Switching Effects in Capacity Circuits with a Vacum Switch

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Abstract—**In this paper is presented results of studies about disable 3-phas capacitor bank through vacuum circuit breaker. All simulation are generated in ATP/EMTP programme and all results comes from this simulations. In this paper is analyzed values of overvoltage and overcurrent appears in 3-phas capacity circuit when the neutral point of capacitor bank is insulated and neutral point of network is grounded.**

Keywords-circuit breaker; ATP/EMTP; simulation;capacitor bank; switching operations; overvoltage; overcurrent;

I. INTRODUCTION

Switching processes are a very common phenomenon occurring in the power system. These processes occurred in inappropriate conditions may pose a danger to both the network as well as for the circuit breaker and installed apparatus.

When examining the phenomenon of switching processes in the capacity circuit the attention should be paid to emerging transitory effects. The most common appears to be the emergence of significant but short-lived surge values of overvoltage. Characteristic to the switching processes in the capacity circuit is the overvoltage value increase during the capacitor bank surge.

Usually the process of attaching a battery is not controlled, the only danger may occur during switching high-power batteries. Thus, the most important is the analysis of the transition phenomenon during the switching-off of the battery.

This process is complex and depends on many factors, some of them are: power of capacitor bank, the quantity of switched-off batteries, power of capacitors already attached to the network circuit breaker and a zero point of both types of networks and the battery (grounded, insulated). It is very important to use a switch that could minimize the possibility of appearing re-ignitions of the arc. Because overvoltage and overcurrent are only dangerous during the re-ignitions of the arc. For this purpose, in medium voltage networks, the vacuum switches are used more often. Due to their many advantages they are slowly replacing other switch types , including widely used in medium voltage networks connectors with SF_6.

According to the company EATON, vacuum switches will represent approximately 80% of all switches in a medium voltage networks until the year 2020.

In this work I will analyze the variants of the 3-phas capacitor bank with insulated neutral point of capacitor bank, with grounded neutral point of the network.

II. MODEL

A model to research transistory effects in capacity circuits has been created inATP\EMTP program. All elements of the circuit, with the exception of the vacuum switch, have been taken from the library of the program.

The switch model has been programmed in the MODELS block in order to reflect as accurately as possible the vacuum arc which appears in real vacuum switch.

The control algorithm is based on a variety of assumptions and checking many variables occuring during the simulation..

The values used in the model:

- Chopping current (I_u)
- Slope of recovery strengh
- Maximal distance of opening contact (d)
- Time of opening contact to maximal distance (t_{op})
- Slope of the current which switch is able to interrupt (di/dt)

TABLE I Values used in the control algorithm

I_u	***d***	***t_{op}***	***di/dt***
[A]	[mm]	[ms]	[A/µs]
3	3	2	150

- Slope of recovery strenght has been calculated based on the formula:
-
- slope of recovery strengh:

$$U_W = A_1 \cdot d^b$$

where: A_1=26,b=0,89- factors dependent on material Cu, d- maximal distance of opening contact [1]

The algorithm written in MODELS block controls an ordinary switch by sending to it the opening and closing sygnals. In this way a vacuum arc is initiated.

- First the switch is mechanicly opened. Overvoltages and overcurrents are presented
- Then is comparable slope of recovery straight with voltages on the switch. If the U_w > u1(t)-u2(t) is real the model finishes work, but if U_w <u1(t)-u2(t) is real the block of MODELS closing the switch and the re-ignition of the arc appears
- Next is checking chopping current and high frequency of current[HF]. If Iu=3A the signal of opening is sent but if Iu≠3 the signal opening is sent when the number of HF=3

The researched capacity circuit is made of:

- ideal 3-phas voltage source(E)
- Induktance and capacity of line (L,C)
- Vacuum switch (VS)
- Capacitor bank (C_b)

TABLE II Parameters of model elements.

E	L1,L2,L3	C1,C2,C3	C_b
[kV]	[mH]	[µF]	[µF]
6	20	0,8	47

During the analyze of the three-phase circuit it is important to pay attention to the neutral point of the network as well as the batteries.

The central point of this work was to find the solution of the aforementioned question. The neutral point is grounded and the battery insolated. It is widely used due to the simplicity of protection from fault in capacitor bank.

