Tagged-Item Performance Protocol (TIPP)
Tagged-Item Grading: Testing Methodology

R1.0 — DEC 18 2014

GS1 US

THE GLOBAL LANGUAGE
OF BUSINESS

CONTENTS

ABOUT GS1

GS1® is a neutral, not-for-profit, global organization that develops and maintains the most widely-used supply chain standards system in the world. GS1 Standards improve the efficiency, safety, and visibility of supply chains across multiple sectors. With local Member Organizations in over 110 countries, GS1 engages with communities of trading partners, industry organizations, governments, and technology providers to understand and respond to their business needs through the adoption and implementation of global standards. GS1 is driven by over a million user companies, which execute more than six billion transactions daily in 150 countries using GS1 Standards.

ABOUT GS1 US

GS1 US, a member of the global information standards organization GS1, brings industry communities together to solve supply-chain problems through the adoption and implementation of GS1 Standards. Nearly 300,000 businesses in 25 industries rely on GS1 US for trading-partner collaboration and for maximizing the cost effectiveness, speed, visibility, security and sustainability of their business processes. They achieve these benefits through solutions based on GS1 global unique numbering and identification systems, barcodes, Electronic Product Code (EPC®)-enabled RFID, data synchronization, and electronic information exchange. GS1 US also manages the United Nations Standard Products and Services Code® (UNSPSC®). www.GS1US.org.

1 DOCUMENT INFORMATION

1.1 DOCUMENT SUMMARY

DOCUMENT ITEM	CURRENT VALUE
DOCUMENT TITLE	Tagged-Item Performance Protocol (TIPP) Tagged Item Grading: Testing Methodology
DATE LAST MODIFIED	9/16/2014
CURRENT DOCUMENT ISSUE	R1.0 Dec 18 2014
STATUS	Final
DOCUMENT DESCRIPTION	Provides the testing procedures for tagged-item grading

1.2 NORMATIVE REFERENCES

This guidance is based on the *EPC™ Radio-Frequency Identity Protocols: Class-1 Generation-2 UHF RFID Protocol for Communications at 860 MHz – 960 MHz (Version 1.2.0)* (referenced as "Gen2" throughout this document).

1.3 TIPP DOCUMENT SERIES

This document is part of a series of documents laying out the tagged-item grading system for specifying tagged-item performance between retailers and suppliers. The series include the following four documents:

- The document entitled *TIPP Tagged-Item Grading: Overview* provides an overview of the tagged-item grading guideline.
- The document entitled *TIPP Tagged-Item Grading: Grade Definitions* defines the grade specifications.
- The document entitled *TIPP Tagged-Item Grading: Testing Methodology* presents the test procedure and measurement methods to qualify or establish the grade for a tagged item. *(This is the current document.)*
- The document entitled *TIPP Tagged-Item Grading Testing Configurations* defines the orientation for various types of tagged items (which is critical for repeatable testing using the TIPP procedure).

1.4 SCOPE

This document defines the normative test procedures used for TIPP tagged-item grading. It defines the method and criteria to establish that a tagged item meets a specified grade level. It is intended for parties learning about the TIPP grading guidelines and methodology including retailers, suppliers and solution providers.

NOTE: As with all GS1 Standards and solutions, the Tagged-Item Grading System is voluntary, not mandatory. It should be noted that use of the words "must" and "require" throughout this document relate exclusively to technical recommendations for the proper application of the testing protocol to support the integrity of your application.

1.5 CONTRIBUTORS

NAME	ORGANIZATION	
SWEENEY, PAM	Macy's	Workgroup Co-Chair
PURCELL, BEBE	VF Corporation	Workgroup Co-Chair
CP, SENTHILKUMAR	Auburn University	Editor
DIETRICH, PAUL	Wrada	Editor and Facilitator
MORGAN, GENA	GS1 US	Facilitator
CHINWALA, MAC	Alien Technology, Corporation	
MITCHELL, NEIL	Alien Technology, Corporation	
MITCHELL, MICHAEL	Alien Technology, Corporation	
ERVIN, PATRICK	Alien Technology, Corporation	
PATTON, JUSTIN	Auburn University	
VARGAS, JULIE	Avery Dennison Corporation	
SOWLE, ELIZABETH	Avery Dennison Corporation	
PERNICE, BOB	Avery Dennison Corporation	
DYCHE, GEORGE	Avery Dennison Corporation	
BARTON, KRIS	Avery Dennison Corporation	
LI, MORUI	Checkpoint Systems, Inc.	
RACETTE, TOM	Checkpoint Systems, Inc.	
COODUVALLI, UMESH	Checkpoint Systems, Inc.	
NUCE, MELANIE	GS1 US	
JAVICK, PATRICK	GS1 US	
ALLIGOOD, TYNDALL	Hanes Brands	
ARNSTEIN, LARRY	Impinj, Inc.	
LIU, JEREMY	Invengo Technology Corp.	
GOMILLION, JOE	Invengo Technology Corp.	
COMPITELLO, BILL	Invengo Technology Corp.	
SMITH, KAREN	Jockey International, Inc.	
MIRSBERGER, MICHAEL	Jockey International, Inc.	
LEMARRE, PAM	Jockey International, Inc.	
STEGALL, GARY	Kayser-Roth	
CULLEN, BRAD	Kohl's Department Stores Inc.	
SOMERS, JOE	Kohl's Department Stores Inc.	
FORECKI, ABBY	Kohl's Department Stores Inc.	
CAVADEL, GLENN	Kohl's Department Stores Inc.	
HOCHKOEPPLER, ERNESTO	Levi Strauss & Company	
CISTERNINO, JOHN	Levi Strauss & Company	
SMITH, ANDREA	Lord & Taylor	
DESMONS, DIMITRI	LSIS Co., Ltd.	
WHITNEY, KRIS	Macy's	
WILKERSON, BRETT	MSM Solutions	

