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Smart Grid Performance Improvement with AC Solid-State Circuit Breaker having Charging and Rebreaking Capabilities

Muhammad Zulqair Nain, Tahir Mahmood*

Department of Electrical Engineering, University of Engineering and Technology, Taxila, Pakistan
Corresponding author: Tahir Mahmood (e-mail: tahir.mehmood@uettaxila.edu.pk).

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***Abstract*- Although traditional electromechanical circuit breakers have a proven track record as efficient and reliable circuit safety devices. Emerging power distribution technologies and architectures such as DC microgrids require advanced breaking performance characteristics (e.g., higher switching speed). The need for faster switching coupled with modern developments in advanced power semiconductor technologies has fueled the growth of semiconductor circuit breaker research and development. The current AC SSCB is a rectifier of silicon which needs auxiliary mechanical devices to accomplish their closure before blame recuperation. Moreover, the new AC SSCB can achieve quick turnoff, after which it can be turned back on without an alternate mechanical device or complicated control, even in a permanent short circuit. In this case, the commutation capacitors are fully charged without auxiliary or main thyristor control. The design and simulated results of a single-phase SSCB are used in this study first to illustrate the execution features of the AC SSCB, followed by the use of three-phase models and results. A flowchart for circuit design is also provided for your convenience.**

***Index Terms*-- Circuit Breaker, Solid-State Circuit Breaker, Over-Current Protection, Overload Protection, Operating Duty, Single line to ground.**

I. INTRODUCTION

Due to the widespread use of IT goods, different loads prone to power quality issues may be easily found everywhere [1]. Moreover, extensive utilization of distributed generators prone to such environment and weather impacts like intense wind, lightning, and snow call for more Power sources that are dependable and steady [2], [3]. A failure to quickly break the fault current will result in the rapid rise of the sea level and might inflict great harm. Electrical fires are caused by fault current [4]. Therefore, a circuit breaker is required to complete the operation swiftly by cutting off the fault current. Solid-state and hybrid circuit breakers are among the quick circuit breakers (SSCBs). The hybrid circuit breakers may be utilized at the medium voltage and still employ mechanical switches as a component [5], [6]. However, compared to the SSCB, the hybrid circuit breaker is considerably slower. Therefore, it is essential to create useful SSCBs that rapidly cut off the fault current. Solid State circuit breakers (SSCBS), safety devices without a moving element to interrupt the fault current, are made of power semiconductors and are renowned for their excellent operational and system advantages. To begin with, traditional circuit breakers use electromechanical mechanisms, which have a reaction time that is several orders of magnitude slower than semiconductor components. Second, semiconductor devices have the potential to stop the current flow without arcing, in contrast to electromechanical circuit breakers that rely on contact separation. Furthermore, solid-state circuit breakers can significantly reduce the risk of tripping through power and exposure to arcing hazards
in the event of a malfunction. This is due to their ultra-short current interruption feature. Furthermore, power semiconductor devices may do a vastly higher number of operations because transfer components are unnecessary. As a result, the lifespan of the circuit breaker will be significantly increased. As a result, semiconductors operate quietly since they lack moving parts. Solid-state circuit breakers offer various other advantages that can be utility-specific in addition to the advantages mentioned above, which are applicable for applications needing maximum power distribution.

Power networks must be able to meet actual energy demands in the event of temporary disruptions brought on by trees or strong winds. As a result, the SSCB needs to be promptly re-closed after the trip operation with fault removal. In any other scenario, a sustained long-term interruption with an open SSCB might cause considerable financial loss and damage. [7]. This is why the operating duty of a circuit breaker must be able to repeatedly perform the re-closing and rebreaking operations following IEEE standard C37.09 [8].

In this sense, modern society needs high-quality energy. It is essential to have a circuit breaker capable of speedy interruption, especially for microgrids and smart grids [9], [10]. There is a demand for SSCBS that can execute fast breaks and operation duties because the current SSCBS have issues carrying out their operating duties. Due to its relatively low conduction losses as compared to other switching devices and the fact that the load power is continuously supplied directly through the SSCB, the silicon-controlled rectifier (SCR) can be a very good choice for SSCB immediately. Malfunctions. However, it has the important disadvantage of no longer being able to do re-close and rebreak operations, as extensively covered in [12]. In particular, reconnection and reactivation operations are almost impossible due to continual short circuits on the load side that prevent the commutating capacitors from being charged.

Previous AC SSCBs were presented in [15], [16]. When the main SCRS is turned on, the previous AC SSCB's circuit charges the commutation capacitors. Similarly, if the load side has a persistent short-circuit problem, the commutation capacitors can be charged by turning on the relevant SCRS.

Consequently, the previous AC SSCB may perform operational activities, including re-closing and rebreaking. In the case of a three-phase supply in a grounded neutral system, the preceding AC SSCB needs the usage of a complicated thyristor to charge the commutation capacitors. At the same time, a single line fault happens to the ground [16].

The study introduces a novel AC SSCB with quick re-closing and rebreaking capabilities to overcome the drawbacks above, giving it the ability to perform operational tasks like resealing and rebreaking operations. The new ac SSCB can be easily used, regardless of whether a three-phase power supply with neutral point earthing is used. The suggested SSCB may readily charge the commutation capacitor for further disconnection even under short-circuit, load-side wire-to-earth fault, and overload circumstances without complex regulation of main and auxiliary thyristors. Finally, the operating characteristics of the planned AC SSCB are validated through various experiments in both single-phase and three-phase media. Its prototype has a rated power of 46.67 [kW] and a line voltage of 380 V.

II. NEW AC SOLID-STATE CIRCUIT BREAKER

The circuit diagram for a single-phase semiconductor circuit breaker is shown in Fig. 1. To assess the new SSCB's performance in real-world applications, we conducted short-circuit and overload tests. This will demonstrate the circuit breaker's usefulness and prove its potential.

