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Industrial Control Innovations Begin Here

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**ModBus Modules
RMC-T300**

**Reference Manual
REV 1.00**

Revision 1.00

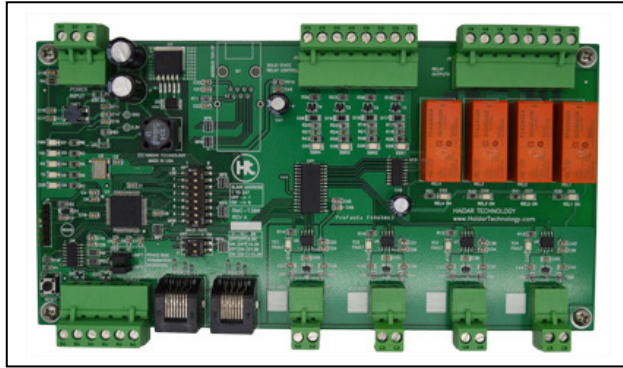
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1. Overview



For more information about RMC Modbus modules, please refer to RMC Series Reference Manual

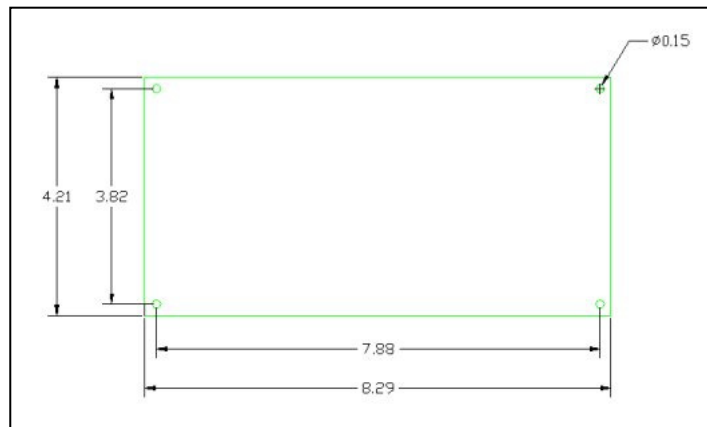
Haidar's RMC-T300 is 4-ch thermocouple inputs, 4-ch PWM outputs and 4-ch relay output ModBus module. Different from other modules, RMC-T300 is not only used to monitor process temperatures but also can be used to control the process temperatures and up to 4 zones or loops. Three types of control modes: P, ON/OFF and Manual, accepts 7 types of thermocouples, 4-ch PWM or general purpose digital outputs and 4 general purpose relays. Moreover, the user can read the status of the thermocouples (open, shorts), relays and digital outputs from the on board LEDs. Built-in full-duplex RS485 ModBus RTU or ModBus TCP interface.

2. Features

- Full-Duplex RS485 interface using ModBus slave RTU communication Protocol
- Optional ModBus TCP Protocol
- Powerful 32-bit @ 80MHZ microcontroller on board
- 4-ch thermocouple inputs
- 4-ch PWM digital outputs (24V @ 0.5A)
- 4-ch type A relay outputs
- Single 24VDC power input
- Optional K, J, N, T, S, R, or E type. Default type K thermocouple
- Up to 4 temperature control loops
- Three types of control modes: Proportional, ON/OFF or Manual
- 1°C temperature resolution
- ±2°C temperature accuracy
- Detects thermocouple shorts to GND or VCC
- Detects open thermocouple
- Programmable digital filters, sampling frequency, averaging and range

- Programmable Low and High Alarms for each control loop
- LED indicators for Power, RX, TX, HB and Error
- LED indicators for thermocouple status, relay outputs and PWM outputs
- Plug-in terminal blocks
- Dual RJ45 connectors allowing a chain of multiple modules
- Data and Power (optional) over single RJ45 cable up to 1200 meters
- $\pm 80V$ fault and $\pm 8KV$ ESD protection on the RS422 lines
- Communication speed and address are set via on board DIP switches
- Full industrial temperature from -40 to 85 Deg C
- Optional DIN-RAIL mounting plate
- Watchdog system timer
- Communication speed from 9600 bps to 115.2 Kbps
- Free modbus test and simulation software

