Charging module for helium battery

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The article describes the fast charging module for small capacity batteries based on the XL4015 chip.

Prologue

The perverted love of Russian “brothers” for Ukraine, and its manifestation in the form of regular rocket attacks on critical infrastructure, has led to some difficulties in energy supply. This did not create a critical situation, it raised the level of Russophobia (what a fool does not do - he does everything wrong), but it created additional minor inconveniences for us, the influence of which had to be quickly leveled. The fact has surfaced that in many uninterruptible power devices, the charging time of the batteries is too long. What was not critical in peaceful conditions turned out to be very significant in military conditions. I don’t see the fault of the manufacturers of this equipment at all, well, who could have imagined that a huge nuclear country in the 21st century would unleash an imperialist war in Europe and come up with all sorts of degenerate justifications for its actions. Greatness turned out to be very inflated, and their parallel reality was from the kingdom

curved mirrors.

This charging module is designed to eliminate these inconveniences. The key points in creating this module were to make it quickly, charge it quickly, and from improvised materials (which people who do something with their own hands always have in abundance).

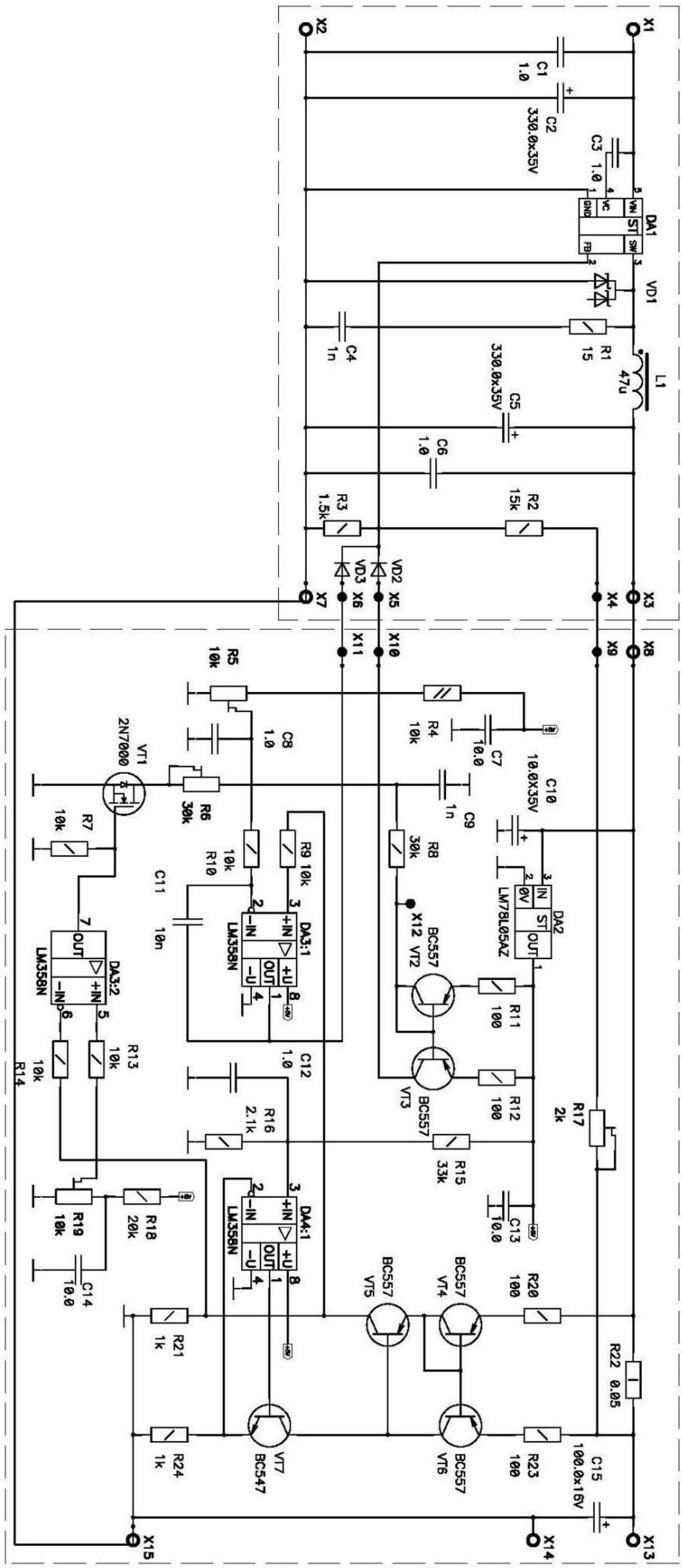
Charging module

There are two options for fast charging acid batteries - according to the Woodbridge ampere-hour law and two-stage charging in CI - CV modes. The first option, of course, provides faster charging, but requires energy accounting and periodic control cycles. The second option is a little slower, but the technical implementation of it much easier, I was guided by it.

