Bluetooth 4.0 Low Energy (BLE)
Technology and RF Testing

Hagen Heggenberger
Regional Manager
Customer Solutions for Wireless Terminals

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Agenda

l **Bluetooth Low Energy Technology and Market**

l **Bluetooth Low Energy Application examples**

l **Bluetooth Low Energy RF Testing with CBT**

l **Bluetooth Low Energy RF Testing with CMW**

Bluetooth Specification Versions

June 2007

Bluetooth Core Spec 2.1 + EDR
Basic Rate: 1 Mbit/s
Enhanced Data Rate: 2 Mbit/s or 3 Mbit/s

Bluetooth RF Test Specification 2.1
(RF.TS/2.1.E.0)
13 TX test cases
10 RX test cases

April 2009

Bluetooth Core Spec 3.0 + HS
same as Core Spec 2.1 + EDR
plus
• Enhanced Power Control
• Protocol Adaptation Layer (PAL) allows handover to high speed technologies like WLAN
• Other protocol enhancements

Bluetooth RF Test Specification 4.0
(RF.TS/4.0.2)
same as RF Test Spec 2.1
plus
• TX test case for Enhanced Power Control
• There is **no** WLAN RF test case in this specification

June 2010

Bluetooth Core Spec 4.0
same as Core Spec 3.0 + HS
plus
Bluetooth Low Energy specification

Bluetooth Low Energy
RF Test Specification
(RF-PHY.TS/4.0.1)
7 TX test cases
7 RX test cases

Bluetooth Low Energy (BLE) Wireless Technology

Bluetooth SMART READY **Bluetooth** SMART

medium data rate
100 kbit/s .. 2 Mbit/s
audio,
file transfer (medium size)

low data rate
0 .. 100 kbit/s
sensors, remote control
file transfer (small size)

**Bluetooth
Basic Rate and EDR
(V2.1 / V3.0 / V4.0)**

NFC

**Bluetooth
Low Energy
(V4.0)**

Handsfree Profile
is the most important
application

A2DP is now getting
more common
(disadvantage:
signal delay)

allows automatic
connection setup
between Bluetooth
devices

Sensors for
sports and fitness,
medical applications
Remote Control

Zigbee

industrial sensors,
smart meters

Bluetooth Low Energy (BLE) Wireless Technology

l **Applications for Low Energy technology**

  l connect any coin cell powered device (e.g. watches, sensors for sports and healthcare, remote control units, …) to other Bluetooth devices (e.g. mobile phones, PDAs, PCs, …)

l **BLE RF is similar to Bluetooth basic rate, but**

  l channel spacing 2 MHz, modulation index 0.5, different packet structure, pure TX and pure RX devices are possible

l **Chipset vendors are currently developing Bluetooth LE chipsets**

  l dual mode chipsets for use in mobile phones, PCs and PDAs
  l single mode chipsets for Low Energy devices

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Bluetooth Low Energy Specifications

Core Version 4.0, Volume 6

30 June 2010

18 July 2011
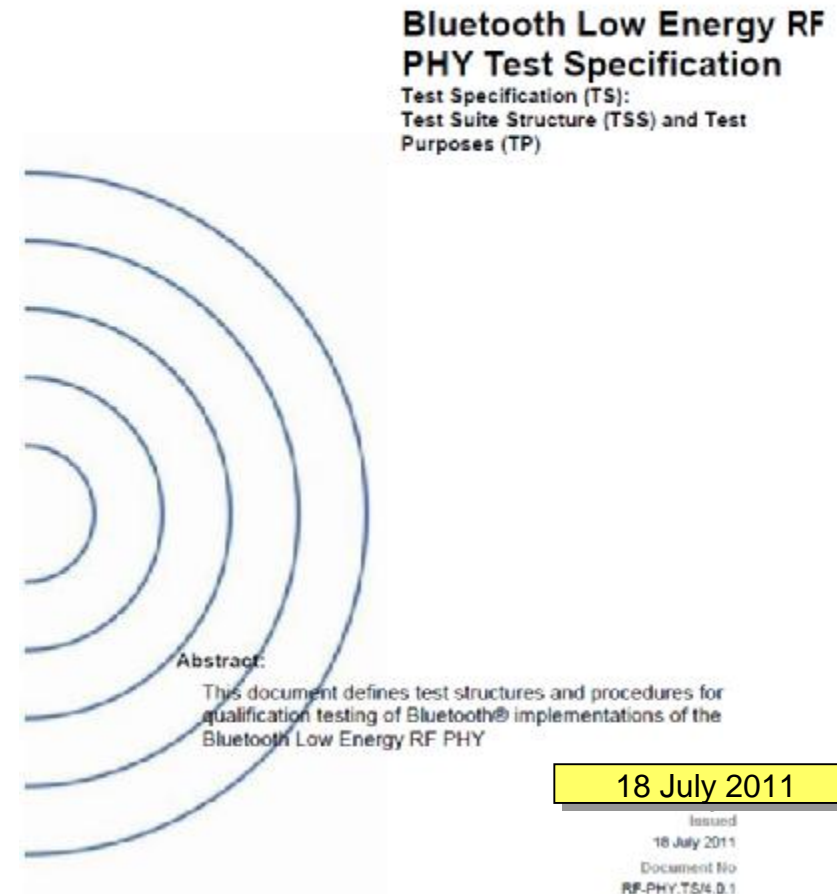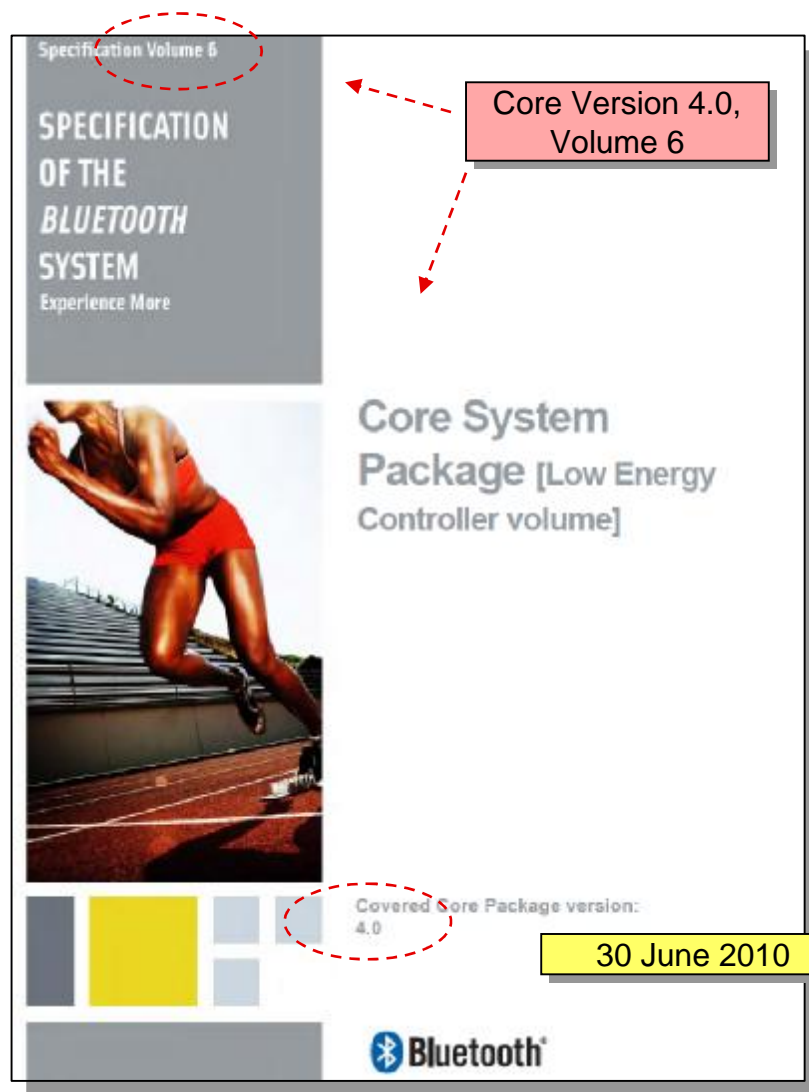
Bluetooth Low Energy RF Parameters

