

DESIGN AUTOMATION & EMBEDDED SYSTEMS

FPGA - SECURITY - EMBEDDED - INTERNET OF THINGS - PCB TECHNOLOGIEËN - BLUETOOTH LE - ELECTRONIC DESIGN & PRODUCTION

11 OKT ←
TECHNOPOLIS, BELGIË
12 OKT ←
BRABANTHALLEN, DEN BOSCH



LTE Cat-M1 and NB-IoT

**How to choose the right
technology for your IoT
application?**



Quectel Wireless Solutions - Dedicated Supplier of M2M Wireless Modules

Quectel Wireless Solutions is one of the leading global suppliers of industrial-grade cellular and GNSS modules, which can be widely applied in IoT markets, such as:

- automotive
- remote control
- wireless POS
- smart metering
- asset tracking
- security and healthcare



Quectel's comprehensive product portfolio includes LTE, UMTS/HSPA(+), GSM/GPRS and GNSS Modules and is also well-known as the world's first supplier of NB-IoT module compliant with 3GPP R13 standard.

The BG96 module supports both NB-IoT and eMTC technologies, all of which are at the frontier of IoT fields.



TOP-electronics is a design-in driven electronic components and modules distributor and representative, working with several high-tech manufacturers in each of our product groups, such as:

- M2M, Wireless and IoT
- Precision Analog
- Power Conversion
- Test and Measurement
- Motion Control
- Active & Passive Components

TOP-electronics has a motivated, experienced team which works directly with our customer's engineers to provide a high level of local assistance, supporting our customers all the way from pre-development, through the design phase to production and after-sales.

TOP-electronics is located in the Netherlands and in the USA.

