

MINISTRY OF SCIENCE AND HIGHER EDUCATION OF THE RUSSIAN FEDERATION
Federal State Autonomous Educational Institution for Higher Education
«North-Caucasus Federal University»

APPROVED BY

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ASSESSMENT TOOLS FOR THE DISCIPLINE (MODULE)
«Power Quality»

Field of study	<u>13.04.02 Electric Power Engineering and</u> <u>Electrical Engineering</u>
Specialization (Profile)	<u>Intelligent Power Supply Systems</u>
Year of commencement of studies	<u>2026</u>
Mode of study	<u>full-time</u>
Implemented in semester(s)	<u>1</u>

Stavropol 2026

Foreword

1. Purpose: This assessment tools (AT) document is intended to assess the level of competency formation during ongoing progress control and intermediate assessment of students in the discipline "Power Quality".

2. The AT is an appendix to the syllabus of the discipline "Power Quality".

3. Developer: Dmitry A. Kostyukov, Associate Professor of the Department of Automated Electric Power Systems and Power Supply.

4. The AT has undergone expert review.

Members of the expert group:

Chairperson: Yu. G. Kononov, Doctor of Technical Sciences, Professor, Head of the Department of Automated Electric Power Systems and Power Supply.

Committee members:

D.A. Kostyukov, Candidate of Technical Sciences, Associate Professor, Department of Automated Electric Power Systems and Power Supply.

A.V. Petrov, Candidate of Technical Sciences, Associate Professor, Department of Automated Electric Power Systems and Power Supply.

Representative of the employer organization:

A.S. Filippov, Head of the Leninsky District Department of the Stavropol Interdistrict Branch of the PJSC «Stavropolenergosbyt».

Expert opinion: The AT is recommended for assessing the level of competency formation during ongoing progress control and intermediate assessment of students in the discipline "Power Quality".

5. The validity period of the AT is determined by the period of implementation of the educational program.

1. Description of indicators and criteria for assessment at various stages of their formation, description of grading scales

Competency(ies), indicator(s)	Levels of competency formation			
	Minimum level not achieved (Unsatisfactory) – 2 points	Minimum level (Satisfactory) – 3 points	Medium level (Good) – 4 points	High level (Excellent) – 5 points
PC-3. Capable of managing the power system operating mode of an electrical power supply system using digital technologies				
Learning outcomes for the discipline (module): Indicator: ID-1 PC-3 Performs calculations of the performance indicators of electrotechnical equipment and its systems	Does not know methods for calculating PQ indices (THD, Pst, unbalance factor). Cannot interpret measurement results.	Performs basic PQ calculations (THD, voltage deviation) with minor errors, using reference materials.	Correctly calculates THD, harmonic orders, unbalance factor, Pst/Plt per IEC 61000-4-7 and IEC 61000-4-15. Assesses compliance with standard limits.	Performs full calculations of all regulated PQ indices per IEC 61000-4-30. Applies CDF and 95th-percentile statistical analysis to long-term monitoring data.
Learning outcomes for the discipline (module): Indicator: ID-2 PC-3 Ensures the required operating modes and specified parameters of the technological process for elements of power supply systems	Does not understand the impact of PQ disturbances on equipment operation. Cannot configure PQ measuring instruments.	Has general understanding of PQ impact on power supply equipment. Configures a PQ analyzer for basic measurements with guidance.	Assesses PQ disturbance impact on transformers, motors, and converters. Independently configures Class A/S analyzers per IEC 61000-4-30. Provides compliance recommendations per EN 50160.	Designs full PQ monitoring programme, statistically analyses data, assesses compliance, and prepares a technical report per IEC 62586-2 with mitigation recommendations

