Alternators, Starters & Parts

2024.03.14

M0028

TEST BENCH FOR DIAGNOSTICS OF ALTERNATORS AND STARTERS

USER MANUAL

QUALITY WARRANTY INNOVATION SERVICE TRAINING UNIQUENESS

CONTENT

INTRODUCTION

The present user manual consists of the information on the application, supply slip, specifications, methods of evaluation technical condition of automotive alternators and starters, as well as the rules of safe operation of M0028 test bench.

Read carefully this manual before putting M0028 (hereinafter “bench”) into operation.

Due to the permanent improvements of the bench, the design, supply slip and software are subject to modifications that are not included to the present user manual. Pre-installed bench software is subject to update. In future, its support may be terminated without a prior notice.

1. APPLICATION

The M0028 bench is designed for assessing the technical condition of:

1. Automotive alternators with a nominal voltage of 12 and 24 V of all types and with any connection terminals.

2. Automotive alternators of the "Stop-Start" system with 12 and 48 V. Diagnosis of such alternators is carried out in generator and starter operating modes.

3. Automotive starters with a power of up to 11 kW and a nominal voltage of 12 and 24 V without load in idle mode.

The bench displays measured parameters as oscillograms in real-time mode, allowing a complete view of the unit's operation and a more accurate determination of its condition.

2. SPECIFICATIONS

Supply voltage, V		400
Supply mains type		Three phase
Drive power, kW		7.5
Dimensions (L x W x H), mm		655×900×1430
Weight, kg		130
Quantity of storage batteries (not included into supply slip)		2 similar lead-acid by 12V
Battery capacity		45Ah min
Storage battery automatic charging		Yes
Rated voltage of the diagnosed units, V		12, 24, 48
Maximum overall length of the diagnosed unit, mm (m)		410 (0,41)
Bench control		On the 12" touchscreen display
Alternator diagnostics		
Load, A	12 V	300
	24 V	150
	48 V	50
Diagnostic modes		Automatic/manual
Load adjustment (0-100%)		Smoothly
Drive speed, rpm		0-3000
Drive speed adjustment		Smoothly
Selecting the direction of rotation of the drive		Available
Drive type (alternator drive)		V-belt drive/Poly V-belt drive
Types of diagnosed alternators	12 V	Lamp, SIG, RLO, RVC, C KOREA, P-D, C JAPAN, COM (LIN, BSS), S/A PSA
	24 V	Lamp, COM (LIN), PWM
	48 V	CAN

Starter diagnostics	
Power of diagnosed starters, kW	up to 11
Additional features	
Software update	Available
Alternator database	Available
Diagnostics results storage	Available
Printing	Available
Internet connection	Wi-Fi (802.11 a/b/g/ac), Ethernet
Connection of peripheral devices	2 x USB 2.0

3. EQUIPMENT SET

The equipment complete set includes:

Item name	Number of pcs
Test bench M0028	1
MS33001 – a universal cable with a kit of adapting wires - for the connection to alternator connector	1
Cable for connection of starter terminal 50	1
Alternator positive terminal adapter	2
MS0114 - Cutout fuse (type 22x58 mm, current 100A)	1
Bench door keys	2
Module Wi-Fi	1
Power outlet 400V / 16A	1
User Manual (card with QR code)	1

4. TEST BENCH DESCRIPTION

The bench consists of the following main elements (fig. 1):

Figure 1. Overall view of the diagnostic bench

1 – Door for access to the battery compartment.

2 – Working platform.

3 – Protective cover.

4 – Touchscreen – displays diagnostic parameters of the tested unit and controls bench functions.

5 – Control panel.

6 – Swivel wheels with brakes.

Test bench M0028

Work Platform (Fig. 2) includes the following elements:

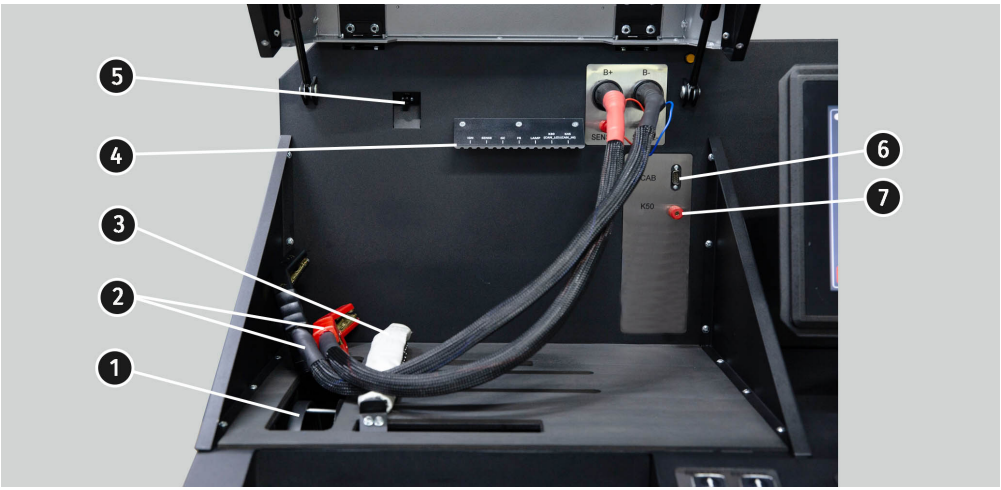


Figure 2. Work platform of the bench

1 – Alternator drive belts: V-belts and poly V-belts.

2 – Power cables «**B+**» «**B-**».

3 – Unit fixing chain.

4 – The bracket for a diagnostic cable “alligator” clips.

5 – Thermal vision camera.

6 – Diagnostic cable connection socket.

7 – Diagnostic cable connection socket to the starter terminal 50.

The control panel (fig.3) consists of:

1 – buttons to control the tightening and loosening of alternator drive belt.

2 – buttons to control the tightening and loosening of unit fixing chain.

3 – button **“COVER”** - opens the protective housing.

4 – button **“OFF/ON”** - is responsible for the power on the bench. The bench is turned off by pressing the button «Turn off the bench» in the main menu of the service program.

5 – Button **“EMERGENCY STOP”** - emergency stop of generator drive and chain/belt tightening.

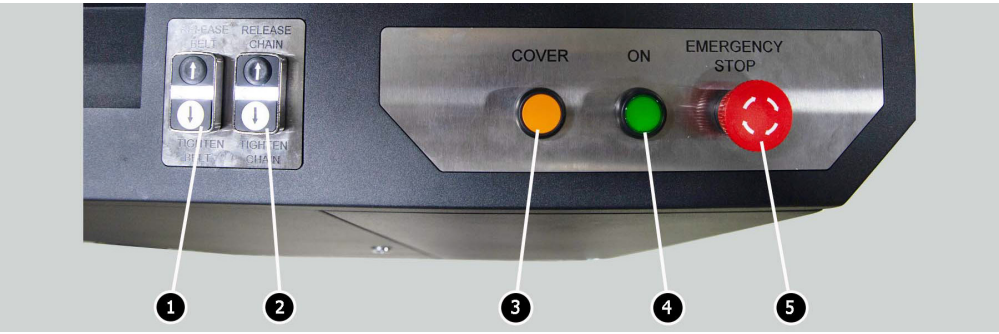


Figure 3. Control panel of the bench

In the bottom of the touch screen there are two USB ports (fig.4 ref. 1) for connecting the computer periphery (mouse, keyboard, WiFi adapter) and network LAN port (ref. 2).

Figure 4. Position of USB and LAN ports

The bench supply slip includes the diagnostic cable (fig.5) that consists of the adapting wire kit (fig.6) - for more convenient connection to alternator connection terminals.

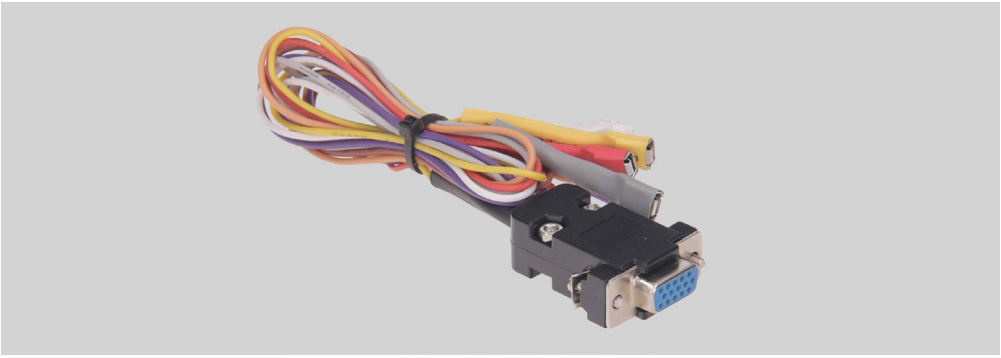


Figure 5. Universal diagnostic cable MS-33001

Figure 6. Adapting wire kit

The diagnostic cable MS-33001 has the following adapting wire color codes (see also Table 1):

- Orange - **S** (Sense Pin) - the terminal that enables the measuring of the storage battery voltage by the voltage regulator as well as it compares the storage battery voltage with the alternator output voltage. This adapting cable is connected to terminal S;
- Red – **IG** (Ignition) – the terminal is used for the connection of the ignition circuit, the terminals: 15, A, IG;
- White – **FR** – the terminal that transmits the data on the regulator load. This adapting wire is connected to the following terminals: «FR», «DFM», «M»;

- Gray – **D+** – the terminal for the connection of the circuit of voltage regulator control lamp. It's connected to the terminals: «D+», «L», «IL», «61»;
- Yellow – **GC** – is used for the connection of the channel of alternator voltage regulator control. This adapting wire is connected to the following terminals: «COM», «SIG», etc.
- Brown – **K30** – is connected to the starter terminal 30 that is connected to the storage battery terminal «+».
- Violet – **K45** – is connected to the starter solenoid output connected with starter electric motor.

Table 1 – Color codes of cable MS-33001

Wire	Terminal
	S
	IG
	FR
	D+
	GC
	K30 (starter)
	K45 (starter)

Test bench M0028

For convenient usage of the diagnostic cable, it's recommended to put the alligator clips onto the bracket (ref. 4, fig.2).

