Keysight Measurement Forum 2016

Choi Dai-Ryu

Automotive Measurement Solutions for Connected Car

KEYSIGHT TECHNOLOGIES

HARDWARE+SOFTWARE+PEOPLE=INSIGHTS

Agenda

- Future Trends for Road Vehicle
- 802.11p for V2X
- Automotive Radar
- eCall
- Sensor Test (TPMS, RKE)
- Bluetooth Audio
- Body and safety Reference Solution

Future Trends for Road Vehicle

KEYSIGHT TECHNOLOGIES

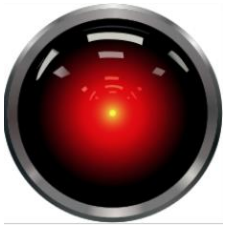
Future Trends for Road Vehicle

Five main spaces to revolution

Future Trends for Road Vehicle

AI or IA?

– AI : Artificial Intelligence

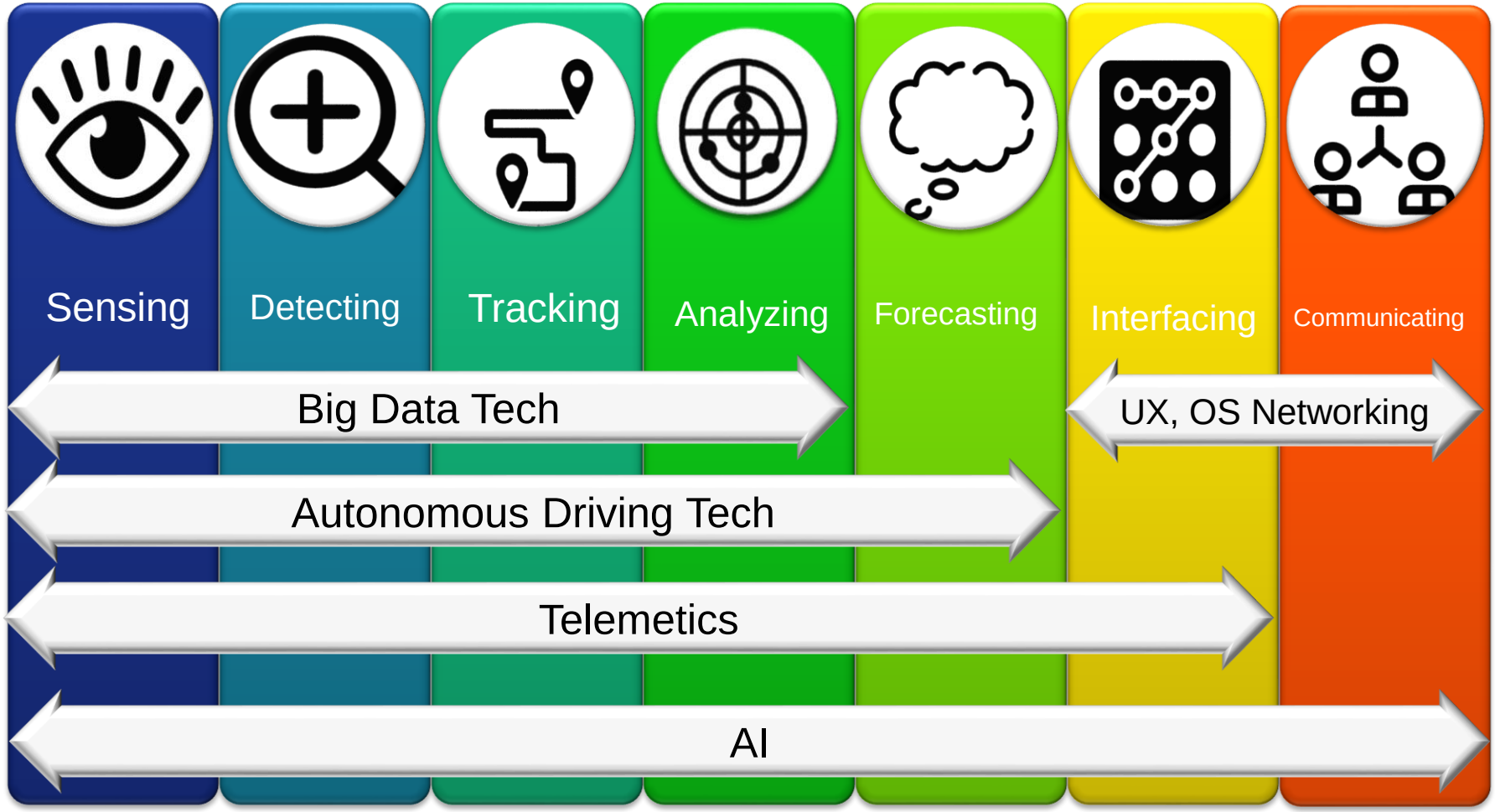


Google Image

– IA : Intelligence Augmented

Future Trends for Road Vehicle

For AI



Future Trends for Road Vehicle

http://www.nhtsa.gov

Autonomous Driving Vehicle 5 levels

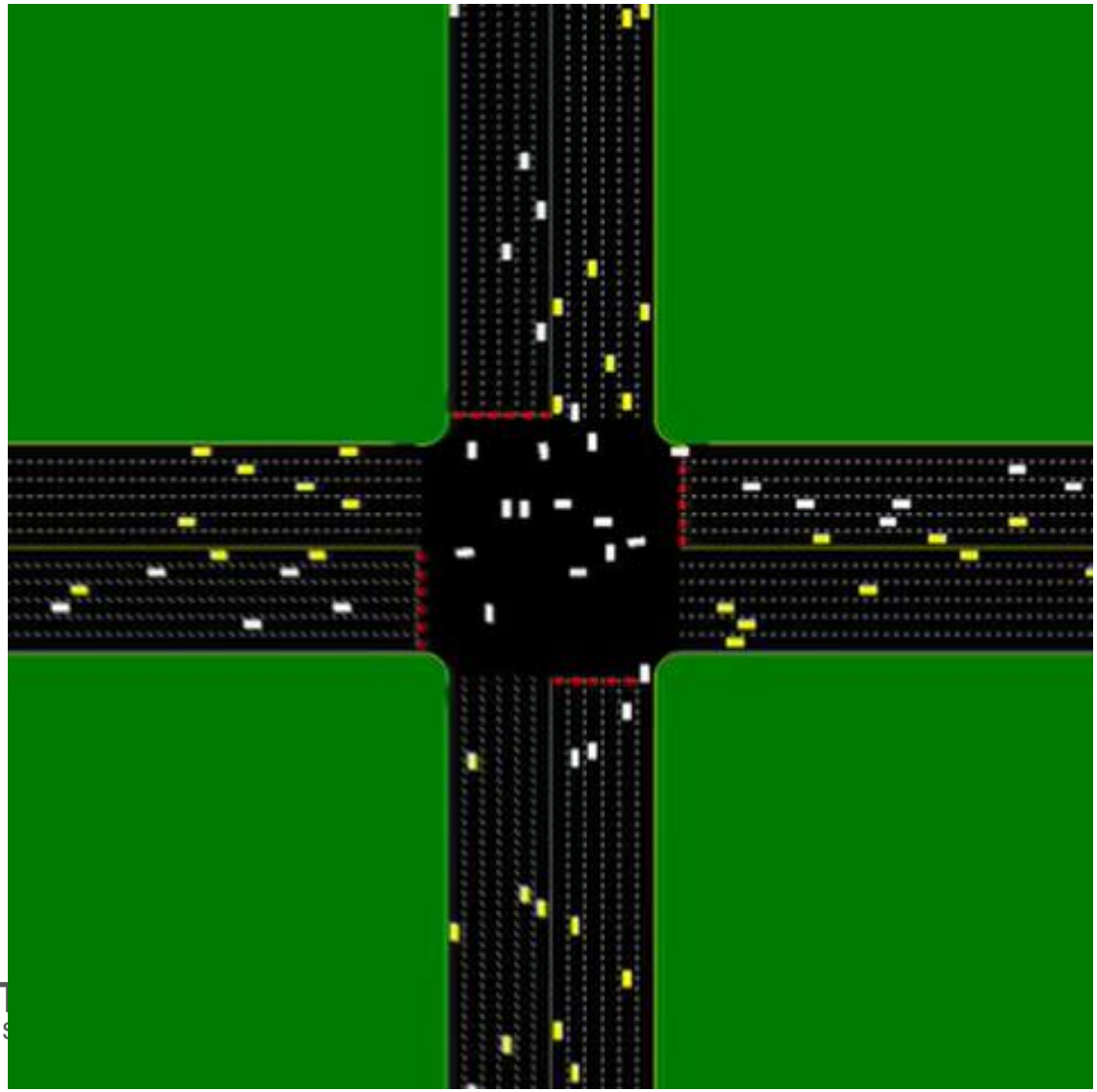
- **No-Automation (Level 0):** The driver is in complete and sole control of the primary vehicle controls – brake, steering, throttle, and motive power – at all times.
- **Function-specific Automation (Level 1):** Automation of one or more specific control functions, such as pre-charged brakes, where the vehicle automatically assists with braking
- **Combined Function Automation (Level 2):** automation of at least two primary control functions designed to work in unison. For example adaptive cruise control in combination with lane centering.
- **Limited Self-Driving Automation (Level 3):** driver to cede full control of all safety-critical functions under certain traffic or environmental conditions. The driver is expected to be available for occasional control.
- **Full Self-Driving Automation (Level 4):** The vehicle is designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip. This includes both occupied and unoccupied vehicles.

Future Trends for Road Vehicle

Less Air pollution, Less delay

Future Trends for Road Vehicle

Less Air pollution, Less delay



Texas University
Autonomous Intersection
Management
2009

Top 5 Market Trends for Driverless Car

– Up to 75% vehicles will be driverless car by 2040 (IEEE)

1. No more driver
2. No more Accidents
3. No More driving Etiquette
4. No more traffic Tickets
5. No more car ownership

http://www.wired.com/insights/2013/08/top-5-market-trends-driverless-cars-will-rev-up-in-the-future/

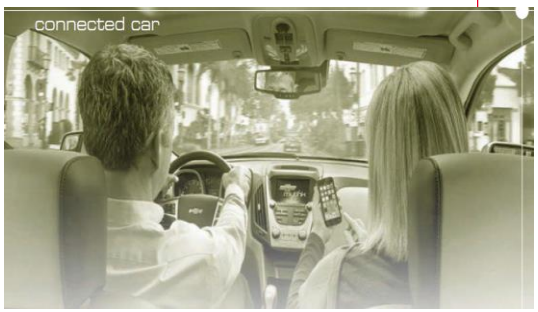
Future Trends for Road Vehicle

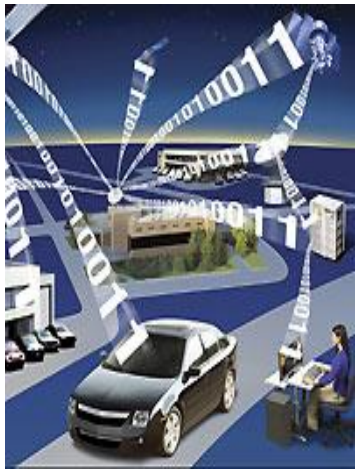
Become a new space

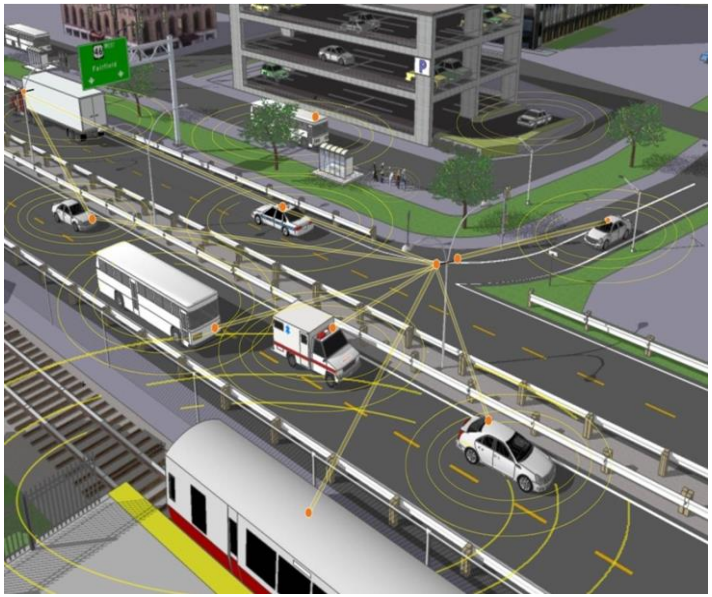
Benz F015 2016

- Rest
- Medical diagnose
- Office, Meeting Room
- Entertainment
- Advertisement
- Get into Home
- Or Anything

802.11p for V2X



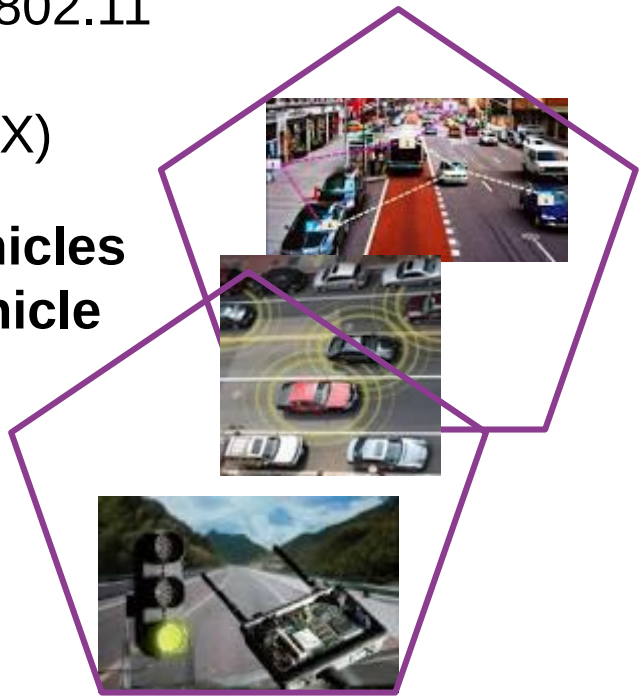




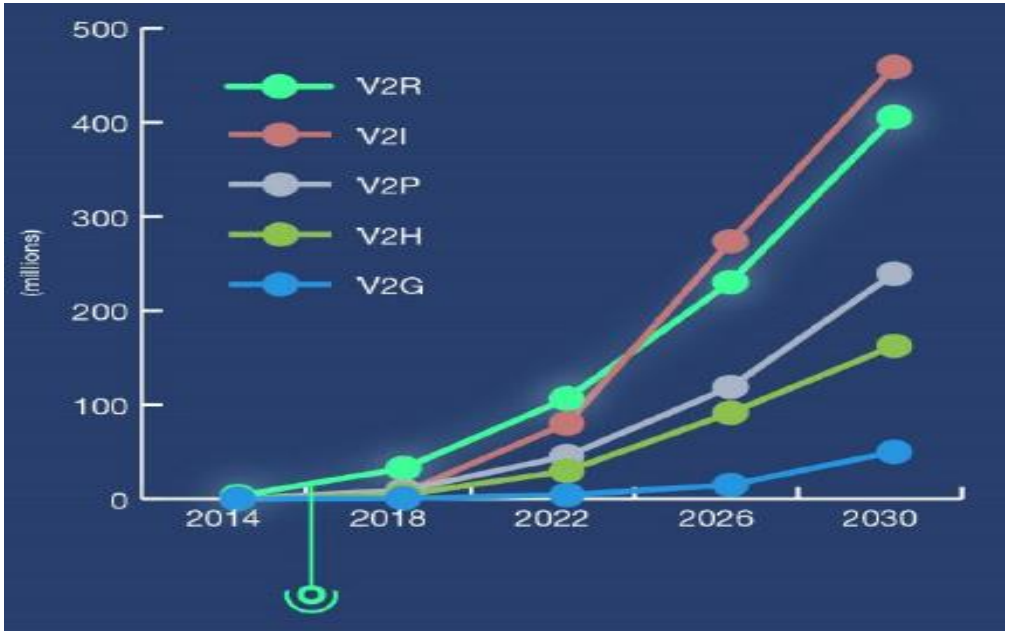
KEYSIGHT TECHNOLOGIES

802.11p Overview

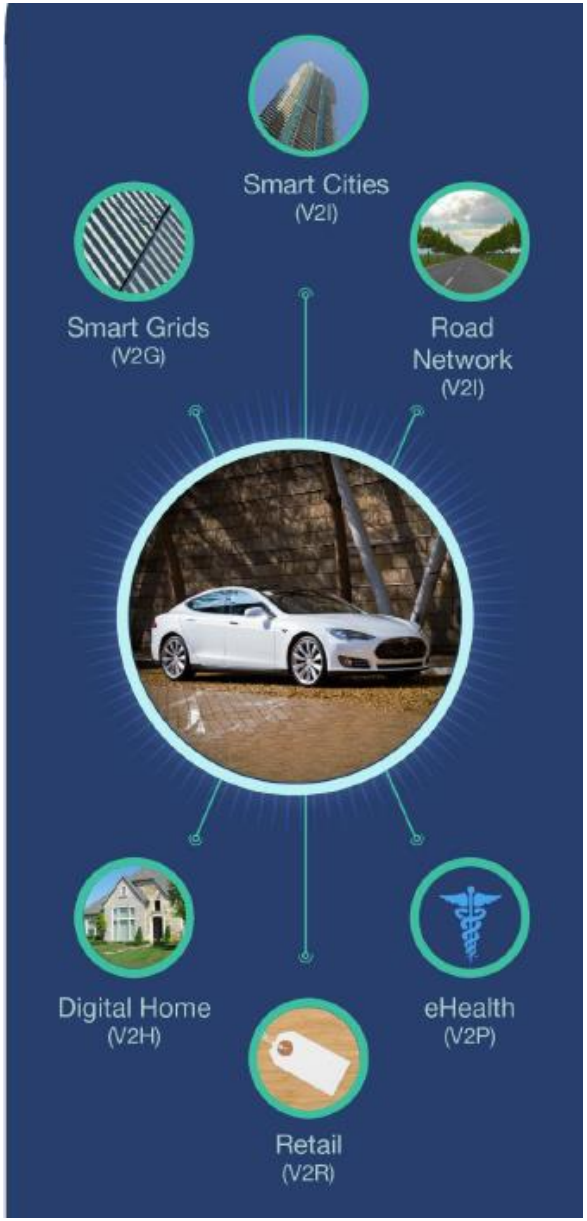
- **802.11p** is an approved amendment to the 802.11 to add **wireless access in vehicular environments** (WAVE, aka ITS, DSRC, V2X)
- **Application:** communications between **vehicles and infrastructure (V2I) or vehicle to vehicle (V2V) etc. V2X**
  - Vehicle safety services
  - Commerce transactions via cars
  - Toll collection
  - Traffic management



V2X Market Forecast



Registered vehicles with IoT application by type
Word market. Forecast: 2014-2030
ABI research



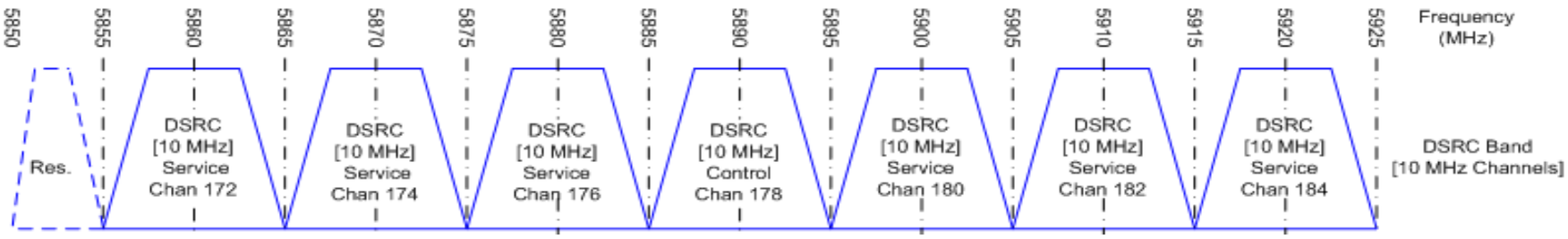
- **Global V2V Penetration in new Cars is expected to increase from 10.9% in 2018 to 69% in 2027**

Source: ABI research, Nov. 2013

US ITS/DSRC Channel Plan

Seven 10 MHz channels from 5.85 to 5.925GHz

5850 MHz							5925 MHz
		CH 175 20 MHz			CH 181 20 MHz		
5850-5855 Reserve 5 MHz	CH 172 Service 10 MHz	CH 174 Service 10 MHz	CH 176 Service 10 MHz	CH 178 Control 10 MHz	CH 180 Service 10 MHz	CH 182 Service 10 MHz	CH 184 Service 10 MHz



