Maintenance and operations manual

DICO MODULE

8 Analog Inputs

7/8 Thermocouples and 1 Pt100

Order no.: **5903512825**

Date: **March 2002**

Rev: **1.1**

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SYSTEM Electronics

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This product meets the **EMC** requirements of **EEC** Directive **89/336.**

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1. General

Module **DICO 7/8 THERMOCOUPLES INPUT and 1 Pt100** is an interface with 8 thermocouple inputs type "J", "K", "T", "R" and "S" Pt100 (or voltage) which can be fitted into one of the slots of the MOTHERBOARD of DICO 102 and 502 units.

Each input can be configured separately for any of the above mentioned types.

If Pt100 probes are to be used, the first channel is the dedicated one. The SW controls allow the other channels to be configured as Pt100 but the accuracy of the readings will be reduced.

The module includes a multiplexing isolated section, a conditioning section and a 16 bit A/D conversion section and related interface.

The acquired data is linearized and converted using digital techniques according to engineering variables (tenths of degree C), thanks to the use of a micro-controller 87C52. When the parameters related to module configuration (number and type of channels enabled for conversion) are changed, they are automatically stored in the non-volatile memory (EEPROM).

A disconnected input signal lead and a reversed polarity thermocouple is provided for each enabled input. The connection is checked automatically at start-up or during normal operation by using the SW control. Control of reversed polarity is always carried out while the module is operating.

To allow the module to operate, a NTC type heat resistor having the required features, should be placed between terminals COMnA and COMnB (Par. 3.2).

This heat resistor is required to compensate for the cold junction and is supplied by **SYSTEM s.p.a. Div. Electronics** (separate from the module in question).

2. Specifications

- **Number of input channels:** Max 8, can be configured with SW control
- **Type of input**

  THERMOCOUPLE J, K, T, R, S

  HEAT RESISTOR Pt100 with 2 or 3 wires

  VOLTAGE (0 - 78.125 mV)

  RESISTANCE (0 - 350 Ohm)

  can be configured independently for each channel by using the SW control
- **Insulation:** yes,

  200 Vdc (for adjacent channels)

  500 Vdc (to GND)
- **Max source resistance:** 1000 Ohm (accuracy is reduced with a 0.1% degree of error FSR every 250 Ohm)
- **Bandwidth:** 0 - 10 Hz
- **A/D conversion:** 16 bit
- **Range of measurement:** (depends on the type of thermocouple)

  J 0 : 850 °C

  K 0 : 1200 °C

  T 0 : 450 °C

  R 0 : 1500 °C

  S 0 : 1700 °C

  Pt100 -230 : +700 °C

  Ohm 0 : 350 Ohm

  mV 0 : 78.125 mV
- **Accuracy:** (depends on the type of thermocouple)
  (Error from 0 to full-scale value)
  (Ta = ambient temperature)

Type	Ta = 25°C	Tmin < Ta < Tmax
J	**1°C**	**2.2°C**
K	**1°C**	**2.7°C**
T	**1°C**	**1.9°C**
R	**3°C**	**6.5°C**
S	**3°C**	**6.5°C**
Pt100	**0.6°C**	**1.7°C**
mV	**300 ppm**	**1200 ppm**
ohm	**0.25 ohm**	**0.7 ohm**

Table 2.1

- **Accuracy:** 0.1 °C
- **Scanning time:** 160 + 100 * (number of enabled channels) msec. (time required to convert all the enabled channels)
- **Operating temperature:** 0 - 60 °C
- **Relative humidity:** up to 85% without condensate
- **Dimensions:** 114 × 68 mm

3. Addressing and configuration

Each module comes with 4 jumpers J1 thru J4 for selecting one of the four the module addresses (see MOTHERBOARD and CPU44 documentation).

WARNING!

NEVER energize more than one addressing jumper on the same module at the same time.

The module addresses are as follows:

	STAND_ALONE (8044)	EXTENDED(80186)
	BASE	BASE
BANK**#1**	**FFC0H/FFC7H**	**$+080H/$+0FFH**
BANK**#2**	**FFC8H/FFCFH**	**$+100H/$+17FH**
BANK**#3**	**FFD0H/FFD7H**	**$+180H/$+1FFH**
BANK**#4**	**FFD8H/FFDFH**	**$+200H/$+27FH**

Table 3.1

Symbol <$>, indicated with the EXTENDED mode active, refers to the base of the I/O peripherals. The value can be set via software by using the CPU186. <1000H> is recommended as it is compatible with the software supplied by **SYSTEM SPA Div. Electronics** (C_Thru_ROM).

