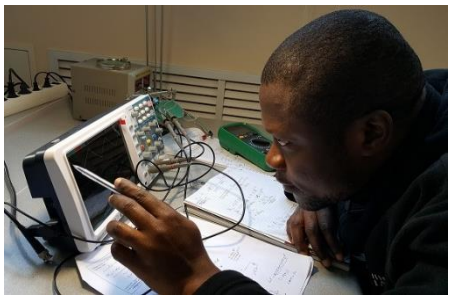
Project: Electronics hands-on training

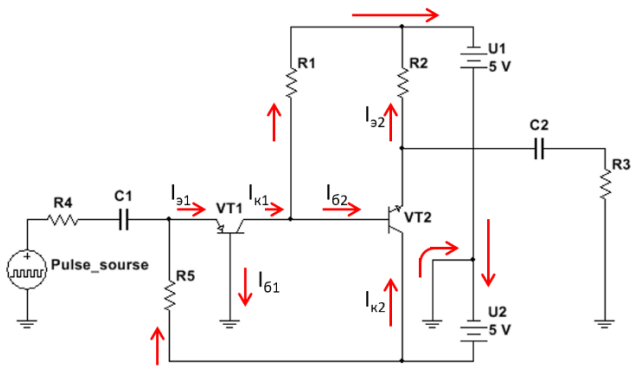
1. Introduction

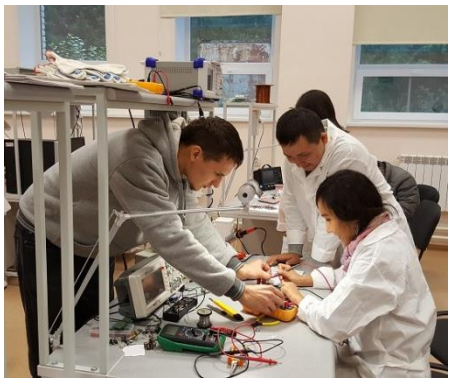
Almost every physicist-experimentalist, and, particularly, engineer working with physical equipment, needs a basic understanding of electronics, e.g. for connection circuits and control elements design. This Lab Work is aimed at studying how to apply the basic radioelectronic components, read electronic circuits and understand the basic principles of electronic devices.

2. Description

The Lab Work on Electronics is aimed at hands-on acquaintance with the main radio-electronic components. Unlike our other engineering lab works, this one includes minimum equipment requirements: a signal generator, an oscilloscope, a tester, and a soldering iron as the main tool. Students do not work with specially designed training models, but with real radio components: resistors, capacitors, diodes, transistors, etc. The Lab Work begins with an introduction to the main elements — resistance / capacitance / inductance. Afterwards, filters, semiconductors (diodes, transistors) are studied. The course ends with assembling a simple preamplifier for a particle detector.







3. Practice plan

The practice is nominally divided into basic (B) and advanced (A) parts. However, final works layout and amount is defined by the students' level.

1. (B) Introduction to the equipment. Soldering basics

Result: skill of work with a multimeter, an oscilloscope, a signal generator and a soldering iron.

2. (B) Introduction to the basic radio components

Result: skill of calculation and soldering of the passive component circuits.

3. (B) Calculation of parameters for high-, mid- and low-pass filters

Result: skill of calculating and constructing the frequency filter with required parameters (cut-off frequency, load, amplitude).

4. (B) Study of semiconductor properties

Result: hands-on skill of work with diodes: general idea of the p-n-junction, diode test using a multimeter, cathode and anode finding, diode applications (signal amplitude limitation, reverse current liquidation, diode bridge etc.)

5. (B) Calculation of stage transistor amplifiers

Result: skill of calculating and constructing the stage transistor amplifier (with a common emitter (CE), with a common collector (CC) and cascades combination by DC and by AC) with required parameters (current and voltage gain, input and output resistance, direct and differential currents). Understanding of the distinction between the stage types. Skill of visual defining the cascade type at the circuit.

6. (B) Calculation and construction of the CB preamplifier for a cosmic rays detector

Result: skill of calculating and constructing the preamplifier based on stage transistor amplifier with a common base (CB) and previously examined stage types (with a common emitter and a common collector). Understanding of the direct currents from the bipolar supply and differential currents in the preamplifier circuit. Skill of working with the real equipment: charge-sensitive amplifier circuit debugging and testing with the real cosmic rays detector.

7. (A) Charge-sensitive amplifier on bipolar transistors for a cosmic rays detector

Result: skill of calculating the differential amplifier (DA), understanding of the direct and signal currents in the DA. Skill of calculating and constructing the charge-sensitive amplifier based on DA, CE and CC. Skill of working with the real equipment: charge-sensitive amplifier circuit debugging and testing with the real cosmic rays detector.

8. (A) Operational amplifiers and feedbacks: from discrete components to integral circuits

Result: general idea of the operational amplifiers (OA) and their parameters, general idea of the feedbacks (FB). Skill of visual defining the FB type at the circuit, ability to choose the convinient FB type for a certain task. Skill of calculating and constructing the amplifier based on OA (LM 358 P precision OA is used in the Lab Work).

9. (A) Investigation of the dependence of the delay time on the cable length using the TTC

Result: general idea of the current mirror, direct and differential currents in it, calculation and application. Skill of calculating and constructing of the time-to-time converter (TTC) on transistor keys. Ability to evaluate TTC transformation ratio.

4. Prerequisites

- Basics of mathematical analysis, linear algebra and analytic geometry.
- Basics of physics: metric prefixes, basics of electricity.
- Basics of computer knowledge: MS Windows, MS Office (especially PowerPoint).
- Appropriate glasses/lenses if the student has poor eyesight: the training includes work with small elements.

5. Recommended number of participants

Up to 6 persons.

6. Supervisors

Dmitriy Belozerov, engineer of the Scientific-Engineering Group of the JINR University Centre.
Georgy Filatov, engineer of the Scientific-Engineering Group of the JINR University Centre.

7. Recommended literature

[1] J. Walker, D. Halliday, R. Resnick. Halliday & Resnick Fundamentals of Physics. Tenth edition. Hoboken, NJ: John Wiley & Sons, Inc., 2014.

[2] P. Horowitz, W. Hill. The Art of Electronics. Cambridge University Press, any edition.

[3] M. Jones. A Practical Introduction to Electronic Circuits, 3rd Edition. Cambridge University Press, 1995.

[4] John R. Barnes. Electronic System Design: Interference and Noise Control Techniques, Englewood Cliffs, New Jersey, 1987.