BrainChild

SPECIAL PURPOSE CONTROLLER FOR JACKET HEATERS
NC30
User Manual



UMNC300A
September 2021
Document Approval No: UMNC301A

Revision History

Version	Description	Date
UMNC300A	❖ Initial release	September, 2021

Warning Symbol

This document contains notices that you should observe to ensure your own personal safety, as well as to protect the product and connected equipment. These notices are highlighted in the manual by a warning triangle and are marked as follows.

⚠ The danger symbol indicates that death or severe personal injury may result if proper precautions are not taken. Do not proceed beyond a warning symbol until the indicated conditions are fully understood and met.

Preface

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NOTE

It is strongly recommended that a process should incorporate a Limit Control like a Brainchild L91 which will shut down the equipment at a preset process condition in order to avoid possible damage to products or systems.

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TABLE OF CONTENTS

1 INTRODUCTION..... 5

1.1 Introduction.....5
1.2 Features.....5
1.3 Specifications..... 7
1.4 Ordering Code.....9
1.4.1 NC30 Ordering Code..... 9
1.4.2 Accessories..... 9
1.4.3 Related Products.....9

1.5 Programming Port.....9
1.6 Keys and Displays.....10
1.7 Menu Flowchart.....12
1.7.1 User Menu..... 13
1.7.2 Auto-Tuning Mode..... 13
1.7.3 Manual Mode Menu..... 13
1.7.4 Setup Menu.....14
1.7.5 Calibration Mode.....15

1.8 Parameters Description.....16

2 INSTALLATION AND WIRING..... 24

2.1 Unpacking.....24
2.2 Mounting.....24
2.2.1 NC30 Dimension.....25

2.3 Wiring.....25
2.3.1 NC30 Terminal Connection.....26
2.3.2 Wiring Terminals.....26

2.4 Power Wiring.....27
2.5 Sensor Installation..... 28
2.5.1 Sensor Input Wiring..... 29

2.6 Control Output Wiring..... 29
2.7 Alarm Wiring..... 29
2.8 RS-485 Wiring.....30

3 PROGRAMMING.....31

3.1 User Security.....31
3.2 Signal Input.....31
3.3 Control Output.....31
3.3.1 Heat only PID Control.....31

3.4 Failure Transfer.....31
3.4.1 Output 1 Failure Transfer.....32

3.5 Auto-Tuning..... 32
3.5.1 Auto-Tuning Operation Steps.....32
3.5.2 Auto-Tuning Error..... 32
3.5.3 Solution for Auto-Tuning Error.....32

3.6 Manual Tuning.....33
3.7 Manual Control.....33

3.7.1 Exit Manual Control....33

3.8 Digital Filter....34
3.9 Alarm....35
3.9.1 Alarm Types....35
3.9.2 Alarm Modes....39
3.9.3 Alarm Delay....40
3.9.4 Alarm Failure Transfer....40

3.10 User Select Menu Configuration....40
3.11 User Calibration....41
3.12 Default Setting....42
3.12.1 Factory Default Setting....42
3.12.2 User Default Setting....42

3.13 Data Communication....43
3.13.1 RS-485 Setup....43

3.14 Heater Break Detection....43
3.15 Output Power Limit....43
3.16 Output Load Power, Voltage, current monitoring....43
3.17 Home Page Display....43

4 CALIBRATION....44

4.1 Equipment Required Before Calibration....44
4.1.1 Manual Calibration Procedure....44

5 COMMUNICATION....46

5.1 Functions Supported....46
5.1.1 Function Code 03: Read Holding Registers....46
5.1.2 Function Code 06: Pre-set Single Register....47
5.1.3 Function Code 16: Pre-set Multiple Register....47

5.2 Exception Responses....48
5.3 Parameter Mapping....48
5.4 Error Code....48
5.5 Mode....49
5.6 Command Mode....50
5.7 PROG Code....50
5.8 Data Conversion....50
5.9 Communication Examples....50
5.9.1 Read PV, SV, MV1....50
5.9.2 Perform Reset Function (same effect as pressing R key)....50
5.9.3 Enter Auto-Tuning Mode....51
5.9.4 Enter Manual Control Mode....51
5.9.5 Read All Parameters....51
5.9.6 Calibrate ADLO....51

1 Introduction

1.1 Introduction

The NC30 is a specially designed controller with fuzzy logic algorithm for cloth jacket heaters to control temperature. The temperature controller takes an input from a temperature sensor and has an output that is connected to a control element such as cloth jacket heaters. The controller equipped with 3 Amp solid-state relay as control output and a 2A, 240VAC Form A relay as alarm output as standard along with RS485 communication.

1.2 Features

The NC30 controller has lot of unique features listed as below.

- Fastest Sampling Rate of 200msec
- Thermocouple & RTD Input
- Fuzzy Logic +PID Technology
- Auto-tuning & Manual tuning
- High Brightness LCD Display
- Maximum Load Current 4.5A @ 50°C ambient temperature
- Instantaneous Power Consumption Display
- Output power limit function
- Load Current, Load Voltage and Load Power display
- Direct connection of heater
- Heater Break Detection
- Alarm Output
- Connect with HMI for Alarm monitoring
- Network up to 247 controllers on RS485 (Modbus Protocol)
- Auto addressing, manual configuration not required
- Safe and Easy wiring leads to reduced system down time

LCD Display

The controller will be equipped with high brightness LCD Display.

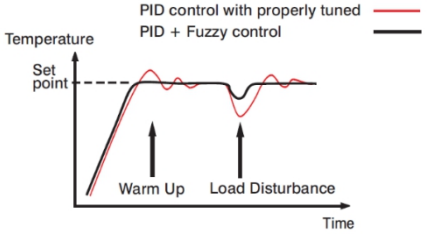
Digital Communication

RS-485 Digital communication is available as standard. These options allow the units to be integrated with supervisory control systems and software. Up to 247 units can be connected together via an RS-485 interface to a host computer.

A Micro USB programming port is available for automatic configuration, calibration and testing without the need to access the keys on the front panel.

Fuzzy PID Technology

By using proprietary Fuzzy modified PID technology, the control loop will minimize overshoot and undershoot in the shortest allowable time. The following diagram is a comparison of results with and without Fuzzy Logic technology.



1- 1.Fuzzy PID Control

High Accuracy

The NC30 manufactured using an innovative technology which contains an 18-bit A to D converter for high-resolution measurement. The innovative technology provides improved operating performance, enhanced reliability and higher density with low cost.

Fast Sampling Rate

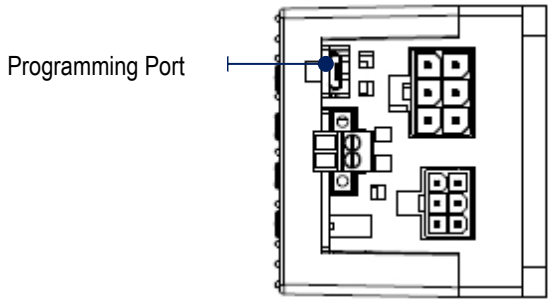
The sampling rate of the input A to D converter reaches 200 msec. This fast-sampling rate allows the controllers to control fast processes.

Fuzzy Control

The function of Fuzzy control is to adjust PID parameters from time to time in order to make manipulation of the output more flexible and adaptive to various processes. The result is to enable a process to reach a predetermined set point in the shortest time, with a minimum of overshoot and undershoot during power-up or external load disturbances.

Programming Port

A Micro USB programming port is available for automatic configuration, calibration and firmware upgrades without the need to access the keys on the front panel.



1- 2.Rear Port

Auto-tuning

The auto-tuning function allows the user to simplify the initial setup for a new system. A clever algorithm is provided to obtain an optimal set of control parameters for the process. It can be applied either as the process is warming up (cold start) or when the process is in a steady state (warm start).

Lockout Protection

According to user security requirements, different security options can be enabled by using Code and Pass parameters.

Bumpless Transfer

The Bumpless transfer allows the controller to continue to control by using its previous output value if the input sensor breaks. Hence, the process can be well controlled temporarily as if the sensor is functioning normally.

Heater Break Detection

The controller will detect the heater break by measuring load current and load power.

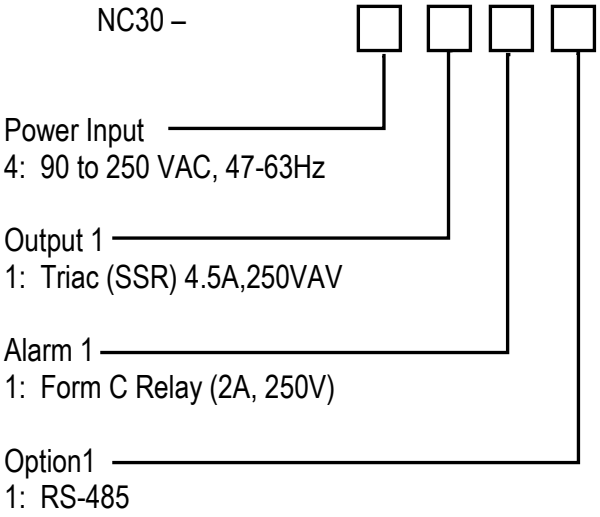
1.3 Specifications

<table>
<tr><th>Specification</th><th>NC30</th></tr>
<tr><td>Power Supply</td><td>90 to 250VAC, 47 to63Hz, 23A</td></tr>
<tr><td>Power Consumption</td><td>800VA,5W Maximum</td></tr>
<tr><td>Over Voltage Category</td><td>II</td></tr>
<tr><td colspan="2">Signal Input</td></tr>
<tr><td>Type</td><td>Thermocouple: J, K; RTD: PT100(DIN)</td></tr>
<tr><td>Resolution</td><td>18 Bits</td></tr>
<tr><td>Sampling Rate</td><td>5 Times / Second (200msec)</td></tr>
<tr><td>Input Characteristics</td><td>
<table>
<tr><th>Type</th><th>Range</th><th>Accuracy @ 25°C</th><th>Input Impedance</th></tr>
<tr><td>J</td><td>-120°C to 1000°C (-184°F to 1832°F)</td><td>±2°C</td><td>2.2 MΩ</td></tr>
<tr><td>K</td><td>-200°C to 1370°C (-328°F to 2498°F)</td><td>±2°C</td><td>2.2 MΩ</td></tr>
<tr><td>PT100(DIN)</td><td>-200°C to 850°C (-328°F to 1562°F)</td><td>±0.4°C</td><td>16.9KΩ</td></tr>
</table>
</td></tr>
<tr><td>Temperature Effect</td><td>1.5µV /°C</td></tr>
<tr><td>Sensor Lead Resistance Effect</td><td>Thermocouple: 0.2 µV /°Ω;
2-wire RTD: 2.6°C /Ω of Sum of Resistance of two leads</td></tr>
<tr><td>Burn-out Current</td><td>200nA</td></tr>
<tr><td>CMRR</td><td>120 dB</td></tr>
<tr><td>NMRR</td><td>55dB</td></tr>
<tr><td>Sensor Break Detection</td><td>Sensor open for Thermocouple, RTD inputs, Sensor short for RTD input</td></tr>
<tr><td>Sensor Break Response Time</td><td>Within 4 seconds for Thermocouple, RTD</td></tr>
<tr><td colspan="2">Control Output (Output 1)</td></tr>
<tr><td>Type</td><td>Triac (SSR)</td></tr>
<tr><td>Rating</td><td>4.5A at 50°C Ambient Temperature</td></tr>
<tr><td colspan="2">Control Mode</td></tr>
<tr><td>Control Action</td><td>Reverse (Heating)</td></tr>
<tr><td>PID</td><td>Fuzzy logic modified Proportional band 0.1 ~ 500.0°C(0.1~900.0°F),
Integral time 0 – 3600 Secs,
Derivative Time 0 - 360.0 Secs</td></tr>
<tr><td>Manual Control</td><td>0 ~ 100 %</td></tr>
<tr><td>Auto-Tuning</td><td>Cold Start and Warm Start</td></tr>
<tr><td>Output Power Limit</td><td>0~100%</td></tr>
<tr><td colspan="2">Digital Filter</td></tr>
<tr><td>Function</td><td>First Order</td></tr>
<tr><td>Time Constant</td><td>0,0.2, 0.5, 1, 2, 5, 10, 20, 30, 60 Seconds, Programmable</td></tr>
<tr><td colspan="2">Alarm</td></tr>
<tr><td>Relay Type</td><td>Form C</td></tr>
<tr><td>Maximum Rating</td><td>2A,250VAC,200000 Life Cycles for Resistive Load</td></tr>
<tr><td>Alarm Functions</td><td>Deviation Low, Deviation High, Deviation High-Low, Process High, Process Low, Process High-Low</td></tr>
<tr><td>Alarm Mode</td><td>Normal, Hold</td></tr>
<tr><td colspan="2">Data Communication</td></tr>
<tr><td>Interface</td><td>RS-485</td></tr>
<tr><td>Protocol</td><td>Modbus RTU (Slave Mode)</td></tr>
<tr><td>Address</td><td>1 to 247</td></tr>
<tr><td>Baud Rate</td><td>2.8KBPS to 115.2KBPS</td></tr>
<tr><td>Parity Bit</td><td>None, Even or Odd</td></tr>
</table>

Specification	NC30
Stop Bit	1 or 2 Bits
Data Length	7 or 8 Bits
Communication Buffer	130 Bytes
User Interface	
Keypad	4 Keys
Display Type	4 Digit LCD Display
No of Display	2
Upper Display Size	0.58” (15mm)
Lower Display Size	0.3” (7.8mm)
Programming Port	
Interface	Micro USB
PC Communication Function	Firmware upgrade
Environmental and Physical Specifications	
Operating Temperature	-10°C to 50°C
Storage Temperature	-40°C to 60°C
Humidity	0 to 90 % RH (Non-Condensing)
Altitude	2000 Meters Maximum
Pollution	Degree II
Insulation Resistance	20MΩ Minimum (@500V DC)
Dielectric Strength	2000VAC,50/60 Hz for 1 Minute
Vibration Resistance	10 to 55 Hz, 10m/s^2 for 2 Hours
Shock Resistance	200 m/s^2(20g)
Housing	Flame Retardant Polycarbonate
Mounting	Strap on a device
DIN Size	1/16
Dimensions (W*H*D) (mm)	180*60*58
Weight (grams)	260
Approval Standards	
Safety	ROHS, REACH

