Development Trends in Connectivity Technology and Automotive Market

Jun. 25, 2015
Today’s Content

Introduction of Murata Manufacturing Co., Ltd

Trends in Connectivity

- Wi-Fi Trend
- Murata’s Position

Introduction of Modules for Automotive

- Actual Performance and Product Development
- Partnership and Wi-Fi Applications
- C2X Market Initiatives
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Facts & Figures

Our Business
We are worldwide leaders in the design, manufacture and supply of electronic components and solutions.
We are Innovators in Electronics.

Our Strengths
• Advanced materials technology and expertise
• Broad product portfolio
• Extensive global manufacturing and sales network

Our Figures
• Turnover 846,716 million JPY*
• Employees 48,288* (23,510 in Japan, 24,778 overseas)
• Number of subsidiaries 101* (30 in Japan, 71 overseas)
• Established in 1944

*as of April 30, 2014
*Murata Manufacturing Co., Ltd. Is not included in the number of subsidiaries
<table>
<thead>
<tr>
<th>SENSORS</th>
<th>ENERGY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gyro Sensors</strong></td>
<td><strong>Lithium Ion</strong></td>
</tr>
<tr>
<td>Makes free standing</td>
<td><strong>Rechargeable</strong></td>
</tr>
<tr>
<td>and super-slow runs</td>
<td><strong>Batteries</strong></td>
</tr>
<tr>
<td>possible</td>
<td>High power and rapid</td>
</tr>
<tr>
<td></td>
<td>charging battery</td>
</tr>
<tr>
<td><strong>Ultrasonic Sensors</strong></td>
<td><strong>DC-DC Converters</strong></td>
</tr>
<tr>
<td>Detects obstacles to avoid</td>
<td>Supply stable current</td>
</tr>
<tr>
<td>collision</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COMMUNICATION</th>
<th>OTHER COMPONENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bluetooth ® Modules</strong></td>
<td><strong>Ceramic Capacitor</strong></td>
</tr>
<tr>
<td>Sends and receives</td>
<td>Stores electrical</td>
</tr>
<tr>
<td>operating signals and</td>
<td>energy</td>
</tr>
<tr>
<td>music</td>
<td></td>
</tr>
<tr>
<td><strong>Antennas</strong></td>
<td><strong>Inductor (Coils)</strong></td>
</tr>
<tr>
<td>Relays radio waves</td>
<td>Stabilizes electric</td>
</tr>
<tr>
<td>from PCs and mobile</td>
<td>current and signals</td>
</tr>
<tr>
<td>phones</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Thermistor</strong></td>
</tr>
<tr>
<td></td>
<td>Monitors circuit</td>
</tr>
<tr>
<td></td>
<td>temperature</td>
</tr>
<tr>
<td></td>
<td><strong>EMI Suppression Filters</strong></td>
</tr>
<tr>
<td></td>
<td>Suppresses</td>
</tr>
<tr>
<td></td>
<td>electromagnetic noise</td>
</tr>
</tbody>
</table>

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Murata Cheerleaders

**STABILITY**
Inverted-pendulum Control Technology
- gyro sensors

**SENSING AND COMMUNICATION**
Position Measurement Technology
- ultrasonic microphones & infrared sensors
- wireless communication module

**SYNCHRONIZATION**
Group Control Technology
- algorithms
## Key Product Line-Up

<table>
<thead>
<tr>
<th>CAPACITORS</th>
<th>NOISE SUPPRESSION PRODUCTS / EMI SUPPRESSION FILTERS</th>
<th>INDUCTORS (COILS)</th>
<th>RESISTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Capacitors" /></td>
<td><img src="image2.png" alt="Noise Suppression Filters" /></td>
<td><img src="image3.png" alt="Inductors" /></td>
<td><img src="image4.png" alt="Resistors" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TIMING DEVICE</th>
<th>FILTERS</th>
<th>RF COMPONENTS &amp; MODULES</th>
<th>SENSORS</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image5.png" alt="Timing Devices" /></td>
<td><img src="image6.png" alt="Filters" /></td>
<td><img src="image7.png" alt="RF Components &amp; Modules" /></td>
<td><img src="image8.png" alt="Sensors" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>THERMISTORS</th>
<th>POWER SUPPLIES</th>
<th>SOUND COMPONENTS</th>
<th>MICROMECHATRONICS</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image9.png" alt="Thermistors" /></td>
<td><img src="image10.png" alt="Power Supplies" /></td>
<td><img src="image11.png" alt="Sound Components" /></td>
<td><img src="image12.png" alt="Micromechatronics" /></td>
</tr>
</tbody>
</table>
Core Technologies

