RAIN RFID System Design Guidelines
Air Interface and Protocol Considerations

RAIN RFID Alliance
Whitepaper

V.1.0
May 2020

Table of Contents

1 Introduction

A RAIN RFID system consists of items, tags, readers, software, and a network. Deployments have many moving parts but the technology, standards, and business eco-system have all evolved to such a level of maturity that successful deployments are routine around the world.

This system design guideline addresses various items that should get special attention when deploying a RAIN RFID system.

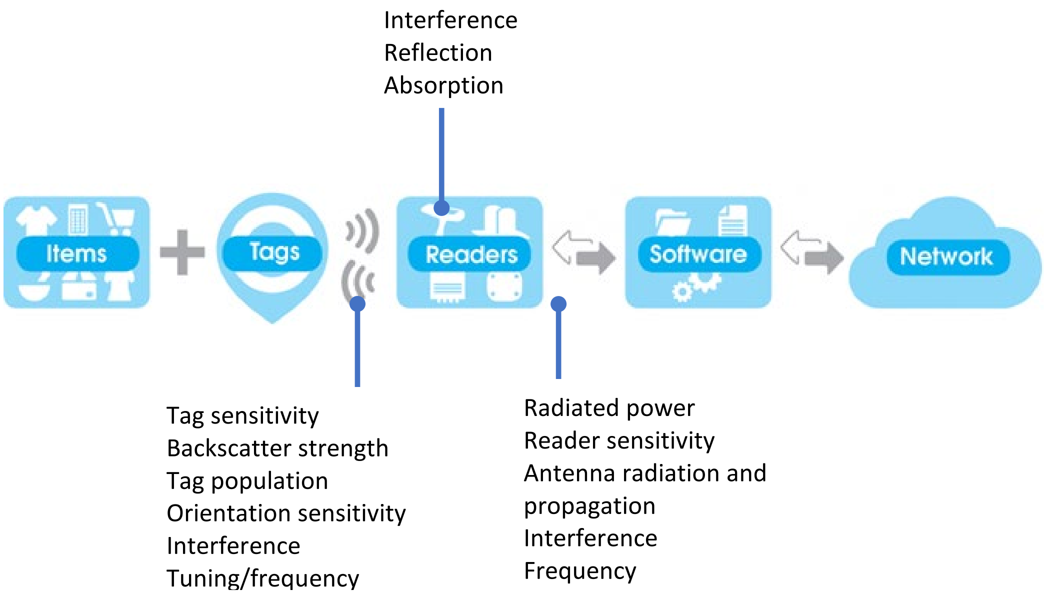

Figure 1: RAIN RFID System Overview

2 Regulatory settings

2.1 Introduction

The regulatory settings for RAIN RFID are different throughout the world. Furthermore, different radio regulations in the world require different settings on the RAIN RFID air interface.

This clause defines codes for recommended settings in particular countries. In general it is intended to have the number of codes as low as possible.

2.2 Overview

Clause 2.3 introduces the country list. Clause 2.4 defines the essential radio frequency setting, the details are then described in clause 2.5.

2.3 Country list

Table 5 in clause 5 lists the specific codes that must be applied for the various countries. The country abbreviation consists of a 2-letter country ISO 3166-1 alpha-2 code.

The code for the essential radio frequency regulations settings consists of the 2-letter country code, a digit representing the frequency range and a letter to distinguish the available options.

For countries that are not listed there is no RAIN RFID recommendation available yet. Country codes may be added in a future edition of this document.

Requests for extensions shall be addressed to RAIN RFID at technical@rainrfid.org.

Additional information is also provided by GS1 under https://www.gs1.org/sites/default/files/docs/epc/uhf_regulations.pdf.

2.4 Essential radio frequency regulations settings

Table 1 defines recommended RAIN RFID settings for UHF RFID regulations in various regions and countries, as developed by the RAIN Alliance. The Table 1 headers are described in detail in Table 2. The intention of RAIN is to keep the number of different codes as small as possible. For that reason, as far as possible, European countries refer to EU, or American countries to US, if possible. Country code abbreviations are based on ISO 3166-1 alpha-2 codes[1].

IMPORTANT NOTE: These tables are guidelines. Current local Regulations must be checked before enabling the RAIN Reader. Please inform the RAIN Alliance of inaccuracies and/or oversights.

[1] See https://en.wikipedia.org/wiki/ISO_3166-1_alpha-2#QM

Table 1: CODE overview for radio frequency regulations settings

CODE	TX-BW / kHz	TX-SP / kHz	BLF / kHz	DRM	CH-USE	REMARK
EU8A	200	600	320	Yes, M=4	AFA	Max. 2 W erp
EU9B	400	1200	640	Yes, M=4	AFA	Max. 4 W erp
US9A	250 (500 channel width)	500	256	Yes, M=4	FHSS	Max. 4 Weirp
CN9A	250	500 (250 would be possible)	256	Yes, M=4	FHSS	Max. 4 Weirp
JP9A	200	1200	320	Yes, M=4	NCS	Max. 1W conducted + 6 dBi antenna, Licensed
JP9B	200 (Note: 200 to 600 are allowed, but not supported by this code)[2]	1200 / 200	320	Yes, M=4	CS	Max. 1W conducted + 6 dBi antenna, Registered
JP9C	200 (Note: 200 to 1000 are allowed, but not supported by this code)[3]	200	320	Yes, M=4	CS	Max. 250mW conducted + 3 dBi antenna, free of license and registration[4]
KR9A	200	600	320	Yes, M=4	FHSS	Max. 4 Weirp
KR9B	200	600	320	Yes, M=4	CS	Max. 4 Weirp

[2] For other TX BW values new codes may be developed, if there is a market need
[3] For other TX BW values new codes may be developed, if there is a market need
[4] However, when EIRP (Equivalent Isotropically Radiated Power) is less than the value of 3dBi plus 250mW of antenna power, you may fill in the gap with the antenna gain.

