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Construction of Basic Scholar Device For Education Proces and For Electro-Chemical Analysis of Solutions

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Abstract

The article deals with construction of electronics device usable in teaching process of technology education. The device is applicable in teaching of programming. Produced activated and tested scholar device is capable make the electro – chemical analysis of liquid solutions. This kind of observation is required in ecology.

Keywords: technology education, operational amplifier, potentiostat, electro – chemical analysis

Inrodution

Actually are trends of practical technical education focused to the electronics circuits combined with applied microcotroller and software. Constructed and managed device should be exploated in education process oriented on electronics circuits with operating amplifiers and their own function. Next application is in computer science by the learning of programming and controlling electronics hardware or construction and development of optimized algorythm. Selected experimental device was served by technology education. It was developed directly in educational process and may be then applied in education of electronics. The next application is in education of programming. Our system is applicable in electro – chemical analysis of solutions e.g. in the ecology. The article describes schematics diagrams of the connection of operating amplifiers and transistors. Used circuits are shortly explained with the basic principles of function of the unique circuits or of the whole device. For specified kinds of educatin models (Průcha, Walterová, Mareš, 2001; Roučová, 2001, p. 104–107; Yu Wang, 2016) is progressive investigated construction or „learning by doing" or similar models of teaching.It is realized at adequate level of practical technology education. The paper covers the technical performing and practical managing and using of electronic device. Referred device that also covers teaching of technology or robotics, automation, computer science and mechatronics. The device is optimized for application in teaching process of more branches also due to non problematic function and low cost components.

Device construction

But, we recomended the first knowledge of device and managing the device to the real creators of electronics and then to activate that one by programmers. The device consists mainly of operational mplifiers (https://www.gme.cz/tl071--dip8-texas-instruments) complementary transistors (https://www.gme.cz/vysledky-vyhledavani?search_keyword=BD139&page=1), BD139 NPN and BD138 PNP (https://www.gme.cz/bipolarni-tranzistor-bd138-16-to126) and available D/A converter. The device is seen in Fig. 1. Usually are presented electronic circuits described in chemical oriented papers and is named potentiostat (https://en.wikipedia.org/wiki/Potentiostat). More information is possibble get in (https://publiclab.org/wiki/potentiostat). The circuit diagram was not very simplificated. It was built by author. The diagram enables to be familiar with the basic connection and it is seen partially in the part 1, 2, 3 of Fig. 1. The first one of the electronic part is the two stage simplified instrumentation amplifier, respectively differential amplifier, see in Fig. 1. In those two stage amplifiers (https://www.gme.cz/tl071-dip8-texas-instruments) with voltage gain 1 and difference amplifier leads the adjustable voltage set by D/A converter to non-inverting input.
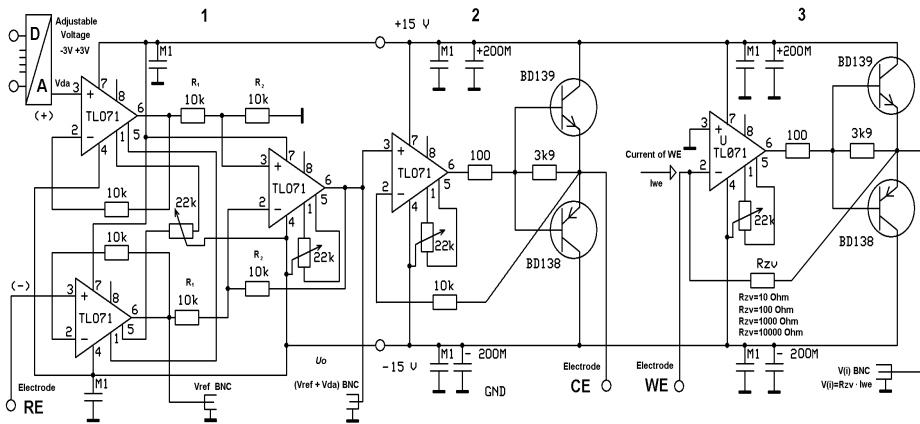

Fig. 1. Differetial amplifier 1, power amplifier 2 and current - voltage converter 3, it was built by author by applied operational amplifier

Voltage of *Vda* is subtracted by the voltage of reference electrode *Vref* in accordance to equation (1). Input of signal of the RE electrode (*Vref*) is lead to inverting input of differential amplifier. The input resistance must be very high and input quiescent current must be near to „0". Exactly should be less than about 10^{-9} A.

