# Z300 PVT user manual

***Z300 PVT - 1500 V / 30A DC***
***Photovoltaic testing and troubleshooting kit***


The troubleshooter for solar energy

# Z300 PVT
# User manual

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# 1 Nomenclature

## 1.1 Warning signs

Please note that the manual uses the following safety instructions. The safety instructions should be followed carefully. Failure to do so may cause personal injury or irreparable damage to the equipment.

**WARNING.**
Personal injury / death. A situation of use of a technical nature or the like which may cause injury or death.

**WARNING.**
Personal injury / death. Risk of electrical shock.

**CAUTION.**
Damage to the machine or accessory. A situation of use of a technical nature or the like, which can cause damage to the machine or accessories.

**NOTICE.**
Important information. A situation of use of a technical nature or the like, which is very important

## 1.2 Tips and recommendations

Please note that the manual uses the following information instruction.

**INFORMATION.**
Provides useful tips and recommendations and provides information on how to use the product efficiently and without interruptions.

## 2 Limited warranty and limitation of warranty

Each emazys (Manufacturer) product is warranted to be free from defects in material and workmanship under normal use and service. The warranty period is one year and begins on the date of shipment. Parts, product repairs, and services are warranted for 90 days. This warranty extends only to the original buyer or end-user customer of a manufacturer authorized reseller, and does not apply to fuses, disposable batteries, or to any product which, in the manufacturers opinion, has been misused, altered, neglected, contaminated, or damaged by accident or abnormal conditions of operation or handling.

The manufacturer warrants that software will operate substantially in accordance with its functional specifications for 90 days and that it has been properly recorded on non-defective emazys does not warrant that software will be error free or operate without interruption.

Manufacturer authorized resellers shall extend this warranty on new and unused products to end-user customers only, but have no authority to extend a greater or different warranty on behalf of the manufacturer. Warranty support is available only if a product is purchased through an emazys authorized sales outlet or Buyer has paid the applicable international price.

The manufacturer reserves the right to invoice Buyer for importation costs of repair/replacement parts when a product purchased in one country is submitted for repair in another country. The manufacturers warranty obligation is limited, at the manufacturers option, to refund of the purchase price, free of charge repair, or replacement of a defective product which is returned to a the manufcaturer authorized service center within the warranty period.

To obtain warranty service, contact emazys service center on E-mail:sales@emazys.com to obtain return authorization information. Then send the product to the service center, with a description of the difficulty, postage and insurance prepaid (FOB Destination). Whenever possible, take the battery out of any product before shipping it to the manufacturer.

The manufacturer assumes no risk for damage in transit. Following warranty repair, the product will be returned to Buyer, transportation prepaid (FOB Destination). If the mnaufcaturer determines that failure was caused by neglect, misuse, contamination, alteration, accident, or abnormal condition of operation or handling, including over-voltage failures caused by use outside the products specified rating, or normal wear and tear of mechanical components, the manufacturer will provide an estimate of repair costs and obtain authorization before commencing the work.

Following repair, the product will be returned to the Buyer transportation prepaid and the Buyer will be billed for the repair and return transportation charges (FOB Shipping Point).

THIS WARRANTY IS BUYER'S SOLE AND EXCLUSIVE REMEDY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. THE MANUFACTURER SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OR LOSSES, INCLUDING LOSS OF DATA, ARISING FROM ANY CAUSE OR THEORY.

Since some countries or states do not allow limitation of the term of an implied warranty, or exclusion or limitation of incidental or consequential damages, the limitations and exclusions of

this warranty may not apply to every buyer. If any provision of this Warranty is held invalid or unenforceable by a court or other decision-maker of competent jurisdiction, such holding will not affect the validity or enforceability of any other provision.

## 2.1 Warranty disclaimer

The Z300 PVT instrument is warranted for 12 months from the reception. The warranty does not cover the battery or other auxiliary items. There is no warranty on the device, if you use other cables than the supplied ones. The warranty will be invalid if the product is damaged due to any of the following:

- Neglect to follow the user manual in general
- Use of the product for purposes for which it was not intended
- Natural wear
- Incorrect fitting
- Mechanical or technical alterations
- Use of unauthorized spare parts
- Use outside the specified power limits

# 3 Unpacking and commissioning

## 3.1 Scope of delivery

The Z300 PVT is delivered in a cardboard box. We recommend to save the box for later if you need to transport the instrument or e.g. send it for service or calibration.

