

Balley
ANALOG

**Analog Master Module
NAMM02**

Calibration Guide

This instruction supplement must be used with Product Instruction EIS-012-3 for the Analog Master Module, NAMM02.

Instruction Supplement
EIS-12

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Section 1 - Introduction

The Analog Master Module (NAMM02) is an intelligent NETWORK 90® module which interfaces to thermocouples, RTDs, and hi-level inputs to provide process measurements, such as temperature, to a control system. The calibration functions are a software mechanism to determine correction factors for errors introduced by minor variations in hardware. Hi-level slaves do not need to be calibrated.

The calibration functions determine the offset and gain errors and compute correction factors for them. In the NAMM02, these factors are combined with a leadwire resistance factor which corrects for the errors induced by the thermocouple and RTD field wiring. These factors are not taken into account during input configuration, so calibration must be performed for each newly configured Analog Input, Exception Report, and Alarm Block (NAMM02).

Points must be calibrated

- when the master and slaves are installed initially,
- when the master is replaced,
- when a slave is changed or replaced,
- when a slave address is changed (changing the numbers of the blocks referring to it),
- when the calibration EEPROM is initialized,
- when a change is made to the lead wire resistance parameter in an Analog Input, Exception Report, and Alarm Block (AIERA),
- when the cable length between the slave and Termination Unit is changed, and
- periodically, to adjust for component aging.

All calibrations must be done with the NAMM02 in Execute Mode, since calibration is considered a tuning operation. In calibrating, the operator interacts with the NAMM02 through the use of five function blocks:

- Calibration Command Block,
- Calibration Status Block,
- Calibration Data Block,
- Thermocouple Termination Unit Temperature Block, and
- AIERA Block.

Through these structures, a calibration sequence is initiated, guided, and terminated. These blocks are read, modified, or monitored over the module bus. The Configuration and Tuning Module (CTM), the Operator Interface Unit (OIU), the Computer Interface Unit (CIU), or any future device with similar capabilities are usable to manipulate the function blocks listed above.

There are a number of alternate strategies available for calibration. A thermocouple or RTD input can be calibrated without affecting the measurement or reporting of any other points on the slave. In this case, the precision voltage or resistance source must be applied directly to the input's terminal block connections. Alternatively, the NAMM02 and its Termination Units have complete hardware built in to allow calibration. To utilize this hardware the slave cable must be removed from the input socket and attached to a special calibration socket. The whole slave is thus removed from service.

The following discussion pertains to those strategies which make use of the calibration sockets on the Termination Units. For RTD inputs, there are jumpers on the NTAI03 which select the point to be calibrated (see Appendix A). There is also a toggle switch that selects a 100 ohm or 400 ohm resistance. RTD inputs require separate calibration steps for each point at both resistance levels.

The thermocouple input calibration socket is used to calibrate all eight inputs on a slave simultaneously. Thermocouples can be calibrated with internal references supplied by the NAMM02 (auto calibration) or with a precision voltage reference applied to terminals on the Termination Unit NTAI02 (external calibration - see Appendix A). The external mode requires explicit 0 millivolt and 80 millivolt measurement steps. A toggle switch selects between the internal references or the externally applied precision voltage source.

Finally, calibration data can be manually inserted into the NAMM02. Later sections of the document describe this procedure in greater detail.

Section 2 - Calibration Specific Blocks

2.1 Calibration Data Block

The correction factors which are computed during calibration are stored in EAROM and may be referenced by the Calibration Data Blocks. The data is stored in function blocks to facilitate restoration of an NAMM02 after an EAROM failure. The computed values from a previous calibration can be entered via a CTM, OIU, or CIU, if necessary.

The data contained in a particular Calibration Data Block pertains to a point defined by an Analog Input, Exception Report and Alarm Block (NAMM02). There is a fixed difference of one hundred (100) between the block numbers for a particular point (i.e., Calibration Data Block #121 corresponds to AIERA Block #21). The block is undefined if the associated point is not configured.

The offset and gain values can be modified in configure mode. Correction data entered explicitly

is also checked against the predefined limits for the input type.

