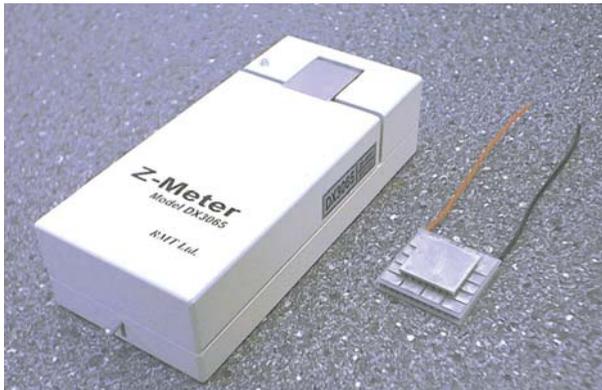


RMT Ltd.
Joint Stock Company

**Z-Meter
(TE Module Parameters Meter)
DX3065 Series**

User Guide



2002
Rev. 1.00

Edition July 2002

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RMT Ltd warrants that DX3065 Meter, if properly used and installed, will be free from defects in material and workmanship and will substantially conform to RMT's publicly available specification for a period of one (1) year after date of DX3065 Meter was purchased.

If the DX3065 Meter which is the subject of this Limited Warranty fails during the warranty period for the reasons covered by this Limited Warranty, RMT, at this option, will :

REPAIR the DX3065 Meter; **OR**

REPLACE the DX3065 Meter with another DX3065 Meter.

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1. Introduction

The DX3065 Z–Meter provides precise measurement of Thermoelectric modules' parameters.

- ***AC resistance (R)***
- ***Figure–of–Merit (Z)***
- ***maximum temperature difference (ΔT_{max})***
- ***time constant***

Using DX3065 Z–Meter it is possible to perform testing of various types of single– and two–stage TE modules.

Additionally, it is possible to evaluate quality of three– or more–stage TE modules by the measurement of electrical resistance.

Although the above listed parameters are measured at ambient temperature DX3065 Z–Meter provides recalculation of them to any standard temperature (+20°C or another software selectable).

The DX3065 Meter is managed by any IBM compatible computer under Windows95/98/2000 operating system.

2. Principles of Time Constant Measuring

2.1. Theoretical Grounding

Let us consider a one – stage thermoelectric cooler (TEC). The ambient temperature is T_a . At a certain moment the electric current in the TEC is turned on. The differential equation result for the TEC transient dynamics can be presented as the following exponential superposition:

$$\Delta T(t, x) = \sum_{i=1}^{\infty} (A_n U_n(x)) e^{-m_n t} + \Delta T_{st}(x) \quad (2.1)$$

where

$\Delta T(t, x) = T - T_a$, T is the temperature of the TEC point located at a time t and a generalized coordinate x ,

U_n and m_n are the eigenfunctions and eigen – values,

A_n are the thermal amplitudes,

$\Delta T_{st}(x)$ is the stationary result value.

The solution (2.1) analysis yields that the cooling process can be divided into two stages: irregular and regular. The first one is dictated by the initial moment's

conditions and is described by a multi-exponential interference. This stage fades out rather quickly and in case TEC pellets thermal conductance is high enough, the temporal behavior can be characterized by the only exponent, i.e:

$$m_{min} \ll m_n \quad (2.2)$$

for all possible indices n .

The theory yields the following expression for the time constant $\tau = 1/m_{min}$ of single-stage TEC's:

$$\tau = \frac{LC}{\left(1 + \frac{L\alpha j}{\kappa}\right) s\kappa N} \quad (2.3)$$

where

- C – TEC cold side heat capacity,
- α – the thermoelectric (TE) material Seebeck constant,
- κ – the TE material thermal conductivity,
- N – the TEC pellets number,
- L – the pellets length,
- s – their cross-section,
- j – the electric current density.

As (2.3) shows, τ calculation is stumbling because in practice the values involved in it are never known to the proper accuracy extent. The DX3065 allows to measure the time constant of single–stage TEC's and to estimate that of more–stage ones.

2.2. Interpolation Results

The procedure of handling the time constant measurement data is as follows.

The temporal behavior of a single–stage TEC temperature difference is measured via the Seebeck voltage that is a corresponding proportional value:

$$U_{\alpha} = \alpha\Delta T \quad (2.4)$$

For a two– or more–stage TEC this simple ratio is not applicable. However the time constant can be *estimated* by the temporal dependence of the Seebeck voltage and the approach for obtaining the stationary voltage values is the same.

The measuring procedure is carried out both for two electric supply polarities. The data collection duration and time step can be varied. The measuring chart window is presented in Fig. 2.1.

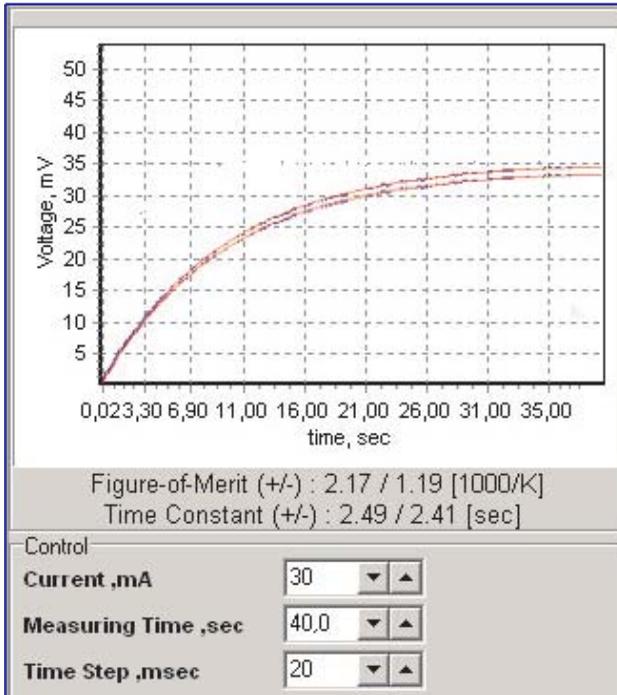


Fig. 2.1. Measuring window of Z-Meter program

The obtained experimental data is then fitted by the following function:

$$U_{\alpha}(t) = Ust_{\alpha}(1 - e^{-t/\tau}) \quad (2.5)$$

The exponential regression is based on the method of least squares. As its outcome the procedure provides the time constant τ and the stationary Seebeck voltage Ust_{α} .

