Strategies to Ensure your UHF RFID Antenna Coverage is Sufficient

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A critical part of executing a successful UHF RFID project is ensuring adequate antenna coverage of the read point. Antenna coverage is best considered during the design phase of a project, when there are many options to ensure proper tag reads. Antenna coverage must be checked during the commissioning phase, which may uncover gaps in antenna coverage. If corrective action is required during commissioning, the RFID application engineer has some options to eliminate the deficiencies. The option selected depends on the specific application and the RFID application engineer's professional judgment.

Generally, coverage is considered the maximum distance between the RFID reader and the RFID tag where the power intensity is great enough to activate the tag and the reader is sensitive enough to receive the signal from the activated tag. However, in multiple tag applications, coverage is more of a maximum volume of space than a maximum distance. Though read points are just regions of space where targeted tags are expected to be located, those regions can vary in size and other characteristics depending on a specific application. Ensuring that a read point is fully covered requires consideration and balance of several factors. Generally, the key decisions regarding antenna coverage are determined during the initial design. However, what does one do to ensure sufficient antenna coverage once the installation has been made?

The first step is to run a test and see what the antenna coverage is. When implementing a UHF RFID system using a Siemens RF600 series reader, a good approach is to use the Tag monitor found in the Diagnostics section of the Web Based Management (WBM). The WBM is a powerful webserver equipped in the RF600 readers. Though the WBM Tag monitor allows one to monitor tags within the read point continuously, for evaluating antenna coverage it is best to trigger the Tag monitor via the application such as an inventory command issued by a PLC, see Figure 1, or other interface.

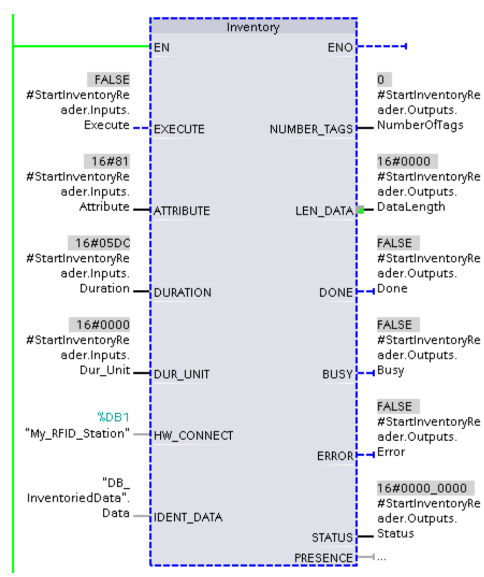

Figure 1: An example of the Inventory block used in a Siemens TIA Portal program. When the Inventory block is executed, the WBM Tag monitor can run at the same time.

Once the target tags have been placed into the read point, navigate to the WBM Tag monitor. If necessary, select the correct read point and antennas. Then click the green arrow. At this point, the WBM Tag monitor is now in 'listening' mode. The final step is to initiate the application trigger. As the Inventory command is executing, the WBM Tag monitor is collecting and displaying data. Once the Inventory command has stopped executing, press the black square to stop the WBM Tag monitor. At this point, one needs to review the tags shown in the "Transponder list."

If all the tags in the read point do not show up in the Transponder list, one must first consider whether the power setting is set to a sufficient intensity to activate all the tags. One could try higher power settings to see if there is a setting in which all the tags in the read point are shown in the Transponder list. Because some applications may be susceptible to cross reads, that is reading tags that are not in the read point, simply increasing power may not be acceptable. It may be that antenna coverage isn't sufficient to reliably see all the tags.

Transponder list

Identified transponders 3 Valid transponders 3 Transponders in the field 0 EPC-ID in ASCII format

EPC-ID	Antenna	Min. power	Power	RSSI	RSSI min.	RSSI max.	Acquisition cycles	Date / time
06102EC9	1	21	21	0	76	80	38	01/30/2018 15:40:57.867
303404DE5C5B308211902452	1	21	21	0	60	64	38	01/30/2018 15:40:57.870
300833B2DDD9014000000000	1	21	21	0	68	70	6	01/30/2018 15:40:59.064

Figure 2: The Transponder list of the WBM Tag monitor shows the tags seen during the Inventory command.

