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**ART/3
THREE PHASE
AUTOMATIC RELAY TEST SET
FOR THE TEST OF ALL TYPES OF RELAYS**

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1 GENERAL

1.1 The instrument

The instrument ART/3 is a programmable and automatic three phase relay test set, that permits for the automatic verification of all types of protection relays, such as those used in the Medium and High voltage networks.

The ART/3 synthesises the voltage and current outputs by a digital memory; outputs are amplified and taken to the output connectors.

The ART/3 is made of two modules (see figures 1 and 2):

Module 3V, that includes the control part and the three AC voltage amplifiers, one auxiliary DC supply, the input contacts and the auxiliary outputs;

Module 3I, that includes three AC current amplifiers.

The instrument operates in connection with a computer, that controls it via the RS232 serial port. The resident control program FWH1 allows the instrument to interpret all commands received from the computer and to transmit test results. The FWH1 program can be downloaded to the instrument by means of a PC and serial interface: this allows upgrading the unit with no physical intervention.

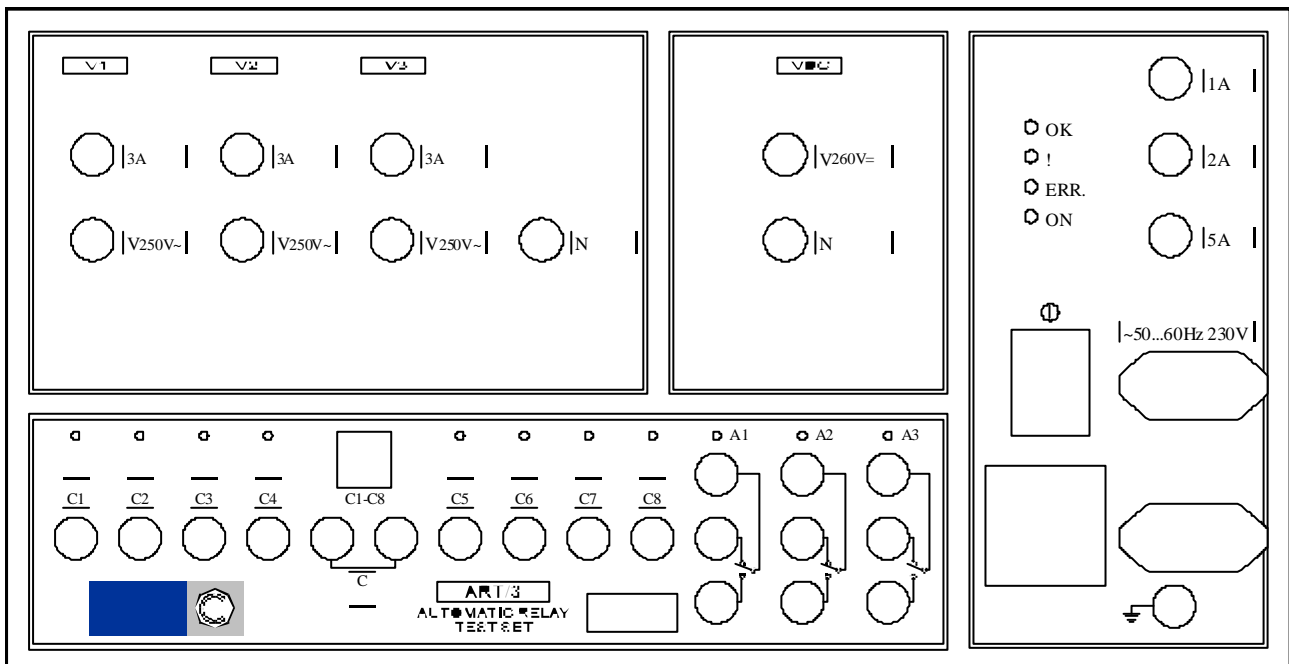


FIGURE 1 - FRONT PANEL OF THE VOLTAGE MODULE

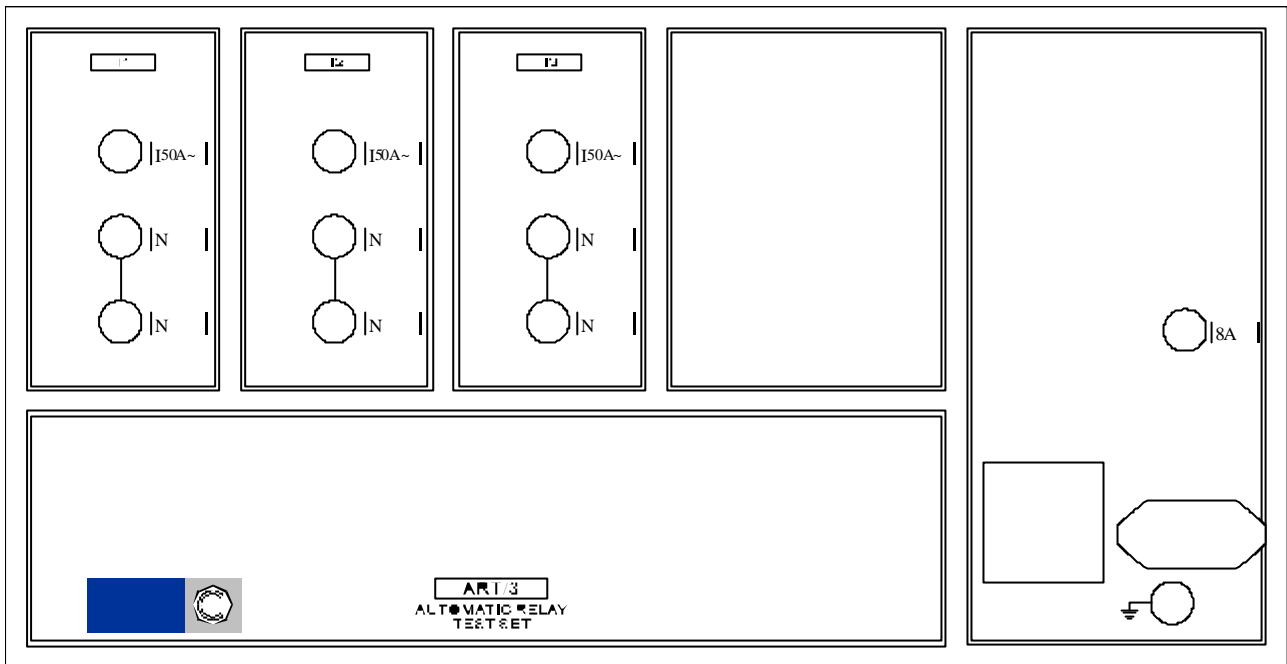


FIGURE 2 - FRONT PANEL OF THE CURRENT MODULE

1.2 TDMS, the software for DRTS

All controls of the instrument are performed by the software TDMS, that is described in document MSE10015.

2 APPLICABLE STANDARDS

The test set ART/3 conforms to the EEC directives regarding Electromagnetic Compatibility and Low Voltage instruments.

2.1 *Electromagnetic Compatibility*

Directive no. 2004/108/EC. Applicable Standard : EN61326-1 + A1 + A2.

EMISSION

- EN61000-3-2: harmonic content induced into the power supply: class A.
- EN 61000-3-3: Limitation of voltage fluctuations and flicker. Acceptable limits: basic.
- CISPR16 (EN 55011 class A): Limits and measurement methods of radio-electric disturbances for industrial, medical and scientific instruments at radio-electric frequencies.

Acceptable limits for conducted emission:

- . 0.15-0.5 MHz: 79 dB pk; 66 dB avg.
- . 0.5-5 MHz: 73 dB pk; 60 dB avg.
- . 5-30 MHz: 73 dB pk; 60 dB avg.

