



OTC  
Ver 1.0.0.0001



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# 1. Warnings

ABB SACE S.p.A. responsibility towards the user necessarily presumes that the program has been used in a professionally correct manner and that the user has followed all the given precautions/instructions.

Even in the case of program defects which have been detected and verified, ABB SACE S.p.A. shall only be responsible for repairing the program in a reasonable length of time.

ABB SACE S.p.A declines all responsibility for either direct or indirect damages, however caused, to the user or third parties by use or non-use or late availability of the program, magnetic support or documentation supplied.

The user must:

- check the use of the program supplied by ABB SACE S.p.A. and the reliability and accuracy of the data entered, and also that the data entered fully corresponds with and is consistent with the printed results;
- take all necessary precautions to safeguard and preserve data and to allow him to reconstruct data using his own means should the data be lost or destroyed due to an error in handling or entering data and/or an error in using the program, or even an operational defect of the program and/or processor used;
- ensure that the program is only used by professionally and technically qualified personnel able to use it correctly.

The user must follow the instructions and notes given and take all the precautions recommended at all times.

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- Changing, adapting, re-designing or creating applications based on the program itself, on the files or documentation supplied is forbidden.
- ABB SACE S.p.A. reserves the right to take legal action to protect its interests.
- The software is not for sale and is distributed for promotional purposes only.

## 2. Introduction

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The thermal calculation module makes it possible to evaluate the thermal behaviour of ABB boards and – if desired – to dimension the fans and air-conditioning units to be installed in the board. It can also be used on sets of boards obtained by installing several units side by side.

## 3. Reference standards

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The algorithms used by the software are as described in Standard IEC 60890, hereinafter the “Reference Standard”; if the use of air-conditioning or fans is specified (a situation not considered in the Reference Standard), the program still uses computation algorithms that are compatible with Standard EN 60439 on low-voltage boards.

### 3.1. Range of applicability of the results

The Reference Standard specifies very clearly the applicability of the calculation algorithms: The proposed method makes it possible to determine the overtemperatures, or the air temperatures, inside the enclosure, but is unable to determine the temperatures of individual equipment, devices and cables contained in it

The temperatures of the air inside the board is the same as that of the ambient air outside the enclosure plus the overtemperatures of the air inside the board due to the power dissipated by the devices installed (when the air-conditioning is used)

Unless otherwise specified, the temperature of ambient air outside the PTТА corresponds to the temperature specified for PTТА units for indoor installation: 35°C (average value over 24 hours). If the temperature of the ambient air outside the PTТА at the utilisation site exceeds 35 °C, this higher temperatures is regarded as the temperature of the ambient air in the PTТА. The distribution of dissipated power inside the enclosure is basically even; the devices are installed in the board so as not to hinder the circulation of the air, other than to a minimal extent

The equipment installed is designed for DC or AC, up to and including 60 Hz, with the sum of supply circuit currents not exceeding 3150A

The cables carrying high currents and the structural parts are arranged so as to ensure that losses due to eddy current will be negligible

In enclosures with ventilation openings, the cross-section of the air outlet holes is at least 1.1 times as big as the cross-section of the air inlet openings

Any of the compartments of the PTТА will not contain more than three horizontal frames

When enclosures with external ventilation openings are divided into cells, the area of the ventilation openings in each internal horizontal frame must cover at least 50% the horizontal section of the cell.



#### **WARNING**

The results of the calculation process are reliable provided that the conditions defined in the Reference Standards are complied with. Otherwise, the algorithms employed might fail to provide a correct interpretation of the physical reality of the temperatures inside the board.

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## 4. Menu commands

Using the menu commands, the management of the ABB thermal calculation module is user-friendly and all the relative calculation processes can be performed easily.

