# Tagged-Item Performance Protocol (TIPP) Tagged-Item Grading: Grade Definitions Guideline

Provides the specific definitions for RFID performance grades

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## Log of Changes

| Release | Date of Change | Changed By | Summary of Change |
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| 0.9 | 26 Feb 2015 | D.Buckley | Created with kind permission of GS1 US from the document *Tagged-Item Performance Protocol (TIPP) Tagged Item Grading: Testing Methodology 9/16/2014 R1.0 Dec 18 2014* |
| 1.0 | Nov 2016 | P Dietrich | Multiple revisions from internal comment review. Initial release following Work Request 14-219 |
| 1.1 | Aug 2017 | G. Rowe, J Partanen & P Iliev | WR 17 Updated Grades, Grade Names, Family Assignments and Backscatter values. Updated Backscatter Values on the grade tables to reflect the new backscatter definition Added Performance grade JSSG05 – Section 4.17 Added Appendix for Grade Family Descriptions |
| 1.2 | April 2024 | Claude Tételin | WR 23-260 Add new family and associated grades for smart enclosures and smart cabinets based applications. |

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# Table of Contents

# 1 Introduction

This document introduces the TIPP grades, explains the TIPP grade naming system, and defines the specifications for tagged-item sensitivity and backscatter for each grade. The document is intended for parties learning about the TIPP grading guidelines and methodology including users, suppliers and solution providers.

The Tagged-Item Performance Protocol (TIPP) Workgroup developed a tagged-item grading system to facilitate the specification of tagged-item performance between users and suppliers. This system defines a set of "grades" based on sensitivity, backscatter power, orientation and frequency. Each grade is represented by a name that comprises four designators: test configuration, performance level, family and (optionally) frequency. As such, "TIPP grades are simply tagged-item performance specifications given a shorthand names."

# 2 Grade identifiers

TIPP provides a shorthand naming system for its grades. The naming system provides a convenient way to reference the large set of performance factors contained within each grade definition.

✅ **Note:** Please see Appendix A for detailed Grade Family Descriptions

TIPP grades are named with a multi-dimensional naming system. A TIPP grade has four components:

- *A single letter (e.g. S, M or J) denoting the test configuration for the tagged item.*

    - **S** stands for single item. When a grade specifies **S**, the test procedure is performed on a single item and must meet the item factors specified by the grade definition.

    - **M** stands for multiple items. When a grade specifies **M**, the test procedure is performed on a stack of 2 items and a stack of 11 items and must meet the item factors specified by the grade definition.

    - **J** stands for densely stacked items. When a grade specifies **J**, the test procedure is performed on a dense stack of items and must meet the item factors specified by the grade definition. The number of test items in the stack is specified by the grade with default value of 7.

- *A number (e.g. 5, 10, 20, etc.) that specifies item factor performance levels.*

    - The initial TIPP numbers are multiples of five to allow space in between existing grades if needed in the future. *(However, it is not anticipated that any intermediate performance levels would be needed.)*

    - Larger numbers correspond to higher performing tagged items.

- *A letter (e.g. A, B, C, D, E, P or V) specifying the family to which the grade belongs.*

The set of all TIPP grades is divided into families to group together grades with common performance characteristics. Grades within a family are "ordered". Within a family, tagged items automatically pass lower numbered grades if they pass higher numbered grades. For example, a tagged-item that passes M15B also passes M10B because they are both in the B family. However the same tagged-item might not pass M15D because M15D is in the D family, or S15B because S15B is an S (single item) grade instead of an M (stacked) grade. As tag and reader technologies and use-cases progress, new grades within families and new families of grades with different characteristics will be needed.

- *An optional 4th component. If present, the 4th component specifies the test frequency range.*

    - If the 4th component is not specified, the grade is tested over the frequency range 865-868 MHz and 902-928 MHz.

    - If the 4th component is specified as FCC, the grade is tested only over the frequency range 902 -928 MHz.