l   Frequency band and channel arrangement
   –   f = 2402 + k*2 MHz, k = 0, … , 39

l   TX characteristics
   –   power
      –   0.01 mW (-20 dBm) … 10 mW (+10 dBm)
   –   modulation
      –   GFSK, BT=0.5, modulation index 0.45 .. 0.55 (freq. deviation 225 kHz .. 275 kHz)
   –   frequency tolerance
      –   max. +/- 150 kHz anywhere in the packet
      –   max. drift +/- 50 kHz within the packet
      –   max. drift rate +/- 400 Hz/µs within the packet
   –   symbol rate
      –   1 mega-symbols per second (+/- 50 ppm)

l   RX sensitivity level
   –   < - 70 dBm (at 0.1% BER)

Bluetooth Low Energy
Reference Test Packet for RF Testing
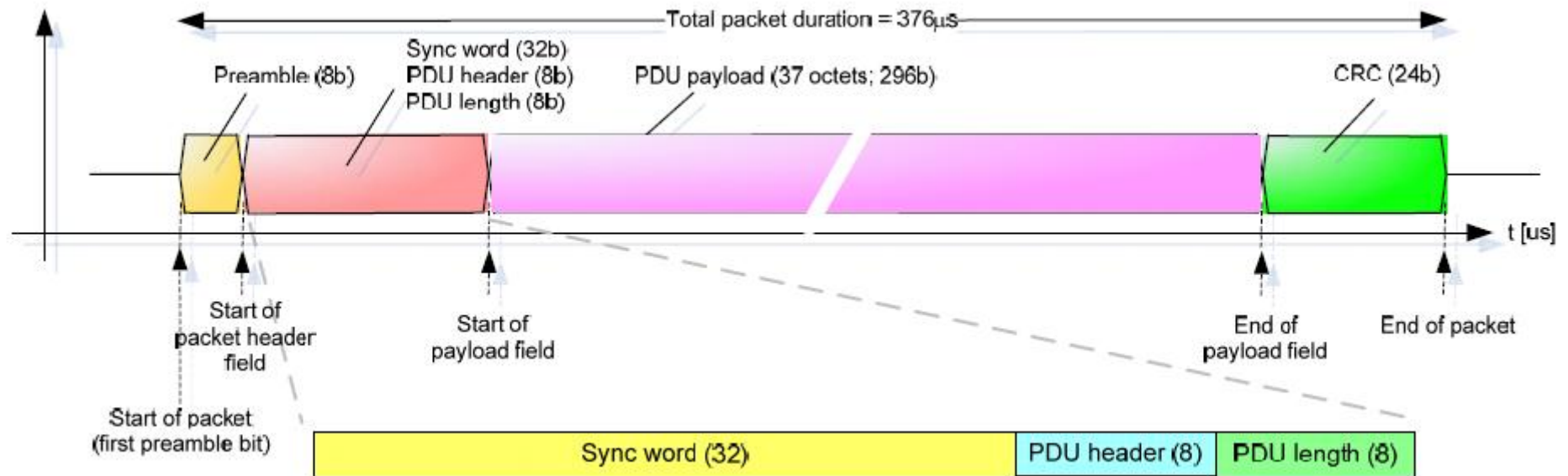
- I   RF test cases use the reference test packet with 37 octets
- I   RF test cases are performed with
  - – whitening off, frequency hopping off, maximum power

Bluetooth Low Energy- Market Update

for LE single mode devices (sensors…)

for LE dual mode devices (phones, tablets,PCs…TVs)

