2net HUB Operational Description

80-KA088-101 Rev. C

March 2014

Qualcomm Services Labs, Inc.
5775 Morehouse Drive
San Diego, CA 92121-1714
U.S.A.

2net HUB Operational Description
80-KA088-101 Rev. C
March 2014

Contents

Figures

Tables

1 Introduction

The 2net™ Hub is a small plug-and-play radio communications unit. The Hub incorporates both short range and WWAN radios as follows:

- GSM/GPRS 850/900/1800/1900 MHz
- UMTS 850/1900 MHz
- 2.4 GHz 802.11 b/g
- 2.4 GHz Bluetooth 2.0 + EDR, BLE 4.0
- 2.4 GHz ANT+

The 2net HUB will be initially marked under the model name QWH-HUB-V1.0A.

1.1 Device Description

The 2net Hub is a self contained “wall wart” unit that plugs directly into an AC power outlet. The device contains three LEDS to show radio status and a single USB port that can be used to connect a paired device.

Wireless connectivity is achieved through two integrated modules:

- Huawei MU5089-C 2G/3G module originally approved under FCC ID QISMU509C
- Murata LBEH59XUHCH497 for 802.11/ANT+/Bluetooth connectivity

Both modules are solder down modules where the RF is routed through the 2NET circuit board to PIFA antennas. Module approval data is not used for the Murata unlicensed modem. Conducted test data is referenced to the Huawei modular approval. Radiated emissions and transmit power has been retested with the device to verify compliance with transmitter requirements.

Although the radio module in 2NET has 802.11n capability, it is disabled in the unit and the user has no means of changing or enabling 802.11n.

ANT and BT LE are MAC level variants of Bluetooth achieved through software variations. 2net Hub does not utilize BT LE buy does incorporate ANT. The maximum transmission duty cycle for ANT is 5%. Testing was completed with 18% enforced through test software as a conservative scenario

2NET does not contain any medical sensors but does collect data from medical devices over the short-range radio communications links. It then wirelessly delivers this data over a cellular network (similar to a mobile phone) to a medical device company’s website/server. The 2net Hub is easy to use and is designed for use in a residential environment. Just plug it into a standard US, electrical wall outlet at your home or office. It does not need any batteries.

The 2net Hub contains two antennas and does not support any form of MIMO (i.e. single TX antennas only).

- Antenna 1: 2G/3G TX/RX only
- Antenna 1: 802.11/ANT+/Bluetooth TX/RX only

The unlicensed and licensed radios can operate simultaneously as follows:

- WWAN + 802.11b
- WWAN + 802.11g
- WWAN + Bluetooth
- WWAN + ANT

The different unlicensed radios are not allowed to operate simultaneously.

1.2 **Technologies Supported**

Table 1-1 describes the technologies and bands supported. Section 0 contains additional information on device capabilities and equipment categories for each technology.

Table 1-1 Technology, Frequency bands and Conducted Transmit Power

Technology	Frequency Band	Transmit Frequency Range	Receive Frequency Range	Antenna	Nominal Conducted Transmit Power (Antenna Feed)
GSM/EDGE/GPRS	850 MHz	824-849	869-894	TX/RX on Antenna #1 only	1,585 mW / 32dBm (+/- 1dB) (Peak Power)
	900 MHz	880-915	925-960	TX/RX on Antenna #1 only	1,585 mW / 32dBm (+/- 1dB) (Peak Power)
	1800 MHz	1710-1785	1805-1880	TX/RX on Antenna #1 only	708 mW / 28.5dBm (+/- 1dB) (Peak Power)
	1900 MHz	1850-1910	1930-1990	TX/RX on Antenna #1 only	708 mW / 28.5dBm (+/- 1dB) (Peak Power)
UMTS/HSDPA	850 MHz (Band II)	824-849	869-894	TX/RX on Antenna #1 only	251 mW / 24dBm (+/- 1dB) (Peak Power)
	1900 MHz (Band IV)	1850-1910	1930-1990	TX/RX on Antenna #1 only	251 mW / 24dBm (+/- 1dB) (Peak Power)
802.11b	2.4 GHz	2402-2484		TX/RX on Antenna #2 only	35 mW / 15.5dBm (+/- 1dB) (Peak Power)
802.11g	2.4 GHz	2402-2484		TX/RX on Antenna #2 only	18 mW / 12.5dBm (+/- 1dB) (Peak Power)
Bluetooth 2.1+EDR, BLE 4.0	2.4 GHz	2402 - 2480		TX/RX on Antenna #2 only	6 mW / 7.5dBm (+/- 1dB) (Peak Power)
ANT+	2.4 GHz			TX/RX on Antenna #2 only	6 mW / 7.5dBm (+/- 1dB) (Peak Power)

