

Application Note

IMPINJ R700 SERIES

READER MODES

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2 INTRODUCTION

The Impinj R700 Series uses reader modes (RF Modes) to configure the communication (link) parameters between the reader and RAIN tags. Selecting the correct reader mode for a given solution is critical, as there are inherent trade-offs in performance when selecting one reader mode over another. This support article details the various reader modes available on the Impinj R700 Series of readers.

General information on reader modes is available in the following linked article: [Reader Modes Made Easy](#).

For help choosing a reader mode for a particular use case or application, please refer to the following article: [What Reader Mode, Session, and Search Mode should I use for my application?](#)

3 READER MODES OVERVIEW

The Impinj R700 reader supports many reader modes, allowing the user to balance the different performance metrics, including read rate, sensitivity, and interference tolerance for a particular use case.

The Impinj R700's reader mode options are extensive, particularly compared to the LLRP modes available on the Impinj Speedway Series that are detailed in the articles linked above. This article intends to define these reader modes when configuring a reader profile.

3.1 LLRP Reader Modes

LLRP Reader modes are identified by their mode index (0 – 5) and are sometimes referenced by their names such as Max Throughput, Hybrid, Dense Reader M4/M8, and Max Miller.

Impinj R700 readers support LLRP modes which are backwards compatible with Speedway series readers.

An added benefit to LLRP modes is that when selected they can run comparable reader modes in the correct region when the profile is applied to readers across different regions. See Table 4 for the LLRP reader mode mapping.

3.2 Static Reader Modes

Impinj R700 supports new static reader modes with a new mode index. These reader modes are expressed by a 3-digit number where the first two digits provide some basic information about the reader mode (see Table 1). A subset of these new static reader modes maps to existing LLRP modes. This mapping is fully described in Table 4.

Table 1: Static Reader Index Modes

Digit Sequence	Definition	Options
First (example: 120)	Region	1 = FCC / FCC-like 2 = ETSI LB and Japan 3 = ETSI HB
Second (example: 120*)	Miller value	0, 2, 4, or 8

* Note: static reader mode versions of a given Miller value may exceed 10, and when this happens, the reader mode continues to increment by 1. For instance, there is a reader mode 290. This mode has a Miller value of 8, not 9.

3.3 Impinj Autoseed Modes

Impinj has created several Autoseed reader modes are designed to capture the benefits of the different reader modes by cycling through multiple modes automatically. These modes are defined by 4-digit numbers starting with either 1 or 5.

Autoseed modes starting with 100x utilize LLRP reader modes.

The 11XX, 12XX, and 13XX series of reader modes use the new 3-digit static reader modes and are differentiated by region through their second digit in their mode index.

Please read the next session for a description of the 5000-series Autosets, which are part of Impinj's first release of Gen2X features in our readers in firmware version 8.4 and higher.

3.4 NEW Impinj Gen2X Performance Autoset Modes

Impinj R700 reader firmware version 8.4 introduces new Impinj AutoSet reader modes that support Impinj Gen2X Performance. Impinj Gen2X Performance features improve reader sensitivity and tag read range, and reduce reader inventory time and tag communication errors. More information about the Impinj Gen2X Solutions Toolbox is available at <https://www.impinj.com/products/technology/gen2x>.

The 5000 series AutoSet modes cycle between Impinj Gen2X Performance link parameters and Gen2v2 link parameters. This behavior enables the solution to see the enhanced readability benefits of Impinj Gen2X while also reading tags which support the Gen2v2 standard.

At time of writing the only tag chips which support Gen2X are Impinj M800 series tag chips. Impinj recommends using these Autoset modes when at least 20% of the total tag population utilizes Impinj M800 series tag chips. The Gen2X Performance benefit in inventory speed and sensitivity will be more noticeable with a higher percentage of M800 tags in the population.

3.5 Available Reader Modes by Region

The following tables summarizes what the available reader modes are using the latest 8.4 firmware on the Impinj R700 reader, organized by region selected.

Table 2: FCC R700 Reader Mode Options

Mode Index	Notes
0 – Max Throughput	LLRP modes.
1 - Hybrid	
2 – Dense Reader M4	
3 – Dense Reader M8	
4 – Max Miller	
1002 – Autoset Dense Reader Deep Scan (default)	LLRP Autoset modes.
1003 – Autoset Static Fast	
1004 – Autoset Static Dense Reader	
1006	
100	Static reader modes (exclusively Impinj R700).
120	
121	
122	
140	
141	
142	
180	
181	
184	
185	Autoset modes using static reader modes.
1110	
1111	
1112	Autoset Gen2X – mode 120 equivalent link parameters
5120	
5140	
5142	Autoset Gen2X – mode 142 equivalent link parameters

Table 3: ETSI LB, FGX, Japan, and HB R700 Reader Mode Options

Mode Index	Notes
0 – Max Throughput	LLRP modes.
1 - Hybrid	
2 – Dense Reader M4	
3 – Dense Reader M8	
5 – Max Miller	
204	ETSI LB Static reader modes (exclusively Impinj R700).
227	
246	
247	
288	
290	
301	
322	

340	ETSI HB Static reader modes (exclusively Impinj R700).
341	
380	
381	
1210	ETSI LB (EU1) Autoset modes based on static reader modes.
1211	
1212	
1310	ETSI HB (EU2) Autoset modes based on static reader modes.
1311	
1312	
5227	Autoset Gen2X – 227 equivalent link parameters
5245	Autoset Gen2X – 245 equivalent link parameters
5246	Autoset Gen2X – 246 equivalent link parameters
5247	Autoset Gen2X – 247 equivalent link parameters
5322	Autoset Gen2X – 322 equivalent link parameters
5341	Autoset Gen2X – 341 equivalent link parameters
5340	Autoset Gen2X – 340 equivalent link parameters

4 READER MODE PERFORMANCE

In the following section, we present graphs that show the maximum measured read rate and average measured receive sensitivity by reader modes organized by region.