ASSESSMENT TOOLS FOR CHECKING THE LEVEL OF COMPETENCY FORMATION

Task No.	Correct Answer	Question Content	Competency
1.	2	Power quality (PQ) is primarily defined as: 1) the ratio of active power to apparent power in a network 2) the set of characteristics of the electricity supply at a given point that allow electrical equipment to function as intended 3) the efficiency of energy transmission from generator to consumer 4) the ratio of fundamental frequency voltage to the supply voltage	PC-3
2.	3	According to IEC 61000-4-30, a Class A power quality instrument is required when: 1) only voltage RMS values need to be recorded 2) measurements are performed for billing purposes only 3) precise, binding measurements are required, e.g., for verifying compliance or resolving disputes 4) the measurement duration does not exceed 10 minutes	PC-3
3.	1	The standard that defines voltage characteristics of electricity supplied by public distribution networks in Europe is: 1) EN 50160 2) IEC 61000-4-30 3) IEEE 1159 4) IEC 62586-2	PC-3

4.	4	Total Harmonic Distortion (THD) of voltage is defined as: 1) the ratio of the 2nd harmonic voltage to the fundamental voltage 2) the sum of all harmonic voltages divided by the nominal voltage 3) the ratio of the fundamental voltage RMS to the total voltage RMS 4) the ratio of the RMS value of all harmonic components (above fundamental) to the RMS value of the fundamental component	PC-3
5.	2	According to EN 50160, the limit for individual voltage harmonics up to order 25 at the point of common coupling in LV networks (95th percentile over one week) generally does not exceed: 1) 10% of the fundamental voltage 2) values specified in Table 1 of EN 50160, e.g., 6% for 5th harmonic 3) 1% for all harmonic orders 4) 3% for all odd harmonics and 2% for all even harmonics	PC-3
6.	3	The basic measurement time interval (aggregation interval) for power quality parameters according to IEC 61000-4-30 is: 1) 1 second 2) 5 minutes 3) 10 minutes 4) 1 hour	PC-3

7.	1	A voltage sag (dip) is defined as a temporary reduction of the supply voltage at a point in the electrical network to a value between: 1) 1% and 90% of the declared voltage, lasting from 0.5 cycles to 1 minute 2) 0% and 50% of the declared voltage, lasting from 1 ms to 10 ms 3) 10% and 50% of the declared voltage, lasting more than 1 minute 4) 90% and 110% of the declared voltage, lasting from 10 ms to 60 s	PC-3
8.	4	Which statement correctly describes Pst and Plt flicker severity indices? 1) 10 minutes 2) 2 hours 3) 5 minutes 4) 10 minutes (Pst), and long-term Plt is calculated from 12 consecutive Pst values over 2 hours	PC-3
9.	2	The standard that specifies measurement methods for harmonics and interharmonics in power supply systems is: 1) IEC 61000-4-15 2) IEC 61000-4-7 3) IEC 61000-4-30 4) IEC 62586-2	PC-3

10.	3	Voltage unbalance in a three-phase system is most commonly characterised by: 1) the ratio of zero-sequence component to positive-sequence component 2) the difference between maximum and minimum phase voltages 3) the ratio of the negative-sequence voltage component to the positive-sequence voltage component (unbalance factor) 4) the total harmonic distortion of the phase voltages	PC-3
11.	1	According to EN 50160, for LV and MV public networks, the supply frequency deviation from 50 Hz must not exceed ± 1 Hz for 99,5% of the year. What is the wider tolerance allowed for 100% of the time? 1) $+4$ Hz / -6 Hz for systems synchronously connected to an interconnected system 2) ± 5 Hz 3) ± 2 Hz 4) $+6$ Hz / -4 Hz	PC-3
12.	4	Interharmonics are spectral components of a voltage or current waveform with frequencies that are: 1) integer multiples of the fundamental frequency 2) subharmonics below the fundamental frequency only 3) equal to the fundamental frequency 4) non-integer multiples of the fundamental frequency (frequencies between harmonics)	PC-3
13.	2	The Discrete Fourier Transform (DFT) as applied in IEC 61000-4-7 uses a basic measurement window of: 1) 10 cycles of the fundamental frequency 2) 10/12 cycles (10 cycles at 50 Hz or 12 cycles at 60 Hz), corresponding to approximately 200 ms 3) 1 second 4) 20 ms (one cycle at 50 Hz)	PC-3
14.	3	A voltage swell is characterised by a temporary increase of the RMS voltage at a point in the network to a value: 1) between 100% and 110% of the declared voltage 2) above 200% of the declared voltage 3) between 110% and 180% of the declared voltage, lasting from 0.5 cycles to 1 minute 4) above 110% of the declared voltage, lasting more than 1 minute	PC-3

