Bluetooth SIG

Bluetooth SIG

The Bluetooth Special Interest Group (SIG) is a group of company working together to promote and define the Bluetooth Specification. The Bluetooth SIG was founded in February 1998 by the following group of core promoters:

Ericsson
Intel
IBM
Toshiba
Nokia
Microsoft
Lucent
3Com
Motorola

- Web Site: http://www.bluetooth.org/specification.htm

Bluetooth

v1.2 + BDR
(Basic data Rate)

v2.1 + EDR
(Basic data Rate)

V4.0 + BLE
(Bluetooth Low energy)

v2.0 + EDR
(Enhanced Data Rate)

v3.0 + HS
(High Speed)

V5.0
(2x speed,
4x range
800% broadcast)

Rev	Date	Comments
5.0	Dec 06 2016	• New features added in 5.0: - CSA 5 features (Higher Output Power) - Slot Availability Mask (SAM) - 2 Msym/s PHY for LE - LE Long Range - High Duty Cycle Non-Connectable Advertising - LE Advertising Extensions - LE Channel Selection Algorithm #2 • Park State was deprecated and removed • Errata for v2.0 + EDR, v2.1 + EDR, v3.0 + HS + 4.0 + 4.1 + 4.2 (ESR09, ESR10 and ESR11). See also [Vol 1] Part C, Section 9.4.

Bluetooth Radio Specification

Technical Specification	Classic Bluetooth	Bluetooth Low Energy
Frequency	2400 to 2483.5 MHz	2400 to 2483.5 MHz
Modulation Technique	Frequency Hopping	Frequency Hopping
Modulation Scheme	GFSK	GFSK
Modulation Index	0.35	0.5
Number of Channels	79	40
Channel Bandwidth	1 MHz	2 MHz
Nominal Data Rate	1 - 3 Mbps	1 Mbps
Application Throughput	0.7 - 2.1 Mbps	< 0.3 Mbps
Nodes / Active Slaves	7	Unlimited
Security	56 to 128 bit	128-bit AES
Robustness	FHSS	FHSS
Voice	Capable	Not capable

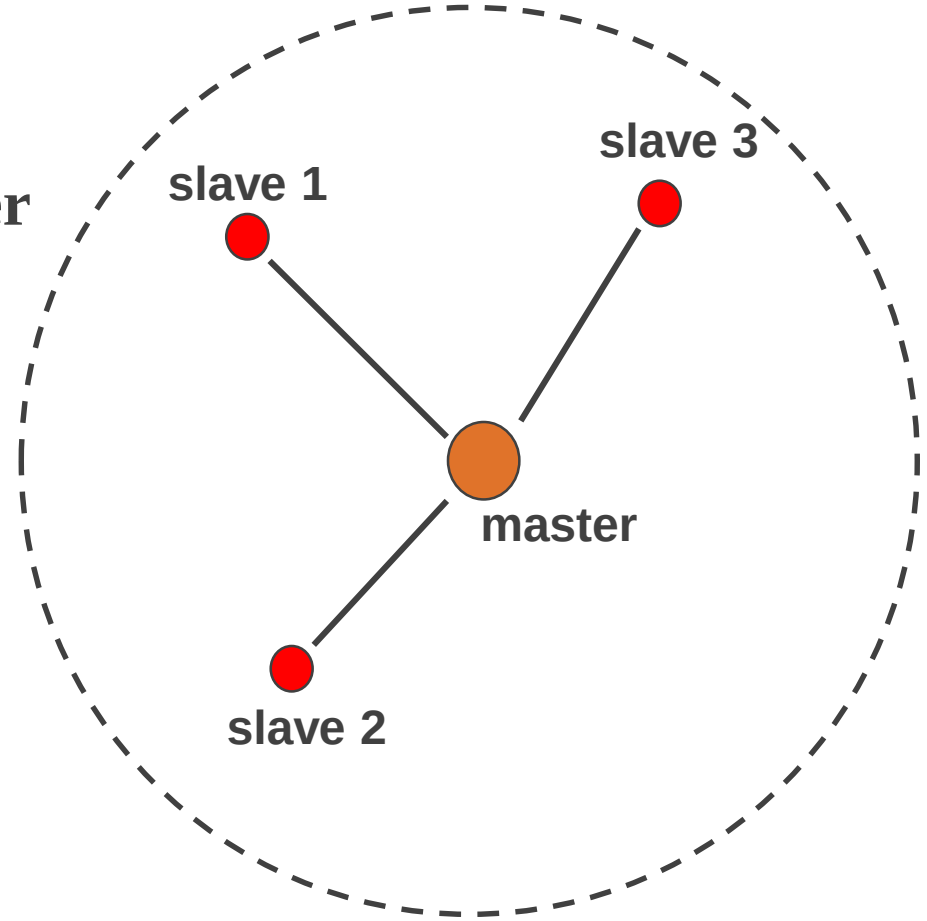
Topology


N.Y.C.TAXI
TAXI FARE
WiMAX
LTE
MIMO
WiFi
Zigbee
Bluetooth
4G
WAVE
FM

Piconet

Consists of

- One (and only one) master
- More than one slave(s)



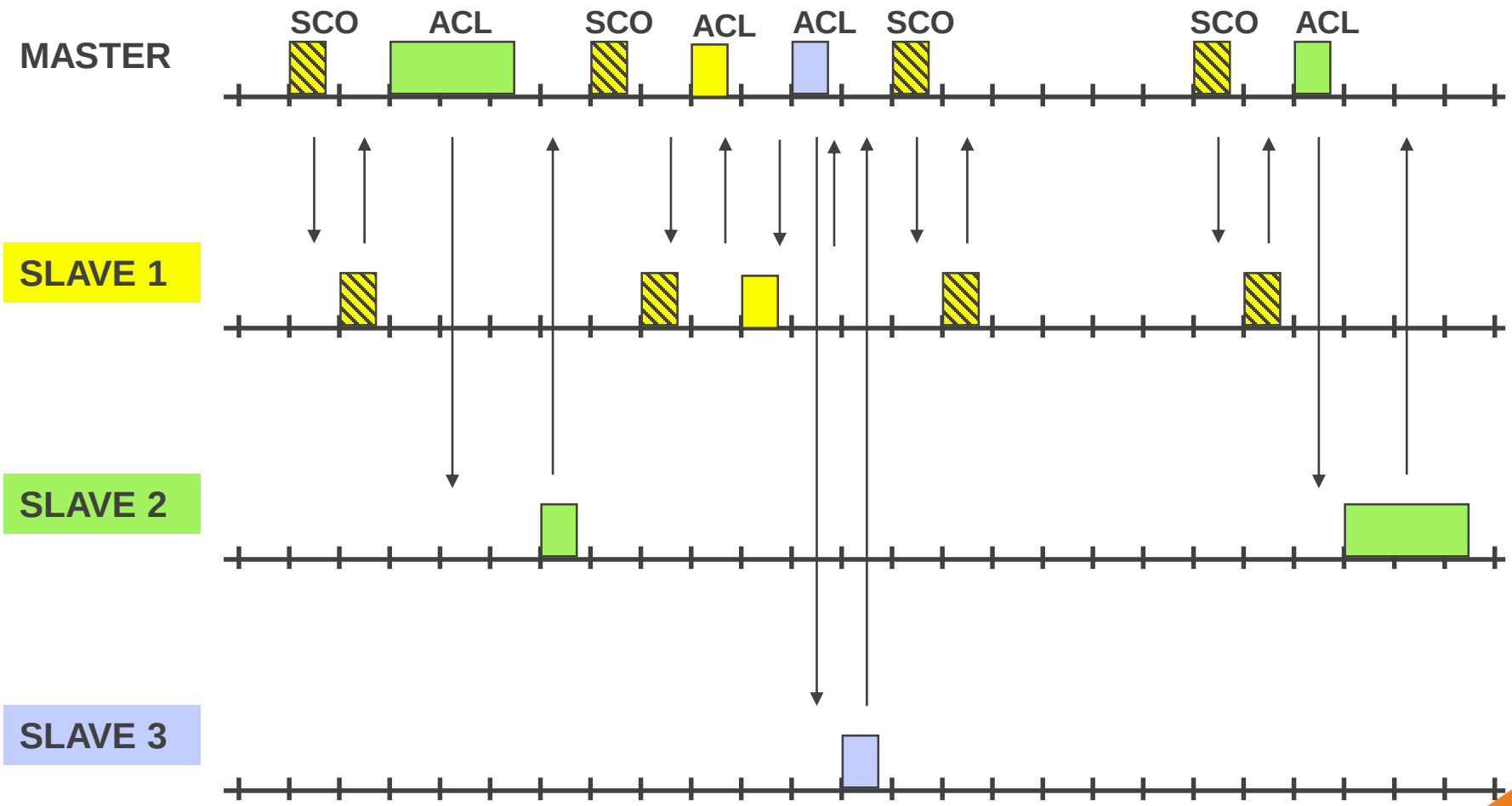
Master: the device which initiates data exchange.

Slave: the device which responds to the Master.

Physical Link Definition

- Synchronous Connection-Oriented (**SCO**) Link
  - circuit switching
  - symmetric, synchronous services
  - slot reservation at fixed intervals
- Asynchronous Connection-Less (**ACL**) Link
  - packet switching
  - (a)symmetric, asynchronous services
  - polling access scheme

Mixed Link Example



Packet Format

Bluetooth Packet Structure

- Modulation
  - 2402 to 2480MHz, 79 channel.
  - GFSK modulation techniques
  - DPSK added for EDR
- Packet format

Packet Type	Description
NULL, POLL, FHS	System packets
DM1, DM3, DM5	Medium rate
DH1, DH3, DH5	High rate
HV1, HV3, HV5	Digitized audio
DV	Mixed data/voice
AUX1	Other uses

Figure 1. Basic Rate packet format. The number of bits per entity is indicated.