1.4 Ordering Code

1.4.1 NC30 Ordering Code



1.4.2 Accessories

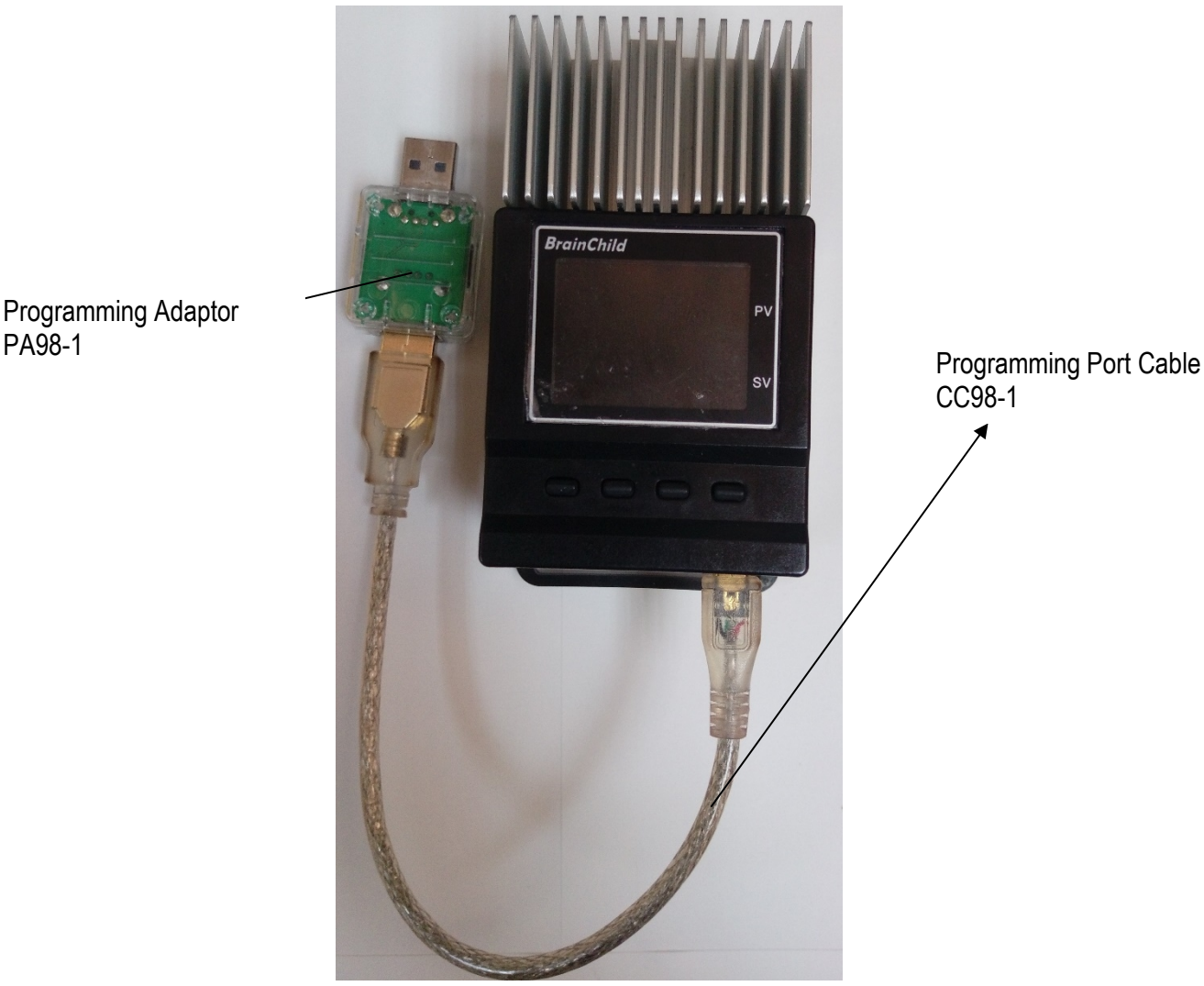
- PA98-1 = USB Programming Adaptor
- CC98-1 = Programming Port Cable (1.5m)

1.4.3 Related Products

- SNA10A = Smart Network Adaptor for third party software, which converts up to 255 channels of RS-485 or RS-422 to be usable on an RS-232 Network.
- BC-Set = Configuration Software

1.5 Programming Port

A Micro USB Port provided on the controller can be used to connect to a PC by using a programming port cable (CC98-1) and a programming adapter (PA98-1) for firmware upgrades. The controller can also be connected to an ATE system for automatic calibration and testing using the micro-USB port. The programming port is used for off-line automatic setup and testing procedures only. Do not attempt to make any connections to this port while the controller is being used during normal operation.



1- 3.Programming Port Connection with Programming Port Adaptor

1.6 Keys and Displays

KEYPAD OPERATION

SCROLL KEY: ⊡

This key is used to select a parameter to be viewed or adjusted.

UP KEY: ⊡

This key is used to increase the value of the selected parameter.

DOWN KEY: ⊡

This key is used to decrease the value of the selected parameter.

RESET KEY: R

This key is used to:

1. Revert the display to the home screen.
2. Stop manual control mode, Auto-Tuning mode or calibration mode.
3. Clear an Auto-Tuning or communication error message.
4. Enter the manual control menu if a failure mode occurs.

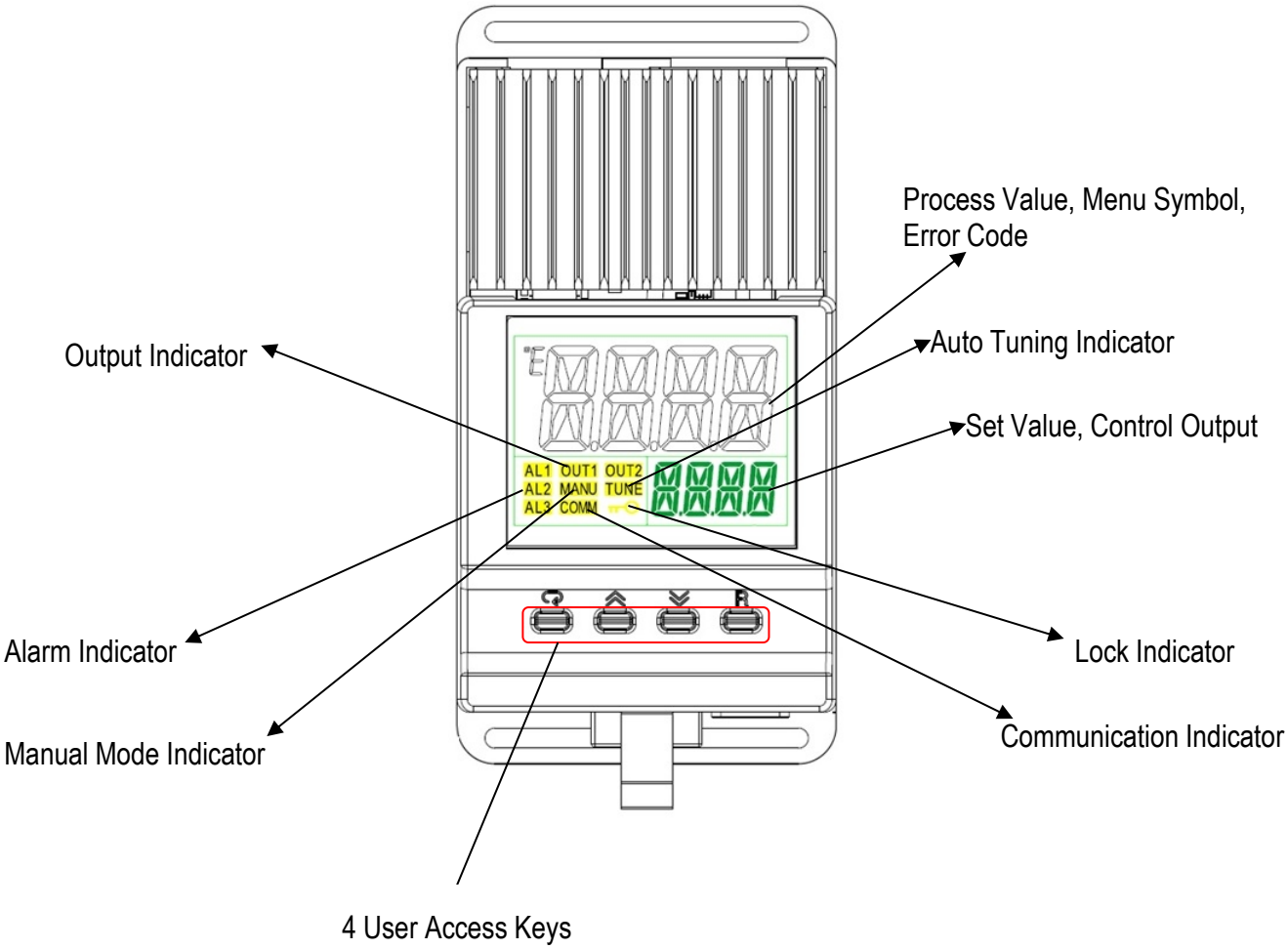
ENTER KEY:

Press ⏎ and hold for 5 seconds or longer to:

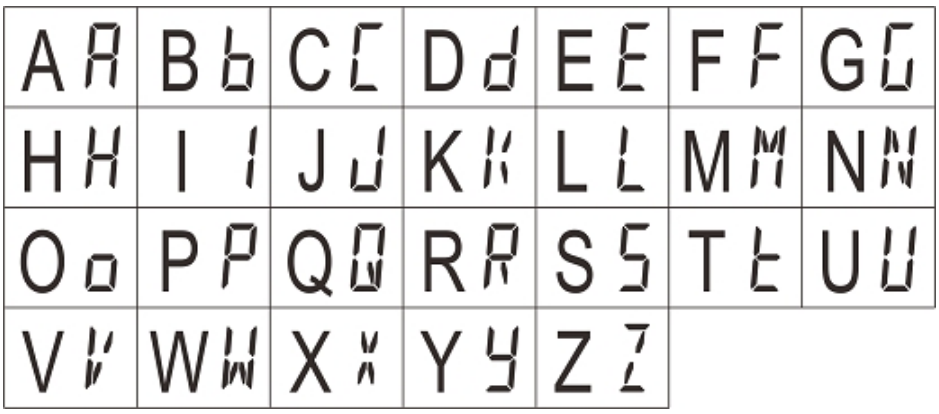
1. Enter the setup menu. The display will show. SEt
2. Enter the manual control mode. The display will show. HAnd
3. Enter the Auto-Tuning mode. The display will show. A-t
4. Perform calibration of a selected parameter during the calibration procedure. The display will show CAL1

Press and hold ⏎ for 6.2 seconds, then let go, to select manual control mode.
Press and hold ⏎ for 7.4 seconds, then let go to select Auto-Tuning mode.
Press and hold ⏎ for 8.6 seconds, then let go to select calibration mode.

During power-up, the upper display will show PROG and the lower display will show the Firmware version for 2.5 seconds.



1- 4. NC30 Front Panel Keys and Display

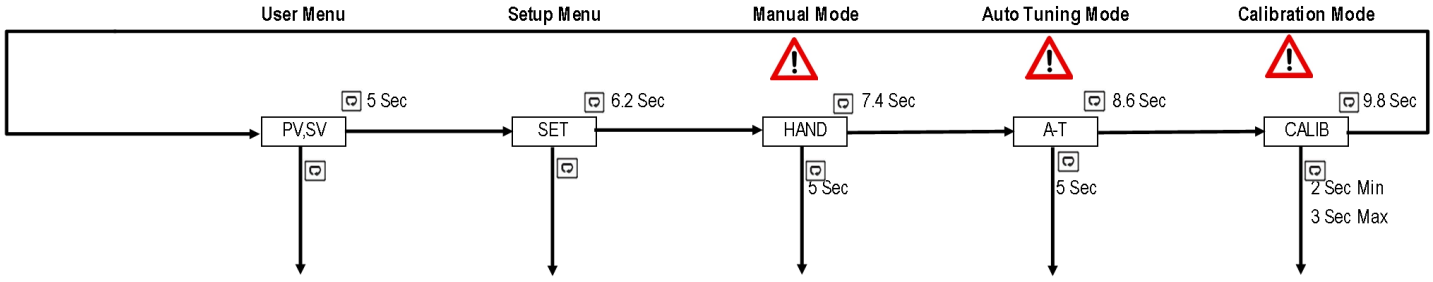


1- 5.How Characters are Displayed on the LCD screen

1.7 Menu Flowchart

The Menu has been divided into 5 groups. They are as follows:

1. User Menu
2. Setup Menu
3. Manual Mode Menu
4. Auto-Tuning Mode Menu
5. Calibration Mode Menu



To access User Menu parameter, Refer to Section 1.7.1

To access Setup Menu parameter, Refer to Section 1.7.2

To start Manual Control Mode, Refer to Section 1.7.3

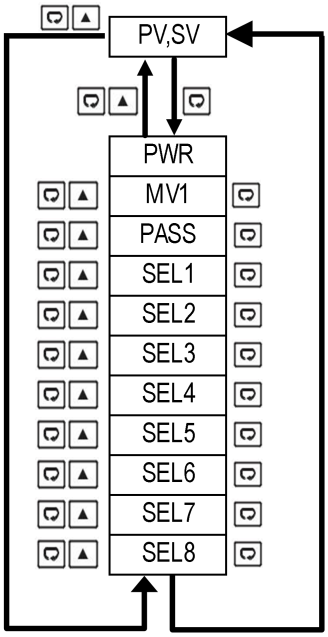
To start Auto-Tuning Mode, Refer to Section 1.7.4

To access Calibration Mode, Refer to Section 1.7.5

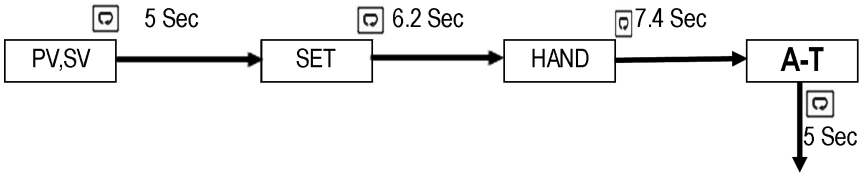
Press ▭ for the next parameter
Press ▭ and ▲ key to return to the previous parameter.

1.7.1 User Menu

The below user menu parameters are available depends on the user selection.

