MITTON INSTRUMENTS

# Instruction Manual

# TT1000

# Tower Earth Tester

**Rev 01**

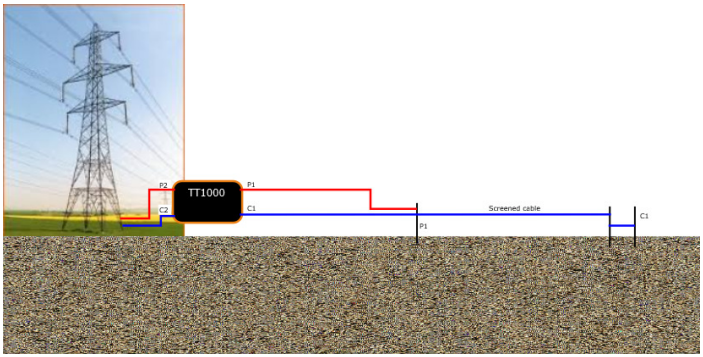
# Contents

# 1 Introduction

The TT1000 is a 4-terminal test meter designed to measure the earth resistance of steel transmission towers, steel poles or steel reinforced concrete poles that are interconnected with an overhead lightning shield wire. It is important to measure tower earth resistance in order to design for appropriate lighting protection or to determine the lightning protection performance of the power system.

The TT1000 operates at a high frequency which results in the shield wire appearing as high impedance to the test signals, due to its relatively high inductance. This means the influence parallel tower or pole earthing during the measurement is avoided. The TT1000 has a simple operating interface.

This manual describes the operation of the TT1000.




# 2 Features

The TT1000 front panel and operation is straightforward and is detailed below:


# 3 Operation

The TT1000 uses a 4-wire measurement system. This ensures that the contact resistance between the test cable clips and the tower steel is eliminated from the measurement. This is particularly important since tower steelwork metalwork is often corroded, oxidised or dirty resulting in poor contact with the test clips. This contact resistance can result in significant errors to the measurement.

Measurements are made at 40, 50, 60, 70 and 80 kHz and the impedance calculated at each of the test frequency, Digital filtering to eliminate noise is also used.

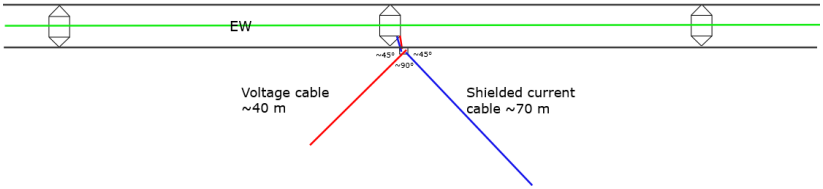
The internal software then implements a linear interpolation to derive a line of best fit. The line of best fit is then used to derive an estimated equivalent low frequency impedance (as would be seen by standard low frequency earth tester with the OHEW disconnected).

A shielded current injection cable is used to minimise losses due to capacitive coupling with the ground. Similarly any coupling of the test current into the cable shield is excluded from the impedance calculations. Effectively, only the

return current through the ground back to the tower is measured.

## 3.1 Test Lead Configuration

The test cables must be correctly installed. Where practical, the test cables should be run at approximately 45⁰ to the transmission line direction:




Two short single core cables (P2, C2) are connected *independently* to one of the tower legs, or to an earth connection on a steel or concrete pole, using crocodile clips. It may be necessary to clean the connection point with sandpaper or a grinder.

The shielded test cable is connected to C1 and the other end to one or more test electrodes located approximately 70 m from the tower. In dry, sandy or stony ground conditions is recommended that two test electrodes be used for the current circuit. Separate the two electrodes by approximately 1 m and connect together with a jumper lead.

The current test probes should be inserted to a depth of at least 200 mm and water poured around them if the ground is dry. In some cases, such as stones and other non-porous soils, longer current electrodes should be used.