Figure 2 depicts the circuit schematic for a new SSCB AC circuit with a three-phase source. Even in a chronic load side short circuit or overload state, the upgraded SSCB can charge the capacitor. In conclusion, the innovative AC SSCB can complete its operating functions within the circuit breaker criteria since the commutating capacitor may be charged regardless of whether it has continued to be in a fault condition on the load side [8].

This article discusses all of the aforementioned major AC SSCB activities by demonstrating single-phase and three-phase short-circuit faults with the largest value of fault current relative to all other faults, in order to validate the overall features of the proposed SSCB. The SSCB is subsequently put through an overload test.

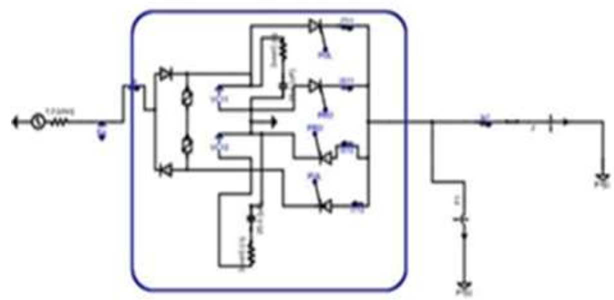

FIGURE 1. New ac SSCB with single-phase source.

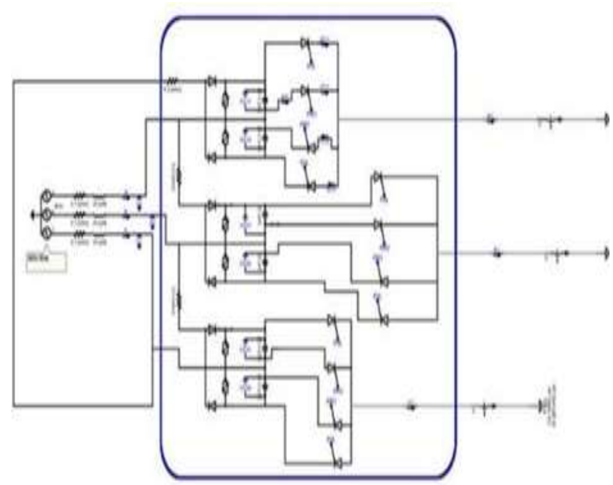

FIGURE 2. New ac SSCB with three-phase source.

III. SHORT-CIRCUIT FAULT

The most frequent risky situation for electrical power networks is short circuit problems. These problems cause a strong current to flow through the transmission system, which can damage alternators and transformers via overheating, overloading, and other effects. The voltage is less impacted in this stage than the current. There is minimal to no voltage drop in the realistic and ideal scenario.

Experiments with single-phase short-circuit, and three-phase fault in three-phase systems are carried out since the SLG and three-phase fault's simulated findings do not differ significantly.

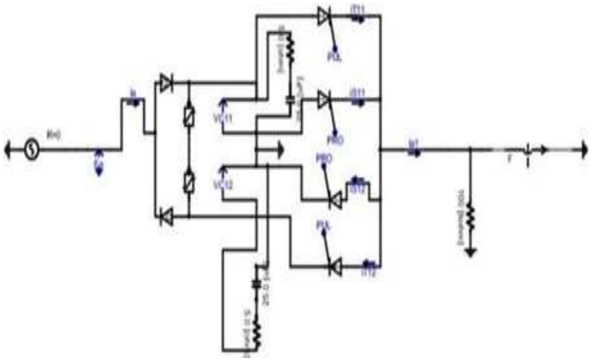

FIGURE 3 (a). Single Phase Short-Circuit Fault Model.

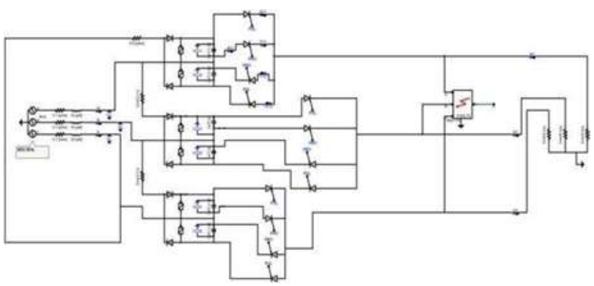

FIGURE 3 (b). 3 Phase Short-Circuit Fault Model

A. CHARGING MODE (T0 ≤ T < T5)

The SSCB can also interrupt the fault current by discharging the pre-charged commutation capacitors during this mode. Hence all commutation capacitors should always be charged before a fault occurs. In the charging mode (t0 - t5) of the SSCB, the commutation capacitor is charged to a specific voltage level using the mains voltage and the varistor for a brief stoppage of the fault current.

The charging of the switching capacitor starts at time t0 in Fig. 4 when the line switch is activated. In a single-phase medium, the switching capacitors C11 and C12 are fully charged at time t0 and t1 in Fig. 4, but in a three-phase system, all capacitors are charged following the phase order of the mains voltage. The proposed AC SSCB does not require any specific switching action to charge the commutation capacitors. All commutation capacitors are charged using a charging loop of a resistor, a diode, and a capacitor. The suggested SSCB can conduct turn-on and re-turn-on operations at any time because it can charge capacitors even when the load side is short-circuited. In this instance, t0 = 0 seconds and t5 = 0.2 seconds are both equal to zero seconds.

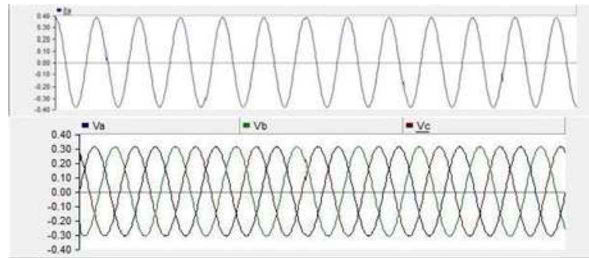

FIGURE 4(a). Single and 3-phase voltage source.

