Application Note

Tag Phase Reporting Technology

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About Sirit

Sirit Technologies designs, develops, manufactures and sells Radio Frequency Identification (RFID) technology. Targeted at a diverse set of markets RFID technology has become a core technology for applications including: electronic toll collection, access control, cashless payment systems, product identification, and supply chain management systems including logistics, warehousing and manufacturing, and asset management.

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1 Introduction

Tag Phase Reporting technology provides an estimate of the signal phase of the backscatter from an ISO 18000-6C (Gen2) tag during its EPCID/UID response. This estimate can then be used to develop other advanced features. For example, Sirit's Stray Tag Elimination (STE) and Antenna Crossing Technology rely on the underlying technology of Tag Phase Reporting.

2 Requirements

This feature requires Sirit 3.0 or newer reader firmware to be installed as well as a software license for the Tag Phase Tracking technology. This feature only works when the ISO 18000-6C (Gen2) protocol is active. Please contact a Sirit representative to obtain and install this feature on your readers.

3 Setup

To utilize Tag Phase Tracking technology, perform the following:

1. Install the feature license.
   a. Launch the Reader Startup Tool (RST) and select your reader.
   b. Select **Configure** to access the embedded Reader Configuration Tool (RCT).
   c. Under **Advanced Functions** select **Import/Export Configuration**.
   d. Under **Import Licenses**, browse to the license file and press **Import License**.
2. Enable the new reporting field **phase** in the **event.tag.report** autonomous event by adding **phase** to the configuration variable.

   ```
   tag.reporting.report_fields=tag id antenna time phase
   ```

3. To disable reporting, remove **phase** from **tag.reporting.report_fields**.

4 Tag Phase Reporting Theory

4.1. Tag Phase

In a typical RFID environment, many objects have significant radar cross sections that reflect an RFID reader's signal. Consequently, the reader's receiver collects these reflections for objects at various distances and phase shifts.

In backscatter RFID systems, the tag communicates data to the reader by modulating its radar cross section. The RF carrier signal transmitted by the reader is reflected off the tag, received back at the reader, and processed to decode the data.

In order to successfully utilize the tag phase information, a good understanding of radio frequency signals and their propagation is required. A brief explanation is provided in the following sections. You are encouraged to pursue this topic in more detail by consulting textbooks and technical papers.

4.2. Tag Phase Estimation

The underlying tag phase θ is not directly observable but is estimated from the noisy receive signal. The quality of this estimate is dependent on the tags signal to noise ratio (SNR) which is dependent on the RF noise environment, signal bandwidth, and tag receive signal strength.

Signal bandwidth depends on the RFID protocol link frequency (for example, 640 KHz uses twice the bandwidth of 320 KHz). Receive signal strength depends on distance *D*, propagation medium, as well as reader and tag antenna orientation relative to one another.

Tags on the fringe of the RF field will likely have a SNR low enough to adversely affect the estimate of the signal phase reported in the phase indicator. Tags within 10–15 feet (3.0–4.5m) will likely have a high enough SNR for the reader to provide a high accuracy estimate (within approximately 5 degrees standard deviation) of the signal phase in the phase indicator.

4.3. Tracking Tag Phase

The tag phase is sampled each time the tag is read (singulated) with ISO 18000-6C. Keep in mind, however, that this is not a uniform sampling rate and the sampling instants are random, non-uniform, and depend very heavily on tag population, antenna configuration, antenna hopping, and the tag singulation algorithm being used in the reader.

The phase θ is a function of the wavelength λ and total propagation distance D. Because of the functional relationship $\theta_\lambda(D)$, there are many distances that map to the same phase. By examining the formula

$$\theta = \left(2\pi \frac{2D}{\lambda} + \phi_{tx} + \phi_{rx} \right) \bmod 2\pi$$

it can be seen that the phase is identical for

$$D \pm n\frac{\lambda}{4},$$

for any integer *n*. Note, ϕ_{tx} and ϕ_{tx} will be discussed in the next section.

4.4. Propagation Distance and RX Carrier Phase

A number of factors combine to set the total signal propagation distance. These factors include propagation inside the coax between reader and antenna, and propagation over the air between antenna and tag.

