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• Features of UHF band RFID system
  • Long range communication
  • Multiple tag reading
  • What deteriorates the reading accuracy?

• Radio Regulations around UHF band RFID system
  • Radio regulations?
  • Japan status
• UHF band RFID features 5-10m reading distance. Primary target is supply chain management.
• Reading accuracy depends on the radio propagation environment as well as tag and reader performance.
• 952-954MHz band will be opened to RFID system in Japan from early FY.2005.
UHF band?

TV ch.1 = 90-96MHz  UHF TV
TV ch.12 = 216-222MHz  470-770MHz

Cellular Phone etc.  Satellite Broadcasting
810-960MHz  12GHz

HF  VHF  UHF  SHF
3MHz  30MHz  300MHz  3GHz  30GHz

860-960MHz RFID

13.56MHz RFID

Frequently referred to as UHF RFID

2.45GHz RFID
Typical Usages of UHF RFID

**High power type**

- Long range, multiple tags reading

**Low power type**

- Short range, individual tag reading
Active RFID:
- carries battery for radio wave transmission

Passive RFID
- Passive backscatter: Power is supplied by interrogator in the form of radio wave.
  - Read only
  - Read/Write
- may carry battery to power the logic circuit in tag (semi-passive).
Basics of UHF passive RFID

- Antenna
- Interrogator
- Tag
- Logic circuit

Command/Power supply → Response
Interrogator – Tag communication in a nutshell

Power shall be supplied to tags by interrogator while tags reply.
Power level chart

Interrogator Output power

Tag reply power

Interrogator reception

90dB down = 1/1000,000,000
Tag needs to efficiently absorb the radio wave energy from interrogator.

Tag needs to reflect the radio wave, generating 1 and 0 states, for the reply.

Absorb ? Reflect?

Solutions
- Optimal design of tag impedance
- Separate antennas for power supply and communications
Accurate and real-time visibility of total supply chain by RFID
Long range communications requirement

Several meters reading range required
Power reception at tag

Path loss

Transmitting power

Wavelength

Path loss

Transmitting power

Power reception at tag

The lower the frequency, the larger the power reception.
The lower the frequency, the larger the tags becomes.

Good compromise = UHF band; Same story as cellular phone

\[ P_r = \left( \frac{G_P}{4\pi} \right) \left( \frac{1}{4\pi L^2} \right) \left( \frac{G_T}{4\pi} \right) \]
Automatic participants tracking in Keio University Open Research Forum 2004.
Comparison of number of passing participants
Counted by using optical gate sensor and RFID reader

Note: Not all the participants has UHF tag.
Optical sensor sometimes missed counting because of overwrapping of persons and/or bags

Satisfactory agreement
### Table: Output level (EIRP)

<table>
<thead>
<tr>
<th>Test case</th>
<th>Person</th>
<th>EIRP 1 (27dBm)</th>
<th>EIRP 2 (23.1dBm)</th>
<th>EIRP 3 (18dBm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Case 1</strong></td>
<td>Person 1</td>
<td>100%(20/20)</td>
<td>100%(20/20)</td>
<td>65%(13/20)</td>
</tr>
<tr>
<td></td>
<td>Person 2</td>
<td>100%(20/20)</td>
<td>100%(20/20)</td>
<td>75%(15/20)</td>
</tr>
<tr>
<td></td>
<td>Person 3</td>
<td>100%(20/20)</td>
<td>85%(17/20)</td>
<td>10%(2/20)</td>
</tr>
<tr>
<td><strong>Case 2</strong></td>
<td>Person 1</td>
<td>100%(20/20)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Person 2</td>
<td></td>
<td>80%(16/20)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Person 3</td>
<td></td>
<td>85%(17/20)</td>
<td></td>
</tr>
</tbody>
</table>

**100% reading accuracy for 2W transmission power**
Exposure time to the sufficient power RF wave in case of a reading of population of tags

Transmitting power

Path loss

Penetration loss

Minimum necessary power for Tag logic circuit

Interrogator

Tag

Path loss
Group Select

Query

Tag selecting particular slot broadcast with identification

Collision notify

Broadcast with identification

Singulated

Tag ID broadcast

Query repeat

Singulated tag dormant

Flag or state transition

(Randomly) select slot

(Randomly) adjust slot

(State transition)
Certain amount of continuous exposure to sufficient power of RF wave is necessary for multiple tag reading.
In practical implementation, it is not always easy to have sufficient time exposure.

Path difference between path 1 and path generates the blind points.
• Region 1 (Europe and Africa)
  • RFID allocation guideline in Short Range Device band (865-868MHz, 869.4-869.65MHz)
  • ERO 70-03, ETSI technical requirements (EN302208, EN302200)
• Region 2 (North and South America)
  • ISM band allocation 902-928MHz
  • FCC15.247 regulates frequency hopping RFID system technical requirements
• Region 3 (Asia Pacific)
  • No allocation
  • Each administration need to establish local radio regulations for UHF RFID
Internationally consistent frequency allocation is impracticable at this moment
Cellular Phone

Present

Future plan

Fundamental rule of frequency allocation
= Newly allocated radio service (RFID) shall not cause harmful interference to the existing service.
Leaking of RFID power may deteriorate the signal to noise ratio of the existing services.
Desired signal of the neighbor services may be suppressed due to the existence of the large RFID power the proximity.
• Licensing
  • Fast track license for type certificated RFIDs
• Frequency bandwidth 952MHz〜954MHz
• Maximum transmission power 4W (EIRP)

(slated to be issued early in 2005 FY)
Present regulation

Applicant → Administration → Cellular company → Applicant

License application → Application information → Interference study → Results → Evaluation → Preliminary license → Test → License

New regulation

Applicant → Administration

License application → Evaluation → License

Type certificated RFID

Significant reduction of time and effort to get license
• UHF band RFID features 5-10m reading distance. Primary target is supply chain management. Diverse application will be developed once the technology is in the market.

• Reading accuracy depends on the radio propagation environment as well as tag and reader performance.

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