Table 2: Parameter description

PARAMETER	DESCRIPTION
CODE	Country code according ISO 3166-1 alpha-2 codes, followed by frequency band (8 for 800 MHz and 9 for 900 MHz), followed by frequency plan numbering (A, B, C, ….)
TX-BW / kHz	Maximum transmit (TX) bandwidth (BW) to be used. Bandwidth definitions may be different depending on the country or region. Refer to regulations and documents
TX-SP / kHz	Channel spacing between two transmit (TX) channels. Use the value defined through regulations, or if not defined by regulations, use the values in Table 1 for this parameter.
BLF / kHz	BLF as defined in GS1 EPC Gen2[5] or ISO/IEC 18000-63[6]
DRM	Defines whether DRM (Dense Reader Mode) shall be applied and what M according Gen2/ISO shall be used
CH-USE	Channel use principle with the following abbreviations: AA Adaptive Frequency Agile FHSS Frequency Hoping Spread Spectrum CS Carrier Sense (or LbT – Listen before Talk) NCS Non-Carrier Sense

2.5 Detailed descriptions of the codes in Table 1

2.5.1 EU8A

This setting is based on CEPT REC 70-03 and EN 302 208 for 865-868 MHz.

2.5.2 EU9A

This setting is based on CEPT REC 70-03 and EN 302 208 for 915-921 MHz with 3 transmit channels at 916.3 MHz, 917.5 MHz, and 918.7 MHz.

[5] GS1 EPC … EPC™ Radio-Frequency Identity Protocols Generation-2 UHF RFID Standard Specification for RFID Air Interface Protocol for Communications at 860 MHz – 960 MHz

[6] ISO/IEC 18000-63 … Information technology — Radio frequency identification for item management — Part 63: Parameters for air interface communications at 860 MHz to 960 MHz Type C

2.5.3 EU9B

This setting is based on CEPT REC 70-03 and EN 302 208 for 915-921 MHz with 4 transmit channels at 916.3 MHz, 917.5 MHz, 918.7 MHz, and 919.9 MHz.

2.5.4 US9A

This setting is based on FCC 15.247 (FCC 47CFR15.247).

Canadian Regulations are managed by Industry Canada. The related standard is RSS-210.

The codes for USA and Canada are the same, as the settings are equal and only the legal documents defining it are different but have the same applicable content.

2.5.5 CN9A

This setting is based on the current regulations for the 920-925 MHz band.

2.5.6 JP9A

ARIB STD-T106/107 applies. This band is 1 W licensed.

If the conducted power is less than 1 W, then the antenna gain may be more than 6 dBi to compensate for this.

2.5.7 JP9B

ARIB STD-T106/107 applies. This band is 1 W registered.

If the conducted power is less than 1 W, then the antenna gain may be more than 6 dBi to compensate for this.

1200 kHz channel spacing applies for the lower channels, while 200 kHz spacing applies for channels 23 and above.

2.5.8 JP9C

ARIB STD-T106/107 applies. This band is 250 mW.

If the conducted power is less than 250 mW, then the antenna gain may be more than 3 dBi to compensate for this.

3 Protocol considerations

3.1 Session flags

3.1.1 Overview

The RAIN RFID protocol supports five session flags, which have three different characteristics and the selection of the session flags for an application depends on:

- session persistence values,
- number of tags in system, and
- reader's throughput (tag reads per second),

Details on the session flag characteristics are shown in Table 3.

Table 3: Session flags

FLAG	PERSISTENCE TIME	PASSIVE TAG BEHAVIOUR ENERGIZED AND BAP[7] TAG BEHAVIOUR ABOVE SENSITIVITY THRESHOLD	PASSIVE TAG BEHAVIOUR NOT ENERGIZED	BAP TAG BEHAVIOUR BELOW SENSITIVITY THRESHOLD
S0	No persistence	Value remains forever	Cleared immediately with tag power loss	Cleared when RF remains below sensitivity threshold and exceeds the RF fade control time for the tag
S1	Persistence time from 0.5 – 5 seconds	Value remains for 0.5 – 5 seconds after it was set	Same behaviour as when energized	Same behaviour as when energized
S2, S3, SL	Persistence time of > 2 seconds	Value remains forever	Cleared at the earliest 2 seconds	Cleared earliest 2 seconds after RF remains below sensitivity threshold and exceeds the RF

[7] Battery Assisted Passive

FLAG	PERSISTENCE TIME	PASSIVE TAG BEHAVIOUR ENERGIZED AND BAP[7] TAG BEHAVIOUR ABOVE SENSITIVITY THRESHOLD	PASSIVE TAG BEHAVIOUR NOT ENERGIZED	BAP TAG BEHAVIOUR BELOW SENSITIVITY THRESHOLD
			after tag power loss[8]	fade control time for the tag

To some extent the maximum regulatory dwell time plays a role, but even without this dwell time limit, the reader must disable RF power to switch antennas or frequency channels. In a large, static tag population the reader will always need to switch antennas or channels to provide spatial or frequency diversity in order to energize/read all tags.

3.1.2 Session flag S0

If the number of tags is small, so that all illuminated tags can be read prior to the maximum dwell regulatory dwell time, then session S0 would normally work fine.

EXAMPLE: Approximately 20 tags in read zone, 100 tags per second throughput, then "number of tags / throughput" = 200 ms (milliseconds), which is less than the FCC part 15 max dwell time of 400 ms. All tags can be read in one dwell period, which is important since as soon as the reader hops frequency, any tags singulated from S0 = A to B will be reset back to A when the RF energy goes away for the hop. These tags will now participate in the next S0 = A singulation round since they reset to A.[9]

COUNTER EXAMPLE: If there are 50 tags under the same conditions as above, then the reader cannot singulate all of them prior to the frequency hop. All tags reset on the hop. Thus, it is not possible to get reliable performance using S0 under FCC part 15 in these conditions. A faster reader or a longer persistence session would be required. However, S0 can be used when supporting ETSI EN 302208 as this standard allows the channel use for 4 seconds dwell time.