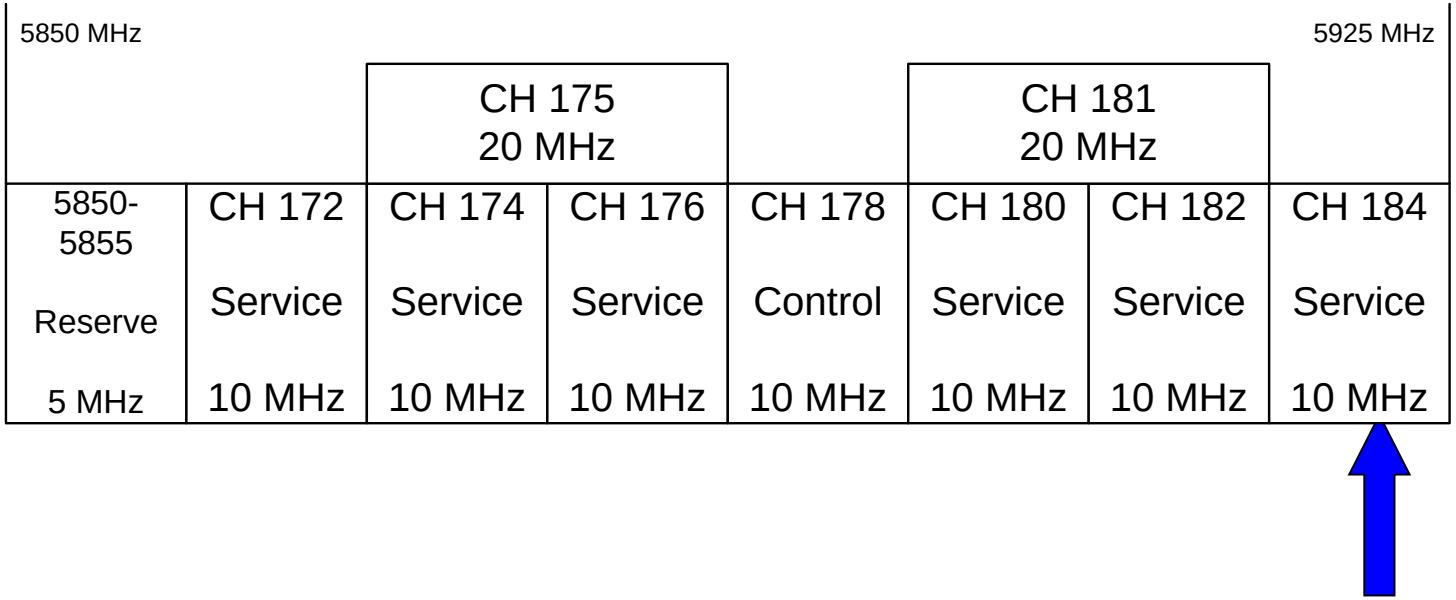
Reference document: https://mentor.ieee.org/802.11/dcn/13/11-13-0541-01-0wng-dsrc-applications-tutorial.pptx

DSRC Spectrum (Channel 172)

5850 MHz							5925 MHz
		CH 175 20 MHz			CH 181 20 MHz		
5850- 5855	CH 172	CH 174	CH 176	CH 178	CH 180	CH 182	CH 184
Reserve	Service	Service	Service	Control	Service	Service	Service
5 MHz	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz	10 MHz

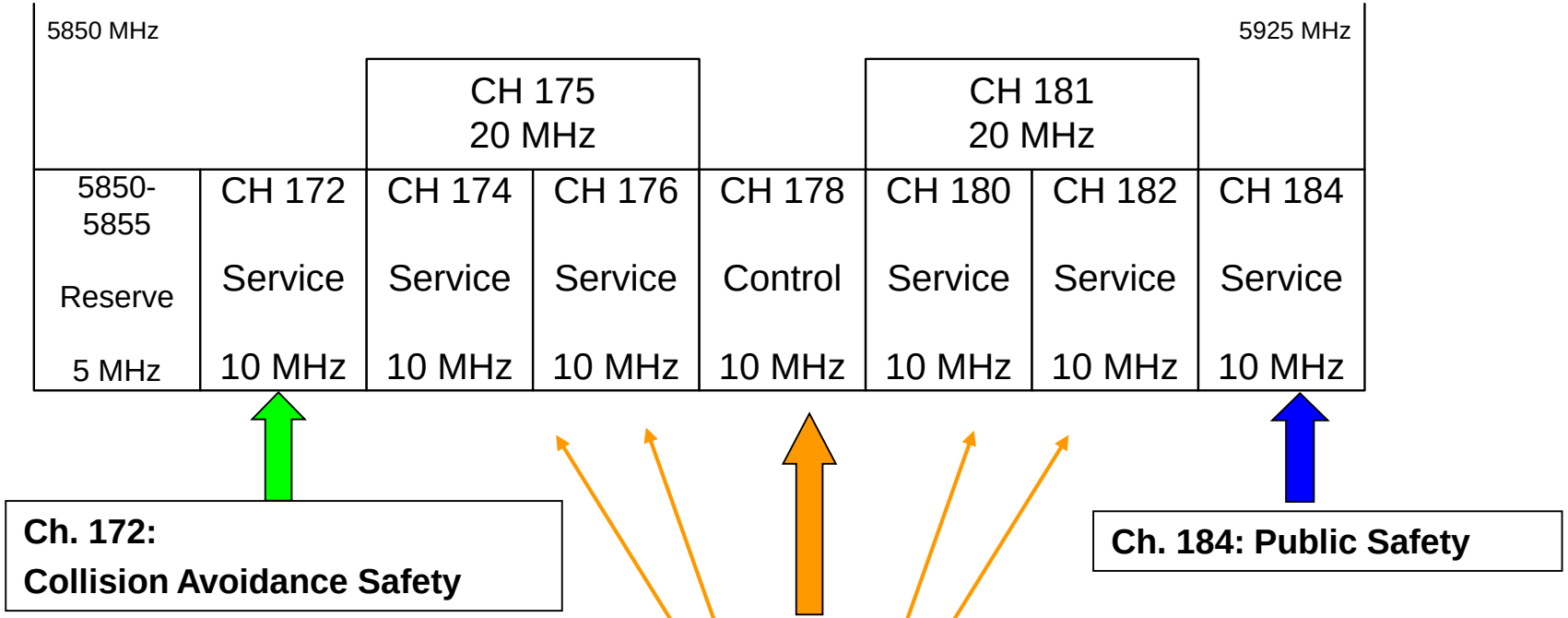
- FCC designated “exclusively for **vehicle-to-vehicle safety communications** for accident avoidance and mitigation, and safety of life and property applications”
- Extensive industry research, testing, and field trials of safety applications using Ch. 172
- Will host 3 message types:
  - **Basic Safety Message (V2V)**
  - **MAP Message (V2I)**
  - **Signal Phase and Timing Message (V2I)**
- Nominal transmit power +20 dBm with 0 dBi antenna

DSRC Spectrum (Channel 184)



- FCC designated “exclusively for high-power, longer-distance communications to be used for **public safety applications involving safety of life and property**, including road intersection collision mitigation”
- Road authorities and public agencies primarily responsible for usage
- Max. power 40 dBm : **High Power** control channel

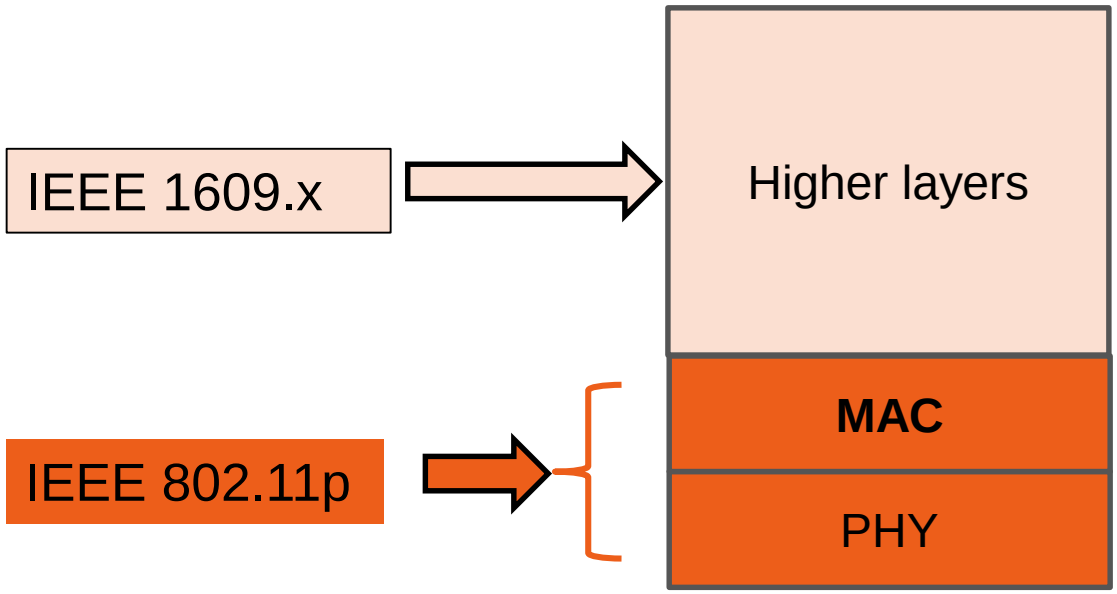
DSRC Spectrum (Channel 178 & Others)

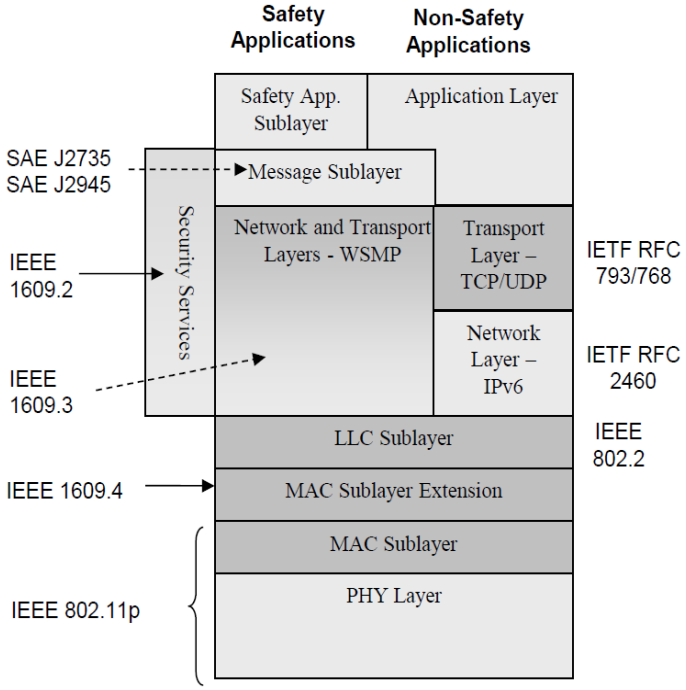


- Ch. 178:
- Control Channel
- **WAVE Service Advertisements are broadcast** here, indicating how to access services on other “Service Channels”

802.11p standard

US ITS protocol stack





The higher layers of ITS are depending on regional regulatory issues

802.11p Physical Layer Basis

Feature	Parameters		
Transmission method	OFDM		
Frequency	5.8 GHz and 5.9 GHz		
Channel bandwidth	5 MHz	10 MHz	20 MHz
FFT size	64	64	64
Data subcarriers / pilots	52 / 4	52 / 4	52 / 4
Subcarrier spacing	78.125kHz	156.25kHz	312.5 kHz
OFDM symbol duration	16us	8 us	4us
Guard interval	3.2us	1.6 µs	0.8 µs
Modulation types	BPSK, QPSK, 16QAM, 64QAM		
Forward error correction	Binary convolutional coding (BCC)		
Coding rates	1/2, 2/3, 3/4		

The PHY difference between 802.11a and 802.11p

Feature	802.11a	802.11p 10MHz half clocked mode
Bit rate (Mbit/s)	6, 9, 12, 18, 24, 36, 48, 54	3, 4.5, 6, 9, 12, 18, 24, 27
Channel bandwidth	20 MHz	10 MHz
FFT size	64	64
Data subcarriers / pilots	52 / 4	52 / 4
Subcarrier spacing	312.5 KHz	156.25kHz
OFDM symbol duration	4us	8 us
Guard interval	0.8us	1.6 µs
Preamble duration	16us	32us
Modulation types	BPSK, QPSK, 16QAM, 64QAM	
Coding rates	1/2, 2/3, 3/4	

802.11p Physical Measurement

Transmitter Test

Transmitter Test	802.11a IEEE-2012	802.11p IEEE-2012
Transmitter Power	19.4.8.2	IEEE 802.11: Annex D2.3; USA: Annex D Table2.2; FCC: 47 CFR[B8] Sec. 90.375 ETSI 302 571 Sec. 6.3
Spectrum Mask	18.3.9.3	IEEE 802.11: Annex D2.3 FCC: 47 CFR [B8] Sec. 95.377 ETSI: 302571 Sec 6.4
Transmission spurious	18.3.9.4	Same as 802.11a
Center frequency tolerance	18.3.9.5	±20 ppm for 20 MHz/10MHz ±10 ppm for 5 MHz
Symbol clock frequency tolerance	18.3.9.6	±20 ppm for 20 MHz/10MHz ±10 ppm for 5 MHz
Center frequency leakage	18.3.9.7.2	Same to 802.11a
Spectral flatness	18.3.9.7.3	Same to 802.11a
Constellation error	18.3.9.7.4	Same to 802.11a
Modulation accuracy	18.3.9.8	Same to 802.11a

802.11p Power Classification Class A-D And RF Transmitter Test Requirement - SEM

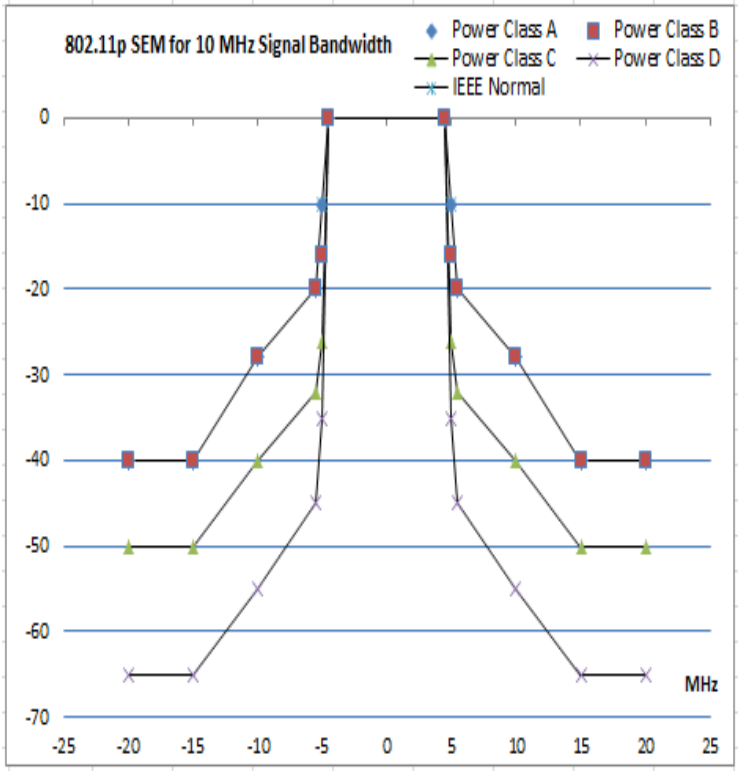
802.11p CLASS A-D power classification

Power class	Max. output power (dBm)
Class A	0
Class B	10
Class C	20
Class D	28.8

802.11p 10 MHz SEM definition

STA transmit Power class	Permitted power spectral density, dBr				
	±4.5MHz offset (± f_1)	±5.0MHz offset (± f_2)	±5.5MHz offset (± f_3)	±10MHz offset (± f_4)	±15MHz offset (± f_5)
Class A	0	-10	-20	-28	-40
Class B	0	-16	-20	-28	-40
Class C	0	-26	-32	-40	-50
Class D	0	-35	-45	-55	-65

802.11p SEM for 10M signal BW For power CLASS A-D



Source: IEEE Std 802.11 ™- 2012

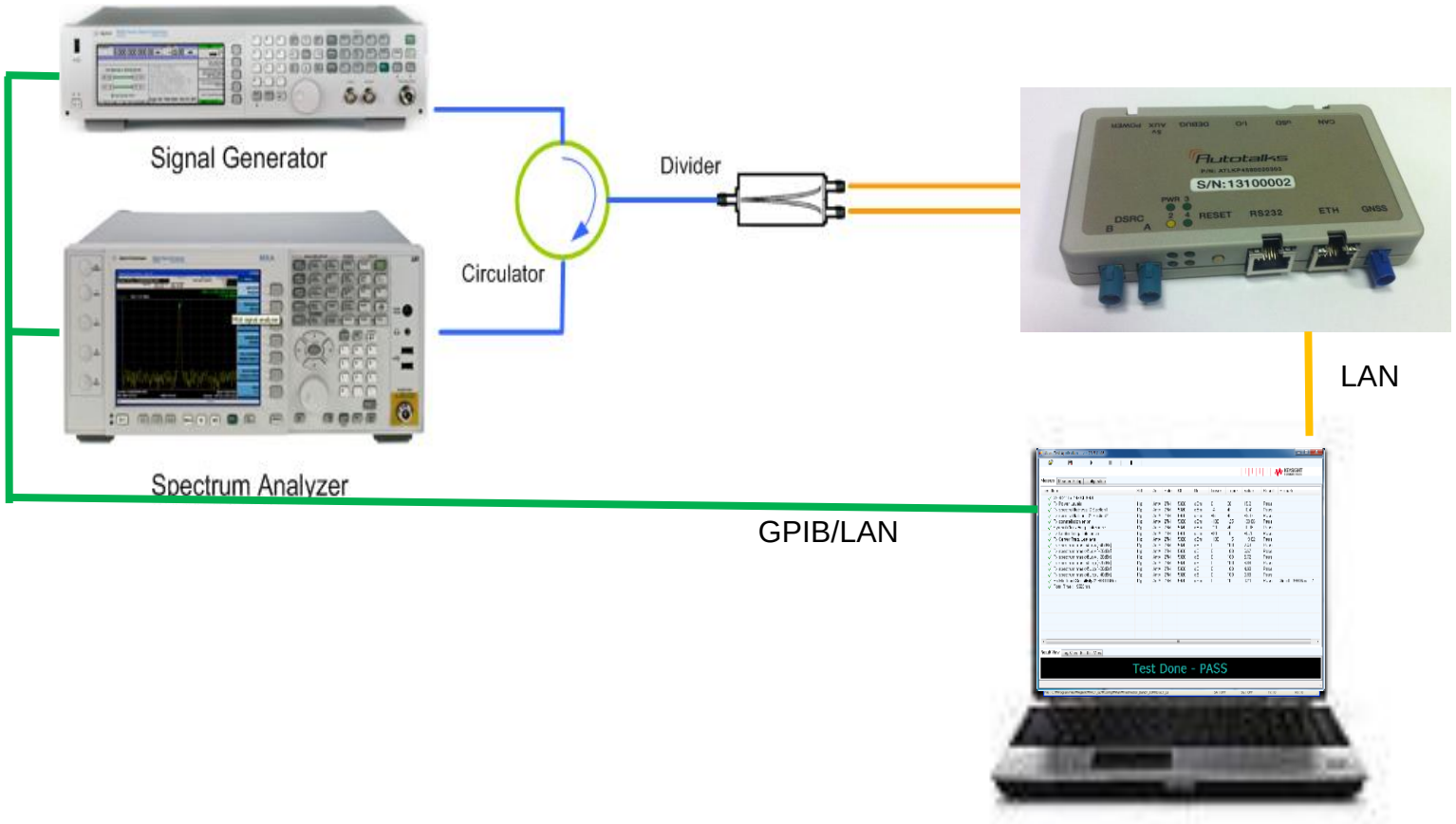
802.11p Physical Measurement

Receiver Test

Receiver Test	802.11a IEEE-2012	802.11p IEEE-2012
Sensitivity	18.3.10.2	Sensitivity for 5 MHz and 10 MHz 20 MHz is same to 802.11a
Adjacent channel rejection	18.3.10.3	12 dB stricter than 802.11a
Non-adjacent channel rejection	18.3.10.4	10 dB stricter than 802.11a
Maximum input level	18.3.10.5	Same to 802.11a
Clear channel assessment	18.3.10.6	–82 dBm for 20 MHz -85 dBm for 10 MHz -88 dBm for 5 MHz
Received Channel Power Indicator Measurement	18.3.10.7	Same to 802.11a