    - If the 4th component is specified as ETSI, the grade is tested only over the frequency range 865 – 868 MHz.

Grades having the same frequency designator can be compared within their families as specified above. If two grades have different frequency designators, they cannot be ranked by performance-number. An example grade S15B-FCC meets the S15B grade specification tested only over the frequency range of 902-928 MHz.

# 3 Pass/Fail Criteria with minimum success rate

The solution brings a new dimension to the grade definitions called "minimum success rate"[1]. These are percentage values that are separately defined for each antenna and orientation angle line. By default, this number is 100%, which is also aligned with the original TIPP US guideline. However also a lower percentage can now be defined to allow the tagged item to fail one or more of the specified test nodes.

| Sensitivity/backscatter (dBm) | | | | | |
|---|---|---|---|---|---|
| Minimum success rate | | 100% | 100% | 100% | 100% |
| | Orientation angle (degrees) | Antenna | | | |
| | | 1 | 2 | 3 | 4 |
| 100% | 0 | | | | |
| 100% | 30 | | | | |
| 100% | 60 | | | | |
| 100% | 90 | | | | |
| 100% | 120 | | | | |
| 100% | 150 | | | | |
| 100% | 180 | | | | |
| 100% | 210 | | | | |
| 100% | 240 | | | | |
| 100% | 270 | | | | |
| 100% | 300 | | | | |
| 100% | 330 | | | | |

If the pass/fail criteria for a grade is not specified or absent, every entry with a performance number must pass the grade test procedure. For entries that contain no performance number, no testing is required.

For example, there are potential 4 columns and 12 rows of potential performance data. A 50% pass/fail criterion in a column of would mean that at least half of the entries specified in the column must meet the performance level. If the column contains 10 performance levels, that at least five must be met. If the column contains less than 12 levels (they are unspecified and thus no testing is required), then at least half of those specified must meet the performance level.

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[1] The original TIPP US Guideline had strict pass/fail interpretation of the test results: if the tested item failed even one of the specified test nodes, the whole test sequence was determined as a failure. Considering the complexities of both the TIPP test procedure, the evolution of tagging and packaging solutions and especially the statistical nature of RFID reads in general, the TIPP global grading system is improved to also consider the occasional non-fatal read failures.

# 4    Grade definitions

Each grade is defined by a set of tables that specify the tagged-item sensitivity and backscatter power at various orientations. The entries in the table specify the power at the tagged-item in Decibel-milliwatts (dBm) according to the test procedures defined in TIPP Tagged-Item Grading: Testing Methodology Guideline. If an entry in a table is blank, then there is no specification for that orientation. To determine if a tagged item meets a given grade, the test must be performed according to the test procedures defined in TIPP Tagged-Item Grading: Testing Methodology Guideline using tag placement and configurations specified in TIPP Tagged-Item Grading: Testing Configurations Guideline.

## 4.1    Performance grade S05V

Test frequency Range: Unless otherwise specified in the grade nomenclature the test frequency range is 902 MHz to 928 MHz and 865 MHz to 868 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| Sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -3.5 | | | |
| 30 | 1 | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | 1 | | | |
| 180 | -3.5 | | | |
| 210 | 1 | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | 1 | | | |

| Backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -33 | | | |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -33 | | | |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

## 4.2 Performance grade S05B

Test frequency Range: Unless otherwise specified in the grade nomenclature the test frequency range is 902 MHz to 928 MHz and 865 MHz to 868 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| Sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -3.5 | -3,5 | -2,5 | -2,5 |
| 30 | 1 | 2 | 4 | 2 |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | 1 | 2 | 4 | 2 |
| 180 | -3.5 | -3,5 | -2,5 | -2,5 |
| 210 | 1 | 2 | 4 | 2 |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | 1 | 2 | 4 | 2 |

| Backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -33 | -34 | -34 | -33 |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -33 | -34 | -34 | -33 |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