Acceptable limits for radiated emission:

- . 30-230 MHz: 40 dB (30 m)
- . 230-1000 MHz: 47 dB (30 m)

IMMUNITY

- EN 61000-4-2: Immunity tests for ESD. Test values: 8 kV in air; 4 kV in contact.
- EN 61000-4-3; Immunity tests for radio frequency interference. Test values ($f= 900 \pm 5$ MHz): field 10 V/m, modulated AM 80%; 1 kHz
- EN 61000-4-4; Immunity tests for high speed transients (burst). Test values: 2 kV peak; 5/50 ns.
- EN 61000-4-5; Immunity tests for surge. Test values: 1 kV peak differential mode; 2 kV peak common mode; 1.2/50 us.
- EN 61000-4-6: immunity to low-voltage sinusoidal waveform. Test values: 0.15-80 MHz, 3 V rms, 80% AM 1 kHz.
- EN 61000-4-8: Immunity tests for low frequency magnetic fields. Test values: 30 Arms/m.
- EN 61000-4-11: Immunity test for power supply drops. Test value: 1 cycle; 100% drop.

2.2 *Low voltage directive*

- Directive n. 2006/95/EC.

Applicable standards, for a class I instrument, pollution degree 2, Installation category II: CEI EN 61010-1. In particular:

- Dielectric Rigidity: 1.4 kV 1 minute.
- Isolation resistance: > 2 MOhm.
- Earth resistance : < 0.1 Ohm.

- Dispersion current: < 5 mA.
- Inputs/outputs protection: IP 2X - CEI 70-1.
- Operating temperature: -5 °C to 50 °C; storage: -25 °C to 70 °C.
- Relative humidity : 5 - 95%, without condensing.
- Altitude: less than 2000 m.

3 CHARACTERISTICS OF THE UNIT

3.1 General

This section resumes the characteristic and the performances of the instrument. Listed characteristics are all used when the instrument is connected to a computer, with the corresponding commands. For each parameter are reported the regulation ranges and the control parameter format, as it is exchanged between ART/3 and PC.

In separate documents are described:

- . The ART/3 user's guide;
- . The resident program FWH2;
- . The TDMS software.

On the 3V module the following connections are available:

- . Mains power supply (2 phase with ground);
- . A separate ground socket, for increased safety;
- . Three voltage outputs, with a common neutral point;
- . Eight trip input contacts, with one zero point;
- . Three auxiliary output contacts, without a common point;
- . Serial interface RS232;
- . The auxiliary D.C. voltage supply;
- . Supplies and signals to the 3V module.

On the 3I module:

- . Three current outputs, without a common point and with a jumper for creating the neutral of the current;
- . Supplies and signals from the 3V module.

All of the outputs of the instrument, except voltage outputs, are isolated from each other; all are isolated in respect to the mains and to the ground.

When the instrument is turned on it performs a self-diagnostic check of all of the logic and analog circuits. During the use, the instrument watches continuously the outputs, checking that they do not deviate from the nominal.

Steps to be followed for test execution are the following:

- . Connect the ART/3 to the portable PC, using the supplied serial cable;
- . Connect the ART/3 to the relay that is to be tested. The input trip contacts can be either clean or with voltage, connected to the optional D.C. voltage supply, or to the auxiliary voltage of the site;
- . Start the suitable TDMS software and execute the test;
- . Test results are examined one at a time on the screen of the PC, and printed later on, after they have been saved.

In the user manual, supplied with the instrument, are contained the following information:

- . User's guide;
- . Physical realisation of the instrument;

- . Electrical drawings;
- . Diagnostic information, failure area, intervention procedures;
- . Calibration procedures.

The following specifications apply with firmware revision 4.50 or later.