The unshielded voltage electrode test lead is connected to P1. The voltage cable should be run to a distance of approximately 40 m and ideally at right angles to the current lead. If this is not possible then run the voltage lead at the most achievable angle (up to 90$^{0}$) and separation from the current lead as is practical.

The voltage electrode should be inserted to a depth of 200 mm. Again, if the ground is dry, pour water around the electrode.

After connecting the test leads, press Power to activate the TT1000. Press Test to start the measurement.

## 3.2 Probe Integrity Test

At the commencement of the test, the TT1000 verifies the integrity of the test cables and P1, P2, C1, C2 probe contact resistance, to ensure that measurements can be made.

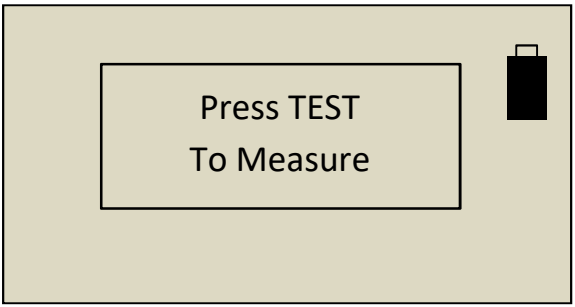
The TT1000 will auto range should there be significant noise (eg 50 Hz) appearing on the P1, P2 connections. In the event of total input voltage (eg noise) exceeding ±9 V peak, P1, P2 over-range check probes will appear after the initial probe test.

If there is no activity for 5 minutes the TT1000 will automatically shut down to conserve the battery.

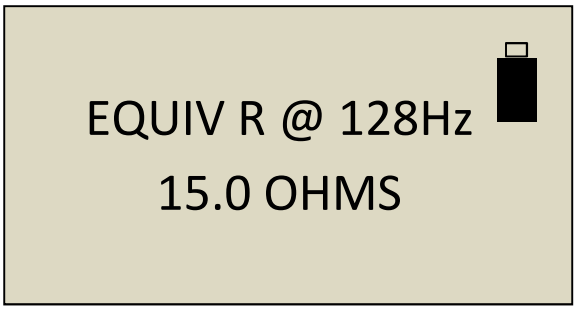
## 3.3 Impedance measurement

To undertake a resistance measurement first setup probes as per section 3.2.

a) Press **Power**




b) Hold down the **Test** button
c) The TT1000 will automatically undertake current and voltage measurements at several frequencies.
d) Once all readings have been undertaken, the system will calculate the tower resistance. If the probes are incorrectly connected an error message will be shown at this point.




e) Press and hold **Power** to turn off instrument, the TT1000 will also automatically power down after 5 min of inactivity.

## 3.4 Battery Charging

The TT1000 can be charged using an external charger use 15 Vdc centre positive with a current rating of at least 2A.

Charging time is around 5hrs, the unit is fully charged with the battery voltage is above 12.4V. Do not charge battery if the ambient temperature exceeds 40°C. The charging process is automatically terminated when charging is complete. In addition the current battery level is indicated during use with the battery icon.

# 4 Field Testing

This section describes some of the practical aspects of field testing.

## 4.1 Test Probes

Recommended test probes are stainless steel rods, approximately 10 mm diameter, 300 mm long. Probes constructed with a 4 mm hole to accept a 4 mm banana plug are suggested.

## 4.2 Test Plugs

The TT1000 will accept 4 mm banana plugs and banana plugs should be used on the test cables. Good quality (gold plated if available) plugs should be used. Plugs should be changed regularly should wear and tear, looseness or dirt become apparent. Spare plugs should be carried.

## 4.3 Test Cables

Test cables and associated plugs should be thoroughly checked for integrity prior to any field testing.

