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CS 193: Design Project
Summer Study Abroad 2014:
System Design Plan & Schematic

OVERVIEW

The goal of the Integrated Appliance System project is to design and implement the control system for a series of solar-powered appliances, in a way that mitigates the end user's need to set up or interface with the system. Several methods and technologies will be implemented. Firstly, several different sensors will be used for data acquisition, in order to determine temperature, humidity, or any other variables that factor into the runtime of the dryer, water heater, space heating, or air conditioning. Microcontrollers will be utilized for the logic to be implemented as both the user interface, and the controls of the system. Within the logic in the microcontrollers, protocols and techniques such as Pulse-Width Modulation, Universal Asynchronous Receiver-Transmitter, feedback loop control, and Finite State Machines will be used to implement the control of the IAS.

DESIGN

The design of the will be implemented through fundamental steps learned from the previous Embedded Systems course taken. Firstly, finite state machines will be drawn to represent the overall process by which the logic in the microcontrollers will run. There will be two microcontrollers to run the system; one for handing the user interface, and the other to handle all controls. This will be done to prevent missed control signals from both the keypad interface or the wireless interface from the Android application. To ensure a proper communication is set up between the two microcontrollers, USART will be utilized to send flags that will be interpreted as a signal for certain controls. Similarly, the Android application will communicate to the controlling microcontroller using USART on a Bluetooth module that will be connected.

The main features of the interface will include the option to view sensor data. This will include temperature (set up to be either Celsius or Fahrenheit), humidity, or motion. To ensure data is accurate, the FSM will allow for a refresh of incoming sensor data every few seconds, or when requested from the interface microcontroller. In terms of control, the controls to actuate the Space Heater, Water Heater, and A/C appliances will be simulated by letting the user know it has been turned on through the LCD display. Figure 1 shows high-level synchronous and concurrent Finite State Machine illustrates the general flow and process of the IAS:

