

¹. Sorin Ioan DEACONU, ². Răzvan DEACONU, ³. Tihomir LATINOVIC

HIGH POWER STATIC CONVERTERS IN INDUSTRY APPLICATIONS

¹. UNIVERSITY POLITEHNICA OF TIMISOARA, FACULTY OF ENGINEERING HUNEDOARA, ROMANIA

². UNIVERSITY OF BANJA LUKA, FACULTY OF MECHANICAL ENGINEERING, BOSNIA & HERZEGOVINA

ABSTRACT: The use of AC Drives in the industry applications has seen tremendous growth over the last 40 years with the rapid development of high-power semiconductors, power converter topology, new control strategies, and their implementation with the advanced digital processors. These have made it possible to design drives with higher VA rating, with PWM and VC / DTC. However, this article present a real application in Kronospan S.A. Sebes Romania, where for the first time in Romania a medium voltage static converter was put in function with the load voltage of 6kV.
KEYWORDS: induction motor, high power, high voltage, static frequency converter

INTRODUCTION

The fast ascension of AC electric drives and static power converters was possible through a continuous and fabulous development of the performances of the semiconductor power devices during the last 50 years. There are two big categories of high power semiconductors: thyristors (which switch currents) where we can include switched rectifiers (SCR), gate-blocked thyristors (GTO), the thyristors with integrated switched gate (ICGT) and transistors (which switch voltages) where we have isolated gate transistors (IGBT) and the transistors with controlled injection gate (IEGT). In the figure 1 there are presented the domains of variation of the voltages and currents for the semiconductor power devices utilized nowadays to build static converters [1]-[5].

IGCT thyristors are with gate controlled current interruption for currents until 6000A (Figure 2). These devices were developed by ABB in 1996. They are characterized by a high closing speed (3000A/ μ s compared to 40A/ μ s at the GTO) and reduced losses during commutation (figure 3). The voltage drop on this device at a current of 6000A is 4V compared to 4.4V on a GTO which has a current of 4000A passing through it. Each semiconductor power device has its specific applications where it has a better behavior those other types of devices.

The direct control strategy of the torque (DTC) has appeared as a method in 1987, as an alternative to the method of orientation with respect to the field, and it was implemented by ABB in 1997. The characteristics of this method are the easy control of the torque and of the stator flux without utilizing the traditional transformations of axis and vectors d-q, without utilizing the pulse of width modulation (PWM), with no current reaction and with no PI-type regulators. The torque developed by the machine is proportional with the product between the rotation stator and rotor flux and the angle between them. The main variable is controlled in the DTC strategy is the flux ψ_s through the stator voltage V_s (by neglecting the resistance of the stator winding). The block scheme of DTC type is presented in the figure 4 [6]-[12].