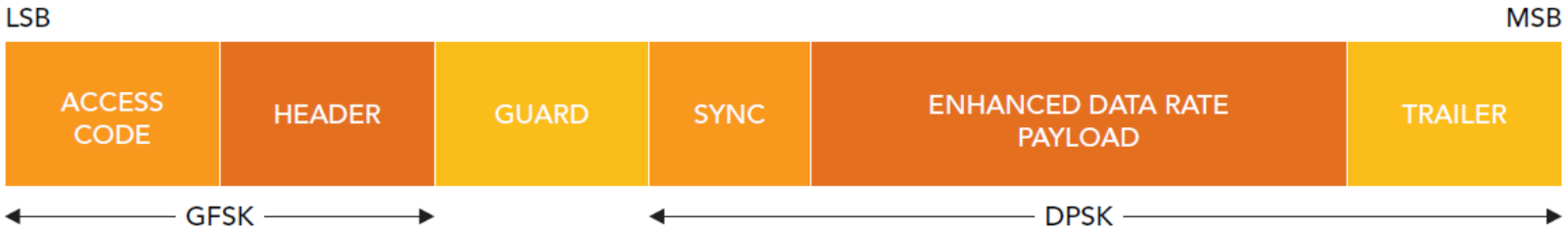
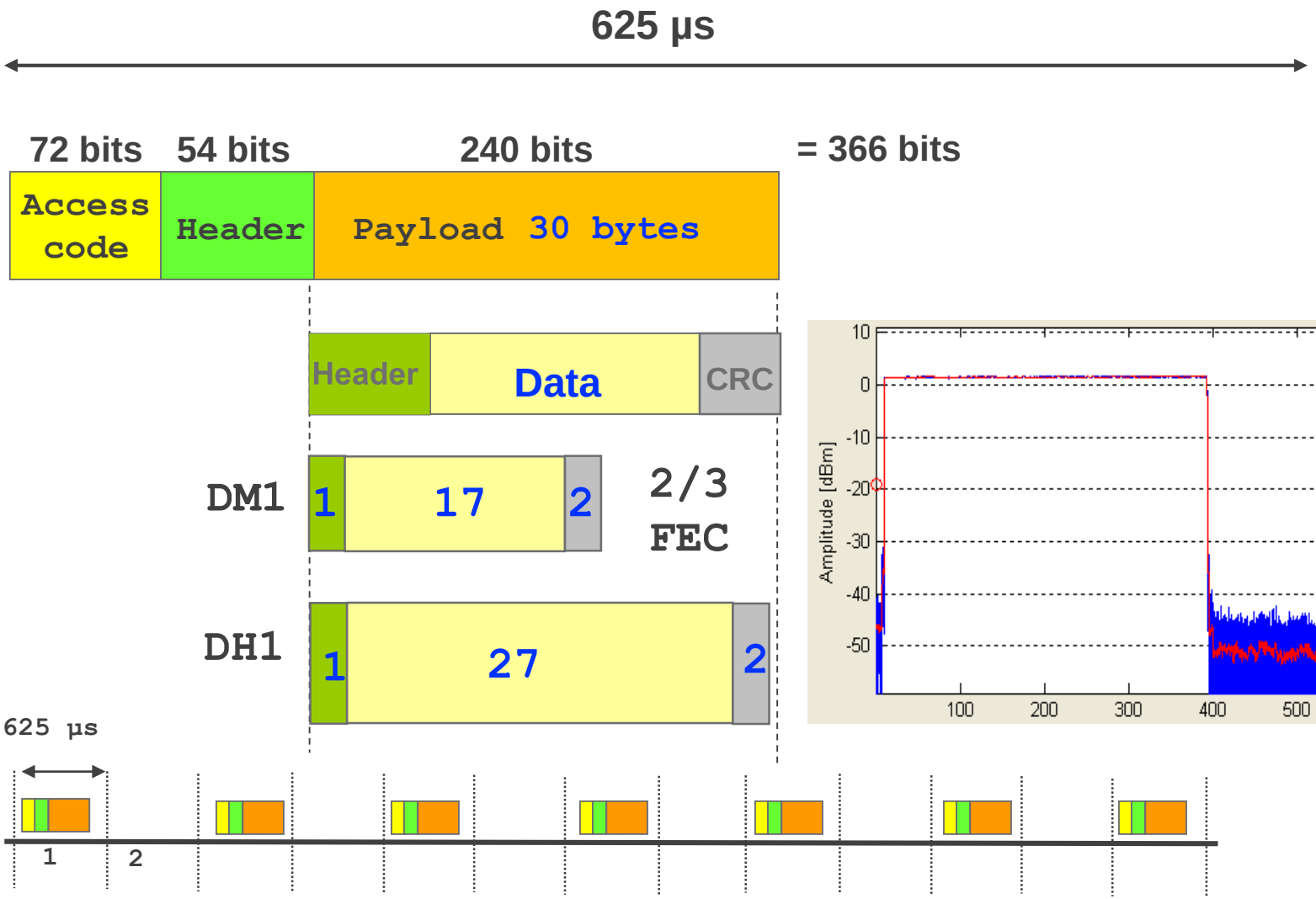
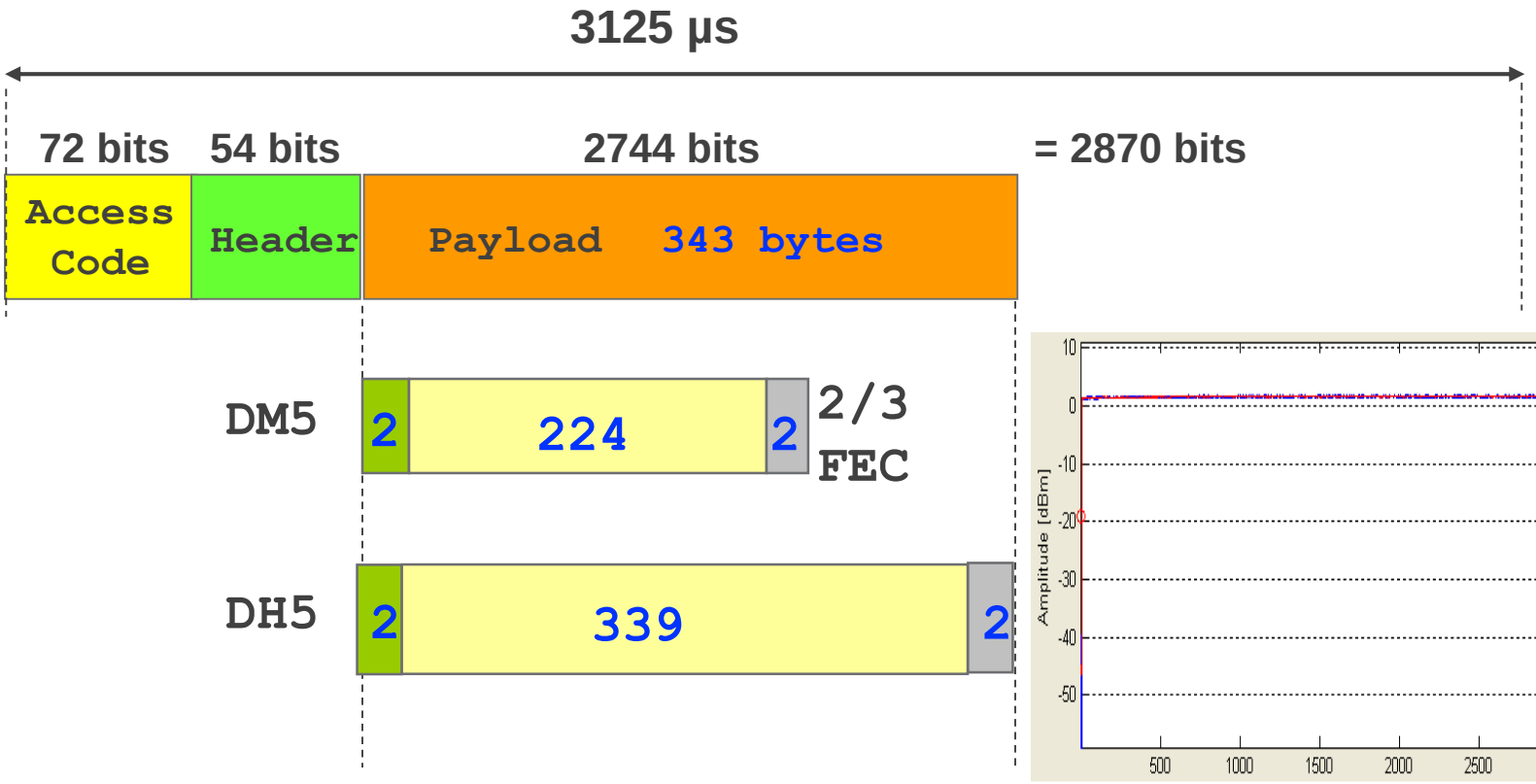


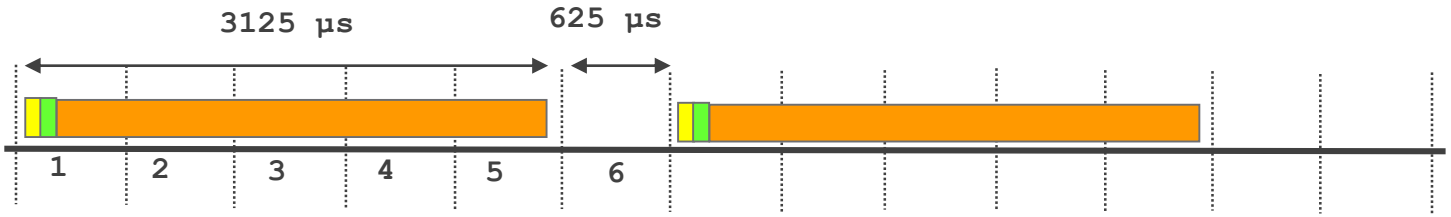
Figure 2. EDR packet format.

