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The Study on The Effectiveness and The Importance of Spark Test to The Earthing in The Single-Phase Housing System

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Abstract: The spark test is the alternative way of earthing safety testing that usually being measured by an earth electrode tester. The more professional way is by using Current Distribution, Electromagnetic Interference, Grounding and Soil Structure Analysis (CDEGS). This system testing has been developed specifically and suitable for housing systems and not for industrial. A simple housing system has been made for this project that has a socket outlet connection with 230 V socket supply, Main Switch, RCCB with 0.1 A sensitivity, and MCB 20 A that connects with the socket outlet. The spark testing has been made by two conditions which are the housing system that has the connection of earthing being spark of neutral cable to earthing terminal and sparking the neutral cable to earth terminal that does not have an earthing connection. The measurement of voltage and current also has been made using the multimeter and clamp meter to measure the leakage voltage and current in on-off condition without load before and after the spark test. The measurement of total voltage and current has also been taken for a full load. The finding of this project has shown that earthing connection systems are important in residential. The leakage voltage and current still able to measure in this smaller scall housing system. Leakage voltage was not able to be earthed and the residential system (RCCB) cannot detect it if the earthing connection does not correct or has a problem. The power supply will not be cut off and the leakage still flows in the residential that can cause harm and bad incident.

Keywords: Spark Test, Housing System, 230 V supply

1. Introduction

Earth electrode is the conductor that connects the current direction with the mass of the earth. The maximum resistance between the rod and the electrical earthing system is one ohm. The good earthing requirement is the low electrical resistance, high corrosion resistance and able to carry high current [1].

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The correct way for measuring of earthing needs to be taken by proper hardware or device which is earth electrode tester [2] or using CDEGS for advance [3]. However, the installation of the earthing rods that been done by the company or individuals always be ignored. Design of the residential house, electrical product, the requirement is to get the lowest resistance for consumer safety [4].

The periodic inspection that should have been done is not complete by the time and rules of the IEEE. This cause condition of the earthing system is not safe, the earth wire not connected perfectly with the rod that been buried. This can cause harm to the users, residents, and the equipment since safety are not been practiced [5].

The purpose of this study is measure, detect the safety of the earthing system in residential. A good earthing system is a system that has smaller earthing tenacity. At certain conditions, earthing tenacity value is influenced by the depth of the electrode, electrode size, type of soil, angle of measurement, and mixture in the soil and able to earth the leakage voltage and current in the system.

Next, this project is to identify an alternative way of earthing testing [6][7]. The objective that has been set is to investigate the alternative way of measuring earthing system effectiveness, then to develop the alternative testing system of earthing testing by performing a spark test. Next is to construct the prototype of a single-phase housing system for earthing evaluation purposes and lastly to analyze and to conclude the finding on the earthing system effect on electrical appliances.

Simple housing system hardware will be built, and the spark test will be done on the hardware as an alternative to the outdoor test. After that result from the hardware collected, the data will show the comparison between the actual and expected result.

2. Literature Review

Our live and neutral wires must each elevate the equal current. But in contrary directions. If they do not trip, it means there is something else bleeding current away and that may be a fault in an appliance, or it can also be your physique carrying the current. In this case, it may be a fault. due to the fact, such faults are not suitable for property nor your fitness potentially, a mechanism needs to be put in the vicinity to change off the power earlier than harm is done [8][9].

Because the RCCB in the breaker detects that there is an imbalance between the current in the live and neutral wires linked via it. This means electricity is leaking to earth, which shows a possible risk to life, so it cuts the supply [10]. Neutral is usually solely a few volts above the earth, however with a low resistance direction triggered through two wires touching, greater than 30mA will leak. Note that if something has been to wreck the neutral wire outside your premises but not the live, then neutral would glide up to the equal voltage as live if any equipment has been become on. It is risky to join body from live to earth in series with a kettle, or even a TV [11]-[13]. This is a long way of saying that neutral is never secure to contact except the supply to the premises is turned off.

If there is the current flowing in the neutral wire, then there will be a possible distinction between the neutral and the earth due to the resistance of the neutral wire. When they touch, that potential difference will reason some of the currents in the neutral wire to divert to the earth wire for its return to the earth / neutral common point. The neutral current will be shared between the neutral and earth wires. Now, the current in the live and neutral wires at the earth leakage trip will no longer be precisely equal, as some neutral current has been diverted to the earth wire, if the distinction is larger than 30 mA standard trip value or 10 mA, the trip will function and switch off the power [14].

