Condensation Controller

The 4-Winds Condensation Controller

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Document revisions:

0/ Original published on January 12, 2020

1/ Revised on February 8, 2020 to describe changes to the sketch:

a) Add acknowledgements.
b) Add a webpage to update the minimum and maximum variables using the HTML post method.
c) Update the look of the Index or report webpage and move its definition from the sketch to SPIFFS.
d) Add a function to update values in the HTML file before using the stream method to deliver the pages to the client.
e) Add ATO code.

Acknowledgements:

Thanks to:

a) Stensat Org for the following lesson that handles requests from a served webpage for its supporting files. Stensat has also included an excellent lesson at:
   a. http://www.stensat.org/docs/sys395/16_simple_webserver.pdf
b) arduino-esp8266.readthedocs for instructions on using the file system and the Over The Air code at:
   a. https://arduino-esp8266.readthedocs.io/en/latest/ota_updates/readme.html
c) Adafruit for the DHT ESP 8266 web server at:
   a. https://learn.adafruit.com/esp8266-temperature-slash-humidity-webserver/code

Abstract:

The 4-Winds Condensation Controller was initiated to curb moisture problems experienced while storing an RV in humid conditions. The device uses a DHT-22 sensor with an ESP8266 to control a ceramic heater and provides a short web-based status report when requested.

RV owners use a range of strategies to defeat condensation including; absorbent materials, 120vac incandescent lights, low wattage electric heaters, circulating fans, dehumidifiers, and

ceramic heaters. Individual circumstance and preference dictate the choice for individual owners and the following project is not the preferred solution for everyone.

Observations:

Condensation occurs at the dew point, when warm air cools and loses its ability to hold moisture. Conversely, when cool air warms, its ability to hold water vapor increases and the relative humidity drops. Keeping the air above the dew point then, prevents water vapor from condensing.

Using a small ceramic heater to keep the interior temperature above the dewpoint works well when the ambient temperature is consistent. As weather conditions change the demand on the heater changes and the simple bimetal rheostat controlling the heater will not maintain a consistent temperature inside the RV.

If, for example: The overnight ambient temperature is 5° C, and; the rheostat is set to keep the interior temperature at 10° C, then; when the daytime temperature warms to 10° C; the interior temperature of the RV may climb as high as 16° C.

Conversely: If the daytime ambient temperature is 5° C, and; the rheostat is set to keep the interior temperature at 10° C, then; when the overnight temperature drops to -5° C; the interior temperature of the RV may fall as low as 0° C.

Also, if the storage is short term, a minimum temperature might be desired to keep contents above freezing. At the same time, the rheostat does not measure or respond to the rising and falling of the interior dew point.

Project Goals:

1. Create a controller that acts as a simple and effective thermostat/humidistat combination,
2. Provide a method for remote monitoring, and;
3. Determine if a small ceramic heater has the capacity required to work well with the controller.

Solution:

Use A microcontroller with WiFi or Cellular Data capability to provide a means for remote monitoring and a temperature/humidity sensor to provide the data needed for thermostatic control. Then use the temperature and humidity data to calculate the dew point and create the humidistatic control.

Calculating an accurate dew point for humidity values below 50-percent requires an involved calculation. However, as the dew point occurs at 100-percent relative humidity, this project can use a simpler equation. Michael Bell writes[1]:

> *If you are interested in a simpler calculation that gives an approximation of dew point temperature if you know the observed temperature and relative humidity, the following formula was proposed in a 2005 article by Mark G. Lawrence in the Bulletin of the American Meteorological Society:*
>
> *Td = T - ((100 - RH)/5.)*
>
> *where Td is dew point temperature (in degrees Celsius), T is observed temperature (in degrees Celsius), and RH is relative humidity (in percent). Apparently, this relationship is fairly accurate for relative humidity values above 50%.*
>
> *More details can be found in the article:*
>
> *Lawrence, Mark G., 2005: The relationship between relative humidity and the dewpoint temperature in moist air: A simple conversion and applications. Bull. Amer. Meteor. Soc.,* ***86****, 225-233. doi: http;//dx.doi.org/10.1175/BAMS-86-2-225*

Once the logic is determined, physical switching of the 110vdc heater is handled with a 110 vdc relay or 110 vdc power tail.

