RFID Reader Detector and Tilt-Sensitive RFID Tag

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Intro: RFID Reader Detector and Tilt-Sensitive RFID Tag

Want to detect the presence of RFID readers? Want to control when a RFID tag is active or readable? We describe how to do both using bits of copper and card, and some readily available electronics hardware.

Longer preamble

Radio frequency identification (RFID) is rapidly growing in popularity. RFID *tags* are found everywhere. They're attached to container freight, in those funny-looking white labels you find in newly purchased books, embedded in many corporate ID cards and passports, etc. The tags have a few common properties: they transmit a unique ID number, are optimized to be 'read' from predefined distances, and are usually small so they can remain unobtrusive or hidden.

RFID *readers* are used to track nearby tags by wirelessly reading a tag's unique ID (see Figure 4); a tag simply has to be brought into physical proximity with a reader to be read. Readers are mostly used for industrial or commercial purposes, e.g. asset tracking or electronic payment. Wal-mart use RFID tags and readers in their supply chain. The technology is also used in mass transit systems in cities like London and Hong Kong. In Japan, many mobile phones incorporate readers to enable e-money payments in shops and vending machines.

For those of us who want to experiment with RFID, the problem is that the technology is almost always black boxed. That is, the inner workings of a tag and its interaction with a reader is hidden from view, and thus difficult to have much control over.

In the two exercises that follow (building a RFID reader detector and a tilt-sensitive RFID tag), we offer an example of how you can start revealing some of the workings of RFID and thus gain some control over the technology. The two exercises also hopefully show that the technology is relatively simple and how it can be extended to support some interesting interactions. We offer some other possibilities that build on our examples at the end.

