

THE ANALYSIS AND THE SIMULATION OF THE SVM GENERATOR USED FOR THE CONTROL OF THE ELECTRIC DRIVES WITH ASYNCHRONOUS MOTORS

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Abstract – In the control of the electric drives with asynchronous motors, it often uses microprocessors, digital signal processors or ASIC (Application Specific Integrated Circuits) to generate the waveforms in real time. One of the modern control strategies for controlling the speed of the induction motors is the space vector modulation strategy.

This paper presents the analysis and the simulation both of the SVM generator, an essential subsystem in this technique [1], and the main constitutive blocks of this. We analyze on a numerical application the way in which the model works, noticing the waveforms of the most important signals of the blocks and this allows a better understanding of every subsystem role.

Keywords: electric drives, SVM, control technique, simulation.

1. INTRODUCTION

The PWM modern inverters in the electric drives with asynchronous motors often use microprocessors, digital signal processors or ASIC (Application Specific Integrated Circuits) to generate the waveforms in real time. The wave shapes can be obtained now with an accuracy which couldn't be realized using the former analog methods of

generation. The advantages brought by these solutions are bound both for getting of waveforms lacked for undesirable harmonics and also for the possibility of controlling the level of the amplitude of harmonics using different generation techniques. The control in real time offers the possibility of changing the amplitude of voltage and the frequency of this, very quickly, and it's a fact which allows the using of a complex strategy to control the induction motor[2]. One of the methods for controlling the speed of the asynchronous machine is the method of vector control, using the SVM (Space Vector Modulation) strategy, a method which was described in [1]. This paper presents the analysis and the simulation of SVM generator, an essential subsystem in the technique of space vector modulation.

2. THE SIMULATION IN MATLAB SIMULINK OF THE SVM GENERATOR

The Simulink scheme of the SVM generator (Fig. 1) is formed by seven subsystems disposed on the structure of the operating principle scheme, presented in [1], each of this having its own Simulink model. We'll show the main blocks from the scheme, their role and the equations on which they were built.

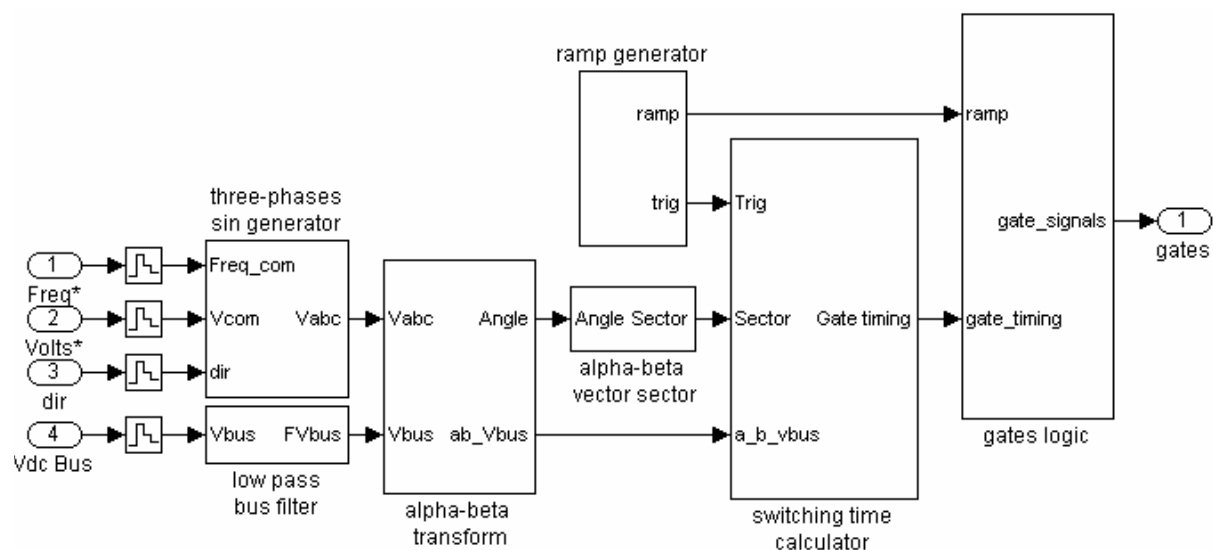


Fig. 1: The Simulink scheme of SVM generator

2.1. The three-phase sinusoidal generator

This subsystem (Fig. 2) realizes three sine waves with variable frequency and amplitude which are out of phase with each other by 120 degrees, being composed of the `sin_phi_0`, `sin_phi_240` and `sin_phi_120` blocks.

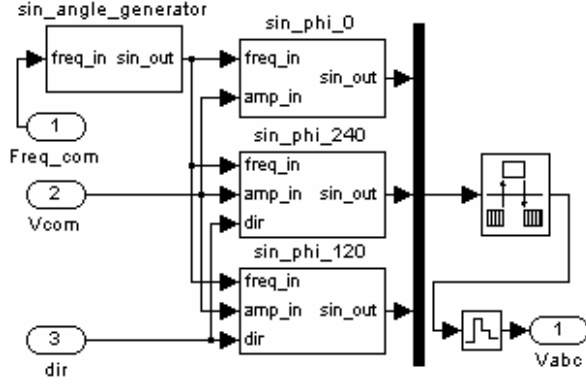


Fig. 2: The three phase generator- Simulink scheme

These have Simulink schemes which applied sin function, being different only from the applied phase shift (0, $-2\pi/3$, $2\pi/3$).

2.2. The abc- $\alpha\beta$ transformation

To write the equations of transformation $abc\text{-}\alpha\beta$, we apply the matrix of initial transformation Park $P(\theta)$, used for $abc\text{-}dqo$ transformation [3]:

$$P(\theta) = \frac{2}{3} \begin{bmatrix} \cos \theta & \cos(\theta - \frac{2\pi}{3}) & \cos(\theta - \frac{4\pi}{3}) \\ -\sin \theta & -\sin(\theta - \frac{2\pi}{3}) & -\sin(\theta - \frac{4\pi}{3}) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix} \quad (1)$$

which we rewrite for the angle $\theta=0$ and we obtain the matrix of Clarke transformation.

We make orthogonal the Clarke matrix (we divide every vector column through its norm) and we obtain the Concordia matrix of $abc\text{-}\alpha\beta$ transformation:

$$[C_c] = \sqrt{\frac{2}{3}} \begin{bmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix} \quad (2)$$

From the multiplication of $[C_c]$ with the column vector with components V_a , V_b , V_c , we obtain:

$$\begin{aligned} V_\alpha &= \sqrt{\frac{2}{3}} (V_a - \frac{1}{2}V_b - \frac{1}{2}V_c) \\ V_\beta &= \sqrt{\frac{2}{3}} (\frac{\sqrt{3}}{2}V_b - \frac{\sqrt{3}}{2}V_c) \end{aligned} \quad (3)$$

relations which are presented in Simulink scheme in Fig. 3.

The signal *Angle* is obtained when we apply $\arctg(V_\beta/V_\alpha)$.

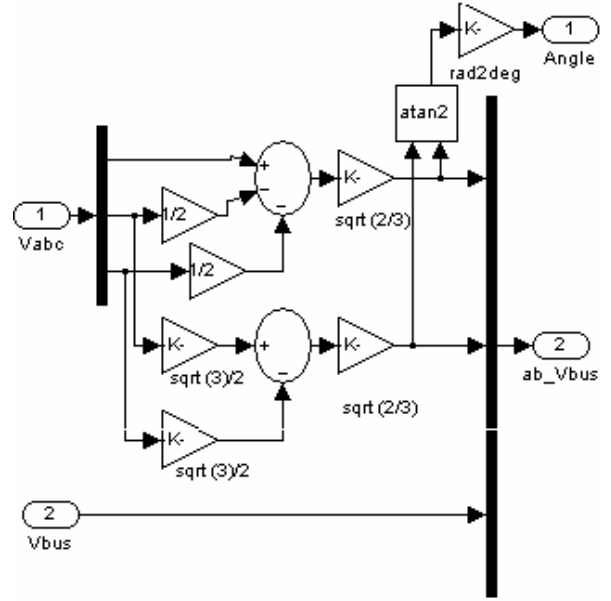


Fig. 3: The Simulink scheme for transform. $abc\text{-}\alpha\beta$

2.3. The vector sector in $\alpha\beta$ coordinates

The subsystem determines the sector (I, II, III, IV, V or VI) in which the voltage vector lies, comparing the signal *Angle* with the limits of every sector: (0, 60°), (60°, 120°), (120°, 180°), (-180°, -120°), (-120°, -60°), (-60°, 0) and multiply the resultant signal by coefficient: 1, 2, 3, 4, 5, 6 so that the output signal is periodical, in six stages of amplitude.

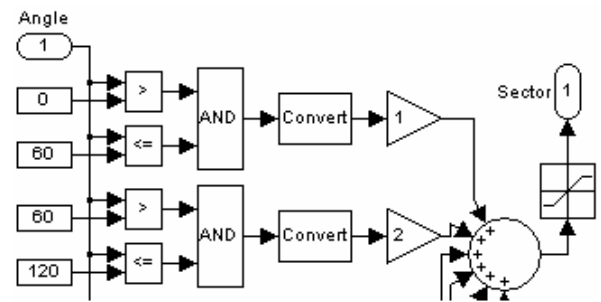


Fig. 4: The $\alpha\beta$ vector sector – Simulink scheme

In Fig. 4 we present the Simulink partial scheme of the subsystem for I and II sector and it is completed in the same way for the other sectors.

2.4. The switching time calculator

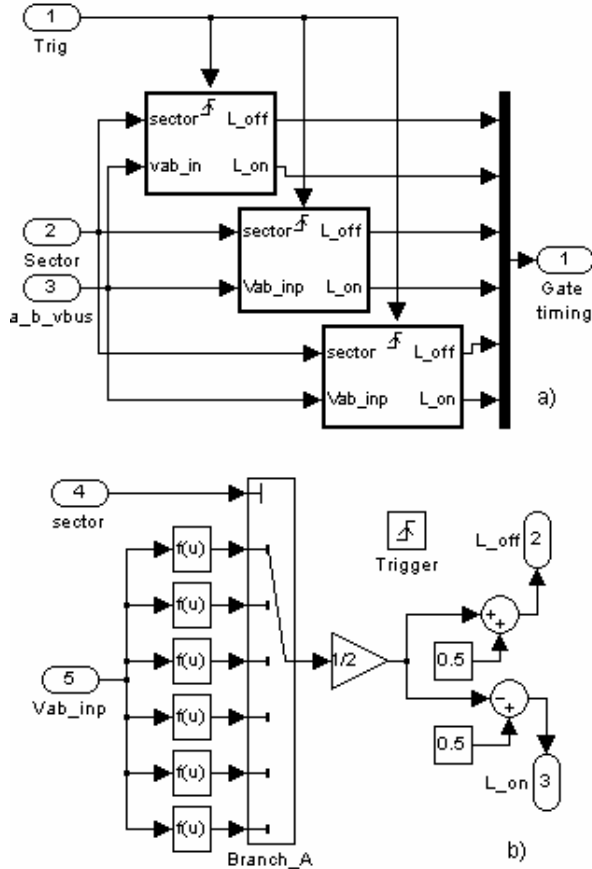


Fig. 5: a) The switching time calc.- Simulink scheme
b) Detail block corresponding to A branch

Funct.	Mathematical expression
f_1, f_4	$\sqrt{2}(\sqrt{2}V_{bus} + \sqrt{3}V_{\alpha} + V_{\beta}) / 4V_{bus}$
f_2, f_5	$(V_{bus} + \sqrt{6}V_{\alpha}) / 2V_{bus}$
f_3, f_6	$\sqrt{2}(\sqrt{2}V_{bus} + \sqrt{3}V_{\alpha} - V_{\beta}) / 4V_{bus}$
f_7, f_{10}	$\sqrt{2}(\sqrt{2}V_{bus} - \sqrt{3}V_{\alpha} + 3V_{\beta}) / 4V_{bus}$
f_8, f_{11}	$(V_{bus} + \sqrt{2}V_{\beta}) / 2V_{bus}$
f_9, f_{12}	$\sqrt{2}(\sqrt{2}V_{bus} - \sqrt{3}V_{\alpha} + V_{\beta}) / 4V_{bus}$
f_{13}, f_{16}	$\sqrt{2}(\sqrt{2}V_{bus} - \sqrt{3}V_{\alpha} - V_{\beta}) / 4V_{bus}$
f_{14}, f_{17}	$(V_{bus} - \sqrt{2}V_{\beta}) / 2V_{bus}$
f_{15}, f_{18}	$\sqrt{2}(\sqrt{2}V_{bus} - \sqrt{3}V_{\alpha} - 3V_{\beta}) / 4V_{bus}$

Table 1: The functions expressions

The subsystem has the Simulink scheme (Fig. 5a), formed by three blocks with identical structure, for the three phases.

In Fig. 5b we present the block which corresponds to the A branch where a multiport switch chose one of the $f_1, f_2, f_3, f_4, f_5, f_6$ functions (from the Table 1), after the value *Sector* on the control input, function which it applies to V_{abinp} that contains the V_{α}, V_{β} and V_{bus} voltages.

The block which corresponds to B branch has specific the functions: $f_7, f_8, f_9, f_{10}, f_{11}, f_{12}$ from the table and that which corresponds to C branch has the functions: $f_{13}, f_{14}, f_{15}, f_{16}, f_{17}, f_{18}$. The *trig* (trigger) signal with 1 or 0 values, received from the ramp generator, is a control signal, which passing from a value $ramp \leq 0$ to a strict positive value (here passing from 0 to 1), determines the execution of the subsystem.

2.5. The gates logic

The subsystem receives:

- the six L_{off}, L_{on} signals through the input gate-timing

- the *ramp* signal obtained through the integration in discrete time of a constant (here 4500 Hz), with reset controlled by the *true* value of the comparison $ramp \geq 1$.

The subsystem, whose Simulink scheme is presented in Fig. 6, compares on every phase, the *ramp* signal with L_{off} ($ramp \leq L_{off}$), respectively with L_{on} ($ramp \geq L_{on}$) and it units with an AND operator the two results. The resultant signal and also the same denied signal are taken off at the output, and they represent the control signals on gate for activate the inverter switches.

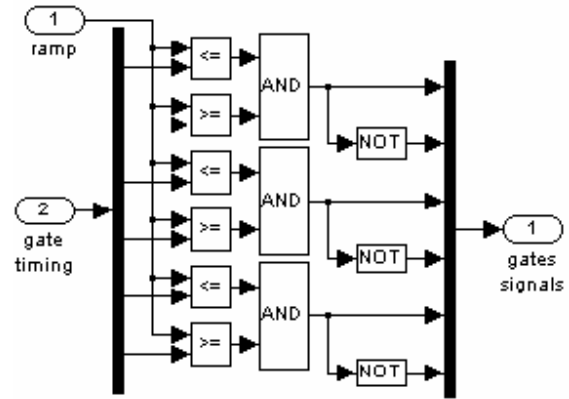


Fig. 6: The gates logic

3. The results of simulations

We make simulations on the complete scheme of electric drive with asynchronous motor tip HXUR 265A2 presented in [1], which contains the SVM generator. We consider its following parameters:

- switching frequency 4500 Hz
- SVM sampling time 20 μs .

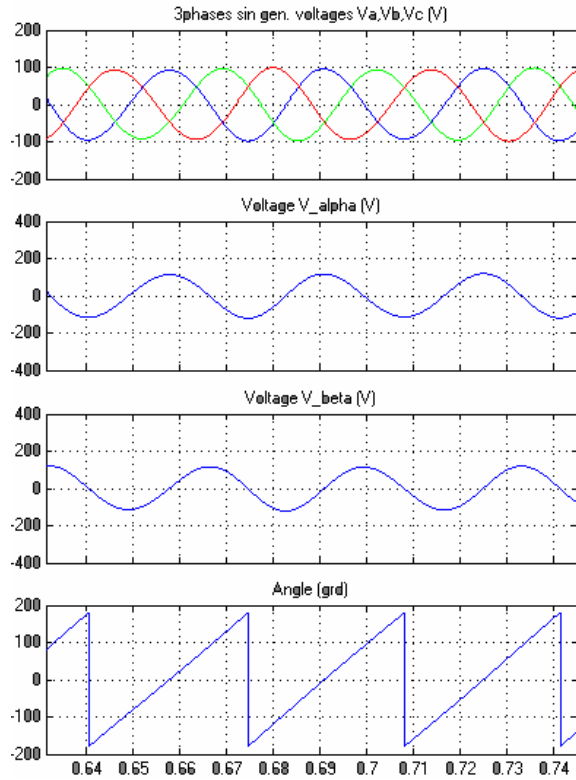


Fig. 7: The signals waveforms in three-phase generator and $abc-\alpha\beta$ transformation

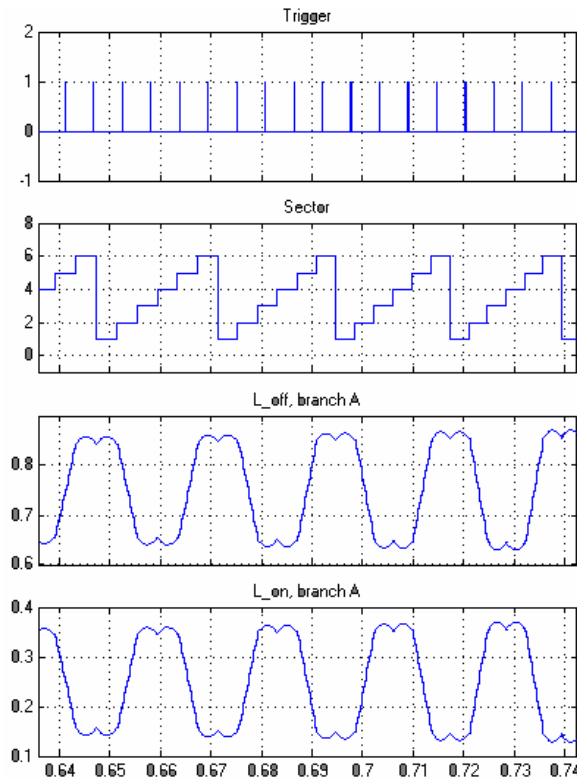


Fig. 8: The signals waveforms in $\alpha\beta$ vector sector and switching time calculator

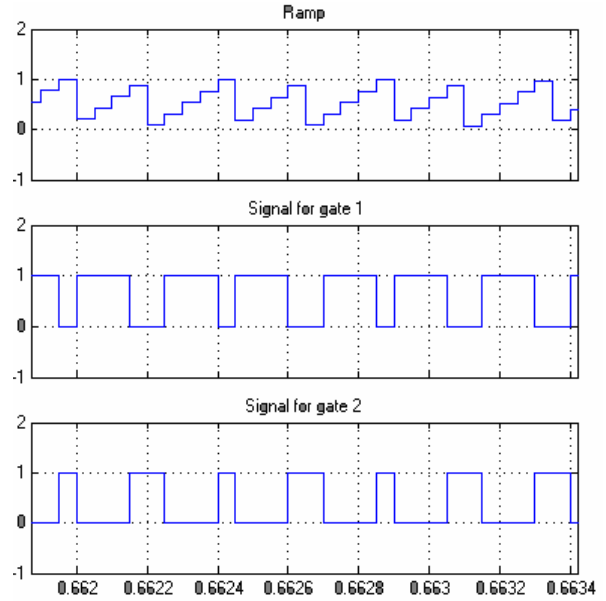


Fig. 9: The signals waveforms in gates logic

In Fig. 7, 8 and 9 we represent the waveforms of the main signals which are specific for the subsystems which compose the SVM generator scheme, obtained after the extension of the time axis, and this allows a better understanding of every subsystem role.

4. Conclusions

We simulate in Matlab Simulink a SVM generator (made of seven subsystems), used to control, through the technique of space vector modulation, of the electric drives with asynchronous motors.

We present the Simulink schemes of the main subsystems of SVM generator, built on the corresponding equations.

We analyze the way in which the model works, noticing the waveforms of different signals.

References

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