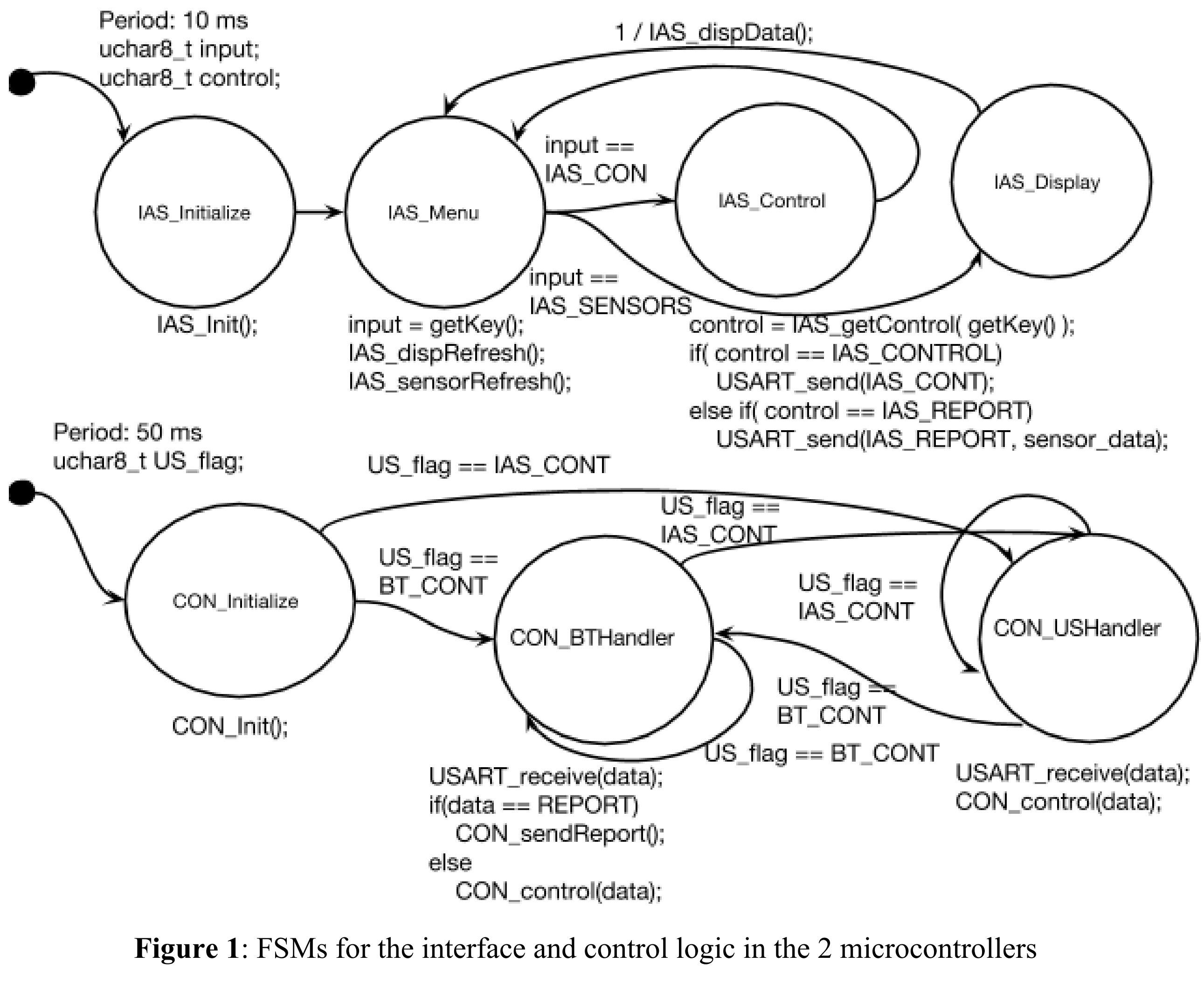

Figure 1: FSMs for the interface and control logic in the 2 microcontrollers

COMPONENTS

The following parts will be used in the design:

Part #	Qty	Description	Vendor	Description & Use
E1	2	Ventilation Fans (top)	N/A	Keeps constant temperature throughout closet
E2	2	In-line fans (side)	Amazon	Draws in heat from solar collector
E3	N/A	22-30 gauge (AWG) Wire	Amazon	Connections between components
E4	1	(Optional) Raspberry Pi	Amazon	May be used as alternative for automated logic with/ microcontrollers.
E5	2	ATmega 1284PU Microcontroller	Digikey	Contains programmed logic for IAS
E5-1	4	MOSFET 60V 30A (FQP30N06L)	Sparkfun	Powers automated fan through logic
E5-2	1	16x2 Character LCD (TC1602A-01T)	Adafruit	Used as display for menu system
E5-3	1	Bluetooth HC-05/06 Module	Adafruit	Allows USART communication to/from phone
E5-4	1	Level Shifter (HEF4050BP)	Adafruit	Converts 5.5V to 3.3V
E5-5	2	Shift Register (CD74HC595)	Digikey	Saves pins on microcontroller ports
E5-6	1	8-pin Keypad (4 row/column)	Digikey	Serves as the input for the user interface
E5-7	2	10K Ohm Potentiometer	Radioshack	Variable resistance
E5-8	10+	100, 330, 1k, 2K Ohm resistors	Radioshack	Limits current
E5-9	10+	1uF and 25uF capacitors	Radioshack	Miscellaneous purposes
E5-10	4	Parallax Single Relay 120VAC/10A	Amazon	Alternative to MOSFET transistors to switch on high-voltage components
E6	1	Temp/Humidity Sensor (DHT22)	Amazon	Used as main sensor for IAS
E7	2	PC Power Supply	N/A	For 12V Fan Source
E8	4	Motion Detector (HC-SR501)	Amazon	Used as safety measures
E9	4	Pressure Sensor (optional)	Amazon	Extra component for safety measure
E10	1	Stepper Motor	Amazon	Used to simulate actuation of valves

The schematic in **Figure 2** and the wiring diagram in **Figure 3** will describe an example of how such components would be wired for one of the appliances for IAS. Included are extra parts that may substitute others if necessary, such as a Raspberry Pi, would could serve as the data logging scripted in Python, in contrast to being programmed in C on the ATmega microcontroller. Similarly, different switches will be experimented to find the most suitable way to power the fans, e.g the relay or the MOSFET transistor listed above.