NAME	ORGANIZATION	
STOTT, NIGEL	NXP Semiconductors	
KOLARIC, VLATK	NXP Semiconductors	
BOUCHER, PIERRE	Peerless Clothing	
WEISENFELD, GALE	PVH Corp.	
NAGY, CHRIS	PVH Corp.	
TEITELBAUM, MICHAEL	r-pac International Corp.	
ARGUIN, PAUL	r-pac International Corp.	
REESE, CHRIS	Smartrac Technology Group	
KOSKELAINEN, TUOMAS	Smartrac Technology Group	
STIGALL, RANDY	Smartrac Technology Group	
WOOD, ROBERT	SML	
STONE, MIKE	SML	
RAMZAN, MO	SML	
DEW, TOMMY	SML	
DAILY, MIKE	SML	
CONSIDINE, THOMAS	SML	
CALDERBANK, PHIL	SML	
REPELLIN, LUCIEN	Stealth Network Communications	
NYSWONGER, MARGARET	Stealth Network Communications	
GROBLER, MIKE	Tageos	
MEDLIN, STAN	VF Corporation	
ISLEY, DAVID	VF Corporation	
CRAFT, JAY	VF Corporation	
PARTANEN, JUHO	Voyantic Ltd.	
BLACK, TIM	Xtreprise	

2 INTRODUCTION

A tagged item is a retail sales item that contains an RFID tag. The Tagged-Item Performance Protocol (TIPP) Workgroup developed a tagged-item grading system to facilitate the specification of tagged-item performance between retailers and suppliers. Tagged-item grades were developed to specify the radio frequency identification (RFID) performance of a tagged item. The tagged-item test procedure defines a method and criteria for establishing that a tagged-item meets a specified grade level. This procedure was validated during the prototype effort to yield consistent results across test facilities and test operators.

The test procedure does not specify when, by whom, or how frequently the retailer and supplier should test items. There is currently no certification procedure to validate a party's ability to perform repeatable testing. Rapid innovation in testing equipment and procedures makes the formal certification process or procedure premature. Retailers may specify a minimum test (or retest) requirement of their suppliers. Suppliers, based on service-level agreements, may determine their own acceptable test requirements that may meet or exceed anything specified by the retailer.

The test procedure's pass/fail criteria are defined to ensure repeatable and unambiguous results. It intentionally does not specify what criteria a retailer uses to establish the consistency or quality of the tagged-item performance. For example, one retailer could ask that the supplier verify items periodically to meet their specified performance grade with some small (<1%) tolerance for failures. Another retailer may sample items through distribution and assess penalties for items failing to meet their specified grade. Yet another might have the technology to measure the grade of every single tagged item through their retail stores and provide pass/fail feedback to their suppliers.

3 TEST PROCESS

3.1 TAGGED ITEMS FOR TESTING

Tagged-item testing requires a sample of 30 tagged items, unless otherwise specified by the retailer. Each tagged item must be uniquely encoded. The tagged items must be encoded such that each identifier (ID) is unique when compared to all current and future items. Each ID must be stored in a file along with all of the other information of the submitted item, and will be referenced during all performance measurements on the tagged item.

3.2 PASS/FAIL CRITERIA

When qualifying a tagged item against a known grade, each item in the set of 30 items must pass the measured specification as per the test procedure below. All of the items must meet the grade level to qualify the set as meeting or exceeding the grade. To meet the grade, an individual tagged item must satisfy both of these conditions:

- At each point in the grade where the sensitivity is defined, the tagged-item test procedure must measure a value less than or equal to (≤) the value specified in the grade. That is, the sensitivity must be as good as or better than specified by the grade level.
- At each point in the grade where sensitivity and backscatter power is defined, the tagged-item test procedure must measure a backscatter power (at the specification sensitivity level) greater than or equal to (≥) the value specified in the grade level.

3.3 TEST EQUIPMENT

The following is the recommended setup for measuring tagged-item performance. Any setup used for measuring tagged-item performance must be equivalent to the equipment herein:

The test equipment is designed and maintained to produce accurate, consistent, and repeatable radio frequency (RF) measurements. A high-level layout of the test equipment is shown in Figure 1 below. The major components of the setup are:

- the anechoic chamber
- the rotating test platform
- the antennas
- the measurement unit

The ***anechoic chamber*** is designed to eliminate reflections of electromagnetic waves and provide an interference-free environment to accurately measure the performance of RFID tagged items.

