STATIC SWITCHING FOR THE COMMUTATION OF COIL TAP's OF SPECIAL TRANSFORMERS

Valberto F. da Silva*, José A. Cortez*, Ângelo J. Rezek*, José Policarpo G. Abreu e Carlos H. da Silva ***

* Grupo de Eletrônica de Potência e Controle Industrial (GEPCI)
** Grupo de Qualidade da Energia Elétrica (GQEE)
UNIFEI/IESTI/ISEE, Universidade Federal de Itajubá, Brasil
valberto@iee.efei.br, rezek@iee.efei.br, cortez@iee.efei.br e polica@iee.efei.br

Abstract - **The advent of the IGBT, power semiconductor controlled by voltage in the decade of 80 and the posterior increasing of their voltage and current to about 3500 V and 1500 A respectively, as well as of the switching times to about 5 μs, in the decade of 90, has propitiated to this type of device to substitute the traditional SCR's in the implementation of moderns static switches. The aim of this paper is to present the development of an optional arrangement of static switching for the commutation of coil tap's of special transformers, using IGBT's to substitute the SCR's .Tap regulators transformers need of fast performance of commuters to effective correction of voltage variations, being, therefore, the value of the voltage deliver to the load the nearest possible of the specified value. This way, modern arrangements of electronic tap commutation, based in this type of semiconductor attend perfectly the exigencies of the system, in a way that the time response remains in the range of 10 to 20 ms.**

Keywords: **Static Converter, Switch Control Strategy.**

I. INTRODUCTION

Electromechanical commuters tap's have been traditionally used for the voltage regulation in distribution transformers. With the development of new power semiconductors, one note a strong tendency to the substitution of the electromechanical commuters, by electronic commuters.

On the contrary of the SCR, IGBT has the current blockade control, by the inhibition of the base voltage signal and because of this fact SCR it is being substituted by the IGBT in modern electronic tap commuters.

Recent works [1,2,3] present commuters switches implemented with IGBT, and the secondary of the regulation transformers have several derivation taps of a only phase coil. In the reference [4], it is presented a topology, with IGBT, that uses the AC-DC-AC conversion, by using the frequency inverters PWM techniques.

The proposed work uses the IGBT for the implementation of the static switches to propitiate the commutation of the tap's of an special autotransformer [5, 6] that has been developed, as a project P&D (Research and development-Patent to be required) with the use of tap coils [7].

II. STATIC SWITCHING USING IGBT'S

Figure 1 shows the scheme of the implemented static switch circuit, by using the IGBT semiconductor. The IGBT, Insulated Gate Bipolar Transistor, operates as an " ideal switch", that is, the switch can be closed with positive gate pulse (G). In this situation the collector – emitter (VCE) voltage is null and the IGBT operates as an ideal closed switch. The switch can be opened, by applying a negative base pulse voltage. As the IGBT operates as an unidirectional device, the current flows in the sense collector to emitter. For the application in alternating current circuits, one may use the bidirectional device, with topology as of type diode bridge, as shown in figure 1. The parallel circuit SNUBBER, installed in parallel with the collector emitter terminals, has the function of protection the device against overvoltage, causing inadequate fire of the device by dv/dt. and to absorb voltage peaks on the switch, in inadequate operations of the system.

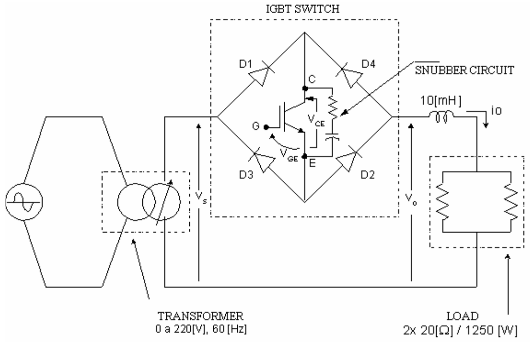

Fig. 1. Schema for connection of IGBT in alternating current circuit.

I. Block diagram of the current module

The logic that supervises the firing and blockade pulses on the IGBT switch is implemented in a PLC device that is a component part of the firing module, main objective of this work.

Figure 2 shows the block diagram of the firing module. The switch control strategy uses the conceits of firing by ZVC (zero voltage crossing) and blockade by ZCC (zero current crossing), both in the switch, in order to minimize the dynamic solicitations over the switch. The modules indicated by "voltage synchronism circuit" and "current synchronism circuit" are responsible by these information, and are implemented by using voltage transformers and Hall current sensors, respectively. The On/Off command is made by the PLC. There is also a module called "reset circuit", that permit to liberate the firing logic, when the overcurrent protection acts.

