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INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS,
NEXT-GENERATION NETWORKS, INTERNET OF
THINGS AND SMART CITIES

Internet of things and smart cities and communities –
Requirements and use cases

**Requirements and use cases for universal
communication module of mobile IoT devices**

Recommendation ITU-T Y.4210



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Recommendation ITU-T Y.4210

Requirements and use cases for universal communication module of mobile IoT devices

Summary

As an important part of mobile Internet of things (IoT) devices, the universal communication module is a key component to achieve economies of scale for mobile IoT devices, accelerate the progress of research and development, and promote the application of new mobile IoT technologies.

Recommendation ITU-T Y.4210 specifies requirements for a universal communication module of mobile IoT devices.

Related use cases are provided in Appendix I. Universal communication module reference types are described in Appendix II.

History

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Recommendation ITU-T Y.4210

Requirements and use cases for universal communication module of mobile IoT devices

1 Scope

Currently, the communication modules produced by different vendors of modules for mobile Internet of things (IoT) devices have different designs, which results in a fragmented communication module market and low compatibility. The universal communication module is a key component to achieve economies of scale for mobile IoT devices, accelerate the progress of research and development and promote the application of new mobile IoT technologies.

This Recommendation introduces the concept of a universal communication module of mobile IoT devices, analyses the requirements for universal communication module implementations of mobile IoT devices, and provides use cases for the universal communication module of mobile IoT devices.

In this Recommendation, the universal communication module actually represents a series of communication modules.

The communication technologies related to all the communication modules which are addressed in this Recommendation – and used by mobile IoT devices – are the 3GPP low power wide area (LPWA) technologies (currently, narrow band-Internet of things (NB-IoT) [b-3GPP TS 36.300] and enhanced machine type communication (eMTC) [b-3GPP TS 36.300]).

Different communication modules can apply to different IoT application scenarios, such as smart utility metering, smart home, logistics tracking, smart bicycles, intelligent buildings and so on.

The scope of this Recommendation includes:

- concept and classification of universal communication module of mobile IoT devices;
- requirements of universal communication module of mobile IoT devices – considering the requirements for the different communication module types of mobile IoT devices;
- use cases of universal communication module of mobile IoT devices.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ETSI TS 127 005] ETSI TS 127 005 V14.0.0 (2017-04), *Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS); LTE; Use of Data Terminal Equipment – Data Circuit terminating Equipment (DTE – DCE) interface for Short Message Service (SMS) and Cell Broadcast Service (CBS) (3GPP TS 27.005 version 14.0.0 Release 14)*.

[ETSI TS 127 007] *ETSI TS 127 007 V13.7.0 (2018-04), Digital cellular telecommunications system (Phase 2+) (GSM); Universal Mobile Telecommunications System (UMTS); LTE; AT command set for User Equipment (UE) (3GPP TS 27.007 version 13.7.0 Release 13).*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 application [b-ITU-T Y.2091]: A structured set of capabilities, which provide value-added functionality supported by one or more services, which may be supported by an API interface.

3.1.2 capability [b-ITU-R M.1224-1]: The ability of an item to meet a service demand of given quantitative characteristics under given internal conditions.

3.1.3 Internet of things (IoT) [b-ITU-T Y.2060]: A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on, existing and evolving, interoperable information and communication technologies.

NOTE 1 – Through the exploitation of identification, data capture, processing and communication capabilities, the IoT makes full use of things to offer services to all kinds of applications, whilst ensuring that security and privacy requirements are fulfilled.

NOTE 2 – In a broad perspective, the IoT can be perceived as a vision with technological and societal implications.

3.1.4 thing [b-ITU-T Y.2060]: In the Internet of things, this is an object of the physical world (physical things) or of the information world (virtual things), which is capable of being identified and integrated into the communication networks.

3.1.5 attention (AT) [b-3GPP TS 27.007]: It is always used to start a command line to be sent from terminal equipment (TE) to terminal adaptor (TA).

3.1.6 terminal equipment (TE) [b-3GPP TS 27.007]: Terminal equipment, such as a computer, equal to data terminal equipment (DTE).

3.1.7 terminal adaptor (TA) [b-3GPP TS 27.007]: Terminal adaptor (TA) such as a global system for mobile communication (GSM) data card, equal to data circuit terminating equipment (DCE).

3.1.8 service centre [b-3GPP TS 23.040]: Function responsible for the relaying and storage and forwarding of a short message between a short message entity (SME) and a mobile subscriber (MS).

3.1.9 short message entity (SME) [b-3GPP TS 23.040]: Entity which may send or receive short messages.

3.1.10 cellular IoT (CIoT) [b-3GPP TS 23.401]: Cellular network supporting low complexity and low throughput devices for a network of things.

3.1.11 extended idle mode DRX (eDRX) [b-3GPP TS 23.682]: The user equipment (UE) and the network may negotiate over non-access stratum signalling the use of extended idle mode discontinuous reception (DRX) for reducing its power consumption, while being available for mobile terminating data and/or network originated procedures within a certain delay dependent on the DRX cycle value.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 package: A casing that holds the circuit.

NOTE – With the package, on one hand, the circuit can be protected from corrosion or physical damage; on the other hand, the circuit still has electrical contacts which can be connected with a printed circuit board.

3.2.2 pad: Physical contact on a module.

3.2.3 pad spacing: Distance between two adjacent pads on a common row or column of a module.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ADC	Analogue-to-Digital Converter
APN	Access Point Name
AT	Attention
CIoT	Cellular IoT
DC	Direct Current
DCE	Data Circuit terminating Equipment
DRX	Discontinuous Reception
DTE	Data Terminal Equipment
EDGE	Enhanced Data rate for GSM Evolution
eDRX	Extended idle mode DRX
eMTC	enhanced Machine Type Communication
GNSS	Global Navigation Satellite System
GPIO	General Purpose Input Output
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communication
I2C	Inter-Integrated Circuit bus
I2S	Integrated Inter Chip Sound
IMEI	International Mobile Equipment Identity
IMSI	International Mobile Subscriber Identification Number
IoT	Internet of Things
IP	Internet Protocol
LCC	Leadless Chip Carriers
LGA	Land Grid Array
LPWA	Low Power Wide Area
MCU	Microcontroller Unit
MS	Mobile Subscriber
NB-IoT	Narrow Band-Internet of Things

PCM	Pulse Code Modulation
PDU	Protocol Data Unit
PLMN	Public Land Mobile Network
RF	Radio Frequency
RTC	Real Time Clock
SDK	Software Development Kit
SIM	Subscriber Identity Module
SME	Short Message Entity
SMS	Short Message Service
SN	Serial Number
SPI	Serial Peripheral Interface
TA	Terminal Adaptor
TBD	To Be Determined
TE	Terminal Equipment
UART	Universal Asynchronous Receiver/Transmitter
UE	User Equipment
URL	Uniform Resource Locator
USB	Universal Serial Bus
USIM	Universal Subscriber Identity Module

5 Conventions

The following conventions are used in this Recommendation:

- The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted, if conformance to this Recommendation is to be claimed.
- The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.
- The keywords "can optionally" and "may" indicate an optional requirement which is permissible, without implying any sense of being recommended. These terms are not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

6 Concept of universal communication module of mobile IoT devices

As an important part of mobile IoT devices, the universal communication module is a key component to achieve economies of scale for mobile IoT devices, accelerate the progress of research and development, and promote the application of new mobile IoT technologies.

A universal communication module of mobile IoT devices is required to include a baseband unit and a radio frequency (RF) front end unit, as shown in Figure 1.

A universal communication module of mobile IoT devices may also include a microcontroller unit (MCU), a global navigation satellite system (GNSS) positioning unit, a sensor unit, a subscriber identity module (SIM)/universal subscriber identity module (USIM) card and an antenna.

NOTE – The baseband unit and RF front end unit are the key parts for communication. The baseband unit and the RF front end unit are mandatory.

As the processing capability of the MCU unit embedded in the communication module may not meet the requirements, another MCU (not embedded in the communication module) may be used. The MCU unit is optional.