For an RF carrier frequency of F_c hertz, the signal's wavelength is

$$\lambda = \frac{c}{F_c},$$

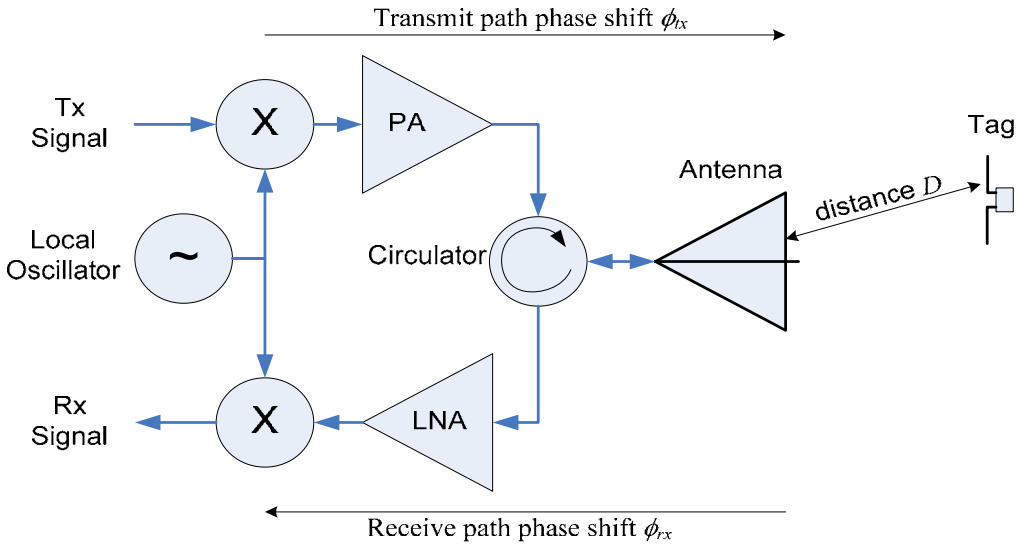
where *c* is the speed of light.

If the distance from the reader's antenna port to the tag is denoted *D*, then the total distance traveled by the RF signal from the reader to the tag and back again is $2D$. This distance represents a phase shift (ϕ_{prop}) that includes both the length of the coax from the antenna port to the antenna, and the distance from the antenna to the tag.

The reader's electronics also add phase shift. The transmitter and receiver contribute ϕ_{tx} and ϕ_{rx}, respectively, to the total phase shift.

$$\phi = \phi_{tx} + \phi_{prop} + \phi_{rx}.$$

Though not explicitly shown in the following equations, the transmitter and receiver components of the total phase shift are also dependent on the carrier frequency. The receiver components are shown in the following figure.



The signal phase is represented by an angular position on a circle (in radians). The distance D determines the phase shift at the reader's receiver due to propagation since the signal will have progressed through

$$\phi_{prop} = 2\pi \frac{2D}{\lambda}$$

radians in the process.

At the reader's receiver, the total phase shift ϕ cannot be measured, but rather a modulo measure of

$$\theta = \phi \bmod 2\pi$$

which is $0 \le \theta < 2\pi$.

In practice, on the INfinity 510, there is an additional 180o phase ambiguity such that any specific phase estimate could be indicated as θ or $\theta + \pi$. Therefore, definitive resolution of the absolute phase measurement is not possible. However, correction techniques can be applied depending upon the algorithm in use. Any application which desires to utilize this phase information needs to account for this ambiguity.

5 Tag Phase with the IN*finity* 510

Applications which attempt to utilize the phase indicator should consider certain practical constraints and behaviors associated with Sirit's IN*finity* 510. It has a wide range of capabilities to optimize for various application environments (for example, the antenna hop sequence can be specified and weighted). The air interface configuration also has great flexibility and the singulation algorithm maximizes tag throughput.

When using 320 KHz link frequency, typical read rates include:

- 425 reads/second for FM0
- 325 reads/second for Miller-2
- 220 reads/second for Miller-4
- 120 reads/second for Miller-8

5.1. ISO-C sample rate and tag population size

With a single tag, the fastest sampling rates are achieved. For tag volumes greater than one, the reader will achieve roughly the same read rate, but the reads are now spread out over the larger tag population. Moreover, the order of the tag reads is completely random, so there are worst case read-to-read times for any given tag to be considered.

The reader dynamically adapts to the tag population and it may be best to use the default reader configuration and let it deal with the changes in tag volume. Applications which utilize the phase indicator must be aware of the worst case read-to-read times and place appropriate constraints to ensure proper results.

5.2. Antenna Multiplexing and Frequency Hopping

When multiple antennas are employed this must also be factored into the sampling rate. Note that tag phase values should only be compared between samples from the same antenna. Attempts to compare phase values between different antennas may be meaningless due to the differences in tag to antenna distance.

In addition, comparisons between phase values for a tag on the same antenna but when a frequency hop occurred between the two samples may not be valid.

5.3. Interpreting Phase Indicator values

When phase reporting is enabled the tag phase is appended to the tag report such as **`phase=0x3456`**. The phase estimate is reported as a twos complement 16 bit hexadecimal number scaled from $-\pi$ to π with 0x8000 = $-\pi$ and 0x7FFF = π.

6 Summary

For additional information or engineering assistance in obtaining and installing Tag Phase Reporting technology on your readers, contact your local Sirit partner or representative.

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