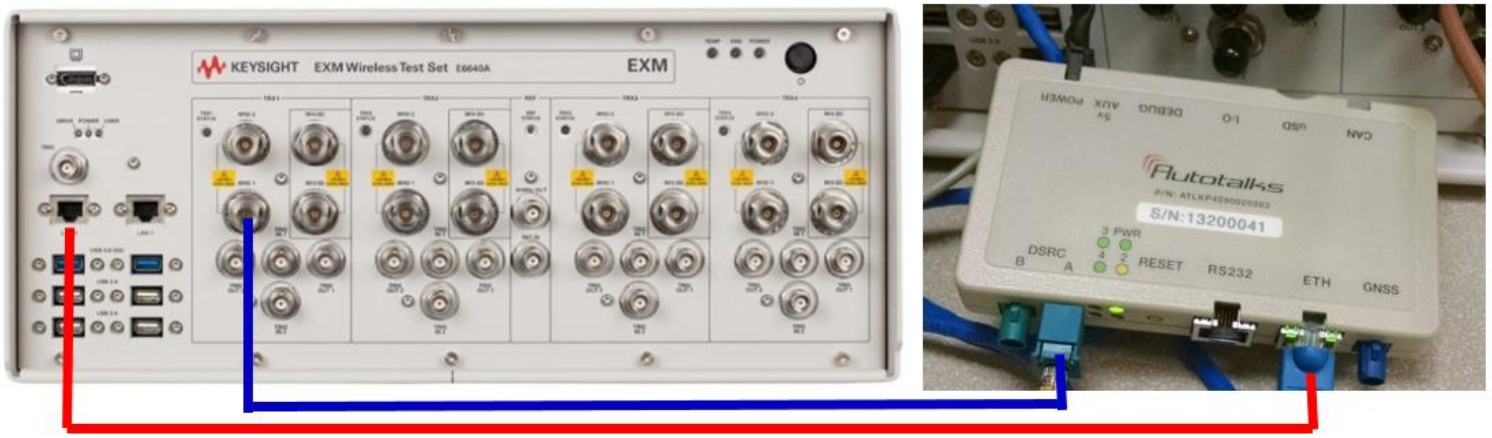
System Configuration

MXG/MXA



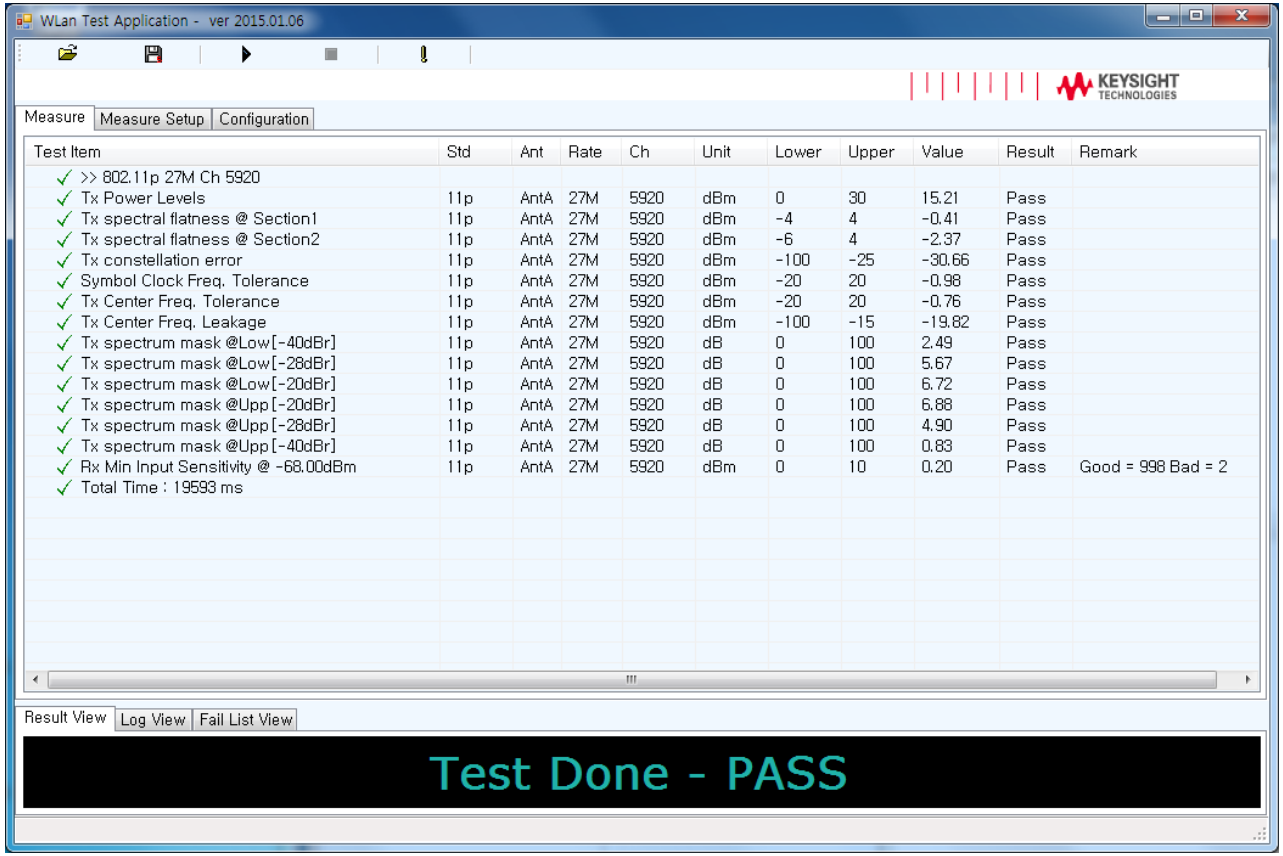
System Configuration

E6640A Wireless Test Set: EXM



802.11p Automation Tool

Automated test for 802.11p

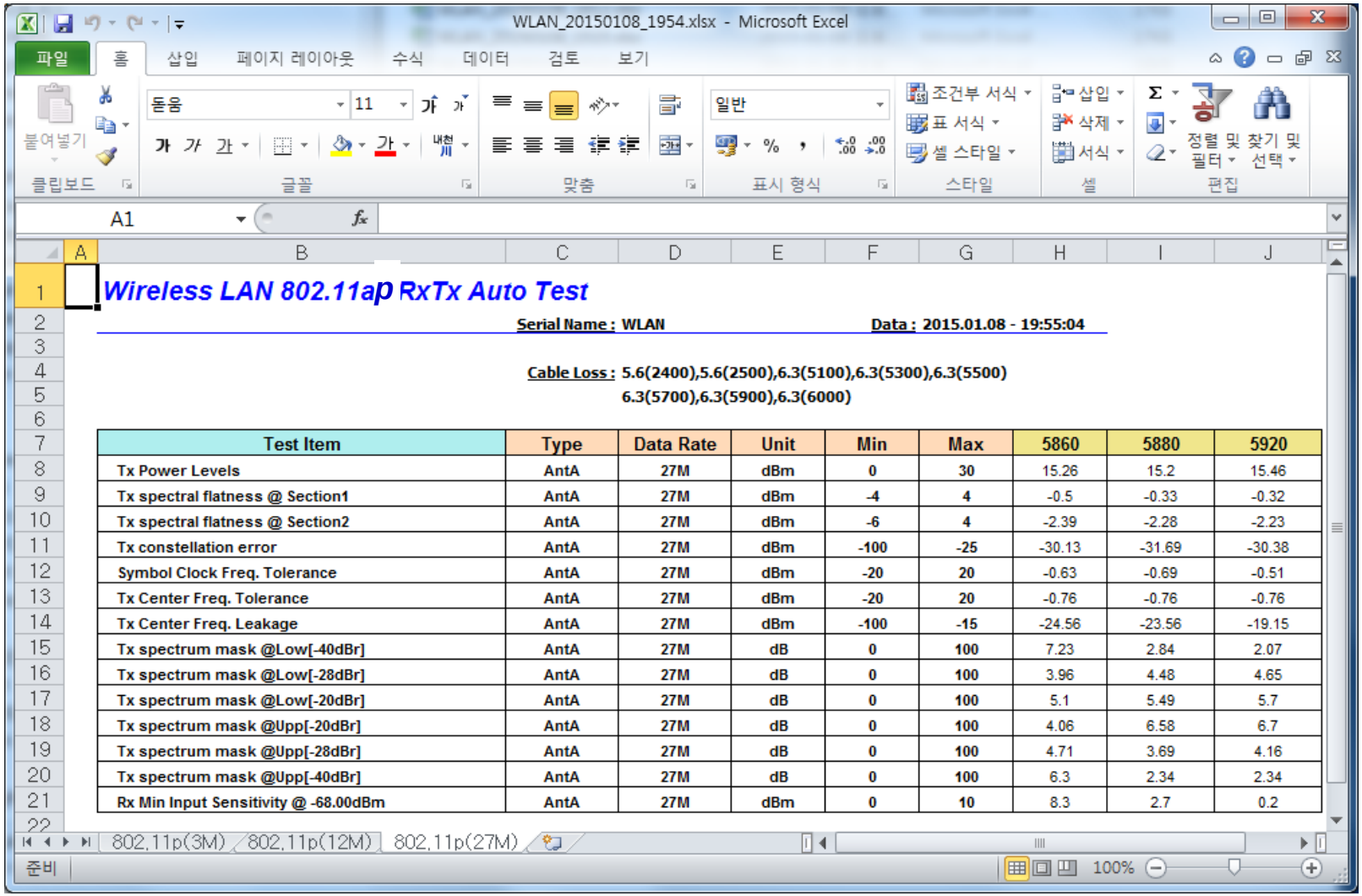


Test Coverage

- Tx Power
- Spectral Flatness
- Constellation Error
- Symbol Clock Freq Tolerance
- Tx Center Freq Leakage
- Tx SEM
- Rx Min Input Sensitivity

802.11p Automation Tool

Report (CSV)



Wireless LAN 802.11ap RxTx Auto Test

Serial Name : WLAN **Data :** 2015.01.08 - 19:55:04

Cable Loss : 5.6(2400),5.6(2500),6.3(5100),6.3(5300),6.3(5500) 6.3(5700),6.3(5900),6.3(6000)

Test Item	Type	Data Rate	Unit	Min	Max	5860	5880	5920
Tx Power Levels	AntA	27M	dBm	0	30	15.26	15.2	15.46
Tx spectral flatness @ Section1	AntA	27M	dBm	-4	4	-0.5	-0.33	-0.32
Tx spectral flatness @ Section2	AntA	27M	dBm	-6	4	-2.39	-2.28	-2.23
Tx constellation error	AntA	27M	dBm	-100	-25	-30.13	-31.69	-30.38
Symbol Clock Freq. Tolerance	AntA	27M	dBm	-20	20	-0.63	-0.69	-0.51
Tx Center Freq. Tolerance	AntA	27M	dBm	-20	20	-0.76	-0.76	-0.76
Tx Center Freq. Leakage	AntA	27M	dBm	-100	-15	-24.56	-23.56	-19.15
Tx spectrum mask @Low[-40dBr]	AntA	27M	dB	0	100	7.23	2.84	2.07
Tx spectrum mask @Low[-28dBr]	AntA	27M	dB	0	100	3.96	4.48	4.65
Tx spectrum mask @Low[-20dBr]	AntA	27M	dB	0	100	5.1	5.49	5.7
Tx spectrum mask @Upp[-20dBr]	AntA	27M	dB	0	100	4.06	6.58	6.7
Tx spectrum mask @Upp[-28dBr]	AntA	27M	dB	0	100	4.71	3.69	4.16
Tx spectrum mask @Upp[-40dBr]	AntA	27M	dB	0	100	6.3	2.34	2.34
Rx Min Input Sensitivity @ -68.00dBm	AntA	27M	dBm	0	10	8.3	2.7	0.2

Single Channel Fading

What Problem Does It Solve?

Designers of mobile devices need to:

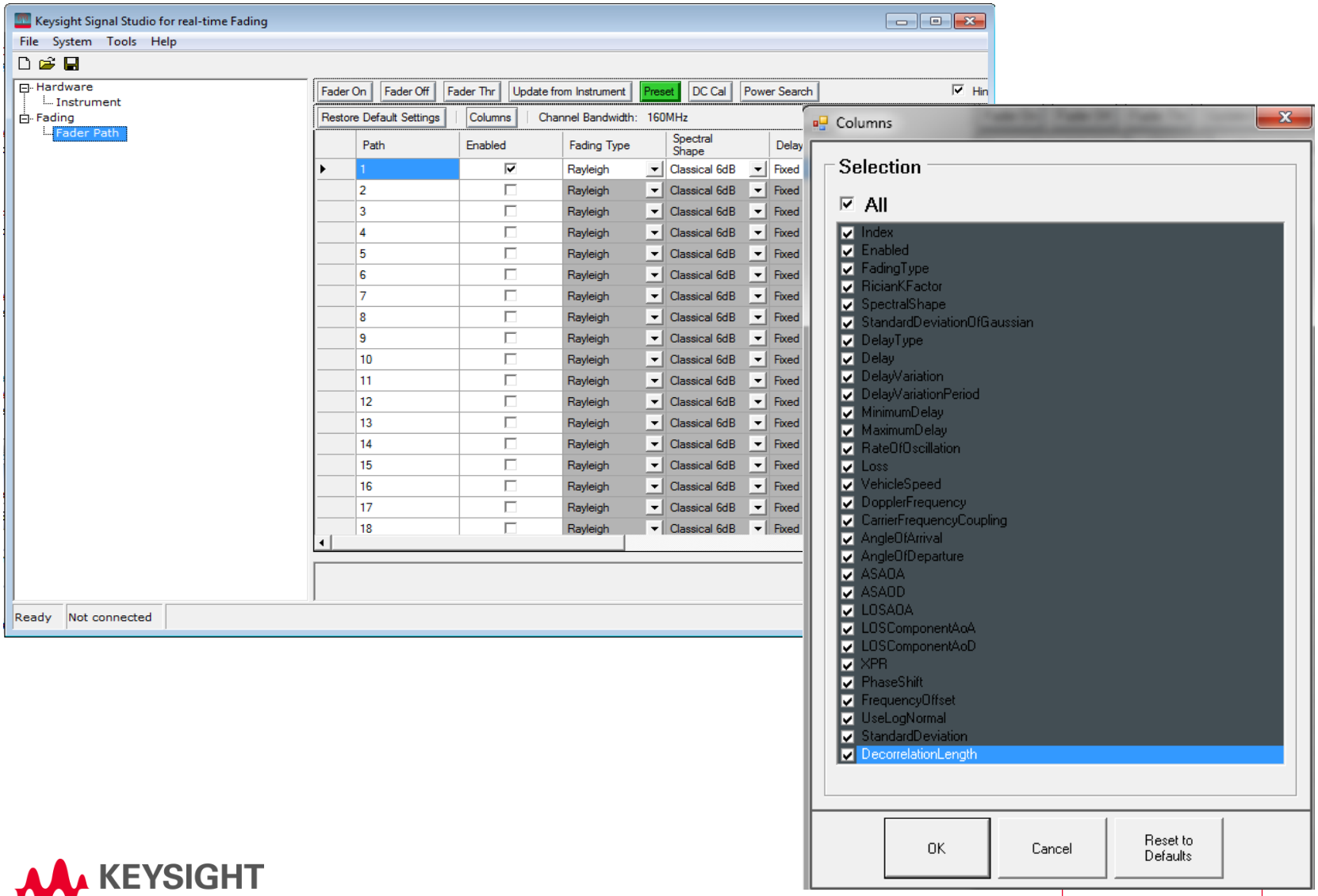
- Test the performance (FER/BER/BLER) of their receivers under realistic channel conditions
- Have accurate and repeatable results
- Do it at a reasonable price

MXG/EXG

+

N7605B Signal Studio for Real-time Fading

Simple Fading UI – N7605B Real Time Fading



KEYSIGHT TECHNOLOGIES

Fading Channel Test

N7605B Real Time Fading and Half-bath tub

	Tap1	Tap2	Tap3		Units
Power	0	-14	-17		dB
Delay	0	83	183		ns
Doppler	0	492	-295		Hz
Profile	Static	HalfBT	HalfBT		

Table 5: Rural LOS Parameters

144km/hr max differential

	Tap1	Tap2	Tap3	Tap4	Units
Power	0	-10	-15	-20	dB
Delay	0	100	167	500	ns
Doppler	0	689	-492	886	Hz
Profile	Static	HalfBT	HalfBT	HalfBT	

Table 8: Highway LOS Parameters

252 km/hr max differential

	Tap1	Tap2	Tap3	Tap4	Units
Power	0	-8	-10	-15	dB
Delay	0	117	183	333	ns
Doppler	0	236	-157	492	Hz
Profile	Static	HalfBT	HalfBT	HalfBT	

Table 6: Urban Approaching LOS Parameters

119km/hr max differential

	Tap1	Tap2	Tap3	Tap4	Units
Power	0	-2	-5	-7	dB
Delay	0	200	433	700	ns
Doppler	0	689	-492	886	Hz
Profile	Static	HalfBT	HalfBT	HalfBT	

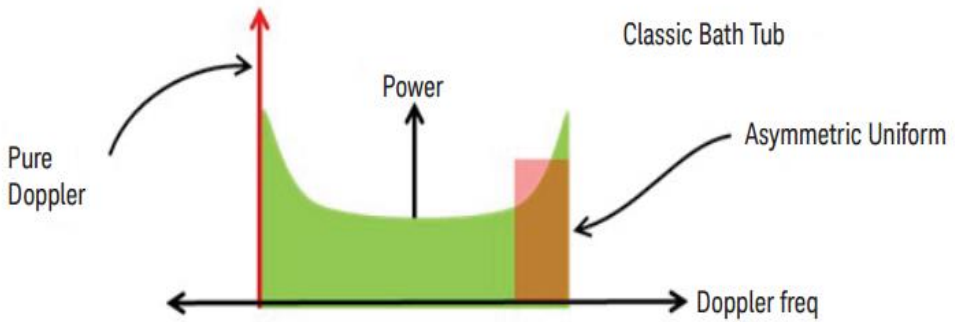
Table 9: Highway NLOS Parameters

252 km/hr max differential

	Tap1	Tap2	Tap3	Tap4	Units
Power	0	-3	-5	-10	dB
Delay	0	267	400	533	ns
Doppler	0	295	-98	591	Hz
Profile	Static	HalfBT	HalfBT	HalfBT	