---

[8] The minimum persistence time for a certain temperature range is defined in ISO/IEC 18000-63. The actual persistence time depends on various parameters as e.g. the available RF power and certainly the temperature, where the minimum type is typically met for the upper temperature range, while it is significantly higher for room temperature and can get very long for freezing temperatures. This variation is not defined in the standard, but tag type dependent.

[9] This example does typically not apply for BAP tags

Session S0 is particularly useful with small populations of fast-moving tags. For example, in conveyor systems or vehicle tolling. The "guarantee" that S0 will reset to A when de-energized is used to advantage to be able to reliably read tags entering the system from a powered off state.[10]

3.1.3 Session S1

If the number of tags is larger, so that all illuminated tags cannot be read prior to the maximum antenna RF dwell time, then session S0 will not be reliable and the reader must use one of sessions S1 through S3. These session flags maintain their state across brief periods of no RF energy. Session S1 is unique in that this flag will always return to the A state even with RF power on, with the persistence time as stated above. This can be used to advantage when the reader is able to reliably singulate all tags in the read zone from A to B state in less than 500 ms, the minimum S1 persistence time. Thus, the reader can continually singulate from A to B in session S1, knowing that no tags will return to the A state within 0.5 seconds. Again, this depends of the tag volume and reader throughput. On the other hand, the reader could use A -> B -> A singulation to get faster read rates. However, if the tag volume divided by reader throughput is greater than 0.5 seconds, then the reader must use session S2 or S3 for reliability.

3.1.4 Session S2 and S3

When there is a larger number of tags than cannot be read reliably within 0.5 seconds, then the "infinite persistence" sessions S2 or S3 must be used.

Which one to use? There may be some advantage in multi-reader deployments to use a "cellular" approach to the sessions, e.g., use session S2 on one reader, then session S3 on the adjacent reader, etc., alternating between the two sessions to provide as much separation as possible between any two readers using the same session. This is because, once a tag joins an inventory round by hearing a matching *Query*, that tag will ignore spuriously heard *QueryRep* and *QueryAdjust* commands.

Once inventoried, getting this large set of tags back from B to A state in session S2 or S3 can be done by inventorying them B -> A, or through select commands. Waiting for the persistence to expire is not a good approach typically, since depending on the temperature and the tag silicon, it can take a very long time for the persistence of S2 and S3 to expire. While the minimum is 2 seconds, the actual value at room temperature can be above 1 minute and even much longer for low temperatures. In general, S2 and S3 might never be assumed to be reset, when arriving in an RFID application. Power harvested from cell towers, cell phones might have provided enough power to keep S2 and S3 alive.

---

[10] This counter-example does typically not apply for BAP tags

3.1.5 Session SL

The timing behaviour of flag SL is the same as S2 and S3. It may be used to select or unselect tags before starting a Query round. The use of the Select command is a requirement to isolate from other RFID tags. For example, for baggage sorting you should only focus on baggage tag and ignore the garment tags inside the suitcase. For that reason, a select on the AFI value C1 might make sense. As tags that miss the select commands due to e.g. RF disturbance would be lost, it is more appropriate to not select the tags that are not intended. So, tags missing the select or late arrivals could then be considered for the Query round instead of missing them.

Example:

This example described how the use of the SL should be used as described above, only showing the relevant command parameters:

Select on AFI <> C1

```
Select (Target=100 [SL], Action=100, MemBank=01 [UII], EBV=00011000 [18h],
Mask=00110001 [C1h], Truncate=0)
```

Query on SL==0

```
Query (Sel=10)
```

Table 4: EPC Gen2 Table 6.32

Table 6.32 — *Query* command

	Command	DR	M	TRext	Sel	Session	Target	Q	CRC
# of bits	4	1	2	1	2	2	1	4	5
description	1000	0: DR=8 1: DR=64/3	00: M=1 01: M=2 10: M=4 11: M=8	0: No pilot tone 1: Use pilot tone	00: All 01: All 10: ~**SL** 11: **SL**	00: S0 01: S1 10: S2 11: S3	0: *A* 1: *B*	0–15	CRC-5

3.2 BAP tags and high sensitivity passive tags

3.2.1 BAP Tags and RF Fade Control

RF fading often occurs from multipath conditions present at the tag as it, or another object, moves within the reader's RF field. If the fade condition drops the RF field strength by a sufficient amount, passive tags will lose power and then power-up again once the fade condition is no longer present. All state and session information in the passive tag is lost due to the fade condition. BAP tags will see the RF field drop below the field detection level and then see it rise again above the detection level when the fade condition is no longer present. Since BAP tags do not lose power during the fade condition, it is possible to retain all state and session information.

RF fade control is implemented by checking the elapsed time since the RF field has dropped below the field detection level. All state and session information is retained so long as the elapsed time does not exceed RF fade control time. Once the RF fade control time has been exceeded, the BAP tag loses its state and session information in the same manner as a passive tag when it loses power. BAP tags benefit the most when having an RF fade control time that is 10 ms to 100 ms.

RF fade control is illustrated below.

It shall be noted that products on the market provide a fixed RF fade control time with nominal values. Typical values available in the market are 125 μs, 1 ms, 10 ms, and 100 ms with the default being 10 ms.