The GNSS unit is useful for positioning based services. Because of its specific applicability, the GNSS unit is optional.

The SIM/USIM card can be supplied by different vendors. The SIM/USIM card is optional.

The size of the antenna depends on the frequencies. The antenna is optional.

The selection of sensors depends on user requirements. The sensor unit is optional.

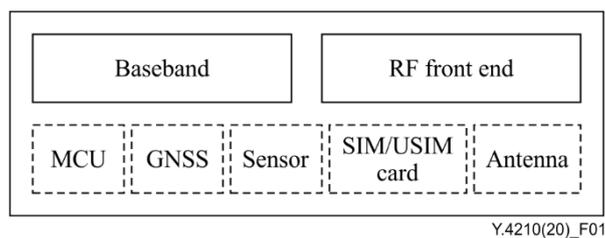


Figure 1 – Structure of a universal communication module of mobile IoT device

7 Universal communication module classification

7.1 Universal communication module characteristics

To facilitate mobile IoT device development, the following common characteristics are based on the collection and selection of characteristics from diverse mobile IoT application scenarios, including mechanical characteristics, electrical characteristics, software characteristics, performance characteristics, application scope characteristics and communication mode characteristics.

1) Mechanical characteristics:

- Package: including but not limited to leadless chip carriers (LCC) [b-Information Package-1] and land grid array (LGA) [b-Information Package-2].

NOTE 1 – LCC and LGA are widely used packages in current mobile IoT modules industry.

- Size: length, width and thickness.

NOTE 2 – Different application requirements have an effect on the module size.

- Pad size and pad spacing
- Pad assignments

2) Electrical characteristics:

- Power supply interface, used to supply the power for universal communication modules.

NOTE 3 – Power supply voltage is a key indicator of power consumption in current mobile IoT modules industry.

- RF interface, used to send or receive wireless signals for universal communication modules.

NOTE 4 – A single RF interface is widely used in current mobile IoT modules industry.

NOTE 5 – In case of position based service support, an additional RF interface for GNSS is usually used.

- Module control and status interface, used to control universal communication modules: including but not limited to Power on/off, Reset, Wakeup.
 - SIM/USIM [b-ETSI TS 102 671] interface, used to connect SIM/USIM card with universal communication modules.
 - Data input/output interfaces, used to implement data exchange between universal communication modules and external circuits: including but not limited to universal asynchronous receiver/transmitter (UART) [b-Information Electrical-Interface-2], general purpose input output (GPIO) [b-Information Electrical-Interface-1], inter-integrated circuit bus (I2C) [b-Information Electrical-Interface-1], serial peripheral interface (SPI) [b-Information Electrical-Interface-1] and universal serial bus (USB) [b-Information Electrical-Interface-2].
 - Analogue interface, used to convert an analogue signal into a digital signal by universal communication modules: including but not limited to analogue-to-digital converter (ADC) [b-Information Electrical-Interface-1].
 - Audio interface, used to support voice communication by universal communication modules: including but not limited to pulse code modulation (PCM) [b-Information Electrical-Interface-1] and integrated inter chip sound (I2S) [b-Information Electrical-Interface-1].
- 3) Software characteristics:
- Universal module management, for maintainability and usability of communication modules.
 - Debugging function, to debug the universal communication modules.
 - Minimum AT commands, for software development compatibility of universal communication modules.
- 4) Performance characteristics:
- Storage
 - Temperature
- 5) Application scope characteristics:
- The application scope deals with the applications the communication module is used for: consumer applications, industrial applications and vehicle applications.
- 6) Communication mode characteristics:
- Communication modes: as examples, global system for mobile communication (GSM)/general packet radio service (GPRS)/ enhanced data rate for GSM evolution (EDGE) [b-3GPP TS 05.01], NB-IoT, eMTC.

NOTE 6 – Based on application scenarios, a communication module may have one or more communication modes.

7.2 Universal communication module classification factors

The universal communication module is recommended to comply with the following requirements.

- Every type of universal communication module is recommended to cover a large variety of application scenarios.
- Every universal communication module of a given type (i.e., small size or normal size as identified in this clause) is recommended to be compatible with other universal communication modules of the same type.

NOTE 1 – Electrical requirements and software requirements are common to both types of universal communication module. The mechanical requirements differ among the different universal communication module types.

The universal communication module classification factors are shown in Figure 2 and described below.

Mechanical requirements	Application scope	Communication modes
-------------------------	-------------------	---------------------

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Figure 2 – Universal communication module classification factors

1) Mechanical requirements:

The mechanical requirements are the key factor. This includes, but is not limited to, the following aspects: layout (package and size), pad size and spacing, and pad assignments.

Layout is used to ensure the same package, same length and same width for universal communication modules of a given type.

Pad size and spacing are used to ensure the same pad size for universal communication module of a given type.

Pad assignments are used to ensure the same pad assignments for universal communication modules of a given type.

While the module size becomes smaller, the number of pads decreases, and the functional capabilities of the universal communication module are reduced; while the module size becomes bigger, the number of pads increases, and the functional capabilities of universal communication module are enhanced.

NOTE 2 – Based on different mechanical requirements, two universal communication module types are identified as described in clause 8: Small size universal communication module (recommended size less than 20mm*20mm) and normal size universal communication module (recommended size more than 20mm*20mm and less than 30mm*30mm) [b-GSMA-Module].

2) Application scope:

The application scope factor addresses three categories of applications: consumer category, industrial category and vehicle category.

3) Communication modes:

The communication modes factor is classified according to two categories:

- Single mode: NB-IoT or eMTC (NB-IoT/eMTC)
- Multimode: NB-IoT and eMTC; NB-IoT and GSM; NB-IoT, eMTC and GSM.

8 Mechanical requirements

A universal communication module of mobile IoT device is recommended to meet the following mechanical requirements according to the communication module type (small size or normal size).

8.1 Mechanical requirements for small size universal communication module

This type of universal communication module is recommended for NB-IoT/eMTC single mode. The application target of this type of universal communication module includes NB-IoT/eMTC applications such as smart utility metering, smart home, intelligent buildings.

It is recommended to use LCC or LGA package.

Figure 3 shows a recommended layout for a small size universal communication module.

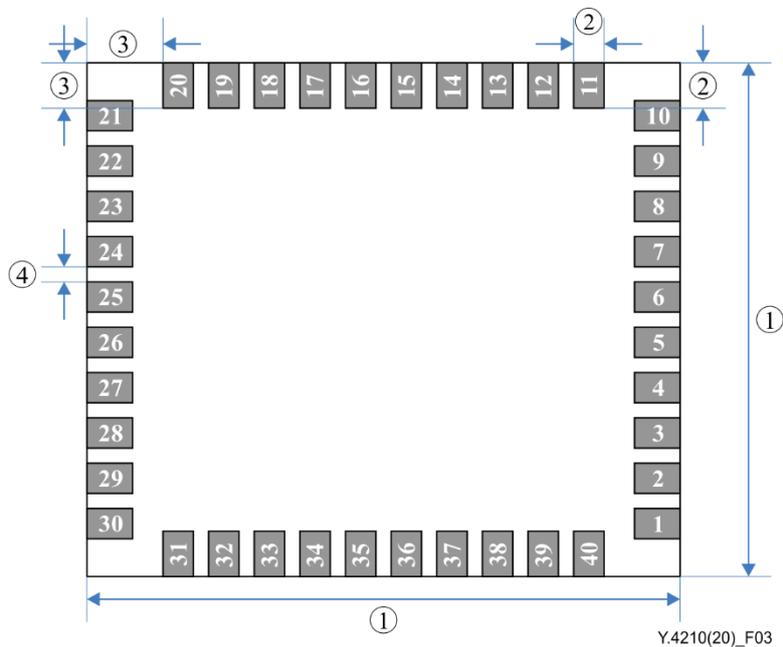


Figure 3 – Recommended layout for small size universal communication module

In Figure 3: ① represents the size of the universal communication module; ② represents the size of the pad; ③ represents the size of pad spacing; ④ represents the edge spacing. Table 1 gives recommended pad assignments for this layout.