From now on, for added clarity, the storage locations taken up by each module will be indicated in terms of OFFSET. The user, during programming, should add the OFFSET value to the BASE address when a specific module register is to be referred to.

Note that the external terminals on the module are related to the slot being used (SLOT 1, 2, 3 and 4) while the module addresses depend on the jumpers selected J1 - J4.

The addresses associated to the logic slots for the STAND_ALONE (CPU8044) and EXTENDED configurations (CPU 80C186) are shown above.

3.1 Addressing

The module (accessible from an external CPU) has an 8 register bank. If the MOTHERBOARD is provided with **DICO CPU186** module (**EXTENDED** mode), the module can be accessed directly from the CPU 80C186. If this is not the case, the data bus is automatically configured so as to directly interface with the **CPU8044** (**STAND_ALONE** mode).

The read/write address maps for the two above mentioned configurations are illustrated below.

READ									
OFFSET									
EXTENDED	**STAND_ ALONE**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0H	0H	FIFO_OUT							
2H	1H								
4H	2H								
6H	3H								
8H	4H								
AH	5H								
CH	6H	0	0	0	0	1	1	TFF	RFF
EH	7H	0	0	0	0	1	0	1	0

Table 3.1.1

FIFO_OUT = Data register for sending messages from the MODULE to an external CPU. This register (1 byte) is used to send messages (replies) from the module to the external CPU and it is written by the CPU 87C52 contained in the module. If this register is read, status bit TFF (FIFO_OUT down-loading) will be reset. The module will then load the FIFO_OUT with the next message byte. This data item is significant (FIFO_OUT full) when the corresponding bit TFF = 1.

TFF = Status of FIFO_OUT register: TFF = 1 if the FIFO_OUT register is full.

RFF = Status of FIFO_IN register: RFF = 1 if the FIFO_IN register is full and the CPU 87C52 on the module has not down-loaded it yet. If a byte is written in the FIFO_IN register when RFF = 1, the previous byte will be overwritten giving rise to a protocol error.

ID_CODE = Module id. code: 0Ah

SCRITTURA									
OFFSET									
EXTENDED	**STAND_ ALONE**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0H	0H	FIFO_IN							
2H	1H								
4H	2H								
6H	3H								
8H	4H								
AH	5H								
CH	6H								
EH	7H								

Table 3.1.2

FIFO_IN = Data register used to send messages from the external CPU to a MODULE (CPU 87C52): This register (1 byte) also serves to send messages (commands) from the external CPU to the module. Status bit RFF is set when writing on this register; the module will then down load the FIFO_IN register.

FIFO_IN can be written from the external CPU when corresponding bit RFF in the FIFO_STATUS register is 0.

3.2 Programming

The programming procedures can be performed by exchanging a limited number of messages by using the 1 byte FIFO interface architecture described above.

Communication protocol

The module is of the slave type, i.e. it can respond to any signal from the external CPU.

All the messages provided and the relevant structure are listed below.

(Each box indicates a message byte)

COMMAND	REPLY
Data read 01	(3+3*configured channels +1) bytes CHAN. STATE | DATA H | DATA L | . . . | CHAN. STATE | DATA H | DATA L | 00
Data requested 04	MODE STATE | 00
Configuration 06 | TYPE 1 | TYPE 2 | . . . | TYPE 7 | TYPE 8	MODE STATE | 00
Enable connection check 07	MODE STATE | 00
Read configuration 08	TYPE 1 | TYPE 2 | . . . | TYPE 7 | TYPE 8 | 00
Reset 09	(No reply)
Read release SW 0A	REL. SW | 00
Configuration heat resist.NTC 0C | 11 | 12 | 13 | TYPE NTC	MODE STATE | 00
Read NTC parameters 0D	TAB 0 H | TAB 0 L | . . . | TAB 9 H | TAB 9 L | TYPE NTC | 00
Load table NTC 0E | TAB 0 H | TAB 0 L | . . . | TAB 9 H | TAB 9 L	MODE STATE | 00

Table 3.2.1

Command 01 (hex)

Data read-out

As shown in Table 3.2.1, the reply is of varying length and depends on the number of configured channels.