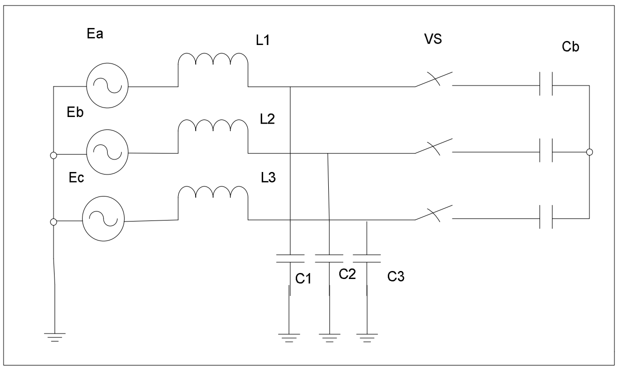

Fig 1 Diagram of simulation model.[2]

As mentioned earlier the most dangerous conditions present a re-ignitions of the arc. The vacuum switch element that could cause trouble and cause a re-ignition of arc is not simultaneous opening of contacts. During the simultaneous opening of contacts under conditions of ideal simulation circuit behaves like a single-phase circuit. If the contacts open not simultaneous add a condition where the battery is isolated capacitors may arise any significant overvoltages and overcurrent could do much damage to both batteries and insulation and connecting devices within switching area.
The case to be considered are:

- Presentation of the arc in phase A
- Successively in phase C and B
- Meanwhile, in phase C and B

III. RESULTS

Simulations carried out in the presented electrical circuit show us (with the parameters that have been used for the connector and a commutated circuit) the appearance of another re-ignition of the arc. The results of the simulation have been compared whilst opening of contacts for the circuits for the circuit with isolated and grounded zero point of the battery.
It clearly appears that the re-ignitions of the arc in the circuit with a grounded zero point of the battery, are a lot smaller and they appear in smaller numbers. On the picture 2-5 we can see some examples of graphs(charts) of returning voltage tension and electric current. These help us define the value and character of the transitory effects for the circuits mentioned above.

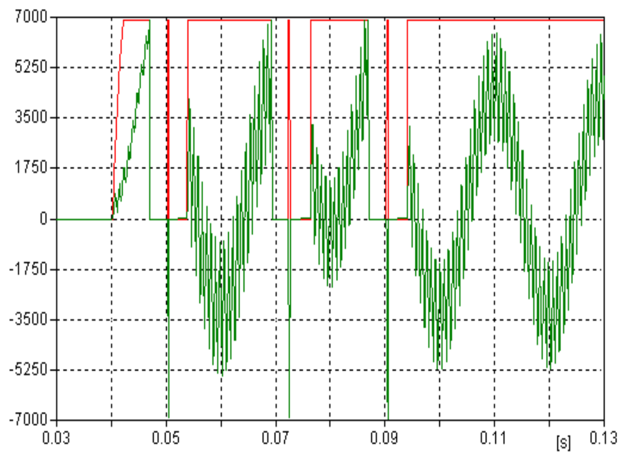

Fig.2 Return voltage (green line) and slop of recovery strength (red line) on the vacuum switch in capacity circuit witch neutral point of battery is insulated.

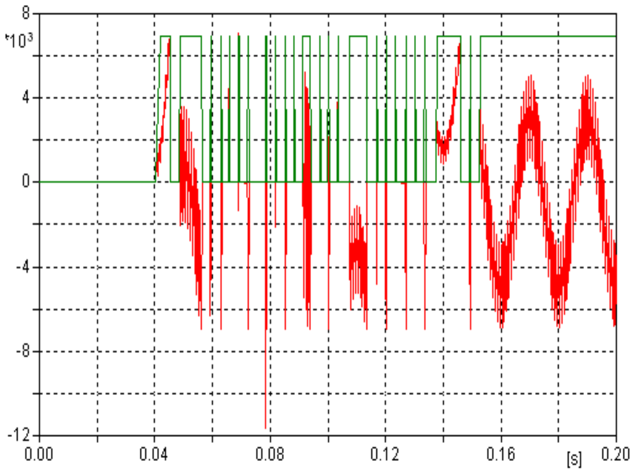

Fig.3 Return voltage (green line) and slop of recovery strength (red line) on the vacuum switch in capacity circuit witch neutral point of battery is insulated.

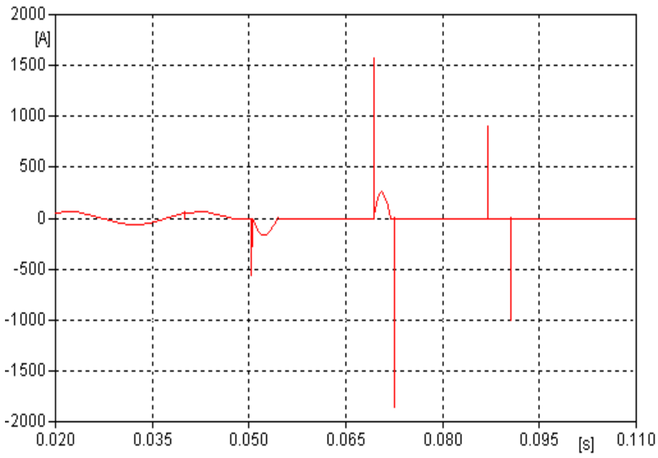

Fig.4 Current on the vacuum switch in capacity circuit witch neutral point of battery is grounded.

