FORM
development, manufacturing
and support of
FORMULA
Test Systems
The FORMULA® R Test System is an automated test and measuring system designed for comprehensive automated verification of the low-current DC electromagnetic relays with up to 8 coils and up to 12 contact groups.

The applications of the Test System are quality control of all stages of the relay lifecycle, including:

- testing and research of newly developed relay types in:
  - Diagnostic modes
  - Modes close to real conditions of relay operation in products
- factory acceptance and in-production testing in serial production: qualification, periodic, approval and stress testing
- certification testing
- analysis of deviations and failure prediction
- incoming inspection

The FORMULA® R meets the requirements of the metrological standards for measurements and tests in microelectronics.
The FORMULA® R Test System have been created to provide highly reliable measurements of the parameters of relays.

The key technical characteristics of the Test Systems are defined by the following values:

**Basic technical characteristics and functional capabilities**

The FORMULA® R Test System have been created to provide highly reliable measurements of the parameters of relays.

The key technical characteristics of the Test Systems are defined by the following values:

<table>
<thead>
<tr>
<th>Characteristic name title</th>
<th>Ranges</th>
<th>Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coil resistance</td>
<td>3 Ohm... 100 kOhm</td>
<td>from ±1 %</td>
</tr>
<tr>
<td>Contact resistance at current through contacts 0.1 ... 100 mA</td>
<td>1 mOhm...100 Ohm</td>
<td>±(1 %+0.01 Ohm)</td>
</tr>
<tr>
<td>Voltage limitation on open contacts</td>
<td>±0.03 V...±8 V</td>
<td>±(1 %+3 mV)</td>
</tr>
<tr>
<td>Pickup and dropout voltage</td>
<td>0.1...120 V</td>
<td>±(1 %+10 mV)</td>
</tr>
<tr>
<td>Pickup and dropout current</td>
<td>0.1...500 mA</td>
<td>±(1 %+20 μA)</td>
</tr>
<tr>
<td>Insulation resistance at voltage 80 ... 750 V</td>
<td>5 MΩ ... 10 GΩ</td>
<td>±3 %</td>
</tr>
<tr>
<td>Operate and release time</td>
<td>0.03 ... 300 ms</td>
<td>±(1 %+3 μs)</td>
</tr>
<tr>
<td>Contact bounce</td>
<td>0.01...300 ms</td>
<td>±(1 %+2 μs)</td>
</tr>
<tr>
<td>Contacts operate and release time difference</td>
<td>0...300 ms</td>
<td>±(1 %+2 μs)</td>
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<tr>
<td>Time of overlap (t-junction) of the contacts under operation and release</td>
<td>0...300 ms</td>
<td>±(1 %+2 μs)</td>
</tr>
<tr>
<td>Contacts stabilization time</td>
<td>0.1 ... 100 ms</td>
<td>±(1 %+0.1 ms)</td>
</tr>
<tr>
<td>Amplitude of EMF of self-inductance</td>
<td>0.1 ... 140 V</td>
<td>±(2 %+50 mV)</td>
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<tr>
<td>Supply of control current and (or) voltage to the relay coils</td>
<td>on a programmable pulse-step cyclogram</td>
<td></td>
</tr>
<tr>
<td>Method of connecting a testing relay</td>
<td>Four-terminal (Kelvin) sensing</td>
<td></td>
</tr>
<tr>
<td>Number of workstations</td>
<td>up to 2, on one or two individual workplaces</td>
<td></td>
</tr>
<tr>
<td>Productivity at 1 workplace</td>
<td>more than 1500 relays per shift</td>
<td></td>
</tr>
</tbody>
</table>

The Test System is a functionally complete automated tool for measuring a wide range of low-current relays, and provides users with the following advantages:

- High readiness of equipment for measurements and tests
- Automation of all stages of the measurement process and data management
- User-friendly, fully functional software
- Automatic diagnostics and metrological calibration
- Reliability in round-the-clock operations and availability of two workstations
- Ability to work with autoloaders
Wide range of application and continuity

The concept implemented in the FORMULA® R relay Test System provides its effective application in three areas:

- as measuring tools when testing relays in full accordance with MIL-PRF-39016F
- as a tool for analyzing the causes and mechanisms of relay failures during production
- as a means of predicting the reliability of the relay on tests and the incoming inspection of relay

Technical advantages

The fundamental innovations that are implemented in the Test System, provide the Consumer with the advantages of technical and metrological level, allowing:

Radically increase the accuracy of measurements:
- Relay timing parameters
- Contact resistance (resistance of the contact circuit at their closure)
- Pick-up and drop-out voltage/current using step voltage/current change program function

Ensure the implementation of requirements for relay monitoring in accordance with MIL-PRF-39016F:
- dielectric withstanding voltage measurements at a voltage up to 800 V (1000 V)
- contact stabilization time and coil EMF measurements

Expand the application field of the measuring tool:
- Identify the latent fault of the relay using a built-in high-resolution oscilloscope and software for testing and research of relays
- Perform failure analysis and prediction of relay reliability using arbitrary cyclograms

Expand functionality of the measuring tool:
- Monitor the electrical parameters of resistor array (customized)
- Measure reed switch with low resistance contacts, short triggering and releasing times and high insulation resistance – up to 10 GΩ
Workplace ergonomics and safety

The Test System test head and the measuring stations for device under test connection are built in a special worktable supplied with the Test System.

