HYBRID DIVERTER SWITCH

Nikolay Gourov

Abstract: Power quality is essential to the economy. To provide it is an important task and depends on whole chain production - distribution - consumption. One of the most important parameters of power quality is the stability of the voltage in the electrical network. The most frequently used way to ensure such stability is to incorporate on-load tap changers in power transformers, which makes it possible to switch output voltage of the transformer up and down depending on the consumption.

The paper proposes new construction of a diverter switch for on-load tap changer with two vacuum interrupters and a thyristor block. The device is relatively simple and could have practical application as specific parameters have some advantages over known diverter switch with three vacuum interrupters and a resistor.

Keywords: Diverter Switch, On-Load Tap Changer, Thyristor, Vacuum Interrupter

I. INTRODUCTION

Nowadays, production and distribution of electrical energy have been liberalized. This means that it is seen as a product which must meet certain quality requirements and naturally leads to an increasing attention to the quality of electrical energy. Although the generation, distribution and consumption of electrical energy are separated, they all influence the quality and ultimately it can be achieved only through the joint efforts of manufacturers, distributors and consumers. Maintaining the necessary quality of electrical energy is extremely important because from it depend the proper, efficient and safe operation of all appliances connected to the electrical network and the health and lives of electricity consumers and service personnel.

Although indicators of power quality are many and different, the stability of the voltage of the electrical network is one of the most important ones. For voltage control in the network are broadly used on-load tap changers. They regulate the voltage in the network by switching up and down sections of the winding of the transformer (taps) to change it turns ratio and maintain stability of the output voltage of the transformer. Switching occurs during operation of the transformer from the diverter switch as part of the on-load tap changer without interrupting the power supply for consumers. Moreover, during switching process in the classic diverter switches ignites electric arc that causes formation of deposits on the contact surfaces, contamination of the transformer oil and electric erosion of the contacts. All this lead to sharp reduction of maintenance intervals of transformers with on-load tap changers compared with those without such devices. To ensure trouble-free operation changing of contacts and oil after given number of switching operations is needed. To perform this change the transformer should be turned off and his work is interrupted before need of maintenance or repair work for it. This makes difficult and expensive operation of such transformers and therefore research is doing continually on increasing the number of switching operations of diverter switches in order to reach the maintenance and repair intervals of transformers without on-load tap changers. Traditional methods to minimize the effects of the electric arc are optimizing contact materials, geometry of movement and constrict of contacts, transition impedances etc. Although such methods can help achieve the goal they are largely exhausted. Therefore, the decision is seeking in support of classic switching contacts with semiconductor ones, which help to avoid ignition of electric arc when switching, or in replacement of classic arcing contacts with vacuum interrupters that have sizable resource for the number of switching operations and in which the electric arc is quenched in vacuum and does not contaminate the transformer's oil.

II. HIBRID DIVERTER SWITCH

Electrical circuit of a hybrid diverter switch for on-load tap changer composed of two vacuum interrupters and a thyristor block of two antiparallel connected thyristors is proposed in [1]. The sequence of operation of this diverter switch is presented in [2].

On Figure 1. is shown a circuit diagram of a diverter switch proposed. Two vacuum interrupters – V_1 and V_2 are connected to two neighboring taps X and Y of the winding of the transformer. Step voltage Uc is applied between the taps. Common terminal O is also a star center for three-phase diverter switch. During switching operation the thyristor block T connects sequentially in parallel to one or the other vacuum interrupter via contact system K_1. The control system consists of a high resistance resistor, current transformer (TT) and a module (M). Through contact system K_2 control system also connects alternatively parallel to V_1 or V_2. K_2 contact system contains airtight contact (XK) commanded by permanent magnets.