TOP-electronics

**a design-in driven
electronic components
and modules distributor
and representative**

**Together we create a
smarter world**



M2M, Wireless and IoT



Test and Measurement



Precision Analog



Motion Control



Power Conversion



Active and Passive
Components

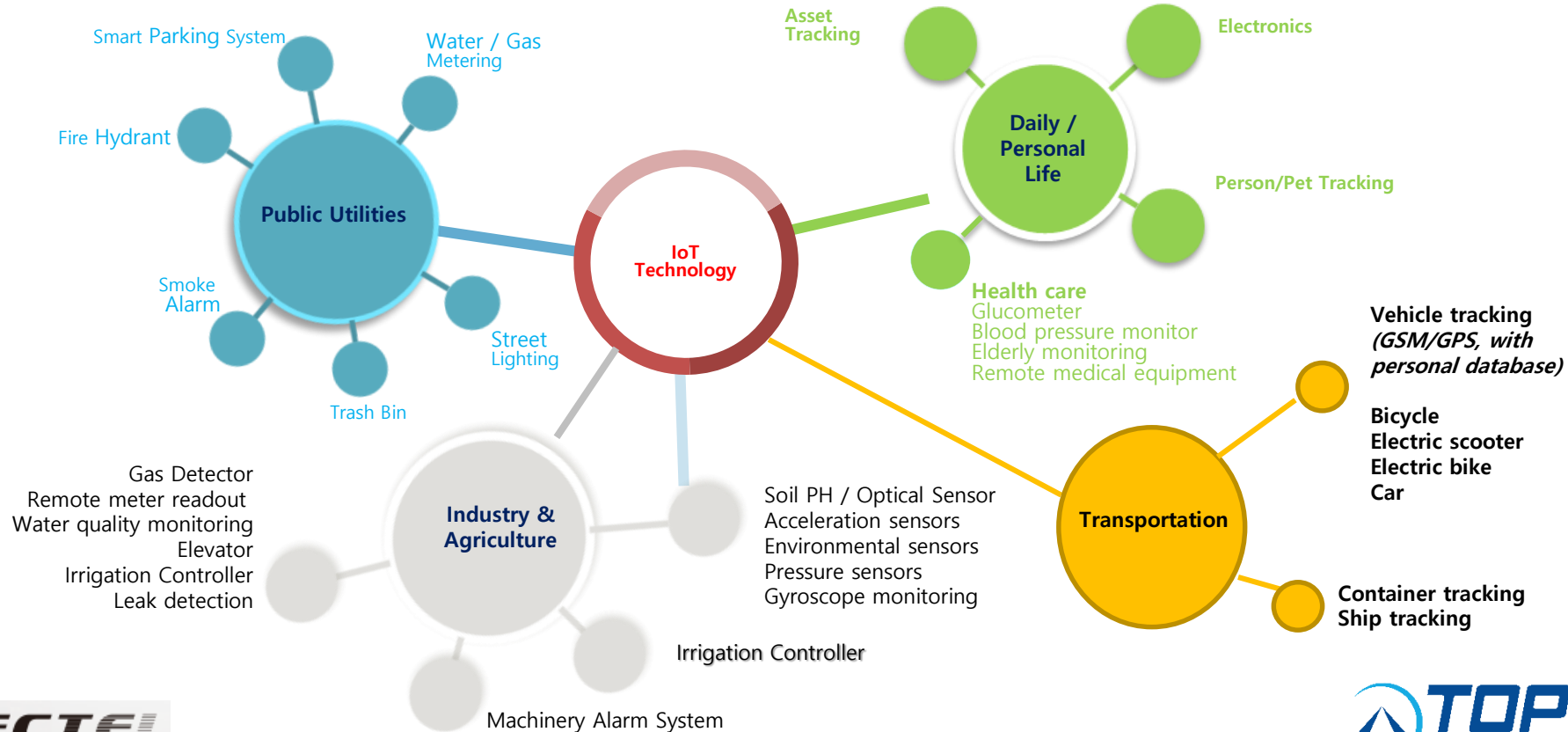
Possible Wireless Technologies

- 0.1 m:** RFID: for linking devices, payment, security, etc.
- 10 m:** IR, Zigbee, Bluetooth, RF4CE: implemented for audio applications and data devices up to 3 Mbps
- 100 m:** WiFi: implemented for local data transmissions. Trend is to increase throughput speeds up to 1 Gbps
- 10 km:** GSM, LTE: for mobile communication systems
Sigfox, LoRa, NB-IoT: for long distance, low speed applications
- Wireless Backhaul:
Point to point communication systems up to 1 Gbps