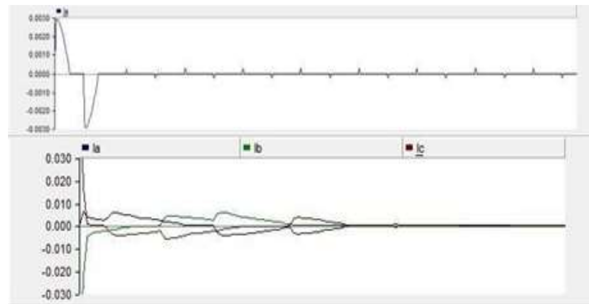

FIGURE 4(b). Single and 3-phase current source.

FIGURE 4(c). Single and 3-phase load currents.

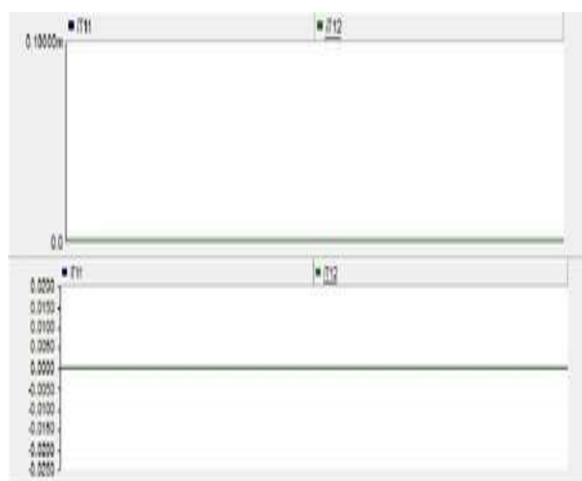

FIGURE 4(d). Main SCR currents.

FIGURE 4(e). Auxiliary SCR currents.

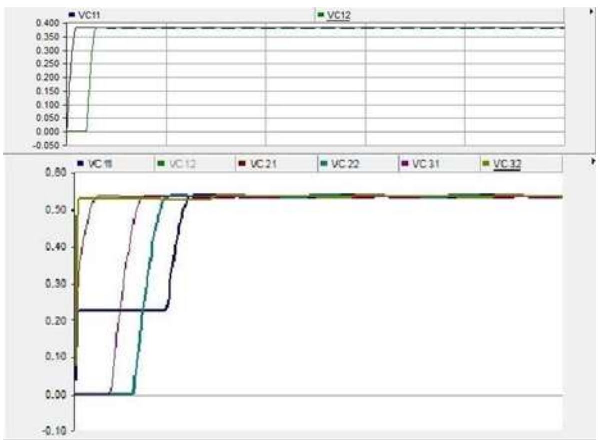

FIGURE 4(f). Commutation Capacitor Voltages.

B. NORMAL MODE (T5 ≤ T < T6)

According to Fig. 3(a) and 3(b), this is the steady state normal operation mode for supplying electricity to the load side (b). For this reason, the T11, T12, T21, T22, T31, and T32 Tall SCRs are all turned on. In addition, when operating in this regular mode, the SSCB may continually monitor line currents and voltages for general problems such overcurrent, sag, and swell.

The source voltage, auxiliary thyristor currents, and capacitor voltage (charged) are unaffected in normal mode. In our scenario, T6 equals 0.4s.

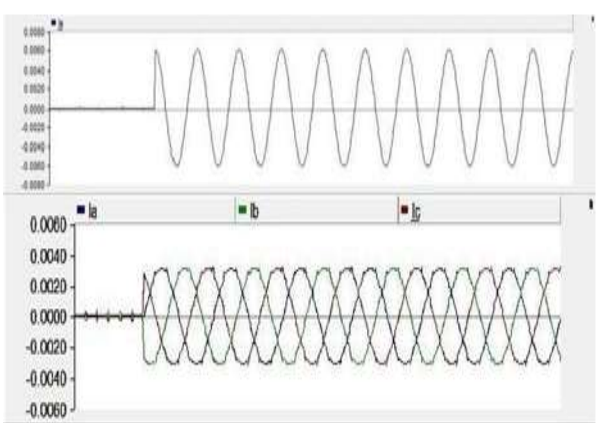

FIGURE 5(a). Single and 3-phase current source.

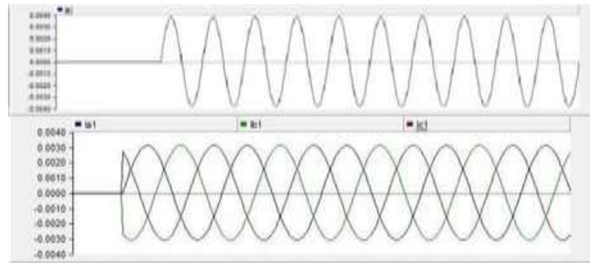

FIGURE 5(b). Single and 3-phase load currents.

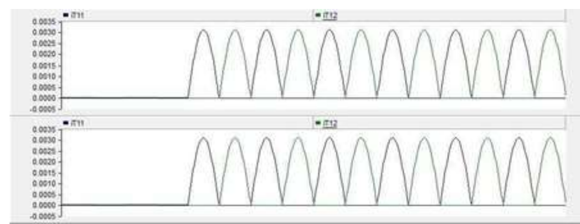

FIGURE 5(c). Main SCR currents.

C. NORMAL MODE (SHORT-CIRCUIT FAULT: T6 ≤ T < T7)

At t6, single-phase and three-phase short-circuit faults can happen, which causes the fault current to increase quickly. The SSCB continues to run in normal mode even after a short-circuit fault has already occurred until the fault current reaches the current value necessary to characterize a short-circuit problem. When one of the phase currents steadily increases to the current value, the recommended AC SSCB prevents the short-circuit fault at t7, starting the subsequent tripping mode. In our situation, T7 equals 0.4001s.