### 4.1. File menus

The “File” menu contains the following commands:

**New** > creates a new computation file

**Open...** > opens a previously saved thermal dimensioning file (extension \*.tra)

**Save** > Saves the calculation underway; it creates a file in binary format with extension \*.tra; at the same time, a text file (\*.txt) is also created to facilitate the consultation of the results obtained

**Save as...** > Saves the thermal dimensioning project underway with a name other than the current one

**Data** > Enables the user to enter, or change, the data in the project heading (customer, plant, project, board ...)

**Export drawing** > Exports the board overtemperatures curve in \*.wmf format for pasting in other applications

**Print...** > Prints the data and the results of the thermal calculations

**Exit** > Closes the thermal calculation module

### 4.2. Help menu

The Help menu gives access to the help file, the information about the product version and its utilisation conditions.

## 5. Module for the determination of overtemperatures

To use the thermal calculation module, first of all you must specify the “Cooling system” that you intend to adopt by selecting one of the three options listed. The next item to be selected is the unknown quantity that you want to determine by selecting the desired “Quantity to be determined” option. Choosing an unknown converts the other options into data that have to be defined before starting the dimensioning process.

Cooling system	Target of calculation
Natural ventilation	Temperature profile Losable power
Forced ventilation	Temperature profile Losable power Fan capacity
Air-conditioning	Temperature profile Losable power Conditioning power

**MCC1-b.tra - Temperature-rise assessment according to IEC 60890**

File Help

**Cooling system**

- ☒ Natural ventilation
- ☐ Forced ventilation (\*)
- ☐ Air-Conditioning (\*)

(\*) Method not contemplated by the reference standard

**Target of calculation**

- ☒ Temperature profile
- ☐ Losable power

Ventilation grid's area: 0.00 [cm²]

**Disposition**

- ☒ Separate enclosure, detached on all sides
- ☐ Separate enclosure for wall-mounting
- ☐ First or last enclosure, detached type
- ☐ First or last enclosure, wall-mounting type
- ☐ Central enclosure, detached type
- ☐ Central enclosure, wall-mounting type
- ☐ Covered on 2 sides and top surface, for wall mountir

**Dimensions [mm]**

Height: 2000  
Width: 800  
Depth: 600

Horizontal frames: 0

**Effective cooling area (Ae)**

		Ao [m²]	b	Ao x b [m²]
Top surface	Exposed	0.48	1.40	0.67
Front surface	Exposed	1.60	0.90	1.44
Back surface	Exposed	1.60	0.90	1.44
Side surface	Exposed	1.20	0.90	1.08
	Exposed	1.20	0.90	1.08
Ae				5.71

Ae < 11.5 m² and Width < 1.5 m, so overtemperature will be calculated on the whole enclosure.

**Dimension used for calculation [mm]**

Height: 2000  
Width: 800  
Depth: 600

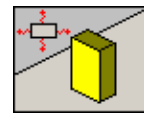
Cancel Next >

(Figure 1) – First window of the tool for the calculation of overtemperatures

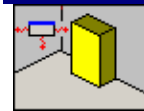
The central part of the interface is dedicated to the definition of the properties of the board, i.e., the input data relating to its construction characteristics; in particular, the user must specify:

Type of installation

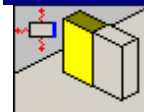
Regardless of the calculation method adopted, the user can choose from among the installation modalities defined in the Reference Standard and listed below.



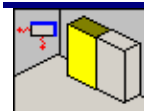
Separate enclosure, detached on all sides



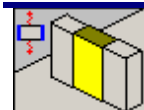
Separate enclosure for wall-mounting



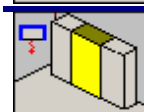
First or last enclosure, detached type



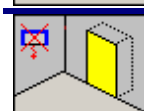
First or last enclosure, for wall-mounting



Central enclosure, detached type



Central enclosure, wall-mounting type



Covered on 2 sides and top surface, for wall mounting

Dimensions of the enclosure

Horizontal frames

(See 3.1 (*Range of applicability of the results*))

Moreover, in the case of natural ventilation, the user must also specify:

The area of the ventilation grids

In the case of forced ventilation or air-conditioning, when the values are not given as outputs from the calculation, the user must specify:

Fan capacity, or

Air-conditioning power

You can enter the air-conditioning power from the keyboard or use a calculator shaped button to select one of the values offered by ABB.