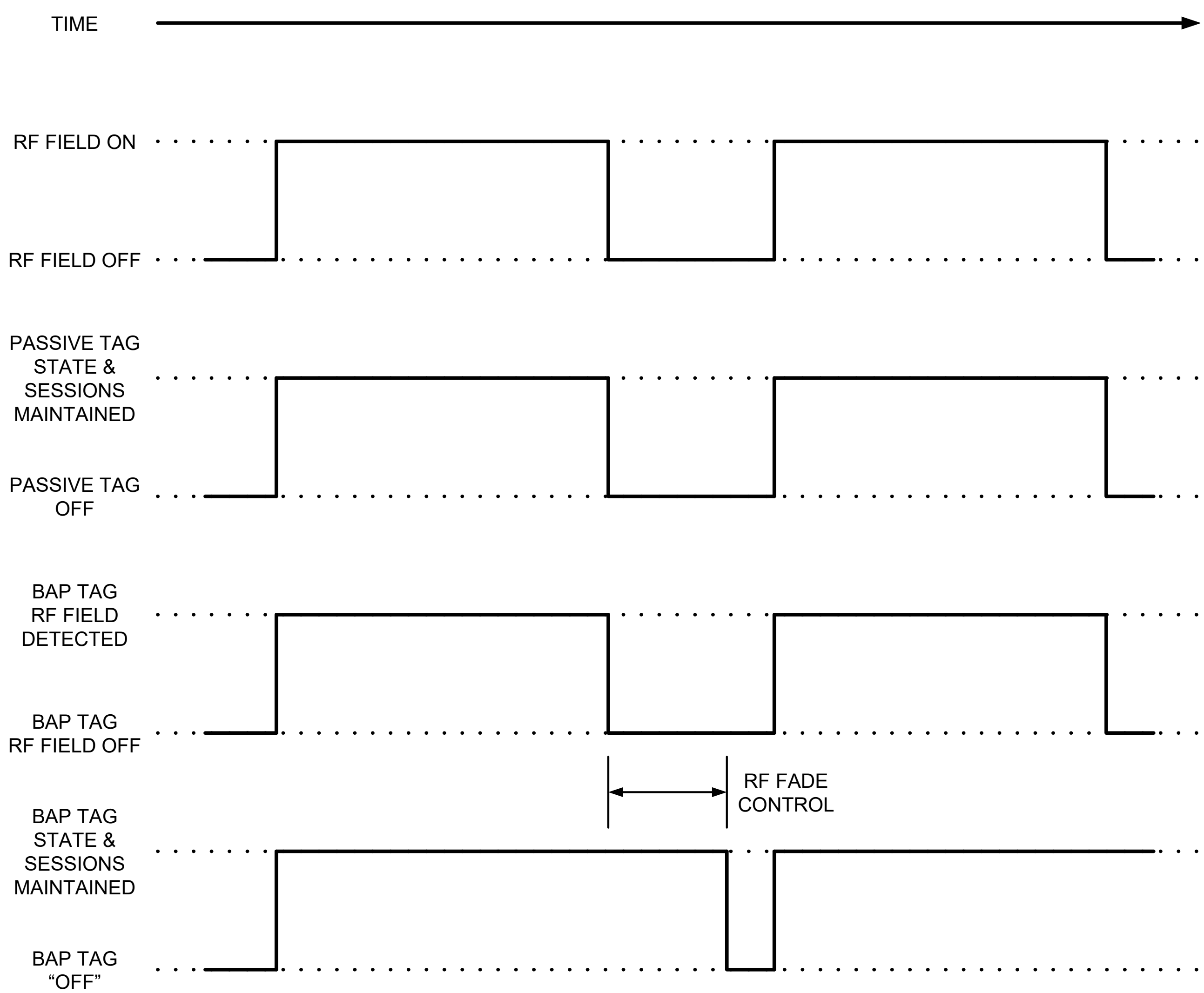

Figure 2: RF Fade control

3.2.2 Readers and BAP Tags

Readers should be aware of two aspects of BAP tags that differ from passive tags:

1. BAP tags implement RF fade control to provide some resistance to temporary nulls in the RF field. The tag maintains state and session information for some period of time after the RF field is no longer detected.
2. BAP tags typically have significantly better sensitivity than passive tags (e.g. -30 dBm for BAP versus -20 dBm for passive). Consequently, the ambient RF noise level in the environment may not be at a high enough level to power-up passive tags but possibly may affect BAP tags in that they detect the presence of an RF field. This situation results in the tag maintaining state and session information even when the

reader has its RF field turned off. **(NOTE: Sensitivity for passive tags continues to improve and eventually ambient RF noise levels will affect them in the same manner as BAP tags.)**

Readers often have several operating mode configurations to support inventory of tags. These configurations obviously support passive tags because that is all that has existed until recently. The same configurations may, or may not, result in different behaviour from a BAP tag as compared to a passive tag. Ideally, readers will implement at least one operating mode configuration that supports BAP tags.

Consider the case below where a reader is performing inventory operations by continuously polling using Frequency Hopping Spread Spectrum (FHSS) operation. Only three frequency hops are shown but it could be many, many more hops.