## 4.3    Performance grade S15B

Test frequency Range: Unless otherwise specified in the grade nomenclature the test frequency range is 902 MHz to 928 MHz and 865 MHz to 868 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| Sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -6.5 | -6.5 | -5.5 | -5.5 |
| 30 | -2 | -1 | 1 | -1 |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | -2 | -1 | 1 | -1 |
| 180 | -6.5 | -6.5 | -5.5 | -5.5 |
| 210 | -2 | -1 | 1 | -1 |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | -2 | -1 | 1 | -1 |

| Backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -35 | -36 | -36 | -35 |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -35 | -36 | -36 | -35 |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

## 4.4 Performance grade S15D

Test frequency Range: Unless otherwise specified in the grade nomenclature the test frequency range is 902 MHz to 928 MHz and 865 MHz to 868 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| Sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -6.5 | -6.5 | -5.5 | -5.5 |
| 30 | -5 | -5 | -4 | -4 |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | -5 | -5 | -4 | -4 |
| 180 | -6.5 | -6.5 | -5.5 | -5.5 |
| 210 | -5 | -5 | -4 | -4 |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | -5 | -5 | -4 | -4 |

| Backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -37 | -36 | -37 | -37 |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -37 | -36 | -37 | -37 |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

## 4.5 Performance grade S20B

Test frequency Range: Unless otherwise specified in the grade nomenclature the test frequency range is 902 MHz to 928 MHz and 865 MHz to 868 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| Sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -9.5 | -9.5 | -8.5 | -8.5 |
| 30 | -5 | -4 | -2 | -4 |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | -5 | -4 | -2 | -4 |
| 180 | -9.5 | -9.5 | -8.5 | -8.5 |
| 210 | -5 | -4 | -2 | -4 |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | -5 | -4 | -2 | -4 |

| Backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -36 | -37 | -37 | -36 |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -36 | -37 | -37 | -36 |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

## 4.6 Performance grade S20A

Test frequency Range: Unless otherwise specified in the grade nomenclature the test frequency range is 902 MHz to 928 MHz and 865 MHz to 868 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| Sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -10 | -9.5 | -9.5 | -10 |
| 30 | -7 | -6 | -6 | -6 |
| 60 | -2 | -2 | | |
| 90 | | | | |
| 120 | -2 | -2 | | |
| 150 | -7 | -6 | -6 | -6 |
| 180 | -10 | -9.5 | -9.5 | -10 |
| 210 | -7 | -6 | -6 | -6 |
| 240 | -2 | -2 | | |
| 270 | | | | |
| 300 | -2 | -2 | | |
| 330 | -7 | -6 | -6 | -6 |

| Backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -32 | -33 | -33 | -32 |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -32 | -33 | -33 | -32 |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

## 4.7    Performance grade S20P-FCC

Test frequency Range: the test frequency range is 902 MHz to 928 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| Sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | 9.0 | | | |
| 30 | 9.0 | | | |
| 60 | | | | |
| 90 | 9.0 | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | 9.0 | | | |
| 210 | | | | |
| 240 | | | | |
| 270 | 9.0 | | | |
| 300 | | | | |
| 330 | | | | |

| Backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -50.0 | | | |
| 30 | -50.0 | | | |
| 60 | | | | |
| 90 | -50.0 | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -50.0 | | | |
| 210 | | | | |
| 240 | | | | |
| 270 | -50.0 | | | |
| 300 | | | | |
| 330 | | | | |