3. Principle of Figure – of – Merit Measuring

3.1. Theory of Operation: Single – stage TEC

Among three parameters (R , Z , ΔT_{max}) measured by DX3065 Meter only AC resistance R is measured directly. The R measurement method is described in the Part “AC Resistance Measurement” of Chapter 4. The determination of the Figure – of – Merit Z and the maximum temperature difference ΔT_{max} of a thermoelectric (TE) module implements an indirect method, which allows to avoid labour – consuming thermophysical measurements. This approach is based on the Harman method.

The Figure – of – Merit is the most important performance parameter of a TE cooler. It is defined as

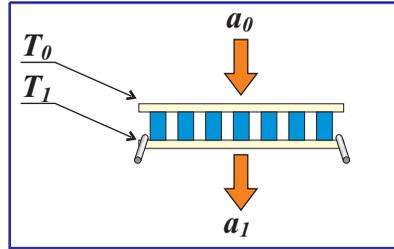
$$Z = \frac{\alpha^2}{kR} \quad (3.1)$$

where

- α – TE material Seebeck coefficient,
- k – thermal conductance of TE pellets material,
- R – Ohmic resistance of TE module.

From this time on we deal with the stationary mode values only (see Ch.2).

The base equations that describe a one-stage TE module power balance



$$\begin{cases} \alpha IT_0 - \frac{1}{2} I^2 R - k' \Delta T = \frac{a_0 (T_a - T_0)}{N} \\ \alpha IT_1 + \frac{1}{2} I^2 R - k' \Delta T = \frac{a_1 (T_1 - T_a)}{N} \end{cases} \quad (3.2)$$

where

- T_0 – cold surface temperature,
- T_1 – hot surface temperature,
- $\Delta T = T_1 - T_0$,
- T_a – ambient temperature,
- I – current passing through TE module,
- N – TE pellets number,
- a_0 – environment–cold side heat transfer term,
- a_1 – environment–hot side heat transfer term,
- k' – effective pellets thermal conductance.

The term k' describes thermal conductance normalized to one pellet between the cold and hot surfaces:

$$k' = k(1 + b_{th}) \quad (3.3)$$

where

$$b_{th} = B_{cond} + B_{rad} \quad (3.4)$$

The B_{cond} and B_{rad} are corrections for inter-pellets thermal conductance values through air thermal conductivity and radiation, respectively:

$$B_{cond} = \frac{\kappa_{air}}{\kappa} \left(\frac{1}{\beta} - 1 \right) \quad (3.4a)$$

Here the pellets filling term is:

$$\beta = \frac{Ns}{S}$$

where

- s – a pellet cross section,
- S – the cold side area.

$$B_{rad} = \gamma \frac{S}{Nk} \sigma T_a^3 (1 - \beta) \quad (3.4b)$$

where

- σ – Boltzman constant,
- γ – thermal emissivity.

At the heat exchange with environment

$$\frac{ai}{N} \ll k' \quad (3.5)$$

and the current

$$I \ll \frac{k'}{\alpha} \quad (3.6)$$

we have

$$\frac{U_{\alpha}}{U_R} = Z' \left(T_a + \frac{I^2 RN}{a_0 + a_1} \right) + \frac{(a_0 - a_1) I \alpha}{2k'(a_0 + a_1)} \quad (3.7)$$

where

$U_{\alpha} = \alpha(T_1 - T_0)$ – thermoelectric component
of the voltage dropout on a TE module (the
Seebeck voltage),

$U_R = IR$ – Ohmic component of the voltage
dropout on a TE module.

$$Z' = \frac{\alpha^2}{k' R}$$

Equation (3.7) contains directly the ambient temperature. If using the average temperature we should have allowed for the additional term $\sim a/2Nk$ characterizing heat dissipation from the external surfaces. Formula (3.7) takes this term into account automatically via the ambient temperature value.

Consider the equation for Z (3.7).

The second term in (3.7) generates a certain correction. It is remarkable however that this term is a linear function of the current. As a consequence summing the

$$\left(\frac{U_\alpha}{U_R}\right)_+ + \left(\frac{U_\alpha}{U_R}\right)_- = 2Z' \left(T_a + \frac{I^2 RN}{a_1 + a_2} \right) \quad (3.8)$$

That is we managed to solve the problem avoiding any asymmetry correction challenge.

So, the value $Z (= \alpha^2/kR)$ could be obtained as

$$Z = \frac{1}{T_a (1 + b_T)} \left\{ \left[\frac{U_\alpha}{U_R} \right]_{\text{averaged}} (1 + b_{th})(1 + b_r) \right\} \quad (3.9)$$

where

$$b_T = \frac{1}{T_a} \frac{I^2 RN}{a_0 + a_1} \quad (3.9a) \quad \left| \begin{array}{l} \text{Correction factor to ambient} \\ \text{temperature due to Joule} \\ \text{heating} \end{array} \right.$$

$$b_{th} = B_{cond} + B_{rad} \quad (3.9b)$$

Correction factor to pellet thermoconductivity due to additional heat flux from the warm side to the cold one through the medium (according to (3.2))

$$b_r = \frac{r}{R_{TEC}} \quad (3.9c)$$

Correction factor because of a non-zero resistance of TE module wires

where

$R_{TEC} = NR$ (The total voltage drop U_R is a sum of the drop U_{TEC} at the module and some additional drop at terminal wires (r is their resistance), so

$$U'_R = I(R_{TEC} + r) = IR_{TEC}(1 + b_r) \quad (3.10)$$

$$U_R = \frac{U'_R}{(1 + b_r)} \quad (3.11)$$

Due to the above formulated correction factors eliminate the effect of actual arrangement of Z-metering technique on the Z-value and allows to estimate the true material Figure-of-Merit.