The zone dedicated to the “Effective cooling area (Ae)” displays some partial results of the calculation, i.e., some parameters determined according to the Reference Standard, which help the user understand the calculation performed; obviously, this requires a good knowledge of the calculation method employed (this is recommended, but is totally at the discretion of the user).

Click “Next>” to access the second and last page of the calculation.

**MCC1-b.tra - Temperature-rise assessment according to IEC 60890**

File Help

Selected method: Natural ventilation -> Temperature profile

**Power losses**

Devices rated power losses	200.0 [W]
Demand factor	0.85 <sup>2</sup>
Conductors power losses	20.0 [W]
Extra power losses	65.0 [W]

Ambient temperature: 35.0 [°C]

**Results**

Power [W]

Devices rated power losses	200.0	x
Demand factor	0.85	<sup>2</sup> =
Devices power losses	144.5	+
Conductors power losses	20.0	+
Extra power losses	65.0	=
<b>Total power losses</b>	<b>229.5</b>	

Ambient temperature: 35.0 [°C]  
 Temperature at maximum height: 51.6 [°C]

**Graph:** Y-axis:  $\Delta t$  [°C] (0.0 to 2.0), X-axis: Delta t [°C] (0 to 20). A red curve shows the temperature rise.

$\Delta t_{1,0}$ : 16.6 [°C]  
 $\Delta t_{0,5}$ : 11.7 [°C]

< Back OK

(Figure 2) – Second window of the tool for the calculation of overtemperatures

The first line under the menu recalls the cooling system and the calculation target selected in the first screen.

The box “Power losses” enables the user to define the powers dissipated and the demand factor, i.e., the main factors contributing to heating the board; in particular, as far as dissipated powers are concerned, it is possible to define the contribution of the devices installed (“Devices rated power losses”), the contribution due to bars and cables (“Conductors power losses”) plus a generic contribution available to the user (Extra power losses).

The calculator to the right of the demand factor opens a window with the preferential values that can be assigned to this factor as a function of the number of main circuits present in the board.





## WARNING

The software performs the calculation in real time and updates whenever an input value is changed. This means there is no need to use a specific command to perform the calculation and consistency between the data is always ensured; the results are displayed on screen for the user to see and can be printed out at any time.

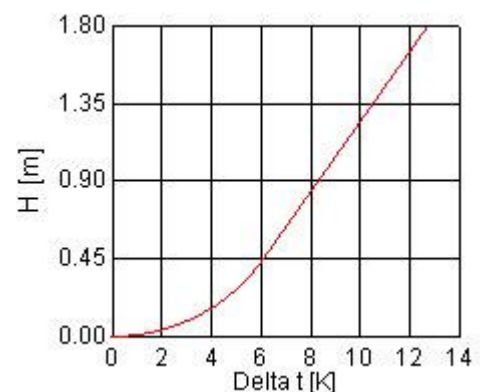
All the results of the calculation are grouped in the “Results” box.

The “Power [W]” box provides an overview of the powers dissipated in the board and, depending on the cooling system adopted, the power removed by the fan or the air-conditioning system.

In this manner it is easy to see how the software determines the value of “Total power losses” which is then used to calculate the internal overtemperatures with the method specified in the Reference Standard.

The overtemperatures vs. enclosure height curve (available only in the case of natural ventilation) makes it possible to determine the temperatures at the points where the devices are installed.

It is sufficient to know the installation height of the device to be checked, read the overtemperature value on the abscissas and add the “Ambient temperature” value to obtain the internal temperature of the board at the desired height.



(Figure 3) – Graphic of overtemperatures inside the enclosure



## Printing the graphic

You can either print the calculation report, or

Use the **Export drawing** command in the **File** menu, or

Move the mouse pointer over the graphic, right click and select “**Export drawing**”: now you can paste the graphic in any other application!