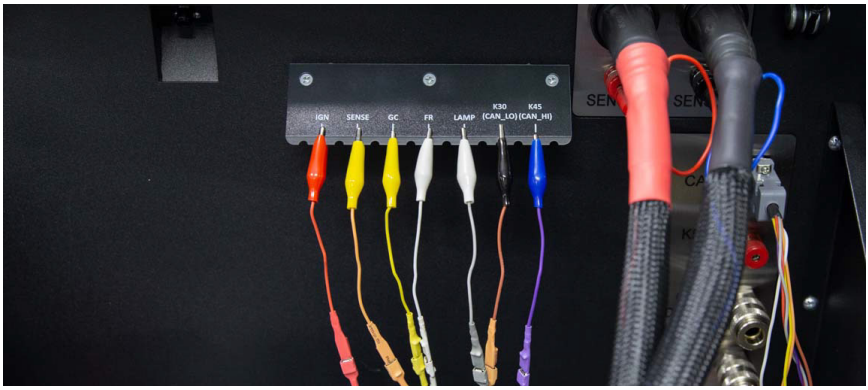


Figure 7. Diagnostic cable alligator clips that are set on the bracket.

To diagnose 48 V alternators, the MS-33401 cable is used (Fig. 8).

Figure 8. Cable for diagnostics of belt starter-generators 48 V AUDI

For diagnosing alternators, the kit includes a set of special cables for quick and safe connection of the bench to the alternator socket (see Fig. 9). The necessary cable can be identified using the alternator database.

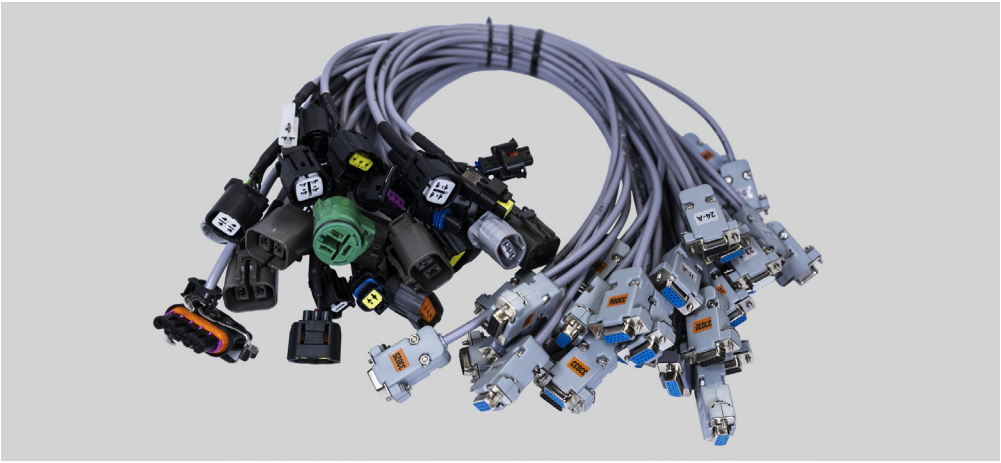


Figure 9. Set of special cables for diagnosing alternators

To diagnose the starter, it is necessary to use the MS-33001 cable and the cable for connecting to starter terminal 50 (see Fig. 10).

Figure 10. Cable for connecting to starter terminal 50

4.1. Test bench menu

The main menu of the bench (Fig. 11) includes:

1 – Bench power-off button.

2 – Alternator search menu based on the database.

3 – Activation of the alternator diagnostic mode.

4 – Connected cable number.

5 – Selected type of diagnosed unit (alternator).

6 – Indicator of chain and belt tension status.

Test bench M0028

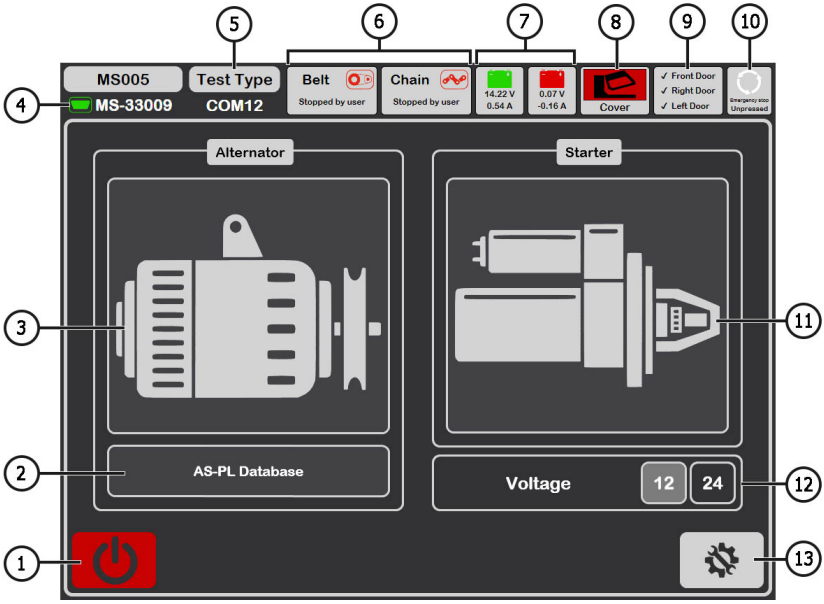


Figure 11. Main menu of the bench

7 – Battery status indicators.

8 – Indicator of open/closed protective cover.

9 – Indicator of closed bench doors. Diagnosis is not possible with any door open.

10 – Indicator of the "EMERGENCY STOP" button pressed.

11 – Activation of the starter diagnostic mode.

12 – Selection of the diagnosed starter voltage.

13 – **"SETTINGS"** menu – adjustment of bench parameters.

The "SETTINGS" menu contains 4 tabs:

"General" – allows setting the company name and contact information. It also provides the option to choose the program interface language.

"Automatic Testing" – allows selecting an automatic testing script for each alternator type. This tab also manages script and automatic testing report files, see Appendix 2.

"Belt Tension" – allows adjusting the tension force of the belt and chain.

"Service" – used by factory service specialists in case of software malfunctions, see Fig. 12.

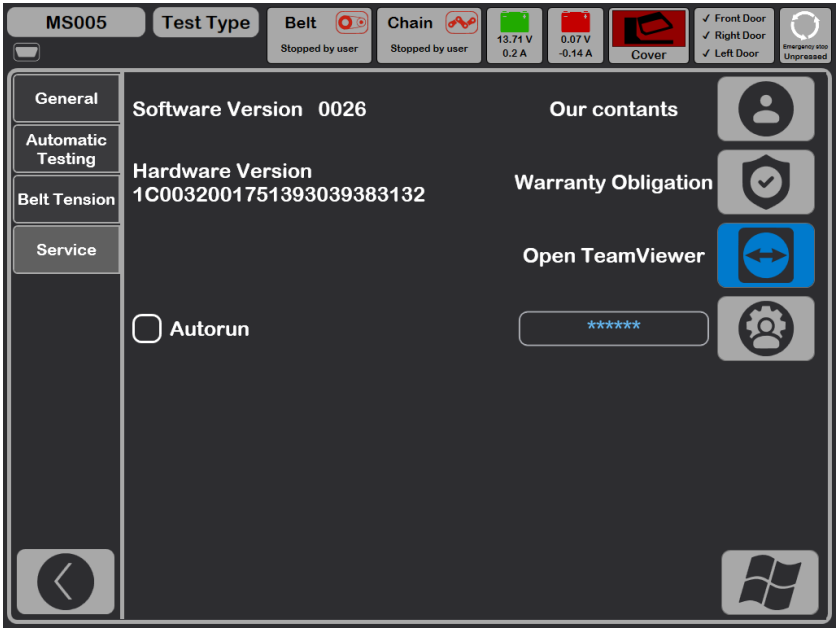


Figure 12

5. APPROPRIATE USE

1. Use the test bench as intended only (see Section 1).
2. The test bench is intended for indoor use at temperatures ranging from +10 to +40 °C and with relative humidity not exceeding 75% without condensation.
3. Turn off the bench through the service program interface by pressing the "Turn off the bench" button in the main menu.
4. When switching the power off, use the “EMERGENCY STOP” button for emergency shutdown only.
5. Connect the clamps of the universal diagnostic cable only to the terminals in the alternator socket.
6. Turn off the bench when not in use.
7. When working with the bench, it is prohibited to:
   - Diagnose generators with obvious mechanical faults.
   - Interfere with the operation of the bench in any way.
   - Obstruct the movement of rotating parts of the bench.
8. To prevent the damage and the failure of the bench, do not make any modifications in the bench in your discretion. Any modifications can be effected by the official manufacturer only. Should the bench have defects contact the manufacturer or a dealer.

8. In case of failures in the operation of the bench, stop further operation and contact the manufacturer or sales representative.

⚠ **WARNING! The manufacturer is not responsible for any damage or injury to human health resulting from non-compliance with the requirements of this user manual.**

5.1. Safety guidelines

1. The test bench shall be operated by the workers qualified to work with certain types of equipment and received appropriate training in the safe operation.
2. In case of a power outage, the test bench shutdown is mandatory when cleaning and lubricating the bench and in emergencies.
4. To ensure electrical and fire safety PROHIBITED:
- connect the bench to the electrical network having faulty protection against current overloads or not having such protection;
— use a socket without a grounding contact to connect the bench;
— use extension cords to connect the bench to the electrical network. If the socket is far from the bench installation site, it is necessary to modify the electrical network and install the socket;
- operation of the bench in defective condition.
- Independently to repair and make changes to the design of the bench, because it can lead to serious damage to the bench and deprive the right to warranty repair.
5. The units with a running drive must not be left unattended on the test bench.
6. While mounting and dismounting of a unit from the bench, to prevent arms from harming, be more cautious.
7. It is forbidden to open the door to access the power part of the stand if the stand is connected to the 400V power supply network.
8. The diagnosed unit must be securely fastened.

5.2. Preparing the bench for operation

The bench is delivered packed. Release the bench from the packaging materials, remove the protective film from the display (if available). After unpacking, it is necessary to make sure that the bench is intact and does not have any damage. If damage is detected before the bench is activated, contact the manufacturer or the sales representative.