Table 1 – Recommended pad assignments for small size universal communication module

Pad No.	Pad name	Pad description
1	UART2_TXD	TXD for the 2 nd UART
2	UART2_RXD	RXD for the 2 nd UART
3	SPI_SS	SS for SPI
4	SPI_MISO	MISO for SPI
5	SPI_MOSI	MOSI for SPI
6	SPI_SCLK	SCLK for SPI
7	UART1_CTS	CTS for the 1 st UART
8	UART1_RTS	RTS for the 1 st UART
9	UART1_TXD	TXD for the 1 st UART
10	UART1_RXD	RXD for the 1 st UART
11	USIM_DETECT	DETECT for USIM
12	USIM_RESET	RESET for USIM
13	USIM_CLK	CLK for USIM
14	USIM_DATA	DATA for USIM
15	USIM_VCC	Power supply for USIM
16	WAKEUP_OUT	Module wakes up host
17	RESET	Reset
18	WAKEUP_IN	Host wakes up module
19	POWER_ON/OFF	Power on/off

Table 1 – Recommended pad assignments for small size universal communication module

Pad No.	Pad name	Pad description
20	VDD	Reference logic level from module
21	SYS_STATE	Module status indication
22	GND	Ground
23	GND	Ground
24	GNSS_ANT	GNSS antenna
25	GND	Ground
26	GND	Ground
27	ANT0	Antenna
28	GND	Ground
29	GND	Ground
30	GND	Ground
31	VCC1	Power supply
32	VCC2	Power supply
33	RTC Power	Power supply for RTC
34	GPIO	General purpose Input/Output
35	GPIO	General purpose Input/Output
36	I2C_SCL	SCL for I ² C
37	I2C_SDA	SDA for I ² C
38	ADC	Analogue-to-Digital Converter
39	RESERVED	To Be Determined (TBD)
40	RESERVED	TBD

NOTE – Appendices II.1 and II.2 describe the reference types for the small size universal communication module.

8.2 Mechanical requirements for normal size universal communication module

This type of universal communication module is recommended for multimode.

This type of universal communication module has a general application target.

It is recommended to use LCC or LGA package.

Figure 4 shows a recommended layout for normal size universal communication module.

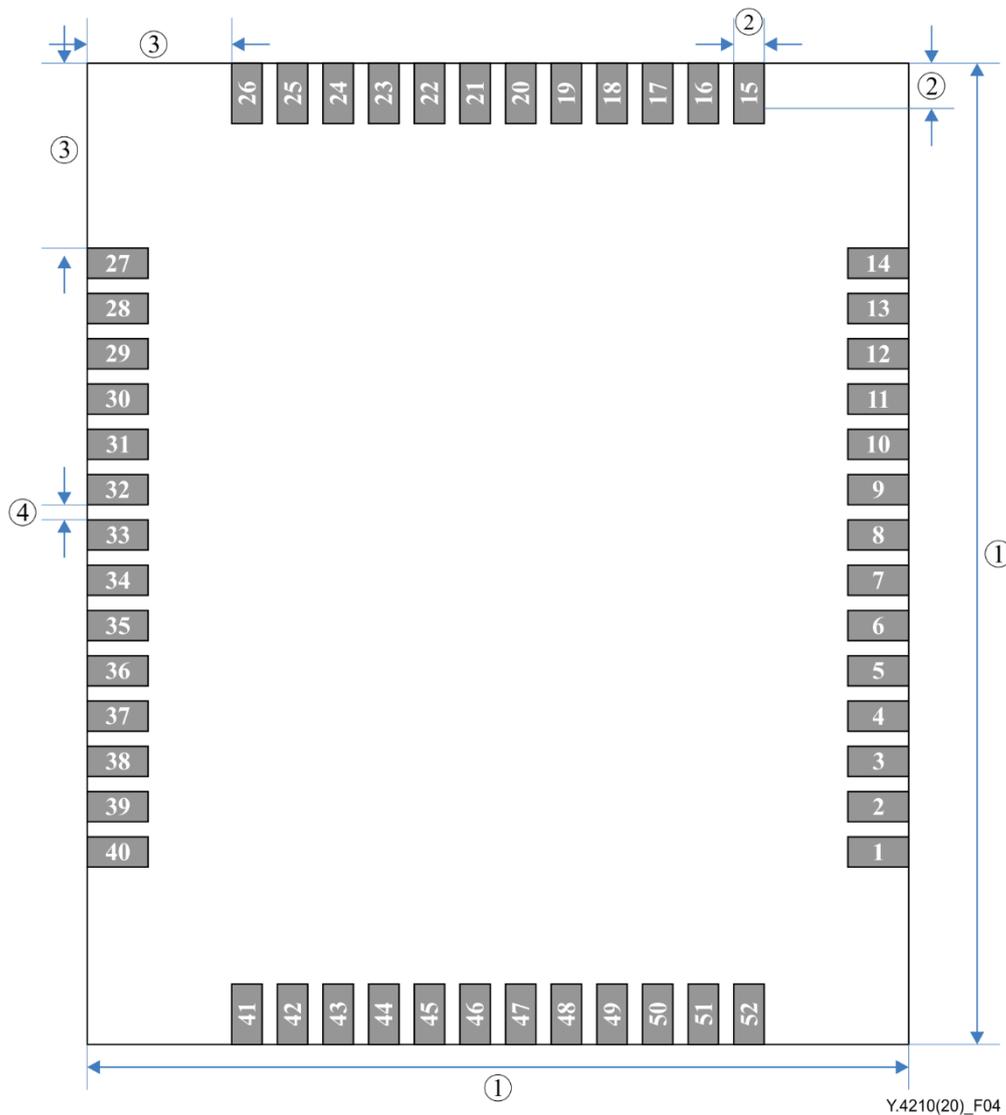


Figure 4 – Recommended layouts for normal size universal communication module

In Figure 4: ① represents the size of the universal communication module; ② represents the size of the pad; ③ represents the size of pad spacing; ④ represents the edge spacing. Table 2 gives recommended pad assignments for this layout.

Table 2 – Recommended pad assignments for normal size universal communication module

Pad No.	Pad name	Pad description
1	UART1_TXD	TXD for the 1 st UART
2	UART1_RXD	RXD for the 1 st UART
3	UART1_CTS	CTS for the 1 st UART
4	UART1_RTS	RTS for the 1 st UART
5	SPI_SS	SS for SPI
6	SPI_MISO	MISO for SPI
7	SPI_MOSI	MOSI for SPI
8	SPI_SCLK	SCLK for SPI
9	USIM_VCC	Power supply for USIM

Table 2 – Recommended pad assignments for normal size universal communication module

Pad No.	Pad name	Pad description
10	USIM_RESET	RESET for USIM
11	USIM_DATA	DATA for USIM
12	USIM_CLK	CLK for USIM
13	USIM_GND	Ground for USIM
14	USIM_DETECT	DETECT for USIM
15	RTC Power	Power supply for RTC
16	VCC1	Power supply
17	VCC2	Power supply
18	GND	Ground
19	GND	Ground
20	GND	Ground
21	GND	Ground
22	GNSS_ANT	GNSS antenna
23	GND	Ground
24	GND	Ground
25	ANT0	Antenna
26	GND	Ground
27	USB_Dp	USB data (positive)
28	USB_Dn	USB data (negative)
29	VBUS	USB detect
30	GND	Ground
31	ADC	Analogue-to-Digital Converter
32	GND	Ground
33	GPIO	General purpose Input/Output
34	GPIO	General purpose Input/Output
35	GPIO	General purpose Input/Output
36	GPIO	General purpose Input/Output
37	WAKEUP_OUT	Module wakes up host
38	RESET	Reset
39	WAKEUP_IN	Host wakes up module
40	POWER_ON/OFF	Power on/off
41	VDD	Reference logic level from module
42	SYS_STATE	Module status indication
43	UART2_TXD	TXD for the 2 nd UART
44	UART2_RXD	RXD for the 2 nd UART
45	I2C_SCL	SCL for I ² C
46	I2C_SDA	SDA for I ² C
47	RESERVED	TBD
48	RESERVED	TBD

Table 2 – Recommended pad assignments for normal size universal communication module

Pad No.	Pad name	Pad description
49	RESERVED	TBD
50	RESERVED	TBD
51	RESERVED	TBD
52	RESERVED	TBD

NOTE – Appendices II.3 and II.4 describe the reference types for the normal size universal communication module.

