Dariusz Gąska [1], Włodzimierz Kalita [2], Kazimierz Zając [1]

[1]HYBRES Electronics Ltd., Dębicka 1, 35-959 Rzeszów, Poland
[2]Rzeszów University of Technology, Dept. of Electronic and Communication Systems, W. Pola 2,35-959 Rzeszów, Poland

LIMITATION OF THIRD HARMONIC OF SUPPLY NETWORK CURRENT IN PHASE CONTROL SYSTEMS OF COMMUTATOR MOTORS

Keywords: supply network distortion, commutator motor, phase control system

This paper presents simple non-conventional circuit design for the third harmonic limitation of power supply current that is drawn by the medium power commutator motor with the phase control. The proposed solution features a simple design, low manufacture costs and operational effectiveness.

1. INTRODUCTION

As the phase control is still the cheapest way to control commutator motor, it is commonly used in the household appliances. Both diac and triac based simple controllers and more complex microcontroller based controllers are used. As the power of controller motor is increased, especially in case of vacuum cleaners, the distortion problem starts to play a significant role.

The phase control causes high distortions in current flowing through the controlled object – the motor. The commutator motor is an inductive load for a power supply network, and the current distortion level is very high that is especially apparent when generating interferences by the drive circuit and exceeding the acceptable level for the third harmonic. The latter phenomenon is especially apparent in case of the motor rated power within range 1500-2000W. In case of 900-1400W motors, the third harmonic level is lower than the acceptable level (2,3A in accordance to the current standards).

2. CIRCUIT DESIGN

There are some commonly known methods to eliminate or limit harmonic level, in particular the third harmonic:

• The compensation method, in which the additional capacity switching allows to limit the harmonic level in the supply network;

• Introduction of PWM instead of the phase control.

Both of methods, as referred to above, are very effective, but too expensive to implement them in the household appliances. Thus our researches were focused on improvement of the phase control system in extent of the third harmonic limitation. The method in this solution relies on the “improvement” of motor current wave in order to reduce the third harmonic under the acceptable level.

The typical phase control system is presented on Figure 1. The Tr triac directly controls the M1 commutator motor. The control signal on the triac’s gate allows for the motor power control.

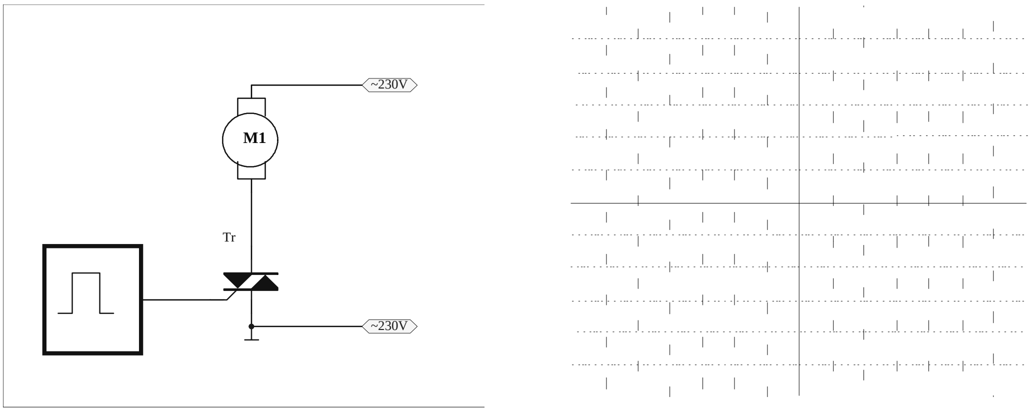

Fig. 1. The simplified phase control system with the current wave

In our presented solution, in order to limit third harmonic level, the conventional circuit was modified to the form presented on Figure 2. One additional triac was added, also controlling the motor via the R_D resistor. The addition of additional resistor into the motor circuit, along with proper control signal sequence for both triacs, causes the motor current wave shape change and, in turn, third harmonic level reduction. Of course, the motor control using additional triac and resistor is realized only when third harmonic level is to high, so that higher than 2,3A. When third harmonic level is lower than 2,3 A, there is no need to turn on additional circuit.