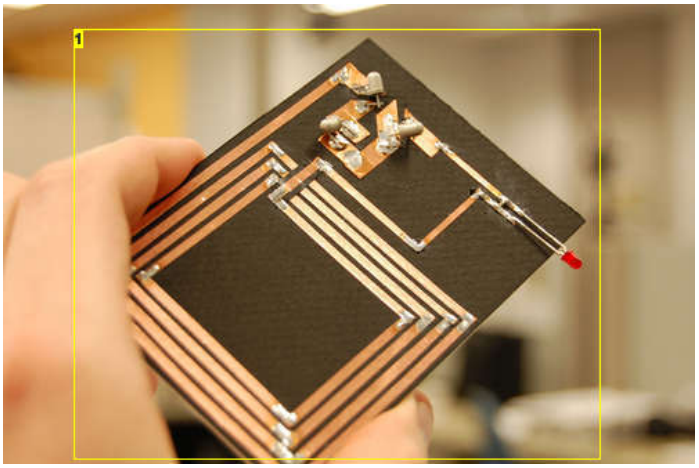

Image Notes
1. Tilt-sensitive RFID tag

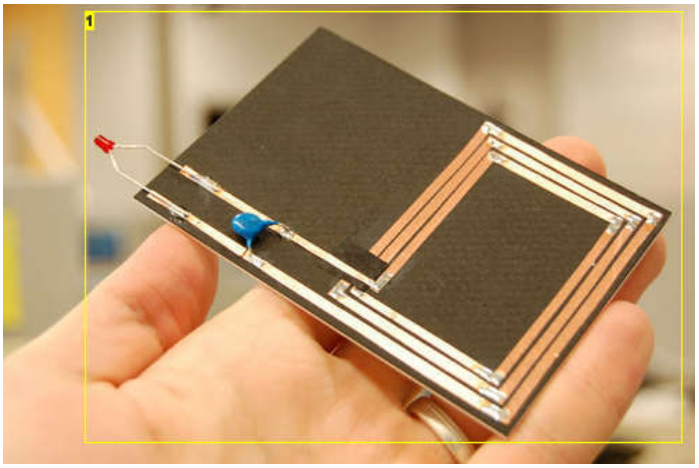

Image Notes
1. Simple RFID reader detector

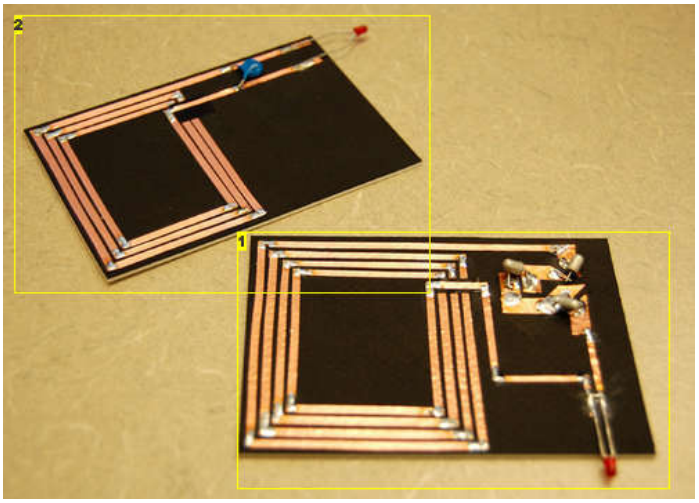

Image Notes
1. Tilt-sensitive RFID tag
2. RFID reader detector

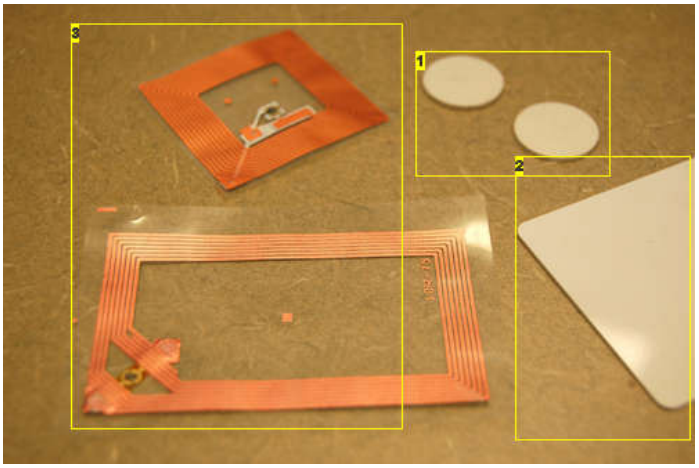

Image Notes
1. Small RFID stickers
2. RFID tag in the form of a credit card
3. Inside of RFID tags: antenna and connected chip

Step 1: Material and Tools

This section provides an overview of the necessary materials and tools.

Materials (see Figure 1):
We need the following material to built the basic RFID reader detector.
- Cardboard (around 100x70 mm)
- Conductive copper tape (e.g., order number 1218478 at www.farnell.com)
- Capacitor 82 pF (picofarad) (e.g., order number 1138852 at www.farnell.com)
- Low current LED (light-emitting diode) (e.g., order number 1003207at www.farnell.com)

Tools (see Figure 2 and 3):
- Craft knife and scissors
- Insulating tape (e.g., order number 1373979 at www.farnell.com)
- Soldering iron and solder

RFID reader for testing (see Figure 4):
To test our RFID tags we need an RFID reader that can operate at a frequency of 13.56 MHz.
There many readers for this widely used RFID standard, for instance the Sonmicro MIFARE USB reader (http://www.sonmicro.com/).
Note: The Phidget RFID reader does *not* work with the tags created in this project, as it uses a different frequency for communication with the tags (125 kHz).

Advanced material (see Figure 5):
The following material is necessary to build the second part of the project: the tilt-sensitive RFID tag.
- Micro tilt switches (e.g., www.digikey.com)
- RFID ICs (e.g., MIFARE Standard 1k, part no. 568-2219-1-ND at www.digikey.com)

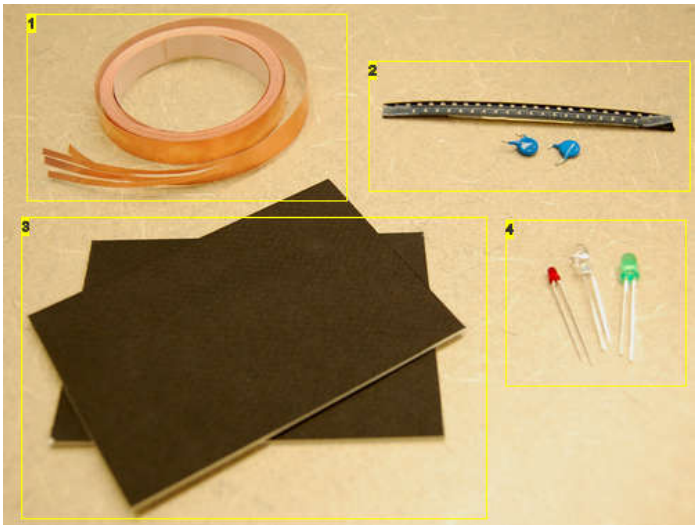

Image Notes
1. Conductive copper tape
2. Capacitors (e.g., SMD) 82pF
3. Cardboard, around 100x70 mm
4. LED (light-emitting diode)

Image Notes
1. Insulation tape

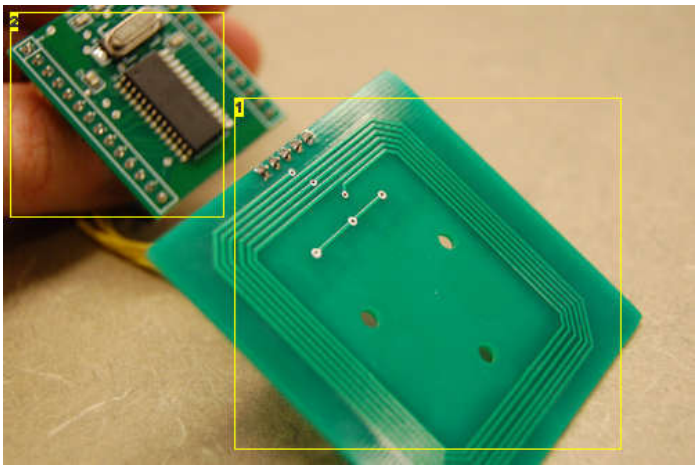

Image Notes
1. Antenna of the Sonmicro RFID reader
2. Sonmicro 13.56 MHz RFID Module

