# DETERMINING BY SIMULATION THE ENERGETIC PARAMETERS OF A SYSTEM WITH AN ASYNCHRONOUS MACHINE

***Ilie Borcosi[1], Constantin Brindusa[2], Nicolae Antonie[3], Adrian Mihailescu[4]***

[1] *"Constantin Brancusi" University of Tg-Jiu, Geneva Street, Nr. 2, Gorj, ilie_b@utgjiu.ro*
[2] *ICMET, Craiova, brindusa@yahoo.com*
[3] *"Constantin Brancusi" University of Tg-Jiu, Geneva Street, Nr. 2, Gorj, nicolaeantonie@yahoo.com*
[4] *Siemens Automotive Timisoara. adrianm@utgjiu.ro*

**ABSTRACT:** Starting from the particularities of the mono phased invertors, at which the modulation technique (the command signal of a completely controlled signal element) also represents the wave form of the current or the tension, the energetic analysis is actually the spectral analysis of the elements command signal.

**ИЗБОР НА СИСТЕМА С АСИНХРОНЕН ДВИГАТЕЛ ЧРЕЗ ИМИТИРАНЕ НА ЕНЕРГИЙНИ ПАРАМЕТРИ**

***Илие Боркоши[1], Константин Бриндуса[2], Николае Антони[3], Адриян Михаилеску[4]***
[1,3,] *Университет "Константин Бранкуши", Търгу Жил, ул. Женева стриит, № 2, Гори, ilie_b@utgjiu.ro, nicolaeantonie@yahoo.com*
[2] *ICMET, Крайова, brindusa@yahoo.com,*
[4] *Автомобили Сименс, Тимишоара, adrianm@utgjiu.ro*

**Резюме:** Възникването на особености на моно-фазните инвевертори, при които техническите похвати на модулация (управляването на сигнал от напълно контролиран сигнал) предизвикват вълна от ел.ток или напрежение. Енергийният анализ е всъщност спектрален анализ на елементите на командния сигнал.

## 1 The mathematic model; the Simulink model

A part of the relations that are used in the energetic analysis a S.A. cu M.A. and CSTF use the effective values of the harmonics of the tension and current and in determining these there where used the following expressions:

- the components amplitude in sinus of the harmonics of "k" order of the tension,

$$A_{ku} = \frac{2}{T}\int_0^T u(t)\sin k\omega t \ \mathrm{dt}\,; \tag{1}$$

- the components amplitude in cosine of the harmonics of "k" order of the tension,

$$B_{ku} = \frac{2}{T}\int_0^T u(t)\cos k\omega t \ \mathrm{dt}\,; \tag{2}$$

-the effective values of the harmonic of "k" order of the tension,

$$U_k = \sqrt{\frac{A_{ku}^2 + B_{ku}^2}{2}}\,; \tag{3}$$

-the lagging of the "k" order of the harmonics of the tension,

$$\varphi_{ku} = arctg\frac{B_{ku}}{A_{ku}}\,; \tag{4}$$

-the components amplitude in sinus of the "k" order of the harmonics of the current,

$$A_{ki} = \frac{2}{T}\int_0^T i(t)\sin k\omega t \ \mathrm{dt}\,; \tag{5}$$

-the components amplitude in cosine of the "k" order of the harmonics of the current,

$$B_{ki} = \frac{2}{T}\int_0^T i(t)\cos k\omega t \ \mathrm{dt}\,; \tag{6}$$

-the effective values of the "k" order of the harmonics of the current,

$$I_k = \sqrt{\frac{A_{ki}^2 + B_{ki}^2}{2}}\,; \tag{7}$$

-the lagging of the "k" order of the harmonics of the current,

$$\varphi_{ki} = arctg\frac{B_{ki}}{A_{ki}}\,; \tag{8}$$

- the lagging between the "k" order of the harmonics of the tension and the current,

$$\varphi_k = \varphi_{ku} - \varphi_{ki}\,. \tag{9}$$

The calculation of the powers P, $Q_B$ and $Q_C$ in different stationary drive can be achieved by simulation and by matrix calculation, utilizing MATLAB Simulink. For this we have created the Simulink block "Aku, Bku, Aki, Bki" (fig. 1), that has as intake the tension and phase current as instant values in a period of the stationary drive also analyzed in the reset condition of the integrators, and as output values there are 4 vectors (Aku, Bku, Aki, Bki), that have there elements calculated according to (2.61), (2.62), (2.65) and (2.66). The dimension of the vectors is (n+1), where n is the number of harmonics that are taken into consideration, and the first element is the time.