3.2 Three phase current generator

- Three independent current sources, isolated among them, with no common neutral. Type of connection: 63 A sockets with banana plug.
- Output ranges: 2.5 A; 10A; 25 A; 50 A per phase, with independent range selection.
- Output frequency: from 25 Hz to 999Hz.
- Waveform resolution: 24 bit (14 for the amplitude, 10 for the shape with a.c. outputs).
- Output adjustable from zero to the maximum value, with the resolution of 1/16384 of the selected range, with a minimum of 1 mA. Corresponding adjustment steps: 1 mA at 2.5 A and 10 A; 1.5 mA at 25 A; 3 mA at 50 A. Independent adjustment of current outputs.
- Possibility of step changing the value of the output within 0.1 ms.
- Possibility of ramping the current. Rate of change programmable between ± 0.001 A/s and ± 999 A/s.
- Output power: 150 VA, on each output. The impedance corresponding to current ranges are respectively: 24 Ohm; 1,5 Ohm; 0.24 Ohm; 0.06 Ohm.
- In case of single phase tests with an output current higher than the maximum rating, it is possible to put in parallel the outputs. It is possible to have a total of 150 A on the load, with a power of 400 VA.
- If it is required a power higher than the maximum at the selected rating, it is possible to connect in series the three current outputs. With this connection, a total power of 400 VA is available.
- Output accuracy.
 - . Typical: $\pm 0.2\%$ of the regulated value $\pm 0.05\%$ of the full scale range.
 - . Maximum: $\pm 0.5\%$ of the regulated value $\pm 0.1\%$ of the full scale range.
- Gradient accuracy: $\pm 0.5\%$ of the selected value.
- Distortion: 1% total maximum, with the maximum of 0.5% for each harmonic, with a load up to 100%.
- Automatic protection for overloads (open circuit). In this case, the output is taken to zero and the ! LED lights.

3.3 Three phase voltage generator

- Voltage outputs have a common neutral.
- Voltage ranges: 12.5 - 62.5 - 125 - 250 V, with independent range selection.
- Output frequency: from 25 Hz to 999 Hz.
- Waveform resolution: 24 bit (14 for the amplitude, 10 for the shape with a.c. outputs).
- Output adjustable from zero to the maximum value, with the resolution of 1/16384 of the selected range, with a minimum of 10 mV. Corresponding steps: 10 mV at 12.5 V, 62.5 V and 125 V; 15.2 mV at 250 V. Independent adjustment of voltage outputs.
- Possibility of step changing the value of the output within 0.1 ms.
- Possibility of ramping the voltage. Rate of change programmable between ± 0.001 V/s and ± 999 V/s.
- Output power per phase:
 - . 25 VA, range of 12.5 V;
 - . 50 VA, all other ranges.The impedance corresponding to the maximum voltage are respectively: 6.25 Ohm; 78 Ohm; 312 Ohm; 1248 Ohm.
- In case of tests with a power higher than the maximum, it is possible to connect in parallel the three voltage outputs, after mismatching them with a resistor equal to 1% of the load (single phase tests). With this connection, a total power of 120 VA is available.
- In case of tests with a voltage higher than the maximum, it is possible to connect in series two voltage outputs (single phase tests). With this connection, a total power of 100 VA is available.
- Output accuracy.
 - . Typical: $\pm 0.2\%$ of the regulated value $\pm 0.05\%$ of the full scale range.
 - . Maximum: $\pm 0.5\%$ of the regulated value $\pm 0.1\%$ of the full scale range.
- Voltage gradient accuracy: $\pm 0.5\%$ of the selected value.
- Distortion: 1% total maximum, with the maximum of 0.5% for each harmonic, with a load up to 100%.
- Automatic protection for overloads (short circuit). In this case, the output is taken to zero and the ! LED turns on.

3.4 Auxiliary D.C. supply

- Output voltage range: 260 V D.C..