Bluetooth SMART

Bluetooth SMART READY

l **2011:** Bluetooth SIG unveils on October 24th, 2011 the Bluetooth Smart mark family for all Low Energy capable devices

l **2010: 3 billion Bluetooth enabled devices on the market**

l **2013: shipment of 2 billion Bluetooth enabled devices**

    l Analyst research firm IMS estimates that by 2013, 1 billion *Bluetooth* low energy devices will be sold every year

l **Most of the mobile phones will have Bluetooth integrated**

    l exception is the very low cost market segment (5%)

l **Bluetooth Low Energy market in 2012**

    l Operating System support for Low Energy (Windows 8, WindowsPhone 8, Android, iOS)

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Bluetooth Low Energy application example

Windows 8 with BT 4.0

iPhone 5, iPad, iPhone 4S, ne

Samsung Galaxy SIII

Motorola Droid RAZR

Nokia Lumia 920

Pircure Source: www.bluetooth.com

Bluetooth Low Energy application example

Bluetooth® SMART

Garmin GPS hiking watch

Nike Bluetooth Smart shoes

Stethoscopes

Porar H7 heart strap

Casio GB-6900

Glucose Monitors

Pulse Oximeters

Pircure Source: www.bluetooth.com

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Bluetooth Low Energy application example

Bluetooth®
SMART

Temperature sensor with Bluetooth LE chip

AMC Navigenio. Your autopilot in the kitchen.

The AMC Navigenio is a miracle of modern kitchen technology and the crown jewel in the AMC Premium System. The exclusive high-tech hotplate with integral radio module controls the whole cooking process in radio contact with the Audiotherm fully automatically!

A universal genius in every household.
Fully automatic cooking in radio contact with the Audiotherm and fully automatic rapid cooking with the Navigenio and Secuquick: It doesn't get any faster or more convenient.

The most energy-saving oven in the world
From toast to hold chickens, from pizzas to cakes: upside-down on top of the unit, baking, browning and crispy frying.

The mobile hotplate for kitchen and leisure
For fondues, raclettes, hot drinks, as a table grill and hotplates are keeping things warm. An enrichment for any party and celebration!
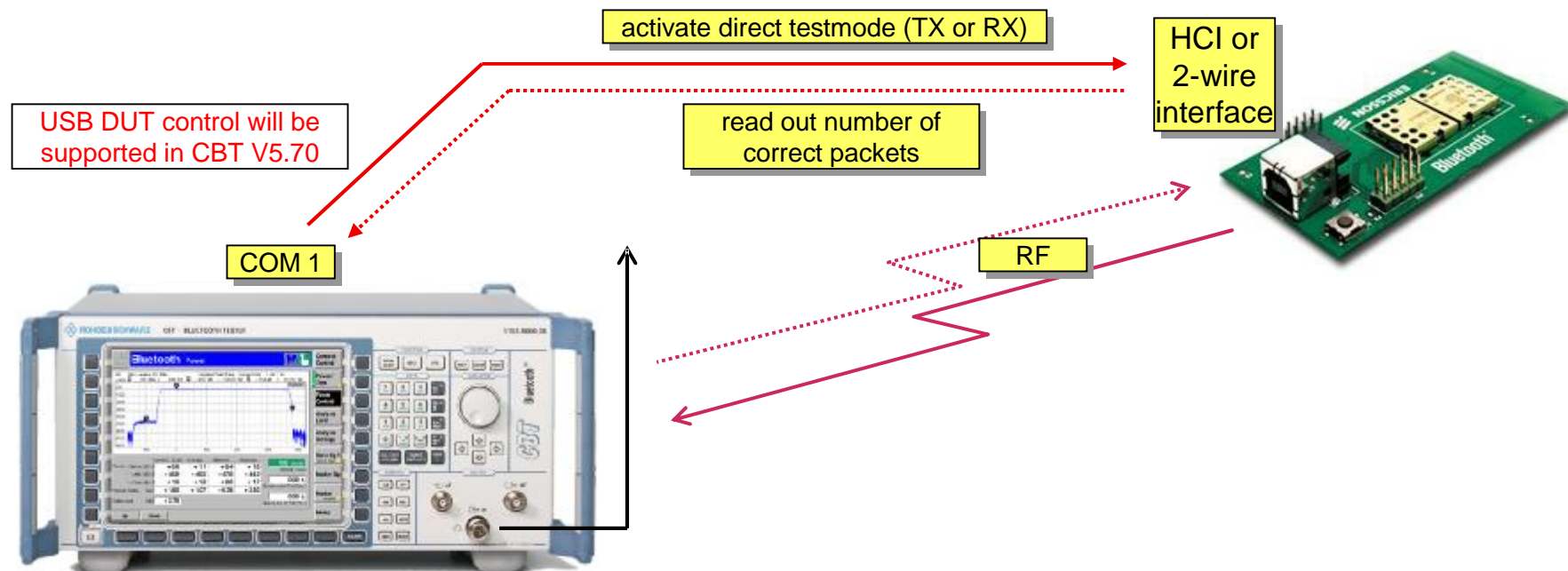
Bluetooth-controlled hotplate

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RF testing of Low Energy devices

l   All tests are performed without setting up an RF connection

l   Local serial DUT interface (‚HCI' or ‚2-wire') allows to

–   switch the DUT into a direct testmode (TX or RX)

–   read out the number of correctly received packets (without CRC error)

activate direct testmode (TX or RX)

HCI or 2-wire interface

USB DUT control will be supported in CBT V5.70

read out number of correct packets

COM 1

RF

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Low Energy RF Test Cases

I   The Bluetooth Low Energy RF PHY Test Specification (RF-PHY.TS/4.0.0) contains the following test purposes:

parametric tests with CBT and LE option CBT-K57

All test cases supported by CBTGo V2.2.0

these tests require additional signal generator(s)