The modes have been arranged in order (from left to right) from highest throughput to lowest. Tracking the plots from left to right shows a general trend that as read rate (blue) decreases, sensitivity (orange) increases (more negative is higher sensitivity), with a few small exceptions.

4.1 Test Set-ups Overview

It is important to note that sensitivity and read rate testing are completed separately using different test conditions.

Over-the-air (OTA) read rate tests include a large tag population (500+) within a single antenna's field of view, at a short distance (<1m). The Impinj R700 reader is configured to use the search mode, Dual Target B to A Select in Session 2 at the maximum transmit power allowed by the region.

Receive sensitivity is measured against the benchmark of 1e-3 bit error rate (BER) in a conducted communication test between an Impinj R700 reader and a tag emulator in a near-ideal set-up. An ideal environment means high return loss (>20 dB) and low time delay (<5 ns).

It is important to remember that these results are collected in a controlled specific test environment at Impinj. Environmental conditions, tag population, tag type, antenna type, and other physical setup variables can affect the results of these tests. We provide the graphs here to show the general performance trends regarding inventory speed (through read rate) and reader sensitivity. Although it is possible to obtain these values in use cases, obtaining these results in every setup, solution, or environment is impossible.

The results shown for the FCC modes are collected from an Impinj R700 FGX reader model configured for FCC Operation.

4.2 LLRP Modes Performance

For LLRP modes, it is commonly seen that LLRP mode 0 (Max Throughput) offers the highest read-rate with the lowest sensitivity, while LLRP Mode 3 (Dense Reader M8) offers the highest sensitivity and interference tolerance but has the slowest read-rate.