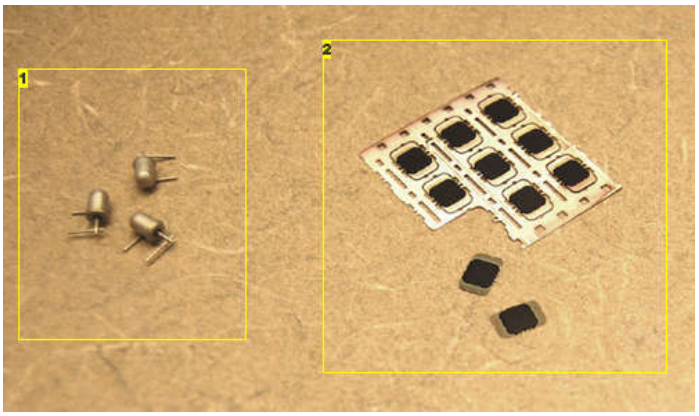

Image Notes
1. Micro tilt switches
2. RFID ICs (MIFARE Standard 1k)

Step 2: Building the RFID Antenna

This step describes how to build the antenna for the RFID tag.

Building the RFID tag antenna
To build the tag's antenna follow these three steps.
1. Cut the conductive copper tape into thin stripes of around 2mm (see Figure 1).
2. Tape these stripes (see Figure 2) in loops around one half of the cardboard (see Figure 3 for the layout of the antenna). The tag should have between 3-4 loops for the antenna.
3. Solder all the connections between the copper tape. Sometimes, this isn't necessary as the tape's adhesive backing is conductive, but solder the connections if you want to be on the safe side.

Now we have created our RFID tag antenna, and we will add the "RFID reader detection" functionality in the following step.

A little background
RFID readers transmit an electromagnetic (EM) field with their reader antenna. This EM field induces a current in the antenna for all RFID tags within reading distance. This induced current activates the RFID chip that is connected to the tag's antenna. This chip then modulates a response (usually the unique ID number) that is transmitted back to the reader. The antenna of an RFID tag is usually a thin copper wire that is arranged in loops. The loops allow the emitted EM field of the RFID reader to induce current to the antenna of the tag.

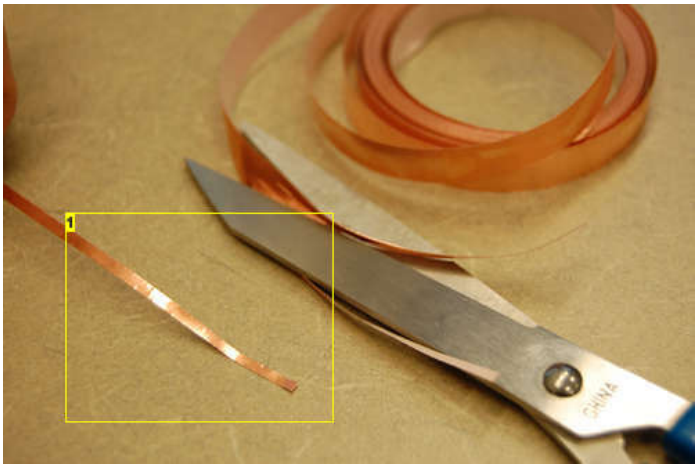

Image Notes
1. Thin stripes of the conductive copper tape (around 2 mm thick)