3.2. Figure-of-Merit and ΔT_{max} for Single-stage TEC

The Z value corresponds to the maximum temperature difference on a module ΔT_{max} by a simple ratio

$$\Delta T_{max} = \frac{1}{2} Z T_0^2 \quad (3.12)$$

However the direct measurement of T_0 is complicated. A more convenient way is to measure the temperature difference through the hot surface temperature T_1 :

$$T_0 = T_1 - \Delta T_{max}$$

If the heat sink thermal resistance is little, the hot side temperature approaches the ambient temperature and $T_1 \approx T_a$ is used instead of T_1 .

Hence there is the following equation for ΔT_{max} :

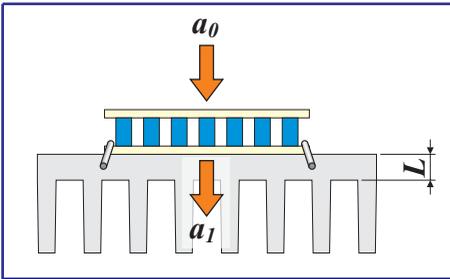
$$\Delta T_{max} = \frac{1}{2} Z (T_a - \Delta T_{max})^2 \quad (3.13)$$

Then it is easy to recalculate the value ΔT_{max} as a function of the ambient temperature:

$$\Delta T_{max}(T_a) = T_a - \frac{\sqrt{1 + 2Z T_a} - 1}{Z} \quad (3.14)$$

Here the dependence of Z on the temperature was ignored, which is quite allowable at the temperature scale considered. For instance if $Z=0.0027 \text{ K}^{-1}$, and $T_a = 300\text{K}$ we have the following temperature difference $\Delta T_{max} \sim 70 \text{ K}$.

3.3. Theory of Operation: a TEC mounted on the heat sink



Heat sink means a noticeable increase of heat dissipation through the TEC basement. It must be taken into account when estimating the

role of this factor in measurement results.

Equation (3.9)

$$Z = \frac{1}{T_a (1 + b_T)} \left\{ \left[\frac{U_\alpha}{U_R} \right]_{averaged} (1 + b_{th})(1 + b_r) \right\}$$

allows for heat dissipation through the warm side of TE with the corresponding term b_T and the voltage averaging. So the estimation of the b_T value of the assembled TE module is possible if taking into account thermal properties of the heat sink.

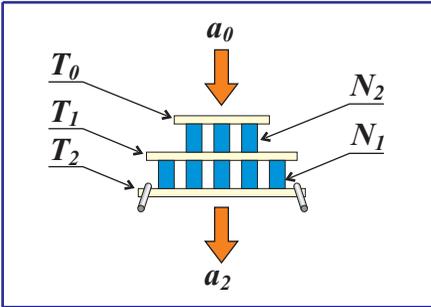
As a rough estimation we can assume

$$a_T = k_S \frac{S_S}{L_S} \quad (3.15)$$

where

- k_S – thermal conductivity of the heat sink,
- S_S – surface of the heat sink as the TEC projecting;
- L_S – thickness of the heat sink.

3.4. Theory of Operation: Z-measuring of a Two-stage TEC



Hereinafter we deal with the stationary mode values only (see Ch.2).

The general formulae for a two-stage module cold and hot sides are:

$$\begin{cases} \alpha IT_0 - \frac{1}{2} I^2 R - k'(T_1 - T_0) = \frac{a_0}{N_1} (T_a - T_0) \\ \alpha IT_2 + \frac{1}{2} I^2 R - k'(T_2 - T_1) = \frac{a_2}{N_2} (T_2 - T_a) \end{cases} \quad (3.16)$$

where

T_0, T_1, T_2 – TE module's cold side, medium and hot side temperatures, respectively.

N_1, N_2 – pellet numbers at the first and second stages.

If it is possible to assume that the heat transfer coefficient a_i and the pellets number N_i are proportional to the corresponding cold side areas S_i

$$\frac{a_0}{N_1} = \frac{a_2}{N_2} = A = \text{const}, \quad (3.17)$$

and

$$\beta_i = \frac{N_i S}{S_i} = \text{const}, \quad (3.18)$$

equations (3.16) are modified the following way:

$$\begin{cases} \alpha I T_0 - \frac{1}{2} I^2 R - k'(T_1 - T_0) = A(T_a - T_0) \\ \alpha I T_2 + \frac{1}{2} I^2 R - k'(T_2 - T_1) = A(T_2 - T_a) \end{cases} \quad (3.19)$$

Summing up equations (3.19) we derive:

$$2\alpha I \bar{T} = (k' + A)\Delta T \quad (3.20)$$

where $\bar{T} = \frac{T_2 + T_0}{2}$ is the average module temperature.

Solving the following set of equations

$$\begin{cases} 2\alpha I \bar{T} = (k' + A)\Delta T \\ I = \frac{1}{2R} \left(\frac{U_{R_1}}{N_1} + \frac{U_{R_2}}{N_2} \right) \\ \Delta T = \frac{1}{\alpha} \left(\frac{U_{\alpha_1}}{N_1} + \frac{U_{\alpha_2}}{N_2} \right) \end{cases} \quad (3.21)$$

we obtain the following

$$Z\bar{T} = (1 + b_{th})(1 + b_r) \frac{U_\alpha}{U_R} \quad (3.22)$$

$$b_{th} = B_{cond} + A_{conv} + (B_{rad} + A_{rad}) \quad (3.23)$$

The parameters B_{cond} , B_{rad} are described above (3.4a, 3.4b).

$$A_{conv} = \frac{al}{\kappa\beta} \quad (3.24)$$

$$A_{rad} = \frac{\gamma}{\kappa\beta} \sigma T_a^3 l \quad (3.25)$$

where A_{conv} , A_{rad} stand for convection and radiation external heat transfers, respectively.