The first three bytes always relate to the temperature of the cold joint. The first status byte is always identified F0 (hex) while the next bytes are data bytes.

Three bytes are then transmitted (one channel status byte and 2 data bytes) for each configured channel.

The last character of the reply message is always 0. Although the number of configured channels is unknown, it is always possible to identify the end of the message because the end character (0) takes up the space of a CHANNEL STATUS character, which can never be zero.

CHANNEL STATUS

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
T3	**T2**	**T1**	**T0**	**S**	**C2**	**C1**	**C0**

Table 3.2.2

(C2, C1, C0) = Channel index to which the two following data bytes refer.

The channel index has a binary code if the number of the channel related to the terminal block is marked CHAN_NUM (see 4.3 Connections):

1 <= CHAN_NUM <= 8 and

(C2, C1, C0) = CHAN_NUM - 1.

(E.g.: if (C2, C1, C0), the two following bytes are related to the data converted in channel 3).

S = Check bit for connection and reverse polarity

When the module is turned on or suitable signals are sent (see below), weak currents are delivered (100 nA, rated) to each input in order to check the resistance in the connection and the electrical continuity.

If an input is disconnected (open circuit), this is indicated by changing corresponding bit S to 1. The bit remains stored until the input connections are checked again.

During module operations, bit S is then set when a temperature less than -10°C is measured in an input is configured as a thermocouple. In this case, the measurement is used for the reverse polarity.

(T3, T2, T1, T0) = Type of converted input

(T3, T2, T1, T0)	Channel configuration	Range
0	Not used	
1	Type J thermocouple	0:+850°C
2	Type K thermocouple	0:+1250°C
3	Type T thermocouple	0:+450°C
4	Type R thermocouple	0:+1500°C
5	Type S thermocouple	0:+1700°C
6	Pt100	-230:+750°C
7	Ohmmeter	0:350 ohm
8	MV_meter	0:78.125 mV
F	cold joint	0:65°C

Table 3.2.3

DATAH and DATAL

The two bytes DATAH and DATAL indicate the less and more significant bytes of the 16 bit word:

DATA_WORD = DATAH and DATAL which stand for the converted data.

Data has a binary code without signs and will provide a value expressed in 1/10 of °C if the corresponding channel is configured as a thermocouple or Pt100.

If the channel is set to a certain voltage, DATA_WORD will not be an engineering variable, i.e.:

DATA_WORD = 65535 * Vin (mV) / 78.125.

Command 04 (hex)

Status request (module)

MODULE STATE

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
S7	S6	S5	S4	S3	S2	S1	S0

Table 3.2.4

S0 = **Configured module**, if this bit is zero, the module will not be configured. This normally takes place when a configuration command is executed.

S1 = **Check connections in use.** If S1 = 1, the module is checking the connections. With this stage (max 3 channel scanning times), no converted data is provided, i.e. the operating state of the module will not be “ready” (see bit S3).

S2 = **Set module.** This bit is always to be 1. If it is not, this means the module is faulty or needs adjustment.

S3 = **Ready.** If S3 = 1, data will be scanned again.

S4 = **ad_failure.** The A/D converter does not work.

S5 = **ad_error.** Communication problems between micro-controller 87C52 and A/D converter.

S6 = **unknown command.** S6 = 1 indicates that the external CPU has sent a wrong signal or the configuration parameters are not correct (e.g. type of channel not existing).

S7 = **eprom_failure.** Communication problems between micro-controller 87C52 and A/D converter.

Command 06 (hex)

Configuration

The command is always a 9 character message. The first character identifies the command and the remaining 8 characters indicate the type of desired input. The type of channel is assigned according to the order in which the characters are sent, i.e. the 2nd character of the message refers to channel 1, the 3rd character to channel 2, etc....

If the conversion of any channel is to be interrupted, type in 0 next to the corresponding TYPE character.

The coding of the TYPE bit is as follows:

TYPE (hex)	Channel Configuration	Range
00	Not used	
10	type J thermocouple	0:+850°C
20	type K thermocouple	0:+1250°C
30	type T thermocouple	0:+450°C
40	type R thermocouple	0:+1500°C
50	type S thermocouple	0:+1700°C
60	Pt100	-230:+750°C
70	Ohmmeter	0:350 ohm
80	MV_meter	0:78.125 mV

Table 3.2.5

Each time the configuration is refreshed, the changes are stored in a non-volatile memory (EEPROM) and remains stored, even after the machine is turned off, until the configuration is changed again.