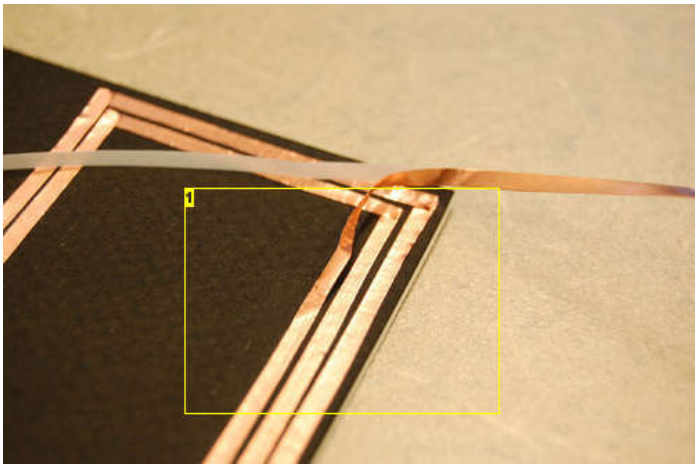

Image Notes
1. Taping the copper stripes onto the cardboard

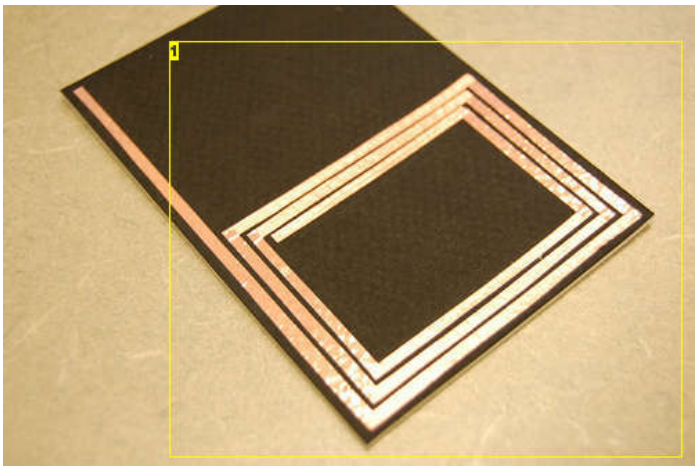

Image Notes
1. Three loops of the antenna

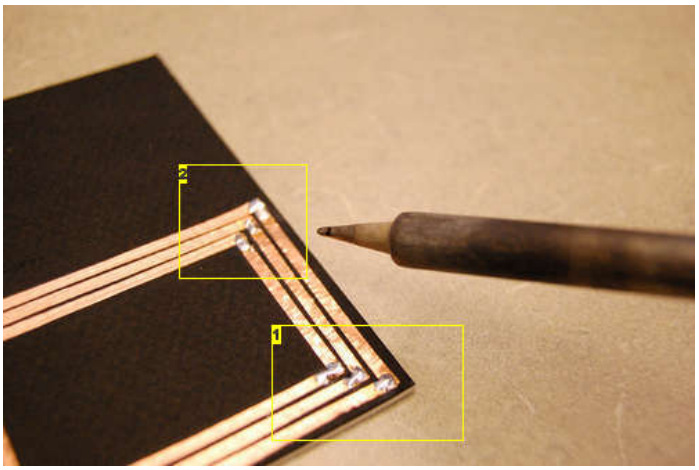

Image Notes
1. Soldering the copper tape connections
2. Soldering the copper tape connections

Step 3: RFID Reader Detection

This step describes how to add a simple mechanism to the RFID tag antenna that allows us detect nearby RFID readers.

Antenna connection
First, we add a small piece of insulation tape for the connection of the inner end of the antenna loop (as illustrated in Figure 1). This is to insulate the outer loops. Then we add another copper tape strip to the inner end of the antenna as shown in Figure 2. Here again we solder the two ends of the conductive copper tape together.

Capacitor and LED
Next, we add the capacitor (82 pF) and the low current LED to the tag as shown in Figure 3. They are connected in parallel. We also solder these two components to the copper tape (see Figure 4).

Testing
With these simple steps, our RFID reader detector is finished! By bringing our DIY RFID detector close to an RFID reader (as shown in Figure 5), the connected LED lights up. With the Sonmicro reader hardware the distance to the reader has to be below 8-10 cm; however, there are RFID readers available with a stronger EM field and therefore a higher maximum reading distance.

In the next step of the instructable we will show how to extend a basic RFID tag and make it tilt-sensitive.

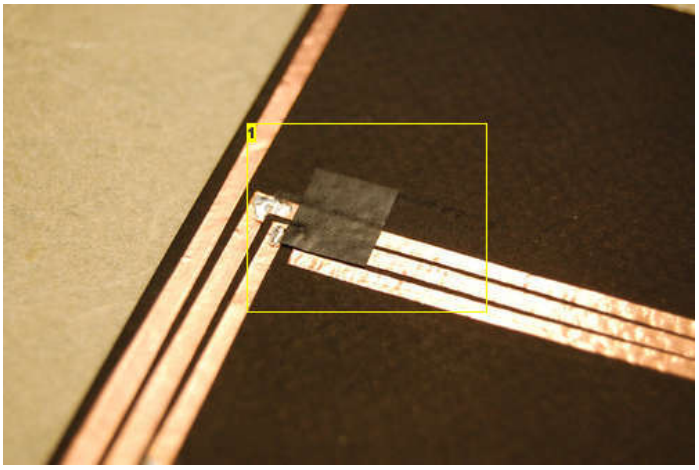

Image Notes
1. Adding insulation tape for the connection

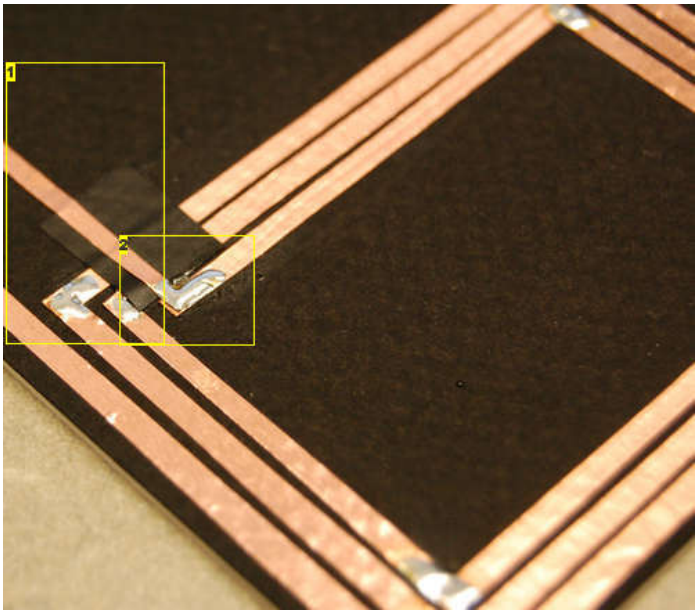

Image Notes
1. Adding connection to the inner end of the antenna loops
2. Soldering connection again