Figure 1: Impinj R700 FCC LLRP Modes

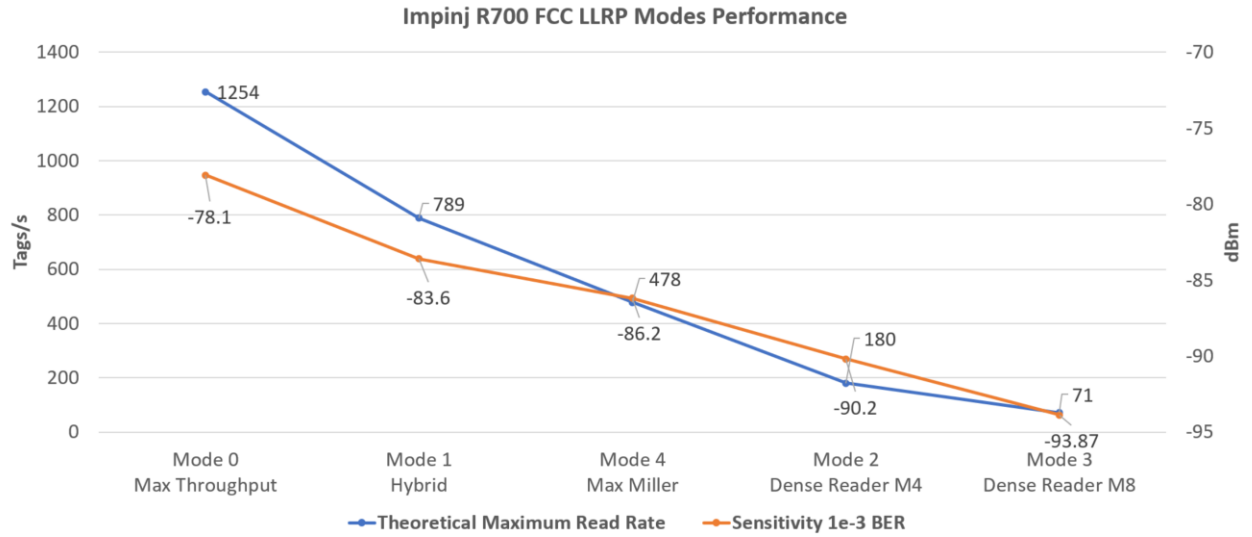


Figure 2: Impinj R700 FGX LLRP Modes

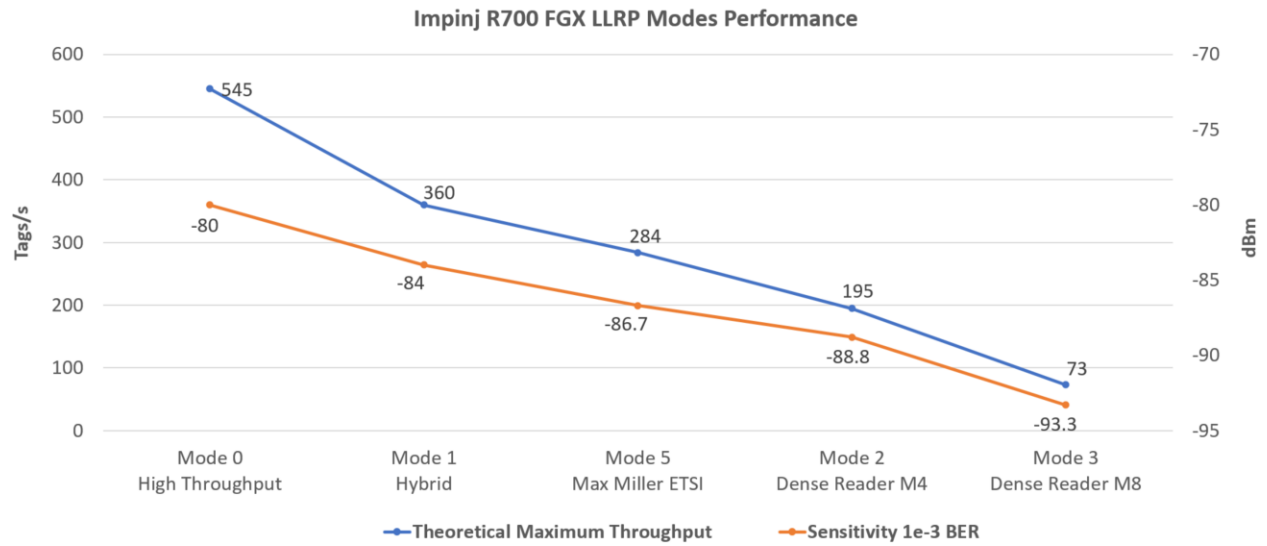


Figure 3: Impinj R700 EU LB LLRP Modes

