BTAG Internal Design Validation Procedure

Document Version: 0.23

Revision Date: 08-14-2012

(page left blank)

Table of Contents

1 About This Document

1.1 Purpose

The purpose of this document is to describe the procedure for each of the tests that will be run as part of the BTAG Internal Design Validation. The intended audience is the engineer/technician performing the tests.

1.2 Document Owners

Requests for corrections or changes should be refered to Justin Reina or Paul Hamlow.

1.3 Distribution Policy
1.4 Revision Control

All test documentation is located in a source repository found here on the Intel Network. You must be granted access to view:

\\VMSPFSFSEG01\BTag\Testing\TestCodeRepos\TestSpec

No revision history is listed in this document or any other, and instead is tracked in the source repositories' log. All test documentation is tracked under a single source and revision number for uniformity.

1.5 References

BTAG Internal Design Validation Test Plan

BTAG Internal Design Validation Test Apparatus

1.6 Glossary

The terms, abbreviations and acronyms listed in Table 1 are used in this document.

Table 1: Terms, Abbreviations and Acronyms

Term	Description
ARTEST	
BTAG	Intel RFID tag designed for use in the Brazilian market.
DUT	Device Under Test
EPC	Electronic Product Code
FOV	Field of view. Defined as area in front of antenna where th antenna's sensitivity is > -30dBm from peak strength. Always measured with respect to either the RFID tag or the RFID Antenna. If not explicitly stated, assume it is measured with respect to the RFID antenna.
G1	First release of the SINIAV protocol
G0	Second release of the SINIAV protocol
PA	ARTEST Protocol
OTA	Over-the-Air
RFID	Radio frequency identification
SINIAV	Sistema Nacional de Identificação Automática de Veículos (National System for Automatic Identification of Vehicles)
wrt	with respect to

2 Functional Tests

2.1 Summary

2.2 P1.1.1 – Wakeup Response Time

Description:

Measure the time taken between active RF from reader and the tag's first successful query command demodulation against RF power level. Test with tag in case.

Purpose:

Baseband Radio bandwidths are first-order and have signal-level dependant DC settling times. While there is no requirement on this wakeup parameter, long wakeup times do impact performance and need to be characterized.

Requirements:

1. There is no specification for minimum wakeup timing.

2. Generate a branch of BTAG firmware which asserts P4.4 for **1.00ms** after correctly decoding the final bit of a query command.

3. Measure the period between first rising CW signal on PCB at PG17 (*on BTAG 0.54.1) and first rising edge on the debug pin P4.4 at PG13 (*on BTAG 0.54.1).

4. Perform #3 over a range of attenuator values [0:3:21].
    a. Repeat measurement a minimum of **(12) times** for each DUT tested.

5. For each data point, initiate measurement from Idle RF. Perform RFID inventory for **500ms** seconds. If no activity was observed for measurement, record as **'-1'** for result. Do not just discard point, as this is an error!

Apparatus:

Test Apparatus 3: OTA with oscope

Operator Procedure:

1. Execute *'Test Setup Procedure'* in [1].

2. Procure the required tags defined in ***runSpec***. BTAGs tested are in case, with signal wires routed through hole in bottom of case.

3. For each sample in ***runSpec***, Execute 'Test *Execution Procedure'* in [1]. Follow instructions by TestApplication

4. For each test point defined in ***runSpec***, execute test and store results per '*Test Execution Procedure*' in [1].
    a. App will launch reader, request operator to setup tag, and then have operator click 'Next' to acquire each data point, one at a time.

5. Log Results per '*Test Result Storage Procedure*' in [1].

Procedure/Algorithm Description:

1. Tag is placed 1m away from antenna on stand in 0°/0° orientation. ensure wires from tag to oscope are routed out of the FOV.

2. Reader boots and loads standard configuration as defined in '*Standard Reader Configurations*' [2]

3. Reader performs a series of 500ms EPC inventories. Test application controls this, having operator setup oscope, and attenuator, and record **Twakeup**[ms] for each run. Application requests operator to set attenuation from 0 to 21dB in steps of 3dB, and at each attenuation value it runs (12) 500ms inventories. Results are recorded to file.

The example below is from 2.1.1 – EPC Inventory Reliability

2.3 P1.2.1 – Low-Power Sleep Entry/Exit Validation

Description:

Monitor the receive comparator's enable line to understand the power state of the Btag over a rfid inventory cycle. The receive comparator is only disabled (DEMOD_ENABLE goes low) when the tag enters low-power sleep, and only enabled on the case where the tag wakes up from low-power sleep.

Purpose:

High-Level validation that the tag goes back to sleep after 750ms. This will add validation to our power budget calculations.

Requirements:

6. Execute a 150ms inventory of the rfid tag and take a scope shot.

7. Configure scope as follows: tdiv=200ms/div. Set toffset=+900ms. use Ch1 as Tx (P1.7*), Ch2 as Rx (P1.2*) and DEMOD_ENABLE (P3.7*) and Ch4 as Vcc. Offset each so they can be clearly oserved on oscope. use vdiv=5V/div on Ch1/2/3, 1V/div for Ch4. use single trigger on rising edge of Ch3, Vtrig=2.0V rising.

8. Connect breakout wires to Rx, Tx, DEMOD_ENABLE and Vcc. There is no pad for DEMOD_ENABLE, instead solder a wire to the top of C4 (green square in picture below).
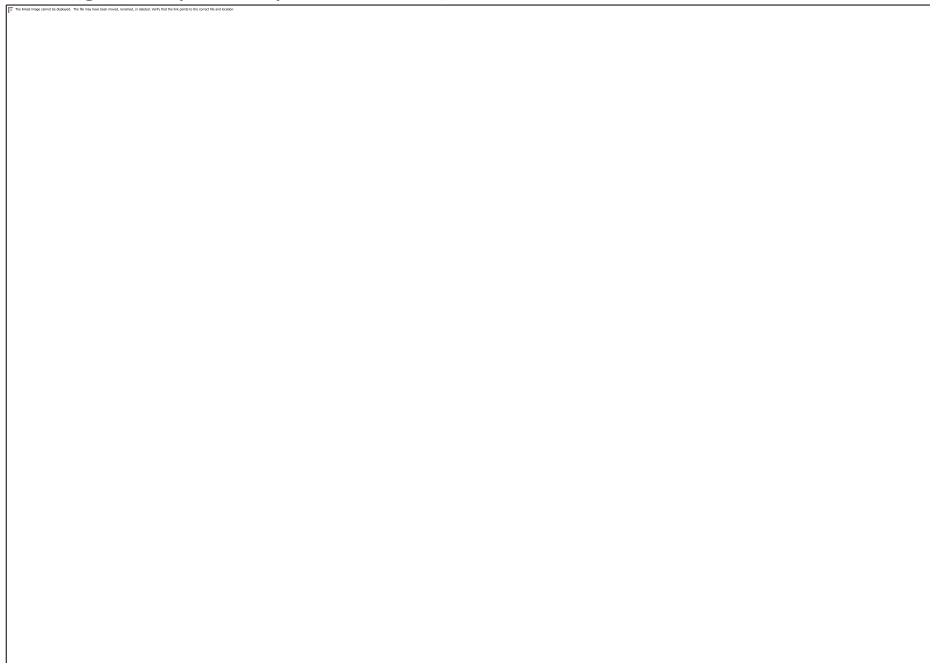
9. For Item #1, record a scope shot of each transaction to the USB stick as a PNG. Repeat this 30 times per tag.

Apparatus:

      Test Apparatus 4:

Operator Procedure:

3 EPC Protocol Compliance Tests

3.1 Summary

3.2   P2.1.1 – EPC Inventory Reliability

Description:

Provide a baseline characterization/validation of EPC inventory rates of BTAG against a reader and compared to reference tags. Record number of reads per 3 second repeatedly over many units.

Purpose:

Understand a baseline performance metric of EPC for tag over several units as compared to a few reference tags, and possibly over many RFID readers.

Requirements:

1. BTAG is in case.

2. Perform inventory measurements over a **3000 ms** inventory, repeated **50 times**.
    a.   The idle time between measurements shall be **600ms.**

Apparatus:

Test Apparatus 1: OTA standard

Operator Procedure:

1. Execute *'Test Setup Procedure'* in [1].

2. Procure the required tags defined in *runSpec*. BTAGs tested are in case.

3. For each sample in *runSpec*, Execute 'Test *Execution Procedure'* in [1]. Follow instructions by TestApplication

4. For each test point defined in *runSpec*, execute test and store results per '*Test Execution Procedure*' in [1].
    a.   App will launch reader, request operator to setup tag, and then have operator click 'Next' to acquire the full test data (i.e. fully automated). Test will provide indication to operator when complete.