3. Project Methodology

This project is focusing on the effect of the system earthing on the residential. So, the first step is to prepare the tester for this system. However, since the lack of the equipment to test the actual system at the house such as CDEGS [13] or earth electrode tester [12], simple housing system hardware is built

to test the functionality of the earthing system by using RCCB, MCB, and socket outlets. So, filament bulb is used as tester equipment to test the functionality of the earthing system and this method is called Spark Test.

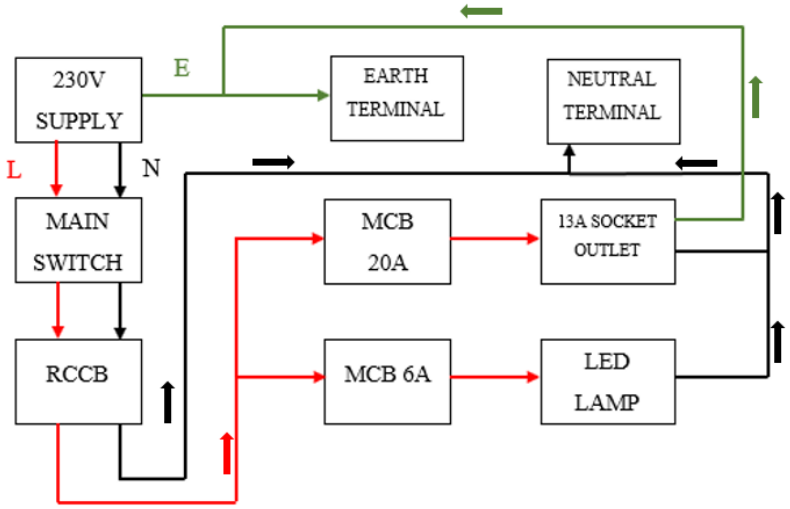

Figure 1: Block Diagram Simple Housing System Connection

Figure 1 shows the connection of the simple housing system. The model gets the 230 V supply, and the Main Switch is the first incoming. Then RCCB receives supply from Outgoing Main Switch, MCB 6 A and 20 A receive outgoing live from RCCB and. Led lamp supplied by MCB 6 A and 13 A socket outlet supplied by MCB 20 A.

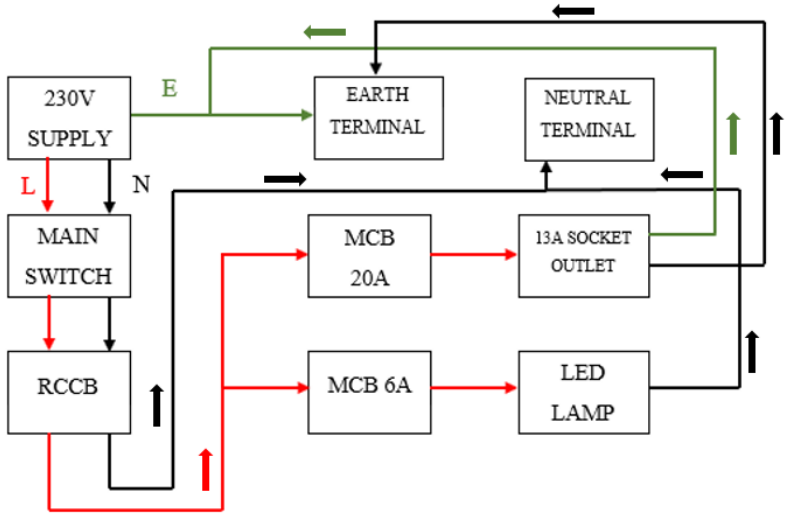

Figure 2: Block Diagram Spark Test with Earthing Connection

Figure 2 showing the earth terminal being sparked by neutral wire from a 13 A socket outlet. The earthing connection is still there connected from 230 V supply and Earth Terminal.

