# Home Automation, Inc.

## RC-Series Communicating Thermostats

## Serial Protocol Description

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## INTRODUCTION

This document describes the serial communications protocol of the HAI RC-Series communicating thermostats. The RC-Series thermostats are capable of several communications modes. This document describes two: RS-232 mode and System mode. These differ in electrical connections and transmission speed. The messages, however, are the same for both modes.

## NOTICE

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## ELECTRICAL CONNECTIONS

RS-232 mode

Intended for connection to personal computers or other systems with RS-232 ports. 4 wires to the thermostat: DTR, RXD, TXD and Ground. All wires are optically isolated in the thermostat. The thermostat transmits with a modified RS-232 transmitter that can be tri-state (high impedance) so that more than one thermostat can be connected in parallel to a single RS-232 port.

In RS-232 mode, the transmitted RS-232 voltage levels are generated by using DTR as a source for +12 volts when transmitting a space (0 bit) and the received RS-232 signal as a source for -12 volts when transmitting a mark (1 bit). Therefore, DTR must be set high at all times by the host, and the host must not transmit while a thermostat is transmitting.

A typical RS-232 port on a personal computer can drive 4 thermostats directly using HAI p/n RC-201 cable. A signal booster (HAI p/n RC-202) is needed to increase the output current of the RS-232 port for more than 4 thermostats.

System mode

Intended for connection to automation systems that do not have RS-232 voltage levels. 3 wires to the thermostat, TXD, RXD, and GND. The communications wires are optically isolated from the hvac circuits in the thermostat. RXD is 0V when the host is sending a mark (bit 1) or idle, 12 V when host is transmitting a space (bit 0). The thermostat TXD is an open collector optoisolator, open when idle or transmitting a mark (bit 1) or conducting to GND when transmitting a space (bit 0.)

## ELECTRICAL SPECIFICATIONS

RS-232 mode:

Thermostat receiver - The thermostat will draw the following current at the following voltage:

| | |
|---|---|
| RS-232 receive space (bit 0): | 2.0 mA at 12V |
| RS-232 receive mark (bit 1) | |
| transmitter idle: | 0.0 mA at -12V |
| transmitter active: | -4 ma max at -12 V |

Thermostat transmitter - The thermostat will provide the following current and voltage. Note that +12 is drawn from DTR, -12 V is drawn from the thermostat receive line (TXD) while it is idle.

| | |
|---|---|
| tri state (off): | open collector, 0 mA |
| RS-232 transmit space (bit 0): | 10V at 4 mA |
| RS-232 transmit mark (bit 1): | -10V at -4 mA |

Note: these levels are compatible with RS-232.

System mode:

Thermostat receiver

| | |
|---|---|
| System mode receive space (bit 0): | 1.0 mA at 12V |
| System mode receive mark (bit 1): | 0.0 mA at 0V |

Thermostat transmitter

| | |
|---|---|
| tri state: (off): | open collector, 0 mA |
| System mode transmit space (bit 0): | 2 V maximum at 4 mA |
| System mode transmit mark (bit 1): | open collector, 0 mA |

**PROTOCOL**

The thermostat will respond to properly formatted messages from a polling device. The thermostat does not initiate messages. The protocol is half-duplex, meaning that the thermostat does not receive while it is transmitting. The host must not transmit while the thermostat is transmitting.

a. Byte format: 1 start bit, 8 data bits, 1 stop bit, no parity. LSB is transmitted first.

b. Data rates: RS-232 mode: 300 baud, System mode: 100 baud

c. Message Format:

Byte 1: Start/Remote Address
- Bit 0-6: Remote address (0 - 127, 0 = broadcast)
- Bit 7: 1 for thermostat reply
  0 for host message

Byte 2: Data Length/Message type
- Bits 7-4: Data Length (0 - 15)
- Bits 3-0: Message Type (0 - 15)

Bytes 3-n: Data
0 to 15 bytes

Byte n+1: checksum (add bytes 1-N to get checksum)