2 Device Equipment Category Declarations

2.1 **UMTS Equipment Category**

The 2net Hub is HSDPA Category 6 as defined in 3GPP TS 25.306.

2.2 **GSM Class**

The 2net Hub is being certified as a multislot class 10 device. It can be operated to support all coding schemes CS1 to CS4 and MSC1 to MSC9. The peak uplink and downlink data rates for GPRS and EDGE are 85.6 kbps and 236.8 kbps respectively.

3 FCC CFR 47 §2.1033 Requirement Documentation

Requirement: §2.1033 (c) Applications for equipment other than that operating under parts 15 and 18 of the rules shall be accompanied by a technical report containing the following information:

3.1 §2.1033 (c) (1) Manufacture Information

Requirement: §2.1033 (c) (1) the full name and mailing address of the manufacturer of the device and the applicant for certification.

Qualcomm information:

5775 Morehouse Drive

San Diego, CA 92121

Second Party Volume Manufacturer TBD

3.2 §2.1033 (c) (2) FCC identifier

Requirement: §2.1033 (c) (2) FCC identifier

Qualcomm information:

The FCC ID of the equipment is J9C2NET

The IC identifier is: 2723A-2NET

3.3 §2.1033 (c) (3) User Manual

Requirement: 2.1033 (c) (3) A copy of the installation and operating instructions to be furnished the user. A draft copy of the instructions may be submitted if the actual document is not available. The actual document shall be furnished to the FCC when it becomes available.

Qualcomm information:

Please see User's Guide.

3.4 **§2.1033 (c) (4) Emissions Designators**

Requirement: 2.1033 (c) (4) Type or types of emission.

Qualcomm information:

Table 3-1 Technology emissions designators

Mode		Tx Frequency Range (MHz)	Emission Designator
GSM \GPRS \EDGE	GMSK	824.2 – 848.8	245KGXW
		1850.2 – 1909.8	247KGXW
	8PSK	824.2 – 848.8	248KG7W
		1850.2 – 1909.8	248KG7W
UMTS		826.4 – 846.6	4M20F9W
		1852.4 – 1907.5	4M17F9W
802.11b		2412 to 2462 (Ch1-11)	13M7G1D
802.11g		2412 to 2462 (Ch1-11)	16M4G1D
Bluetooth 2.1+EDR		2402 - 2480	1M22F1D, 857KF1D
ANT		2402 - 2480	744KF1D

3.5 **§2.1033 (c) (5) Frequency range**

Requirement: 2.1033 (c) (5) Frequency range.

Qualcomm information:

The frequency ranges that the 2net Hub supports are listed in Table 2-1 of this document. In the US and Canada, only 850 MHz (Cellular) and 1900 MHz (PCS) bands are used for GSM and UMTS transceivers.

3.6 **§2.1033 (c) (6) Range of Transmit Power**

Requirement: 2.1033 (c) (6) Range of operating power values or specific operating power levels, and description of any means provided for variation of operating power.

Qualcomm information:

The power control in UMTS/HSPA mode is similar as in CDMA mode. The 2net Hub is a Power Class 3 UE. The output power dynamic operation is defined in 3GGP TS 25.101 section 6.2.