Table 7: Crossing NLOS Parameters

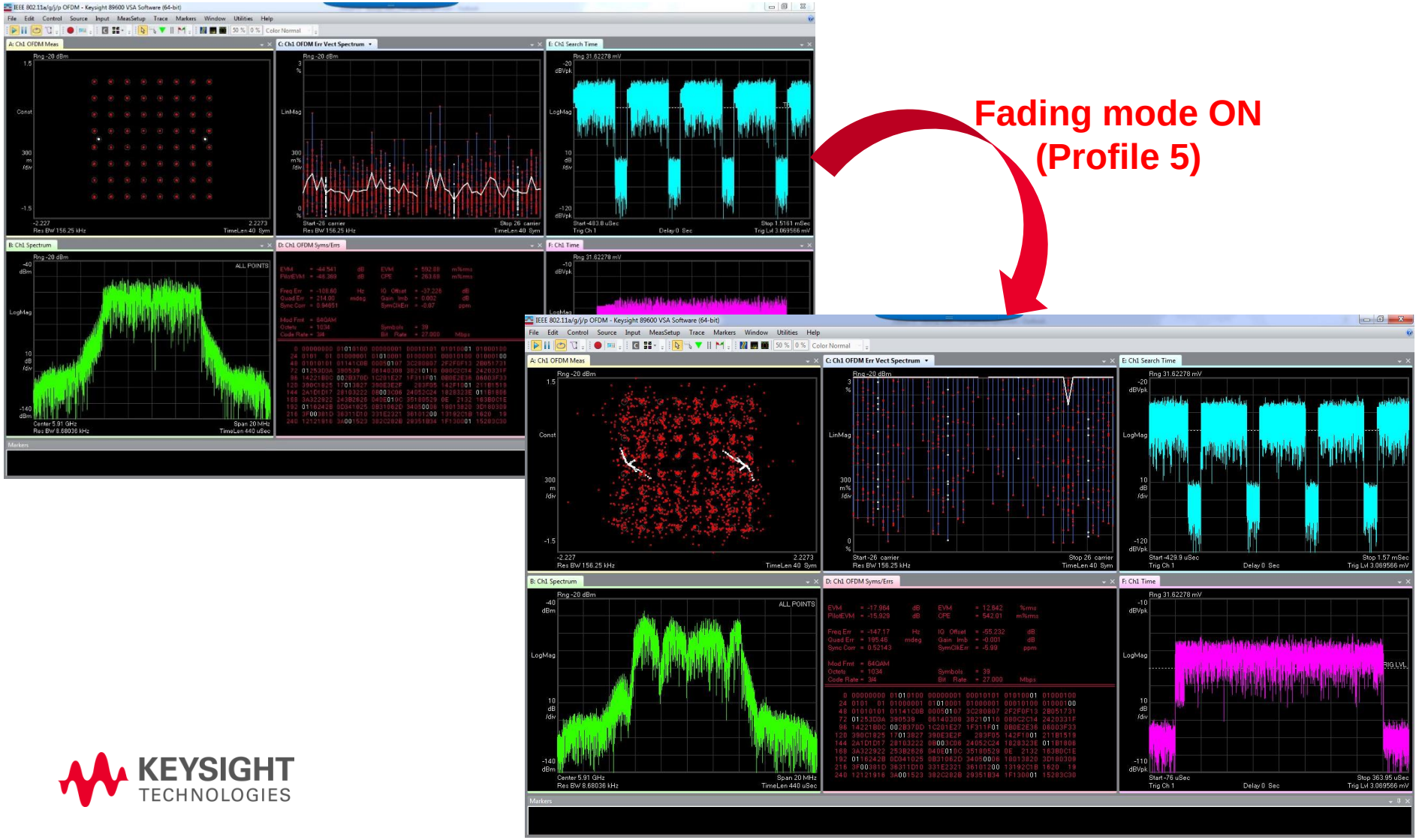
126km/hr max differential



KEYSIGHT TECHNOLOGIES

Real Time Fading Test

802.11p_27M 64QAM



KEYSIGHT TECHNOLOGIES

Automotive Radar

E8707A RTS

KEYSIGHT TECHNOLOGIES

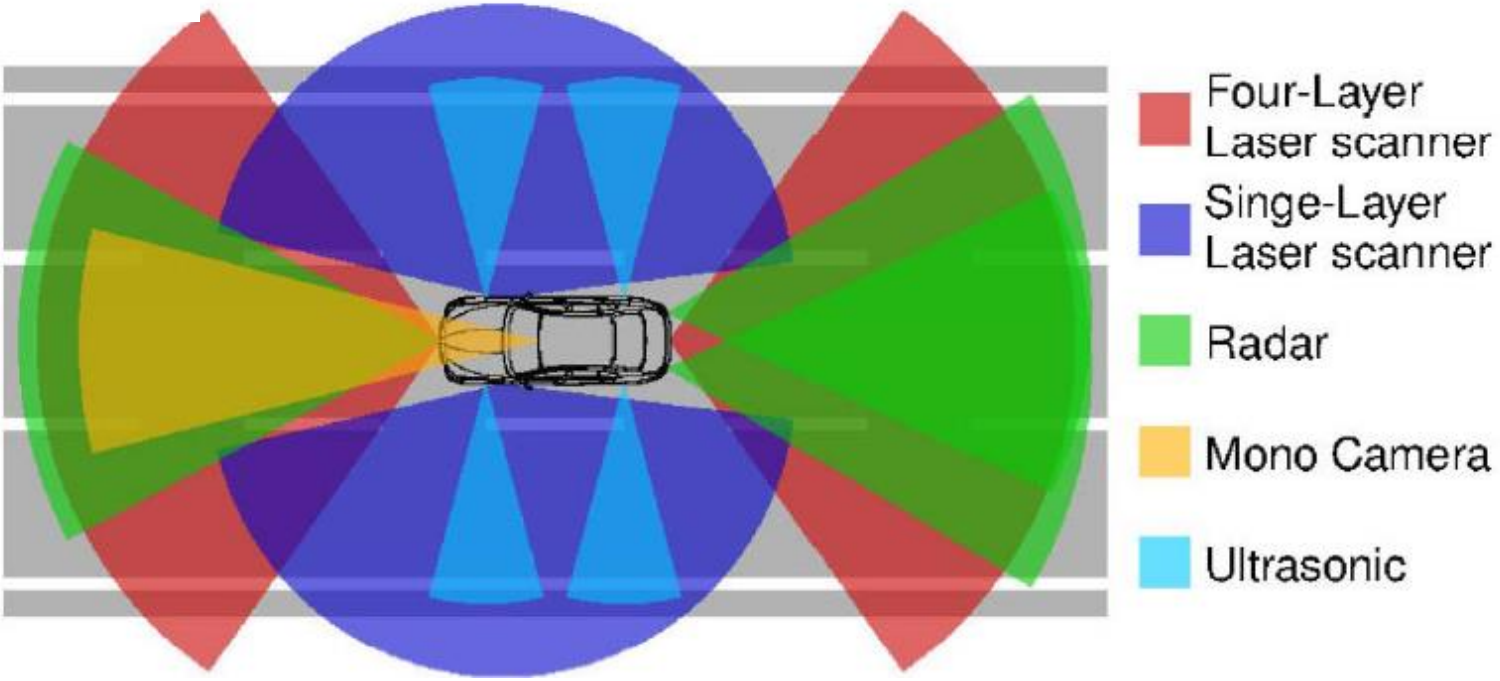
ADAS Technologies

Ultrasonic

Camera

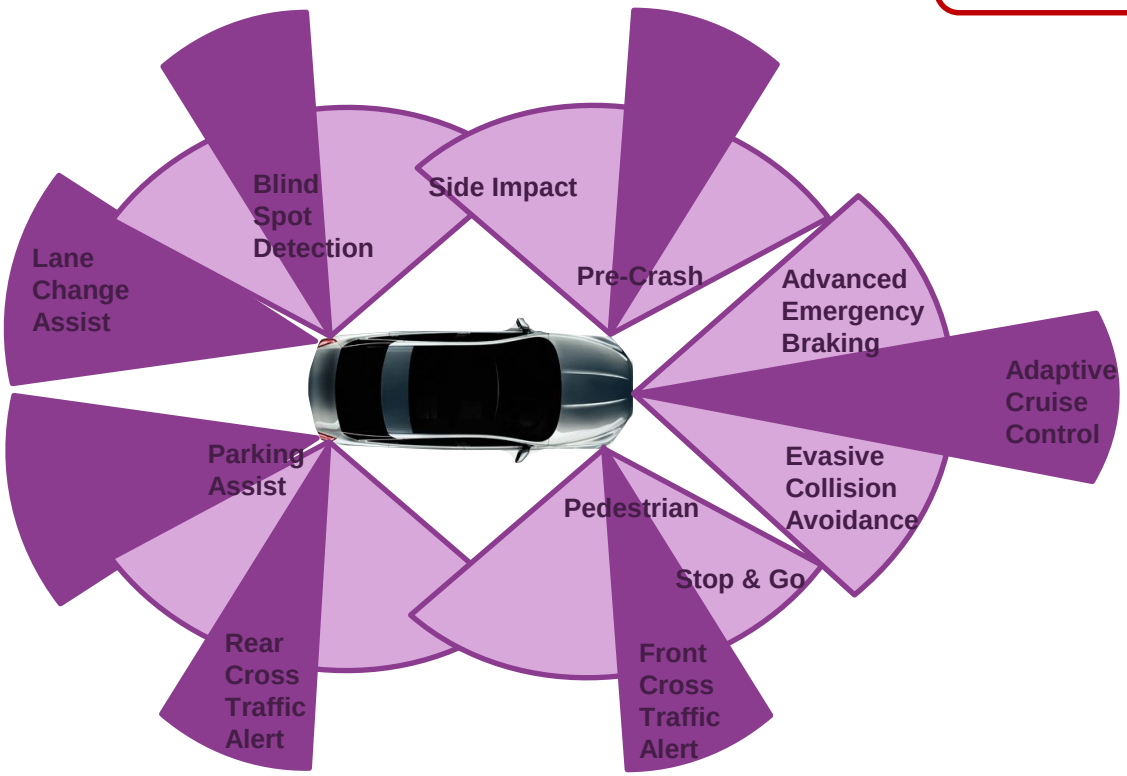
Radar

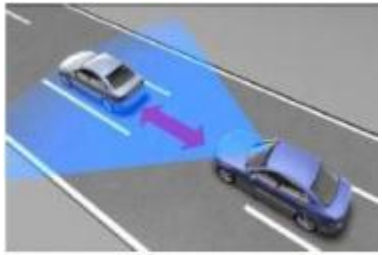
Lidar



Automotive Radar – What is it ?

Making our Roads Safer
360 degree vision

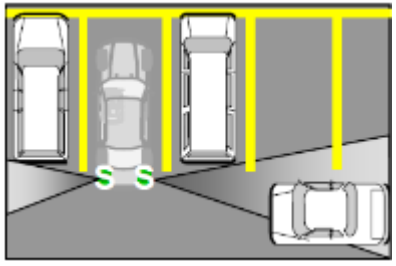




Adaptive Cruise Control (ACC)

Blind Spot Monitoring

Lane Change Assist



Rear traffic crossing alert

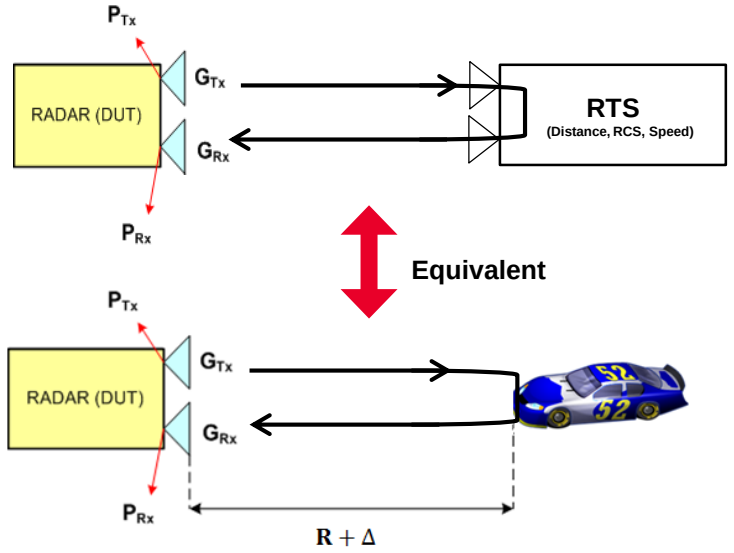
KEYSIGHT TECHNOLOGIES

Radar Target Simulators

Basic Functionality:

The actual UUT radar signal is

a) Received
b) manipulated
c) retransmitted



A radar target simulator will apply …	to simulate …
Time Delay	Range (Distance)
Doppler Frequency Shift	Radial velocity
Attenuation	Radar Cross Section (object size)

Radar Target Simulator Overview

Manufacturing Test concept and Capabilities

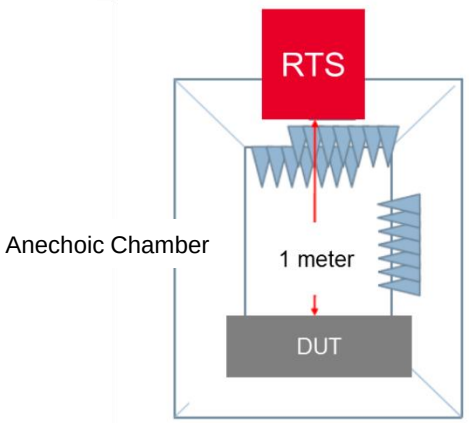
- Frequency Band : 76GHz -77GHz
- Bandwidth : 1GHz
- Single Target
- Range : 10m to 450m
- RCS Range
  - -7dBsm ~ 47dBsm @ 10m
  - 40dBsm ~93dBsm@ 150m
  - 55dBsm ~105dBsm@ 300m
  - 60dBsm ~110dBsm@ 450m
- Speed 0 to +/- 360Km

Scalable

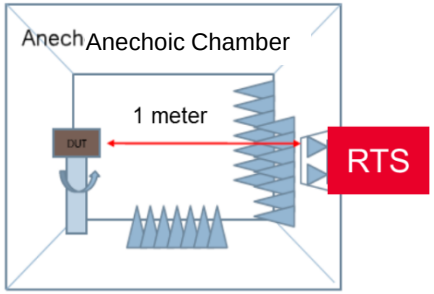
Basic – Fixed range simulation (ie 75m & 150m)
Comprehensive – Full range, RCS, Doppler & DUT Transmit Power

Designed, manufactured and ***supported by single company Keysight Technologies***
World wide support, calibration and warranty
Default 3 years factory warranty
Optional upgrade with onsite calibration, onsite spare and 7x24 support packages
CE and Safety certified

Vertical setup



Horizontal setup



Keysight Radar Target Simulator

Scalable system configurations

Description	Fixed range RTS	+ Full Range	+ Doppler	+ DUT Tx Power
Key Features	• 76-77GHz • 1 or 2 Horns • 75 & 150m • 1GHz BW • Full RCS • DUT Tx simulated power	• 10 – 450m with 1m resolution	• +/- 360 Km/h with 1Km/h resolution	• Enable DUT Tx power measurement
Hardware Configuration	 Base System	Base system internal HW upgrade	 N5183A MXG	 U2042XA Power Meter

Support & Warranty	• 3 Years Keysight Factory warranty with calibration certificate valid for 1 year
	• Optional 1 or 3 years contract
	  ○ Return to Keysight or onsite calibration
	  ○ Spare onsite swap			

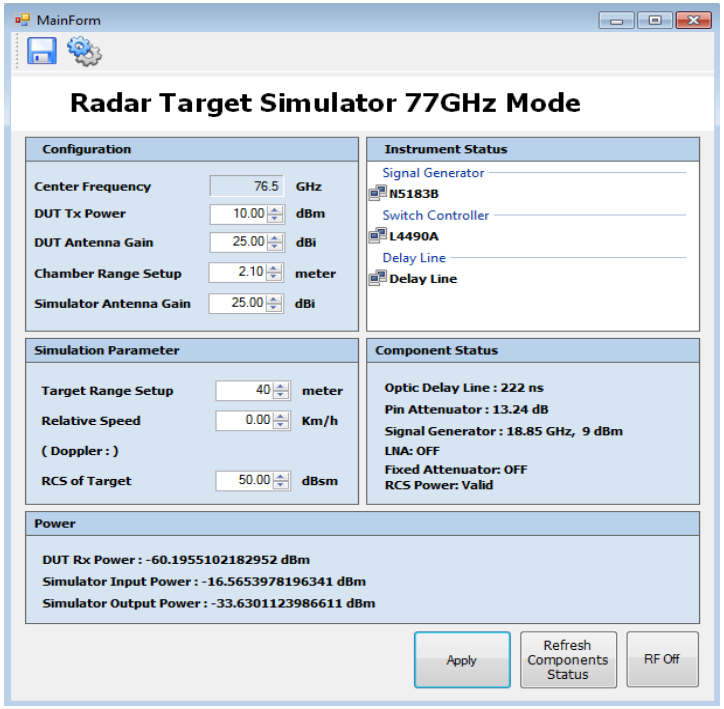
- ***Maximum Phase noise option is available.***
- ***-90dBc/Hz @ 10KHz***

+ Note: Additional features on top of Basic system offering

Keysight Radar Target Simulator

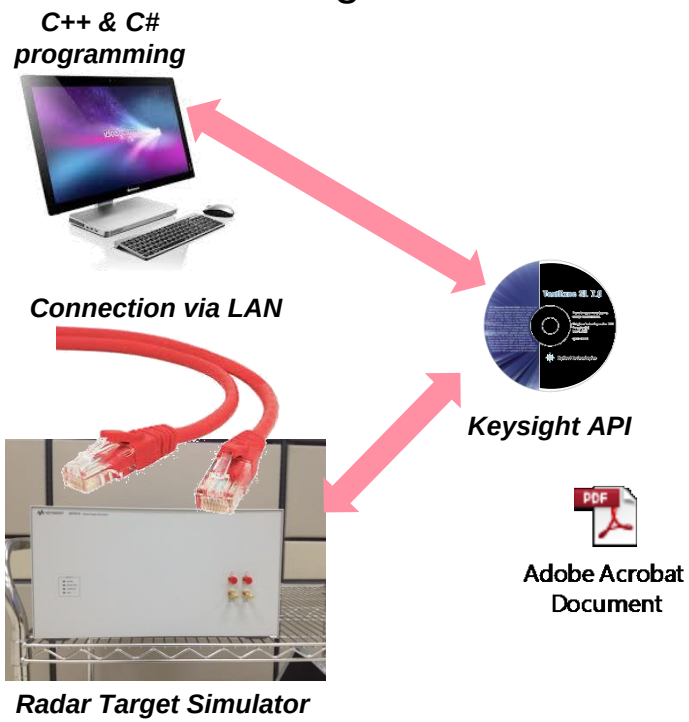
User Interface and controlling software

Bench Environment



Simple and Ease of use GUI

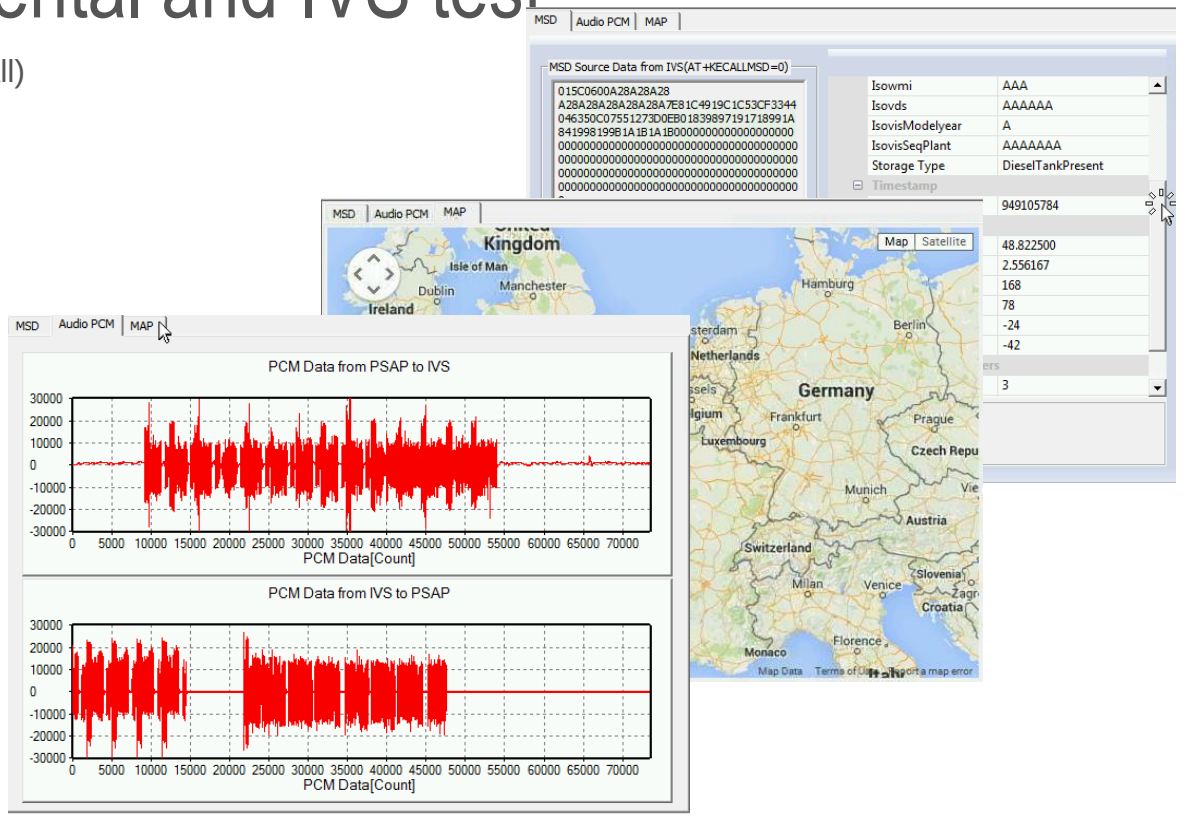
Manufacturing Environment



SW API supporting C++ & C# environment

eCall Fundamental and IVS test

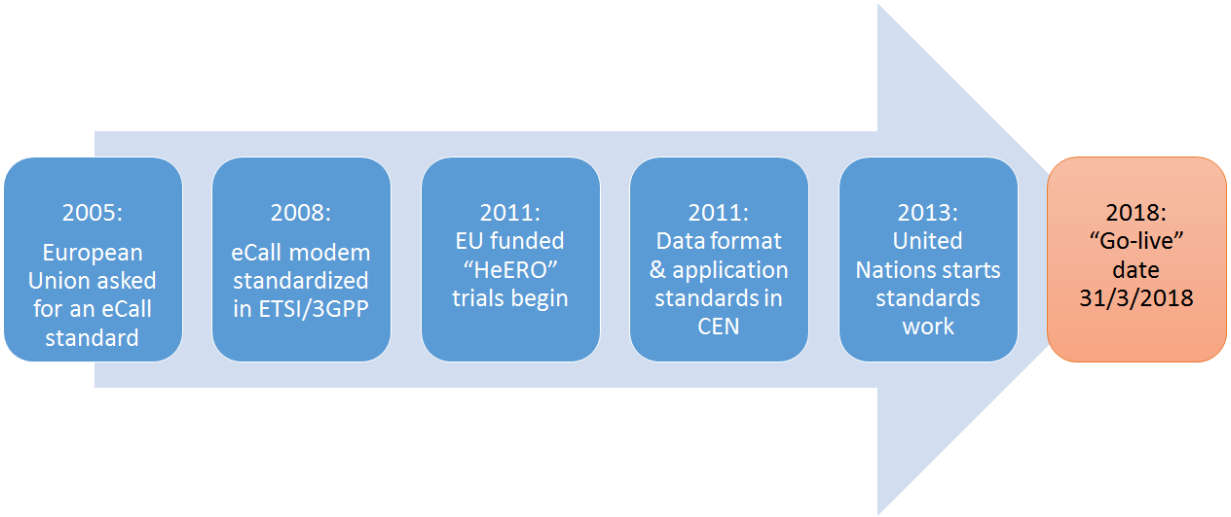
(IVS: In Vehicle System on eCall)



KEYSIGHT TECHNOLOGIES

Yes I know that I need to test it

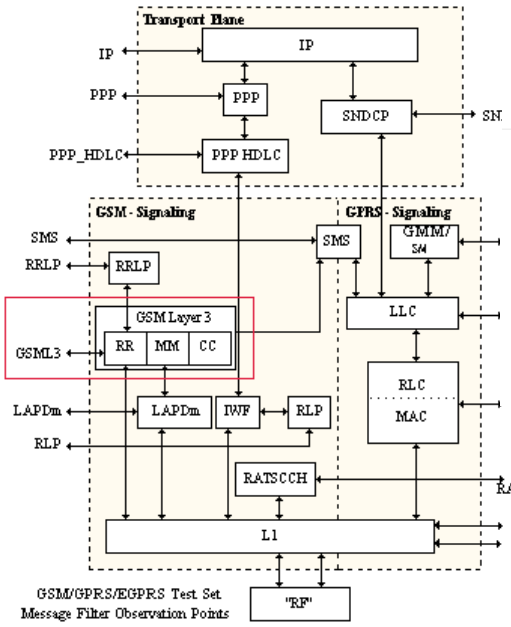
– eCall will “Go-live” 31/3/2018 in Europe.



– All car manufacturers and tiers know that IVS should be equipped in their car

  • needs to prepare test setup for making sure it works fine.