If the correction factors are out of the normal range, the calibration quality flag is set in the exception report record. The operator has access to this information by monitoring the AIERA Block of the point in question.

The following summarizes the NAMM02 Calibration Data Block.

Calibration Data Block (NAMM02) Function Code: 73

The Calibration Data Block contains the offset and gain error correction factors determined during the slave calibration. These blocks are referenced by fixed numbers equal to the input block number plus one hundred (i.e., 101-164). Monitoring this block gives the raw value of the input in millivolts corrected for the master.

Specification List Calibration Data Block (NAMM02) Function Code: 73

SPEC ID #	SYMBOL	FUNCTION	DATA TYPE	DEFAULT	TUNABLE
1	OFFSET	Parameter	REAL-3	-0.500	No
2	GAIN	Parameter	REAL-3	-0.500	No

where:

OFFSET is the offset error correction factor for the channel as determined by calibration.

GAIN is the gain error correction and microvolt conversion factor as determined by calibration.

2.2 Calibration Command Block

The operator initiates, guides, and terminates a calibration sequence through the Calibration Command Block.

Commands are entered only by tuning this block. A command and a point number (1-64) must be specified. If, after tuning the block, the CTM responds with a GOOD message, the operation was successful. If the response was C114, the operation failed, and the Calibration Status Block must be read to determine the cause. At an OIU, the suc-

cess/failure is indicated by the command field value. A value of 0 indicates the error condition. The following describes the block and the commands available to the user.

The various commands can be classified into a number of categories. These classifications are discussed briefly below.

Disable Operation

A point must be disabled before any calibration can

begin. This is done to prevent calibration related data from being interpreted as process data by the rest of the system. A whole slave may be disabled at once. This should be done when the calibration sockets are used. The user may also disable only a single point. This should be done if calibration is done at the termination blocks one point at a time.

Calibration Command Block **Function Code: 74**
(NAMM02)

The Calibration Command Block contains the information necessary to initiate and control a calibration sequence on the Analog Master Module (NAMM02). This function is obtained by specifying the fixed block number, Block #60.

Slave Calibration

The slave related commands (excluding Enable/Disable) can only be used for thermocouple inputs. There are two ways to calibrate all of the inputs on a thermocouple slave simultaneously:

- calibration using internal references generated automatically by the NAMM02, and
- calibration in which the user connects and sets an external millivolt source.

In the external mode, the user must perform the zero and full scale calibration steps explicitly, and in that order. Regardless of which slave calibration method is used, every point on the slave must be disabled previous to the command. Any point

Specification List **Calibration Command Block (NAMM02) Function Code: 74**

SPEC ID #	SYMBOL	FUNCTION	DATA TYPE	DEFAULT	TUNABLE
1	COMMAND	Parameter	INTEGER-1	0	Yes
2	POINT	Parameter	INTEGER-1	0	Yes

where:

COMMAND* = Code which specifies a calibrate operation on the Analog Master Module (NAMM02).

POINT = Number of the point to be calibrated or any point on the slave to be calibrated, $1 \leq \text{POINT} \leq 64$.

- 1 - Disable point †
- 2 - Disable slave ‡
- 3 - Perform complete thermocouple slave calibration automatically using internal references
- 4 - Perform thermocouple slave external 0 millivolt calibration
- 5 - Perform thermocouple slave external 50 millivolt calibration
- 6 - Perform thermocouple point external 0 millivolt calibration
- 7 - Perform thermocouple point external 50 millivolt calibration
- 8 - Perform RTD point external 100 ohm calibration
- 9 - Perform RTD point external 400 ohm calibration
- 10 - Enable point
- 11 - Enable slave
- 12 - Escape ‡

* **COMMAND** field will be set to zero if an abnormal condition was detected during calibration (see Calibration Status Block).

† The Disable Point command should be used only if the precision source or resistance is applied at the terminal blocks for the field inputs.

‡ The Disable Slave command should be used if the calibration is done using the special calibration sockets on the termination units.

‡ The Escape command is used to reset the calibration logic in the middle of a sequence (i.e., after a 0 volt or 100 ohm measurement has been taken).

number on the slave is sufficient to identify the slave for any of the slave commands. The write to EAROM of the new correction factors happens only when the entire calibration sequence is finished, specifically after the full scale measurement has been taken.