DM1/DH1



DM5/DH5





LE Packet Structure

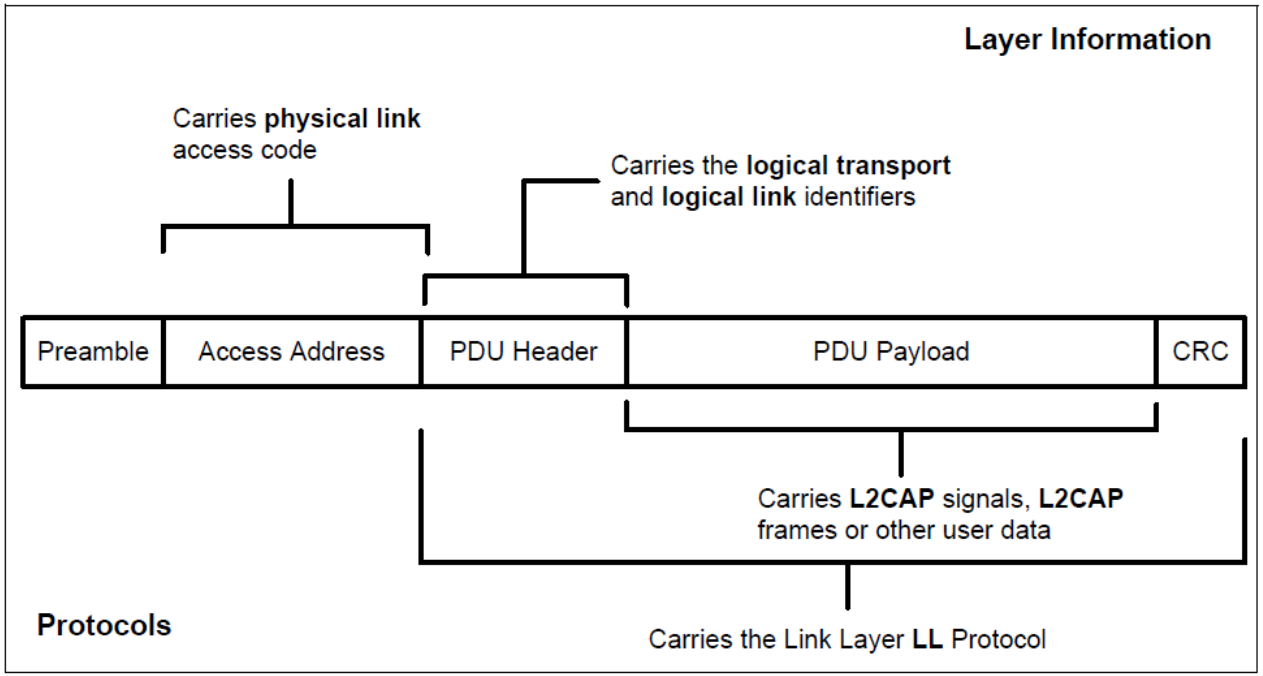


Figure 3.5: LE packet structure

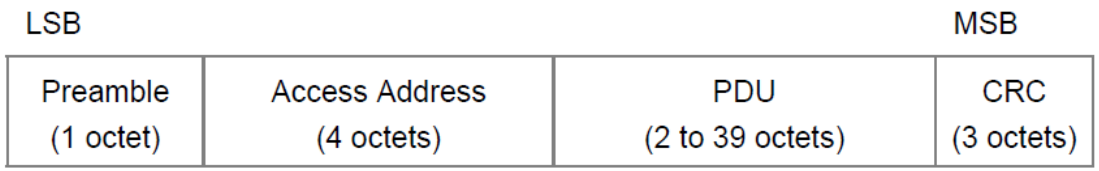


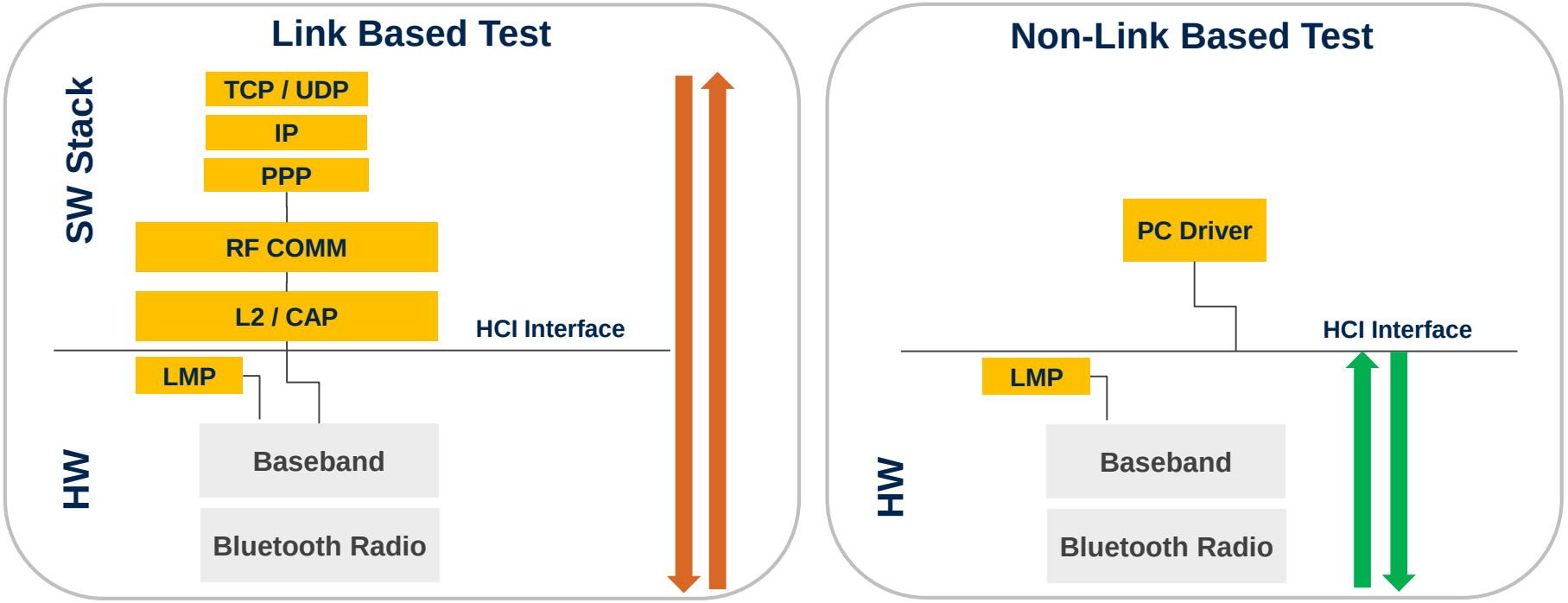
Figure 2.1: Link Layer packet format

RF Test


N.Y.C.TAXI
TAXI FARE
WiMAX
LTE
MIMO
WiFi
Zigbee
Bluetooth
4G
WAVE
FM

Link v.s. Non-link Mode Test

- Traditionally, Bluetooth SIG has given manufacturers the option to test with **either Link or Non-Link mode**
- Non-link testing is faster: it tests the hardware – not the software
  - For this reason, LitePoint has always advocated to use Non-Link mode



HCI: Host Control Interface

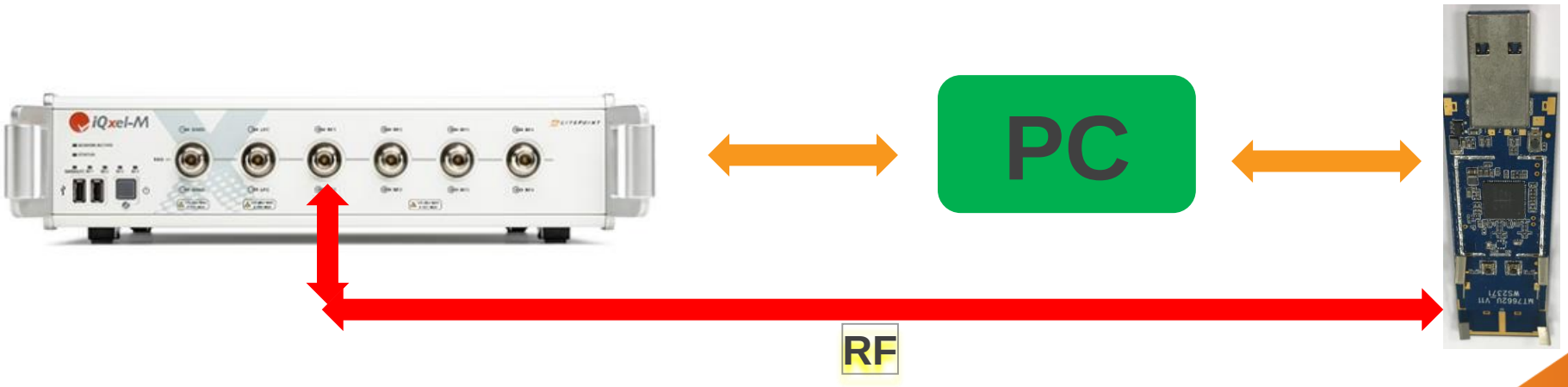
LMP: Link Manager Protocol

L2 / CAP: Logical Link Control and Adaptation Layer Protocol

RF COMM: Serial Port Emulation

RF testing – NonLink Test

- All tests are performed without setting up an RF connection.
- Controller(PC) control DUT into test condition.
- Controller(PC) control Tester to capture DUT's signal to analyze it(TX) or transmit BT packets to DUT(RX).



RF test Cases (BDR + EDR)

- Transmitter tests
  - TRM/CA/01/C (Output Power)
  - TRM/CA/02/C (Power Density)
  - TRM/CA/03/C (Power Control)
  - TRM/CA/04/C (TX Output Spectrum – Frequency range)
  - TRM/CA/05/C (TX Output Spectrum – 20dB Bandwidth)
  - TRM/CA/06/C (TX Output Spectrum – Adjacent channel power)
  - TRM/CA/07/C (Modulation Characteristics)
  - TRM/CA/08/C (Initial Carrier Frequency Tolerance)
  - TRM/CA/09/C (Carrier Frequency Drift)
  - TRM/CA/10/C (EDR Relative Transmit Power)
  - TRM/CA/11/C (EDR Carrier Frequency Stability and Modulation Accuracy)
  - TRM/CA/12/C (EDR Differential Phase Encoding)
  - TRM/CA/13/C (EDR In-band Spurious Emissions)
  - TRM/CA/14/C (Enhanced power control)
- Receiver tests
  - RCV/CA/01/C (Sensitivity - single slot packets)
  - RCV/CA/02/C (Sensitivity – multi-slot packets)
  - RCV/CA/03/C (C/I performance) ➡
  - RCV/CA/04/C (Blocking performance) ➡
  - RCV/CA/05/C (Intermodulation Performance) ➡
  - RCV/CA/06/C (Maximum Input Level)
  - RCV/CA/07/C (EDR Sensitivity)
  - RCV/CA/08/C (EDR BER Floor Performance)
  - RCV/CA/09/C (EDR C/I Performance) ➡
  - RCV/CA/10/C (EDR Maximum Input Level)

- All test cases supported by IQxel.
- Red arrow (➡) test items require two signal generators.

RF test Cases (BLE)

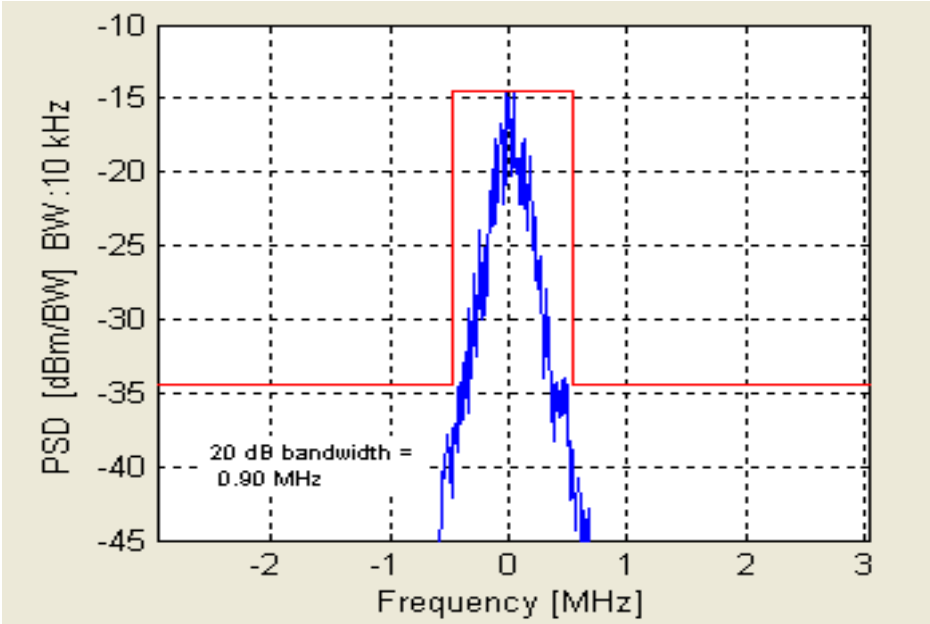
- Transmitter tests
  - TRM/CA/01/C (Output Power at NOC)
  - TRM/CA/02/C (Power Density at EOC)
  - TRM/CA/03/C (In-band emissions at NOC)
  - TRM/CA/04/C (In-band emissions at EOC)
  - TRM/CA/05/C (Modulation characteristics)
  - TRM/CA/06/C (Carrier frequency offset and drift at NOC)
  - TRM/CA/07/C (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 Level)
  - RCV/CA/07/C (PER Report Integrity)

- All test cases supported by IQxel.
- Red arrow (➡) test items require two signal generators.