The ***test platform*** in the chamber can be rotated 360 degrees in 1 degree increments to measure the tag in multiple positions. The height of the test platform is adjustable to accommodate products of different sizes.

The linearly polarized ***antennas*** are mounted at angles of 0 degrees, 30 degrees, 60 degrees, and 90 degrees with respect to the floor of the chamber and are named Antenna 1, Antenna 2, Antenna 3 and Antenna 4, respectively. The antennas are mounted with their horizontal polarization plane parallel to the floor of the anechoic chamber. The antennas are directed at a single incident point. This incident point is where the tagged item to be tested is positioned. The minimum distance between the antenna and the incident point is 0.4 meters at all times. The tagged-item remains in the far field of all four antennas during all the measurements.

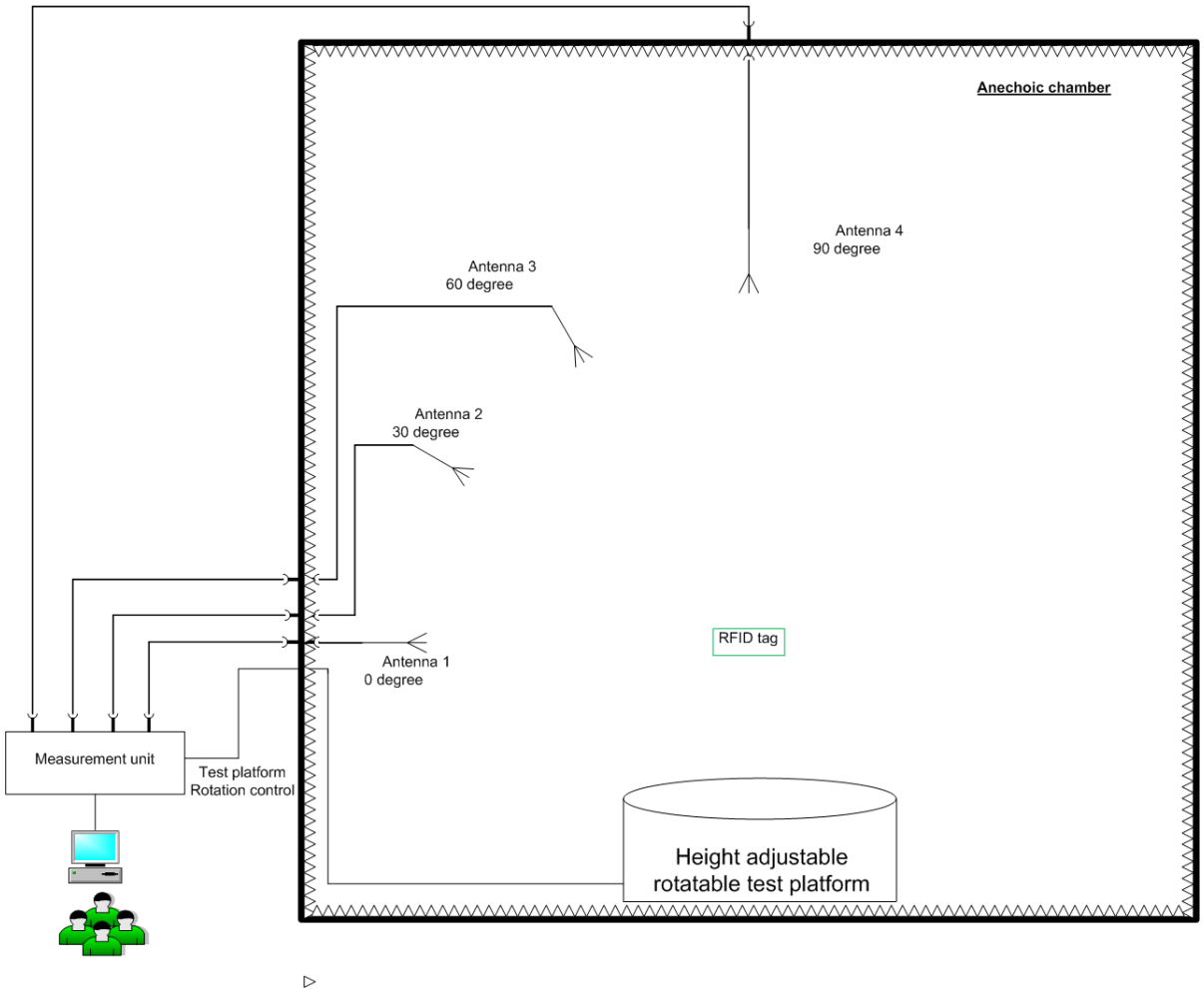

Figure 1. High Level Layout of Test Equipment

The ***measurement unit*** is effectively a network analyzer optimized for measuring the performance of RFID tags. The measurement unit can generate, transmit, receive, and process UHF[1] RF communication. The measurement unit can operate in the 800 MHz[2] to 980 MHz frequency range, and the frequency of operation can be dynamically controlled in increments of 1 MHz. The output power range of the measurement unit calculated at the incident point of all four antennas should be from –25 dBm[3] to 5 dBm or larger range, and can be dynamically controlled in increments of 0.1 dBm. The modulator in the measurement unit supports double-sideband amplitude shift keying (DSB-ASK) modulation.