## 4.8    Performance grade S25A

Test frequency Range: Unless otherwise specified in the grade nomenclature the test frequency range is 902 MHz to 928 MHz and 865 MHz to 868 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| Sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -11 | -10.5 | -10.5 | -11 |
| 30 | -9 | -9 | -8.5 | -8 |
| 60 | -2.5 | -2.5 | -1 | |
| 90 | | | | |
| 120 | -2.5 | -2.5 | -1 | |
| 150 | -9 | -9 | -8.5 | -8 |
| 180 | -11 | -10.5 | -10.5 | -11 |
| 210 | -9 | -9 | -8.5 | -8 |
| 240 | -2.5 | -2.5 | -1 | |
| 270 | | | | |
| 300 | -2.5 | -2.5 | -1 | |
| 330 | -9 | -9 | -8.5 | -8 |

| Backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -33 | -34 | -34 | -33 |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -33 | -34 | -34 | -33 |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

## 4.9 Performance grade S30P-FCC

Test frequency Range: the test frequency range is 902 MHz to 928 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| Sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | 3.0 | | | |
| 30 | 3.0 | | | |
| 60 | | | | |
| 90 | 3.0 | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | 3.0 | | | |
| 210 | | | | |
| 240 | | | | |
| 270 | 3.0 | | | |
| 300 | | | | |
| 330 | | | | |

| Backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -43.0 | | | |
| 30 | -43.0 | | | |
| 60 | | | | |
| 90 | -43.0 | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -43.0 | | | |
| 210 | | | | |
| 240 | | | | |
| 270 | -43.0 | | | |
| 300 | | | | |
| 330 | | | | |

## 4.10   Performance grade S35A

Test frequency Range: Unless otherwise specified in the grade nomenclature the test frequency range is 902 MHz to 928 MHz and 865 MHz to 868 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| Sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -13.5 | -13 | -13.5 | -13.5 |
| 30 | -11.5 | -11.5 | -12 | -12 |
| 60 | -5 | -5 | -5 | -2 |
| 90 | | | | |
| 120 | -5 | -5 | -5 | -2 |
| 150 | -11.5 | -11.5 | -12 | -12 |
| 180 | -13.5 | -13 | -13.5 | -13.5 |
| 210 | -11.5 | -11.5 | -12 | -12 |
| 240 | -5 | -5 | -5 | -2 |
| 270 | | | | |
| 300 | -5 | -5 | -5 | -2 |
| 330 | -11.5 | -11.5 | -12 | -12 |

| Backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | | | | |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | | | | |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

## 4.11    Performance grade S30F

Test frequency Range: Unless otherwise specified in the grade nomenclature the test frequency range is 902 MHz to 928 MHz and 865 MHz to 868 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| Sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -15 | -14 | -14 | -14 |
| 30 | -12 | -11 | -11 | -11 |
| 60 | -6 | -6 | -4.5 | |
| 90 | | | | |
| 120 | -6 | -6 | -4.5 | |
| 150 | -12 | -11 | -11 | -11 |
| 180 | -15 | -14 | -14 | -14 |
| 210 | -12 | -11 | -11 | -11 |
| 240 | -6 | -6 | -4.5 | |
| 270 | | | | |
| 300 | -6 | -6 | -4.5 | |
| 330 | -12 | -11 | -11 | -11 |

| Backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -29 | -30 | -30 | -30 |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -29 | -30 | -30 | -30 |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

## 4.12 Performance grade S40P-FCC

Test frequency Range: the test frequency range is 902 MHz to 928 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| Sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -6.0 | | | |
| 30 | -6.0 | | | |
| 60 | | | | |
| 90 | -6.0 | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -6.0 | | | |
| 210 | | | | |
| 240 | | | | |
| 270 | -6.0 | | | |
| 300 | | | | |
| 330 | | | | |

| Backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -33.5 | | | |
| 30 | -33.5 | | | |
| 60 | | | | |
| 90 | -33.5 | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -33.5 | | | |
| 210 | | | | |
| 240 | | | | |
| 270 | -33.5 | | | |
| 300 | | | | |
| 330 | | | | |