The bench has to be placed on the level floor, with the pivot wheels fixed from rotating (min. two wheels) by the activating of the brake mechanism.

The bench ensures the operation at the temperature from +10^{0}C up to +40^{0}C and relative air humidity from 10% up to 75%.

When installing the bench, keep the minimum space gap 0.5 m from the rear bench side - for a proper air circulation.

Prior to the bench operation, connect:

1) Storage batteries 12V that have to be located in the storage battery section of the bench (fig.9). The left door is opened with the keys (included to the supply slip). While connecting the storage batteries refer to the power cable markings. If only one storage battery is connected just 12V diagnostic mode will be available, 24V diagnostic mode will be unavailable.

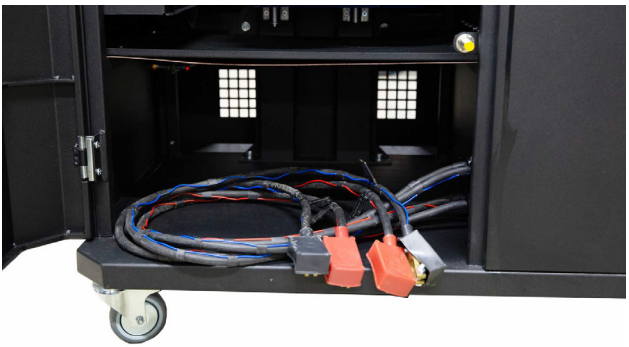


Figure 9. Location of the storage batteries in the bench.

2) Electric network 400V, for this purpose it is necessary to use the socket supplied with the bench, inside there is a marking L1 L2 L3 N PE which must be observed when connecting the socket to the supply network.

6. ALTERNATOR TESTING

For all types of alternators, the following common diagnostic stages are provided:

1. Installation of the alternator on the bench and its fixation.
2. Installation of the belt on the pulley and its tensioning.
3. Connection of power wires to the alternator. For convenient connection, an adapter should be screwed onto the positive terminal of the alternator for the connection of the power terminal B+.
4. Connect the diagnostic cable to the terminals in the alternator socket.
5. Select the appropriate parameters for the alternator test.
6. Diagnosis of the alternator.
7. Dismounting the unit from the bench.

6.1. Installation and de-installation of the alternator

1. Use the "Release Chain" button to increase the length of the chain sufficient for securing the alternator. A single press increases the length of the chain, and a subsequent press stops this process.

2. Position the alternator on the working platform so that the pulley is directly above the belt.

3. Place the chain on the alternator and secure the end of the chain on the bench. Then use the "Tighten Chain" button to tension the chain; the bench will automatically stop the chain tensioning process.

⚠ **CAUTION! Be careful not to injure your fingers.**

4. Use the "Release Belt" button to loosen the belt enough to fit it onto the alternator pulley. A single press loosens the belt, and a subsequent press stops this process.

5. Use the "Tighten Belt" button to tension the belt. The bench will automatically stop the tensioning process.

⚠ **CAUTION! Ensure that the position of the chain on the alternator is such that after tightening the belt, the alternator is in a horizontal position (see Fig. 14). Misalignment of the alternator leads to belt slippage on the pulley and rapid wear.**

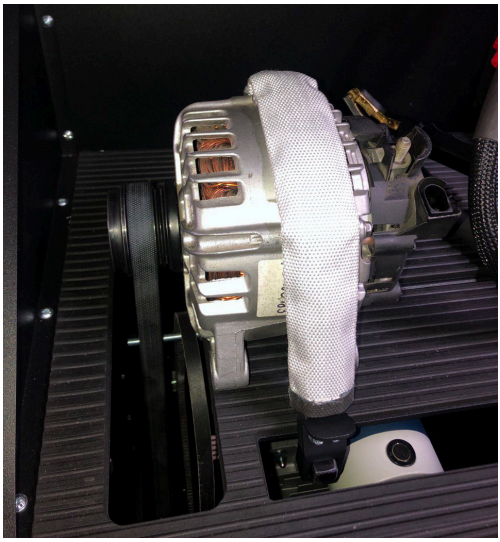


Figure 14. Installation and Fixation of the Alternator on the Bench

6. Screw the adapter onto the "B+" terminal (see Fig. 15).

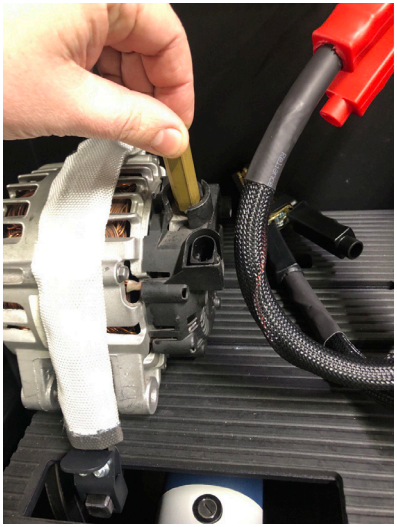


Figure 15

7. Connect the black power wire "B-" to the unit's housing and the red power wire "B+" to the adapter (see Fig. 16).

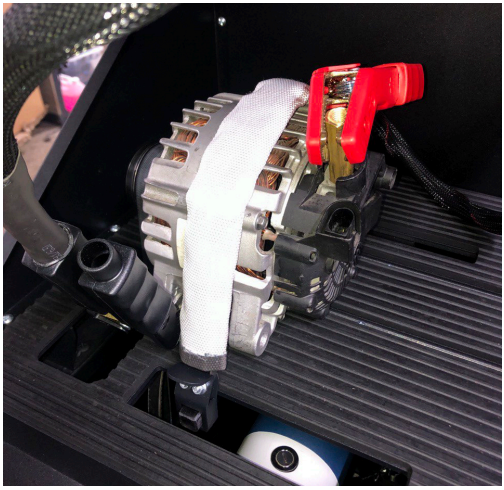


Figure 16. Connection of Power Wires to the Alternator

8. After diagnosis, disassembly of the alternator is performed in reverse order.

WARNING! Disassembly of the alternator is allowed only after the drive has completely stopped, and the testing mode has been exited.

6.2. Connecting the diagnostic cable to the alternator connector

To assess the operability of the alternator, it is necessary to select an appropriate special cable or correctly connect the universal cable to the terminals in the alternator socket.

To select a special cable, go to the alternator database (see Fig. 17). Using the original alternator number, which is often located on the housing or rear cover, search for the alternator in the "Search" tab.

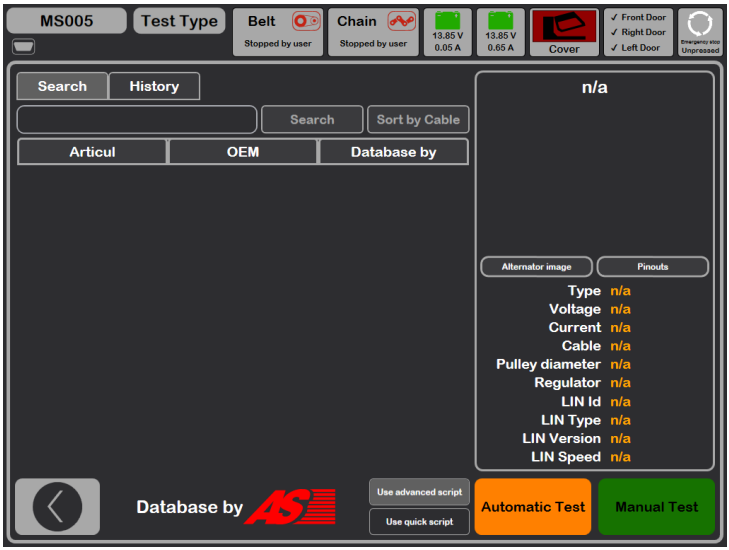


Figure 17

If the desired alternator is in the bench's database, its type, main characteristics, photo, connection terminal designations, and **the number of the required cable** will be displayed. If the desired alternator is in the bench's database, its type, main characteristics, photo, connection terminal designations, and the number of the required cable will be displayed.

Connect the special cable to the bench and the alternator, after which you can proceed with the diagnosis.

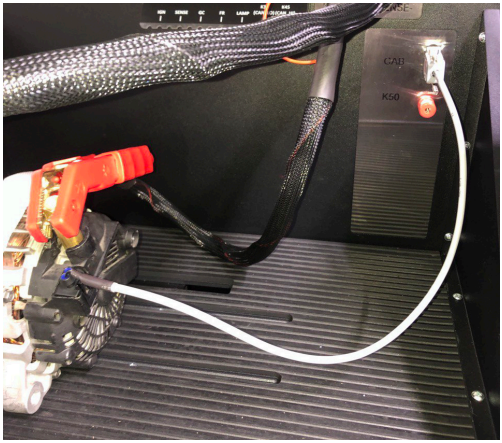


Figure 18

In case the alternator is not in the database, it is necessary to find the terminal designation in the alternator socket on the internet. Then, by identifying the alternator type based on the socket terminals, using the information in Appendix 1, you can select a suitable special cable or connect the universal cable.

As an example, let's consider connecting the universal cable to the Bosch 0986049191 alternator (Fig. 19).

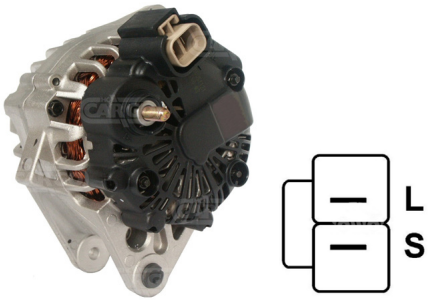


Figure 19. Bosch 0986049191 Alternator and Terminal Designations in the Socket

Based on the socket terminals in Fig. 19, we first determine the alternator type. In this case, terminal L defines the alternator type as Lamp. Next, using Appendix 1, we identify which diagnostic cable wires need to be connected to the alternator socket. The connection scheme is provided in Table 2.

Table 2 – Connection of Bosch 0986049191 Alternator to the Bench

Terminal in the alternator socket	Diagnostic cable wire	Color of the diagnostic cable wire
L	Lamp	gray
S	S	orange

As another example, let's consider connecting the universal cable to the Toyota 2706020230 alternator (Fig. 20).

