Class-1 Generation 2
UHF RFID

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An RFID Chip

More transistors than the processor in a 1985 IBM PC-AT
Lower power consumption than a honeybee’s brain
Agenda

• Overview of Gen2 features
• Five challenges that Gen2 solves
• Gen2 FAQ
## Gen2 Features

<table>
<thead>
<tr>
<th>Requirement / Feature</th>
<th>Gen2 Capability</th>
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<tr>
<td>Global regulatory compliance</td>
<td>Europe, North America, others</td>
</tr>
<tr>
<td>Memory access control</td>
<td>32-bit access password, memory locking</td>
</tr>
<tr>
<td>Fast read speed</td>
<td>&gt; 1000 tags/sec</td>
</tr>
<tr>
<td>Dense-reader operation</td>
<td>Dense-reader operating mode</td>
</tr>
<tr>
<td>Kill security</td>
<td>32-bit kill password</td>
</tr>
<tr>
<td>Memory write capability</td>
<td>&gt; 7 tag/second write rate</td>
</tr>
<tr>
<td>Bit masked filtering</td>
<td>Flexible <em>Select</em> command</td>
</tr>
<tr>
<td>Optional user memory</td>
<td>Vendor option</td>
</tr>
<tr>
<td>Low cost</td>
<td>Multi-vendor availability</td>
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<tr>
<td>Industry certification plan</td>
<td>EPCglobal™ certification</td>
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<tr>
<td>Certified products</td>
<td><strong>Q2 2005</strong></td>
</tr>
</tbody>
</table>
Agenda

- Overview of Gen2 features
- **Five challenges that Gen2 solves**
- Gen2 FAQ
#1: Tag Identification

- Suppose...you are all tags
  - You are all blindfolded
  - You are nearly deaf
  - You talk by whispering
  - You can’t hear each other

- Suppose...I’m a reader
  - I’m blindfolded
  - I don’t know who is in the room
  - I need to yell so you can hear me
  - If two of you talk at once, I can’t understand you
  - I’m not allowed to say your name

- I need to identify everybody in the room

What do I do?
The Q algorithm

Query(Q) — everybody pick 2 numbers
First: Between 0 and $2^Q$ [$2^7=128$]
Second: Between 0 and 65535

Does anybody have 1st number = 0?

- Nobody
- 1 person
- 2 or more people

Tell me your 2nd number

Everybody subtract 1

Can you hear me?

Tell me your name

Go to sleep

Wait until Next Query

Everybody else subtract 1
#2: Tags That Oversleep

- **Fact:** Some tags are heavy sleepers
- **Problem:** A tag may still be asleep, from being counted by a prior reader, when it reaches me
  - How do I count it?

  ![Reset]

  - Late-arriving tags won’t hear the reset
  - Multiple resets will interrupt a Query round
**A↔B Symmetry**

- **Gen2 doesn’t put tags to sleep. It uses a “flag” instead**
  - Flag can be set to “A” or “B”

- **Count tags from A↔B↔A**
  - Step 1: Query(A)
    - Only “A” tags respond
    - “A” tags set their flag to “B” when they are counted
  - Step 2: Query(B)
    - Only “B” tags respond
    - “B” tags set their flag to “A” when they are counted
  - Go to step 1

After A↔B↔A, all tags have been counted and are in A
#3: Reader Interruptions

- **Problem:** Handheld reader interrupts a dock-door reader
  - Don’t want the dock-door reader to lose its ongoing inventory
- **Solution:** Tags have 4 flags rather than just 1
  - One for each of 4 sessions
  - A reader Queries tags in a single session
  - Different readers can use different sessions

- **Example**
  - Shelf reader uses session #1; handheld reader uses session #2
#4: Variable Read Speed

- **Issue:** Read speed depends on the environment

<table>
<thead>
<tr>
<th>Environment</th>
<th>Reader/tag communication speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noisy</td>
<td>Need to talk slowly and carefully</td>
</tr>
<tr>
<td>Europe</td>
<td></td>
</tr>
<tr>
<td>Many readers</td>
<td></td>
</tr>
<tr>
<td>Quiet</td>
<td>Can talk fast</td>
</tr>
<tr>
<td>North America</td>
<td></td>
</tr>
<tr>
<td>Few readers</td>
<td></td>
</tr>
</tbody>
</table>