The problem stated by eq. (3.16) is polarity–symmetrical. So, the averaging of the different polarity voltage ratios for accuracy concerns is appropriate. So eq. (3.22) can be rewritten as:

$$Z\bar{T} = (1 + b_{th})(1 + b_r) \left[\frac{U_\alpha}{U_R} \right]_{averaged} \quad (3.26)$$

Knowing the Z –value we can evaluate $\Delta T_{max} = T_1 - T_0$ finding the maximum of the following function:

$$\Delta T(x) = T_a - \frac{x^2}{2Z(x+1)} - \frac{I}{((\xi - 1)x + \xi + 1)(x+1) - 1} \\ \times \left[(\xi + 1) \frac{x^2}{2Z} + \xi T_a + \frac{x^2}{2Z(x+1)} \right] \quad (3.27)$$

where

$$\xi = \frac{N_2}{N_1} \quad - \text{the cascading coefficient,}$$

$$x = \frac{\alpha I}{k'} \quad - \text{dimensionless current.}$$

For instance if $Z = 0.0027 \text{ K}^{-1}$, and $T_a = 300 \text{ K}$ we have the following temperature difference $\Delta T_{max} \sim 100 \text{ K}$.

3.5. Material Z and measured Z

Regarding all the correction factors discussed above, it is clear that the material Figure-of-Merit (when there is no heat exchange with environment) is always higher than the measured Figure-of-Merit. It is convenient to relate the two values via the coefficient $a > 1$:

$$Z = a Z_{measured} \quad (3.28)$$

4. Technics

4.1. DX3065 Meter Arrangement

The body of the DX3065 Meter is made of an aluminum alloy. The metal body executes a function of a passive thermostat for measured modules. Temperature of the body is measured with digital thermometer with accuracy not worse than 0.1°C .

A module to be measured is placed in this box.

The connection of the module is made through special connectors. For a reduction of the effect of contact resistance the modules are connected under the four-wire (Kelvin Clips) scheme.

Simplified Functional Diagram of DX3065 Meter is shown in Fig. 4.1.

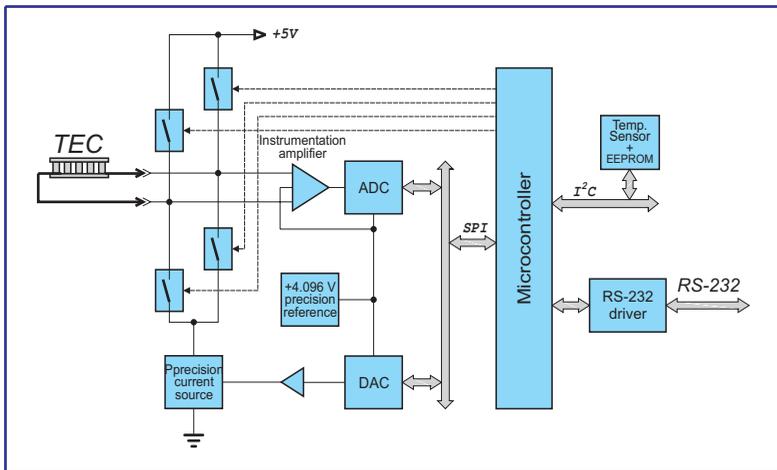


Fig. 4.1. Simplified functional diagram of DX3065 Meter

4.2. AC Resistance Measurement

For resistance measuring the module is tested by AC of a small amplitude. The AC is simulated with the Commutator, which periodically (with 50% duty circle) reverses a circuit of the reference current I_m . The simplified diagram of the Commutator is shown in Fig. 4.2.

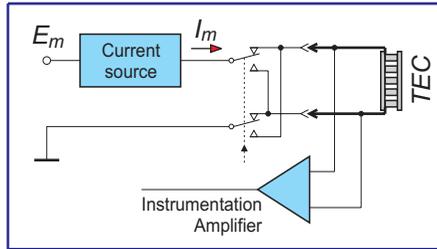


Fig. 4.2. The simplified diagram of AC resistance measuring

In the no input signal state the output voltage of the Instrumentation Amplifier (IA) is equal to $E_m/2$, where $E_m = 4.096$ V (Fig. 4.3).

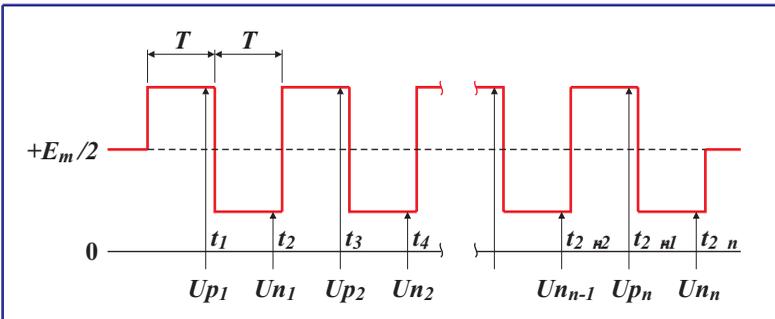


Fig. 4.3. Output signals of Instrumentation Amplifier at AC resistance measuring

During AC resistance measuring the output voltage of the IA is sampled and measured by 12 bit ADC every time before I_m current reversing. The sampling points are marked as t_i in Fig. 4.3. The voltage drops on TE module when positive current (Up_i) and negative current (Un_i) are used for a TE module resistance (R) calculation under the following formula :

$$R = \frac{\sum_{i=1}^n (Up_i - Un_i)}{2 \cdot I_m \cdot A_V \cdot n} \quad (4.1)$$

where

- Up_i – voltage drop on TE cooler at positive testing current I_m
- Un_i – voltage drop on TE cooler at negative testing current I_m
- I_m – testing current
- A_V – voltage gain of Instrumentation Amplifier
- n – total number of samples per measurement

The typical values of parameters in formula (4.1) are as follows:

- $I_m = 2 \text{ mA}$
- $A_V = 5 \text{ or } 50$
- $n = 50$

4.3. U and U_α Measurement

At measurement of U and U_α parameters the small current I_T is applied to a module periodically (with 50% duty circle).

Two successive measuring sessions are necessary to obtain the U and U_α values at different testing current polarities.