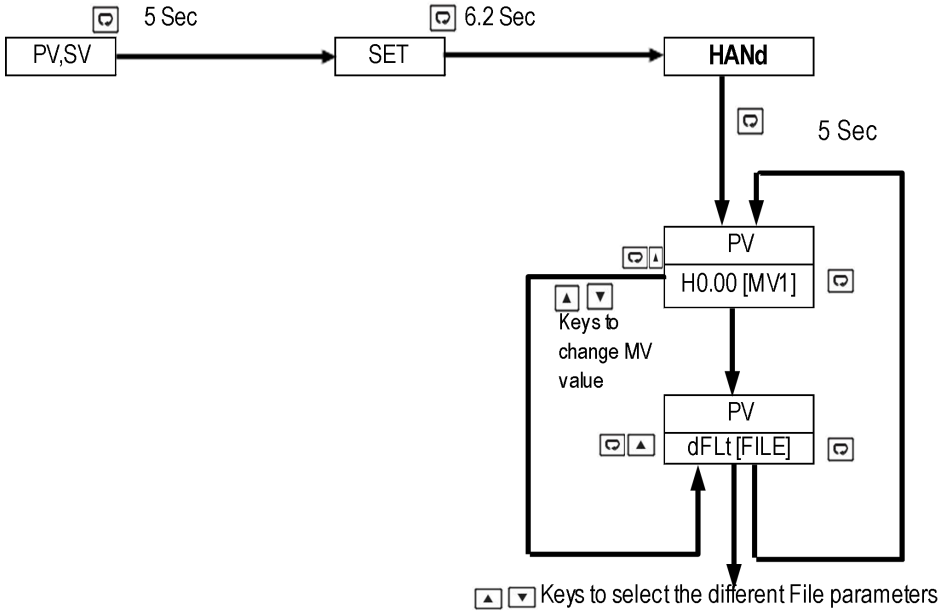


1.7.2 Auto-Tuning Mode



Press key 5 seconds to activate Auto-Tuning Mode

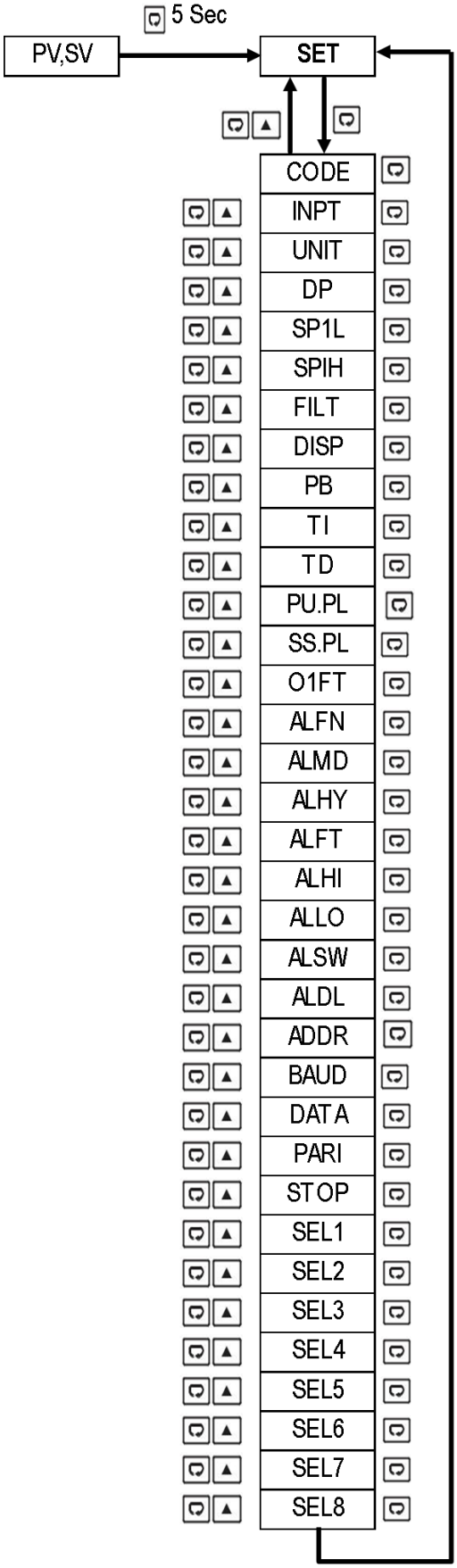
1.7.3 Manual Mode Menu



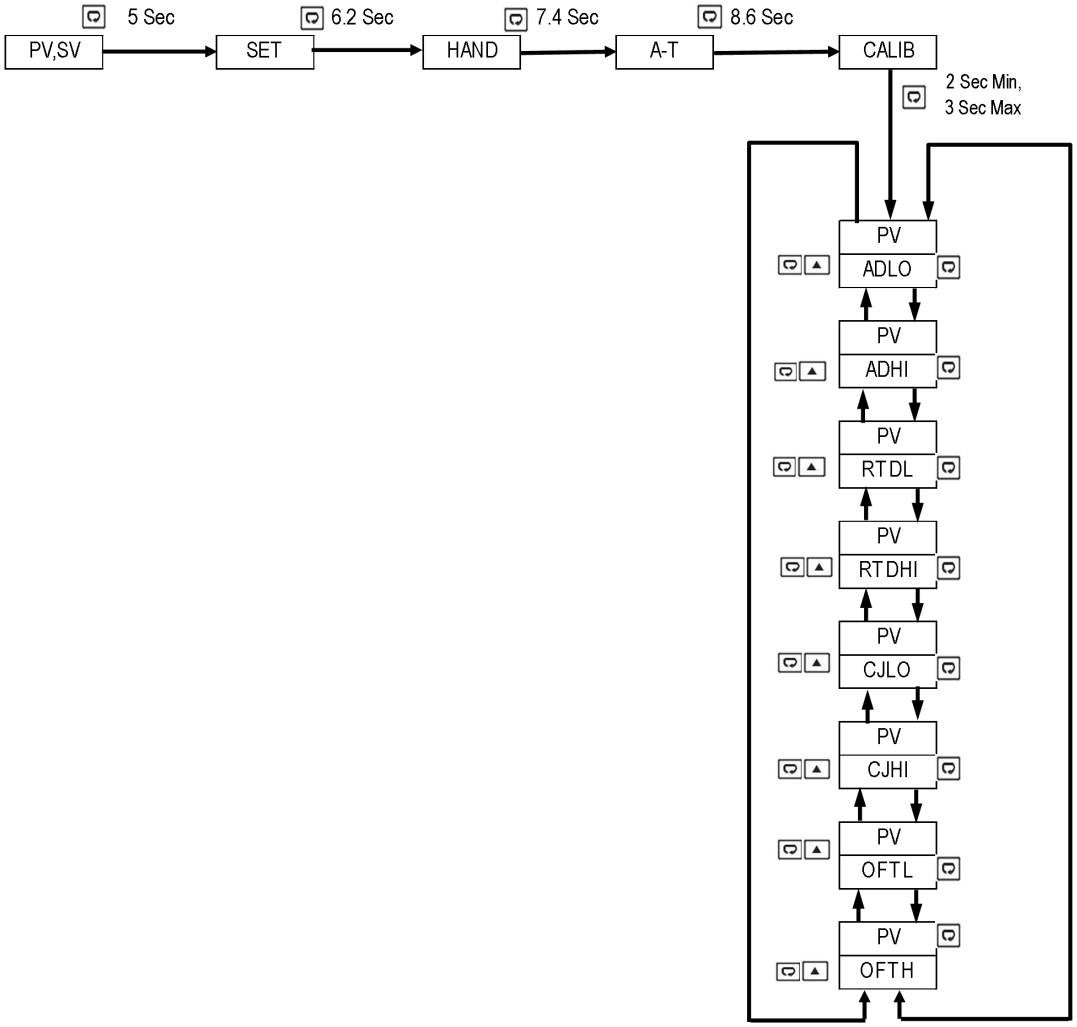
Press key 5 seconds to execute the selected program. All the parameter values are changed to the default values stored in the program.

1.7.4 Setup Menu

The setup menu has the below parameters.



1.7.5 Calibration Mode



Press key for 2 seconds or longer (not more than 3 seconds) then release it to enter calibration Mode.
Press Key for 5 seconds to perform calibration.
Note:

- Using Manual, Auto-Tuning, Calibration modes will break the control loop and change some of the previous setting data. Make sure that the system is allowable to apply these modes.
- The flow chart shows a complete list of all parameters. For actual application, the number of available parameters will vary depending on the setup and model of the controller and will be less than that shown in the flow chart.
- The user can select up to 8 parameters to put in the user select menu by using the SEL1~SEL8 parameters in the setup menu

1.8 Parameters Description

Modbus Register Address	Parameter Notation	Parameter Description	Range	Default Value	Data Access Type	Scale	
						Low	High
0	SP1	Set Point 1	Low: SP1L High: SP1H	25.0°C (77.0°F)	R/W	-19999	45536
1	INPT	Input sensor selection	**0. *J_tC***: J type Thermocouple **1. *K_tC***: K type Thermocouple **2. *PtdN***: PT100 Ω DIN curve	1	R/W	0	65535
2	UNIT	Input unit selection	***0 oC: °C unit***	0	R/W	0	65535
3	DP	Input sensor selection	**0. *NodP:*** *No decimal point* **1. *1-dP***: One decimal point	1	R/W	0	65535
4	SP1L	Low limit of set point value	Low: -19999 High: 45536	-17.8°C (0.0° F)	R/W	-19999	45536
5	SP1H	High limit of set point value	Low: SP1L High: 45536	537.8°C (1000.0° F)	R/W	-19999	45536
6	FILT	Filter damping time constant of PV	**0. 0:** 0 second time constant **1. 1:** 0.2 second time constant **2. 0.5:** 0.5 second time constant **3. 1:** 1 second time constant **4. 2:** 2 seconds time constant **5. 5:** 5 seconds time constant **6. 10:** 10 seconds time constant **7. 20:** 20 seconds time constant **8. 30:** 30 seconds time constant **9. 60:** 60 seconds time constant	2	R/W	0	65535

Modbus Register Address	Parameter Notation	Parameter Description	Range	Default Value	Data Access Type	Scale	
						Low	High
7	DISP	Home page display selection	***NoRM***: Display PV/SV **0.** ***MV1***: Display MV1 **1.** ***PWR***: Display Power	0	R/W	0	65535
8	PB	Proportional band value	Low: 1.0°C High: 500.0°C (900.0°F)	10.0° C (18.0° F)	R/W	0	65535
9	TI	Integral time value	Low: 1 High: 3600 sec	100	R/W	0	65535
10	TD	Derivative time value	Low: 0.0 High: 360.0 sec	25.0	R/W	0	65535
11	PU. PL	Power limit for power up stage	Low: 0 High: 100 (%)	100	R/W	0	65535
12	SS. PL	Power limit for steady state	Low: 0 High: 100 (%)	100	R/W	0	65535
13	O1FT	Output 1 failure transfer mode	Low: 0.0% High: SSPL (≤100%) **BPLS:** Bumpless Transfer	0	R/W	-19999	45536
14	ALFN	Alarm function	**0.** ***NoNE***: No alarm function **1.** ***PVHI***: Process value high alarm **2.** ***PVLo***: Process value low alarm **3.** ***PVHL***: Process value high/low alarm **4.** ***dE.HI***: Deviation high alarm **5.** ***dE.Lo:*** Deviation low alarm ***6.*** ***dEHL***: Deviation high/low alarm	2	R/W	0	65535
15	ALMD	Alarm mode	**0.** ***NoRM***: Normal alarm action ***1.*** ***HoLd:*** Hold alarm during power up or setpoint is changed	1	R/W	0	65535

Modbus Register Address	Parameter Notation	Parameter Description	Range	Default Value	Data Access Type	Scale	
						Low	High
16	ALHY	Hysteresis control of alarm	Low: 0.1°C High: 50.0°C (90.0°F)	0.1 °C (0.2 °F)	R/W	0	65535
17	ALFT	Alarm failure transfer mode	**0.** ***oFF***: Alarm output OFF if the sensor fails **1.** ***oN***: Alarm output ON if the sensor fails	1	R/W	0	65535
18	ALHI	Alarm value high	**ALFN=PVHI, PVHL** Low: 25.0 High: 500.0°C **ALFN=DEHI, DEHL** Low: 5.0 High: 40.0°C	10.0 °C (50.0°F)	R/W	-19999	45536
19	ALLO	Alarm value low	**ALFN= PVLO, PVHL** Low: 0.0 High: ALHI-5.0°C **ALFN=DELO, DEHL** Low: -40.0 High: -5.0°C	-10.0 °C (14.0°F)	R/W	-19999	45536
20	BPL1	Bumpless transfer value of MV1	Low: 0.00 High: 100.00	------	R	0	65535
21	CJCL	Sense voltage during cold junction calibration low	Low: 0 High: 7552	------	R	0	65535
22	EROR	Error code	Low: 0 High: 65535	------	R	0	65535
23	MODE	Operation mode and alarm status	Low: 0 High: 65535	------	R	0	65535
24	PROG	Program code	**NC 30:** 30. XX	------	R	0	65535
25	CMND	Command code	Low: 0 High: 65535	------	R/W	0	65535
26	JOB1	Job code	Low: 0 High: 65535	------	R/W	0	65535
27	JOB2	Job code	Low: 0 High: 65535	------	R/W	0	65535
28	JOB3	Job code	Low: 0 High: 65535	------	R/W	0	65535

Modbus Register Address	Parameter Notation	Parameter Description	Range	Default Value	Data Access Type	Scale	
						Low	High
29	CJCT	Cold junction temperature	Low: -4000 High: 9000	------	R	-19999	45536
30	ADLO	mV calibration low coefficient	Low: -1999 High: 1999	------	R/W	-19999	45536
31	ADHI	mV calibration high coefficient	Low: -1999 High: 1999	------	R/W	-19999	45536
32	RTDL	RTD calibration low coefficient	Low: -1999 High: 1999	------	R/W	-19999	45536
33	RTDH	RTD calibration high coefficient	Low: -1999 High: 1999	------	R/W	-19999	45536
34	CJLO	Cold junction calibration low coefficient	Low: -5.00 High: 40.00	------	R/W	-19999	45536
35	CJHI	Cold junction calibration high coefficient	Low: -1999 High: 1999	------	R/W	-19999	45536

Modbus Register Address	Parameter Notation	Parameter Description	Range	Default Value	Data Access Type	Scale	
						Low	High
36	SEL1	Select 1'st parameter for the user menu	**0.** ***NoNE***: No parameter selected **1.** ***AddR:*** ADDR is moved to user menu **2.** ***PUPL:*** PUPL is moved to user menu **3.** ***SSPL:*** SSPL is moved to user menu **4.** ***dISP:*** DISP is moved to user menu **5.** ***Pb***: PB is moved to user menu **6.** ***tI***: TI is moved to user menu **7.** ***td***: TD is moved to user menu ***8.*** ***INPt:*** INPT is moved to user menu **9.** ***UNit***: UNIT is moved to user menu **10.** ***ALHI***: ALHI s moved to user menu ***11.*** ***ALLO:*** ALLO is moved to user menu	0	R/W	0	65535
37	SEL2	Select 2'nd parameter for user menu	Same as SEL1	0	R/W	0	65535
38	SEL3	Select 3'rd parameter for user menu	Same as SEL1	0	R/W	0	65535
39	SEL4	Select 4'th parameter for user menu	Same as SEL1	0	R/W	0	65535
40	SEL5	Select 5'th parameter for user menu	Same as SEL1	0	R/W	0	65535

Modbus Register Address	Parameter Notation	Parameter Description	Range	Default Value	Data Access Type	Scale	
						Low	High
41	SEL6	Select 6'th parameter for user menu	Same as SEL1	0	R/W	0	65535
42	SEL7	Select 7'th parameter for user menu	Same as SEL1	0	R/W	0	65535
43	SEL8	Select 8'th parameter for user menu	Same as SEL1	0	R/W	0	65535
44	ADDR	Address assignment of digital communication	Low: 1 High: 255	------	R/W	0	65535
45	BAUD	Baud rate of digital communication	**0. *2K4***: 2.4 Kbits/s baud rate **1. *4K8:*** 4.8 Kbits/s baud rate **2. *9K6:*** 9.6 Kbits/s baud rate **3. *14K4:*** 14.4 Kbits/s baud rate **4. *19K2:*** 19.2 Kbits/s baud rate **5. *28K8:*** 28.8 Kbits/s baud rate **6. *38K4:*** 38.4 Kbits/s baud rate **7. *57K6:*** 57.6 Kbits/s baud rate **8. *115K:*** 115.2 Kbits/s baud rate	2	R/W	0	65535
46	DATA	Data bit count of digital communication	**0. *7bIt:*** 7 data bits ***1. 8bIt***: 8 data bits	1	R/W	0	65535
47	PARI	Parity bit of digital communication	***0. EVEN:*** Even parity ***1. odd:*** Odd parity ***2. NoNE:*** No parity bit	0	R/W	0	65535
48	STOP	Stop bit count of digital communication	***0. 1bIt:*** One stop bit ***1. 2bIt:*** Two stop bits	0	R/W	0	65535

Modbus Register Address	Parameter Notation	Parameter Description	Range	Default Value	Data Access Type	Scale	
						Low	High
49	FILE	Default file selection	***0. dFLt:*** Default Menu ***1. LdUs:*** Load User Setting ***2. StUs:*** Store User Setting	0	R/W	0	65535
50	PV	Process value	Low: -19999 High: 45536	------	R	-19999	45536
51	SV	Current set point value	Low: SP1L High: SP1H	------	R	-19999	45536
52	MV1	Output 1 control percentage value	Low: 0.00 High: 100.00 (%)	------	R (R/W for manual mode)	0	65535
53	PASS	Password entry	Low: 0 High: 9999	0	R/W	0	65535
54	CODE	Security code for parameter protection	Low: 0 High: 9999 Refer Chapter 3.1 for more details	0	R/W	0	65535
55	OFSTL	Offset value for low point calibration	Low: -1999 High: 1999	0	R/W	-19999	45536
56	OFSTH	Offset value for high point calibration	Low: -1999 High: 1999	0	R/W	-19999	45536
57	CALO	Input signal value during low point calibration	Low: -19999 High: CAHI-1	0	R/W	-19999	45536
58	CAHI	Input signal value during high point calibration	Low: CALO+1 High: 45536	1000	R/W	-19999	45536
59	ALDL	Alarm delay time	Low: 0 High: 99.59 (Hour: Minute) ALSW =ON for Alarm Delay function to function	0	R/W	0	65535

Modbus Register Address	Parameter Notation	Parameter Description	Range	Default Value	Data Access Type	Scale	
						Low	High
60	ALSW	Alarm delay switch	***0. oFF:*** Stop alarm action and reset delay time **1. *oN:*** Activate alarm action	0	R/W	0	65535
61	PWR	Load power (KW)	Low: 0 High: 9.999 (KW)	…	R	0	65535
62	VOLT	Load voltage (Volt)	Low: 0 High: 500.0 (V)	…	R	0	65535
63	AMP	Load current (Amp)	Low: 0 (A) High: 30.0 (A)	…	R	0	65535

2 Installation and Wiring

⚠Sometimes dangerous voltages capable of causing death are present in this instrument. Before doing the installation or any troubleshooting procedures, the power to the equipment must be switched off and isolated. Units suspected of being faulty must be disconnected and removed to a properly equipped workshop for testing and repair. Component replacement and internal adjustments must be made by a qualified maintenance person only.

⚠To minimize the possibility of fire or shock hazards, do not expose this instrument to rain or excessive moisture.

