# Home Climate Control System

**The temperature you want . . .**
**. . . when you want it . . .**
**. . . where you want it**

---

**EE402**
**Dr. Huggins**
**April 16, 2001**

# Table of Contents


| | Page |
|---|---|
| Functional Description | 3 |
| Target Market | 3 |
| Technical Specifications | 3 |
| Block Diagram | 4-5 |
| Software Flowchart | 5 |
| System Job Sheet | 6 |
| Hardware Job Sheet | 7 |
| Software Job Sheet | 8 |
| Prototype Job Sheet | 9 |
| Parts List | 10 |
| Manufacturing Cost | 11 |
| Cost Estimate | 12 |
| Conclusion | 12 |

## Functional Description

The team will be designing a heating and cooling system that allows users to program the temperature of each room in a house from a central location. This central location, containing a microcontroller, is the heart of the system. Thermostats, located in various areas of a home, feed information to the microcontroller, which opens and closes dampers in the heating and cooling ducts to the various zones in a home. By controlling the airflow in the specific zones, this system will give the user the necessary control to meet the temperature preferences of individuals living in the house. By increasing the control, it will also increase the efficiency of the system by allowing users to select the rooms that they would like heated. Lowering heating and cooling costs while raising the level of comfort will result from this increase in control.

Programmable Options Include:

- 7-day planner (Weekdays/Weekends)
- Day/Night
- Room to Room

## Target Market

General Contractors of new and remodeled homes, as well as general heating and cooling contractors will be the target market for this product. These contractors will be better equipped to sell the product to the end user because of the nature of their business and technical knowledge base. Because of the increase in heating and cooling costs, this system should be an attractive option for many contractors and homeowners.

## Technical Specifications

Zoned temperature control is able to control the temperature of all zones of a home or building. Sensors in each zone operate a baffle in that zone's supply duct that will control the flow of conditioned air to each zone. The baffles will automatically open or close, based on the demands of the zone sensor.

The base unit comes with four baffle motors and four temperature sensors.
The microprocessor can accept as many as 10 individual inputs, and additional peripheral modules can be applied to the base unit to accommodate any number of zones. In addition, a single temperature sensor can control multiple baffles in order to maintain a larger zone that is supplied by more than one duct. The versatility of this system is such that it can be easily assembled for any application.

The code for the system is burned onto an EPROM chip, which allows the microprocessor to maintain the program code with no power supplied to the system.

There will also be a backup battery that is internal to this microprocessor board that will preserve the users settings for an extended period of time without external power. Although the program code seems simple, it is one of the most important parts of system.

The motor driving circuitry contains an h-bridge configuration that allows the TTL level signals from the microprocessor to control high current DC motors. The major function of the h-bridge is to reverse the polarity of the signal, allowing the motors to be adjusted in both directions. The DC motors contain internal potentiometers that provide the position feedback signals.

The main elements in the design include: temperature sensors, motor controls, control panel, and a microprocessor to ensure all the elements are working together.

