CURRENT SUPPLIES FOR WATER DISINFECTION

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Abstract: The article refers about functional samples of current supply, which will be used as a power supply for a small water disinfection device. This device is developed to create drinking water from service water or polluted water. Functional samples will be tested in a special stand with different kinds of polluted water and after that, most suitable variant will be used in mass production.

Keywords: drinking water, polluted water disinfection, battery, adjustable current supply

1 INTRODUCTION

Nowadays, many people have a problem with a lack of drinking water due to pollution all over the world. Drinking water is also needed in caravans, cottages and similar conditions. Drinking water can be distributed in plastic bottles, but it creates problems with plastic waste. Water can be also treated by some chemicals. Other solution is the small water disinfection device, which will be able to clean polluted water and turn it into drinking water by using mechanical filter and silver electrodes.

2 DESIGN OF THE WATER DISINFECTION DEVICE

The body of the device, which will be mounted on the tap, is made from plastic. Polluted water flows through a two-position valve into filter, where mechanical impurities are removed. In the next step, water flows into small chamber with silver electrodes. Electrodes are supplied from adjustable current supply. Water is disinfected by dissolved silver in this chamber. The valve in its second position also allows to leave out the filter and chamber, so polluted water flows directly from the tap for example to the sink. This second position is necessary, when user needs warm water. The device is powered from a 9 V battery, so it can run without mains. The filter and electrodes with their holder are replaceable after the end of their service life.

3 DISINFECTION OF WATER BY SILVER IONS

Disinfection by silver ions, which is one of the oldest methods, is based on oligodynamic effect. It means that silver (also copper, tin, lead, etc.) ions cause protein denaturation, which makes proteins biologically inoperative. In fact, ions destroy germs, mold spores and fungi [1], [2]. The advantage of silver ions consists in that they don´t change the taste of water. On the other hand, silver ions are not able to destroy viruses [3]. The amount of dissolved silver ions depends on current, which flows from one electrode to other one through water. The value of the current depends on the conductance of water, which is affected by various dissolved ions, for example calcium, sodium, chlorine, etc. The optimal conductance of drinking water is from 25 to 50 $mS \cdot m^{-1}$. The limit value is 125 $mS \cdot m^{-1}$. On the other hand, the conductance of the distilled water fluctuates from 0,05 up to 0,3 $mS \cdot m^{-1}$. The conductance of usual natural water (surface water and subterranean water) fluctuates from 5 to 50 $mS \cdot m^{-1}$ [4]. The amount of dissolved silver ions depends also on water flow, respectively on water pressure in the pipeline. Experiments with many samples of usual natural water and different water pressures have brought these results: The value of the current is required from 8 to 30 mA. Two basic arrangements of electrodes will be tested: The first arrangement are two soluble silver electrodes, the second one is the soluble silver electrode and three insoluble electrodes made from stainless steel. More suitable arrangement will be used in final prototype. Electrodes during their life become rusted, so there is a need of current polarity change. The design of current supplies was developed in according to these requirements.

4 THE DESIGN OF CURRENT SUPPLIES

In the beginning of the development, one sample that was not constructed because the requirements were modified, was designed. But some ideas were used in further constructions. The circuit diagram of this first sample is in Figure 1.