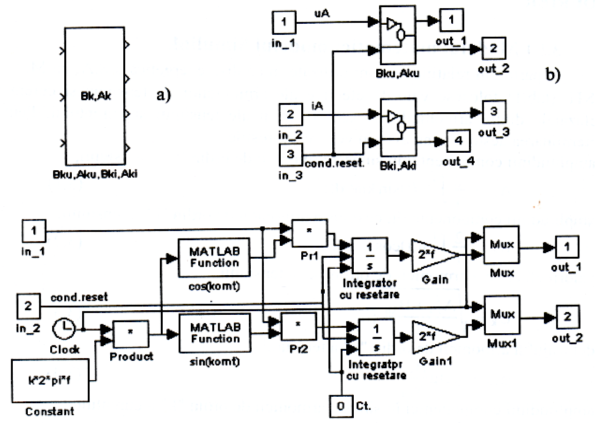


**Fig. 1 The Simulink Model for calculating the components amplitude in sinus and cosine of the tension and current harmonics : the mask block –a); it's structure –b); the structure of the blocks "Bku, Aku" and "Bki, Aki" –c)**

Utilizing the integrators with reset allows integration only on one period and reset and the end of it.

In the block "Constant", the k value is a vector, that has it's n components as the orders of the harmonics that are taken into consideration in the energetic analysis.

Because the calculation of the apparent power and other power and synthetic factors need the determination of the effective values of the phase current and the tension there was realized the block "Uef, Ief" (fig. 2). The third intake value is the reset condition of the integrators that is the same to all the integrators in the graphic. The blocks "MATLAB Functions" do the mathematical function square root.

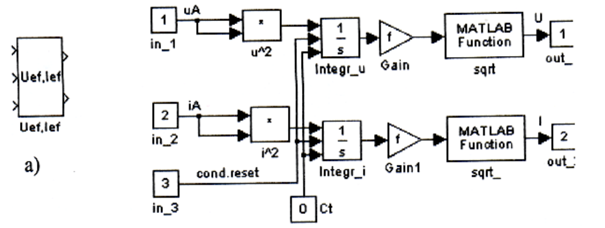


**Fig. 2 The Simulink Block for the calculation of the effective values of the tension and the current : the mask block –a); the blocks structure –b)**

The complete Simulink Model of S.A. with M.A. and CSTF (fig. 3), permits by simulation the determination of all the values needed for the calculation of the energetic parameters, for different stationary drives. For this, there was used the "V_I_p" block, that has it's output values as the reset conditions of the integrators and as the validation of the integration. (fig. 3.4). The block "Signal Generator (Generator de Semnal) " gives a logic signal, generated so that it will be in the 1 stage more times, in the 1/f time interval, in the time that the integration is wished to take place, and 0 the rest of the time. This is also the integration condition. The evolution in time of this value is specified for every functioning frequency in a Matlab program.

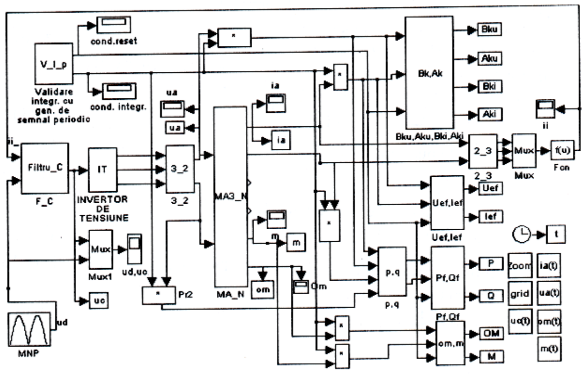


**Fig. 3 The Simulink model of S.A. with M.A. and indirect CSTF, tension source with the determination of energetic parameters**