For GMSK modulation, the 2net Hub supports Class 4 GSM850 and Class 1 PCS1900 mobile station power class. For 8PSK modulation, it supports Class E2 GSM850 and PCS1900 mobile station power class. In GSM CS operations, the transmitted power of the mobile station is controlled from the uplink level and quality of the mobile station transmission received at the BTS. For GPRS the mobile station adjusts its transmitted power based on:

The received power measured on the downlink.

The dynamic control parameters sent by the GPRS sub-network on the PACCH. These dynamic control parameters are based on the uplink received level of the mobile station at the BTS.

The detail of the output level dynamic operation is defined in 3GPP TS 45 008 Section 10.

Unlicensed maximum transmit power is defined in Table 1-1.

3.7 §2.1033 (c) (7) Maximum Transmit Power

Requirement: 2.1033 (c) (7) Maximum power rating as defined in the applicable part(s) of the rules.

Qualcomm information:

The 2net Hub supports the maximum output power as defined Table 1-1.

All licensed modes meet the 7 W ERP (+8.45 dBW) maximum power limitation of CFR 47 §22.913 and 2 watts E.I.R.P. peak power of CFR 47 Part §24.232 (b) and part 27.52. The equipment is able to limit the output power to the minimum necessary for successful communications.

3.8 §2.1033 (c) (8) DC Voltages

Requirement: §2.1033 (c) (8) the dc voltages applied to and dc currents into the several elements of the final radio frequency amplifying device for normal operation over the power range.

Qualcomm information:

The 2net Hub is powered by an internal AC to DC concvertered supplied by Spec is 100 (-10%) VAC to 240(+6%) VAC, 47 Hz to 63 Hz. The internal converter provides the HUB with 5Vdc voltage that can vary 4.7 to 5.4 Vdc with a maximum output load of 2A.

3.9 §2.1033 (c) (9) Tune-up procedure

Requirement: §2.1033(c) (9) Tune-up procedure over the power range, or at specific operating power levels.

Qualcomm information:

Qualcomm does not control or adjust the transmit power for the Huawei or Murata modules.

3.10 §2.1033 (c) (10) Schematic

Requirement: §2.1033(c)(10) A schematic diagram and a description of all circuitry and devices provided for determining and stabilizing frequency, for suppression of spurious radiation, for limiting modulation and for limiting power.

Qualcomm information:

Schematic:

See schematic exhibit and block diagram exhibit.

Stabilizing Frequency:

The circuit provided for determining and stabilizing frequency is in the schematic attachment.

A 19.2 MHz crystal, an external thermistor with an ADC that is measured by the modem to determine drift over temperature is employed as a frequency reference for all of the transceiver local oscillators. This crystal oscillator is specified to remain within +/- 2.5 ppm over temperature and voltage variations. The lock status indicator of all synthesizers is monitored by the microprocessor and an out of lock condition will inhibit transmission. In all modes, the mobile receiver monitors the received signal and adjusts the frequency of the VCTCXO, this corrects any errors between the mobile frequency and the base station transmitter. The mobile is locked to the base station.

Suppression of Spurious Radiation:

The circuit provided for suppression of spurious radiation is in schematic attachment.

The transmitter front end provides filtering of the RF signal in order to meet FCC specifications. For radiated spurious suppression, proper design techniques and the use of proper shielding techniques reduced the emission levels well below the permissible FCC limit.

Limiting Power:

Transmitted power is monitored by a RF detector diode which is coupled from the Power Amplifier (PA) output. The detected DC voltage is fed into a microprocessor which uses a calibration table along with an offset correction and temperature correction table to control power limits. When the RF power exceeds a predetermined limit the gain of the stage preceding the PA is reduced.

3.11 **§2.1033 (c) (11) FCC Identifier Drawing**

Requirement: §2.1033 (c) (11) A photograph or drawing of the equipment identification plate or label showing the information to be placed thereon.