Figure 20. Toyota 2706020230 Alternator and Terminal Designations in the Socket

Based on the socket terminals in Fig. 20, we determine the alternator type. In this case, terminal L defines the alternator type as Lamp. Next, using Appendix 1, we identify which diagnostic cable wires need to be connected to the alternator socket. The connection scheme is provided in Table 3.

Table 3 – Connection of Toyota 2706020230 Alternator

Terminal in the alternator socket	Diagnostic cable wire	Color of the diagnostic cable wire
S	S	orange
IG	IG	red
L	Lamp	gray
DFM (M)	FR	white

As a final example, let's consider connecting the universal cable to the Nissan 23100EN000 alternator (Fig. 21).

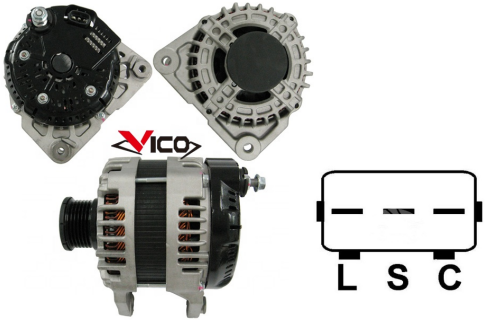


Figure 21. Nissan 23100EN000 Alternator and Terminal Designations in the Socket

Based on the socket terminals in Fig. 21, we determine the alternator type. In this case, terminal C and the association with Japanese vehicles define the alternator type as C JAPAN. Next, using Appendix 1, we identify which diagnostic cable wires need to be connected to the alternator socket. The connection scheme is provided in Table 4.

Table 4 – Connection of Nissan 23100EN000 Alternator

Terminal in the alternator socket	Diagnostic cable wire	Color of the diagnostic cable wire
L	Lamp	gray
S	S	orange
C	GC	yellow

6.3. Alternator test menu

When the alternator diagnostic mode is activated, a menu for selecting the type of diagnosed alternator opens (see Figure 22), which includes:

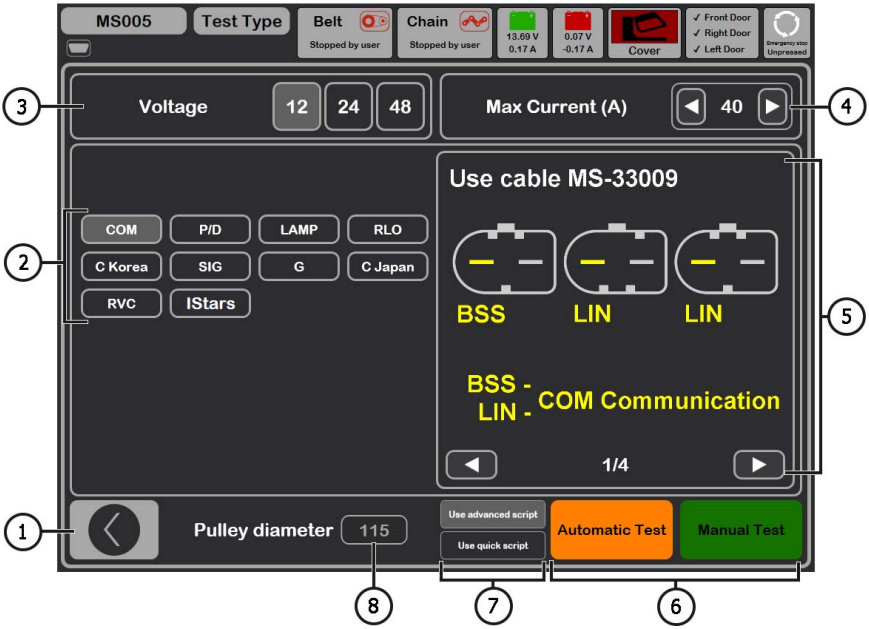


Figure 22. Menu for Selecting the Diagnosed Alternator Type

1 - Button to return to the main menu.

2 - Selection of the type of diagnosed alternator.

3 - Selection of the nominal voltage of the diagnosed alternator.

4 - Selection of the maximum current for testing the alternator.

5 - Terminal markings in the sockets of the most common alternators of the selected type of alternator.

6 - Selection of the alternator diagnostic mode.

7 - Selection of the automatic test variant:

Advanced script – an advanced variant of the automatic test where the check is performed for the maximum number of criteria with obtaining the alternator's current-speed characteristic.

Quick script – a simple (faster) variant of the automatic test where the check is performed based on key criteria.

Any alternator test script can be modified by the user at their discretion (see Appendix 2).

8 – Setting the value of the alternator pulley diameter. This parameter is set for diagnosing the alternator with rotation frequencies equal to those on the car.

During the diagnostic mode of any type of alternator, the following information may be displayed on the screen (see Figure 23):

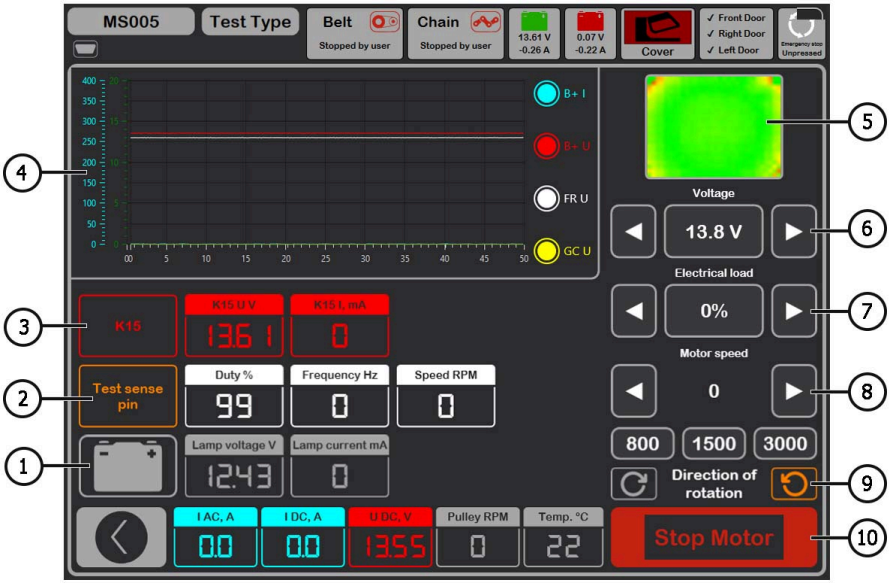


Figure 23. Alternator Test Mode Menu

1 - Indicator of the control lamp operation.

2 - The **"Test sense pin"** button is used to check the operability of the "S" terminal. Via the "S" (Sense) terminal, the voltage regulator reads the actual battery voltage and increases the alternator's output voltage to compensate for charge loss.

3 - The **"K15"** button simulates the ignition signal supplied to the alternator voltage regulator. If the alternator has a terminal: "A" or "IG," or "15," then it is necessary to press the "K15" button before testing the alternator.

4 - Field for the graphic display of measured parameters.

5 - Display of the aggregate temperature from the thermal imaging camera.

6 - Control of the alternator's output voltage, if provided.

7 - Control of the load on the alternator, the value is set in percentage of the value set in menu item 4 of Figure 22.

8 - Control of the alternator drive rotation frequency.

9 - Control of the alternator rotation direction. Usually, alternators rotate clockwise (viewed from the pulley side).

10 - Button to stop the diagnostic process.

"K15 U V" – Ignition circuit voltage value (K15).

"K15 I mA" – Ignition circuit current value (K15).

"Duty %" - Duty cycle of the signal received via channels FR, DFM, M (degree of rotor winding activation).

"Frequency Hz" - Frequency value of the signal received via channels FR, DFM, M.

"Speed RPM" - Alternator revolutions measured by the regulator.

"Lamp voltage V" – Voltage value on the control lamp.

"Lamp current mA" – Current strength value on the control lamp.

"I AC, A" – Alternating current value in the B+ circuit.

"I DC, A" – Direct current value in the B+ circuit.

"U DC, V" – Voltage value at terminal B+.

"Pulley RPM" – Rotation frequency on the alternator pulley. If the pulley size is not specified in menu item 8 of Figure 22, the drive revolution value is displayed.

"Temp. °C" – Maximum temperature value of the diagnosed unit captured by the thermal imaging camera.

On the diagnostics screen of **COM 12V, 24V** type alternators (see Figure 24), the following distinctive information is displayed:

"Status" – indicator of the alternator connection status.

"COM port" – indicator of the voltage regulator protocol version: BSS, LIN1, or LIN2.

"ID" – identification number of the voltage regulator.

"COM speed" – indicator of data transmission speed from the control unit to the voltage regulator. This parameter is displayed for alternators controlled by the LIN protocol. The following speed values are possible:

- **L** – 2400 Baud (low);
- **M** – 9600 Baud (medium);
- **H** – 19200 Baud (high).

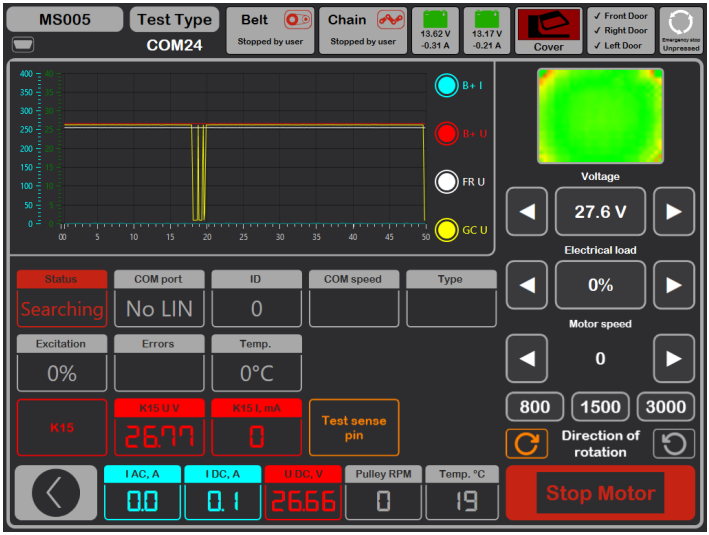


Figure 24. Menu of the COM type alternator check mode

"Type" – displays the code of the voltage regulator type operating under the "LIN" protocol: A1, A2, A3, A4, B1, B2, B3, B4, C3, D1, D2, E1.