Output Spectrum – BDR: 20dB Bandwidth

- Verification the emissions inside the operating frequency are within the limits..
- Find the highest power value.
- Find the lowest frequency f_L that power drop 20dB below the highest power.
- Find the highest frequency f_H that power drop 20dB below the highest power.
- The difference $\Delta f = |f_H - f_L|$
- Test Criteria:
  - $\Delta f = |f_H - f_L| \leq 1MHz$

Modulation payload is PRBS 9



EDR: Adjacent Channel Power

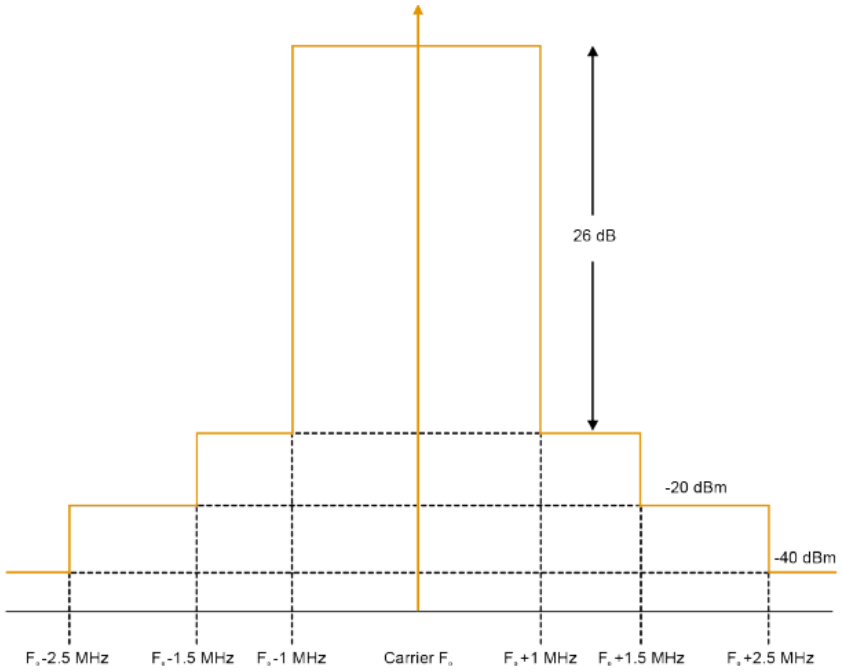


Figure 8. Transmitter spectral mask for EDR mode Bluetooth signal.

Δ Channel Number	Frequency Offset	Transmit Power
|M-N|=2	= 2 MHz	-20 dBm
|M-N|≥ 3	≥ 3 MHz	-40 dBm

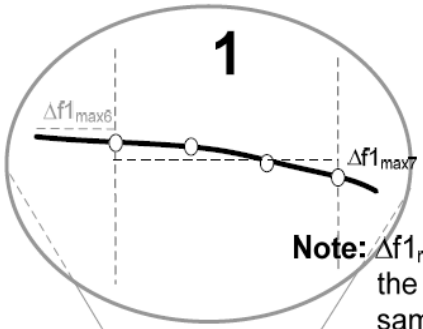
Table 4. Adjacent Channel Power specifications.

BLE: Modulation Characteristics

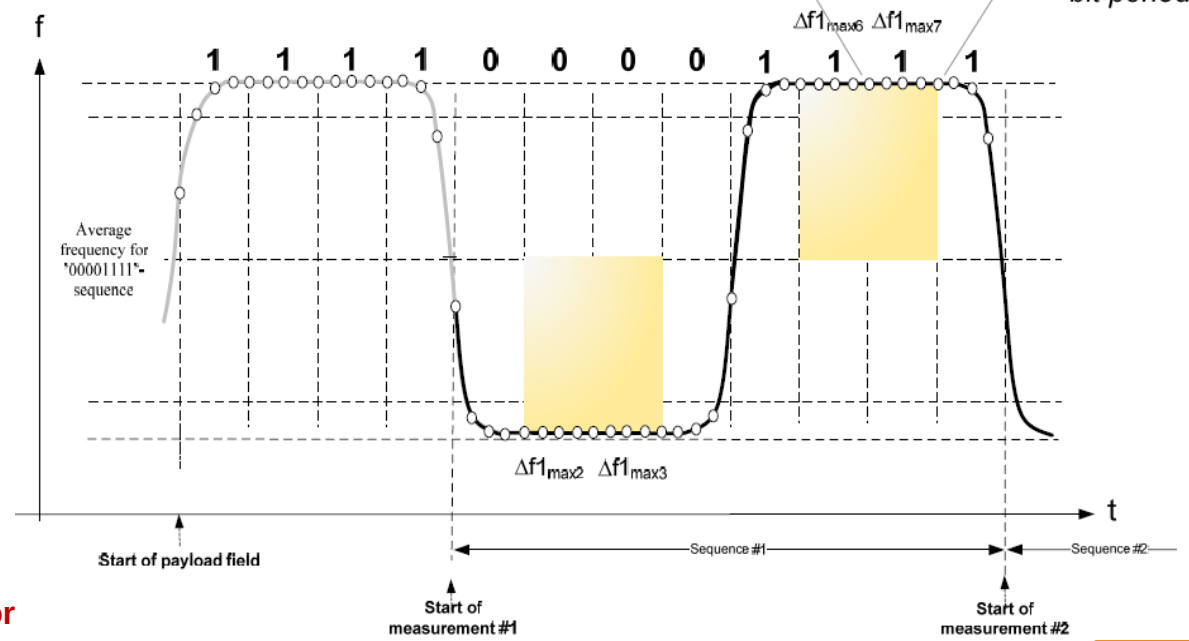
- Verifies that the modulation characteristics of the transmitted signal are correct
  (i.e. the frequency deviation is measured with different payload sequences).

- Test Criteria:

1. 225 kHz ≤ $\Delta f1_{avg}$ ≤ 275 kHz
2. At least 99.9% of all $\Delta f2_{max}$ frequency values recorded over 10 test packets must be greater than 185 kHz
3. $\frac{\Delta f2_{avg}}{\Delta f1_{avg}} \geq 0.8$



Note: $\Delta f1_{max}$ is defined as the average of the samples *within the bit period*



Infor

BLE: Carrier Frequency Offset and Drift

- Verifies that the carrier frequency offset and carrier drift of the transmitted signal

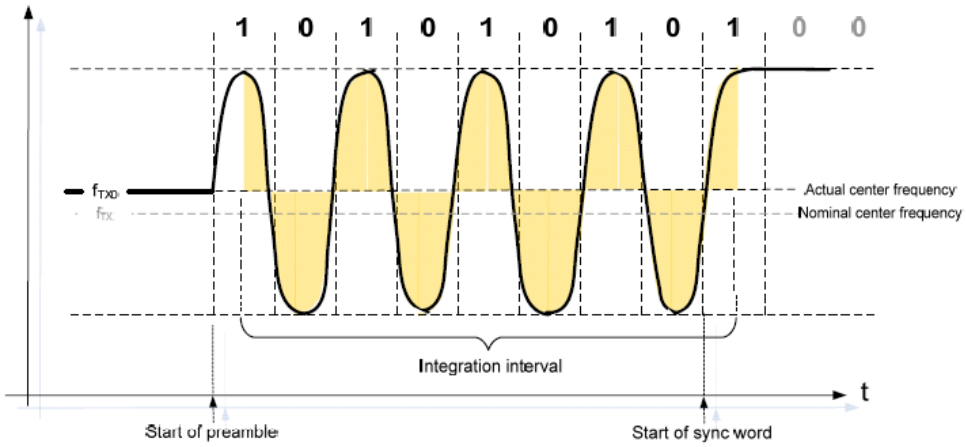


Figure 6.3: Initial frequency offset (f_0) measurement principle

- $f_{TX} - 150\ kHz \le f_n \le f_{TX} + 150\ kHz$
  where f_{TX} is the nominal transmit frequency and n=0,1,2,3…k
- $|f0 - fn| \le 50\ kHz$
  where n=2,3,4…k
- $|f_1 - f_0| \le 20kHz$ and $|f_n - f_{n-5}|_{n=6,7,8...k} \le 20kHz$

BLUETOOTH TEST SPECIFICATION Page 26 of 56

Bluetooth low energy RF PHY 0.7

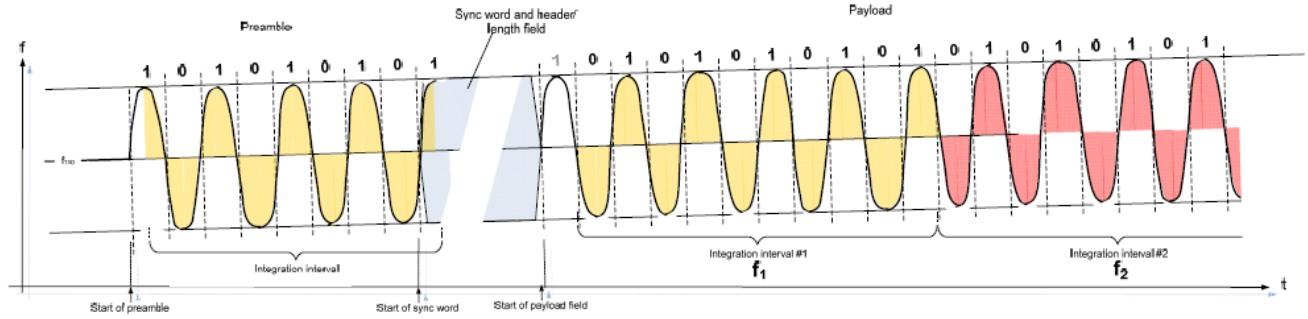


Figure 6.4: Frequency drift measurement principle

BDR: Sensitivity

- The sensitivity is tested using non-ideal transmitter(one-slot/multi-slot packet).
- Receive level of DUT is -70dBm
- The tester sends DH1/DH3/DH5 packets to the DUT and payload is PRBS 9.
- Adding dirty transmitter to tester.

  First 20ms using first parameter set

  Second 20ms using second parameter set.

  And so forth.

  After 10th sets of parameter has been used, the tester uses the first again.

Set of Parameters	Carrier Frequency offset	Modulation index	Symbol Time Period Error
1	75 kHz	0.28	- 20 ppm
2	14 kHz	0.30	- 20 ppm
3	- 2 kHz	0.29	+ 20 ppm
4	1 kHz	0.32	+ 20 ppm
5	39 kHz	0.33	+ 20 ppm
6	0 kHz	0.34	- 20 ppm
7	-42 kHz	0.29	- 20 ppm
8	74 kHz	0.31	- 20 ppm
9	-19 kHz	0.28	- 20 ppm
10	-75 kHz	0.35	+ 20 ppm

Table 5.4: Dirty Transmitter Single Slot Packets

$$BER = \frac{\gamma}{\xi}$$

γ: # payload bits counted in error

ξ: # payload bits received from DUT

- Test Criteria:
  - BER ≤ 0.1% (minimum number of samples, 1,600,000 returned payload bits).