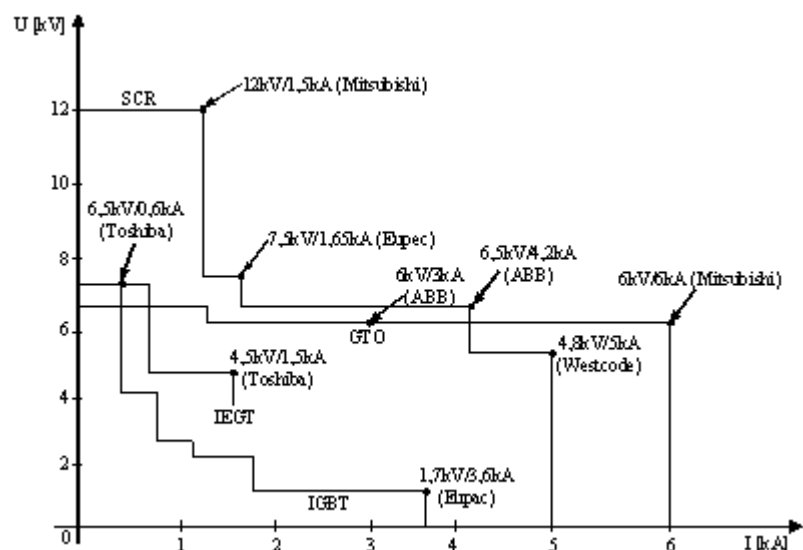


Figure 1. Domains of variation voltage/current for semiconductor power devices

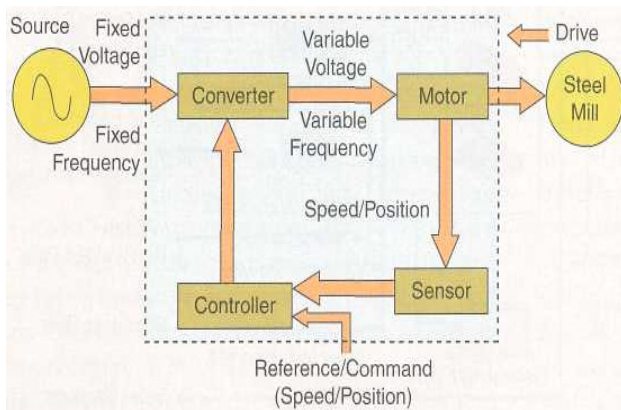


Figure 2. Block scheme for a high power AC electric drive

The calculation of the motor data is made every sampling period ($25 \mu\text{s}$). In the DTC strategy the typical torque response is 10 ms compared to 10-20 ms for the vectorial control case or more than 100 ms at PWM-type control in open loop. If an encoder is not utilized when measuring the speed the error is about $\pm 0,5\%$ while with an encoder it can get to $\pm 0.01\%$. The recent development of flux and torque control allow the utilization of DTC even at low speed [1].

PRACTICAL APPLICATION

However, this article present a real application in Kronospan S.A. Sebes Romania, where for the first time in Romania a medium voltage static converter was put in function with the load voltage of 6 kV. Because of the high losses caused by the repeated stops of the production flux (this ventilator is vital for the MDF factory) after the analysis of the history of this application there was a solution proposed, with an induction motor with the rotor in short circuit, having the power of 1800 kW supplied from a static frequency converter of ACS 5000 type from ABB. Initially, the ventilator with the moment of inertia $J=4001 \text{ kgm}^2$ was moved by an induction motor with wound rotor and starting resistances with the same power but which got broken pretty fast. The characteristics of the converter are: apparent power $S_n=2100\text{kVA}$, nominal load current $I_n=200 \text{ A}$, nominal load voltage $U_n=6000 \text{ V}$, the domain of variation of the load voltage 0.6000 V, the domain of variation of the load frequency 0.75 Hz, the number of load phases $m=3$, the rectifier has 18 pulses and the accepted overcharge 110% one minute at every 10 minutes.



Figure 5. The panel of the ACS 5000 type converter - 2100 kVA



Figure 6. ABB motor of 1800 kW which moved the ventilator with $J=4001 \text{ kgm}^2$

In Figure 5 there is presented the panel of the converter and in Figure 6 the motor from ABB. In Figure 7 and 8 there is presented the SCADA application, in which the drive system that has just been described is included, and in figures 9, 10, and 11 there is presented the value of the current, of the power absorbed by the motor and of the speed in the turn-on process.

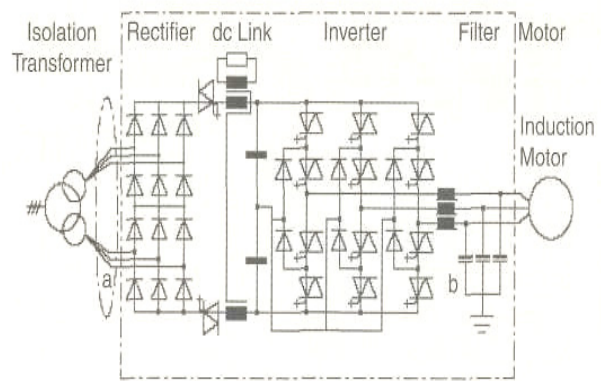


Figure 3. Three-level voltage converter with IGCT for an induction motor

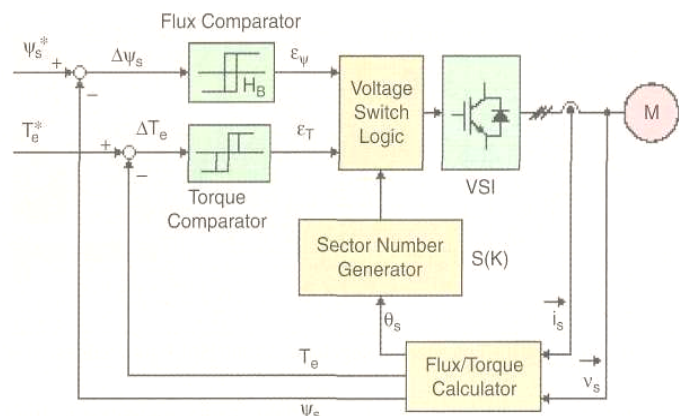


Figure 4. Block scheme for the direct torque control (DTC)

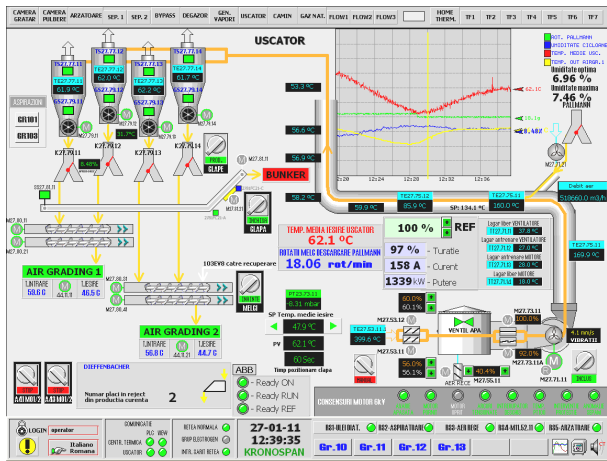


Figure 7. Proces of MDF drying (SCADA application)