Emergency Service Category



26	00101110	2e	Service category Id=2e(hex)
27	00000001	01	Length= 1 octet(s)
28	00000001	01	Police= 1(dec)
	00000001		Ambulance= 0(dec)
	00000001		Fire Brigade= 0(dec)
	00000001		Marine Guard= 0(dec)
	00000001		Mountain Rescue= 0(dec)
	00000001		Spare= 0(dec)

24	00011111	1f	Codec Bitmap for SysID= 1f(hex)
25	00000000	00	
26	00101110	2e	Service category Id=2e(hex)
27	00000001	01	Length= 1 octet(s)
28	00000001	02	Police= 0(dec)
	00000010		Ambulance= 1(dec)
	00000010		Fire Brigade= 0(dec)
	00000010		Marine Guard= 0(dec)
	00000010		Mountain Rescue= 0(dec)
	00000010		Spare= 0(dec)

24	00011111	1f	Codec Bitmap for SysID= 1f(hex)
25	00000000	00	
26	00101110	2e	Service category Id=2e(hex)
27	00000001	01	Length= 1 octet(s)
28	00000100	04	Police= 0(dec)
	00000100		Ambulance= 0(dec)
	00000100		Fire Brigade= 1(dec)
	00000100		Marine Guard= 0(dec)
	00000100		Mountain Rescue= 0(dec)
	00000100		Spare= 0(dec)

24	00011111	1f	Codec Bitmap for SysID= 1f(hex)
25	00000000	00	
26	00101110	2e	Service category Id=2e(hex)
27	00000001	01	Length= 1 octet(s)
28	00001000	08	Police= 0(dec)
	00001000		Ambulance= 0(dec)
	00001000		Fire Brigade= 0(dec)
	00001000		Marine Guard= 1(dec)
	00001000		Mountain Rescue= 0(dec)
	00001000		Spare= 0(dec)

24	00011111	1f	Codec Bitmap for SysID= 1f(hex)
25	00000000	00	
26	00101110	2e	Service category Id=2e(hex)
27	00000001	01	Length= 1 octet(s)
28	00010000	10	Police= 0(dec)
	00010000		Ambulance= 0(dec)
	00010000		Fire Brigade= 0(dec)
	00010000		Marine Guard= 0(dec)
	00010000		Mountain Rescue= 1(dec)
	00010000		Spare= 0(dec)

24	00011111	1f	Codec Bitmap for SysID= 1f(hex)
25	00000000	00	
26	00101110	2e	Service category Id=2e(hex)
27	00000001	01	Length= 1 octet(s)
28	00010000	10	Police= 0(dec)
	00010000		Ambulance= 0(dec)
	00010000		Fire Brigade= 0(dec)
	00010000		Marine Guard= 0(dec)
	00010000		Mountain Rescue= 0(dec)
	00100000		Manually Initiated eCall= 1(dec)

eCall Architecture

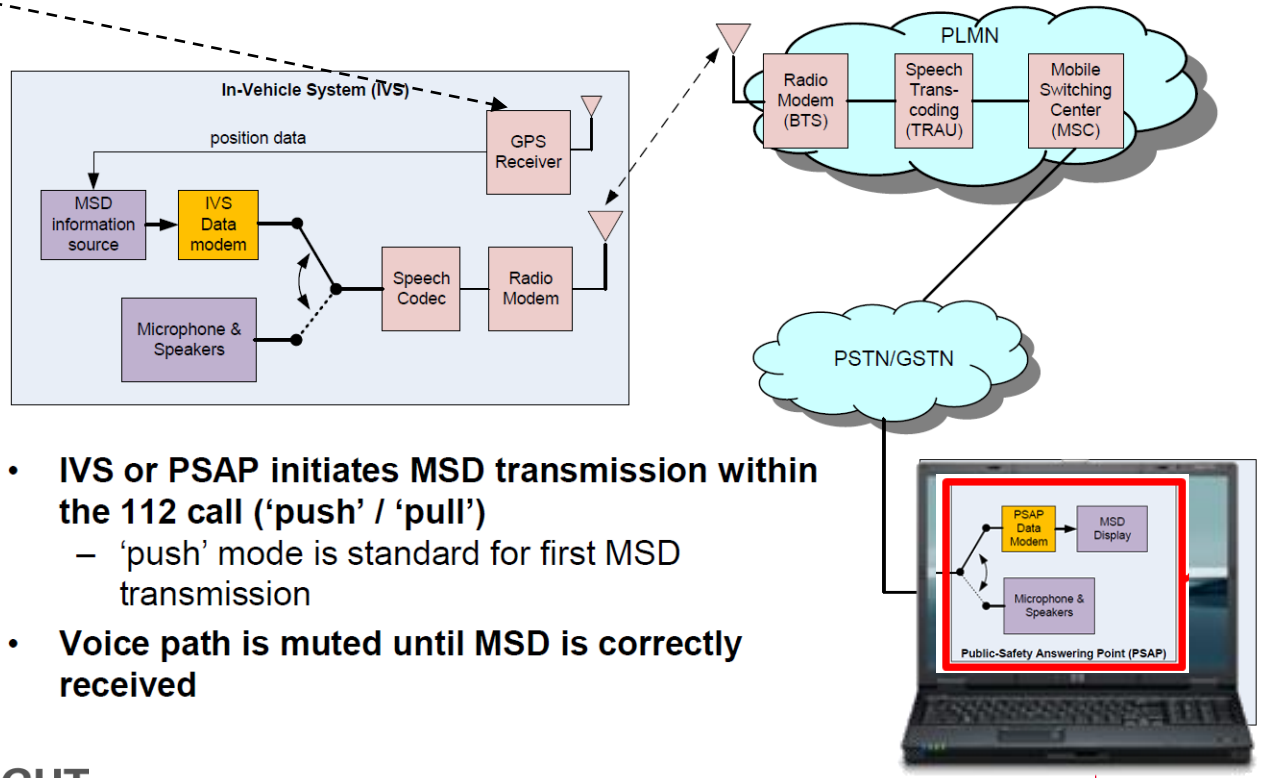
Qualcomm proposal

Pan-European eCall, *Marc Werner*
April 2011

QUALCOMM

N5172B EXG w Signal Studio

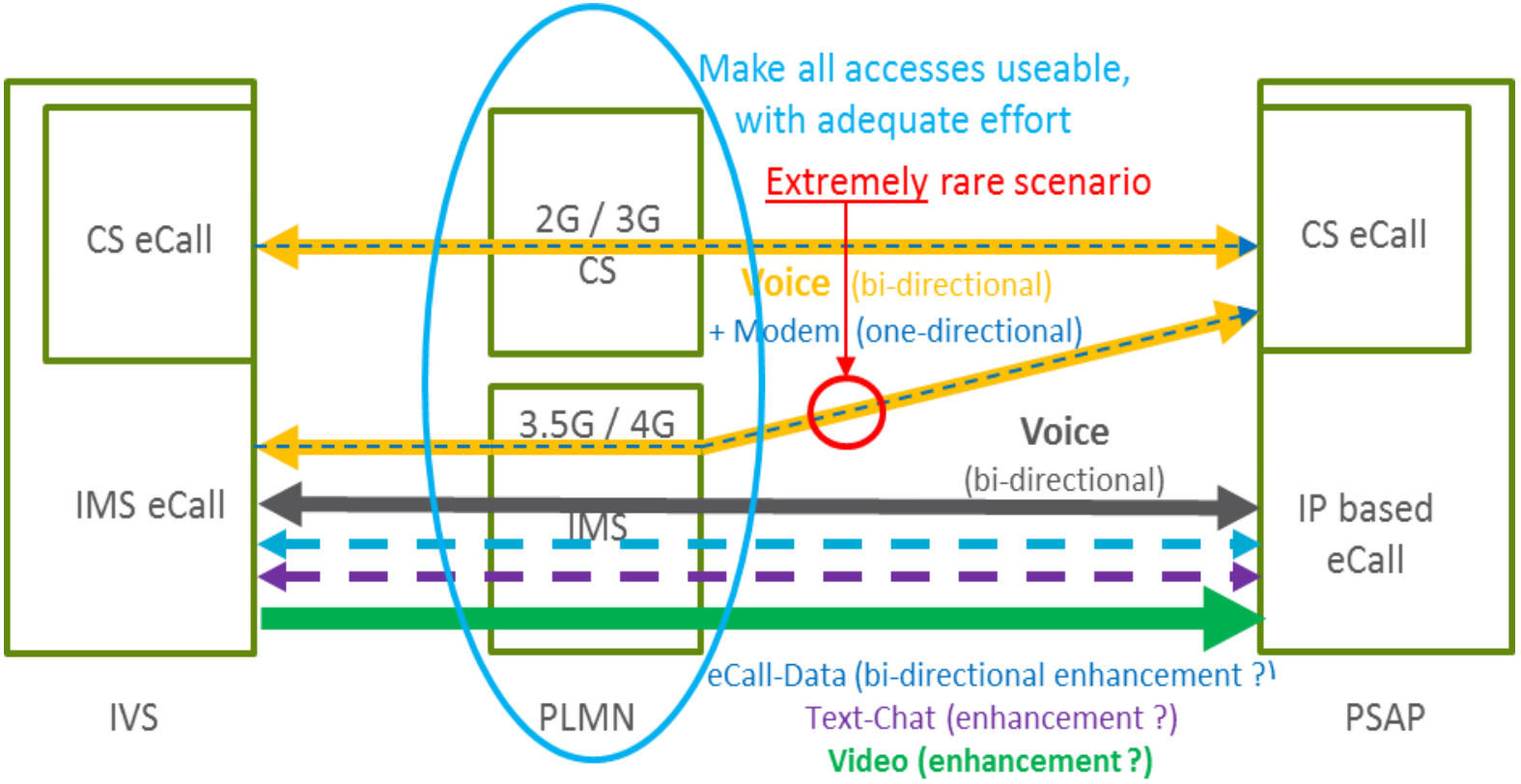
eCall In-band Modem within the Cellular Architecture



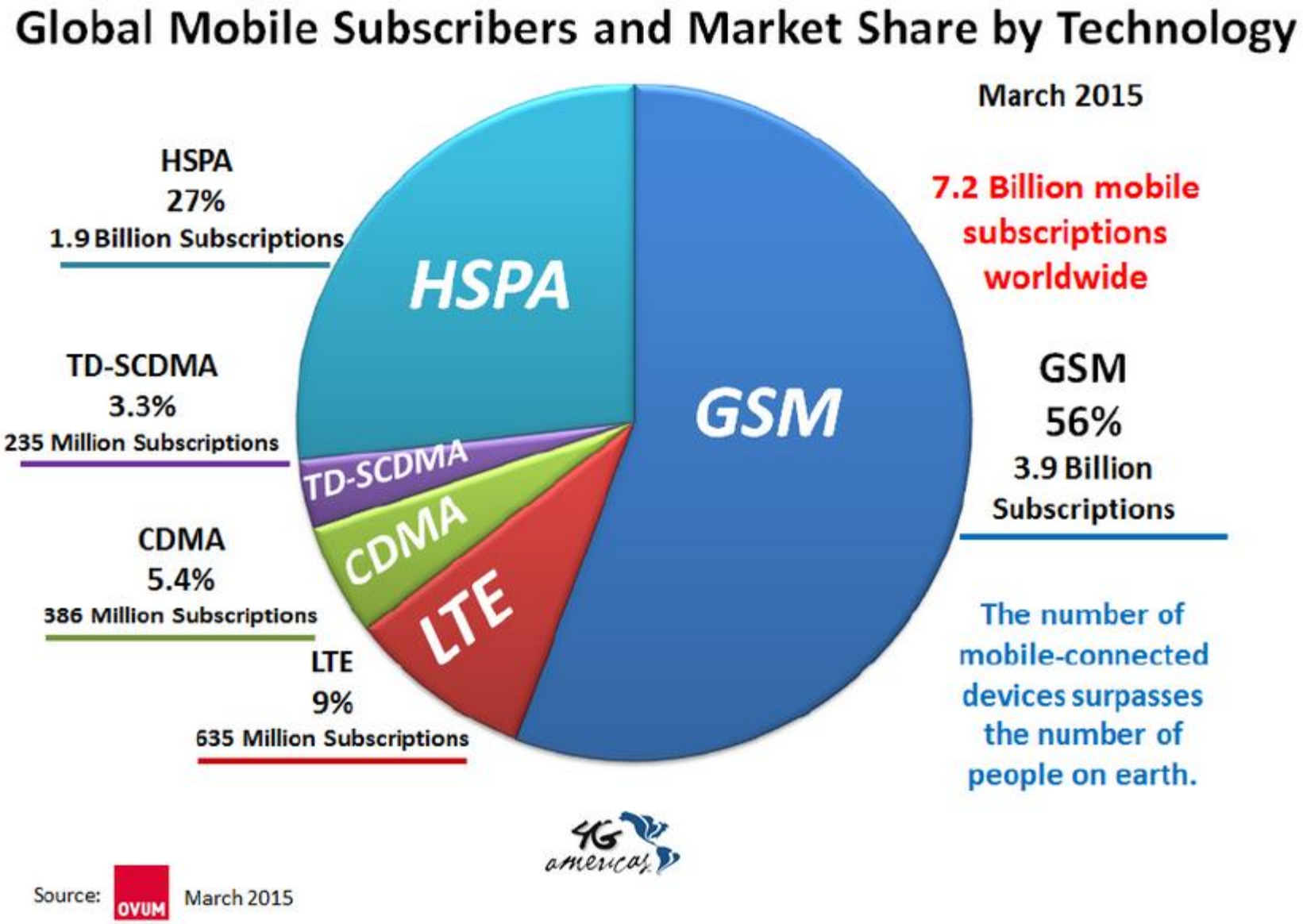
- **IVS or PSAP initiates MSD transmission within the 112 call ('push' / 'pull')**
  - 'push' mode is standard for first MSD transmission
- **Voice path is muted until MSD is correctly received**

Co-existence of CS and IMS eCall

Migration of eCALL Transport : ETSI STF456



2G 3G 4G market – Who will be the biggest?



Via: The 3G4G Blog - blog.3g4g.co.uk

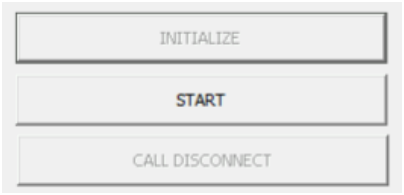
Budget, Budget, Budget

Full Conformance test is not required for all cases

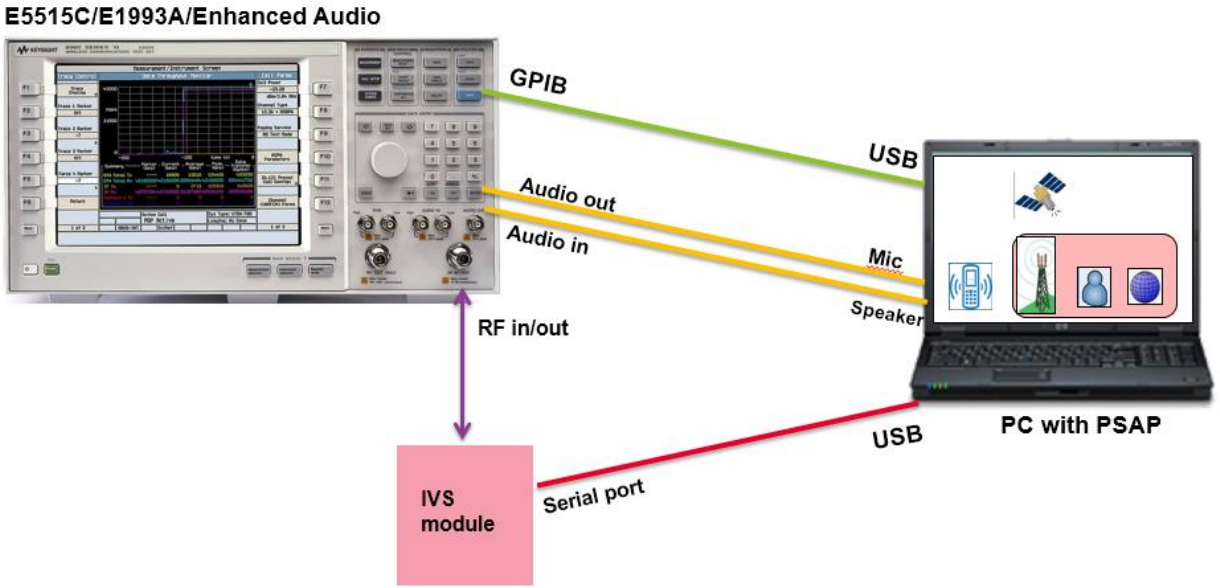
- Conformance test system price for IVS can be up to 500K USD
- If user just wants its IVS is working and properly communicating with PSAP, this type test system is too much.
- To match up increasing test needs, simple and cost effective way for testing IVS functionality is highly required.

Focused on Insanely simple

Focused on IVS is functioning

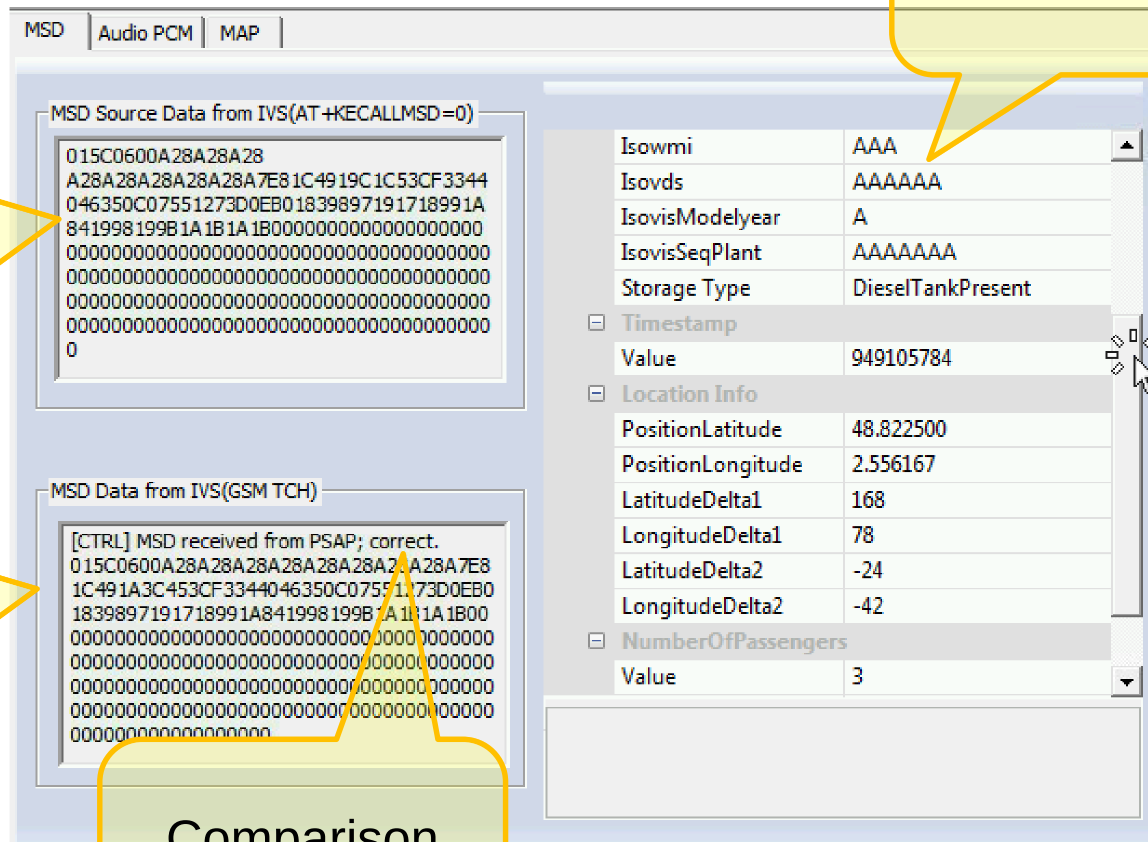


- Software has only 3 buttons, each button is activated only when it is required.
- Simply hook up and running will show you all the information of message when IVS is in eCall communication.
- You can check every each items of MSD(Minimum Set of Data) and verify that IVS is properly reporting.