**HOST TIMING REQUIREMENTS**

a. The host initiates polls. The host should not poll while a thermostat is transmitting.

b. The thermostat will reply to a poll with a response.

c. Thermostats do not reply to broadcast messages (remote address 0.)

d. A thermostat will not take action on, nor reply to a message with an invalid checksum byte. Should a thermostat not reply, the host should try again after an intermessage timeout.

e. Intermessage (between messages) timeout: 1.25 seconds. If a thermostat does not reply, the host should wait a minimum of 1.25 seconds after the end of the host's transmission to retry the message.

f. Intramessage (within messages) timeout: 500 mS. There should be no gaps longer than 500 mS between bytes of a message.

g. The thermostat takes a maximum of 30 mS to set a register. When setting registers, the thermostat will reply after it has written the registers to its internal EEPROM. The host may transmit another message immediately after the thermostat completes its reply. If setting registers with a broadcast message, the thermostat will not reply, and it will not enable its receiver until after it has written all registers. Therefore, when using a broadcast message, the host must wait at least 30 mS per register set before starting any subsequent message. A worst case example is to send a broadcast message that sets 14 registers. The host must wait 14*30 mS = 420 mS before sending any other message.

**THERMOSTAT ERROR HANDLING AND BIT TIMING:**

a. Error handling: If a framing error occurs (no start or stop bit where one was expected) or an incorrect checksum is detected, the thermostat ignores the remainder of the message. The thermostat will continue to receive and ignore bytes until an intramessage timeout occurs.

b. Bit timing: The center of each bit of the reply occurs at integer intervals of the beginning of the start bit of the last byte in the message that caused the reply. The thermostat requires anywhere from 0 to 420 mS to format a reply and begin sending it. Therefore, a reply could begin anywhere from 0.5 to 42.5 bit times after the end of the stop bit of the message that caused the reply at 100 baud. However, the reply will always start on .5 bit time intervals. (1.5, 3.5, etc.)

Note: this bit timing is compatible with all PC serial ports, and any other port with a hardware Universal Asynchronous Receiver Transmitter (UART). It also allows communications with a software UART using input/output pins, because the bits of the reply are synchronized with the transmitter's bit clock.

**MESSAGE TYPES**

a. Host to Thermostat

0: Poll for register(s)

This message requests from one to 14 registers be returned in a Data message. The thermostat will reply with the data or a negative acknowledge.

| | |
|---|---|
| RA | |
| DL/MT | 2 / 0 |
| DATA | first register address, number of registers (1-14) |
| CKSUM | |

Valid response message types:
Data
Negative Acknowledge (message received but invalid register address)

1: Set Register(s)

This message tells the thermostat to set one to 14 consecutive registers starting with the "start register address". The number of registers to set with the data bytes following the "start register address" is determined by subtracting one (1) from the data length DL.

| | |
|---|---|
| RA | |
| DL/MT | 2-15 / 1 |
| DATA | start register address, data byte(s) |
| CKSUM | |

Valid response message types:
Acknowledge (message received and accepted)
Negative acknowledge (one or more registers out of range)

2: Poll for Group 1 data

This message requests a special data message containing cool setpoint, heat setpoint, mode, fan, hold and current temperature.

| | |
|---|---|
| RA | |
| DL/MT | 0 / 2 |
| CKSUM | |

Valid response
Group 1 data

3: Poll for group 2 data

Request for a special data message containing group 2 data (not yet defined)

| | |
|---|---|
| RA | |
| DL/MT | 0 / 3 |
| CKSUM | |

Valid response
Group 2 data

b. Thermostat responses to Host

0: Acknowledge

Information sent by the host has been received and accepted.

| | |
|---|---|
| RA | |
| DL/MT | 0 / 0 |
| CKSUM | |

1: Negative acknowledge

Information sent by the host has been received but is invalid or out of range.