**INFORMATION.**
If you use knives or sharp objects when unpacking, please observe great care.

After unpacking, make sure that you have received all parts ordered. Accessories and special items may have been ordered as well, so please check with your purchase order and invoice, that nothing is missing. If you have not received all parts, please contact emazys or your local distributor.


Z300 PVT kit

1. Z300 PVT instrument
2. RRC2054 Battery
3. RRC-SMB-MBC Standard Battery Charger
4. Banana-MC4 PV testing leads
5. Banana Croc. GND testing lead
6. Power cord (comes as either US, EU or UK)
7. Tone pickup

**Note:** The picture shows the std. Z300 PVT kit. A range of different accessories can be supplied from emazys - please go to emazys.com and see what we can offer. We recommend to also buy and use the tone pickup, when ordering the kit. The tone pickup will enable more fault localisation functionality in your instrument.

## 3.2 Commissioning

### 3.2.1 Battery

Prior to start-up please check that the RRC2054 battery is fully charged. The battery can be charged using the charger that comes with the instrument.

### 3.2.2 Control interface

The control interface is separated from the main instrument box in a wireless manner, and you may use a smart device with Bluetooth transceiver that runs either iOS or Android. The front panel itself only includes instrument status LEDs, the ON-OFF/WAKE UP button, battery access, and WiFi connector.

### 3.2.3 Cables

Connect the supplied cables to the instrument. The red wire is connected to the Red (+) connection socket, the black wire is connected to the Black (-) connection socket and the Yellow/Green wire is connected to GND. Different solar PV modules may use different connectors, than supplied with the Z300 PVT kit. If you need other types of adaptors, please contact emazys or your local distributor.


Make sure to connect the inputs correctly on the Z300 PVT instrument.
(Cables are all colored accordingly)

**WARNING.**
Personal injury /death. Make sure cables used to connect the instrument to photovoltaic modules and strings are CAT III, 1000V AC / 1500V DC compliant.

**WARNING.**
Personal injury / death. Risk of electrical shock.

**CAUTION.**
Damage to the machine or accessory. It is not recommended to use cables other than the supplied. The instrument's warranty is no longer valid if other types of cables are used.

# 4 Safety

Before carrying out measurements with the Z300 PVT, you must ensure that:

- there is sufficient space to operate the instrument
- the necessary tools are present on the site
- the operator has a general knowledge of PV modules (photovoltaic modules) and is trained to work in high voltage environments
- the instrument is correctly connected
- the instrument and the measurement cables are in good condition. Check that the cables are not cracked or damaged in any way.

**NOTICE.**

- The Z300 PVT and the user manual are intended for use by adequately trained personnel.
- Before use, the operator must have read the user manual.
- The User manual must be kept near the instrument.

**WARNING.**

- PV module measurements are performed in high voltage areas. Always use approved safety equipment designed for high voltage installations.
- If subjected to an electrical shock, you must seek medical advice, even if you feel well. Some potentially harmful effects may not occur until several hours after exposure.

**CAUTION.**

- Exercise caution in use.
- The Z300 PVT should be used wherever possible in a dry environment.
- The instrument's lid should always be closed during long-term measurements. Make sure to mark up the measuring site.

# 5 Operation

**Caution:**

- Do not connect the instrument to the inverter.
- When testing PV-strings connected in parallel consider the specifications of the instrument.
- The instrument is not suitable for continuous operation at the DC PV source.
- Disconnect all leads after testing.
- Do not operate the instrument with the battery cover open.
- Failure to comply can lead to instrument damage and loss of warranty.

The Z300 PVT is a portable and battery powered instrument used to test and troubleshoot faults in strings of series connected photovoltaic modules. Further it has the capability to help in mapping the layout of an arrays of PV modules when using the tone generator and tine pickup.

**INFORMATION.**
All Z300 PVT analysis algorithms, assumes that the instrument is connected to a series string of solar PV modules. When testing parallel strings, the fault positioning algorithms may not always indicate the correct position. Consider breaking up the strings when troubleshooting PV arrays. In general it will make the work easier and faster.