5. Log Results per '*Test Result Storage Procedure*' in [1].

Procedure/Algorithm Description:

1. Tag is placed 1m away from antenna on stand in 0°/0° orientation (i.e. TestApparatus 1).

2. Reader boots and loads standard configuration as defined in '*Standard Reader Configurations*' [2].

3. Reader performs a series of (50) 3000ms EPC inventories. Test application controls this, recording the readCount, average RSSI and stdDevRSSI for each 3000ms inventory as a single <result/> element in result file. Results are stored to file.
    a.   Between each inventory the reader dwells in idle for 600ms

3.3   P2.1.2 – EPC Multi-Tag Inventory

Description:

Test the Btag in an environment consisting of multiple rfid tags, either other btags or reference tags. Validate the Btag's ability to co-exist in this environment with uniform (or acceptable) inventory rates across different configurations and combinations of tags. Multi-Tag operation is implemented through the random-number generator (RNG) within the tag which seeds a EPC inventory state-variable, the *slot-count*.

Slot Count values are set for each tag at the beginning of an inventory off the sent parameter *Q* from the reader. A tag will load its slot count as a random number pulled from its RNG, and then cap this value at $2^{(Q-1)}$. During inventory tags decrement their slot count during different commands. When the slot count reaches zero, a tag will talk back.

Purpose:

If the implementation of this *mechanism* or the implementation of the *rfid state machine* is not in compliance, multi-tag operation will be compromised or just fail completely. There is no hard requirement for multi-tag in ARTESP/SINIAV, but there is in ISO18000-6C and if the Btag is not in soft-compliance in multi-tag this will be a big issue to resolve with the certifying bodies.

Requirements:

1. For a selection of rfid tags including BTags and/or reference tags measure tag count quantities over a specified duration **(DwellMs)** using different values of **Q.**
   a.   Each tag must have a unique EPC ID.
   b.   The test shall repeat the inventory **10** times and record the results to file.

2. For each run of the test a different apparatus (affects tag-tag spacing) may be used. Currently this test is supported by apparatus 7.0 and 8.0.

3. This test may be executed with different physical layouts of the tags across the test apparatus (e.g. swap tag locations and repeat the test). For each test, the locations of each individual tag , in addition to that tag's unique EPC, must be recorded for later analysis.

Apparatus:

Test Apparatus 7 or 8.

Operator Procedure:

1. Execute *'Test Setup Procedure'* in [1].

2. Procure the required tags defined in *runSpec*. BTAGs tested are in case.

3. For each sample in *runSpec*, Execute 'Test *Execution Procedure'* in [1]. Follow instructions by TestApplication

4. For each test point defined in *runSpec*, execute test and store results per '*Test Execution Procedure*' in [1].
   a.   App will launch reader, request operator to setup tag, and then have operator click 'Next' to acquire the full test data (i.e. fully automated). Test will provide indication to operator when complete.

5. Log Results per '*Test Result Storage Procedure*' in [1].

3.4   P2.2.1 – EPC Read Compliance

Description:

Validate compliance of BTAG against a large range of possible EPC Read Command Parameters, and validate proper memory permissions/access per ARTESP PASJ5511 protocol specification. Exercise tag over a full range, with good coverage, of bank/pointer/lengths for the read command.

Purpose:

Validation of EPC Read Compliance and ARTESP PA memory permissions.

Requirements:

1. For each combination below, attempt an EPC read
    a. each **memory bank (RES/TID/UII/USR)**
    b. each **offset from [0..BankLength] as calculated below:**

    ```
    int newOffsetVal = oldOffsetVal + 2;

    if(bankLength < 30) {
            return newOffsetVal;
    }
    if(newOffsetVal >30) {

            if(newOffsetVal <= (bankLength-15) ) {
                    newOffsetVal += 9;
            }
    }
    ```

2. each **length [0:1:(LENGTH-offset+5)]**
    a. *If a determined length is longer than 16 words, cap it to 16 words

3. For each attempt, perform up to **25 retries** if the attempt fails.
    a. when attempting retries, perform a 500ms sleep after the 10th & 20th sequential retries

Apparatus:

Test Apparatus 1: OTA standard

Operator Procedure:

1. Execute *'Test Setup Procedure'* in [1].

2. Procure the required tags defined in *runSpec*. BTAGs tested are in case.

3. For each sample in *runSpec*, Execute 'Test *Execution Procedure'* in [1]. Follow instructions by TestApplication.

4. For each test point defined in *runSpec*, execute test and store results per '*Test Execution Procedure*' in [1].
    a. App will launch reader, request operator to setup tag, and then have operator click 'Next' to acquire the full test data (i.e. fully automated). Test will provide indication to operator when complete.

5. Log Results per '*Test Result Storage Procedure*' in [1].

Procedure/Algorithm Description:

1. Tag is placed 1m away from antenna on stand in 0°/0° orientation (i.e. TestApparatus 1).

2. Reader boots and loads standard configuration as defined in '*Standard Reader Configurations*' [2].

3. Reader performs a series of EPC Reads. Test application controls this, recording the readResult and numRetries for each EPC Read as an <result/> element in result file. If reader reports a memLock/memOverrun error, this is also logged. Results are stored to file.

3.5 P2.3.1 – EPC Write Compliance

Description:

Validate compliance of BTAG against the full range of possible EPC Write Command Parameters, and validate proper memory permissions/access per ARTESP PASJ5511 protocol specification. Exercise tag over a full range, with good coverage, of bank/pointer for the Write command.

Purpose:

Understand a baseline performance metric of EPC for tag over several units as compared to a few reference tags.

Requirements:

1. Measure performance over **(6) units**, and compare to **(6)** reference tags. BTAGs are in case.

2. For each combination below, attempt an EPC Read, Write, Read of length=1 using a random 16-bit value.
   b. each **memory bank (RES/TID/UII/USR)**
   c. each **offset [0:1:BANK_LENGTH+5]**

3. For the sequence in #2, repeat this **4** times

4. For the special case of the PC word in UII[1], read the value of this word first, then write that value. do not write a new value to the PC.

5. For each attempt, perform up to **25 retries** if the attempt fails.
   d. when attempting retries, perform a 500ms sleep after the 10th & 20th sequential retries

6. For each write or read, the reader application shall sleep 50ms before executing another read or write

Apparatus:

Test Apparatus 1: OTA standard

Operator Procedure:

1. Execute *'Test Setup Procedure'* in [1].

2. Procure the required tags defined in *runSpec*. BTAGs tested are in case.

3. For each sample in *runSpec*, Execute 'Test *Execution Procedure'* in [1]. Follow instructions by TestApplication

4. For each test point defined in *runSpec*, execute test and store results per '*Test Execution Procedure*' in [1].
   a. App will launch reader, request operator to setup tag, and then have operator click 'Next' to acquire the full test data (i.e. fully automated). Test will provide indication to operator when complete.

5. Log Results per '*Test Result Storage Procedure*' in [1].

Procedure/Algorithm Description:

1. Tag is placed 1m away from antenna on stand in 0°/0° orientation (i.e. TestApparatus 1).

2. Reader boots and loads standard configuration as defined in '*Standard Reader Configurations*' [2].

3. Reader performs a series of write attempts. Each write attempt starts with an EPC read of that word in memory. A write is then attempted of a random value, finally followed by a final read for verification. Test application controls this, recording the data/readCount/numAttempts, inventory as a single <result/> element in result file. Results are stored to file.
   a. After each read or write the reader shall pause in idle RF for a minimum of 50ms.

4. For each Write attempt, the following outcomes are defined:
   a. '0': write failed on number of retries
   b. '1': received an expected overrun response when trying to write outside the bank.
   c. '2': received an unexpected memory overrun response for a valid write location
   d. '3': received an expected lock response when trying to write to a locked word.
   e. '4': received an unexpected lock response for a valid write location.
   f. '5': write reported successful to a word outside bank limits
   g. '6': write reported successful to a locked word
   h. '7': write succeeded, but verification read failed
   i. '8': write succeeded, but verification read reported unexpected lock
   j. '9': write succeeded, but verification read reported unexpected overrun
   k. '10': write succeeded and verification data matched
   l. '11': write succeeded but verification data failed

3.6 P2.4.1 – EPC Select Memory Access Compliance

Description:

Exercise the EPC Select command over the (4) banks, varying bitPtr and length for both a matching & non-matching mask. Interrogate specific regions including bitPtr=0, 127 (i.e. min and max). Also interrogate a few ARTESP permissions 'areas of interest' in the UII and TID banks. Vary length around each interest area of a few lengths.

Purpose:

Validate compliance of The EPC Memory Access model wrt to memory location. Coverage over bitPtr and length over the (4) RFID Banks. The Custom protocols specify specific memory models for the Select command, and these are covered as well.