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$$V_o = \left(V_{DA} - V_{REF}\right) \cdot \frac{R_2}{R_1}, \tag{1}$$

where resistors R_2 and R_1 are equal to 10k and voltage gain is then equal to 1. The first stage has voltage gain equal to 1 and the second stage according (1) is also voltage gain equal to 1. Output voltage of differential amplifier Vo is forced by power amplifier 2 with presented two complementary tansistors and its output is lead to the electrode CE. The electrode CE serves as „supplying power" for all connected electrodes and optional chemical solution. Both the Voltages Vref and Vo are measured as sum (-Vref $+ V_{DA}$). Both amplifiers have set the voltage gain to 1. The third connected electrode is named working electrode WE. This WE electrode serves as current input with the current-voltage converter. It consists of one stage operating amplifier and must dispose by the current forced output.This is ideal ammeter with zero input resistance and zero inner impedance. There is input current Iwe converted to output voltage $V(i)$. The stage 3 converts input current according to Ohms´ law (2) to voltage.

$$V_{(i)} = R_{ZV} \cdot I_{WE} \tag{2}$$

The input current I_{WE} is lead to the inverting input and operating amplifier converts it according Ohms´ law and value of settable R_{ZV} to the output voltage $V_{(i)}$. Current I_{WE} of electrode WE is so converted to equivalent voltage output $V_{(i)}$. Output current of operational amplifier (interpreted as voltage) must be also forced by complementary transistors.

Output voltage at electrode CE, reference voltage at electrode RE (measured on the first stage of differerntial amplifier) and output voltage $V_{(i)}$ of current – voltage converter are measured with respect to the „virtual zero" at current input of electrode WE. For all the output voltages measurement are prepared connectors BNC. All the measured voltages provides information about applied solution where to are immersed electrodes CE, RE, WE. This description of the problem is basic. Problems of layers and electro – chemical potentals arised at all used electrodes is depeding on their material and applied kind of chemical solutions. It is the other branch of study of electro-chemical analysis. For more information is better (https://publiclab.org/wiki/potentiostat).

Recomended advices: - the developed device may be constructed as is presented with low cost operating amplifiers. – difference amplifier and other operational amplifiers consits strongly of low cost components – used D/A converter (digital – to analog conveter) may be the type of mounted type on chip of microprocessors

[some kind of ARDUINO (https://arduino-shop.cz/arduino), RASBERRY PI (http://rpishop.cz/raspberry-pi-pocitace/8-raspberry-pi-0766897151323.html) and others] – this is the same recommendation of kind of the processor control unit.
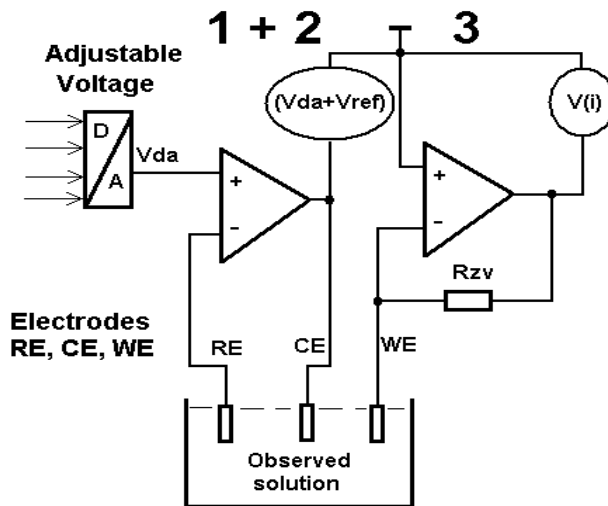
Fig. 2. Principle of connection of electro – chemical analysis, modified potentiostat picture
Source: https://en.wikipedia.org/wiki/Potentiostat.

Optional improvements: it may be used LabJack (https://labjack.com/) with integrated 12 bit Analog-to-digital converter, may be also to develop the complicated software equipment, also may be used better operational amplifiers, with electrometric input and better offset CA3140 (https://www.intersil.com/content/dam/Intersil/documents/ca31/ca3140-.pdf) for achievement of higher impedance to separate of reference electrode RE to achieve „zero input current", apply the16 bit D/A converter for precious setting of output voltage (http://www.components-shop.com/product/Texas-Instruments/PCM54HP.html). So it is possible make improvement of construction to the sophisticated device. The device is similar to the parameters of professional devices. The all recommendation only improve the measuring parameters and only causes the higher costs of school device.

Controlling system
Controlling system be arbitrary microcontroler e.g. ARDUINO, RASPBERRY PI or or other sophisticated computer. The applied controlling programm system may be written in available of programming language and is depending on used microprocessor unit or computer kit and higher requirements of user.

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Conclusion

Developed device should to serve and to help in ducational process and is capable perform basic measurement of electro – chemical analysis of solutions.

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