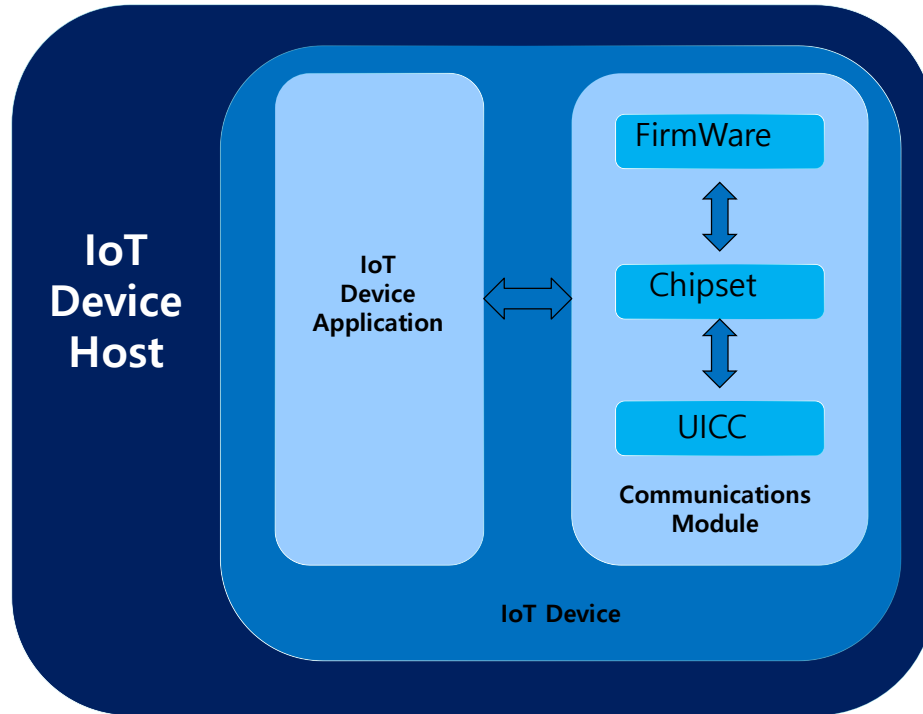
LTE Cat-M1 and NB-IoT

What are the capabilities of the latest cellular technologies like NB-IoT and LTE Cat-M1 compared to older technologies like GPRS, UMTS / HSPA for your IoT application.

IoT technology



General IoT device architecture, slide 1

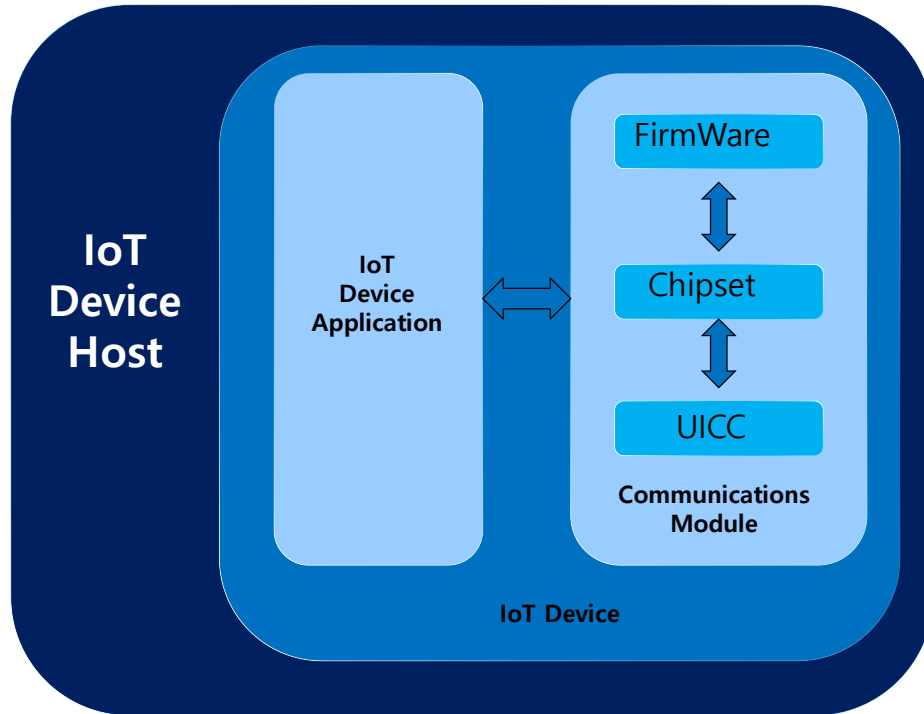


IoT Device Host – The application specific environment containing the IoT device e.g. vehicle, utility meter, security alarm etc.

IoT Device – The combination of both the IoT Device Application and the Communications Module.

IoT Device Application – The application software component of the IoT Device that controls the Communications Module and interacts with an IoT Service Platform via the Communications Module

General IoT device architecture, slide II



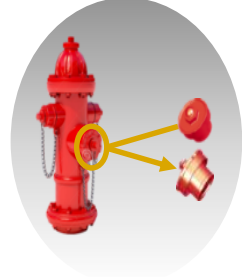
Communications Module – The communications component which provides wide area (2G, 3G, 4G) radio connectivity. Comprising of Communications Module Firmware, Radio Baseband Chipset and UICC.

Communications Module Firmware – The functionality within the Communications Module that provides an API to the IoT Device Application and controls the Radio Baseband Chipset.

Radio Baseband Chipset – The functionality within the communications module that provides connectivity to the mobile network.

UICC – The smart card used by a mobile network to authenticate devices for connection to the mobile network and access to network services.