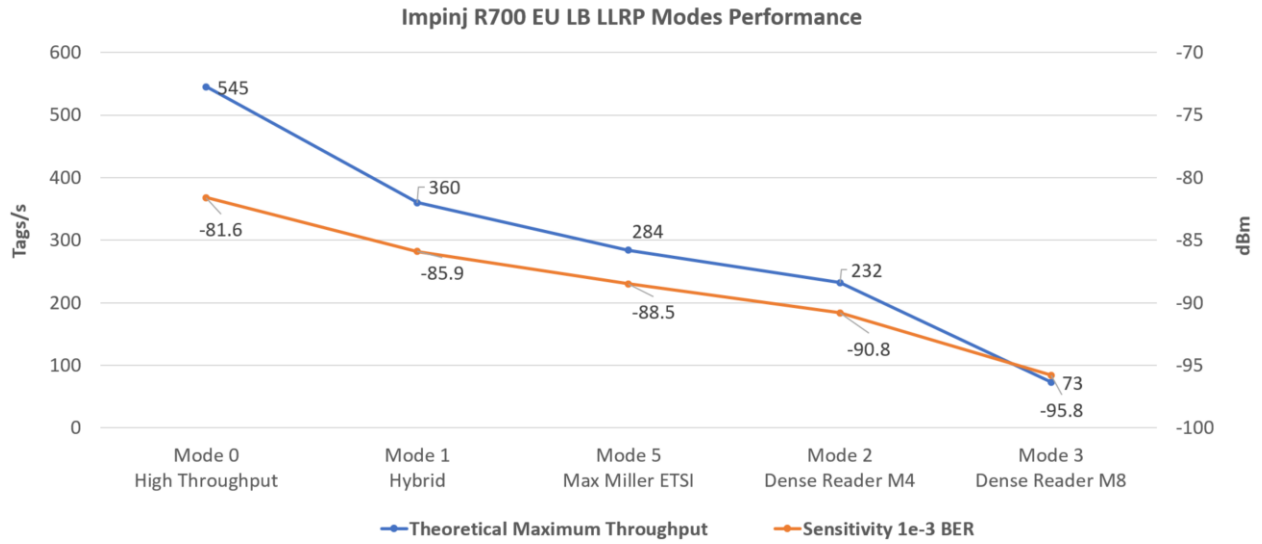


Figure 4: Impinj R700 EU HB LLRP Modes

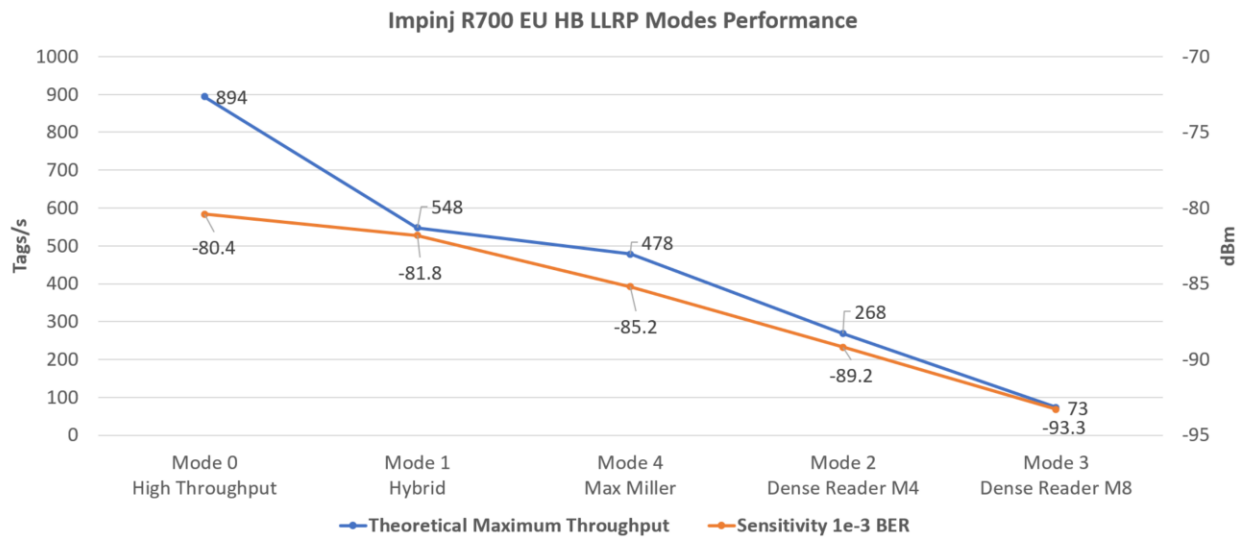
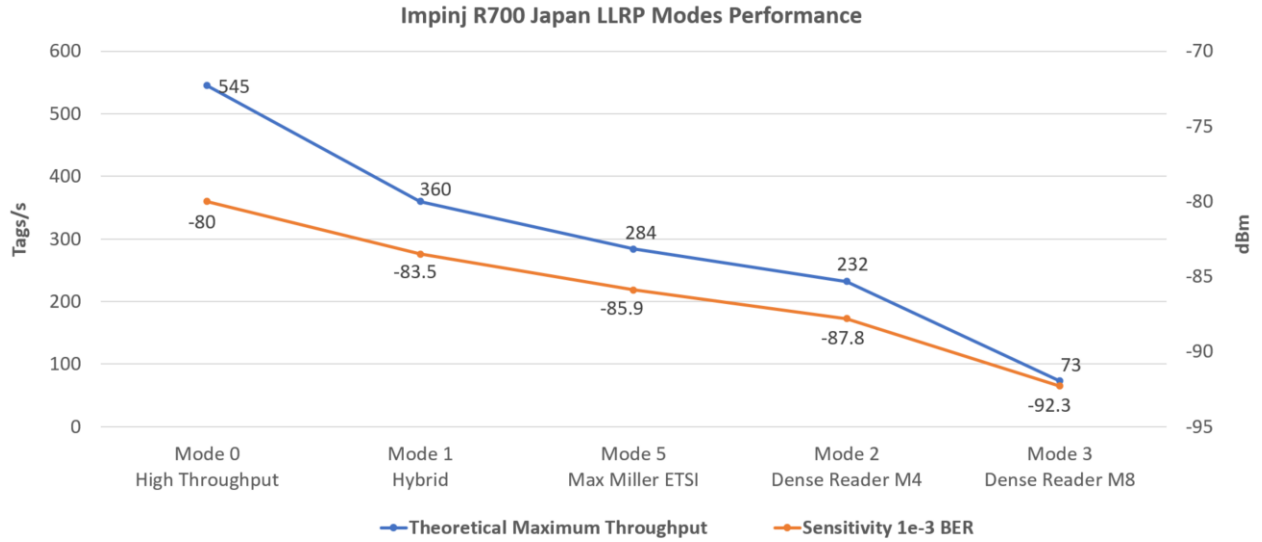