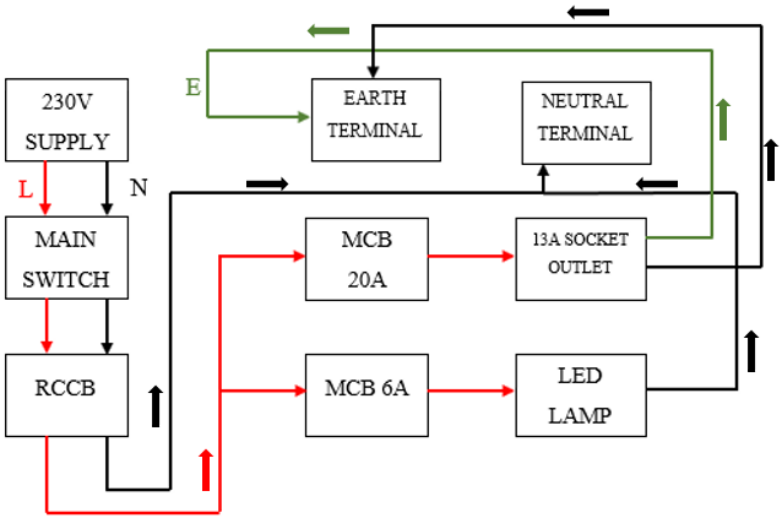

Figure 3: Block Diagram Spark Test without Earthing Connection

The second test difference shown in Figure 3 is there is no earthing connection when the neutral wire from the outgoing 13 A socket outlet being spark at the earthing terminal.

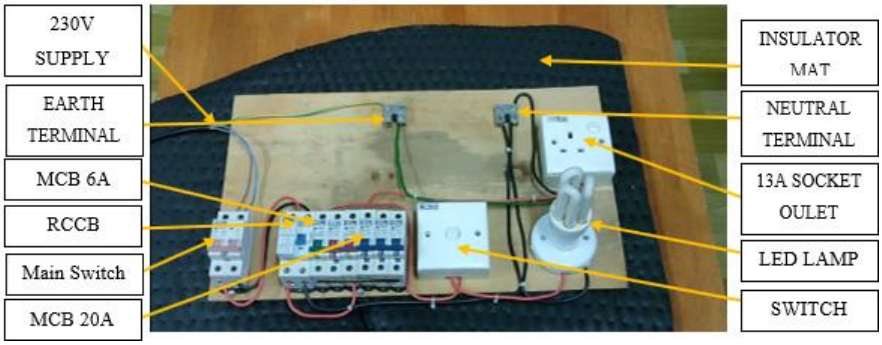

Figure 4: Equipment in Housing Model System

The equipment setup for Spark Test in Figure 4 shows the equipment from 230 V to give supply for housing model system. The Main Switch to allow current and voltage flow to the RCCB. The RCCB act as a protective device for the housing system. The MCB 6 A and 20 A that connect with the LED lamp and 13 A socket outlet to decrease current as suitable for the load.

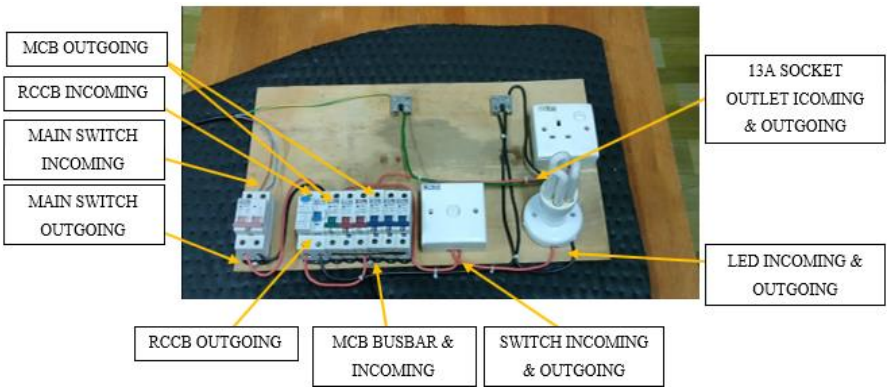

Figure 5: Equipment in Housing Model System

Figure 5 shows incoming and outgoing for each piece of equipment. Outgoing live and neutral for Main Switch is the Incoming live and neutral for RCCB. The Outgoing live and neutral RCCB is incoming for Both MCB 6 A and 20 A and neutral connected to the neutral terminal. Outgoing live for

MCB 6 A is incoming live for LED lamp and outgoing live for MCB 20 A is for incoming live 13 A socket outlet. Outgoing neutral for both LED and 13 A socket outlet connected to the neutral terminal. The switch has no incoming and outgoing neutral connection since it just allows or blocks current flowing to the LED lamp.

2.1 Flow of the project

The procedure taken to complete this project is seen in the flowchart in Figure 6. The project begins with some literature work to get a basic understanding of how the machine operates. Before the building work starts, the system design and simulation were then carried out.

