Telecommunications Standards Advisory Committee (TSAC)

Technical Specification

Internet of Things

Draft IMDA TS IOT
Issue 1, September 2017

Info-communications Media Development Authority
Resource Management & Standards
10 Pasir Panjang Road
#10-01 Mapletree Business City
Singapore 117438

Acknowledgement

The Info-communications Media Development Authority (IMDA) and the Telecommunications Standards Advisory Committee (TSAC) would like to acknowledge the following members of the TSAC Working Group 6 Low-Power Wide-Area Network Task Force (TSAC WG6 LPWAN TF) for their invaluable contributions to the preparation of this Technical Specification:

Draft IMDA TS IOT Issue 1, September 2017	Technical Specification for Internet of Things
Chairperson(s)	Dr Zander Lei; Senior Researcher, Huawei Singapore Research Center (Chairman)
	Mr Kuan Wai Mun; Assistant Director, Singapore Telecommunications Limited (Co-Chairman)
Chief Editor	Dr Ma Yugang; Senior Scientist, Institute for Infocomm Research (I²R), A*STAR
Editors	Dr Chen Qian; Scientist, Institute for Infocomm Research (I²R), A*STAR
Secretary	Ms Kong Pei Wee; Manager, Resource Management and Standards , Info-communications Media Development Authority

List of TSAC WG 6 LPWAN Task Force Members (2015-2018)

S/N	Organisation	Name
1	Ericsson Telecommunications Pte Ltd	Mr Samid Tennakoon, Chief Technical Officer
2	Gemalto Pte Ltd	Ms Jasling Ong, Country Manager
3	Huawei International Pte Ltd	Mr Chang Kian Kwan, Strategic Marketing Manager
4	Info-communications Media Development Authority	Mr Leck Leng Chye, Executive Manager
5		Mr Cason Neo, Manager
6	M1 Limited	Mr Denise Seek, Chief Technical Officer
7		Mr Simon Foo, Assistant General Manager
8		Ms April Cheam, Senior Engineer
9	National University of Singapore	Dr Biplab Sikdar, Assoc Professor
10	NOKIA	Mr Guillaume Mascot, Head
11	QUALCOMM	Ms Julie Welch, Senior Director
12		Mr Alex Orange, Director
13	Rohde & Schwarz	Mr Mike Cheong, Account Manager
14	Singapore University of Technology and Design	Dr Chau Yuen, Assistant Professor
15	StarHub Ltd	Mr Eddie Teo, Senior Manager

Telecommunications Standards Advisory Committee (TSAC)

The TSAC advises IMDA on the setting of ICT standards as well as on the development and recommendation of specifications, standards, information notes, guidelines and other forms of documentation for adoption and advancement of the standardisation effort of the Singapore ICT industry (hereafter termed "IMDA Standards").

Telecommunications standards-setting in Singapore is achieved with the assistance of TSAC, where professional, trade and consumer interest in telecommunications standards is represented on the TSAC with representatives from network and service operators, equipment suppliers and manufacturers, academia and researchers, professional bodies and other government agencies.

List of TSAC Members (2015-2018)

TSAC Chairman:

Mr Raymond Lee	Director (Resource Management & Standards) Info-communications Media Development Authority

TSAC Members:

Mr Lim Yuk Min (TSAC Vice-Chairman)	Senior Executive Consultant (Resource Management and Standards) Info-communications Media Development Authority
Mr Darwin Ho Kang Ming	Member Association of Telecommunications Industry of Singapore (ATIS)
Mr Yip Yew Seng	Honorary Secretary Association of Telecommunications Industry of Singapore (ATIS)
Dr Sun Sumei	Cluster Head Institute for Infocomm Research (I²R), A*STAR
Mr Denis Seek	CTO M1 Limited
Mr Tan Tiong Heng	Deputy Director, Engineering M1 Limited
Mr Goh Kim Soon	Senior Vice President Mediacorp Pte Ltd
Assoc Prof Guan Yong Liang	Nanyang Technological University School of Electrical & Electronic Engineering
Ms Lim Siew Eng	Director, Centre of Innovation for Electronic and IOT Nanyang Polytechnic
Assoc Prof Tham Chen Khong	National University of Singapore Department of Electrical & Computer Engineering
Dr Yu Changyuan	National University of Singapore Department of Electrical & Computer Engineering
Mr Widjaja Suki	Director, Products, Business Development & Process Netlink Trust Pte Ltd
Mr Ronald Lim	Head, Regulatory and Risk Management Nucleus Connect Pte Ltd
Mr Neo Yong Chiang	Chief Information Officer, Office of Information Services Republic Polytechnic
Mr Manik Narayan Saha	Singapore Infocomm Technology Federation
Assoc Prof Steven Wong Kai Juan	Programme Director Singapore Institute of Technology
Assoc Prof Ian Thng Li-Jin	Programme Director Singapore Institute of Technology
Dr Wong Woon Kwong	Director, Research and Industry Collaborations Singapore University of Technology and Design
Mr Kuan Wai Mun	Associate Director, Radio Network Quality Singapore Telecommunications Ltd

Mr Lew Yoon Heng	Senior Engineering Manager Singapore Telecommunications Ltd
Mr Jason Tan	Head, Standards SPRING Singapore
Mr Lim Eng Huat	Vice President StarHub Ltd
Mr Hong Tse Min	Assistant Director, Resource Management and Standards Info-communications Media Development Authority
Ms Woo Yim Leng	Senior Manager, Resource Management and Standards Info-communications Media Development Authority

Content

This Technical Specification is a living document which is subject to review and revision.

The Specifications of Devices for Internet of Things

1 Scope

This Specification defines the minimum technical requirements for Internet of Things (IoT) devices that use low power wide area network (LPWAN) technologies to operate in one of the authorised frequency bands or frequencies and transmit within the corresponding output power levels stated in this specification.

LPWAN technologies provide low-throughput, low-power and wide-area coverage for connecting IoT devices. Due to the diversity of IoT application requirements, a single technology is not capable of addressing all of the low power wide area technology use cases. While this Specification sets out requirements for User Equipment (UE) and Base Station (BS) which employ the Narrowband-IoT (NB-IoT) and/or Category M1 technologies defined in 3GPP Release 13 onwards, it is intended to include the different LPWAN technologies that operate in both licensed and licence-exempted frequency bands moving forward.

2 References

For the technical requirements captured in this Specification, reference has been made to the following standards. Where versions are not indicated, implementation of this Specification shall be based on current and valid versions of these standards published by the respective Standards Development Organisations.

[1] ITU-R Recommendation SM.329-12: Unwanted emissions in the spurious domain

[2] ITU-R Recommendation SM.328-11: Spectra and bandwidth of emission

[3] 3GPP TS 36.101 V13.8.0 (2017-06): 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception (Release 13)

[3a] 3GPP TS 36.101 V14.4.0 (2017-06): 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception (Release 14)

[4] 3GPP TS 36.104 V13.8.0 (2017-06): 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception (Release 13)

[5] 3GPP TS 37.104 V13.6.0 (2017-06): 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) radio transmission and reception (Release 13)

[6] 3GPP TS 36.521-1 V14.3.0 (2017-06): 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) conformance specification; Radio transmission and reception; Part 1: Conformance Testing (Release 14)

[7] 3GPP TS 36.141 V13.8.0 (2017-06): 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) conformance testing (Release 13)

[8] 3GPP TS 37.141 V13.8.0 (2017-06): 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; E-UTRA, UTRA and GSM/EDGE; Multi-Standard Radio (MSR) Base Station (BS) conformance testing (Release 13)