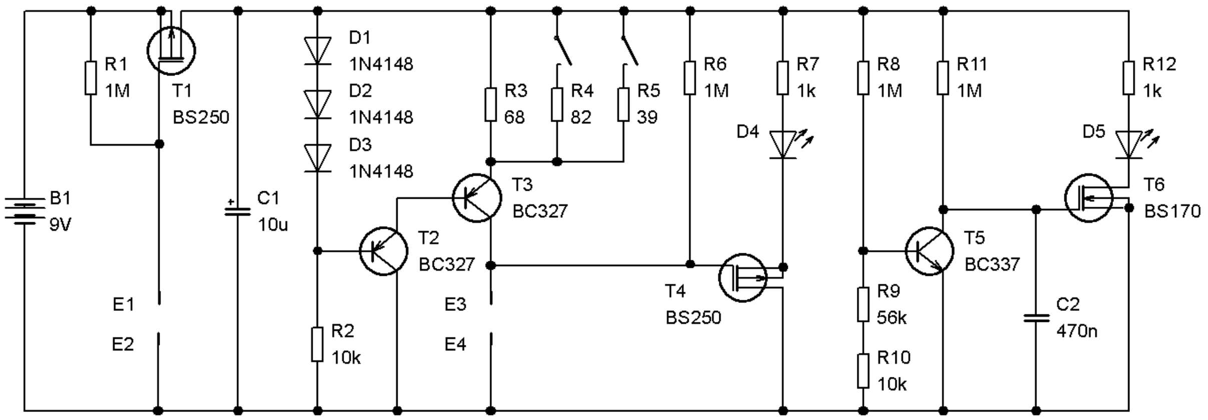

Figure 1: Circuit diagram of simple current supply

The supply is powered from a 9 V battery B1. Transistor T1 switches the supply on, when electrodes E1 and E2 are submerged into the water. Transistors T2 and T3 with diodes D1, D2 and D3 create adjustable current supply. The value of the current is adjusted with two DIP-switches in four steps from 8 to 30 mA. Transistor T4 switches the green LED D4 on, when working electrodes E3 and E4 are submerged and the water is disinfected. Transistors T5 and T6 are main parts of flip-flop circuit, which works as a low-battery indicator. When the battery voltage decreases below 7 V, the red LED D5 is turned on. This sample of the current supply was not constructed, because it did not allow the change of the current polarity. This problem was solved in the second sample, whose photograph can be seen in Figure 2.