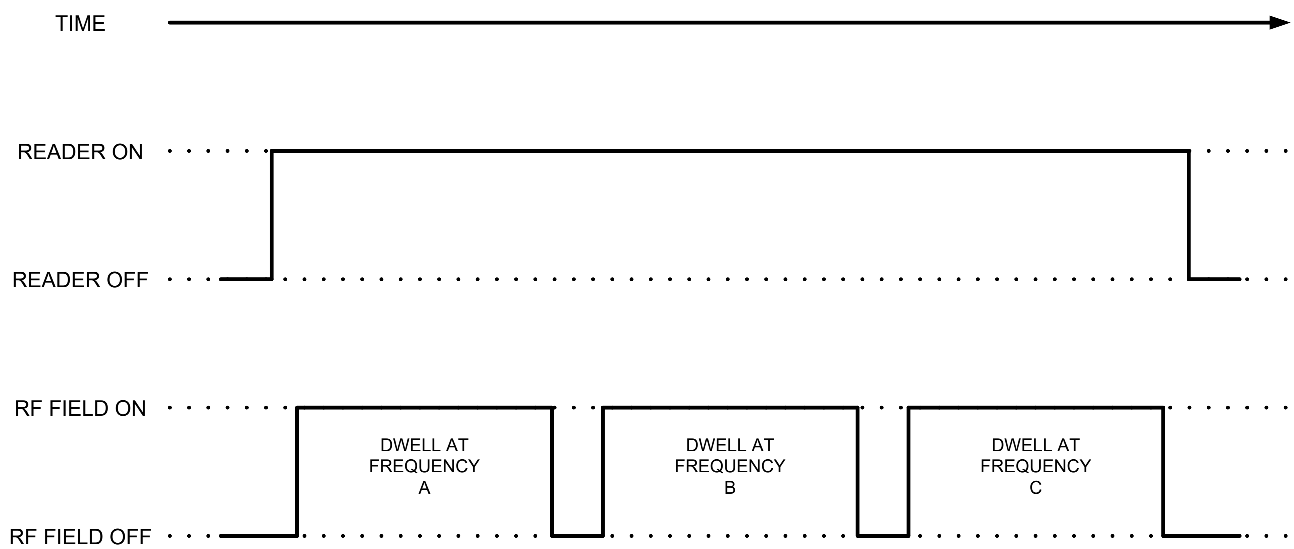

Figure 3: Reader Continuously Polling with FHSS Operation

The reader is turned on to begin polling and FHSS operation begins. The reader turns on the RF field and dwells at one frequency for some period of time, turns off the RF field to hop to another frequency, turns on the RF field and dwells at a different frequency for some period of time, turns off the RF field to hop to another frequency, and so on until the reader is turned off. The maximum time between frequency hops and the minimum RF off time during a hop must meet the local regulatory requirements. FCC 15.247 requires the maximum dwell time for a reader to be less than 400 ms and the RF off time between frequency hops to be at least 1 ms.

It can be seen above that the RF fade control mechanism in BAP tags must be considered. If the RF fade control time is less than the RF off time during frequency hops, then the BAP tag behaves the same as a passive tag. However, if the RF fade control time is more than the RF off time during frequency hops, then the BAP tag behaves differently from a passive tag in that it will maintain its state and session information.

Readers have two options to always ensure that BAP tags and passive tags behave in the same manner. The first option is to increase the RF off time to be longer than the RF fade control time. This may not be desirable for relatively long RF fade control times. The second option is to never assume session states due to turning the RF field off and on again. This is easily implemented in a reader by starting an inventory session using a Select command. It also has the added benefit of correctly processing tags in environments that have an ambient RF noise level above tag sensitivity levels. Two simple examples are provided to illustrate how this works.

3.3 Session implementation examples

3.3.1 Example #1. Typical inventory session in which the reader assumes all tags are powered off when RF field is off. (Bad example)

Reader is turned on.
RF field is turned on to start first inventory session. Reader assumes all tags in field will power-up and by default set S0 inventoried flag --> A. Reader issues Query command to inventory all tags with S0 inventoried flag = A. Reader inventories tags in field using QueryRep/QueryAdjust and ACK commands. RF field is turned off at end of inventory round.
RF field is turned on to start second inventory session. Reader assumes all tags in field will power-up and by default set S0 inventoried flag --> A. Reader issues Query command to inventory all tags with S0 inventoried flag = A. Reader inventories tags in field using QueryRep/QueryAdjust and ACK commands. RF field is turned off at end of inventory round.
and so on ...
Reader is turned off.

3.3.2 Example #2. Typical inventory session in which the reader assumes nothing about the tags. (Good example)

Reader is turned on.
RF field is turned on to start first inventory session. Reader assumes nothing and issues Select command to have all tags in field set S0 inventoried flag --> A. Reader issues Query command to inventory all tags with S0 inventoried flag = A. Reader inventories tags in field using QueryRep/QueryAdjust and ACK commands. RF field is turned off at end of inventory round.
RF field is turned on to start second inventory session. Reader assumes nothing and issues Select command to have all tags in field set S0 inventoried flag --> A. Reader issues Query command to inventory all tags with S0 inventoried flag = A. Reader inventories tags in field using QueryRep/QueryAdjust and ACK commands. RF field is turned off at end of inventory round.
and so on ...
Reader is turned off.

The difference between the two examples is the addition of the Select command at the start of each inventory session in Example #2. Now, let's examine the affect this has on BAP tags and passive tags. Assume that the reader's RF off time is less than the tag's RF fade control time and that the ambient RF noise level is below the tag's sensitivity level.

Example #1: The first time the RF field is turned on to start the first inventory session will result in a BAP tag setting its S0 inventoried flag --> A. During the first inventory session, the BAP tag will participate in the session, respond to the reader, and change its S0 inventoried flag --> B. The BAP tag then maintains the session info when the RF field is turned off and then back on again. During the second inventory session, the BAP tag will not participate in the session. The BAP tag then maintains the session info when the RF field is turned off and then back on again. During all the subsequent inventory sessions, the BAP tag will not participate in the sessions. Eventually, the reader suspends all inventory sessions and the RF field is off long enough to exceed the RF fade control time and the BAP tag will no longer maintain the session info.

Example #2: The first time the RF field is turned on to start the first inventory session will result in a BAP tag setting its S0 inventoried flag --> A. The inventory session starts with the reader using the Select command and the BAP tag will set its S0 inventoried flag --> A.

During the first inventory session, the BAP tag will participate in the session, respond to the reader, and change its S0 inventoried flag --> B. The BAP tag then maintains the session info when the RF field is turned off and then back on again. The inventory session starts with the reader using the Select command and the BAP tag will set its S0 inventoried flag --> A. During the second inventory session, the BAP tag will participate in the session, respond to the reader, and change its S0 inventoried flag --> B. The BAP tag then maintains the session info when the RF field is turned off and then back on again. During all the subsequent inventory sessions, the session starts with the reader using the Select command and the BAP tag will set its S0 inventoried flag --> A, the BAP tag will participate in the session, respond to the reader, and change its S0 inventoried flag --> B. Eventually, the reader suspends all inventory sessions and the RF field is off long enough to exceed the RF fade control time and the BAP tag will no longer maintain the session info.

In Example #1, passive tags participate in every inventory session, but a BAP tag will only participate in the very first inventory session. In Example #2, both passive tags and BAP tags participate in every inventory session.

A variation of Example #2 is found in many readers whereby successive inventory sessions continuously alternate between the A and B states for a session flag. This is often represented by a reader as Target = AB or referred to as Dual Target.

3.4 Req_RN use - Advantage/Disadvantage

Earlier types of ISO/IEC 18000 used a collision arbitration where the tag replied its unique identifier (e.g. UII) and was assuming that the reader recorded the identifier. However, when there was a communication problem, the tag identifier was lost.