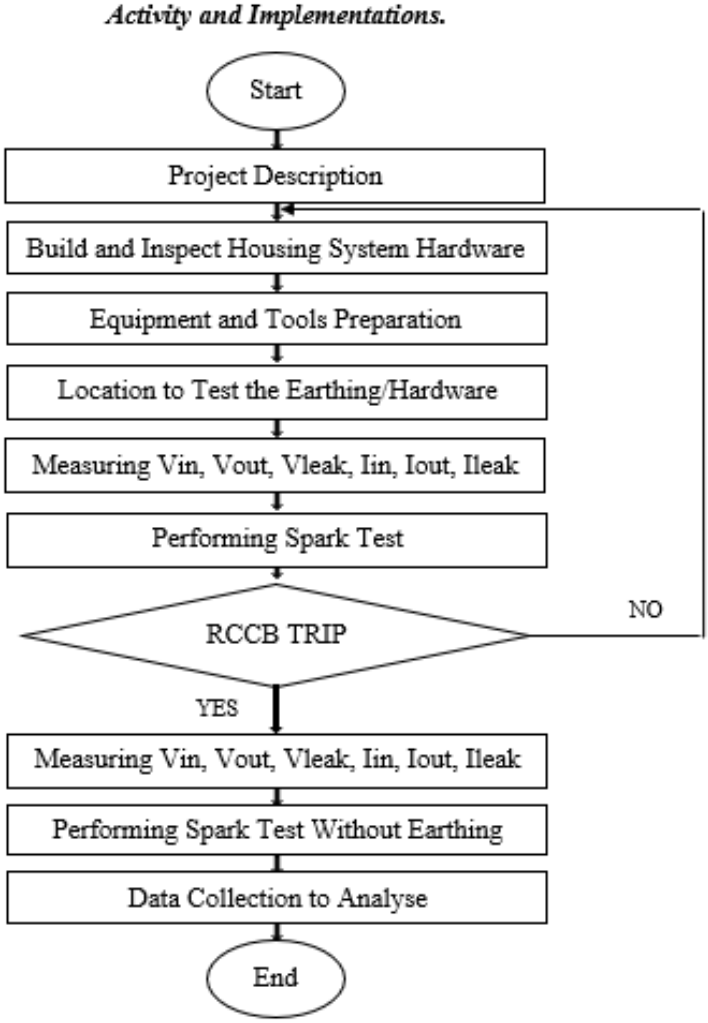

Figure 6: Flow Chart Implementation of the Activity and Data Collection

4. Results and Discussion

CDEGS is a software that can give the simulation of earth resistance for safety to consumers and the installation. Test with using earth tester also is efficient to be used in this project. This chapter will practically how the spark test are been carried out the test the functionally of the earthing system and the effectiveness of this method.

4.1. Spark Test Leakage Voltage & Current Measurement.

This part is the data presenting for the measurement of leakage voltage and current that been measured while equipment in off condition, while main switch and RCCB are switch on.

Table 1: Leakage Voltage & Current

Equipment	Condition	V_{leak} (V)	I_{leak} (A)
Main Switch	OFF	1.652	0.020
RCCB	OFF	1.406	0.020
MCB 6A	OFF	1.133	0.020
MCB 20A	OFF	0.281	0.010
SOCKET 13A	OFF	0.080	

The leakages shown in the table above are leakage voltage and current when all equipment's are in off condition while receiving supply 230 V. The Main Switch has the highest leakage voltage due to the location as the first 230 V supply receiver and RCCB is the second highest. MCB 6 A and MCB 20 A has a big difference with 0.852 A while socket 13 A is the lowest referring to Table 1. By using the clamp meter, the leakage current obtains are very low however, safety precautions are compulsory. MCB 20 A has a difference of 0.01 A with MCB 6A.

Table 2: Leakage Voltage & Current

Equipment	Condition	V_{leak} (V)	I_{leak} (A)
Main Switch	ON		
RCCB	ON		
MCB 6A	OFF	8.750	0.000
MCB 20A	OFF	10.620	0.000
SOCKET 13A	ON	10.260	
SOCKET 13A	OFF	0.648	

Leakage Voltage and Current value of MCB and Socket when Main Switch and RCCB in ON condition shown that MCB 20 A has the highest leakage due to its bigger size ampere followed by MCB 6 A with the difference of 1.87 V while the current value is too small and can be assumed as ~0 A and the least is Socket 13 A in OFF condition as shown in Table 2.

4.2. Voltage & Current Measurement in all On Condition.

This section will show the measurement of voltage and current which is full load when all equipment is in on condition. The input-output voltage and current will be stated.