⚠Do not use this instrument in areas under hazardous conditions such as excessive shock, vibration, dirt, moisture, corrosive gases or oil. The ambient temperature of the area should not exceed the maximum rating specified in the specification

⚠Remove stains from this equipment using a soft, dry cloth. Do not use harsh chemicals, volatile solvents such as thinner or strong detergents to clean the equipment in order to avoid deformation.

⚠If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

2.1 Unpacking

Upon receipt of the shipment, remove the controller from the carton and inspect the unit for shipping damage. If any damage is found, contact your local representative immediately. Note the model number and serial number for future reference when corresponding with our service center. The serial number (S/N) is labelled on the box and the housing of the controller. The controller is designed for indoor use only and is not intended for use in any hazardous area. It should be kept away from shock, vibration, and electromagnetic fields (such as variable frequency drives), motors and transformers. It is intended to operate under the following environmental conditions.

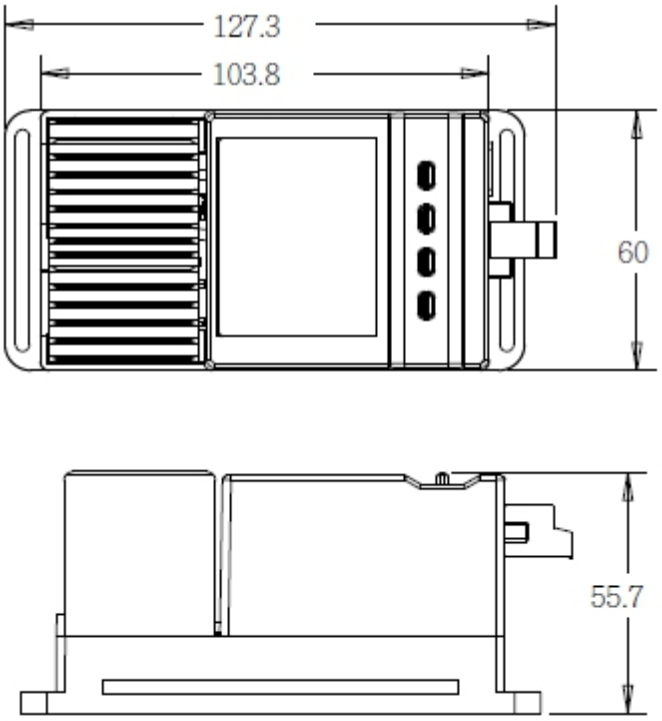
Environmental Parameter	Specification
Operating Temperature	-10°C to 50 °C
Humidity	0% to 90% RH(Non-condensing)
Altitude	2000 M Maximum

2- 1. Environmental Specification

2.2 Mounting

The NC30 controller is designed for wall mounting on cloth jacket heaters.

2.2.1 NC30 Dimension



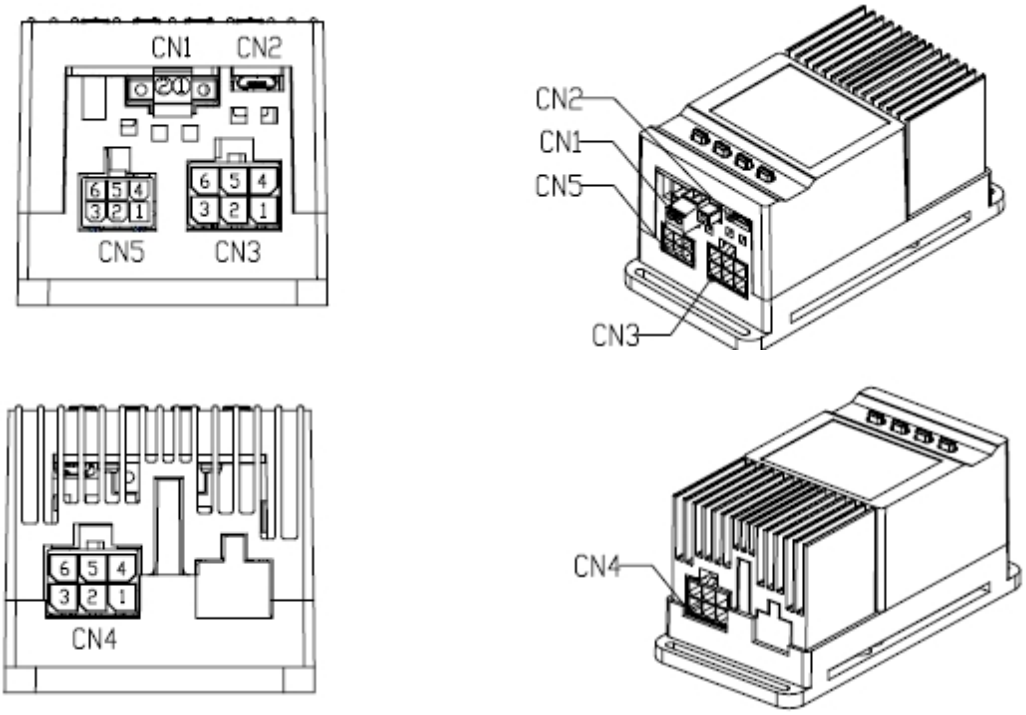
2- 1. NC30 Dimension

2.3 Wiring

Sometimes dangerous voltages capable of causing death are present in this instrument. Before doing the installation or any troubleshooting procedures, the power to the equipment must be switched off and isolated. Units suspected of being faulty must be disconnected and removed to a properly equipped workshop for testing and repair. Component replacement and internal adjustments must be made by a qualified maintenance person only. The utmost care must be taken to ensure that the maximum voltage rating specified on the label is not exceeded. It is recommended that the supply power of these units be protected by fuses or circuit breakers rated at the lowest value possible

All units should be installed inside a suitably grounded metal enclosure to prevent live parts being accessible to human hands and metal tools. All wiring must conform to appropriate standards of good practice and local codes and regulations. Wiring must be suitable for the voltage, current, wire size and temperature rating of the system. The tightening torque on the Screw terminals should not exceed 1 N-m (8.9 Lb-in or 10.2 Kg F-cm). Except Thermocouple Wiring, all other wires used are to be standard copper conductors with the Gauge 18AWG or 12 AWG as mentioned on the wiring diagram. Before powering on the controller, the equipment ground must be connected with a minimum of 1.6mm diameter conductor for protective grounding.

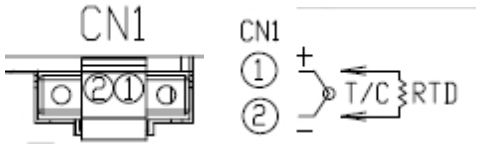
2.3.1 NC30 Terminal Connection



2- 2. NC30 Terminals

2.3.2 Wiring Terminals

2.3.2.1 CN1



2- 3. NC30 CN1 Terminals

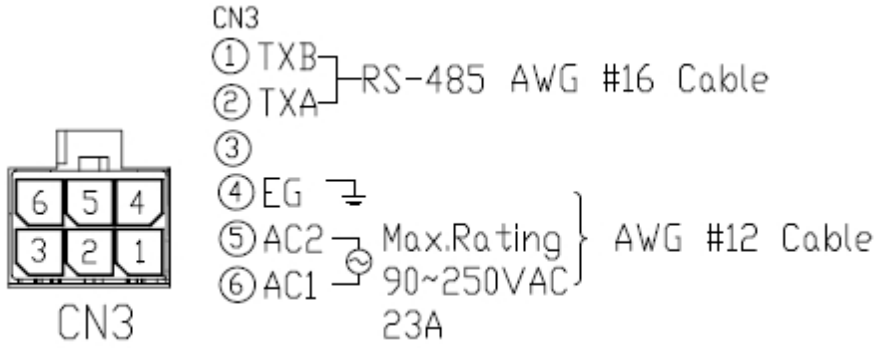
Note: For RTD input, AWG#16 or larger diameter size cable must be used.

2.3.2.2 CN2



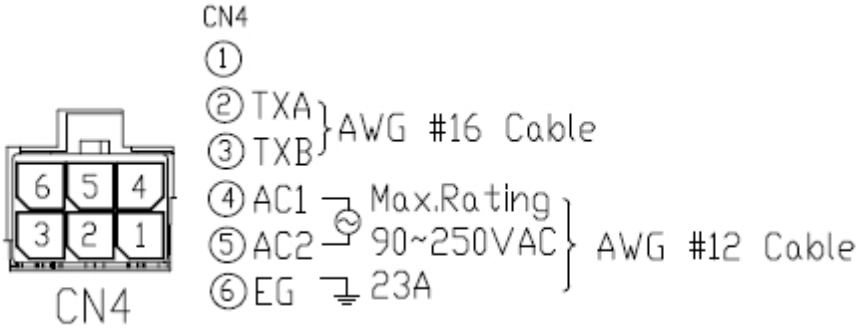
2- 4. NC30 CN2 Terminals

2.3.2.3 CN3



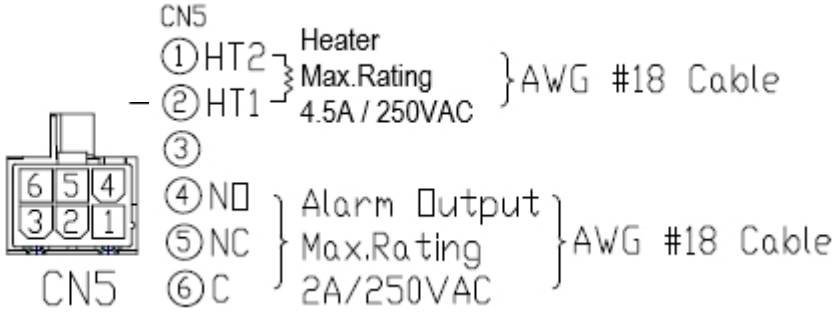
2- 5. NC30 CN3 Terminals

2.3.2.4 CN4



2- 6. NC30 CN4 Terminals

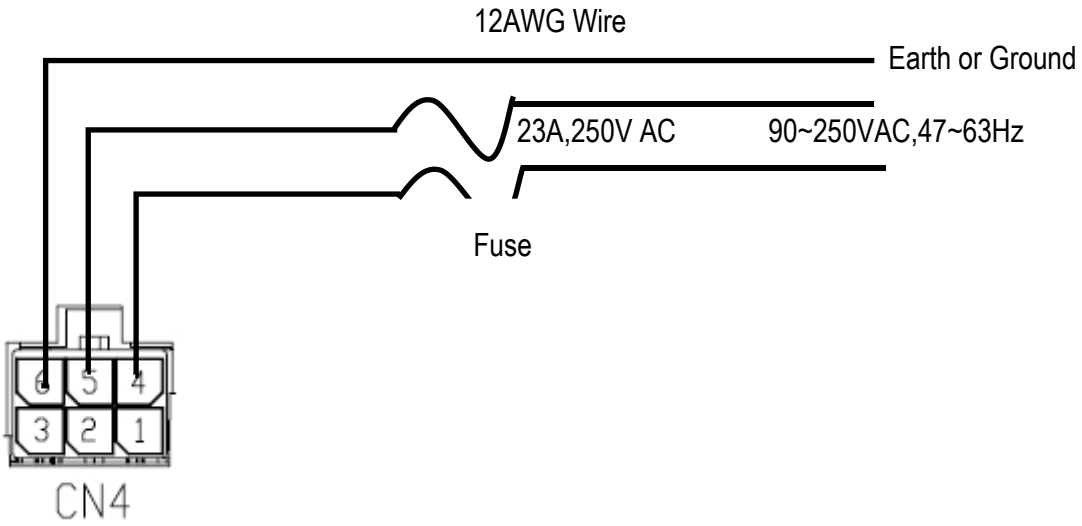
2.3.2.5 CN5



2- 7. NC30 CN5 Terminals

2.4 Power Wiring

The controller is designed to operate at 90-250VAC power input. Check that the installation voltage corresponds with the power rating indicated on the product label before connecting power to the controller. Near the controller, a fuse and a switch rated at 23A/250VAC should be equipped as shown below.



2- 8. NC30 Power Wiring

⚠This equipment is designed for installation in an enclosure which provides adequate protection against electric shock. The enclosure must be connected to earth ground.

⚠Local requirements regarding electrical installation should be rigidly observed. Consideration should be given to prevent unauthorized persons from accessing the power terminals.

Note: When using multiple controllers in a pipe or line the power and communication terminals can be linked by connecting the CN4 of the one controller to CN3 of another controller. This will save the wiring cost and time.

2.5 Sensor Installation

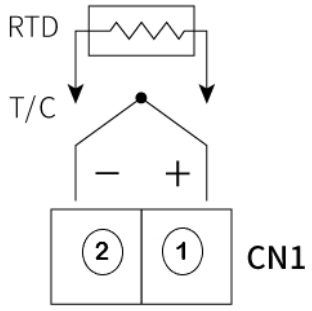
Proper sensor installation can eliminate many problems in a control system. The probe should be placed so that it can detect any temperature change with minimal thermal lag. In a process that requires fairly constant heat output, the probe should be placed close to the heater. In a process where the heat demand is variable, the probe should be closed to the work area. Some experiments with probe location are often required to find this optimum position.

In a liquid process, the addition of a stirrer or agitator can help to eliminate thermal lag. Since the thermocouple is basically a point measuring device, placing more than one thermocouple in parallel can provide average temperature readout and produce better results in most air heated processes.

The proper sensor type is also a very important factor to obtain precise measurements. The sensor must have the correct temperature range to meet the process requirements. In special processes, the sensor might need to have different requirements such as being leak-proof, ant vibration, antiseptic, etc.

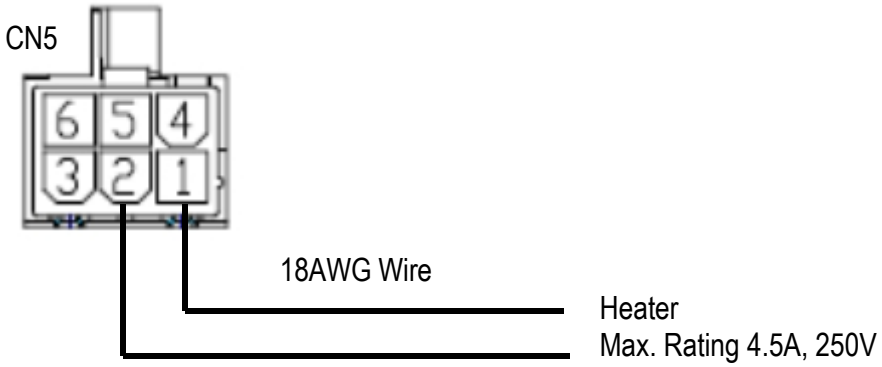
Standard sensor limits of error are ±4°F (± 2°C) or 0.75% of sensed temperature (half that for special) plus drift caused by improper protection or an over-temperature occurrence. This error is far greater than controller error and cannot be corrected on the sensor except by proper selection and replacement.

2.5.1 Sensor Input Wiring



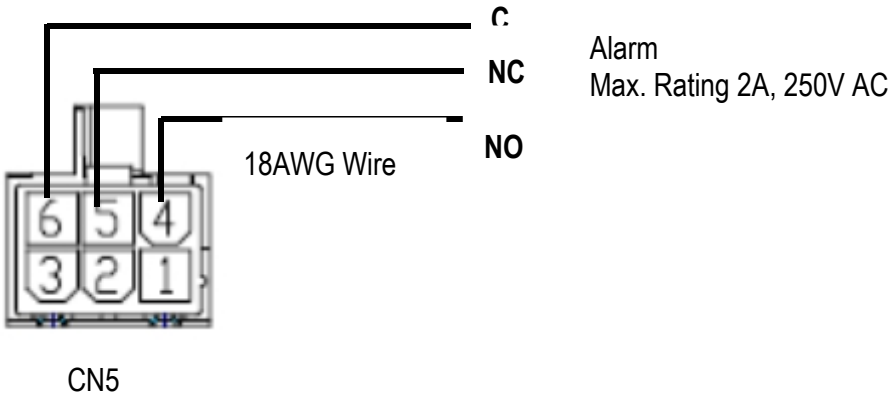
2- 9. NC30 Sensor Input Wiring

2.6 Control Output Wiring



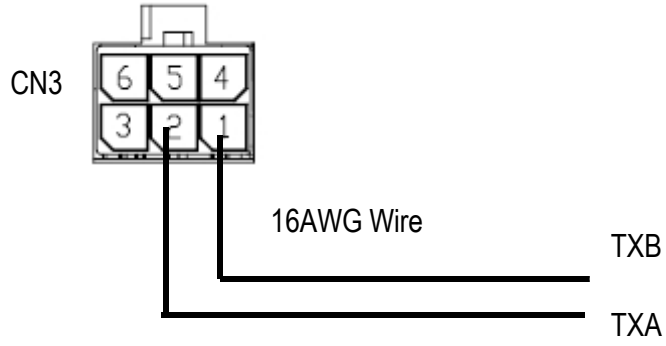
2- 10. NC30 Control Output Wiring

2.7 Alarm Wiring

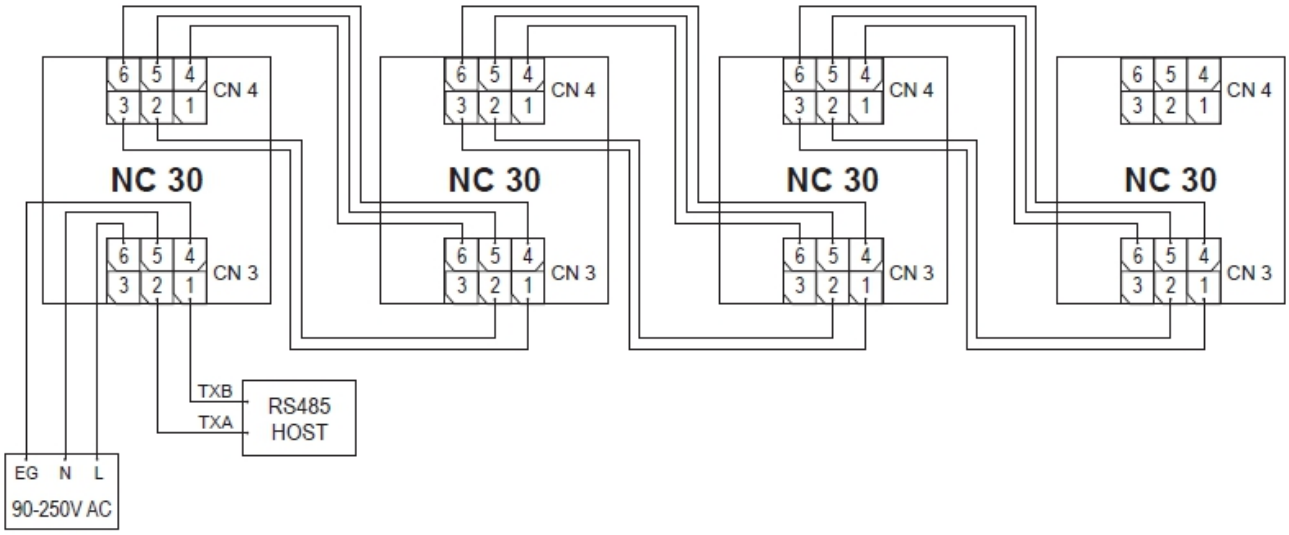


2- 11. NC30 Alarm Wiring

2.8 RS-485 Wiring



2- 12. NC30 RS485 Wiring



2- 13. NC30 Networking Wiring

3 Programming

Press ⏀for 5 seconds and release to enter the setup menu. Press and release ⏀ to select the desired parameter. The upper display indicates the parameter symbol, and the lower display indicates the value of the selected parameter.

3.1 User Security

There are two parameters PASS (password) and CODE (security code) which will control the data security function.

CODE Value	PASS Value	Access Rights
0	Any Value	All parameters are changeable
1000	=1000	All parameters are changeable
	≠1000	User menu parameters only changeable
9999	=9999	All parameters are changeable
	≠9999	SP1 to SP7 only changeable
Others	=CODE	All parameters are changeable
	≠CODE	No parameters can be changed

3- 1.User Access Rights

3.2 Signal Input

INPT: Select the sensor type or signal type for signal input
Range: (Thermocouple) J_tC, K_tC,
(RTD) PT. DN
UNIT: Select the processing unit
Range: °C,
DP: Select the resolution of the process value.
Range: For Thermocouple and RTD Signal NO. DP, 1-DP

3.3 Control Output

3.3.1 Heat only PID Control

The control output will do the PID control for heating. For the initial setup perform Auto-tuning with the values of PB and TI should not be zero. Otherwise set PB, TI and TD using historical values. If the control result is not satisfactory, use manual or Auto-Tuning to improve the control performance. The unit contains a very clever PID and Fuzzy algorithm to achieve the set point with a very small overshoot and very quick response to the process if it is properly tuned. The cycle time of the control output SSR is 2 seconds.

3.4 Failure Transfer

The controller will enter failure mode if one of the following conditions occurs.

1. An SBER error occurs due to an input sensor break,
2. An ADER error occurs due to the A-D converter of the controller fails.

Output 1 will perform the failure transfer (O1. FT) function as the controller enters failure mode.

3.4.1 Output 1 Failure Transfer

If Output 1 Failure Transfer is activated, it will perform as follows:

1. If output 1 is configured as proportional control (PB≠0), and BPLS is selected for O1FT, then output 1 will perform a Bumpless transfer. After that, the previous average value of MV1 will be used for controlling output 1.
2. If output 1 is configured as proportional control (PB≠0), and a value of 0 to 100.0 % is set for O1FT, then output 1 will perform failure transfer. After that, the value of O1FT will be used for controlling output 1.

3.5 Auto-Tuning

⚠ The Auto-Tuning process will be performed at the setpoint (SP1). The process will oscillate around the setpoint during the tuning process. Set a set point to a lower value if overshooting beyond the normal process value will cause damage. It is usually best to perform Auto-Tuning at the Setpoint the machine is expected to be operated at, with the process running normally (i.e. material in the oven, etc.)
Auto-Tuning is generally applied in the following cases:

- ❖ Initial setup for a new process
- ❖ The setpoint is changed substantially from the previous Setpoint when Auto-Tuning was performed.
- ❖ The control result is unsatisfactory

3.5.1 Auto-Tuning Operation Steps

1. The system has been installed normally.
2. Do not use a zero value for PB or TI; otherwise, the Auto-Tuning program will be disabled.
3. Set the set point to a normal operating value or a lower value if overshooting beyond the normal process value will cause damage.
4. Press and hold the key until A-t appear on the upper display, then let go.
5. Press and hold the key for at least 5 seconds. The TUNE indicator will begin to flash, and the Auto-Tuning process has begun.

NOTE:

If the ramping function is used, it will be disabled once Auto-Tuning is started. The Auto-Tuning mode is disabled if either a failure mode or manual control mode occurs.

Procedures:

Auto-Tuning can be applied either as the process is warming up (Cold Start) or as the process has been in a steady state (Warm Start). After the Auto-Tuning process is completed, the TUNE indicator will stop flashing and the unit will revert to PID control by using its new PID values. The PID values obtained are stored in nonvolatile memory.

3.5.2 Auto-Tuning Error

If Auto-Tuning fails, an ATER AtEr message will appear on the upper display in any of the following cases.

- ❖ If PB exceeds 900.0°F or 500.0°C
- ❖ If TI exceeds 3600 seconds
- ❖ If the setpoint is changed during the Auto-Tuning process

3.5.3 Solution for Auto-Tuning Error

1. Try Auto-Tuning once again.

2. Do not change the setpoint value during the Auto-Tuning process.
3. Do not set zero value for PB and TI.
4. Use manual tuning
5. Touch RESET [R] key to reset the [AtEr] message.

3.6 Manual Tuning

In certain applications (very few), using Auto-Tuning to tune a process may be inadequate for the control requirement. In this case, the user can try manual tuning.

If the control performance by using Auto- Tuning is still unsatisfactory, the following guidelines can be applied for further adjustment of PID values.

ADJUSTMENT SEQUENCE	SYMPTOM	SOLUTION
Proportional Band (PB)	Slow Response	Decrease PB
	High overshoot or Oscillations	Increase PB
Integral Time (TI)	Slow Response	Decrease TI
	Instability or Oscillations	Increase TI
Derivative Time (TD)	Slow Response or Oscillations	Decrease TD
	High Overshoot	Increase TD

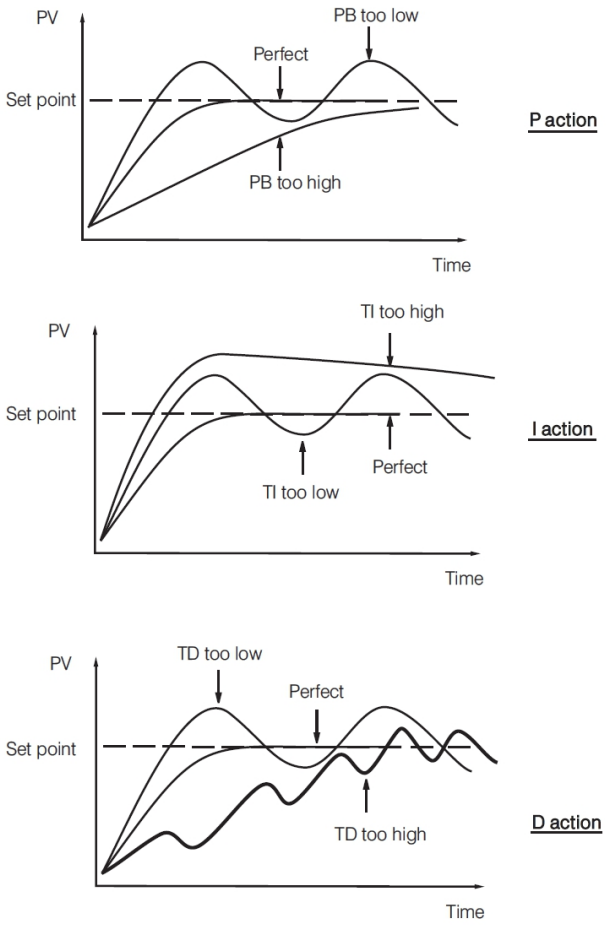
3- 2.PID Parameter Adjustment Guide

3.7 Manual Control

To enable manual control, ensure that CODE=0 or CODE=PASS . Press and hold [⊙] for 6.2 seconds or until [HAnd] [----] (Hand Control) appears on the display. Press and hold [⊙] for 5 seconds or until the MANU indicator begin to flash. The lower display will show [H---]. The controller has now entered manual control mode. [H---] Indicates the output control variable for output 1, The user can use the up-down keys to adjust the percentage values for the heating output. The controller performs open loop control as long as it stays in manual control mode. The manual mode menu can be reached by pressing [▼][⊙] keys also

3.7.1 Exit Manual Control

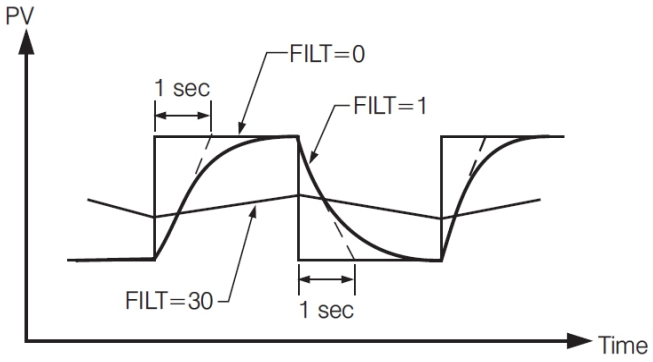
Pressing the [R] key will revert the controller to its normal display mode.



3- 1. Effects of PID Adjustment

3.8 Digital Filter

In certain applications, the process value is too unstable to be read. To improve this, a programmable low pass filter incorporated in the controller can be used. This is a first-order filter with a
time constant specified by the FILT parameter. A value of 0.5 seconds is used as a factory default.
Adjust FILT to change the time constant from 0 to 60 seconds. 0 seconds represents no filter applied to
the input signal. The filter is characterized by the following diagram.



3- 2.Filter Characteristics

Note

The Filter is available only for the process value (PV) and is performed for the displayed value only. The controller is designed to use an unfiltered signal for control even when a filter is applied. If a lagged (filtered) signal is used for control; it may produce an unstable process.

3.9 Alarm

The controller has one alarm output as standard. There are 6 different alarm functions and two different modes available for the user to select. The alarm function and alarm mode can be setup using the parameter ALFN and ALMD respectively.

3.9.1 Alarm Types

There are 6 different types of alarms as listed below that the user can assign to different alarm outputs.

1. **dE.HI:** Deviation high alarm
2. **dE.Lo:** Deviation low alarm
3. **dE.HL**: Deviation high / low alarm
4. **PV.HI:** Process value high alarm
5. **PV.Lo:** Process value low alarm
6. **PV.HL:** Process value high/low alarm

A deviation alarm alerts the user when the process value deviates too far from the set point. When the process value is higher than SV+ALHI, a **deviation high alarm (dE.HI)** occurs. The alarm is off when the process value is lower than SV+ALHI-ALHY.

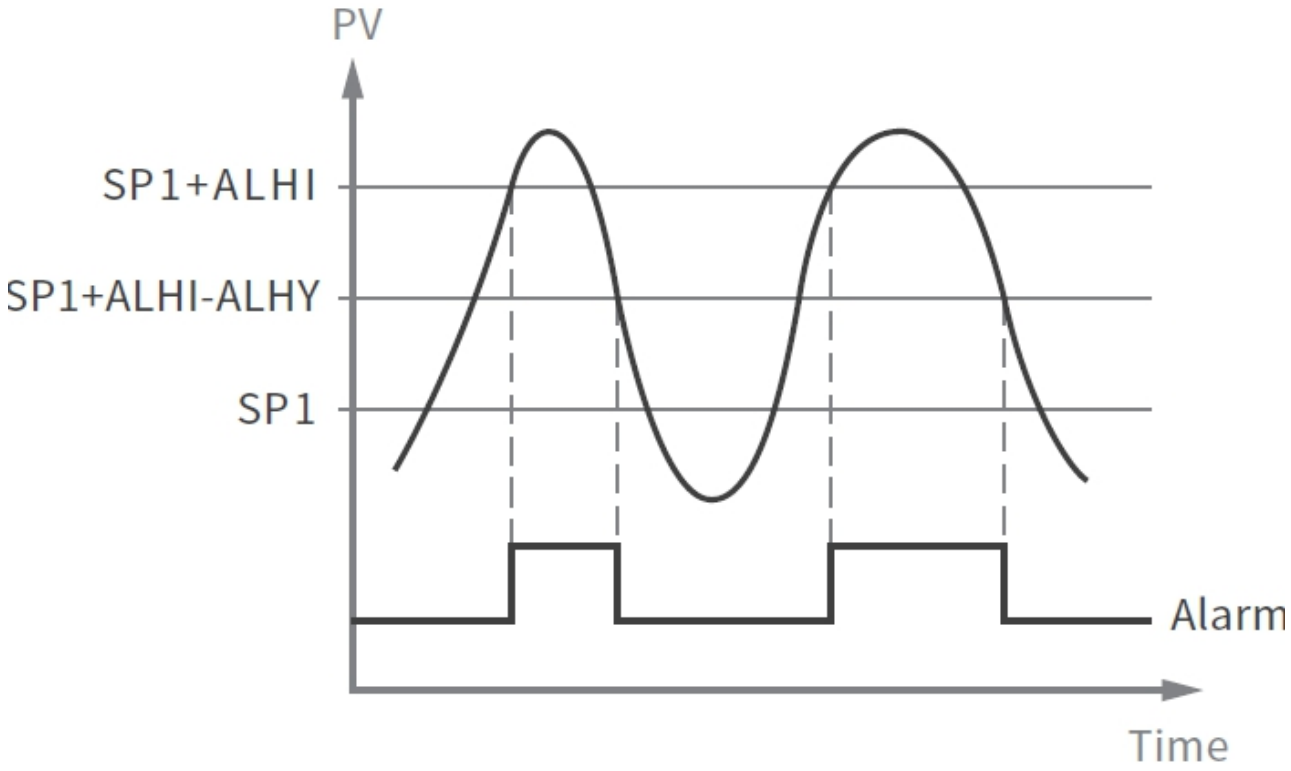
When the process value is lower than SV+ALLo, a **deviation low alarm (dE.Lo)** occurs. The alarm is off when the process value is higher than SV+ALLo+ALHY. The trigger level of a deviation alarm moves with the setpoint.