Challenges for IoT Terminal Development



- RF designs with highly integrated solutions
- Friendly and complete development environment
- Power consumption for 5 ~ 10 years of life cycle
- Adapted throughput for the application
- Global standardization and certification
- Following the evolution of the latest technology standards

Advantages

They have employed 1500 antennas

In the USA 30% coverage

In Europe mainly in Spain, UK, Netherlands, Belgium and France are growing towards other countries like Italy, Denmark, Ireland

The hardware is cheap, but there's a connecting price

Disadvantages

No Global Standard and Certification

No Authentication, no full Security
Throughput is limited < 0.1 kbps

Closed technology, the only operator is Sigfox

The antennas have limited range

Using unlicensed frequencies, so sensitive to interferences

LoRa

Advantages

Low cost, easy to install

Open Source Technology

Widely employed in some countries

Large deployment

Main application for connecting a large number of items within range

Growing number of memberships

Can be used by non-Telecom Operators and Private Networks

Disadvantages

Only for static applications

No Global Standard and Certification, based on LORA

No full network coverage

Not all operators participate

Not compatible between manufacturers

No full security

Coverage of stations (15 km range)

Needs a dedicated gateway

Throughput < 50 kbps

Who pays for the base stations? Service charges

Using unlicensed frequencies, so sensitive to interferences

Needs Base Station Management

NB-IoT

Advantages

APT (*Adaptive Power Control*) for power saving

Some modules can switch between
NB-IoT – Cat M1

Cat-NB1 (<100 kbps) - Cat-M1 (<375 kbps)

LTE 4G Network is already in place

Full Worldwide Coverage

Global 3GPP Licensed Standard with
Security and Certification

Disadvantages

Need to subscribe to a Network Operator

Only operates in Public Models

CAT M1

Advantages

Global

4G LTE (Long Term Evolution) network with an open environment

Coverage

Security (licensed spectrum, which provides a secure and private network)

Efficiency (significantly smaller bandwidth than other cellular services, but it's more than enough for most IoT applications)

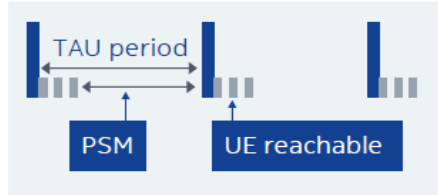
Disadvantages

Need to subscribe to a Network Operator

Only operates in Public Models

NB-IoT Advantage – Long Battery Life

The industry aims to achieve around **10 years** of battery operation for simple daily connectivity with a small amount of data exchanged.

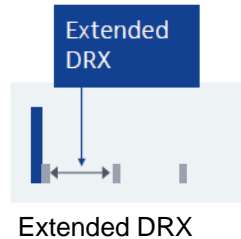


Rel-12 Power Saving Mode (PSM)

Rel-13

*TAU (Tracking Area Update)

*UE (User Equipment)



PSM (Power Saving Mode) and eDRX (Enhanced Discontinuous Reception) are the key technologies to extend the battery life in NB-IoT.

Terminal in PSM is still registered with the network but the signals can not reach until it wakes up automatically. This kind of deep sleeping can help conserving energy.

eDRX is a new feature released in Rel-13, which extends the sleep cycle of the terminal in Idle mode to reduce the unnecessary start-up of the RX units. It improves the reachability of downlink greatly compared with PSM.

- Simplified protocol, low power consumption
- High PA efficiency
- Short Tx/Rx time

Calculation example of the power consumption

Power consumption of BC95

PSM mode	3,2 uA
Idle/Standby	6 mA
Active TX (@23 dBm)	250 mA
Active RX	61 mA



Example of Sensor application with Received Signal is -129 dBm and Transmission Power is 23 dBm

	DURATION	CONSUMPTION
Startup → Attach (one time)	17,5 s	175,46 uAh
Connect State	5 s	72,9 uAh
PSM → Attach	830,9 ms	10,7 uAh
PSM → Send 200bytes	3,1 s	119,6 uAh
PSM	24 h	80,8 uAh
Total		284 uAh

