DIGITAL CONTROLED POWER SUPPLY

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Abstract: This work deals with the design of a laboratory power supply with a modular number of additional modules for individual inputs, outputs or monitoring circuits. Design of individual parts of control circuits, circuits for monitoring of output parameters and their control by the user is solved. Furthermore, the design of the control module, which is in charge of managing the entire source, including the added modules, is solved.

Keywords: Power supply, modularity, digital control, STM32, regulation, control, communication

1 INTRODUCTION

Laboratory supply is integral part of every laboratory or home electrical workshop. Most of the experiments used with laboratory power supply is powered by single ended supply. There are also some special applications, like audio amplifiers, which needs symmetrical power supply. This type of power supply also needs quite solid accuracy and low output noise and adequate power. This work is about construction and hardware design of such a power supply. There is also a description of software, hardware design and realization. The power supply is a modular type, which means that is possible to connect up to 127 modules such as another power supplies, monitoring circuits or controlling circuits. Modules are galvanic isolated from themselves and from the mains. There is also variant of grounding them with build-in relays. All of the modules, of the power supply, can be controlled from any connected control module or remote device, such as computer. There are two build-in modules, which can operate in voltage range 0-24 V_{DC} and with current range 0-5 A_{DC}. These modules are easily changeable to voltage ranges up to 100 V_{DC}. For the change, you only needed to change main transformer, voltage divider and software description (identification) of module. Regulators and other parts are already ready.

2 CONTROLL AND DEVICE DRIVE PART

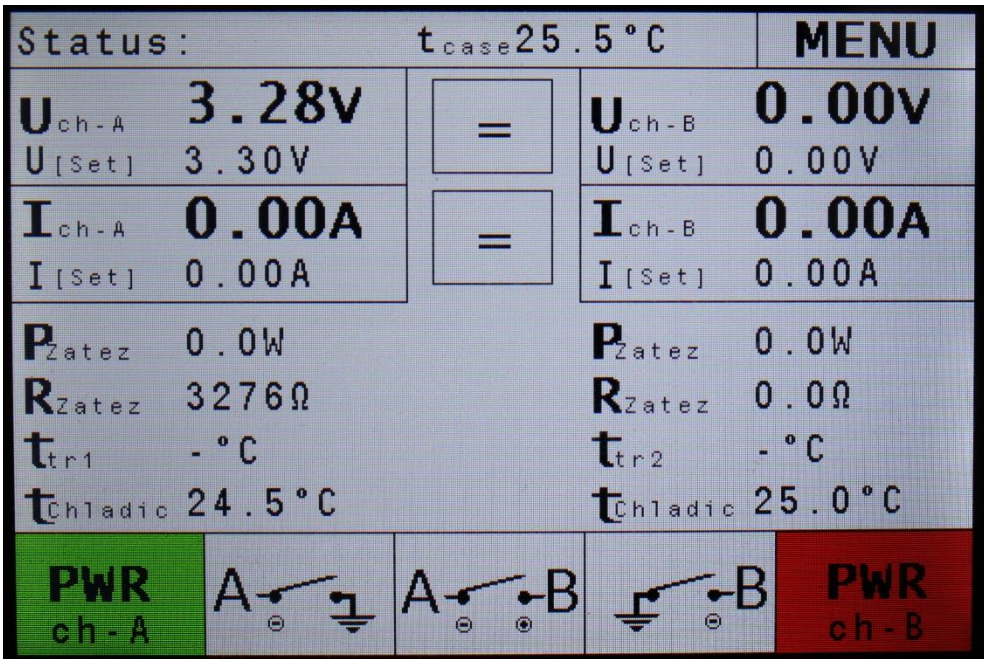
The control part of the power supply is implemented as separate PCB (module). That module contains I2C [3] bus for communication with the individual modules of power supply, individual I2C bus for temperature sensors and other elements in basic part power supply. Whole power supply is divided into 2 modules of power supply and one control module. Control module also contains RS232 for communication with remote control such as PC. That external control part can be also connected with I2C. All of the functions are controlled by MCU STM32F103[1]. That microcontroller provide driving of cooling system, user input control of power part, communication with other modules / PC, etc.

As a user interface is used LCD display about size 3,95“, with resolution of 480x320 px. That resolution is enough for organized representation of individual parameters and simple control by using touch surface. On the LCD is displayed all of the necessary data of power supply.

Control module communicate with other modules on a frequency about 400 kHz. This frequency is enough fast for communication with all the 127 modules till 300 ms including elaboration accepted or sent data. Because of this, most of the communication is performer by using DMA requirements and the core is taking care only about screen redrawing and user control interface.

User control of the power supply is mostly managed by using display by touchscreen. There is also rotary encoder for variable settings such as setting of voltage or current amplitude. This type of input, specifically for this type of data, is more comfortable. Main on/off the power supply to the stand-by regime is provided by using separate button on the main panel. The power supply is also possible to shut down by mains switch, which is placed on the back side of the device.

External modules are connected on the I2C bus, which work on 400 kHz frequency. The I2C bus has big limitations on load capacity and because of this is not possible to connect the external devices with the long power cord or connecting the external devices at all. Due to extension of the I2C bus and elimination the problem with capacity, there was used converter P82B96 [2]. This driver moves the voltage on the bus up to 12 V and ensure greater line-capacity loads.



Picture 1: Device home screen with shown main values

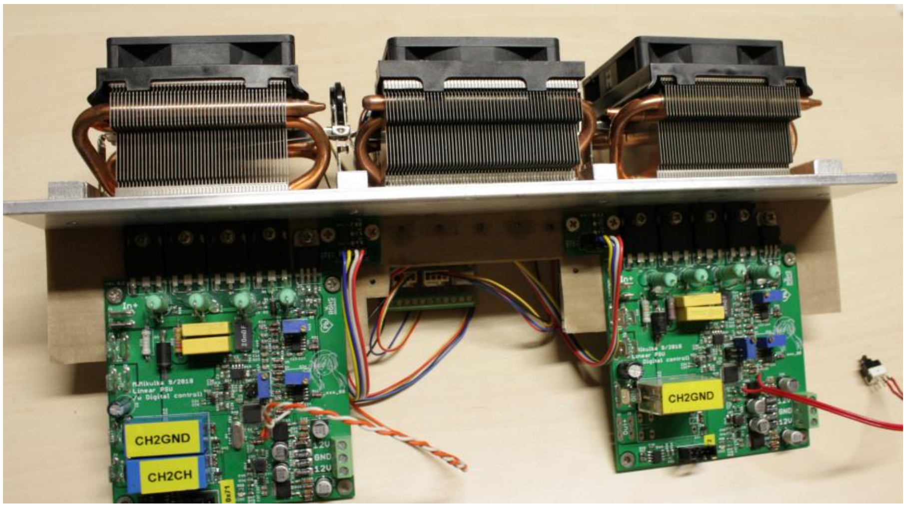
3 POWER SUPPLY MODULE

Module of the power supply is main part of the device. Its function is step regulation of output parameters (voltage, current or even frequency or signal shape) and their measurement. Each module has its own galvanically isolated power supply and own power input. The two main power supply modules have the possibility of regulating the output voltage in the range of 0-24 V and the current in the range of 0-5 A. These parameters are determined only by the used transformer. Transformers are the industrial older type with an output voltage of 24 V and a power of 120 VA. The basic modules do not have the possibility to regulate the output current waveform or its frequency. Connectable external power supply modules, which are not part of this work, could control these signal properties, respectively, the main control unit is ready for this control.

The power supply is starting the search for modules automatically every time the power supply is started. There is also an option of manual searching in the menu. This feature allows automatic mapping of external modules connected to the power supply. Each module (each I2C address) is asked for identification using a special data package. The power supply works with packages with a size of 28 bytes and for this reason this size has been preserved for the identification data package. If no response is received at the given address (NACK), the address is skipped. If the response arrives (ACK), an identification request is sent, the response is decoded and stored in the database in the control module and then the module is accessible to the user for switching it in the menu or control from remote controller such as PC. The identification packet is described in Table 1. If the module has other options that did not fit into the basic identification packet, the appropriate value is set to the 24th byte ("Module status"), which the control module evaluates and sends a request for closer identification (e.g. signal output shape, shift control, etc.). The modules are then included in the memory. If they are selected by the user (the given module of the power supply is switched on), they are regularly asked for start of measuring values, as well as entering new values. The communication timestamp is set to 300 ms when an 8 bit address is used. Control module and basic power supply modules are software-ready to change to a 10-bit address for connecting up to 1023 devices, but this option is not preset in the user settings and must be activated in the software itself. During communication, each module has approximately 30 ms in response to the control module. The module must process the desired data into a communication protocol and calculate a checksum during that time. Full communication transfer takes about 80 ms. The measurement of individual values in the power supply modules takes place based on DMA transfer from peripheral to memory. Meanwhile software part only checks for possible errors when there isn't any calculation needed (checksum, temperature, etc.).

Table 1: Communication identification packet

Size	**SLAVE action use**	**MASTER action use**
32 bits	-	Maximal input voltage
32 bits	-	Input voltage ½
32 bits	-	Input voltage $^2/_2$
32 bits	-	Maximal output current
32 bits	-	Maximal output frequency
8 bits	Identification command byte 1	DAC resolution [bit]
8 bits	Identification command byte 2	ADC resolution [bit]
8 bits	-	Additional module parts (relay etc.)
8 bits	-	Module state (Error, OK etc.)
32 bits	CRC	CRC



Picture 2: Two of basic modules on common heatsink

4 REMOTE CONTROL

Remote control of the power supply is possible via the RS232 bus or by connecting the control device to the external I2C bus. Control via the RS232 bus is provided using ASCII characters and it is therefore possible to control it clearly from any console that allows communication via RS232. The communication contains several commands listed after sending the character "?". When control module receives invalid command, that command table is also printed. Communication via the I2C interface is a bit more complicated. That I2C bus must follow special protocol described earlier. It's necessary to use special program or device for that reason. This communication has two control options, one is reading data from modules and writing data directly to the modules in the same form as the control module. The control module reads this data in the same way as the controlled module and writes the data to the display as if it were entered directly there.

The second possibility of communication via I2C is the connection as a slave device. When this variant is selected, that device appears as new slave device and need identical ID (address). When the control module selected this device, it is needed to transfer needed data such as new values of voltage amplitude etc. In the case of a request for reading rather than writing to these modules, the desired information is sent during the next communication cycle.

5 CONCLUSION

The result of the work is a fully functional adjustable power supply with two basic power supply modules, cooling, and other blocks necessary for full-fledged operation. The power supply is tested and gradually measured, which provides the necessary data for the design and development of other modules with higher quality. That new modules will be still connectable to this basic source, which can easily manage their work. The measured parameters of the power supply are sufficient for all the work that is expected from the power supply.

The first of the other modules is almost done. It is an AC power supply module with the possibility of sampling a signal with triangle, sine or rectangle shape. There will be also space for customized signal. Signal can be sampled with frequency up to 50 kHz with a resolution of 360 samples per period. The output range of this power supply module is still only in range of -50 V to +50 V with maximum current 2 A (current and voltage adjustable). Next version of that module is prepared for voltages up to 350 V to allow sampling fully separated output like island photovoltaic system.

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