Figure 5: Impinj R700 Japan LLRP Modes



4.3 Static Mode Performance

Figure 6: Impinj R700 FCC Static Reader Modes

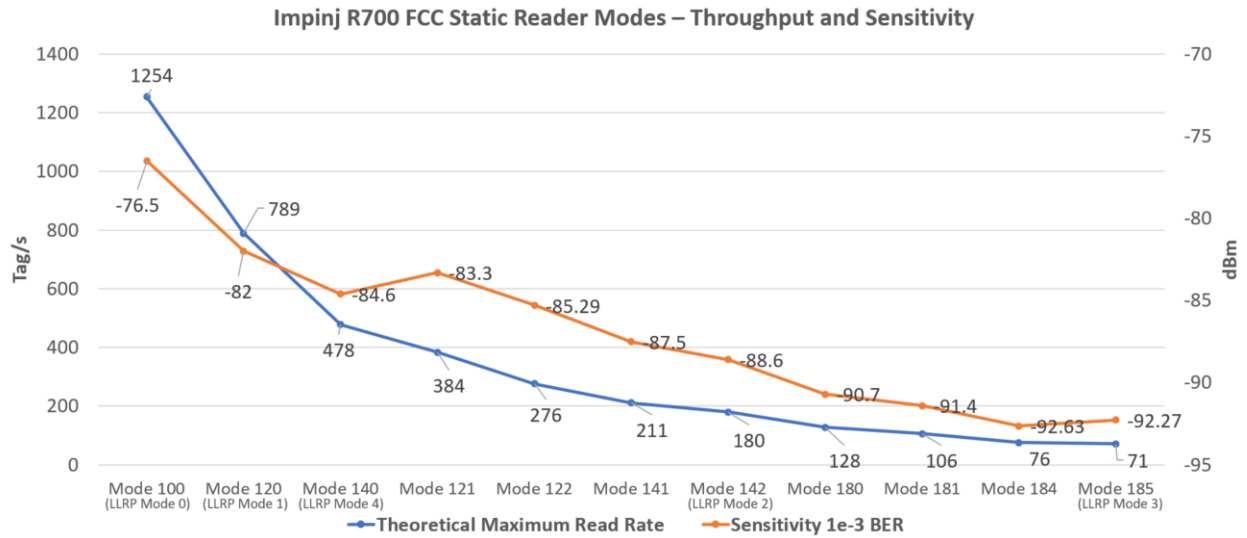


Figure 7: Impinj R700 FGX Static Reader Modes

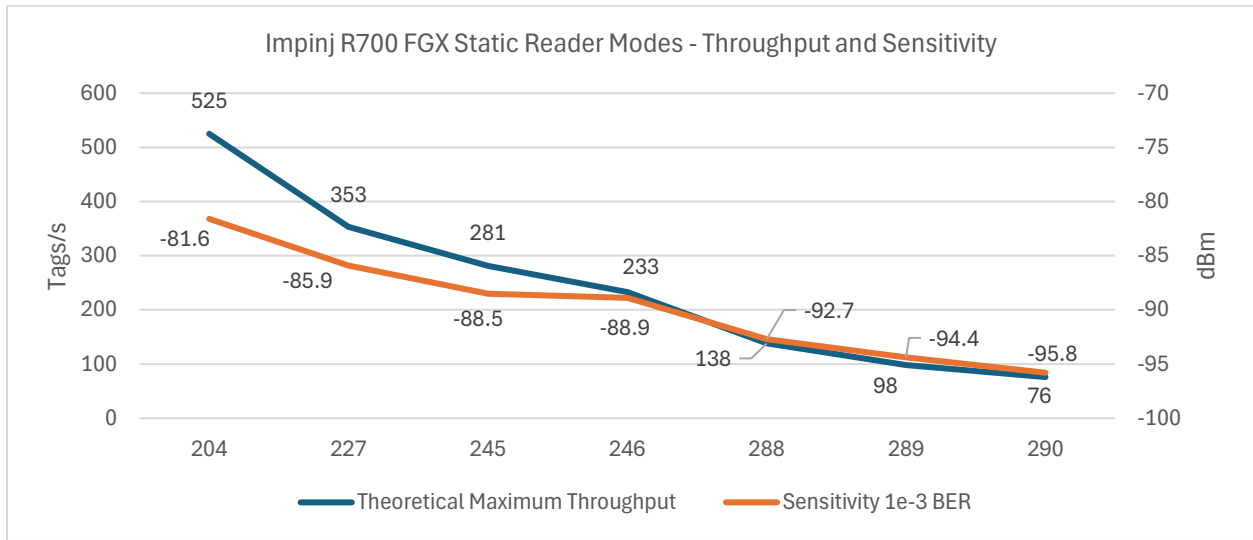