– Transmitter tests
  – TRM/CA-01-C (Output power at NOC)
  – TRM/CA-02-C (Output power at EOC)
  – TRM/CA-03-C (In-band emissions at NOC)
  – TRM/CA-04-C (In-band emissions at EOC)
  – TRM/CA-05-C (Modulation characteristics)
  – TRM/CA-06-C (Carrier frequency offset and drift at NOC)
  – TRM/CA-07-C (Carrier frequency offset and drift at EOC)
– Receiver tests
  – RCV/CA-01-C (Receiver sensitivity at NOC)
  – RCV/CA-02-C (Receiver sensitivity at EOC)
  – RCV/CA-03-C (C/I and receiver selectivity performance)
  – RCV/CA-04-C (Blocking performance)
  – RCV/CA-05-C (Intermodulation performance)
  – RCV/CA-06-C (Maximum input signal level)
  – RCV/CA-07-C (PER Report Integrity)

NOC: normal operating conditions
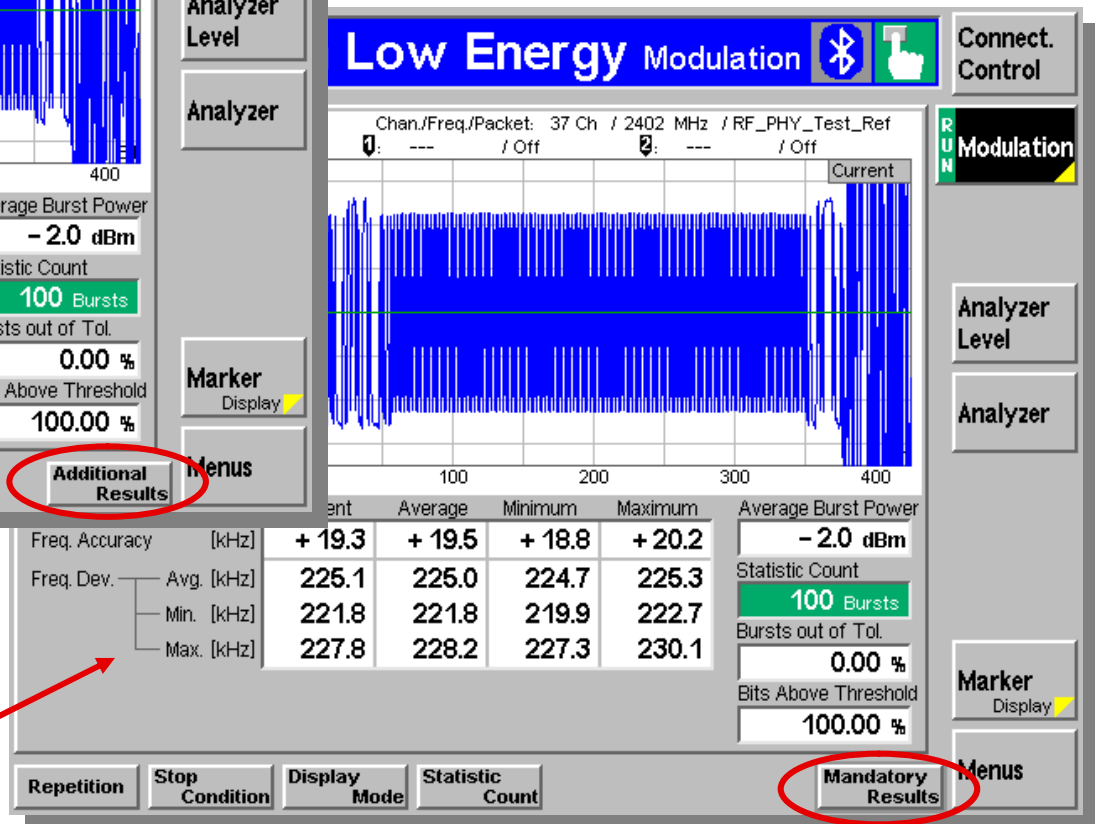EOC: extreme operating conditions