## 4.13 Performance grade M05B

Test frequency Range: Unless otherwise specified in the grade nomenclature the test frequency range is 902 MHz to 928 MHz and 865 MHz to 868 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| 2 stack sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -0.5 | 1 | 1.5 | 1.5 |
| 30 | 2 | 4 | 4 | 3 |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | 2 | 4 | 4 | 3 |
| 180 | -0.5 | 1 | 1.5 | 1.5 |
| 210 | 2 | 4 | 4 | 3 |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | 2 | 4 | 4 | 3 |

| 11 stack sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | 5 | 5 | 6 | 6 |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | 5 | 5 | 6 | 6 |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

| 2 stack backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -37 | -38 | -41 | -40 |
| 30 | -39 | -39 | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | -39 | -39 | | |
| 180 | -37 | -38 | -41 | -40 |
| 210 | -39 | -39 | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | -39 | -39 | | |

| 11 stack backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | | | | |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | | | | |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

## 4.14 Performance grade M10B

Test frequency Range: Unless otherwise specified in the grade nomenclature the test frequency range is 902 MHz to 928 MHz and 865 MHz to 868 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| 2 stack sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -3.5 | -2 | -1.5 | -1.5 |
| 30 | -1 | 1 | 1 | 0 |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | -1 | 1 | 1 | 0 |
| 180 | -3.5 | -2 | -1.5 | -1.5 |
| 210 | -1 | 1 | 1 | 0 |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | -1 | 1 | 1 | 0 |

| 11 stack sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | 2 | 2 | 3 | 3 |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | 2 | 2 | 3 | 3 |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

| 2 stack backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -36 | -37 | -40 | -39 |
| 30 | -38 | -38 | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | -38 | -38 | | |
| 180 | -36 | -37 | -40 | -39 |
| 210 | -38 | -38 | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | -38 | -38 | | |

| 11 stack backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | | | | |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | | | | |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

## 4.15    Performance grade M15B

Test frequency Range: Unless otherwise specified in the grade nomenclature the test frequency range is 902 MHz to 928 MHz and 865 MHz to 868 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| 2 stack sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -7 | -6 | -3 | -4 |
| 30 | -3.5 | -2.5 | -2.25 | -2 |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | -3.5 | -2.5 | -2.25 | -2 |
| 180 | -7 | -6 | -3 | -4 |
| 210 | -3.5 | -2.5 | -2.25 | -2 |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | -3.5 | -2.5 | -2.25 | -2 |

| 11 stack sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -1 | -2 | -3 | -2 |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -1 | -2 | -3 | -2 |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

| 2 stack backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -35 | -34 | -34 | -29 |
| 30 | -36 | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | -36 | | | |
| 180 | -35 | -34 | -34 | -29 |
| 210 | -36 | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | -36 | | | |

| 11 stack backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | | | | |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | | | | |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

## 4.16    Performance grade M20D

Test frequency Range: Unless otherwise specified in the grade nomenclature the test frequency range is 902 MHz to 928 MHz and 865 MHz to 868 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| 2 stack sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -8 | -6.5 | -7 | -7 |
| 30 | -5.5 | -6.5 | -5.5 | -2.5 |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | -5.5 | -6.5 | -5.5 | -2.5 |
| 180 | -8 | -6.5 | -7 | -7 |
| 210 | -5.5 | -6.5 | -5.5 | -2.5 |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | -5.5 | -6.5 | -5.5 | -2.5 |

| 11 stack sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -1 | -4 | -5 | -1 |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -1 | -4 | -5 | -1 |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

| 2 stack backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -25 | -30 | -30 | -28 |
| 30 | -28 | -29 | -30 | -31 |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | -28 | -29 | -30 | -31 |
| 180 | -25 | -30 | -30 | -28 |
| 210 | -28 | -29 | -30 | -31 |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | -28 | -29 | -30 | -31 |

| 11 stack backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | | | | |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | | | | |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