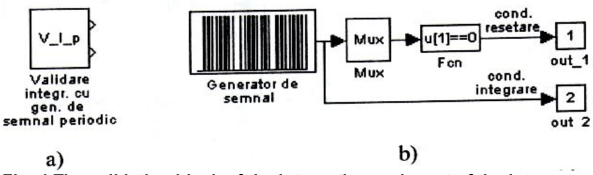


**Fig. 4 The validation block of the integration and reset of the integrators: the mask block -a); the structure –b)**

For every stationary drive, after the integration, in the matrix Bku, Aku, Bki, Aki, Uef, Ief we add an additional line. It's similar for P, Q, to which we come back in 3.2.1 but as well for OM and M which contain the medium values of the angular velocity and electromagnetic couple (in stationary drive).

## 2. Numeric results

After the functioning simulation S.A. with M.A. and CSTF the tension source with modulation in frequency having n=24, at three frequencies (10Hz, 20Hz and 40Hz) and $M_S \in [0, M_N]$ and the determination of the energetic parameters taking into consideration the harmonics until the 31 order, was graphically presented their dependence to the couple (fig 5, 6). To compare with the experimental results there were taken into consideration:

-the reactive power on the fundamental,

$$Q_1 = 3U_1 I_1 \sin\varphi_1 ; \quad (10)$$

and the following synthetic factors which characterize the deforming drive:

-the deforming factor in both forms,

$$fd\_B = \frac{D_B}{S}; \quad fd\_C = \frac{D_C}{S}; \quad (11)$$

-the global power factor,

$$fp = \frac{P_B}{S}; \quad (12)$$

-the power factor on the fundamental,

$$fpf = \frac{3U_1 I_1 \cos\varphi_1}{S}; \quad (13)$$

-the distortion factor of the current (FTDi);

-the motors efficiency,

$$\eta = \frac{M_S \Omega_{med}}{P_B} . \quad (14)$$

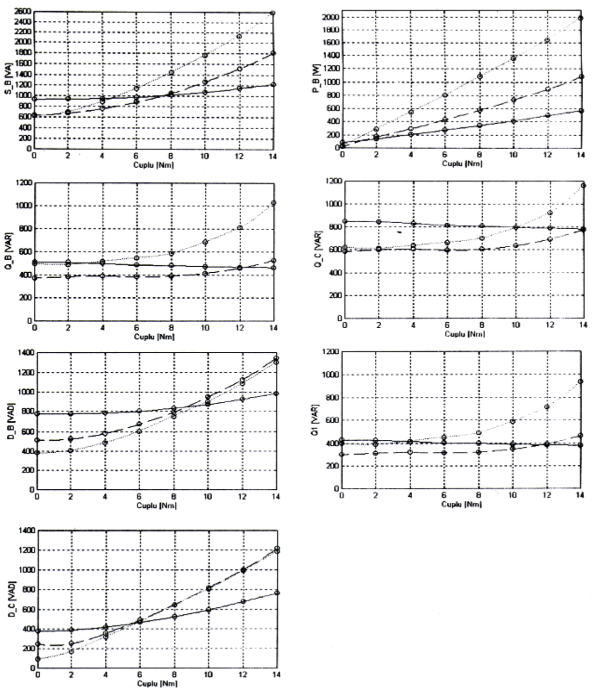

**Fig. 5 The dependence of the power with the couple for S.A. with M.A. and CSTF power source with modulation in frequency: at f=10Hz – continuous line; at f=20 Hz – interrupted line; at f=40Hz – dotted line.**