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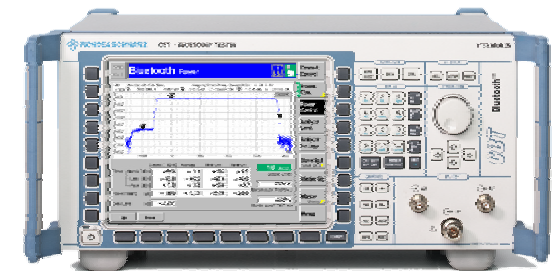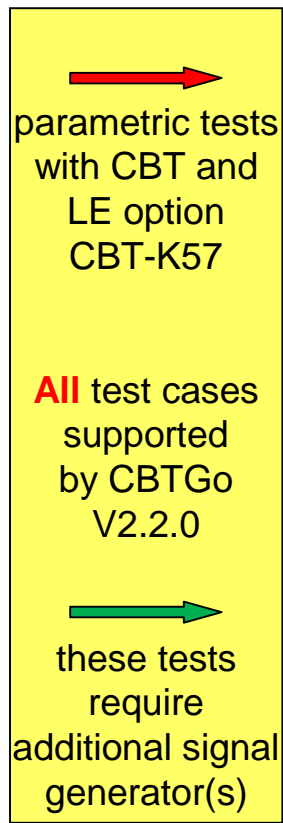
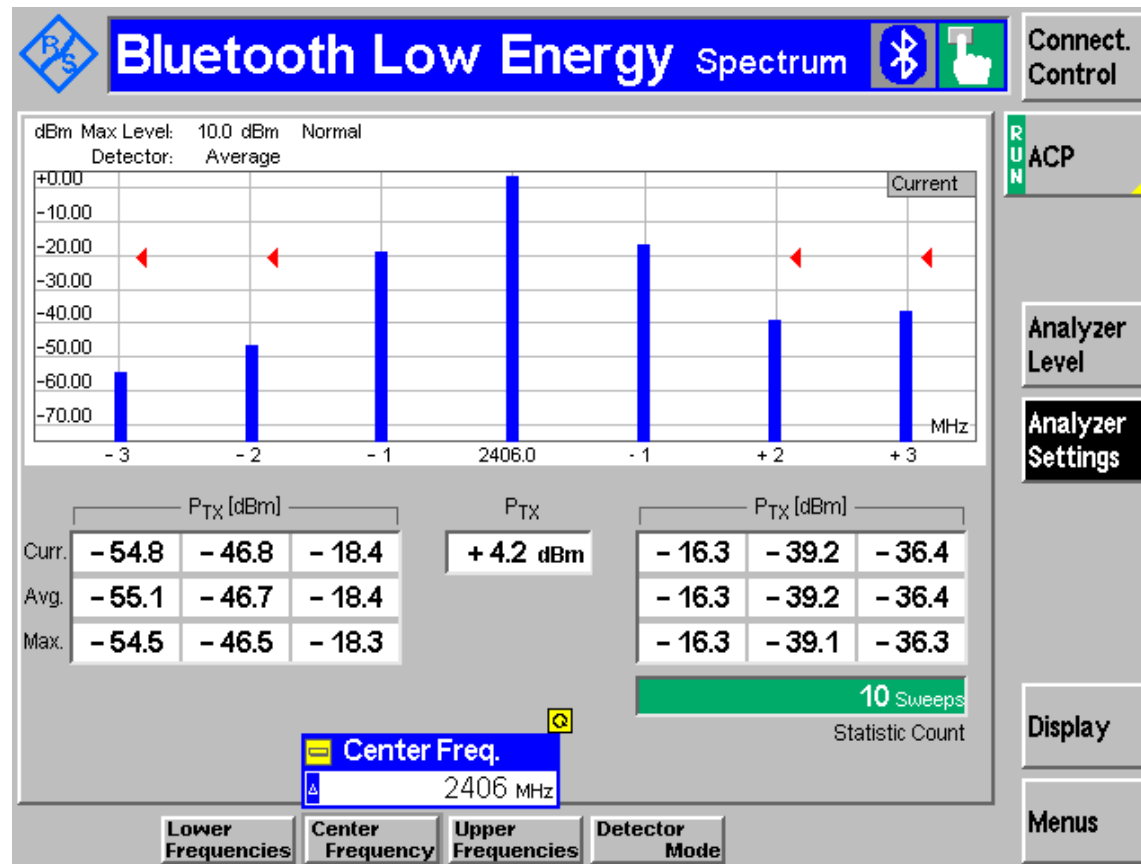# CBT Low Energy Modulation Analyzer
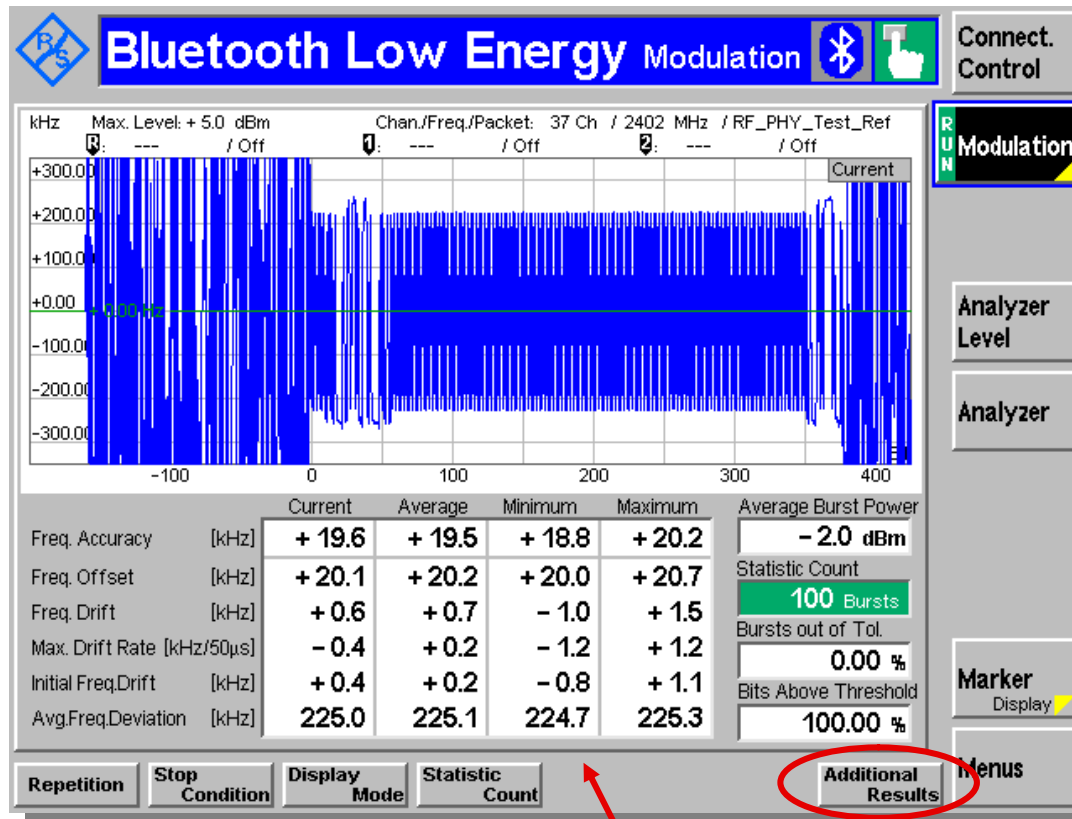
Screen with all mandatory results for frequency and modulation according to the RF test specification

