DESIGNING A HEATING APPLIANCE MODEL
TO PRACTICE DIGITAL CONTROLLERS SYNTHESIZING

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Introduction

Heating appliance is designed to improve skills of synthesizing and tuning digital controllers. Nowadays various digital controllers are necessary elements of any control system, which are used in manufacturing and scientific spheres, as well for private needs. Problem of any control is a primary engineering challenge, so practical ABCs of control are important researching course for young specialists. For these reasons, we design the heating appliance.

Design of heating appliance

The heating appliance consists of a heating spiral, a control driver, a resistance temperature detector, a microcontroller and a water container. Using microcontroller, we plan to program different control algorithms (e.g. for programming of PID controllers). The heating spiral has 0.5 kW power.
The control driver circuit diagram is shown in Figure 1. [1]
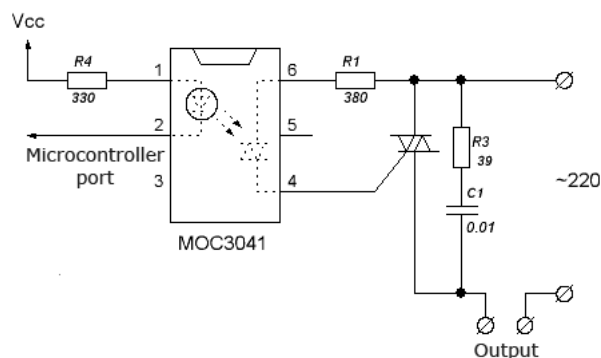

Figure 1. Circuit diagram of control driver

This driver is designed to switch power supply of the heating appliance. The microcontroller generates control signal. BT137-600 TRIAC and MOC3041 TRIAC-based opto-isolator are used for commutation of power circuit [2]. MOC3041 provides galvanic isolation of logical and power signals between themselves. The main disadvantage of any triode for alternating current is ability to conduct current even after removing the control voltage. However, applying TRIAC in this control driver greatly reduces the price of the designed board on a whole. In contrast, using insolated-gate bipolar transistors, which are also able to switch alternating-current electric power supply (220 V, 50 Hz), considerably increases costs of the designed board.

When current direction is changed, TRIAC automatically ceases to conduct current, it means that if we use AC electric power supply, we will ignore the above-mentioned disadvantage.

There are two ways to control power. It is pulse-phase modulation (PPM) method and method of voltage half-cycles skipping [4].

Closing of TRIAC occurs only when current changes its direction, so we are able to realize classical PWM to control only with frequency less than 100 Hz. It is a working principle of voltage half-cycles skipping method. This method suffers from considerable disadvantage, e.g. using this method, low frequency blinking of an incandescent lamp with small inertia will be visible to human eyes. However, the heating spiral has large inertia and it means that the above-mentioned disadvantage does not affect our experiment.

PPM is able to fix the problem of output signal blinking. PPM principle is shown in Figure 2.
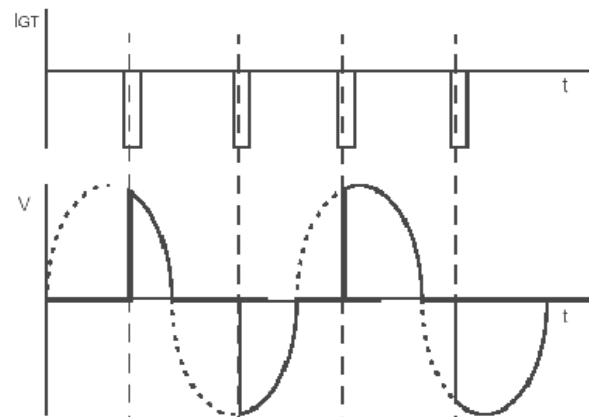

Figure 2. Time graph of PPM.

PPM control is realized as follows: when the trigger pulse turns on the TRIAC, it conducts current until the actual voltage half-cycle of electric power supply current/voltage ends. The next trigger pulse must be supplied within the following voltage half-cycle. Delay between voltage half-cycle beginning and trigger pulse time moment sets actual root mean square value (RMS) and power of output signal (temperature in this case).

Detection of half-cycle changing time is a priority task, so it is implemented in the MOC3041 through application of zero cross technology. Figure 3 shows our oscillogram, which explains control driver working principle. The signal at the top of the oscillogram is the zero cross, input trigger pulses are

shown at the bottom. Figure 4 illustrates output signal that is converted to measurements.
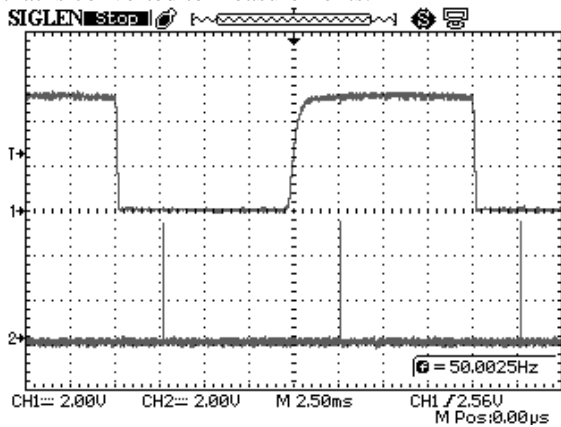

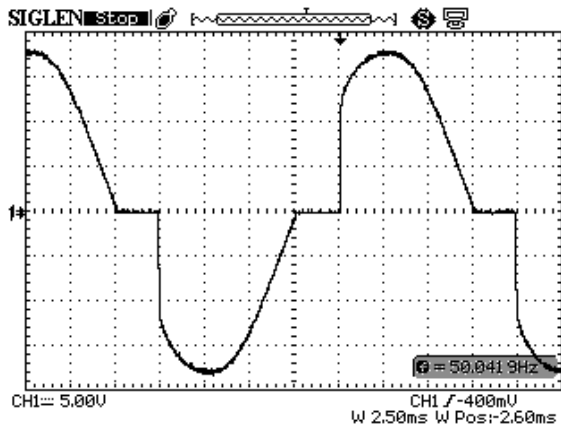Figure 3. Oscillogram of zero cross signal and trigger pulses

Figure 4. Output signal oscillogram

Circuit diagram (Figure 1) shows that we are able to connect control driver and any microcontroller between themselves. Now we are applying PinBoard 2.0 breadboard [5] based on 8-bit core – ATMega 16 microcontroller. The general view of PinBoard 2.0 is shown in Figure 5.
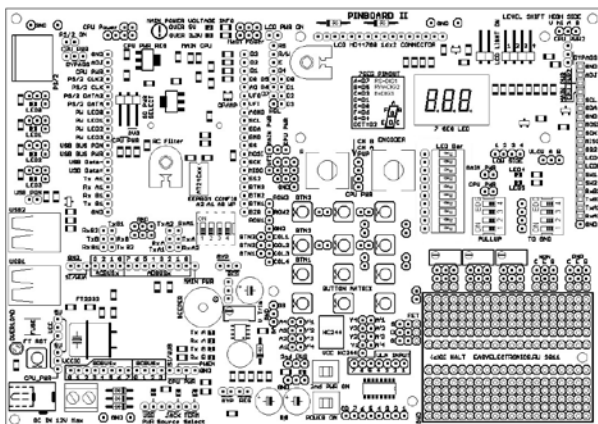

Figure 5. General view of PinBoard 2.0

PinBoard 2.0 breadboard has many functions. PinBoard application of experimental goals is completely useful, because it allows us to save money

and time for selecting and configuring external power supplies, searching a chip programmer and brazing screw terminals. Breadboard advantages:

1. microcontroller configurations latitude;
2. internal chip programmer;
3. versatility of integrated units – we will use many units independently;
4. various ports and indicators are available – there are buttons, LEDs, an encoder, LCD indicators and Modbus/Ethernet interfaces;
5. basic analog circuits are available too - different filters, internal digital-to-analog converter, separate transistors and potentiometers.

As for the microcontroller, we chose ATMega 16, because it is cheap, easy to program; required software is free and available. Moreover, we have already had ATMega programming experience.

As for the feedback, we use a copper thermistor with unified output signal (4…20 mA), with operating temperature of -50˚…+150˚C.

Conclusion

Currently we are testing and debugging this appliance. During constructing, we dealt with different difficulties, which are not described in this article. However, in the nearest future we are going to cope with its implementation and then start programming.

References
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