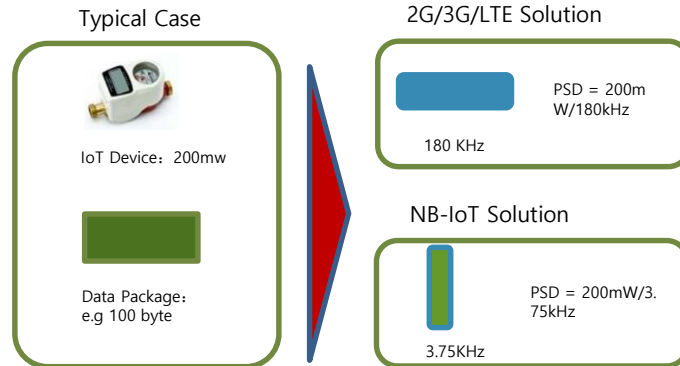
Using a 1000 mAh battery, battery life is $(1000 \times 1000) / (284 \times 365) = 9.7$ Years

NB-IoT Advantage – Extended Coverage

The target for the IoT connectivity link budget is an enhancement of **20dB**. This coverage enhancement would typically be equivalent to the signal penetrating a wall or floor, enabling deeper indoor coverage.

Uplink PSD increase 17dB

Repetition / Retransmission 6~16dB

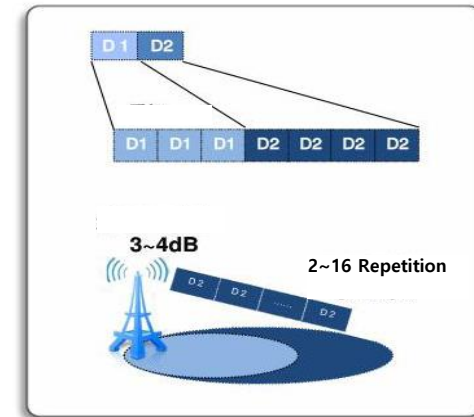


Note

GSM terminal Tx. can reach 33dBm. NB-IoT Tx. is about 23dBm.

The PSD of NB-IoT is 7dB more than GPRS.

PSD (Power Spectral Density)



NB-IoT / Cat.M1 Advantage – Massive Connection

It is ideal to have about **50K** devices per cell; this is possible assuming the household density per every sq. m is 1500 with 40 devices in every household.

Typical Model

15 min. ~ 1 day

> 100 byte



~50K Devices/Cell



delay-tolerant



Special System Design for Massive Links

Key Technology 1: **Narrowband technology**
Uplink Equivalent Power(36 channel * 23dBm)

Key Technology 2: **Decrease Signal Interaction**
Optimize the efficiency of frequency spectrum

Key Technology 3: **Nodes optimization**
Independent congestion controls
Terminal context saves

Key Technology 4: **Core net optimization**
Save registered information
Download data cache