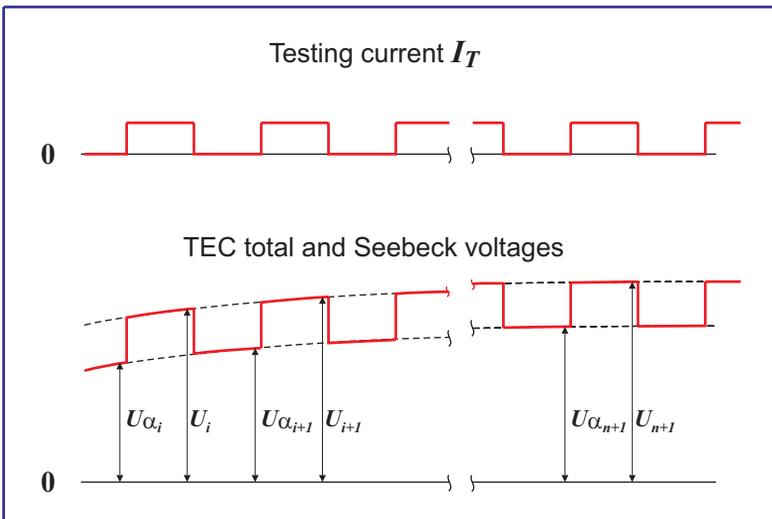


Fig. 4.3. Test current and voltages schematic temporal behaviour

5. Working with Z–Meter

The DX3065 Meter works under the control of the **Z–Meter** program. The **Z–Meter** program provides all possible operational modes of the DX3065 Meter. The **Z–Meter** has the simple interface and does not demand a User's special knowledge.

The **Z–Meter** software is delivered with the DX3065 Meter.

5.1. System Requirements

- IBM PC compatible computer with Windows 95/98/2000 operating system
- Free COM port
- 2 MB free hard drive space (additional space may be required later as your database grows)
- Mouse or compatible pointing device

5.2. Program Installation

Z–Meter is supplied on CD.

Insert the CD into the appropriate drive and start the Setup program.

The window of the standard Windows installer will appear (Fig. 5.1).

Pass all the steps of the installation procedure sequentially according to the installer directions.

When selecting the logic disk you must keep in mind that the program requires not less than 2 Mb of hard disk space. (As database size increases the additional disk space can be required).

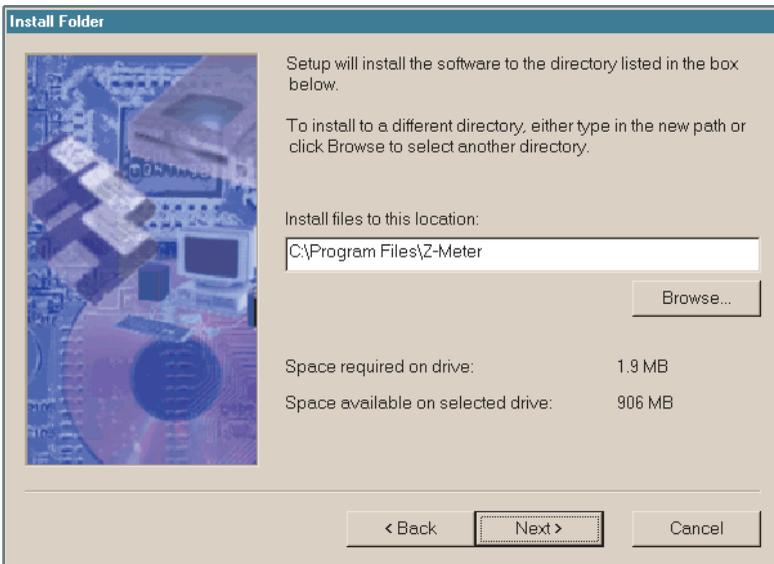


Fig. 5.1. The Z-Meter installation window

5.3. Hardware Preparation

Turn DX3065 Meter back side to yourself. From this side you will find out the following elements (Fig. 5.2):

- Power ON/OFF button
- LED power indicator
- Power supply input connector
- RS-232 connector

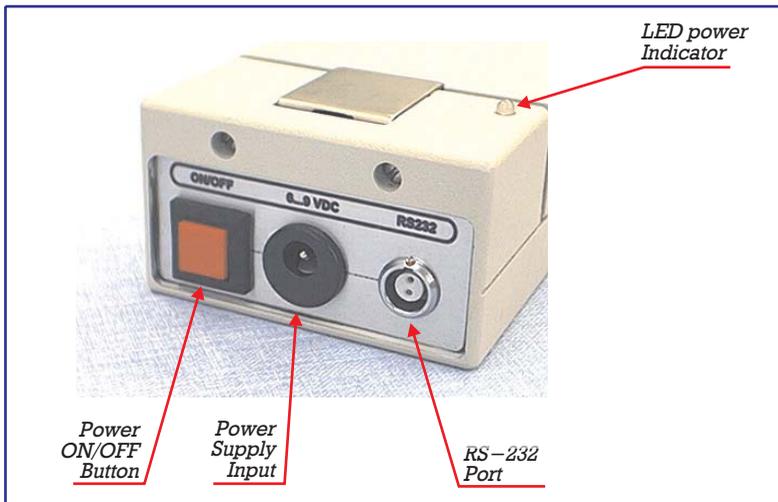


Fig. 5.2. The back side of DX3065 meter



Fig. 5.3. RS-232 interface cable connection

1. Make sure, that the DX3065 is switched off.
2. Using the DX3065-C-01 cable connect DX3065 Meter to COM port which you are going to use for DX3065 driving (Fig. 5.3).
3. Connect the AC/DC adaptor to Power Supply Input (Fig 3.4).
4. Push «Power ON/OFF» button and turn the Meter on.
5. Turn on your computer if it was off.

Now you can run the «Z-Meter» program and measure parameters of TE coolers.



Fig. 5.4. AC/DC adaptor connection

5.4. Measurement of Parameters of TE coolers

Before measuring it is necessary to keep the DX3065 Meter and tested TE modules indoor during one hour in the same room where TE modules will be measured. This is necessary to even temperature of TE modules and DX3065 Meter.

Important !

If the DX3065 Meter was outdoor at low temperature for a long time (temperature below +10°C), it is necessary to keep Z-Meter at room temperature for not less than 2 hours.

Press the handle down (Fig. 5.5) and open the cover of the DX3065 Meter. There are six terminal blocks underneath. The first three are intended for one lead of a TE cooler, the other three for the other lead.