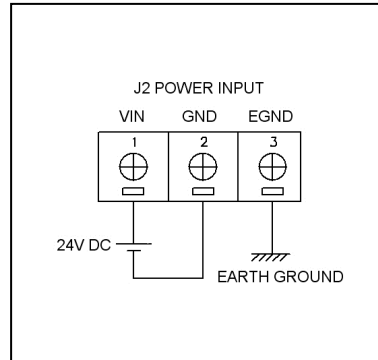
3. Board Dimensions



Width	4.21" (107mm)
Length	8.29" (210mm)
Depth	0.71" (18mm)

4. Supply Voltage (Vin)

Typical Supply Voltage (Vin)	24V DC
Supply Current	TBD



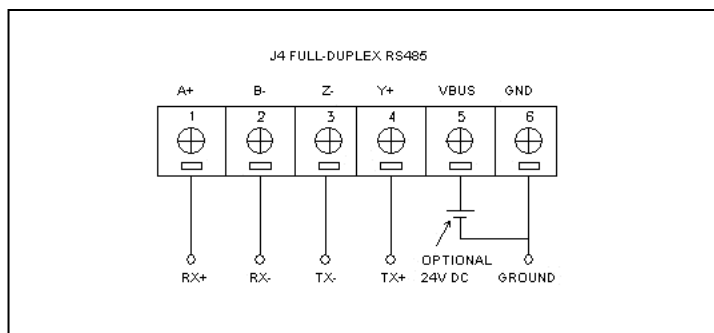
J3 Pin Number	Description
1	Supply Voltage Input (VIN)
2	Power Ground
3	Earth Ground

5. Full-Duplex RS485 (RS422) Connectors

- Specifications

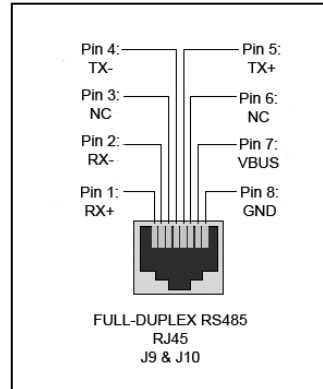
Driver	MAX13448E
Isolation	None
Fault Protection	$\pm 80V$ on the RS485 I/O Ports
ESD Protection	$\pm 8KV$ ESD Protection
Common Mode	$-7V$ to $+12V$ common-mode input voltage range
Data Rate	Max 250Kbps
Hot Swap	Yes
Slew Rate Limiting	Yes
True Fail-Safe	Yes
Bus Transceivers	Up to 256

- J4 (6-pole screw terminal block)



J4 Pin Number	Description
1	Receiver + (RX+ Or A+)
2	Receiver - (RX- Or B-)
3	Transmitter - (TX- Or Z-)
4	Transmitter + (TX+ Or Y+)
5	Optional Bus Voltage (Typical 24V DC). Not required for normal operation.
6	Common Ground

- **J9 and J10 (RJ45)**



J4 Pin Number	Description
1	Receiver + (RX+ Or A+)
2	Receiver - (RX- Or B-)
3	Not Connected
4	Transmitter - (TX- Or Z-)
5	Transmitter + (TX+ Or Y+)
6	Not Connected
7	Optional Bus Voltage (Typical 24V DC). Not required for normal operation.
8	Common Ground

6. Thermocouple Inputs

- Specifications

Channel	4
Converter	MAX31855
Isolation	None
Resolution	1°C
Type	Default K Type Optional J, N, T, R Or E Type
Accuracy	±2°C for K-Type from -200°C to +700°C
Range	-270°C To +1800°C
Fault Detection	Open, Short to GND or Short to VCC Fault LED per channel
Cold-Junction Compensation	-55°C To +127°C
ESD Protection	Up to ±2KV air discharge
Sampling Interval	User Defined from 100msec To 1.6sec
Moving Window Average	User Defined 1, 2, 4, or 8 Samples

- J8, J11, J12 and J13 (2-pole screw terminal block)