The reply will be the same as for Status Request.

Command 07 (hex)

Check connections

This command starts a check procedure on all the connections. Weak currents (100nA, rated) are delivered to each input in order to check the resistance at the connections and the correct polarity of the sensor.

If an input is disconnected (open circuit) or polarity is reversed (reversed terminals) this is indicated in the corresponding STATUS bit: bit S will change to 1.

This bit remains stored until the input connections are tested again.

If an input is disconnected:

DATA_WORD = FFFFh

if polarity is reversed and the input is set up as a thermocouple:

DATA_WORD = 0

After the signal has been sent, no converted data will be provided (3 channel scanning times), i.e. the operating state of the module will not be “ready”.

The reply to this command is identical to that of Status Request.

Command 08 (hex)

Read configuration

The reply to this command is given with a 9 character string. The first 8 characters are the TYPE bytes of the actual configuration system, while the ninth character is the ending one.

The coding of this command is identical to that used for the configuration.

Command 09 (hex)

Reset

This command is sent to reset the module.

Command 0A (hex)

Read release SW

Byte REL_SW contains a data item that represents the decimal coding of the actual firmware version in micro-controller 87C52 (e.g. for version 4.0 REL_SW = 40).

If REL_SW > 63, the actual version in the module will be 3.0 or earlier.

Command 0C (hex)

Set heat resistor NTC

(cold joint compensation)

This command is indicated by a 4 character string, which minimise the possibility of wrong modifications by the application software.

Byte TYPE_NTC allows the user to set the type of NTC thermistor to be used for cold joint compensation.

The required TYPE_NTC byte is selected among 5 preset bytes present in the firmware or of the “custom” type (if TYPE_NTC = 5) according to the characteristics that the user has specified on the EEPROM by using command “Load NTC table” (see command 0E).

The chart below shows the types, main characteristics and **SYSTEM SPA Electronics** order numbers for the NTC heat resistors included in the firmware.

TYPE NTC	Rated value at 25°C (Kohm)	Tollerance on the rated value	Accuracy rate (MAX error)	System code
0	1	1%	NO	7409121000
1	2	1%	NO	7409122000
2	2.7	3%	0.4°C	7409122700
3	2.2	5%	1.3°C	7409122200
4	1	20%	6°C	9999351070
5	<3	?	?	NO

Table 3.2.6

WARNING!

If TYPE_NTC = 5 is selected without entering data with the “Load table NTC” command, the module will not work; the STATUS_MOD byte will always be zero.

Command 0D (hex)

Read NTC parameters (presently configured)

The reply consists in a vector of 18 bytes that should be considered as 8 words. Each word includes two consecutive bytes TABnH and TABnL that are of more or less importance:

TABn = TABnH, TABnL

TABn where n = 0 thru 8 which are the normal values in the line table of the NTC presently configured.

Data item 19 of the reply is byte TIPO_NTC described in the previous paragraph.

Command 0E (hex)

Load table NTC (on EEPROM)

This command can be used to configure a module for the heat resistor that compensates for cold joints having different characteristics from those provided with the firmware.

Each word is composed of two consecutive bytes TABnH and TABnL, which are more or less significant:

TABn = TABnH, TABnL

The values in the table are to be calculated on the basis of the following formula:

TABn = 256 * Rnom / 1000 * exp (1 / TRn - 1 / Trif)) with n = 0 thru 8

where:

Rnom = rated resistance (in Ohm) at 25 °C

B = Constant B (determined by manufacturer)

TRn = 268 + 10 * n

Trif = 298

WARNING!

The max Rnom value = 3Kohm. This table should then be selected by sending the command signal “Set heat resistor NTC” by setting TYPE_NTC = 5.

4. Installation and connections

4.1 Installation

The I/O modules come with unifilar connectors, located on the edge on the soldered side, which are to be fitted into the selected on the MOTHERBOARD.