Fig. 5.5. Cover unlock handle

Turn the arm type buttons of those contacts that best correspond to the TE cooler size and insert the leads into holes (Fig. 5.6).

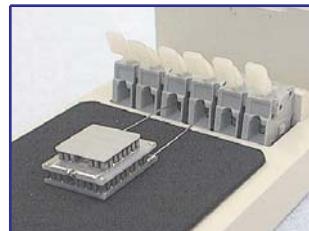
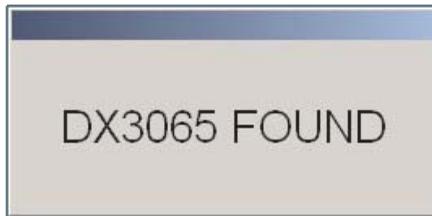
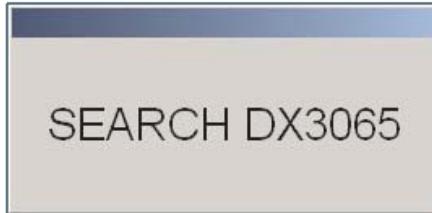


Fig. 5.6. TE coolers's leads insertion

Close the cover and run the **Z-Meter** program.

If you run the **Z-Meter** program for the first time after the program setup, the following windows will be displayed one after another:



Then the window as shown in Fig. 5.7 will appear.

If the following message appears



make sure you have switched on the device and have the COM port and device cabled, and retry.

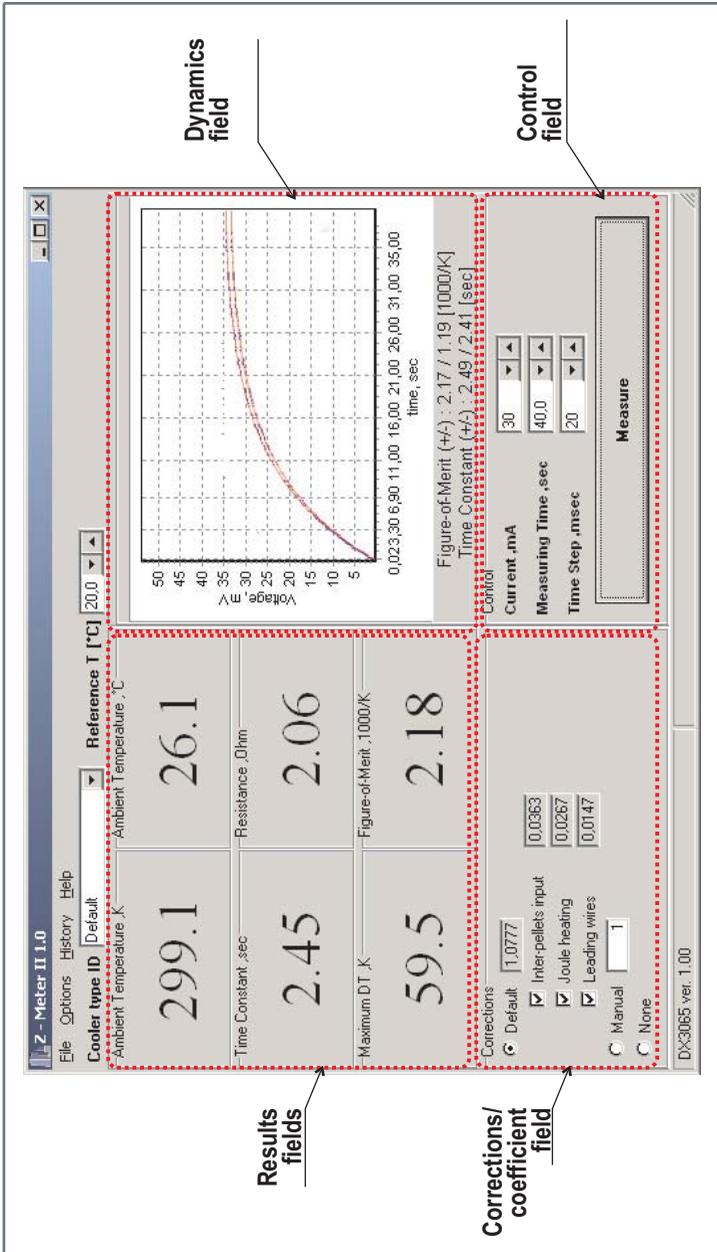


Fig. 5.7. The main window of Z-Meter program

5.5. The Main Program Window

The main program window is shown in Fig. 5.7. Its functional structure is common for three Z-meter measurement options:

- Single-stage TEC measuring
- Single-stage TEC mounted on a heat-sink measuring
- Two-stage TEC measuring

This general window includes the following:

5.5.1. Title



The narrow band at the top of the Main window is a window title. It's header consists of constant and variable parts. The constant part includes the application name and revision number. The variable one points to the TECs measuring option selected.

5.5.2. Menu bar



There are four commands in Menu bar.

- «**File**» is used when it is necessary to reconnect the Device or exit.



- «**Options**» command allows to:
 - 1) add/edit cooler type;
 - 2) select a TEC database;

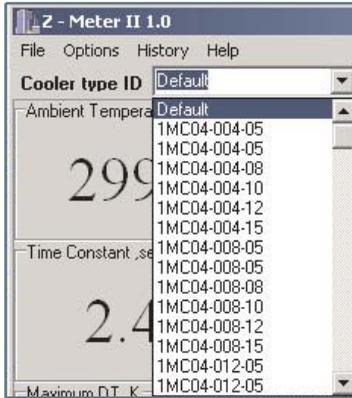


- «**History**» command allows to view the list of current measuring session results stored in the History file.
- «**Help**» command allows to derive the information concerning Z-meter program



5.5.3. Reference Bar

There are two fields in the Reference bar.



The left field « Cooler type ID» in the Reference bar is a list box for selecting a TE cooler type to be tested.

The right field «Reference T» in the Reference bar serves for reference temperature input. You may type any reference T

directly in the window or increment/ decrement the current value by 0.1 with the  and  buttons.