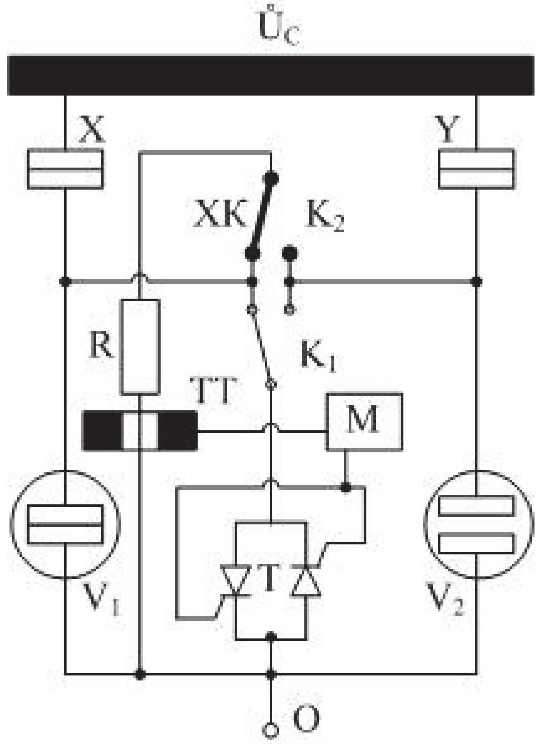


Figure 1. Electrical circuit

Are there advantages of this scheme can be assessed only after making a constructive variant of the diverter switch. This can be done based on the cyclogram of Figure 2., using the experience of [3]. It is typical that this K_1 must be switched in the beginning of the process in both directions X → Y and Y → X.

The diverter switch developed is shown in longitudinal sectional view in Figure 3. a) On Figure 3. b) a top view (A) and two transverse cuts (B-B and C-C) of the diverter switch are shown. The supporting construction is composed of a metal bottom 21, a cylinder 2 made of insulating material and an upper disc 13, also of insulating material. In the middle of the metal bottom by means of rolling bearings is mounted a drive shaft 7. It is provided with a buffer system 19. Both vacuum interrupters 5 are secured to the insulating disk 13 by means of contact-holders 6. Through them the diverter switch is gripped to the contacts of oil vessel not shown on the figure. Each vacuum interrupter is triggered [4] of cam 18 by bearing 20 and L-shaped lever 22. Contact spring 23 and flexible current-carrying connection 3 are also included. The diverter switch is a three-phase one, for each phase between the two vacuum interrupters are disposed the elements of contact systems K_1 and K_2. On Figure 3. a) K_1 and K_2 are rotated on 180^0 for better clarity.