Figure 8: Impinj R700 EU LB Static Reader Modes

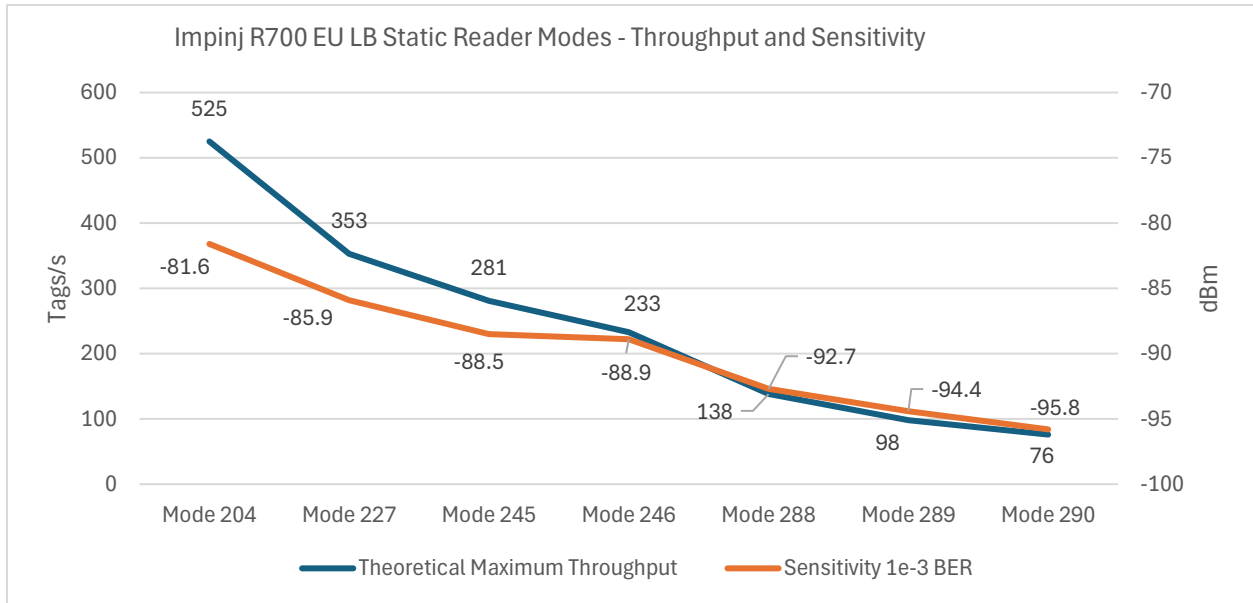


Figure 9: Impinj R700 EU HB Static Reader Modes

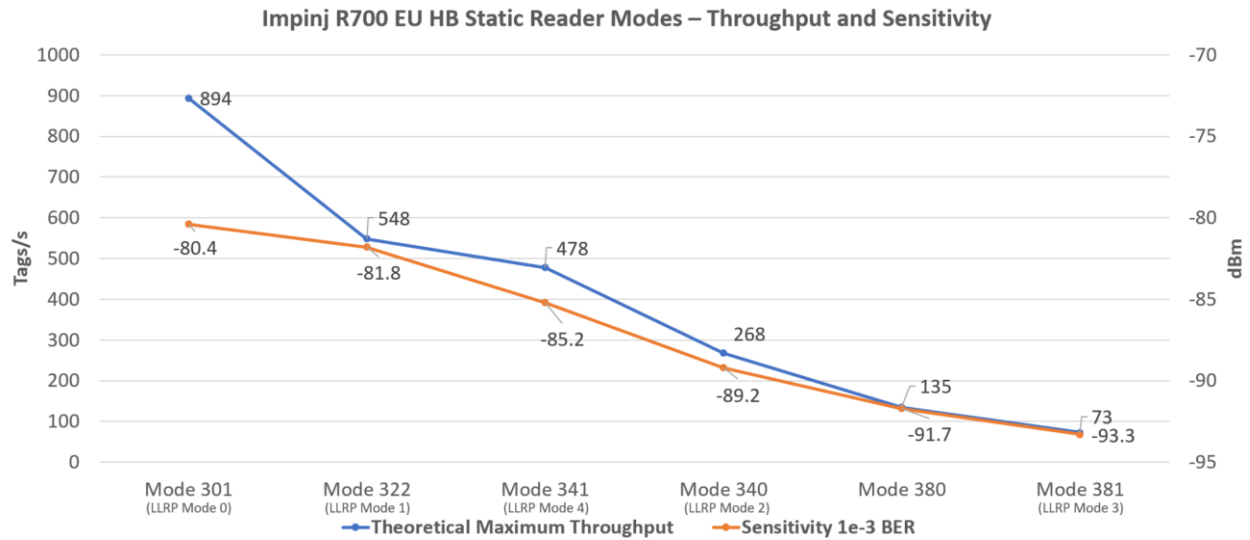
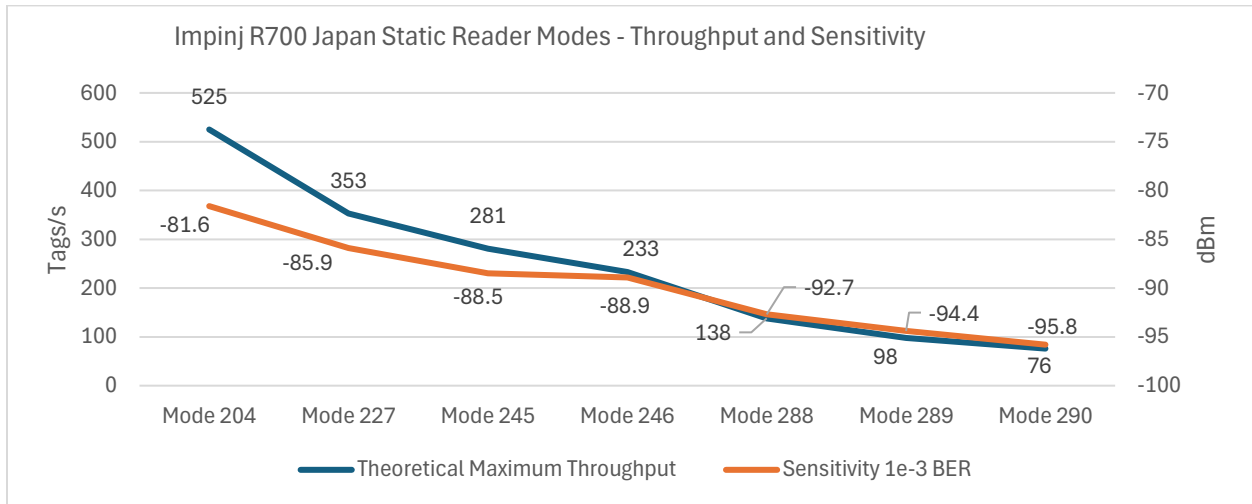