[9] ETSI EN 301 489-1: EMC standard for radio equipment and services; Harmonised Standard covering essential requirements of article 3.1(b) of the Directive 2014/53/EU and the essential requirements of article 6 of Directive 2014/30/EU; Part 1: Common technical requirements

[10] ETSI EN 301 489-24: EMC standard for radio equipment and services; Part 24: Specific conditions for IMT-2000 CDMA Direct Spread (UTRA and E-UTRA) for Mobile and portable (UE) radio and ancillary equipment

[11] ETSI EN 301 489-50: EMC standard for radio equipment and services; Part 50: Specific conditions for Cellular Communication Base Station (BS), repeater and ancillary equipment

[12] IEC 60950-1: Information technology equipment – Safety – Part 1: General requirements

[13] IEC 62368-1: Audio/video, information and communication technology equipment – Part 1: Safety requirements

[14] IEC 60215: Safety requirements for radio transmitting equipment

3 Abbreviations

3GPP	3rd Generation Partnership Project
AC	Alternating Current
ACLR	Adjacent Channel Leakage power Ratio
BS	Base Station
DC	Direct Current
EARFCN	E-UTRA Absolute Radio Frequency Channel Number
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EMS	Electromagnetic Sustainability
EN	European Standard
ETSI	European Telecommunications Standards Institute
E-UTRA	Evolved Universal Terrestrial Radio Access (also known as LTE)
FDD	Frequency Division Duplex
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEC	International Electrotechnical Commission
ITU-R	ITU Radiocommunication Sector
LTE	Long Term Evolution (also known as E-UTRA)
MPR	Maximum power reduction
NB-IoT	Narrowband – Internet of Things
OOB	Out-of-band
RF	Radio Frequency
UE	User Equipment

4 General Requirements

4.1 Power Supply

The IoT device may be AC powered or DC powered. For AC powered equipment, the Specification shall be complied with when operating from an AC mains supply of voltage, 230V ± 10%, and frequency, 50 Hz ± 2%. Where external power supply is used (e.g. AC/DC power converter), it shall not affect the capability of the equipment to meet the requirements of this Specification.

4.2 Radiation Safety Requirements

4.2.1 Use of the IoT device (UE or BS) shall comply with the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz).

4.2.2 Compliance with the specified radiation safety standards does not by itself confer immunity from legal obligations and requirements imposed by national health or safety authorities. IMDA may invalidate the equipment registration if so requested by the relevant authority for reasons of safety or hazards that would likely be caused to users.

4.3 Electromagnetic Compatibility (EMC) and Equipment Safety Requirements

4.3.1 EMC assessment

For EMC assessment, the IoT device (UE or BS) shall be classified as equipment for portable/mobile use (i.e. powered by its integral battery); or equipment for fixed use. This equipment classification is used to determine the applicability of the EMC (emission and immunity) testing requirements based on §5.5 and §7 of ETSI EN 301 489-1 [9].

EMI or emission measurements shall be performed on the IoT device (UE or BS), where applicable. EMS or immunity testing may be performed on the IoT device (UE or BS), where applicable.

The ETSI EN 301 489-1 [9] standard shall be used in conjunction with the ETSI EN 301 489-24 [10] standard for IoT device of UE Category NB1 and/or UE Category M1; and the ETSI EN 301 489-50 [11] standard for BS of E-UTRA, E-UTRA with NB-IoT, or standalone NB-IoT.

4.3.2 Equipment safety testing

Equipment safety testing or assessment shall be performed to requirements defined in IEC 60950-1 [12] or IEC 62368-1 [13], based on the following assumptions:

(a) IoT device (UE or BS) is powered by a dedicated external power supply, AC/DC power converter or charger/power adapter; and

(b) IoT device (UE or BS) operates with SELV in environments where overvoltage from telecommunication networks may be possible. SELV refers to voltages not exceeding 42.4 V peak or 60 V DC.

