UDC 621.31.83.52

THE IGB-TRANSISTOR EXCITER OF SYNCHRONOUS MACHINE

D. Mykhailichenko, **A. Chernyshev**
Kremenchuk Mykhailo Ostrohradskyi National University
vul. Pershotravneva, 20, Kremenchuk, 39600, Ukraine. E-mail: seem@kdu.edu.ua

The article deals with the actuality of the field of study concerning the development of the semiconductor base; the power IGB-transistor in particular really makes it possible to review the structure of formation of system-generating elements of excitement system of the synchronous electric machine. The variant of the circuit of IGB-transistor exciter of the synchronous machine that provides high reliability by means of number of the elements reduction at the expense of overlapping has been studied. The schematic and technical solution also provides the high power factor consumed from the complementary circuit of the whole electrotechnical complex IGB-transistor exciter – synchronous machine.

Key words: IGB-transistor exciter, excitement system, synchronous electric machine.

IGB-ТРАНЗИСТОРНИЙ ЗБУДНИК СИНХРОННОЇ МАШИНИ

Д. А. Михайличенко, А. А. Чернишев
Кременчуцький національний університет імені Михайла Остроградського
вул. Першотравнева, 20, 39600, м. Кременчук, Україна. E-mail: seem@kdu.edu.ua

Визначено актуальність напряму дослідження, пов'язаного з розвитком напівпровідникової бази, а саме силових IGB-транзисторів. Це дозволить реально переглянути структуру формування системоутворюючих елементів системи збудження електричних двигунів. Надано варіант схеми IGB-транзисторного збудника синхронної машини, який забезпечує високу надійність унаслідок скорочення чисельності елементів за рахунок об'єднання функцій. Схемотехнічне рішення також забезпечує високий коефіцієнт потужності, що споживається з допоміжної мережі всього електротехнічного комплексу IGB-транзисторний збудник – синхронна машина.

Ключові слова: IGB-транзисторний збудник, синхронна електрична машина.

PROBLEM STATEMENT. The electric drives with synchronous electric motors (machines) are the most important electric power consumers in mining and metallurgical works.

The problems of development of efficient excitation system of SEM have always been and are of great importance, and it is impossible to extend the field of application of electric drive with the following types of machines. [1, 2]

The development of semiconductor base and the power IGB-transistor in particular really made it possible to review the structure of formation of system-generating elements of ES of SEM.

The aim of the present paper is to consider the theoretical foundations and design the efficient IGB-transistor exciter of the synchronous electric machine (SEM).

EXPERIMENTAL PART AND RESULTS OBTAINED. While developing the excitement system of asynchronous machine the following statements were considered:

– the reduction of number of elements of exciter, - semiconductor devices, resistors, – by means of overlapping;

– the record of influence on process in the excitation circuit of a synchronous motor frequency regulation that carried out by the converter in the circuit of stator.

It was considered that the IGB transistor system of excitement was a starting base [1].

The use of large quantity of thyristors in the circuit is inappropriate as thyristors are to be used at frequency switching, and in the following case they are used for the circuit conversion into long-acting modes. Besides, it is necessary to do forced cutoff of thyristors that as a rule wastes valuable time for taking protective measures.

It makes sense to review the previous solutions concerning implementation of the fast-acting contactors.

In order to study the processes in synchronous machine at frequency start-up, the equivalent circuit was used, fig. 1 [2, 3]:

$$\left.\begin{aligned} \bar{U}_S &= \bar{I}_S R_S + j\omega_S \bar{\psi}_S; \\ 0 &= \bar{I}_R \frac{R_r + R_R}{S} + j\omega_S \bar{\psi}_R; \end{aligned}\right\} \quad (1)$$

$$\left.\begin{aligned} \omega_S \bar{\psi}_S &= \bar{I}_S X_{Sl} + \bar{I}_\mu X_\mu; \\ \omega_S \bar{\psi}_r &= \bar{I}_r X_{rl} + I_\mu X_\mu . \end{aligned}\right\} \quad (2)$$

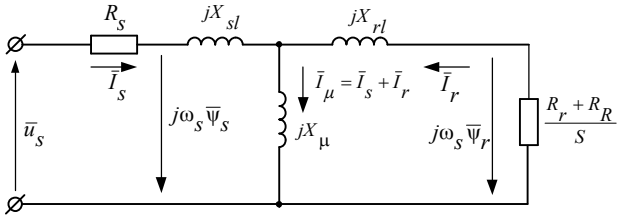

Figure 1 – The equivalent circuit of a synchronous motor at start-up

There is an available $R_S \approx 0$ with error ~1 % and, $R_r + R_R \to R_R$, an external start resistance is defined as $R_R \geq 10R_r$ [4], and

$$\bar{\psi}_S = \frac{\bar{U}_S}{j\omega_S}; \; \bar{\psi}_r = -\bar{I}_r \frac{R_R}{j\omega_S S}. \quad (3)$$