"Excitation" – the value of the excitation winding current of the alternator. Measured in percentage. Read from the voltage regulator via the LIN protocol.

"Errors" – indicator of errors transmitted by the regulator to the engine control unit. The following errors are possible:

- **E** – electrical malfunction;
- **M** – mechanical malfunction;
- **T** (thermal) – overheating.

"Temp. °C" – the voltage regulator's own temperature measured by it.

On the diagnostics screen of **IStars 12V** type alternators (see Figure 25), information similar to COM type alternators is displayed, as well as the following parameters inherent to this type of alternators:

"Speed RPM" - alternator revolutions measured by the voltage regulator.

"Voltage" – stabilization voltage measured by the voltage regulator.

The **"Starter"** button performs alternator testing in starter mode.

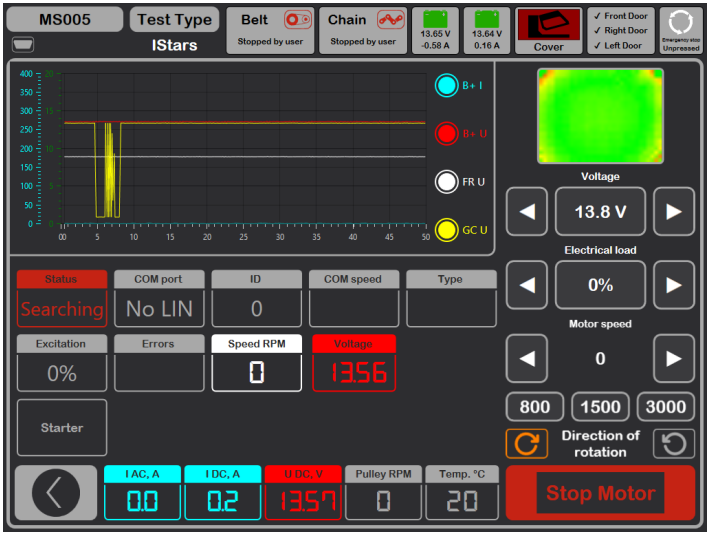


Figure 25. Menu of the IStars 12V type alternator check mode

6.4. Manual mode
12 V and 24 V alternator diagnostics

1. After fixing and connecting the alternator, go to the "Alternator" menu.

2. In the opened window, select: the nominal voltage of the diagnosed alternator, 12 or 24 V, the type of alternator, the maximum test current, the diameter of the pulley. When using the alternator database, the test parameters are set automatically.

2.1. In the upper right corner of the program, select the maximum current that the alternator can provide, usually indicated on the alternator itself. During the testing process, this current will not be exceeded when the load reaches 100%.

⚠ **WARNING! Selecting a maximum test current for the alternator that exceeds its passport data may damage the alternator.**

3. To start the diagnostics process, press the **"Manual test"** button.

3.1. After activating the diagnostics mode, a preliminary alternator check window will open, see Figure 26.

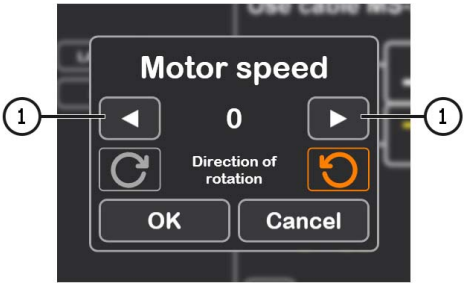


Figure 26

3.2. Using the alternator drive control buttons (see item 1 in Figure 26), set the speed of the alternator pulley rotation within the range of 100 to 150 rpm.

⚠ **WARNING! If the alternator pulley has a freewheel clutch, carefully select the direction of rotation.**

3.3. Visually assess whether the alternator rotates normally. If there are noises or vibrations from the alternator indicating mechanical malfunction or incorrect alternator installation, stop the diagnostics by pressing the **"Cancel"** button.

3.4. To continue the diagnostics, press the **"Ok"** button.

4. Evaluate the operation of the voltage regulator according to the following criteria:

4.1. If the diagnosed alternator is of the **COM** or **IStars 12V type**, the bench should identify the alternator's **ID**, **COM speed**, and **TYPE**, and the **Errors** indicator should display a message about mechanical malfunction **"MEC"**.

4.2. If the alternator has a control lamp, the indicator of the control lamp should light up (see item 1 in Figure 23).

5. Conduct a check to determine at what RPM the alternator starts generating, for this:

⚠ **WARNING! For alternators with a voltage regulator terminal labeled "A" or "IG" or "15", activate the "K15" button.**

5.1. Gradually increase the speed using the alternator drive control buttons until the output voltage reaches the set value. Most functional alternators start generating at 700-850 rpm. Some COM-type alternators start generating at speeds above 1200 rpm, and there are also alternators with Load Response Control (LRC) function that have a temporary delay in generating.

5.2. For **Lamp-type** alternators, the stabilization voltage should be within 14 to 14.8 V for 12V alternators and 28 to 29.8 V for 24V alternators.

5.3. If the alternator has a control lamp indicator, it should turn off.

5.4. If the diagnosed alternator belongs to the **COM** or **IStars 12V** type, the mechanical error should disappear.

6. Evaluate the operation of the voltage regulator by:

6.1. Setting the drive speed within 1500-2000 rpm.

6.2*. Using the output voltage control buttons (see item 6 in Figure 23), smoothly adjust the alternator's output voltage within the range from minimum to maximum. The measured voltage should change proportionally.

***For Lamp-type alternators without output voltage control, this step is not required.**

6.3. For C JAPAN type alternators, set the stabilization voltage setting to **"OFF"** mode – the measured stabilization voltage should be equal to the battery voltage. Then set the stabilization voltage setting to **"ON"** mode – the measured stabilization voltage should be within 14 to 14.7 V.

7. Evaluate the alternator's performance under load by:

7.1. Setting the drive speed within 2500-3000 rpm.

7.2. Setting the generation voltage within 14 to 14.8 V. For C JAPAN type alternators, switch to the **"ON"** mode.

7.3. Gradually increase the load on the alternator using the load control buttons (see item 7 in Figure 23) while keeping the output voltage constant, and the alternating current value in the B+ circuit "I, AC" should not exceed 10% of the set load value (for example, at a load of 50 A, the "I, AC" value should not exceed 5 A). Also, there should be no significant peaks observed on the current oscillogram, the values should fluctuate within consistent limits.

⚠ **To determine the technical condition of the alternator, it is sufficient to set a load from 50 to 80 A.**

8. For IStars 12V type alternators, perform a check of its operation in starter mode by:

8.1. Stopping the alternator drive.

8.2. K Pressing the **"Starter"** button to start the test mode, during which the alternator should reach the idle speed of the engine.

9. To complete the alternator diagnostics, stop the alternator drive and then exit the test mode. After that, the alternator can be removed from the bench.

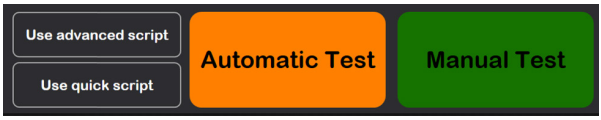
10. Failure to comply with any of the requirements in points 4 – 8.2 indicates a fault in the alternator.

6.5. Automatic mode
Diagnostic mode for 12 and 24 V alternators

1. After fixing and connecting the alternator, go to the "Alternator" menu.

2. In the opened window, select: the nominal voltage of the diagnosed alternator, 12 or 24 V, the type of alternator, the maximum test current, the diameter of the pulley (if the value is known). When using the alternator database, the test parameters are set automatically.

3. Next, select the script to be used during the automatic test: Advanced script or Quick script, then press the "Automatic test" button.



4. After clicking the "Automatic test" button, a preliminary alternator check window will appear, see Figure 26.

4.1. Using the alternator drive control buttons (see item 1 in Figure 26), set the speed of the alternator pulley rotation within the range of 100 to 150 rpm.

4.2. Visually assess whether the alternator rotates normally. If there are noises or vibrations from the alternator indicating mechanical malfunction or incorrect alternator installation, diagnostics should be stopped by pressing the "Cancel" button.

4.3. To continue the diagnostics, press the "Ok" button.

5. To start the test, press the button  in the opened window (see Figure 27). Then, the bench will automatically perform all checks according to the selected script. If necessary, the test process can be interrupted by pressing the button  .

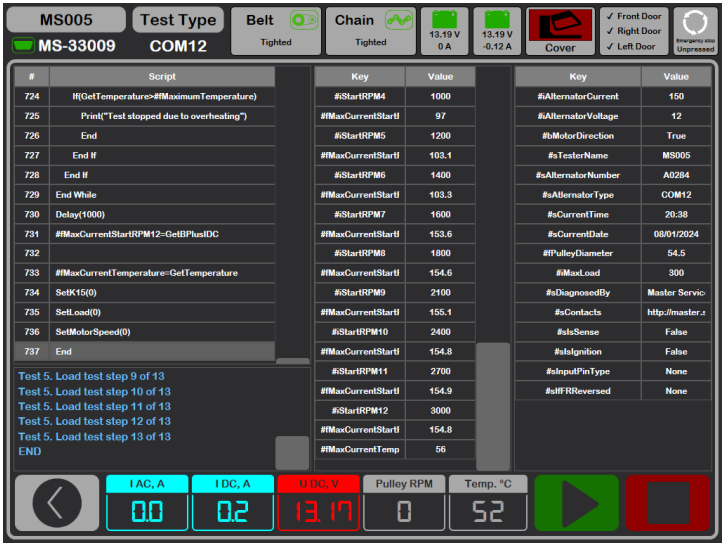


Figure 27. Menu of the automatic test mode

6. After completing all the test stages, the bench automatically generates a report and opens it. Reports are saved in the folder C:\UserFiles\Reports. If it is necessary to find a specific test result in the future, it is necessary to save the obtained report under your name (for example, order number, client name, and date) in another folder.