- **Gen2 sometimes needs fast tag reads**
  - Pallets moving through a dock door
- **Gen2 sometimes needs slow tag reads**
  - Noisy environments
- **Solution:** Variable read rates
Variable Tag Read Rate

Throughput for 96-bit EPC

- 640 kbps tag backscatter
- Dense-reader modes
  - NA
  - Europe

Backscatter Link BER vs. Tags per Second
Dock-Door Scenario

240 cases on a pallet
Pallet is 1.2m x 0.8m

V=8 mph
(3.6m/s)

Probability of a Tag being powered at any given time varies between 0.2 and 0.8 (uniformly distributed)
Dock Door: 240 tags @ 3.6 m/s

Dock Door Scenario

- Pallet Dimensions = 0.8 m x 1.2 m x 1 m (LxWxH)
- Case Dimensions = 0.1 m x 0.2 m x 0.2 m (LxWxH)
- Pallet Velocity = 3.57 m/s
- Dock Door Width = 2.5 m
- Probability Tag in RF Null = U(0.2, 0.8)
- R => T BER = 0.001; T => R BER = 0.001
- R => T Tari = 25us T => R rate = 80 kbps

Graph:
- X-axis: Time (s)
- Y-axis 1: Tags in Field of View
- Y-axis 2: % Tags Singulated
- Blue line: Tags in Field of View
- Red line: % Tags Singulated
#5: Dense Readers

- **User requirement**
  - Many readers operating simultaneously in a distribution center

- **Problem**
  - With many readers talking, how can anybody hear the tags???

- **Gen2 solution: Dense-reader mode**
  - Isolate tags and readers in frequency
    - Readers collide with readers
    - Tags collide with tags
    - Readers don’t collide with tags

- **Simple analogy**
  - Readers talk in deep, booming voices
  - Tags talk in squeaky, high-pitched voices
Gen2 Dense-Reader Mode

Readers collide with readers but not tags
Readers filter interfering readers from their tag responses

- **EPCglobal™ will certify 3 classes of Gen2 readers**
  - Single-reader environment (1 reader per DC)
  - Multi-reader environment (~10 readers per DC)
  - Dense-reader environment (~50 readers per DC)

- **Dense-reader mode needs dense-reader certification**
  - One non-dense reader can spoil the whole plan
Agenda

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Is My Reader Upgradeable?

- Gen2 says
  
  To conform to this specification, an Interrogator shall modulate/transmit and receive/demodulate a sufficient set of the electrical signals defined in the signaling layer of this specification to communicate with conformant Tags,

- Most existing readers will be “upgradeable” to Gen2
  - But...“sufficient set” may mean “bare minimum”

- Not all upgraded readers will
  - Support dense-reader operation
  - Support maximum read and write rates

- Two key questions you can ask
  - Will my reader be “dense-reader certifiable”?
  - Will my reader support 640kbps tag backscatter?
Is Gen2 Really Better?

- Simple answer: Yes
- Example: A recoverable signal for a Generation-1 reader
Is Gen2 Really Better?

- A recoverable signal for a properly designed Gen2 reader
Are All Tags Created Equal?

- Fact: Any Gen2 tag is readable by any Gen2 reader
- Fact: Some tags will perform better than others
  - Example: Gen2 allows tag noise filtering

**What the reader(s) send**

**What the tag sees**

-6dB modulating interferer in adjacent channel
-6dB CW interferer 20MHz away
Will Gen2 Solve My Problems?

- **Typical problems**
  - Ghost reads
  - Poor read reliability
  - Reader-on-reader interference
  - Noise sources degrading tag sensitivity

- **Answer: Gen2 is a framework, not a solution**
  - Properly implemented Gen2 will outperform today’s systems
  - Improperly implemented Gen2 will perform no better than Gen1

- **Solution: An educated buyer**
  - Understand what Gen2 offers
  - Demand a reader-tag RFID system that “just works”
Will Gen2 Cost More?

- **Gen2 readers will drop in price**
  - Gen2 readers can use the same radio principles as Wi-Fi
  - Gen2 reader chips will drive reader costs down

- **Gen2 tags should be less expensive than Gen1**
  - Smaller die = lower cost

First-generation
Impinj ZumaRFID™ (Class 0+)

First-generation
Impinj Gen2 die is smaller
Questions?