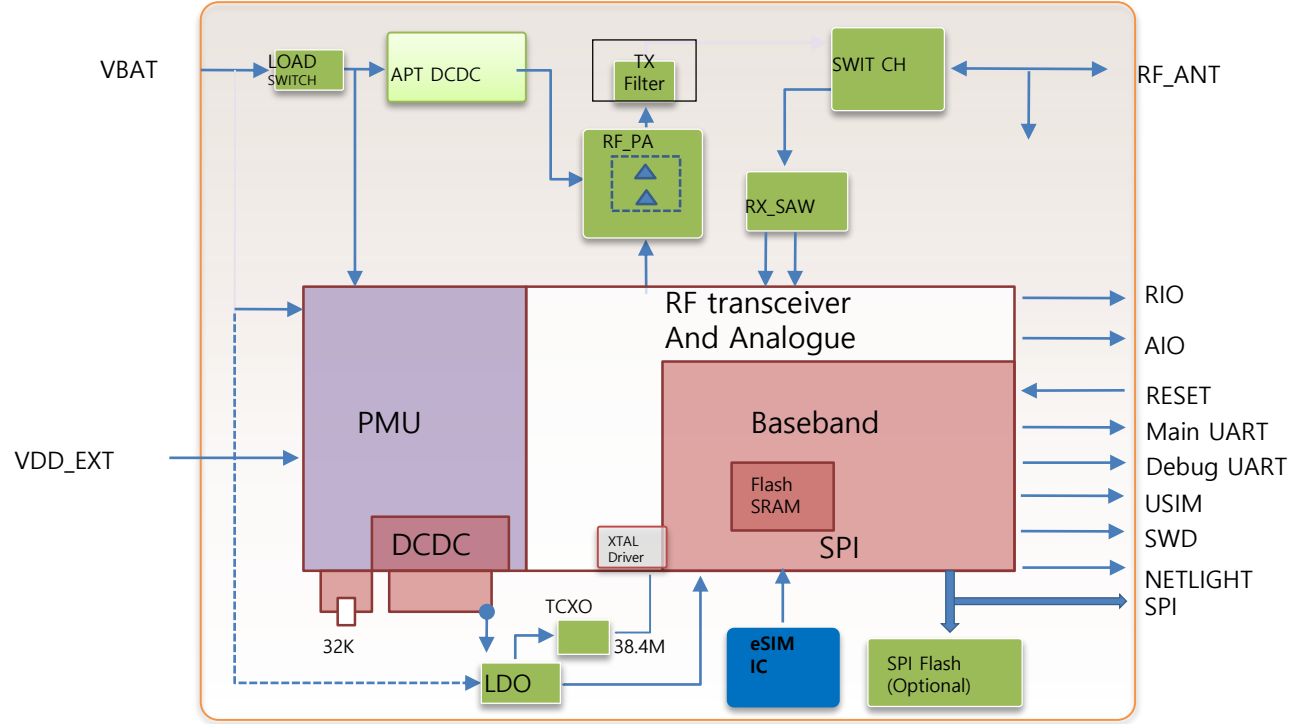
Comparison between LPWA Technologies

	NB-IoT	CAT-M1	LoRa (Semtech)	UNB (Sigfox)
Spectrum	LTE & 2G Bands	LTE & 2G Bands	Unlicensed 433/868MHz	Unlicensed 902MHz
Modulation & Demodulation	pi/4 QPSK pi/2 BPSK	QPSK QAM	Chirp Spread Spectrum	FSK
Uplink Data Rate	< 180 kbps	< 375 kbps	< 10kbps	< 0.1kbps
Bandwidth	200KHz	1MHz	125-500kHz	100KHz
Transmit Power	23dBm	20dBm or 23dBm	14dBm	14dBm
Network	Mostly S/W Upgrad	S/W Upgrad	Green Field	Green Field
Terminal Price	~2G Price	~2G Price	~2G Price	~2G Price
Battery Life (200byte/day)	>10 years	>10 years	>10 years	>10 years
Coverage	164dB ~15km	155.7dB ~15km	157dB ~10km	160dB EU ~12km
Standard	Open 3GPP	Open 3GPP	Proprietary	Proprietary

eMTC Evolution *(Enhanced Machine Type Communication)*

	Rel-8 Cat.4	Rel-11 Cat.1	Rel-13 Cat-M1	Rel-13 NB-IoT
Downlink Peak Rate	150Mbps	10Mbps	1Mbps	<100Kbps
Uplink Peak Rate	50Mbps	5Mbps	1Mbps (Full Dup.)	<100Kbps
Coverage MCL (Minimum Couplink Loss)	140.7dB	140.7dB	155.7dB	164dB
Battery Life (200 bytes / day)	< 1 year	< 1 year	~ 10 years	~ 10 years
Number of Antennas	2	2	1	1
UE Receive Bandwidth	20MHz	20MHz	1,4MHz	200KHz
UE Transmit Power	23dBm	23dBm	23dBm	23dBm
Standard Readiness	Now	Now	Now	Now
Network Readiness	Now	Now	Now	Now

NB-IoT - LTE Cat.NB1 (module diagram)