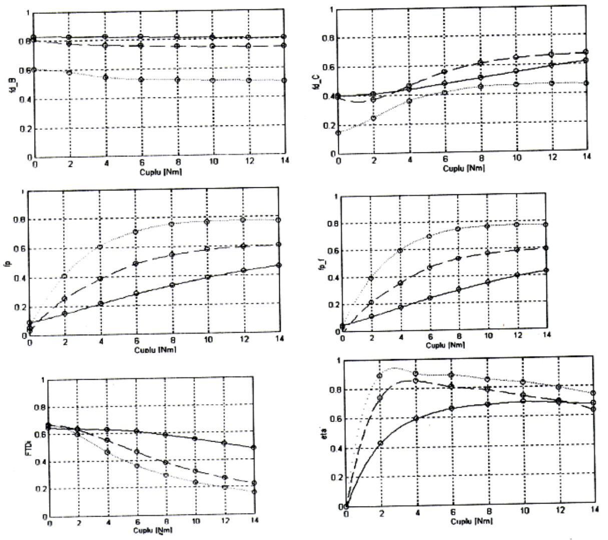

**Fig. 6 The dependence of the synthetic factors of energetic analysis with the couple for S.A. with M.A. and CSTF power source with modulation in frequency: at f=10Hz – continuous line; at f=20 Hz – interrupted line; at f=40Hz – dotted line.**

To compare the different definitions of the same energetic parameters, they were represented graphically depending on the couple, at two different functioning frequencies.

These dependencies show that, at smaller frequencies, the apparent active and deforming powers (S, $P_B$, $D_B$ and $D_C$) grow a bit with the load and , comparing with bigger frequencies, are bigger at lower loads. The reactive powers drop a little with the load at 10Hz frequency and grow with the load at frequencies starting with 40%$M_N$. Watching the fast rise with the load, at the same frequency, of $Q_C$ comparing with $Q_N$ and as an effect of the lower values

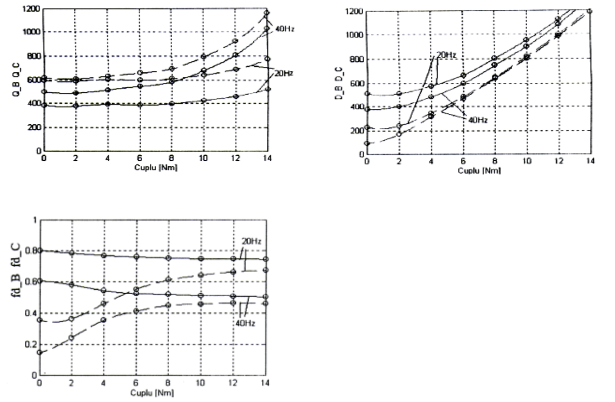

**Fig. 7 The difference between the definition of the energetic parameters: Continuous line – Budeanu variant , interrupted line – Czarnecki variant**

chosen at high frequencies and small loads), the fd_C factor rises with the load and has a lot lower values then fd_B, especially at small loads. So FTDi is smaller at higher frequencies and loads. Watching the known evolution with the load, the efficiency is bigger than at low frequencies.

## 3. Conclusions

Comparing the three analyzed systems (fig. 8 and 9) we find out the following:

-the apparent power is bigger at smaller loads with ~15% in the case of frequency modulation and the other way around at higher loads;

-the active powers and practically the same;

-$Q_B$ is bigger with ~25% with no load for frequency modulation a value that gets lower with the load; $M_N$ values with sinus modulation and with the elimination of the harmonics are close;

-$Q_C$, keeping the difference towards $Q_B$ taken from the definition ($Q_C>Q_B$ because $Q_B$ doesn't include the whole reactive power /12/), illustrate the same thing like $Q_B$, but at $M_N$, the 3 values are equal;

-the differences between the values of $D_C$ appear in load, rising with it, showing a higher value the case of eliminating of the harmonics;

-the equality of the three values of $D_C$ in no load isn't kept at $D_B$, because $D_B$ is bigger in frequency modulation;

-fd_B is just a bit different at $M_N$ (~1%);

-fd_C is almost identical for sinus modulation and with the eliminations of the harmonics, and in load it's value for frequency modulation is smaller with ~15%;

-the biggest FTDi characterizes the frequency modulation (0.7 in no load and 0.2 at $M_N$), and the smaller is with modulation with the elimination of the harmonics (with ~50% in load);

-the differences between the values of FTDi in the case of sinus modulation and with the elimination of the harmonics are very low;

-the maximum value of the efficiency appears in the case of the sinus modulation ($\rightarrow$ 1) , and at $M_N$ the efficiency values are very close (~0.6).