Experiment:

The “4-Winds Condensation Controller” uses:

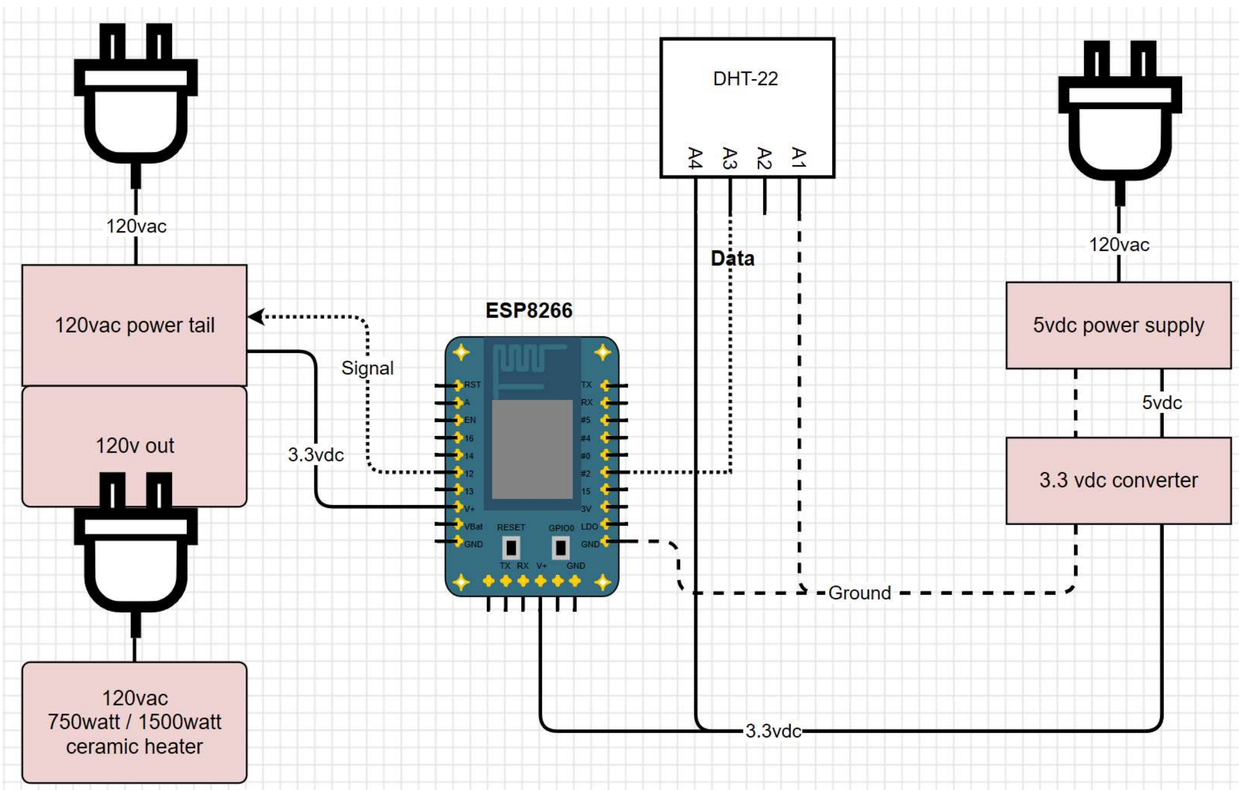
1. An adafruit HUZZAH ESP8266 breakout board,
2. A DHT-22 temperature and humidity sensor,
3. A Power Switch Tail II,
4. A 5vdc 1-amp power supply,
5. A Pololu 3.3V Step-Up/Step-Down Voltage Regulator S7V8F3, and;

[1] https://iridl.ldeo.columbia.edu/dochelp/QA/Basic/dewpoint.html

6. a 110vac 750watt/1500watt manually switched ceramic heater.

