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AUTOMATED DC POWER SUPPLY WITH POSSIBILITY OF REMOTE CONTROL FOR RESEARCH PURPOSES

Lyashko S. D., Lyashko D. A.

Taurida National V. I. Vernadsky University, 4 Vernadsky Ave., Simferopol 95007, Ukraine
***E-mail**: roton@crimea.edu*

In this article we described stabilized DC power supply with microcontroller control, which allows to get the output voltage range (-40 - +40) with a load current up to 10 A, having the ability to stabilize both the output current and voltage. This power supply can be used for measurement automation of the magneto-optical parameters of thin magnetic films, giant magnetic impedance characteristics in amorphous magnetic microwires, parameters magneto-optical switches and modulators for fiber communication lines etc.
***Keywords*:** DC power supply, Microcontroller (MC), Pulse-width modulation (PWM), Operational amplifier (OA), Analog-digital converter (ADC).

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INTRODUCTION

Despite the fact that the development of switching power supplies constantly receives much attention [1-3], and industry produces large number of power supplies that have high performance, not all devices of this type can be used in cases where the output voltage must have possibility to change polarity. A typical example of such application can be a power supply designed to power the electromagnet used to study the hysteresis of magnetic materials.

For convenience and efficiency purposes of work with these devices, it is desirable to have manual control mode, a set of specific programmable modes and remote control mode.

We have developed a controlled bipolar stabilized DC power supply, which has the following parameters:

1. Voltage Range -40 - +40 V, with the possibility of a smooth change of polarity;
2. Current range - 0 – 10A;
3. Stabilization mode for both voltage and current
4. Remote control from PC;
5. Compact size.

1. DEVICE DESCRIPTION

Block diagram of the developed power supply is shown in Fig. 1.

Input power filter and rectifier is assembled by the standard scheme. In order to increase the efficiency of the device and decrease its working temperature, the device uses the principle of dual stabilization.

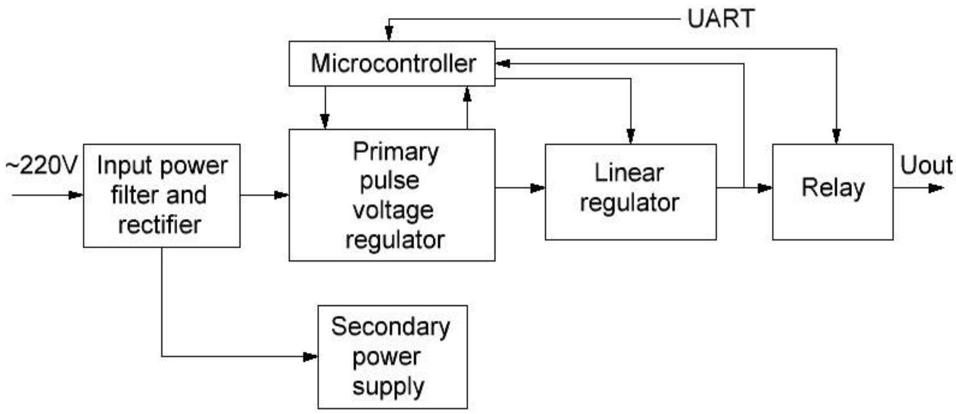

Fig. 1. Block diagram of the power supply.

2. PRIMARY PULSE VOLTAGE REGULATOR

The primary stabilizer is constructed by the circuit of PWM-controlled flyback switching power supply. This choice is due to the fact that their efficiency is rather high (80-90 %), such solutions are widespread and are used as power supplies for the PC, so that most of their components are easily accessible. As the PWM generator we chose the chip TL494, and as key elements - MJE13009 the most widely used in the sources of this kind.

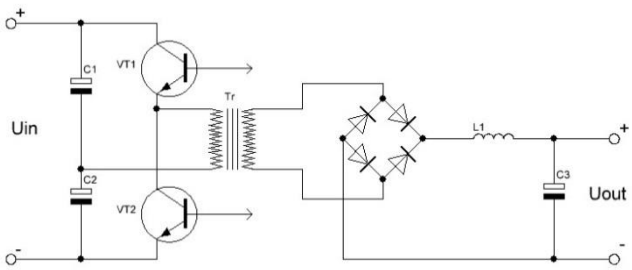

Fig. 2. Half bridge converter circuit.

Scheme of the half bridge rectifier is shown in Fig. 2.

After passing through the filter and the rectifier voltage is applied to the emitter VT1 and collector VT2. The signals from the PWM generator are applied (via the matching circuit) to the bases of the transistors VT1 and VT2 by turns forming on the primary winding of the transformer AC current with a frequency in the tens of kHz. After dropping in the transformer this current is rectified by a diode bridge and smoothed via output filter.

Control of the PWM generator TL494 is performed by applying to its control input +IN1 voltage from the source output through a resistive divider, and to -IN1 - PWM signal output from MC AtMega32 through a low pass filter of the second order. Filter should be placed as close as possible to the pins of the chip to minimize crosstalk.

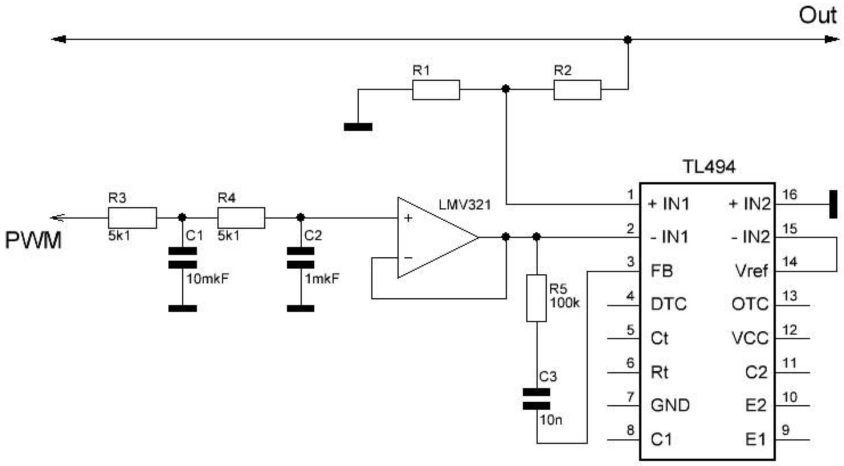

Fig. 3. Primary pulse voltage regulator control circuit.

In order to supply circuits of the PWM generator and control circuits we used a separate low-power secondary voltage source 15 V. We used classic single-cycle pulse converter circuit constructed by the standard scheme of blocking oscillator with using a separate transformer for this purpose.

Due to the significant heat of the power circuit elements, they were fixed on aluminum radiators with sufficient heat capacity. In addition to this the fan was used to ease heat dissipation.

3. LINEAR REGULATOR

One of the disadvantages of switching power supplies is the presence of impulse noise in their output voltage, the second disadvantage - lack of precision in stabilizing a small voltage (less than 1V). To eliminate these drawbacks and improve the accuracy of the device we used the second - controlled linear voltage regulator circuit which is shown in Fig. 4. Application of the linear regulator circuit provides the modes of stabilization of both voltage and current.

The linear regulator has a single supply and consist of two separate rail-to-rail op amp LMV321 (to eliminate crosstalk voltage and current stabilization) and n-channel field transistor IRFD120 as a driver for the p- channel keys. P- channel transistors are connected by the source repeater circuit. Zener diode DZ1 provides limit for these transistors gate voltage. The positive inputs of op-amp comparator linear regulator are supplied with a reference voltage from PWM pins MK AtMega32 through the integrating circuits (Uset and Iset in scheme), and the negative ones - with the measured values of current and voltage.

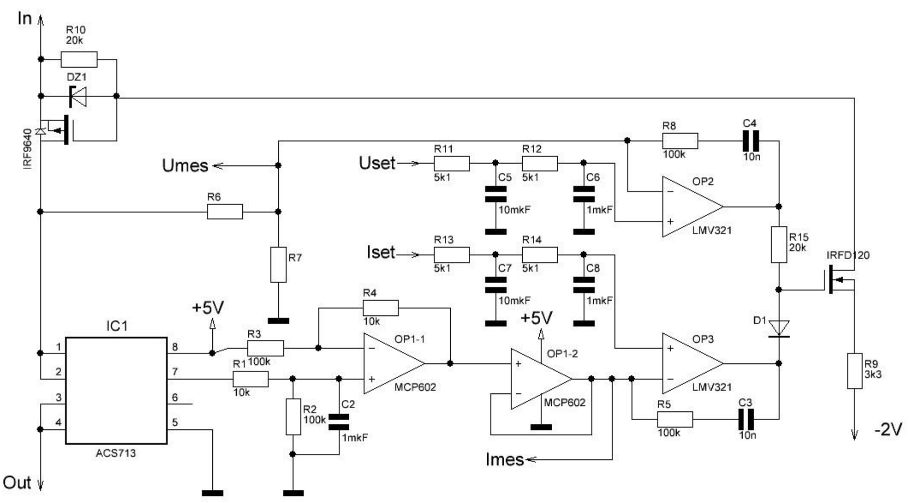

Fig. 4. Linear regulator circuit.

For current measure purpose we used chip ACS713, included in the positive output gap. In order to compensate its initial bias of the chip's output in 0,1Vcc [6] we used compensating chain based on rail-to-rail op amp MCP602 [4]. The second op-amp can be used as a non-inverting amplifier for precise measurement of small currents. In this scheme, it is connected as repeater, because the output voltage level is sufficient for a given range of currents.

Voltage comparator (OP2 in circuit) provides voltage stabilization. Current comparator when exceeding a predetermined maximum value reduces the gate voltage of the FET IRFD120 through the diode D1. This reduces the output voltage and stabilizes output current. Imes and Umes outputs are connected to the inputs of the ADC of the microcontroller.

Primary power supply voltage is set exceeding the output voltage by 2-2.5 V. This is due to the fact that all excess voltage will drop at the linear regulator transistor causing it to heat. The voltage from the primary power source is measured by the ADC of the MC, so that the gap voltage is set automatically.

To create a voltage -2V (which is required for stable operation of the linear regulator), we applied the scheme of the inverting converter based on chip 34063, made by the classical scheme [7].

4. MANAGEMENT AND CONTROL CIRCUIT

As a control element we chose widely known microcontroller AtMega32, features and outputs of which were enough to solve this problem. We used PWM outputs of the microcontroller to control the linear regulator and PWM generator of the main power source.

In order to display modes described power supply have three LEDs that display mode of the connected load, current stabilization mode and inversion of the output voltage polarity. To indicate the current mode of operation, acting and limiting current and voltage values power supply has LCD WH1604B of 4 lines and 16 characters per line. Measurement of the voltages and current are made by using the built-in AtMega32 10-bit ADC.

To change the polarity of the output voltage, as well as opportunities of remote switching off load we applied relays controlled by microcontroller pins via switching FETs. Circuit diagram of the relay block is shown in Fig. 5. The smooth transition over 0 is made in following way: at 0 point microcontroller measures the output voltage as long as the measured voltage is not equal to 0(according to ADC accuracy) and only then the first relay disconnects the load (Rel3), and then relays of the output voltage inversion switches (Rel1 and Rel2). Load relay is connected in the first step of the voltage of opposite polarity. Thus, we receive a smooth transition through the zero voltage point and guarantee the absence of voltage spikes at the moment of switching polarity.

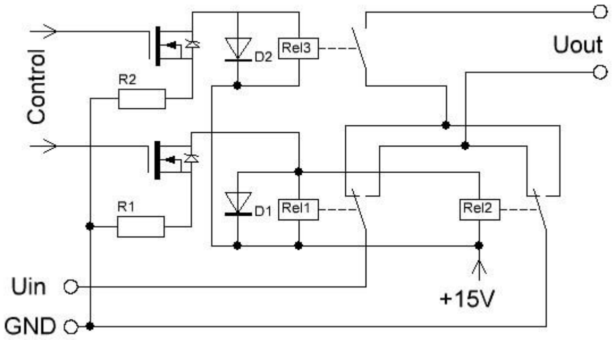

Fig. 5. Relay block circuit.

In order to obtain smooth voltage changing we applied the following algorithm: after changing the voltage for one step, the next step will be made only when the source' output stop transients and voltage become constant (according to the ADC accuracy). Application of this algorithm allows smooth voltage change without the need to manually select the delay time, although this possibility is also present.

Encoder and buttons were applied as control elements of the power supply. Depending on the selected mode of the power supply, the rotation of the encoder allows to control duty cycle of the PWM generators of AtMega32, responsible for setting values of current and voltage, and control the state of both primary and secondary stabilizers.

For remote control from a PC UART interface was used with following parameters: IC 115200 baud, 1 start bit, 8 data bits, no parity. Since most of the modern computers do not have COM-ports, we chose FT232RL scheme as the converting chip due to its simplicity and reliability. Special program was written in order to control power supply from PC, which allows both manual control of the power source and special automatical modes. While enabled the microcontroller at regular intervals sends to the PC measured voltage and current values and the maximum level of current. It is possible to change the specified voltage and current directly from PC, as well as control relays of load and polarity. Control method of the output parameters is the same as in the case of controlling the encoder. Data obtained from the computer are written to the appropriate registers and PWM generators, and, by changing its the duty cycle, set the desired values at the output of power supply.

Primary and secondary voltage sources were calibrated using attorneys measuring tools. Calibration of the current is not required because of the chip ACS713 output linearity [6].

SUMMARY

This article presents description of the stabilized power supply microcontroller control with the ability to stabilize both the output current and voltage and required to automate a number of scientific studies. The device showed good performance during testing. We plan to create a number of similar devices for measurement automation of the magneto-optical parameters of thin magnetic films, giant magnetic impedance characteristics in amorphous magnetic microwires, parameters magneto-optical switches and modulators for fiber communication lines.

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Ляшко С. Д. Автоматизоване джерело постійного струму з функцією дистанційного керування для лабораторних досліджень / С. Д. Ляшко, Д. А. Ляшко // Вчені записки Таврійського національного університету імені В. І. Вернадського. Серія : Фізико-математичні науки. – 2013. – Т. 26 (65), № 2. – С. 151-157.

У роботі описане стабілізоване джерело живлення з мікроконтролерним керуванням, яке дозволяє отримати на виході напругу в діапазоні (-40 - +40 В) при струмі навантаження до 10 А з можливістю стабілізації як по вихідному струму, так і по напрузі. Розроблений пристрій може бути використаний для автоматизації вимірювань магнітооптичних параметрів тонких магнітних плівок, характеристик гігантського магнітного імпеданса в аморфних магнітных мікродротах, параметрів магнітооптичних перемикачей та модуляторів для волоконно-оптичних ліній зв'язку тощо.

Ключові слова: мікроконтроллер (МК), широтно-імпульсна модуляція (ШІМ), операційний підсилювач (ОП), аналогово-цифровий перетворювач (АЦП).

Ляшко С. Д. Автоматизированный источник постоянного тока с функцией дистанционного управления для лабораторных исследований / С. Д. Ляшко, Д. А. Ляшко // Ученые записки Таврического национального университета имени В. И. Вернадского. Серия : Физико-математические науки. – 2013. – Т. 26 (65), № 2. – С. 151-157.
В работе описан стабилизированный источник питания с микроконтроллерным управлением, который позволяет получить на выходе напряжение в диапазоне (-40 - +40В) при токе нагрузки до 10 А с возможностью стабилизации как по выходному току, так и по напряжению. Описанное устройство может быть использовано для автоматизации измерений магнитооптических параметров тонких магнитных пленок, характеристик гигантского магнитного импеданса в аморфных магнитных микропроводах, параметров магнитооптических переключателей и модуляторов для волоконно-оптических линий связи и т.п.
Ключевые слова: микроконтроллер (МК), широтно-импульсная модуляция (ШИМ), операционный усилитель (ОУ), аналогово-цифровой преобразователь (АЦП).

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