Figure 10: Impinj R700 Japan Static Reader Modes



4.4 NEW Gen2X Autoset Performance

The set-up for Gen2X Autoset read rate testing varied from the testing described in Sections 4.2 and 4.3. This OTA read rate testing included 288 Gen2X-enabled (M800) tags at <1m distance.

The receive sensitivity set-up was the same as the sections above.

Figure 11: Impinj R700 FCC Autoselect Reader Modes

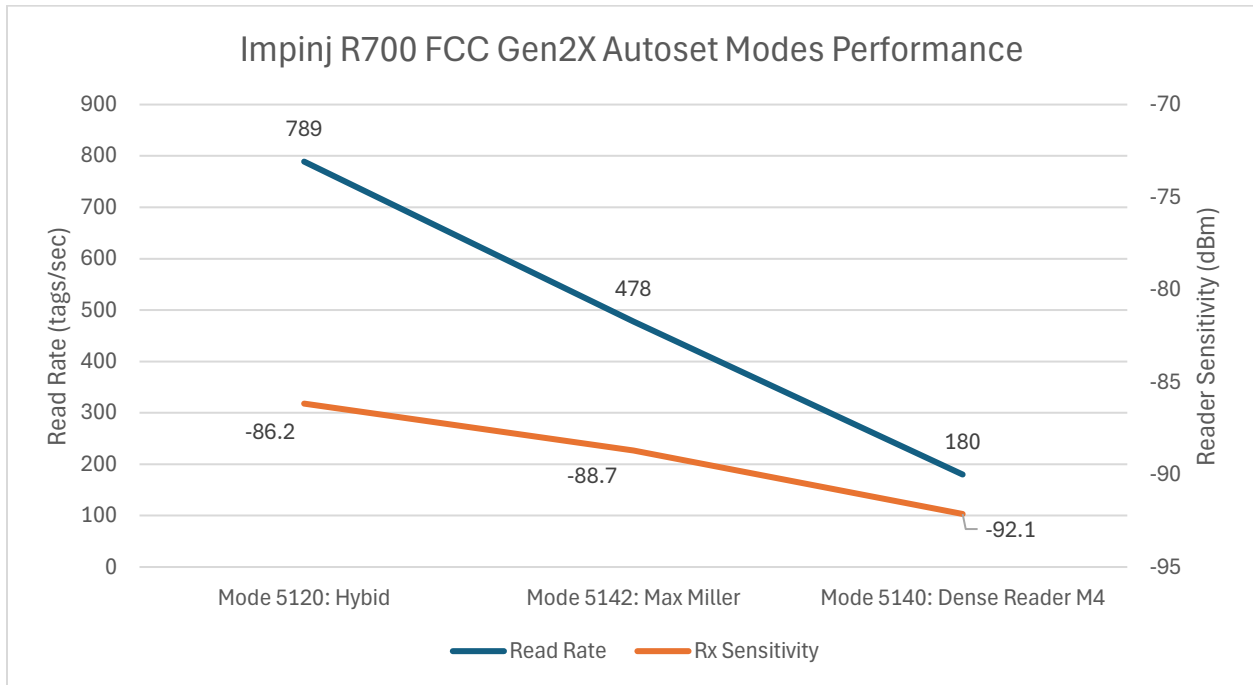


Figure 12: Impinj R700 EU1 (LB) Autoselect Reader Modes

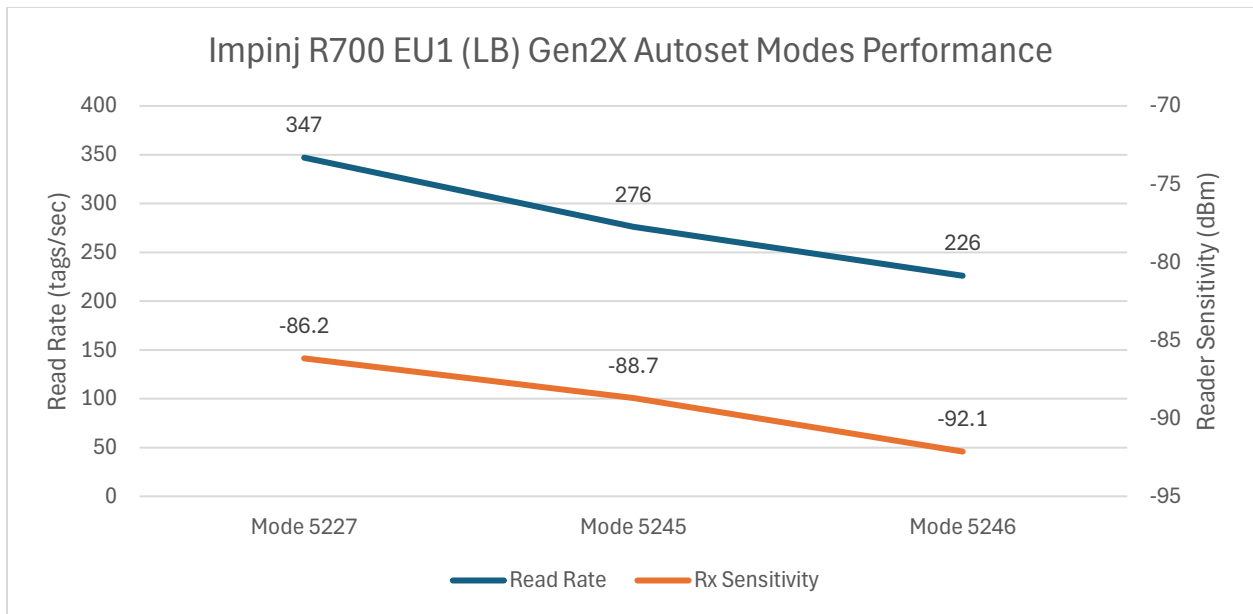


Figure 13: Impinj R700 EU HB Autoset Reader Modes

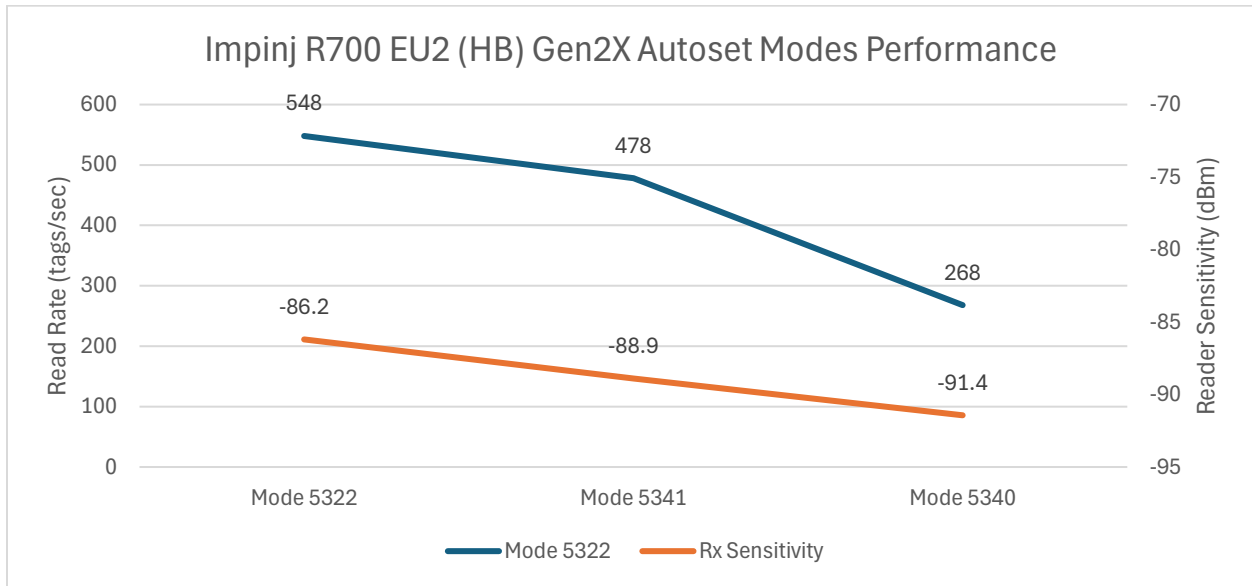
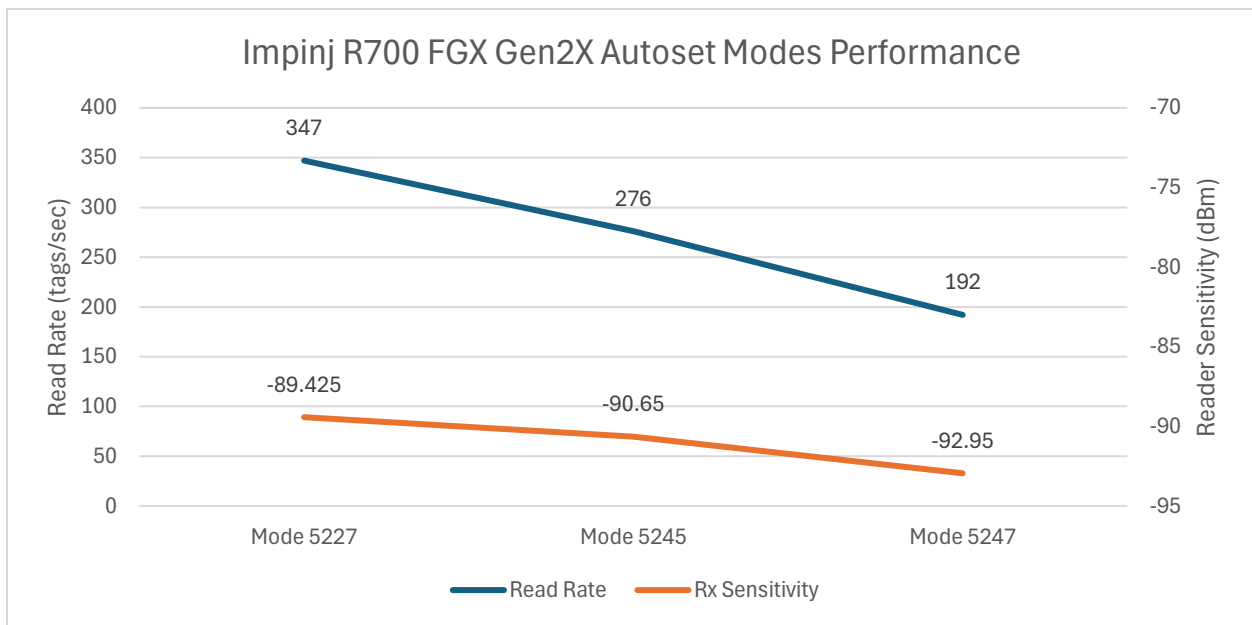