LTE Cat-NB1

LTE Cat.NB1

DL/UL	<100 kbps
BC95-B8	900MHz
BC95-B5	850MHz
BC95-B20	800MHz,
BC95-G	B1/B3/B5/B8/B20/B28 @LTE-FDD (TBD)
Protocols	IPv4 / IPv6* / UDP / CoAP



Support embedded eSIMPCB footprint
LCC package for robust soldering
Dimensions 19.9mm × 23.6mm × 2.2mm
Temperature range -40°C~ +85°C

The BC95 is compatible with the Quectel M95/UG96/UG95/EG91 modules

LTE Cat.NB1

Industry's smallest NB-IoT module

B1@H-FDD	2100MHz
B3@H-FDD	1800MHz
B8@H-FDD	900MHz
B5@H-FDD	850MHz
B20@H-FDD	800MHz
B28@H-FDD	700MHz



LCC package for robust soldering
Dimensions 17.7mm × 15.8mm × 2.3mm
Temperature range: -40°C~ +85°C

The BC68 is compatible with the Quectel M66 module

Cat-M1 / Cat-NB1 / EGPRS

Cat-M1 / Cat-NB1 / EGPRS

LTE Cat.M1/Cat.NB1/EGPRS module with ultra-low power consumption Compact SMT form factor ideal for size-constrained applications with tight space
Easy drop-in migration to GSM/GPRS/HSPA/LTE modules. Super slim profile in LGA package.

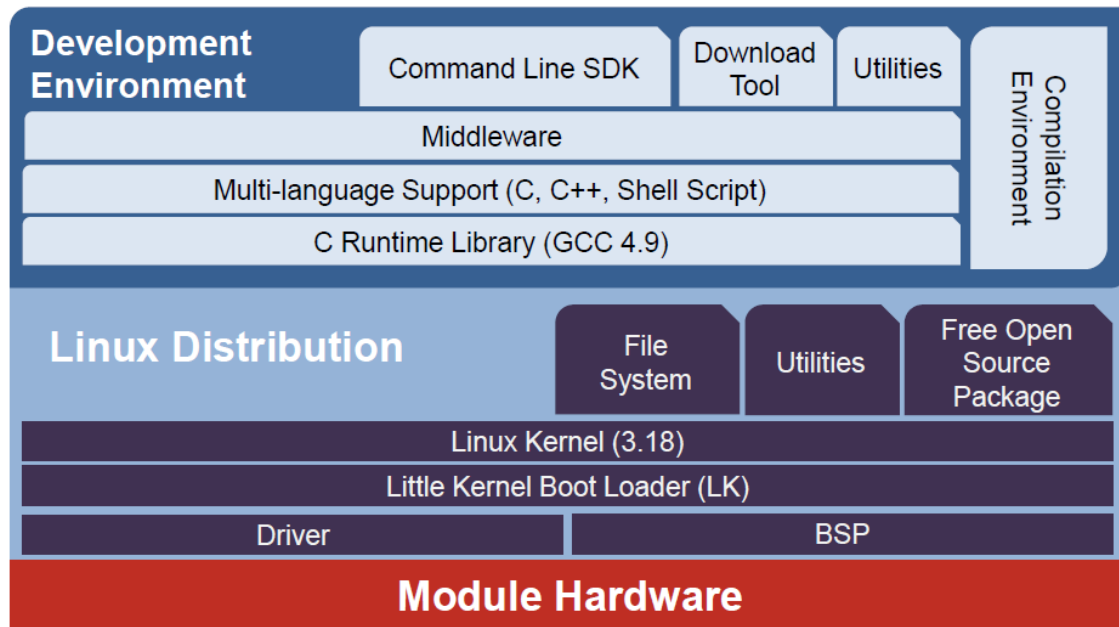
LTE Cat-M1	Max. 375kbps (DL) Max. 375kbps (UL)	LTE Cat-NB1	Max. 32kbps (DL) Max. 70kbps (UL)
GPRS	Max. 85.6kbps (DL) Max. 85.6kbps (UL)	EGPRS	Max. 236.8kbps (DL) Max. 236.8kbps(UL)
Protocols	PPP / TCP / UDP / SSL / TLS / FTP(S) / HTTP(S)		
Functions	Data / VoLTE / GNSS / FOTA / (U)SIM / UART USB / I2C/I2S / ADC /GPIO / Antenna		
Temperature Range	-40°C~ +85°C		
LGA package	22.5mm × 26.5mm × 2.3mm		



