Project Proposal: Self Heating Bed

Team Members: Team 44

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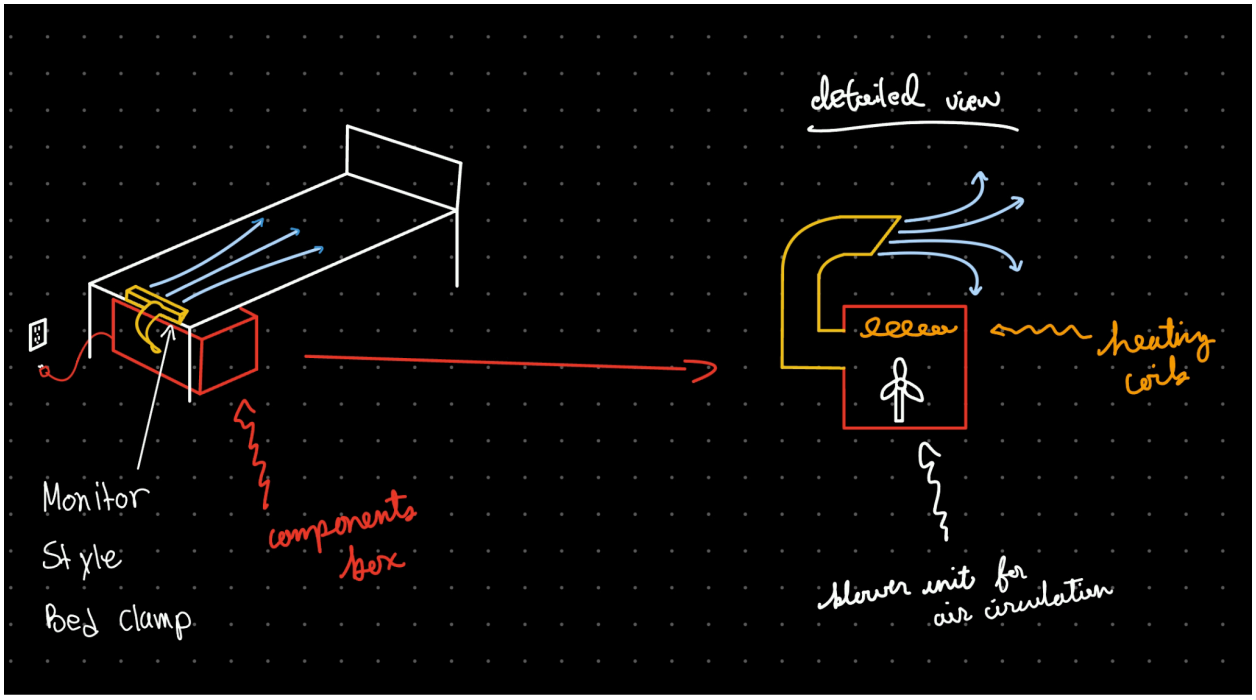
Problem

Many prefer a fan or heater next to their bed, so as to get a restful night's sleep. Certain solutions such as the BedJet or EightSleep have been produced, but are financially out of scope for the majority of people. Additionally, standing ventilation systems can often be loud or not provide temperature control for the entire bed, leaving a non-uniform warmth or coolness which may become uncomfortable over time.