The generic 5vdc power supply was selected for price and availability. The voltage regulator ensures the required voltage and would, in this case, still be used with a 3vdc power supply.

The 3.3-vdc positive lead from the regulator is connected the power-in pin of the ESP8266 with a female end jumper wire to ensure the regulator's power is removed before flashing the chip.



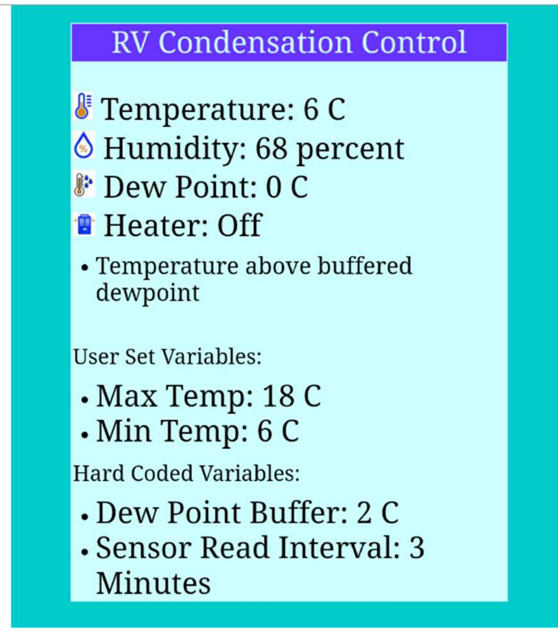
Project Schematic – made with Digi-Key's Scheme-It

The 120-vac power-tail is operated with an input signal voltage within the range of 3vdc to 12vdc. The sketch for the ESP8266 defines pin-12 as output. The signal from pin-12 is connected to the negative terminal of the power tail and the 3+ pin is attached to the power tail's positive terminal.

Observations:

During test-assembly it was noted that; the HUZZAH breakout board is quite robust and will run on 5vdc. At that input voltage the pinout low voltage was high enough to pull the relays in the power tail closed resulting in an always on condition. At 3.3vdc in the pinout low voltage was approximately 1.8vdc, allowing the power tail to switch properly.

Testing Particulars	
Item	**Value**
Test RV volume	1200 cubic feet
Maximum Temperature	18° C
Minimum Temperature	10° C
Dew Point Buffer	2° C
Sensing Interval	3-minutes
Heater Wattage 1	750-watts
Heater Wattage 2	1500-watts



Testing occurred over a period of several weeks and was monitored with the web page shown above right. Variables were adjusted withing the limits displayed in the image on the bottom left, above. Limits are set as a property of the HTML form object.

The sensing interval is set in milliseconds and displayed in minutes. The values of the variables are arbitrary and used for experimentation. The Max/Min Temp and Dew Point Buffer variables are used by the heater logic routine that works as follows:

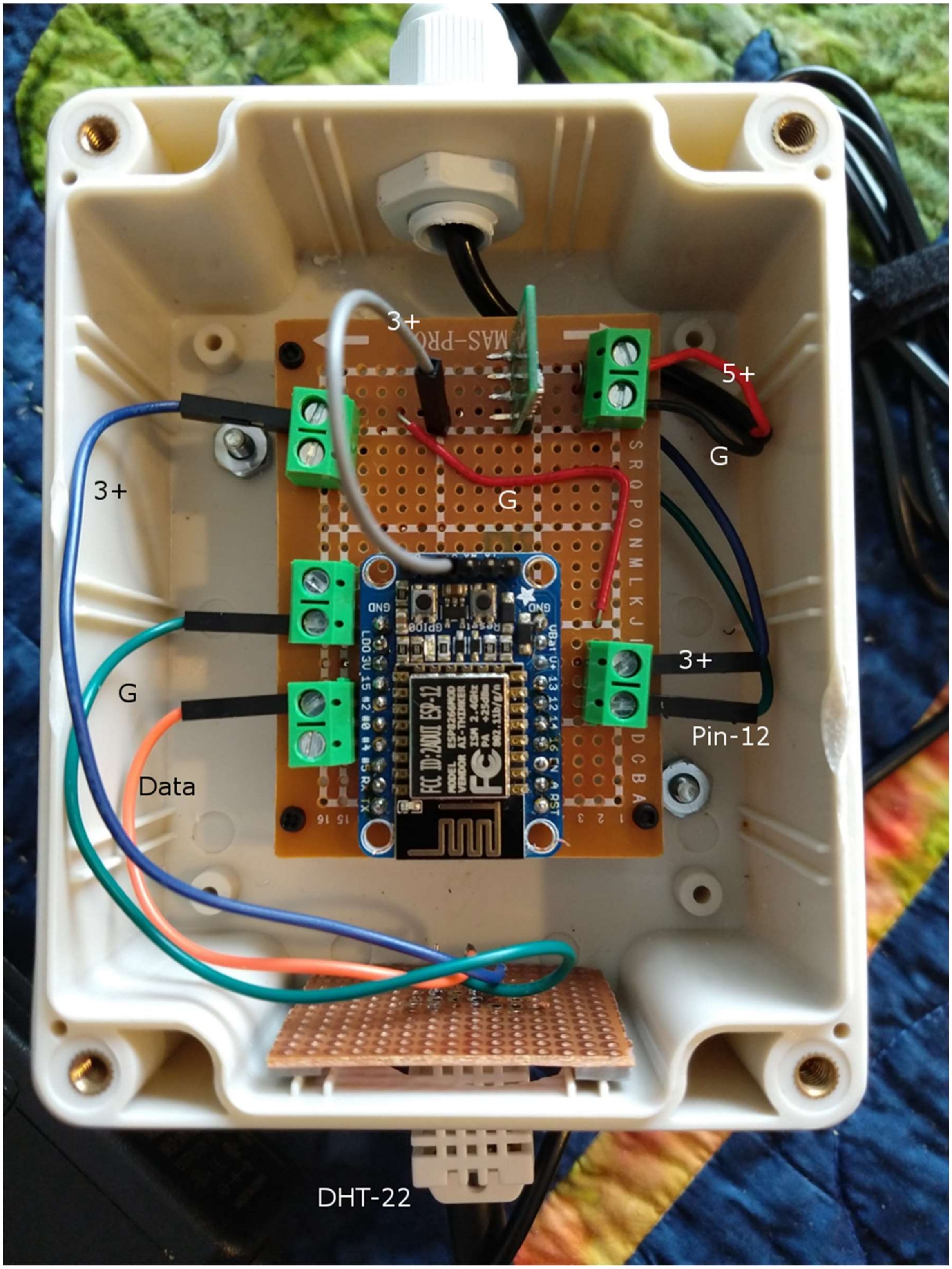
1. If the temperature falls below the minimum, turn the heater on and exit the routine, otherwise,
2. If the temperature is above (the dewpoint + the dewpoint buffer), turn the heater off and exit the routine, otherwise,
3. If the temperature is below (the dewpoint + the dewpoint buffer), turn the heater on and exit the routine, otherwise,
4. If the temperature is above the maximum, turn the heater off and exit the routine.

During the test period, daytime highs ranged from -3º C up to 12º C while nighttime lows ranged from -7º C up to 9º C.

At an ambient temperature of -6º C the ceramic heater could maintain an interior temperature of 3º C while set on 750-watts output. At the same ambient temperature, on the output setting of 1500-watts, the heater could maintain the minimum allowed interior temperature of 10º C. In both cases, the heater kept the interior well above the dewpoint temperature.

Conclusions:

The heater works sufficiently well for the local climate when set to 1500 watts. The heater logic routine worked for all weather conditions occuring during the test period. The webpage status report and variables page are fit for purpose.



The project components mounted in a box

Power Tail bolted to the back of the project box