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Project Details

Name: Speedway RFID Swimming Prototype
Researcher: Richard McCarthy
Date: 10th April 2020

Purpose

Preliminary “*dry land*” findings were carried out using an RFID Reader and a corresponding RFID Tag to determine data for the following -

- Tag read range discovery
- Positioning of the tag and how it affects signal
- Direct line of sight and signal
- Signal strength
- How water affects the reading of the tag
- How a “*tag on head*” scenario affects the reading of the tag

Equipment Used

- Speedway Connect Reader r420
- Smartrac Frog 3D tag
- CS-777 Brickyard Near Field Antenna

Work Carried Out

After an initial period of familiarisation with the Impinj Speedway Revolution Reader device involving locating and reading through relevant technical material to gain insight into the configuration options that were available. This also enabled creating a more clear roadmap for carrying out the initial findings.

The next step was setting up the device on a local network and connecting to it. Once this was up and running the Impinj ItemTest application was installed on a Windows operating system (a requirement by Impinj) to allow for configuring and testing the basic RF behaviour of the Speedway Reader device.

This led to the first successful read of a tag and confirmation that the system was fully operational. This was successful and the tags were immediately picked up and an inventory of the reads provided through the application web interface.

At this point further in-depth analysis of the Speedway Reader device settings was carried out.

Of particular interest are the various setting options for Sessions, Search Modes and Reader Modes.

These will have an impact on the read rate, sensitivity to interference, read range and timing of the tag read flags allowing control of persistence of states.

Now more detailed preliminary findings were carried out based around :

- signal strength
- read range discover
- positioning of the tag
- direct line of sight

Time executed: 15 seconds (approximate - manually started and stopped)

Power: 30 dBm

Tag angle: 80 degrees (approximate)

Direct line of sight.

Level of antenna to tag approximately equal (no height difference)

| Distance | Max RSSI | Avg RSSI | Min RSSI | No. Reads |
|-------------|------------|--------------|--------------|-----------|
| 15cm | -33.5 | -38.1 | -58.5 | 999 |
| 40cm | -41 | -43.7 | -53 | 674 |
| 50cm | -47 | -49.2 | -53 | 655 |
| 1m | -57.5 | -60.7 | -66 | 665 |
| 1.25m | -61.5 | -64.1 | -70 | 663 |
| 1.5m | -71 | -71.4 | -71.5 | 27 |

Moved away from the factory settings and configured the power to 31.5 dBm - which is the limit.

Time executed: 15 seconds (approximate - manually started and stopped)

Power: 31.5 dBm

Tag angle: 80 degrees (approximate)

Direct line of sight.

Level of antenna to tag approximately equal (no height difference)

| Distance | Max RSSI | Avg RSSI | Min RSSI | No. Reads |
|----------|----------|----------|----------|-----------|
| 1.75m | -67 | -68.6 | -74.6 | 311 |
| 2m | -62 | -67.4 | -72.5 | 622 |
| 2.25m | -65 | -68.1 | -70 | 383 |

| | | | | |
|--------------|--------------|--------------|--------------|-----------|
| 2.5m | -63 | -66.0 | -71.5 | 595 |
| 2.75m | -71.5 | -72.1 | -72.5 | 47 |

Adjusted the angle of the tag from 80 degrees to two other approximations at 30 & 60 degrees.

Time executed: 15 seconds (approximate - manually started and stopped)

Power: 31.5 dBm

Tag angle: 60 degrees for first run then 30 degrees for second run (approximate)

Direct line of sight.

Level of antenna to tag approximately equal (no height difference)

| Distance | Max RSSI | Avg RSSI | Min RSSI | No. Reads | Tag Angle |
|----------|----------|----------|----------|-----------|-----------|
| 2.75m | -67.5 | -68.8 | -71 | 328 | 60 |
| 2.75m | -66 | -67.7 | -69 | 313 | 30 |

Adjusted the distance back to 2 meters.

Time executed: 15 seconds (approximate - manually started and stopped)

Power: 31.5 dBm

Tag angle: 60 degrees for first run then 30 degrees for second run (approximate)

Direct line of sight.

Level of antenna to tag approximately equal (no height difference)

| Distance | Max RSSI | Avg RSSI | Min RSSI | No. Reads | Tag Angle |
|----------|----------|----------|----------|-----------|-----------|
| 2m | -55 | -59.1 | -67 | 310 | 60 |
| 2m | -59.9 | -62.5 | -65.5 | 334 | 30 |

Adjusted the height of the Antenna in relation to the Tag. Put the Antenna approximately 13cm higher than the Tag. Also tested Tag at zero degrees.