The possibility of monitoring electromagnetic relays is provided at one or two measuring stations, with independent monitoring of two different types of relays.

As a matter of convenience, the start buttons on the operator panel are placed under the right and left hand.

In manual measurement mode, operators only work with the «Start» button and display panel that show the «Accept» and «Reject» results.

All testing results are automatically saved in the database of the Test system, as well as in the cloud data base Kamchatka®.

The design ensures reliable protection of the high-voltage measurement zone, guaranteeing complete electrical safety for the operator.

For maximum performance and safety, the Test system has a fully automatic measurement mode using autoloaders and environmental chambers.

The test system’s maintainability is provided by its modular design and automated diagnostic tools, both autonomously and via the Internet, to identify test system faulty unit. Diagnostic system and test system design allow to repair the test system in case of failure within 1 day in field.
FORMULA® R Test system software

FORMULA® R Test System operation is highly automated and controlled by FR software developed by FORM for maximum user convenience.

FR software automates all phases of the measurement process, from test routine development and debugging to measurements and service procedures.

The software is uniquely simple to use, consisting of an intuitively understandable high-level symbolic graphical environment represented in table form Fig. 2. This means that the test program developer does not need to be qualified as a programmer.

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**Fig. 2**
Operator mode interface

<table>
<thead>
<tr>
<th>№</th>
<th>Пропилан,</th>
<th>Вариант</th>
<th>Номер</th>
<th>Ед.</th>
<th>Результат</th>
<th>Годы</th>
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ACCEPT
The basis for automating ATE operations is the Library of Low-Current Relays Measurement Methods, created in compliance with metrological requirements and built into the FR software.

The Library of Low-Current Relays Measurement Methods includes all the electrical test methods, significantly simplifying the development, updating and modification of test programs and reducing processing time and quantity of errors created, as well as error correction.

Using the Library of Low-Current Relays Measurement Methods, the measurement program is created by simply moving data from the technical specification or datasheet for the item tested to the «Measurement Program Editor» table Fig. 3.

It takes a maximum of 10 minutes to write one test program: just select the necessary measurement methods from the Library, and enter the test conditions and anticipated results.

All tests and the parameters indicated within them are automatically combined into one measurement program, which can be run immediately on the DUT, either in full or step by step.

The convenience of the FR program tool for creating tests leaves the engineer free to concentrate on the most important thing – the operating features of the DUT and effective resolution of quality control issues with the low-current relays tested.
Testing process control includes automatic documentation of the data used to confirm the conformity or nonconformity of the DUT to the requirements of the technical specification or technical assignment. The test routines are generated with various levels of detail, from «Accept/Reject» inspection to comprehensive reports on measurement modes and results for each relay and each parameter.

Documentation of data and results

At the same time, statistical reports can be generated for any period by lots, types of relays and other criteria.

The test records are saved, easily converted to standard forms used by the Client, and serve as the documentary and metrological basis for managing deviations, and as a basis for quality complaint follow-up at the incoming inspection stage.

There is an on-line data translation into a specialized information quality control system and traceability Kamchatka®, as well as in other information systems of the enterprise, executed in accordance with CALS standards.
Means of analysis and display

The tools of graphical interpretation of the measurements data developed for the FORMULA® R Test system facilitate the analysis of deviations and accelerate the identification of sources of deviations.

The «Statistics» software unit makes it possible to plot bar charts and graphs for visual interpretation of summary reports on measurements of various lots of devices over the required period Fig. 5 with the ability to analyze deviations in parameters and other indicators of items/lots.

The built-in high-resolution oscilloscope helps to make a visual assessment of the transients occurring at the contacts of the relay under test, as well as to investigate the behavior of the measured relay (Fig. 6, 7):

- detect hidden defects in the settings of the electromechanical system and the relay contact system
- estimate the stability of relay parameters

Information content and visibility of oscillographic methods in combination with the software tools of the FORMULA® R Test system make them as accessible to the Consumer as standard measurement methods.
Fig. 7
Coil voltage/current waveforms during the operation of the relay

Fig. 8
Step function voltage/current change

For the first time the user is given the opportunity to independently define various forms of cyclograms with the help of the Cyclogram Editor (Fig. 7), which allows:

- monitor the results of deviations in the technology of manufacturing and relay settings with the specified accuracy
- conduct additional research of the behavior of the relay under various forms of the driving voltage on the coils.

In addition, the user is provided with a built-in library of precision typical cyclograms (Fig. 8).

Fig. 9
Example of a specified pickup value (voltage) using a step function voltage change

Cyclograms are the third most important tool of the test system for graphical interpretation of measurements.
Automation of service
and metrological support

The FR software service package covers all aspects of FORMULA® R Test System operation, including equipment serviceability, hardware diagnostics and verification of metrological conformity.