Point Calibration

The point related commands are used for both the thermocouple and RTD input types. Furthermore, these commands are permissible regardless of whether calibration is done using the calibration sockets or not. In addition, the command must be consistent with the configuration for a successful operation to occur (i.e., point must exist and be of the type specified in the command).

Again, the write to EAROM of the correction factors happens only after the full scale measurement has been taken.

Enable Operation

A point must be enabled before normal input processing can occur. This action terminates the calibration sequence for a particular point. A whole slave can be enabled at once. The slave enable is

allowed even if the points were disabled individually.

Escape Operation

The "escape" command is included to allow the user to stop the calibration of a point/slave after the zero scale measurement has already taken place. Specifying any other action at this time, besides an escape or a full scale measurement on the same point/slave, causes a command sequence error.

2.3 Calibration Status Block Function Code: 75

The Calibration Status Block contains the status from the most recent calibration command on the Analog Master Module (NAMM02). The block has a fixed number on the NAMM02, Block #81. It can be read, but not modified.

Format #1

This format is used whenever the previous calibration command referred to a slave rather than a point. The eight points are all from a common slave.

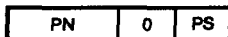
Specification List Calibration Status Block Function Code: 75

Format #1

SPEC ID#	SYMBOL	FUNCTION	DATA TYPE	DEFAULT	TUNABLE
1	OPSTAT	Parameter	INTEGER2	0	No
2	POINT1	Parameter	INTEGER2	0	No
3	POINT2	Parameter	INTEGER2	0	No
4	POINT3	Parameter	INTEGER2	0	No
5	POINT4	Parameter	INTEGER2	0	No
6	POINT5	Parameter	INTEGER2	0	No
7	POINT6	Parameter	INTEGER2	0	No
8	POINT7	Parameter	INTEGER2	0	No
9	POINT8	Parameter	INTEGER2	0	No

where:

POINT_n =



Point Status

- 0 - Command performed without error
- 1 - Point not configured
- 2 - Point not disabled
- 3 - Calculated gain or offset over range
- 4 - EAROM error
- 5 - Operation not performed