| | |
|---|---|
| RA | |
| DL/MT | 0 / 1 |
| CKSUM | |

2: Data

The thermostat is returning the data requested in a "Poll for registers" message.

| | |
|---|---|
| RA | |
| DL/MT | 1-15 / 2 |
| DATA | Start register, 1 - 14 bytes corresponding to registers requested |
| CKSUM | |

3: Group 1 Data

The thermostat is returning the following specific registers: cool setpoint, heat setpoint, mode, fan, hold, current temperature.

| | |
|---|---|
| RA | |
| DL/MT | 6 / 3 |
| DATA | cool setpoint, heat setpoint, mode, fan, hold, current temperature |
| CKSUM | |

4: Group 2 Data

The thermostat is returning specific registers (not yet defined, similar to Group 1 data message.)

Example Messages (Data shown in parenthesis are in Hex)

Host: Poll thermostat 1 for Group 1 data:
RA(01), DL/MT(02), CS(03)

Thermostat 1: RA(81), DL/MT(63), low setpoint(xx), high setpoint(xx), mode(xx), fan(xx), hold(xx), current temperature (xx), CS(xx)

Host: Broadcast time:
RA(00), DL/MT(41), start register(41), seconds(xx), minutes(xx), hours(xx), CS(xx)

Thermostat(s): no reply, it was a broadcast message.

The host should wait a minimum of 90 mS before transmitting next message.

Host: Set cooling setpoint on thermostat 5
RA(05), DL/MT(21), start register(3B), setpoint(xx), CS(xx)

Thermostat 5: RA(85), MT/DL(00), CS(85) (acknowledge)

**INTERNAL REGISTERS (RO = READ ONLY)**

See thermostat manual for exact description of registers 0 - 17.

0 (00) - Thermostat address (ro) (1 - 127)
1 (01) - Communications mode (ro) (0, 1, 8 or 24)
2 (02) - System options (ro)
3 (03) - Display options
4 (04) - Calibration offset (1 to 59, 30=no change - ½ C units)
5 (05) - Cool setpoint low limit (Omnitemp units)
6 (06) - Heat setpoint high limit (Omnitemp units)
7 (07) - Reserved
8 (08) - Reserved
9 (09) - Cooling anticipator (0 to 30) (RC-80, -81, -90, -91 only)
10 (0A) - Heating anticipator (0 to 30) (RC-80, -81, -90, -91 only), Stage 2 differential (RC-112)
11 (0B) - Cooling cycle time (2 - 30 minutes)
12 (0C) - Heating cycle time (2 - 30 minutes)
13 (0D) - Aux heat differential, (RC-100, -101, -112), Stage 2 differential (RC-120, -121, -122) (Omnitemp units)
14 (0E) - Clock adjust (seconds/day) 1=-29, 30=0, 59=+29
15 (0F) - Days remaining until filter reminder
16 (10) - System run time, current week - hours
17 (11) - System run time, last week - hours

Registers 18 - 20 are used only in models with real time pricing.

18 (12) - Real time pricing setback - Mid (Omnitemp units)
19 (13) - High
20 (14) - Critical

Programming registers

21 (15) - weekday morning time
22 (16) - cool setpoint
23 (17) - heat setpoint
24 (18) - weekday day time
25 (19) - cool setpoint
26 (1A) - heat setpoint
27 (1B) - weekday evening time
28 (1C) - cool setpoint
29 (1D) - heat setpoint
30 (1E) - weekday night time
31 (1F) - cool setpoint
32 (20) - heat setpoint

33 (21) - Saturday morning time
34 (22) - cool setpoint
35 (23) - heat setpoint
36 (24) - Saturday day time
37 (25) - cool setpoint
38 (26) - heat setpoint
39 (27) - Saturday evening time
40 (28) - cool setpoint
41 (29) - heat setpoint
42 (2A) - Saturday night time
43 (2B) - cool setpoint
44 (2C) - heat setpoint