The **deviation high/low alarm (dE.HL)** will occurs When the process value is higher than SV+ALHI or When the process value is lower than SV+ALLo. The alarm is off when the process value is lower than SV+ALHI-ALHY or SV+ALLo+ALHY.

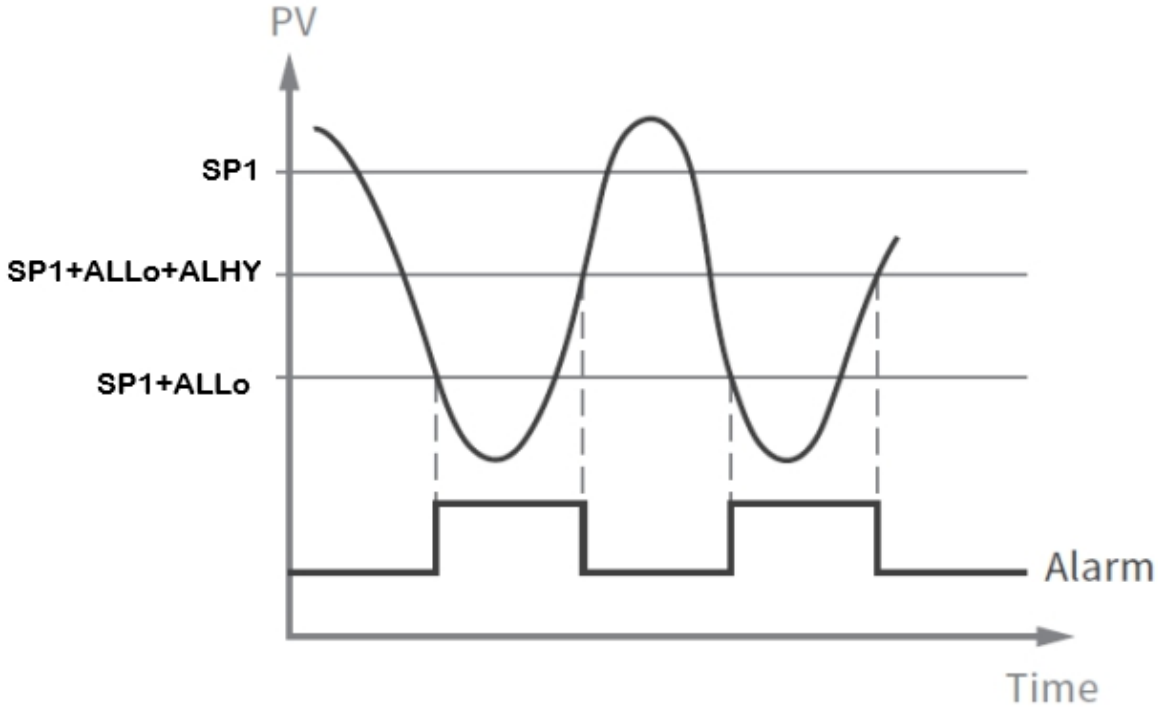
A process alarm can set two absolute trigger levels. When the process value is higher than ALHI, a **process high alarm (PV.HI)** occurs. The alarm is off when the process value is lower than ALHI-ALHY.

When the process value is lower than ALLo, a **process low alarm (PV.Lo)** occurs. The alarm is off when the process is higher than ALLo+ALHY. A process alarm is independent of the set point.

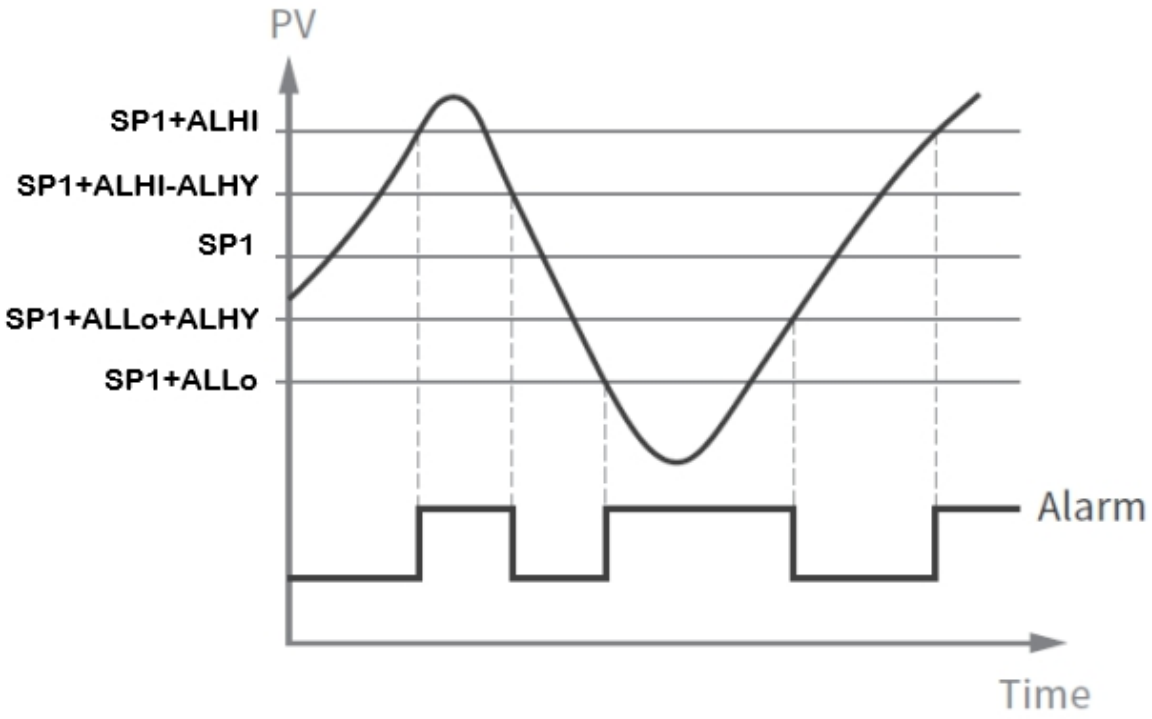
The **process high/low alarm(PV.HL)** will occurs when the process value is higher than ALHI or lower than ALLO. The alarm is off when the process value is higher than ALLo+ALHY or lower than ALHI-ALHY.



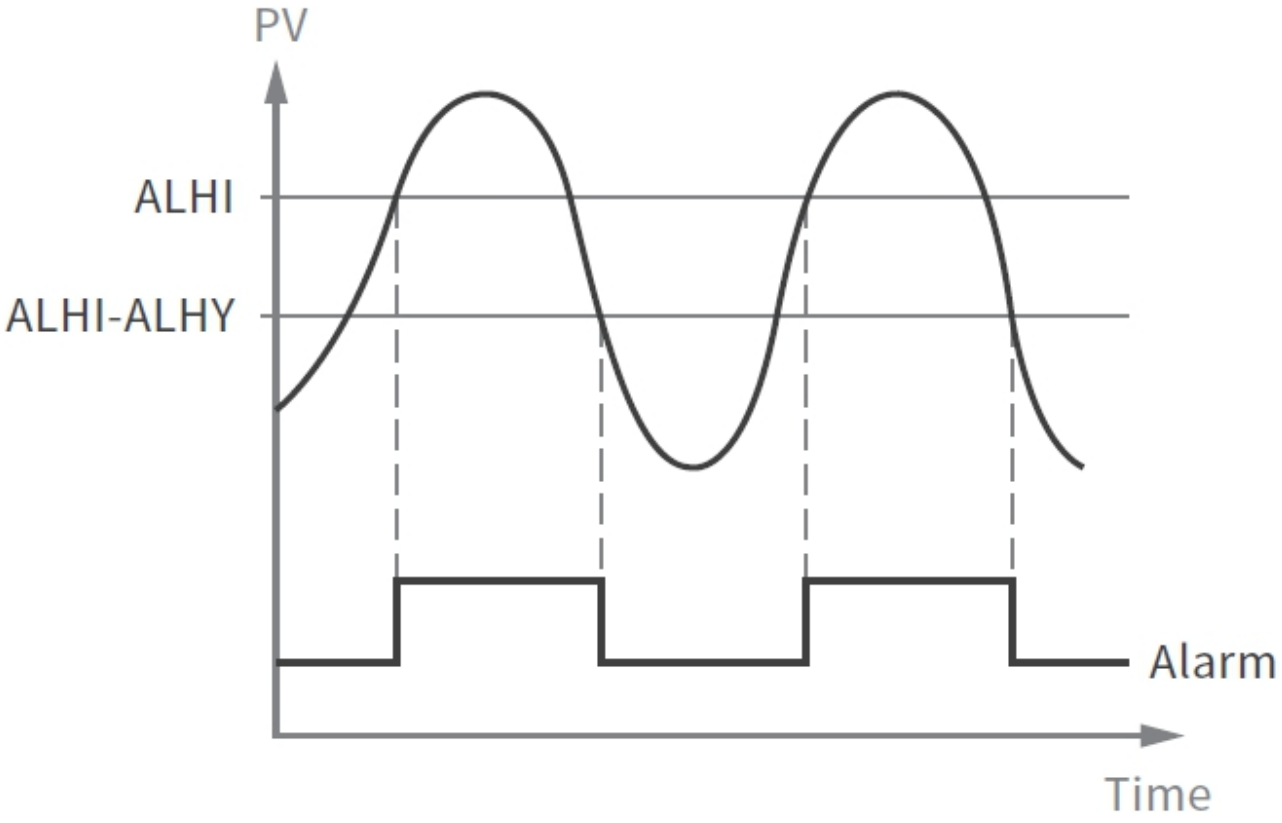
3- 3 Deviation High Alarm (dE.HI)



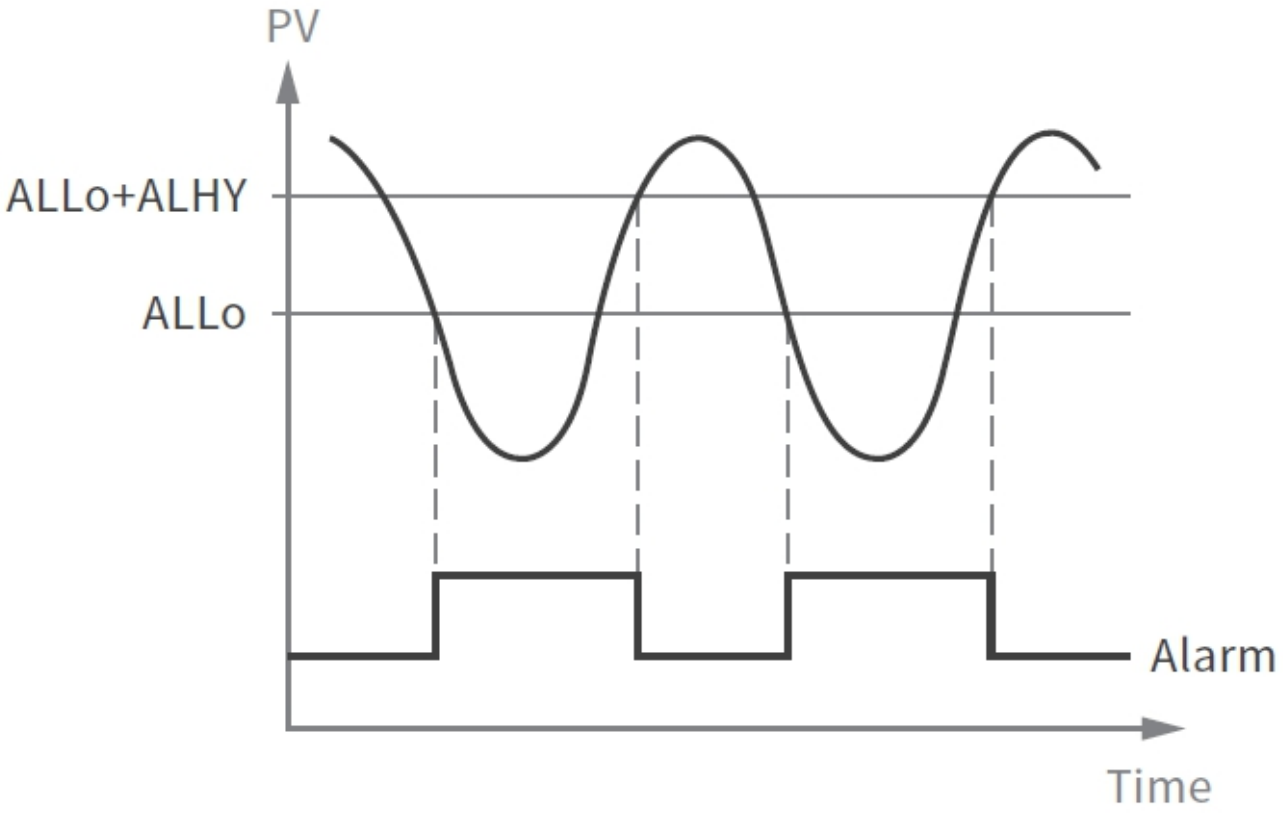
3- 4 Deviation Low Alarm (dE.Lo)



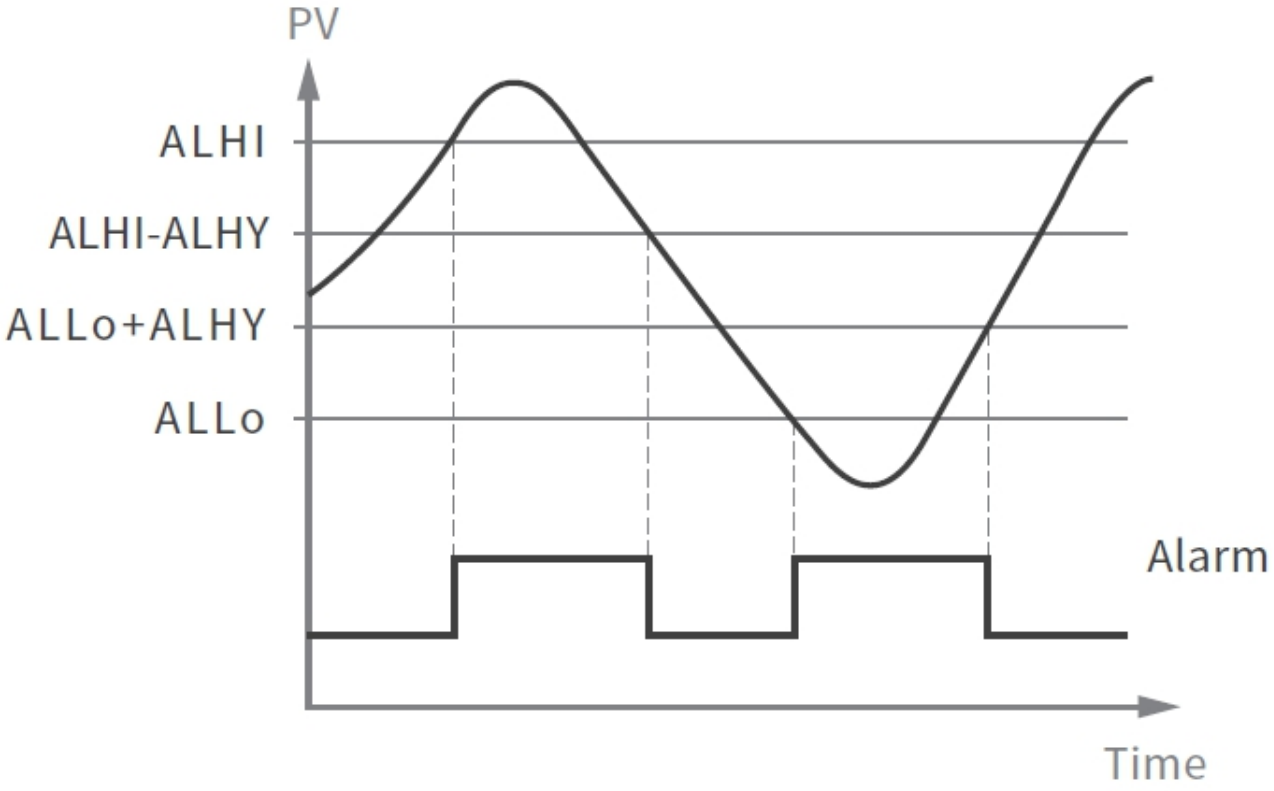
3- 5 Deviation High Low Alarm (dE.HL)



3- 6 Process Value High (PV.HI)



3- 7 Process Value Low (PV.Lo)



3- 8 Process Value High Low (PV.HL)

3.9.2 Alarm Modes

There are two types of alarm modes available for each alarm function.

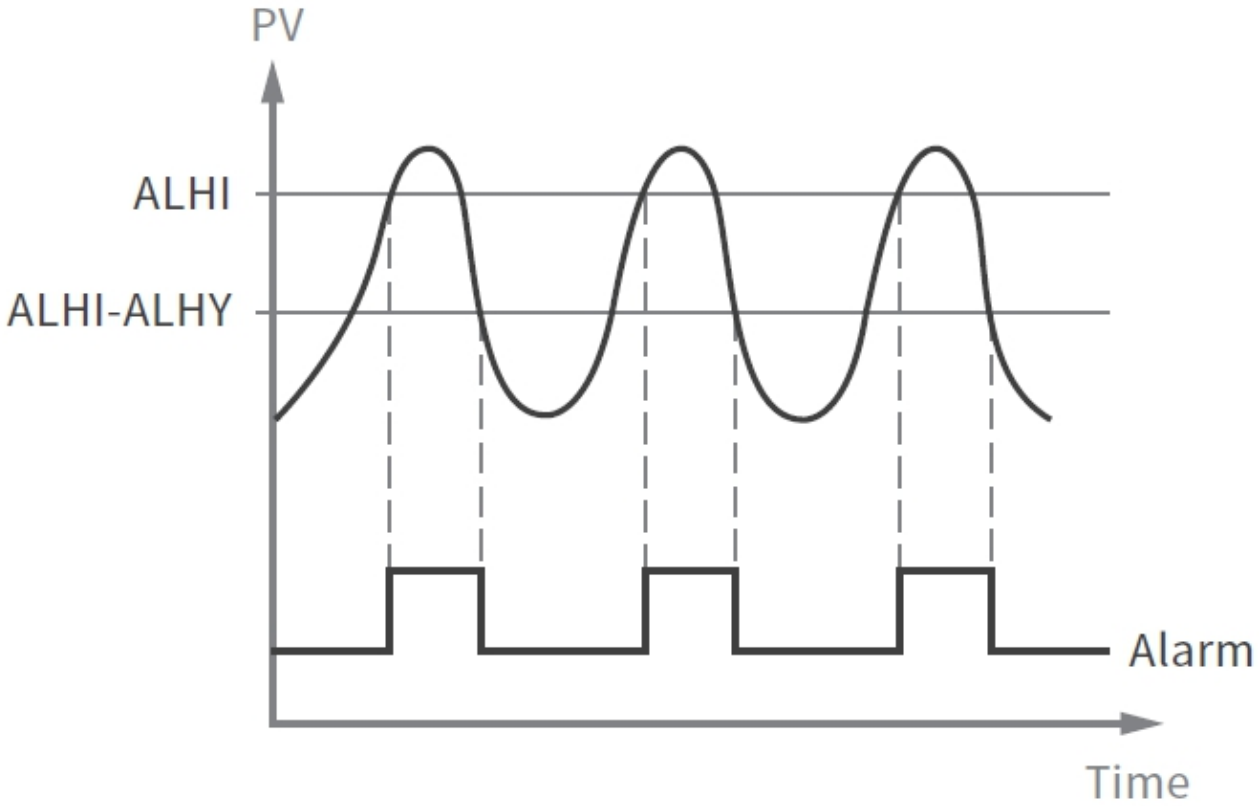
1. Normal alarm
2. Holding alarm

3.9.2.1 Normal Alarm: ALMD = NORM

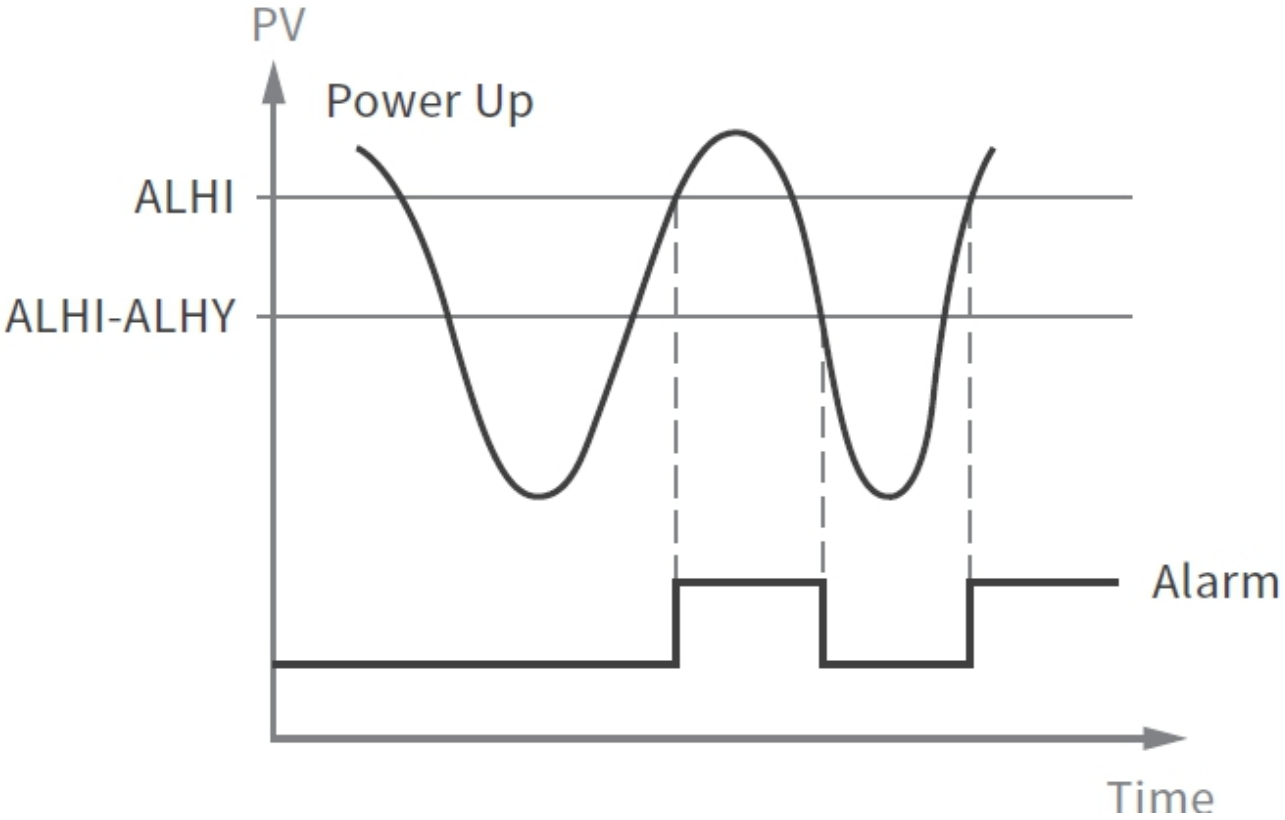
When a normal alarm is selected, the alarm output is de-energized in the non-alarm condition and energized in an alarm condition.

3.9.2.2 Setpoint Holding Alarm: ALMD = HOLD

A setpoint holding alarm prevents an alarm from power-up and/or changing set point. The alarm output is de-energized whenever the setpoint is changed even if it is in an alarm condition. The alarm reverts to a normal alarm once the alarm condition is removed...



3- 9 Process Value High- Normal Alarm



3- 10 Process Value High- Setpoint Holding Alarm

3.9.3 Alarm Delay

In certain applications during startup, nuisance alarms will be generated before the process value reaches the set point. To avoid these kinds of nuisance alarms, a time delay for alarm is available. To enable the time delay for alarms, set the alarm delay switch ALSW to ON and set the delay time using the ALDL parameters. This parameter will avoid the nuisance alarm during the process value reaches the setpoint.

For example, the process set point set to 100. When the process approaching 100 it will go to 103 and 97. During this time the Hi Alarm will be activated and deactivated continuously. To avoid these kinds of nuisance alarms the alarm delay function can be used. It will generate the alarm after the PV is in alarm condition continuously at least for the period of time configured in alarm delay parameters. The alarm delay can be configured in minutes and seconds.

3.9.4 Alarm Failure Transfer

Alarm Failure transfer is activated as the unit enters failure mode. The Alarm will go on if ON is set for ALFT and will go off if OFF is set for ALFT. The unit will enter failure mode if a sensor break occurs or if the A-D converter fails.

3.10 User Select Menu Configuration

Conventional controllers are designed with parameters in a fixed order. If the user needs a friendlier menu operation to suit their application, most conventional controllers do not offer a solution. The NC30 controller have the flexibility for the user to select those parameters which are most significant and put these parameters in an easy access USER menu.

There are eight user-friendly parameters from the below list that can be set for user select menu configuration using the SEL1-SEL8 parameters.

0. **NoNE:** No parameter selected
1. **AddR:** ADDR is moved to user menu
2. **PUPL:** PUPL is moved to user menu
3. **SSPL:** SSPL is moved to user menu
4. **dISP:** DISP is moved to user menu
5. **Pb:** PB is moved to user menu
6. **tI:** TI is moved to user menu
7. **td:** TD is moved to user menu
8. **INPt:** INPT is moved to user menu
9. **UNit:** UNIT is moved to user menu
10. **ALHI:** ALHI s moved to user menu
11. **ALLO:** ALLO is moved to user menu

When using the up-down key to select parameters, all of the above parameters may not be available. The number of visible parameters is dependent on the setup configuration.

3.11 User Calibration

Each unit is calibrated in the factory before shipment. The user can still modify the calibration in the field.

The basic calibration of the controller is highly stable and set for life. User calibration allows the user to offset the permanent factory calibration in order to:

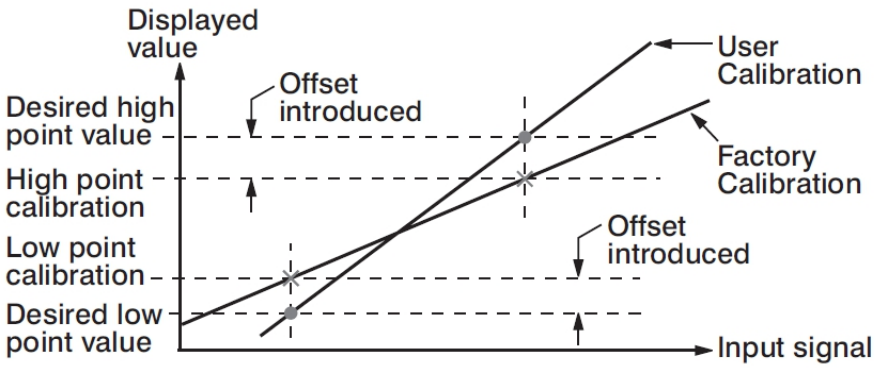
- ❖ Calibrate the controller to meet a user reference standard.
- ❖ Match the calibration of the controller to that of a particular transducer or sensor input.
- ❖ Calibrate the controller to suit the characteristics of a particular installation.
- ❖ Remove long term drift in the factory set calibration.

There are two parameters: Offset Low (OFTL) and Offset High (OFTH) for adjustment to correct an error in the process value.

There are two parameters for the sensor input. These two signal values are CALO and CAHI. The input signal low and high values are to be entered in the CALO and CAHI parameters respectively.

Refer to section 1.6 for key operation and section 1.7 for the operation flowchart. Press and hold the ⏎ key until the setup Menu page is obtained. Then, press and release the ⏎ key to navigate to the calibration low parameter OFTL. Send your low signal to the sensor input of the controller, then press and release the⏎ key. If the process value (the upper display) is different from the input signal, the user can use ▲and▼ keys to change the OFTL value (the lower display) until the process value is equal to the value the user needs. Press and hold the ⏎key for 5 seconds to complete the low point calibration. A similar procedure is applied for high scale calibration.

As shown below, the two points OFTL and OFTH construct a straight line. For the purpose of accuracy, it is best to calibrate with the two points as far apart as possible. After the user calibration is complete, the input type will be stored in the memory.



3- 11.Two Point User Calibration

3.12 Default Setting

3.12.1 Factory Default Setting

The controller's parameters can be loaded with default values listed in the parameter description table. In certain situation, it is desirable to retain these values after the values of the parameters have been changed. The below procedure to be followed to reload the default values.

1. Ensure CODE=0 or CODE=PASS.
2. Press and hold ⊡ for 6.2 seconds or until HAnd ---- (Hand Control) appear on the display.
3. Press ⊡ key to navigate to the manual mode menu then using ▼ or ▲ key to select the desired default FILE.
4. Press and hold ⊡ for 5 seconds or until the upper display flash for a moment.

The default values of all parameters are loaded now.

3.12.2 User Default Setting

The user can store the default parameter setting as per their requirement and load the stored default parameters.

3.12.2.1 Store User Default Setting

The user default setting can be stored by using the below steps.

1. Ensure CODE=0 or CODE=PASS
2. Press ⊡ and ▼ to access the manual mode parameters. The lower display will show H0.00.
3. Press using ▼ or ▲ key to select St.US
4. Press ⊡ key for 5 seconds to store the user default setting parameter. The upper display will blink a moment for the user confirmation.

3.12.2.2 Load User Default Setting

The stored user default setting can be loaded by using the below steps.

1. Ensure CODE=0 or CODE=PASS
2. Press ⊡ and ▼ to access the manual mode parameters. The lower display will show H0.00.
3. Press using ▼ or ▲ key to select Ld.US
4. Press ⊡ key for 5 seconds to load the user default setting parameter. The upper display will blink a moment for the user confirmation.

3.13 Data Communication

The controllers support RS-485 Modbus RTU protocol for data communication. Using a PC for data communication is the most economical way. The signal is transmitted and received through the PC communication Port. Since a standard PC can't support an RS-485 port, a network adaptor such as an RS232 to RS485 Converter or USB to Serial Converter must be used to convert RS-485 to RS-232 or USB for a PC. Many RS-485 units (up to 247 units) can be connected to one RS-232 port or USB Port. Therefore, a PC with 4 comm. ports can communicate with up to 988 units. It is quite economical.

3.13.1 RS-485 Setup

- Enters the setup menu.
- Set individual addresses for units connected to the same port.
- Set the Baud Rate (BAUD), Data Bit (DATA), Parity Bit (PARI) and Stop Bit (STOP) such that these values are accordant with PC setup conditions.

3.14 Heater Break Detection

The controller will display the heater break error Ht.bR when there is a heater break. The controller will give the heater break error when the control variable MV reached to its maximum or minimum value, the PV doesn't increase or decrease for the period of 2TI (double of integral time, but 120 seconds maximum)

3.15 Output Power Limit

The output power at power up state and the steady state can be limited by using the parameters PU. PL and SS.PL respectively.

3.16 Output Load Power, Voltage, current monitoring

The controller will continuously monitor the output load power, voltage and current. The user can access these data from the parameters PWR, VOLT, AMP.

3.17 Home Page Display

The controller will display the home page display parameter as configured in DISP parameter. This will be shown when the controller is idle for more than two minutes.

4 Calibration

⚠Do not proceed through this section unless there is a definite need to re-calibrate the controller. All previous calibration data will be lost. Do not attempt recalibration unless you have appropriate calibration equipment. If calibration data is lost, you will need to return the controller to your supplier who may charge you a service fee to re-calibrate the controller.

⚠Entering the calibration mode will break the control loop. Make sure that the system is allowable to apply the calibration mode.

