4. TEST SPECIFICATION

The following tests will allow an individual to determine if the constraints of the design have been met. The tests consist of a procedure for performing the test and the expected results of the test. If the expected and measured values agree then the design has met the constraints. If the test results do not agree with the expected results then the design constraints have not been met.

4.1. Temperature Sensing

The full measurement range will be tested by adjusting the ambient temperature between 49°F and 91°F. Values read from the ADC will be compared with the expected values to determine if they are within the specified range.

Remote Test Procedure:

1. Load modified software into the remote's PIC that will display the measured temperature over the full measurement range. The modified software will be the same as the normal software with the exception that the LCD display will be able to display the full measurement range and not just the user adjustable range.
2. Place the remote in an environment that has an ambient temperature of 49°F. Once the remote is in the environment, allow 3 minutes for the remotes temperature to stabilize. Record the ambient temperature as measured by a second, reference thermometer and the temperature as displayed on the remote unit.
3. Increase the ambient temperature in 1°F increments. After an adjustment is made, wait until the environment has reached the increased temperature. Once the environment is at the desired temperature wait 3 minutes and record the temperature measured on the display. Additionally, record the temperature indicated on the reference thermometer. Continue this process through 91°F.
4. Compare the temperatures recorded from the remote with those obtained by the reference thermometer. At 49°F the expected temperature measured by the remote is 50°F. Between 50°F-90°F the expected temperature measured by the remote is +/- 1°F of the reference thermometer's values. At 91°F the expected temperature measured by the remote is 90°F.

Base Test Procedure:

1. Load modified software on the PC that will display the measured temperature over the full measurement range. The modified software will be the same as the normal software with the exception that the screen will have the ability to display the full measurement range and not just the user adjustable range.
2. Place the base hardware unit in an environment that has an ambient temperature of 49°F. Once the base is in the environment, allow 3 minutes for the bases temperature to stabilize. Record the ambient temperature as measured by a reference thermometer and the temperature as displayed on the PC.
3. Increase the ambient temperature in 1°F increments. After an adjustment is made, wait until the environment has reached the increased temperature. Once the

environment is at the desired temperature wait 3 minutes and record the temperature measured on the PC. Additionally, record the temperature indicated on the reference thermometer. Continue this process through 91°F.

4. Compare the temperatures recorded from the PC with those obtained by the reference thermometer. At 49°F the expected temperature measured by the PC is 50°F. Between 50°F-90°F the expected temperature measured by the PC is +/- 1°F of the reference thermometer's values. At 91°F the expected temperature measured by the PC is 90°F.

4.2. Packaging

The unit will also be placed on a scale to determine that its weight is less than the 10-ounce specification. The finished packaging will be mounted on a piece of dry wall to verify that it can be wall mounted. The HVAC wires, a RS232 cable, and a power cable will be connected to the back of the unit through the drywall. The unit will then be turned on. The PC will send data to the base unit asking the base unit to turn on the heating and cooling systems. This will verify that the connections are working properly. The RS232 and power wires will then be removed and connected through the bottom of the unit. Once again, the PC will ask the base unit to turn on the heating and cooling systems to verify that the RS232 and power connections are working properly on the bottom of the unit.

4.3. RS-232E

The computer will communicate with the base hardware unit by RS232. Several components will be controlled from this port. The input data will include a local temperature sensor and the RF data coming from the portable unit. The output data will be the information sent to the HVAC unit. A RS232 connection will be used to control the flow of data between these components. The diagram below shows the flow of data for the base unit.

Pin No.	Function	Pin No.	Function
1	DCD (Data Carrier Detect)	6	DSR (Data Set Ready)
2	RX (Receive Data)	7	RTS (Request To Send)
3	TX (Transmit Data)	8	CTS (Clear To Send)
4	DTR (Data Terminal Ready)	9	RI (Ring Indicator)
5	GND (Signal Ground)		

Figure 15. Pin-out diagram for a 9-pin serial port.

The RS232 connection consists of data and handshaking signals. To test the data and handshaking signals, a bit sequence will be sent from the PC to the base hardware unit over the RS232 connection (the actual value of the bit sequence will be determined once more progress has been made on the hardware). The data will be interpreted by the base hardware unit and a reply bit sequence will be sent to the PC (the actual value of the bit sequence will be determined once more progress has been made on the hardware). The received data will be displayed on the PC and compared with the expected received data. If the received and expected data are the same this will indicate that the RS232 data and handshaking paths are working properly.

4.4. LCD Output

The LCD output displays three pieces of information, desired temperature, ambient temperature, and mode of operation (AC, heat, etc.). A voltage source will be used to simulate the output of the temperature circuit. The final PIC software will be loaded onto the PIC before any of the following tests are performed. The testing of the LCD will be done in three parts.

Ambient Temperature Test Procedure:

1. Power the remote circuit with an external voltage source. Connect a second voltage source to the ADC input of the PIC. The negative terminals of both supplies should be connected together. The voltage source supplying power to the remote circuit should be set to 5V before being turned on. The voltage source connected to the ADC should be set to 0V before being turned on.
2. Slowly sweep the voltage source connected to the ADC from 0V to 5V. Record the displayed ambient temperature. The measured values should start at 55 and increment to 85 in steps of 1. The values that will be changing on the LCD are the first two left most values as shown in Figure 4.4.1, test A. The third character position will remain blank.

Desired Temperature Test Procedure:

1. Power the remote unit with its normal power supply.
2. Press the “Temperature Down” button until the fourth and fifth positions of the LCD read 55. Figure 4.4.2 shows where the desired temperature will be output on the LCD.
3. Press the “Temperature Up” button one time and record the reading on the fourth and fifth positions on the LCD. Repeat this process until the fourth and fifth positions of the LCD read 85. Figure 4.4.1, Test B, shows where the desired temperature will be output on the LCD.