45 (2D) - Sunday morning time
46 (2E) - cool setpoint
47 (2F) - heat setpoint
48 (30) - Sunday day time
49 (31) - cool setpoint
50 (32) - heat setpoint
51 (33) - Sunday evening time
52 (34) - cool setpoint
53 (35) - heat setpoint
54 (36) - Sunday night time
55 (37) - cool setpoint
56 (38) - heat setpoint

57 (39) - Reserved - do not write

58 (3A) - Day of week (0=Monday - 6=Sunday)
59 (3B) - Cool setpoint
60 (3C) - Heat setpoint
61 (3D) - Thermostat mode (0=off, 1=heat, 2=cool, 3=auto) (4=Emerg heat: RC-100, -101, -112 only)
62 (3E) - Fan status (0=auto 1=on)
63 (3F) - Hold (0=off 255=on)

64 (40) - Actual temperature in Omni format
65 (41) - Seconds 0 - 59
66 (42) - Minutes 0 - 59
67 (43) - Hours 0 - 23
68 (44) - Outside temperature
69 (45) - Reserved
70 (46) - Real time pricing mode (0=lo, 1=mid, 2=high, 3=critical) (RC-81, -91, -101, -121 only)
71 (47) - (ro) current mode (0=off 1=heat 2=cool)
72 (48) - (ro) output status
73 (49) - (ro) model of thermostat

**DATA FORMATS**

a. Registers: All registers are 1 byte long.

b. Temperatures: "Omni" format: Temperatures are 1 byte, 0 to 255. 0 is -40 degrees Celsius and -40 degrees Fahrenheit. 255 is 87.5 degrees Celsius, 189 degrees Fahrenheit. Each increment is .5 degrees Celsius. A table is presented in appendix A relating temperature bytes to degrees C and F. In Fahrenheit mode, the thermostat rounds the display to the nearest whole degree. (71.6 and 72.5 will be displayed as 72.) In Celsius mode, half degree increments are displayed.

c. Programming register time: Time in 15 minute increments. 0 is 0:00 hours, 1 is 0:15, 2 is 0:30,… 95 is 23:45. 96 = blank display, thermostat treats this as having no time for this period (period not in use)

d. Output status register: reflects the positions of the control relays on the thermostat.

bit 0: heat/cool bit - set for heat, clear for cool
bit 1: auxiliary heat bit - set for on, clear for off (RC-100, -101, -112 only)
bit 2: stage 1 run bit - set for on, clear for off
bit 3: fan bit - set for on, clear for off
bit 4: stage 2 run bit: set for on, clear for off (RC-112, 120, 121, 122 only)

**Note:** The thermostat will only switch the heat/cool bit at the moment that the system run bit is turned on. Therefore, it is possible for the mode to be cool with the heat/cool bit set to heat. To determine the actual operating condition of the hvac equipment, use the stage 1 run bit to determine whether its on or off. If on, the heat/cool bit or mode byte will show whether it is heating or cooling.

e. Model register: indicates thermostat model

| Thermostat model | Model register |
|---|---|
| RC-80 | 0 |
| RC-81 | 1 |
| RC-90 | 8 |
| RC-91 | 9 |
| RC-100 | 16 |
| RC-101 | 17 |
| RC-112 | 34 |
| RC-120 | 48 |
| RC-121 | 49 |
| RC-122 | 50 |

f. Outside Temperature: writing to the outside temperature register will cause the thermostat to display the outside temperature every 4 seconds. The thermostat will stop displaying the outside temperature if this register is not refreshed at least every 5 minutes.

g: Other registers: see individual register for format.

h. Display Options:
bit 0: set for Fahrenheit, clear for Celsius
bit 1: set for 24 hour time display, clear for AM/PM
bit 2: set for non-programmable, clear for programmable (disables internal programs in thermostat)
bit 3: set for real time pricing (RTP) mode, clear for no RTP (RC-81, -91, -101, -121 only)
bit 4: set to hide clock, RTP and filter display, clear to show them.