## 4.17 Performance grade M25C

Test frequency Range: Unless otherwise specified in the grade nomenclature the test frequency range is 902 MHz to 928 MHz and 865 MHz to 868 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| 2 stack sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -10 | -8 | -9 | -8.5 |
| 30 | -7 | -6 | -6 | -6.5 |
| 60 | -2 | | | |
| 90 | | | | |
| 120 | -2 | | | |
| 150 | -7 | -6 | -6 | -6.5 |
| 180 | -10 | -8 | -9 | -8.5 |
| 210 | -7 | -6 | -6 | -6.5 |
| 240 | -2 | | | |
| 270 | | | | |
| 300 | -2 | | | |
| 330 | -7 | -6 | -6 | -6.5 |

| 11 stack sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -8.5 | -7 | -7 | -7 |
| 30 | -5 | -4 | -4 | -4 |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | -5 | -4 | -4 | -4 |
| 180 | -8.5 | -7 | -7 | -7 |
| 210 | -5 | -4 | -4 | -4 |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | -5 | -4 | -4 | -4 |

| 2 stack backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -30 | -33 | -33 | -32 |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -30 | -33 | -33 | -32 |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

| 11 stack backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | | | | |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | | | | |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

## 4.18 Performance grade M30E

Test frequency Range: Unless otherwise specified in the grade nomenclature the test frequency range is 902 MHz to 928 MHz and 865 MHz to 868 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| 2 stack sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -13 | -11.5 | -12 | -11.5 |
| 30 | -9.5 | -9 | -9 | -9 |
| 60 | -3.5 | -3 | -3 | |
| 90 | | | | |
| 120 | -3.5 | -3 | -3 | |
| 150 | -9.5 | -9 | -9 | -9 |
| 180 | -13 | -11.5 | -12 | -11.5 |
| 210 | -9.5 | -9 | -9 | -9 |
| 240 | -3.5 | -3 | -3 | |
| 270 | | | | |
| 300 | -3.5 | -3 | -3 | |
| 330 | -9.5 | -9 | -9 | -9 |

| 11 stack sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -11 | -9 | -9.5 | -9.5 |
| 30 | -8 | -7 | -6.5 | -7 |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | -8 | -7 | -6.5 | -7 |
| 180 | -11 | -9 | -9.5 | -9.5 |
| 210 | -8 | -7 | -6.5 | -7 |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | -8 | -7 | -6.5 | -7 |

| 2 stack backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -30.5 | -34 | -34 | -32 |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -30.5 | -34 | -34 | -32 |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

| 11 stack backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | | | | |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | | | | |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

## 4.19  Performance grade M35E

Test frequency Range: Unless otherwise specified in the grade nomenclature the test frequency range is 902 MHz to 928 MHz and 865 MHz to 868 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| 2 stack sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -15.5 | -14 | -14 | -13.5 |
| 30 | -11 | -11 | -11 | -11 |
| 60 | -6 | -5.5 | -5.5 | |
| 90 | | | | |
| 120 | -6 | -5.5 | -5.5 | |
| 150 | -11 | -11 | -11 | -11 |
| 180 | -15.5 | -14 | -14 | -13.5 |
| 210 | -11 | -11 | -11 | -11 |
| 240 | -6 | -5.5 | -5.5 | |
| 270 | | | | |
| 300 | -6 | -5.5 | -5.5 | |
| 330 | -11 | -11 | -11 | -11 |

| 11 stack sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -13.5 | -11.5 | -11.5 | -11 |
| 30 | -9.5 | -8.5 | -8 | -8.5 |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | -9.5 | -8.5 | -8 | -8.5 |
| 180 | -13.5 | -11.5 | -11.5 | -11 |
| 210 | -9.5 | -8.5 | -8 | -8.5 |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | -9.5 | -8.5 | -8 | -8.5 |

| 2 stack backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -28 | -29 | -30 | -30 |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -28 | -29 | -30 | -30 |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

| 11 stack backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | | | | |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | | | | |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