Table 3: Voltage & Current Before Spark Test

Equipment	Condition	V_{in} (V)	V_{out} (V)	I_{in} (A)	I_{out} (A)
Main Switch	ON	230	230	0.440	0.450
RCCB	ON	230	230	0.450	0.410
MCB 6A	ON	230	230	0.410	0.050
MCB 20A	ON	230	230	0.410	0.360
SOCKET 13A	ON	230	230	0.360	0.370
Neutral Wire		230	230	0.430	0.360

When all load is in ON condition, the actual input, output voltage and input, output current has shown in Table 3. MCB 6 A is the lowest for output current since the load is only an LED lamp. For MCB 20 A, the output current higher by 0.310 A because it is connected to the filament bulb that requires a higher supply current. Main Switch and RCCB have a small difference of 0.01 A while MCB 6 A and MCB 20 A same input current since it receives from RCCB and Socket 13 A is the least. The neutral wire has a 0.43 A current which is a 0.01 difference with the input Main Switch.

Output Current for Main Switch and RCCB in Table 3 has a 0.04 A difference while MCB 20 A that supply to Socket 13 A has the same Output Current 0.36.A The neutral wire has a 0.09 A difference with Main Switch.

4.3. Spark Test Result

The spark test will be performed when all the equipment measuring the voltage and current before them, and when equipment is ready, in all on the condition, the earthing terminal will be sparked with neutral cable and the expecting result is the RCCB should trip.

Table 4: Spark Test Result

Life Wire	Neutral Wire	Filament Bulb	Socket Switch	Led Lamp	RCCB
Life Port	Neutral Port	ON	OFF	OFF	ON
Life Port	Neutral Port	ON	ON	ON	ON
Life Port	Pull Out	OFF	ON	ON	ON
Life Port	Earth Port	OFF	ON	OFF	TRIP

The important part of this project has successfully shown in this data, all appliances should be trip when the Live wire being Spark at Earth Terminal as shown in **Error! Reference source not found.** that show the earthing system are safe.

4.4. Leakage Voltage & Current Measurement after Spark Test

To get comparable data and the relevance for this testing, the measurement of voltage and current after the terminal earth being spark will be taken to ensure the housing system is safe and cut-off the supply.

Table 5: Voltage & Current After Spark Test

Equipment	Condition	V_{in} (V)	V_{out} (V)	I_{in} (A)	I_{out} (A)
Main Switch	ON	230	230	0.000	0.000
RCCB	TRIP	230	2.601	0.000	0.000
MCB 6A	ON	2.601	1.859	0.000	0.000
MCB 20A	ON	2.601	2.451	0.000	0.000
SOCKET 13A	OFF	2.451	0.119	0.000	0.000
SOCKET 13A	ON	2.451	1.429	0.000	0.000

The voltage and current measurement after Spark Test show that current value is too small and can be assumed to ~0 A however there is still have leakage voltage at MCB and 13 A socket outlets as shown in **Error! Reference source not found.**. The leakage output voltage from RCCB little bit higher since Main Switch is still in on condition, MCB 6 A and 20 A receive the same Output Voltage Leakage from RCCB as leakage Voltage. However, leakage output for MCB 6 A lower than MCB 20 A because of the MCB size.

4.5. Spark Test perform without earth

To proof the theoretical value for this project, the spark test also will be done in the condition where the housing system does not have an earthing connection. The earthing terminal will be sparked with neutral cable, then the expecting result is the RCCB not able to trip since it cannot receive sensing and imbalanced current return to it.

Table 6: Spark Test Without Earth.

Life Wire	Neutral Wire	Filament Bulb	Socket Switch	Led Lamp	RCCB
Life Port	Neutral Port	ON	OFF	OFF	ON
Life Port	Neutral Port	ON	ON	ON	ON
Life Port	Pull Out	OFF	ON	ON	ON
Life Port	Earth Port	OFF	ON	ON	ON

The second important part of this project is where there is no earthing connection. **Error! Reference source not found.** showing the result that when neutral wire Spark at Earthing Terminal, the RCCB does not trip which means the Earthing system is not safe. The housing has not been able to detect failure, leakage, and imbalance of current return since the earth connection is not connected to the housing system.

4.6. Leakage without Earth Connection.

Measurement and data of the leakage voltage and current also need to be taken to see the difference when the housing system does not have an earthing connection and have an earthing connection.