**Block Diagram**

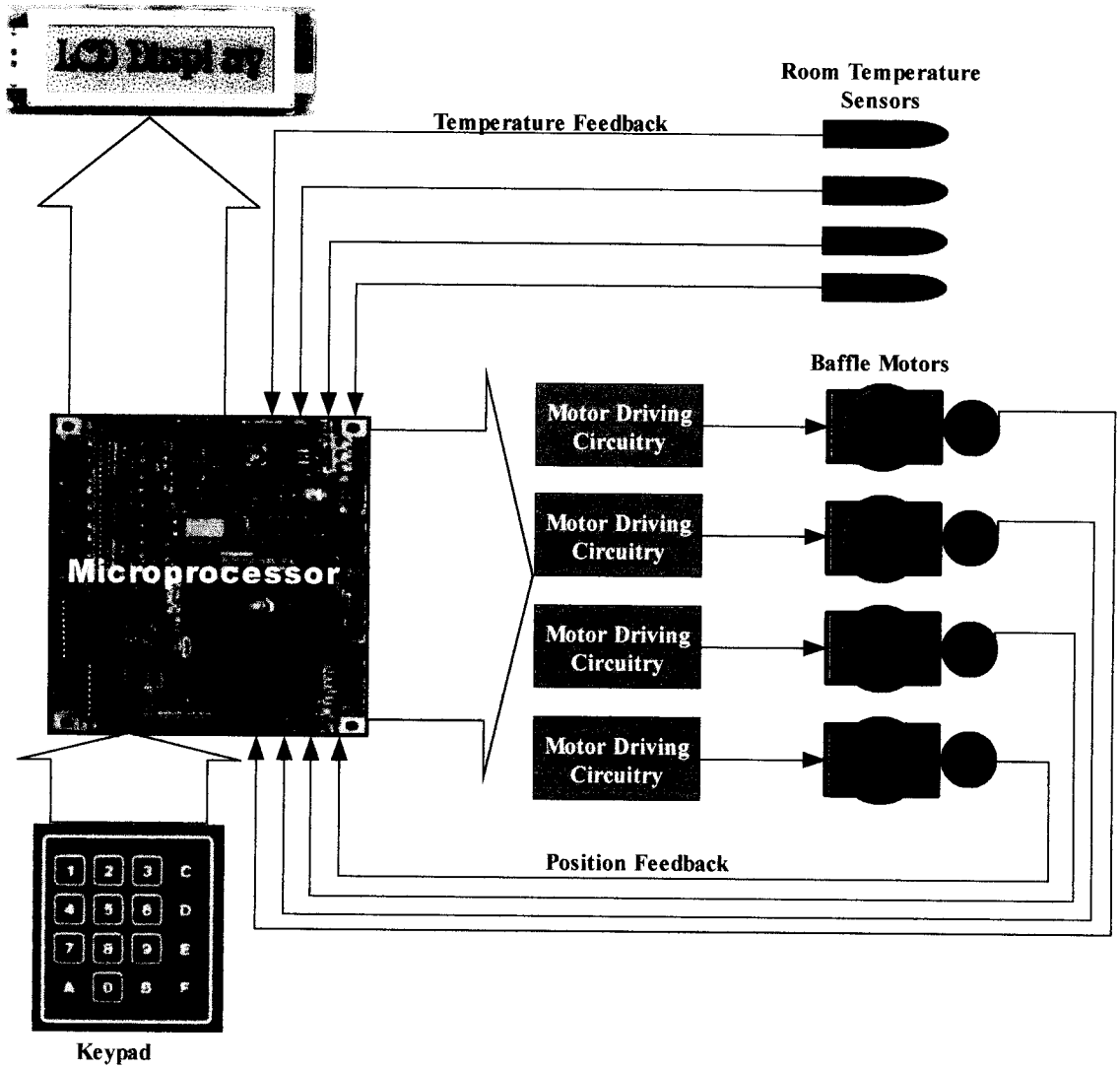