Figure 14: Impinj R700 FGX Autoset Reader Modes



5 IMPINJ STATIC READER MODES LINK PARAMETERS

The following sections are intended for reference when looking to find comparable reader modes between regions and gain an understanding of similarities and differences in different reader mode link parameters.

5.1 Reader Mode Mapping

Many of these reader modes have similar performance to one another across regions because their link parameters are similar. The differences in performance are due to regional standards, restrictions, and frequencies. Table 4 clarifies how reader modes correlate to each other across regions and naming conventions.

Table 4: Reader Mode Mapping Reference

LLRP Mode	FCC Static Reader Mode*	EU LB & Japan Static Reader Mode	EU HB Static Reader Mode	FGX Static Reader Mode**
0 – Max Throughput	100	204	301	204
1 - Hybrid	120	227	322	227
2 – Dense Reader M4	142	246	340	246
3 – Dense Reader M8	185	290	381	290
4 – Max Miller	140	N/A	341	N/A
5 – Max Miller	N/A	245	N/A	245
1000 – Autoset	Not Supported	Not Supported	Not Supported	Not Supported
1002 – Autoset Dense Reader Deep Scan (profile default)	1110 [100,140,142,184]	1210 [201,242,240,284]	1310 [301,341,340,381]	1213 [201,242,243,284]
1003 – Autoset Static Fast	1111 [100,140]	1211 [201,242]	1311 [301,341]	1211 [201,242]
1004 – Autoset Static Dense Reader	1112 [142,185]	1212 [240,284]	1312 [340,381]	1214 [243,284]
No LLRP equivalent	5120 [similar 120 performance with Gen2X benefit]	5227 [similar 227 performance with Gen2X benefit]	5322 [similar 322 performance with Gen2X benefit]	5227 [similar 227 performance with Gen2X benefit]
No LLRP equivalent	5140 [similar 140 performance with Gen2X benefit]	5245 [similar 245 performance with Gen2X benefit]	5341 [similar 341 performance with Gen2X benefit]	5245 [similar 245 performance with Gen2X benefit]
No LLRP equivalent	5142 [similar 142 performance with Gen2X benefit]	5246 [similar 246 performance with Gen2X benefit]	5340 [similar 340 performance with Gen2X benefit]	5247 [similar 247 performance with Gen2X benefit]

* Note: When the Impinj R700 FGX reader model is configured for FCC Operation, the reader has the modes shown in the "FCC Static Reader Mode" column of the table above.

**Note: When the Impinj R700 FGX reader model is not configured for FCC Operation, the reader has the modes shown in the "FGX Static Reader Mode" column of the table above.

5.2 FCC and FCC-Like Regions

The following tables reference the key forward- and reverse-link parameters by reader mode, organized by region.

Static Reader Modes	Fwd Modulation	TARI	PIE	BLF	M	DR
100	DSB-ASK	6.25	1.5	640	1	64/3
120	DSB-ASK	6.25	1.5	640	2	64/3
121	PR-ASK	14.29	1.5	320	2	64/3
122	PR-ASK	20	2	256	2	64/3
140	PR-ASK	7.14	1.5	640	4	64/3
141	PR-ASK	20	2	320	4	64/3
142	PR-ASK	20	2	256	4	64/3
180	PR-ASK	20	2	320	8	64/3
181	PR-ASK	20	2	256	8	64/3
184	DSB-ASK	6.25	1.5	160	8	8
185	PR-ASK	20	2	160	8	64/3

5.3 ETSI Regions

Static Reader Modes	Fwd Modulation	TARI	PIE	BLF	M	DR
204	PR-ASK	15.625	2	320	1	64/3
227	PR-ASK	15.625	2	320	2	64/3
245	PR-ASK	15.625	2	426	4	64/3
246	PR-ASK	15.625	2	320	4	64/3
288	PR-ASK	15.625	2	320	8	8
290	PR-ASK	15.625	2	160	8	8
301	PR-ASK	8.33	1.5	426	1	64/3
322	PR-ASK	8.33	1.5	426	2	64/3
341	PR-ASK	7.14	1.5	640	4	64/3
340	PR-ASK	7.14	1.5	320	4	8
380	PR-ASK	14.29	2	320	8	8

381	PR-ASK	14.29	2	160	8	8
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5.4 Japan Region

Static Reader Modes	Fwd Modulation	TARI	PIE	BLF	M	DR
204	PR-ASK	15.625	2	320	1	64/3
227	PR-ASK	15.625	2	320	2	64/3
245	PR-ASK	15.625	2	426	4	64/3
246	PR-ASK	15.625	2	320	4	64/3
288	PR-ASK	15.625	2	320	8	8
290	PR-ASK	15.625	2	160	8	8

5.5 FGX Regions

Static Reader Modes	Fwd Modulation	TARI	PIE	BLF	M	DR
204	PR-ASK	15.625	2	320	1	64/3
227	PR-ASK	15.625	2	320	2	64/3
245	PR-ASK	15.625	2	426	4	64/3
246	PR-ASK	15.625	2	320	4	64/3
288	PR-ASK	15.625	2	320	8	8
290	PR-ASK	15.625	2	160	8	8

6 NOTICES

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