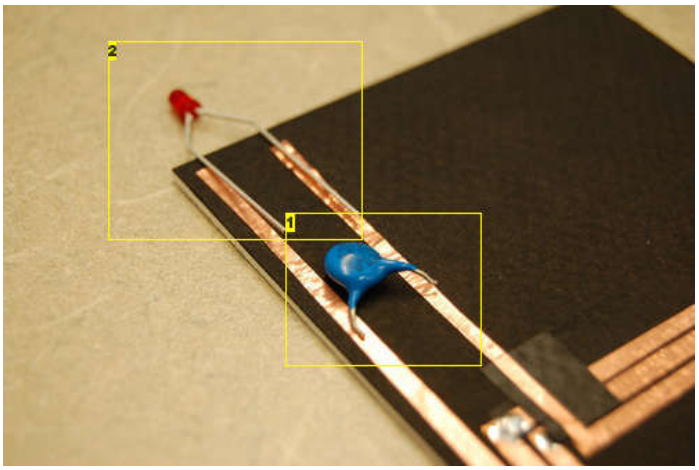

Image Notes
1. 82pF Capacitor
2. Low current LED

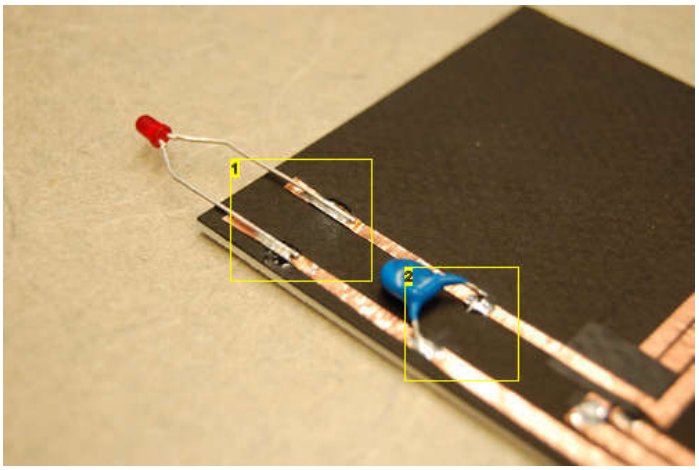

Image Notes
1. Soldering connections
2. Soldering connections

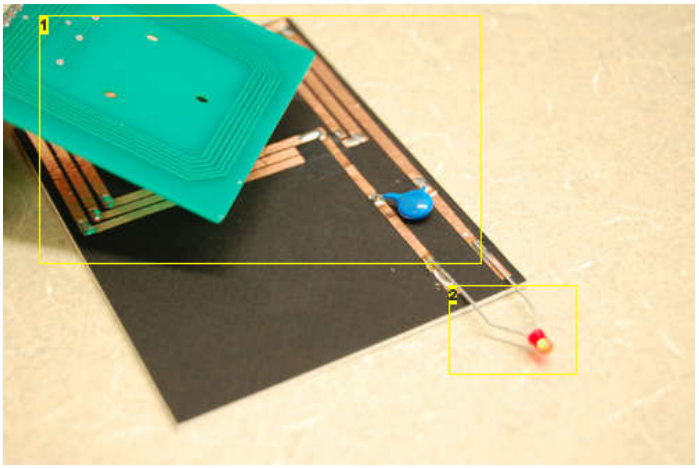

Image Notes
1. RFID reader is near the tag
2. LED lights up

Step 4: Tilt-Sensitive RFID Tag

We now describe the process of how to build a tilt-sensitive RFID tag. This extends the previous exercise.

Antenna
The antenna for this second RFID tag is similar to the first antenna we built. We thus need another piece of cardboard and to repeat the steps described earlier in STEP 2 of this instructable.

Tilt-sensitive tag
Next, we add additional copper tape connections to the tag, as shown in Figure 1. These connections allow us to connect three tilt switches, a capacitor, and the LED to the antenna. Again, all the connections of the copper tape are soldered together.
We add the three tilt switches to the tag as shown in Figure 3. The tilt switches are soldered to the copper tape, and it is important to connect them in a slight angle (around 5-10 degrees) as shown in Figure 4. This makes sure that the silt switches are in a *closed* state while the RFID tag is in a horizontal position, and in a *open* state while the tag is in a vertical position.
Again, we also add an LED and a capacitor to the antenna as shown in Figure 3 (we use a different form factor of the capacitor here just to illustrate the alternative options).

Testing the tilt-sensitive tag
We can now use our Sonmicro RFID reader again to test our new tilt-sensitive RFID tag. The tag is activate while in a horizontal position as in Figure 5, and is inactive when in a vertical position as in Figure 6.

Using RFID chips
We can now replace the connected capacitor and LED from our tag with an RFID chip (e.g., the MIFARE 1k shown in Figure 7). By doing this, the activity of our tag is no longer visible through the LED, but our tag is then readable by the RFID reader and responds with the unique ID number of the chip.

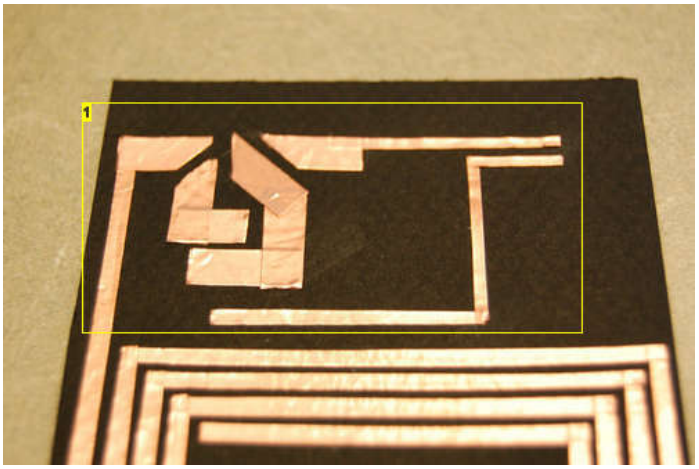

Image Notes
1. Additional copper tape for connecting the tilt switches, the capacitor, and the LED with the antenna.