Screen with additional results for minimum and maximum frequency deviation

# CBT Low Energy Spectrum Measurement
## In-band emissions

CBT Low Energy Receiver Quality Tests

l   **DUT direct test mode control from CBT**

- DUT is connected with CBT COM port (USB support planned for Q1/2013)
- CBT enables DUT for RX test
- CBT transmits a defined number of LE packets to the DUT
- DUT checks the CRC of every packet and counts the number of correctly received packets
- DUT reports the number of correct packets back to the CBT
- CBT calculates and displays the PER result
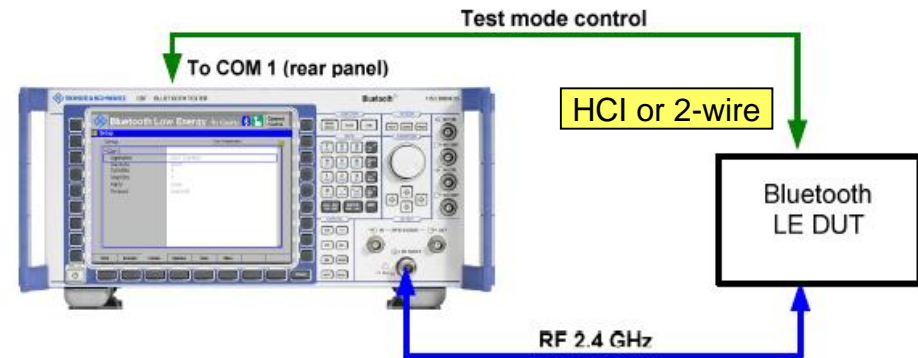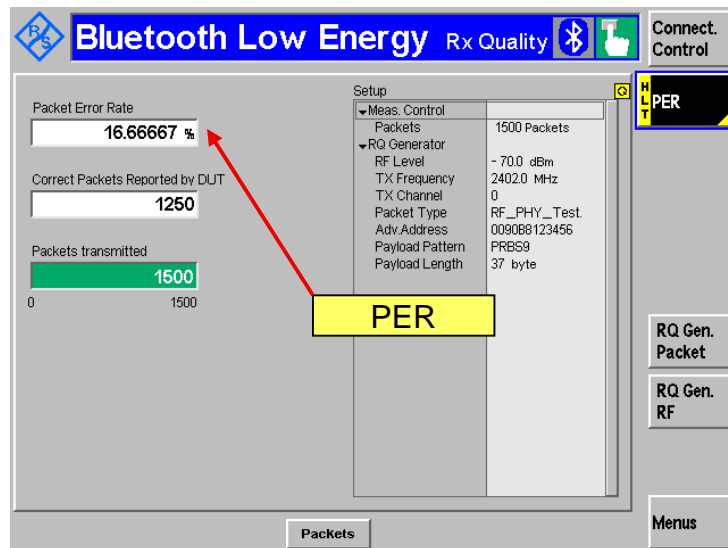
CBT Low Energy Receiver Quality Tests

l **DUT direct test mode control from external PC**
  – DUT is connected with PC
  – PC enables DUT for PER test and starts CBT generator
  – CBT now transmits a defined number of LE packets to the DUT
  – DUT checks the CRC of every received packet and counts the number of correct packets
  – DUT reports the number of correct packets back to the PC
  – PC calculates and displays the PER result
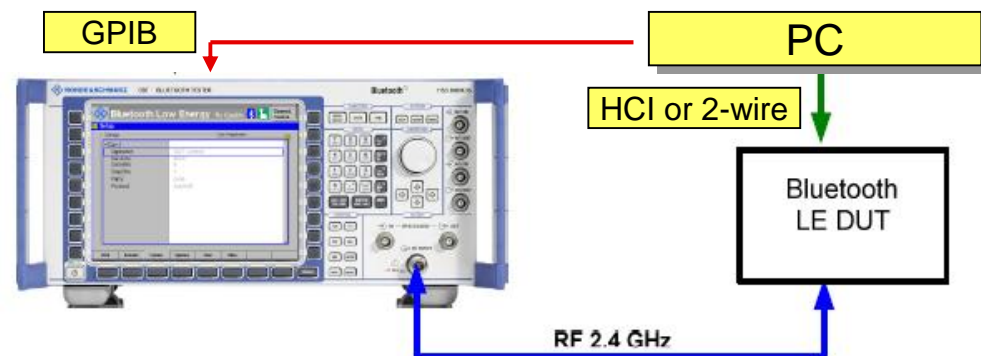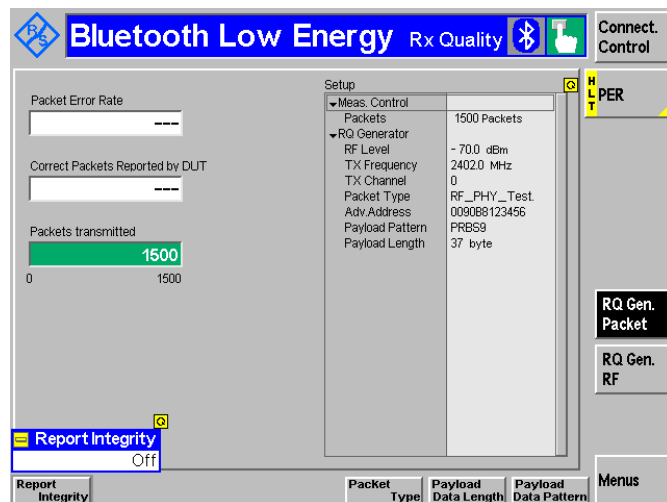
CBT LE Generator - Dirty Transmitter