15.	1	The Cumulative Distribution Function (CDF) is used in power quality monitoring primarily to: 1) determine the percentage of time during which a parameter remains below a specified threshold, enabling 95th-percentile compliance assessment 2) calculate the total energy consumed by non-linear loads 3) determine the instantaneous peak value of voltage disturbances 4) measure the propagation speed of voltage transients in the network	PC-3
16.	3	IEC 62586-2 relates to: 1) measurement methods for harmonic distortion in power systems 2) voltage characteristics of public distribution networks 3) functional tests and uncertainty requirements for power quality instruments in power supply systems 4) recommended practice for monitoring electric power quality (IEEE standard)	PC-3
17.	2	The negative-sequence component of an unbalanced three-phase voltage system causes: 1) additional heating and counter-torque in induction motors, reducing efficiency and lifespan 2) resonance in power factor correction capacitor banks 3) increase in the THD of supply voltage 4) increase in flicker severity Pst at the point of common coupling	PC-3
18.	4	IEEE Std 1159 classifies power quality disturbances. Short-duration voltage variations lasting from 0.5 cycles to 3 seconds are classified as: 1) momentary interruptions if voltage drops to zero 2) temporary overvoltages 3) sustained interruptions 4) instantaneous, momentary, or temporary sags/swells/interruptions depending on the duration sub-category	PC-3
19.	2	The aggregation of 10-minute PQ measurement values into 2-hour values according to IEC 61000-4-30 is performed by: 1) taking the arithmetic mean of the 12 consecutive 10-minute values 2) calculating the RMS of the 12 consecutive 10-minute aggregated values 3) taking the maximum of the 12 consecutive 10-minute values 4) calculating the median of the 12 consecutive 10-minute values	PC-3

20.	3	Electric vehicle (EV) fast chargers primarily affect power quality by: 1) generating fundamental frequency current that causes voltage sags lasting more than 1 minute 2) producing supraharmonics only (above 9 kHz) with no effect on standard PQ parameters 3) injecting harmonic and interharmonic currents, causing voltage distortion and reactive power demand at the point of connection 4) generating significant voltage swells during the charging initiation phase	PC-3
21.	1	The 95th percentile value used in EN 50160 compliance assessment means that: 1) the measured parameter must not exceed the limit for 95% of all 10-minute mean RMS values over any one-week observation period 2) 95% of consumers in the network must receive power within the specified quality parameters 3) the parameter must not exceed the limit for 95% of time in any 24-hour period 4) 95% of all measurement samples must lie within $\pm 5\%$ of the nominal value	PC-3
22.	4	Which of the following signal processing methods provides simultaneous time and frequency localisation, making it suitable for detecting transient PQ disturbances? 1) Fast Fourier Transform (FFT) 2) Arithmetic mean calculation 3) Discrete Fourier Transform (DFT) with rectangular window 4) Wavelet transform	PC-3
23.	2	A technical report on a power quality measurement campaign, prepared in accordance with IEC 62586-2, must include: 1) the internal configuration parameters of the PQ analyzer only 2) a description of the measurement setup, the measurement results with statistical evaluation, compliance assessment against applicable standards, and conclusions 3) the financial cost estimate for corrective measures	PC-3
24.	3	Passive harmonic filters in distribution networks operate on the principle of: 1) generating compensating harmonic currents equal in magnitude and opposite in phase 2) amplifying the fundamental frequency voltage to suppress harmonic voltages 3) providing a low-impedance path for specific harmonic frequencies, thereby diverting harmonic currents away from the network 4) increasing the short-circuit power at the point of common coupling by injecting reactive power	PC-3
25.	1	The main reason for increased harmonic distortion in modern distribution networks is: 1) the widespread use of non-linear loads such as power electronic converters, variable speed drives, switched-mode power supplies, and EV chargers 2) the ageing of transformer insulation in distribution substations 3) the increase in conductor cross-section in low-voltage networks 4) the transition to underground cable lines in urban distribution networks	PC-3