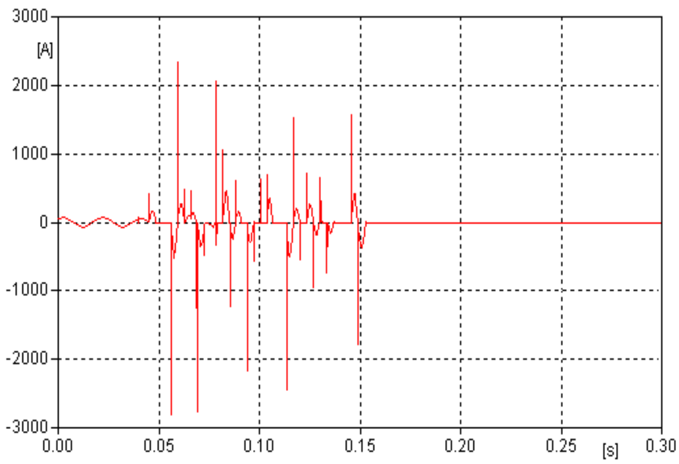

Fig .5 Current on the vacuum switch in capacity circuit witch neutral point of battery is insulated.

The result from analyzing the changes of the functions of the time that has passed from the moment of opening the vacuum connection contact is that the breakdown of the recovery strength in the circuit with isolated point zero happens faster.

The result from analyzing the changes of the functions of the time that has passed from the moment of opening the vacuum connection contact is that the breakdown of the recovery strength in the circuit with isolated point zero happens faster. The repeated arc appears earlier that in the circuit with grounded point zero and therefore this causes another repeated ignitions. A safe return voltage that does not threat the battery and does not breakdown the slope of recovery strength takes place after a longer period of time than in the case of a circuit with a grounded point zero. However, simulations in which the values of overvoltage and overcurrent appearing in the circuit have been compared, where contacts of a circuit breaker are parted at different times, are more interesting. On the picture 6-9 we are observing the course in three phases for circuits with isolated point zero network, with simultaneous and not simultaneous opening of the contact. Therefore it can be said that not simultaneous division of the contacts is a worse case. This results in a higher return voltage in the third phase and bigger amount of current overvoltage and a longer time for transitory effects that threat the battery of capacitor bank.

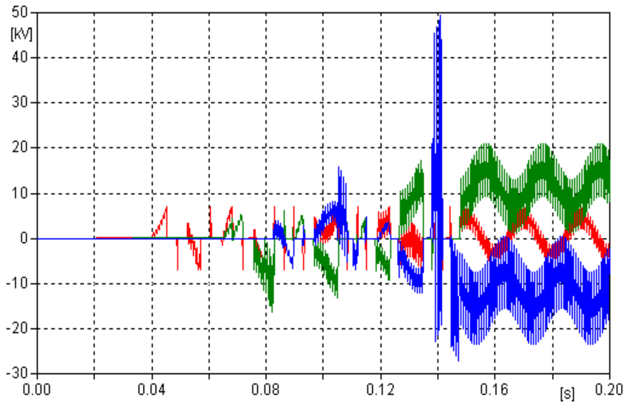

Fig. 6.Voltages in capacity circuit witch neutral point of battery is insulated and contacts open not simultaneous..

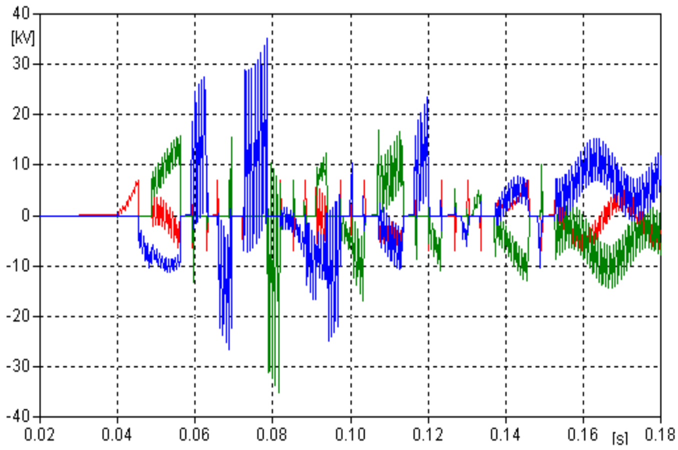

Fig 7 Voltages in capacity circuit witch neutral point of battery is insulated and contacts open simultaneous..

