VIAVI Solutions

Application Note

Narrowband Internet of Things (NB-IoT)

CellAdvisor JD700B Series

Internet of Things (IoT) technology is augmenting wireless services by enabling devices to connect to mobile networks via narrowband signals. These signals can be transmitted as a stand-alone service or co-existing with cellular broadband signals such as GSM or LTE.

The industry has defined three main technologies to transmit NB-IoT in cellular bands:

- Extended Coverage GSM for Internet of Things (EC-GSM-IoT)
- Long Term Evolution Machine Type Communications Category M1 (LTE MTC Cat M1, or LTE-M)
- Narrowband IoT (NB-IoT)

The standards body group 3GPP has defined the following key requirements for cellular IoT:

- Low power consumption by IoT devices, enabling battery operation for 10 years
- Low cost of IoT devices in terms of tenths of dollars
- Improved outdoor and indoor penetration coverage
- Secure connectivity and strong authentication
- Efficient data transmission supporting small and intermittent data blocks
- Simplified network topology and deployment

There are several industries and applications that will benefit from IoT technology:

- Application 1: mobility use cases involving tracking persons or devices for assisted living and remote health monitoring.
- Application 2: mobility use cases involving industrial asset tracking, microgeneration, agricultural livestock and environmental near-real-time monitoring (for example, for fire hydrants and industrial tank processes).
- Application 3: stationary use cases requiring deep indoor coverage, such as smart water and gas metering, smart parking, smart building, home automation, smart grid, and industrial machinery
- Application 4: stationary use cases, such as smart city lighting and vending machines that are externally powered and battery is used as backup.

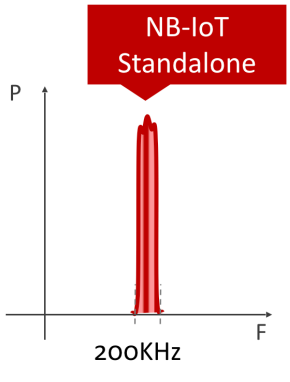
Requirements	Application 1	Application 2	Application 3	Application 4
Battery Life	5 years	5 to 10 years	10 to 15 years	As back-up
Coverage	Indoors and Outdoors	Mostly outdoors	Mostly Indoors	Indoors and Outdoors
Mobility	Low to high	Low	Stationary	Stationary
Latency	~30s	< 10s	10s to 60s	< 30s

Narrowband Internet of Things Definition

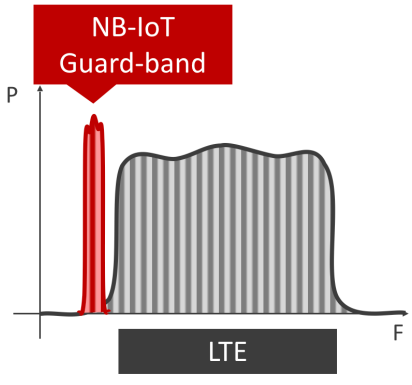
Narrowband IoT has been defined by 3GPP based on the characteristics of LTE to enable rapid adoption and seamless integration into existing LTE networks, with simple modifications considering the use cases of IoT, particularly related to extended coverage and low power consumption.

NB-IoT can be implemented in three different operation modes:

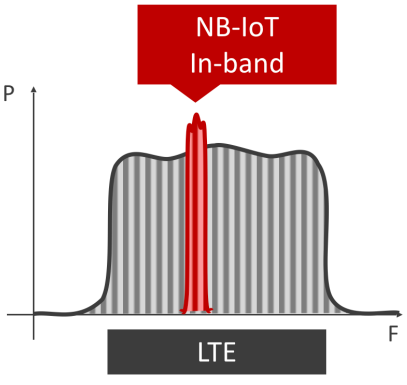
1. Standalone mode, for instances where cellular services are not present or are decommissioned to make narrowband spectrum available, which is the case of cellular GSM; by reframing one or more GSM carriers to carry NB-IoT traffic, operators can ensure a smooth transition to LTE for massive machine type communication
2. Guard-band mode, for instances where cellular services are present and NB-IoT is positioned in the guard band of LTE carriers, without allocating LTE resources and avoiding possible interference
3. In-band mode, for instances where cellular services are present and NB-IoT is positioned in the LTE carrier sharing LTE resources; this mode of operation is perhaps the more cost-effective and seamless for mobile operators since it does not require any hardware changes of the radio access network, and efficiently uses spectrum resources for LTE or NB-IoT services based on demand from mobile users or devices



Stand Alone



Guard-Band



In-Band

NB-IoT in coexistence with LTE can operate in the following bands:

Band	Uplink (MHz)	Downlink (MHz)	Duplex Type 1
1	1920 to 1980	2110 to 2170	FDD
2	1850 to 1910	1930 to 1990	FDD
3	1710 to 1785	1805 to 1880	FDD
5	824 to 849	869 to 894	FDD
8	880 to 915	925 to 960	FDD
11	1427.9 to 1447.9	1475.9 to 1495.9	FDD
12	699 to 716	729 to 746	FDD
13	777 to 787	746 to 756	FDD
17	704 to 716	734 to 746	FDD
18	815 to 830	860 to 875	FDD
19	830 to 845	875 to 890	FDD
20	832 to 862	791 to 821	FDD
25	1850 to 1915	1930 to 1995	FDD
26	814 to 849	859 to 894	FDD
28	703 to 748	758 to 803	FDD
31	452.5 to 457.5	462.5 to 467.5	FDD
66	1710 to 1780	2110 to 2200	FDD
70	1695 to 1710	1995 to 2020	FDD

NB-IoT Signal Analysis

NB-IoT signal analysis is performed for installation and maintenance activities to:

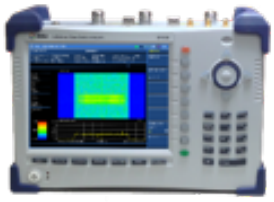
- Ensure proper communication and service delivery is achieved
- Avoid the consumption of additional bandwidth, which will also reduce the number of IoT devices that can be connected to the network
- Avoid the effects of improper power levels that might limit signals reaching IoT devices, or create multiple retransmissions that will shorten battery operation time of IoT devices

Wireless signal analysis for installation and maintenance covers two main aspects:

A. The signal's physical profile, including RF power and frequency characteristics, and its verification to mobile operators' configuration and conformance to 3GPP standards

B. The signal's data (modulation) quality, including modulation testing and error vector magnitude (EVM) distortion

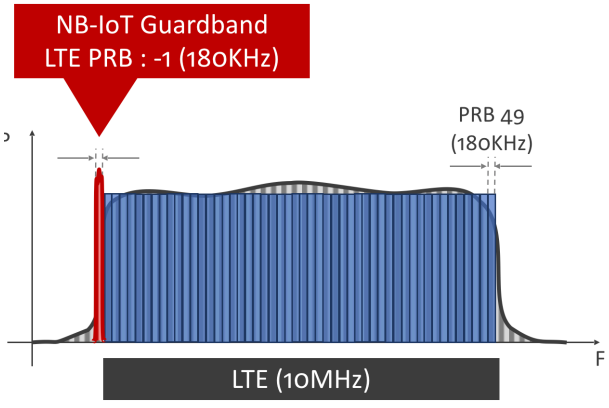
VIAVI CellAdvisor™ is the solution of choice for installation and maintenance, performing wireless signal analysis covering conventional cellular services 2G, 3G, 4G as well as advanced mobile services, such as MBMS and NB-IoT.

Physical Profile	Modulation Quality	Test Solution
· Channel power · Occupied bandwidth · Adjacent channel power · Spectrum emission mask · Spurious emissions	· GSM, GPRS, EDGE · CDMA, EVDO · WCDMA, HSDPA · LTE, LTE-Advanced · eMBMS · NB-IoT	 CellAdvisor

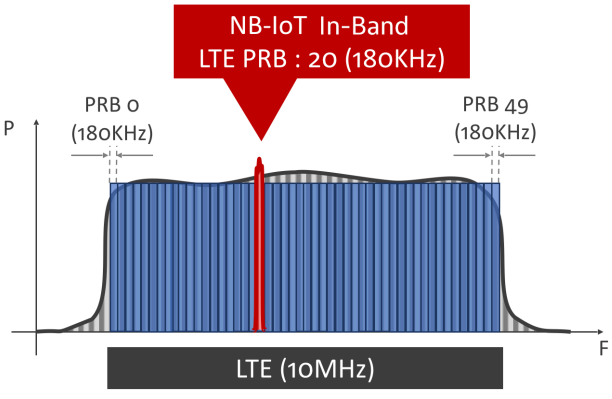
NB-IoT Bandwidth

NB-IoT transmission bandwidth is defined by 3GPP as follows:

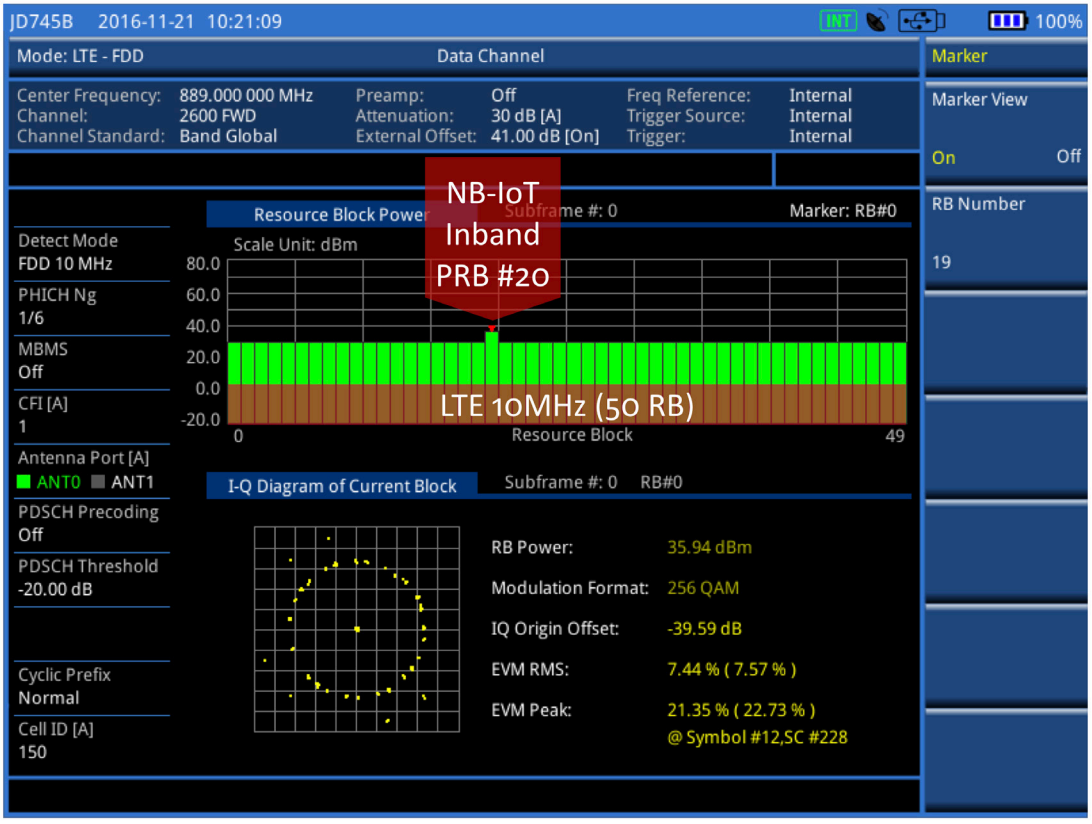
Bandwidth	NB-IoT Standalone	NB-IoT In-Band	NB-IoT Guard-band
Channel bandwidth [Defined in kHz]	200	Per LTE channels	Per LTE channels edges ≥ 5MHz
Transmission bandwidth (LTE Resource Blocks)	1	1	1
Transmission bandwidth (N-tone 15kHz)	12	12	12
Transmission bandwidth (N-tone 3.75kHz)	48	48	48



Guard-Band



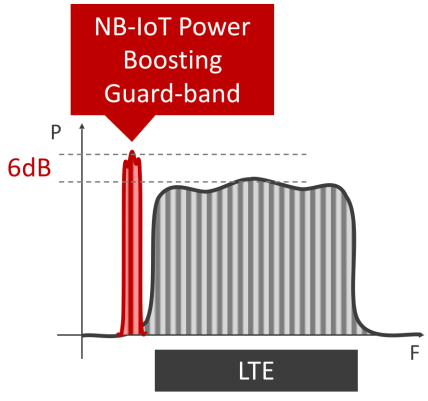
In-Band



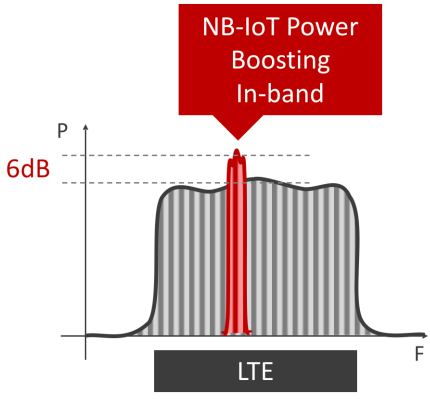
CellAdvisor LTE Resource Blocks and NB-IoT In-Band

NB-IoT Power

NB-IoT power dynamic (power boosting) defined by 3GPP in terms of LTE physical resource block (PRB) shall be larger than or equal to +6dB for in-band and guard band operation modes.