7. Exit the diagnostic mode, after which the alternator can be removed from the bench.

6.6. Diagnostics of 48 V alternators

In the alternator diagnostic mode for 48 V alternators (see Figure 28), the following distinctive information may be displayed on the screen:

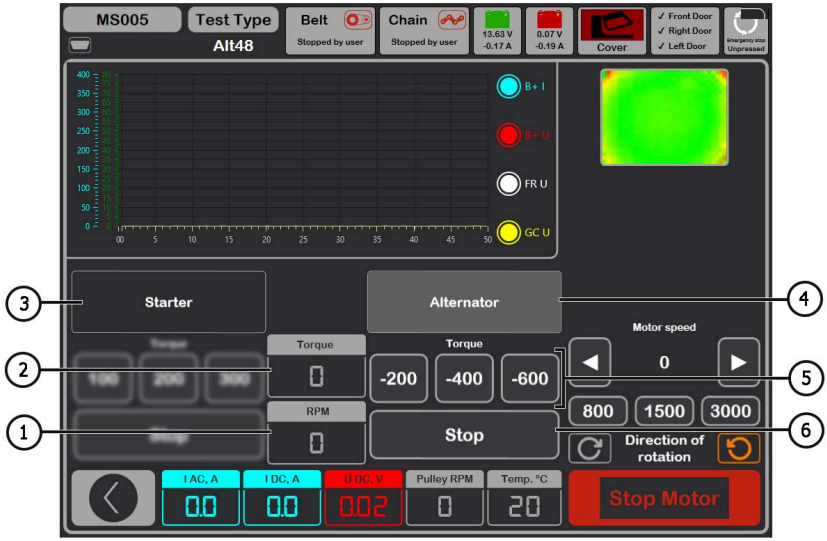


Figure 28. 48V Alternator Testing Mode Menu

1 - Measured alternator speed by the control unit.

2 - Current resistance or torque, which is set by buttons at position 5.

3 - Activation of testing in starter mode.

4 - Activation of testing in alternator mode.

5 - Selection of resistance moment (in alternator mode) or torque moment (in starter mode).

6 - Stop the testing process.

The sequence of operations is as follows:

1. Fix the alternator on the bench, connect the power cables. Use cable MS-33401 for connection to the socket.

2. Go to the "Alternator" menu, and then enter the diagnostic mode for 48 V alternators.

3. Before activating the diagnostic mode, a preliminary alternator check window will appear, see Figure 26.

3.1. Using the alternator drive control buttons (see position 1 in Figure 26), set the alternator pulley rotation speed within the range of 100 to 150 rpm.

3.2. Visually assess whether the alternator rotates normally. If there are noises or vibrations from the alternator indicating mechanical malfunction or incorrect alternator installation, diagnostics should be stopped by pressing the "Cancel" button.

3.3. To continue the diagnostics, press the "Ok" button.

4. Connect the diagnostic scanner to the OBD II socket using cable MS-33401 and try to read data from the alternator control unit.

5. Set the drive speed within the range of 1500 to 3000 rpm.

6. Activate the testing in alternator mode.

6.1. Sequentially increase or decrease the resistance moment (position 5 in Figure 28). At the same time, the current value "I DC, A" should also increase or decrease proportionally.

6.2. Stop the testing mode by pressing the "Stop" button (position 6 in Figure 28).

7. Stop the alternator drive with the "Stop motor" button. After the alternator drive is completely stopped, activate the testing in starter mode.

7.1. By setting the torque value, the alternator should start rotating. Increasing or decreasing the torque moment should proportionally increase or decrease the current value "I DC, A".

7.2. Stop the testing mode by pressing the "Stop" button (position 6 in Figure 28).

8. Exit the diagnostic mode, after which the alternator can be removed from the bench.

7. STARTER DIAGNOSTICS

When switching to the starter diagnostic mode, the following information is displayed on the screen (see Figure 29):

1 - Graph of measured parameters for the entire test duration.

2 - Graph of measured parameters at the moment of starter engagement.

3 - Display of the unit's temperature from the thermal imaging camera.

4 - Values changed one second after the start of the test.

5 - Current values.

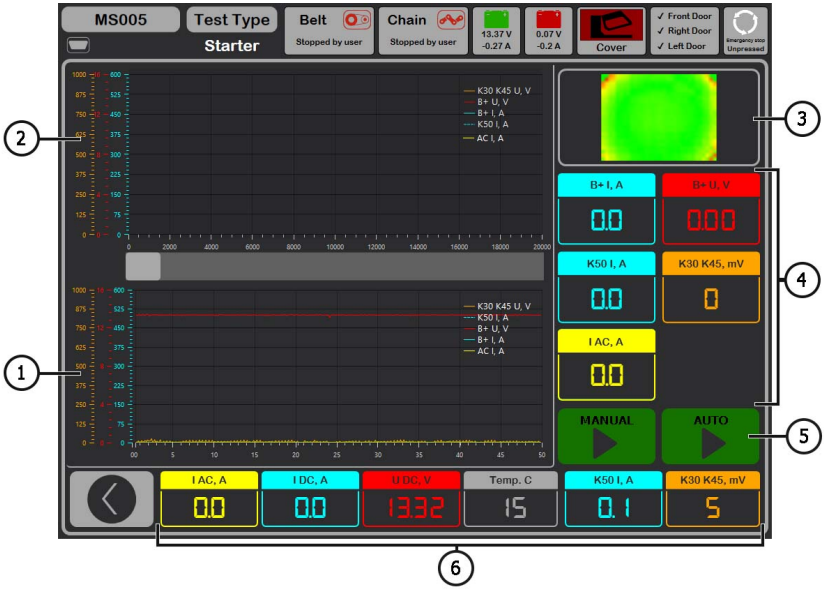


Figure 29. Starter Testing Mode Menu

6 - Test initiation buttons:
"MANUAL" - initiates the test in manual mode, the test lasts as long as the button is pressed;
"AUTO" - initiates the test in automatic mode, the test lasts for 2 seconds. After the test, a report is generated.

"I AC, A" - Alternating current value in the B+ circuit (terminal 30).

"I DC, A" - Direct current value in the B+ circuit (terminal 30).

"U DC, V" - Voltage in the B+ circuit (terminal 30).

"Temp. C" - Maximum temperature value of the diagnosed unit recorded by the thermal imaging camera.

"K50 I, A" - Current strength at terminal 50.

"K30 K45, mV" - Voltage at terminal 45.

The sequence of operations for starter diagnostics is as follows:

1. Place the starter on the workbench and secure the unit.

2. Attach the adapter to the positive terminal of the starter and connect the power cable "B+" there. Connect the power cable "B-" to the unit's housing.

3. Connect the bench connector "50" with a cable to the control output of the starter solenoid terminal 50, see Figure 30.

4. Connect the universal diagnostic cable K30 and K45 wires to the corresponding terminals of the starter, see Figure 30.

5. In the main menu, select the starter testing mode, then choose the nominal voltage of 12 or 24 V.

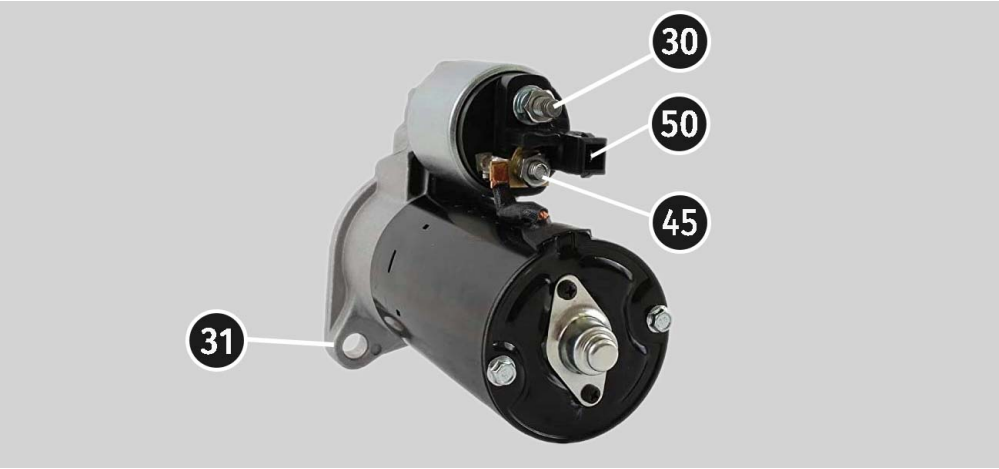


Figure 30. Terminal Locations on the Starter

6. Press the "AUTO" start button if a report needs to be generated. After the specified time, the bench will stop the diagnostic process. Conclusions about the technical condition of the starter and possible causes of malfunctions are drawn based on the graphs of voltage and current changes.

6.1. If it's necessary to find a specific test result in the future, it's essential to save the generated report under your name (for example, order number, client name, and date) in another folder.

7. Press and hold the "MANUAL" start button if manual diagnostics are required. We do not recommend holding the button for more than 15 seconds to avoid damaging the starter.

8. Exit the diagnostic mode, after which the starter can be removed from the bench.

8. TEST BENCH MAINTENANCE

The bench is designed for a long operation life and doesn't have any special maintenance requirements. At the same time, to ensure the maximum operation life, the regular monitoring of bench technical condition should be made as follows:

- motor operation inspection (uncommon noises, vibration etc.);
- alternator drive belts condition (visual inspection);
- power wires condition (visual inspection);

• inspection of bench operation environment (temperature, humidity etc.).

8.1. Test bench firmware update

Being connected to the Internet, with every switching on, the test bench checks for software updates of diagnostics program, database and bench firmware. In case the bench finds the software update at company server, you'll be offered to install the update or disregard it. To start updating, press OK, to decline – SKIP.

⚠ **ATTENTION! Updates may take a while to install.**

⚠ **WARNING! It's forbidden to switch off the bench supply to stop the updating.**

8.2. Cleaning and care

Use soft tissues or wipe cloths to clean the surface of the device with neutral detergents. Clean the display with a special fiber cloth and a cleaning spray for touch screens. To prevent corrosion, failure, or damage to the test bench, do not use any abrasives or solvents.