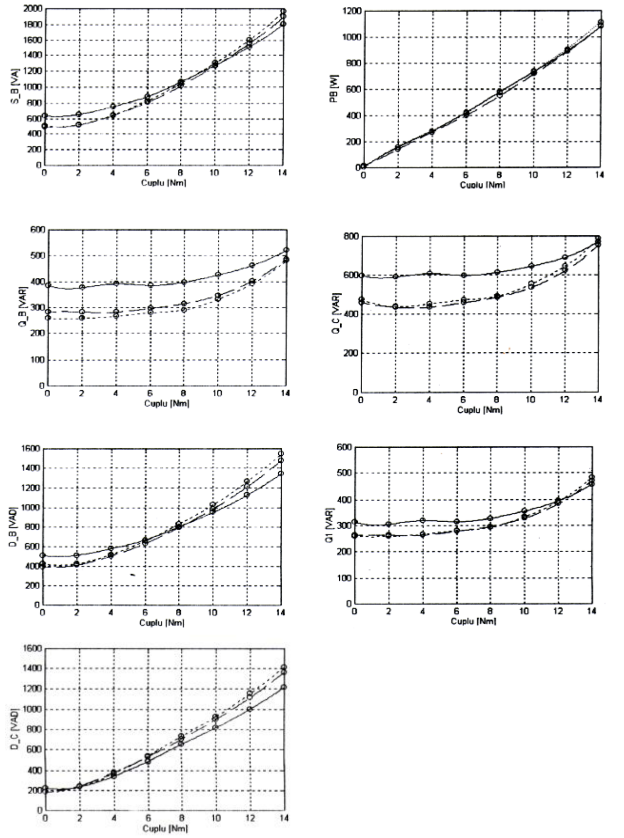


**Fig. 8 The dependency of the powers in couple, at f=20Hz for: S.A. with M.A. and CSTF cu frequency modulation – continuous line; S.A. with M.A. and CSTF with sinus modulation – interrupted line; S.A. with M.A. and CSTF with the elimination of the harmonics – dotted.**

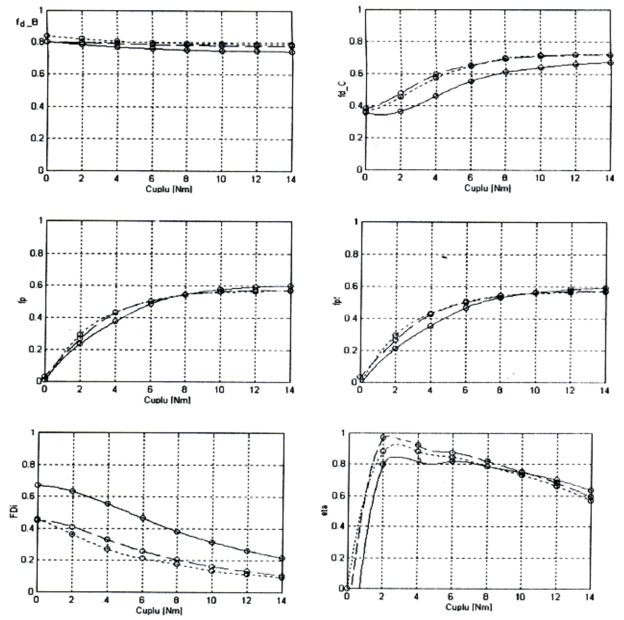


**Fig. 9 The dependency of the powers in couple of the synthetic factors of energetic analysis at f=20Hz for: S.A. with M.A. and CSTF cu frequency modulation – continuous line; S.A. with M.A. and CSTF with sinus modulation – interrupted line; S.A. with M.A. and CSTF with the elimination of the harmonics – dotted.**

*Recommended for publication by the Editorial staff*

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