Qualcomm information:

See FCC label exhibit for FCC label information.

3.12 **§2.1033 (c) (12) Photographs**

Requirement: §2.1033 (c) (12) Photographs (8x10) of the equipment of sufficient clarity to reveal equipment construction and layout, including meters, if any, and labels for controls and meters and sufficient views of the internal construction to define component placement and chassis assembly. Insofar as these requirements are met by photographs or drawings contained in instruction manuals supplied with the certification request, additional photographs are necessary only to complete the required showing.

Qualcomm information:

See photograph exhibits for the external and internal photos.

3.13 §2.1033 (c) (13) Modulation Description

Requirement: §2.1033 (c) (13) For equipment employing digital modulation techniques, a detailed description of the modulation system to be used, including the response characteristics (frequency, phase and amplitude) of any filters provided, and a description of the modulating wavetrain, shall be submitted for the maximum rated conditions under which the equipment will be operated.

Qualcomm information:

2

3.13.1 UMTS (Release 99, HSDPA, HSUPA)

The description here is limited to only what the 2net Hub supports in a UMTS operational mode.

The access scheme is Direct-Sequence Code Division Multiple Access (DS-CDMA) with information spread over approximately 5 MHz bandwidth. The operational mode of the equipment is Frequency Division Duplex (FDD).

The characteristics of the spreading and modulation in the FDD mode are described in 3GPP TS 25.213. Figure 3-1 from 25.213 illustrates the principle of the spreading of uplink dedicated physical channels.

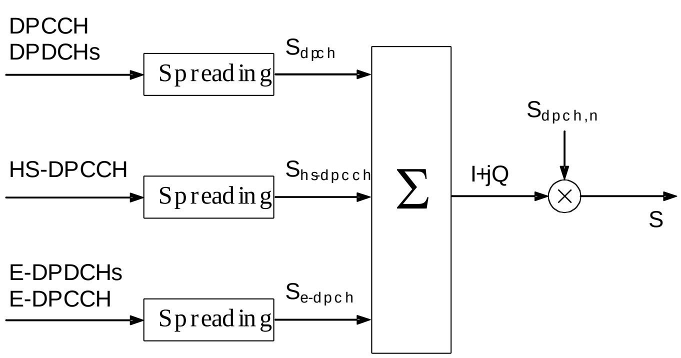


Figure 3-1: Spreading for uplink dedicated channels

Spreading is applied to the physical channels. It consists of two operations. The first is the channelization operation, which transforms every data symbol into a number of chips, thus increasing the bandwidth of the signal. The number of chips per data symbol is called the Spreading Factor (SF). The second operation is the scrambling operation, where a scrambling code is applied to the spread signal.

With the channelization, data symbols on so-called I- and Q-branches are independently multiplied with an OVSF code. With the scrambling operation, the resultant signals on the I- and Q-branches are further multiplied by complex-valued scrambling code, where I and Q denote real and imaginary parts, respectively.

Channelization: The channelization codes are Orthogonal Variable Spreading Factor (OVSF) codes that preserve the orthogonality between a user's different physical channels. The OVSF code tree from 25.213 is expressed as Figure 3-2.