RAIN RFID (ISO/IEC 18000-63 / GS1 Gen2) handles this differently. If a *Req_RN* with the correct RN16 is received, then the tag transfers to the open or secured state respectively. In case the tag does not receive the *Req_RN* it goes back to the Arbitrate or Ready state. In case of dedicated commands like *Select* or *Query* it goes back to the Ready state and join the next collision arbitration loop again.

The RAIN protocol does not require the use of the Req_RN command for reading all the EPC/UII of the tags present. It is also possible to skip the Req_RN and to continue with e.g. QueryRep. The advantage of this is that time is saved, and the identification is faster. The disadvantage is that tags do not transfer to the open state and the tag does not know whether it has been identified.

4 System budget and tag backscatter

4.1 Introduction

There are differences in the power propagation for near and far field. The near field characteristics are complex to describe and are not covered in this document yet. The far field starts at a distance $= \frac{2L^2}{\lambda}$, where λ lambda is the wavelength and L is the maximum dimension of the test antenna. The far field power prorogation is described through the Friis formula as follows:

Equation 1: $$P_{tag,read} = P_{reader,TX} \left(\frac{\lambda}{2\pi R}\right)^2$$

Equation 2: $$P_{tag,read}\, G_{tag} = P_{tagchip,read}$$

Equation 3: $$P_{treader,TX} = P_{reader,out}\, G_{reader}$$

RAIN RFID tags were first introduced in 2006. Since then there was major progress reducing the minimum power for a tag. The examples in 4.2 also show that the backscatter power[11] became lower and lower as well resulting in differences up to 10 dB from the early tags. Furthermore, following the Friis Formula the available power at the receiver of the reader became even lower. The link budget calculations are outlined in 4.3.

[11] Following ISO/IEC 18046-3 the backscatter power (P_{back}) is measured slightly above the minimum operating power (P_{min}) at P_{min} + 2.

4.2 Examples

Vendor A

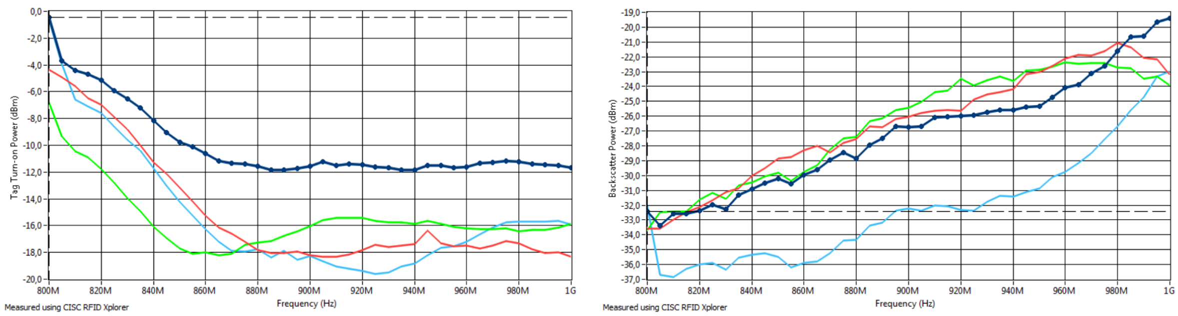

Figure 4: $P_{tag,read}$ and $P_{tag,back}$ example A

Vendor B

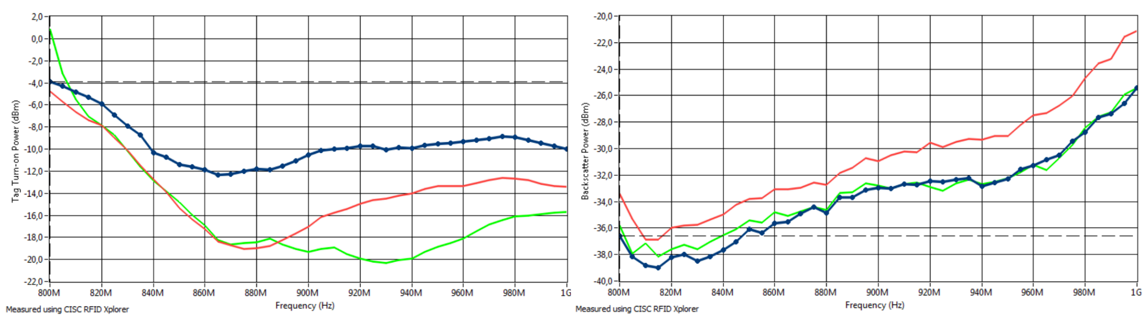

Figure 5: $P_{tag,read}$ and $P_{tag,back}$ example A

4.3 Link budget calculations

The link budget calculations are done according Figure 6, Equation 4 and Equation 5, which are derived from Equation 1, Equation 2 and Equation 3.