Requirements:

1. BTAGs are in case. Tags may be activated or non-activated, memory map model dependent.

2. For each combination below, attempt an EPC Read of
    a. BANK=RES, wordCt=1, wordPtr=0, retries=2
    b. Query.Sel = **SL** (3)

3. Using these combinations of the Select Filter
    a. each **memory bank (RES/TID/UII/USR)**
        i. each **bitPtr (0, 124, 127)**
        ii. each **length (1, 3, 7, 8, 11)**
    b. in **memory bank TID**
        i. each **bitPtr (39, 45, 46, 47)**
        ii. each **length (1, 3, 7, 8, 11)**
    c. in **memory bank UII**
        i. each **bitPtr (71, 77, 78, 79)**
        ii. each **length (1, 3, 7, 8, 11)**

    All select filter configurations shall use **action = ASSERT_DEASSERT(0)**

4. The reader shall remain idle for a minimum of 600ms between inventories

Apparatus:

Test Apparatus 1: OTA standard

Operator Procedure:

1. Execute *'Test Setup Procedure'* in [1].

2. Procure the required tags defined in *runSpec*. BTAGs tested are in case.

3. For each sample in *runSpec*, Execute 'Test *Execution Procedure'* in [1]. Follow instructions by TestApplication

4. For each test point defined in *runSpec*, execute test and store results per '*Test Execution Procedure*' in [1].
    a. App will launch reader, request operator to setup tag, and then have operator click 'Next' to acquire the full test data (i.e. fully automated). Test will provide indication to operator when complete.

5. Log Results per '*Test Result Storage Procedure*' in [1].

Procedure/Algorithm Description:

1. Tag is placed 1m away from antenna on stand in 0°/0° orientation (i.e. TestApparatus 1).

2. Reader boots and loads standard configuration as defined in '*Standard Reader Configurations*' [2].

3. Reader performs a series of 100ms inventories with different filter configurations applied. The result is recorded. Test application controls this, recording the result as a single <result/> element in result file. Results are stored to file.
    a. After each inventory the reader should pause in idle RF for a minimum of 20ms.

3.7 P2.4.2 – EPC Select Action Compliance

Description:

Validate compliance of BTAG against the full range of possible EPC Select Command actions. Exercise tag over a full range, with good coverage, of action/target for the Write command, including the specific PA SJ5111 configurations.

Purpose:

Understand a baseline performance metric of EPC for tag over several units as compared to a few reference tags. The Select command compliance is a requirement for ARTESP certification. Additionally as each reader executes the select actions in its own interpretations, this will provide good verification of Btag behavior wrt to reference tags.

Requirements:

1. Measure performance over **(10) units**, and compare to **(4)** reference tags. BTAGs are in case.

2. For each combination below, attempt a 100ms EPC inventory
    a. mask = **matching**, **non-matching**
    b. action values **0-7** for target **SL** *(or as many as reader allows)*
    c. action values **0-7** for target **Inventoried***(or as many as reader allows)*
    d. **memory bank (RES)**
    e. each **offset[0:2:4]**
    f. each **length[1:2:6]**

3. For each ARTESP combination below, attempt a 100ms EPC inventory
    a. mask = **matching**, **non-matching**
    a. action values **0-7** for target **SL** *(or as many as reader allows)*
    b. action values **0-7** for target **Inventoried***(or as many as reader allows)*
    c. each vector below
        i. bank=TID / ptr=0   / length=24 / mask=$0xE28194_h$
        ii. bank=TID / ptr=0   / length=20 / mask=$0xE2819_h$
        iii. bank=TID / ptr=8   / length=14 / mask=$0b10000001100101_2$
        iv. bank=UII / ptr=32 / length=8 / mask=first byte of EPC

Apparatus:

Test Apparatus 1: OTA standard

Operator Procedure:

1. Execute *'Test Setup Procedure'* in [1].

2. Procure the required tags defined in **runSpec**. BTAGs tested are in case.

3. For each sample in **runSpec**, Execute 'Test *Execution Procedure'* in [1]. Follow instructions by TestApplication

4. For each test point defined in **runSpec**, execute test and store results per '*Test Execution Procedure*' in [1].
   a. App will launch reader, request operator to setup tag, and then have operator click 'Next' to acquire the full test data (i.e. fully automated). Test will provide indication to operator when complete.

5. Log Results per '*Test Result Storage Procedure*' in [1].

Procedure/Algorithm Description:

4. Tag is placed 1m away from antenna on stand in 0°/0° orientation (i.e. TestApparatus 1).

5. Reader boots and loads standard configuration as defined in '*Standard Reader Configurations*' [2].

6. Reader performs a series of 100ms inventories with different filter configurations applied. The result is recorded. Test application controls this, recording the result as a single <result/> element in result file. Results are stored to file.
   a. After each inventory the reader should pause in idle RF for a minimum of 20ms.

3.8   P2.4.3 – Select Filter Subset from ARTESP Certification

For the test vectors listed in test SLM#1 found in test spec [15], a certain subset can be reproduced using a Sirit Reader and their RAPID SDK. This test shall exercise these vectors.

Description:

Validate a series of EPC Select filter configurations which capture the memory bounds of the ARTESP SJ5511 V1.0.0 protocol well.

Purpose:

Validation of the set of test vectors in SLM#1 in [15].

Requirements:

1. For the following test vectors, record the tag's response to **(4) 500ms** inventories (listed on next page)
   a. Perform a 650ms idle CW dwell between inventories.

(Listed Test Vectors for 2.4.3):

PreConditions

Tag Type	ARTESP SJ5511 V1.0.0
Tag State	Activated or Not-Activated. This is specified, and expected results listed below for each.
Initial State	S0.InvFlag=A, InvSelFlag = ~SL
RES Mem (00)	Don't Care (DC)
UII Mem (01)	CRC16 + 0x1800001001FFFFFF
TID Mem (10)	0xE28194004000000000
USR Mem (11)	0xAAAAAAAAAAAAAAAA..toEnd

Test Vectors

											Tag State = NOT ACTIVATED				Tag State = ACTIVATED					
	Select Command Config						Query Command Config				Select Command Resp		Query Command Resp			Select Command Resp			Query Command Resp	
ID	**Tgt**	**Act**	**Bank**	**Ptr**	**Len**	**Mask**	**Q.Sel**	**Q.Sess**	**Q.Tgt**	**Q.q**	**Mask Matches?**	**Sel Filter Action**	**Query Sel Field Matches?**	**Exp Query Resp(not_act)**	**SLM#1 Listed Vector**	**Mask Matches?**	**Mem Permitted?**	**Sel Filter Action**	**Query Sel Field Matches?**	**Exp Query Resp(act)**	**SLM#1 Listed Vector**
1	100	100	00	0x000, 0x003E, 0x007F	8	0xFF	SL	S0	A	0	D.C	Ignore	N	No Resp	-	D.C	N	Ignore	N	No Resp	No Resp
2	100	100	00	0x000, 0x003E, 0x007F	8	0xFF	~SL	S0	A	0	D.C	Ignore	Y	Resp	-	D.C	N	Ignore	Y	Resp	Resp
3	100	000	00	0x000, 0x003E, 0x007F	8	0xFF	SL	S0	A	0	D.C	Ignore	N	No Resp	-	D.C	N	Ignore	N	No Resp	No Resp
4	100	000	00	0x000	8	0xFF	~SL	S0	A	0	D.C	Ignore	Y	Resp	-	D.C	N	Ignore	Y	Resp	Resp
5	100	000	01	0x028	19	0x1001E	SL	S0	A	0	Y	match, so assert SL	Y	Resp	-	Y	Y	match, so assert SL	Y	Resp	Resp
6	100	000	01	0x028	19	0x1001E	~SL	S0	A	0	Y	match, so assert SL	N	No Resp	-	Y	Y	match, so assert SL	N	No Resp	No Resp
7	100	100	01	0x028	19	0xFFFFF	SL	S0	A	0	N	!match, so assert SL	Y	Resp	-	N	Y	!match, so assert SL	Y	Resp	Resp
8	100	100	01	0x028	19	0xFFFFF	~SL	S0	A	0	N	!match, so assert SL	N	No Resp	-	N	Y	!match, so assert SL	N	No Resp	No Resp
9	100	000	10	0x008	14	0x8194	SL	S0	A	0	Y	match, so assert SL	Y	Resp	-	Y	Y	match, so assert SL	Y	Resp	Resp
10	100	000	10	0x008	14	0x8194	~SL	S0	A	0	Y	match, so assert SL	N	No Resp	-	Y	Y	match, so assert SL	N	No Resp	No Resp
11	100	100	10	0x008	14	0xFFFFF	SL	S0	A	0	N	!match, so assert SL	Y	Resp	-	N	Y	!match, so assert SL	Y	Resp	Resp
12	100	100	10	0x008	14	0xFFFFF	~SL	S0	A	0	N	!match, so assert SL	N	No Resp	-	N	Y	!match, so assert SL	N	No Resp	No Resp
13	100	000	10	0x000	16	0xE281	SL	S0	A	0	Y	match, so assert SL	Y	Resp	-	Y	Y	match, so assert SL	Y	Resp	Resp
14	100	000	10	0x000	16	0xE281	~SL	S0	A	0	Y	match, so assert SL	N	No Resp	-	Y	Y	match, so assert SL	N	No Resp	No Resp
15	100	100	10	0x000	16	0xFFFFF	SL	S0	A	0	N	!match, so assert SL	Y	Resp	-	N	Y	!match, so assert SL	Y	Resp	Resp
16	100	100	10	0x000	16	0xFFFFF	~SL	S0	A	0	N	!match, so assert SL	N	No Resp	-	N	Y	!match, so assert SL	N	No Resp	No Resp
17	100	000	10	0x010	32	0x94004000	SL	S0	A	0	Y	match, so assert SL	Y	Resp	-	Y	Y	match, so assert SL	Y	Resp	-
18	100	100	10	0x010	32	0xFFFFFFFF	SL	S0	A	0	N	!match, so assert SL	Y	Resp	-	N	Y	!match, so assert SL	Y	Resp	-
19	100	000	10	0x030	16	0x0000	SL	S0	A	0	Y	match, so assert SL	Y	Resp	-	Y	N	Ignore	N	No Resp	No Resp
20	100	100	10	0x0030, 0x0048, 0x0068	8	0xBB	SL	S0	A	0	N	!match, so assert SL	Y	Resp	-	N	N	Ignore	N	No Resp	No Resp
21	100	000	10	0x0030, 0x0048, 0x0068	8	0xBB	SL	S0	A	0	N	!match, so deassert SL	N	No Resp	-	N	N	Ignore	N	No Resp	No Resp
22	100	100	11	0x0000,0x0048,0x0078	8	0xBB	SL	S0	A	0	N	!match, so assert SL	Y	Resp	-	N	N	Ignore	N	No Resp	No Resp
23	100	100	11	0x0000,0x0048,0x0078	8	0xBB	~SL	S0	A	0	N	!match, so assert SL	N	No Resp	-	N	N	Ignore	Y	Resp	Resp
24	100	000	11	0x0000,0x0048,0x0078	8	0xAA	SL	S0	A	0	Y	match, so assert SL	Y	Resp	-	Y	N	Ignore	N	No Resp	No Resp
25	100	000	11	0x0000,0x0048,0x0078	8	0xAA	~SL	S0	A	0	Y	match, so assert SL	N	No Resp	-	Y	N	Ignore	Y	Resp	Resp