J8 Pin Number	Description
1	Thermocouple 1 +
2	Thermocouple 1 -

J11 Pin Number	Description
1	Thermocouple 2 +
2	Thermocouple 2 -

J12 Pin Number	Description
1	Thermocouple 3 +
2	Thermocouple 3 -

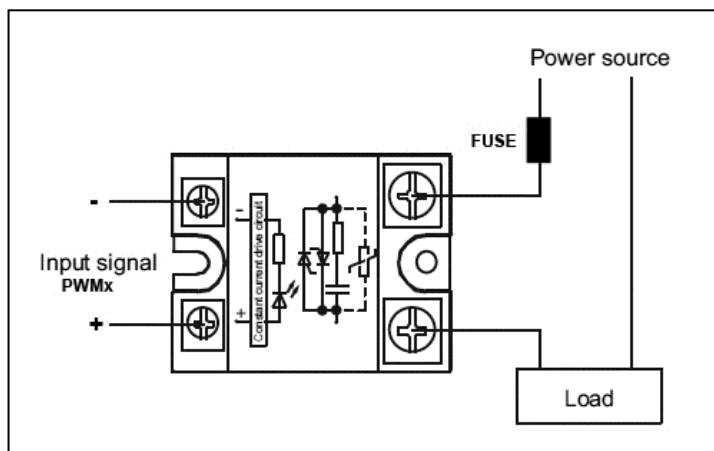
J13 Pin Number	Description
1	Thermocouple 4 +
2	Thermocouple 4 -

7. PWM or SSR Control Outputs

- Specifications

Channel	4 (Used to control external Solid State Relays)
Isolation	None
Resolution	7-bit
Range	0 to 100%
Switching Frequency	100Hz
Driver	MOSFET
Output Voltage	+24V
Max Output Current	0.5A per channel
Status LEDs	LED per channel

- J6 (8-pole screw terminal block)



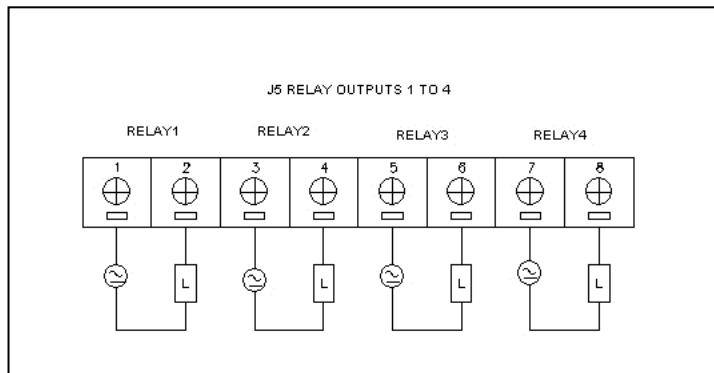
J6 Pin Number	Description
1	PWM 1 / SSR1 Positive (+24V)
2	PWM 1 / SSR1 Negative
3	PWM 2 / SSR2 Positive (+24V)
4	PWM 2 / SSR2 Negative
5	PWM 3 / SSR3 Positive (+24V)
6	PWM 3 / SSR3 Negative
7	PWM 4 / SSR4 Positive (+24V)
8	PWM 4 / SSR4 Negative

8. Relay Outputs

- Specifications

Channel	4 Industrial Grade Mechanical relays
Type	1 Form A (NO)
AC Load	250VAC @ 8A
DC Load	24VDC @ 4A
Load Connection	Sink or Source
ON/OFF Response	~50 msec
Status LEDs	4 (ON when Relay is Closed)

- J5 (8-pole screw terminal block)



J5 Pin Number	Description
1	Relay Output 1
2	Relay Output 1
3	Relay Output 2
4	Relay Output 2
5	Relay Output 3
6	Relay Output 3
7	Relay Output 4
8	Relay Output 4

9. ModBus Registers

- **Input Registers (16 Registers)**

Address	Name	Value Type	Description
0	TC1	Signed Integer	TC1 Temperature in °C
1	TC2	Signed Integer	TC2 Temperature in °C
2	TC3	Signed Integer	TC3 Temperature in °C
3	TC4	Signed Integer	TC4 Temperature in °C
4	Status 1	Unsigned Integer	TC1/Loop1 Status Register
5	Status 2	Unsigned Integer	TC2/Loop2 Status Register
6	Status 3	Unsigned Integer	TC3/Loop3 Status Register
7	Status 4	Unsigned Integer	TC4/Loop4 Status Register
8	CJT1	Signed Integer	TC1 Cold Junction Temperature in °C
9	CJT2	Signed Integer	TC2 Cold Junction Temperature in °C
10	CJ3T	Signed Integer	TC3 Cold Junction Temperature in °C
11	CJ4T	Signed Integer	TC4 Cold Junction Temperature in °C
12 to 15	x	x	Reserved (Reads 0)