[1] UHF = Ultra High Frequency

[2] MHz = mega-hertz

[3] dBm = Decibel-milliwatts

3.4 MEASUREMENT GEN2 PROTOCOL SETTINGS

The following ***Gen2 physical layer parameters*** must be used for executing the command sequence defined below.

- Modulation = DSB-ASK
- Tari[4] = 25 usec.[5]
- TRcal[6] = 200 usec.

The following ***Gen2 protocol parameters*** must be used in the measurement command sequence defined below.

- M[7] = 1 (value of 0b00 in query command)
- DR[8] = 8 (value of 0b0 in query command)
- Truncate = disabled (value of 0b0 in select command)
- TRext[9] = 0 (value of 0b0 in query command)

3.5 MEASUREMENT COMMAND SEQUENCE

The following measurement command sequence must be used.

The Select and Query commands (specified in Gen2) are used to measure the performance of tagged items. A combination of Select and Query commands can be used to individually test a specific tag ID number in a population of multiple tags present in the test environment. The tag ID number is specified for all the performance measurements even if only a single tagged item is measured. This process prevents the accidental substitution of items.

As shown in Figure 2, the measurement unit sends a Select command with the ID value of the tag to measure. The Select command is followed by a Query command for which the tag should reply with a random number. The test system then generates an Ack[10] command. Finally, the tagged-item backscatters the PC[11], EPC, and CRC[12]. The PC, EPC, and the valid Packet CRC are used to validate the tag response, and thus measure the tagged-item performance.

---

[4] Reference time interval for a data-0 in Interrogator-to-Tag signaling. The mnemonic “Tari” derives from the ISO/IEC 18000-6 (part A) specification, in which Tari is an abbreviation for Type A Reference Interval.

[5] microsecond (one one-millionth of a second)

[6] Tag-to-Reader calibration symbol. It is used along with DR (divide ratio) to specify the tag’s backscatter link frequency.

[7] Number of subcarrier cycles per symbol

[8] Divide ratio

[9] TRext chooses whether the Tag to Reader Preamble is prepended with a pilot tone. The value of 0 indicates that there is no pilot tone.

[10] Acknowledgement

[11] Protocol control

[12] Cyclic redundancy check

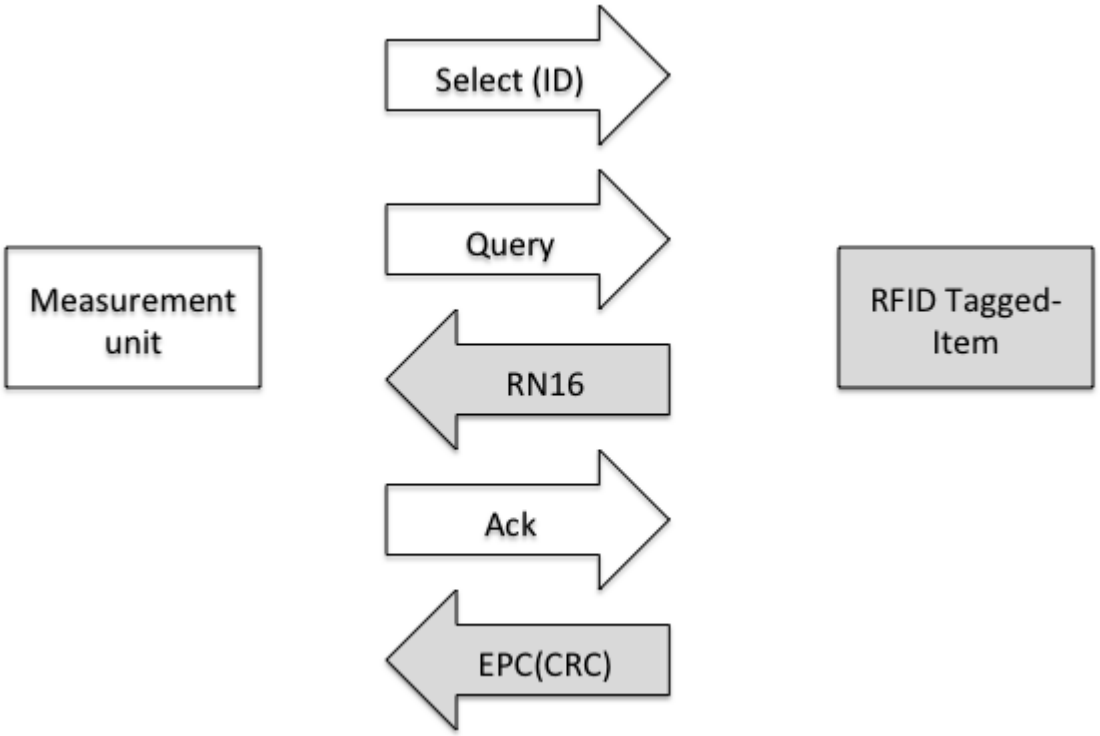

Figure 2. Communication between Measurement Unit and RFID Inlay

3.6 EQUIPMENT CALIBRATION AND MAINTENANCE

The following procedures are recommended to calibrate and maintain a tagged-item test facility:

The transmitter of the test equipment is calibrated using a power meter with a power trace in the entire operational frequency and power range. Both the I and Q channels and their phase difference in the receiver is calibrated through the entire frequency range by connecting the calibrated transmitter to the receiver.