The module was based on the simplest (and cheapest) Chinese pony board a power converter on an XL4015E1 chip, found in a drawer with various junk. In principle, despite the limited functionality, a very successful microcircuit: high efficiency, ease of use, stability and reliable protection. I want to immediately draw your attention to the fact that at currents of more than 2 amperes (it doesn’t matter what the sellers write) use it is undesirable in its original form due to overly intense thermal regimes. How to get around this, I'll tell you later.

The module was designed with a backlog for the future. I was not at all satisfied with the current sensor in the common wire, which is used by the Chinese in boards with current regulation, and it was moved to the positive circuit, the ability to connect a processor was added for temperature compensation input, output voltage control, and switching threshold switch to CV mode.

The complete diagram of the module is shown in Figure 1. For convenience of description and understanding in it also includes a circuit for switching on the XL4015E1 chip. The module itself is physically implemented on two boards - the converter itself and the control circuit. The XL4015E1 chip is included according to a typical scheme, and its operation is described in detail in the documentation.


X1
X2
C1 1.0
C2 330.0x35V
C3 1.0
DA1
VIN
ST
SW
GND
VC
FB
VD1
R1 15
C4 1n
L1 47u
C5 330.0x35V
C6 1.0
R2 15k
R3 1.5k
VD2
VD3
X3
X4
X5
X6
X7
X8
X9
X10
X11
R5 10k
R4 10k
C7 10.0
C8 1.0
C10 10.0X35V
VT1 2N7000
R6 30k
C9 1n
R7 10k
R8 30k
R9 10k
R10 10k
C11 10n
DA2 LM78L05AZ
IN
0V
OUT
X12
VT2 BC557
DA3:1 LM358N
DA3:2 LM358N
+IN
-IN
OUT
+U
-U
R11 100
R12 100
VT3 BC557
R13 10k
R14 10k
C12 1.0
R16 2.1k
R15 33k
R17 2k
C13 10.0
DA4:1 LM358N
R19 10k
R18 20k
C14 10.0
VT5 BC557
VT4 BC557
R20 100
R22 0.05
R21 1k
R24 1k
VT7 BC547
VT6 BC557
R23 100
C15 100.0x16V
X13
X14
X15

Picture 1

The only difference is the addition of a damping circuit R1, C4, which ensures stable operation at high load currents. The control circuit is powered by a voltage of + 5V from a three-terminal

stabilizer DA2. Information about the current is taken from the resistor R22 and, after amplification of the UPT VT4÷VT6, is fed to the input of the current error amplifier DA3:1 and the threshold device DA3:2. In fact, the UPT is a cascode current source, the mode of which, independent of the output voltage, is set by the current source on the transistor VT7 and op amp DA4:1. I want about

Note that such a simplified scheme is well suited for recording threshold values, but not very suitable for accurate measurements. The circuit has good stability, especially when VT4, VT5 is a matched pair on the same chip, but lacks linearity. The current limit threshold is set by resistor R5. From the output DA3:1, through the diode VD3, the amplified error signal enters the circuit of the main divider R2, R3, which determines the output voltage. Until the output current has reached the limit threshold, there is a low potential at the DA3:1 output, the VD3 diode is locked and does not affect the output.

running voltage.

The output voltage of the stabilizer is controlled by current injection into the circuit of the main divider by the current mirror VT2, VT3 through the diode VD2. This way of calling

allows you to change the output voltage over a wide range without changing other parameters

stabilizer. The

moment of transition to the "containment" mode of the battery is determined by the value of the current for the row, which is controlled by a comparator implemented on the op-amp DA3:2. The current threshold value is set by resistor R19. While the charge current exceeds the threshold, there is a low potential at the output of DA3: 2, the transistor VT1 is locked, and the injected current is zero.

When the charge current drops below the threshold, the transistor VT1 is unlocked by a high potential at the output DA3:2, and the chain R6, R8 sets the amount of current injected into the main divider of the stabilizer.

There is no need to introduce additional positive feedback circuits into the comparator, it is formed naturally. During the charging process, the module can repeatedly switch from charging mode to charging mode.

"content".

There is no indication of the mode of operation of the module. Mainly because I was not going to look at this module. If desired, you can enter such an indication using the signal from the output DA3:2.