9 Electrical requirements

A universal communication module of mobile IoT device is recommended to meet the following electrical requirements, including power supply interface, module control and status interface, RF interface, SIM/USIM interface, data input/output interface, analogue interface and audio interface.

9.1 Power supply interface

9.1.1 DC power supply interface

Universal communication modules are required to support a direct current (DC) power supply interface. Table 3 provides a DC power supply interface description.

Table 3 – DC power supply interface description

Interface type	Pad name	Description	Type
Power supply interface	VCC _n , n=0,1, ...	External DC power supply	Input

9.1.2 RTC power supply interface

Universal communication modules may support a real time clock (RTC) power supply interface. Table 4 provides a RTC power supply interface description.

Table 4 – RTC power supply interface description

Interface type	Pad name	Description	Type
Power supply interface	RTC Power	Module clock power input	Input

NOTE – RTC power supply interface is used to ensure that the internal clock of universal communication modules can still work even if DC power supply doesn't work.

9.2 Module control and status interface

9.2.1 Power switch and status indication interface

Universal communication modules are recommended to support a power switch and status indication interface. Table 5 provides a power switch and status indication interface description.

Table 5 – Power switch and status indication interface description

Interface type	Pad name	Description	Type
Control and status interface	POWER_ON/OFF	Power switch to power on/off the module	Input
	SYS_STATE	Indication of module current status.	Output

9.2.2 Module reset interface

Universal communication modules are required to support a module reset interface. Table 6 provides a module reset interface description.

Table 6 – Module reset interface description

Interface type	Pad name	Description	Type
Control and status interface	RESET	Used for module reset	Input

9.2.3 Module wakeup interface

Universal communication modules may support module wakeup interface. Table 7 provides a module wakeup interface description.

Table 7 – Module wakeup interface description

Interface type	Pad Name	Description	Type
Control and status interface	WAKEUP_IN	For external device to wake up the module	Input
	WAKEUP_OUT	For module to wake up other devices	Output

9.2.4 Reference voltage of VDD output interface

Universal communication modules may support a reference voltage of VDD output interface. Table 8 provides a reference voltage of VDD output interface description.

Table 8 – Reference voltage of VDD output interface description

Interface type	Pad name	Description	Type
Control and status interface	VDD	Reference voltage output interface	Output

NOTE – Reference voltage of VDD output interface is used to supply the standard power for circuits external to the universal communication module.

9.3 RF interface

Universal communication modules are required to support ANT0 interface (main antenna interface) and may support GNSS ANT interface. Table provides a 9 RF interface description.

Table – 9 RF interface description

Interface type	Pad name	Description	Type
Radio interface	ANT _n , n=0,1, ...	Main antenna	Input/Output
	GNSS_ANT	GNSS antenna	Input

NOTE – GNSS ANT interface is used for position-based services.

9.4 SIM/USIM interface

Universal communication modules are required to support SIM/USIM interface. Table 10 provides a SIM/USIM interface description.

Table 10 – SIM/USIM interface description

Interface type	Pad name	Description	Type
USIM interface	USIM_GND	USIM ground	N/A
	USIM_DETECT	USIM DETECT signal	Input
	USIM_RESET	USIM RESET signal	Output
	USIM_CLK	USIM CLK signal	Output
	USIM_DATA	USIM DATA signal	Input/Output
	USIM_VCC	USIM power output	Output

9.5 Data input/output interfaces

9.5.1 UART interface

Universal communication modules are required to support a two-wire UART interface and are recommended to support four-wire UART interface. Table 11 provides a UART interface description.

Table 11 – UART interface description

Interface type	Pad name	Description	Type
Data Input/Output interface	UART _n _RXD, n=0,1, ...	Receive data	Input
	UART _n _TXD, n=0,1, ...	Transmit data	Output
	UART _n _RTS, n=0,1, ...	Request to send data	Input
	UART _n _CTS, n=0,1, ...	Clear to send data	Output

NOTE – Two-wire UART interface only contains UART_RXD and UART_TXD interfaces. Four-wire UART interface contains UART_RTS, UART_CTS, UART_RXD and UART_TXD interfaces, which can supply more powerful communication capability.

9.5.2 GPIO interface

Universal communication modules are recommended to support a GPIO interface. Table 12 provides a GPIO interface description.

Table 12 – GPIO interface description

Interface type	Pad name	Description	Type
Data Input/Output interface	GPIO _n , n=0,1, ...	General input /output interface with recommended interrupt function	Input/Output

9.5.3 I2C interface

Universal communication modules are recommended to support I2C interface. Table 13 provide a I2C interface description.

Table 13 – I2C interface description

Interface type	Pad name	Description	Type
Data Input/Output interface	I2C_SCL	Bidirectional clock line	Input/Output
	I2C_SDA	Bidirectional data line	Input/Output

9.5.4 SPI interface

Universal communication modules are recommended to support SPI interface. Table 14 provides a SPI interface description.

Table 14 – SPI interface description

Interface type	Pad name	Description	Type
Data Input/Output interface	SPI_SS	SS signal of SPI interface	Input
	SPI_MISO/SPI_MISO	MISO signal of SPI interface	Output
	SPI_MOSI/SPI_MOSI	MOSI signal of SPI interface	Input
	SPI_SCLK/SPI_SCLK	SCLK signal of SPI interface	Input

9.5.5 USB interface

Universal communication modules may support USB interface. Table 15 provides a USB interface description.

Table 15 – USB interface description

Interface type	Pad name	Description	Type
Data Input/Output interface	USB_Dp	USB USB data signal lines (positive differential)	Input/Output
	USB_Dn	USB USB data signal lines (negative differential)	Input/Output
	VBUS	Power supply	Input

9.6 Analogue interface

9.6.1 ADC interface

Universal communication modules may support ADC interface. Table 16 provides an ADC interface description.

Table 16 – ADC interface description

Interface type	Pad name	Description	Type
Analogue interface	ADC _n , n=0,1, ...	AD conversion interface	Input/Output

9.7 Audio interface

9.7.1 PCM interface

Universal communication modules may support PCM interface. Table 17 provides a PCM interface description.

Table 17 – PCM interface description

Interface type	Pad name	Description	Type
Audio interface	PCM_SYNC	PCM synchronization signal	Output
	PCM_DIN	PCM input data	Input
	PCM_DOUT	PCM output data	Output
	PCM_CLK	PCM clock	Input

NOTE – PCM interface is used to support voice communication service.

9.7.2 I2S interface

Universal communication modules may support I2S interface. Table 18 provides a I2S interface description.

Table 18 – I2S interface description

Interface type	Pad name	Description	Type
Audio interface	I2S_WS	I2S word select signal	Input/Output
	I2S_DIN	I2S input data	Input
	I2S_DOUT	I2S output data	Output
	I2S_CLK	I2S clock	Input

NOTE – I2S interface is used to support voice communication service.

10 Software requirements

A universal communication module of a mobile IoT device is recommended to meet the following software requirements, including universal communication module management, debugging function and minimum AT commands.

10.1 Universal communication module management

In order to improve the maintainability and usability of universal communication modules, it is required to support universal communication module management which includes module identification management, module status management, firmware upgrading management, module parameters profile management, module communication management and module SIM/USIM interface management.

10.1.1 Module identification management

In order to allow IoT platforms to manage mobile IoT devices, universal communication modules are required to be identified. Module identification is recommended to include but not limited to the following identification methods: international mobile equipment identity (IMEI), international mobile subscriber identification number (IMSI) and serial number (SN).