Specifically, the instrument has the following features and measurement applications:

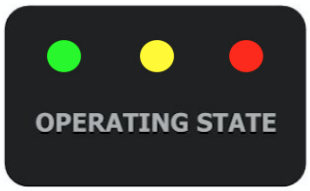
1. Measure position of a single ground fault in a PV string
2. PV string string open circuit voltage $V_{OC}$
3. PV string string short circuit current $_{SC}$
4. PV system isolation resistance $R_{ISO}$
5. Tone generator and tone tracer pickup
6. Build in PDF report generator, where the report includes a list of meta data points such as GPS coordinates, digital photos, time-stamp etc.

The instrument is connected to the string terminals e.g. at the string inverter or combiner box and also to the ground reference for the PV installation.

## 5.1 Front panel elements

In the illustrations below, you will find a description of each element found on the front panel of the Z300 PVT. The tables below show sections of the front panel seen in Figure 1.


Figure 1: Z300 PVT front panel. Placed on the middle of the front panel we find the ON/OFF switch. When the instrument is turned on a small LED in the button will emit green light. The instrument USB connector is found above the ON/OFF button. This connector can be used for various purposes such as software updates etc.

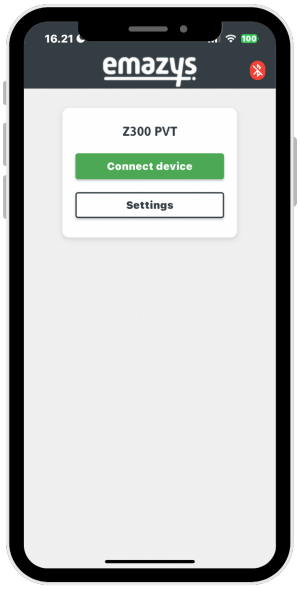



The operating state of the instrument is indicated by 3 colored light emitting diodes (LEDs) - upper left in Figure 1. The green diode is on when the instrument is turned on. The yellow diode will blink when the Bluetooth computer is ready to transmit and receive data. The yellow diode will stop blinking, and turn fully on, when the device is connected. The red LED will blink when the instrument is busy.

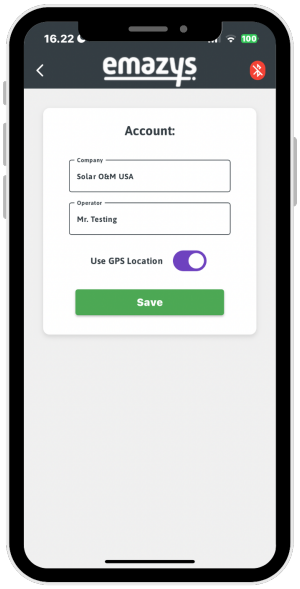
## 5.2 Using the controller app

You will communicate with the Z300 PVT using a smart device with the Z300 PVT controller app installed. The app is available for iOS and Android - please go to either Apple app store or Google play store and download the app for free.

**INFORMATION.**
After downloading the Z300 PVT controller app, please create a user account. Having a user account is a requirement to use the emazys data cloud. Furthermore, emazys will not be able to support your field work and help to analyse test results, if the data is not saved to the emazys data cloud.

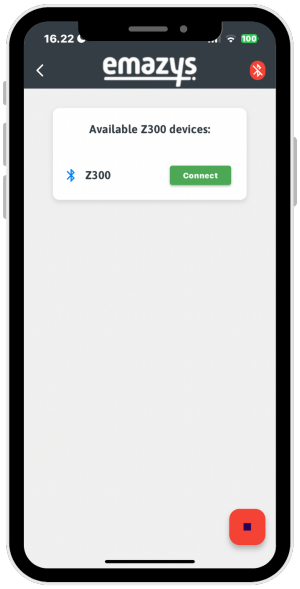



**Home**
Home screen. The main screen that appears after opening the controller app.



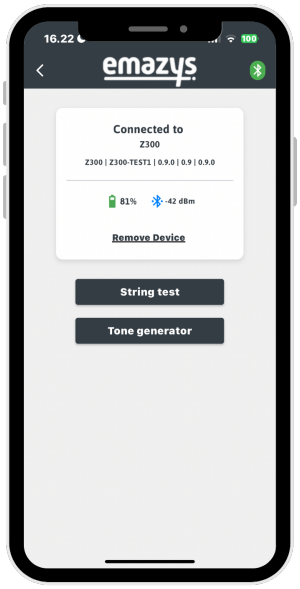

## Settings

The information entered here will be printed in the user reports that can be generated after testing. The user may allow the smart device to record and store the GPS coordinates associated with a certain measurement.