BLE: Sensitivity with “Dirty Packets”

- **Dirty Packets in Bluetooth Low Energy Testing**

  The Bluetooth LE PHY Test Spec document specifies the use of **“dirty packets” for sensitivity testing**

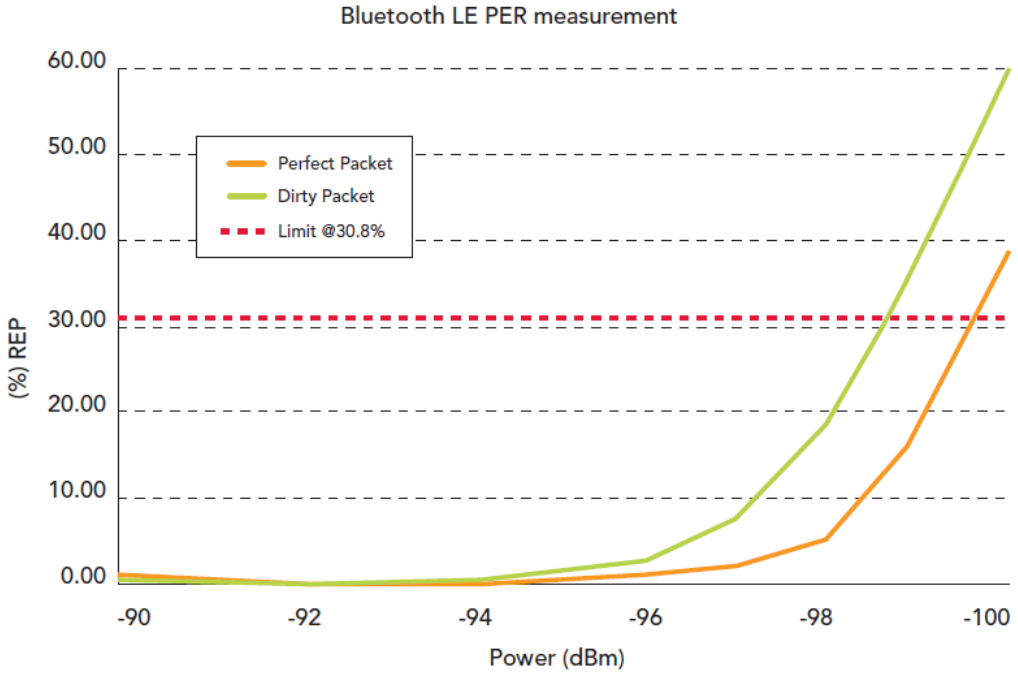
  -Every 50 packets, the Frequency Offset, Modulation Index and Symbol Timing Error are changed to specific value combinations described in the Test Spec

  -Additionally, a defined frequency drift is superimposed on the source output signal

  the frequency drift phase varies by 180° from packet to packet.

- Test Criteria: PER ≤ 30.8% (minimum number of samples, 1,500 packet).

- **Comparison of Perfect Packet and Dirty Packet**

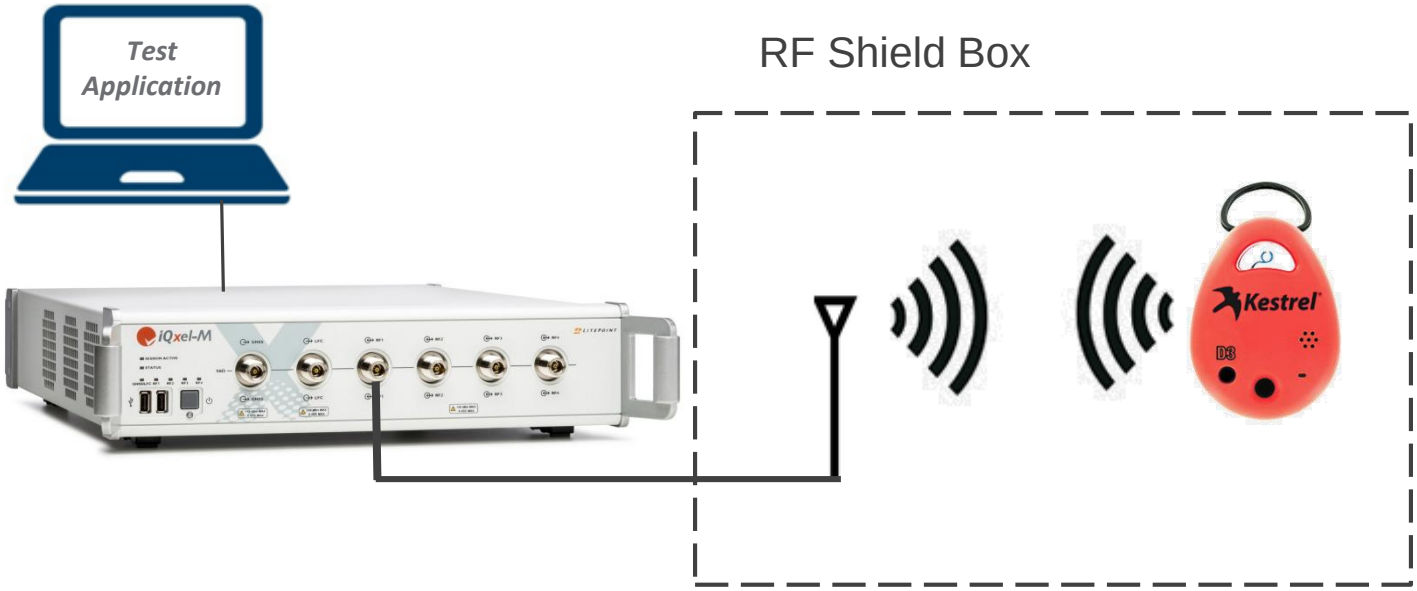


Bluetooth Advanced - A LitePoint BLE OTA Testing

Bluetooth Advanced

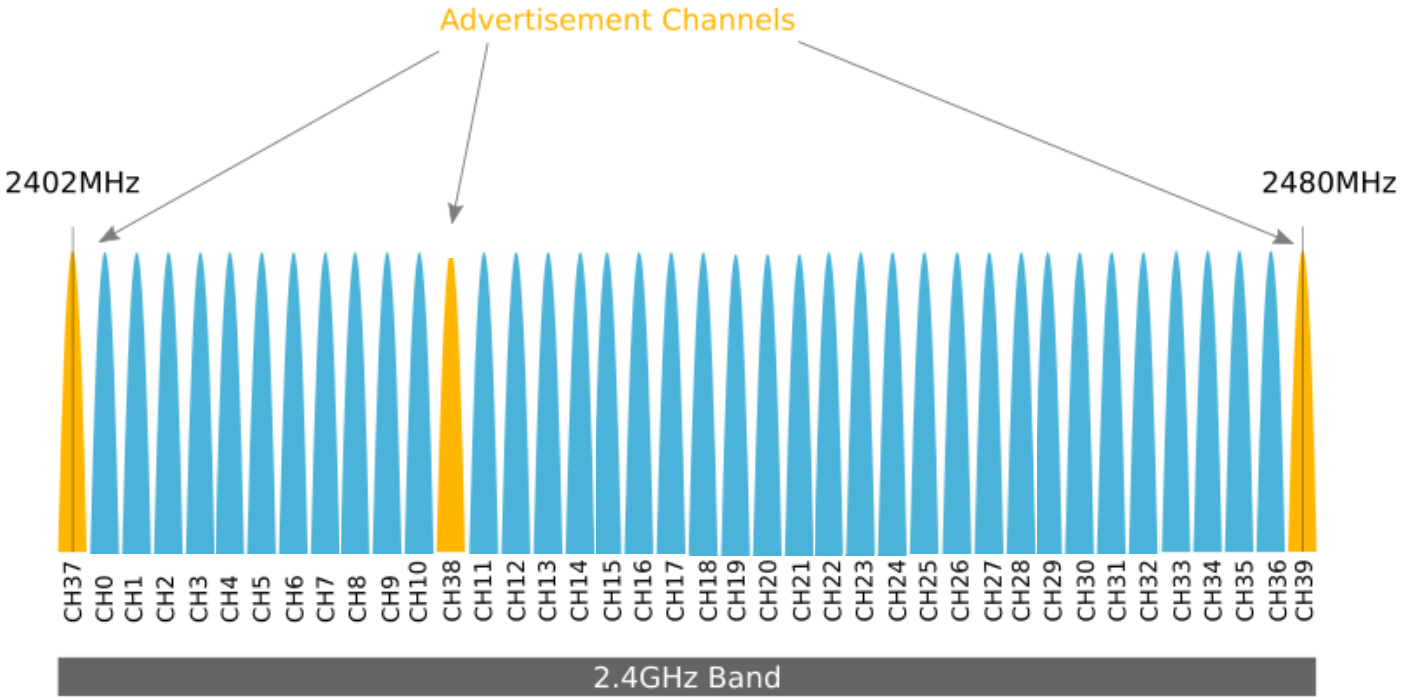
Designed for 100% OTA

Bluetooth Advanced



Advertising Channels

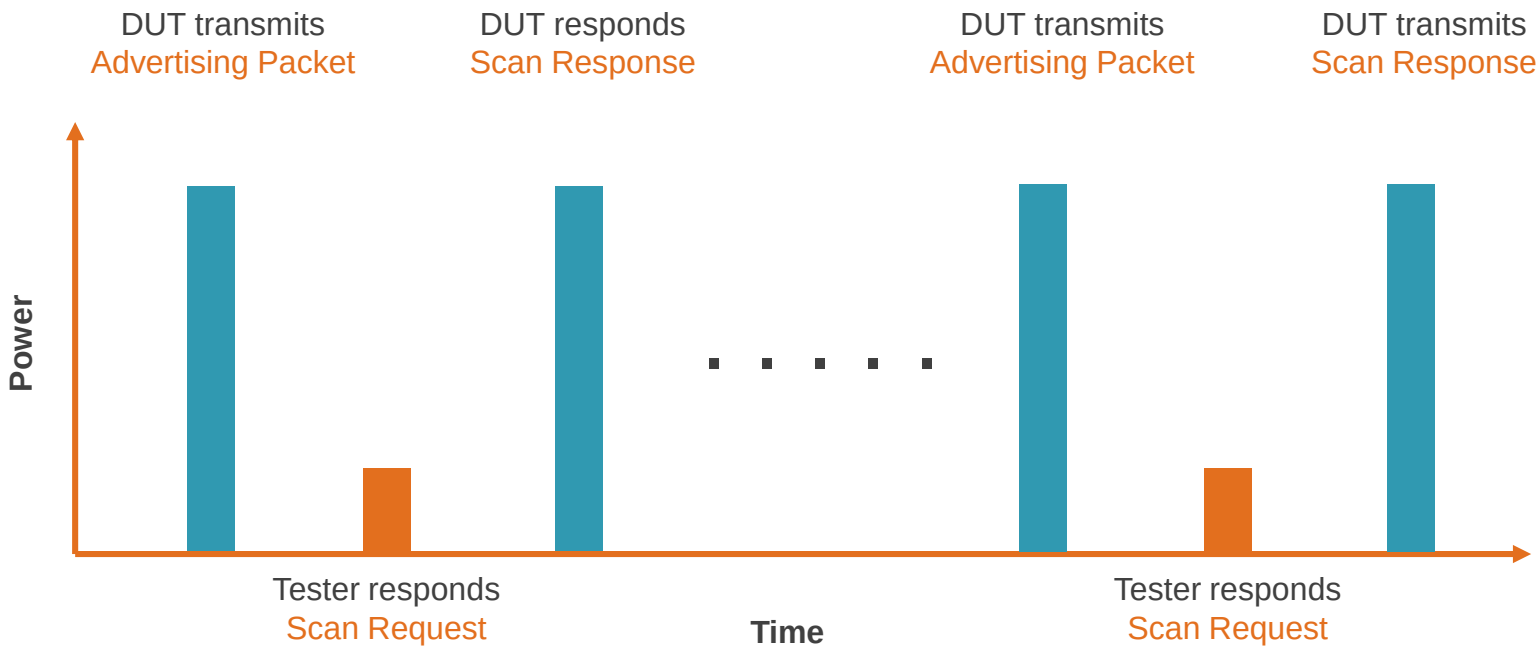
Provides good coverage across entire 2.4GHz band