There is no polarization or guide for plugging in the connector, therefore make sure:

a) the connector pins are inserted into the respective female fittings

b) the module is properly positioned in relation to the MOTHERBOARD by referring to the connector numbering and the reference mark as shown below:

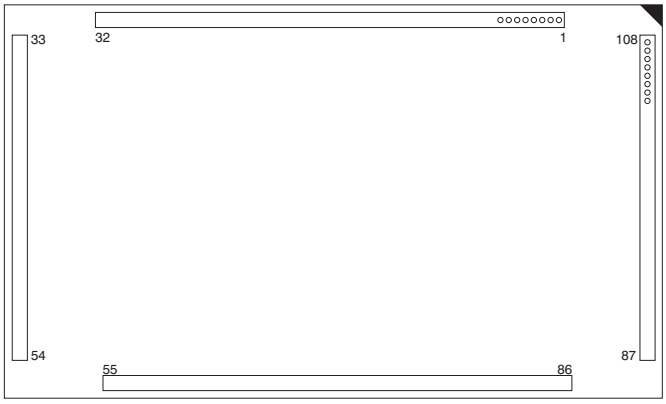

Figure 4.1.1 Module positioning.

4.2 Layout of jumpers and other components

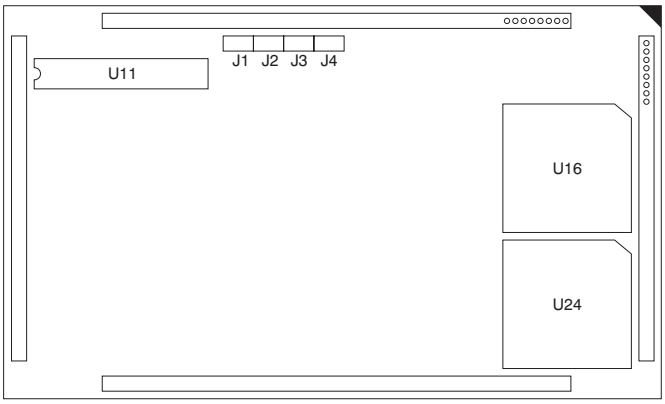

Figure 4.2.1 Jumper location.

4.3 Connections

TERMINAL BLOCK DICO 108

WD-B	1	2	WD-A
0 IO-16	3	4	0 IO-14
0 IO-15	5	6	COM 0
REF 0	7	8	REF 1
1 IO-1	9	10	1 IO-2
1 IO-3	11	12	1 IO-4
1 IO-5	13	14	1 IO-6
1 IO-7	15	16	1 IO-8
1 IO-9	17	18	1 IO-10
1 IO-11	19	20	1 IO-12
1 IO-13	21	22	1 IO-14
1 IO-15	23	24	1 IO-16
COM 1A	25	26	COM 1B
2 IO-1	27	28	2 IO-2
2 IO-3	29	30	2 IO-4
2 IO-5	31	32	2 IO-6
2 IO-7	33	34	2 IO-8
2 IO-9	35	36	2 IO-10
2 IO-11	37	38	2 IO-12
2 IO-13	39	40	2 IO-14
2 IO-15	41	42	2 IO-16
COM 2A	43	44	COM 2B
REF2	45	46	REF3
3 IO-1	47	48	3 IO-2
3 IO-3	49	50	3 IO-4
3 IO-5	51	52	3 IO-6
3 IO-7	53	54	3 IO-8
3 IO-9	55	56	3 IO-10
3 IO-11	57	58	3 IO-12
3 IO-13	59	60	3 IO-14
3 IO-15	61	62	3 IO-16
COM 3A	63	64	COM 3B

Figure 4.3.1 Terminal Block DICO 108.