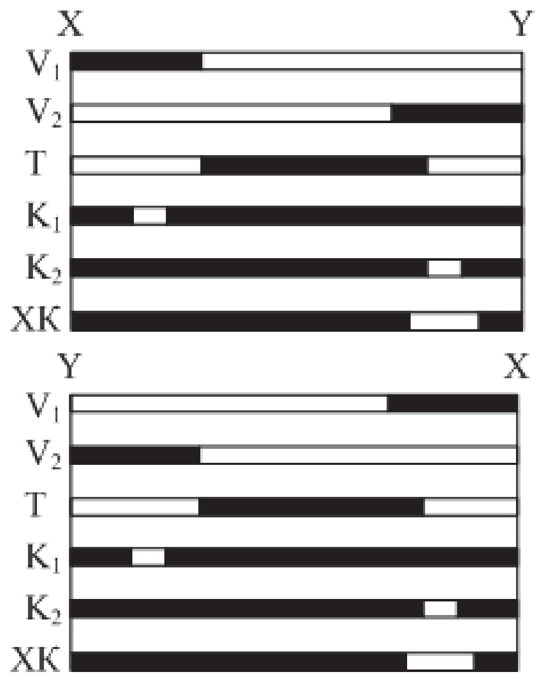
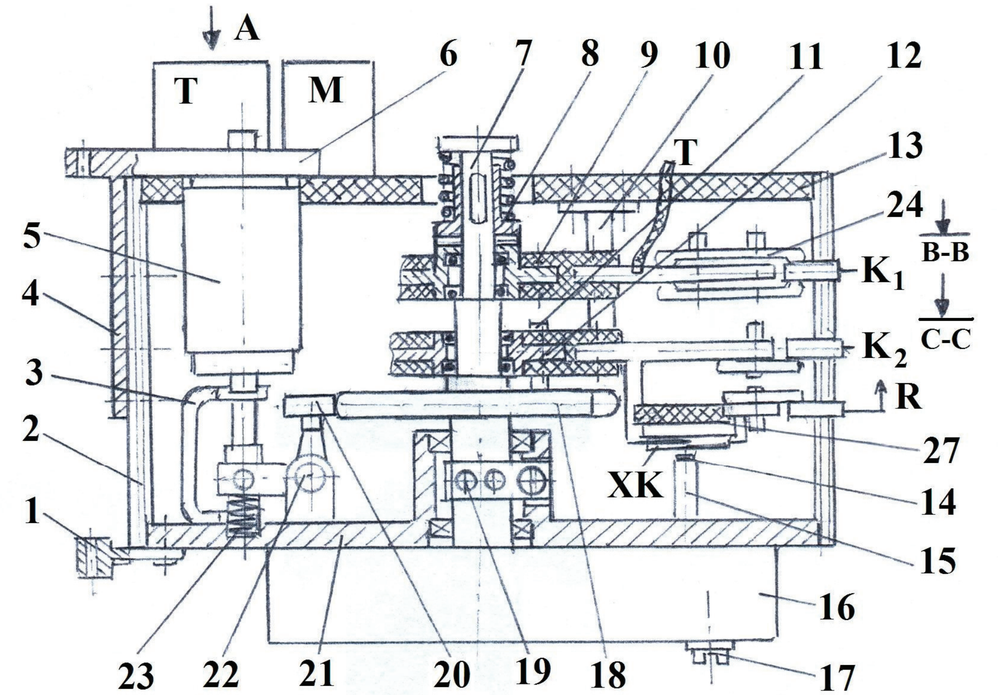
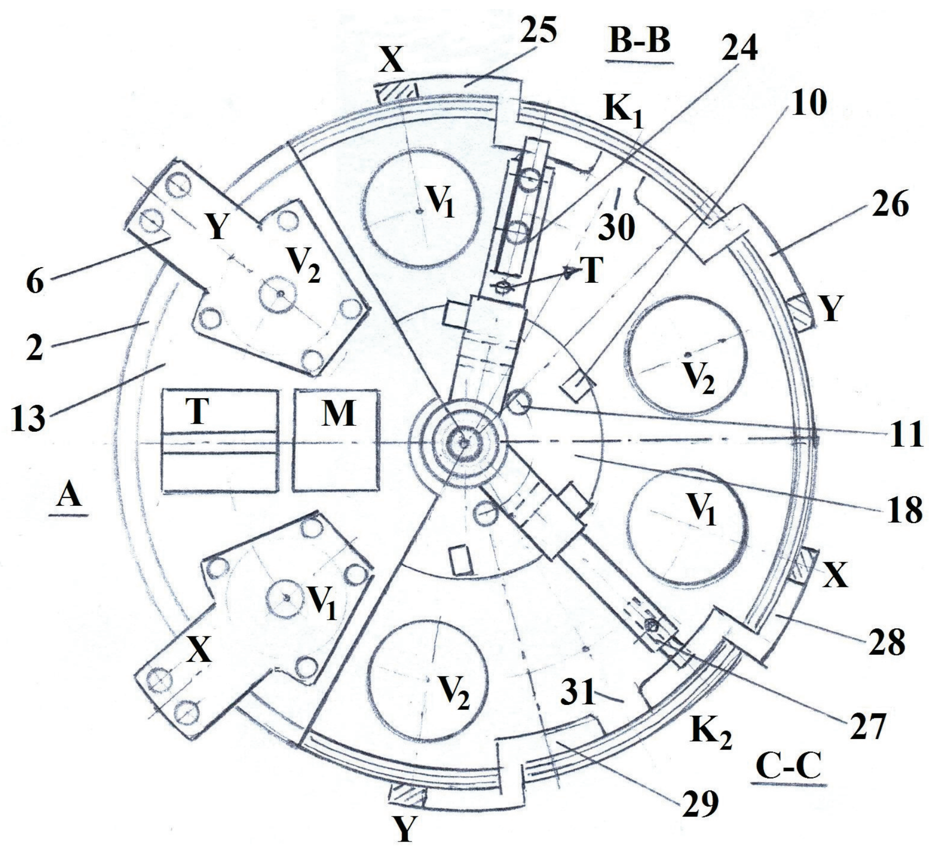


Figure 2. Cycloramas of the proposed diverter switch

The contact system K_1 is located on the upper floor (section B-B on Figure 3. b)). Contact system K_2 – below it (section C-C on Figure 3. b)). The moving contacts 24 of K_1 are mounted to an insulating carrier 9, and for the three phases are shifted on 120^0. The carrier 9 is bear on the drive shaft 7. On the shaft 7 is axially mounted spring overloading connector 8 with an appropriately shaped front teeth. They engage with similar front teeth of the star 9. The flexible connection T connects the movable contact 24 with thyristor block T (Figure 1.). The fixed contacts of K_1 25 and 26 are connected to the vertical elements 4 of the carriers 6 of the two vacuum interrupters. There is insulating gap 30 between them.