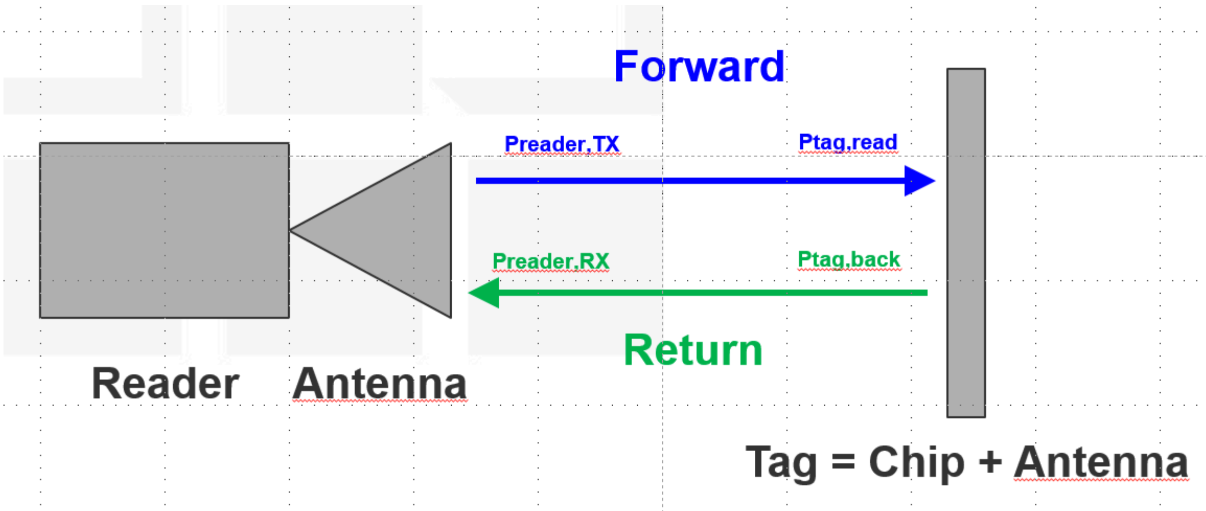

Figure 6: RAIN RFID System budget overview

Equation 4: $$R_{forward} = \frac{\lambda}{2\pi}\sqrt{\frac{P_{reader,TX}}{P_{tag,read}}}$$

Equation 5: $$R_{return} = \frac{\lambda}{2\pi}\sqrt{\frac{P_{tag,back}}{P_{reader,RX}}}$$

The impact of the reader receiver sensitivity, which gets worse with lower backscatter, can be seen in the figure below, with the following terms used:

- Reader gap is the range loss caused by the reader sensitivity limits
- Tag gap is the range loss caused by the tag minimum operating power limit

Minimum is the minimum range on forward and return link, caused by the limits of the following performance parameters:

- reader transmit power (maximum is limited by radio regulations)
- reader sensitivity (measured according ISO/IEC 18046-2)
- tag operating power (measured according ISO/IEC 18046-3)
- tag backscatter power (measured according ISO/IEC 18046-3)

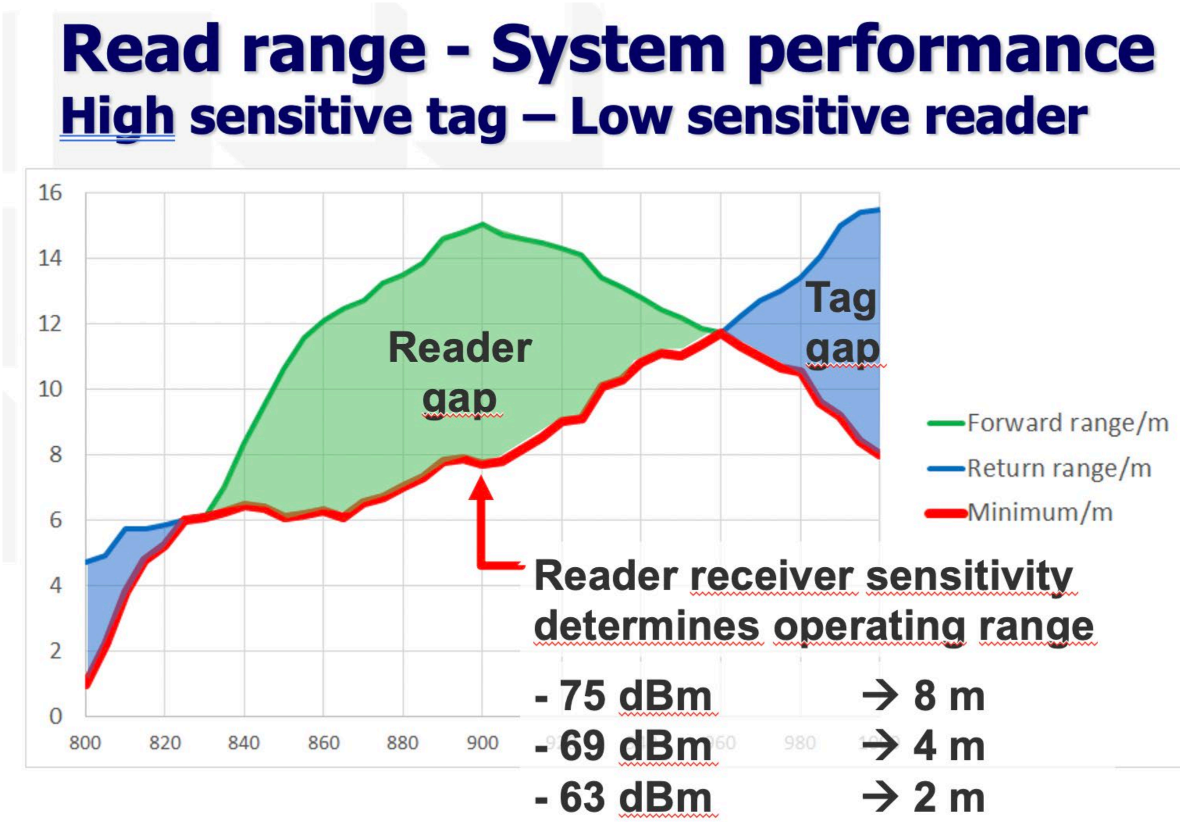

Figure 7: RAIN RFID System limitations

NOTE: In multi-reader environment, tags may be influenced by received commands from multiple readers as the tag is not frequency selective, which might have significant impact on the ability of the tag to respond. ISO/IEC 18046-3 clause 9.5 “Interference rejection” describes a test method for this.

5 Country list

The information included in this Clause and is believed to be correct as of publication of this document. Regulations can change at any time. Users of this information are advised to contact the country in question before making any decisions. RAIN is not liable for the accuracy of this information.

Country codes are a best effort, however, unofficial overview with no liability of UHF allocations for RAIN RFID within the 860 to 960 MHz band worldwide.

All worldwide countries and shows the applicable code. "nyi" means that RAIN RFID has "not yet investigated".

NOTE: Adoption of EU9A is an ongoing effort and several updates are expected in year 2020.

