Water Cooler Buddy

Development of an Intelligent Energy Saving Solution for Water Dispensers

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Background/Purpose

Since water dispensers consume energy 24 hours a day, it is important to keep track and reduce its power consumption. One method in solving this is prioritizing when to actually draw power from the systems functionalities. Water Cooler Buddy (WCB) is an internet of things (IOT) device implemented with limited edge intelligence and enabled to be controlled through wifi. The device is designed with an array of sensors in order to track user behavioral patterns and weigh the effectiveness of each sensor type on tracking said behavior.

Key Functionalities

The WCB meets the essential requirements of regulating water temperature and dispensing water, required of any water cooling unit. Furthermore, the WCB is built with the following additional functionalities:

1) Active power consumption monitoring
2) Active temperature monitoring of hot and cold water reservoirs and dispensed water temperature
3) Active power control through different power-saving operating modes
4) Active local motion sensing to determine WCB operational mode
5) Temperature hysteresis control of hot and cold water reservoir temperatures
6) Active water mixing for dispensing at a user-specified temperature
7) Connect to wifi for MQTT server connection
8) Connect to MQTT server and publish operational data
9) User interface (UI) able to:
   i. Allow user to set dispensed temperature
   ii. Indicate water dispensing temperature range available to user
   iii. Indicate WCB current power state
   iv. Actively indicate whether WCB experiences issues with wifi connectivity, MQTT server connectivity, or system crashes.

External Hardware Design

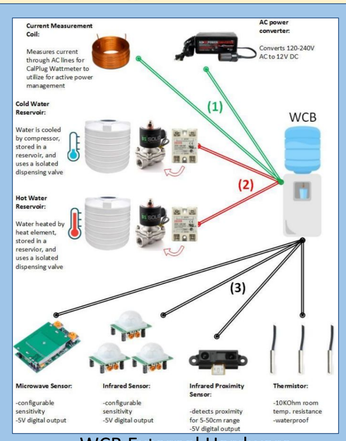
-ESP 32 for processing and communication of data

-ATMEGA 168 for high speed temperature readings

- Motion sensors for calibrating power mode and detecting users

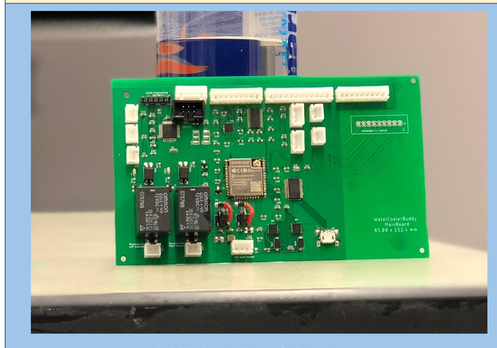
-Relays to control temperature and offset

-Internet connectivity for sending data to MQTT server



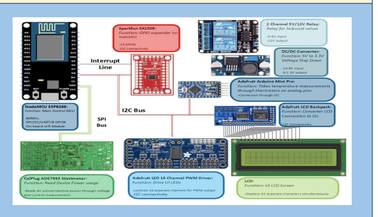
WCB External Hardware Component Diagram

Hardware Design



WCB MainBoard Circuit

The WCB printed circuit board is designed to create a compact smart solution to preexisting water coolers. The main board shown above processes and accepts all connections from sensor peripherals and the external hardware of the water cooler system.



WCB utilizes a PB which controls two solid state relays and two solenoid valves. The PB acts as the essential control unit of the device. It was constructed by hand, using a combination of breakout boards and power units wired together with additional resistor networks, buttons, and fly back diodes for power spike protection.

Application/Software Design

WCB is designed with software that actively regulates the temperatures of hot and cold reservoirs. While normal water coolers choose the set points that the reservoirs are held at, WCB is unique in that it will actively adjusts reservoir temperature based on the frequency of use. MQTT connectivity allows for WCB to log its behavioral-determined data to allow for an outside controller to control when WCB saves energy. Water temperature self-regulation is primarily controlled by two variables, which are used to set the reservoirs to the temperatures they are supposed to oscillate at. After a certain amount of time in low-power mode, WCB modifies the temperature by the same increment the user is able to modify the temperature

```
// function uses the encoder position val
// temperatures currently unavailable and
// can dispense at lower/higher temperatu
void trackEncoderTurn(int temp, int val)
{
  if(temp==HOT)
  {
    if(hotTempSet<165)
    {
      hotTempSet = hotTempSet + val;
      adjustingTemp = 2;
    }
  }

  else if(temp==COLD)
  {
    if(coldTempSet>=40)
    {
      coldTempSet = coldTempSet - val;
      adjustingTemp = 1;
    }
  }
}
```

Self Regulation pseudo-code

When using the rotary encoder, the user can continue rotating the encoder past the maximum cold and hot temperatures to make the light indicators flash. If this happens, WCB modifies the heater or cooler and begins to change the temperature of its reservoirs to suit the user needs.

Future Impact

With the development of the WCB, a part of household's electricity consumption will be monitored and greatly reduced. The users will discover that their water drinking habit is altered due to the additional functionalities. The WCB is only one house appliance, but with further developments, other appliances can be connected to the same network, operate concurrently and share information that can conserve even more energy. Therefore the WCB is a stepping stone to smarter and more energy efficient solution to existing products.

Acknowledgements

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