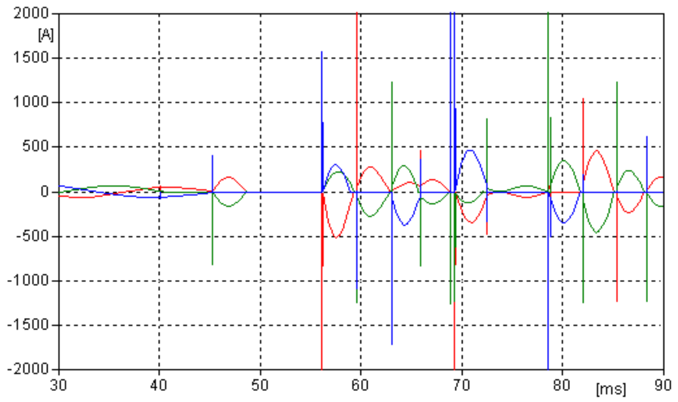

Fig.8 Currents in capacity circuit witch neutral point of battery is insulated and contacts open simultaneous.

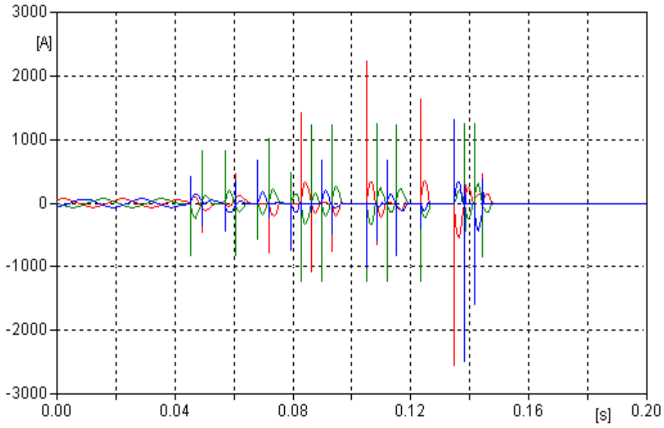

Fig.9. Currents in capacity circuit witch neutral point of battery is insulated and contacts open not simultaneous.

It is important to turn attention to the fact that there is a possibility to open contacts at two poles at the same time. See pictures 10-11 where contacts B and C have been opened at the same time, with a contact A opened before B and C.

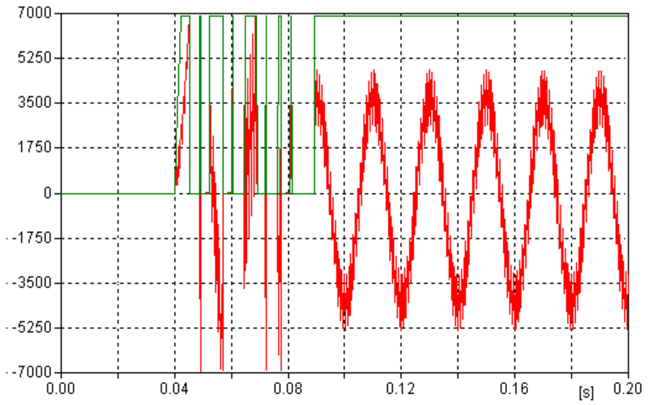

Fig10. Return voltage (green line) and slop of recovery strength (red line) on the vacuum switch in capacity circuit witch neutral point of battery is insulated and two pole open simultaneous.

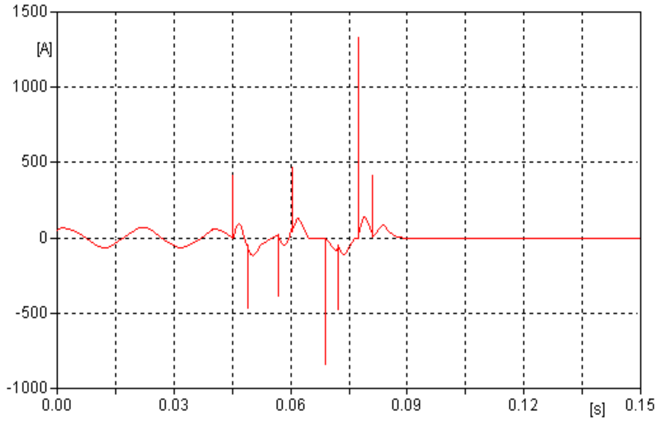

Fig. 11 Current on the vacuum switch in capacity circuit witch neutral point of battery is insulated and two pole open simultaneous.

It could be said that this example is only dangerous when repeated ignition appears in switching off phases B and C at the same time.In this situation the overvoltage can be three times higher than a normal voltage and overvcurrent double the normal current.

CONCLUSION

The described model is a result of the introductory phase of work(research) and its final goal is to make a model to simulate switching process appearing during switching capacity circuit by vacuum switch. This has been created using several simplistic stipulations. Carried out simulations allowed to analyze many configurations and to check the possibility of changing the parameters that influence the value of overvoltage and overcurrent . All the results confirm harmony of the model with the descriptions in mathematics books**.**

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