**THERMOSTAT MODELS**

The RC-Series family includes models for standard, heat pump and multi stage units.

| | Model No. |
|---|---|
| Standard heat/cool | RC-80 |
| Heat/cool for zoning | RC-90 |
| heat pump | RC-100 |
| two speed heat pump | RC-112 |
| two stage | RC-122 |

Models RC-81, -91, -101 and -121 are the same as the basic models (-80, -90…) with Real Time Pricing capability.

**OTHER COMMUNICATIONS MODES**

Day/Night Mode:

Models RC-80, -90, -100, -112, and -122 also have Day/night mode: The thermostat input is a 12V signal to select preprogrammed night setpoints, no 12V signal to select preprogrammed day setpoints. This mode is intended for operation with occupied/unoccupied switches or control systems. Serial protocol is not used in day/night mode.

PESM Mode:

Models RC-80, -90, -100 and -120 have PESM (programmable energy saver module) mode, where the thermostat output is a frequency proportional to temperature (10 Hz = 75 F), the thermostat input is a 12 V signal to shut the HVAC system off, no 12V signal allows the HVAC unit to run normally. This mode is used for compatibility with HAI and other controllers using this format. Serial protocol is not used in day/night mode.

# APPENDIX A – Omnitemp to C to F Table

| Deg. I | Deg. C | Deg. F | Deg. I | Deg. C | Deg. F | Deg. I | Deg. C | Deg. F |
|---|---|---|---|---|---|---|---|---|
| 0 | - 40.0 | - 40.0 | 44 | - 18.0 | - 00.4 | 88 | 04.0 | 39.2 |
| 1 | - 39.5 | - 39.1 | 45 | - 17.5 | 00.5 | 89 | 04.5 | 40.1 |
| 2 | - 39.0 | - 38.2 | 46 | - 17.0 | 01.4 | 90 | 05.0 | 41.0 |
| 3 | - 38.5 | - 37.3 | 47 | - 16.5 | 02.3 | 91 | 05.5 | 41.9 |
| 4 | - 38.0 | - 36.4 | 48 | - 16.0 | 03.2 | 92 | 06.0 | 42.8 |
| 5 | - 37.5 | - 35.5 | 49 | - 15.5 | 04.1 | 93 | 06.5 | 43.7 |
| 6 | - 37.0 | - 34.6 | 50 | - 15.0 | 05.0 | 94 | 07.0 | 44.6 |
| 7 | - 36.5 | - 33.7 | 51 | - 14.5 | 05.9 | 95 | 07.5 | 45.5 |
| 8 | - 36.0 | - 32.8 | 52 | - 14.0 | 06.8 | 96 | 08.0 | 46.4 |
| 9 | - 35.5 | - 31.9 | 53 | - 13.5 | 07.7 | 97 | 08.5 | 47.3 |
| 10 | - 35.0 | - 31.0 | 54 | - 13.0 | 08.6 | 98 | 09.0 | 48.2 |
| 11 | - 34.5 | - 30.1 | 55 | - 12.5 | 09.5 | 99 | 09.5 | 49.1 |