Time executed: 15 seconds (approximate - manually started and stopped)
Power: 31.5 dBm

Tag angle: In order of 60 degrees, 30 degrees and 0 degrees (approximate)

Direct line of sight.

Level of antenna to tag: 13cm higher (approximate)

| Distance | Max RSSI | Avg RSSI | Min RSSI | No. Reads | Tag Angle |
|-----------|------------|--------------|--------------|------------|-----------|
| 2m | -62 | -63.3 | -64.5 | 301 | 60 |
| 2m | -52 | -52.7 | -53.5 | 300 | 30 |
| 2m | -60 | -60.7 | -61.5 | 300 | 0 |

Further tests were then carried out to extend on the initial preliminary findings to now include tests in the following areas -

- Signal strength and read count at further distances (*Dry and Wet tag*)
- Placing the tag underneath water
- On head test

Signal strength and read count at further distances

Time executed: 15 seconds (approximate - manually started and stopped)

Power: 31.5 dBm

Direct line of sight.

Height Diff refers to the difference in height between the antenna and tag with the antenna always being at the higher point. (approximate measurements)

Tag is dry

| Distance | Max RSSI | Avg RSSI | Min RSSI | No. Reads | Tag Angle | Height Diff |
|----------|----------|----------|----------|-----------|-----------|-------------|
|----------|----------|----------|----------|-----------|-----------|-------------|

| | | | | | | |
|-------|-------|-------|-------|-----|----|------|
| 2.75m | -69 | -70.6 | -74.5 | 640 | 0 | 10cm |
| 2.75m | -68 | -70.3 | -73 | 660 | 0 | 10cm |
| 2.75m | -55.5 | -58.7 | -60 | 654 | 80 | 10cm |

Tag is dry

| Distance | Max RSSI | Avg RSSI | Min RSSI | No. Reads | Tag Angle | Height Diff |
|----------|----------|----------|----------|-----------|-----------|-------------|
| 2.75m | -59.5 | -61.2 | -62.5 | 1729 | 60 | 20cm |
| 2.75m | -64 | -69.1 | -75 | 1727 | 30 | 20cm |
| 2.75m | -59 | -60.4 | -61.5 | 1754 | 0 | 20cm |

Tag is dry

| Distance | Max RSSI | Avg RSSI | Min RSSI | No. Reads | Tag Angle | Height Diff |
|----------|----------|----------|----------|-----------|-----------|-------------|
| 3m | -59.5 | -60.7 | -61.5 | 1650 | 0 | 85cm |
| 4m | -61.5 | -62.8 | -64 | 1686 | 0 | 85cm |
| 4m | -60.5 | -62.0 | -63.5 | 1680 | 0 | 20cm |

Tag is wet

| Distance | Max RSSI | Avg RSSI | Min RSSI | No. Reads | Tag Angle | Height Diff |
|----------|----------|----------|----------|-----------|-----------|-------------|
| 2.75m | -62.5 | -64.1 | -66 | 1481 | 0 | 20cm |
| 2.75m | -58 | -59.3 | -61 | 1764 | 60 | 85cm |
| 4m | -66.5 | -68.0 | -70 | 1553 | 0 | 85cm |

Placing the tag underneath water

For this the tag was placed in a bucket of water 5cm underneath the surface. The antenna was brought very close to the surface and the test started from which the following observations were made -

There were zero tag reads no matter how close the antenna was brought to the surface of the water.

Reset the modulation rate of data encoding to increase resistance to interference but there were still zero tag reads.

Reset the search mode to a single target inventory to allow for its deepest scan but there were still zero tag reads.

Reset the reader to the original settings and then started altering the angle of the tag underneath the water, rotating it through various angles from both its X and Y axis but there were still zero tag reads.

Started to “flash” the tag to the surface of the water and instantly got multiple tag reads.

As soon as the tag was put under the surface the tag reads would immediately stop but return the instant the tag was brought to the surface and stop again once brought under.

The process of bringing the tag as quickly as possible to the surface and under was repeated multiple times with moving the antenna as far up from the water surface as was possible to do with current set up (over 1m) and it yielded the same result each time, multiple tag reads at the surface.

On head test

Placed a tag (with sellotape) on the top of a standard racing swimming hat. The position of the tag was kept near the top to try and simulate close to a 0 - 20 degree angle during the test.

Note: The angles and height differences used here are very much a rough approximation as the test was conducted alone with no easy way to verify exactly but based on using certain marker points and reflections of head position an effort was made to keep the tag angle closer to 0 degrees and the height difference between the antenna and the head above 20cm (with the antenna being higher).