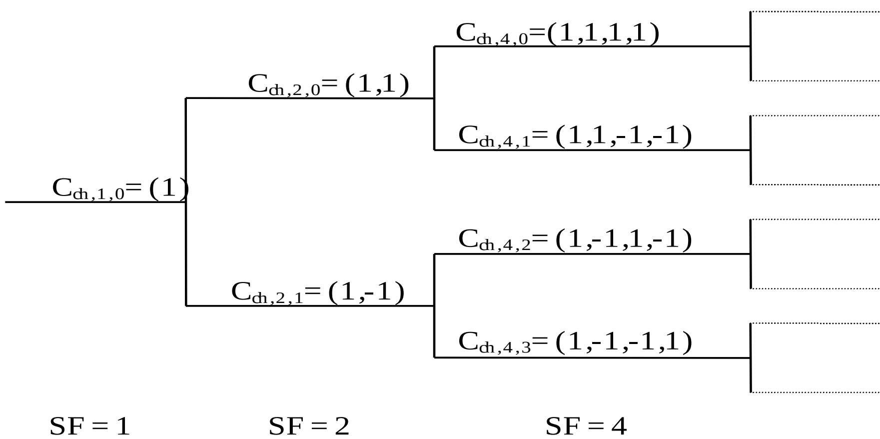


Figure 3-2: Code-tree for generation of OVSF codes

The spreading factor can vary from 2-256. The summary of spread factor for DPCCH/DPDCH, HS-DPCCH, E-DPCCH/E-DPDCH is listed in the table 7-2.

Spreading Factor

	DPDCH	DPCCH	HS-DPCCH	E-DPDCH	E-DPCCH
Spreading Factor	4 to 256	256	256	2 to 256	256

Note: DPDCH and E-DPDCH spreading factors are dependent on data rate and number of channels

Scrambling operation: All uplink physical channels shall be scrambled with a complex-valued scrambling code. There are 2^{24} long and 2^{24} short uplink scrambling codes, whose sequences are described in the Section 4.3.2.2 and 4.3.2.3 of TS 25.213. The dedicated physical channels may be scrambled by either a long or a short scrambling code, defined in the Section 4.3.2.4. Uplink scrambling codes are assigned by higher layers.

Modulation: The modulation scheme is BPSK and the modulating chip rate is 3.84 Mcps. The uplink modulation of the complex-valued chip sequence generated by the spreading process is shown in Figure 3-3 below.

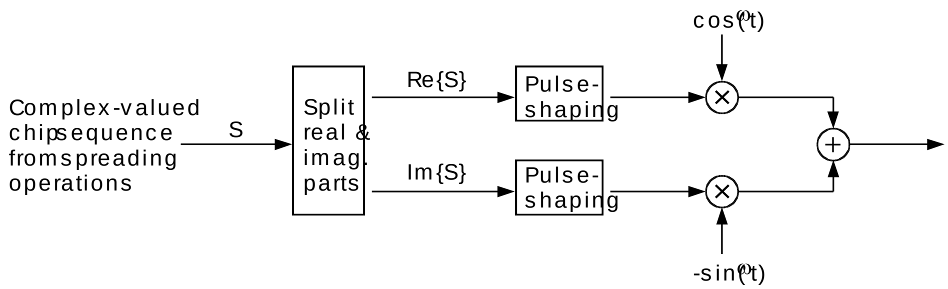


Figure 3-3: Uplink modulation

Pulse Shape Filter: The pulse shape characteristics described here is from 3GPP TS 25.101 standard. Transmit modulation defines the modulation quality for expected in-channel RF transmissions from the UE. The used transmit pulse shaping filter is a root-raised cosine (RRC) with roll-off α□=0.22 in the frequency domain. The impulse response of the chip impulse filter $RC_0(t)$ is:

$$RC_0(t) = \frac{\sin\left(\pi \frac{t}{T_C}(1-\alpha)\right) + 4\alpha \frac{t}{T_C}\cos\left(\pi \frac{t}{T_C}(1+\alpha)\right)}{\pi \frac{t}{T_C}\left(1-\left(4\alpha \frac{t}{T_C}\right)^2\right)}$$

Where the roll-off factor α □=0.22 and the chip duration is

$$T = \frac{1}{chiprate} \approx 0.26042 \mu s$$

The minimum requirements for the modulation characteristics are specified in the Section 6.8 of TS 25.101, including error vector magnitude, peak code domain error, relative code domain error, phase discontinuity for uplink DPCH and phase discontinuity for HS-DPCCH.