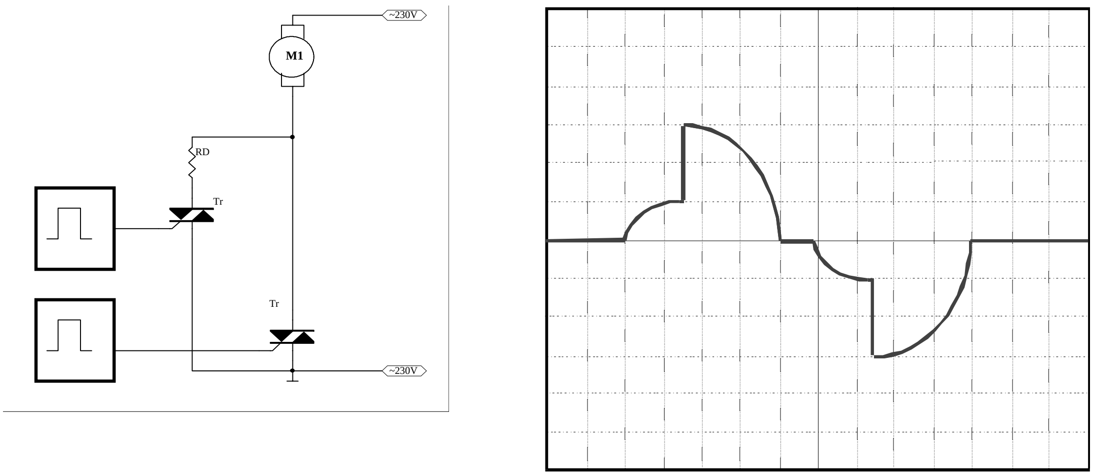

Fig. 2. The modified phase control system with the current wave

In such a case, motor is controlled via primary triac.

Due to high power emitted on the R_D resistor, the proposed solution for third harmonic limitation may be used only where suitable conditions for heat dissipation exist. In case of vacuum cleaners, where third harmonic limitation is necessary for 1500-200W motors, there is possibility of intensive R_D resistor cooling. The Figure 3 presents the diagram of proposed circuit design, in which the MICROCHIP PIC12C671 microcontrollers is used. The P1 potentiometer is connected via the RC filter (R3 & C3) to the internal A/C converter of PIC12C671. The triacs are controlled by the microcontroller using the T1 & T2 transistors, acting as the buffers providing with the suitable current level for the both triacs' gates.

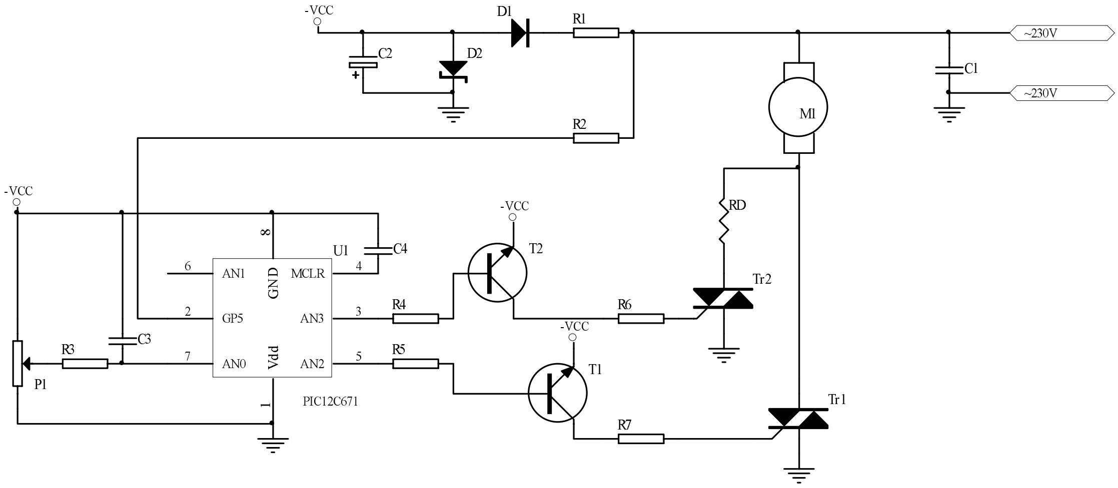

Fig.3. The proposed solutions' diagram

The additional R_D resistor is produced as a thick film resistor, of which resistance is selected depending on two conditions:

- third harmonic limitation to the required level;
- limitation of the power dissipated.

The entire electronic circuit was produced using the thick film technology on the alundum substrate. The circuit is currently under production implementation.

3. EXAMINATIONS RESULTS

The Table 1 summarizes the harmonic content measurement results for individual power values. Such measurements were performed for two types of phase controllers :

- the controller without third harmonic limitation circuit,
- the controller with third harmonic limitation circuit.

Both controllers drove 1800W motor.