E-UTRA, E-UTRA with NB-IoT or standalone NB-IoT BS shall also be assessed for meeting the safety requirements defined in IEC 60215 [14] for radio transmitting equipment, operating under the responsibility of skilled persons.

5 Technical Requirements

5.1 Operating Frequencies

5.1.1 The IoT device (UE or BS) shall operate within the applicable frequency bands given in Table 1 of this Specification.

5.1.2 The precise operating frequency range of an IoT device (UE or BS) shall follow that of the Network Operator from whom the service is obtained.

Table 1: IoT Operating Frequency Bands

E-UTRA Band	Frequency Range		Duplex Mode
	Uplink (UL) BS receive / UE transmit	Downlink (DL) BS transmit / UE receive	
1	1920 MHz – 1980 MHz	2110 MHz – 2170 MHz	FDD
3	1710 MHz – 1785 MHz	1805 MHz – 1880 MHz	FDD
7	2500 MHz – 2570 MHz	2620 MHz – 2690 MHz	FDD
8	880 MHz – 915 MHz	925 MHz – 960 MHz	FDD
40	2300 MHz – 2400 MHz Note 1	2300 MHz – 2400 MHz Note 1	TDD

Note 1: Category M1 UE may operate in bands 1, 3, 7, 8 and 40 (§5.5E, 3GPP TS 36.101 [3a]). However, Category M1 UE operating in band 40 shall only transmit and receive within 2300 MHz – 2340 MHz.

Note 2: NB-IoT (UE and BS) may operate in E-UTRA bands 1, 3 and 8.

5.2 Radio Frequency (RF) Requirements

5.2.1 RF requirements for UE

Manufacturers or suppliers shall demonstrate that the UE (an IoT device which supports UE Category NB1 and/or Category M1) has been tested for operating in the applicable frequency bands stated in clause 5.1, Table 1. In addition to the general requirements outlined in Table 2 of this Specification, the UE shall be tested to comply with requirements specific to UE Category NB1 and/or Category M1 (differentiated by clauses with suffix F and E).

5.2.2 RF requirements for BS

Manufacturers or suppliers shall demonstrate that the BS which supports E-UTRA, E-UTRA with NB-IoT (in band and/or guard band) or standalone NB-IoT, has been tested for operating in frequency bands stated in clause 5.1, Table 1 and requirements outlined in Table 3 of this Specification. E-UTRA BS shall interwork with Category M1 UE operating in the same frequency bands.

Table 2: RF requirements for UE Category NB1 and Category M1

RF requirement	3GPP TS 36.101 [3]			3GPP TS 36.521-1 [6]
	General Requirements	Suffix F Requirements for UE Category NB1	Suffix E Requirements for UE Category M1	Reference for conformance testing
TX-RX frequency separation	§ 5.7.4	§ 5.7.4F for in-band and guard operations, it is flexible within the assigned channel bandwidth	§ 5.7.4E	§ 5.3
Channel bandwidth	§ 5.6	§ 5.6F, Table 5.6F-1	-	§ 5.4.2
Channel spacing	§ 5.7.1	§ 5.7.1F	-	§ 5.4.1
Channel raster	§ 5.7.2	§ 5.7.2F	-	§ 5.4.3
Carrier frequency and EARFCN	§ 5.7.3	§ 5.7.3F	-	§ 5.4.4
Transmit power	§ 6.2			§ 6.2
- UE maximum output power	§ 6.2.2	§ 6.2.2F, Table 6.2.2F-1	§ 6.2.2E, Table 6.2.2E-1	§ 6.2.2
- Maximum power reduction (MPR)	§ 6.2.3	§ 6.2.3F	§ 6.2.3E-1, Table 6.2.3E-2	§ 6.2.3
- Additional maximum power reduction (A-MPR)	§ 6.2.4	§ 6.2.4F	§ 6.2.4E-1, Table 6.2.4E-1	§ 6.2.4
- UE transmitted output power	§ 6.2.5	§ 6.2.5F	-	§ 6.2.5
Output power dynamics	§ 6.3			§ 6.3
- Minimum output power	§ 6.3.2	§ 6.3.2F	-	§ 6.3.2
- Transmit OFF power	§ 6.3.3	§ 6.3.3F	-	§ 6.3.3
- ON/OFF time mask	§ 6.3.4	§ 6.3.4F	-	§ 6.3.4
- Power control	§ 6.3.5	§ 6.3.5F	§ 6.3.5E	§ 6.3.5
Transmit signal quality	§ 6.5			§ 6.5
- Frequency error	§ 6.5.1	§ 6.5.1F	§ 6.5.1E	§ 6.5.1
- Transmit modulation quality	§ 6.5.2	§ 6.5.2F	§ 6.5.2E	§ 6.5.2
- Error vector magnitude		§ 6.5.2F.1	§ 6.5.2E.1	§ 6.5.2.1
- Carrier leakage		§ 6.5.2F.2	§ 6.5.2E.2	§ 6.5.2.2
- In-band emissions		§ 6.5.2F.3	§ 6.5.2E.3	§ 6.5.2.3