Change of parameter set every 50 packets
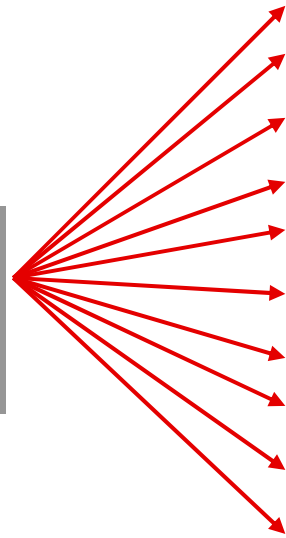
Test run	Carrier frequency offset	Modulation index	Symbol timing error
1	100 kHz	0.45	- 50 ppm
2	19 kHz	0.48	- 50 ppm
3	- 3 kHz	0.46	+ 50 ppm
4	1 kHz	0.52	+ 50 ppm
5	52 kHz	0.53	+ 50 ppm
6	0 kHz	0.54	- 50 ppm
7	- 56 kHz	0.47	- 50 ppm
8	97 kHz	0.5	- 50 ppm
9	- 25 kHz	0.45	- 50 ppm
10	- 100 kHz	0.55	+ 50 ppm

Additional superposition of a frequency drift:
- Deviation +/- 50 kHz
- Modulation frequency 625 Hz
- Alternate packets switch start phase between 0 and 180 degrees

CBT-K57 – Low Energy Option
Feature Set, Roadmap

l **CBT firmware V5.61** *(available)*
  – LE TX measurements:
    – DUT control via COM port for TX tests
    – power, modulation, frequency
    – in-band emissions (ACP) spectrum measurement
  – RX quality measurement displays PER result read out from DUT
    – DUT control via COM port for RX tests
    – dirty TX: 'Single Value' mode
    – dirty TX: 'Specification Table' mode (dynamic)
    – PER integrity check
    – Pseudo continuous mode for BLE PER tests
  – BLE generator:
    – continuous stream of packets
      dirty TX: single value mode

l **CBT firmware V5.70** *(Q1/2013)*
  – USB support for direct test mode control

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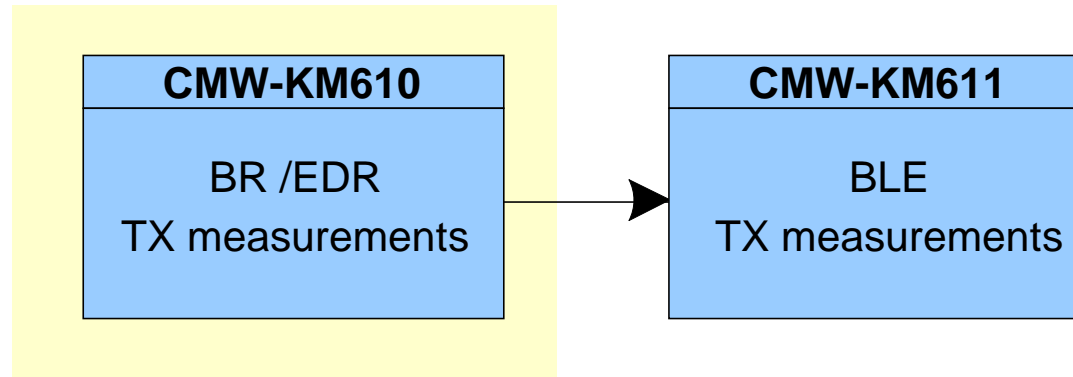# Agenda

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Bluetooth, BR/EDR TX Measurements

CMW-KM610		CMW-KM611
BR /EDR TX measurements	→	BLE TX measurements

I   Auto detection of input signal

I   Full set of TX measurements

– Basic rate:
  – Nominal power
  – Frequency accuracy, frequency drift and max. drift rate
  – Frequency deviation
  – Spectrum - 20 dB bandwidth
  – Spectrum - adjacent channel power (79 channels)

– Enhanced data rate
  – Nominal power (GFSK, DPSK)
  – Frequency stability ω_i and $\omega_{0\,max}$ (drift)
  – Differential error vector magnitude
  – I/Q constellation diagram
  – Phase difference graph
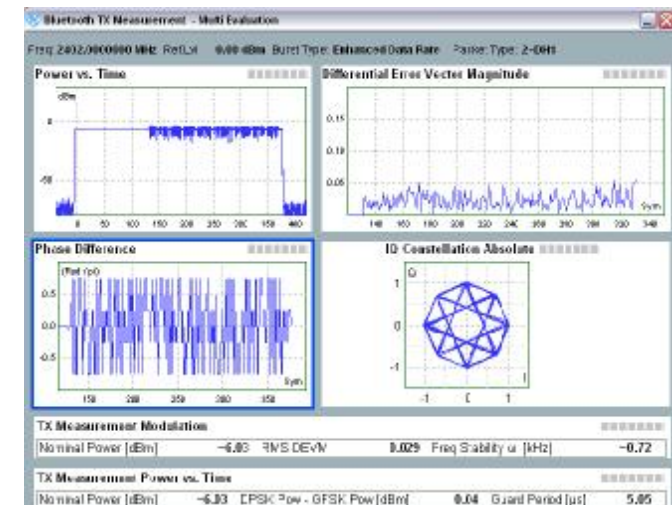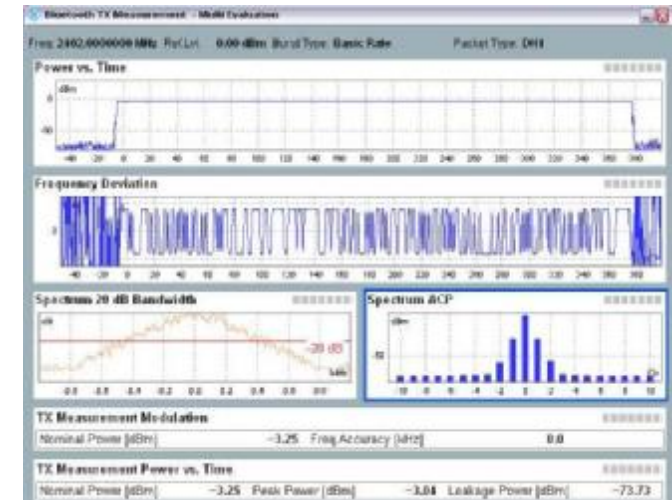
Bluetooth BLE TX Measurements