Table 1

The measurement results

Normal phase control			Phase control with third harmonic limitation circuit		
P [W]	***I_1 [A]***	***I_3 [A]***	***P [W]***	***I_1 [A]***	***I_3 [A]***
100	2,02	0,5	**100**	2,02	0,5
200	2,6	0,8	**200**	2,6	0,8
300	3	1,6	**300**	3	1,6
400	3,53	2	**400**	3,53	2
500	3,8	2,27	**500**	3,55	2,15
600	4,2	2,39	**600**	3,87	2,1
700	4,4	2,54	**700**	4	2,15
800	5	2,76	**800**	4,4	2,14
900	5,4	2,80	**900**	4,98	2,16
1000	5,87	2,58	**1000**	5,43	2,15
1100	6,29	2,45	**1100**	5,94	2,1
1200	6,53	2,32	**1200**	6,35	2,2
1300	6,8	2,25	**1300**	6,62	2,15
1400	7,16	2	**1400**	7,16	2
1500	7,41	1,8	**1500**	7,41	1,8
1600	7,56	1,4	**1600**	7,56	1,4
1700	7,78	1,22	**1700**	7,78	1,22
1800	7,98	0,8	**1800**	7,98	0,8

The chart, presented in Figure 4 and 5, was plotted basing in the Table 1. The chart contains the third harmonic values vs. power consumed by the controller and the motor.

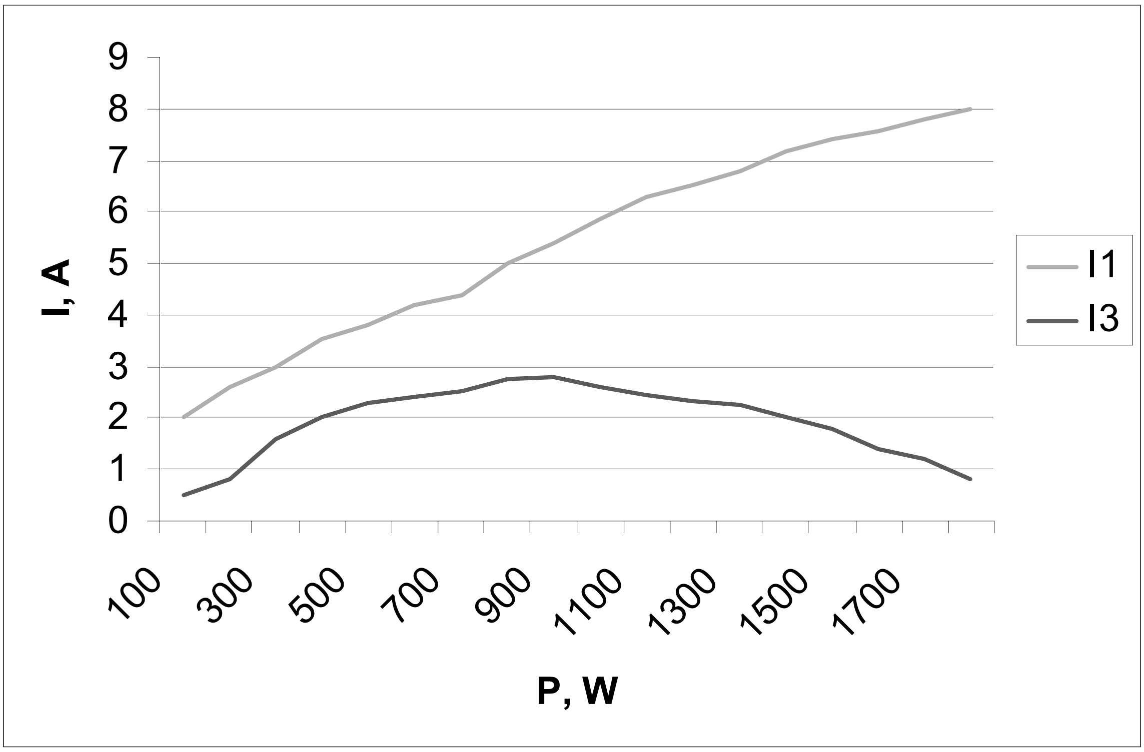

Fig.4. The harmonic content – currents vs. Power (normal phase control)