4.1 Equipment Required Before Calibration

1. A high accuracy calibrator (Fluke 5520A Calibrator recommended) with the following functions
   - ❖ 0 - 100 mV millivolt source with 0.005 % accuracy
   - ❖ 0 - 300Ω resistant source with 0.005 % accuracy
2. A test chamber providing 25°C - 50°C temperature range
3. A switching network (SWU16K, optional for automatic calibration)
4. A calibration fixture equipped with programming units (optional for automatic calibration)
5. A PC installed with calibration software (optional for automatic calibration)

The calibration procedures described in the following section are step by step manual procedures. Since a controller needs 30 minutes to warm up before calibration, calibrating the units one by one is quite inefficient. An automatic calibration system for small quantity as well as for an unlimited quantity is available upon request.

4.1.1 Manual Calibration Procedure

Set the Lock parameter to the unlocked condition (CODE= 0). Press and hold the scroll key until CAL, appears on the display, then release the scroll key. Press the scroll key for 2-3 seconds then release, the lower display will show AdLo and the unit will enter the calibration mode.

4.1.1.1 Calibrate Zero of A to D Converter

Set the input sensor selection at K_TC .Short the thermocouple input terminals, then press scroll key for at least 5 seconds. The upper display will blink a moment and a new value is obtained. If the display didn't blink then the calibration failed.

4.1.1.2 Calibrate Gain of A to D Converter

Press scroll key until the display shows AdH, . Send a 60-mV signal to the thermocouple input terminals with the correct polarity. Press scroll key for at least 5 seconds. The upper display will blink a moment and a new value is obtained. If the display didn't blink then the calibration fails.

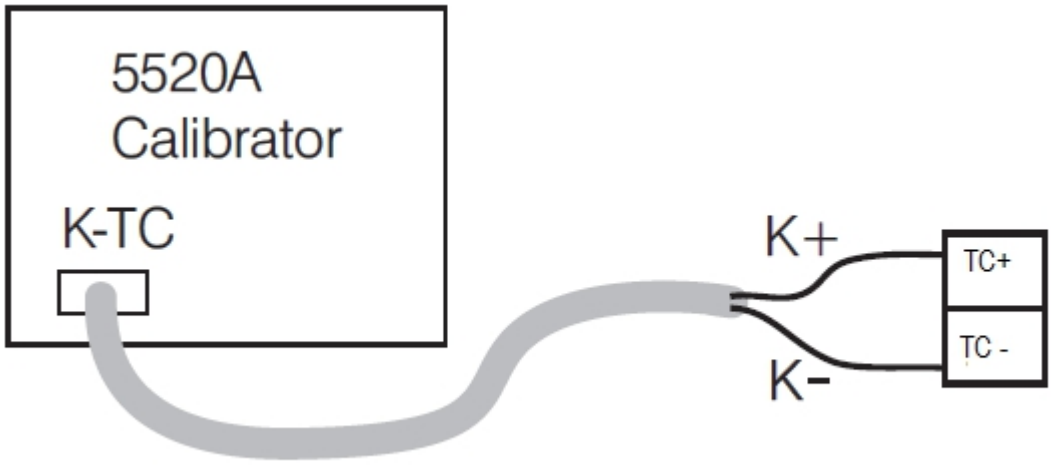
4.1.1.3 Calibrate RTD Input

Set the input sensor selection at PT.DN .Press the scroll key until the display shows rtdL . Send a 100 Ω signal to the RTD input terminals according to the connection. Press the scroll key for at least 5 seconds. The upper display will blink a moment, otherwise, the calibration failed.

Press scroll key and the display will show rtdH . Change the resistance value to 300Ω. Press scroll key for at least 5 seconds. The display will blink a moment and two values are obtained for RTDH and RTDL. If the display didn't blink then the calibration failed.

4.1.1.4 Calibrate Offset of Cold Junction Compensation

Setup the equipment according to the following diagram for calibrating the cold junction compensation. Note that a K type thermocouple must be used.



4- 1.Cold Junction calibration Setup

Let controller sit at least 20 minutes in a room temperature of 25±3°C. The 5520A calibrator is to be configured as a K type thermocouple output with internal compensation. Send a 0.00°C signal to the controller. Perform the steps mentioned above to enter calibration mode, and then press scroll key until the display shows CJLo. Press the scroll key for at least 5 seconds. The upper display will blink a moment and a new value is obtained. If the display didn't blink then the calibration failed.

Note: CJLO must be calibrated before CJHI calibration

4.1.1.5 Calibrate Gain of Cold Junction Compensation

Setup the equipment the same as during Offset calibration of Cold Junction Compensation. The unit under calibration is to be powered in a room with a temperature of 50±3°C for at least 20 minutes. The calibrator source is to be set to 0.00° C with internal compensation mode. Perform steps mentioned above to enter calibration mode, and then press scroll key until the display shows CJHi. Press the scroll key for at least 5 seconds. The upper display will blink a moment and a new value is obtained. If the display didn't blink then the calibration failed.

This setup is performed in a high-temperature chamber; hence it is recommended to use a computer to perform the procedures

5 Communication

This chapter explains the Modbus Communication protocol of the controller using RS-485 communication. This supports only RTU mode. Data is transmitted as 8-bit binary bytes with 1 start bit,1 stop bit and optional parity checking (None, Odd, Even). Baud rate may be set to 2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600 and 115200 BPS.

5.1 Functions Supported

Only function code 03,06 and 16 are available for this series of controllers. The message formats for each function code are described as follows.

5.1.1 Function Code 03: Read Holding Registers

Query (From Master)	Slave Address (1~247)	Response (From Slave)	Slave Address (1~247)
	Function Code (03)		Function Code (03)
	Starting Address of Register Hi (00)		Byte Count
	Starting Address of Register Lo (00~63)		Data1 Hi
	No of Words Hi (00)		Data1 Lo
	No of Words Lo (1~64)		Data2 Hi
	CRC16 Hi		Data2 Lo
	CRC16 Lo		…
			Data ‘n’ Hi
			Data ‘n’ Lo
			CRC16 Hi
			CRC16 Lo

5- 1.Function Code 03

5.1.2 Function Code 06: Pre-set Single Register

Query (From Master)	Slave Address (1~247)	Response (From Slave)	Slave Address (1~247)
	Function Code (06)		Function Code (06)
	Starting Address of Register Hi (00)		Starting Address of Register Hi (00)
	Starting Address of Register Lo (00~63)		Starting Address of Register Lo (00~63)
	Data Hi		Data Hi
	Data Lo		Data Lo
	CRC16 Hi		CRC16 Hi
	CRC16 Lo		CRC16 Lo

5- 2.Function Code 06

5.1.3 Function Code 16: Pre-set Multiple Register

Query (From Master)	Slave Address (1~247)			Response (From Slave)	Slave Address (1~247)		
	Function Code (16)				Function Code (16)		
	Starting Address of Register Hi (00)				Starting Address of Register Hi (00)		
	Starting Address of Register Lo (00~63)				Starting Address of Register Lo (00~63)		
	No of Words Hi (00)				No of Words Hi (00)		
	No of words Lo (1~64)				No of words Lo (1~64)		
	Bytes Count (2~128)				Bytes Count (2~128)		
	Data1	Hi			Data1	Hi	
	Data1	Lo			Data1	Lo	
	Data2	Hi			Data2	Hi	
	Data2	Lo			Data2	Lo	
	…				…		
	Data	’n’	Hi		Data	’n’	Hi
	Data	’n’	Lo		Data	’n’	Lo
	CRC16	Hi			CRC16	Hi	
	CRC16	Lo			CRC16	Lo	

5- 3.Function Code 16

5.2 Exception Responses

If the controller receives a message which contains a corrupted character (parity check error, framing error etc.), or if the CRC16 check fails, the controller ignores the message. However, if the controller receives a syntactically correct message which contains an illegal value, it will send an exception response, consisting of five bytes as follows:
Slave address +offset function code + exception code + CRC16 Hi +CRC16 Lo

Where the offset function code is obtained by adding the function code with 128 (i.e. function 3 becomes H'83), and the exception code is equal to the value contained in the following table.

Exception Code	Description	Reason
1	Bad Function Code	The function code is not supported by the controller
2	Illegal Data Addresses	Register address out of range
3	Illegal Data Value	Data value out of range or attempt to write a read-only or protected data

5- 4.Exception Code

5.3 Parameter Mapping

The parameter mapping of Modbus address is available in section 1.8

5.4 Error Code

The description of the Error code is explained below

Error Code	Display Symbol	Description & Reason	Corrective Action
10	ER10	**Communication error:** bad function code	Correct the communication software to meet the protocol requirements.
11	ER11	**Communication error:** register address out of range	Do not issue an over-range address of the register to the slave
14	ER14	**Communication error:** attempt to write a read-only data	Do not write read-only data or protected data to the slave.
15	ER15	**Communication error:** write a value which is out of range to a register	Do not write an over-range data to the slave register
26	ATER	**Auto-Tuning Error:** Failed to perform Auto-Tuning function	The PID values obtained after Auto-Tuning process are out of range. Retry Auto-Tuning. Do not change the setpoint value during Auto-Tuning process. Use manual tuning instead of Auto-Tuning process. Do not set a zero value for TI. Do not set a zero value for PB. Touch RESET key
27	CAER	**Calibration Error:** CALO>CAHI	The CAHI > CALO. Use lower PV value to calibrate OFTL and higher PV to calibrate OFTH.
29	EEPR	EEPROM can't be written correctly	Return to factory for repair.
30	CJER	Cold junction compensation for Thermocouple malfunction	Return to factory for repair.

Error Code	Display Symbol	Description & Reason	Corrective Action
39	SBER	Input sensor break	Replace the input sensor.
40	ADER	A to D converter or related component(s) malfunction	Return to factory for repair.
51	PWER	Communication Interruption or abnormal reading from power IC	Return to factory for repair
53	HTBR	Heater Break Error	Check the heater wiring

5- 5.Error Code

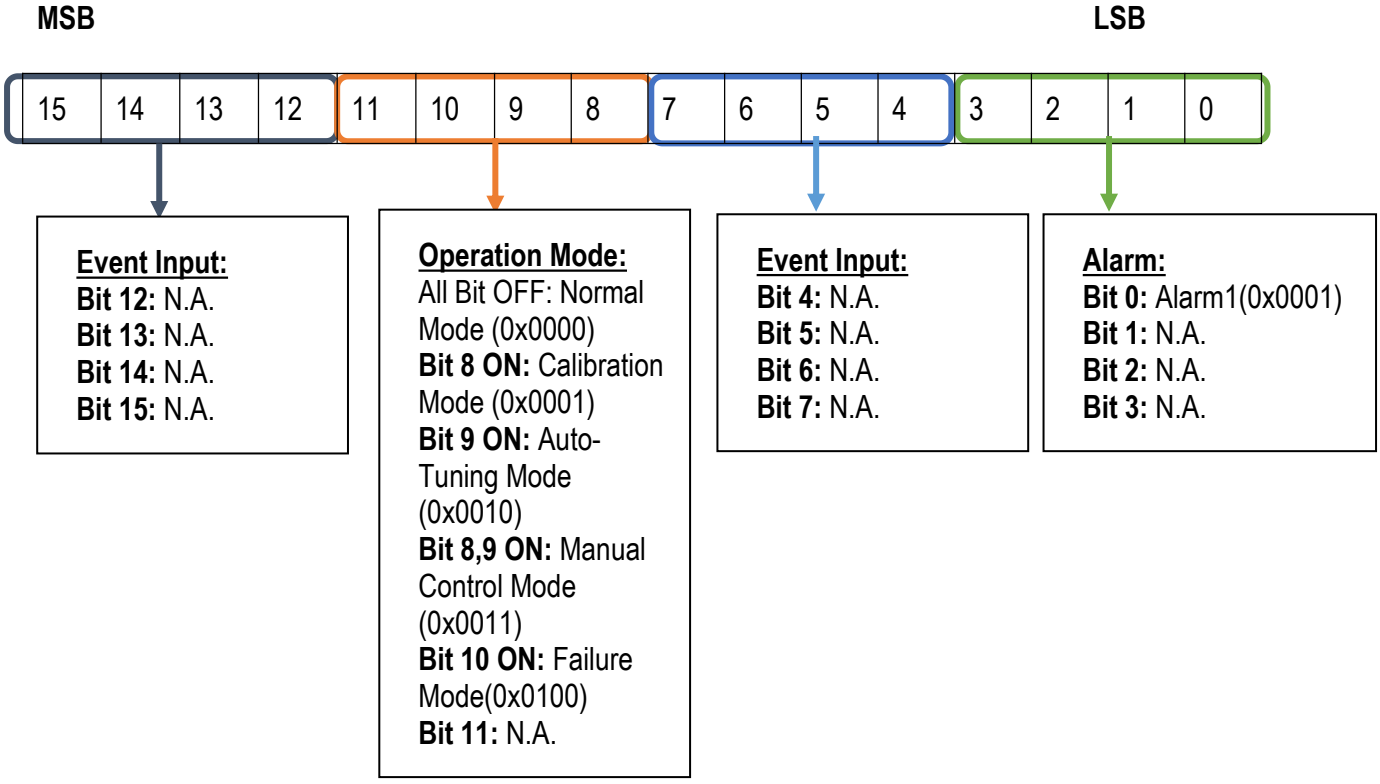
5.5 Mode

The Value of the Mode Register is as below.

Value	Mode
H'000X	Normal mode
H'010X	Calibration mode
H'020X	Auto-Tuning mode
H'030X	Manual control mode
H'040X	Failure mode
H'0X00	Alarm status is off
H'0x01	Alarm status is on

5- 6.Operation Mode

Bit wise description of Mode register value as below.



5.6 Command Mode

The Value of the Command Mode and job registers are as below.

Command Mode Value		Mode	Description	Job1 Value			Function Code	
Dec	Hex				Dec	Hex	06	16
26665	6829	Calibration Mode	Calibrate ADLO	ADLO	30	001E		✓
			Calibrate ADHI	ADHI	31	001F		✓
			Calibrate RTDL	RTDL	32	0020		✓
			Calibrate RTDH	RTDH	33	0021		✓
			Calibrate CJLO	CJLO	34	0022		✓
			Calibrate CJHI	CJHI	35	0023		✓
26664	6828	Auto-tuning Mode	Go to auto-tuning mode	…	…	…	✓	✓
26663	6827	Manual Mode	Go to manual mode	…	…	…	✓	✓
26661	6825	Reset	Do same action as Reset Key	…	…	…	✓	✓

5- 7.Command Mode

5.7 PROG Code

The Program Code is defined in the below table.

Program Code	Model No
30. XX	NC 30

5- 8.Program Code

5.8 Data Conversion

The word data are regarded as unsigned (positive) Integer data in the Modbus message. However, the actual value of the parameter may be a negative value with the decimal point. The high/low scale values for each parameter are used for such conversion. Let

M = Value of Modbus message
A = Actual value of the parameter
SL = Scale low value of the parameter
SH = Scale high value of the parameter
The conversion formulas are as follows:

$M=(65535\div(SH-SL))*(A-SL)$

$A=((SH-SL)/65535)*M)+SL$

5.9 Communication Examples

5.9.1 Read PV, SV, MV1

Send the following command to the controller via the communication port

	03	00	H'32	00	03	HI	LO
Slave Address	Function Code	Starting Address		No of Words		CRC16	

5.9.2 Perform Reset Function (same effect as pressing R key)

Query

	06	00	H'19	H'68	H'25	HI	LO
Slave Address	Function Code	Register Address		Data Hi /Lo		CRC16	

5.9.3 Enter Auto-Tuning Mode

Query

	06	00	H'19	H'68	H'28	HI	LO
Slave Address	Function Code	Register Address		Data Hi /Lo		CRC16	

5.9.4 Enter Manual Control Mode

Query

	06	00	H'19	H'68	H'27	HI	LO
Slave Address	Function Code	Register Address		Data Hi /Lo		CRC16	

5.9.5 Read All Parameters

Query

	03	00	00	00	H'40	HI	LO
Slave Address	Function Code	Starting Address		No of Words		CRC16	

5.9.6 Calibrate ADLO

	H'10	00	H'19	00	02	04	H'68	H'29	00	H'1E	HI	LO
Slave Address	Function Code	Register Address		No of Words		Bytes Count	Data Hi /Lo		Data Hi /Lo		CRC16	