10.1.2 Module status management

Universal communication modules are recommended to support module status detection and management, including but not limited to hardware status, software status and communication status.

10.1.3 Firmware upgrading management

Universal communication modules are recommended to support firmware upgrade, including local firmware upgrade and remote firmware upgrade over the air.

10.1.4 Module parameters profile management

Universal communication modules are recommended to pre-set cellular network configuration parameters, including but not limited to access point name (APN), short message service (SMS) service centre address, IoT platform Internet protocol (IP) address or uniform resource locator (URL) and port number.

10.1.5 Module communication management

Universal communication modules are recommended to support IPv6.

Detailed optional support related to IPv6 may be based on GSMA TS.34 (clause 5.3) [b-GSMA TS.34].

10.1.6 Module SIM/USIM interface management

Universal communication modules are recommended to support SIM/USIM interface management to enable SIM/USIM over the air management and remote provisioning.

Detailed optional support for SIM/USIM over the air management and remote provisioning may be based on GSMA TS.34 (clause 5.6) [b-GSMA TS.34].

10.2 Debugging function

Universal communication modules are recommended to support debugging function. If this feature is enabled, debugging logs are recommended to be configured to output through the following data input/output interfaces, including but not limited to UART, USB and SPI.

10.3 Minimum AT commands

In order to ensure the software development compatibility for different universal communication modules, it is recommended to define minimum AT commands, including AT minimum commands for SMS, AT minimum General commands, AT minimum commands for network services, AT minimum commands for mobile termination control and status, AT minimum commands for Mobile termination errors and AT minimum commands for packet domain.

NOTE – 3GPP and ETSI has defined hundreds of AT commands [ETSI TS 127 005] [ETSI TS 127 007] [b-3GPP TS 27.007]. Currently, only a small part of these AT commands is usually implemented, which leads to compatibility problems for software development. It is needed to define minimum AT commands to ensure the software development compatibility for different universal communication modules.

10.3.1 AT minimum commands for SMS

Table 19 lists the recommended AT minimum commands for SMS derived from [ETSI TS 127 005], including the basic functionality of SMS service.

Table 19 – AT minimum commands for SMS

AT commands	Description
CSMS (Recommended)	Select message service
CMGF (Recommended)	Set command to choose input and output format of messages (protocol data unit (PDU) or text mode)
CSCA (Recommended)	Set command to update the SMS service centre address, through which mobile originated SMS are transmitted.
CMGS (Recommended)	Execution command to send message to the network
CNMI (Recommended)	Set command to select the procedure about how to receive new messages from the network
CNMA (Recommended)	Execution command to confirm correct reception of a new message

10.3.2 AT minimum general commands

Table 20 lists the recommended AT minimum general commands derived from [ETSI TS 127 007], which are for the identification of universal communication modules.

Table 20 – AT minimum general commands

AT commands	Description
CGMI (Recommended)	Request manufacturer identification
CGMM (Recommended)	Request model identification
CGMR (Recommended)	Request revision identification
CGSN (Recommended)	Request product serial number identification
CIMI (Recommended)	Request international mobile subscriber identity

10.3.3 AT minimum commands for Network services

Table 21 the recommended AT minimum commands for network services, derived from [ETSI TS 127 007], and the optional AT minimum commands for Network services, derived from [b-3GPP TS 27.007]. These commands are for NB-IoT/eMTC network service-related commands.

Table 21 – AT minimum commands for network services

AT commands	Description
CREG (Recommended)	Network registration
COPS (Recommended)	Public land mobile network (PLMN) selection
CPSMS (Recommended)	Power saving mode setting
CEDRXS (Optional)	Extended idle mode DRX (eDRX) setting
CEDRXRDP (Optional)	eDRX read dynamic parameters
CCIOTOPT (Optional)	Cellular IoT (CIoT) optimization configuration

10.3.4 AT minimum commands for mobile termination control and status

Table 22 lists the recommended AT minimum commands for mobile termination control and status, derived from [ETSI TS 127 007], and the optional AT minimum commands for mobile termination control and status, derived from [b-3GPP TS 27.007]. These commands are for power, display, indicator handling and setting real time clock facilities.

Table 22 – AT minimum commands for mobile termination control and status

AT commands	Description
CFUN (Recommended)	Set phone functionality
CSQ (Recommended)	Signal quality
CCLK (Recommended)	Clock
CLAC (Recommended)	List all available AT commands
CRCES (Optional)	Reading coverage enhancement status

10.3.5 AT minimum commands for mobile termination errors

Table 23 lists the recommended AT minimum commands for mobile termination errors, derived from [ETSI TS 127 007], which are for an error report.

Table 23 – AT minimum commands for mobile termination errors

AT commands	Description
CMEE (Recommended)	Report mobile termination error
CME (Recommended)	Mobile termination error result code

10.3.6 AT minimum commands for packet domain

Table 24 lists the recommended AT minimum commands for packet domain, derived from [ETSI TS 127 007], and the optional AT minimum commands for packet domain, derived from [b-3GPP TS 27.007]. These commands are used by universal communication modules to support packet switched services.

Table 24 – AT minimum commands for packet domain

AT commands	Description
CGDCONT (Recommended)	Define PDP context
CGATT (Recommended)	PS attach or detach
CGPADDR (Recommended)	Show PDP address
CEREG (Recommended)	EPS network registration status
CSCON (Recommended)	Signalling connection status
CNMPSD (Recommended)	No more PS data
CSODCP (Optional)	Sending of originating data via the control plane
CRTDCP (Optional)	Reporting of terminating data via the control plane

11 Performance requirements

In order to ensure the quality of universal communication modules, performance requirements for universal communication modules are identified for the following aspects: storage and temperature.

11.1 Storage

To satisfy the communication requirements between universal communication modules and IoT platforms, the modules are recommended to reserve free space in the main chipset for IoT software development kit (SDK). The amount of free space depends on the size of the IoT SDK.

11.2 Temperature

In order to meet the different service requirements, universal communication modules are required to adapt to the proper operating and storage temperature range requirements.

Appendix I

Use cases for universal communication module of mobile IoT devices

(This appendix does not form an integral part of this Recommendation.)

This appendix provides some use cases for universal communication module of mobile IoT devices.

I.1 Smart utility metering

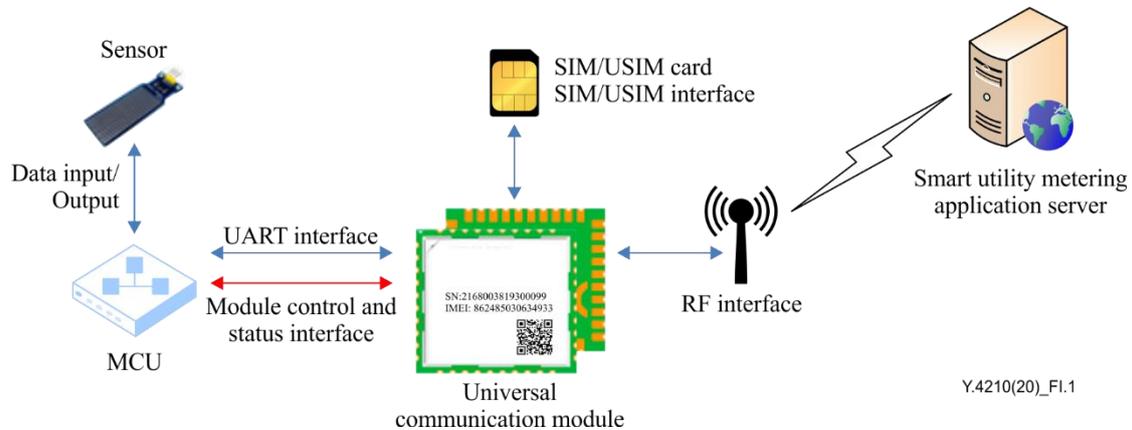


Figure I.1 – Smart utility metering design with universal communication module

Smart utility metering devices (including but not limited to gas/heat metering, water metering, electricity metering) may use a universal communication module as shown in Figure I.1. On one hand, the MCU in a smart utility metering device controls the universal communication module by the module control and status interface, and, on the other hand, it collects data from sensors and uses the universal communication module by the UART interface to send data to a smart utility metering application server. The SIM/USIM card and antenna of the universal communication module ensure the data can be sent successfully. In order to support long-term metering, adequate space is needed in the smart utility metering device for large capacity battery; therefore, a small size universal communication module is preferred to ensure sufficient space for the battery.