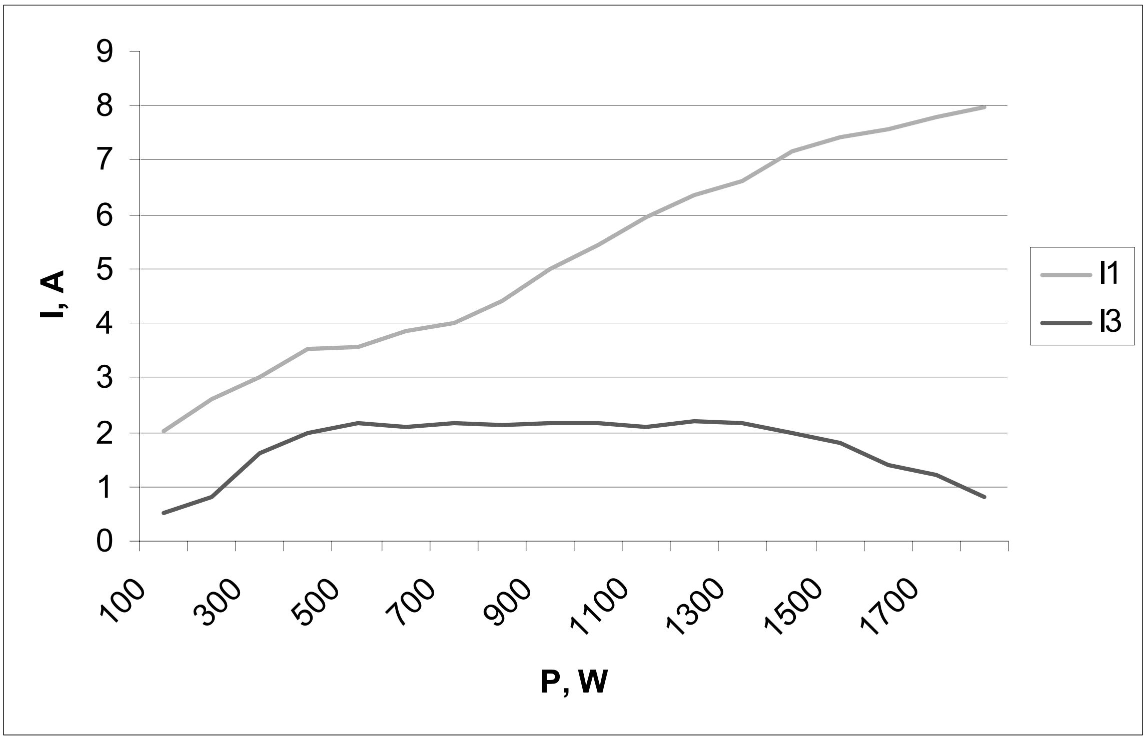

Fig.5. *The harmonic content – currents vs. Power*
(phase control with third harmonic limitation circuit)

4. CONCLUSIONS

When analyzing the measurement results, we can say that the controller with third harmonic limitation circuit, of which operation principles were presented in this paper, operates effectively by limiting the supply network current third harmonic level. The presented controller with third harmonic limitation circuit is maybe a non-conventional solution for the higher harmonic content problem, but its effectiveness combined with simplicity makes it a very interesting solution.

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Wiesław Sabat [1], Włodzimierz Kalita [1], Bogusław Wisz [1], Dieter Sperling [2]

[1]Rzeszów University of Technology, Dept. of Electronic and Communication Systems, W. Pola 2,35 959 Rzeszów, Poland
[2]Rzeszów University of Technology, Dept. of Electronic and Communication Systems, W. Pola 2, 35 959 Rzeszów, Poland

USING OF MOMENT METHOD FOR PARASITIC PARAMETERS OF PRINTED CIRCUITS IN PLANAR STRUCTURES

Keywords: moment method, parasitic parameters, hybrid circuit

This paper presents using of moment method for printed circuit residual parameters' calculation in single-layer planar structures. In accordance to the method's assumptions, the relations specifying the potential coefficients for printed circuit with arbitral geometric parameters were determined. Using the Mathcad program, basing on the relations as referred to above, the program was developed for calculation of unitary matrices of parasitic capacities and inductances of printed circuit of mutually parallel lines. In order to verify the developed program operation, the hybrid test printed circuits with different geometric parameters were made. The correctness of calculation procedures within the developed program was experimentally verified using the direct measurement for the capacity and the indirect measurement for the inductance.

1. INTRODUCTION

The planar structures, being the conductive line circuits, placed on a dielectric substrate, are able to collect the electric and magnetic field energy. The measure of this capability is expressed as a value of capacities and inductances of the printed circuit [1, 2]. The lack of analytical relations, specifying the charge distribution within such structure types, facilitates no consistent notation of relations describing the charge value. This problem may be resolved using IT means – one of analytical or numerical methods.

Upon a deep analysis of analytical methods and solutions applied in commercial applications, the moment method was chosen in order to determine printed circuit parasitic parameters. This is an approximate method, derived from weighted residue method. This method,