D. BREAKING MODE (T7 ≤ T < T8)

According to Fig. 6, the fault is cut off in this mode at 0.4 seconds. (t7). The primary SCRs T11, T22, and T32 are correspondingly turned off by the capacitors C11, C22, and C32's recharged voltage, while the auxiliary SCRs S11, S22, and S32 are switched on based on the direction of the

Corresponding phase current. The discharged capacitors C11, C22, or C32 are then recharged to interrupt the fault current's waveform as it flows through R, L, and C in each phase. The fault currents have finally stopped. For us, t8 is

0.402 seconds.

E. BREAKING MODE (T8 ≤ T < T9)

This condition completely stops the fault current. All SCR SSCBs are therefore turned off at time t8. The commutating capacitors discharge up to t9, which in our case is 0.403 sec, because they have already been extended in the charging mode by the voltage across the associated varistor.

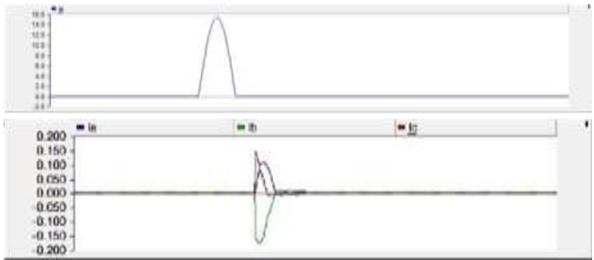

FIGURE 6(a). Single and 3-phase current source.

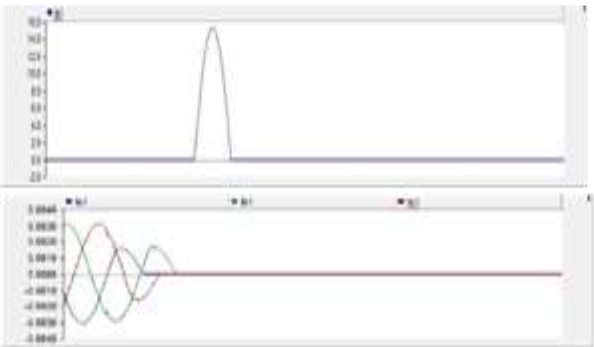

FIGURE 6(b). Single and 3-phase load currents.

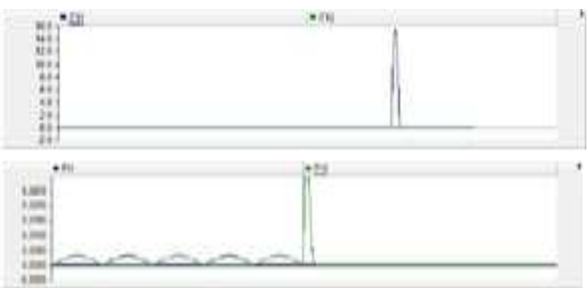

FIGURE 6(c). Main SCR currents.

F. RECHARGING MODE (T10 ≤ T < T13)

In the current shutdown mode, the commutation capacitors discharged in the prior shutdown mode are replenished once more. Capacitors C11, C22, and C32 (t8 t12) are charged while all SCRs are off; the new SSCB is able to charge commutation capacitors without thyristor control even if there is a short circuit on the load side. The new SSCB is prepared to restore the fault current even in the case of a load side short circuit, thus once the recharge mode is complete, the SSCB can also carry out a re-closing operation by firing the main SCR.

G. RECLOSING MODE (T13 ≤ T < T14)

All of the main SCRs (T11, T12, T21, T22, T31, and T32) are active during the re-closing mode. The circuit breaker must perform a predetermined re-closing action in accordance with the operating mode re-closing schedule. No matter whether there is a load side short circuit, all primary SCRs need to be turned on. The action is repeated once the system goes back into normal mode following a short.

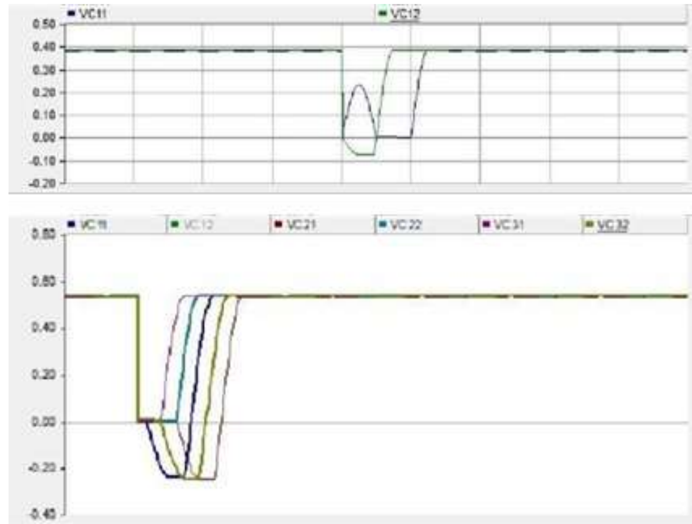

FIGURE 7. Commutation Capacitor Voltages

IV. OVERLOAD FAULT

Less congestion means more than a frantic demand on the power system grid. Although it will fall to a very low value, the overload voltage cannot be zero. Even if the current in an overload condition is high, it is still far less than the current in a short circuit. Overloading raises the joule temperature, which results in burns and harms the electrical system. An overload condition damages equipment in the power system. For instance: If an 800 watt load is connected across an inverter with a 400 watt rating, an overload will result.

A short circuit results from a fault between lines or between a line and ground, but an overload happens when a device draws too much current from the source. This is one of the key distinctions between the two. As seen in Fig. 1 and 2, overload conditions are investigated on single-phase and three-phase systems, similar to the tests mentioned before. 100 MW plus 25 MVar is the overload value.