A calibrated network analyzer is used to measure the Scattering parameters of each antenna and cable combinations for the frequency range of 800 MHz to 980 MHz in increments of 1 MHz. The free-space loss in the chamber for the distance between the antennas and the incident point is calculated using the Friis equation. The loss of each antenna and cable combination combined with the corresponding free-space loss is used to calculate the total loss between the measurement unit and the incident point in both directions.

At the start of the day, the equipment is warmed up for at least 20 minutes and until a consistent series of measurements is observed. This process is done by repeatedly measuring a tag using the test equipment for the set time and a consistent sensitivity measurement is observed.

The equipment and the environment are operated and maintained in a temperature/humidity-controlled environment.

3.7 MEASUREMENT PARAMETERS

The tagged items are measured for parameters that reflect the performance of the tagged item. The parameters measured are not focused on any single use case, but rather a variety of use cases to provide a complete profile of the tagged item. These parameters are measured in a variety of test configurations, which are described in the *TIPP Tagged-Item Grading: Grade Definitions* document.

- ***Frequency Range:*** Each antenna measures the tagged item from 902 MHz to 928 MHz in increments of 1 MHz.
- ***Power Range:*** The tagged items are measured for response from -25 dBm sensitivity in increments of 0.1 dB until there is a successful response from the tag for each of the frequencies from 902 MHz to 928 MHz.

The read sensitivity and associated backscatter signal are measured during the test process.

3.7.1 READ SENSITIVITY

Read sensitivity of a tagged item, measured in dBm, is the minimum amount of power the tagged item requires to complete a successful command sequence (See Section 0).

The read sensitivity can be established by repeating the command sequence while increasing the power sent from the measurement unit until there is a response from the tag. Sensitivity can be calculated from this power level by subtracting the measurement unit antenna gain, cable loss, free space loss, and any other losses/gains in the measurement unit.

The read sensitivity at a given orientation is the worst (highest) read sensitivity across the measured frequency range.

3.7.2 BACKSCATTER POWER

Backscatter is the amount of power reflected back from the tagged item when a successful command sequence is completed at the tagged item at a specific sensitivity level.

When validating a tagged item meets a grade level, the backscatter power measurement must be performed at the sensitivity level contained in the grade specification (see the grade specifications defined in the document entitled *TIPP Tagged-Item Grading: Grade Definitions*).

Backscatter is calculated by calibrating the power measured at the receiver of the measurement unit with the loss/gain during the transmission.

The backscatter power at a given orientation is the worst (lowest) backscatter power across the measured frequency range.

Both Sensitivity and Backscatter will be the same across different test setups because they are the power required and the power reflected back ‘from’ the tag. All the variables like distance between the antenna and tag, antenna gain, loss in the cables, etc. are part of the calibration and are not represented in this variable.

3.8 TEST VARIABLES

Two primary variables are altered during the testing: test platform position and measurement antenna. A description with example values for each is discussed below.

- ***Test Platform Position -*** The test platform is rotated from 0 to 270 degrees in increments of 30 degrees.
- ***Measurement Antenna -*** At each test platform position, the tagged item is measured with four antennas. As shown in Figure 1, the antennas (named Antenna 1, Antenna 2, Antenna 3 and Antenna 4) are mounted at 0 degrees, 30 degrees, 60 degrees and 90 degrees with respect to the test platform.

The antennas are directed at a single incident point. This incident point is where the tagged item to be tested is positioned, and can be seen in Figure 3, Figure 4, and Figure 6. The antennas are mounted such that the incident point is exactly above the center of rotation of the testing platform as shown in Figure 3.