Functions

MSD compare, decoding



Parsed MSD contents

MSD data that IVS trying to send

Received and decoded MSD data

Comparison result

KEYSIGHT TECHNOLOGIES

Functions

Audio PCM data displaying and recording

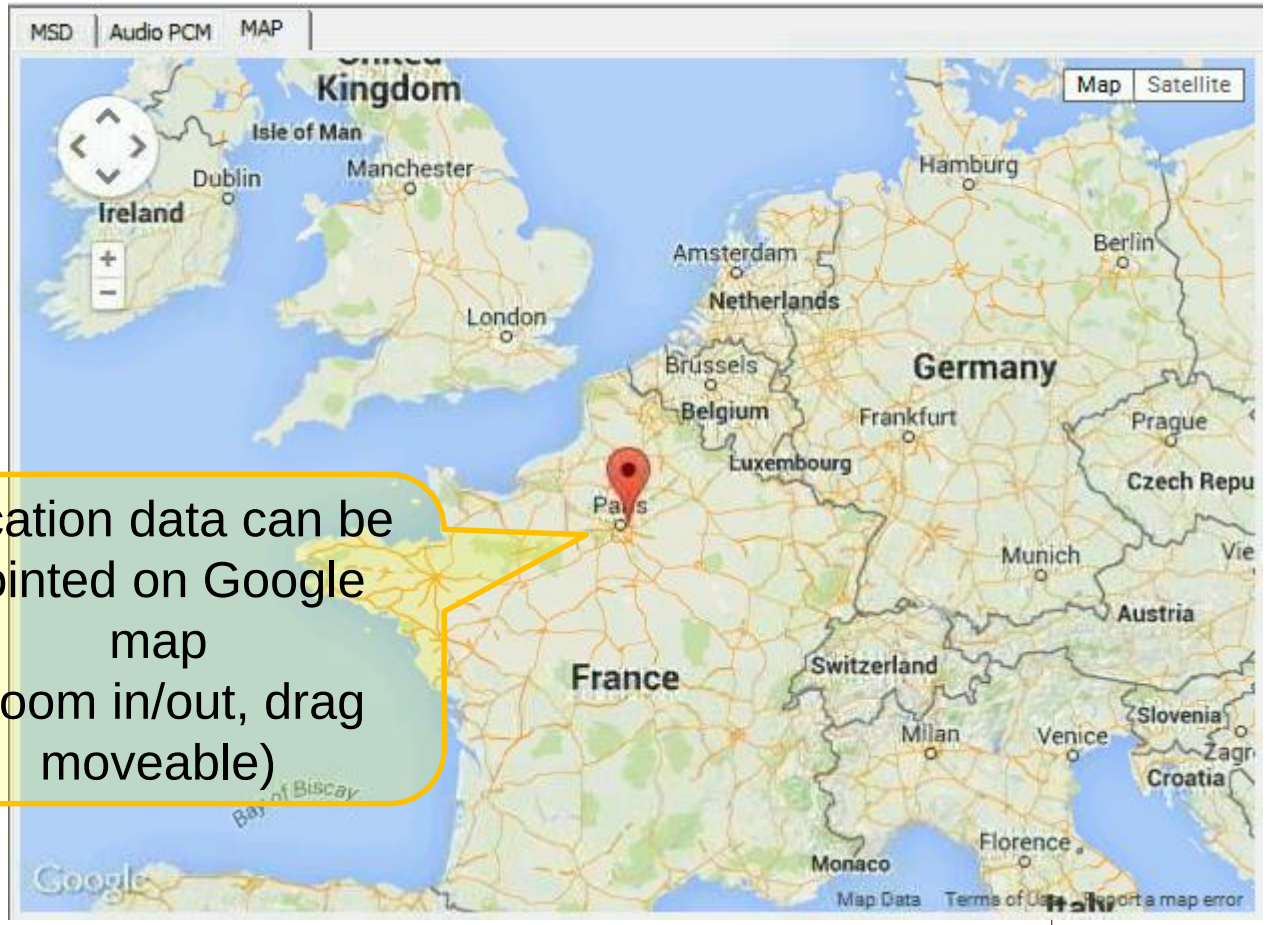
PSAP responded audio

Received audio on PSAP

This audio signal is saved as wav format

Functions

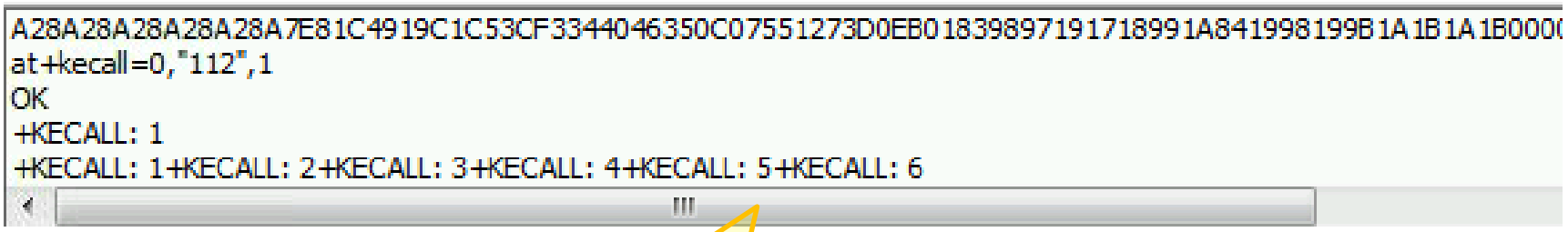
Locate IVS location data on the map



Location data can be pointed on Google map
(Zoom in/out, drag moveable)

Functions

Monitor IVS interface



All the AT commands & responses between IVS and software can be monitored

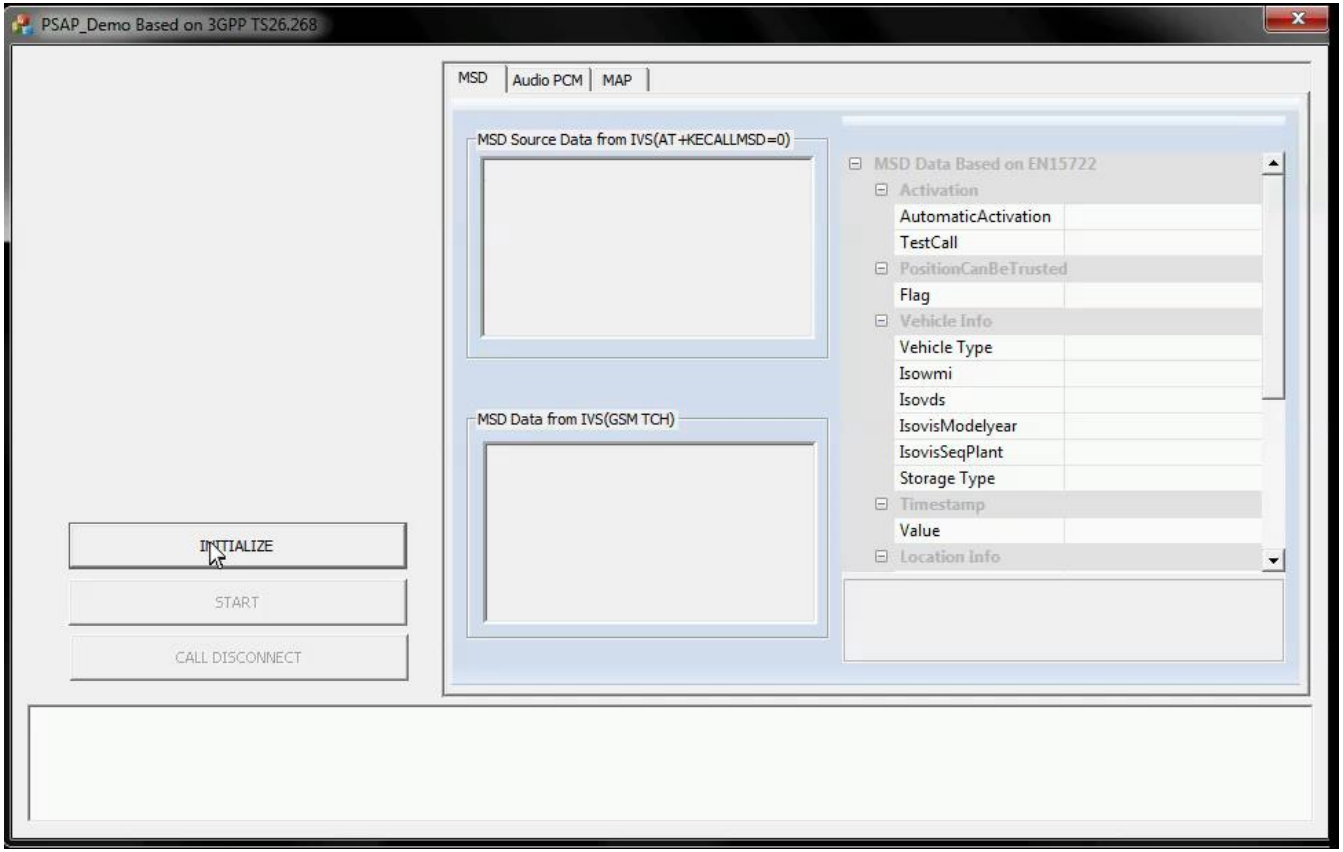
Typical usage

– When specific accident simulated thru electrical signal, for example, front crash on load vehicle made airbag blow, user can verify if IVS automatically make a phone call and report current vehicle status.

Diesel Car from A company, we have 3 passengers, and we are where and …

Demo

Click to run



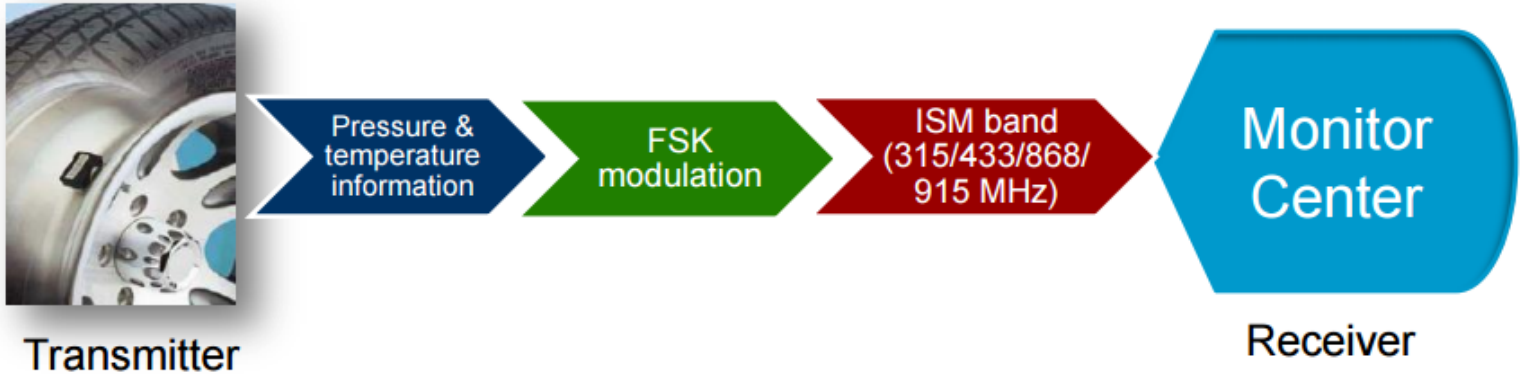
Sensor Test (TPMS, RKE)

KEYSIGHT TECHNOLOGIES

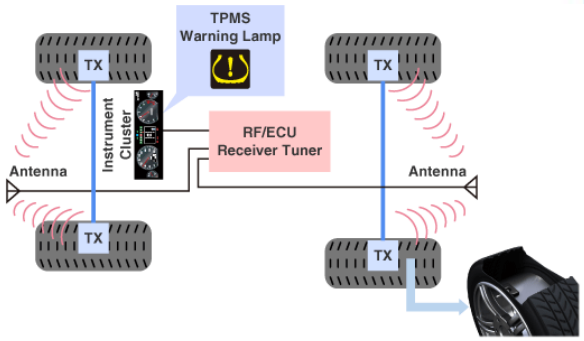
Facts about TPMS

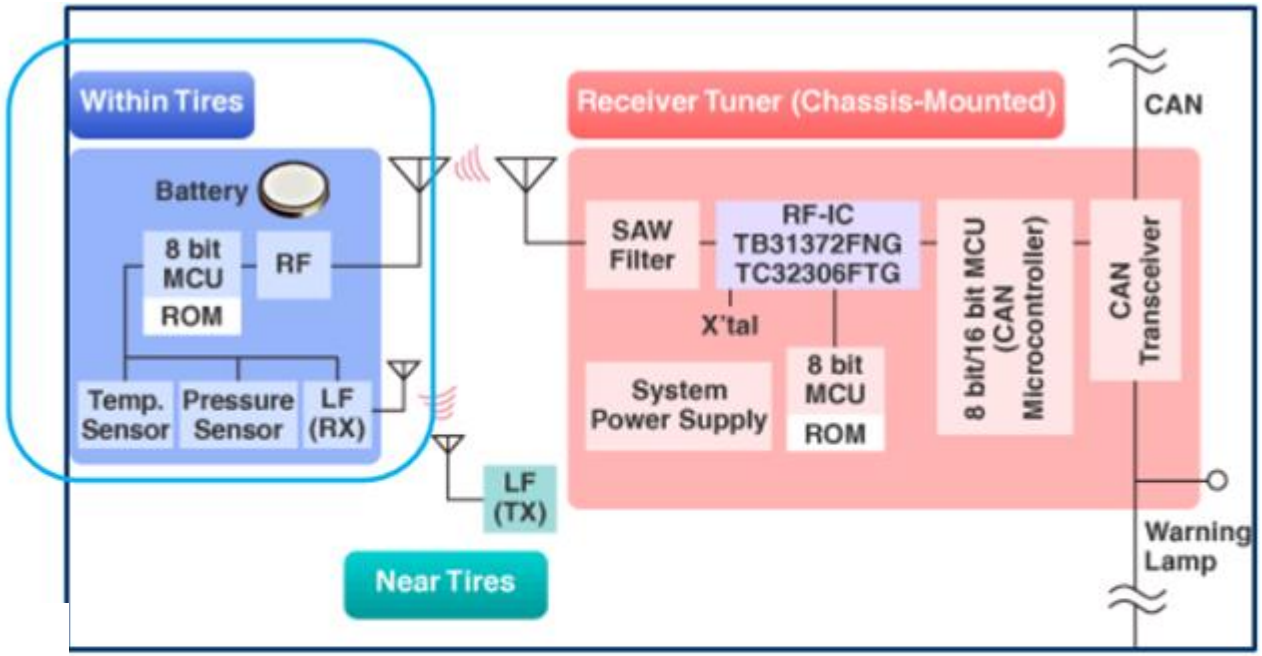
Tire Pressure Measurement System (TPMS)

- Includes tire pressure monitoring module in the tires and the MCU in the vehicle control unit
- Measures conditions in each tire and transmit the data to the MCU via radio
- Works at ISM band, e.g.315MHz,433.92MHz,868MHz or 915MHz。
- Modulation format: FSK or ASK with Manchester encoding



Example Block Diagram

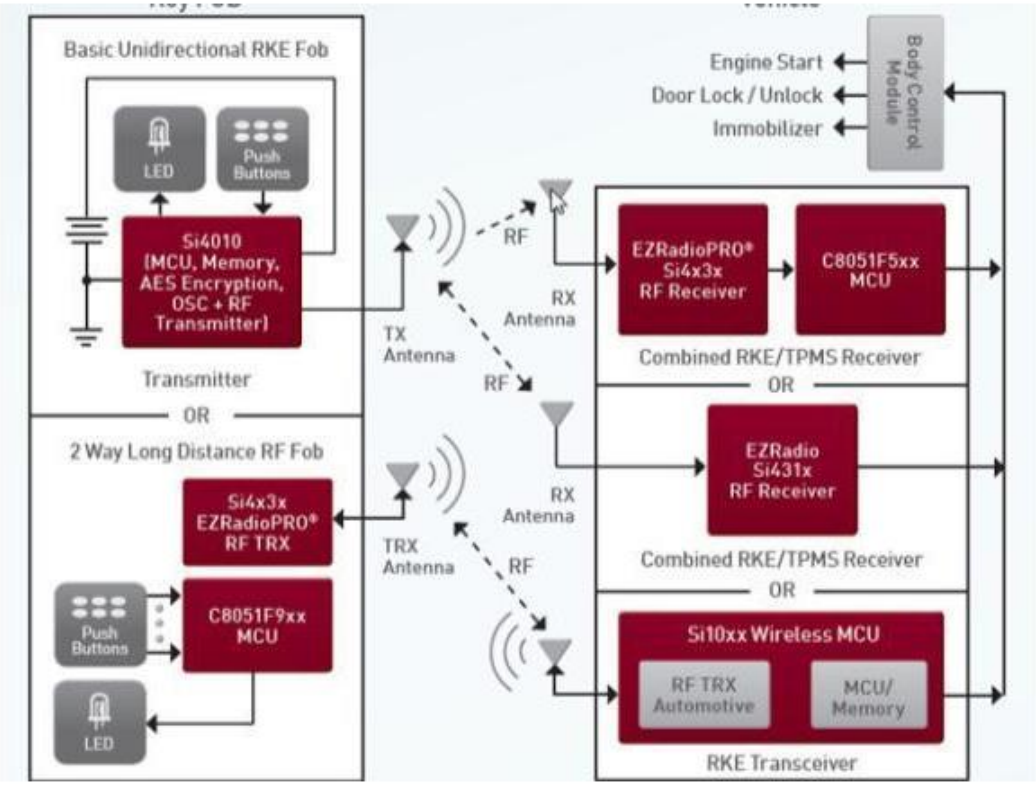




Transmitter Test:
- Frequency
- Power
- FSK deviation

Receiver Test :
- Sensitivity-Bit error
- Frequency

Similarities in RKE/PKE Testing



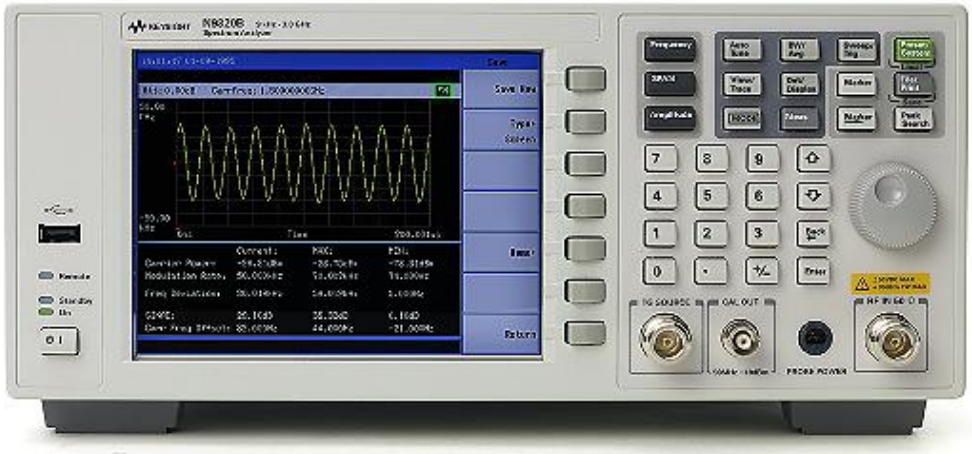
RKE/PKE also utilizes the same technologies:
ISM bands and ASK/FSK modulation format.

N9320B Spectrum Analyzer Overview

Directly demodulates on the carrier

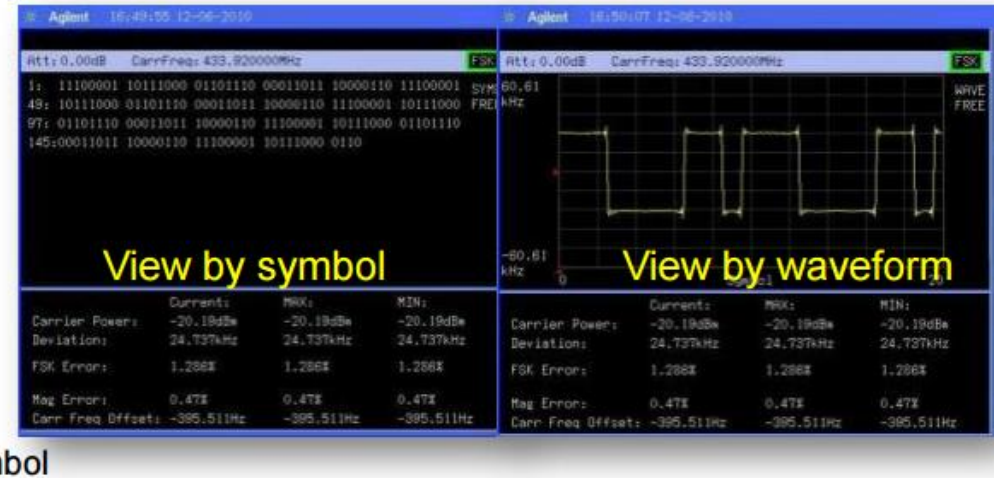
Intuitively shows the modulation metrics

Multiple view maps



N9320B in ASK/FSK demodulation mode (with option DMA)

- Freq range: 10 MHz to 3 GHz
- Power accuracy: ± 1 dB typ.
- Input power: -30 to +20 dBm
- Synchronized by RF trigger
- ASK depth: 10 to 90%
- FSK deviation: 1 to 400 kHz
- Max measurement length: 1100 symbol



Why should I use the ASK/FSK demodulation analysis mode in Keysight N9320B/N9322C?

Traditional spectrum analyzers	Agilent N9320B/N9322C BSA
Customer needs use “Max hold” to get the spectrum of the FSK modulation signal, then use marker and marker delta to read out the power and FSK deviation	Customer can rely on the ASK/FSK demodulation analysis (option DMA) to easily get all the RF and demodulation metrics in one screen.
Disadvantages: Time consuming Consumes the DUT’s battery power	Advantages: Fast Accurate Multiple metrics in one test

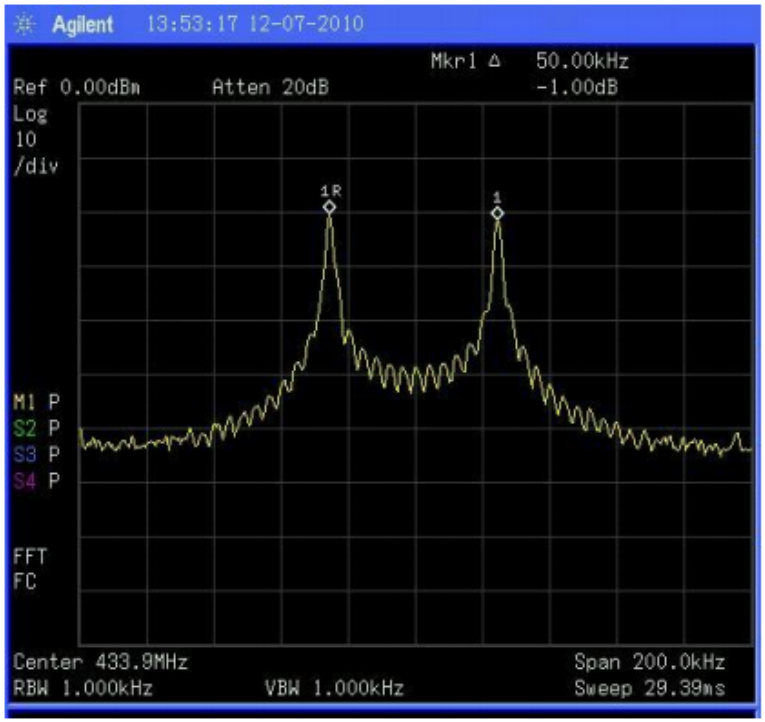
Max-hold takes about 10 seconds to fully capture a FSK signal

One-stop demodulation metrics!