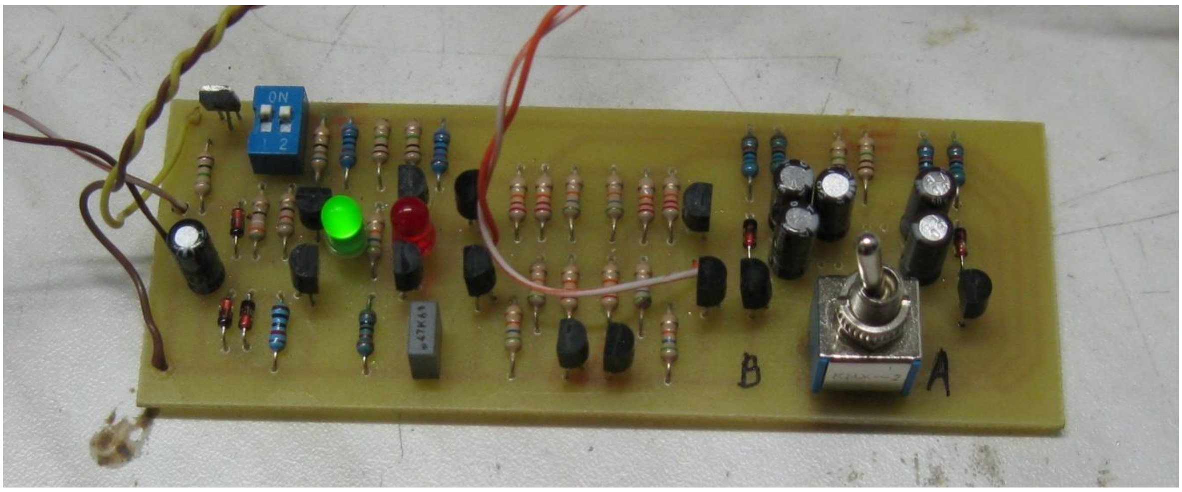

Figure 2: Current supply with H-bridge

The circuit diagram is in Figure 3. The switching transistor T1, adjustable current supply with transistors T2 and T3 and low-battery indicator are taken from the first sample (Figure 1). The change of the current polarity is carried out by H-bridge. This H-bridge, which consists of transistors T6-T11, is powered from adjustable current supply with transistors T2 and T3. Working electrodes E3 and E4 are connected to the output of the bridge. Transistors T8 and T9 work as signal inverters, which are necessary for switching the transistors T6 and T7 on. The current flows from electrode E3 to electrode E4, when transistors T6, T9 and T11 are switched on. In the next step, transistors T7, T8 and T10 are switched on and the current flows from electrode E4 to electrode E3. The H-bridge is driven by astable flip-flop circuit with transistors T12 and T13. The length of both intervals is set by values of resistors R28 and R29 and capacitors C3 and C4. Longer interval (30 seconds) is set by resistor R28 and capacitor C3, shorter interval (3 seconds) is set by resistor R29 and capacitor C4.