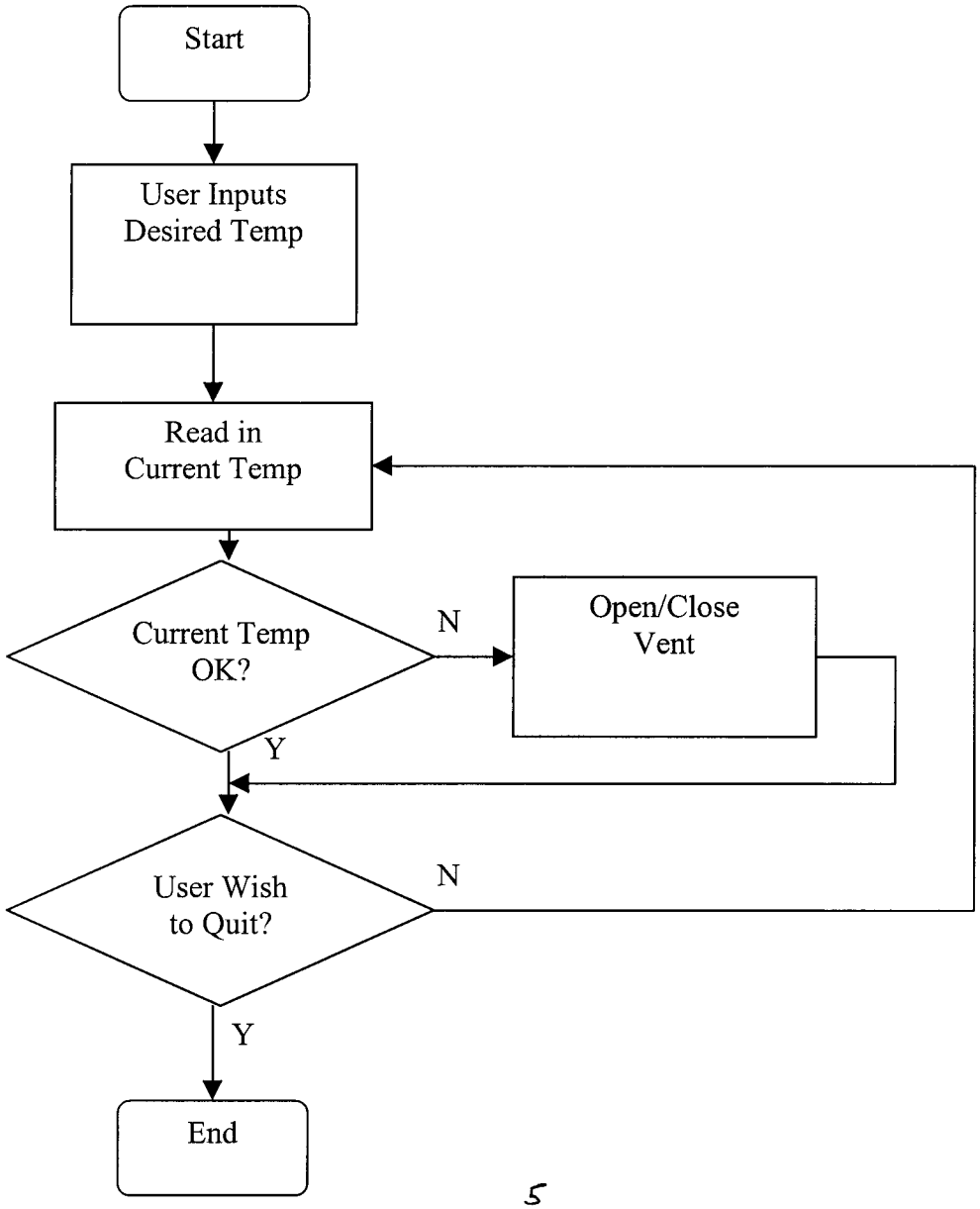