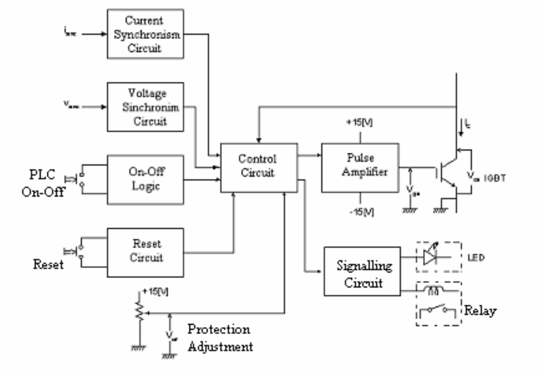

Fig. 2. Block diagram of the firing module.

These above feedback signals supply the control circuit module, which receives also the IGBT VCE voltage information, in order to promote the instantaneous blockade of the IGBT in the case of overcurrent in the circuit. The output signal of this module is the +15 [V] gate signal to fire the IGBT, or -15[V] to blocking it. There is also in the card, a signal to the PLC, by relay terminals that indicates the operations of the IGBT, fired or blockade. The typical waveforms of the developed device are shown in figure 3.

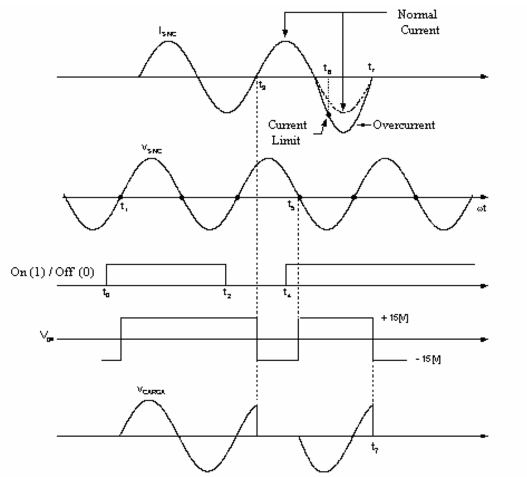

Fig. 3. Expected Waveforms

Considering the waveforms of figure 3, in the instant to is done an order to fire/close one switch, which was in the state of blockade/open. Only in the instant t1, in the zero crossing voltage signal, vsinc, occurs the fire of the IGBT. In the instant t2 occurs a blockade order to the IGBT, but only in the instant t3, corresponding to the zero current crossing (ZCC), isinc, there will be in fact the blockade of the IGBT. Another situation besides the blockade/fire operation in normal conditions is the overcurrent protection operation. In the instant t4 is given another fire order, but the effective fire occurs in the instant t5, corresponding to the zero crossing of the synchronism voltage vsinc. In the previous instant to t6, the overcurrent occurs, and the limiting signal is detected immediately in the instant t6. However, the vge signal will block the IGBT only in instant t7, corresponding to the zero crossing current (ZCC) signal isinc.

III. EXPERIMENTAL RESULTS

In figures 4 to 10 the top signal is voltage and the bottom signal is current. Qualitative aspects of electrical signals are shown.

- Figure 4 shows the current and voltage signals, registered in the secondary of the transformer.
- Figure 5 shows the current and voltage signals, registered in the load.
- Figure 6 shows the current and voltage signals, registered in the load, when the firing occurs command done by the PLC.
- Figure 7 shows the current and voltage signals, registered in the load, when occurs the blockade command done by the PLC.
- Figure 8 shows the current and voltage signals, registered in the load , when the operation of the overcurrent protection.
- Figure 9 shows the VCE voltage signal and the current in the load, when the operation of the overcurrent protection.
- Figure 10 shows the VCE voltage signal and the current in the load, when the firing command done by the PLC occurs.

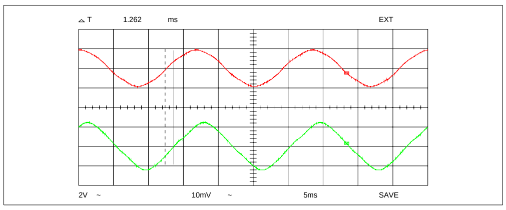

Fig. 4. Voltage and Current signals, registered in the secondary of the transformer.