Advertisement channel spacing enables good test coverage for Low, Mid, High channels. Does not require DUT to support special profiles.

How it Works…

Simplified Handshake and Timing Diagram

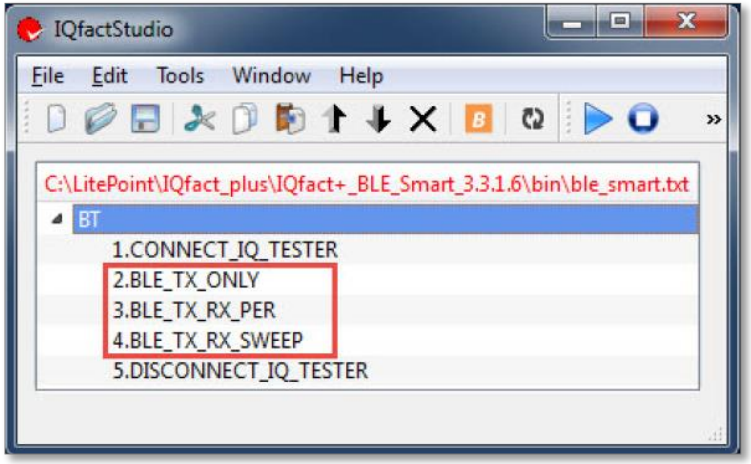


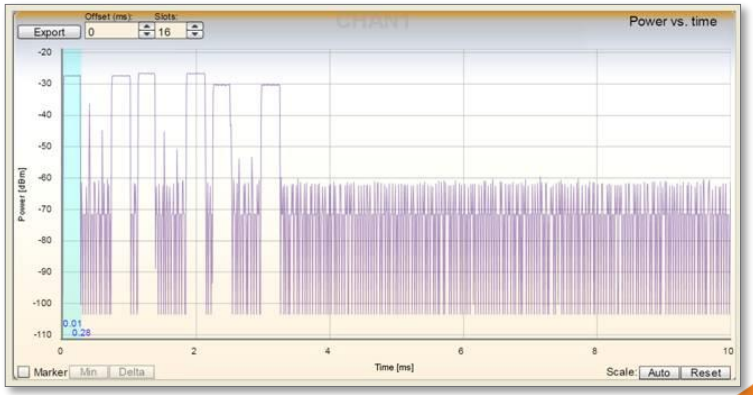
Repeat this sequence with decreasing Scan Request power level until no DUT Scan Response is received

Bluetooth Advanced Test Coverage

- Configurable test plans for transmit & receive measurements

- **Transmitter Tests** (@ CH 37, 38, 39):
  - Power (Min, Max, Average)
  - Delta F1
  - Delta F2
  - Minimum Deviation
  - Frequency Drift
  - Frequency Offset
  - Adjacent Channel Power
  - Advertising Packet Period
  - Advertising Payload

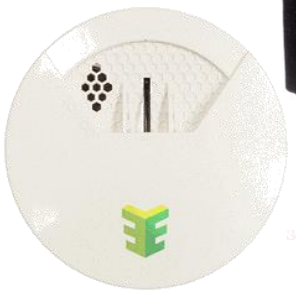




- **Receiver Tests** (@ CH 37, 38, 39):
  - Packet Error Rate
  - Sensitivity

Bluetooth Advanced Key benefits:

- **Get results quickly** with any Bluetooth Smart (Low Energy) device
  - No need to install special software on the DUT
  - No DUT communication port needed
  - No need for special chipset drivers
  - RF can be radiated or conducted



- **Good RF parametric test coverage**
  - Transmitter Power, Modulation quality
  - Receiver Sensitivity
  - Results for Low, Mid, and High channels
  - Advertising Address, Interval, and Payload

Bluetooth® SMART

- **Simplify Over-The-Air test setup**
  - Calibrate air loss from known TX power or RX sensitivity

Bluetooth 5

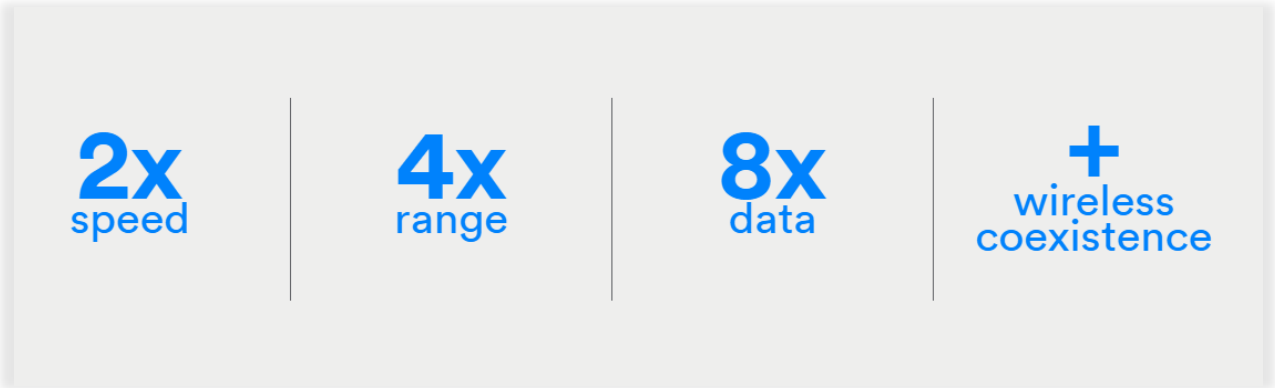

N.Y.C.TAXI
TAXI FARE
WiMAX
LTE
MIMO
WiFi
Zigbee
Bluetooth
4G
FM
WAVE

BT5 Key Features

2x Speed Moving from 1Msym/sec to 2Msym/sec

4x Range “Coding gain” increases range four times

8x Data Larger packets allows more data per packet



Compliments of the BT SIG website

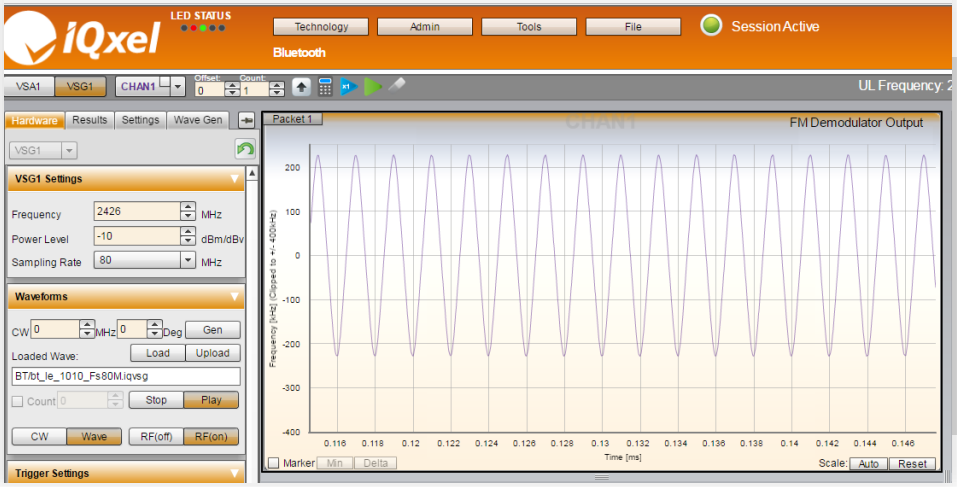
BT5.0

- 2M/500K/125Kbps rates in

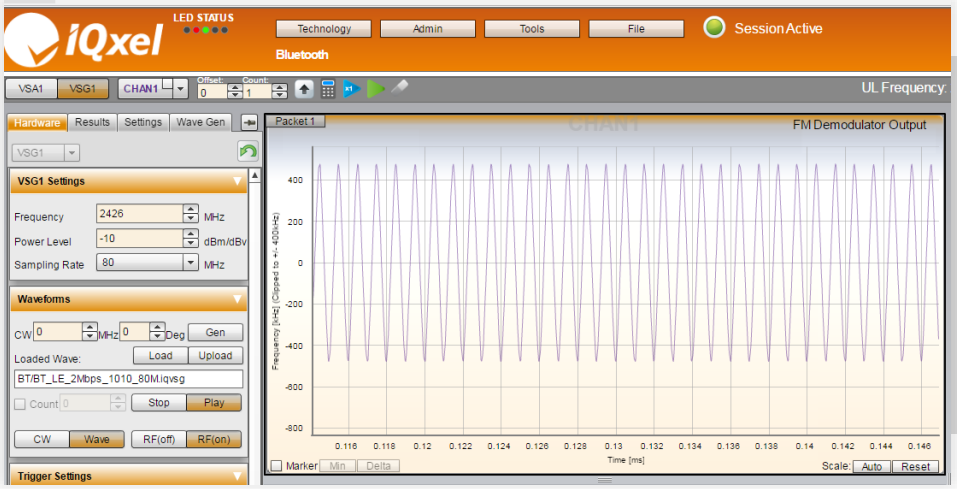
PHY	Modulation Scheme	Coding Scheme		Data Rate
		Access Header	Payload	
LE 1M	1 Msym/s modulation	Uncoded	Uncoded	1 Mb/s
LE 2M	2 Msym/s modulation	Uncoded	Uncoded	2 Mb/s
LE Coded (error correction)	1 Msym/s modulation	S=8	S=8 S=2	125 kb/s 500 kb/s

- Remain channel definition: 2402 + n*2; n:[0 – 39]