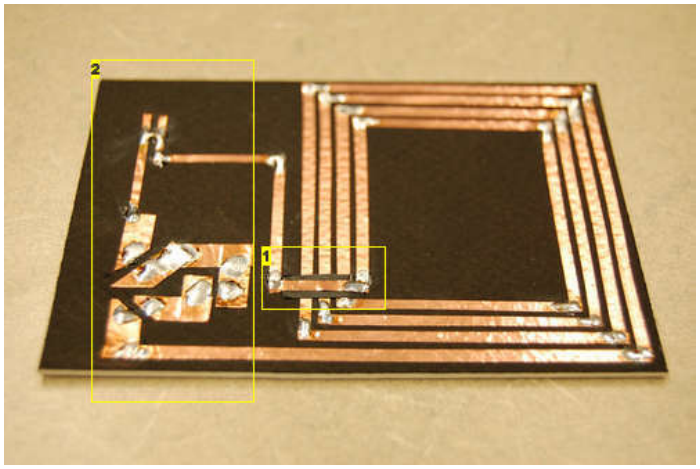

Image Notes
1. Again we use insulation tape for the connection
2. Soldering all copper tape connections

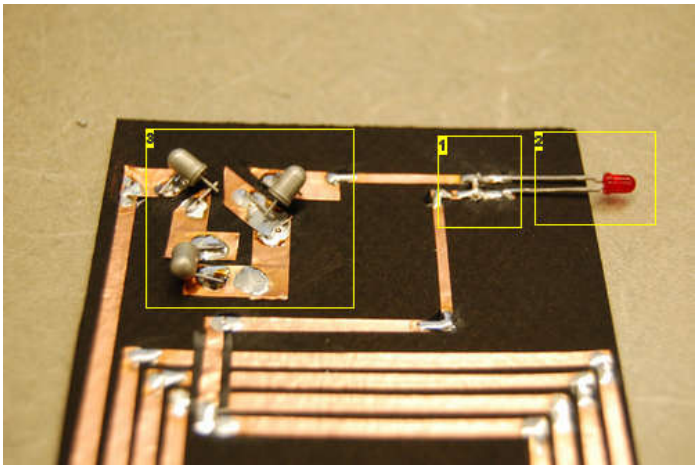

Image Notes
1. SMD capacitor (82 pF)
2. Again a connected low current LED
3. This arrangement of the tilt sensors makes is possible to sense the horizontal or vertical position of the tag.