Guard - Band



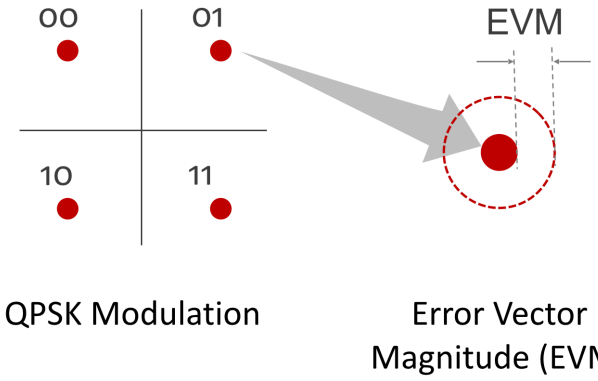
In - Band

CellAdvisor NB-IoT Adjacent Channel Power Test and Power Boosting Verification

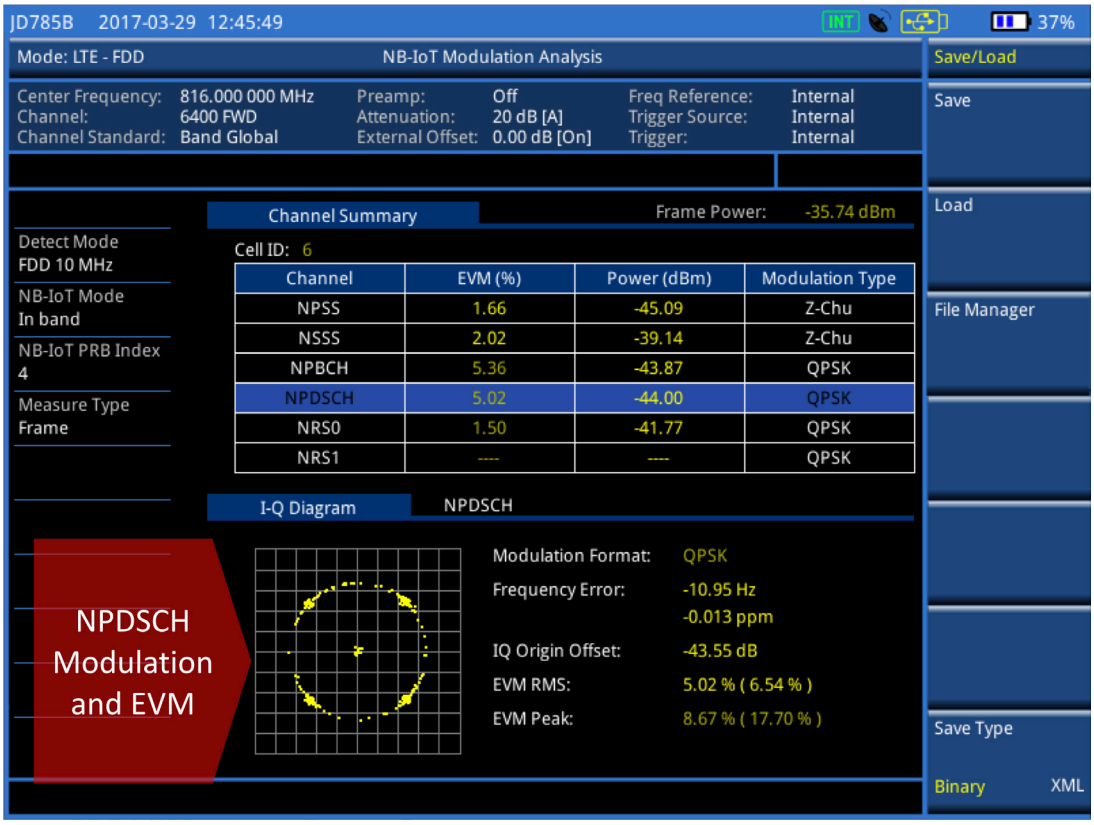
NB-IoT Modulation

NB-IoT modulation for all bandwidths is specified by 3GPP in terms of physical downlink shared channel (PDSCH) with a maximum distortion defined by error vector magnitude (EVM) parameter, as follows:

NB-PDSCH Modulation	Error Vector Magnitude
Quadrature Phase-Shift Keying (QPSK)	EVM ≤ 17.5%



QPSK Modulation and Error Vector Magnitude



CellAdvisor NB-IoT Data Channel Modulation Quality

Summary

NB-IoT has emerged as a key technology enabler to support wirelessly connectivity in licensed spectrum to devices (static or mobile) that will increase network demand to properly serve existing mobile users and devices.

Connected devices will reshape wireless network capacity and coverage demand due to their diversity of applications, ranging from static sensors with sporadic communication to mobile sensors with latency constraints; in addition, Strategy Analytics estimates that over 3 billion connected devices will be deployed by 2020.

The ability to evolve the radio access network and implement NB-IoT services is critical for mobile operators and consumers, and VIAVI CellAdvisor provides the necessary installation and maintenance measurements to validate proper performance of current cellular services, as well as advanced network densification technologies, including NB-IoT.

References

- Global IoT: A Billion Not Trillion Dollar Opportunity, Strategy Analytics, April 2017
- 3GPP Low Power Wide Area Technologies, GSMA, October 2016
- 3GPP TR 45.820 V13.1.0 – Cellular system support for ultra-low complexity and low throughput Internet of Things (CIoT)
- 3GPP TS 36.104 V14.3.0 – Base Station (BS) radio transmission and reception

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