Looking in the Transponder list, one would see a listing of tags under the column showing EPC identification numbers, see Figure 2. Each tag listing will show the antenna(s) that saw the tag, power intensity when the tag was seen, RSSI values, acquisition cycles, and the date/time. Acquisition cycles are a powerful indicator of how good the antenna coverage is. Acquisition cycles are the number of times a reader identified a tag during the reading period. By using the application trigger, the Inventory command is executed for an application-appropriate duration as set by the Inventory block's duration parameter when the block is set to "duration" mode. Thus, each tag in the read point will be activated at the same time. Tags with many acquisition cycles are those tags that are very well covered by the antennas. Tags with fewer acquisition cycles have poor antenna coverage. This is especially true with those tags that have few acquisition cycles but have high RSSI values.

How many acquisition cycles should a tag get within a period is a matter of debate on a per-application basis. A reasonable rule of thumb is a minimum of five acquisition cycles per second. The tags shown in Figure 2 are the result of a 1.5 second Inventory command. While all three tags are in the read point, the third tag was only identified by the reader 6 times while the other two tags were seen 38 times. Of the 6 times that the tag was identified, the RSSI values were comparable to those of the other two tags. This is suggestive of an antenna coverage problem.

Solving an antenna coverage problem onsite can be very challenging since by the commissioning stage, much of the flexibility to make changes has been solidified leaving only a few options. However, there are some relatively minor alternatives that may be made to attack an antenna coverage problem.

Add Antennas

The first possibility, and quite possibly the most obvious, is to add antennas. Depending on the type of reader that has been deployed, it may be possible to add an additional antenna to the read point. For instance, if one has deployed a Siemens RF680R reader then one could add an antenna to an unused antenna port. The RF680R has four ports total, making it a very versatile reader. Once an antenna has been added and positioned in a likely beneficial location, then the antenna needs to be added to the read point via the WBM under the Settings menu.

In applications in which there are no more antenna ports available, one could consider adding another antenna via the use of an RF splitter. Figure 3 shows an example of how additional antennas can be added to a single port. Because there really is no such thing as a free lunch, adding an antenna in this manner has some costs. First is that the splitter will have about 3 dB of cable loss that will need to be accounted for in the antenna configuration within the WBM. This means that there will be a slight reduction in coverage from the original antenna to accommodate the second antenna. Second, the installer must make sure that the length of the two antenna feedlines between the splitter and the antennas are identical cabling and length.   If the installer ignores this requirement, then there will be a mismatch in gain between the two antennas since there is only one cable loss entry available per antenna port. The implications of this should be reviewed prior to completion of the project.

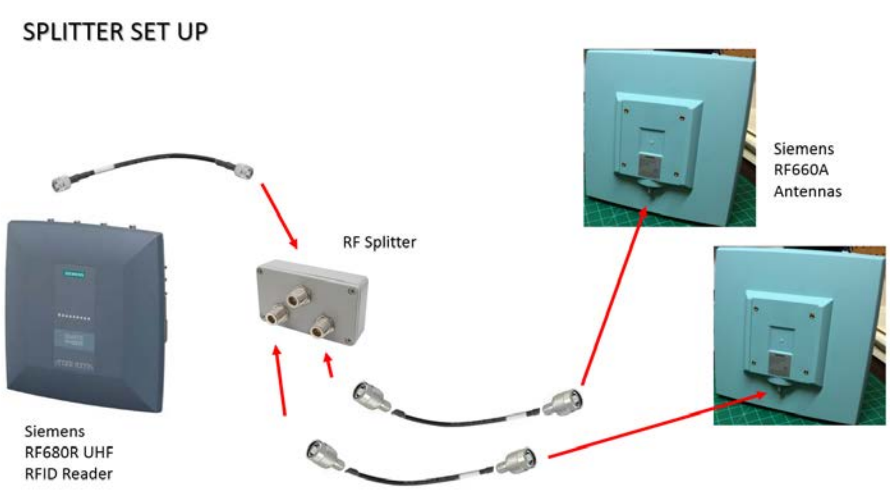

Figure 3: Showing how using an RF Splitter can allow for additional antennas to be added to a port.