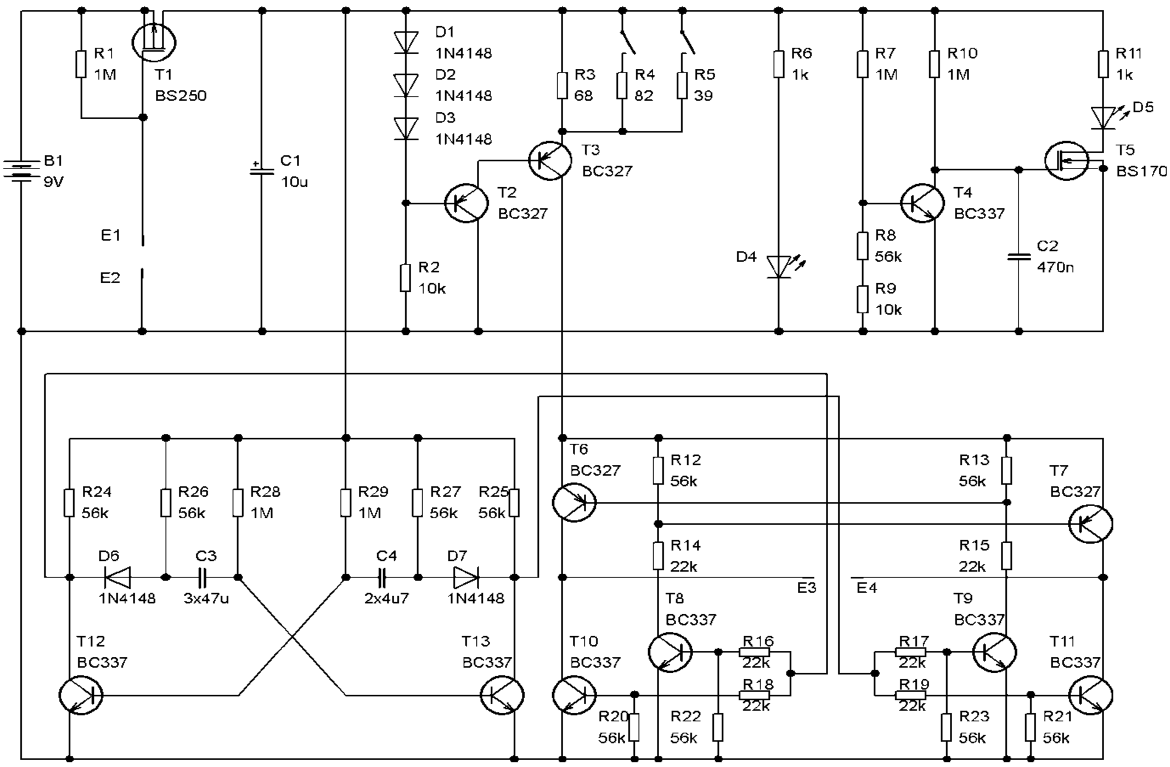

Figure 3: Circuit diagram of current supply with H-bridge

The disadvantage of astable flip-flop circuit is a random logic state on the outputs of the circuit at the time of turning on. It means that once it starts with longer interval and another time with shorter interval. It is caused by different collector current of both transistors, which is a result of slight asymmetry in the flip-flop circuit. The oscillogram of the output current is in Figure 4. The random logic state was unacceptable, so the circuit diagram was modified in according to new requirements. The variant with one soluble silver electrode requires a shorter interval (3 seconds, negative current polarity) at the time of turning on, which is followed by a longer interval (30 seconds, positive current polarity). The variant with two soluble silver electrodes requires two intervals with the same length (30 seconds, positive and negative current polarity) and current polarity change at the time of turning on. For example, once it starts with positive current polarity, the second time it starts with negative polarity. It means that the current supply needs a memory, which is permanently supplied from battery. The circuit diagram for variant with one soluble silver electrode is in Figure 5. Transistors in astable flip-flop circuit were replaced by Schmitt-trigger inverter 40106 (IC1A). Capacitor C3 is charged by resistor R13 and diode D4 for 3 seconds and discharged by resistor R14 for 30 seconds. Other Schmitt-trigger inverter (IC1B) works as a signal inverter. H-bridge with transistors T6-T11 is replaced by inverting buffers 4049 (IC2A-IC2F).

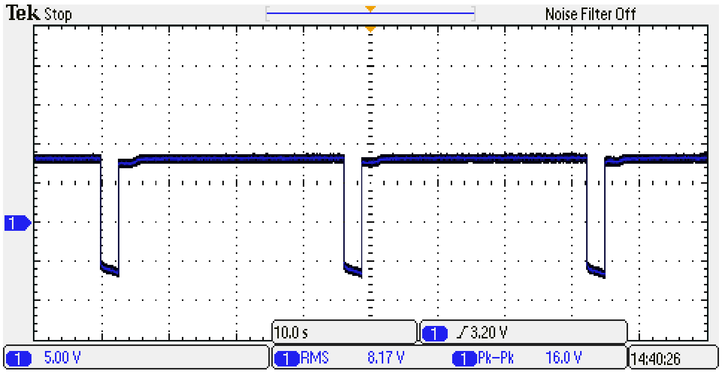

Figure 4: The oscillogram of the output current

Three and three buffers are parallel-connected and they are powered from adjustable current supply. Current supply, low-battery indicator and switching circuit are the same as in Figures 1 and 3.

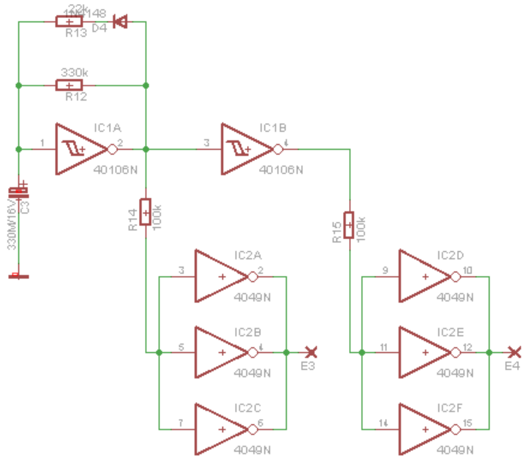

Figure 5: Circuit diagram for variant with one soluble electrode

The circuit diagram of the current supply for variant with two soluble silver electrodes can be seen in Figure 6. Timing oscillator with Schmitt-trigger inverter 40106 (IC1A) is slightly modified.