Increased Peak Data Rate



BT 4.2
1 bit per symbol
1 Msym/sec
Symbol period = 1us



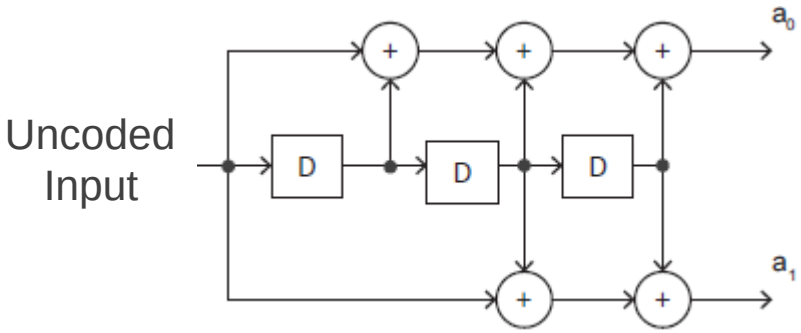
BT 5.0
1 bit per symbol
2 Msym/sec
Symbol period = 0.5us

Long Range – Packet Coding

Longer range achieved by adding error correct, which lowers the effective data rate for user data

Data Rate	Coding Strength	Symbol Rate
1 Mbps	Uncoded	1M sym/sec
2 Mbps	Uncoded	2M sym/sec
125 kbps	Coded with S=8	1M sym/sec
500 kbps	Coded with S=2	1M sym/sec

FEC



Used with S=2 and S=8

Pattern Mapper

Input bit from the convolutional FEC encode	Output sequence when P=4 (used by S=8)
0	0011
1	1100

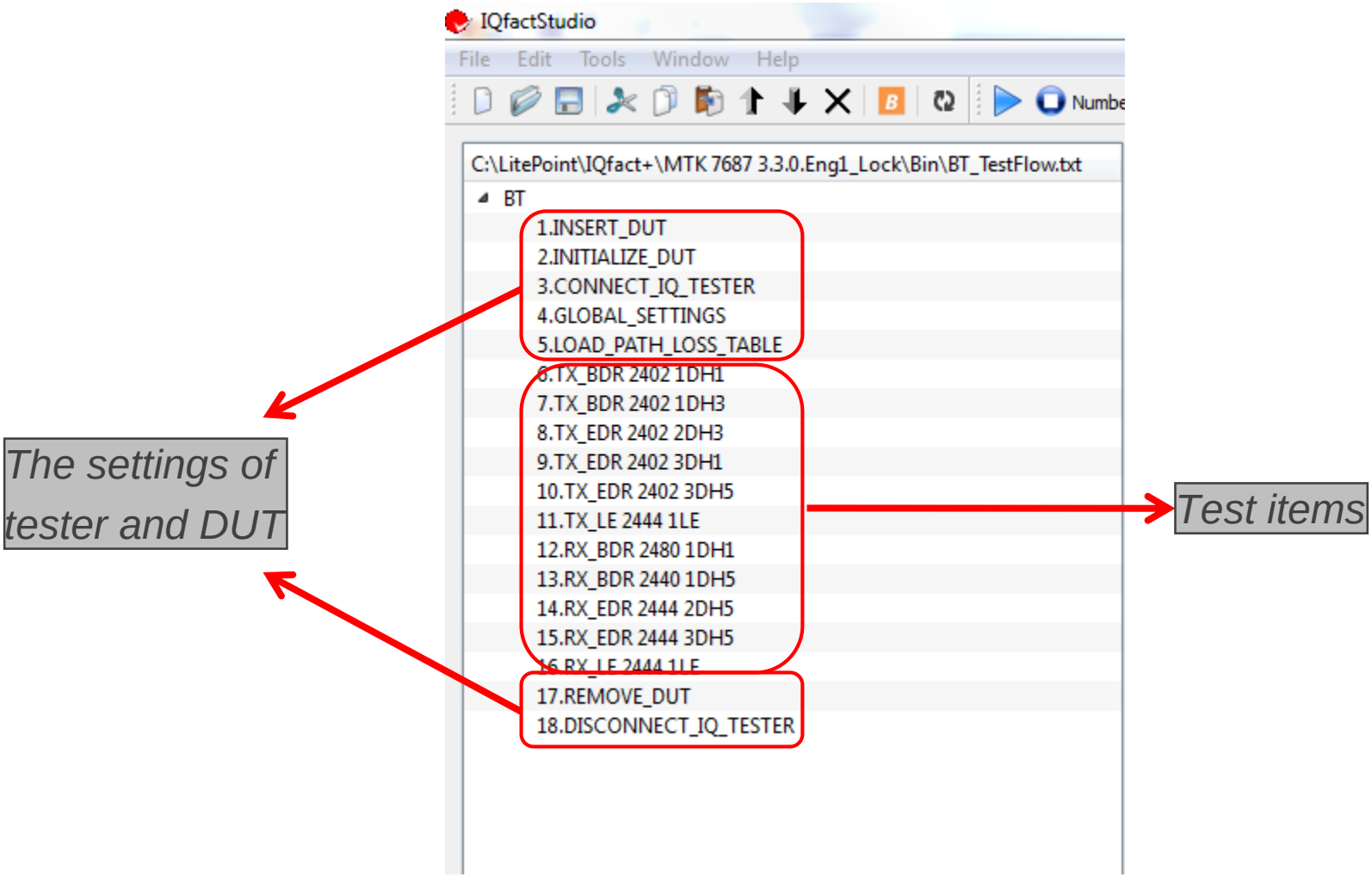
Used with S=8

Bluetooth 5.0 Supported Testing (TX)

- For all data rate
  - TP/TRM-LE/CA/BV-01-C [Output power]
- Test for 1Mbps signal
  - TP/TRM-LE/CA/BV-03-C [In-band emissions, uncoded data at 1 Ms/s] (ACP).
  - TP/TRM-LE/CA/BV-05-C [Modulation Characteristics, uncoded data at 1 Ms/s]
  - TP/TRM-LE/CA/BV-06-C [Carrier frequency offset and drift, uncoded data at 1 Ms/s]
  - TP/TRM-LE/CA/BV-09-C [Stable Modulation Characteristics, uncoded data at 1 Ms/s]
- Test for 2Mbps signal
  - TP/TRM-LE/CA/BV-08-C [In-band emissions at 2 Ms/s]
  - TP/TRM-LE/CA/BV-10-C [Modulation Characteristics at 2 Ms/s]
  - TP/TRM-LE/CA/BV-11-C [Stable Modulation Characteristics at 2 Ms/s]
  - TP/TRM-LE/CA/BV-12-C [Carrier frequency offset and drift at 2 Ms/s]
- Test for 125kbps signal
  - TP/TRM-LE/CA/BV-13-C [Modulation Characteristics, LE Coded (S=8)]
  - TP/TRM-LE/CA/BV-14-C [Carrier frequency offset and drift, LE Coded (S=8)]


BT Test with IQfact+
N.Y.C.TAXI
TAXI FARE
WiMAX
LTE
MIMO
WiFi
Bluetooth
Zigbee
4G
WAVE
FM

Auto Test Tool – IQfact+



Test item of IQfact+ Tx BDR

```
6.TX_BDR 2402 1DH1 ____________________________________________________________
ANALYZE_POWER_ONLY                : 0
FREQ_MHZ                          : 2402 MHz
PACKET_LENGTH                     : 0
TRANSMIT_0XF0_SEQUENCE_FOR_DELTA_F1_AVG : 1
TX_POWER_LEVEL                    : 8 Level
CABLE_LOSS_DB                     : 0.00 dB
EXPECTED_TX_POWER_DBM             :  dBm
SAMPLING_TIME_US                  : 0.00 us
PACKET_TYPE                       : 1DH1
Test Time = 1.575 s
    PAYLOAD_ERRORS            :           0              error (, )
    ACP_MAX_POWER_DBM_OFFSET_-1:         -20.05            dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_-2:         -51.75            dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_-3:         -56.63            dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_-4:         -58.11            dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_-5:         -59.48            dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_0:            5.10           dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_1:          -22.00           dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_2:          -52.75           dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_3:          -56.92           dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_4:          -58.70           dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_5:          -59.79           dBm (, )
    BANDWIDTH_20DB            :         830.31           kHz (, )
    CABLE_LOSS_DB             :          29.00            dB (, )
    DATA_RATE_DETECT          :           1.00          Mbps (, )
    DELTA_F1_AVERAGE          :         163.64           kHz (, )
    DELTA_F2_AVERAGE          :         161.19           kHz (, )
    DELTA_F2_AV_ACCESS        :         163.65           kHz (, )
    DELTA_F2_F1_AV_RATIO      :           0.99                (, )
    DELTA_F2_MAX              :         155.48           kHz (, )
    DELTA_F2_MAX_ACCESS       :         162.65           kHz (, )
    FREQ_DEVIATION            :         161.39           kHz (, )
    FREQ_DEVIATION_PK_TO_PK   :         369.57           kHz (, )
    FREQ_DRIFT                :          -3.11           kHz (, )
    FREQ_EST                  :         -12.64           kHz (, )
    FREQ_EST_HEADER           :         -20.94           kHz (, )
    MAX_FREQ_DRIFT_RATE       :           0.79           kHz (, )
    POWER_AVERAGE_DBM         :           3.92           dBm (, )
    POWER_PEAK_DBM            :           4.17           dBm (, )
    TARGET_POWER_DBM          :           8.00           dBm (, )
    ERROR_MESSAGE             :[Info] Function completed.
```

TRM/CA/06/C

TRM/CA/05/C

TRM/CA/07/C

TRM/CA/09/C

TRM/CA/08/C

TRM/CA/09/C

TRM/CA/01/C

Test item of IQfact+ Tx EDR

```
22.TX_EDR 2440 3DH5 ____________________________________________________________
FREQ_MHZ                        : 2440 MHz
PACKET_LENGTH                   : 0
TX_POWER_LEVEL                  : 8 Level
CABLE_LOSS_DB                   : 0.00 dB
EXPECTED_TX_POWER_DBM           : -99999.99 dBm
SAMPLING_TIME_US                : 0.00 us
PACKET_TYPE                     : 3DH5
Test Time = 1.045 s
    PAYLOAD_ERRORS             :           0              error (, )
    ACP_MAX_POWER_DBM_OFFSET_-2:         -31.77               dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_-3:         -49.59               dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_-4:         -51.13               dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_-5:         -51.71               dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_0 :           1.09               dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_2 :         -34.65               dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_3 :         -49.67               dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_4 :         -51.65               dBm (, )
    ACP_MAX_POWER_DBM_OFFSET_5 :         -52.39               dBm (, )
    ACP_MAX_POWER_DB_OFFSET_-1 :         -34.45                dB (, )
    ACP_MAX_POWER_DB_OFFSET_1 :          -34.69                dB (, )
    CABLE_LOSS_DB              :          29.00                dB (, )
    DATA_RATE_DETECT           :           3.00              Mbps (, )
    EDR_EVM_AV                 :           0.05                   (, )
    EDR_EVM_PK                 :           0.14                   (, )
    EDR_EXTREME_OMEGA_0        :           1.00               kHz (, )
    EDR_EXTREME_OMEGA_I0       :         -17.32               kHz (, )
    EDR_OMEGA_I                :         -17.56               kHz (, )
    EDR_POW_DIFF_DB            :           0.13                dB (, )
    EDR_PROB_EVM_99_PASS       :         100.00                 % (, )
    FREQ_DEVIATION             :         163.54               kHz (, )
    FREQ_DEVIATION_PK_TO_PK    :         395.92               kHz (, )
    FREQ_EST                   :         -15.59               kHz (, )
    FREQ_EST_HEADER            :         -17.56               kHz (, )
    POWER_AVERAGE_DBM          :           4.19               dBm (, )
    POWER_PEAK_DBM             :           7.01               dBm (, )
    TARGET_POWER_DBM           :           8.00               dBm (, )
    ERROR_MESSAGE              :[Info] Function completed.
```