TERMINAL BLOCK 028

– –	127 128	– –	– –	1 2	– –
– –	125 126	– –	– –	3 4	– –
6 I/O 15	123 124	6 I/O 16	COM 1A	5 6	COM 1A
6 I/O 13	121 122	6 I/O 14	REF 1	7 8	COM 1B
6 I/O 11	119 120	6 I/O 12	1 I/O 1	9 10	1 I/O 2
6 I/O 9	117 118	6 I/O 10	1 I/O 3	11 12	1 I/O 4
6 I/O 7	115 116	6 I/O 8	1 I/O 5	13 14	1 I/O 6
6 I/O 5	113 114	6 I/O 6	1 I/O 7	15 16	1 I/O 8
6 I/O 3	111 112	6 I/O 4	1 I/O 9	17 18	1 I/O 10
6 I/O 1	109 110	6 I/O 2	1 I/O 11	19 20	1 I/O 12
REF 6	107 108	COM 6B	1 I/O 13	21 22	1 I/O 14
COM 6A	105 106	COM 6A	1 I/O 15	23 24	1 I/O 16
5 I/O 15	103 104	5 I/O 16	COM 2A	25 26	COM 2A
5 I/O 13	101 102	5 I/O 14	REF 2	27 28	COM 2B
5 I/O 11	99 100	5 I/O 12	2 I/O 1	29 30	2 I/O 2
5 I/O 9	97 98	5 I/O 10	2 I/O 3	31 32	2 I/O 4
5 I/O 7	95 96	5 I/O 8	2 I/O 5	33 34	2 I/O 6
5 I/O 5	93 94	5 I/O 6	2 I/O 7	35 36	2 I/O 8
5 I/O 3	91 92	5 I/O 4	2 I/O 9	37 38	2 I/O 10
5 I/O 1	89 90	5 I/O 2	2 I/O 11	39 40	2 I/O 12
REF 5	87 88	COM 5B	2 I/O 13	41 42	2 I/O 14
COM 5A	85 86	COM 5A	2 I/O 15	43 44	2 I/O 16
4 I/O 15	83 84	4 I/O 16	COM 3A	45 46	COM 3A
4 I/O 13	81 82	4 I/O 14	REF 3	47 48	COM 3B
4 I/O 11	79 80	4 I/O 12	3 I/O 1	49 50	3 I/O 2
4 I/O 9	77 78	4 I/O 10	3 I/O 3	51 52	3 I/O 4
4 I/O 7	75 76	4 I/O 8	3 I/O 5	53 54	3 I/O 6
4 I/O 5	73 74	4 I/O 6	3 I/O 7	55 56	3 I/O 8
4 I/O 3	71 72	4 I/O 4	3 I/O 9	57 58	3 I/O 10
4I/O 1	69 70	4I/O 2	3 I/O 11	59 60	3 I/O 12
REF 4	67 68	COM 4B	3 I/O 13	61 62	3 I/O 14
COM 4A	65 66	COM 4A	3 I/O 15	63 64	3 I/O 16

Figure 4.3.2 Terminal Block DICO 028.

All the terminals shown in the figure are indicated with the following notation:

<N> IO-<n>

where:

N number of slots (shown on the MOTHERBOARD) the terminal in question is connected to;

n input/output index related to the module fitted into slot N.

In reference to this documentation the following can be stated:

TERMINAL		INPUT	FUNCTION
<N>	IO-1	T-(1)	negative pole, channel 1 of Thermocouple or heat resistor Pt100
<N>	IO-2	T+(1)	positive pole, channel 1 of Thermocouple or heat resistor Pt100
<N>	IO-3	T-(2)	negative pole, channel 2 of Thermocouple
<N>	IO-4	T+(2)	positive pole, channel 2 of Thermocouple
<N>	IO-5	T-(3)	negative pole, channel 3 of Thermocople
<N>	IO-6	T+(3)	positive pole, channel 3 of Thermocouple
<N>	IO-7	T-(4)	negative pole, channel 4 of Thermocouple
<N>	IO-8	T+(4)	positive pole, channel 4 of Thermocouple
<N>	IO-9	T-(5)	negative pole, channel 5 of Thermocouple
<N>	IO-10	T+(5)	positive pole, channel 5 of Thermocouple
<N>	IO-11	T-(6)	negative pole, channel 6 of Thermocouple
<N>	IO-12	T+(6)	positive pole, channel 6 of Thermocouple
<N>	IO-13	T-(7)	negative pole, channel 7 of Thermocouple
<N>	IO-14	T+(7)	positive pole, channel 7 of Thermocouple
<N>	IO-15	T-(8)	negative pole, channel 8 of Thermocouple
<N>	IO-16	T+(8)	positive pole, channel 8 of Thermocouple
COM	<N>A	COMP	heat resistor for compensation of cold joint
COM	<N>B	COMP	heat resistor for compensation of cold joint
REF	<N>	COMPT100	compensation cable (third wire) for Pt100

Table 4.3.1

If 2 wire Pt100 heat resistors are used, connect the terminals at T+ (channel number) and T- (channel number) and bridge terminals T- (channel number) and COMPT100.

If a channel is set to operate as an ohmmeter, the resistor should be connected in the same way as the two wire heat resistor described above.

Heat resistor NTC is to be connected to terminals COM <N> A and COM <N> B.

WARNING!

In order for the module to operate properly, a NTC type heat resistor, having the required characteristics, should be installed between terminals COMnA and COMnB.