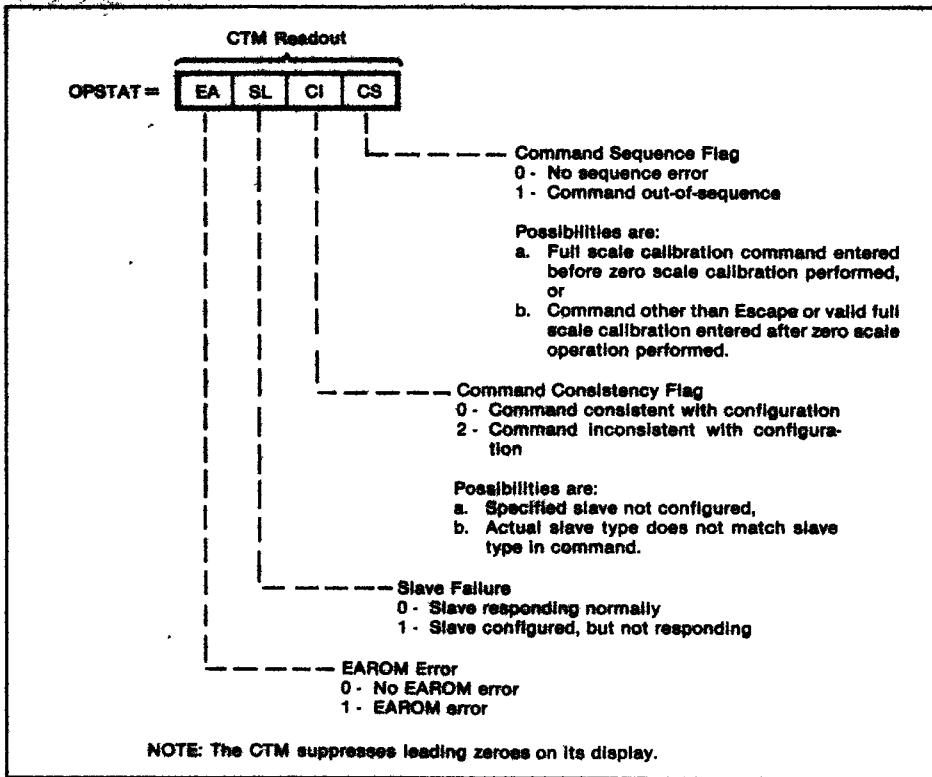
Point Number

Number of the point to which the status applies (1 ≤ POINT_n ≤ 64)

NOTE: The CTM suppresses leading zeroes on its display.

Specification List (Cont'd) Calibration Status Block Function Code: 75

Format #1

**Format #3**

This format is used whenever the previous calibration command referred to a point rather than a slave.

Specification List Calibration Status Block Function Code: 75

Format #2

SPEC ID	#	SYMBOL	FUNCTION	DATA TYPE	DEFAULT	TUNABLE
	1	OPSTAT	Parameter	INTEGER2	0	No
	2	POINT _n	Parameter	INTEGER2	0	No
where:						
		OPSTAT	= See Format #1.			POINT _n = See Format #1.

2.4 Thermocouple Termination Function Code: 78 Unit Temperature Block

These blocks enable the Termination Unit temperature to be monitored. The blocks, numbered 90-93, can only be accessed via a READ POINT module bus message (monitor funct on on the CTM). The relationship between block number and RTD pair is as follows:

Block No.	RTD Pair
90	A
91	B
92	C
93	D

All termination unit temperatures are given in degrees C.

If a slave is not associated with an RTD pair, then the block number is undefined. The quality associated with an RTD pair is bad when the calculated temperature is outside the allowable

range of 0 to 70°C, or when an open input is detected. The High/Low alarm status available during block monitoring indicates at what extreme the calculated temperature resides.

2.5 Analog Input, Exception Report, and Alarm Block Function Code: 70

The Analog Master Module (NAMM02) contains up to 64 inputs. Each of these must have a defined block (block 1-64) that performs analog input, alarm detection, and exception reporting. The block also has some value in calibration. Through it, the calibration quality for a particular input is viewed. If a block is being monitored by the CTM and the "next" button is depressed, the calibration quality can be determined. If a "C" is displayed in the numeric field, the calibration quality is bad. If not, the calibration quality is presumed good. If an "S" is displayed in the numeric field, the point is disabled. If not, the point is enabled and being processed.

Section 3 - NAMM02 Calibration Examples

This section provides concrete examples of the several calibration options available to the user. The commands can be entered from a CTM or an OIU. The operation of these devices is described in Product Instructions E93-900-1 (Operator Interface Unit) and E93-903 (Configuration and Tuning Module).

Tables 1 and 2 give the possible responses from the CTM or OIU assuming error free operation. The examples of calibration given do not consider the various errors possible. The failure of any particular command must be followed up by a read of the Calibration Status Block to determine the exact cause.

3.1 Single Thermocouple Point Calibration

This example shows how to calibrate a single thermocouple input without disturbing the data collection of any other point on the slave.

a. Disable point by tuning the Calibration Command Block (CCB)

- Spec. #1 ← 1
- Spec. #2 ← point #

Operator Feedback

Device	Index #
CTM	1
OIU	1

Response Index	Meaning
1	"Good" displayed within one second.
2	"Good" displayed within 30 seconds.
3	"Good" displayed within 60 seconds.

TABLE 1 — CTM Response Table (assuming no errors).

Response Index	Meaning
1	Calibration Command Block rewritten on OIU screen with Command Field (Spec. #1) unchanged from operator supplied value.
2	"Module Busy" messages written on OIU screen. Operator should redisplay the Calibration Command Block at 30 second intervals.

TABLE 2 — OIU Response Table (assuming no errors).

b. If using an external precision millivolt source, then attach it to the specific point terminal blocks on the NTA02 in place of the field wiring. If using the internal test source, then attach jumper wires from the internal test output posts (TP1, TP2) on the NTA02 to the specific point terminal blocks on the NTA02 in place of the field wiring.

c. If external source used, set it to 0 millivolts.

d. Tune CGB to perform 0 millivolt calibration.