- Output programmable from 0 to maximum value, with resolution of 1/1023rd of the range, corresponding to 254 mV.
- Output power: 100 W or 2 A; continuous duty (100 W at 50 V and 110 V; 48 W at 24 V).
- Possibility of stepping the selected value. NOTE: the velocity of variation is affected by the capacitance of the load, that is charged with the current output of 2 A.
- Possibility to ramp the voltage. Velocity of variation is between ± 0.1 V/s and ± 999 V/s. Voltage changes occurs every 10 ms.
- Output accuracy: $\pm 1\%$ of the regulated value $\pm 0.1\%$ of the full scale, with load of 25% to 100%.
- Gradient accuracy: $\pm 1\%$ of the nominal.
- Self protected in case of an overload greater than 100 W.
- Isolated from the rest of the instrument.

3.5 Angles

- All angles are referred to the same absolute reference.
- Possibility to set independently the angle of all the outputs: V1; V2; V3; I1; I2; I3, in the field between zero and $\pm 360^\circ$ (phase angle). Resolution: 0.1° .
- Possibility of slewing all the angles, separately between them. Variation range: $0.1^\circ/\text{s}$ to $999^\circ/\text{s}$.
- Angle accuracy: $\pm 0.5^\circ$, with a p.f. between 0.8 and 1.

3.6 Output frequency

- Possibility of selecting the nominal frequency between 25.0000 and 999.0000 Hz. Resolution: 0.1 mHz.
- Possibility to select an independent frequency on output V1 only or on all outputs. Frequency range: 25.0000 to 999.0000 Hz. Resolution: 0.1 mHz.
- Maximum frequency error: 50 uHz (1 PPM).
- Possibility of step switching the output frequency, separately or together to the amplitude change.
- Possibility of slewing the frequency, with a slope from 0.001 Hz/s to 999.999 Hz/s. Resolution: 0.001 Hz/s.

3.7 *Waveform*

- Possibility to program, for outputs V and I, the following waveform (other than the fundamental).
 - A) Sinusoidal waveform: second; third, fifth, seventh, eighth harmonic;
 - B) Saturated C.T. on current outputs; sinusoidal on voltage outputs;
 - C) Sinusoid with superimposed a second harmonic distortion equal to: 50% and 70%;
 - D) Sinusoid with superimposed a third harmonic distortion equal to: 6%; 12%; 18%; 24%; 30%.

Output waveform cannot have a peak output greater than the corresponding fundamental one; as a consequence, second harmonic distorted waveform cannot generate outputs higher than 200 V and 40 A.

3.8 *Intervention time measurements*

- Digital inputs: 8 inputs, either clean or with voltage, from 24 to 220 Vdc (60 to 220 Vac), with a point in common.
- Connections: on safety banana plugs, marked C1 - C8.
- Selection of the contacts free of with voltage by a bistable push-button with light.
- In the case of the selection of clean contacts, inputs are protected in the voltage range specified above.
- Inputs are isolated at 2 kV a.c. from the rest of the instrument.
- Indication of the state of the inputs by lights mounted on the operator panel.
- Selection N.O./N.C., independent for each input.
- Measurements available:
 - . Timing from the start of the test (injection) until the change of state of the selected input;
 - . Timing from the change of state of an input in respect to any other input.
- Timer range: 0 - 9999.9999 s; resolution: 0.1 ms.
- Timer accuracy: 0.001% of the measure $\pm 0,1$ ms, for input changes lasting more than 1 ms.

3.9 *Auxiliary outputs*

- Two auxiliary contacts (A1, A2), timed, clean, not polarised, whose termination C, N.O., N.C. are connected to safety banana connectors mounted on the operator panel. Characteristics of the contacts with a resistive load:
 - . Maximum voltage : 250 V AC - DC;
 - . Maximum current : 8 A.

- Range of time delay: from 0 to 999.98 s.
- One auxiliary contact (A3), that repeats the input C8, whose termination C, N.O., N.C. are connected to safety banana connectors mounted on the operator panel. Characteristics of the contacts with a resistive load:
 - . Maximum voltage : 250 V AC - DC;
 - . Maximum current : 8 A.
- Indication of the state of the outputs by lights mounted on the operator panel.
- All output contacts are isolated from the rest of the instrument.