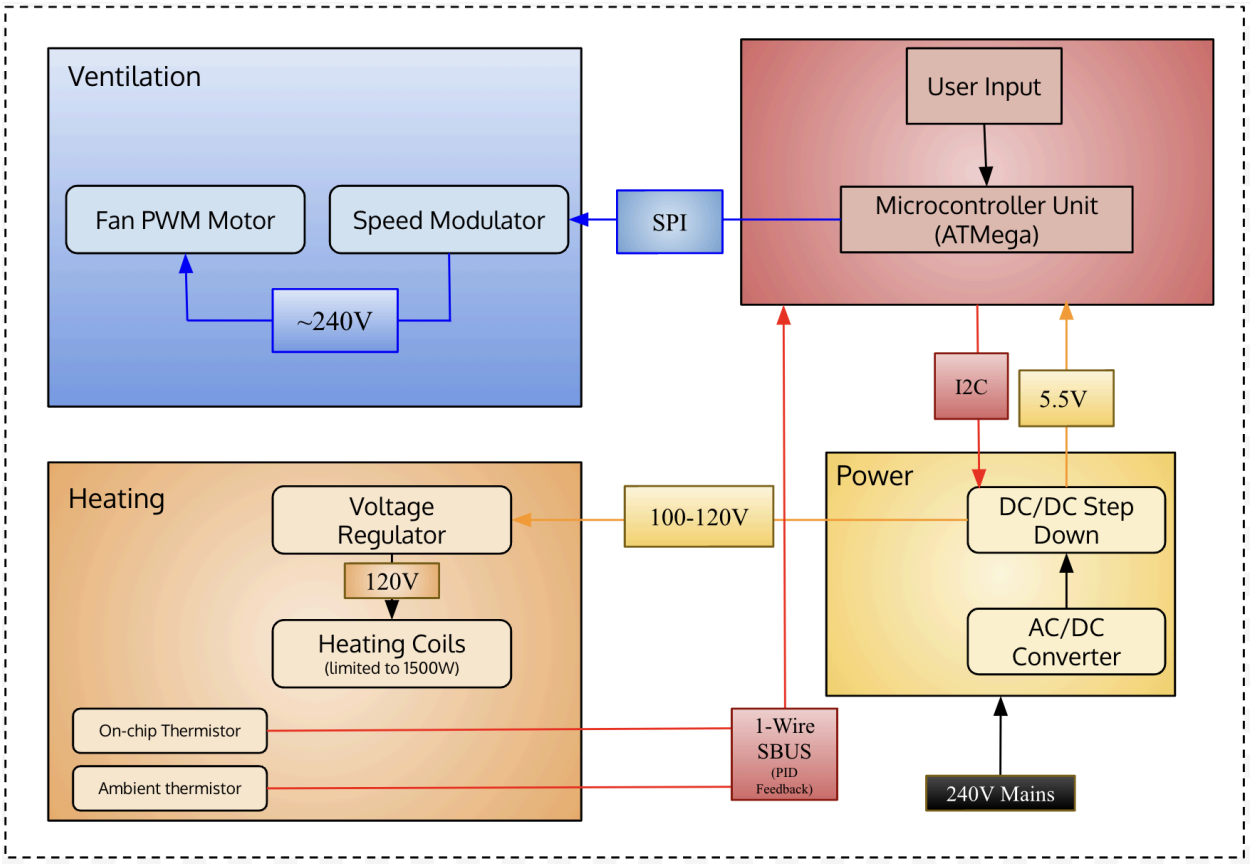
Solution

A heating mattress is our answer to the many who feel uncomfortable with frigid temperatures in the middle of winter. The system would be an attachment to one's bed frame (through clamps), with hot air circulating through bed sheets to simulate a warmer environment. Four splits can be made for this project: heating, circulation, and safety. Each will be expanded on below.

Visual Aid:



Solution Components



Subsystem 1 - Heating

We intend on implementing heating using independent and smaller heating coils, due to their cost effectiveness compared to the circulatory system in most apartments and houses. This coil is usually a resistor in most heating systems, coupled into an electric system where more power sent through the resistor results in more heat being dissipated. We are currently exploring heating options available to us through places like McMaster Carr, who have a variety of options available in different form factors. Another option is to use nichrome wires as used in toaster and heating coils. We intend on using a solid state switch for current control via the heating element. This allows us to control its power using PWM, which is essential for ensuring the coil temperature remains below a certain prescribed level. Ideally, we'll have an N-channel power MOSFET such as the TSM170N06CH[5] to modulate the power. To measure the temperature, we will use three temperature sensors; one measures the temperature of the ducted air, one will monitor ambient temperature in the room, and a thermistor on the board (inside a separate enclosure).