TRM/CA/13/C

TRM/CA/11/C

TRM/CA/10/C

TRM/CA/11/C

BT LE test item vs IQfact+

475.TX_LE 2444 1LE _____
ANALYZE_POWER_ONLY : 0
FREQ_MHZ : 2444 MHz
PACKET_LENGTH : 0
TRANSMIT_0XF0_SEQUENCE_FOR_DELTA_F1_AVG : 1
TX_POWER_LEVEL : 0 Level
CABLE_LOSS_DB : 0.00 dB
EXPECTED_TX_POWER_DBM : -1 dBm
SAMPLING_TIME_US : 0.00 us
PACKET_TYPE : 1LE
Test Time = 2.856 s
CRC_OK : 1 (,)
ACP_MAX_POWER_DBM_OFFSET_-1: -11.69 dBm (,)
ACP_MAX_POWER_DBM_OFFSET_-2: -38.59 dBm (, -20.00)
ACP_MAX_POWER_DBM_OFFSET_-3: -47.78 dBm (, -30.00)
ACP_MAX_POWER_DBM_OFFSET_-4: -52.98 dBm (, -30.00)
ACP_MAX_POWER_DBM_OFFSET_-5: -55.08 dBm (, -30.00)
ACP_MAX_POWER_DBM_OFFSET_0: 8.70 dBm (,)
ACP_MAX_POWER_DBM_OFFSET_1: -11.26 dBm (,)
ACP_MAX_POWER_DBM_OFFSET_2: -38.71 dBm (, -20.00)
ACP_MAX_POWER_DBM_OFFSET_3: -47.58 dBm (, -30.00)
ACP_MAX_POWER_DBM_OFFSET_4: -53.19 dBm (, -30.00)
ACP_MAX_POWER_DBM_OFFSET_5: -56.12 dBm (, -30.00)
CABLE_LOSS_DB : 9.50 dB (,)
DATA_RATE_DETECT : 1.00 Mbps (,)
DELTA_F1_AVERAGE : 245.12 kHz (225.00, 275.00)
DELTA_F2_AVERAGE : 229.04 kHz (,)
DELTA_F2_F1_AV_RATIO : 0.93 (0.80,)
DELTA_F2_MAX : 189.77 kHz (,)
DELTA_F0_Fn_MAX : 3.43 kHz (,)
DELTA_F1_F0 : 0.77 kHz (,)
DELTA_Fn_Fn5_MAX : 2.71 kHz (,)
FREQ_DEV_SYNC_AVG : 255.16 kHz (,)
FREQ_OFFSET : 1.50 kHz (-150.00, 150.00)
Fn_MAX : 4.55 kHz (,)
POWER_AVERAGE_DBM : 8.15 dBm (,)
POWER_PEAK_DBM : 9.06 dBm (,)
TARGET_POWER_DBM : -1.00 dBm (,)
ERROR_MESSAGE :[Info] Function completed.

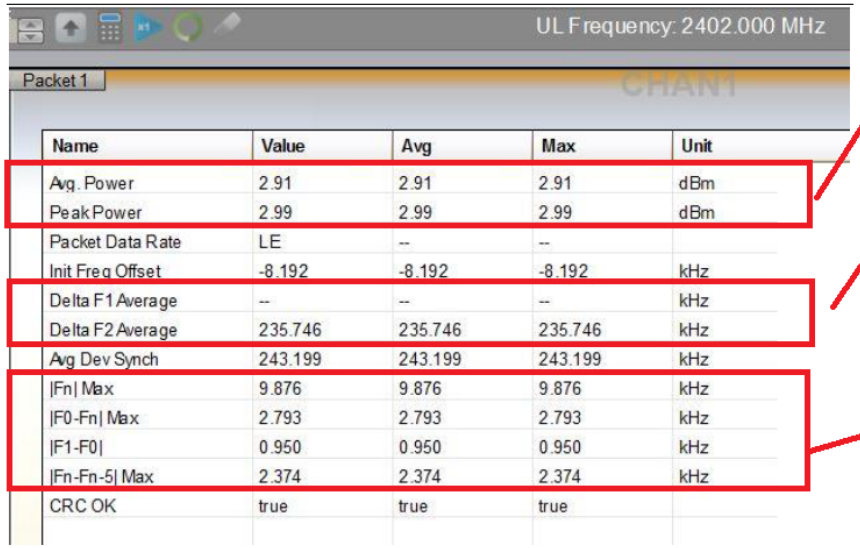
6.2.3 TRM-LE/CA/03/C (In-band emissions at NOC)

6.2.5 TRM-LE/CA/05/C (Modulation characteristics)

6.2.6 TRM-LE/CA/06/C (Carrier frequency offset and drift at NOC)

6.2.1 TRM-LE/CA/01/C (Output power at NOC)

BT LE correlation with IQxel GUI



Name	Value	Avg	Max	Unit
Avg. Power	2.91	2.91	2.91	dBm
Peak Power	2.99	2.99	2.99	dBm
Packet Data Rate	LE	--	--	
Init Freq Offset	-8.192	-8.192	-8.192	kHz
Delta F1 Average	--	--	--	kHz
Delta F2 Average	235.746	235.746	235.746	kHz
Avg Dev Synch	243.199	243.199	243.199	kHz
|Fn| Max	9.876	9.876	9.876	kHz
|F0-Fn| Max	2.793	2.793	2.793	kHz
|F1-F0|	0.950	0.950	0.950	kHz
|Fn-Fn-5| Max	2.374	2.374	2.374	kHz
CRC OK	true	true	true	

6.2.1 TRM-LE/CA/01/C (Output power at NOC)

- -20 dBm ≤ P_{AVG} ≤ +10 dBm EIRP
- P_{PK} ≤ (P_{AVG} + 3 dB)

6.2.5 TRM-LE/CA/05/C (Modulation characteristics)

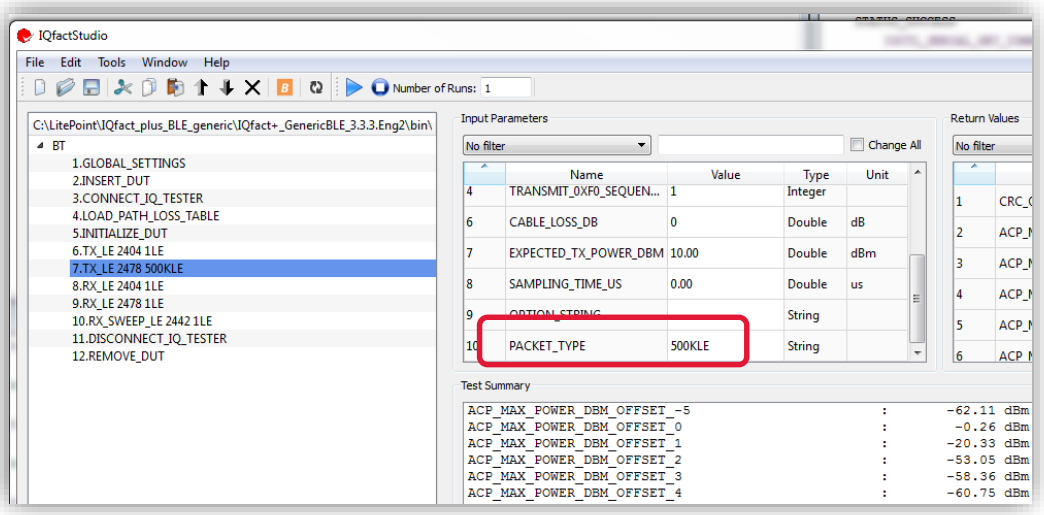
1. 225 kHz ≤ $\Delta f1_{avg}$ ≤ 275 kHz
2. At least 99.9% of all $\Delta f2_{max}$ frequency values recorded over 10 test packets must be greater than 185 kHz
3. $\frac{\Delta f2_{avg}}{\Delta f1_{avg}} \geq 0.8$

6.2.6 TRM-LE/CA/06/C (Carrier frequency offset and drift at NOC)

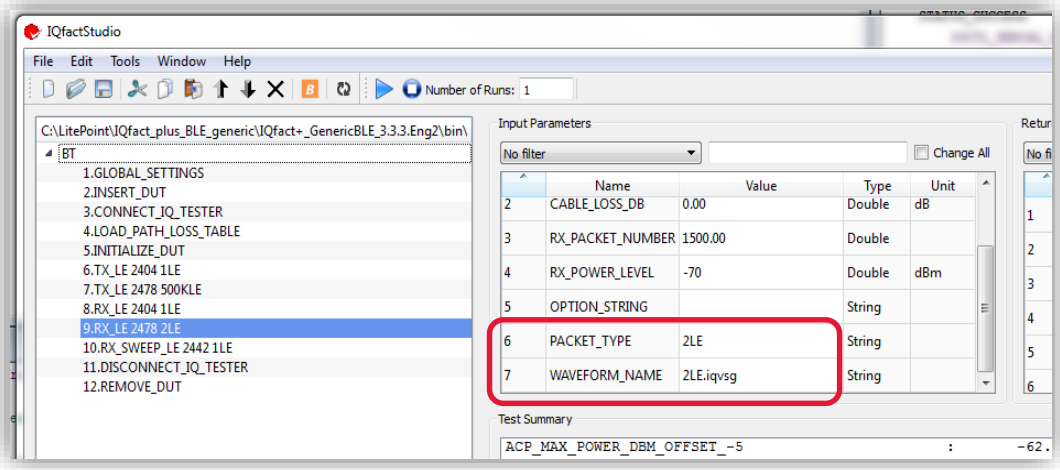
Pass Verdict

- $f_{TX} - 150\ kHz \leq f_n \leq f_{TX} + 150\ kHz$
  where f_{TX} is the nominal transmit frequency and n=0,1,2,3…k
- $|f0 - fn| \leq 50\ kHz$
  where n=2,3,4…k
- $|f_1 - f_0| \leq 20kHz$ and $|f_n - f_{n-5}|_{n=6,7,8...k} \leq 20kHz$

IQfact+ for BT5



Transmitter Test:
Configure “Packet Type” as one of the configurations in the test item



Receiver Test:
Configure “Packet Type” and “Waveform Name” in the configuration of the test item

Thank You