3.13.2 GSM (GSM, GPRS, EDGE)

The GSM modulation characteristics described in the following pages is from 3GPP TS 05.01, V8.9.0 (2004-11) and 3GPP TS 05.04 V8.4.0 (2001-11).

In a GSM mode, the access scheme is Time Division Multiple Access (TDMA) with eight basic physical channels per carrier. The carrier spacing is 200 kHz. A physical channel is defined as a sequence of TDMA frames, a time slot number (modulo 8) and a frequency hopping sequence as described in Section 5, 05.01.

The basic radio resource is a time slot lasting ≈ 576,9 μs (15/26 ms) and transmitting information at a modulation rate of ≈ 270.833 kbit/s (1 625/6 kbit/s).

The modulation scheme may be either Gaussian MSK (GMSK) or 8-PSK, depending on the type of channel. Section 2 in TS 05.01 defines all applicable traffic channels (TCH) and signaling channels.

The channel coding for GPRS PDTCH has four coding schemes, CS-1 to CS-4, listed in the table below.

Scheme	Code rate	USF	Pre-coded USF	Radio Block excl. USF and BCS	BCS	Tail	Coded bits	Punctured bits
CS-1	1/2	3	3	181	40	4	456	0
CS-2	≈2/3	3	6	268	16	4	588	132
CS-3	≈3/4	3	6	312	16	4	676	220
CS-4	1	3	12	428	16	-	456	-

The channel coding for EGPRS PDTCH has nine modulation and coding schemes, MCS-1 to MCS-9. The coding parameters are shown in the table below.

Scheme	**Code rate**	**Header Code rate**	**Modulation**	**RLC blocks per Radio Block (20ms)**	**Raw Data within one Radio Block**	**Family**	**BCS**	**Tail payload**	**HCS**	**Data rate kb/s**
MCS-9	1.0	0.36	8PSK	2	2x592	A	2x12	2x6	8	59.2
MCS-8	0.92	0.36		2	2x544	A				54.4
MCS-7	0.76	0.36		2	2x448	B				44.8
MCS-6	0.49	1/3		1	592 *48*+544	A	12	6		29.6 27.2
MCS-5	0.37	1/3		1	448	B				22.4
MCS-4	1.0	0.53	GMSK	1	352	C				17.6
MCS-3	0.85	0.53		1	296 *48*+248 and 296	A				14.8 13.6
MCS-2	0.66	0.53		1	224	B				11.2
MCS-1	0.53	0.53		1	176	C				8.8

Note: The italic captions indicate the 6 octets of padding when retransmitting MCS-8 block with MCS-3 or MCS-6. For MCS-3, the 6 octets of padding are sent every second block (see 3GPP TS 04.60).

The modulation format from the Section 2 and 3 of TS 05.04 is:

For GMSK:

1. ***Modulating symbol rate:*** 1/T = 1 625/6 ksymb/s (i.e. approximately 270.833 ksymb/s), which corresponds to 1 625/6 kbit/s (i.e. 270.833 kbit/s). T is the symbol period.
2. ***Start and stop of the burst:*** The illustration in Figure 3-4 defines the start and stop of the active and the useful part of the burst.

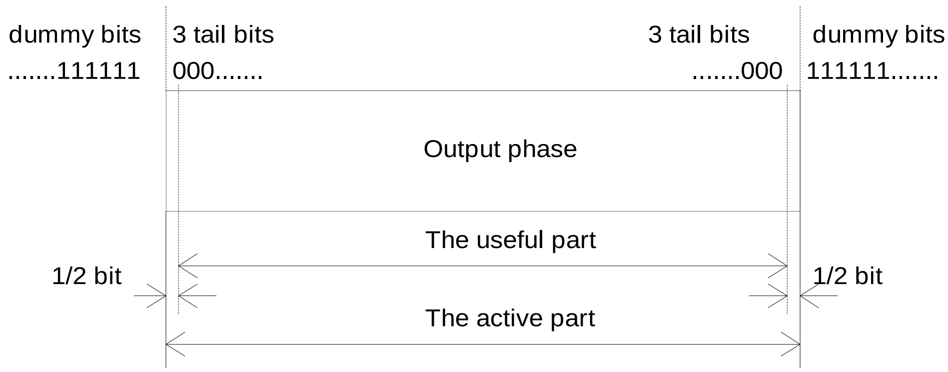


Figure 3-4: Relation between active part of burst, tail bits and dummy bits. For the normal burst the useful part lasts for 147 modulating bits