**By programming the module CAT-M1
can switch to NB-IoT with GPRS data
for GSM**

Compatible with Quectel M95/UG95/UG96/BC95/EG91/EG95 module

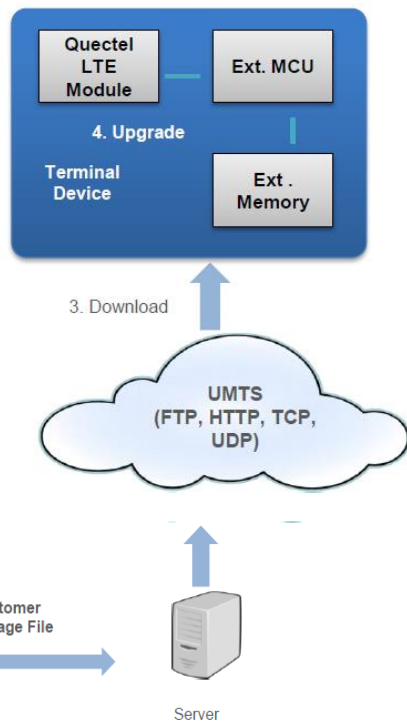
QuecOpen



QuecOpen is an open source embedded development platform based on Linux system, which is intended to simplify the design and development process for IoT-applications.

Figure: Framework of QuecOpen™*

DFOTA – Delta Firmware Upgrade Over-the-Air



DFOTA is an acronym for Delta Firmware Upgrade Over-the-Air.

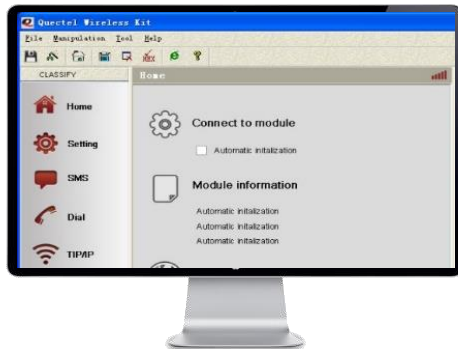
DFOTA technology enables mobile device manufacturers to remotely update software. New software can be delivered over the air, eliminating the need for users to bring the device to a service facility.

Firmware Upgrade Process via DFOTA

- DFOTA Sync
- DFOTA Packet
- DFOTA Upgrade Error Handle

Quick Start

QNavigator



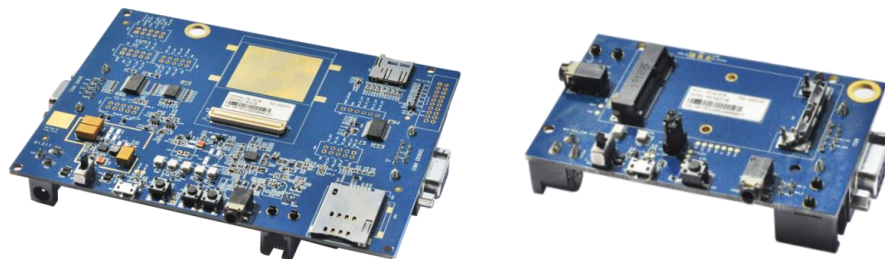
Quectel offers a GUI tool named **QNavigator**.

It can help customers quickly test Quectel modules functionality even if they are not familiar with AT commands.

GRPS / NB-IoT EVB Kit



UMTS & LTE EVB Kit



Questions ?



Thanks for your attention !

**You are more than welcome
at the TOP-electronics and Quectel booth**

**Belgium → number 22
the Netherlands → number 7**