A. CHARGING MODE (T0 ≤ T < T5)

In charging mode, the main or auxiliary SCRs are not operating, and the commutation capacitors are charged to their maximum capacity value. Because they interfere with the power system by sending reverse voltage to the main SCR, capacitors charge ahead of the regular current flow to the loads, as discussed in Part III of this study. The outcomes in Fig. 4 depict the full course of the charging mode. The

In the typical mode of operation, the loads are powered by single-phase and three-phase voltage sources, and the commutation capacitors continue to charge without interfering with any kind of SCR. An external pulse generator fires the primary thyristors at t5 in order to generate a channel for the current supply. This procedure keeps going until the system experiences an overload error.

The source voltage, auxiliary thyristor currents, and capacitor voltage (charged) will all remain unchanged in normal mode from charging mode, as was previously stated. Figure 5 displays the outcomes of this mode.

C. NORMAL MODE (OVERLOAD FAULT: T6 ≤ T < T7)

The demand for current from single-phase and three-phase sources will rise dramatically if the system experiences an overload condition. There also appears to be a voltage drop on the supply side due to this. It should be observed that the current increase during an overload is lower than the current during a short circuit.

The SSCB system will not trip if a fault occurs until the current fault value is achieved. The suggested ac SSCB starts the second tripping mode when the value matches, interrupting the overload fault at t7

D. BREAKING MODE (T7 ≤ T < T9)

Applying the reverse voltage provided by the commutation capacitors to the main SCRs in this mode causes the fault current to be totally eliminated from the system. The auxiliary SCRs are simultaneously turned on for a brief period and instantly turned off. Under overload fault circumstances, Fig. 8 depicts fault current interruption.

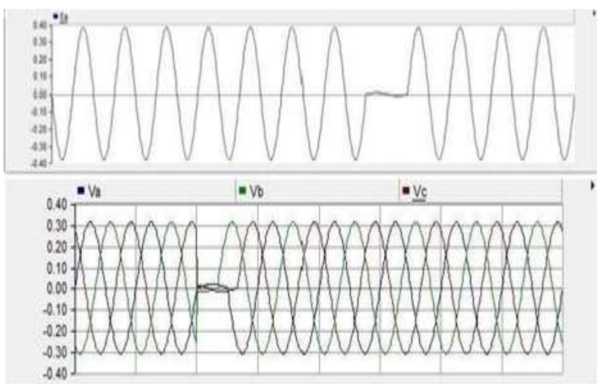

FIGURE 8(a). Single and 3-phase voltage source.

FIGURE 8(b). Single and 3-phase current source.

E. RECLOSING MODE (T13 ≤ T < T14)

In this mode, the commutating capacitors' action causes the ac SSCB, which was previously opened owing to an overload fault, to be closed once more. This demonstrates the break and close system's functionality without the need for SCR. This facilitates quick and precise switching in addition to assisting in trustworthy applications.


FIGURE 8(c). Single and 3-phase load currents.

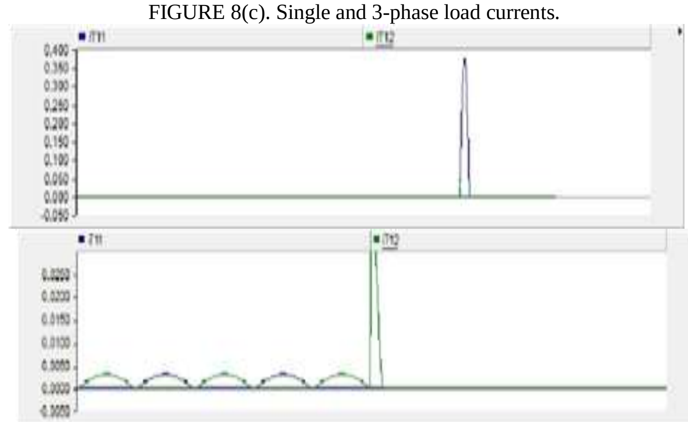
FIGURE 8(d). Main SCR currents.

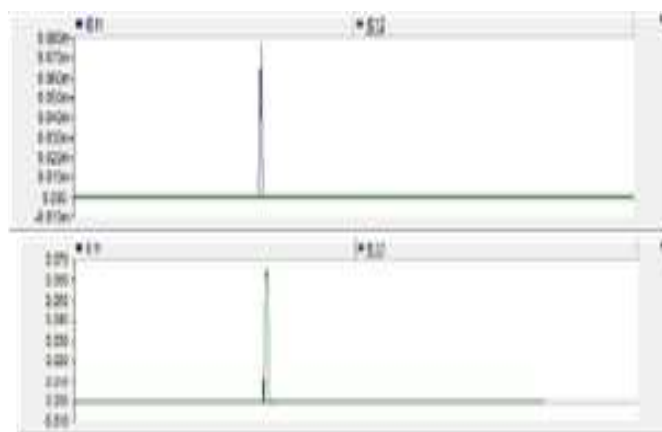
FIGURE 8(e). Auxiliary SCR currents

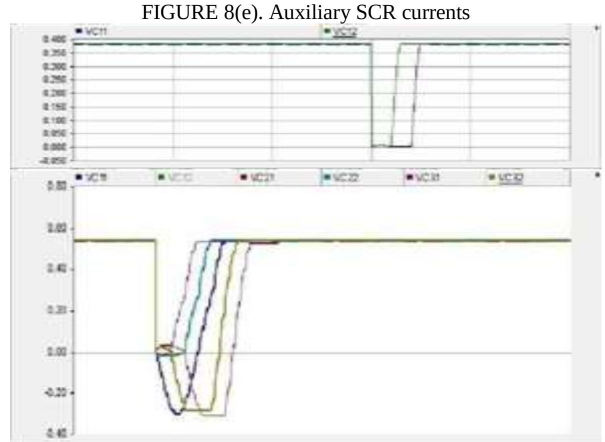
FIGURE 9. Capacitor Voltages.