Table 2: RF requirements for UE Category NB1 and Category M1 (Cont'd)

RF requirement	3GPP TS 36.101 [3]			3GPP TS 36.521-1 [6] Reference for conformance testing
	General Requirements	Suffix F Requirements for UE Category NB1	Suffix E Requirements for UE Category M1	
Output RF spectrum emissions	§ 6.6			§ 6.6
- Occupied bandwidth	§ 6.6.1	§ 6.6.1F	-	§ 6.6.1
- Out-of-band (OOB) emission	§ 6.6.2	-	-	§ 6.6.2
- Spectrum emission mask	§ 6.6.2.1	§ 6.6.2F.1	-	§ 6.6.2.1
- Adjacent Channel Leakage power Ratio	§ 6.6.2.3.1	§ 6.6.2F.3, Table 6.6.2F.3-1	-	§ 6.6.2.3
- Spurious emission	§ 6.6.3 (in line with Category B limits defined in § 4.3 of ITU-R SM 329-12 [1])	§ 6.6.3F	-	§ 6.6.3
Transmit intermodulation	§ 6.7.1	§ 6.7.1F	-	§ 6.7

Table 3: RF requirements for E-UTRA, E-UTRA with NB-IoT or NB-IoT BS

RF requirement (Note 1)	3GPP TS 36.104 [4] or 3GPP TS 37.104 [5]	3GPP TS 36.141 [7] or 3GPP TS 37.141 [8] Reference for conformance testing
Operating bands	§ 5.5 [4] or § 4.5 [5] BS shall operate within applicable frequency bands given in § 5.1 and Table 1 of this Specification.	§ 5.5 [7] or § 4.4 [8]
Channel bandwidth	§ 5.6 NB-IoT requirements for channel bandwidths are defined in Tables 5.6-3, 5.6-3A [4].	§ 5.6, Tables 5.6-1, 5.6-3, 5.6-3A [7]
Channel arrangement		
Channel spacing	§ 5.7.1 [4] or § 4.6.1 [5]	§ 5.7.1 [7] or § 4.5.1 [8]
Channel raster	§ 5.7.2 [4] or § 4.6.2 [5]	§ 5.7.2 [7] or § 4.5.2 [8]
Carrier frequency and numbering	§ 5.7.3 [4] or § 4.6.3 [5]	§ 5.7.3 [7] or § 4.5.3 [8]
Transmitter characteristics		
Base station output power	§ 6.2 [4 or 5] - BS rated output power shall be as specified in Table 6.2-1, according to the BS class of the E-UTRA (LTE) BS (Note 2) deployed. § 6.2.1 [4 or 5] - Accuracy requirements § 6.5.4 [4] and § 6.2.6 [5] - Minimum requirement for DL NRS power	§ 6.2 [7or 8] § 6.5.4 [7] or § 6.2.2, § 6.2.5 [8]
Output power dynamics	§ 6.3, § 6.3.1, § 6.3.2, § 6.3.3 [4]; or § 6.3.1, § 6.3.5 [5]	§ 6.3 [7 or 8]
Transmitter signal quality	§ 6.5 [4 or 5]	§ 6.5 [7 or 8]
- Frequency error	§ 6.5.1, Table § 6.5.1-1 [4] or § 6.5.2.1, § 6.5.2.5 [5]	§ 6.5.1, Table 6.5.1-1 [7] or § 6.5.2, § 6.5.2.5.1, 6.5.2.5.5 [8]
