting current in zone 1 are 400 A for the setting current in zone 2 is 300 A and the OCR Time Multiplier Setting (TMS) value in zone 1 is 0.2 and in zone 2 is 0.05. Meanwhile, the GFR setting current in zone 1 is 80 A and in zone 2 is 60 A, then the TMS GFR in zone 1 is 0.175 and in zone 2 is 0.05 with the current value and moment time of both OCR and GFR that have been determined indicating that both relays are in good condition with the OCR time difference (Δt) value of around 0.6 seconds and for the GFR time difference of around 0.8 seconds.

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