| 12 | - 34.0 | - 29.2 | 56 | - 12.0 | 10.4 | 100 | 10.0 | 50.0 |
| 13 | - 33.5 | - 28.3 | 57 | - 11.5 | 11.3 | 101 | 10.5 | 50.9 |
| 14 | - 33.0 | - 27.4 | 58 | - 11.0 | 12.2 | 102 | 11.0 | 51.8 |
| 15 | - 32.5 | - 26.5 | 59 | - 10.5 | 13.1 | 103 | 11.5 | 52.7 |
| 16 | - 32.0 | - 25.6 | 60 | - 10.0 | 14.0 | 104 | 12.0 | 53.6 |
| 17 | - 31.5 | - 24.7 | 61 | - 09.5 | 14.9 | 105 | 12.5 | 54.5 |
| 18 | - 31.0 | - 23.8 | 62 | - 09.0 | 15.8 | 106 | 13.0 | 55.4 |
| 19 | - 30.5 | - 22.9 | 63 | - 08.5 | 16.7 | 107 | 13.5 | 56.3 |
| 20 | - 30.0 | - 22.0 | 64 | - 08.0 | 17.6 | 108 | 14.0 | 57.2 |
| 21 | - 29.5 | - 21.1 | 65 | - 07.5 | 18.5 | 109 | 14.5 | 58.1 |
| 22 | - 29.0 | - 20.2 | 66 | - 07.0 | 19.4 | 110 | 15.0 | 59.0 |
| 23 | - 28.5 | - 19.3 | 67 | - 06.5 | 20.3 | 111 | 15.5 | 59.9 |
| 24 | - 28.0 | - 18.4 | 68 | - 06.0 | 21.2 | 112 | 16.0 | 60.8 |
| 25 | - 27.5 | - 17.5 | 69 | - 05.5 | 22.1 | 113 | 16.5 | 61.7 |
| 26 | - 27.0 | - 16.6 | 70 | - 05.0 | 23.0 | 114 | 17.0 | 62.6 |
| 27 | - 26.5 | - 15.7 | 71 | - 04.5 | 23.9 | 115 | 17.5 | 63.5 |
| 28 | - 26.0 | - 14.4 | 72 | - 04.0 | 24.8 | 116 | 18.0 | 64.4 |
| 29 | - 25.5 | - 13.9 | 73 | - 03.5 | 25.7 | 117 | 18.5 | 65.3 |
| 30 | - 25.0 | - 13.0 | 74 | - 03.0 | 26.6 | 118 | 19.0 | 66.2 |
| 31 | - 24.5 | - 12.1 | 75 | - 02.5 | 27.5 | 119 | 19.5 | 67.1 |
| 32 | - 24.0 | - 11.2 | 76 | - 02.0 | 28.4 | 120 | 20.0 | 68.0 |
| 33 | - 23.5 | - 10.3 | 77 | - 01.5 | 29.3 | 121 | 20.5 | 68.9 |
| 34 | - 23.0 | - 09.4 | 78 | - 01.0 | 30.2 | 122 | 21.0 | 69.8 |
| 35 | - 22.5 | - 08.5 | 79 | - 00.5 | 31.1 | 123 | 21.5 | 70.7 |
| 36 | - 22.0 | - 07.6 | 80 | 0 | 32.0 | 124 | 22.0 | 71.6 |
| 37 | - 21.5 | - 06.7 | 81 | 00.5 | 32.9 | 125 | 22.5 | 72.5 |
| 38 | - 21.0 | - 05.8 | 82 | 01.0 | 33.8 | 126 | 23.0 | 73.4 |
| 39 | - 20.5 | - 04.9 | 83 | 01.5 | 34.7 | 127 | 23.5 | 74.3 |
| 40 | - 20.0 | - 04.0 | 84 | 02.0 | 35.6 | 128 | 24.0 | 75.2 |
| 41 | - 19.5 | - 03.1 | 85 | 02.5 | 36.5 | 129 | 24.5 | 76.1 |
| 42 | - 19.0 | - 02.2 | 86 | 03.0 | 37.4 | 130 | 25.0 | 77.0 |
| 43 | - 18.5 | - 01.3 | 87 | 03.5 | 38.3 | 131 | 25.5 | 77.9 |