The value assumed by the calculation target selected in the first page appears in the bottom part of the screen.

The table below provides an overview of the parameters calculated by the software depending on type of cooling system and the calculation target selected by the user.

Cooling system	Target of calculation	Results
Natural ventilation	Temperature profile	Temperatures at the top of the enclosure Overtemperature at the middle of the enclosure Overtemperature at the top of the enclosure
	Losable power	Maximum losable power Maximum losable power still available (residual) Overtemperature at the middle of the enclosure Overtemperatures at the top of the enclosure
Forced ventilation	Temperature profile	Temperatures at the top of the enclosure Overtemperature at the middle of the enclosure Overtemperature at the top of the enclosure
	Losable power	Maximum losable power Maximum losable power still available (residual) Overtemperature at the middle of the enclosure Overtemperatures at the top of the enclosure
	Fan capacity	Power losses extracted by the fan Fan capacity Overtemperature at the middle of the enclosure Overtemperatures at the top of the enclosure
Air-conditioning	Temperature profile	Average temperature inside the enclosure
	Losable power	Maximum losable power Maximum losable power still available (residual)
	Conditioning power	Power losses extracted by the air-conditioning Air-conditioning power

## 6. Calculation algorithms and formulas: basics

As mentioned above, if natural ventilation is used, the calculation method adopted is that of the Reference Standard. In the presence of air-conditioning or fans (situations not envisaged by the Reference Standard), the calculation algorithms used are still compatible with Standard EN 60439.

Some important details of the calculation process are given below.

### 6.1. Determination of Ae

The determination of Ae (Effective cooling area that determines the heat exchange between the enclosure and the external environment) is generalised to the entire ABB thermal calculation module and is applied both in the case of natural ventilation and in the case of forced ventilation or air-conditioning.

For further details on the calculation process see the Reference Standard.

### 6.2. Forced ventilation

In the case of forced ventilation (a situation not considered by the Reference Standard), the thermal power extracted by the fan is determined with this formula:

$$P = Q \cdot (T_e - T_i) / f_x$$

where:

P = Power to be extracted [W]

Q = Fan capacity [m<sup>3</sup>/h]

f<sub>x</sub> = Thermal exchange coefficient [m<sup>3</sup> °C/Wh]

T<sub>e</sub> = Ambient temperatures [°C]

T<sub>i</sub> = Temperatures inside the enclosure [°C] (T<sub>e</sub> < T<sub>i</sub>)

The table below gives the values of f<sub>x</sub> as a function of altitude above sea level (from the qualitative standpoint, air density decreases with increasing altitude and its capacity to subtract heat decreases accordingly).

Altitude above sea level of installation site [m]	f <sub>x</sub> [m <sup>3</sup> °C/Wh]
0 – 100	3.1
100 – 250	3.2
250 – 500	3.3
500 – 750	3.4
750 – 1000	3.5

Then, the power extracted by the fan is subtracted from the power dissipated in the enclosure and the calculation is performed according to the Reference Standard without natural ventilation openings.

For further calculation details, see the Reference Standard.

### 6.3. Air-conditioning

Air-conditioning is not taken into account in the Reference Standard; in this case, the software uses the formulas given below.

As a rule, the use of air-conditioning shows that ambient temperature is greater than the

interior temperature of the enclosure: in this case, the contribution of the thermal power that is transmitted through the surface of the board must be summed to the power losses due to the devices, the cables, etc.

This contribution is obtained from the following formula:

$$P_a = K_f \cdot A_e \cdot (T_e - T_i)$$

where

$P_a$  = Power entering the enclosure through the environment [W]

$A_e$  = Effective cooling area [m<sup>2</sup>]

$T_e$  = External temperature [°C]

$T_i$  = Interior temperature [°C]

$K_f$  = Thermal exchange coefficient (depending on the board wall material; in our case it is  $K_f = 5.5$  [W / m<sup>2</sup> °C])

The air-conditioning power to be installed is given by this formula:

$$P_c = P_t / K_x$$

where

$P_c$  = Air-conditioning power to be installed [W]