Besides that, you can click the **right** mouse button inside the «Reference T» input field. The following list must fall down

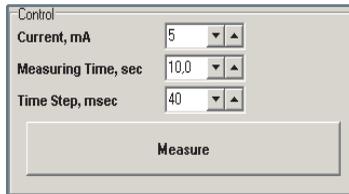


You may choose one from standard reference temperatures (20 and 30°C) or use the ambient temperature as a reference.

5.5.4. Functional Fields

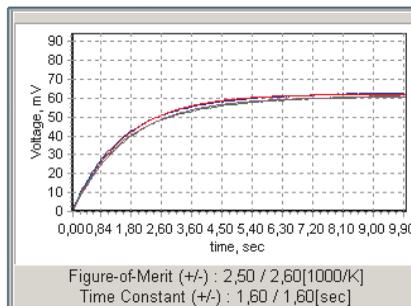
There are four functional fields :

- «Control» field presents the Seebeck voltage temporal behavior and Z – metering input parameters (see Chapter 2):
 - 1) measuring current,
 - 2) total measuring time,
 - 3) time step;



The «Measure» button starts the measuring procedure.

- «Dynamics» field presents the Seebeck voltage temporal behavior telemetry chart window (see Chapter 2): $U_{\alpha}(t)$: measured and interpolated at different current polarities.



It also provides obtained values:

- 1) Time constants at different current polarities,
- 2) Z at different current polarities.

- «Corrections/Coefficient» field includes calculated corrections values (see Chapter 3). It allows to switch a certain correction ON or OFF. As an alteration it provides the corrections compounding into a general coefficient a (see Formula (3.28)).

Corrections

Default 1,05952

Inter-pellets input 0,05778

Joule heating 0,00006

Leading wires 0,00169

Manual 1

None

For this coefficient determination it allows to choose one of the three following approaches:

- ♦ Default – Using the corrections calculated in the corrections field
 - ♦ Manual – Using a User's own coefficient value
 - ♦ None – Using neither corrections nor coefficients at all
- «Results» field contains measured/calculated results:
 - 1) TEC ACR,
 - 2) Ambient temperature,

- 3) TEC figure-of-merit (averaged via the values calculated in the Dynamics field),
- 4) TEC maximum delta-temperature.

Ambient Temperature, K 298,2	Ambient Temperature, °C 25,1
Time Constant, sec 1,60	Resistance, Ohm 17,00
Maximum DT, K 65,7	Figure-of-Merit, 1000/K 2,50

The window, besides, implements the function of the status indicating device.

5.6. Single–stage TEC Z–metering

To measure a single–stage TEC select a «Single stage» option from the «**Option >> Cooler Type**» command.

5.6.1. Reference

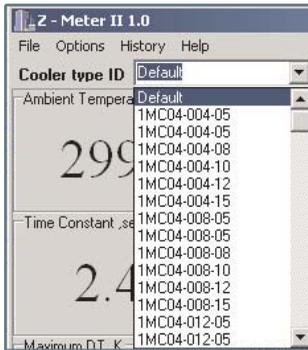
The parameters of TE coolers can be measured at various ambient temperatures. The indications of DX3065 Meter will be varied with temperature (See Chapter 3. Principle of Operation).

Hence, measured parameters must be corrected to some reference temperature. RMT Ltd uses 30°C reference temperature, other manufacturers may use their own values.

Choose a reference temperature from the «Reference T» list.

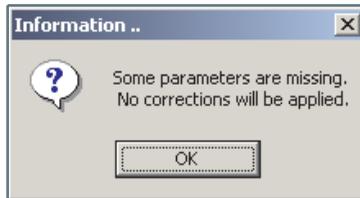
If there is no required reference temperature in the list,

5.6.2. Cooler Type



Choose a type of TE cooler to be tested from the « Cooler type ID» list. The list represents a TEC base selected via the «Options» – «TEC Base» command. RMT is the default TEC base.

The following window reports that one or more fields of the TEC base string selected is/are blank.



Keep in mind that the 'TE coolers' list is sorted alphabetically.

If you cannot find the necessary type in the list, you should introduce TEC parameters to the database manually. (See Chapter “Database Update”).

If you have no information on parameters of the tested TE cooler, you may choose the corrections/coefficient default mode and the TEC will be measured excluding any corrections.

5.6.3. Corrections Field

Once the measuring procedure is completed you can see the obtained corrections and results in the corresponding fields. With all TEC parameters available all the corrections are taken into account by default.

The corrections are specified in Table 5.1.

You are able to switch this or that correction on/off with the help of corresponding radio button pairs on the «Corrections» field. The Results window fits the changes automatically.

Table 5.1. Corrections (for the One – stage option calculated by (3.9a – c) for the Two – stage option calculated by (3.22 – 3.25) excluding the Joule heating correction).

#	Field Title	Mnemonics	Description
1		b_T	Correction factor showing Joule heating - energy dissipation ratio
2	Inter-pellets input	b_{th}	Correction factor to pellet thermoconductivity due to additional heat flux from the warm side to
3		b_r	Correction factor because of non-zero resistance of TE module wires

By default the «Results» field data are calculated with all the corrections switched ON in the «Corrections» field. These corrections are equivalent to a certain coefficient a . The latter is described in formula (3.28)

The «Coefficient Mode» Field allows a User to apply either the coefficient calculated within all the ON – corrections (Default Mode), or to offer one's own coefficient (Manul Mode), or to refuse any corrections and therefore set the coefficient equal one.

5.6.4. Measurement Notes

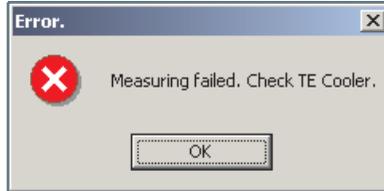
Important !

The temperature of a TE cooler changes slightly owing to a hands touching. Also the measuring procedure induces slight cooler temperature increasing.

So maintain a pause of about this test 3 time constants before the next one. It is 30 seconds on average.

This time is approximately enough to stabilize the TE cooler temperature (see Chapter 2).