# APPENDIX A – Omnitemp to C to F Table

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 132 | 26.0 | 78.8 | | 176 | 48.0 | 118.4 | | 220 | 70.0 | 158.0 |
| 133 | 26.5 | 79.7 | | 177 | 48.5 | 119.3 | | 221 | 70.5 | 158.9 |
| 134 | 27.0 | 80.6 | | 178 | 49.0 | 120.2 | | 222 | 71.0 | 159.8 |
| 135 | 27.5 | 81.5 | | 179 | 49.5 | 121.1 | | 223 | 71.5 | 160.7 |
| 136 | 28.0 | 82.4 | | 180 | 50.0 | 122.0 | | 224 | 72.0 | 161.6 |
| 137 | 28.5 | 83.3 | | 181 | 50.5 | 122.9 | | 225 | 72.5 | 162.5 |
| 138 | 29.0 | 84.2 | | 182 | 51.0 | 123.8 | | 226 | 73.0 | 163.4 |
| 139 | 29.5 | 85.1 | | 183 | 51.5 | 124.7 | | 227 | 73.5 | 164.3 |
| 140 | 30.0 | 86.0 | | 184 | 52.0 | 125.6 | | 228 | 74.0 | 165.2 |
| 141 | 30.5 | 86.9 | | 185 | 52.5 | 126.5 | | 229 | 74.5 | 166.1 |
| 142 | 31.0 | 87.8 | | 186 | 53.0 | 127.4 | | 230 | 75.0 | 167.0 |
| 143 | 31.5 | 88.7 | | 187 | 53.5 | 127.3 | | 231 | 75.5 | 167.9 |
| 144 | 32.0 | 89.6 | | 188 | 54.0 | 129.2 | | 232 | 76.0 | 168.8 |
| 145 | 32.5 | 90.5 | | 189 | 54.5 | 130.1 | | 233 | 76.5 | 169.7 |
| 146 | 33.0 | 91.4 | | 190 | 55.0 | 131.0 | | 234 | 77.0 | 170.6 |
| 147 | 33.5 | 92.3 | | 191 | 55.5 | 131.9 | | 235 | 77.5 | 171.5 |
| 148 | 34.0 | 93.2 | | 192 | 56.0 | 132.8 | | 236 | 78.0 | 172.4 |
| 149 | 34.5 | 94.1 | | 193 | 56.5 | 133.7 | | 237 | 78.5 | 173.3 |
| 150 | 35.0 | 95.0 | | 194 | 57.0 | 134.6 | | 238 | 79.0 | 174.2 |
| 151 | 35.5 | 95.9 | | 195 | 57.5 | 135.5 | | 239 | 79.5 | 175.1 |
| 152 | 36.0 | 96.8 | | 196 | 58.0 | 136.4 | | 240 | 80.0 | 176.0 |
| 153 | 36.5 | 97.7 | | 197 | 58.5 | 137.3 | | 241 | 80.5 | 176.9 |
| 154 | 37.0 | 98.6 | | 198 | 59.0 | 138.2 | | 242 | 81.0 | 177.8 |
| 155 | 37.5 | 99.5 | | 199 | 59.5 | 139.1 | | 243 | 81.5 | 178.7 |
| 156 | 38.0 | 100.4 | | 200 | 60.0 | 140.0 | | 244 | 82.0 | 179.6 |
| 157 | 38.5 | 101.3 | | 201 | 60.5 | 140.9 | | 245 | 82.5 | 180.5 |
| 158 | 39.0 | 102.2 | | 202 | 61.0 | 141.8 | | 246 | 83.0 | 181.4 |
| 159 | 39.5 | 103.1 | | 203 | 61.5 | 142.7 | | 247 | 83.5 | 182.3 |
| 160 | 40.0 | 104.0 | | 204 | 62.0 | 143.6 | | 248 | 84.0 | 183.2 |
| 161 | 40.5 | 104.9 | | 205 | 62.5 | 144.5 | | 249 | 84.5 | 184.1 |
| 162 | 41.0 | 105.8 | | 206 | 63.0 | 145.4 | | 250 | 85.0 | 185.0 |
| 163 | 41.5 | 106.7 | | 207 | 63.5 | 146.3 | | 251 | 85.5 | 185.9 |
| 164 | 42.0 | 107.6 | | 208 | 64.0 | 147.2 | | 252 | 86.0 | 186.8 |
| 165 | 42.5 | 108.5 | | 209 | 64.5 | 148.1 | | 253 | 86.5 | 187.7 |
| 166 | 43.0 | 109.4 | | 210 | 65.0 | 149.0 | | 254 | 87.0 | 188.6 |
| 167 | 43.5 | 110.3 | | 211 | 65.5 | 149.9 | | 255 | 87.5 | 189.5 |
| 168 | 44.0 | 111.2 | | 212 | 66.0 | 150.8 | | | | |
| 169 | 44.5 | 112.1 | | 213 | 66.5 | 151.7 | | | | |
| 170 | 45.0 | 113.0 | | 214 | 67.0 | 152.6 | | | | |
| 171 | 45.5 | 113.9 | | 215 | 67.5 | 153.5 | | | | |
| 172 | 46.0 | 114.8 | | 216 | 68.0 | 154.4 | | | | |
| 173 | 46.5 | 115.7 | | 217 | 68.5 | 155.3 | | | | |
| 174 | 47.0 | 116.6 | | 218 | 69.0 | 156.2 | | | | |
| 175 | 47.5 | 117.5 | | 219 | 69.5 | 157.1 | | | | |

