How to Build an Electronic Bee Counter

Turns out you can measure the capacitance of a bee

By Paul Perrault & Mike Teachman
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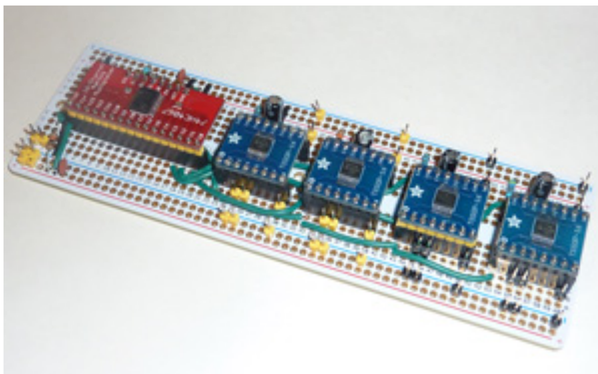
Photo: Mike Teachman

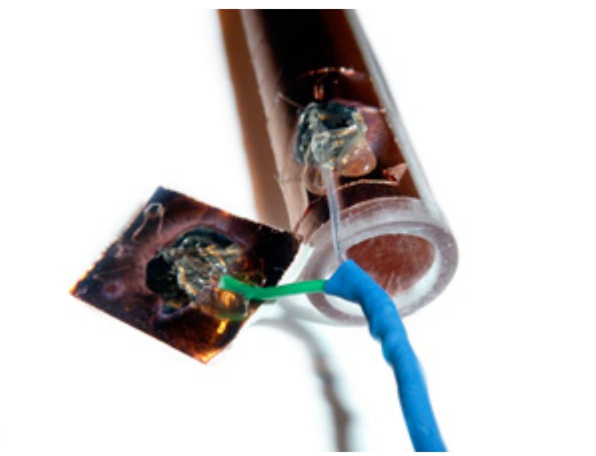
Bees are important: they pollinate dozens of crops, including almonds, cacao, and coffee (https://en. /wiki/List_of_crop_plants_pollinated_by_bees). While there has been a lot of attention paid to Western ho (http://www.ars.usda.gov/News/docs.htm?docid=15572), this specific disease and others like it are reall And in any case, honeybees are not the only important bee pollinators. What we need is the ability to mo

Historically, such monitoring was the purview of undergraduates armed with clipboards. More recently, detection of bees entering and exiting the hive. But placing optical sensors in a habitat of pollen, mud, a effectiveness. What if there was a better way?

A solution suggested itself when the two of us—a field applications engineer for Analog Devices and an
together on a previous project that involved capacitive sensing. Teachman (the bee enthusiast) commen
the sensitivity of the AD7746 (http://www.analog.com/media/en/technical-documentation/data-sheets/AI
conversion chip was better than he had expected, and wondered, "Do you think we could measure bees
capacitance between two electrodes depends on the dielectric constant of the substance between them.
while water comes in at around 80. As living cells are mostly water, a bee should have a detectable diel
developed a custom sensor setup to measure just that.

Bee Aware





We concentrated on Mason bees (http://www.fs.fed.us/wi
month/mason_bees.shtml), which are important pollinat
honeybees, these bees are solitary types: Every female w
build their nests in tubes, such as a reed or a hollow twi
from the back of the nest, the bee fills the tube with a se
egg is then sealed in, along with food in the form of poll

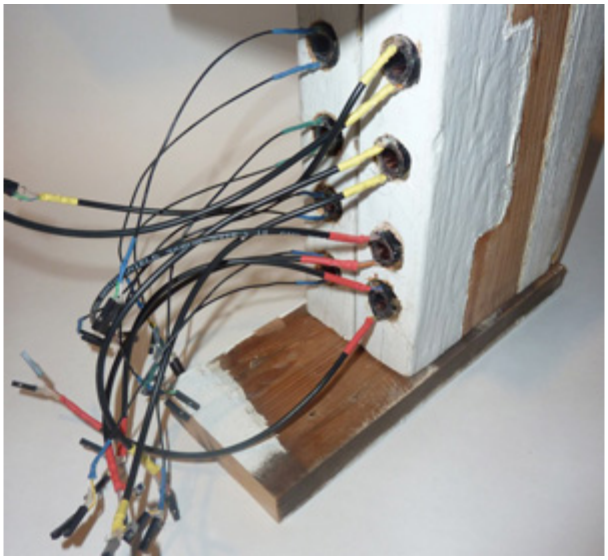
Previously, a group at the University of Prince Edward Is
(http://www.islandscholar.ca/fedora/repository/ir%3Air-b
entrance. But we realized that Mason bees' nesting pref
activity inside their homes, as well as their entrances an
into a capacitive sensor.

We placed two 1.27-centimeter-wide strips of copper tap
diameter acrylic plastic tube and sealed it at one end. W
shielded leads. By instrumenting the entire tube, not jus
bees are within their nests, along with information abou

Using some blocks of wood, we housed eight of these ins
bee cocoons on top of the blocks to ensure that the empt
bees emerged.

One AD7746 chip can handle two channels, so we mount
connected it to an Arduino microcontroller using the I2C
/en/Reference/Wire). We gathered information about loc
pressure by using the Adafruit (https://www.adafruit.com
/products/439), MCP9808 (https://www.adafruit.com/pro
(https://learn.adafruit.com/adafruit-htu21d-f-temperatur
(https://www.adafruit.com/products/1603) sensor boards
I2C. The Arduino logged data and relayed it to an SD me
data via a second, Wi-Fi–enabled Arduino to SparkFun's
The total cost of the electronics was around US $200.

Converting the raw capacitance data into meaningful inf
challenge. For starters, over the course of 24 hours ther
of the nests due to temperature and humidity shifts. Rat
these shifts on the baseline from our separate temperat
blocked the entrance of one of the eight tubes to preven
baseline variations seen in the empty tube from the sign
video of the tubes and time-aligned it with the logged ca



Photos: Mike Teachman (4)

We wired up four AD7746 chips [top] to strips of foil [second from top] in eight Mason bee nests [second from bottom], allowing us to gather data about the bees inside [bottom].

This allowed us to be sure we were recognizing entrance

As the bee brings material into the nest to build cells, it
capacitance of the cell. Although we've only just begun d
possible to determine not just the volume of material add
of material involved (mud, eggs, pollen, and so on). As th
causes fluctuations in the capacitance. Together, this allo
outside the nest, how active they are when they return, a
day or other alterations in local conditions.

Through more rigorous analysis—perhaps by employing
produced over the course of a year—it should be possibl
producing and the general health of the colony, and to be
important pollinators. During the next growing season, v
see if it can be extended to other types of bees.

This article originally appeared in print as "Bee Counter