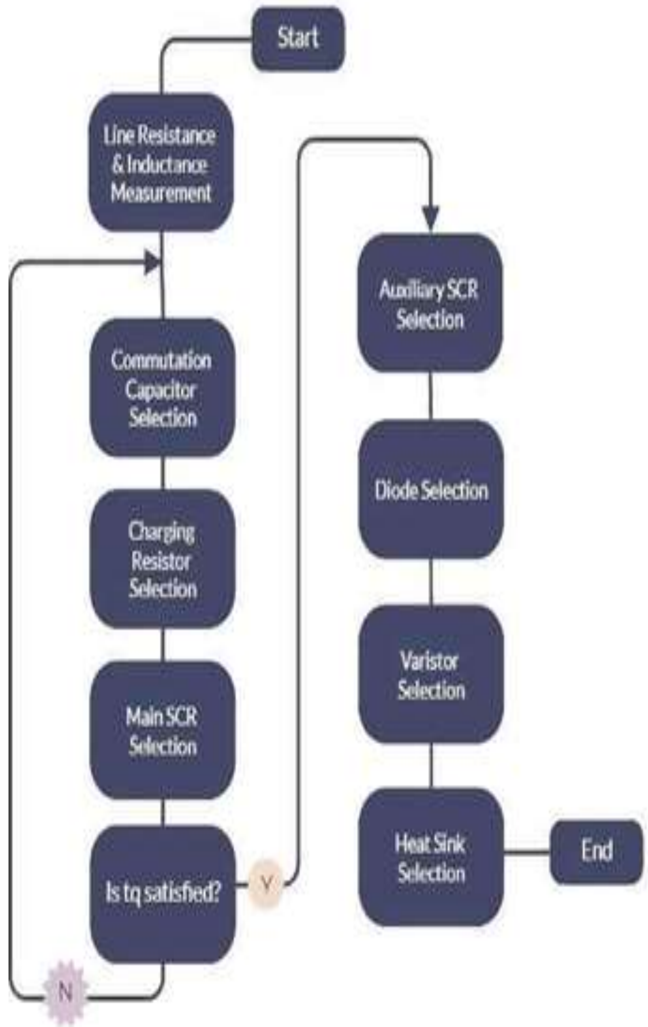

FIGURE 10. Design Flowchart.

V. SOME COMMON MISTAKES

Figure 10 Line condition monitoring, charging circuit design and main circuit device design, commutation circuit design, and heat generation architecture.

A. LINE CONDITION MEASUREMENT

The resistance and inductance of the line at the installation site of the circuit breaker are referred to as "line condition." The line resistance values are necessary for optimum charging resistance distribution in the charging mode. The location of the

The commutation capacitor also requires the correct measurement of the line's inductance. The switching capacitor's voltage increases in the off state due to the power saved on the line inductance being transferred there. This article measures the resistance and inductance of the line where the circuit breaker is installed as 99 [mΩ] and 37 [μH].

B. COMMUTATION CAPACITOR SELECTION

It is essential to determine the maximum fault current via the capacitors in order to obtain an accurate capacitance value because the entire fault current passes through the commutating capacitors during the fault. For clarity, Fig. 11 shows the equivalent AC SSCB circuit that has been proposed. The equation generated from the circuit will determine the system's maximum fault current.

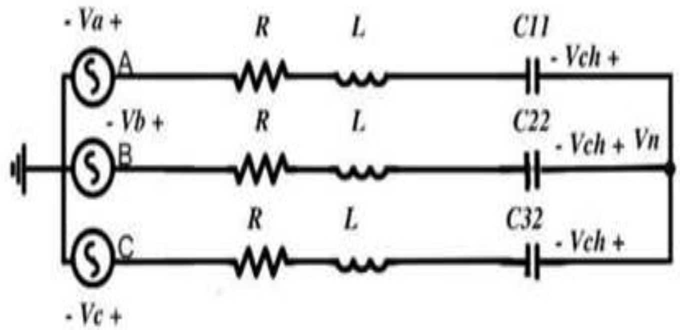

FIGURE 11. Equivalent circuit in fault condition.

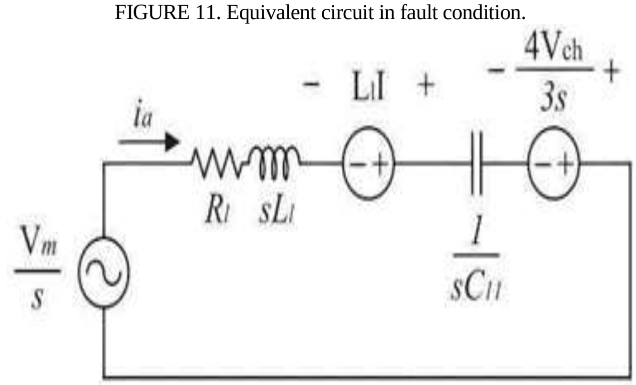

FIGURE12. Equivalent circuit of phase "a".

The neutral point "Vn" cannot be set to zero because the commutating capacitor C11 from phase "a" charges in a different direction from the other two capacitors, C22 and C32. Therefore, we can calculate the capacitor's compensating voltage using the following formulae.

$$(V\_n - V\_a - V\_ch)/Z + (V\_n - V\_b + V\_ch)/Z \; + \; (V\_n - V\_c + V\_ch)/Z = 0 \tag{1}$$

$$V_{Cea} = -V_n = \frac{V_{ch}}{\sim}[V](V_a + V_b + V_c = 0) \tag{2}$$

Z represents the overall impedance created by the capacitor's and the line's resistance and inductance. A straightforward 120° phase shift can be used to determine the current for each phase. Ia (3) is the phase current via phase "a" and I is the preset value of current through the commutating capacitor that must be reached for SSCB warning in the Laplace equivalent circuit of Fig. 11 shown in Fig. 12.

$$〖I〗\_a(s) = (sL\_(l\hat{}I) + (4+\sqrt{3})/3\,V\_ch)/(L\_(l\hat{}(s\hat{}2)) + R\_(l\hat{}s) + 1/C\_11) \tag{3}$$

The fault current's peak value can be ascertained using the hit-and-try method shown in Fig. 13. As the voltage capacitance and commutation capacitor's capacitance increase, so does the peak value of the current.