- **Holding (Output) Registers (28 Registers)**

Address	Name	Value Type	Description
0	Relay Output	Unsigned Integer	Relay Output Register
1	PWM1	Unsigned Integer	PWM1 Output
2	PWM2	Unsigned Integer	PWM2 Output
3	PWM3	Unsigned Integer	PWM3 Output
4	PWM4	Unsigned Integer	PWM4 Output
5	Configuration	Unsigned Integer	Configuration Register
6	Control	Unsigned Integer	Control Register
7	SP1	Unsigned Integer	Loop1 Set Point Temperature
8	LSTS1	Unsigned Integer	Loop1 Sampling Time Scaler
9	Band/Gain1	Unsigned Integer	Loop1 Band or Gain
10	ALH1	Unsigned Integer	Loop1 Alarm High
11	ALL1	Unsigned Integer	Loop1 Alarm Low
12	SP2	Unsigned Integer	Loop2 Set Point Temperature
13	LSTS2	Unsigned Integer	Loop2 Sampling Time Scaler
14	Band/Gain2	Unsigned Integer	Loop2 Band or Gain
15	ALH2	Unsigned Integer	Loop2 Alarm High
16	ALL2	Unsigned Integer	Loop2 Alarm Low
17	SP3	Unsigned Integer	Loop3 Set Point Temperature
18	LSTS3	Unsigned Integer	Loop3 Sampling Time Scaler
19	Band/Gain3	Unsigned Integer	Loop3 Band or Gain
20	ALH3	Unsigned Integer	Loop3 Alarm High
21	ALL3	Unsigned Integer	Loop3 Alarm Low
22	SP4	Unsigned Integer	Loop4 Set Point Temperature
23	LSTS4	Unsigned Integer	Loop4 Sampling Time Scaler
24	Band/Gain4	Unsigned Integer	Loop4 Band or Gain
25	ALH4	Unsigned Integer	Loop4 Alarm High
26	ALL4	Unsigned Integer	Loop4 Alarm Low
27	x	x	Reserved (Reads 0)

10. Input Registers Description

- **TCx Temperature**
This register contains the thermocouple (TC) channel temperature in °C. It is 12-bit signed integer with bit 11 is the sign. The last high 4 bits are 0.
- **CJT_x TC_x cold junction temperature**
This register contains the thermocouple (TC) channel cold junction temperature in °C. It is 8-bit signed integer with bit 7 is the sign. The high byte is 0.
- **Status_x**
This register contains the thermocouple channel and control loop status bits. There is a status register for each TC channel.

Bit 0: [OC]

0 = Thermocouple is Not open
1 = Thermocouple is Open

Bit 1: [SCG]

0 = Thermocouple is Not shorted to GND
1 = Thermocouple is Shorted to GND

Bit 2: [SCV]

0 = Thermocouple is Not shorted to VCC
1 = Thermocouple is Shorted to VCC

Bit 3: [TCF]

0 = No Thermocouple Fault
1 = Thermocouple Fault (One or more of bit 0, 1 or 2 is 1)

Bit 4: [TS]

0 = Temperature is not stable
1 = Temperature is stable (Process temperature is within ± 5 °C of the set point)

Bit 5: [ON/OFF]

0 = Heater is OFF
1 = Heater is ON

Bit 6: [ALL]

0 = Alarm Low is OFF
1 = Alarm Low is ON
(If loop alarm is enabled, the corresponding relay will be Open or Closed according to ALL value)

Bit 7: [ALH]

0 = Alarm High is OFF
1 = Alarm High is ON
(If loop alarm is enabled, the corresponding relay will be Open or Closed according to ALH value)

Bit8 - Bit15: [Heater Output Control]

The high byte of the status register contains the heater output control from 0% to 100%.
For ON/OFF Control, the heater output control will be either 0% (heater is fully OFF) and 100% (heater is fully powered).
For Proportional Control, the heater output control will be a value from 0% to 100%.