Antenna Selection

A second possibility is to change the antenna types. If tags in the problem application are always located in the same orientation and location, it may be possible to employ the use of a 'linearly polarized' antenna. Linearly polarized antennas broadcast the radio waves in a single plane. When a tag's orientation is lined up with the antenna's broadcast plane, the tag is visible, and the reader range is longer. However, if the tag's orientation is not lined up with the antenna's broadcast plane, the tag is invisible to the reader. Thus, the potential benefits to using a linearly polarized antenna are the increased range permitted, the possibility of increased power intensities without increased cross-reads, and not sensing tags which are not properly aligned with the antenna.

A 'circularly polarized' antenna broadcasts the radio waves in a spiral fashion. Such antennas are best used when the orientation of the tags is not known or cannot be accessed directly in a linear fashion. Because circularly polarized antennas broadcast the radio waves in a spiral fashion, these antennas have less range than linearly polarized antennas. A potential benefit to using circularly polarized antennas is that the mounting of the antennas can be flexible which can allow reading tags from various vantage points.

Move the Target Through the Read Point

Sometimes RFID application engineers will describe a UHF field in a read point to be like Swiss cheese. The field is not homogeneous. There will be places in the field that have weaker coverage. These places are often called 'null spots.' These null spots are created when reflected waves obliterate or cancel the main wave in those places. In fact, a similar thing happens outside the read point where reflected waves add to the main wave creating what is referred to as overreach.

When a tag is in a null spot, adjustments can be made to eliminate the null spot. Typical adjustments would be to change antenna angles or increase power intensity. While both of these approaches could solve the null spot problem, they also create other problems. In the case of adjusting antenna angles, the system becomes reliant on those angles. Any post commissioning changes, by well-meaning operation or maintenance personnel could disrupt the performance of the RFID station. Increasing power intensity may increase the range of the read point. This could cause cross reads where tags outside the read point are unintentionally seen.

Another approach is to move the tags through the read point while reading. In this way, a tag may move in and out of null points. When a tag moves from a null point into a normal field, the tag will be able to harness sufficient power to perform its operations. By doing this, changes to power intensity or tweaking antenna angles can be avoided. When adopting this approach, one must make sure that the distance of movement is sufficient for the tags to move fully out of a null spot. Further, the read duration must be set long enough to read the tag as it moves out of a null spot. A balance may be required since the longer a reader is operating, the greater the chance that a cross read may occur with a tag outside of but nearby the read point.

Add Reflective Structures

A less obvious approach to improving antenna coverage is the use of reflection. Certain materials will cause a UHF wave to 'bounce' off its surface and change direction. Due to this phenomenon, one can erect walls made of metal to help guide both the reader broadcast and the tag backscatter. This approach improves antenna coverage by keeping more of the broadcasted field within the read point than without the reflective structure. In this way, tags can be read from different angles than the direct line of sight approach. This means that additional antennas may not be needed in applications where antennas are very close to the tags, yet the spread of tags is large.

Use of reflective structures also allows one to capitalize on secondary fields such as rear and side lobes. Properly positioned reflective structures can reflect those fields towards the tags in the read point. Sometimes, these fields will sense tags that are not already being sensed by the primary field. An added benefit to this approach is that cross reads of tags behind or beside the antennas can be reduced.

Generally reflective structures should be made of materials such as galvanized sheet metal or aluminum plating. Often RFID application engineers will use perforated sheeting to reduce the weight and improve the appearance of a structure. The rule of thumb is that all gaps, holes, and openings must be less than one-tenth of the wave length of the RF signal. This ensures that the broadcasted field doesn't escape the reflective structure. For the FCC compliant Siemens RF680R UHF RFID reader, the frequency range is 902 to 928 MHz. This means that the length of the waves would be between 32.3 to 33.2 centimeters. Thus, any gaps, holes, or openings must be less than 3.23 centimeters. For this reason, RFID application engineers tend to specify one or two inches as the maximum permissible opening in a reflective structure for a Siemens UHF RFID application.

In summary, antenna coverage is best considered during the design phase of a project. However, once the commissioning stage has commenced antenna coverage must be checked. If corrective action is required, the RFID application engineer has some options to eliminate the deficiencies. The option selected depends on the specific application and the RFID application engineer's professional judgment.