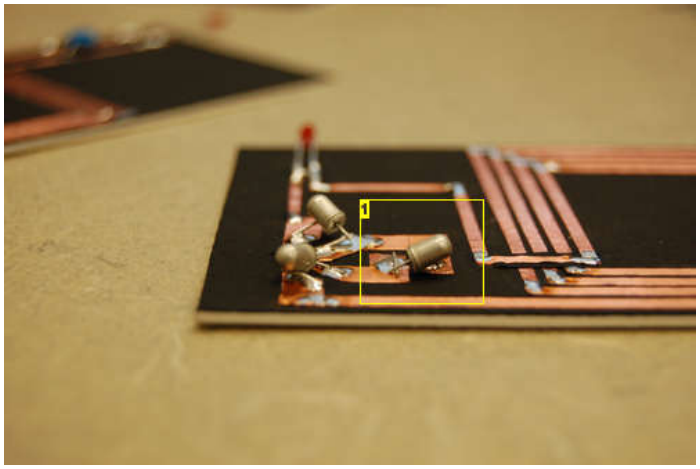

Image Notes
1. The angle of the tilt sensors is important

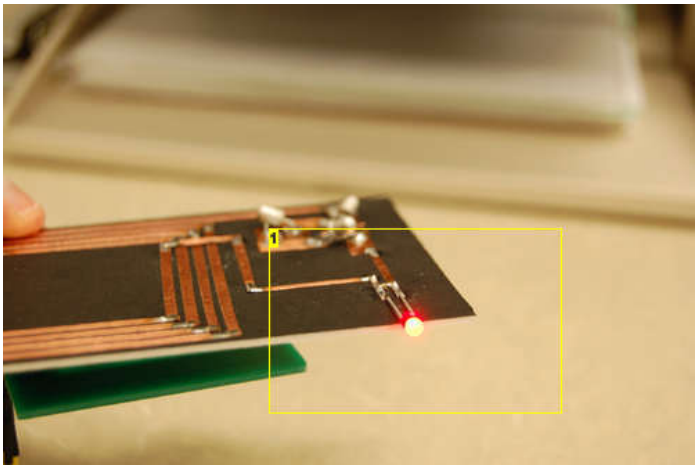

Image Notes
1. The tag is activated when it is in a horizontal position

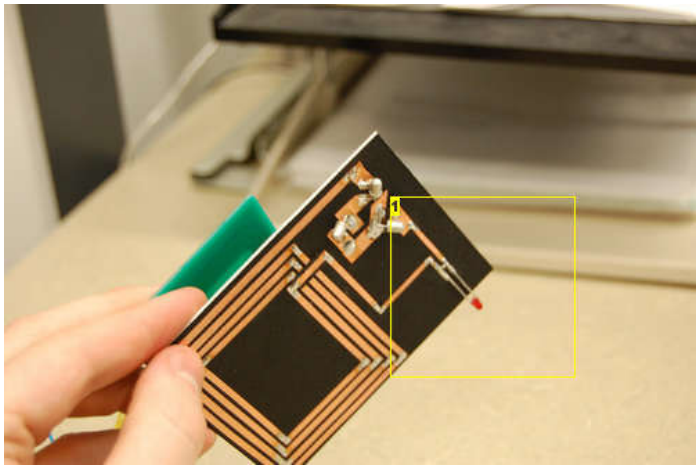

Image Notes
1. As long as the tag is in a vertical position, the tag is inactive

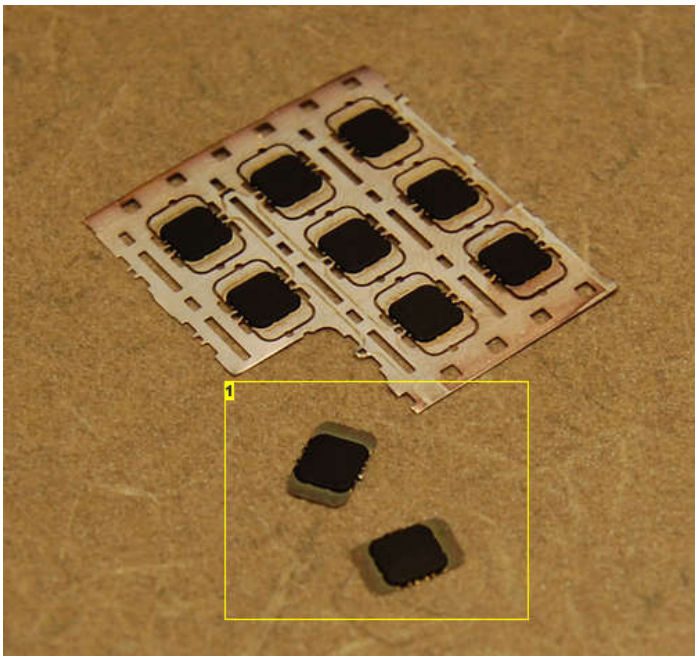

Image Notes
1. Using the MIFARE RFID chips to create a tilt-sensitive RFID tag

Step 5: Variations

This section concludes our *instructable* of how to build custom RFID tags. Here are a few additional tags to show the possible variations.

- Variable length of the tag antenna, and therefore also variable reading distance of the tag (Figure 1).
- Experiments with the tag size and material (Figure 2)
- Switching between the LED and an RFID chip (Figure 3)
- Light-sensitive tag: the tag is active in daylight, and inactive in darkness (Figure 4)
- Touch-sensitive: tag is active when someone touches the tag with a finger (Figure 5)
- Different material for antenna by using conductive silver ink (Figure 6)
- Stamped layout of an RFID tag antenna (Figure 7) that is in fact working!

Many other variations of RFID tags are feasible... Happy DIY!

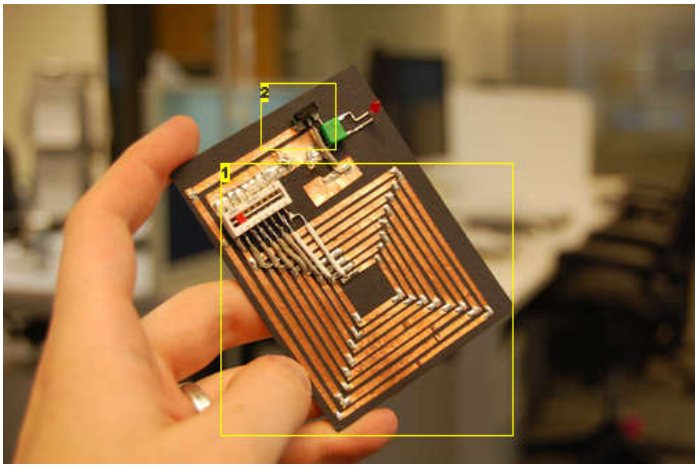

Image Notes
1. Variable length (and loops) of the antenna
2. Switch to activate and deactivate the RFID IC