Apparatus:

Test Apparatus 1: OTA standard

Operator Procedure:

1. Execute *'Test Setup Procedure'* in [1].

2. Procure the required tags defined in **runSpec**. BTAGs tested are in case.

3. For each sample in **runSpec**, Execute *'Test Execution Procedure'* in [1]. Follow instructions by TestApplication

4. For each test point defined in **runSpec**, execute test and store results per *'Test Execution Procedure'* in [1].
   a. App will launch reader, request operator to setup tag, and then have operator click 'Next' to acquire the full test data (i.e. fully automated). Test will provide indication to operator when complete.

5. Log Results per *'Test Result Storage Procedure'* in [1].

Procedure/Algorithm Description:

1. Tag is placed 1m away from antenna on stand in 0°/0° orientation (i.e. TestApparatus 1).

2. Reader boots and loads standard configuration as defined in *'Standard Reader Configurations'* [2].

3. Reader performs a series of 500ms EPC inventories. Test application controls this
   a. Between each inventory the reader dwells in idle for 500m**s.**

3.10 P2.5.1 – EPC T1/T2 Compliance

Description:

Validation of the time-before-transmit (T1) and time-before-ready (T2) for tag responses to EPC commands.
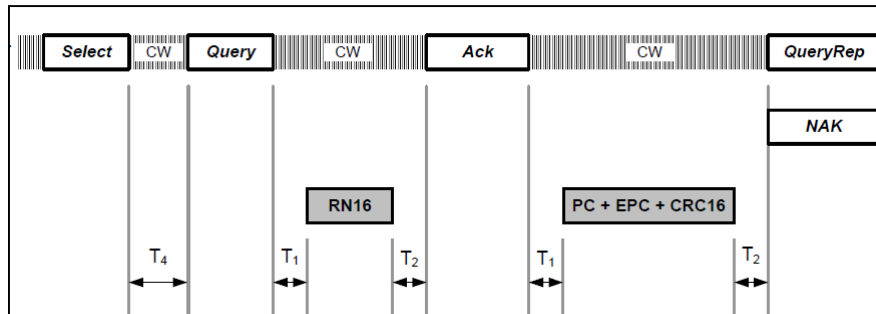

Figure 1: *Illustration of T1/T2 from EPC UHF Gen2 Spec.*

Purpose:

T1 and T2 are a requirement, and impact performance if they are not within the specified timing range. Expected values listed below in Table 2. Tags should ideally have T2=0us, but processing requirements limit this to something non-zero. BTAG is >15us typical.

Table 2: *Expected T1/T2 Measurements*

	T1[us]			T2[us]		
	min	nom	max	min	nom	max
LF=320kHz	26.13	31.25	36.38	9.38	62.50	62.50
LF=640kHz	11.28	15.63	19.97	4.69	31.25	31.25

Requirements:

1. For both Link Frequencies of 320kHz and 640kHz on a Sirit 510 reader using Q=3.

2. In a FOV with (2) reference tags and (1) Btag (DUT). Store a photograph of this configured test apparatus with each run.
   a. The reference tags are placed on cardboard mount directly above tag case and affixed to tag case with masking tape or equivalent. Document reference tag IDs in the Test Info notes. Any (2) tags can be selected.

3. Measure over (5) units T1 and T2 for the Query, QueryRep, QueryAdj, Ack, ReqRN, Read, and Write commands. Repeat the measurement for each command 15 times.

4. Generate individual branches of BTAG firmware which asserts P4.4 directly before responding to the selected command, and deasserts as the last instruction before becoming active to receive the next command. Use this rising edge trigger to capture timing measurements on the oscilloscope.
   a. For trigger assertion, use: P4DIR |=BIT4; P4OUT |= BIT4;
   b. For trigger de-assertion, use: P4OUT &= ~BIT4;

5. Measure Rx signal on PG17(*BTAG 0.54.1) using Ch1, Tx signal on PG4* using Ch2, and Trigger(P4.4) on PG13* using Ch3 of the oscilloscope.
   a. When capturing signals, use Single Trigger with time division set to 100us/div. also acquire in 'Normal Resolution'.
   b. Trigger on a falling edge of Ch3(*P4.4*) with a trigger level of 2.20V.

    c. T1 is defined as duration between last rising edge of reader command(Ch1) to the first rising edge of tag response (Ch2)

    d. T2 is defined as the time between the last falling edge of tag response (Ch2) and falling edge of Trigger pulse (Ch3).

Apparatus:

Test Apparatus 2: OTA standard with oscilloscope. For this test, the oscilloscope may be moved closer to the operator, offset and within FOV of tag antenna, to record measurements more efficiently.

Operator Procedure:

1. Execute *'Test Setup Procedure'* in [1].

2. Procure the required tags defined in **runSpec**. BTAGs tested are in case w/hole protruding from bottom to run wires to oscilloscope. Route wires through test apparatus. Ensure reference tags are in the FOV.

3. For each sample in **runSpec**, Execute 'Test *Execution Procedure'* in [1]. Follow instructions by TestApplication

4. For each test point defined in **runSpec**, execute test and store results per '*Test Execution Procedure*' in [1].
   a. App will launch reader and then proceed through a sequence of T1/T2 measurements for each command. The App will pause in between different commands, requesting the operator reflash the BTAG to the appropriate FW version for next test.

5. Log Results per '*Test Result Storage Procedure*' in [1].

Procedure/Algorithm Description:

1. Tag is placed 1m away from antenna on stand in 0°/0° orientation (i.e. TestApparatus 1). (2) reference tags are placed on cardboard mount directly above tag case and affixed to tag case with masking tape or equivalent.

2. Reader boots and loads standard configuration as defined in '*Standard Reader Configurations*' [2].

3. Reader will initiate an active inventory, and will halt this inventory when the operator presses 'RF Off'. The operator will then input the measured values and press 'Submit' to proceed to the next measurement. Application will log results to file upon completion.
   a. During the query measurement, Q=0 so that tag actually responds to queries! return to Q=3 for other tests.

3.11 P2.6.1 – RNG Quality Compliance

Description:

Provide a characterization of the RNG random number quality, both bitwise and wordwise. Provide a verification of the RNG quality compliance for the EPC specification.