26.	4	According to IEC 61000-4-30, time synchronisation of PQ measurement instruments is required with an accuracy of: 1) ± 1 second 2) ± 100 ms 3) ± 10 ms 4) ± 1 s for Class S and ± 20 ms for Class A (GPS or equivalent synchronisation)	PC-3
27.	2	The harmonic group concept defined in IEC 61000-4-7 is used to: 1) calculate the total RMS value of voltage including all spectral components 2) group DFT spectral lines around each harmonic order to account for spectral leakage and improve measurement accuracy 3) separate odd and even harmonics for independent compliance assessment 4) determine the phase angle between voltage and current harmonics of the same order	PC-3
28.	3	A STATCOM (Static Synchronous Compensator) is used in power systems to mitigate PQ problems primarily related to: 1) harmonic voltage distortion above the 25th harmonic order 2) long-duration interruptions lasting more than 3 minutes 3) voltage fluctuations, flicker, and reactive power compensation, including fast dynamic voltage support 4) frequency deviations beyond the limits specified in EN 50160	PC-3
29.	4	Which device is most suitable for fast dynamic mitigation of voltage fluctuations and reactive power variations in a distribution network? 1) a fuse switch disconnecter 2) an electromechanical energy meter 3) an unloaded distribution transformer 4) STATCOM or active power compensator based on voltage-source converter technology	PC-3
30.	1	The main purpose of long-term power quality monitoring at the point of common coupling is to: 1) collect statistically representative data for assessing compliance with power quality standards and identifying disturbance sources 2) replace all protection relays in the power supply system 3) measure only the instantaneous value of active power 4) eliminate the need for technical reporting and mitigation recommendations	PC-3

2. Description of the grading scale

Within the framework of the rating system, student performance in each discipline is assessed during ongoing progress control and intermediate assessment. The rating system for assessing student knowledge is based on the use of a set of control measures (checkpoints) for testing the material covered, optimally located throughout the entire time interval of studying the discipline. The principles of the rating system for assessing student knowledge are based on the provisions described in the "Regulations on the organization of the educational process based on the rating system for assessing student knowledge" at North Caucasus Federal University.

The rating assessment system is not provided for students studying in master's degree programs, or for students studying in bachelor's degree programs by correspondence or part-time (evening) forms of study.

3. Criteria for assessing competencies

The grade "Excellent" is awarded to a student who has deeply and firmly mastered the program material, presents it exhaustively, consistently, clearly, and logically coherently, is able to closely link theory with practice, handles tasks, questions, and other types of knowledge application with ease, and does not struggle to answer when assignments are modified.

The grade "Good" is awarded to a student who has a solid command of the material, presents it competently and substantively without making significant inaccuracies in answering questions, correctly applies theoretical principles to practical questions and tasks, and possesses the necessary skills and techniques for their execution.

The grade "Satisfactory" is awarded to a student who has knowledge of only the basic material but has not mastered its details, makes inaccuracies, insufficiently correct formulations, and violates logical sequence in presenting the program material.

The grade "Unsatisfactory" is awarded to a student who does not know a significant part of the program material and makes substantial errors.