If the recorded values increment from 55 to 85 in increments of one, then the desired temperature portion of the display is working correctly.

Mode of Operation Test Procedure:

1. Power the remote circuit with its normal supply.
2. Place the "Mode of Operation" switch in the OFF position. Record the three right most values displayed on the LCD. The expected output is shown below in Table 3, Test C.
3. Place the "Mode of Operation" switch in the AC position. Record the three right most values displayed on the LCD. The expected output is shown below in Table 3, Test D.
4. Place the "Mode of Operation" switch in the HEAT position. Record the three right most values displayed on the LCD. The expected output is shown below in Table 3, Test E.
5. Place the "Mode of Operation" switch in the FAN position. Record the three right most values displayed on the LCD. The expected output is shown below in Table 3, Test F.
6. Place the "Mode of Operation" switch in the AUTO position. Record the three right most values displayed on the LCD. The expected output is shown below in Table 3, Test G.
7. If all of the recorded an expected values are the same then the LCD correctly displays the modes of operation.

A	Ambient Temp. (10's Position)	Ambient Temp. (1's Position)	Blank	XX	XX	XX	XX	XX
B	XX	XX	Blank	Ambient Temp. (10's Position)	Ambient Temp. (1's Position)	XX	XX	XX
C	XX	XX	Blank	XX	XX	O	F	F
D	XX	XX	Blank	XX	XX	Blank	A	C
E	XX	XX	Blank	XX	XX	Blank	H	T
F	XX	XX	Blank	XX	XX	Blank	F	N
G	XX	XX	Blank	XX	XX	Blank	A	T

Table 3. Position of ambient temperature in relation to LCD output (XX indicates a "don't care")

4.5. Anticipator

The anticipator will be tested with both the remote and the base. To test the anticipator function on the remote, adjust the ambient temperature to 70°F. Set the heater anticipator to 3 degrees Fahrenheit and the mode to heat. Over a 5-minute period, change the ambient temperature to 75 degrees Fahrenheit. Monitor the HVAC output and note at what temperature the HVAC system cutoff. Repeat this procedure for heater anticipator settings of 2 and 1. The recorded values should be 75 minus the heater anticipator setting. Repeat this procedure for the base. To test the anticipator on the AC system, set the AC anticipator to 3, the operating mode to AC, and the ambient temperature to 80

degrees Fahrenheit. Follow the same procedure as above except reduce the temperature to 75°F. The recorded values should be 75 plus the AC anticipator setting.

4.6. Over-Current

To test the over-current protection, an attempt will be made to turn the HVAC system on and off quickly.

Test Procedure:

1. Turn on the remote and place it in AC mode.
2. Adjust the ambient temperature to 70oF. Set the desired temperature to 67oF, or until the AC system is activated.
3. Wait for the system to reach the desired temperature and turn off.
4. Once the system is turned off, adjust the desired temperature to 63°F (or 4 degrees below the desired temperature used in step 2). Every 5 seconds adjust the desired temperature from 63°F to 62°F and then back to 63°F after another 5 seconds. Note how long it has been system the system AC turned off each time the desired temperature is adjusted.
5. Continue with step 4 until the AC system turns back on. The time it takes should be at least as long as the time set by the over-current protection system, and at most the time set by the over-current protection system plus one minute.

Repeat this process with the base unit having control of the AC system. To test the over-current with the heating system, follow the test procedure below.

Test Procedure

1. Turn on the remote and place it in heat mode.
2. Adjust the ambient temperature to 70°F. Set the desired temperature to 73°F, or until the heating system is activated.
3. Wait for the system to reach the desired temperature and turn off.
4. Once the system is turned off, adjust the desired temperature to 77°F (or 4 degrees above the desired temperature used in step 2). Every 5 seconds adjust the desired temperature from 77°F to 78°F and then back to 77°F after another 5 seconds. Note how long it has been system the system heating turned off each time the desired temperature is adjusted.
5. Continue with step 4 until the heating system turns back on. The time it takes should be at least as long as the time set by the over-current protection system, and at most the time set by the over-current protection system plus one minute.

4.7. HVAC Connectivity

Our system will connect to HVAC units with a standard 5-wire interface. Some 5-wire systems contain a sixth wire that is a common. HVAC units that have the extra common wire will operate with this thermostat. No standard has been found that specifies this. However, this thermostat is not compatible with heat pump systems. The 5 wires are as follows:

- RC: Cooling Transformer
- RH: Heating Transformer
- G: Fan Relay
- Y: Cooling Relay
- W: Heat Relay

The HVAC interface will be tested at the rated voltage and current conditions of 24VAC and 1.2A to verify that they meet the specifications. This will be done by applying the rated voltages and currents to the load side of the circuitry for AC, heat and fan modes. It will be verified that the HVAC interface operates correctly in the on and off conditions as well as when switching.

4.8 Supported Operating Systems

Windows 95, Windows 98, Windows ME, and Windows XP will be supported by the PC software. The software will be tested for correct operation and stability. Correct operation will be tested by sending and receiving data to and from the base unit. The purpose of the communications test is to determine that the drivers and operating system work correctly in transmitting and receiving data.

To test communication, a command will be sent to the base unit asking it to turn on the heating unit. The heat relay will then be checked to see that the contact is closed. The same will be followed again, except that the AC will be turned on and the AC contact checked. This will verify that the PC is correctly sending the data.

To test data received by the PC, the base unit will send temperature readings for three different temperatures. The received temperatures will be compared to the temperature that was expected. If the temperatures match, then the PC is correctly receiving the data.

The program will operate for four hours on each operating system to determine stability. If the program does not stall the computer, then the program will be considered stable.