- Spec. #1-6

Operator Feedback
Device Index #

CTM	2
OIU	1 or 2

e. If external source used, set it to 80 millivolts.

f. Tune CGB to perform 80 millivolt calibration.

- Spec. #1-7

Operator Feedback
Device Index #

CTM	2
OIU	1 or 2

g. Retest field wiring.

h. Enable point by tuning CGB.

- Spec. #1-10

Operator Feedback
Device Index #

CTM	1
OIU	1

2.2 Thermocouple Slave External Calibration
This example shows how to calibrate a whole thermodynamic slave at once using a precision millivolt source.

a. Disable slave by tuning the Calibration Command Block (CGB)

- Spec. #1-2
- Spec. #3- any point # on the slave

Operator Feedback
Device Index #

CTM	1
OIU	1

b. Move input cable on NTA02 from the input socket (P1 or P2) to the calibrate socket (P3). Red/green LED on affected slave should turn red.

c. Attach source to external test input posts (TP1, TP2) provided on NTA02.

d. Set toggle switch (S1) on NTA02 to the external calibration position.

e. Set toggle switch (S1) on NTA02 to the external calibration position.

e. Set source to 0 millivolts.

f. Tune CGB to perform 0 millivolt calibration.

- Spec. #1-4

Operator Feedback
Device Index #

CTM	2
OIU	1 or 2

g. Set source to 80 millivolts.

h. Tune CGB to perform 80 millivolt calibration.

- Spec. #1-5

Operator Feedback
Device Index #

CTM	2
OIU	1 or 2

i. Move input cable on NTA02 from the calibrate socket to the input socket (P1 or P2). Red/green LED on affected slave should turn green.

j. Enable slave by tuning CGB.

- Spec. #1-11

Operator Feedback
Device Index #

CTM	1
OIU	1

3.3 Thermocouple Slave Auto Calibration

Shown below is the sequence of operations necessary to calibrate a whole thermocouple slave automatically by using internal references.

a. Disable slave by tuning the Calibration Command Block (CCB).

- Spec. #1 ← 2
- Spec. #2 ← any point # on the slave

Operator Feedback
Device Index #

CTM	1
OIU	1

b. Move input cable on NTAI02 from the input socket (P1 or P2) to the calibrate socket (P3) Red/green LED on affected slave should turn red.

c. Set toggle switch (S1) on NTAI02 to the internal calibration position.

d. Tune CCB to perform slave calibration.

- Spec. # ← #3

Operator Feedback
Device Index #

CTM	3
OIU	1 or 2

e. Move input cable on NTAI02 from the calibrate socket to the input socket (P1 or P2). Red/green LED on affected slave should turn green

f. Enable slave by tuning CCB.

- Spec. #1 ← 11

Operator Feedback
Device Index #

CTM	1
OIU	1

3.4 Single RTD Point Calibration with Minimal Data Collection Impact

The example below shows how to calibrate a single

RTD input without disturbing the data collection of any other point on the slave.

a. Disable point by tuning the Calibration Command Block (CCB).

- Spec. #1 ← 1
- Spec. #2 ← point #

Operator Feedback
Device Index #

CTM	1
OIU	1

b. Attach a 100 ohm precision resistor to the specific point termination blocks on the NTAI03 in place of the field wiring.

c. Tune CCB to perform 100 ohm calibration.

- Spec. #1 ← 8

Operator Feedback
Device Index #

CTM	2
OIU	1 or 2

d. Replace the 100 ohm precision resistor at the point termination blocks with a 400 ohm precision resistor.

e. Tune CCB to perform 400 ohm calibration.

- Spec. #1 ← 9

Operator Feedback
Device Index #

CTM	2
OIU	1 or 2

f. Reattach field wiring.

g. Enable point by tuning CCB.