# APPENDIX B – Direct Connect Cables

A typical RS-232 port on a personal computer can drive 4 thermostats directly on up to 500 feet of wire. HAI makes a 10 foot cable, p/n RC-201, with a DB-9F on one end and the thermostat connector on the other. You can make this cable easily as described below. For more than 4 thermostats or wiring lengths greater than 500 feet, HAI recommends the RC-202 signal booster to increase the drive capacity of the RS-232 port and to provide additional surge protection for the serial port. An RC-202 can drive up to 127 thermostats over 10,000 feet of wire.

Direct Connect Cables

Serial ports on most computers have two connector types: DB-9M and DB-25M. To make a cable to connect one or more thermostats to this port, you will need:

1. One DB-9F or DB-25F connector, depending whether your computer has a DB-9M or DB-25M connector for its serial port. (F stands for female, M stands for male.)
2. Four (4) conductor wire. Use 22 to 24 gauge shielded or unshielded, stranded or solid, twisted or untwisted, the wire type is not critical. Use shielded if your environment calls for running the communications wire along with power wires, and connect the shield to a good ground at the computer. Do not connect the shield at the thermostat.)
3. One or more HAI communications plugs. Each HAI thermostat is supplied with one HAI communications plug. You need one for each thermostat.

Make the connections as follows:

If using a DB-9F connector:

1. On the DB-9F connector: Connect pins 7 and 8 together. (RTS and CTS)
2. On the DB-9F connector: Connect pins 1, 6 and 4 together. (DCD, DTR and DSR)
3. Connect pin 4 of the DB-9F to the YELLOW wire on the thermostat plug (DTR)
4. Connect pin 3 of the DB-9F to the GREEN wire on the thermostat plug (TXD)
5. Connect pin 2 of the DB-9F to the RED wire on the thermostat plug (RXD)
6. Connect pin 5 of the DB-9F to the BLACK wire on the thermostat plug. (GND)

If using a DB-25F connector:

1. On the DB-25F connector: Connect pins 4 and 5 together. (RTS and CTS)
2. On the DB-25F connector: Connect pins 8, 6 and 20 together. (DCD, DTR and DSR)
3. Connect pin 20 of the DB-25F to the YELLOW wire on the thermostat plug (DTR)
4. Connect pin 2 of the DB-25F to the GREEN wire on the thermostat plug (TXD)
5. Connect pin 3 of the DB-25F to the RED wire on the thermostat plug (RXD)
6. Connect pin 7 of the DB-25F to the BLACK wire on the thermostat plug. (GND)

Additional thermostats are connected in parallel. (Yellow to yellow, green to green, red to red and black to black.) Wiring for additional thermostats can be home run or daisy chained, or a combination of both.