Table 7: Leakage Voltage & Current Without Earth Connection

Equipment	Condition	V_{leak} (V)	I_{leak} (A)
Main Switch	OFF	1.237	0.010
RCCB	OFF	0.287	0.010
MCB 6A	OFF	0.328	0.000
MCB 20A	OFF	0.681	0.000
SOCKET 13A	OFF	0.264	0.000

Leakage Voltage and Current without earthing connection has been measured as shown in Table . The data show it does not differ too much with Leakage that has an earthing connection. The leakage voltage of Main Switch is the highest, while the MCB 20 A second highest with the difference of 0.353 A with MCB 6 A due to the size of the MCB. The Leakage Current without earth showing that Main Switch and RCCB has 0.01 A leakage while MCB and 13 A sockets to small and can be assumed ~0.

Table 8: Leakage Voltage & Current Without Earth

Equipment	Condition	V_{leak} (V)	I_{leak} (A)
Main Switch	ON		
RCCB	ON		
MCB 6A	OFF	9.000	0.000
MCB 20A	OFF	11.080	0.000
SOCKET 13A	ON	10.70	0.000

The data shown in **Error! Reference source not found.** is the leakage voltage and current that happened to the MCB and 13 A socket outlet if the Main Switch and the RCCB turn on which in the condition without earthing connection. The MCB 20 A leakage voltage is high without earthing connection with 11.08 A followed by 13 A socket outlet and MCB 6 A. Safety precautions must be practiced safely and compulsory.

4.7. Measurement of Voltage and Current in all on condition without Earth.

This section will present the measurement of voltage and current which is full load but there is no earthing connection, and all equipment is in on condition. The input-output voltage and current will be stated.

Table 9: Voltage & Current Without Earth.

Equipment	Condition	V_{in} (V)	V_{out} (V)	I_{in} (A)	I_{out} (A)
Main Switch	ON	230	230	0.440	0.410
RCCB	ON	230	230	0.410	0.420
MCB 6A	ON	230	230	0.420	0.050
MCB 20A	ON	230	230	0.420	0.370
SOCKET 13A	ON	230	230	0.370	0.370
Neutral Wire		230	230	0.430	0.410

The input and output current for all equipment , in all on condition, without earthing connection based on the data from Table 9 is balanced with the measurement that have earthing connection. The output RCCB is the input for MCB 6 A and 20 A. Input Current for Main Switch from supply socket is 0.44A. The input RCCB is 0.41 A and a little bit lower than MCB 6 A and 20 A with a 0.01 A difference. This happened due to the leakage current to the MCB. The 13 A socket outlet is the lowest with 0.37 A because came from output MCB 20 A. The neutral wire input current 0.43 A with a difference of 0.01 A Main Switch. The output current showing the MCB 6 A is the least with a reading of 0.05 A since it loads for LED lamps that consume low current. The MCB 20 A and 13 A socket outlets have the same reading with 0.37 A and the neutral wire reading is 0.41 A.

4.8. Data Comparison

The comparable data will be compared in this section to show the safety level, differences, and how the result of the spark test being done in the condition been stated. The leakage voltage has been compared for the housing system has the earth and not has earth connection and the current too for both input and output.

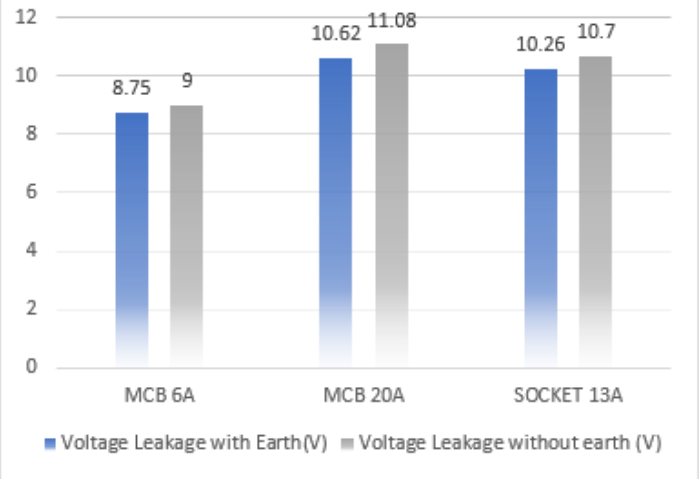

Figure 18: Graph Comparison of Leakage Voltage with & without Earth

Overall data for leakage voltage as shown in Figure 18 showing that without earthing has higher leakage. For MCB 6 A has a difference of 0.25 A and for MCB 20 A has a difference of 0.46 A and 13 A socket outlet has a difference of 0.44 A. The difference happened because of the leakage value that is not able to be earthed since not have an earthing connection.