## Connect

Make sure the Z300 PVT has the battery installed and that the device is turned on. After pressing SCAN, you will see the Z300 Bluetooth network. The connection takes few seconds to complete.




## Menu

Once you have connected the Z300 PVT with your smart device you should see the main testing menu featuring the string test and the tone generator options.

# 6 Applications and Measurements

All modules in the string under test must be illuminated by at least 100–150 $\mathrm{W/m^2}$ during string testing. If the irradiance is below this threshold, impedance-based measurements will not return realistic values.

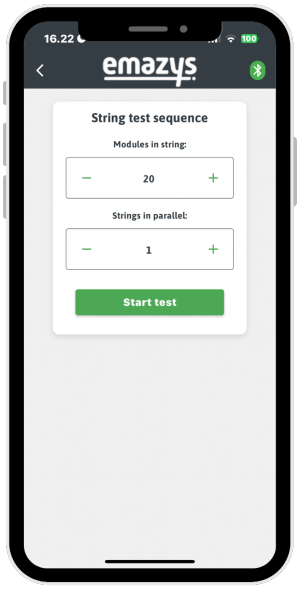
When verifying the output performance of a solar array (voltage and current), it is essential to test the solar panels under stable environmental conditions. Ideally, modules should be tested under Standard Test Conditions (STC). STC refers to 1000 $\mathrm{W/m^2}$ solar irradiance, a cell temperature of 25 °C, an air mass of 1.5, and the ASTM G173-03 standard spectrum.

## 6.1 Measuring Functions

- Open circuit voltage, $V_{\mathrm{OC}}$: [0–1500 V]
- Short circuit current, $I_{\mathrm{SC}}$: [0–30 A]
- Electrical polarity: [OK / not OK]
- Isolation resistance, $R_{\mathrm{ISO}}$: [0–40 MΩ]
- Isolation resistance fault location: $R_{\mathrm{ISO}} < 3\,\mathrm{M\Omega}$
- Series resistance, $R_{\mathrm{S}}$: [0–10 kΩ]
- Tone generator + amplifier probe

## 6.2 String Test

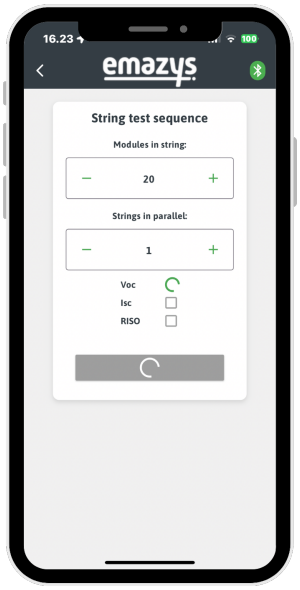
The String Tester is the main test program of the Z300 PVT. After selecting the test, the initialization screen appears, where you specify the number of PV modules in the string. This information is used to calculate fault positions and other relevant values.



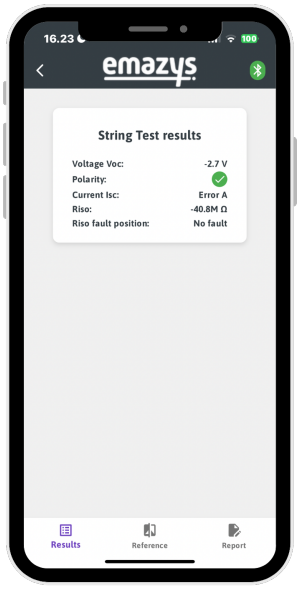

**Initialization screen.** Before starting the string test, the user must adjust the number of PV modules in the string by pressing the plus or minus symbols. Once the correct number is set, press *Start Test.*

When the string test is complete, the result screen will appear. Examples of result screens are shown below (top and bottom views). The string test provides values for $V_{\mathrm{OC}}$, polarity, $I_{\mathrm{SC}}$, $R_{\mathrm{ISO}}$, and the potential position of an $R_{\mathrm{ISO}}$ fault. The screen also displays the status for recording GPS coordinates of the measurement.