MATERIAL DEVELOPMENT
- Material design
- Powder

PROCESS DEVELOPMENT
- Ceramic sheet lamination and stacking
- Printing
- Deposition and fine processing

PRODUCT DESIGN
- High frequency design
- Simulation
- Modular design
- Sensor element design

MANUFACTURING TECHNOLOGY
- Automatic machinery design
- Industrial Engineering
Innovative electronics solutions

- from core electronics for mobile phones, audiovisual, home appliances and computers
- to new applications in automotive, healthcare, energy and environment

### Business Fields

#### Increasing safety, quality of life and efficiency

**MOBILE PHONES**
- Smartphones
- Mobile router

**PCs & PERIPHERALS**
- Laptops
- Tablets
- Printers

**AV & HOME APPLIANCES**
- Flat-screen TVs
- Refrigerators
- Digital Still Cameras
- Air-con

**AUTOMOTIVE**
- Safety systems
- Electric cars
- Infotainment

**HEALTHCARE & MEDICAL**
- Medical devices
- Lifelog

**ENERGY & ENVIRONMENT**
- HEMS
- BEMS
- Smart meters
Today’s Content

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- Wi-Fi Trend
- Murata’s Position

Introduction of Modules for Automotive
- Actual Performance and Product Development
- Partnership and Wi-Fi Applications
- C2X Market Initiatives
# Comparison Wi-Fi Standard

<table>
<thead>
<tr>
<th>System</th>
<th>Wireless LAN</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>IEEE802.11ad (WiGig)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IEEE</strong></td>
<td>IEEE802.11b</td>
<td>IEEE802.11g</td>
<td>IEEE802.11a</td>
<td>IEEE802.11n</td>
<td>IEEE802.11ac</td>
<td></td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>2.4GHzBand</td>
<td>2.4GHzBand</td>
<td>5GHz Band</td>
<td>2.4/5GHzBand</td>
<td>5GHz Band</td>
<td>60GHz Band (57～66GHz)</td>
</tr>
<tr>
<td><strong>system</strong></td>
<td>DS-SS</td>
<td>OFDM</td>
<td>OFDM</td>
<td>OFDM</td>
<td>OFDM</td>
<td>OFDM and single</td>
</tr>
<tr>
<td><strong>Range</strong></td>
<td>50～150m</td>
<td>50～120m</td>
<td>50～100m</td>
<td>50～100m</td>
<td>50～100m</td>
<td>10～20m</td>
</tr>
<tr>
<td><strong>Thoughtput (Theory) (Max. Mbps)</strong></td>
<td>~11Mbps</td>
<td>~54Mbps</td>
<td>~54Mbps</td>
<td>~54Mbps</td>
<td>72M (1x1:20MBW)</td>
<td>433Mbps (1x1:80MBW)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>150M (1x1:40MBW)</td>
<td>866Mbps(1x1/160)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>300M (2x2:40MBW)</td>
<td>867Mbps(2x2/80)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>450M (3x3:40MBW)</td>
<td>1.3Gbps(3x3/80)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>600M (4x4:40MBW)</td>
<td>3.6Gbps(4x4/160)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;MIMO&gt;</td>
<td>6.9Gbps(8x8/160)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;MU-MIMO&gt;</td>
</tr>
<tr>
<td><strong>Band Width</strong></td>
<td>22MHz</td>
<td>22MHz</td>
<td>20MHz</td>
<td>20/40MHz</td>
<td>20/40/80MHz</td>
<td>20/40/80MHz (Option: 160MHz)</td>
</tr>
<tr>
<td><strong>Release time</strong></td>
<td>1999/10</td>
<td>2003/6</td>
<td>1999/10</td>
<td>2009/9</td>
<td>2013/12</td>
<td>2012/12</td>
</tr>
<tr>
<td><strong>Feature</strong></td>
<td>Low cost Common</td>
<td>Low cost High speed</td>
<td>High Quality</td>
<td>High Quality Ultra</td>
<td>High Quality Giga bit</td>
<td>High Quality Giga bit</td>
</tr>
<tr>
<td><strong>Main Application</strong></td>
<td>PC/Smart phone for Internet or intranet</td>
<td>PC/Smart phone for Internet or intranet</td>
<td>PC for internet Video transfer</td>
<td>PC/Smart phone for internet Video transfer</td>
<td>PC/Smart phone for internet Video transfer</td>
<td>PC for internet HD Video transfer in 1 room</td>
</tr>
</tbody>
</table>
**IEEE802.11ac Technology**