Purpose:

The RNG is required to meet a certain quality standard via the EPC specification, section 6.3.2.5 as follows:

1.   **Probability of a single RN16:** The probability that any RN16 drawn from the RNG has a value RN16=j, for any j, shall be bounded by 0.8/216 < P(RN16=j) < 1.25/216.

2.   **Probability of simultaneously identical sequences:** For a Tag population of up to 10,000 Tags, the probability that any two or more Tags simultaneously generate the same sequence of RN16's shall be less than 0.1%, regardless of when the Tags are energized.

3. **Probability of predicting an RN16:** An RN16 drawn from a Tag's RNG 10ms after the end of Tr in Figure 6.3 shall not be predictable with a probability greater than 0.025% if the outcomes of prior draws from the RNG, performed under identical conditions, are known.

Requirements:

2. The procured tags shall be in cases and in the initialization state.
3. Perform a series of 2000 EPC Reads to the following location:
   a. bank=User, ptr=0, length=8
   b. estimated time: 20min
4. Custom tag FW shall report back the RNG buffer instead of the actual user bank. This firmware shall additionally reseed the buffer after each successful read.
5. The test application shall dwell a minimum of 25ms between each read, and additionally attempt the reads with a retry value of 8.

Apparatus:

Test Apparatus 1: OTA standard

Operator Procedure:

6. Execute *'Test Setup Procedure'* in [1].
7. Procure the required tags defined in **runSpec**. BTAGs tested are in case.
8. For each sample in **runSpec**, Execute 'Test *Execution Procedure'* in [1]. Follow instructions by TestApplication
9. For each test point defined in **runSpec**, execute test and store results per '*Test Execution Procedure*' in [1].
   a. App will launch reader, request operator to setup tag, and then have operator click 'Next' to acquire the full test data (i.e. fully automated). Test will provide indication to operator when complete.
10. Log Results per '*Test Result Storage Procedure*' in [1].

Procedure/Algorithm Description:

3.12 2.6.2 – PA RNG Characterization

Description:

Provide a characterization of the RNG random number quality during the PA inventory procedure.

Purpose:

The RNG is required to meet a certain quality standard via the EPC specification, section 6.3.2.5 as follows:

1. **Probability of a single RN16**: The probability that any RN16 drawn from the RNG has a value RN16=j, for any j, shall be bounded by $0.8/2^{16} < P(RN16=j) < 1.25/2^{16}$.
2. **Probability of simultaneously identical sequences:** For a Tag population of up to 10,000 Tags, the probability that any two or more Tags simultaneously generate the same sequence of RN16's shall be less than 0.1%, regardless of when the Tags are energized.
3. **Probability of predicting an RN16:** An RN16 drawn from a Tag's RNG 10ms after the end of T_r in Figure 6.3 shall not be predictable with a probability greater than 0.025% if the outcomes of prior draws from the RNG, performed under identical conditions, are known.

Requirements:

1. The procured tags shall be in cases and in the activatedstate.
2. Perform a series of 2000 250 ms PA inventories, and record the returned RN16 value from the encrypted tag response.
3. A dwell of 750ms shall be applied between inventories.

Apparatus:

Test Apparatus 1: OTA standard

Operator Procedure:

1. Execute *'Test Setup Procedure'* in [1].
2. Procure the required tags defined in **runSpec**. BTAGs tested are in case.
3. For each sample in **runSpec**, Execute 'Test *Execution Procedure'* in [1]. Follow instructions by TestApplication
4. For each test point defined in **runSpec**, execute test and store results per '*Test Execution Procedure*' in [1].
   a. App will launch reader, request operator to setup tag, and then have operator click 'Next' to acquire the full test data (i.e. fully automated). Test will provide indication to operator when complete.
5. Log Results per '*Test Result Storage Procedure*' in [1].

Procedure/Algorithm Description:

3.13 Pn.n.n –
Description:

Purpose:

Requirements:

Apparatus:

Operator Procedure:

Procedure/Algorithm Description:

4 Custom Protocol Compliance Tests

4.1 Summary

4.2   3.1.1 - Siniav G0 OBU_Auth_ID Inventory Reliability

Description:

Provide a baseline characterization/validation of G0 Obu_Auth_ID inventory rates of BTAG against a reader supporting Siniav G0. Record number of reads per 3 seconds repeatedly over many units. This test will be executed against all available readers supporting Siniav G0.

Purpose:

Understand a baseline performance metric of Siniav G0 for tag over several units.

Requirements:

1. Measure performance over **(10) units**. BTAGs are in case.

2. Perform inventory measurements over a **3000 ms** inventory, repeated **50 times**.
   a. The idle time between measurements shall be **500ms.**

Apparatus:

Test Apparatus 1: OTA standard

Operator Procedure:

1. Execute *'Test Setup Procedure'* in [1].

2. Procure the required tags defined in ***runSpec***. BTAGs tested are in case.

3. For each sample in ***runSpec***, Execute 'Test *Execution Procedure'* in [1]. Follow instructions by TestApplication

4. For each test point defined in ***runSpec***, execute test and store results per '*Test Execution Procedure*' in [1].
   a. App will launch reader, request operator to setup tag, and then have operator click 'Next' to acquire the full test data (i.e. fully automated). Test will provide indication to operator when complete.

5. Log Results per '*Test Result Storage Procedure*' in [1].

Procedure/Algorithm Description:

1. Tag is placed 1m away from antenna on stand in 0°/0° orientation (i.e. TestApparatus 1).

2. Reader boots and loads standard configuration as defined in '*Standard Reader Configurations*' [2].

3. Reader performs a series of (50) 3000ms G0 Obu_Auth_ID inventories. Test application controls this, recording the readCount, average RSSI and stdDevRSSI for each 3000ms inventory as a single <result/> element in result file. Results are stored to file.
   a. Between each inventory the reader dwells in idle for 500ms

4.3   3.2.1 - PA OBU_Auth_ID Inventory Reliability

Description:

Provide a baseline characterization/validation of PA Obu_Auth_ID inventory rates of BTAG against a reader supporting PA. Record number of reads per 3 seconds repeatedly over many units. This test will be executed against all available readers supporting PA.

Purpose:

Understand a baseline performance metric of PA for tag over several units.

Requirements:

3. Measure performance over **(10) units**. BTAGs are in case.

4. Perform inventory measurements over a **3000 ms** inventory, repeated **50 times**.
   a. The idle time between measurements shall be **500ms.**

Apparatus:

Test Apparatus 1: OTA standard

Operator Procedure:

6. Execute *'Test Setup Procedure'* in [1].

7. Procure the required tags defined in *runSpec*. BTAGs tested are in case.

8. For each sample in *runSpec*, Execute 'Test *Execution Procedure'* in [1]. Follow instructions by TestApplication

9. For each test point defined in *runSpec*, execute test and store results per '*Test Execution Procedure*' in [1].
   a. App will launch reader, request operator to setup tag, and then have operator click 'Next' to acquire the full test data (i.e. fully automated). Test will provide indication to operator when complete.

10. Log Results per '*Test Result Storage Procedure*' in [1].

Procedure/Algorithm Description:

4. Tag is placed 1m away from antenna on stand in 0°/0° orientation (i.e. TestApparatus 1).

5. Reader boots and loads standard configuration as defined in '*Standard Reader Configurations*' [2].

6. Reader performs a series of (50) 3000ms PA Obu_Auth_ID inventories. Test application controls this, recording the readCount, average RSSI and stdDevRSSI for each 3000ms inventory as a single <result/> element in result file. Results are stored to file.
   a. Between each inventory the reader dwells in idle for 500ms

5 Protocol Reliability Tests

5.1 Summary

6 Electrical/RF Characterization Tests

6.1 Summary

Procedure Set: 6

- 6.1 – Full Lifetime Simulations
- 6.2 –
- 6.3 – RF Sensitivity
- 6.4 –

6.2   P6.1.1 - Lifetime – EPC Power Consumption

Description:

A basic test that performs EPC Inventories on (4) RF isolated tags on (4) separate antennas at a specified rate and duty cycle. Read performance for each tag is recorded, and the battery voltage monited.

Purpose:

A coarse level verification that the firmware remains operational over a long period. Also a coarse level verification of the battery performance of the tag

Requirements:

1. aispec: 100ms
2. rospec: 425ms
3. RF Power: 22dBm
4. attenuator: 10dB
5. store data point of reads every 30seconds
6. store Vcc measurement every 2 seconds
7. store waveform snapshot and trace every 30 minutes
8. After all 4 tags have stopped responding, halt the RF signal from reader. Continue recording Vcc for (1) day.

Apparatus:

Test Apparatus 6: Mini-Chamber Shielded OTA

Operator Procedure:

1. Execute *'Test Setup Procedure'* in [1].
2. Procure the required tags defined in ***runSpec***. BTAGs tested are in case.
3. For each sample in ***runSpec***, Execute 'Test *Execution Procedure'* in [1]. Follow instructions by TestApplication
4. For each test point defined in ***runSpec***, execute test and store results per '*Test Execution Procedure*' in [1].
   a. App will launch reader, request operator to setup tag, and then have operator click 'Next' to acquire the full test data (i.e. fully automated). Test will provide indication to operator when complete.
5. Log Results per '*Test Result Storage Procedure*' in [1].