9. TROUBLESHOOTING GUIDE

Table with the possible problems and the solutions on their elimination:

Problem	Causes	Solutions
1. The bench doesn't start.	The automatic switch behind the bench left door got activated	Open the left door with the key from the supply kit, turn on the automatic switch to the up position.
	The left door is open, the protective terminal switch of the left door got activated	Close the left door.
	One of the bench supply phases (L1/L2/L3) or neutral N are lacking	Restore the supply.
	The variable speed drive software error.	Contact the dealer.

2. The bench runs but the electric motor doesn't start.	The bench wiring is damaged.	
3. When the bench runs the abnormal noises are heard.	The diagnosed unit is mounted wrong. (The driving belt is over tightened or out of alignment)	Re-mount the unit for the diagnostics.
4. When the bench runs the abnormal noises are heard.	The belt tightening is not enough	Stop the drive and check the tightening intensity
	The wear of the belt.	Replace the belt.
5. During the alternator test the contact clips heat up much. (alligator clips)	The contact area is small.	Use a positive terminal adapter of the alternator.

10. RECYCLING

European WEEE Directive 2002/96/EC (Waste Electrical and Electronic Equipment Directive) applies to the test bench waste.

Obsolete electronic equipment and electric appliances, including cables, hardware, and batteries, must be disposed of separately from household wastes.

Use available waste collection systems to dispose of outdated equipment.

Proper disposal of old appliances prevents harm to the environment and personal health.

APPENDIX 1

Alternator connection terminals

Code	Application		Type of alternator	Diagnostic cable wire
B+	Battery (+)			
30				
A	(Ignition) Ignition start input			IG
IG				
15				
AS	Alternator Sense	Terminal for measuring of battery voltage		S
BVS	Battery Voltage Sense			
S	Sense			
B-	Battery (-)			
31				
E	(Earth) Earth, battery (-)			
D+	For the connection of indicating lamp that supplies the initial voltage excitation and indicates the alternator performance capacity.		Lamp	D+
I	Indicator			
IL	Illumination			
L	(Lamp) Output for the alternator performance capacity indicating lamp			
61				
FR	(Field Report) Output for the control of the alternator load by the engine control unit			FR
DFM	Digital Field Monitor			
M	Monitor			
LI	(Load Indicator) Similar to FR, just with the inverted signal			
D	(Drive) Input for the P-D regulator control, for the alternators Mitsubishi (Mazda) and Hitachi (Kia Sephia 1997-2000)		P/D	GC

Code	Application	Type of alternator	Diagnostic cable wire
SIG	(Signal) Voltage code setting input	SIG	GC
D	(Digital) Input for voltage code setting on the American Ford, similar to SIG		
RC	(Regulator Control) Similar to SIG		
L(RVC)	(Regulated Voltage Control) Similar to SIG, with just the voltage variation range 11.0-15.5V. The control signal is supplied to the terminal L	RVC	
L(PWM)			
C	(Communication) Input for the control of voltage regulator by engine control unit. Korean cars.	C KOREA	
C (G)	Input for the control of voltage regulator by engine control unit. Japanese cars.	C JAPAN	
RLO	(Regulated Load Output) Regulator stabilizing voltage control within11.8-15V (TOYOTA)	RLO	
COM	(Communication) The general references of the physical control interface and alternator diagnostics. The protocols BSD (Bit Serial Device), BSS (Bit Synchronized Signal) or LIN (Local Interconnect Network) can be used	COM	
LIN	Direct reference to the control and diagnostics of alternator through the protocol LIN (Local Interconnect Network)		
PWM	Used for 24V alternators where one of the pins in the connector is marked as PWM	PWM	
Stop motor Mode	The control of the operation of Valeo alternator that are installed into the cars with the Start-Stop option	S/A PSA	
DF	Rotor winding coil output Connection of the regulator with the rotor winding coil		
F			
FLD			
67			

Test bench M0028

Code	Application	Type of alternator	Diagnostic cable wire
P	Output of one of the alternator stator winding coils It's used for the identification of the alternator excitation level by the voltage regulator		
S			
STA			
Stator			
W	(Wave) Output of one of the alternator stator winding coils - to connect the speed gauge in the diesel cars		
N	(Null) Stator winding coil centerpoint output For the control of the performance capacity indicating lamp of alternator with the mechanical voltage regulator		
D	(Dummy) Empty, no connection, mainly in Japanese cars		
N/C	(No connect) No connection		
LRC (Regulator option)	(Load Response Control) Option for the delay of voltage regulator reaction to the alternator load increasing. Within 2.5-15 seconds. At the load increasing (light, cooling fan), the regulator smoothly adds the excitation voltage that makes the engine speed stable. It can be easily seen at idle.		

APPENDIX 2

Manual for creating scripts for automatic testing of alternators

CONTENT

INTRODUCTION

Automatic testing of alternators on the stand is carried out using scripts. You can use existing "Default script" or create your own "User script".

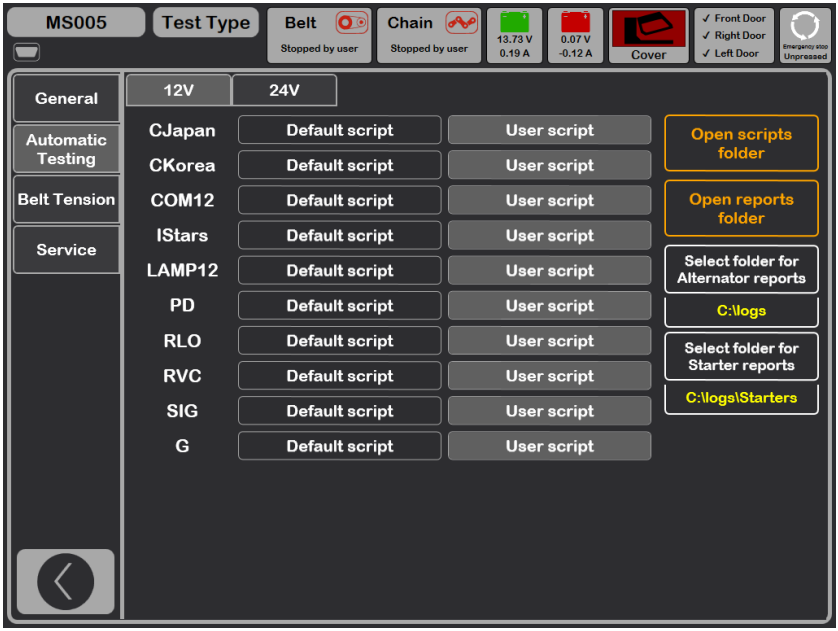
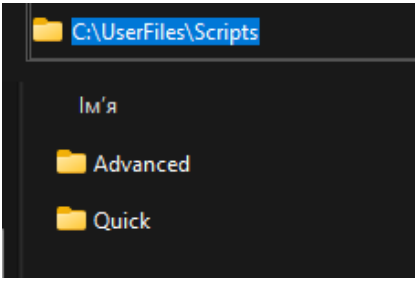


Figure 2.1. Automatic generator test settings menu

To make the program use custom scripts, you need to write them, name them accordingly (for example, if the generator type is Lamp 12 volts, then the script file name should be LAMP12.txt), and insert them into the scripts folder. The folder is located at C:\UserFiles\Scripts, and you can also navigate to the scripts folder by clicking the corresponding button in the "Automatic test" tab of the stand settings menu. In this folder, there are two subfolders, Advanced and Quick, containing templates for scripts. Ready-made scripts should be inserted into these folders.



Next, in the automatic generator test settings menu, you need to set the appropriate "User script" checkbox opposite the generator type for which the user script is written.

⚠ **ATTENTION! If scripts are accidentally deleted, new template files will be created when the software is launched. This also applies to reports discussed in section 2.**

1. Writing a script

Script writing is done using a special scripting language, which includes:

- 26 functions;
- 4 data types;
- 1 loop;
- 1 conditional operator.

For a better understanding of how the scripting language works, after studying the manual, it is recommended to analyze the provided scripts in the folder C:\UserFiles\Scripts.

1.1. Data types

As in many programming languages, this language has its own data type system used for creating variables. Data types define the internal representation of data, the range of values an object can take, and even the permissible operations that can be applied to an object.

In this language, there are the following basic data types:

- #iVariable: stores an integer from 0 to 4294967295, representing a UInt32.
- #fVariable stores a floating-point number from $-3.4 \cdot 10^{38}$ to $3.4 \cdot 10^{38}$.
- #sVariable: stores a textual value.

Declaring variables is done as follows: `# + type + name`. For example, when declaring `#fMaximumTemperature=15.2`, we declare a floating-point number named `MaximumTemperature`, which equals 15 integers and 2 tenths. Similar to the integer type but without a fractional part.

Another example: `#sOutputText="Starting operation"`. Here, we declare a string value named OutputText and assign the value "Starting operation" as text.

With numeric types, you can also perform standard mathematical operations (addition, subtraction, multiplication, division). For example:

```
#fNormalCurrent=10
#fCurrent=13.7
#fCurrent=#fCurrent - #fNormalCurrent
```

Here, we declared two numeric variables and assigned the difference of one of them to the other.

There are also several built-in variables (constants) in the language;

`#iAlternatorCurrent` – current of the selected alternator;

`#iAlternatorVoltage` – current of the selected alternator;

`#bMotorDirection` – motor direction for rotation;

`#sTesterName` – the name of the test bench;

`#sAlternatorNumber` – the article number of the selected alternator from the database;

`#sAtlernatorType` – the type of the alternator;

`#sCurrentTime` – current time;

`#sCurrentDate` - current date;

`#fPulleyDiameter` – the diameter of the selected alternator's pulley;

`#sDiagnosedBy` – the name of the company conducting the test (set in the settings);

`#sContacts` – contacts (set in the settings);

`#sIsSense` – information on whether the "S" terminal is used: 0 – off, 1 - on;

`#sIsIgnition` – information on whether the "15" terminal is used: 0 – off, 1 - on;

`#sInputPinType` – the type of the "FR" terminal.

1.2. Conditional statement

The `if-else` conditional construct directs the program's flow down one of the possible paths depending on a condition. It checks the truth of the condition and, if true, executes a block of instructions. In its simplest form, the `if construct` has the following abbreviated form:

```
If(condition)
Else
End If
```

Let's consider an example of using this operator:

```
If(#sIsSense="True")
    #sIsSense="False"
End If
```

Here, we check if the value of the variable `#sIsSense` equals the text `"True"`. If it does, the variable is assigned a new value `"False"`.