Design and details

There are no special requirements - the details must be in good condition. LM358 op amp can be replaced with LM324. It is advisable to select transistors in current mirrors in pairs. Resi-

Stores R21, R24 are desirable to use one percent or pick up in pairs, trimming resistors - multi-turn. The printed circuit board was not developed, the control circuit was hastily assembled on a small breadboard. The control board connects to the short converter board.

kim wires.

Module setup

When properly assembled, setting up the module consists in installing the necessary voltages and current thresholds. To do this, you need a power source with a voltage of 18 ÷ 25 volts and a permissible current of 3 ÷ 4 amperes, a multimeter, a load, and, preferably, an oscilloscope. The sequence of actions is as follows: 1. Set the trimmer resistors to the middle position.

2. Disconnect the circuits suitable for the diodes VD2, VD3.
3. Supply voltage to the stabilizer, do not connect the load. Check the presence of + 5V and voltage across resistors R21, R24. They should be around 0.3V and equal. Resistor R17 sets the maximum output voltage (usually 15V). It is advisable to then measure the resistance R17, and replace the tuning resistor with a constant one.

4. Restore the VD2 diode circuit. Since there is no load current, the current source on transistors VT2, VT3 will turn on. Resistor R6 sets the “hold” voltage (usually 13.4÷13.5V).

5. Restore the VD3 diode circuit, connect the load and set R5 to the maximum load current (depending on the type and capacity of the battery used). The moment of current limitation start is fixed by the beginning of output voltage decrease. Theoretically, with a smooth increase in the load current, the current comparator can “interfere”. To eliminate its influence, temporarily turn off the circuit of the diode VD2. 6. Restore all connections and, gradually increasing the current, set the threshold current comparator with resistor R19 (usually, continuous bladeless current for a battery is 100÷150mA).
7. In the presence of an oscilloscope, check the absence of self-excitation of the stabilizer in all modes of operation.

Specifically, in my case, the maximum charge current is 4A, the comparator threshold is 0.3A, the maximum charge voltage is 15V, the “containment” voltage is 13.5V. Battery capacity 14Ah. If you plan to limit the maximum charge current to 2A, then the value of the current sensor resistor must be increased to 0.1 Ohm. If you use a microcircuit with a large output current (for example, XL4016), then the value will need to be reduced
sew.

Alteration of the **stabilizer**

Although, according to the documentation, the XL4015 chip allows you to provide an output current of up to 5A, but the design of the board I have, well, did not allow this. Not enough foil under the chip, not thermal pads, not enough space to solder a heatsink. As a result, components that could be useful were “blown away” from the board, and the board went to the trash.

The issue was resolved in this way: a very simple new board was made using using only SMD components, the stabilizer chip itself, the diode and the inductor are removed from the board. For the board, fiberglass 1 mm thick was used, equal in thickness to the ceramic gasket under the TO220 case. How it looks is shown in Figure 2.

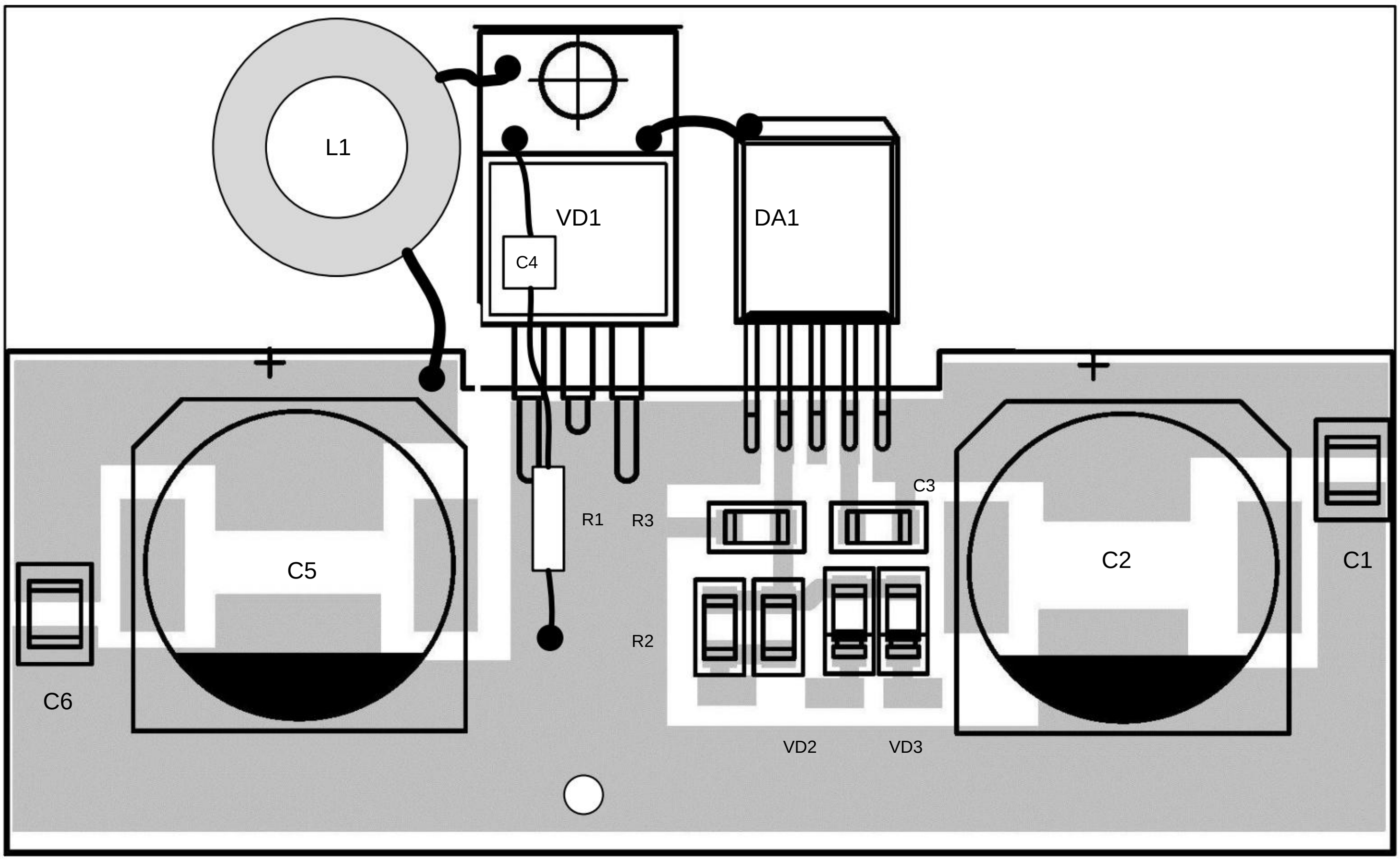
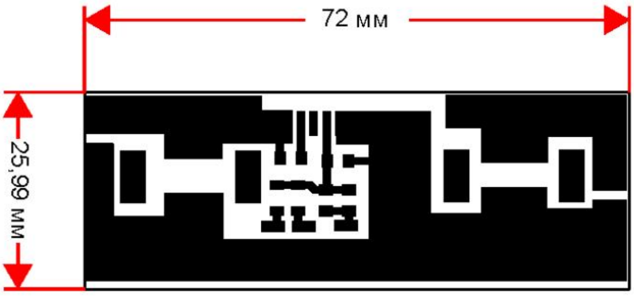


Figure 2

From the figure, in general, everything is clear. This whole structure is installed on the cooler, ceramic gaskets are installed under the stabilizer chip and the diode. The diode is attached in a regular way, the stabilizer chip is pressed against the gasket with a standard spring clip. A thermal insulating gasket is placed under the throttle and pressed with a screw with a washer.

A few words about the choice of diode VD1. The diode in the TO220 package was chosen solely because of ease of fastening. The circuit should use a diode with a reverse voltage of 40 ÷ 45 volts and a permissible current of 5-6 amperes. Diodes with large forward currents should not be used due to their significant intrinsic capacitance. Therefore, the scheme uses only one diode, if there are two of them in the case. Well suited diodes like 12CTQ045, 6TQ045P, MBR1045CT.

I repeat once again - the above decision is forced and is associated with a limited time. But if someone wants to repeat this solution, then below is a drawing of a printed circuit board on a scale of 1: 1. The board is already mirrored and suitable for manufacturing using a simplified technology.



Conclusion

Although everything said below no longer applies directly to the charging module, but may be of interest to readers. The module was used in a mini UPS to power telecommunications equipment. Quite important is the stable voltage of its supply and seamless switching.

Therefore, the UPS also has an output stabilizer. Here it is very important to use to install a stabilizer with the highest possible efficiency, having the ability to maintain the output voltage regardless of the input value (both higher and lower). For these purposes, the LTC3780 chip-based stabilizer is very well suited, which has an exceptionally high efficiency and automatic switching between step-up and step-down operation. On some of the available boards with such a chip, there is also an input voltage comparator, which, after a slight refinement of the circuit, allows you to protect

battery from overdischarge.