Taking into consideration the maximum slip

$$S_M = \frac{R_R}{X'_r}, \quad (4)$$

where $X'_r = X_{rl} + \frac{X_{Sl} \cdot X_\mu}{X_{Sl} + X_\mu}$

and $X'_r = X_{Sl} X_{rl}$, was transformed into (3)

$$\bar{\psi}_r = \frac{X_\mu}{X'_s} \frac{\bar{U}_S}{j\omega_s} \frac{S_m}{S_m + jS}. \quad (5)$$

The equitation of the rotational moment of synchronous machine in general will be as follows

$$M = \frac{3}{2} \frac{\omega_S X_\mu}{X'_S X'_r} \left[\bar{\psi}_r \bar{\psi}_S \right]. \quad (6)$$

According to (1)–(5), and having considered $S_m >> S$, and omitted the mathematical manipulations, the expression will be the following

$$M = \frac{3}{2} \left(\frac{X_\mu}{X'_S} \right)^2 \frac{U_S}{\omega_S} \frac{U_S S}{R_R}, \quad (7)$$

where $M = const$; $\frac{U_S}{\omega_S} = const$; $U_S S = const$, so

$$R = const. \quad (8)$$

Therefore, the external resistance in the excitement circuit can be considered as constant at the frequency start-up of a synchronous machine.

In addition, at frequency start-up, the voltage induced in exciting winding is considerably lower in comparison with the direct start-up that's why the resistance value of external resistor can vary within wide limits that makes it possible to coordinate it with the value of resistor's resistance of field discharge and combine some resistors into one.

The improved scheme of the IGB transistor exciter is shown in Fig. 2, where

- *KL* – line switch/breaker;
- *UD* – diode rectifier;
- *LZ, CZ* – filter-accumulator;
- *UM* – chopper;
- *TM* – IGB-transistor;
- *DM* – zero diode;
- *RR* – start resistor and field discharge resistor;
- *KR, KM* – contactors;
- *M* – synchronous machine.

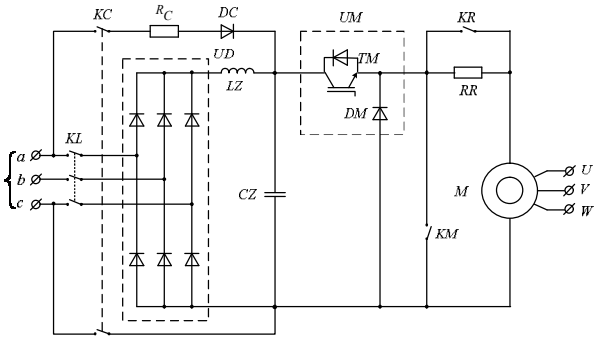

Figure 2 – The principal circuit of IGB-transistor exciter of synchronous machine

KC, RC, DC is a charging circuit used in preparation the exciter to the operation; it limits the primary current inrush of the capacitor *CZ*.

When the motor is started-up, *PR* is open-circuited, *KM* is closed, *UM* is off. In the mode of field discharge, *UM* is off, *KR* and *KM* are open-circuit. In the normal mode *KR* is closed, *KM is* open-circuit, *UM* – by means *of* PWM the voltage regulates the excitation current.

CONCLUSIONS. The well-grounded and suggested circuit of the exciter makes it possible to provide the high reliability and power coefficient of the whole electrotechnical complex of IGB-transistor exciter–synchronous machine.

REFERENCES

1. *Semiconductors Electric Energy Converters in Electric Drive Structures. Circuit Technology and Principles of Control: Textbook* / I.O. Sinchuk, A.A. Chernyshev, O.V. Pasko and oth. – Kremenchuk: PE Scherbatykh O.V., 2008. – 88 p.

2. *The Transient Processes in AC Machines* / K.P. Kovach, I.Ya. Rats. – M.–L.: Gosenergoizdat, 1963. – 744 p.

3. Kliuchev V.I. *Theory of Electric Drive: Textbook for Higher Schools.* – M.: Energoizdat, 1998. – 704 p.

4. Preshev I.I. *Electromechanical Processes in AC Machines.* – L.: Energiya, 1980. – 344 p.

IGB-ТРАНЗИСТОРНЫЙ ВОЗБУДИТЕЛЬ СИНХРОННОЙ МАШИНЫ

Д. А. Михайличенко, А. А. Чернышев
Кременчугский национальный университет имени Михаила Остроградского
ул. Первомайская, 20, г. Кременчуг, 39600, Украина. E-mail: seem@kdu.edu.ua

Обозначена актуальность направления исследования, связанного с развитием полупроводниковой базы, в частности, силовых IGB-транзисторов. Это позволяет реально пересмотреть структуру формирования системообразующих элементов системы возбуждения электрических двигателей. Представлен вариант схемы IGB-транзисторного возбудителя синхронной машины, обеспечивающий высокую надежность благодаря сокращению числа элементов за счет совмещения функций. Схемотехническое решение также обеспечивает высокий коэффициент мощности, потребляемой из вспомогательной сети всего электротехнического комплекса IGB-транзисторный возбудитель – синхронная машина.

Ключевые слова: IGB-транзисторный возбудитель, синхронная электрическая машина.

Стаття надійшла 10.07.2012.
Рекомендовано до друку
д.т.н., проф. Сінчуком О.М.