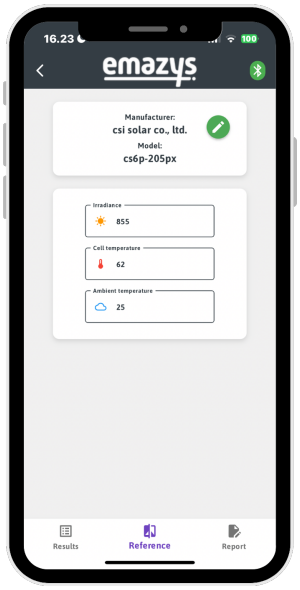
Please note that newer versions of the Z300 PVT also return the module string series resistance, $R_{\mathrm{S}}$. Below the measurement values, there are data entry fields where system information can be added for the report. Before generating the PDF report, the user can use the smart device's camera to capture a photo of the PV system under test—for example, the backplate of the tested PV module to document STC values. Additionally, photos of observed issues can be stored for later evaluation.




**Testing screen.** During testing, the user will see progress displayed. Note that the $R_{\mathrm{ISO}}$ measurement can take up to 20 seconds.




**Result screen (top view).** At the bottom of the screen are tabs for setting up a reference and printing the PDF report.




**Result screen (top view).** Same as above, showing the reference setup and report generation tabs.

## 6.3 Locating Riso faults

The Z300 PVT measurement of isolation resistance is based on measuring voltage transients in energized circuits. This testing principle allows to measure the position of an isolation fault when $R_{\mathrm{ISO}} < 3\,\mathrm{M}\Omega$. The calculation will return the fault position as the distance (module number) from the PV+ terminal. In the calculation, it is assumed that there is one dominating isolation fault, but this may not always be the case. Isolation issues can also be widespread in the PV array.

## 6.4 Power Considerations for Field Testing

High-efficiency (HE) solar PV modules have become popular for utility-scale solar installations. HE modules are characterized by efficiencies above 19% and are usually designed for 1500 V applications. While HE modules offer higher performance, they also present challenges for field testing and maintenance.

### 6.4.1 Inrush Current in High-Efficiency PV Modules

Modern solar modules are built with advanced materials that can store charge for extended periods. When a short-circuit condition is established, this stored capacitance releases a burst of current, creating a high inrush current during the first few milliseconds.

The Z300 PVT can tolerate a certain level of inrush current. However, if the current surges toward the limit, the over-current protection will activate, interrupting the measurement and displaying **Error 6**. Inrush current scales positively with the following factors:

- Module efficiency
- String current and voltage
- Number of parallel strings
- Irradiance
- Temperature

Bifacial modules increase capacitance further, which can amplify inrush current. To mitigate this, users may:

- Break up strings to reduce voltage
- Adjust tracker orientation to reduce irradiation
- Test under lower irradiance
- Break up parallel strings into single strings

According to emazys user data, the Z300 PVT has successfully tested high-current string assemblies with up to five parallel strings and high-efficiency bifacial modules. However, occasional Error 6 events may still occur.

## 6.5 Tone Generator

The tone generator is a simple yet powerful tool for tracing cables, modules, and faults in PV arrays. When activated, it transmits signals that can be traced using a handheld tone amplifier probe.

**Tone amplifier probe.** Pictured is the IDEAL tone amplifier probe, which works well with the Z200 and Z300 PV series instruments.