- Modulation quality	§ 6.5.2, Table 6.5.2-1, Table 6.5.2-2 [4] or § 6.5.1.1, § 6.5.1.5 [5]	§ 6.5.2, Table 6.5.2.5-1, Table 6.5.2.5-1a [7] or § 6.5.1, § 6.5.1.5.1, § 6.5.1.5.5 [8]
- Time alignment error	§ 6.5.3 [4] or § 6.5.3.1, § 6.5.3.4 [5]	§ 6.5.3 [7 or 8]
Unwanted emissions	§ 6.6 [4 or 5], Category B limits (Note 3) defined in ITU-R SM.329-12 [1] shall be applied.	§ 6.6 [7 or 8]
- Occupied bandwidth	§ 6.6.1 [4] or § 6.6.3 [5] ITU-R SM.328-11 [2]	§ 6.6.1 [7] or § 6.6.3 [8]
- Adjacent Channel Leakage power Ratio (ACLR)	§ 6.6.2 [4]; or § 6.6.4.1, § 6.6.4.5 [5]	§ 6.6.2 [7] or § 6.6.4 [8]
- Operating band unwanted emissions	§ 6.6.3, § 6.6.3.2 [4]; or § 6.6.2 [5] § 6.6.3.2E [4] – Minimum requirements for standalone NB-IoT BS	§ 6.6.3 [7] or § 6.6.2 [8]
- Transmitter spurious emissions	§ 6.6.4, § 6.6.4.1.2, § 6.6.4.2 [4]; or § 6.6.1, § 6.6.1.1.2 [5]	§ 6.6.4 [7] or § 6.6.1, § 6.6.1.5.2 [8]

Table 3: RF requirements for E-UTRA, E-UTRA with NB-IoT or NB-IoT BS (Cont'd)

RF requirement (Note 1)	3GPP TS 36.104 [4] or 3GPP TS 37.104 [5]	3GPP TS 36.141 [7] or 3GPP TS 37.141 [8] Reference for conformance testing
Co-location with other BS	§ 6.6.4.4 [4] or § 6.6.1.4 [5]	§ 6.6.4.5.5 [7] or § 6.6.1.5.6 [8]
Transmitter intermodulation	§ 6.7.1 [4 or 5], shall not exceed the unwanted emission limits defined in § 6.6 [4 or 5] in the presence of interfering signal outlined in Table 6.7.1-1, Table 6.7.1-2 and Table 6.7.1-3 [4]; or Table 6.7.1-1 [5].	§ 6.7 [7 or 8]

Note 1: Where relevant, requirements shall be applied to BS that supports E-UTRA, E-UTRA with NB-IoT in-band and/or guard-band operation; or NB-IoT standalone operation.

Note 2: For NB-IoT in-band and guard band operations, the E-UTRA (LTE) carrier and the NB-IoT carrier shall share the E-UTRA (LTE) carrier output power. Category M1 operations shall share the same E-UTRA (LTE) carrier and carrier output power.

Note 3: Category B limits have been adopted for fixed and mobile equipment defined in § 4.3 of ITU-R SM.329-12 [1], e.g. land mobile services and short range devices.