11. Holding (Output) Registers Description

- **Relay Output**
This register is used to control the output relays. Only the first 4 bits are used. A value of 0 will turn all the relays off (open) while a value of 15 will turn all the relays on (closed).
NOTE: This register must be set only using “Writes Single Holding Register” ModBus command.
- **PWM_x**
This register is used to set the PWM channel value. Only the first 7 bits are used with a range from 0 to 100%. This register is not available if the control loop mode is set to ON/OFF or Proportional.
NOTE: This register must be set only using “Writes Single Holding Register” ModBus command.
- **Configuration Register**
This register contains the thermocouple channel and control loop configuration bits.
NOTE: This register must be set only using “Writes Single Holding Register” ModBus command.

Bit 0, 1: [AVE] Average

0 = No Average (Default)

1 = 2 Samples Average

2 = 4 Samples Average

3 = 8 Samples Average

Bit 2, 3: [x]

Not used. Read 0

Bit 4, 5, 6: [TYPE] Thermocouple Type

0 = K (Default)

1 = J

2 = N

3 = S

4 = T

5 = E

6 = R

7 = Not used

Bit 7: [x]

Not used. Read 0

Bit 8, 9, 10, 11: [SI] Sampling Interval

0 = 100msec (Default)

1 = 200msec

2 = 300msec

.

.

9 = 1sec

10 = 1.1sec

.

.

15 = 1.6sec

Bit 12: [AL1E]

0 = Loop 1 Alarm is Disabled

1 = Loop 1 Alarm is Enabled

Bit 13: [AL2E]

0 = Loop 2 Alarm is Disabled
1 = Loop 2 Alarm is Enabled

Bit 14: [AL3E]

0 = Loop 3 Alarm is Disabled
1 = Loop 3 Alarm is Enabled

Bit 15: [AL4E]

0 = Loop 4 Alarm is Disabled
1 = Loop 4 Alarm is Enabled

- **Control Register**

This register contains the control loops control bits.

NOTE: This register must be set only using “Writes Single Holding Register” ModBus command.

Bit 0, 1, 2: [CL1Mode] Control Loop1 Mode

0 = Manual (Default)
1 = ON/OFF Control
2 = Proportional Control
3..7 = Not used

Bit 3: [x]

Not used. Read 0

Bit 4, 5, 6: [CL2Mode] Control Loop2 Mode

0 = Manual (Default)
1 = ON/OFF Control
2 = Proportional Control
3..7 = Not used

Bit 7: [x]

Not used. Read 0

Bit 8, 9, 10: [CL3Mode] Control Loop3 Mode

0 = Manual (Default)
1 = ON/OFF Control
2 = Proportional Control
3..7 = Not used

Bit 11: [x]

Not used. Read 0

Bit 12, 13, 14: [CL4Mode] Control Loop4 Mode

0 = Manual (Default)
1 = ON/OFF Control
2 = Proportional Control
3..7 = Not used

Bit 15: [x]

Not used. Read 0

- **SP**
This register is used to set the loop Set Point temperature in °C. The loop set point temperature range is from 0 °C to 2047 °C.
- **LSTS**
This register is used to set the loop sampling time prescaler. It is range from 0 to 255.
The loop sampling time is calculated as follow:
 $LST = SI * (1 + LSTS)$
Where SI is the Temperature sampling Interval.
For example: If Configuration Register bits [8..11] = 9, then SI = 1sec.
If LSTS = 4 then LST = 5sec.
If LSTS = 9 then LST = 10sec.
- **Band/Gain**
This register is used to set the loop Band or Gain. It is range from 1 to 255.
For ON/OFF Control loop, this register set the dead band in °C.
For Proportional Control loop, this register set the gain.
- **ALH**
This register is used to set the loop Alarm High in °C. It is range is from 0 °C to 2047 °C.
If the loop process temperature or value (PV) is equal or higher than ALH and the loop alarm is enabled, then the loop status bit [ALH] will be high and the corresponding relay will be ON too.
- **ALL**
This register is used to set the loop Alarm Low in °C. It is range is from 0 °C to 2047 °C.
If the loop process temperature or value (PV) is equal or lower than ALL and the loop alarm is enabled, then the loop status bit [ALL] will be high and the corresponding relay will be ON too.

12. Temperature Control Operation

RMC-T300 is capable to control up to four heaters at the same time. Three modes of operation are provided.