Table 5: Country list

COUNTRY	COUNTRY	APPLICABLE CODES
Albania	AL	EU8A
Algeria	DZ	
Argentina	AR	--- nyi
Armenia	AM	--- nyi
Andorra		EU8A
Australia	AU	--- nyi
Austria	AT	EU8A EU9A
Azerbaijan	AZ	EU8A
Bahrain	BH	--- nyi
Bangladesh	BD	--- nyi
Belarus	BY	EU8A
Belgium	BE	EU8A
Bolivia	BO	--- nyi
Bosnia and Herzegovina	BA	EU8A
Botswana	BW	--- nyi
Brazil	BR	
Brunei Darussalam	BN	--- nyi
Bulgaria	BG	EU8A
Cambodia	KH	--- nyi
Cameroon	CM	--- nyi
Canada	CA	US9A
Chile	CL	--- nyi
China	CN	
Colombia	CO	--- nyi
Congo, Rep.	CD	--- nyi
Costa Rica	CR	--- nyi
Côte d'Ivoire	CI	--- nyi
Croatia	HR	EU8A
Cuba	CU	--- nyi
Cyprus	CY	EU8A
Czech Republic	CZ	EU8A

COUNTRY	COUNTRY	APPLICABLE CODES
Denmark	DK	EU8A
Dominican Republic	DO	--- nyi
Ecuador	EC	--- nyi
Egypt, Arab Rep.	EG	--- nyi
El Salvador	SV	--- nyi
Estonia	EE	--- nyi
Finland	FI	EU8A
France	FR	EU8A
Georgia	GE	--- nyi
Germany	DE	EU8A
Ghana	GH	--- nyi
Greece	GR	EU8A
Guatemala	GT	--- nyi
Honduras	HN	--- nyi
Hong Kong, China	HK	--- nyi
Hungary	HU	EU8A
Iceland	IS	EU8A
India	IN	--- nyi
Indonesia	ID	--- nyi
Iran, Islamic Rep.	IR	--- nyi
Ireland	IE	--- nyi
Israel	IL	--- nyi
Italy	IT	EU8A
Jamaica	JM	--- nyi
Japan	JP	
Jordan	JO	--- nyi
Kazakhstan	KZ	--- nyi
Kenya	KE	--- nyi
Korea (DPR)	KP	--- nyi
Korea, Rep.	KR	--- nyi
Kuwait	KW	--- nyi
Kyrgyz Republic	KG	--- nyi
Latvia	LV	EU8A

COUNTRY	COUNTRY	APPLICABLE CODES
Lebanon	LB	--- nyi
Libya	LY	--- nyi
Liechtenstein	LI	EU8A
Lithuania	LT	EU8A
Luxembourg	LU	EU8A
Macao, China	MO	--- nyi
Macedonia, FYR	MK	EU8A
Malaysia	MY	--- nyi
Malta	MT	EU8A
Mauritius	MU	--- nyi
Mexico	MX	--- nyi
Moldova	MD	EU8A
Mongolia	MN	--- nyi
Montenegro	ME	--- nyi
Monaco		EU8A
Morocco	MA	
Netherlands	NL	EU8A
New Zealand	NZ	--- nyi
Nicaragua	NI	--- nyi
Nigeria	NG	--- nyi
Norway	NO	EU8A
Oman	OM	--- nyi
Pakistan	PK	--- nyi
Panama	PA	--- nyi
Paraguay	PY	--- nyi
Peru	PE	--- nyi
Philippines	PH	--- nyi
Poland	PL	EU8A
Portugal	PT	EU8A
Romania	RO	EU8A
Russian Federation	RU	--- nyi
San Marino		EU8A
Saudi Arabia	SA	--- nyi

COUNTRY	COUNTRY	APPLICABLE CODES
Senegal	SN	--- nyi
Serbia	RS	EU8A
Singapore	SG	--- nyi
Slovak Republic	SK	--- nyi
Slovenia	SI	EU8A
South Africa	ZA	--- nyi
Spain	ES	EU8A
Sri Lanka	LK	--- nyi
Sudan	SD	--- nyi
Sweden	SE	EU8A
Switzerland	CH	EU8A
Syrian Arab Rep.	SY	--- nyi
Taiwan	TW	--- nyi
Tajikistan	TJ	--- nyi
Tanzania	TZ	--- nyi
Thailand	TH	--- nyi
Trinidad and Tobago	TT	--- nyi
Tunisia	TN	--- nyi
Turkey	TR	EU8A
Turkmenistan	TM	--- nyi
Uganda	UG	--- nyi
Ukraine	UA	--- nyi
United Arab Emirates	AE	--- nyi
United Kingdom	GB	EU8A
United States	US	US9A
Uruguay	UY	--- nyi
Uzbekistan	UZ	--- nyi
Venezuela, RB	VE	--- nyi
Vietnam	VN	--- nyi
Yemen, Rep.	YE	--- nyi
Zimbabwe	ZW	--- nyi

6 Background and Contributors

This document was developed within the RAIN RFID Technical Workgroup. While frequently updated drafts were available for comment to the entire Workgroup, the following contributors played a major role in shaping the final document:

Bernhard Hinteregger	(ST Microelectronics)
Bertus Pretorius	(LicenSys)
Jacques Hulshof	(RAIN Alliance)
Jim Springer	(EM Microelectronic)
Josef Preishuber-Pflügl	(CISC Semiconductor GmbH)
Thomas J. Frederick	(Clairvoyant Technology LLC)

ABOUT RAIN RFID ALLIANCE

The RAIN RFID Alliance is an organization supporting the universal adoption of RAIN UHF RFID technology. A wireless technology that connects billions of everyday items to the internet, enabling businesses and consumers to identify, locate, authenticate, and engage each item. The technology is based on the EPC Gen2 UHF RFID specification, incorporated into the ISO/IEC 18000-63 standard. For more information, visit www.RAINRFID.org. The RAIN Alliance is part of AIM, Inc. AIM is the trusted worldwide industry association for the automatic identification industry, providing unbiased information, educational resources, and standards for nearly half a century.

RAIN RFID Alliance

One Landmark North
20399 Route 19
Cranberry Township, PA 16066

Visit the RAIN RFID website – RAINRFID.org.

If you are interested in learning more about the RAIN RFID Alliance, contact us at info@rainrfid.org.