Procedure/Algorithm Description:

1. Reader boots and initiates a single ROSpec to cycle through the 4 antennas. The reader leaves this running until the controlling application signals abort.
2. The DAQ and DAQ application begin acquiring Vcc samples according to the acquisition spec.
3. The data is recorded at the rates specified in a streaming to file format. The acquisition continues until all 4 tags stop reporting EPC reads.
4. The test operator with then halt the RFID test application, which yields idle RF.

6.3   P6.1.2 – Lifetime – PA Power Consumption

Description:

A basic test that performs PA Inventories on (4) RF isolated tags on (4) separate antennas at a specified rate and duty cycle. Read performance for each tag is recorded, and the battery voltage monited.

Purpose:

A coarse level verification that the firmware remains operational over a long period. Also a coarse level verification of the battery performance of the tag

Requirements:

1. aispec: 100ms
2. rospec: 425ms
3. RF Power: 22dBm
4. attenuator: 10dB
5. store data point of reads every 30seconds
6. store Vcc measurement every 2 seconds
7. store waveform snapshot and trace every 30 minutes
8. After all 4 tags have stopped responding, halt the RF signal from reader. Continue recording Vcc for (1) day.

Apparatus:

Test Apparatus 6: Mini-Chamber Shielded OTA

Operator Procedure:

1. Execute *'Test Setup Procedure'* in [1].
2. Procure the required tags defined in **runSpec**. BTAGs tested are in case.
3. For each sample in **runSpec**, Execute 'Test *Execution Procedure'* in [1]. Follow instructions by TestApplication
4. For each test point defined in **runSpec**, execute test and store results per '*Test Execution Procedure*' in [1].
   a. App will launch reader, request operator to setup tag, and then have operator click 'Next' to acquire the full test data (i.e. fully automated). Test will provide indication to operator when complete.
5. Log Results per '*Test Result Storage Procedure*' in [1].

Procedure/Algorithm Description:

1. Reader boots and initiates a single ROSpec to cycle through the 4 antennas. The reader leaves this running until the controlling application signals abort.

2. The DAQ and DAQ application begin acquiring Vcc samples according to the acquisition spec.

3. The data is recorded at the rates specified in a streaming to file format. The acquisition continues until all 4 tags stop reporting EPC reads.

4. The test operator with then halt the RFID test application, which yields idle RF.

6.4   P6.3.1 – OTA-Lab Min RF Sensitivity I

Description:

Test the minimum RF sensitivity of multiple tags both in a case and out of a case.

Purpose:

Minimum RF Sensitivity is a requirement of certification bodies. Understand variance in production over units. Understand minimum sensitivity in terms of both Receive (***Vbitline***) and Transmit (***RSSI***) signals.

Requirements:

1. Record RFID Reader's ***reported RSSI*** in dBm and **readCount** at different RF Power Levels
2. Perform #1 & #2 over a range of power levels using Test Apparatus 3
   a. To implement power levels, vary the inline attenuator from 0dB to MAXdB, or until the tag stops responding.
3. For each data point, initiate measurement from Idle RF. Perform RFID inventory for 4 seconds.
   a. In any given 4 second measurement, if 0 tags are found repeat measurement for <u>12</u> seconds.
   b. Test finishes when four consecutive measurements report 0 tags.

Apparatus:

Test Apparatus 3: OTA with inline attenuator

Operator Procedure:

1. Execute the '*Test Setup Procedure*' in [1] for ***Test_X_X_XrX***. locate the .EXE and runSpec.docx
2. Setup Test Apparatus defined in ***runSpec*** and as described in [2].
3. Procure the required tags defined in ***runSpec***.
4. For each test point defined in ***runSpec***, execute test and store results per '*Test Execution Procedure*' in [1]
   a. Follow instructions from ***Test_X_X_XrX.exe***, executing repeated measurements of #reads, RSSI as the operator increases the attenuation (per instruction of EXE).
5. Log Results per '*Test Result Storage Procedure*' in [1]

Procedure/Algorithm Description:

1. Tag is placed 1m away from antenna on stand
2. Reader boots and loads standard configuration as defined in '*Standard Reader Configurations*' [2]
3. Reader performs a series of 4 or 12 second EPC inventories. Test application controls this, having operator vary attenuation per run.
4. Test application records each measurements number of reads & average RSSI. results are stored to file on completion.

6.5 P6.3.2- OTA-Lab Spherical Signal Strength

Description:

Characterize the Receive and Transmit Signal Levels against orientation of tag wrt to reader.

Purpose:

Verification/Characterization of actual antenna/radio design. Not required for certification. Useful for later tag/case designs and analysis.

Requirements:

1. For the position points listed below (in degrees), execute each requirement while taking a 500ms EPC Inventory.
   a. Phi [-50:20:+50, 0]   : Theta[0:20:180]
   b. Phi [60:40:300]   : Theta[0:50:150,180]
   c. Phi[70,80,90,250,270,280]   : Theta[0:50:150,180]
2. Measure **Vbitline** on PCB at PG14 (*on BTAG 0.54.1) 1.75ms into active RF. Measure from CW level before a delimiter down to center point of delimiter.
3. Record RFID Reader's **reported RSSI** in dBm and **readCount** from the inventory.

Apparatus:

Test Apparatus 2: OTA with oscope. Ensure tag wires from PCB to oscope are as far away from antenna and FOV as possible for each data point.

Operator Procedure:

1. Execute the '*Test Setup Procedure*' in [1] for **Test_X_X_XrX**. locate the .EXE and runSpec.docx
2. Setup Test Apparatus defined in **runSpec** and as described in [2].
3. Procure the required tags defined in **runSpec**.
4. For each test point defined in **runSpec**, execute test and store results per '*Test Execution Procedure*' in [1]
   a. Follow instructions from **Test_X_X_XrX.exe**, executing repeated measurements of **Vbitline**, **readCount**, and **RSSI** as the operator increases the attenuation (per instruction of EXE).
5. Log Results per '*Test Result Storage Procedure*' in [1]

Procedure/Algorithm Description:

1. Tag is placed 1m away from antenna on stand, and orientation is set using phi/theta arrows as described in [2].
2. Reader boots and loads standard configuration as defined in '*Standard Reader Configurations*' [2]
3. Reader performs a series of 500ms EPC inventories. Test application controls this, having operator vary orientation, and record results.
   a. Before each measurement the oscope is configured for single trigger.
4. Operator inputs **Vbitline** measurement into application. Test application records **Vbitline**, **readCount**, **average rssi** and **standard deviation of rssi** for each orientation. Results stored to file after completion.

6.6 P6.3.3 – OTA-Lab Min RF Sensitivity II

Description:

Estimate the minimum RF sensitivity of the device as an aggregate value by estimation of the EPC Inventory Rate Performance. Note this is similar to the ARTESP testing specification, where at some low level the Inventory Rate reaches a *50%* threshold.
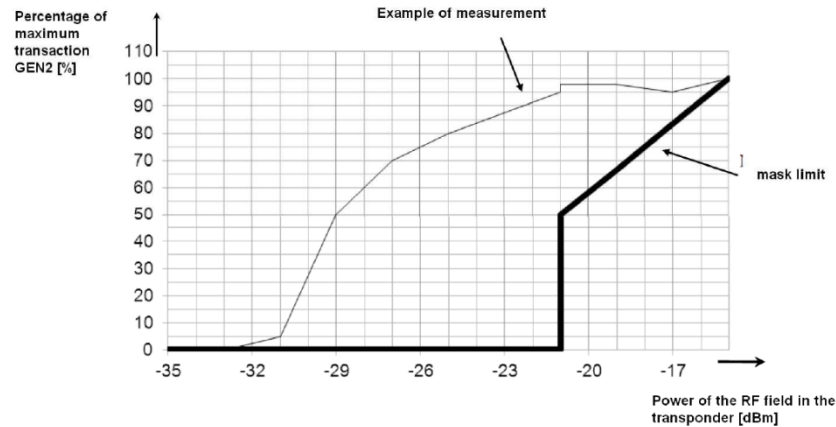

Figure 2: *Example Mask for performance limit for an EPC Performance Rate.*

Purpose:

Establish additional metrics on the tags minimum sensitivity.