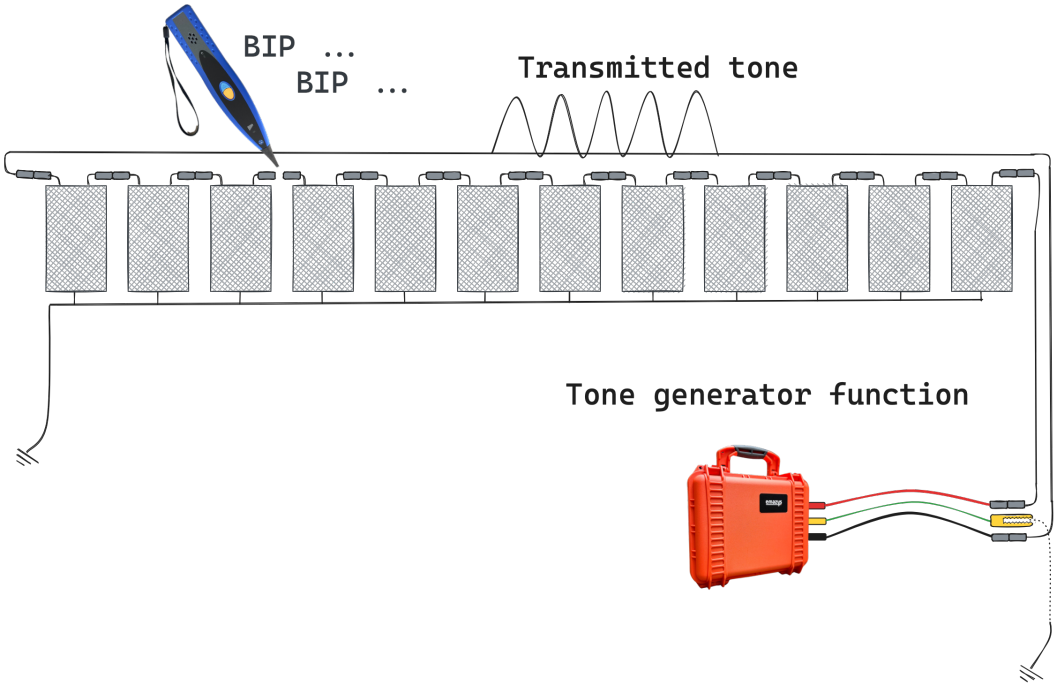



Figure 2: Testing principle of the tone generator function. The Z300 PVT transmits frequencies into the PV system. These tones are picked up and amplified by a handheld tone pickup device. This helps locate disconnections or trace wiring.


**Tone generator main screen.** Press the green button to start transmitting tones into the PV system.


**Tone generator active.** An on-screen animation guides the user to begin tracing signals with the tone pickup device.

## 6.6 Data Cloud and Controller App

The Z300 PVT is controlled via a free app available for iOS and Android. Search for *"emazys"* or *"Z300 PVT"* in the App Store or Google Play Store.

While the Z300 PVT can be used without logging in, note that results will not be saved to the emazys user cloud unless logged in. To ensure traceability, create a free user account and log in during testing. Enabling GPS further enhances traceability.

Log in at `https://data-cloud.emazys.com` to view your stored test results. The dashboard offers multiple viewing options, including GPS and table views. Data can be filtered and exported as CSV files for fast reporting. Individual measurements can be inspected in detail by clicking map points or table entries.

# 7 Calibration

To maintain the specified accuracy of testing results, the instrument must be re-calibrated with fixed intervals by emazys. We recommend to re-calibrate the Z300 PVT once per year.

**WARNING.**
Should the Z300 PVT become faulty please remove the battery and secure the instrument so that it can not be used. Ship the unit back to emazys and report to us what happened.

1. Remove the battery before shipping the instrument
2. The instrument must be securely packed in a suitable cardboard box
3. Shipping back and forth is exclusively at the user's responsibility and cost.

Simply go to our website https://emazys.com and use the main contact form to report any need for service, repair or calibration.

# 8 Storage and disposal

## 8.1 Storage

If the Z300 PVT is taken out of service for a long time, we recommend to remove the battery and store the battery safely.

## 8.2 Disposal

The Z300 PVT should be returned to emazys for correct disposal. Dismount the battery before shipping.

**NOTICE.**
DO NOT try to disassemble the instrument. It must be disposed correctly according to EU regulations

# 9 Support

If you need support, please contact emazys. Go to our website emazys.com and find updated contact information e.g. phone numbers. This manual and our website is updated whenever a customer reports a new topic that must be attended. The website also contains various articles with background information and videos to help you. Please carefully study this manual to unveil the many features and capabilities we put into this instrument. If you still need support after exploring the materials on your own, please do not hesitate to contact us.

**NOTICE.**
If you need support use the contact form on our website. In this way you make sure that we see your message. If you send a standard e-mail it may end up in a spam folder or get blocked.