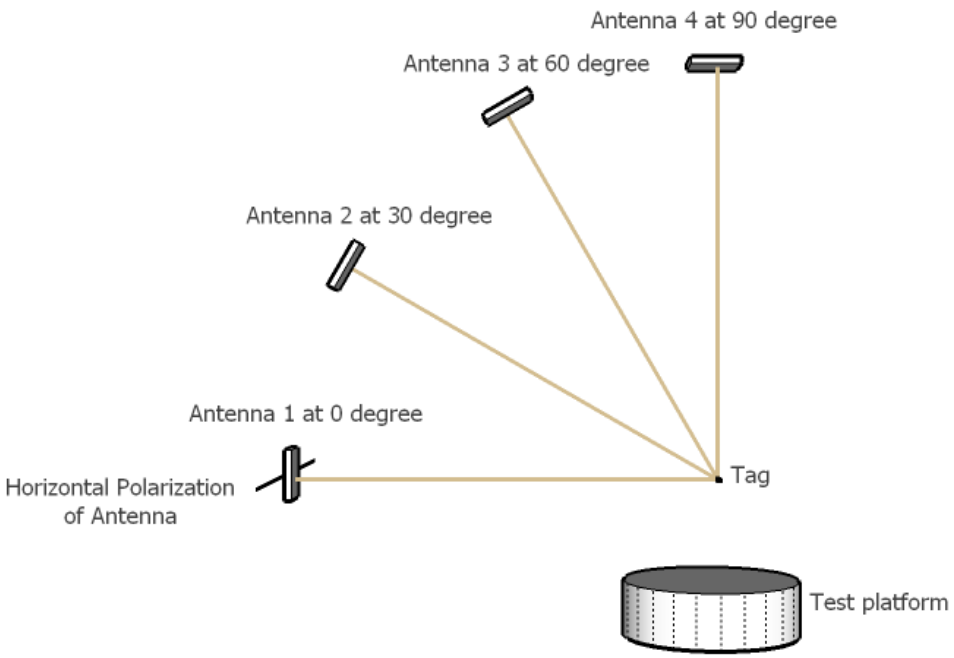

Figure 3. Antenna Configuration

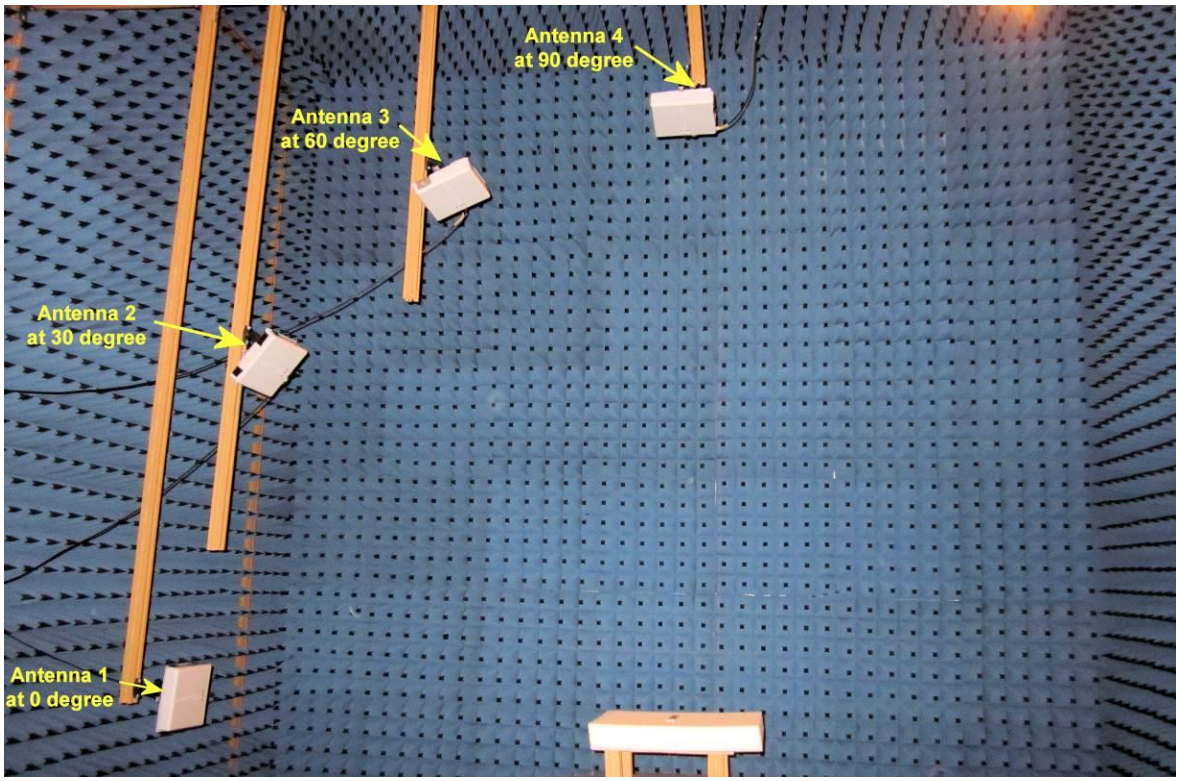

Figure 4. Antenna Configurati0n

3.9 TAGGED-ITEM PLACEMENT

The tagged item is measured when the item is placed on the platform with its front and top positioned according to *TIPP Tagged-Item Grading Testing Configurations* document. See this document for the information on the item placement. Figure 5 shows the top view of the measurement setup (View from Antenna 4) at several platform orientations.