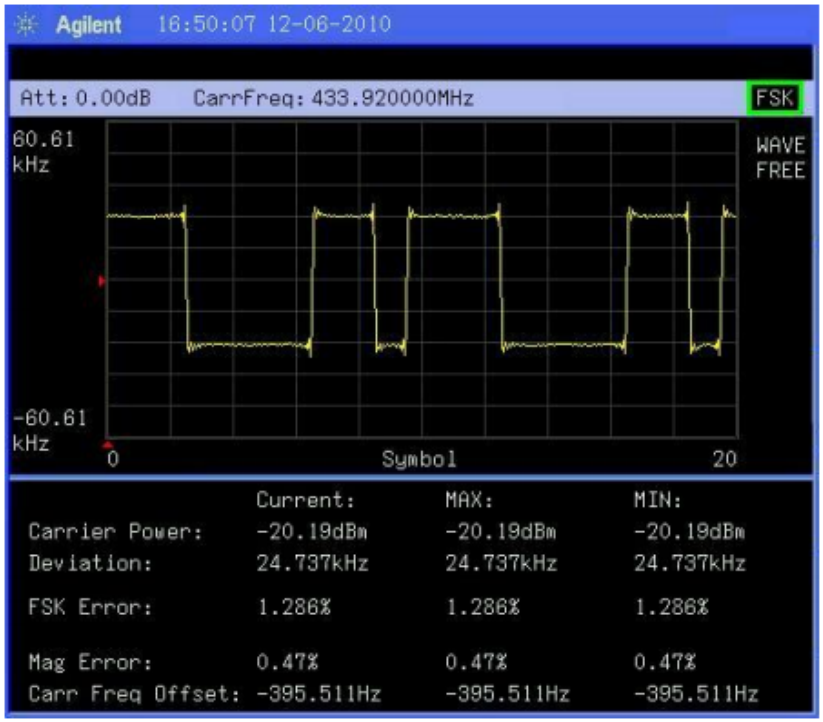
	Current:	MAX:	MIN:
Carrier Power:	-20.05dBm	-20.05dBm	-20.05dBm
ASK Error:	0.23%	0.23%	0.23%
ASK Depth:	97.62%	97.62%	97.62%
ASK Index:	95.35%	95.35%	95.35%
Carr Freq Offset:	-473.402Hz	-473.402Hz	-473.402Hz

Typical Test Results

Tx Measurement example: 2FSK signal
(CF = 433.92 MHz, Power = -20 dBm, symbol rate = 4 ksps, Peak-Peak FSK deviation = 50 kHz,
Baseband pattern = 1110000110)

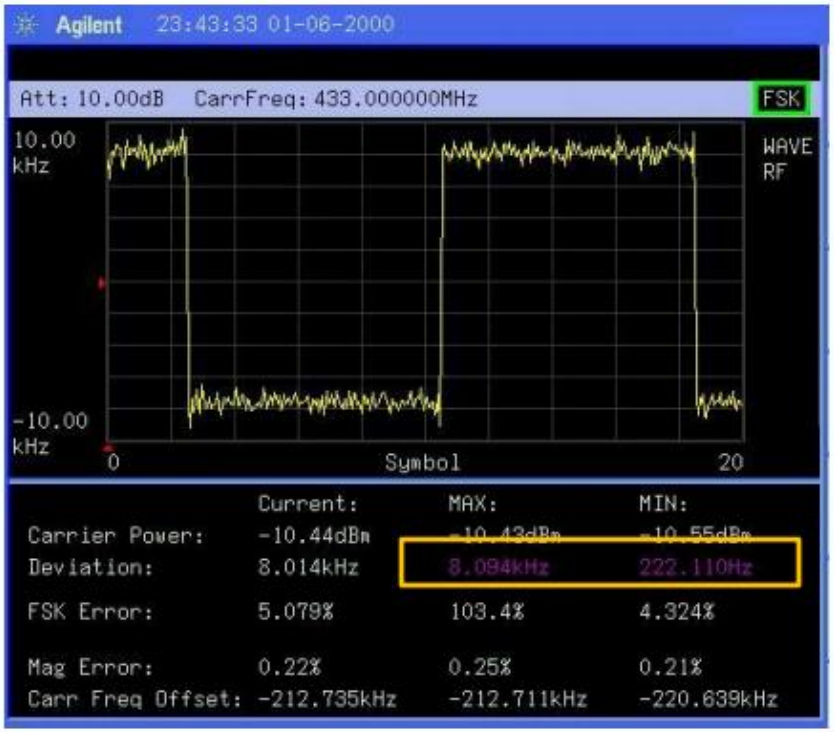


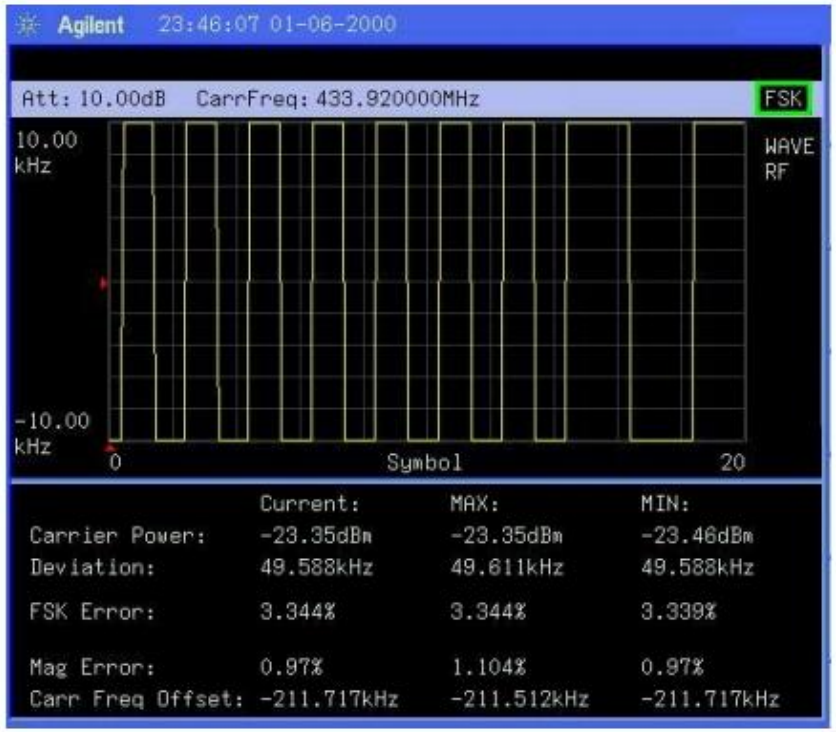
Measuring a FSK signal in the normal spectrum analyzer mode, using trace max hold



Measuring a FSK signal in the ASK/FSK demodulation mode (Opt. DMA)

Typical Test Results





Add Pass/Fail Testing on the FSK deviation (Purple color = Fail, out of tolerance)

Add Pass/Fail Testing on the FSK deviation (White color = Pass)

Receiver Test Solution for TPMS receiver

The economy

Product configuration
N9310A RF Signal Generator, 9 kHz - 3 GHz
33500 Function/Arbitrary Waveform Generator
33503A BenchLink Waveform Builder Pro

The performance

Product configuration
N5172B EXG Signal Generator, 9 kHz -3 GHz
Custom digital modulation

Keysight Solution (Economic version)

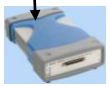
Receiver Test

33503A BenchLink Software

33200/33500 Series waveform generator

N9310A RF Signal Generator

DUT



U2531A Data Acquisition

Transmitter Test

DUT

N9320B/N9322C BSA Spectrum Analyzer

Bluetooth Audio

U8903B

KEYSIGHT TECHNOLOGIES

U8903B's *Bluetooth* Option

Bluetooth 4.0

Driven by market trend with more devices compatible with *Bluetooth* 4.0

Eliminate the uncertainty of pairing and connection issue when testing the Bluetooth 4.0 devices

High Output Power

Transmit up to 5 dBm

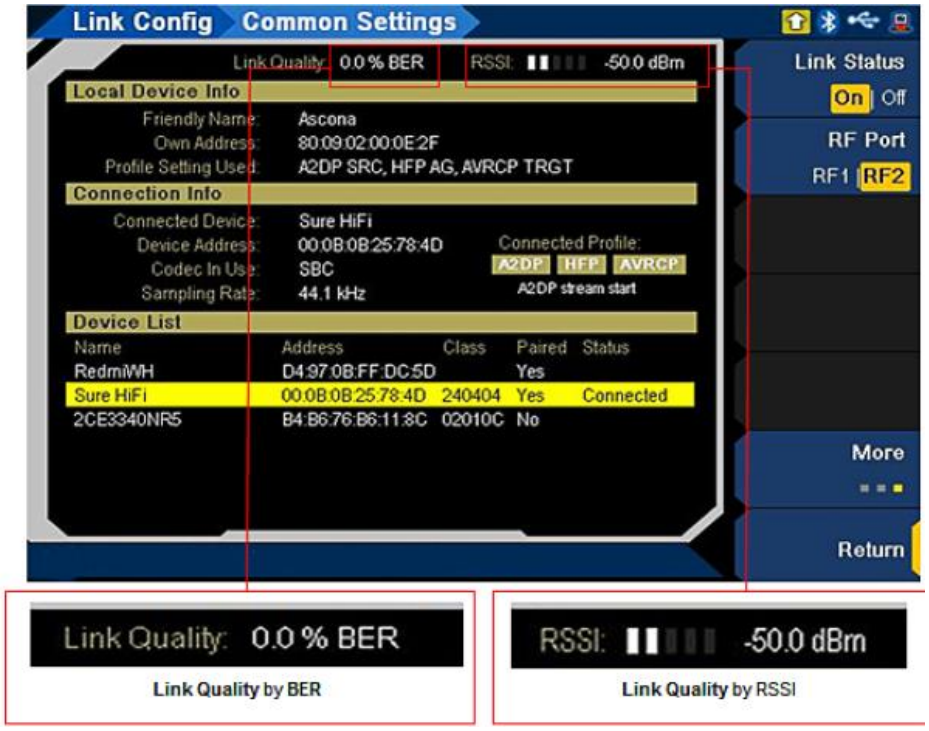
Test a wide range of Bluetooth devices (class 1, 2 & 3)

U8903B's *Bluetooth* Option

Link Monitoring

Ensure the *Bluetooth* link quality and easily troubleshoot connection issues via

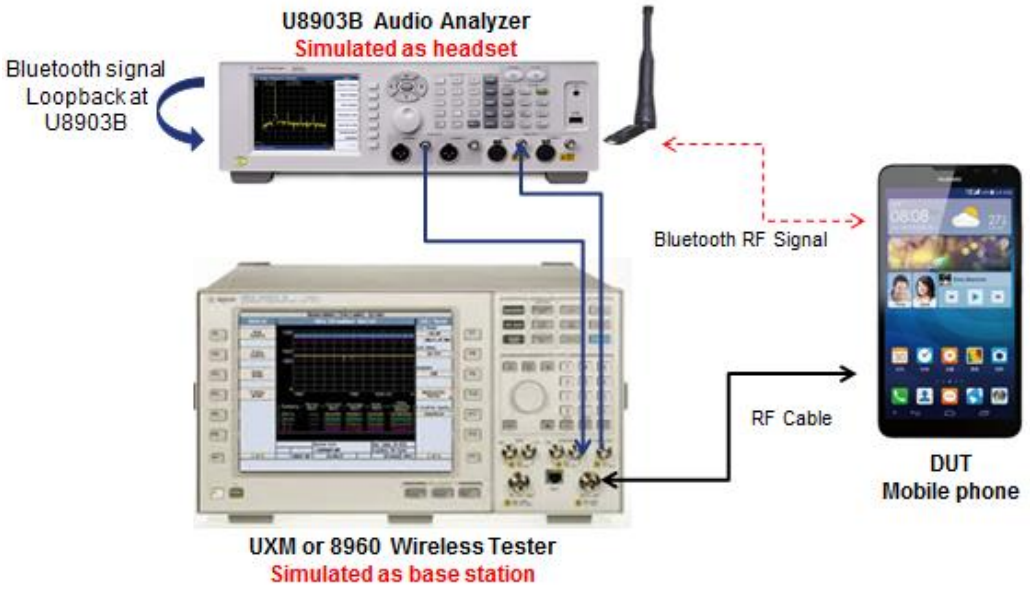
- Bit error rate (BER) measurement
  - Measure the link quality between U8903B and the to-be-measured *Bluetooth* device
  - Causes of link quality deterioration can be determined by monitoring the changes in BER value
- Received signal strength indicator (RSSI)
  - Estimate link quality



U8903B's Bluetooth Option

Local Loopback Capability

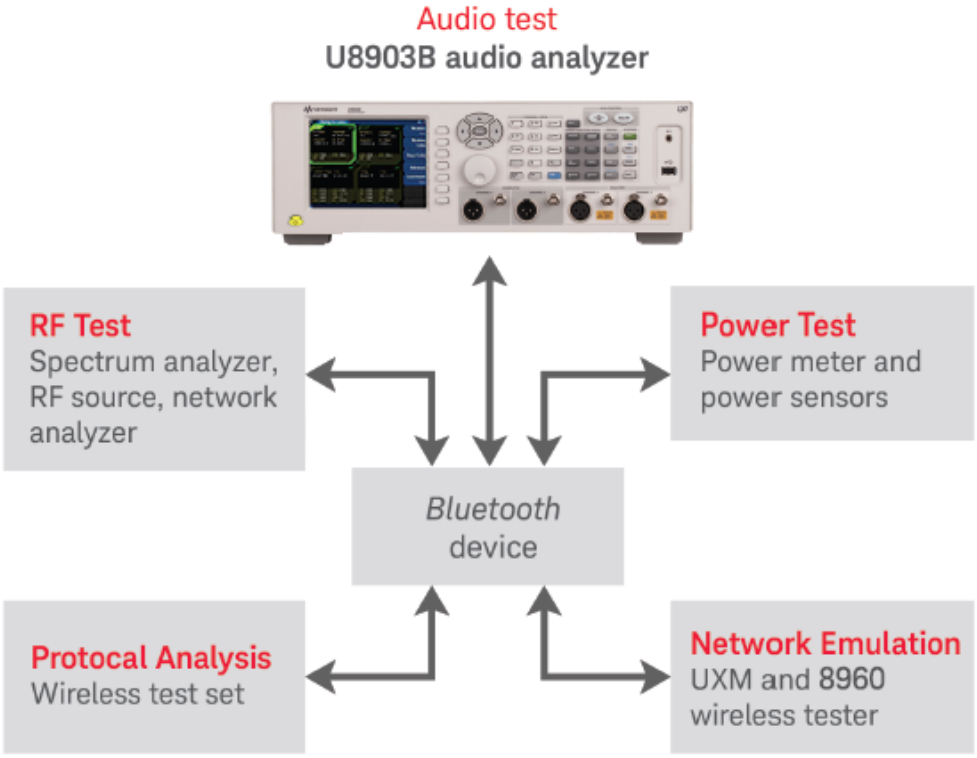
- **Quick and Convenient**:
  - Enable simultaneous uplink and downlink test
- **Accurate:**
  - No potential audio degradation by the U8903B's internal audio signal processing
- **Full functions of audio measurement:**
  - Tests processed in analog audio domain, not Bluetooth domain



Example: Bluetooth audio quality test of mobile phone

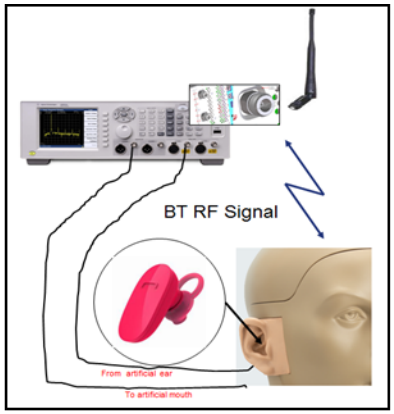
Total Keysight Bluetooth Solution

- With the U8903B's Bluetooth option, Keysight now offers a total Bluetooth test equipment solution
- One-stop center: saving your time, effort and money

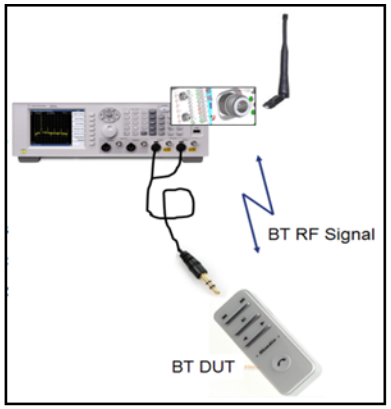


Bluetooth Audio Test Solution

Customer test cases

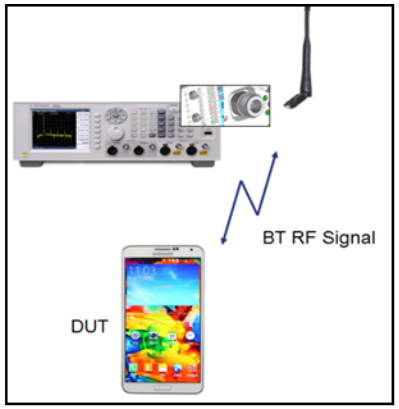


Testing headset phone call quality

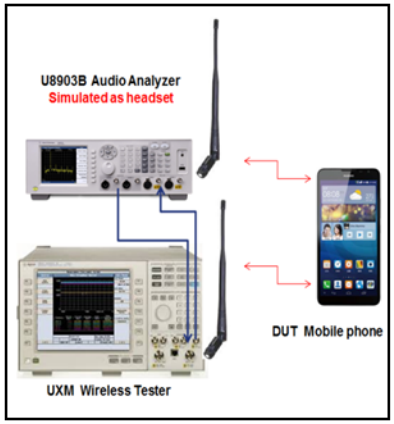


Testing headset playback audio quality

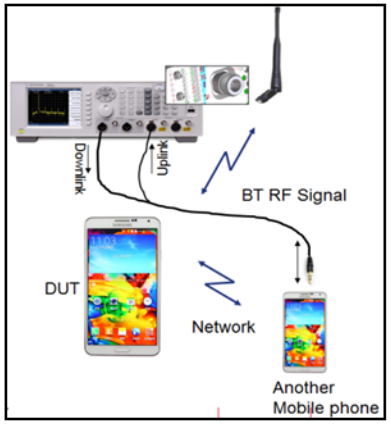
Testing headset phone call dual link quality



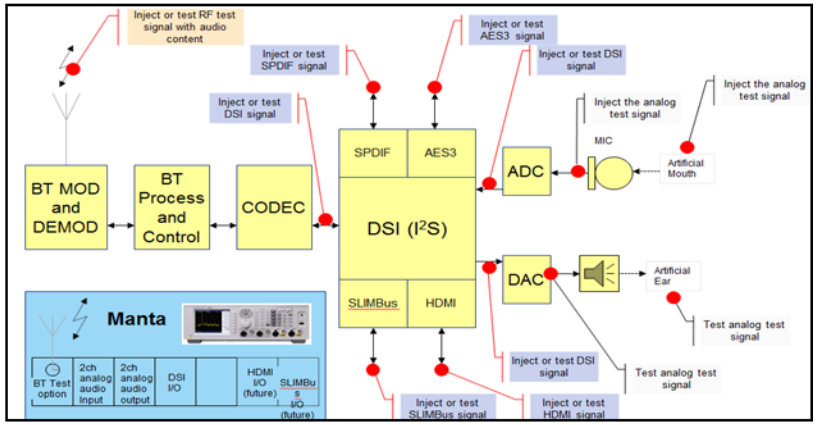
Testing mobile phone playback quality



Testing mobile phone call quality



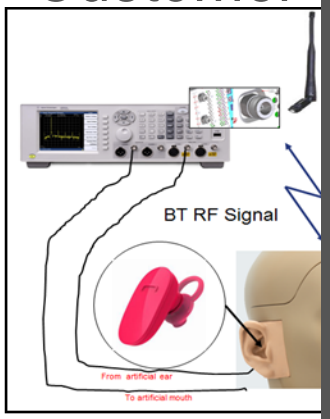
Testing mobile phone call quality with real network



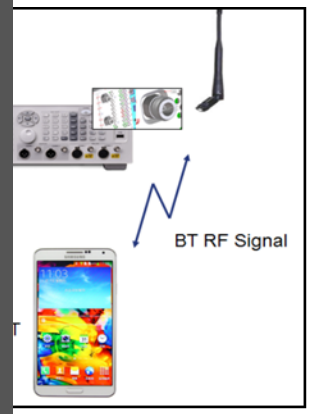
R&D testing: validation, characterization and trouble shooting