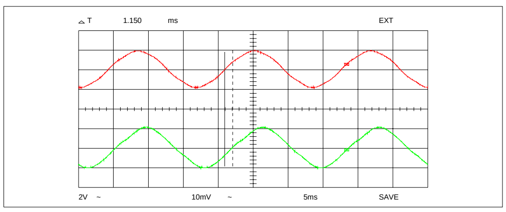

Fig. 5. Voltage and Current signals, registered in the load.

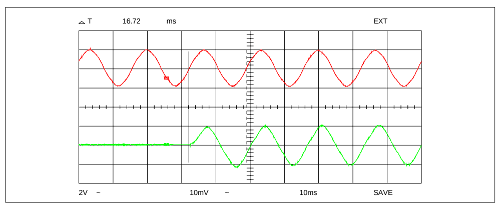

Fig. 6. Voltage and Current signals, registered in the load, when occurs the firing command done by the PLC.

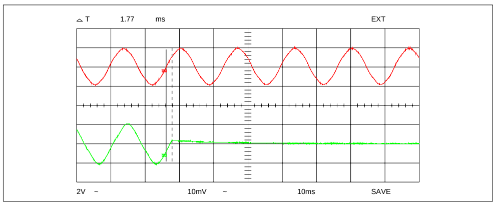

Fig. 7. Voltage and Current signals, registered in the load, when occurs the blockade command done by the PLC.

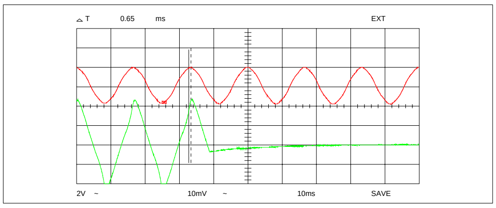

Fig. 8. Voltage and Current signals, registered in the load , when the operation of the overcurrent protection.

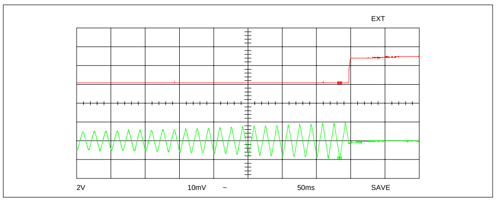

Fig. 9. VCE voltage signal and the current in the load, when the operation of the overcurrent protection.

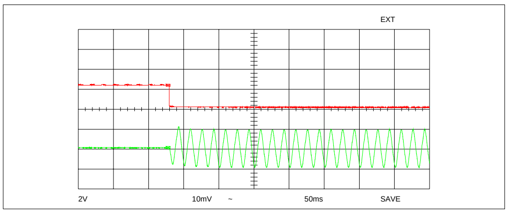

Fig. 10. VCE voltage signal and the current in the load, when occurs the firing command done by the PLC.

IV. CONCLUSION

- The implementation of the electronic switching prototype is technically viable and with lower cost of implementation.
- The time response of the switching is about 10 to 20 [ms], very fast one.
- The protection of the IGBT against dv/dt and instantaneous overcurrent is made only in the current zero crossing, isinc. The firing is made in the voltage zero crossing, vsinc. The blockade is made in the zero current crossing, isinc, when asked by the PLC or when a overcurrent occurs.
- When the blockade of the IGBT occurs, there is no overvoltage across the IGBT collector –emitter terminals. So, complex snubbers as that ones referenced in [2,3] are no more necessary.

V. REFERENCES

[1]. Echavarria, R. et all - Desing and implementation of a fast on-load tap changing regulator using soft switching commutation techniques – Power Electronics Specialist Conference, Pesc 00, 18-23 june, 2000, Galway, Ireland;

[2]. Bauen, P. et all - Electronic tap changer for 10KV distribution transformer - EPE 97, Trondheim, september 97;

[3]. Bauer, P. et all - Solid state control for transformer tap changing - PEMC 96, Budapest, September 96;

[4]. Heinmann, L.; Mauthe, G. - The universal power electronics based distributi- on transformer, an unified, approach - IEEE PESC 2001;

[5]. Abreu, J. P. G.; Monteiro, A. J. - Transformadores especiais e o emprego de bobinas particionadas - Nota Técnica 1.3, Ciclo 2001-2002, ELPA-FUPAI-UNIFEI, 2002;

[6]. Silva, V. F.; Cortez, J. A.; Abreu, J. P. G. - Métodos de comutação de bobinas para transformadores especiais - Nota técnica 2.1, Ciclo 2001-2002, ELPA-FUPAI-UNIFEI, 2002;

[7]. Abreu, J. P. G. - Desenvolvimento e Implementação de um Transformador com Relação de Transformação Complexa Variável - Phasor Controller - Tese de Doutorado, Unicamp, 1991.