Another example:

```
If(#sTesterName="M0028")
    #iMaxLoad=300
Else
    #iMaxLoad=150
End If
```

In this case, we check if the value of the variable `#sTesterName` equals the text `"M0028"`. If it does, the variable `#iMaxLoad` is assigned a new value of `300`. If not, it is assigned a new value of `150`.

This operator must always be followed by the closing command `End If`.

1.3. Loop

Loops are control structures that allow a certain action to be performed multiple times depending on specific conditions. In the scripting language, there is one loop with the following structure:

```
While(Condition)
    Exit
End While
```

This loop immediately checks a certain condition, and if the condition is true, the loop's code is executed. Here is an example of using the loop:

```
While(#iSetRPM<3000)
    SetMotorSpeed(#iSetRPM)
    If(GetBPlusU>#fLampMinimalVoltage)
        Exit
    End If
    #iSetRPM=#iSetRPM+100
End While
```

In this case, the loop runs as long as the value of the variable `#iSetRPM` is less than `3000`. Two functions, `SetMotorSpeed` (which is discussed in the relevant section), are used to set the value of the variable `#iSetRPM` obtained from the stand. Then, a conditional statement is used to compare the value obtained by the function `GetBPlusU` with the variable `#fLampMinimalVoltage`. И если `#fLampMinimalVoltage` is less, the loop is exited using the `Exit`.

It is essential to always include the `End While` command at the end of the loop.

1.4. Wait operator

This operator can be useful when you need to check a condition over a certain period of time. It has the following structure:

```
Wait(condition, time_in_milliseconds)
```

It checks the condition every 100 milliseconds. If the condition is `true`, it continues down the script. If not, after the specified time, it continues regardless of whether the condition was met or not. After that, it is advisable to perform an additional check of this condition. If the check fails, the test should be terminated. Here is an example of usage:

```
Wait(GetBPlusU>#fLampMinimalVoltage,16000)
If(GetBPlusIAC>#fLampMaxACCurrent)
    End
End If
```

In this case, we check if the value obtained by the function `GetBPlusU` is greater than the value of the variable `#fLampMinimalVoltage`. The wait time is 16 seconds. After that, we check if the value obtained by the `GetBPlusIAC` The wait time is 16 seconds. After that, we check if the value obtained by the `#fLampMaxACCurrent`, , and if it is, we stop the test.

1.5. Functions

Functions are essential for setting or retrieving specific values from the test stand or performing certain actions. There are a total of 26 functions available. Depending on the function, they may take 0 or 1 argument. Let's go through them:

`Print()` – used to display specific text in the console. For example, if you write `Print("Alternator Test Started")` the text `Alternator Test Started` will be displayed in the console.

`Delay()` – introduces a delay in execution for the specified time in milliseconds. It accepts one argument, which should be a number between 0 and 65535. For instance, the function `Delay(10000)` will pause the script execution for 10 seconds.

`GetMotorSpeed()` – returns the motor speed from the test stand as a floating-point number ranging from 0 to 3000.

`GetMotorVoltage()` – returns the motor voltage in volts from the test stand as a floating-point number ranging from 0 to 1000.

`GetMotorCurrent()` – returns the motor current in amperes from the test stand as a floating-point number ranging from 0 to 20.

`SetMotorAccel()` - sets the motor's acceleration in seconds.

`SetType(номер)` - configures the type of the output signal as a floating-point number between 1 and 11.

`SetVoltage()` - sets the output voltage in volts for the controlled alternator as a floating-point number between 10.6 and 16.

`SetLoad()` – sets the load in amperes. It accepts one argument as a number ranging from 0 to 300.

`GetBPlusU()` – returns `BPlusU` from the test stand as a floating-point number ranging from 0 to 65535.

`GetBPlusIDC()` – returns `BPlusIDC` from the test stand as a floating-point number ranging from 0 to 1000.

`GetBPlusIAC()` – returns `BPlusIAC` from the test stand as a floating-point number ranging from 0 to 255.

`SetK15()` – returns BPlusIAC from the test stand as a floating-point number ranging from 0 to 255.

`GetK15U()` – returns the voltage on K15 from the test stand as a floating-point number ranging from 0 to 60 volts.

`GetK15I()` – returns the current on K15 from the test stand as a floating-point number ranging from 0 to 2 amperes.

`SetSence()` – enables or disables Sense. It takes an argument of 0 (to disable) or 1 (to enable).

`GetLinID()` – returns the Lin ID of the alternator from the test stand as a number.

`GetLinExc()` – returns the Lin FR of the alternator from the test stand as a percentage number from 0 to 100.

`GetLinErr()` – returns the error of the Lin alternator from the test stand as a number.

`GetLinSpeed()` – returns the speed of the Lin alternator from the test stand as a number.

`GetLinType()` – returns the type of the Lin alternator from the test stand as a number ranging from 0 to 13.

`SetFRPullup()` – turns FRPullup on or off. It takes an argument of 0 (to turn off) or 1 (to turn on).

`GetFRDuty()` – returns the FR Duty of the alternator from the test stand as a floating-point number from 0 to 100.

`GetCOMExc()` – many alternators send a signal back to the vehicle indicating its load. Typically, this is read as `GetFRDuty`, but for COM alternators where everything is transmitted digitally through a single wire, it is read as `GetCOMExc`.

`GetFRFreq()` – returns the FR Freq of the alternator from the test stand as a floating-point number in Hz with a range from 0 to 10000.

`GetTimeStamp` – returns the time from the start of script execution. This is needed to calculate delays from the moment the script started to the point when the alternator produced a result.

`GetLampI()` – returns the LampI of the alternator from the test stand as a floating-point number in milliamperes with a range from 0 to 500.

`GetTemperature()` – returns the temperature of the alternator from the test stand as a floating-point number in degrees Celsius with a range from 0 to 200.

1.6. Limitations

To ensure the proper functioning of scripts, there are several limitations. For a better understanding of these limitations, you can visit the "Manual Test" section and review the data requirements.

Number of Revolutions: When setting the number of revolutions, it's important to understand that the test stand can rotate from 0 to 3000 revolutions per minute. Setting a value outside this range may lead to unstable test stand performance.

Current and Voltage: When configuring these parameters, it's essential to consider the alternator type and its specifications. For instance, if you set a load of 300 for a alternator with a maximum current of 100A, it can have extremely negative consequences.

K15 and Sense: These parameters are automatically enabled when entering the testing mode and disabled when exiting. This should be taken into account to avoid writing unnecessary code. It won't affect the process but may slow down execution.

2. Report generation

Generating a custom report is similar to creating a custom script.

To make the program use custom reports, you need to write them, name them accordingly (for example, if it's a 12-volt lamp alternator, the name should be LAMP12.xlsx), and insert them into the reports folder. The folder is located at C:\UserFiles\Reports.

In turn, it contains two subfolders, Advanced and Quick. These folders contain templates for scripts. Accordingly, Advanced is for reports for advanced scripts, and Quick is for reports for quick scripts. Ready-made reports should be inserted into these folders.

After conducting the test, a report will be automatically generated based on the created template.

IMPORTANT: The program works in such a way that when a specific script is selected, the corresponding report is also selected. For example, if we choose an advanced script for a 12-volt lamp alternator (the path to it will be C:\UserFiles\Scripts\Advanced\LAMP12.txt), the corresponding report located at C:\UserFiles\Reports\Advanced\LAMP12.xlsx will be used.

2.1. Creating your own report

A report template is created in Excel. You create a table where you record the values of variables generated during the automatic test or constants. For example, if you want to display the constants `#sCurrentTime` и `#sCurrentDate` you should make the following entry in the table:

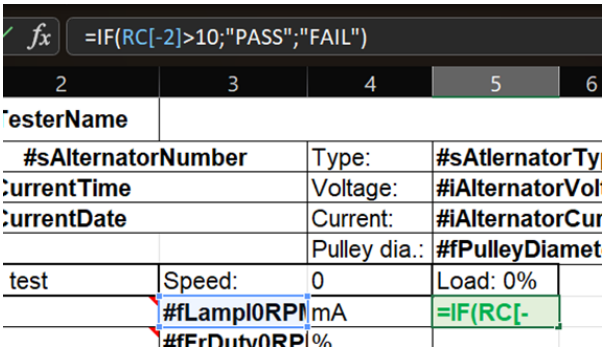
Time:	**#sCurrentTime**
Date:	**#sCurrentDate**

When generating the report, these placeholders will be automatically replaced with the values generated during the test.

This way, you can include any variables created during the test in your report.

Tester ID:	#sTesterName			**Alternator test report**			
AS-PL number:	#sAlternatorNumber		Type:	#sAtlernatorType	MSG EQUIPMENT		
Time:	#sCurrentTime		Voltage:	#iAlternatorVolta			
Date:	#sCurrentDate		Current:	#iAlternatorCurre			
			Pulley dia.:	#fPulleyDiameter			
Test 1	Idle test	Speed:	0	Load: 0%	Diagnosed By:	#sDiagnosedBy	
Lamp current		#fLampl0RPI	mA	PASS	Contacts:	#sContacts	
FR duty		#fFrDuty0RP	%		Tips:		
FR frequency		#fFrFreq0RP	Hz				
Test 2	Start RPM	Speed:	0 - 3000	Load: 0%			
Start time		#iStartTime	msec				
Test 3	Freerun test	Speed:	0 - 3000	Load: 0%			
Start speed		#ЗНАЧ!	RPM	FAIL			
Voltage set point		#fFreeRunVo	V	FAIL			
Lamp current		#fLamplStart	mA	FAIL			
FR duty		#fFrDutyStar	%		Standart pulley diameter:	115	
FR frequency		#fFrFreqStar	Hz		#iStartRPM		
Battery charging current, DC		#fFreeRunDC	A				
Battery charging current, AC		#fFreeRunAC	A				

Since the report is created in Excel, you can use its full functionality when creating a template: formulas, rules, formatting, etc. Here's an example of using a function:



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