Time executed: 15 seconds (approximate - manually started and stopped)

Power: 31.5 dBm

Direct line of sight.

Tag is dry and placed on a swimming hat on the head

| Distance | Max RSSI | Avg RSSI | Min RSSI | No. Reads |
|----------|----------|----------|----------|-----------|
| 2m | -66 | -67.6 | -69 | 1701 |
| 4m | -67.5 | -69.1 | -71 | 1544 |

Images

In the first image the chair is 4 meters away from the antenna. You can't see it easily in the image but there is a tag lying flat that chair that was read 1680 times in 15 seconds.



In the second image you can see a sample height difference between the antenna and the tag. The tag is being tried at various angles there. This particular test was under 2 meters.



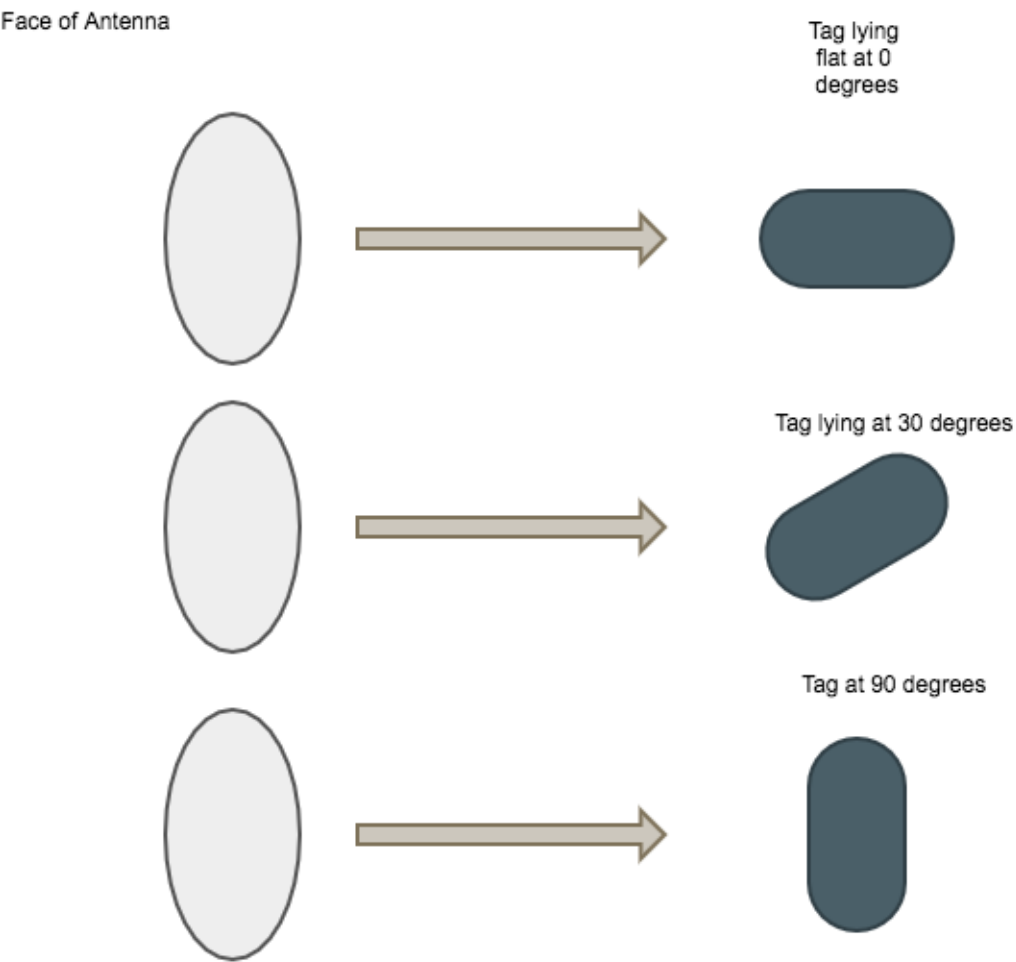
The third image shows the tag taped to a swimming hat.



The fourth image shows the position of the tag on the swimming hat on the head.



Antenna and Tag Angles



Conclusion

It has been decided that the preliminary findings warrant further development of the project in respect to building a Minimum Viable Product (MVP).

This MVP constitutes a software application that is capable reading tags and showing the interval between the reads.

Due to the impact of Covid-19 it has been decided to skip the pool trials as this is not possible in the current environment for the near future.

Further work will now be carried out to spec the requirements of a MVP software application and an estimation of the timeline involved.