Bluetooth Audio Test with U8903B

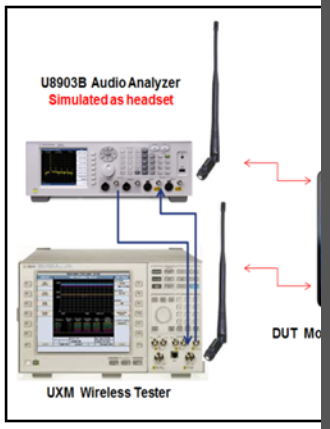
Customer



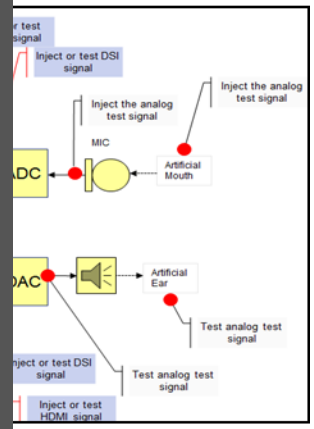
Testing headset phone call quality



ng mobile phone
layback quality



Testing mobile phone call quality



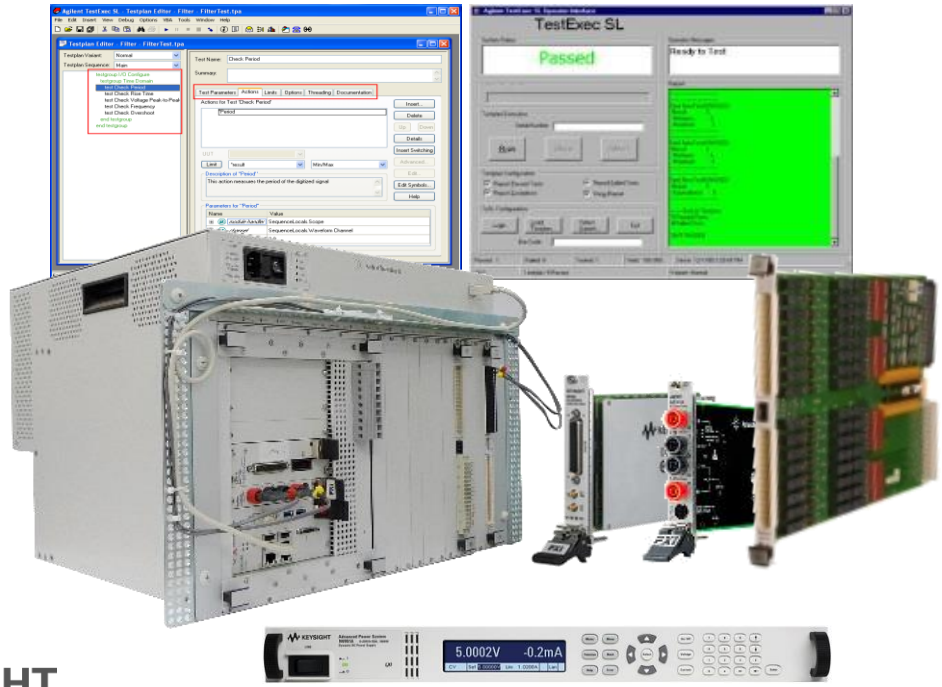
and trouble shooting

Full validation and characterization of *Bluetooth* device's audio performance

- Distortion and Noise : ≤-108dB, Typ. ≤-110dB
- Frequency Response: Flatness ±0.008dB (20kHz)
- Phase (Stereo): $\pm 2^{o}$
- Crosstalk (Stereo): ≤-130dB
- Inter-modulation: SMPTE IMD and DFD (IEC 60118/IEC 60268)
- PESQ/POLQA: ITU-T P.862.3 and P.863
- Spectrum Analysis (FFT):1.5MHz BW, 2M points
- Sweep Analysis: By frequency, amplitude and phase

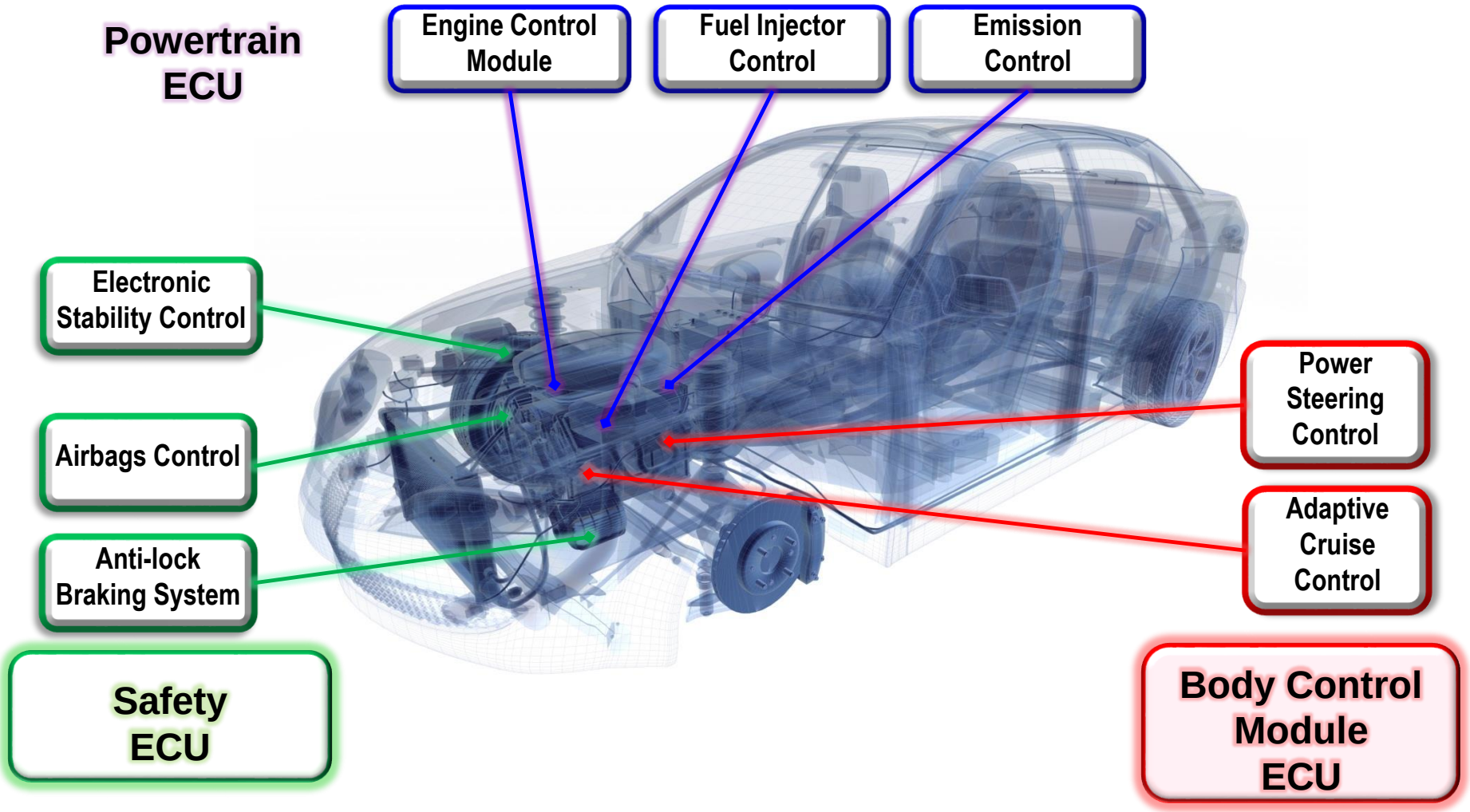
Body and Safety Reference Solution

Faster Integration, Auto-Electronics Ready Solution with Fast Test Development

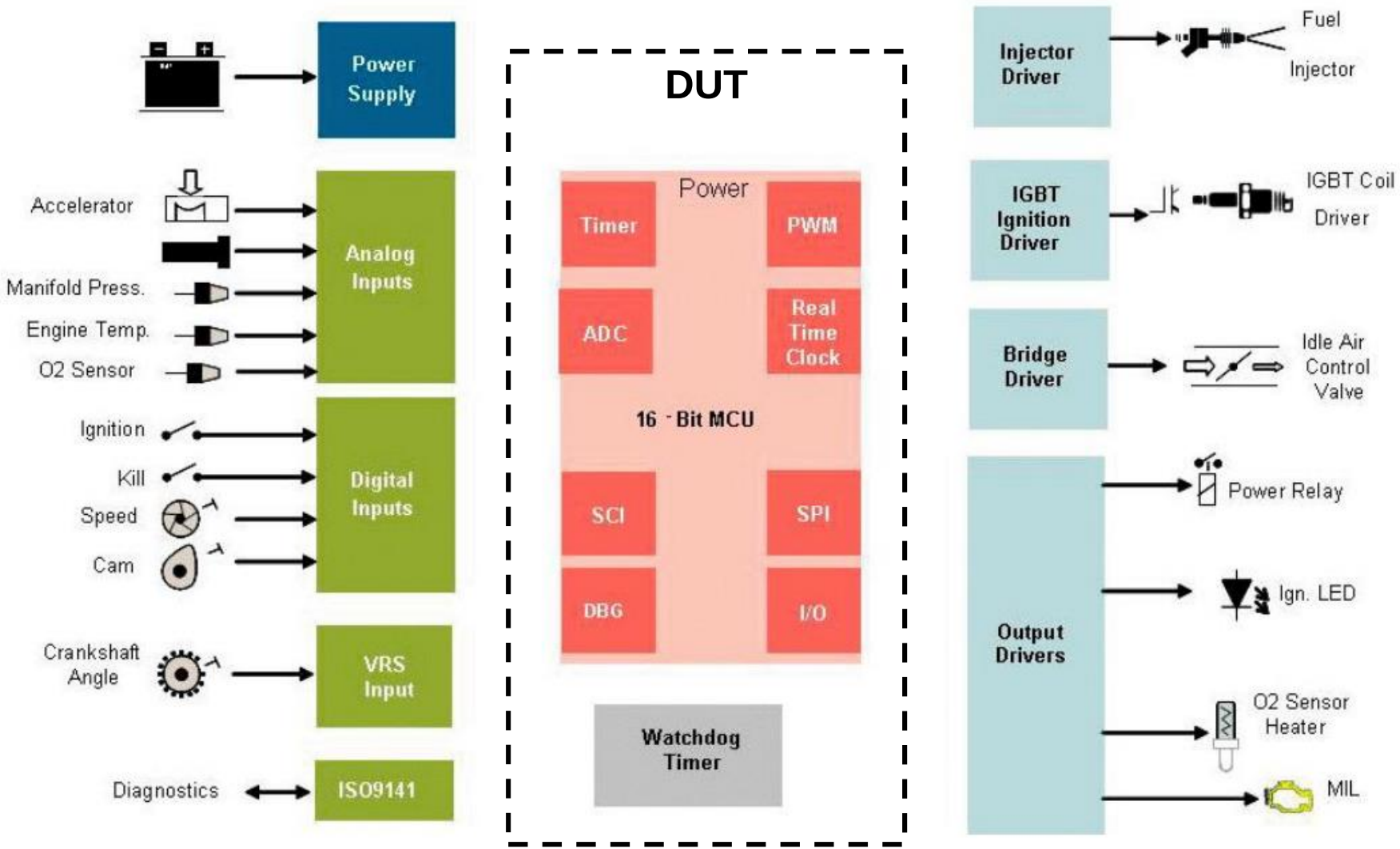


KEYSIGHT TECHNOLOGIES

Electronic Control Unit (ECU) in a Car

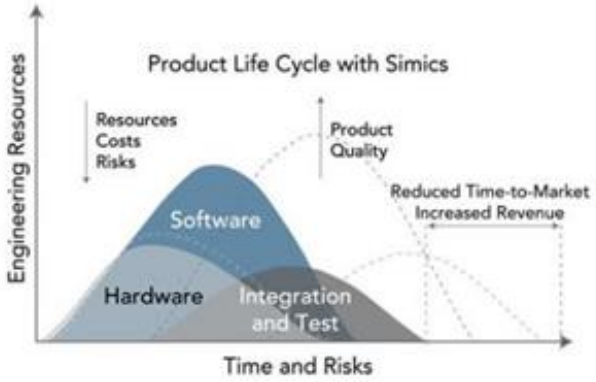


ECU, Sensors and Loads



Cost of Ownership and Challenges

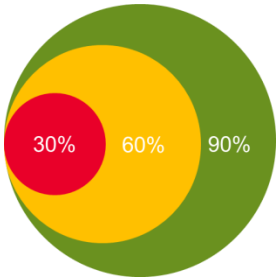
Decreasing TIME TO MARKET for your products



Focusing on your CORE BUSINESS GOALS

Building systems is **NOT** your core business goals

Optimizing Throughput and Test Coverage **IS**



TS-8989 – One BOX Solution

U8989A

Keysight PXI Instruments & Chassis

Switch Load Unit

Embedded Controller

INTEGRATED HIGH-CURRENT SWITCH WITH PXI BASED MEASUREMENT SYSTEM IN A BOX!

Setup as bench top system or integrated into a Rack & Stack system
Space optimization of up to **8U** rack space
Up to *168 test nodes (*3 x Pin Cards)
Up to **40A** current loads
Suitable for Functional test of Mechatronics applications with high Current and voltage ranges (**ideal for Automotive**)
Windows 7, Keysight IO, **TestExec SL 7.1, TS-5000 7.1**

KEYSIGHT TECHNOLOGIES

Reference for Body/Safety Control Modules

❑ **SLU E8782A + PXI M9183A**

- *Switching for all test nodes*
- ***All** Voltage/Current Measurement*
- ***All** Resistance Measurement*

❑ **Power Supply N6702A/N6951A**

- *Power Up DUT*

❑ **PXI M9186A**

- *Voltage/Current Source, Force Voltage/Current with measureable sense resistor*
- *Pin check -> open short and leakage test*

❑ **PXI M9188A**

- *Various multiple automotive sensor signal emulation – up to frequency ~50kHz*
- *Dynamic voltage/current source to emulate the corresponding change of hall effect or magnetic field sensors.*

❑ **PXI M9187A**

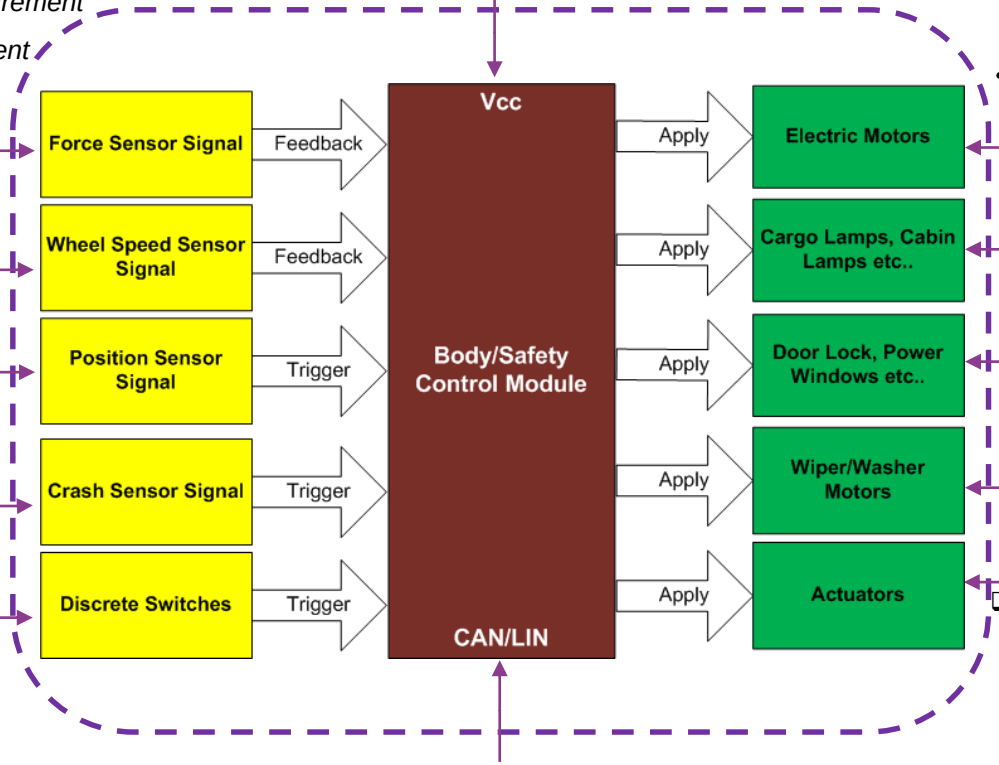
- *32 channels Digital Input / Output for automatic fixture control*

❑ **SLU U7177A**

- *Discrete Input Switches Simulation*
- *2A load card with current sense capability*

❑ **SLU E6176A,U7179A,U7178A etc**

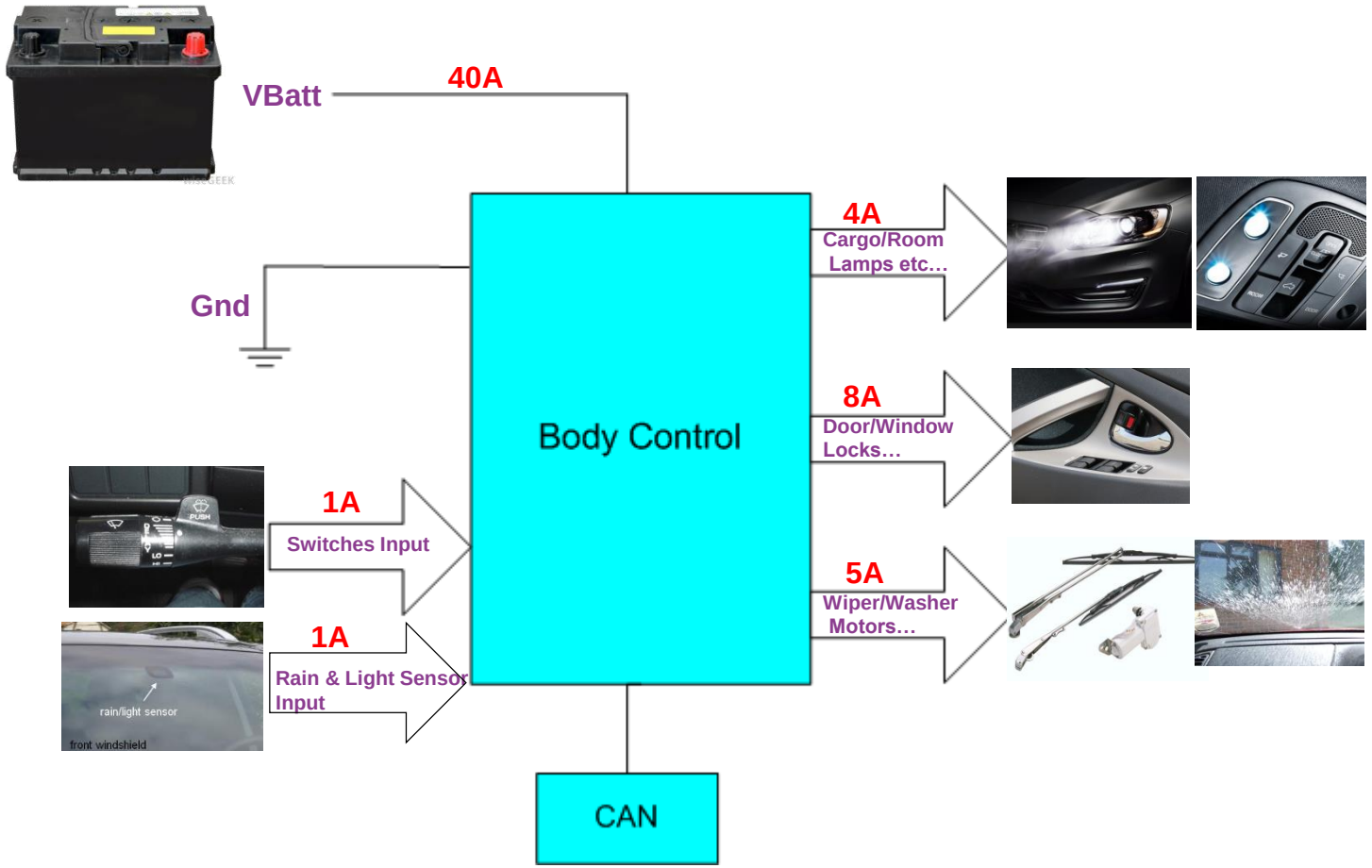
- ***Various load card for simulation of load effect (motors, lamps etc..) using resistive/inductive load***
- ***Establish Low Side, High Side or Bridge Load Driver***
- ***Current handling up to 40A with sense capability***



❑ **3rd party PXI CAN/LIN Communication Card**

- *DUT assisted communication*
- *High Speed, Low Speed or Single Wire CAN, LIN*

Customer application #1 – Body Control Module



Partnering with Keysight Systems

Faster Time-to-market, due to re-usability of systems across products and manufacturing lines

Standardized systems enable on-the-fly changeover and adaptation to capacity fluctuations

Faster and more robust system deployment, solid support and spare parts strategy

Lower total costs of ownership

Quality, Repeatability and Reproducibility

SW Framework to enforce high re-usability of test code and

Minimized/ No efforts for system confirmation and troubleshooting


Thanks!