SCHEMATIC

The following schematic in **Figure 2** provides a layout of how the components will be put together to form the interface and control system for the Integrated Appliance System:

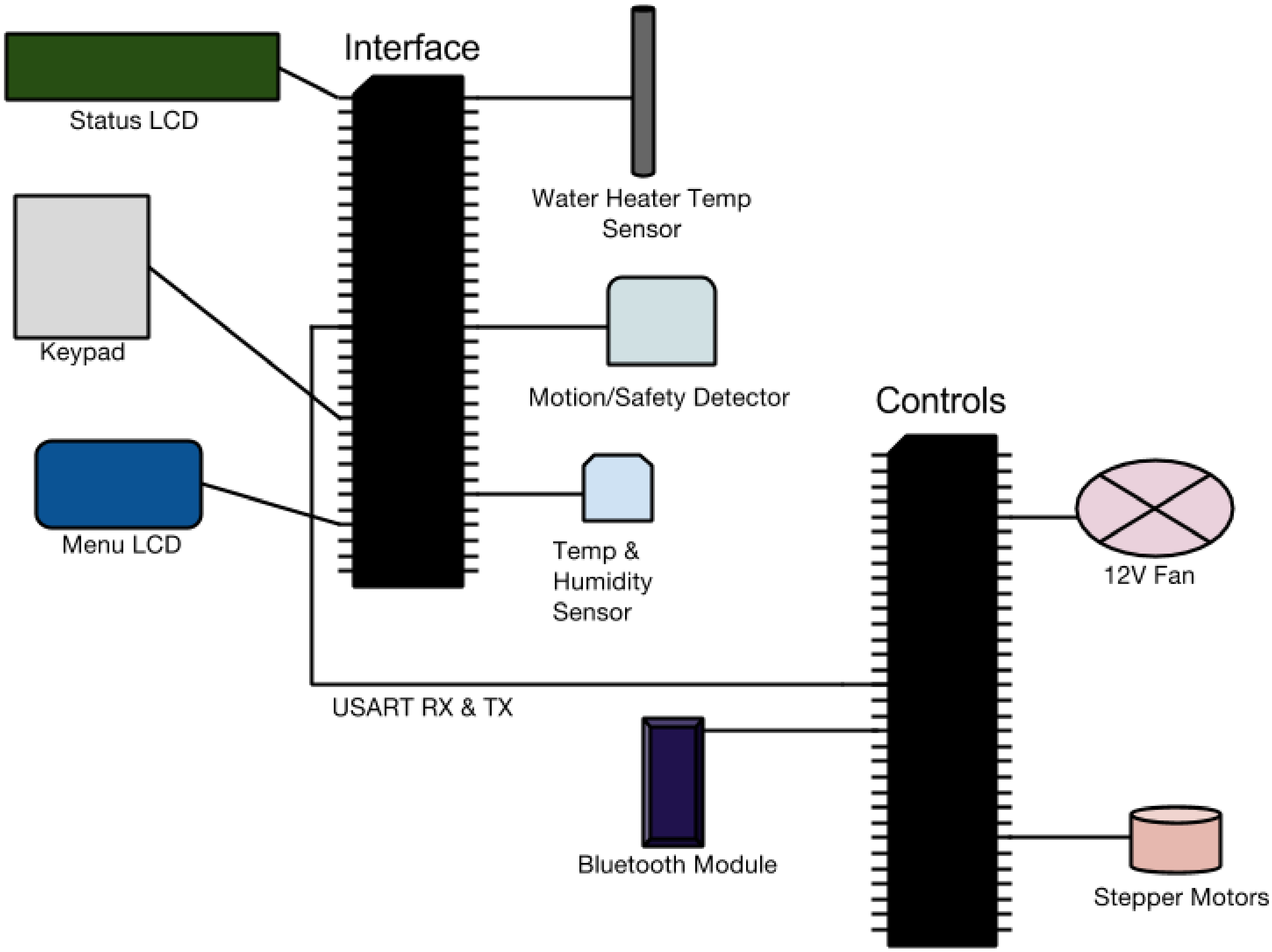

Figure 2: The schematic of the IAS.

Note that most components connected to the ATmega1284 microcontrollers will require more than one pin, with some taking up to an entire port (8 pins.) The Bluetooth module will serve as the connection between the Android application and the control system through USART. Both microcontrollers will be powered on 5V.