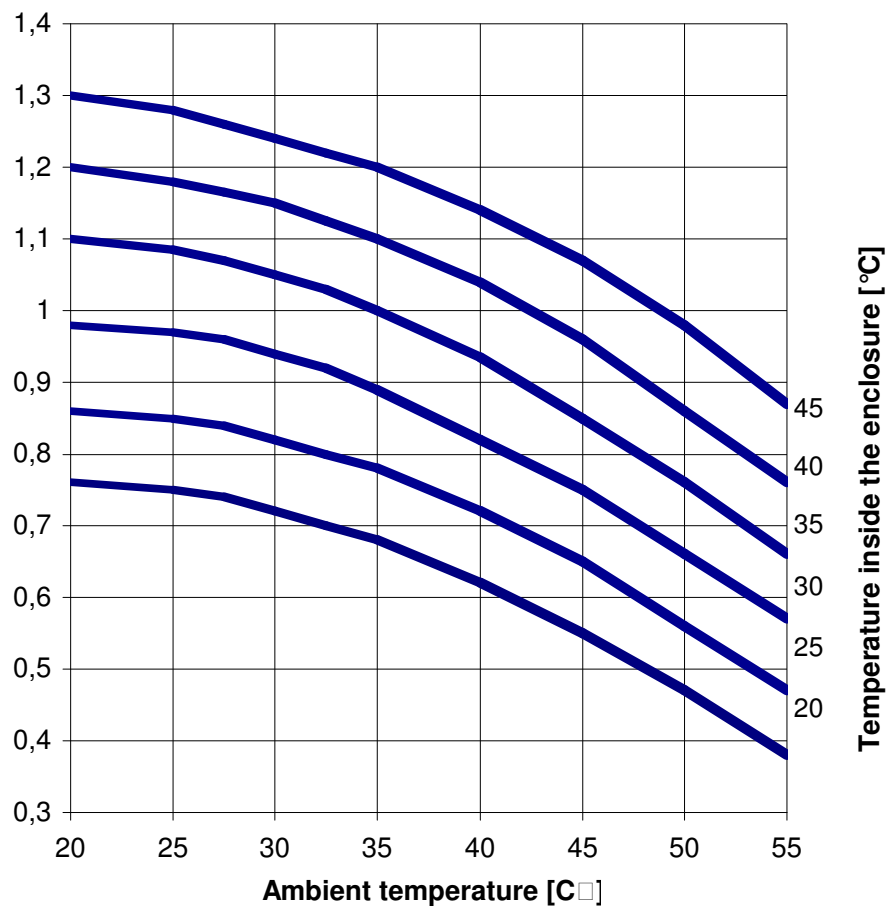
$K_x$  = Cooling efficiency of the air-conditioning

$P_t$  = Total power loss in the board ( $P_a$  included) [W]

The  $K_x$  factor, which is a function of the ambient temperature and the temperature you want to obtain inside the board, is given by the manufacturer of the air-conditioning system. For ABB air-conditioners,  $K_x$  is obtained from the diagram shown below (only ambient temperatures in the 20 - 55°C range and interior temperatures in the 20 - 45°C range can be considered).

The software adds the power  $P_a$  to the power dissipated inside the board, subtracts the power removed by the air-conditioning and then performs the calculation according to the Reference Standard without natural ventilation openings.

For further details on the calculation process, see the Reference Standard.



(Figure 4) – Kx factor determination diagram

## 7. Printouts

The thermal calculation module offers ad hoc report forms as a function of the “Cooling system” adopted; printed reports contain all the parameters needed for the thermal dimensioning calculation: both the input data (dimensions of the board, installation modalities...) and the results (temperatures, power losses...).

The items – Customer, Plant, Project/Quotation, Board, Designer and Date – that appear in the heading of the printed documents can be added to the calculation report through the main menu **Data** command.

If they are not associated with a numerical value, the items “Total power losses”, “Losable power” and “Losable power still available (residual)” will not be taken into account.