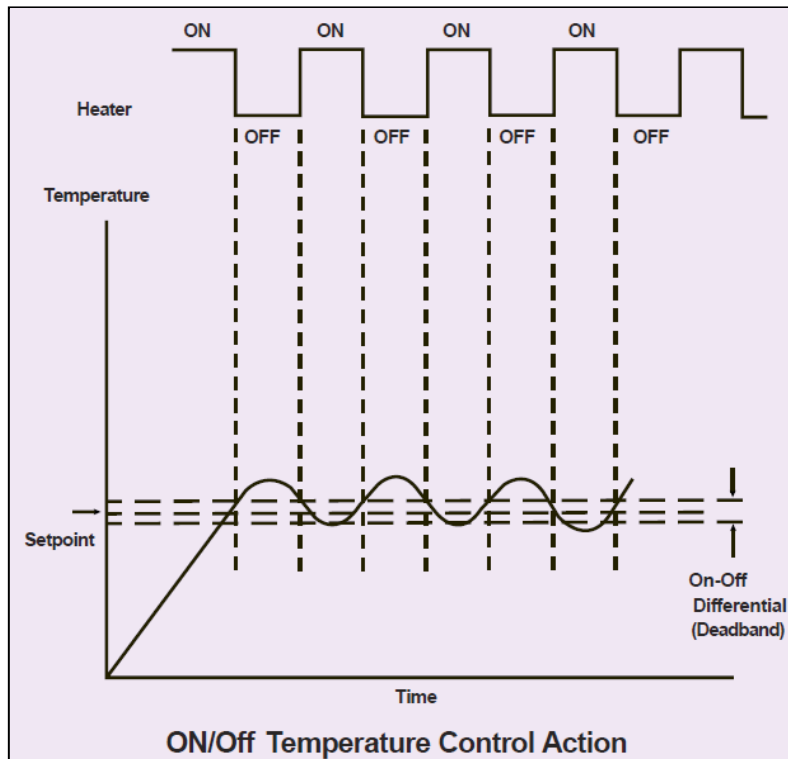
- **Manual Mode**

In this mode, the control loop is open (No Control) and the host controller can use the corresponding PWM register to control the heater. This mode is the default settings after power up or reset.

- **ON/OFF Mode**

An on-off controller is the simplest form of temperature control device. The output from the device is either on or off, with no middle state. An on-off controller will switch the output only when the temperature crosses the setpoint. For heating control, the output is on when the temperature is below the setpoint, and off above setpoint. Since the temperature crosses the setpoint to change the output state, the process temperature will be cycling continually, going from below setpoint to above, and back below. In cases where this cycling occurs rapidly, and to prevent damage to contactors and valves, an on-off differential, or “hysteresis,” is added to the controller operations. This differential requires that the temperature exceed setpoint by a certain amount before the output will turn off or on again. On-off differential prevents the output from “chattering” (that is, engaging in fast, continual switching if the temperature’s cycling above and below the setpoint occurs very rapidly).

On-off control is usually used where a precise control is not necessary, in systems which cannot handle the energy’s being turned on and off frequently, where the mass of the system is so great that temperatures change extremely slowly, or for a temperature alarm.



Band/Gain register is used to set the ON/OFF hysteresis or dead band (DB). A good initial value is 5% of the setpoint. LSTS register is used to set the loop sampling time of interval (LST). LST is highly depends on the process thermal mass or time constant. Higher thermal mass like water boiler means higher time constant (longer time for the temperature to rise to 0.707 of the setpoint) and this require longer sampling time. A good initial value is 2 times the process time constant.

Example:

SP = 500 °C

DB = 25 °C

LST (Loop Sampling Time) = 5sec

Every 5sec the controller will check the process temperature (PV) and turn the heater ON or OFF based on:

If $PV \geq 525 \text{ °C} \Rightarrow$ Heater is OFF

If $PV \leq 475 \text{ °C} \Rightarrow$ Heater is ON

If PV is between 475 °C and 525 °C \Rightarrow Heater is OFF

- **Proportional Mode**

Proportional controls are designed to eliminate the cycling associated with on-off control. A proportional controller decreases the average power being supplied to the heater as the temperature approaches setpoint.

This has the effect of slowing down the heater, so that it will not overshoot the setpoint but will approach the setpoint and maintain a stable temperature. This proportioning action can be accomplished by turning the output on and off for short intervals.