- Spec. #1 ← 10

Operator Feedback
Device Index #

CTM	1
OIU	1

3.5 Single-RTD Point Calibration Using Termination Unit Calibration Hardware

Below is an example which demonstrates how to calibrate an RTD input by using the jumpers and precision resistors provided on each NTA103.

a. Disable slave by tuning the Calibration Command Block (CCB).

- Spec. #1 ← 2
- Spec. #2 ← any point # on the slave

Operator Feedback

Device Index #

CTM	1
OIU	1

b. Move input cable on NTA103 from the input socket (P1 or P2) to the calibrate socket (P3). Red/green LED on affected slave should turn red.

c. Select point # on slave with jumpers (CH1 thru CH8) on NTA103.

d. Select 100 ohm resistor with toggle switch (S1) on NTA103.

e. Tune CCB to perform 100 ohm calibration.

- Spec. #1 ← 8
- Spec. #2 ← point #
(the point # should correspond to the local point # on the slave selected in "c")

Operator Feedback

Device Index #

CTM	2
OIU	1 or 2

f. Move toggle switch (S1) on NTA103 to select 400 ohm resistor.

g. Tune CCB to perform 400 ohm calibration.

- Spec. #1 ← 9

Operator Feedback

Device Index #

CTM	2
OIU	1 or 2

h. Do "c" through "g" repetitively for each point on slave, if desired.

i. Move input cable on NTA103 from the calibrate socket (P3) to the input socket (P1 or P2). Red/green LED on affected slave should turn green.

j. Enable slave by tuning CCB.

- Spec. #1 ← 11

Operator Feedback

Device Index #

CTM	1
OIU	1

Section 4 - Slave Channel Monitoring

The actual millivolt input value is available for each slave input channel. This value is only corrected for master induced errors. No slave offset and gain correction is performed.

To inspect the raw input, the operator must use the monitor function of the CTM or OIU. The block to be monitored is the Calibration Data Block for the desired block.

The raw input is not available on the first point of

the particular block. That first message informs the NAMM02 which raw value should be saved on its next pass through the input list. Consequently, the bad quality indication may be seen initially at the CTM or OIU. Subsequent points will have the true millivolt reading. The bad quality flag remains set if the value is unreadable (slave not present or point disabled) or if the value is out-of-range.

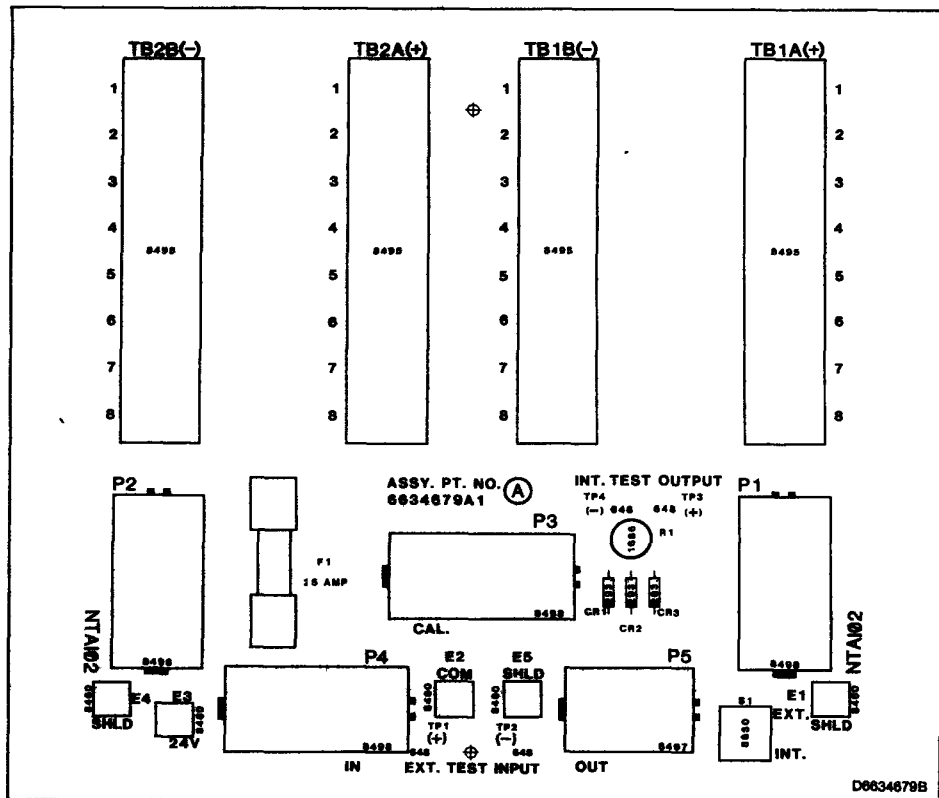
Section 5 - Manual Calibration Data Writes