Image Notes
1. Experiments with form factors for the RFID tags

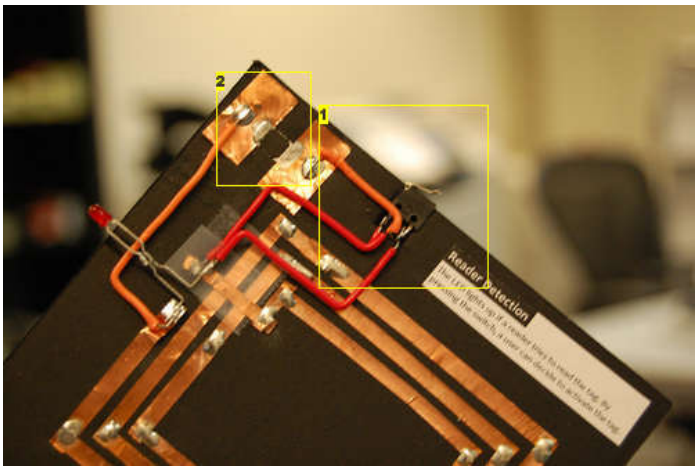

Image Notes
1. Button to switch between LED reader detection and the RFID tag
2. RFID chip MIFARE 1k

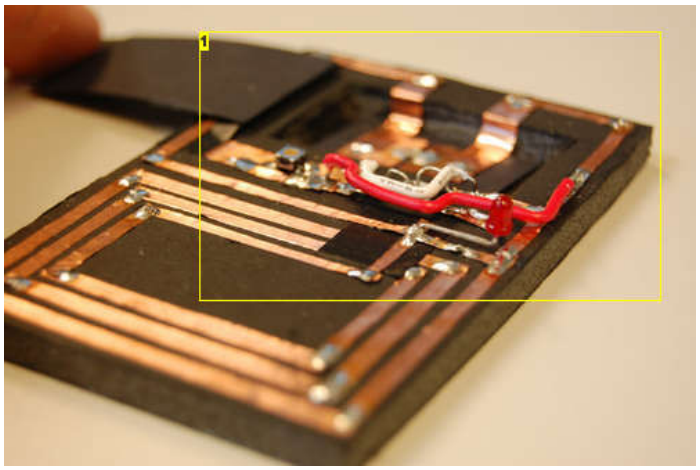

Image Notes
1. Light sensitive tag

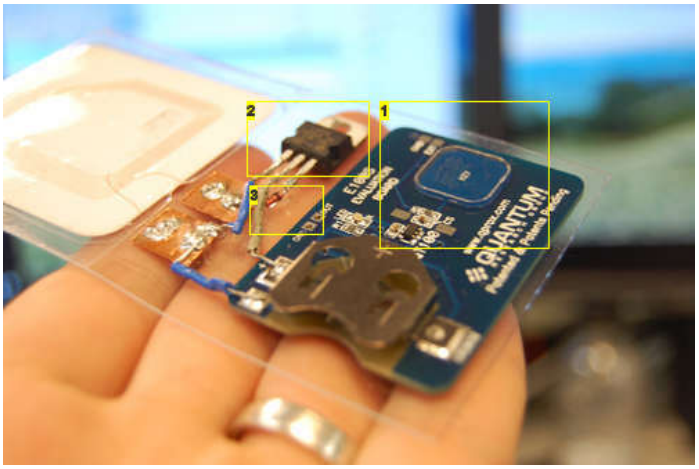

Image Notes
1. Capacitive touch-sensitive pad
2. Voltage regulator
3. Diode

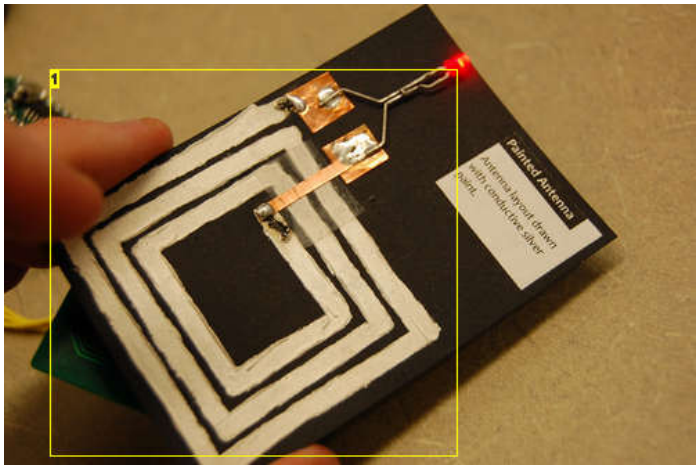

Image Notes
1. Antenna layout painted with conductive silver ink.

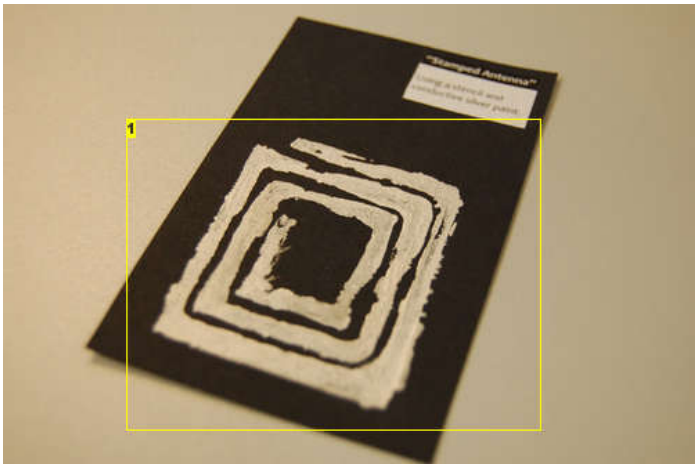

Image Notes
1. This antenna layout is stamped with conductive silver ink (and the antenna is in fact working!)