The IAS senior design team currently only has a prototype for the closet dryer, so the focus is placed on this appliance in particular. **Figure 3** describes the wiring and placement for the controls of the system:

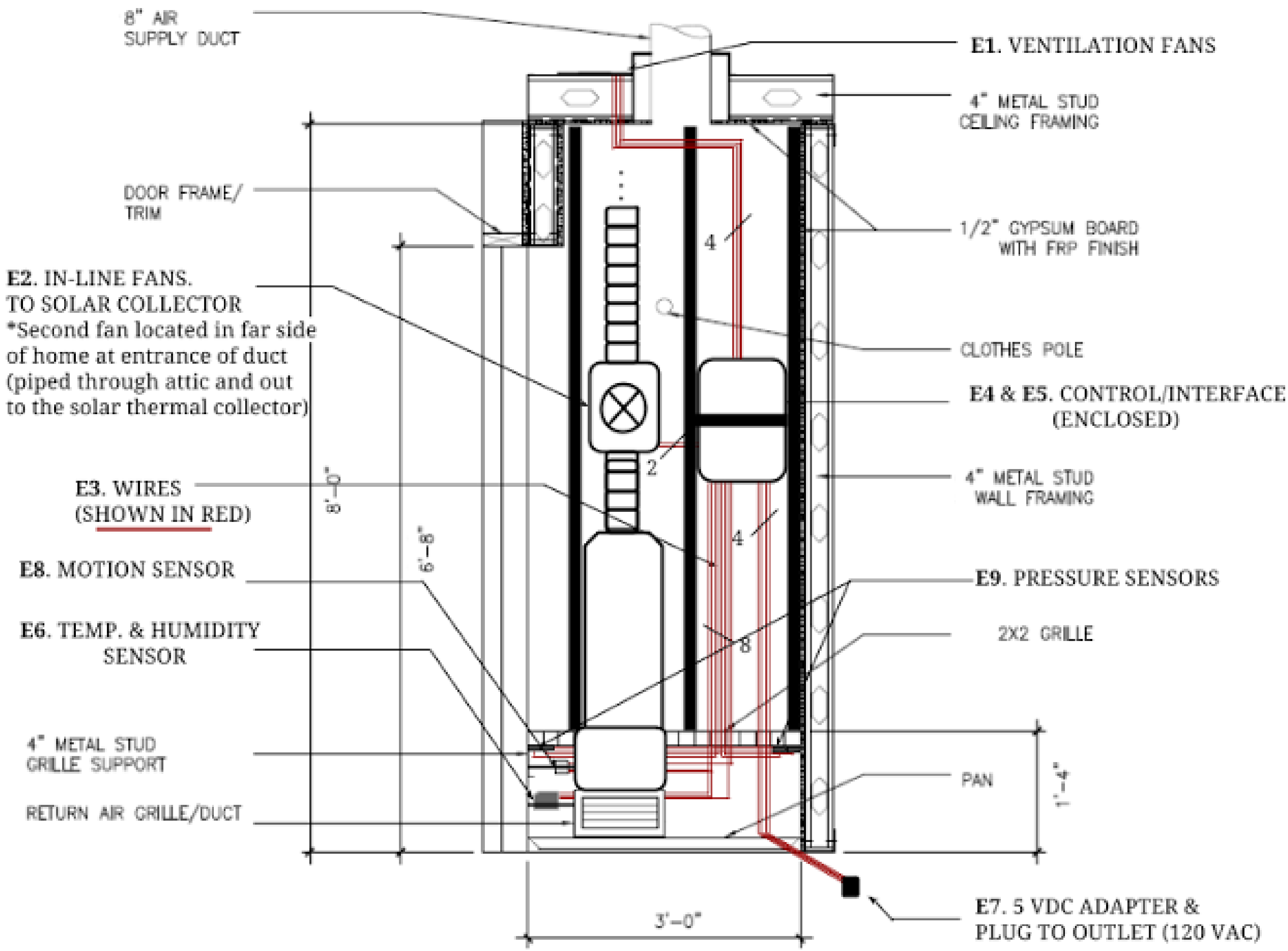

Figure 3: The Side view of the Closet Dryer.

The plan intends for the microcontrollers to be enclosed and protected from the environment, leaving only wiring and the sensors/motors outside. The figure illustrates how the closet dryer works: the inline fans,with variable speed based on the current inside temperature, will draw in heated air from a solar collector (not picture,) into the closet. From this, the ‘Air Supply Duct’ will allow for vents leading into the home to essentially function as the space heater. Although this is simulated, it shows the robust functionality of the IAS, as the vents may also allow for integration for the water heater and A/C as well.