**IEEE802.11ac (5GHz High speed Wi-Fi standard)**

- **Wide Channel B.W.:**
  - 40MHz (11n) → 80MHz or 160MHz

- **High Modulation:**
  - 64QAM<6bit>(11n) → 256QAM<8bit>

- **MU-MIMO:**
  - 4x4 (11n) → 8x8 Multi user-MIMO (MU-MIMO)
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BT, Wi-Fi Module Market Share

#1 Market Share

Connectivity Module Market Share
(2013CY - mobile devices)

- muRata: 60%
- A: 13%
- B: 22%
- C: 3%
- Others: 2%
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The Top 14 Automotive manufacturers, according to experts, account for 80% of the worldwide market, all have a connected car strategy.

Data Communication Module Integration into vehicles

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales (millions)</td>
<td>10.0</td>
<td>20.0</td>
<td>30.0</td>
<td>40.0</td>
<td>50.0</td>
<td>60.0</td>
<td>70.0</td>
<td>80.0</td>
</tr>
</tbody>
</table>

BT/Wi-Fi

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales (millions)</td>
<td>1.0</td>
<td>2.0</td>
<td>3.0</td>
<td>4.0</td>
<td>5.0</td>
<td>6.0</td>
<td>7.0</td>
<td>8.0</td>
</tr>
</tbody>
</table>

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Vehicle will be intelligent by connecting various scenes of the car. Murata contributes to the connected car with connectivity solution!
History of Connectivity Module for Automotive

<table>
<thead>
<tr>
<th>Year</th>
<th>BT Module</th>
<th>Total Shipment Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>1st generation</td>
<td>10M (Cumulative)</td>
</tr>
<tr>
<td>2008</td>
<td>2nd generation</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>3rd generation</td>
<td>20M (Cumulative)</td>
</tr>
</tbody>
</table>

**BT Module 1st generation**
- BT Ver1.2
- Hands-Free Call
- Audio Streaming

**BT Module 2nd generation**
- BT Ver1.2
- Hands-Free Call
- Audio Streaming

**BT Module 3rd generation**
- BT Ver2.1+EDR
- Hands-Free Call
- Simple Paring

**Combo Module 1st generation**
- BT Ver4.0(+EDR)
- IEEE802.11bgn
  (2.4GHz band)

**Combo Module 2nd generation**
- BT Ver4.1(+EDR)
- IEEE802.11abgn+ac
  (2.4GHz, 5GHz band)
- Application: Miracast

Total Shipment Unit:
- 10M (Cumulative for BT Module)
- 20M (Cumulative for Combo Module)
Module Roadmap for Automotive

**BT + Wi-Fi**

- Wi-Fi: 11bgn
- BT: 4.0+BLE
- GPS
- SISO

- Wi-Fi: 11abgn
- BT: 4.0+BLE
- GNSS
- SISO

- **5GHz 11ac**

- Wi-Fi: 11abgn+acHT80
- BT: 4.0+BLE
- 2x2MIMO/SISO

**Others**

- Wi-Fi: 11p
- Tx/Rx Diversity/Single

- **BLE Complete**
- BT: 4.0LE

**MP**

- Under Development
- Under Planning

**Others**

- Wi-Fi: 11ad ???

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Partnership

Ubiquitous

Fast Boot (QuickBoot) + Connectivity Software

R-Car Fast Boot + Wi-Fi Solution for Automotive

Wi-Fi module for Automotive

R-Car platform
Miracast

Movie Contents Streaming

Visual · Audio

Miracast®/Wi-Fi® Direct Connection

• Murata Manufacturing Co., Ltd: Wi-Fi® · Bluetooth® Connectivity Modules
• Ubiquitous: Ubiquitous Miracast® Solution/ Wi-Fi® Solution Package

Sink

Source

Wi-Fi® · Bluetooth® Connectivity Modules for Automotive

Under Development
Miracast Demonstration

Murata: 802.11a/b/g/n module
Ubiquitous: Miracast Software
Renesas: R-MobileA1

Showcased at various exhibitions – CES, Electronica, CEATEC, etc.

Murata: 802.11a/b/g/n/ac module
Ubiquitous: Miracast Software
Renesas R-CarM2
Provide One-Stop Solution through Partnership with Ubiquitous

1) Possible for Total Development Proposal
   (include WPS, Wi-Fi Direct, Miracast compliance)
2) Strong Partnership with Ubiquitous & Rich Implementation Experience
3) Efficient Development System to Commercialization
   (include Development / Evaluation / Certification)
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➢ C2X Market Initiatives
C2X(V2X) Communication

- Development of car to car / car to X communication is progressing in relation to ADAS (Advanced Driver Assistance system). Europe and USA utilizes IEEE802.11p, Japan uses unique system with 5.8GHz, 760MHz band.