Requirements:

     a. For each

Apparatus:

Test Apparatus 1: OTA standard

Operator Procedure:

11. Execute *'Test Setup Procedure'* in [1].

12. Procure the required tags defined in ***runSpec***. BTAGs tested are in case.

13. For each sample in ***runSpec***, Execute 'Test *Execution Procedure'* in [1]. Follow instructions by TestApplication

14. For each test point defined in ***runSpec***, execute test and store results per '*Test Execution Procedure*' in [1].
    a. App will launch reader, request operator to setup tag, and then have operator click 'Next' to acquire the full test data (i.e. fully automated). Test will provide indication to operator when complete.

15. Log Results per '*Test Result Storage Procedure*' in [1].

Procedure/Algorithm Description:

4. Tag is placed 1m away from antenna on stand in 0°/0° orientation (i.e. TestApparatus 1).

5. Reader boots and loads standard configuration as defined in '*Standard Reader Configurations*' [2].

6. Reader performs a series of (50) 3000ms EPC inventories. Test application controls this, recording the readCount, average RSSI and stdDevRSSI for each 3000ms inventory as a single <result/> element in result file. Results are stored to file.
   a. Between each inventory the reader dwells in idle for 500ms

6.7   P6.3.3 – OTA-Lab Backscatter Index

Description:

Measure the tag's backscatter strength as reported by the RSSI of an RFID Reader. Separate this data as a function of reader power and reader CW frequency. Additionally calculate the tag's backscatter modulation index.

Purpose:

Quantify the tag's backscatter strength across frequency and power.

Requirements:

1. For reader power levels of 30:0.5:0.5 dBm
2. Perform a 12 second inventory, capturing individual tag reads that report the tag's RSSI, and reader CW frequency.
3. Post-Process the reports and determine the average RSSI per frequency and power from each inventory. Assemble statistics as:
   a. >
   b. ?
   c. ?

Apparatus:

Test Apparatus 1.1: OTA standard

Operator Procedure:

16. Execute *'Test Setup Procedure'* in [1].

17. Procure the required tags defined in **runSpec**. BTAGs tested are in case.

18. For each sample in **runSpec**, Execute 'Test *Execution Procedure'* in [1]. Follow instructions by TestApplication

19. For each test point defined in **runSpec**, execute test and store results per '*Test Execution Procedure*' in [1].
    a. App will launch reader, request operator to setup tag, and then have operator click 'Next' to acquire the full test data (i.e. fully automated). Test will provide indication to operator when complete.

20. Log Results per '*Test Result Storage Procedure*' in [1].

Procedure/Algorithm Description:

7. Tag is placed 1m away from antenna on stand in 0°/0° orientation (i.e. TestApparatus 1).

8. Reader boots and loads standard configuration as defined in '*Standard Reader Configurations*' [2].

9. Reader performs a series of (50) 3000ms EPC inventories. Test application controls this, recording the readCount, average RSSI and stdDevRSSI for each 3000ms inventory as a single <result/> element in result file. Results are stored to file.
    a. Between each inventory the reader dwells in idle for 500ms

6.8   P6.4.1 – Radio Characterization - Baseband

Description:

Measure the variation in frequency response over many tags in the baseband radio section of the BTAG. Compare to reference information of predicted design values. Note: wires must be less than 3 inches.

Purpose:

Verification of BTAG radio baseband design over manufacturing lot for frequency response. Primary metric for this test is characterizing variation and comparison to designed behavior. An example of predicted behavior is illustrated below for BTAG 0.54.1:

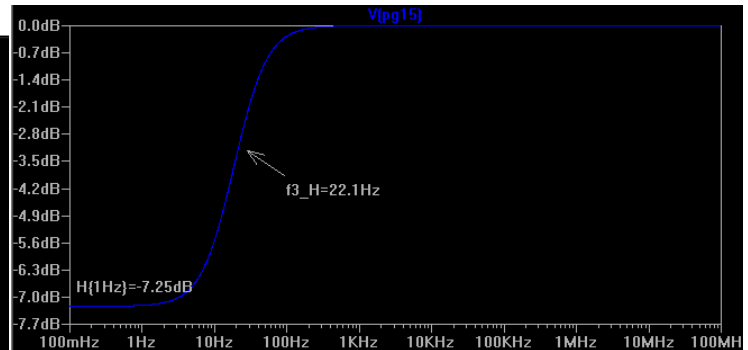**Figure 3:** *Predicted response for the measurement in test 1.*

Figure 4: *Predicted Response for the measurement in test 2. H{1Hz} is actually H{DC}.*

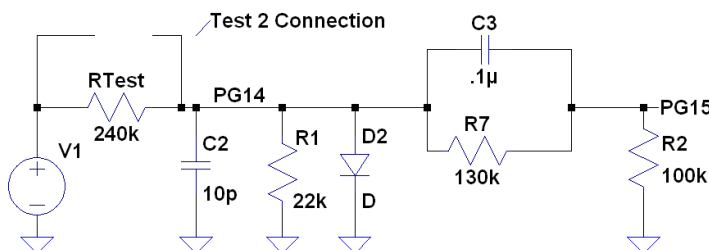**Figure 5:** *BTAG 0.54.1 HW representation for test 1*

Table 3: *Expected results for test*

	H{DC}[dB]	f3_L[Hz]	f3_H[kHz]
Test 1	-6.35	18.70	950.00
Test 2	-7.25	22.10	-

Requirements:

4. **Test 1:**
    a. Apply Vin_pkpk=3.50V using the function generator at the input of a 240kΩ resistor. Apply the output side of the resistor to node PG14. For frequencies in the range 1Hz..20MHz, record the amplitude of output waveforms at PG14 and PG15.
    b. Connect Ch1 of oscilloscope to VfcnGen(V1 in Figure). Connect Ch2 to PG14, or PG15, depending on measurement taken.

5. **Test 2:**
    a. Apply Vin_pkpk=250mV using the function generator directly at PG14. For frequencies in the range 1Hz..20MHz, record the amplitude of output waveform at PG15. Also record the DC value passed through.

6. For a lot of **(20) units**, execute Test 1 and Test 2 above. Store Amplitude[V] vs frequency to an Excel Table, and provide the calculated **H{DC}/f3_L/f3_H** for Test 1, and **H{1Hz}/f3_H** for Test 2. Also record measured resistor value, and measured input waveform level.

7. When stepping through frequencies, execute coarse logarithmic steps first, e.g. 1, 10, 100, 1k… 20MHz. After recording these values, go back through frequency range to selected regions where characteristic information (e.g. f3_L) needs to be retrieved and seek out those points directly.
   a. If any abnormalities arise during acquisition, note them and if necessary take more fine-resolution data to explain.

8. Measuring the DC frequency response is easiest to achieve by setting freq = 2kHz, vAmpl=60mV and vOffset=Test_Setting_For_V_pkpk [V]. Then record the Mean value of the 'RMS voltage' of the channel to record.

9. Oscilloscope shall be set in the following manner:
   a. Acquisition Mode: Averaging, 4 Sample
   b. Trigger on Ch1, rising edge, trigger=80mV
   c. Voltage divisions for Ch1 and Ch2 set to 200mV/div. Ensure entire waveform is viewed on screen, no clipping. For each measurement, ensure 3-4 periods are displayed on screen.
   d. If possible, use quick measurement for amplitude:mean to determine the waveform amplitude.

10. Function Generator shall be set in the following manner:
   a. Output Impedance is set to HighZ
   b. Output is Sine Wave, with V_low = 0.00V for all test points.

Apparatus:

Test Apparatus 4: Desktop Electrical Measurement with Function Generator and Oscilloscope version (see run spec for specific selection).

Operator Procedure:

21. measure actual value of resistor RTest and record.

22. Execute *'Test Setup Procedure'* in [1].

23. Procure the required tags defined in *runSpec*. BTAGs tested are not in case, and have no battery attached.

24. For each sample in *runSpec*, Execute 'Test *Execution Procedure'* in [1]. There is no test application for this test.
   a. Begin at f=1Hz
   b. Sweep range up to 20MHz
   c. Calculate estimated voltage levels for f3_L/f3_H, seek these values by adjusting the frequency. Record results
   d. Take a few more frequency measurements as needed
   e. Determine H{1Hz}. Record.

25. For each test point defined in *runSpec*, execute test and store results per '*Test Execution Procedure*' in [1].
   a. Generate one excel file per tag tested. Record identifying information on each tag and test into each excel result file.

26. Log Results per '*Test Result Storage Procedure*' in [1] to the shared drive.

A   Procedure Template

The example below is from 2.1.1 – EPC Inventory Reliability

Description:

> Provide a baseline characterization/validation of EPC inventory rates of BTAG against a reader and compared to reference tags. Record number of reads per 3 second repeatedly over many units. This test will be executed against several different readers.

Purpose:

> Understand a baseline performance metric of EPC for tag over several units as compared to a few reference tags.