It may happen that after clicking the «Measure» button the following message appears:



This message means one of the following:

- open circuit inside the TE cooler,
- short circuit inside the TE cooler.

The latter reason is practically improbable, so really only the first one can occur.

Check the terminals. Maybe the contact is poor. Retry measuring. If still you see the same message, the TE cooler must be rejected.

As it was mentioned above, the DX3065 Meter can be applied for more than two–stage TE coolers' quality checking by measuring electrical resistance.

To do this, leave the «TE Cooler Type» unselected (Default Type in the «TE Cooler Type» field). Insert a TE cooler into the DX3065 Meter and click the «Measure» button. You should ignore all the results except the resistance one.

5.7. Z-metering of a Single-stage TEC on the Heat Sink

All the information presented above for Option 1 remains true except for the Heat Sink Parameters Field. With the help of these parameters the corrections are calculated allowing for Formula (3.9a–c) and (3.15).

5.8. Z-metering of a Two-stage TEC

All the information presented above for Option 1 remains true except the following.

1. A default Cooler type does not allow to estimate ΔT_{\max} because for this purpose the cascading coefficient value is necessary.
3. The Corrections field is the same but the corrections values are calculated differently for this case (see formulae (3.22) – (3.25)).
2. For a two-stage TEC ratio (2.4) is not applicable and the time constant can be only roughly *estimated* by the temporal dependence of the Seebeck voltage.

5.9. History

The outcomes of each measurement are stored in the file. You can view or clear it using the «History» command.

The history file is created in the “/History” folder of the “/Z-meter” directory in every measuring session after the first successful measurement. (“Measuring session” means the period between the first successful measurement and the program exit). The history file name has the form of the date and time of the history file creating.



If you need to add some title, comment or any other additional short information into the history file, you must type it in the «Comment» field on the top of the «History» window.

If you need to save the «History» file with another name, use the «Save» command.

With the «Print» command you can make the hard copy of the «History» file on a default printer.

The «New» command closes the current history file and opens a new one with no data.

The order of data arrangement in the «History» window is represented below.



The screenshot shows a window titled "History" with a menu bar containing "File". Below the menu bar is a "Comment:" field with the text "15 - jun - 2002 13:00". Below the comment field is a table with the following data:

N	Chk	ID	T(C)	R(Dhm)	RefT(C)	Time	dTmax	Z
1	<input checked="" type="checkbox"/>	1MC04-004-15	40,0	17,00	20,0	1,60	66,00	2,50
2	<input checked="" type="checkbox"/>	1MC04-008-05	40,0	17,00	30,0	1,60	69,00	2,50
3	<input checked="" type="checkbox"/>	1MC04-008-05	40,0	17,00	20,0	1,60	65,00	2,50

The «Chk» field is sacred for records marking. Only marked records will be copied on a printer under the «Print» command.

The marking/unmarking is performed with the mouse left button click on the appropriate field. The default condition is "Marked".

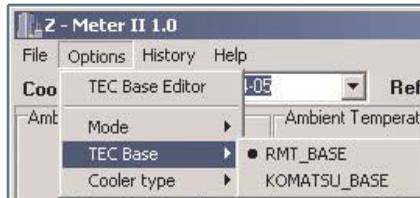
5.10. Database Update

If the parameters of a TE cooler you are going to deal with are not introduced in the database, you must add them yourself.

To do it you should first of all find out the following parameters of TE cooler :

- TEC cold size dimensions
- The number of pellets (for a two–stage TEC the pellets number at each cascade)
- TE pellet cross–section
- TE pellet height
- TEC wires material
- Wire length
- Wire thickness

If there are no these parameters in the manufacturer's specification, you can measure them yourself by means of slide gauge.



After you have prepared all the necessary data, select the «Options» – «TEC Base Editor» command from the «Cooler» menu. The window titled «Add TE cooler» will

appear as shown below.

There are two input boxes in the window: «Cooler» and «Leads». All fields are beforehand filled in with defaults. You should enter the true values of parameters in them.

The contents of «cooler ID» field are not used for calculations. You can fill any information in this field, but you had better enter there the manufacturer's brand.

Add TE Cooler

Cooler

Cooler ID: Default

Cooler type: Single stage Two stage

Cold size dimensions (mm x mm): 0 x 0

Hot size dimensions (mm x mm): 0 x 0

Ceramics thickness (mm): 0

Pellets number: 0

TE pellets cross-section (mm x mm): 0 x 0

TE pellets height (mm): 0

Leads

Electrical resistivity (xE-6 Ohm x mm): 0

Length (mm): 0

Thickness (mm): 0

Buttons: Cancel, Delete, Add/Modify

After all the fields in both boxes are filled in with the appropriate data click on «Add/Modify» button.

To remove the record concerned some TE cooler from the database, select it from the «**Cooler ID**» list and click on the «**Delete**» button.

6. Maintenance

The DX3065 Meter does not require any maintenance or service.

Nevertheless if for any reason you feel doubtful about the device's accuracy, you can check up it by measuring a precision resistor instead of a TE cooler.

It is best to measure a resistor of 5 to 20 Ohms. If a precision resistor is not available, any other can be used. But at first it should be measured with a digital multimeter with the accuracy not less than 3 decimal digits.

Compare the obtained data. If the difference in the resistance values is within 0.5%, it is possible to consider the Z – Meter serviceable.

7. Standard Kit

#	Item	Code	Quan.
1	Z-Meter	DX3065	1
2	AC/DC Adaptor		1
3	RS-232 Cable	DX3045-C-01	1
4	CD with software	Z-Meter	1
5	User's Manual		1



8. Specifications

Measured parameters

Electrical Resistance

Range	0.1 to 100 Ohms
Accuracy	0.5%
Repeatability	0.3%

Thermoelectric Efficiency

Range	$1..5 \times 10^{-3} \text{ K}^{-1}$
Accuracy	0.5%
Repeatability	0.3%

Supply requirements

Supply voltage	+7 to +9 V DC
Supply current	250 mA max

Operation conditions

Temperature range	0° to 45°C
Relative humidity	0 to 95%

Mechanical

Dimensions	60 × 35 × 135 mm
Weight	310 g (max)