Band/Gain register is used to set the Proportional Gain (Gp). A good initial value is 5% of the setpoint. LSTS register is used to set the loop sampling time of interval (LST). LST is highly depends on the process thermal mass or time constant. Higher thermal mass like water boiler means higher time constant (longer time for the temperature to rise to 0.707 of the setpoint) and this require longer sampling time. A good initial value is 2 times the process time constant.

The heater control value is calculated as follows:

$$CV = GP*(SP - PV)$$

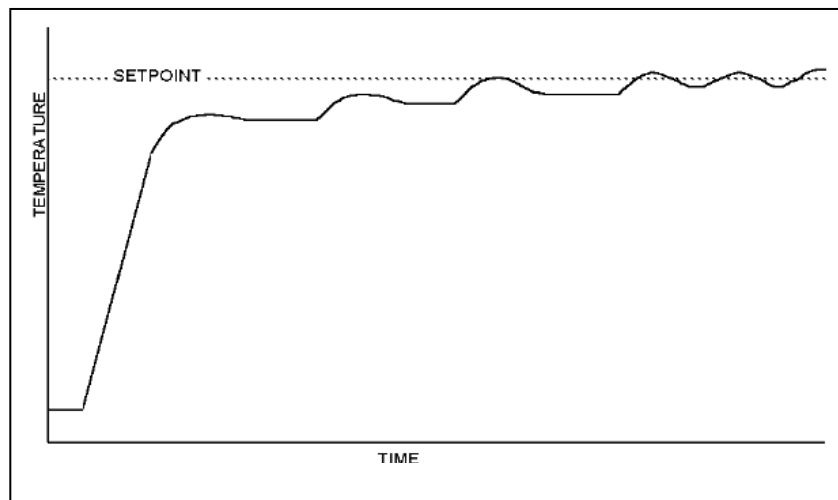
Where:

SP is the setpoint temperature in °C.

PV is the process value or temperature in °C.

GP is the proportional gain (1 to 255).

CV is the PWM value from 0 to 100%



13. Manual Change History

Date	Revision	Change
10/07/2015	REV1.00	Initial version of this manual

14. Hardware Limited Warrnty

Haidar Technology, LLC. Warrants its hardware products to be free from manufacturing defects in materials and workmanship under normal use for a period of one (1) year from the date of purchase from Haidar. This warranty extends to products purchased directly from Haidar or an authorized Haidar distributor. Purchasers should inquire of the distributor regarding the nature and extent of the distributor's warranty, if any. Haidar shall not be liable to honor the terms of this warranty if the product has been used in any application other than that for which it was intended, or if it has been subjected to misuse, accidental damage, modification, or improper installation procedures. Furthermore, this warranty does not cover any product that has had the serial number altered, defaced, or removed. This warranty shall be the sole and exclusive remedy to the original purchaser. In no event shall Haidar be liable for incidental or consequential damages of any kind (property or economic damages inclusive) arising from the sale or use of this equipment. Haidar is not liable for any claim made by a third party or made by the purchaser for a third party. Haidar shall, at its option, repair or replace any product found defective, without charge for parts or labor. Repaired or replaced equipment and parts supplied under this warranty shall be covered only by the unexpired portion of the warranty. Except as expressly set forth in this warranty, Haidar makes no other warranties, expressed or implied, nor authorizes any other party to offer any warranty, including any implied warranties of merchantability or fitness for a particular purpose. Any implied warranties that may be imposed by law are limited to the terms of this limited warranty. This warranty statement supercedes all previous warranties, and covers only the Haidar hardware.

15. Returns and Repair Policy

No merchandise may be returned for credit, exchange, or service without prior authorization from. To obtain warranty service, contact the factory and request an RMA (Return Merchandise Authorization) number. Enclose a note specifying the nature of the problem, name and phone number of contact person, RMA number, and return address. Authorized returns must be shipped freight prepaid to Haidar Technology with the RMA number clearly marked on the outside of all cartons. Shipments arriving freight collect or without an RMA number shall be subject to refusal. Haidar reserves the right in its sole and absolute discretion to charge a 15% restocking fee, plus shipping costs, on any products returned with an RMA.

Return freight charges following repair of items under warranty shall be paid by Haidar, shipping by standard ground carrier. In the event repairs are found to be non-warranty, return freight costs shall be paid by the purchaser.