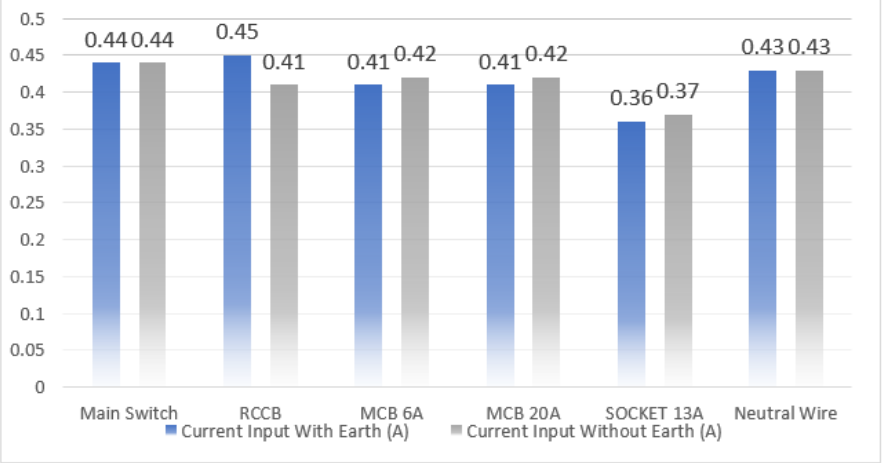

Figure 19: Graph Comparison of Input Current Measurement in all On Condition With & Without Earth

Data comparison for Input current with and without earthing. The main switch is the same since it receives the 230 V supply socket. However, RCCB with earthing connection is higher than the Main Switch input and RCCB without connection 0.01 A differences both. MCB 6 A without earthing higher than with earthing. MCB 20 A has a difference of 0.01 A and the higher is input current without earth. The neutral wire has 0.43 A both and has 0.01 A differences with Main Switch as shown in Figure 19.

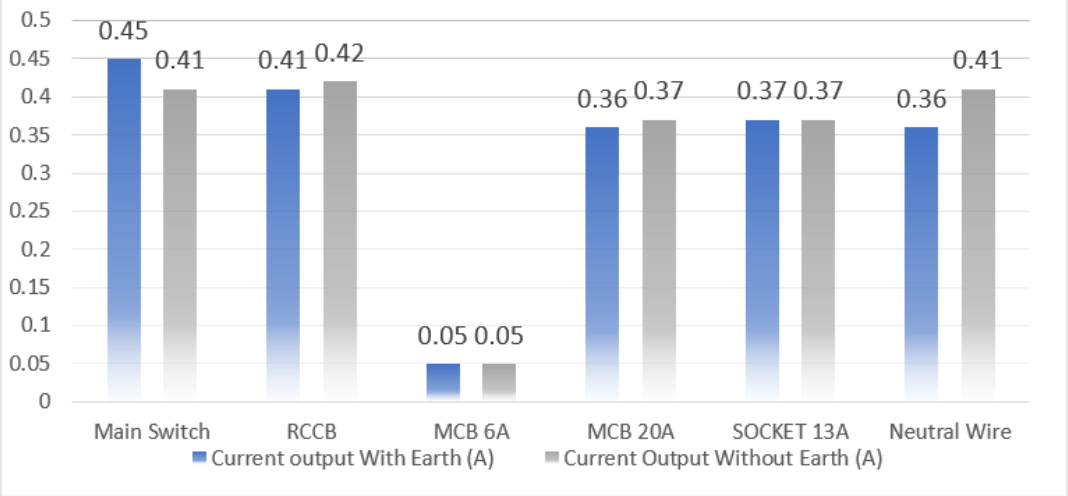

Figure 20: Graph Comparison of Output Current Measurement in all On Condition With & Without Earth

The main Switch with earthing connection is higher as shown in Figure 20. RCCB without earthing connection is higher than has an earthing connection, MCB 6 A both is 0.05 A and MCB 20 A without earth connection higher than with connection. 13 A socket outlets also have the same output current. Neutral output current has a 0.05 A difference. Without earthing connection higher than has earth connection due to leakage current not been able to be earthed. The leakage current outgoing will keep flowing in the system.

Table 10: Result Spark Test Comparison

Live Wire	Neutral Wire	Filament Bulb	Socket Switch	Led Lamp	RCCB	Earthing Safety
Life Port	Neutral Port	ON	OFF	OFF	ON	
Life Port	Neutral Port	ON	ON	ON	ON	
Life Port	Pull Out	OFF	ON	ON	ON	
Life Port	Earth Port	OFF	ON	OFF	TRIP	✓
Life Port	Earth Port	OFF	ON	ONN	ON	X

The objective of this project has been successfully achieved by the data result showed in Table 10 When there is an earthing connection, the RCCB will trip when the neural wire being spark at the earthing terminal. While, where there is no earthing connection, the RCCN does not trip when the earthing terminal being spark with neutral wire as shown in Table 10.