It is possible to control diagnostics and calibration of the test system and automatically generate verification records.

![Fragment of the automatically generated test report](image)

Equipment maintenance time can be minimized and thus giving users complete confidence in the accuracy of measurement results.

Test fixture.
TestBox® Test Solutions

The FORMULA® R Test System delivery package includes diverse types of measurement accessories developed and manufactured by FORM to ensure that the system is introduced into the user’s operations as quickly as possible and provide a faster return on investment.

The Delivery set of the Test System includes complete instructions and documentation for self-development of test fixture for connecting the relay.

So that FORMULA® R Test System clients can more quickly achieve their business objectives and promptly see a return on investment, FORM offers both factory-ready and custom TestBox® Test Solutions for measuring specific types of relay.
On customer request we can develop and build a custom workplace solution, with external equipment integration if needed.

To meet traceability requirements, workplaces based on the FORMULA® Test System are connected to the Kamchatka® information database.

Each TestBox® Test Solution includes:

- specialized test fixture for connecting a specific type of relay
- a disk with relay test program
- a datasheet with TestBox® operating manual
- manufacturer’s warranty

The quality of the TestBox® Test Solutions is defined by their compliance with the electronic component base regulations, the technical requirements and the Customer’s specifications. The TestBox® test solutions are supplied as part of the Test System delivery set, or individually, any time throughout the life cycle of the equipment.

Today, more than 550 types of Test Solutions already developed are used by the FORMULA® Test System Clients, providing consistent metrological support for quality control of electronic components.

By purchasing the TestBox®, Clients can significantly reduce the time required to put their products on the market.

Means for integration with external equipment and IT systems

On customer request we can develop and build a custom workplace solution, with external equipment integration if needed.

To meet traceability requirements, workplaces based on the FORMULA® Test System are connected to the Kamchatka® information database.
Manufacturer’s services

To reduce the Client’s time and costs for support work, FORM offers the following technical services to FORMULA® R Test System Clients:

- Integration of FORMULA® R Test Systems into the Client’s technological, informational and testing infrastructure, with connection of external equipment, instruments and IT networks
- Scheduled maintenance, repair and metrological services at the place where the ATE is operated
- Development of non-standard methods of testing on the Customer’s terms of reference
- Expansion of the ATE configuration according to a list of typical options, or with custom development of options
- Design of specialized test fixture or TestBox® test solutions for measurements and tests of relay
- Technical support of the Consumer at the claim settlement

The FORMULA® R Test System quality

Quality is determined by the following most important criteria, which the FORM company provides as a developer and manufacturer of the Test System:

1. Test system characteristics are metrologically ensured during production and operation. Metrological procedures are performed in the own accredited Calibration Laboratory of the FORM manufacturing company.

2. Modern technology of design and production of the Test Systems compliance with the regulations of the quality management system QMS according to standard ISO 9001–2011. Business development processes, manufacture, supply and maintenance of FORMULA® R Test Systems, as well as training and support for Consumers are regulated and are carried out by the FORM enterprise subdivisions with observance of these requirements, which is confirmed by the results of annual inspection of the QMS since 2009.

3. The right ownership of a complete set of the design documentation for Test Systems provides support for all stages of the life cycle of the Test System.

4. The quality of each exemplar of the Test System assured by selection of its components and materials, as well as current state of mounting automation and assembly check. The conformity of the manufactured products is confirmed by the tests of each assembly and the Test System according to the programs and testing methods, including finish calibration procedures.

5. The positive experience of using the Test systems FORMULA® R is confirmed by the successful operation at the manufacturing enterprises of electromagnetic relays, at the incoming inspection, in test houses and laboratories.
Delivery composition of FORMULA® R Test System

The configuration of each Test System is determined based on an analysis of the Client’s tasks, requirements and preferences, and is reflected in the Delivery Specification, as well as in the data sheet for each Test System.

The FORMULA® R Test System has modular bus architecture and allows for custom hardware and software configuration according to the design versions indicated in the type description of the means of measurement.

The delivery set includes complete operating and metrological documentation and an initial calibration certificate.

Manufacturer’s warranties and operator support

The hardware warranty is 1 year and provides for free visits by engineers to the place where the ATE is operated for warranty repair and unscheduled metrological calibration.

At the end of the warranty period, FORM offers Clients a service contract and provides technical service and metrological service upon individual Client request.

The FORM technical support service provides FORMULA® Test System Clients with the following unlimited free services:

• Consultation via telephone, email and fax and during terminal sessions
• Methodological assistance in complaint analysis
• Remote ATE diagnostics with fault detection
• Updating of software versions
• Arranging for maintenance and repair
• Information on new ATE options and new Test Solutions
Delivery time and price

The FORMULA® R Test System delivery time is from 9–15 weeks, depending on the configuration.

The cost includes:

- 1 year warranty
- Client personnel training on rules for FORMULA® ATE operation and development of test programs
- Commissioning of Test System with application of TestBox® Test Solutions
FORM develops, produces, delivers and supports the ECB FORMULA® Test System in operation.