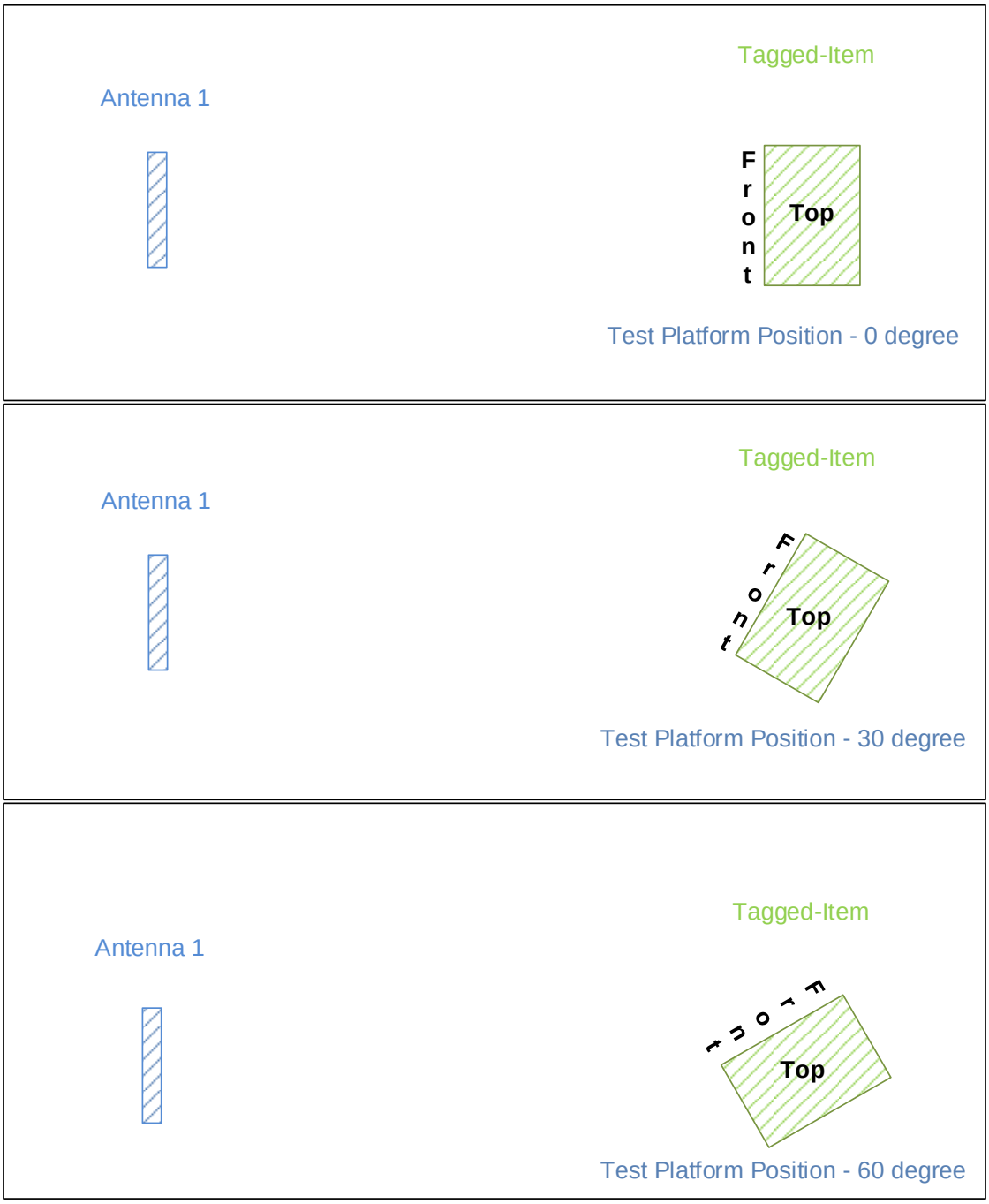

Figure 5. Orientation of the Tagged-Item – Top View

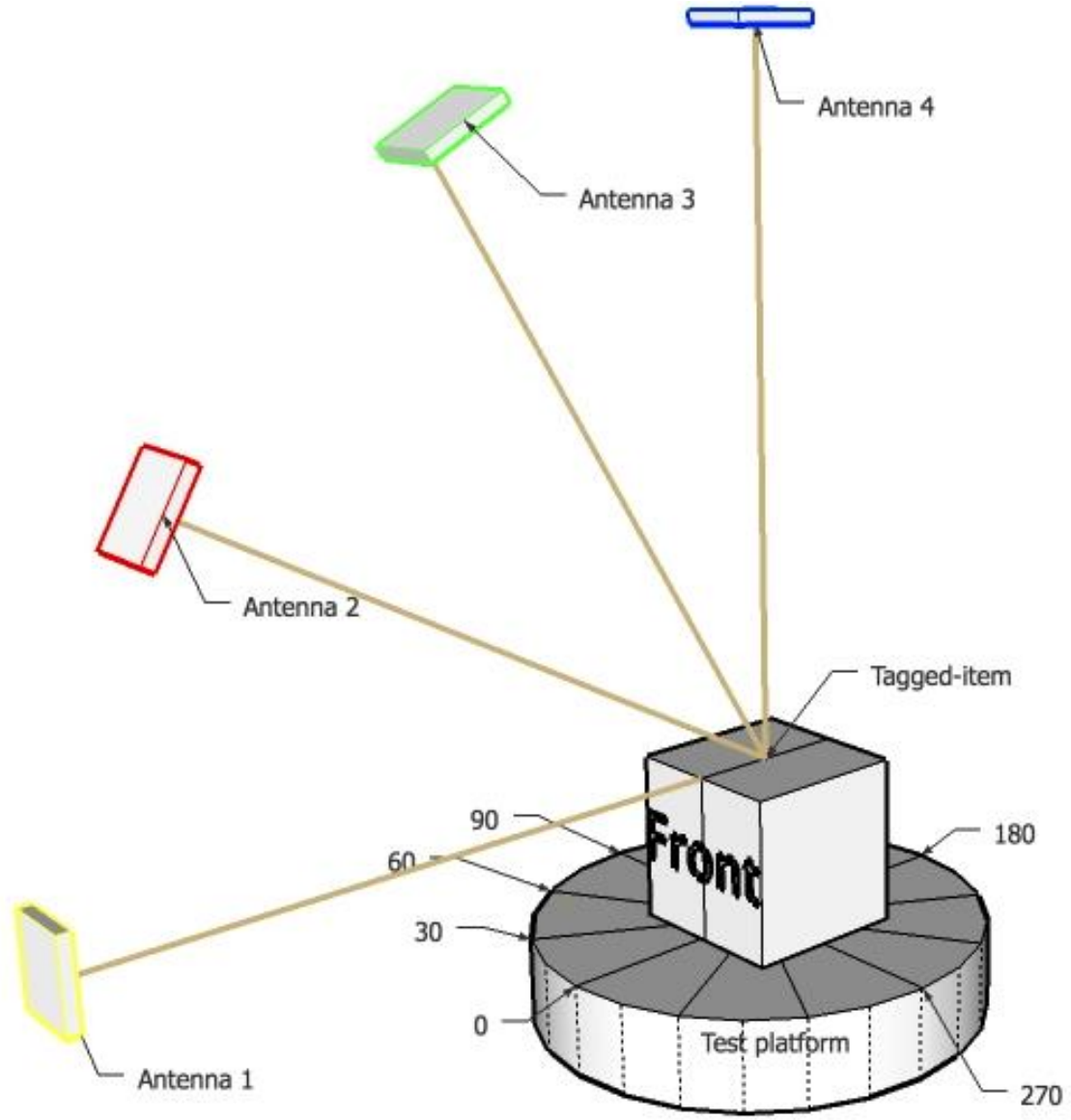

Figure 6. Tagged-item at 0 degree test platform position

PROPRIETARY STATEMENT

This document contains proprietary information of GS1 US. Such proprietary information may not be changed for use with any other parties for any other purpose without the expressed written permission of GS1 US.

IMPROVEMENTS

Improvement and changes are periodically made to publications by GS1 US. All material is subject to change without notice. Please refer to GS1 US website for the most current publication available.

DISCLAIMER:

Except as may be otherwise indicated in specific documents within this publication, you are authorized to view documents within this publication, subject to the following:

1. You agree to retain all copyright and other proprietary notices on every copy you make.

2. Some documents may contain other proprietary notices and copyright information relating to that document. You agree that GS1 US has not conferred by implication, estoppels or otherwise any license or right under any patent, trademark or copyright (except as expressly provided above) of GS1 US or of any third party.

This publication is provided "as is" without warranty of any kind, either express or implied, including, but not limited to, the implied warranties of merchantability, fitness for a particular purpose, or non-infringement. Any GS1 US publication may include technical inaccuracies or typographical errors. GS1 US assumes no responsibility for and disclaims all liability for any errors or omissions in this publication or in other documents which are referred to within or linked to this publication. Some jurisdictions do not allow the exclusion of implied warranties, so the above exclusion may not apply to you.