3. ***Differential encoding:*** Each data value *di = [0,1]* is differentially encoded. The output of the differential encoder is:

$$\hat{d}_i = d_i \oplus d_{i-1} \qquad (d_i \in \{0,1\})$$

Where ⊕ denotes modulo 2 addition.

The modulating data value αi input to the modulator is:

$$\alpha_i = 1 - 2\hat{d}_i \qquad (\alpha_i \in \{-1,+1\})$$

4. ***Filtering:*** The impulse response of a linear filter used is defined by:

$$g(t) = h(t) * rect\left(\frac{t}{T}\right)$$

Where the function *rect(x)* is defined by:

$$rect\left(\frac{t}{T}\right) = \frac{1}{T} \qquad for\ |t| < \frac{T}{2}$$

$$rect\left(\frac{t}{T}\right) = 0 \qquad otherwise$$

And * means convolution. *h(t)* is defined by:

$$h(t) = \frac{\exp\left(\frac{-t^2}{2\delta^2 T^2}\right)}{\sqrt{(2\pi)}\ .\ \delta T}$$

where

$$\delta = \frac{\sqrt{\ln(2)}}{2\pi BT} \qquad and\ BT = 0.3$$

B is the 3 dB bandwidth of the filter with impulse response *h(t)*.

5. ***Output phase:*** The phase of the modulated signal is:

$$\varphi(t') = \sum_i \alpha_i \pi h \int_{-\infty}^{t'-iT} g(u)du$$

where the modulating index *h* is ½. The time reference *t' = 0* is the start of the active part of the burst as shown in figure 7-4.

6. ***Modulation:*** The modulated RF carrier, except for start and stop of the TDMA burst may therefore be expressed as:

$$x(t') = \sqrt{\frac{2E_c}{T}}\ .\ \cos(2\pi f_0 t' + \varphi(t') + \varphi_0)$$

where E_c is the energy per modulating bit, f_0 is the centre frequency and φ_0 is a random phase and is constant during one burst.

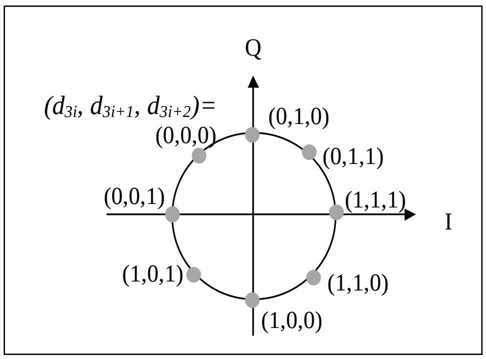
<u>*For 8PSK:*</u>

1. ***Modulating symbol rate:*** 1/T = 1 625/6 ksymb/s (i.e. approximately 270.833 ksymb/s), which corresponds to 1 625/6 kbit/s (i.e. 270.833 kbit/s). T is the symbol period.
2. ***Symbol mapping:*** The modulating bits are Gray mapped in groups of three to 8PSK symbols by the rule

$$s_i = e^{j2\pi l/8}$$

Where *l* is given by Table 7-3.