Nichrome Wires:
https://morelectricheating.com/coilhd10332-20-ga-ni60-25id-20-09-ohm-cln-cut-coil

Subsystem 1 - Requirements

The temperature in the enclosure will be under 200F, while the temperature in our circuitry enclosure should be under 100F. Additionally, we are measuring the temperature for the air ducted to the user; this should be clamped at 80F.

Subsystem 2 - Ventilation

Circulation is an issue even in conventional air conditioning systems, which makes its implementation all the more pertinent in our project. Through a fan or air blower, we can circulate air under the blankets and bed sheets to increase the temperature of the bed without having the problems of Eight Sleep (leakage issues, temperature mismatches, etc.). Additionally, we intend on giving the user control of this function through a motor control system and receiver implemented on our PCB. Easy access and variability through an app or remote of some sort will most certainly satisfy user expectations and leave a good experience. Since most fans use PWM, we'll use an ATMega328 as a microcontroller for communication (expanded on below). We will have our ventilation unit situated under the bed.

Subsystem 2 - Requirements

Our requirement for the ventilation system lies in whether or not the user feels cooler when the heat is not on. We will use a focus group to assess this requirement.
Potential Blower Options:
Wide Flow Blowers: Link
Fan Based Blower: Link, https://dannermfg.com/products/pondmaster-air-pumps

Subsystem 3 - Control System

We are using the ATMega328 microcontroller onto a PCB, in order to control our PWM based systems, as well as the feedback loop for PID to make sure that we are establishing the proper temperatures that we need and the coils are at the appropriate temperature. This control system will also include the input areas, which will have a physical dial/knob so that the user can control the temperature and behavior of the device. *As a stretch goal*, we may try to implement some kind of wireless control system, such as having the device communicate to an app or web page of some kind, so the user can control the system remotely.

ATMega Pinouts:
https://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-7810-Automotive-Microcontrollers-ATmega328P_Datasheet.pdf

Subsystem 3 - Requirements

The requirements will be being able to control the power delivery to the heating and ventilation systems. It will be responsible for monitoring the various sensors that we place around the enclosure and the system, as well as regulating the power appropriately to stay within the safe limits.

Tolerance Analysis

Our tolerance for the heating element is between 0.5-1 degrees, as our ambient temperature sensor (MAX31820) has a +- accuracy of 0.5 degrees (1 if accounting for dynamic air flow). Our voltage and current monitoring system will be on the PCB - we will also have fuses to ensure safety and hard limits on our electrical system. +-0.5V is the maximum limit for voltage fluctuation from our buck boost converter.

Ethics and Safety

Safety and power are the last two issues, and largely hinge on limits that we need to implement on the heating system. The coils that we buy will likely have a wattage rating that we can abide by, and set hard limits for using fuses within the system and on the PCB. Furthermore, checks and balances will be made for the power system through multiple voltage valuations and current examinations, feeding back to the main controller on the PCB and allowing us to monitor the system at all times. A potential option for the feedback system is PID based, as it provides the most flexibility and has been tested numerous times in other projects. The feedback system will be core to how we control our fan and heating, and will require fine tuning at the end of our project to ensure that we stay within safe operating temperatures. We'll be following the IEEE standards (62395-1-2024) for heating elements and fire safety.

Criterion For Success

Our project should:

1. Be able to modulate the temperature of its surroundings (defined as the temperature within a square box of the bed) within 3 degrees Fahrenheit of what the user inputs
2. Have a quiet air ventilation system, measured around 50-60 decibels (when sleeping, noise around one should not exceed 60)
3. Not power hungry and able to subsist off of the wattage of a normal fan and heater (1000W), the pulled power will be lower when the heater coils are not being used.