otto on board.™

OTTO on Board™

5.9 GHz Dedicated Short Range Communications from MARK IV Transportation Technologies

Overview

OTTO on Board™, the Dedicated Short-Range Communications (DSRC) at 5.9 GHz is here today to provide increased highway safety, improved mobility and reduced highway maintenance costs.

Intersection and road departure collisions account for nearly 50 percent of all crashes and fatalities on our roads. By improving vehicle-to-vehicle coordination as well as vehicle-roadside communication, OTTO on Board DSRC can contribute significantly toward highway safety and reduce traffic accidents, injuries and deaths.

DSRC emerged from a partnership among automobile manufacturers, state and federal transportation officials, toll transponder equipment suppliers and the Federal Communications Commission. There is a recognized need for on-the-go communication with motor vehicles and reliable communication between vehicles to increase highway safety by providing warnings and alerts that enable drivers to take corrective and/or evasive actions. At the same time, it holds the potential to provide drivers with real-time information that can improve mobility and motorist convenience, such as information on congestion or traffic incidents.

OTTO on Board uses a digital radio technology to pass information over distances of up to 1000 meters between fixed roadside infrastructure and OTTO a small, onboard, imbedded DSRC device. The technology builds on popular Wi-Fi standards using IEEE 802.11p, a standard named Wireless Access in a Vehicular Environment (WAVE).

OTTO on Board operates at 5.9 GHz, a vast 75MHz of radio spectrum reserved by the FCC specifically for high priority highway safety messages and which may also be used for private applications.

OTTO Enables On-the-Go Communication

OTTO on Board 5.9 GHz DSRC is comprised of three component parts:

- An Onboard Unit that is imbedded in the vehicle's infrastructure;
- Roadside Units;
- Public and private applications that take advantage of the communication capabilities.

The expectation is that vehicle manufacturers will begin equipping all new vehicles for North America with 5.9 GHz DSRC beginning in 2010, and that the roadside infrastructure will be deployed using federal funds in a manner that allows public deployment of safety initiatives and private applications, including electronic toll collection, electronic preclearance and others.

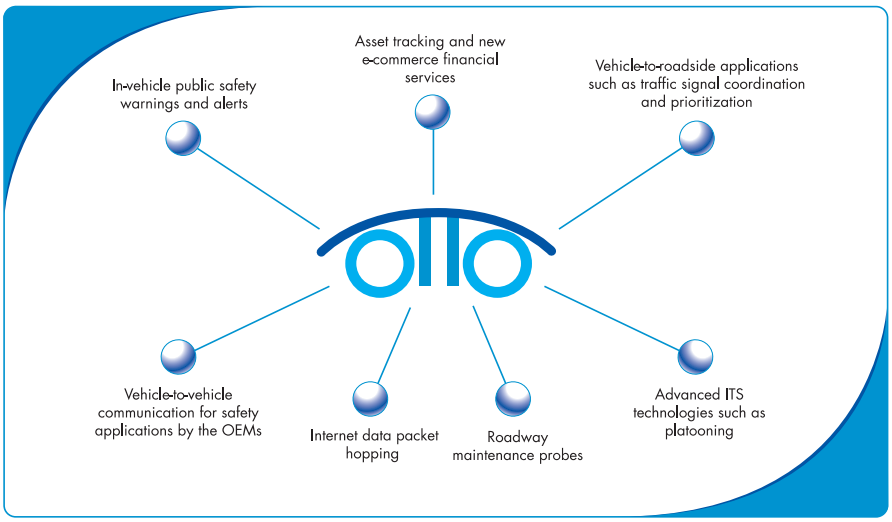
5.9 GHz Advantages

Communication using 802.11p in the 5.9 GHz band has advantages over current transponder technology. Principle among these advantages is the ability to facilitate low latency and faster communications over longer ranges, which also accommodates larger quantities of data. Also, traffic safety messages will receive priority over other messages and transactions so they are delivered rapidly.

These advantages, in turn, make possible the deployment of many new and exciting applications, including but not limited to:

- In-vehicle public safety warnings and alerts
- Asset tracking and new e-commerce financial services
- Vehicle-to-roadside applications such as traffic signal coordination and prioritization
- Vehicle-to-vehicle communication for safety applications by the OEMs
- Internet data packet hopping
- Advanced ITS technologies such as platooning
- Roadway maintenance probes

DSRC at 5.9 GHz does not interfere with current electronic toll collection or other roadside applications that exist today at 915 MHz.



otto on board. MARKIV REINVENTING THE ROAD™

Technical Specifications

The OTTO on Board™ 5.9 GHz system operates in 10 MHz channels with a single antenna that can be omni or directional. The OTTO on Board 5.9 GHz DSRC system provides robust, fast, localized transmissions from vehicle–to-vehicle (V-V) and vehicle-to-infrastructure (V-I) to serve many public safety and private applications (in-vehicle signage, collision avoidance, fee collection, internet access, etc). DSRC Units intended for mounting in vehicles are called On Board Units (OBU) and DSRC Units intended for mounting on the highway infrastructure are called Road Side Units (RSU). RSU and OBU support Internet Protocol (IP) transactions and WAVE Short Message (non IP based) transactions.