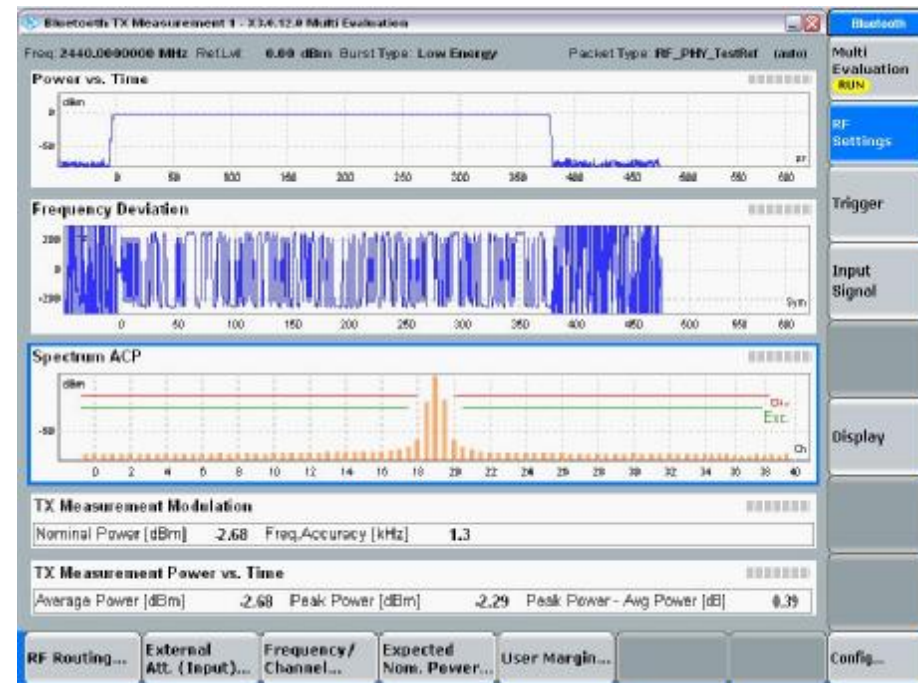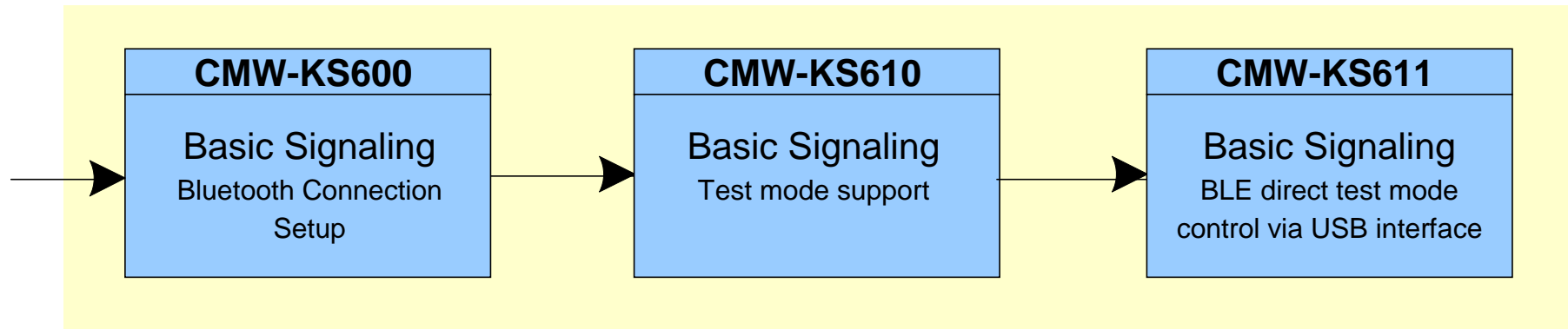| CMW-KM610	CMW-KM611
BR /EDR TX measurements	BLE TX measurements
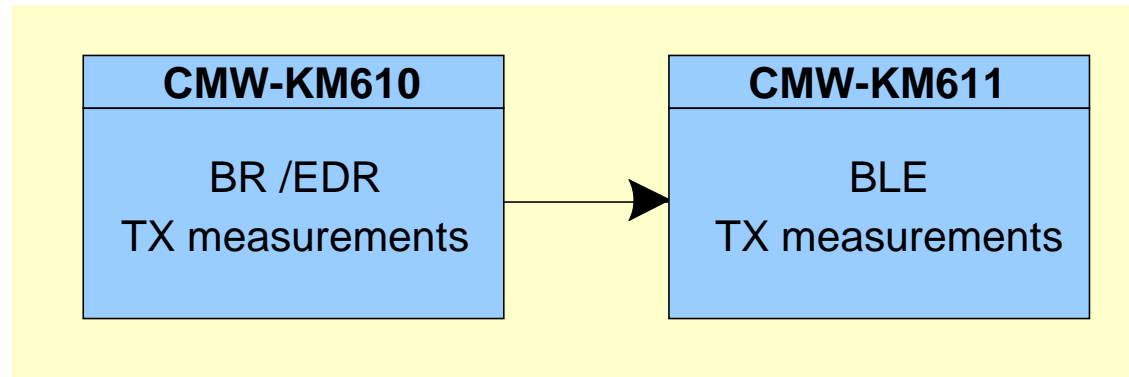
I **Full set of TX measurements**
  – Power (average, peak, difference)
  – Frequency accuracy
  – Frequency drift (max., initial)
  – Drift rate (max)
  – Frequency deviation
  – Spectrum - adjacent channel power (in-band-spurious emissions)

Bluetooth Low Energy Signaling for CMW

CMW-KS600	CMW-KS610	CMW-KS611
Basic Signaling Bluetooth Connection Setup	Basic Signaling Test mode support	Basic Signaling BLE direct test mode control via USB interface

I **CMW Bluetooth Low Energy direct Test Mode Support planed for 2013**

I **Please contact you local Sales Office**

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