Diagram Description

As previously mentioned, the heart of the system is a microprocessor. This microprocessor accepts inputs from the keypad, temperature sensors, and position sensors. The outputs of the microprocessor are used to control the LCD display and the motor driving circuitry. The LCD will display the current temperature as well as provide an interface between the user and the programmable features of the product.

Entering the information is easy with on-screen instructions, and an easy to use keypad. After all of the data has been entered, the microprocessor will do the rest of the work. It will read the data from the temperature and position sensors, which are placed in each of the zones, and make any of the necessary corrections to the baffle motors.

**Software Flowchart**



**System Job Sheet**

The direct costs associated with the system include direct labor, materials, and equipment. Below is the system job sheet and the individual job sheets based on the first year cost of manufacturing 5,200 units of the product.

Considerations

- $85 / hour for labor
- Office = $2500 per quarter
- 40 hr. work week

Responsible Engineers: 6

Objective: Design of a Automatic Home Climate Control System.

Milestones:

1. Hardware Design
2. Software Design
3. Prototyping and Testing
4. Manufacturing

Schedule and Resources: ECET Department Resources

| Milestone | 2001 | | | 2002 | Costs | | | |
|---|---|---|---|---|---|---|---|---|
| | Q2 | Q3 | Q4 | Q1 | Labor | Material | Equipment | Total |
| Office Space | X | X | X | | | | $10,000.00 | $ 10,000.00 |
| Hardware Design | X | | | | $40,800 | $605.35 | | $ 41,405.35 |
| Software | X | | | | $40,800 | | | $ 40,800.00 |
| Prototyping & Testing | | X | X | | $ 34,000.00 | $ 3,475.15 | | $ 37,475.15 |
| Manufacturing | | | X | X | | | | $4,044,666.67 |
| Total | | | | | $115,600.00 | $ 4,080.50 | | $4,164,347.17 |

| Milestone | Costs | | | |
|---|---|---|---|---|
| | Labor | Material | Equipment | Total |
| Office Space | | | $ 10,000.00 | $ 10,000.00 |
| Hardware Design | $40,800 | $605.35 | | $ 41,405.35 |
| Software | $40,800 | | | $ 40,800.00 |
| Prototyping & Testing | $ 34,000.00 | $ 3,475.15 | | $ 37,475.15 |
| Manufacturing | | | | $ 4,044,666.67 |
| Total | $ 115,600.00 | $ 4,080.50 | | $ 4,164,347.17 |

**Hardware Job Sheet**

Responsible Engineers: 1

Objective: Create and test Hardware Design of a Automatic Climate Control system.

Milestones:
1. Parts Selection
2. Control Panel
3. Microprocessor Interface
4. Troubleshooting

Schedule and Resources: ECET Department Resources

| Milestone | 2001 | | | 2002 | Costs | | | |
|---|---|---|---|---|---|---|---|---|
| | Q2 | Q3 | Q4 | Q1 | Labor | Material | Equipment | Total |
| Parts Selection | X | | | | $4,080.00 | $ - | $ - | $ 4,080.00 |
| Control Panel | X | | | | $ 16,320.00 | $ - | $ - | $ 16,320.00 |
| Microprocessor Interface | X | | | | $ 8,160.00 | $ - | $605.35 | $ 8,765.35 |
| Troubleshooting | X | | | | $ 12,240.00 | $ - | $ - | $ 12,240.00 |
| Total | | | | | $ 40,800.00 | $ - | $ 605.35 | $ 41,405.35 |

Used 12 wh Q

**Software Coding and Testing Job Sheet**

Responsible Engineers: 1

Objective: Create and test software of a Automatic Climate Control system.

Milestones:
1. LCD display driver
2. Sensor Reading
3. Communication
4. Readout and features
5. User Interface
6. Testing

Schedule and Resources: ECET Department Resources

| Milestone | 2001 | | | 2002 | Costs | | | |
|---|---|---|---|---|---|---|---|---|
| | Q2 | Q3 | Q4 | Q1 | Labor | Material | Equipment | Total |
| LCD display Driver | X | | | | $ 6,120.00 | $ - | $ - | $ 6,120.00 |
| Sensor Reading | X | | | | $ 2,040.00 | $ - | $ - | $ 2,040.00 |
| Communication | X | | | | $ 8,160.00 | $ - | $ - | $ 8,160.00 |
| Readout and Features | X | | | | $ 12,240.00 | $ - | $ - | $ 12,240.00 |
| User Interface | X | | | | $ 4,080.00 | $ - | $ - | $ 4,080.00 |
| Testing | X | | | | $ 8,160.00 | $ - | $ - | $ 8,160.00 |
| Total | | | | | $ 40,800.00 | $ - | $ - | $ 40,800.00 |

**Prototype Job Sheet**

Responsible Engineers: 1

Objective: Build prototype of a Automatic Climate Control system.