The gain and offset correction factors for any slave input can be manually entered into the Calibration Data Block. The operation is permissible in Configure mode only using the Modify Block Command.

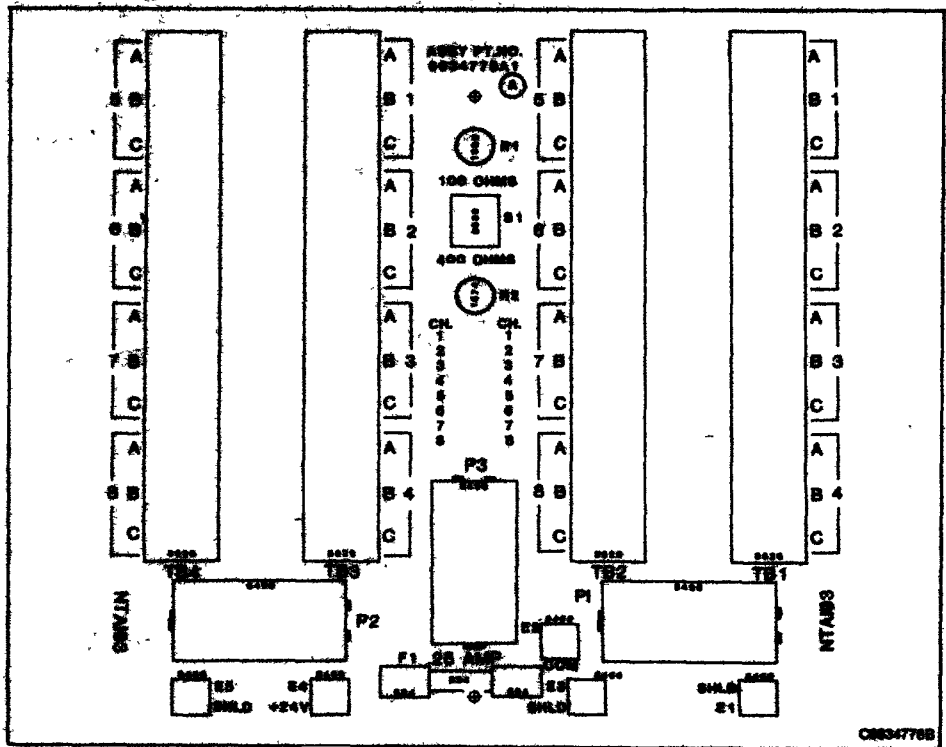
Regardless of how the correction values are ascertained, either from the NAMM02 through

calibration or from the operator through manual insertion, the factors are still compared against reasonable bounds with the calibration quality set accordingly. The quality of the input correction values is accessible only in Execute mode by monitoring the AIERA block (1-64) of the desired point.

Appendix A



Thermocouple Termination Unit NTA102



08047708

RTD Termination Unit NTA1S

Appendix B

Mapping Block Numbers and Slave Point Numbers

AIERA Slave #	Calibration		Slave Local Point # on Slave
	Block #	Slave Point #	
1-8	101-108	0	1-8
9-16	109-116	1	1-8
17-24	117-124	2	1-8
25-32	125-132	3	1-8
33-40	133-140	4	1-8
41-48	141-148	5	1-8
49-56	149-156	6	1-8
57-64	157-164	7	1-8

Example:
AIERA Block # = 9

Therefore -
Calibration Data Block # = 100
Slave # = 1
Local Point # on Slave = 1

00 06 20 04 11 07

09 00 00 00 00 00 00 00 00 00



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