I.2 Smart home

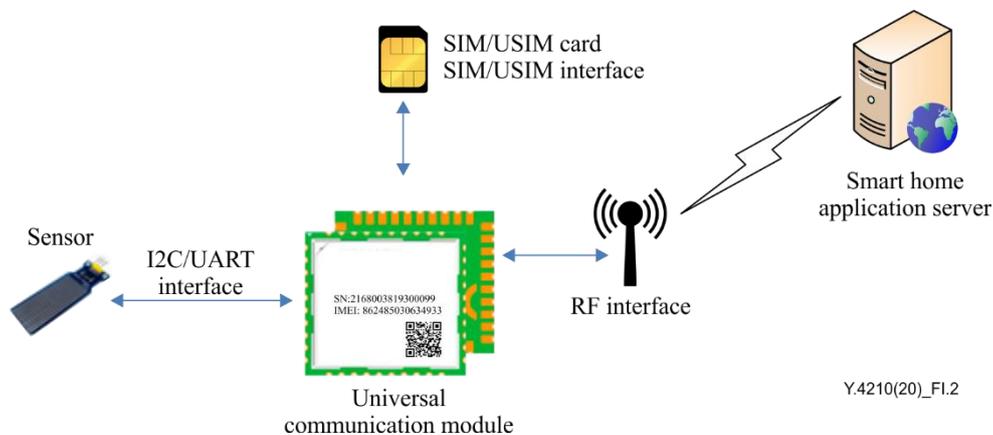


Figure I.2 – Smart home design with universal communication module

Smart home devices (including but not limited to washer, air conditioner and refrigerator) may use a universal communication module as shown in Figure I.2. Universal communication module can collect the data from sensors by I2C/UART interface and send data to a smart home application server. In order to ensure the data can be sent successfully, SIM/USIM card and antenna are needed. Because smart home devices usually have external electric power supply, battery is not a must; therefore, a normal size universal communication module is a good choice.

Appendix II

Universal communication module reference types

(This appendix does not form an integral part of this Recommendation.)

Appendices II.1 and II.2 describe the universal communication module reference types which are used for the small size universal communication module.

Appendices II.3 and II.4 describe the universal communication module reference types which are used for the normal size universal communication module.

II.1 Universal communication module reference Type 1

Universal communication module reference Type 1 is recommended to use LCC package, the length is recommended to be 18mm, and the width is recommended to be 16mm. The pad size and spacing for this type are shown in Figure II.1. All measurements are specified in millimeters. The pad assignments for this type are described in Table II.1.

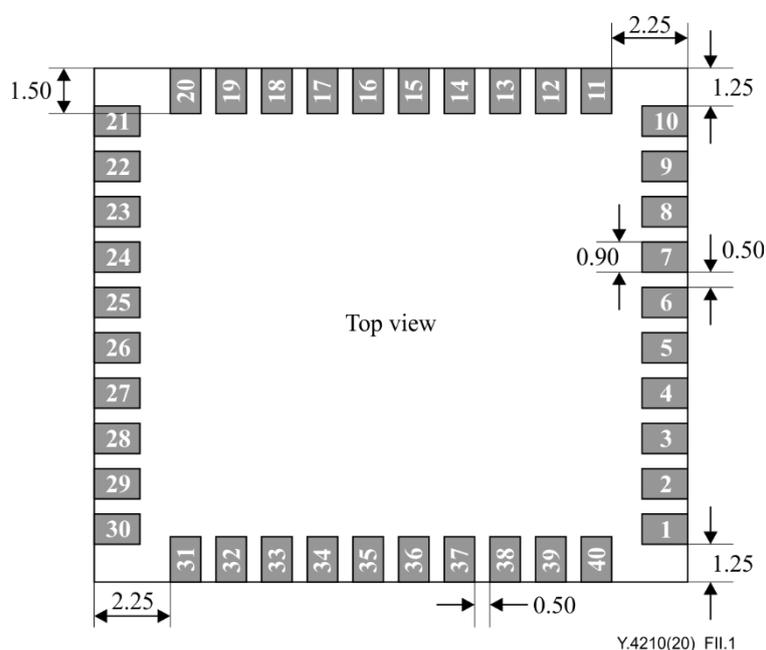


Figure II.1 – Pad size and spacing for universal communication module reference Type 1

Table II.1 – Pad assignments for universal communication module reference Type 1

Pad No.	Pad name	Pad description
1	UART2_TXD	TXD for the 2 nd UART
2	UART2_RXD	RXD for the 2 nd UART
3	SPI_SS	SS for SPI
4	SPI_MISO	MISO for SPI
5	SPI_MOSI	MOSI for SPI
6	SPI_SCLK	SCLK for SPI
7	UART1_CTS	CTS for the 1 st UART
8	UART1_RTS	RTS for the 1 st UART

Table II.1 – Pad assignments for universal communication module reference Type 1

Pad No.	Pad name	Pad description
9	UART1_TXD	TXD for the 1 st UART
10	UART1_RXD	RXD for the 1 st UART
11	USIM_DETECT	DETECT for USIM
12	USIM_RESET	RESET for USIM
13	USIM_CLK	CLK for USIM
14	USIM_DATA	DATA for USIM
15	USIM_VCC	Power supply for USIM
16	WAKEUP_OUT	Module wakes up host
17	RESET	Reset
18	WAKEUP_IN	Host wakes up module
19	POWER_ON/OFF	Power on/off
20	VDD	Reference logic level from module
21	SYS_STATE	Module status indication
22	GND	Ground
23	GND	Ground
24	GNSS_ANT	GNSS antenna
25	GND	Ground
26	GND	Ground
27	ANT0	Antenna
28	GND	Ground
29	GND	Ground
30	GND	Ground
31	VCC1	Power supply
32	VCC2	Power supply
33	RTC Power	Power supply for RTC
34	GPIO	General purpose Input/Output
35	GPIO	General purpose Input/Output
36	I2C_SCL	SCL for I ² C
37	I2C_SDA	SDA for I ² C
38	ADC	Analogue-to-Digital Converter
39	RESERVED	To Be Determined (TBD)
40	RESERVED	TBD

II.2 Universal communication module reference Type 2

Universal communication module reference Type 2 is recommended to use LCC package, the length is recommended to be 20mm, and the width is recommended to be 16mm. The pad size and spacing for this type are shown in Figure II.2. All measurements are specified in millimeters. The pad assignments for this type are described in Table II.2.