Table 7-3: Mapping between modulating bits and the 8PSK symbol parameter *l*.Modulating bits d_{3i},, d_{3i+1}, d_{3i+2}	Symbol parameter *l*
(1,1,1)	0
(0,1,1)	1
(0,1,0)	2
(0,0,0)	3
(0,0,1)	4
(1,0,1)	5
(1,0,0)	6
(1,1,0)	7



Start and stop of the burst: **illustrated in Figure 3-5.**

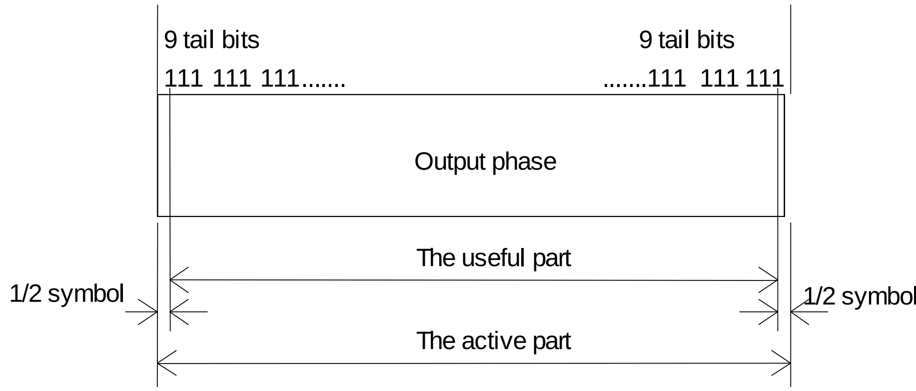


Figure 3-5: Relation between active part of burst and tail bits. For the normal burst the useful part lasts for 147 modulating symbols

3. ***Symbol rotation:*** The 8PSK symbols are continuously rotated with 3π/8 radians per symbol before pulse shaping. The rotated symbols are defined as

$$\hat{s}_i = s_i \cdot e^{j i 3\pi/8}$$

4. ***Pulse shaping:*** The modulating 8PSK symbols excite a linear pulse shaping filter. This filter is a linearised GMSK pulse. The impulse response is defined by:

$$c_0(t) = \begin{cases} \prod_{i=0}^{3} S(t+iT), & for\ 0 \le t \le 5T \\ 0, & else \end{cases}$$

where

$$S(t) = \begin{cases} \sin(\pi \int_0^t g(t')dt'), & for\ 0 \le t \le 4T \\ \sin(\frac{\pi}{2} - \pi \int_0^{t-4T} g(t')dt'), & for\ 4T < t \le 8T \\ 0, & else \end{cases}$$

$$g(t) = \frac{1}{2T}\left(Q(2\pi \cdot 0.3 \frac{t-5T/2}{T\sqrt{\log_e(2)}}) - Q(2\pi \cdot 0.3 \frac{t-3T/2}{T\sqrt{\log_e(2)}}) \right)$$

and $$Q(t) = \frac{1}{\sqrt{2\pi}} \int_t^{\infty} e^{-\frac{\tau^2}{2}} d\tau$$

The base band signal is

$$y(t') = \sum_i \ddot{s}_i \cdot c_0(t' - iT + 2T)$$

The time reference *t' = 0* is the start of the active part of the burst as shown in figure 7-5.

5. ***Modulation:*** The modulated RF carrier during the useful part of the burst can be expressed as

$$x(t') = \sqrt{\frac{2E_s}{T}} \operatorname{Re}\left[y(t') \cdot e^{j(2\pi f_0 t' + \varphi_0)}\right]$$

where E_s is the energy per modulating symbol, f_0 is the centre frequency and φ_0 is a random phase and is constant during one burst.

3.14 **2.1033 (c) (14) Test Data**

2.1033 (c) (14) The data required by Sec. Sec. 2.1046 through 2.1057, inclusive, measured in accordance with the procedures set out in Sec. 2.1041.

Qualcomm information:

See test report Exhibits.

3.15 **2.1033 (c) (18) Software Defined Radio Statement.**

Requirement: 2.1033 (c) (18) An application for certification of a software defined radio must include the information required by Sec. 2.944.

Qualcomm information:

The 2net Hub is not a software defined radio (SDR).