a)



b)

Figure 3. Construction of the diverter switch

The movable contacts 27 of K_2 are also attached to the insulating star 12 which is mounted on the shaft 7. The carrier of contacts 27 is U-shaped. On its top is located a switching contact, which is connecting alternatively fixed contacts 28 and 29 of K_2. On the lower part is shaped contact which is leading the current to the resistor R (Figure 1.). Airtight contact is connected in series there. Between contacts 28 and 29 has too an insulating gap 31.

Thyristor block T and control module M, for each phase are fixed to the insulating disk 13 between holders 6 of both vacuum interrupters.

The diverter switch operates in the following sequence. In each switching the drive shaft 7 rotates rapidly to 90^0 driven by spring-energy accumulator 16 charging via plug 17 [5]. At the beginning overloading connector 8 rotates the star 9 while rolling contact 24 is rotated to 30^0, is passed the insulation gap 30 and is stopped at the end limiter 10. Overloading connector 8 is releasing and is disengaging the star 9 in further rotation to 60^0. Limiters 10 are securely fastened to the insulating disk 13. At the end of the switching, the two pins 11 mounted on the cam 18 are rotating the star 12 of K_2 on 30^0. The cam 18 controls the switching off of V_1 and switching on of V_2. On the metal bottom 21 onto insulators 15 are situated two permanent magnets 14. They are mounted on 30^0 apart and provide switching on of airtight contact in both end positions and switching off during passing of the contact 27 trough the insulating gap 31. Thus, the contact elements 28 and 29 are not exposed to electric erosion. With the described sequence of operation are realized the cyclograms of Figure 2.

The operation of the control system (Figure 1.) is performed in the following manner: After opening V_1 of the cam disc 18 the operating current passes through zero. Current flows for about 100-150 μs through the auxiliary resistor R. During this time the current transformer TT is sending a command to the control module M and the thyristors of thyristor block T are switched on. Before that K_1 has switched to tap Y (Figure 2.) and through T begins to flow load current. Trough R is flowing only circulating current. Following is the switching on of V_2 [2] and switching of K_2. This switching is without current because before the operation the airtight contact has interrupted the circulating current. So the thyristors of T are switched off and the current flows only through V_2. Reverse switching is similar. The resistor R is of high impedance. It is made of thin resistive wire, and the resistance value complies with the step voltage. For example, at a nominal current of the diverter switch 400 A and step voltage 1500 V value of R can be 300 Ω. This means that the circulating current will be 5 A. Therefore, R must be sized for short current pulses from about 20 A for 150 μs and 5 A for not more than 20 ms. For such period will run and the operating current through T. This makes possible to use thyristors for relatively small currents and simplified control system. Simplified version of K_2 is possible without using of airtight contact. Circulating current is small and its direct switching off from the contact elements 28, respectively 29 (Figure 3. b)) will not cause noticeable electric erosion. Suitable material for the contacts can be selected.

An advantage of the considered diverter switch compared to such with three vacuum interrupters and resistor [4] can be obtained if the set of thyristor unit and control system is cheaper than the one supplied from a vacuum interrupter and current limiting resistor. This depends on the specific parameters of the diverter switches. In the diverter switch shown here only one arc is extinguished during the switching process, while the one with three vacuum interrupters both arcs are extinguished. This may result in less wear-resistance.

III. CONCLUSIONS

A new construction of a diverter switch is developed with two vacuum interrupters and thyristor block. It is relatively simple and could be applied in practice.

The new diverter switch for specific parameters may have some advantages over a known diverter switch with three vacuum interrupters and resistor. There are prerequisites that it will have practical application.

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Contacts:

Nikolay Gourov, Department of Electrical Measurements, Faculty of Automatics, Technical University - Sofia,
8 Kl. Ohridski Blvd., 1000-Sofia, Bulgaria
Phone: +359-2-965-2366, Fax: +359-2-965-2447, e-mail: nrg@tu-sofia.bg