Milestones:
1. Construction
2. Testing
3. Debugging

Schedule and Resources: ECET Department Resources

| Milestone | 2001 | | | 2002 | Costs | | | |
|---|---|---|---|---|---|---|---|---|
| | Q2 | Q3 | Q4 | Q1 | Labor | Material | Equipment | Total |
| Construction | | X | X | | $ 6,800.00 | $3,475.15 | $ - | $ 10,275.15 |
| Testing | | | X | | $ 27,200.00 | | $ - | $ 27,200.00 |
| Debugging | | | X | | | | | |
| Total | | | | | $ 34,000.00 | $ 3,475.15 | $ - | $ 37,475.15 |

## Parts List

| Part | Quantity | Price/ Unit | Price/1000 | Extended Price/ Unit | Extended Price/1000 | Description |
|---|---|---|---|---|---|---|
| Sensors | 4 | $2.39 | $0.72 | $9.56 | $2.88 | Senses room temperature |
| Baffle Motor | 4 | $65.00 | $65.00 | $260.00 | $260.00 | Controls the damper position |
| EMAC Transformer | 1 | $4.79 | $4.79 | $4.79 | $4.79 | Powers EMAC board |
| Transformer | 1 | $20.00 | $20.00 | $20.00 | $20.00 | Converts 120VAC to 24VAC |
| LCD | 1 | $67.34 | $36.78 | $67.34 | $36.78 | Backlit display / user interface |
| Keyboard | 1 | $30.00 | $30.00 | $30.00 | $30.00 | User input |
| Wall-Mount Housing | 1 | $0.50 | $0.50 | $0.50 | $0.50 | Enclosure for the user interface |
| EMAC | 1 | $129.95 | $129.95 | $129.95 | $129.95 | Microprocessor |
| Electrical enclosure | 1 | $18.69 | $18.69 | $18.69 | $18.69 | Transformer housing |
| Dampers | 4 | $15.00 | $15.00 | $60.00 | $60.00 | Controls the airflow through the duct work |
| H-Bridge | 4 | $23.55 | $10.44 | $94.20 | $41.76 | Switching power device to control motors |
| **Total** | | | | **$695.03** | **$605.35** | |

**Additional Zone Parts List**

| | | | | | | |
|---|---|---|---|---|---|---|
| Sensors | 1 | $2.39 | $0.72 | $2.39 | $0.72 | Senses room temperature |
| Baffle Motor | 1 | $65.00 | $65.00 | $65.00 | $65.00 | Controls the damper position |
| Dampers | 1 | $15.00 | $15.00 | $15.00 | $15.00 | Controls the airflow through the duct work |
| H-Bridge | 1 | $23.55 | $10.44 | $23.55 | $10.44 | Switching power device to control motors |
| **Total** | | | | **$105.94** | **$91.16** | |

**Manufacturing Job Sheet**

| | |
|---|---|
| Responsible Engineers: | 1 |
| Objective: | Build prototype of a Automatic Climate Control system. |
| Milestones: | 1. Contract a manufacturer<br>2. Finalize production<br>3. Production of 5,200 units |
| Schedule and Resources: | ECET Department Resources |

(Calculations on following Cost Estimate)

- Total Materials Cost = $605.35
- Total Direct Cost = $672.61
- Manufacturing Vendor = $269.04

**Cost Estimate**

- Total Direct Cost = Total Material Cost / 0.90 → adjusted for our project
- TDC = $605.35/0.90 = $672.61
- Manufacturing Cost = (.40)*Total Direct Cost
- MFC = (0.40)*$672.61 = $269.04
- Total Labor and Equipment Cost = $125,600
- Cost / Unit = $125,600 / 5200 Units = $24.15
- Cost Estimate = MFC + TLEC
- $269.04 + $24.15 = $293.19

**Conclusion**

There are several benefits of the Home Climate Control System including: comfort, convenience, conservation, and common sense. This combination makes for a great heating and cooling option for many people.