3.10 Interface connection type RS232

- Type of interface: RS232 (see appendix 1).
- Transmission rate: 19,200 baud.
- Serial interface cable: 2 meters, included.
- Protocol of the serial interface: BUSY/READY.
- Compatibility: PC with MS-DOS revision 5.0 or later.

3.11 Signalisation lights

Mounted on the operator panel of the instrument are the following lights of signalisation:

- . OK: it lights when turning on the instrument;
- . !: it lights when on an output (V or I) exists an overload, or in case of an internal failure of the instrument;
- . ERR: it lights in case of a failure of the internal logic circuits;
- . ON: it lights whenever there is a voltage or current on the outputs of the instrument;

3.12 Sequence of commands

- The PC software allows controlling the instrument for the execution of automatic or manual tests.
- The elementary operations which compose all tests are:
 - . Measurement of the time delay from parameters step change;
 - . Search of the threshold, slewing parameters and memorising the value at the instant of input tripping;
 - . Step change of parameters during a fixed time, reporting inputs that have changed their state.
- Tests are executed in the following way:
 - . The PC defines the parameters to inject or vary;

- . At the command of the operator, parameters are transmitted to the ART/3 by the serial interface;
 - . The ART/3 generates the specified values, waits for the trip of the selected input contacts, and then transmits the results to the PC by the same serial interface;
 - . The PC examines the results, performs calculations and then displays them to the operator.
- During the execution of the test the ART/3 is self controlled and does not depend on the serial communication.
 - The simulation of the fault can be made of single or multiple tests (case of evolving failures).
 - Between two test or fault simulations parameters may return to zero, return to the healthy value or maintain the last injected value.
 - Maximum number of elementary tests (cycles) in a multiple test: 49.
 - Duration of the cycle: from 1 ms to 9999.99 s;
 - Accuracy of the cycle duration: 1 ms.
 - Delay between two cycles: 1 ms maximum.

3.13 Reproduction of faults

- Possibility to reproduce a fault that has been recorded with a COMTRADE format, by means of the software R-PRO.
- Maximum recording dimension: 16 word; 32 kWord per channel; maximum sampling frequency 50 kHz.
- Transient files bandwidth: 0.5 Hz to 5 kHz.
- The software R-PRO filters out the low frequencies that cannot be reproduced by ART/3.

3.14 Protections

- Fuse on the mains supply.
- Protections and signalisation in case of missing of any internal d.c. supply.
- Electronic protection for overload on the current (open circuit) or on AC or DC voltage outputs (short circuit), with immediate release of the output and lighting of the ! alarm light. The program resets the fault condition.
- Protection against over-temperature, on all outputs.

3.15 Mains power supply

- Mains power supply: 230 V \pm 15%, 50-60 Hz, single phase. Optionally: 115 - 230 V \pm 15%, with automatic selection. To be specified at order.
- Power consumption:
 - . at rest: less than 100 W;
 - . maximum load: less than 1200 W.

3.16 Realisation

- Case: made in aluminium sheet, with carrying handles and removable lid for transit. The instrument may be operated in the horizontal or vertical position.
- Furnished complete with:
 - . Mains supply cable;
 - . Serial cable;
 - . Two cables for connection between modules;
 - . Relay connection cables kit: 12 in all, 4 red, 4 black, 2 blue, 2 yellow; length 2 m, cross section 1 sq. mm.
 - . Ground connection cable: 2 m, yellow/green, terminated with crocodile clamp.

3.17 Weight and dimensions

- Weight (without the lid): 33 kg each module.
- Dimensions (lid included): 290 (h) x 500 (w) x 370 (d) mm.

APPENDIX 1: SERIAL INTERFACE

CONNECTOR TYPE: 9 WAY D TYPE FEMALE.

PIN N°	SIGNAL
1	DCD
2	RXD
3	TXD
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	-