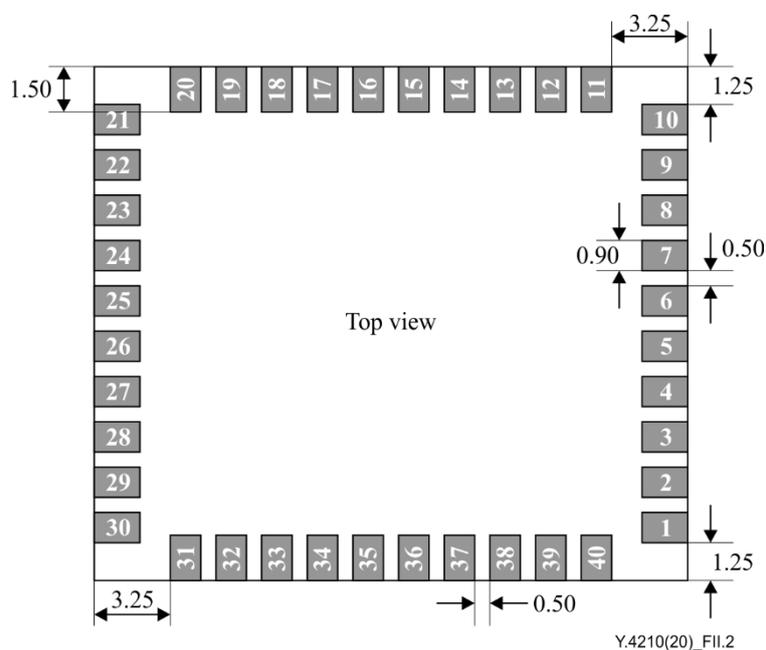


Figure II.2 – Pad size and spacing for universal communication module reference Type 2

Table II.2 – Pad assignments for universal communication module reference Type 2

Pad No.	Pad name	Pad description
1	UART2_TXD	TXD for the 2 nd UART
2	UART2_RXD	RXD for the 2 nd UART
3	SPI_SS	SS for SPI
4	SPI_MISO	MISO for SPI
5	SPI_MOSI	MOSI for SPI
6	SPI_SCLK	SCLK for SPI
7	UART1_CTS	CTS for the 1 st UART
8	UART1_RTS	RTS for the 1 st UART
9	UART1_TXD	TXD for the 1 st UART
10	UART1_RXD	RXD for the 1 st UART
11	USIM_DETECT	DETECT for USIM
12	USIM_RESET	RESET for USIM
13	USIM_CLK	CLK for USIM
14	USIM_DATA	DATA for USIM
15	USIM_VCC	Power supply for USIM
16	USIM_GND	Ground for USIM
17	WAKEUP_OUT	Module wakes up host
18	RESET	Reset
19	WAKEUP_IN	Host wakes up module
20	POWER_ON/OFF	Power on/off
21	VDD	Reference logic level from module
22	SYS_STATE	Module status indication
23	GND	Ground

Table II.2 – Pad assignments for universal communication module reference Type 2

Pad No.	Pad name	Pad description
24	GNSS_ANT	GNSS antenna
25	GND	Ground
26	GND	Ground
27	ANT0	Antenna
28	GND	Ground
29	GND	Ground
30	GND	Ground
31	VCC1	Power supply
32	VCC2	Power supply
33	RTC Power	Power supply for RTC
34	GPIO	General purpose Input/Output
35	GPIO	General purpose Input/Output
36	I2C_SCL	SCL for I ² C
37	I2C_SDA	SDA for I ² C
38	ADC	Analogue-to-Digital Converter
39	RESERVED	TBD
40	RESERVED	TBD

II.3 Universal communication module reference Type 3

Universal communication module reference Type 3 is recommended to use LCC package, the length is recommended to be 24 mm, and the width is recommended to be 20 mm. The pad size and spacing for this type are shown in Figure II.3. All measurements are specified in millimetres. The pad assignments for this type are described in Table II.3.

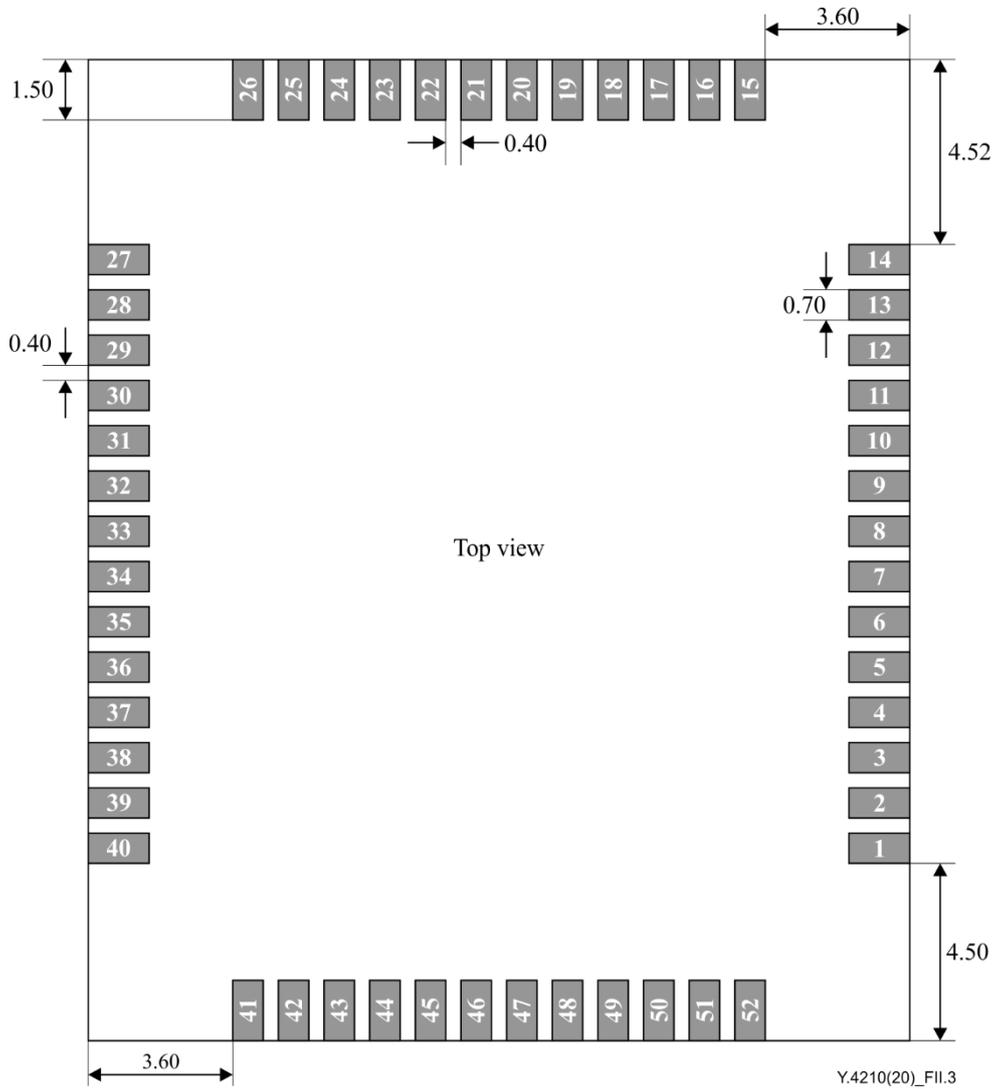


Figure II.3 – Pad size and spacing for universal communication module reference Type 3

Table II.3 – Pad assignments for universal communication module reference Type 3

Pad No.	Pad name	Pad description
1	UART1_TXD	TXD for the 1 st UART
2	UART1_RXD	RXD for the 1 st UART
3	UART1_CTS	CTS for the 1 st UART
4	UART1_RTS	RTS for the 1 st UART
5	SPI_SS	SS for SPI
6	SPI_MISO	MISO for SPI
7	SPI_MOSI	MOSI for SPI
8	SPI_SCLK	SCLK for SPI
9	USIM_VCC	Power supply for USIM
10	USIM_RESET	RESET for USIM
11	USIM_DATA	DATA for USIM
12	USIM_CLK	CLK for USIM
13	USIM_GND	Ground for USIM

Table II.3 – Pad assignments for universal communication module reference Type 3

Pad No.	Pad name	Pad description
14	USIM_DETECT	DETECT for USIM
15	RTC Power	Power supply for RTC
16	VCC1	Power supply
17	VCC2	Power supply
18	GND	Ground
19	GND	Ground
20	GND	Ground
21	GND	Ground
22	GNSS_ANT	GNSS antenna
23	GND	Ground
24	GND	Ground
25	ANT0	Antenna
26	GND	Ground
27	USB_Dp	USB data (positive)
28	USB_Dn	USB data (negative)
29	VBUS	USB detect
30	GND	Ground
31	ADC	Analogue-to-Digital Converter
32	GND	Ground
33	GPIO	General purpose Input/Output
34	GPIO	General purpose Input/Output
35	GPIO	General purpose Input/Output
36	GPIO	General purpose Input/Output
37	WAKEUP_OUT	Module wakes up host
38	RESET	Reset
39	WAKEUP_IN	Host wakes up module
40	POWER_ON/OFF	Power on/off
41	VDD	Reference logic level from module
42	SYS_STATE	Module status indication
43	UART2_TXD	TXD for the 2 nd UART
44	UART2_RXD	RXD for the 2 nd UART
45	I2C_SCL	SCL for I ² C
46	I2C_SDA	SDA for I ² C
47	RESERVED	TBD
48	RESERVED	TBD
49	RESERVED	TBD
50	RESERVED	TBD
51	RESERVED	TBD
52	RESERVED	TBD

II.4 Universal communication module reference Type 4

Universal communication module reference Type 4 is recommended to use LCC package, the length is recommended to be 26 mm, and the width is recommended to be 24 mm. The pad size and spacing for this type are shown in Figure II.4. All measurements are specified in millimeters. The pad assignments for this type are described in Table II.4.

