

From: Robert Lieb

To: Christoph Gorder, Robin Cho --Charity Water

David Laone – Mindinspire Inc.

CC: Gianfranco Bonanome, Hilary Farnsworth, Bob Wild

IPS

Date: Aug 2, 2017

Subject: Temperature Analysis on Water Detection Algorithm

On yesterday’s conference call, we discussed findings from David that when the unit was operated in the hot sun (approx. 90 degree F) that he saw innacuracies in the measurement data.

Today to help recreate the failure, I ran an experiment using a Thermocoupler to measure the air temperature inside the housing near where the capacitive sensors reside, and a heat gun to raise the ambient temperature at the pads. With the temperature changes, I was able to see an increase in “unknown” measurements that increased in frequency as the temperature approached 49C (120F). When the temperature returned to room temerature 26C (78F), the occurrence of “unknowns” decreased.

An “unknown” measurement is an instance when one or more pads report “water” above pads that report “air”. “unknown” measurements may cause an inaccurate water flow calculation depending on which algorithm we use for determining the highest water level.

Looking at the Water Detection Algorithm, I see an explanation of why the problem is occurring.

I observed in the data that **the capacitance value measured by the ADC went down at higher temperatures**. The lower value could result in a false “water” detection should the measured data go below the “midpoint”. This would account for problems reported to us with the first version of the software where “it worked better in the factory than in the field”.

The Water Detection Algorithm is based on measuring accurate “air” and “water” target values where the location of a current ADC value determines whether the pad is covered with water and what percantage of the pad is covered with water. In the experiments today, I measured that the Target Range between “air” and “water” was growing as the air temperature increased.

The following chart shows the width of the target range and how it changes as the temperature goes from 26C to 53C. The dark blue line shows the temperature of the air within the housing right next to where the pads reside. The other lines show how the target range width changes over temperature changes over time.

What I saw was that the target range grew as the temperature increased, but it did not “contract” back to its original level once the temperature decreases again.

The Water Detection Algorithm uses the range between the air and water targets for each pad to determine the water level over the pad.



Should this range become inaccurate, then the midpoint will shift and the determination of water vs. air could cause a false determination of the pad’s state. Looking at the raw data, the midpoint shifting is the cause of the “unknown”s seen.

The exising unit design (old and new board designs) has a measurement of ambient temperature, but it is measured in the microprocessor

Water Detection Algorithm does not have a way of measuring ambient temperature at the pads within the housing, so the software has no way of knowing whether a capacitance level change is due to the presence of water, or the temperature change that the cooler water would cause at the sensor.