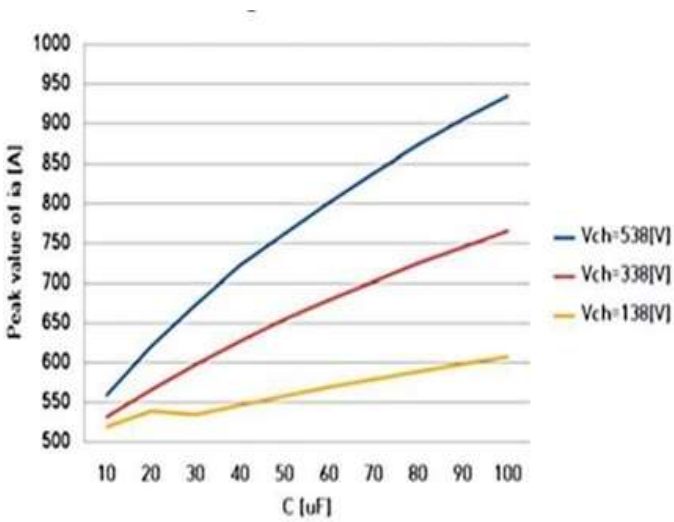

FIGURE 13. Max Value of fault current due to capacitor

The primary SCRs' turnoff time is another factor to take into account when selecting a switching capacitor. But even if the primary thyristors' current is zero, a complete shutdown is necessary to remove any danger. There must be a turnoff time tq in order to properly turn the SCR off. For this reason, the voltage of the switching capacitors must be positive until the SCR is completely turned off. The terms "tq device" and "tq circuit" will appear frequently throughout this investigation. Device tq, as stated on the product sheet, is the SCR's turnoff time. The time interval between the thyristor current and switching capacitor voltage being reduced to zero is known as the circuit tq.

The statistics demonstrate that the primary SCRs will typically turn off if the circuit tq exceeds the device tq. The main SCR cannot be switched off effectively if the device's tq is higher than the circuit's tq. As a result, the tq circuit needs to be set up to always have a higher tq than the device.

When the capacitance and voltage capacitance of the switching capacitors change, Fig. 14 illustrates how the circuit tq changes. The figure indicates that a longer circuit tq can be produced by using capacitors with higher capacitance values and voltage ratings. The bigger fault current value that will occur if the larger capacitance value is chosen is another issue that comes with this decision. So, a suitable capacitance value is chosen with the aid of Figs. 13 and 14.

In our model, the charging voltage is set to 583V and the switching capacitor capacity is set to 25 [uF]. As a result, the circuit tq is 22 [us] and the maximum fault current is 648A.

C. CHARGING CIRCUIT DESIGN AND MAIN SCR DESIGN

A charging resistor must be chosen to control the current flow to the commutating capacitors after the commutating capacitor and circuit tq are chosen. Overcharging is avoided by the interference between the supply and charge capacitor.

$$I_{ch}(s)=\frac{V_{ch}\sqrt{2}}{2L_{l}s+(2R_l+R_{ca})+\frac{1}{sC_{11}}} \quad (4)$$

$$R_{ca}\geq\sqrt{\frac{8L_l}{C_{11}}}-2R_l \quad (5)$$

Current flowing into a charging capacitor is expressed as (4). And equation (5) needs to be satisfied in order to prevent the over-charge problem. The equation can be written as follows, assuming that the resistance of the short-circuit fault is relatively low:

$$I_{Rab}(s)=\frac{C_{11}V_{c11}}{R_{ab}C_{11}s+1} \quad (6)$$

When shown in (6), the circuit tq decreases as the Rab value decreases because more current passes through the off-mode capacitors. The charging time for the computing capacitors will be extended if the resistor value is high. Thus, selecting the appropriate value for the charging resistors is necessary. We chose a charging resistance of 5 Ohm for our example. The primary SCR must be chosen once the resistor has been chosen. The current value will significantly increase if a short circuit or overload fault occurs in the system, and the SSCB will break the system when the preset value is reached. It can be argued that the highest value of the current travelling through the SCR is therefore equal to the predefined value. The default value for our model is set to 500 [A], meaning that the maximum current that can pass through the primary thyristor will also be 500 [A]. The applied voltage to the main SCR can be expressed as: since the main SCR is connected in parallel with the capacitor in series and the auxiliary thyristors.

B. $V_{Tmain}=V_C+V_{(Saux.ON)}\approx V_c$ (7)

Where V and VSaux.ON are the commutating capacitor voltage and the dropout voltage of the auxiliary SCR. where VSaux and V. The dropout voltage of the auxiliary SCR and the commutating capacitor voltage are both ON. Because VSaux.ON is so little compared to V, the entire reverse voltage applied to the main SCR can be considered the capacitor voltage V. Therefore, V may be calculated using the commutation capacitor's capacitance and current.

Fig. 15 depicts the variation of the primary SCR's maximum voltage in response to the commutation capacitor's capacitance. According to the diagram, the commutation capacitor's capacitance and the voltage applied to the main SCR are inversely proportional. Our model used 8 [us] as the device tq and 716[V] as the maximum SCR voltage.