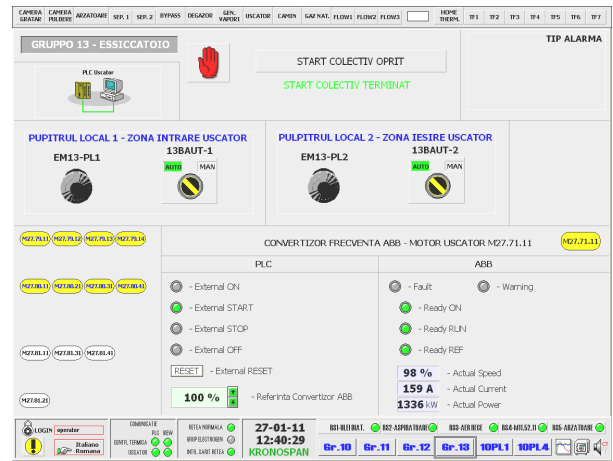


Figure 8. ABB motor and static frequency converter ACS 5000 (SCADA application)

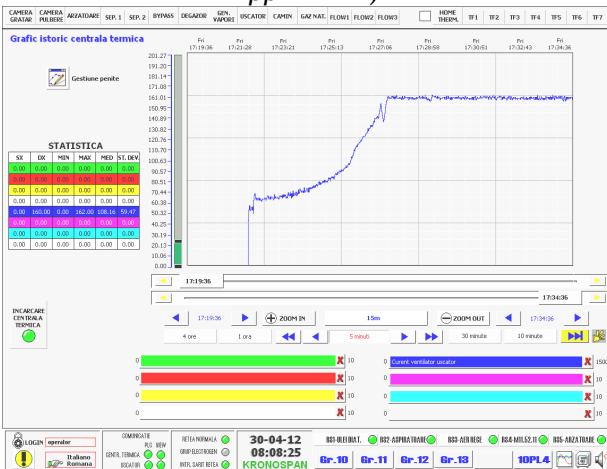


Figure 9. The current in the turn-on process

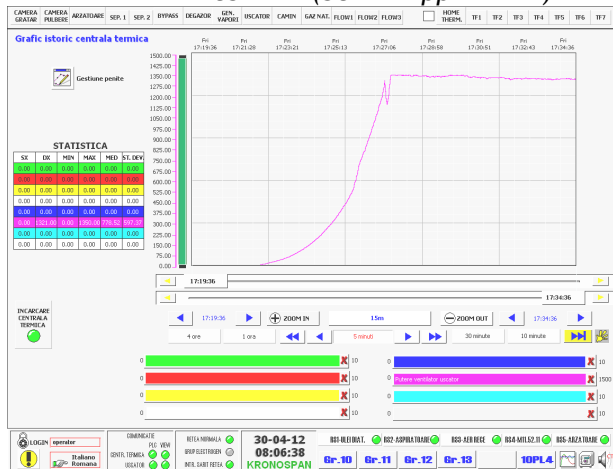


Figure 10. The power in the turn-on process

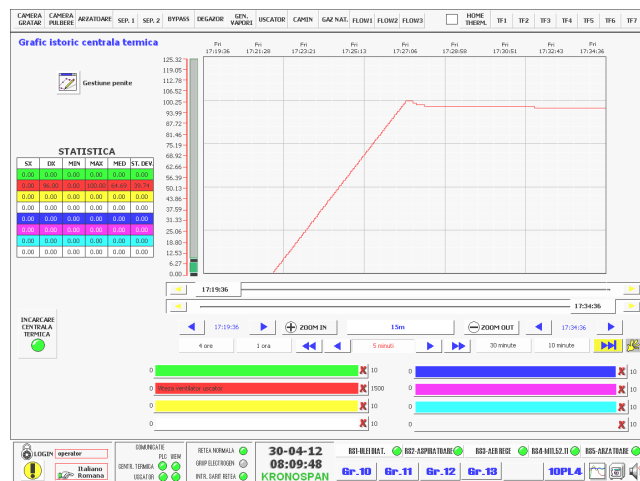


Figure 11. The speed in the turn-on process

CONCLUSIONS

The static converters allow the control of the electric drives which are found in all the industrial and lately, residential domains. In the paper there are presented the main topologies of converters utilized, especially in the high and very high power drives. There is described the direct torque control strategy DTC and to give an example there is shown a practically-implemented application in a plant used to produce wooden fiber tiles (MDF), where the drive system with no static converter has produced important losses due to the many issues. After restarting there have been no other problems, and the investment was paid back in 8 months just by eliminating accidental turn-offs.

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