## 4.20 Performance grade J04V

Test frequency Range: Unless otherwise specified in the grade nomenclature the test frequency range is 902 MHz to 928 MHz and 865 MHz to 868 MHz. The pass/fail criteria are 100% for all rows and columns and are omitted here for brevity.

| Sensitivity (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | 0 | | | |
| 30 | 2 | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | 2 | | | |
| 180 | 0 | | | |
| 210 | 2 | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | 2 | | | |

| Backscatter (dBm) | | | | |
|---|---|---|---|---|
| Orientation angle (degrees) | Antenna | | | |
| | 1 | 2 | 3 | 4 |
| 0 | -40 | | | |
| 30 | | | | |
| 60 | | | | |
| 90 | | | | |
| 120 | | | | |
| 150 | | | | |
| 180 | -40 | | | |
| 210 | | | | |
| 240 | | | | |
| 270 | | | | |
| 300 | | | | |
| 330 | | | | |

# A    Appendix Grade Family descriptions

### 'A' Family Grades

- A-family grades present very good readability for single items from many directions, including all the elevation angles.
- High sensitivity requirement means that these items can be scanned from relatively long distances from the front and backsides, but read sensitivity to sides is relatively lower.
- Consider these grades for single item detection in EAS applications. Utilize higher sensitivity grades for overhead reader installations, lower grade for gates.

### 'B' Family Grades

- B-family grades are applied both for single items and stacked items.
- Backscatter requirement is low, which suggest the grade is best applied at short distances, event below 2 meters.
- Tagged items in this family present fair readability also from elevation angles.
- Consider applying the grades for handheld scanning.

### 'C' Family Grades

- C-family grades offer high readability for stacked items especially from the front and back even from all the elevation angles.
- Readability from the side directions is more limited in range, but possible at proximity scanning.
- Backscatter suggests that read distance is fairly short, in the range of a meter or so.
- Consider C-family grades for stacked item applications in transition reading: especially bulk reading of attest passing from stockroom to sales floor.

### 'D' Family Grades

- D-family grades offer good readability both for single and stacked items from the front and back sides.
- Elevation angles are well covered, but the side orientation reads are not required.
- Backscatter values are specified, but the magnitude is not high.
- Prominent use cases include handheld scanning.

### 'E' Family Grades

- E-family grades present fairly high read sensitivity for stacked items.
- Read distance is longest from the front and back, however, also the side angles are specified.
- Relatively high backscatter requirement suggest long read ranges, making this a relatively high-performance grade in TIPP.
- Consider these grades for inventory of stacked items with overhead reader system.

### 'F' Family Grades

- F-family grades present fairly high read sensitivity for single items to all elevations angles.
- The read distance is more limited to the side orientations, but overall the grade is fairly unidirectional.
- It should be noted, that the F-family does not include requirements for the backscatter signal strength.
- This implies that these grades are not fit for applications, where read distance is long and tag size is small.
- One application example is therefore EAS implemented with gate readers.

### 'P' Family Grades

■ P-family grades present very good readability for single items from many orientations but for only Antenna 1.

■ For a given performance grade, the values of sensitivity and backscatter power are the same for all orientation angles.

■ Consider these grades for single item detection in smart enclosures or smart cabinets applications.

✅ **Note**: The P-family grades are based on some tested healthcare enclosures that were available at the time this document has been written. Compliance with the highest performance P-family grade (S40P-FCC) does not mean that the Tagged-items will be read by all existing or future enclosures available in the market.

### 'V' Family Grades

■ The V-family includes simple 1 channel grades that well respond to requirements of sporting goods inventory on the shelfs and identification at POS.

■ The J04V addresses the performance requirements of dense item stacks that are inventoried from a short distance with handheld scanners.

■ The lack of elevation angle requirement means that these items are best identified from the front or back. Having only one test channel keeps the test arrangement simple, thus enabling many parties to conduct the tests.