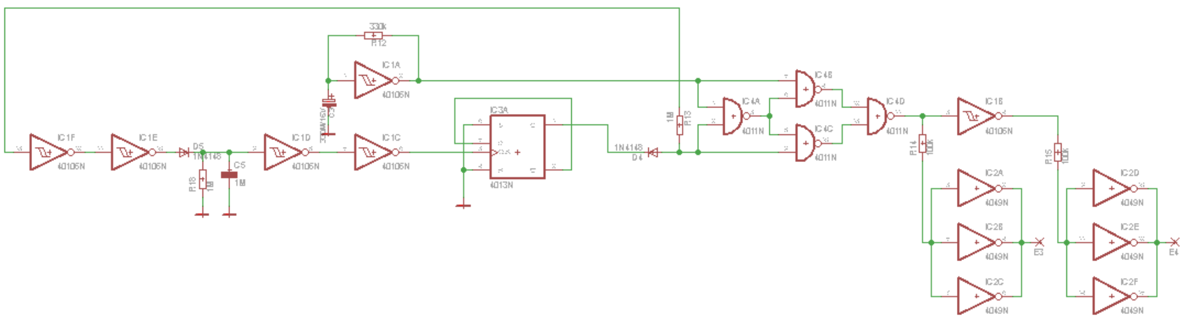

Figure 6: Circuit diagram for variant with two soluble electrodes

Capacitor C3 is charged and discharged for 30 seconds by resistor R12. One-bit memory is based on circuit 4013 (IC3A). This circuit is permanently supplied from battery. Signals from oscillator and from one-bit memory are compiled in logic XOR-gate (IC4A-IC4D), which is created from four NAND gates (4011). Three buffers (IC2A-IC2C) are driven from the output of the XOR-gate. Other three buffers (IC2D-IC2F) are driven by inverted signal from a Schmitt-trigger inverter (IC1B). Schmitt-trigger inverters (IC1C-IC1F) work as the input signal shaping circuit. Diode D5 with resistor R18 and capacitor C5 creates low-pass filter, which eliminates possible interferences caused by multiple contact of water with electrodes E1-E2 in the chamber. Oscillograms of the output current are in Figure 7. On the left, there is an oscillogram for variant with two soluble silver electrodes (30 seconds intervals), and on the right, there is an oscillogram for variant with one soluble silver electrode (3 seconds and 30 seconds intervals).

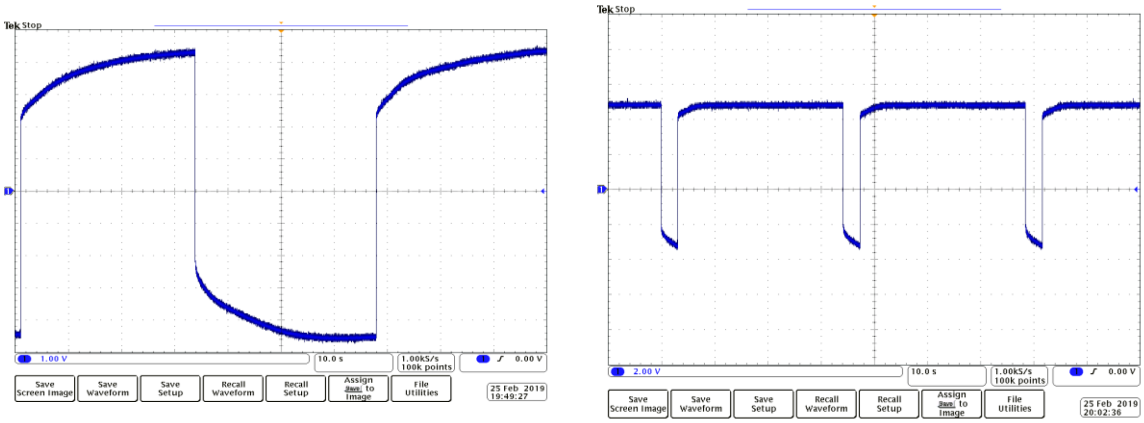

Figure 7: Oscillograms of the output current

5 CONCLUSION

This article described the development of current supplies, which will be used in a small water disinfection device. Both current supplies, which are powered from a 9 V battery, are based on transistors and CMOS gates. The value of the output current is required from 8 to 30 mA. The change of the current polarity is also needed. The first variant with one soluble silver electrode requires two intervals with different length (3 seconds for negative current polarity and 30 seconds for positive current polarity). The second variant with two soluble silver electrodes needs two intervals with the same length (30 seconds for both polarities) and current polarity change at the time of turning on.

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