

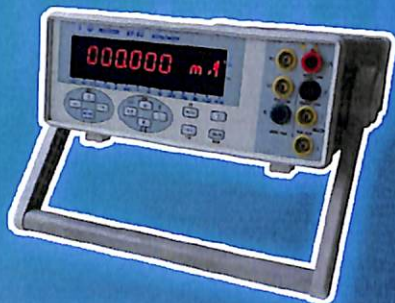
389.1  
MS4

DEPARTMENT OF DEFENSE OF UKRAINE  
KHARKIV NATIONAL UNIVERSITY OF AIR FORCE  
NAMED AFTER IVAN KOZHEDUB



# METROLOGY AND STANDARDIZATION

## Part II



Kharkiv  
2019

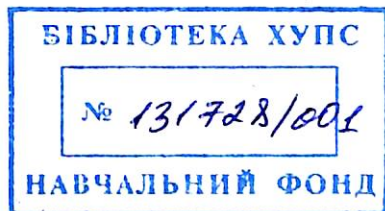
389.1  
М54

МІНІСТЕРСТВО ОБОРОНИ УКРАЇНИ  
ХАРКІВСЬКИЙ НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ  
ПОВІТРЯНИХ СИЛ імені ІВАНА КОЖЕДУБА

# METROLOGY AND STANDARDIZATION

## Part II

Навчальний посібник



Харків  
2019

УДК 006.91:621.317(075.8)  
М-54

*Рекомендовано до друку вченою радою  
Харківського національного університету  
Повітряних Сил імені Івана Кожедуба  
(протокол № 5 від 28.05.2019)*

**Автори:** В. Б. Кононов (ch. 1); Ю. І. Шевяков (ch. 2);  
В. А. Бородавка (ch. 4); А. М. Науменко (ch. 3);  
А. В. Коваль (ch. 5); Ю. В. Ратнакар (ch. 6, 10)  
Л. О. Фадеева (ch. 8); Ю. П. Шамаєв (ch. 7);  
В. Ю. Запека (ch. 9).

**Рецензенти:** М. Д. Кошовий, професор, доктор технічних наук;  
С. І. Кондрашов, професор, доктор технічних наук.

**Metrology and standardization: навч посіб. / В. Б. Кононов;  
М-54 Ю. І. Шевяков; В. А. Бородавка та ін. – Х. : ХНУПС, 2019. – 92 с.**

The theoretical and practical positions which are needed for the study of disciplines of «Bases of metrology and electric measurings», «Bases of metrology and standardization». A train aid is intended for students of all faculties of university.

У навчальному посібнику викладені основи теоретичних та практичних положень, що необхідні при вивченні дисциплін “Основи метрології та електричних вимірювань”, “Основи метрології та стандартизації”.

Навчальний посібник призначений для курсантів та студентів усіх факультетів університету.

УДК 006.91:621.317(075.8)

© Кононов В. Б., Шевяков Ю. І., Бородавка В. А.,  
Науменко А. М., Коваль О. В., Ратнакар Ю. В.,  
Фадеева Л. О., Шамаєв Ю. П., Запека В. Ю., 2019  
© Харківський національний університет  
Повітряних Сил імені Івана Кожедуба, 2019

## CONTENTS

PREFACE	4
INTRODUCTION	5
Chapter 1. State System of Standardization	6
Chapter 2. General information about metrology	13
Chapter 3. Random errors	18
Chapter 4. Direct measuring devices	26
Chapter 5. Measuring generators	43
Chapter 6. Power measuring	48
Chapter 7. Frequency measurement	54
Chapter 8. Electronic oscilloscopes	59
Chapter 9. Multifunctional devices	67
Chapter 10. Calibration of measuring devices	77
Answers to the tasks	83
DICTIONARY	88
BIBLIOGRAPHY	89

## PREFACE

The suggested manual is written in accordance with the new program of discipline „Bases of metrology and electric measurements” and contributes to the training of such specialists.

At the head of the chapters the short data about physical unit to be measured are given. Then there are given the measuring procedures, the design concepts of measurements that implement the measuring procedures according to the kind of measuring value, the limits of its values, the range of operating frequency and necessary accuracy of measurement. To illustrate this the structural flow charts of measuring devices and basic diagrams of some units are given.

Development, manufacturing and operation maintenance of radioelectronic and electronic-calculating means are inevitably connected with the numerous measurements. With that the obtained measurement information is used both for proper measurement and for generating the corresponding signals. It's obvious that the choice of measurement technology in each particular case must provide the realization of necessary quality index of end result.

It's important for the specialist to correctly take the measurement technology, arrange the measuring experiment, process and set out the measurement results as to the cornerstone principles of metrology and acceptability. Productivity enhancement, repair works, test and evaluation are also connected with wide application of different forms and methods of standardization.

The training manual is designated for preparation of licentiates in the field of study " Metrology and information-measuring equipment" in accordance with the requirements of State Educational Standards of higher professional education. The present manual may be useful for cadets and students of other engineering specialities, and also for engineers and postgraduate students. The authors express particular gratitude to the readers: Professor Coshovi V. D., Kondrashov S.I., and to the members of Measurement and Standards department for helpful remarks while reviewing the manual.

## INRODUCTION

Under current conditions the electroradiotechnical measurements are widely used in all spheres including the military sector. The quick rates of development of electroradiomeasuring instruments and the output of different measuring instruments are determined by the fact that the research in the field of physics, energy sector, electronics, radio technology and the most spheres is based on the definition of electric and magnetic quantities. Millions of measurements are made every day. It's obvious that the measurements taken with the help of different means can be useful only then when the results could be trusted, when the measurement results, obtained by different experimentators at different times and in diverse places, can be compared.

Being at the place of production, the specialist who is directly or indirectly connected with measurements, comes in contact with enormous number of measuring tasks and reference documents the accomplishment of which is necessary (standards, recommended practices, instructions).

But the knowledge of rules and standards alone does not guarantee the successful military or engineering activity. It is absolutely necessary to learn the measurement methods and the main construction principles of physical quantities measuring means. In these conditions the knowledge of measurement methods should be put first. This is due to the fact that measurement methods and physical operating principles of the instruments are the most constant components, while the specific circuitry and element base of measurement means are constantly changing and improving.

The material of a training manual contains the information that provides the necessary level of specialist training in the field of design engineering and production technique, operation activity of radio electronic and electronic computing means. The understanding of the manual material provides an opportunity to knowingly approach to the learning of measurement methods of the prevailing quantities, to the analysis of the measurement results and errors. It also contains the basic principles of metrological support of weapons and military equipment that gives the opportunity to use the obtained knowledge in practice. There are the examples of solving the practical tasks that arise in processing the measurement results, and the tasks for working out with no outside help. The material is presented in English that will be helpful for cadets and students to improve it.