The standard setup for tower earth impedance is shown in Section 3.1.

a) Connections to the tower from P2 and C2 are made using large crocodile clips. Use 1.5 $mm^2$ single core appliance wire or pre-made jumper leads (approx 1 m long) with 4 mm banana plugs fitted. Ensure that any paint, rust and galvanized coating is removed before attaching clips.
b) The remote C1 electrode is connected using flexible RG58 co-axial cable. The C1 connection is made with a 2 pin Lemo connector (part number FGG.1B 2 pin). The pin opposite the red dot connected to the core of the RG58 cable and the other pin to the screen. At the remote end, only the core is connected to the electrode.
c) The remote P1 electrode is connected via 1.5 $mm^2$ appliance wire.

All cables should be carefully stored on reels. Note that during testing the current cables must be completely unwound to minimise the inductance in the test cables.

# 5 Calibration Check

The instrument is supplied to the user pre-calibrated, there are two high precision internal resistors that the unit uses to self-calibrate at start-up. If the user needs to check the calibration use high precision (< +/-1%) 1 Ω, 10 Ω and 100 Ω resistors connected to the meter using short leads and using the 4-wire method. The use of metal film resistors is preferred over wire-wound types as they have lower inductance at high frequencies.

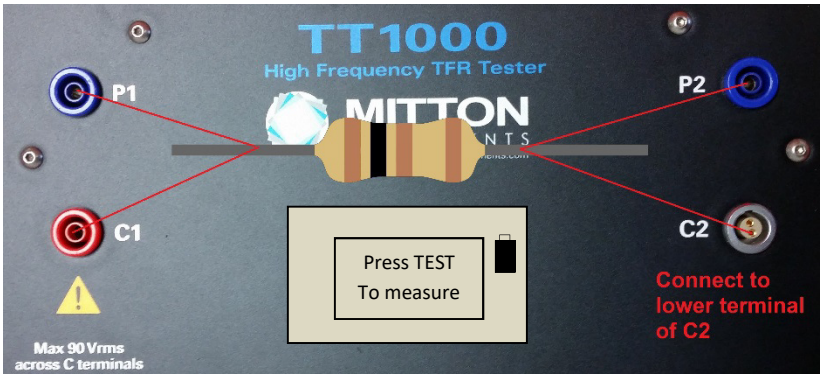



**Figure 4: Connections for calibration check**

If the readings match within 1% the instrument can be considered to be in calibration, if not contact Mitton Instruments for an adjustment procedure.

## Specifications

**Input Voltage (auto ranging):** 1x range 8.98 V peak, 10x range 0.898 V peak.
**Test frequency:** 40 – 80 kHz (auto sweep). Software calculates equivalent impedance at 128 Hz.
**Resolution:** 0.5 Ω with 2% FSD accuracy.
**Output frequency:** 45 Hz - 65 Hz (in 1 Hz steps)
**Output voltage:** 28.9 $V_{rms}$ max. The actual test voltage depends on impedance of C probe circuit, with lower impedance resulting in lower voltages.
**Output current:** 38.2 $mA_{rms}$ max. The actual test current depends on impedance of C probe circuit, with lower impedance resulting in higher currents. To ensure lowest measurement error higher, a test current is recommended this can be aided with the addition of multiple remote electrodes for the C probe circuit.
**Input impedance:** 1 MΩ
**Measurement range:** 0 – 200 Ω (1x range) 0 – 15 Ω (10x range).
**Dimensions:** 270 mm L x 250 mm W x 130 mm D
**Weight:** 2 kg
**LCD:** Resolution of 128×64 pixels with a display size of 55 x 64 mm.
**Battery:** The integrated 11.1V/7.8Ahr battery pack offers a run time of approximately 16 hrs.

# 6 Contact Details

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# 7 Kit List

The following parts are included with the full kit.

a) TT1000 meter
b) 70 m RG58 flexible cable (C1 electrode connection)
c) 50 m single core 1.5 $mm^2$ appliance wire (P1 electrode connection)
d) 2 x 1 m jumpers & crocodile clips (P2, C2 connections)
e) 2 x 300 mm long stainless steel test electrodes