Several products and company names mentioned herein may be trademarks and/or registered trademarks of their respective companies. GS1 US does not, by promulgating this document on behalf of the parties involved in the creation of this document, represent that any methods, products, and/or systems discussed or recommended in the document do not violate the intellectual property rights of any third party. GS1 US has not performed a search to determine what intellectual property may be infringed by an implementation of any strategies or suggestions included in this document. GS1 US hereby disclaims any liability for any party's infringement of intellectual property rights that arise as a result of any implementation of strategies or suggestions included in this document.

This publication may be distributed internationally and may contain references to GS1 US products, programs and services that have not been announced in your country. These references do not imply that GS1 US intends to announce such products, programs or services in your country.

NO LIABILITY FOR CONSEQUENTIAL DAMAGE

In no event shall GS1 US or anyone else involved in the creation, production, or delivery of the accompanying documentation be liable for any damages whatsoever (including, without limitation, damages for loss of business profits, business interruption, loss of business information, or other loss) arising out of the use of or the results of use of or inability to use such documentation, even if GS1 US has been advised of the possibility of such damages.

IAPMO

In this publication, the letters "U.P.C." are used solely as an abbreviation for the "Universal Product Code" which is a product identification system. They do not refer to the UPC, which is a federally registered certification mark of the International Association of Plumbing and Mechanical Officials (IAPMO) to certify compliance with a Uniform Plumbing Code as authorized by IAPMO.

THE GLOBAL LANGUAGE
OF BUSINESS

CORPORATE HEADQUARTERS
Princeton Pike Corporate Center
1009 Lenox Drive, Suite 202, Lawrenceville, NJ 08648 USA
T +1 937.435.3870 E info@gs1us.org W www.gs1us.org

FOLLOW US: