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Power electronic drive circuit for DC motor with addition of energy

Svetoslav Cvetanov Ivanov, Yanka Nikolova Ivanova
Technical University Sofia, Branch Plovdiv, email: etehsv@gmail.com

GOAL OF THE STUDY

- When using DC motors with brushes, the pulse control allows smooth adjustment of the speed and torque of the motor. A rapid change in the starting current in the armature winding when a pulse is received can be achieved with a supply of higher voltage than the maximum allowable for the motor, but for a short time. The purpose of the experimental research done in this article is to be presented a comparative analysis of DC motor control by the conventional method and with the addition of energy to the pulses, to be compared the change in the current consumption of the drivers from the power supply, the change in the speed of rotation, and the efficiency of the driver-motor system.

DESIGNED SCHEME FOR INVESTIGATION OF THE METHOD WITH ADDITION OF ENERGY

In order to be added electrical energy to each control pulse for the motor armature, a boost converter is added to the pulse control circuit. A single-transistor circuit with a switch element Q1 is used for pulse control of the motor (Fig.1).

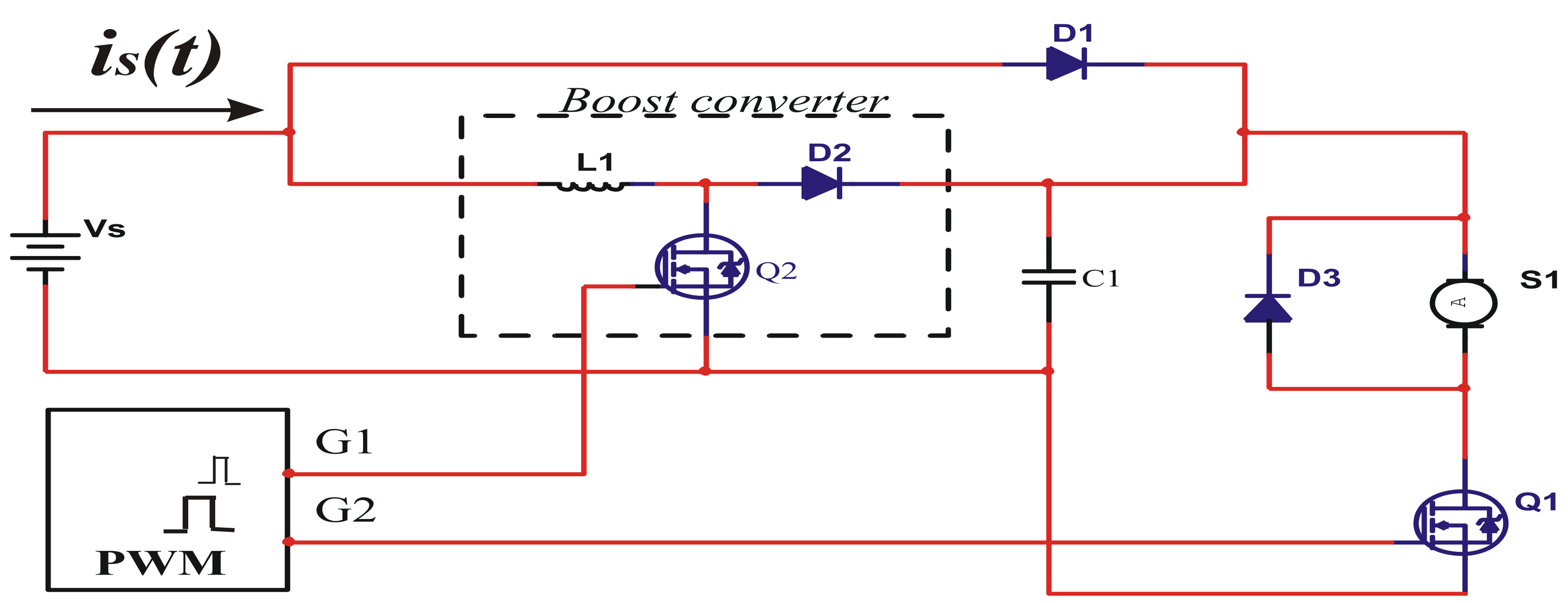

Fig. 1. Schematic diagram of power electronic drive for DC motor with addittion of energy

Thus, at the beginning of each pulse of the motor armature, the voltage has a maximum value Vmax equal to the sum of the voltage of the power supply Vs and the voltage of the charged capacitor V_{C1} (Fig.2).

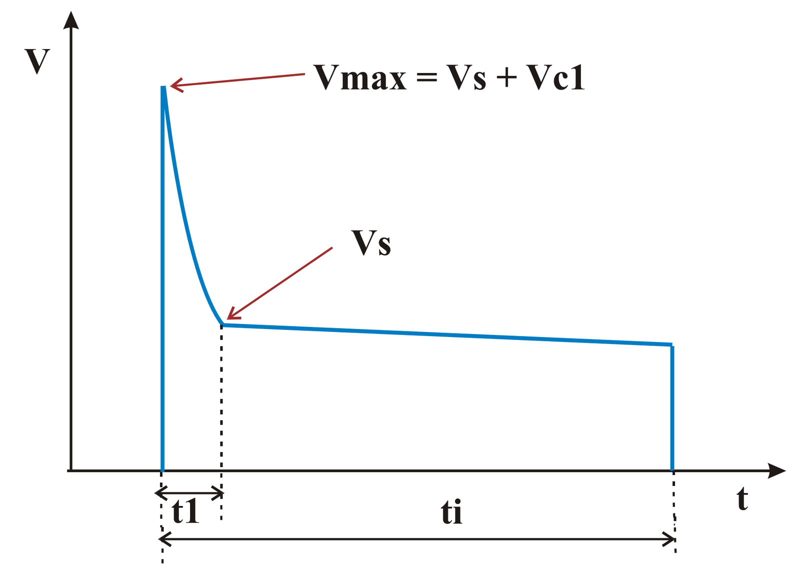

Fig.2 Shape of pulse feeding the armature winding with addition of energy

RESULTS FROM EXPERIMENTAL RESEARCH

On the following oscillograms (fig.3) and (fig.4) the change of the voltage and current during the control by both methods is shown at duty cycle of the control pulses D= 70%.

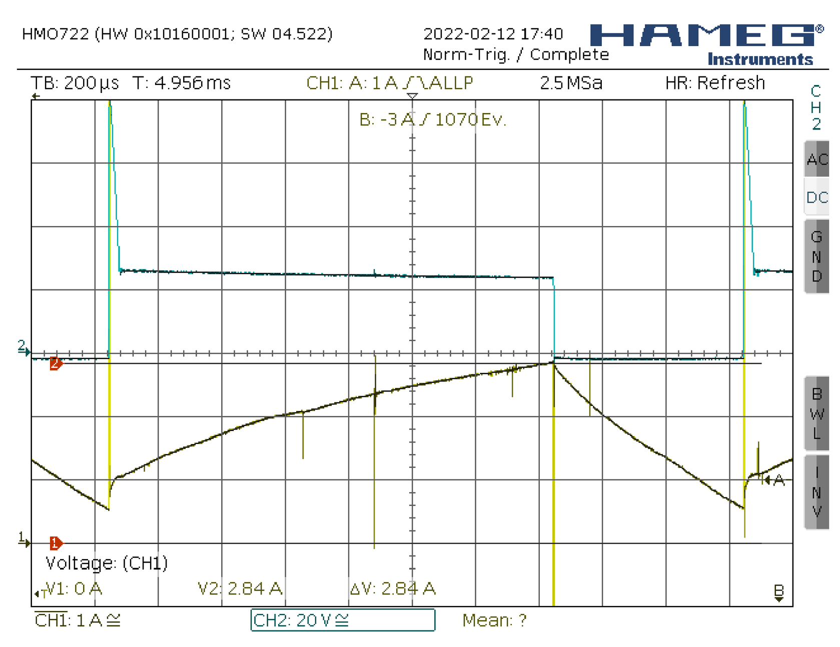

Fig.3 Shape of voltage and current of the armature winding with addition of energy to the pulses

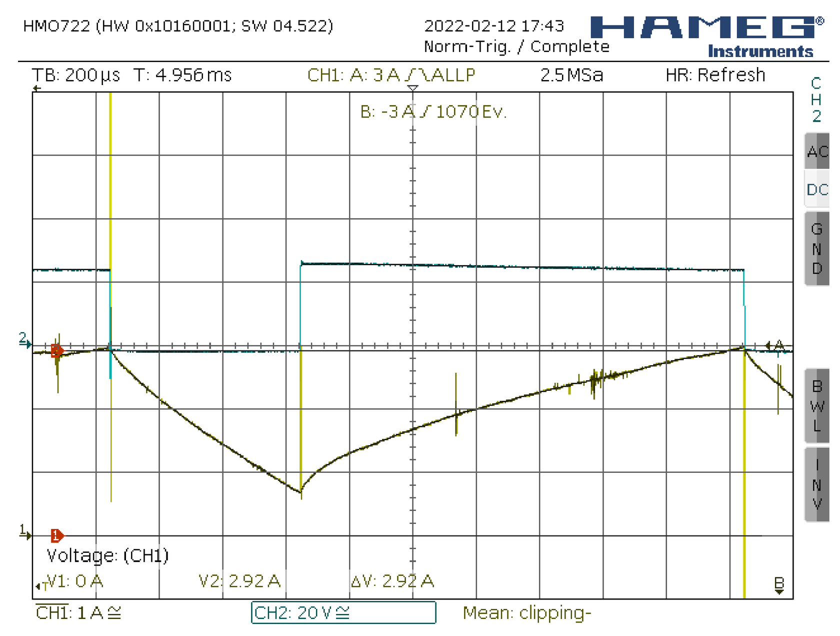

Fig.4 Shape of voltage and current of the armature winding in pulse control by the conventional method

The following oscillograms Fig. 5 and Fig. 6 show the forms of the current consumed by the DC power supply Vs from the driver circuits in control with addition of energy and in the conventional method.

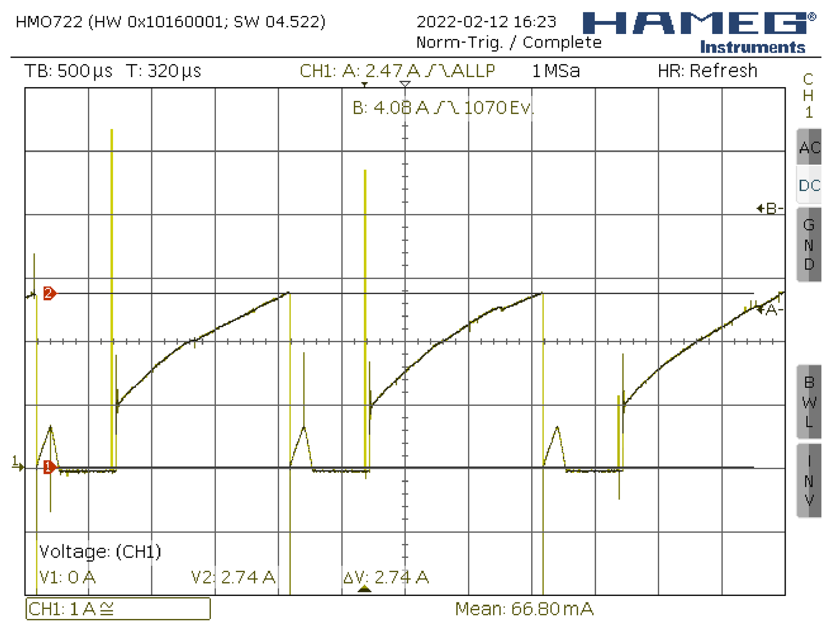

Fig. 5 Form of current consumed by the power supply for the motor Vs at duty cycle D = 70% by the method with addition of energy

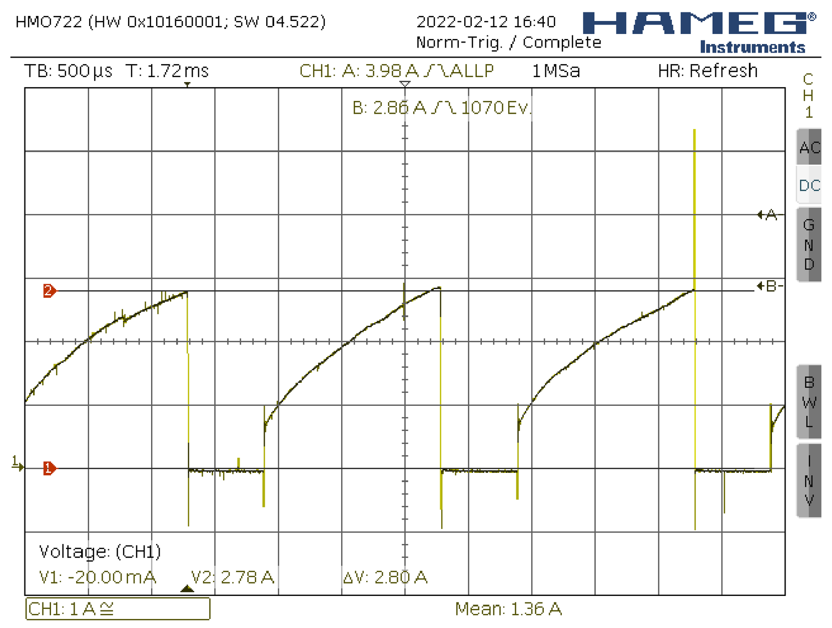

Fig. 6 Form of current consumed by the power supply for the motor Vs at duty cycle D = 70% by the conventional method

Table I shows the calculations made for power consumption P_{Cons} *[W]* by the driver control circuits of the motor in both control methods: with addition of energy and in the conventional method.

Table 1

D [%]	*I[A]* With addition of energy	P_{Cons}*[W]* With addition of energy	*I[A]* Conventional method	P_{Cons}*[W]* Conventional method
20	0.401	12.03	0.758	22.74
30	0.549	16.47	0.961	28.83
40	0.780	23.40	1.201	36.03
50	1.024	30.72	1.430	42.90
60	1.272	38.16	1.643	49.29
70	1.521	45.63	1.846	55.38
80	1.810	54.30	2.030	60.90

Table 2

D[%]	***Pmech [W]*** with addition of energy	***η*** with addition of energy	***Pmech[W]*** Conventional method	***η*** Conventional method
20	1,71	14,21	1,05	4,62
30	6,42	38,98	5,15	17,86
40	11,02	47,09	9,89	27,45
50	16,33	53.16	15,34	35.76
60	22,28	58,39	21,11	42,83
70	28,38	62,20	27,33	49,35
80	35,51	65,40	34,39	56,47

The change in speed of rotation of the motor when driving by both methods in graphical form is shown in Fig.7.

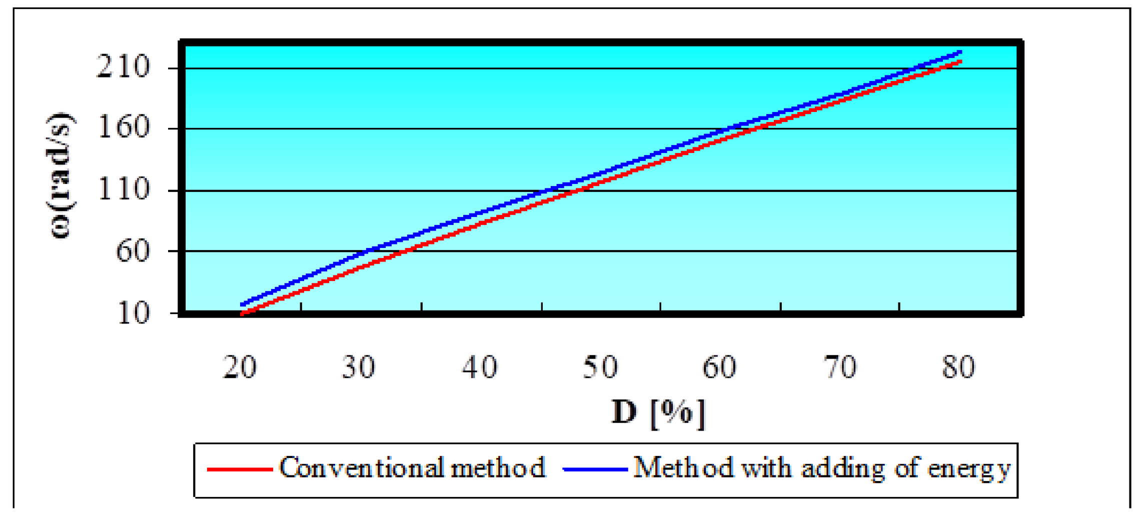

Fig. 7 Motor rotation speed in two investigated control methods depending on duty cycle

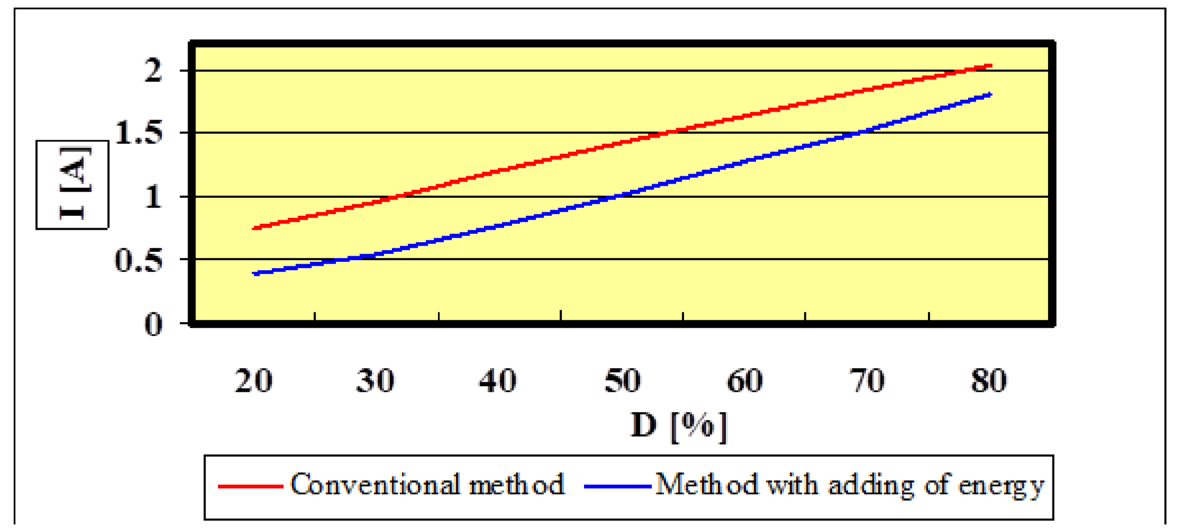

Fig. 8 Current consumed by the driver control circuits of the motor in two investigated control methods depending on the duty cycle

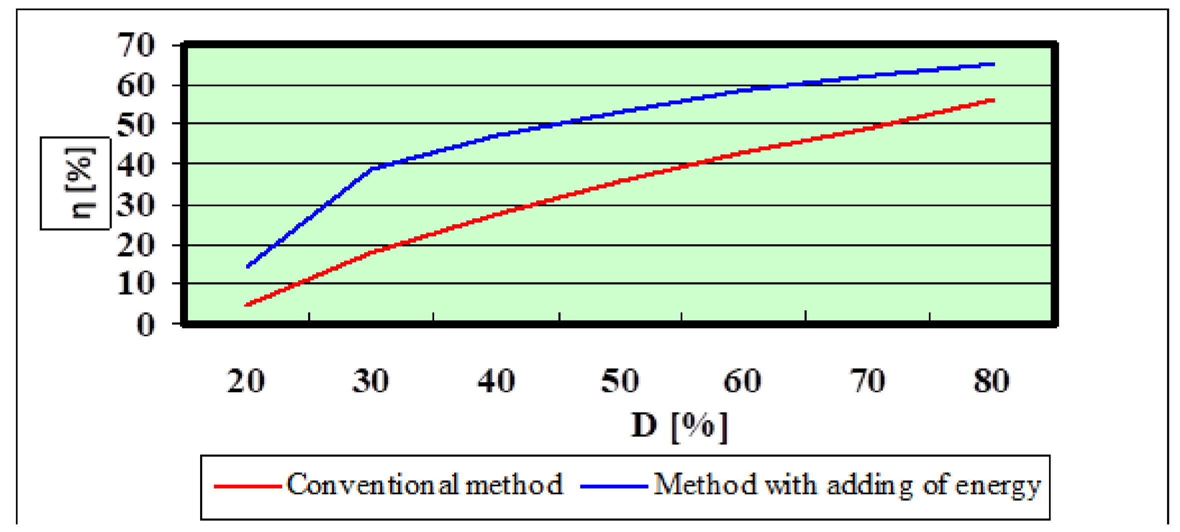

Fig. 9 Change of efficiency of two driver control circuits of the motor as a function of the duty cycle D

CONCLUSION

The higher speeds developed by the motor at low duty cycle allow the motor to rotate quickly when starting with the development of higher torque. The driver with the added Boost converter consumes less current and correspondingly less electric power than the conventional driver. The increase in rotation speed and the higher value of the back e.m.f. are the reason for the reduction of the consumed electric power P_{Cons} and the increase of the mechanical power P_{mech} at the motor output. This is the reason for the higher efficiency η in control with the proposed method with the addition of energy in each pulse.

ACKNOWLEDGMENT

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