- Demonstration proceeds in each region, but as long as the government do trigger implementation, market does not proceed.

<table>
<thead>
<tr>
<th></th>
<th>USA</th>
<th>EU</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>5.9GHZ</td>
<td>5.9GHz</td>
<td>760MHz</td>
</tr>
<tr>
<td>Channel</td>
<td>10MHz x 7ch</td>
<td>10MHz x 3ch</td>
<td>10MHz x 1ch</td>
</tr>
<tr>
<td>Modulation</td>
<td>OFDM</td>
<td>OFDM</td>
<td>OFDM</td>
</tr>
<tr>
<td>Access</td>
<td>CSMA/CA</td>
<td>CSMA/CA</td>
<td>CSMA/CA</td>
</tr>
<tr>
<td>Data rate</td>
<td>3-27Mbps</td>
<td>3-27Mbps</td>
<td>3-18Mbps</td>
</tr>
</tbody>
</table>

IEEE802.11p ETSI ES 202 663 *Based on 11p ARIB STD-T109 ARIB-STD-T75/T85
NXP Becomes World’s First Supplier to Deliver V2X Chipset for Mass-Production Secure Connected Cars
September 30, 2014

_NXP supplies Delphi with RoadLINK technology for major global automaker, enabling cars to securely connect with one another and with traffic infrastructure_

NXP Semiconductors (NASDAQ: NXPI), a global technology leader for the secure connected car, today announced a significant breakthrough for automotive drivers around the world. For the first time, V2X chipsets will be put into high-volume manufacturing. NXP will supply Delphi Automotive PLC (NYSE: DLPH) with its RoadLINK™ chipset for Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication. The wireless technology significantly improves road safety by alerting drivers of critical traffic information. Having secured a partnership with a leading global automaker, Delphi’s platform will be first to market and is expected to be on the roads in as little as two years.

Using NXP’s technology combined with application software from Cohda Wireless, Delphi’s platform allows alerts to be delivered to vehicles from other cars and surrounding infrastructure, such as traffic lights and signage to alert drivers about potentially hazardous traffic situations even beyond the line of sight, optimally complementing Advanced Driver Assistance Systems (ADAS) like radar. Messages could include blind-intersection collision, road condition hazards, road works, presence of emergency vehicles, stationary or slow moving vehicles, traffic jam, and accident warnings, as well as traffic signals or signage indicators. The solution avoids cellular or other networks that can be slow or unreliable, instead operating on IEEE 802.11p, a wireless communication standard designed for the needs of the automotive industry, and directly connects surrounding infrastructure and vehicles to each other to achieve immediate transmission and ensure reliable road safety communications. The V2X communication is protected against illegal attacks or data theft by NXP’s V2X hardware security module.

# C2X Connectivity Chipset Comparison

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>11p/Wi-Fi</td>
<td>11p/Wi-Fi</td>
<td>11p/Wi-Fi</td>
<td>11p</td>
</tr>
<tr>
<td>No. of chip</td>
<td>2 (without need for external CPU)</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Antenna Configurations</td>
<td>2Tx/2Rx</td>
<td>2Tx/2Rx</td>
<td>2Tx/2Rx</td>
<td>1Tx/2Rx</td>
</tr>
<tr>
<td>AEC-Q100</td>
<td>Planned</td>
<td>Planned</td>
<td>Planned</td>
<td>Planned</td>
</tr>
<tr>
<td>Remarks</td>
<td>High performance</td>
<td>High performance</td>
<td>Low cost</td>
<td>Low cost</td>
</tr>
</tbody>
</table>

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System Configuration Example

**Murata C2X module**

- **RF section** PA, LNA, etc.
- **11p Chipset**

**MAC Firmware**

**Driver, Firmware**

**Network Management**

**Facility**

**Networking & Transport**

**Security**

**Communication Middleware**

**HOST CPU**

- Ethernet PHY
- CAN PHY
- Memory
- Hardware Security Module

**HOST**

**Vehicle Ethernet**

**Vehicle CAN**
Communication Technology is essential feature for the cars in future. “Connectivity” will be added to current basic functions.

Market focus on Wi-Fi. One after another, latest standards will be introduced.

C2X evaluation fully in progress. Anticipation of the trend in next generation ADAS.

Armed with No.1 technical capability and actual performance, Murata’s connectivity modules contributing to car connectivity.
Thank you very much for your attention!

www.murata.co.jp