5. Conclusion

As the conclusion, the objective has been achieved successfully for the spark test of a developed hardware building. The spark test has been done successfully and safely. This method is easier, and less cost rather than using CDEGS however it still lacking exact data or reading of current in and out. With the result obtained, the appliances will be saved if the RCCB trip when the spark test is done as shown and to find the best result, future improvement of data reading and the exact calculation of current in and out need to be done during the test. Protector such as a glove also is important to prevent any electrical shock. This system is not convenient to show exactly how the appliances will be damaged when the earthing system is not safe since the voltage and current values are low. However, it can show that the effect is the leakage current and voltage will keep flowing in the housing system and if it keeps for a long period will be dangerous.

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References

[1] J. Acharya and W. Xu, “Ground potential rise of multi-grounded neutral and shield wires in joint systems,” *Electr. Power Syst. Res.*, vol. 80, no. 9, pp. 1074–1081, 2010, doi: 10.1016/j.epsr.2010.01.014.

[2] N. Products, “Megger DET4TCR2 Earth & Ground Resistance Tester 200kΩ CAT IV 100 V,” pp. 7–10, 2020.

[3] A. Szczepanski, “Simulation of grounding networks in the SES CDEGS software,” *2015 Sel. Probl. Electr. Eng. Electron. WZEE 2015*, 2016, doi: 10.1109/WZEE.2015.7394037.

[4] I. K. T. Lim and L. Kim, “Enhancing Compliance To MS IEC 60364 – Standards for Residential Wiring Electrical Accidents in Malaysia,” no. November, 2015.

[5] L. Shulin and Z. Yongxiu, “Research on short-circuit discharge behavior of circuits

based on safety spark test apparatus," *Proc. - 2014 Int. Symp. Comput. Consum. Control. IS3C 2014*, vol. 63, no. 1, pp. 63–69, 2014, doi: 10.1109/IS3C.2014.29.

[6] J. G. Pereyras, "Development of an electrical wiring installation trainer," *Int. J. Sci. Technol. Res.*, vol. 9, no. 3, pp. 4458–4461, 2020.

[7] S. Tenaga, "Guidelines for Electrical Wiring in residential Buildings," *Energy Comm. Kuala Lumpur*, pp. 1–50, 2008.

[8] H. Mafi, R. Yared, and L. Bentabet, "Smart Residual Current Circuit Breaker with Overcurrent protection," *2019 IEEE 2nd Int. Conf. Renew. Energy Power Eng. REPE 2019*, pp. 6–9, 2019, doi: 10.1109/REPE48501.2019.9025151.

[9] M. Mitolo, "Shock hazard in the presence of protective residual-current devices," *IEEE Trans. Ind. Appl.*, vol. 46, no. 4, pp. 1552–1557, 2010, doi: 10.1109/TIA.2010.2051068.

[10] R. F. David Wilmshurst, Nigel Arnot, "Neutral Wire touches the Earth - RCCB Trip," pp. 3–6, 2018.

[11] ABB SACE, "Distribution systems and protection against indirect contact and earth fault. Technical Application Papers," no. 3, 2008.

[12] L. Resnekov and L. McDonald, "Complications in 220 patients with cardiac dysrhythmias treated by phased direct current shock, and indications for electroconversion.," *Br. Heart J.*, vol. 29, no. 6, pp. 926–936, 1967, doi: 10.1136/hrt.29.6.926.

[13] R. Fish and L. Geddes, "Educación Popular en la elaboración de materiales para capacitación en TICs para el desarrollo social," pp. 407–421, 2009.

[14] A. Szczepanski, "Simulation of grounding networks in the SES CDEGS software," *2015 Sel. Probl. Electr. Eng. Electron. WZEE 2015*, 2016, doi: 10.1109/WZEE.2015.7394037.

[15] X. Wei, W. Wei, Z. Gui, Y. Li, Z. Yang, and G. Wu, "Research of Protective Grounding Current Distribution of 380B EMU Based on AT Power Supply Mode," *Tiedao Xuebao/Journal Res. Prot. Grounding Curr. Distrib.*, vol. 41, no. 5, pp. 64–70, 2019, doi: 10.3969/j.issn.1001-8360.2019.05.008.