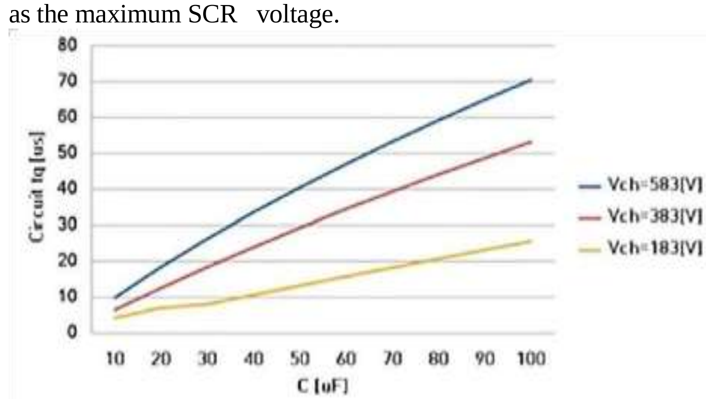

FIGURE 14. Value of Circuit tq to Capacitance and Voltage

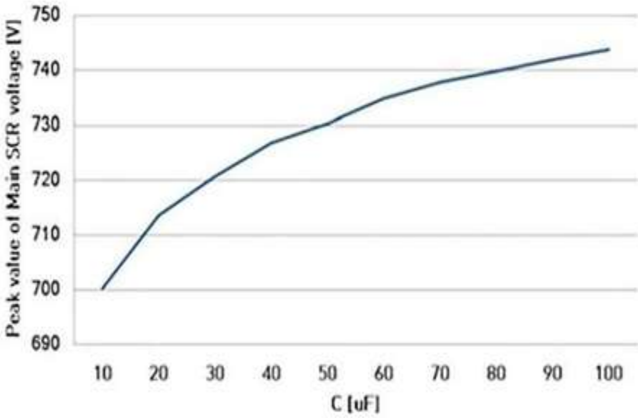

FIGURE 15. Variation of SCR voltage due to capacitance.

D. COMMUTATION CIRCUIT DESIGN

An auxiliary SCR, varistors, and diodes are included in the switching circuit for our investigation. Since the auxiliary SCR is only activated briefly during the turnoff operation, it is chosen based on the maximum current and voltage.

Figure 6 illustrates the auxiliary SCR activates when the fault current reaches the predetermined current value. The current passing through the charging resistor is the reason the auxiliary current is higher than the actual fault current. Additionally, Giant. 6 demonstrates that the peak current of the auxiliary SCR is equal to the phase current's peak value. As a result, the auxiliary SCR's value needs to be chosen following the maximum fault current. In our model, 648 [A] is selected as the maximum current that can pass through the auxiliary SCR.

In the off mode, the voltage is also applied to the auxiliary SCR when the commutation capacitor is charged in the opposite direction. At that time, the auxiliary SCR's maximum voltage is expressed as:

$$V_c+V_a=V_{Saux} \qquad (8)$$

In our research, the auxiliary SCR's maximum voltage SCR is found to be 689 [V]. Before making a decision, it is important to take notice of the amount of current that passes through a charging diode in both charging and shutdown modes. The diode current is calculated in (4) and (6). It is preferable to make measurements at the peak current through the diode rather than the average current since the current runs through the diode for a relatively brief period of time.

The charging diode's peak current flow in our model is 255 [A]. The system's varistor, one of its key components, is chosen using the breakdown voltage and energy. When operating in normal mode, the switching capacitor's charging voltage should be higher than the varistor's breakdown voltage.

When power begins to flow into the varistor and the breakdown voltage of the varistor drops below the rated voltage of the commutating capacitor, the varistor begins to function. The switching capacitor's permitted reverse voltage determines how much energy the varistor can store.

E. HEAT SINK DESIGN

A cooler is selected based on the overall heat generated by all of the system's devices. Since the heat created by the diode, varistors, and auxiliary SCR is only present for a very little time, it need not be considered. Therefore, when modelling the heat sink, just the primary SCR's conduction loss needs to be taken into account. The following is an expression for the primary SCR's overall conduction loss:

$$P_{Total}=V_{TO}\times I_{avg}+I_{rms}^2\times R_T \qquad (9)$$

Where R is the internal resistance and V is the SCR threshold voltage. The cooler should be constructed to achieve the proper TJ at full load. A silicon semiconductor device's nominal temperature is typically 150 [°C]. It is advisable to maintain the TJ below 110 [°C] due to the possibility that the SSCB will be installed in an area with high ambient air temperature and restricted airflow.

TABLE 1. DESIGN PARAMETERS AND SPECIFICATION

Parameters	Specification
Power rating	46.67 [kW]
L-Voltage	380 [V]
Current of full load	100 [Apeak]
R_L (Resistance of Line)	99 [mΩ] (1.29%)
L_L (Inductance of Line)	37 [μH] (0.201%)
Resistance, Capacitance	5 [Ω], 25 [μF]
Resistance for a short fault switch	200 [Ω]
Trip Setting Range	100[Apeak]→500[Apeak]

VI. DISCUSSION

Table II shows the comparison between the numbers of SSCB Components required. The number of components of the proposed SSCB and already existing SSCB is almost equal. However, the varistor rating of the proposed SSCB can be smaller than that of the already existing SSCB, which will lower the cost. Moreover, the commutation capacitors of the proposed SSCB are naturally changed without complex switching operations. As a result, the reliability of the proposed ac SSCB is relatively high.

TABLE II COMPARISON OF THE NUMBER OF SSCB DEVICE

Circuit topology	Fig. 4 of [12]	Fig.14 of [12]	Fig.5 of [16]	Proposed SSCB
Capacitor	3	6	6	6
SCR	18	12	12	12
Diode	0	6	6	6
Varistor	3	6	3	6
Charging Circuit	Required	Not	Not	Not

VII. CONCLUSION

The traditional work of breaking and re-closing the system was performed by a novel semiconductor circuit breaker that was proposed in this research study with a few more components. The two most typical faults, short circuit fault and overload fault, have been tested in both single-phase and three-phase media. Both failures were present in the system, and the new SSCB could operate the circuit breakers without incident. Furthermore, no sophisticated SCR switching or charging techniques were utilized. Therefore, it can be said that the suggested SSCB complies with all IEEE standards' guiding principles and requirements and may be securely implemented to support contemporary power systems.

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CONFLICTS OF INTEREST

The authors declare they have no conflicts of interest to report regarding the present study.

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