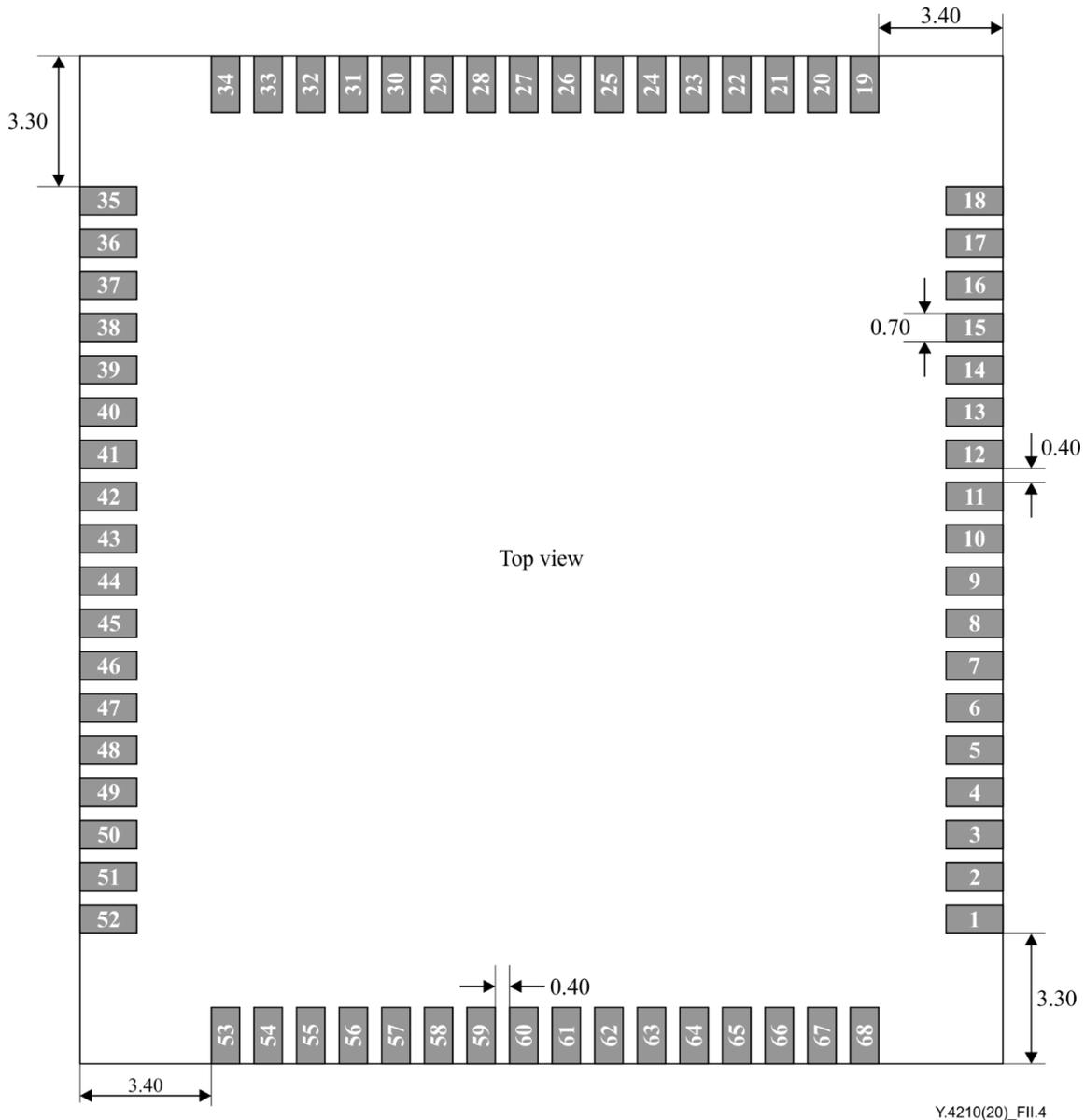


Figure II.4 – Pad size and spacing for universal communication module reference Type 4

Table II.4 – Pad assignments for universal communication module reference Type 4

Pad No.	Pad name	Pad description
1	UART1_TXD	TXD for the 1 st UART
2	UART1_RXD	RXD for the 1 st UART
3	UART1_CTS	CTS for the 1 st UART
4	UART1_RTS	RTS for the 1 st UART
5	SPI_SS	SS for SPI

Table II.4 – Pad assignments for universal communication module reference Type 4

Pad No.	Pad name	Pad description
6	SPI_MISO	MISO for SPI
7	SPI_MOSI	MOSI for SPI
8	SPI_SCLK	SCLK for SPI
9	USIM_VCC	Power supply for USIM
10	USIM_RESET	RESET for USIM
11	USIM_DATA	DATA for USIM
12	USIM_CLK	CLK for USIM
13	USIM_GND	Ground for USIM
14	USIM_DETECT	DETECT for USIM
15	RESERVED	TBD
16	RESERVED	TBD
17	RESERVED	TBD
18	RESERVED	TBD
19	RTC Power	Power supply for RTC
20	VCC1	Power supply
21	VCC2	Power supply
22	GND	Ground
23	GND	Ground
24	GND	Ground
25	GND	Ground
26	GNSS_ANT	GNSS antenna
27	GND	Ground
28	GND	Ground
29	GND	Ground
30	ANT0	Antenna
31	GND	Ground
32	GND	Ground
33	GND	Ground
34	GND	Ground
35	RESERVED	TBD
36	RESERVED	TBD
37	RESERVED	TBD
38	RESERVED	TBD
39	RESERVED	TBD
40	RESERVED	TBD
41	USB_Dp	USB data (positive)
42	USB_Dn	USB data (negative)
43	VBUS	USB detect
44	GND	Ground

Table II.4 – Pad assignments for universal communication module reference Type 4

Pad No.	Pad name	Pad description
45	ADC	Analogue-to-Digital Converter
46	GND	Ground
47	GPIO	General purpose Input/Output
48	GPIO	General purpose Input/Output
49	GPIO	General purpose Input/Output
50	GPIO	General purpose Input/Output
51	GPIO	General purpose Input/Output
52	GPIO	General purpose Input/Output
53	WAKEUP_OUT	Module wakes up host
54	RESET	Reset
55	WAKEUP_IN	Host wakes up module
56	POWER_ON/OFF	Power on/off
57	VDD	Reference logic level from module
58	SYS_STATE	Module status indication
59	UART2_TXD	TXD for the 2 nd UART
60	UART2_RXD	RXD for the 2 nd UART
61	I2C_SCL	SCL for I ² C
62	I2C_SDA	SDA for I ² C
63	PCM_SYNC/I2S_WS/GPIO	Digital Audio signal
64	PCM_DIN/I2S_DIN/GPIO	Digital Audio signal
65	PCM_DOUT/I2S_DOUT/GPIO	Digital Audio signal
66	PCM_CLK/I2S_CLK/GPIO	Digital Audio signal
67	UART3_TXD	TXD for the 3 rd UART
68	UART3_RXD	RXD for the 3 rd UART

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