Device Configuration (electronics unit enclosure with power supply and antenna, all dimensions are approximations):

- OBU & RSU Enclosure
  - o Size:4.20" x 9.00" x 1.35" (106.7 x 228.6 x 34.3 mm)
  - o Material:Extruded clear anodized aluminum with rubber standoffs
  - o Additional heat sinking is recommended in non-controlled environments
- Mini-PCI Radio Card (Atheros AR500x Chipset), 2.35" x 1.75" (59.6 x 44.6 mm) with Type 3B, mini-PCI connector
- Motherboard, 3.94" x 8.50" (100.1 x 215.9 mm)
- Features:
  - o Frequency: 5.850 - 5.925 GHz (172 thru 184 with 178 being the Control Channel)
  - o Channel Bandwidth: 10 MHz
  - o Data Rates: Programmable from 3 to 27 Mbps (6 Mbps default)
  - o Sensitivity: -82 dBm @ 6 Mbps
  - o Power Output: 20 dBm peak in an FCC Class C Spectral Mask
  - o RSU/OBU Processor: MPC5200 @ 396 MHz
  - o Processing: > 300 MIPS (64 Mb SDRAM / 16 Mb Flash / 64Kb EEPROM)
  - o Provided Functions: Watchdog Timer, BIST & JTAG

Enclosure Interfaces:

Input Power:	+12VDC (9-16) @ 0.8 A nominal (peak 3.2 A, fuse 5 A)
Air/RF:	50±10% Ω SMA female
Serial #1 (test) & #2 (debug):	RS-232, DB-9 Female, up to 115.2 KB, (8, 1, N)
RS-232 Pin Assignments:	2-TX, 3-RX, 5-GND, 7-CTS & 8-RTS
Ethernet:	10/100 BaseT, RJ-45
Five LEDs:	LED1=Power (green), LED2-5 are dual color software controllable Red/Green
Buzzer:	TTL (90 dB @ 10cm, 3.5k±1 Hz)

Software

Supporting Features:

Operating system:	VxWorks 5.5.1
Network layer:	IPv6, SNMP3
Firmware Update:	Remote thru Serial port
Operation:	Up to 32 OBUs in an RSU zone

DSRC WAVE Standards Used:

- DIC020 (P1609.1/D08), Resource Manager
- DIC021 (P1609.3/D13), Network Services
- DIC022 (P1609.4/D03), Multi-Channel Operation
- DIC024 (802.11p/D1.3), Physical & MAC Layer

Communication Services (through Ethernet port):

1. WAVE Short Message Service (WSM):
   - o Broadcast of a WAVE Short Message
   - o Exchanged from an RSU to an OBU or between two OBUs
   - o Supported on the control channel and the service channel
2. WAVE Aware Infrastructure Transaction Service:
   - o WAVE-aware applications are registered with the RSU and OBU
   - o A link is established using the Provider Service Table transmitted on the control channel.
   - o Information is exchanged on the service channel between the RSU and the OBU
3. Non-WAVE Aware Transaction Service (General Purpose Intranet/Internet Access):
   - o IPv6 applications that do not support WAVE application registration & notification
   - o This service establishes a link using the Provider Service Table transmitted on the control channel
   - o Information is exchanged on the service channel between applications residing on RSU back-office computers and OBU vehicle host interfaced (OVHI) devices

Test Support (features evaluated through the use of the serial port and Ethernet port):

Communication Services

- o WAVE Short Message (WSM)
- o WAVE Aware IP Transactions
- o Non-WAVE Aware IP Transactions

- **IEEE 802.11p Radio Module**
  - o Communication Range
  - o Transaction Size
  - o Data RateEnvironment:
- Temperature – Operating: -10∞C _ +70∞C
- Humidity (designed): 100% RH RSU 95% RH OBU
- Shock: 2G Vibration (designed): 1G @ 5-500Hz
- Altitude (designed): -270 to 12,000 ft

Antenna (can be procured separately):

- RSU antenna, Type I (15 dBi gain, directional)
- RSU antenna, Type II (6 dBi, omni-directional)
- OBU antenna, Type I (VSC roof-mount, magnetic, black, 0 dBi gain)

Prototype Team activity:

- Broady Cash of ARINC (bcash@arinc.com)
- Roger O'Connor of Highway Electronics (rjoconnor@highwayelectronics.com)

Reference Documents:

[1] **ASTM Std E2213-03:** Standard Specification for Telecommunications and Information Exchange Between Roadside and Vehicle Systems – 5 GHz Band Dedicated Short-Range Communication (DSRC) Medium Access (MAC) and Physical Layer (PHY) Specifications.

[2] **IEEE Std 802.11a-1999:** Information technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: High-speed Physical Layer in the 5 GHz Band.

[3] **IEEE 802.11p draft:** Amendment to STANDARD FOR Information technology - Telecommunications and information exchange between systems - LAN/MAN Specific Requirements - Part 11: Wireless LAN Medium Access Control (MAC) and physical layer (PHY) specifications: Wireless Access in Vehicular Environments (WAVE)

[4] **IEEE 1609.1 draft:** Wireless Access in Vehicular Environments - WAVE Resource Manager

[5] **IEEE 1609.3 draft:** Wireless Access in Vehicular Environments (WAVE) Network Services

[6] **IEEE 1609.4 draft:** Wireless Access in Vehicular Environments (WAVE) Multi-Channel Operation.

[7] **IEEE 1556 draft:** Standard for 5.9 GHz Intelligent Transportation System (ITS) Radio Service Security

[8] **DIC004:** Demonstration Applications Selection

[9] **DIC005:** Prototype Requirements

[10] **DIC006:** Architecture and Design Specification

[11] **DIC501:** OBU External Interface Control

[12] **DIC502:** RSU External Interface Control

[13] **White paper (Jan 2005):** DSRC Technology and the DSRC Industry Consortium (DIC) Prototype Team

[14] **White paper (May 2005):** 5.9 GHz DSRC Antennas

Prototype Future Enhancements:

- IEEE P1556 DSRC Security
- Automotive grade and outside environment -40∞C to +85∞C
- In-vehicle Vibration Environment
- FCC Spectral Mask Class D
- FCC 47 Part 15 Class B, 15.247, 15.107