Requirements:

11. Measure performance over **(10) units**, and compare to **(4)** reference tags. BTAGs are in case.

12. Perform inventory measurements over a **3000 ms** inventory, repeated **50 times**.
    a. The idle time between measurements shall be **500ms.**

Apparatus:

> Test Apparatus 1: OTA standard

Operator Procedure:

27. Execute *'Test Setup Procedure'* in [1].

28. Procure the required tags defined in ***runSpec***. BTAGs tested are in case.

29. For each sample in ***runSpec***, Execute 'Test *Execution Procedure'* in [1]. Follow instructions by TestApplication

30. For each test point defined in ***runSpec***, execute test and store results per '*Test Execution Procedure*' in [1].
    a. App will launch reader, request operator to setup tag, and then have operator click 'Next' to acquire the full test data (i.e. fully automated). Test will provide indication to operator when complete.

31. Log Results per '*Test Result Storage Procedure*' in [1].

Procedure/Algorithm Description:

10. Tag is placed 1m away from antenna on stand in 0°/0° orientation (i.e. TestApparatus 1).

11. Reader boots and loads standard configuration as defined in '*Standard Reader Configurations*' [2].

12. Reader performs a series of (50) 3000ms EPC inventories. Test application controls this, recording the readCount, average RSSI and stdDevRSSI for each 3000ms inventory as a single <result/> element in result file. Results are stored to file.
    a. Between each inventory the reader dwells in idle for 500ms

B   Tests Queued For Addition

B.1   notice

This section of the document shall not be distributed without permission of document owners! This is for bookkeeping only!!

B.2   Functional Tests

B.2.1 Lifetime Testing – Functional Validation

B.2.2 Low-Power Sleep Reliability & Validation

does it always go to sleep?

B.2.3 Application of Reset Signal

B.2.4 Tamper Activation

B.2.5 Multi-Tag – Std Gen2

B.2.6 Multi-Tag – Btags

B.2.7 Full Lifecycle Simulation – PA

B.2.8 Full Lifecycle Simulation – G0

B.3   EPC Protocol Compliance

B.3.9 Custom EPC Configuration Compliance

B.3.10   T1/T2 Timing on Custom Commands

B.3.11   LF Measurement

B.3.12   Hard EPC Performance

when the tag only talks back 500 times

B.4   Custom Protocol Compliance

B.4.13   PA Activation

B.4.14   PA OBU_Auth_ID Performance

B.4.15   G0 Auth_ID Performance

B.4.16   G0 Full-Pass Performance

B.4.17   Random Number Quality of CSPRNG

B.4.18   EPC Select Filter Permissions for Activated Tag

B.4.19   Cryptographic Module Validation

> Time to encrypt, valid/invalid keys

B.5   Device Reliability

B.5.20   Wakeup Effects – Performance vs Inv Period

B.5.21   The Toaster Test

B.6   Electrical and RF Characterization

B.6.22   Lifetime Testing – Power Consumption

B.6.23   Power State Characterization

B.6.24   Min V_{cc} Operation

B.6.25   Voltage Droop Characterization over Lifetime

B.6.26   FLASH Endurance – EPC Write

B.6.27   FLASH Endurance – High Throughput

B.6.28   Baseband Radio Circuit Characterization

B.7   Field Tests

B.7.29   Road – Single Tag

B.7.30   Road – Multi-Tag

B.7.31   OpenField – Ref Data 1sec reads

B.7.32   Lab – Dynamic Attenuation Profile Performance

B.8   PA Cert Dry Run

B.8.33   The Whole Darn Thing

C   Tests To Run If Time

C.1   notice

This section of the document shall not be distributed without permission of document owners! This is for bookkeeping only!!

C.2   Screen Captures

Capture screen shots of various RFID transactions and save for future reference.

C.3   Command Timings

Measure across a few units T1/2/3/4/etc and custom command response times.

C.4   S0/1/2/3 Behavior

Because BTAG has specific sessioning behavior, develop a test to characterize EPC sessioning behavior.

C.5   Reader Specific Stress Tests

Operate a given reader under non-standard configuration and characterize tags behavior.

C.6   Full Lifetime Simulations

Accelerated tests to simulate a full lifecycle…

C.7   Compl/Relib Tests at Different Power Levels

Most compliance and reliability tests are executed at a single power level. how will they work at different power levels? for a selected subset of tests, repeat against power levels to validate same behavior!

C.8   EPC BlockWrite Compliance

C.9   RF Sensitivity Vs Frequency on 5100

C.10   Temperature Tests

C.11   Shock/Vibration Tests

C.12   Interference Resilience

C.13   Battery-Temperature Characterization

C.14   Open Field – Rain

C.15   Stress Testing

C.16   Road – Different Cars/Orientations

C.17 G0 MemMap Rd and MemMap Wr Validation

C.18 BTAG V$_{CC}$ Ripple Rejection

C.19 ISO-180006C Tests

C.20 RF Circuit Characterization

C.21 Component Failures

characterize test isolated battery

current consumption characterization

     per transaction

     over time

lifetime test - basic EPC cycling

      - Custom command cycling

      - full lifecycle cycling

Go To Sleep Tests

7 Environmental Tests

7.1 Summary

7.2 P9.1.1 – Impact Test – 1m

Description:

Provide baseline qualification of the tag operation after a series of impacts in testing similar to the ARTESP certification testing.

Purpose:

Gain a first pass understanding of the tag's ability to endure impact and drops.

Requirements:

1. The procured tags shall be in cases and activated for PA use with known keys and memory banks. If no manufacturing sealed tags are available, use epoxy (XYZ epoxy) tacked on the case corners for seal.
2. Perform the following sequence four times:
   a. Record a validation set of five 3000ms PA inventories using the procedure in test 3.2.1. Validate the tamper flag has not been set as indicated in the tags reported EPC ID value. Dwell 500ms between each inventory.
   b. Perform a series of 25 drops of the assembled tag, using different tag orientations each time, from a height of 1m. Onto what surface? Carpet? Concrete? Asphalt? Quicksand?
3. Record a final validation set of five 3000ms PA inventories using the procedure in test 3.2.1. Validate the tamper flag has not been set as indicated in the tag's reported EPC ID value. Dwell 500ms between each inventory.
4. Take two or three photos of the exterior of the case and store with the result data set.

Apparatus:

Test Apparatus 1: OTA Standard

Operator Procedure:

1. Execute the *'Test Setup Procedure'* in [1].
2. Procure the required tags defined in ***runSpec***. BTAGs tested in case.
3. For each sample in ***runSpec***, execute *'Test Execution Procedure'* in [1]. Follow instructions by Test Application.
4. For each test point defined in ***runSpec***, execute test and store results per *'Test Execution Procedure'* in [1].
   a. The application will launch reader, request operator to set up tag, and then have the operator click *'Next'* to acquire the full test data (i.e., fully automated). The test will indicate to the operator when it is complete.
5. Log the results per *'Test Result Storage Procedure'* in [1].

Procedure/Algorithm Description:

7.3 P9.2.1 – Temperature Qualification – Simple

Description:

Provide baseline qualification of the tag operation at high temperature. The tag is subjected to a controlled, elevated temperature for a specified duration, after which its RF performance and a few basic RFID sequences are performed and compared to a set of reference data taken beforehand.

Requirements:

1. The procured tags shall be in cases and activated for PA use with known keys and memory banks.
2. Record a set of reference data on each tag subjected to the test, including:
   a. RF Sensitivity Data
      i. Execute the dataset and procedure given in Test 6.3.1.
   b. Battery Voltage Level
      i. Measure the voltage between V_{CC} and GND.
   c. PA Inventory Rate
      i. Execute the dataset and procedure given in Test 3.2.1.
   d. 300 16-word Read Statistics (Number of retries)
      i. Reset the tag to the initialization state.
      ii. Execute a series of 300 EPC Reads to USR/prt:0/length:16 using retries=15.
      iii. Implement a 15ms dwell between each read.
      iv. Activate the tag for PA use.
3. Subject the tag to a temperature of <TBD>°C for <TBD> hours.
4. Record the battery voltage immediately after removal from the temperature chamber.
5. Record final comparison data 30 minutes after removal from the chamber. Comparison data shall be a repeated set of Requirement #1.
6. For any battery voltage measurement, ensure the Tag is in a field of idle RF.

Apparatus:

Test Apparatus 3: OTA standard + DigAtten.

Operator Procedure:

1. Execute *'Test Setup Procedure'* in [1].
2. Procure the required tags defined in *runSpec*. BTAGs shall be tested in a case.
3. For each sample in *runSpec*, execute *'Test Execution Procedure'* in [1]. Follow instructions by Test Application.
4. For each test point defined in *runSpec*, execute test and store results per *'Test Execution Procedure'* in [1].
   a. Application will launch reader, request operator to setup tag, and then have operator click *'Next´* to acquire the full test data (i.e. fully automated). Test will provide indication to operator when complete.
5. Log results per *'Test Result Storage Procedure'* in [1].

Procedure/Algorithm Description: