



# SENSE MCE IBC Operating Instructions



Revision D  
MYNXG Manual Product Number: 450012

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## Notice

These operating instructions are an integral part of the Sense MCE IBC system and should always be kept at hand. Observance of the instructions given within this manual is required for proper performance and correct operation of Sense MCE IBC.

The Sense MCE IBC and its accessories must not be used for any other purpose than described in the accompanying documentation (intended use). Violation will result in loss of warranty.

MYNXG Product GmbH does not accept liability for injury to personnel or damage to equipment that may result from misuse of this equipment, failure to observe the hazard notices contained in this manual, or failure to observe local health and safety regulations.

MYNXG Product GmbH shall be under no circumstances liable for incidental or coincidental damage arising from use of the equipment described in this document.

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# Contents

1.	Safety Regulations .....	9
1.1	Terms Used.....	9
1.2	User Groups .....	9
1.3	Product Safety .....	10
1.4	Responsibility of the Owner.....	10
1.5	Intended Use.....	11
1.6	Intended Locations.....	11
1.7	Changes and Alterations.....	12
1.8	General Safety Regulations .....	12
1.9	Certification / Compliance.....	13
1.9.1	FCC.....	13
1.9.2	Industry Canada.....	14
1.10	Warranty.....	15
1.11	Disposal of Sense MCE IBC – Save the Environment.....	15
1.12	Behavior in Case of Malfunctions and Irregularities.....	16
2	Construction and Description .....	17
2.1	Product Number .....	18
2.2	Key Benefits .....	18
2.3	User Group .....	19
2.4	Industrial Usage.....	19
2.5	Industrial Design.....	20
2.6	Interfaces on the Sense MCE IBC .....	20
2.7	EMC and ESD concept .....	21
2.8	Sense MCE IBC Security .....	22
2.9	Functional Block Diagram.....	23
2.10	Typical Application.....	23
3	Installation.....	25
3.1	Delivery and Unpacking.....	25
3.2	Placing the Sense MCE IBC .....	26
3.3	Installation Instructions .....	26
3.4	Antennas .....	28
3.5	Electrical Power .....	28
4	RF Interfaces .....	29
4.1	Wi-Fi Interfaces.....	29
4.2	LTE Interfaces.....	29
4.2.1	SIM-Card.....	29
4.3	Sub-1GHZ Network Interfaces.....	29



- 5 Electrical Standards and Specifications.....31
  - 5.1 Recommended Operating Conditions.....31
  - 5.2 Power consumption .....32
  - 5.3 LTE and WCDMA Module Specifications.....32
    - 5.3.1 LTE and WCDMA Operating Bands.....33
    - 5.3.2 LTE and WCDMA Receiver Sensitivity .....33
    - 5.3.4 LTE and WCDMA Transmit Power.....34
  - 5.4 Wi-Fi Specifications.....35
    - 5.4.1 Wi-Fi Channels 802.11b/g/n-HT20.....36
    - 5.4.2 Wi-Fi Channels 802.11b/g/n-HT40.....36
  - 5.5 ISM Sub-1GHz Band .....37
    - 5.5.1 ISM Sub-1GHz Band (Frequencies North America) .....38
  - 5.6 Ultrasonic Fill level measurement .....38
  - 5.7 LTE and WCMA Antenna Specifications.....39
  - 5.8 Wi-Fi Antenna Specifications.....40
  - 5.9 Sub-1GHz (SRD) Specifications.....40
- 6 Annex: Troubleshooting.....41
- 7 Annex: Supported & Unsupported Features .....43
- 8 Memorandum.....45

## List of Figures

Figure 1: Sense MCE IBC identification label .....	18
Figure 2 Solution Coverage of the Sense MCE IBC for Hazardous Environments .....	19
Figure 3: MYNXG Sense MCE IBC .....	20
Figure 4: Sense MCE IBC cable gland.....	20
Figure 5: Functional Block Diagram.....	23
Figure 6: Wi-Fi Analyzer App .....	26
Figure 7: Principle of installation of Sense MCE IBC and connected piezo disc on IBC. ....	26
Figure 8: Antennas for LTE and WCDMA Networks with U.FL connector .....	28
Figure 9: Wi-Fi on module printed antenna .....	28
Figure 10: Sub-1GHz SRD printed antenna .....	28



## List of Tables

Table 1: Recommended operating conditions .....	31
Table 2: Power consumption according to datasheets .....	32
Table 3: Operating bands. ....	33
Table 4: Conducted Rx sensitivity.....	33
Table 5: Conducted Tx power specifications.....	34
Table 6: Wi-Fi specifications.....	35
Table 7: Wi-Fi channels for 20MHz band width .....	36
Table 8: Wi-Fi channels for 40MHz band width .....	36
Table 9: RF specifications and current consumption .....	37
Table 10: RF channels for North America.....	38
Table 11: Fill level measurement parameters.....	38
Table 12: LTE and WCDMA antenna specifications.....	39
Table 13: Wi-Fi antenna specifications .....	40
Table 14: Sub-1GHz antenna specifications .....	40



## 1. Safety Regulations


Before installing and using the Sense MCE IBC device, please read the following safety and handling instructions carefully. Every owner / user of the Sense MCE IBC should have understood the complete content and be aware of potential direct or indirect hazards of operators, other parties, stationary / mobile equipment, environmental and facilities by disregarding of warnings. This device must be professionally installed.

### 1.1 Terms Used

#### NOTICE

#### IMPORTANT NOTICE

Throughout this User's Guide, hazardous situations or operations are identified by **WARNING**, **CAUTION** and **NOTICE**, where:

Sign	Meaning
 <b>WARNING</b>	is used whenever you or somebody else could be injured if you do not observe the accompanying safety regulation.
<b>CAUTION</b>	is used to address issues related to possible hardware damage.
<b>NOTICE</b>	is used to address operational issues not related to personal injury or hardware damages.

### 1.2 User Groups

This manual is intended for personnel with the following expertise:

Area	Expertise
Installation	Experts
Start-up, operation and shutdown	Experts Trained personnel
Maintenance	Experts
Troubleshooting	Experts

**Trained personnel (DIN EN 60204-1):**

Any person who has been trained by experts in the tasks they need to perform, the risks associated with improper use, and the necessary safety equipment and safety precautions.

**Experts (DIN EN 60204-1):**

Any person who has the necessary specialist training, experience, and knowledge of the relevant standards needed to appraise their work and to recognize the possible dangers.

**NOTICE****IMPORTANT NOTICE**

The device cannot be sold via retail to the general public or by mail order; it is sold to authorized dealers or installers only.

## 1.3 Product Safety

The appliance described in this manual is technically sophisticated, manufactured using high-quality materials and subject of testing in the factory. It contains the latest technology and comply with recognized technical safety regulations. However, there are still risks involved, even when the appliance is used as intended.

## 1.4 Responsibility of the Owner

The owner of the appliance:

- is responsible for the flawless condition of the appliance and for its proper operation in accordance with its intended use;
- is responsible for ensuring that persons who are to operate or service the appliance are qualified to do this, have been instructed accordingly and are familiar with the operating instructions at hand;
- must know about the applicable guidelines, requirements and operational safety regulations, and train staff accordingly;
- is responsible for ensuring that unauthorized persons have no access to the appliance;
- is responsible for ensuring that the maintenance plan is adhered to and that maintenance work is carried out properly;
- must ensure that the appliance and its surroundings are kept clean and tidy, for example through corresponding instructions and inspections.

## 1.5 Intended Use

The Sense MCE IBC is designed for both indoor and outdoor installations. The device can be installed in ordinary or in hazardous locations. The device is intended for the following user scenarios (industrial applications):

- Digitalization of all IBCs via smart IBC solution
- Integrate a full sensorics profile that measures
  - fill-level of the IBC
  - location (indoor/outdoor)
  - movement
  - environment (light/air temperature)
  - pressure (bulging)
- Integrate all data for people and systems to run core business processes
  - production and goods issues, inventory count, cleaning, filling/emptying
  - alerting and warning
  - automatic Electronics / Things Inventory

## 1.6 Intended Locations

The Sense MCE IBC is intended for operation in the following locations:

- Zone 1
  - NEC 505 Class I Zone 1 for Gas Groups
  - ATEX Group II, Equipment Category 2G
- Zone 2
  - NEC 500 Class I Division 2
  - NEC 505 Class I Zone 2
  - ATEX Group II, Equipment Category 3G

### WARNING

#### WARNING

**The classification of Hazardous Zones is outside of the responsibility of MYNXG. The Zones must be classified by the MYNXG Customer and their Customers**

## 1.7 Changes and Alterations

No unauthorized changes or alterations may be made to the appliance. No parts may be added or inserted which have not been approved by the manufacturer. Unauthorized modifications or changes result in the CE declaration of conformity losing its validity and the appliance must no longer be operated. The manufacturer is not liable for any damage, danger or injuries that result from unauthorized changes or alterations, or from non-observance of the regulations in this manual.

**CAUTION****CAUTION**

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

---

## 1.8 General Safety Regulations

**CAUTION****CAUTION**

Devices on which moisture has developed because of temperature changes must not be charged unless they have been completely dried.

---

**CAUTION****CAUTION**

Assembly, extension, modification or repair shall be carried out only by MYNXG Product GmbH or by experts who are authorized by MYNXG Product GmbH. Violation of this prescription will result in loss of warranty.

MYNXG Product GmbH cannot be held liable for any damages resulting from the use of accessories or consumables, which are not provided or approved by the manufacturer.

---

## 1.9 Certification / Compliance

### 1.9.1 FCC

The MYNXG Sense MCE IBC is FCC certified. This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. this device may not cause harmful interference, and
2. this device must accept any interference received, including interference that may cause undesired operation.

#### **NOTICE**

#### **IMPORTANT NOTICE**

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

#### **Federal Communication Commission Interference Statement**

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- § Reorient or relocate the receiving antenna.
- § Increase the separation between the equipment and receiver.
- § Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- § Consult the dealer or an experienced radio/TV technician for help.



### FCC Caution

Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

### Radiation Exposure Statement

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator and your body.

## 1.9.2 Industry Canada

### Industry Canada Statement

This device complies with license-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's license-exempt RSS standard(s).

Operation is subject to the following two conditions:

- (1) this device may not cause harmful interference, and
- (2) this device must accept any interference received, including interference that may cause undesired operation.

*L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence.*

*L'exploitation est autorisée aux deux conditions suivantes*

- (1) l'appareil ne doit pas produire de brouillage, et*
- (2) l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.*

### Radiation Exposure Statement

This equipment complies with Canada radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20 cm between the radiator & your body.

#### *Déclaration d'exposition aux radiations*

*Cet équipement est conforme Canada limites d'exposition aux radiations dans un environnement non contrôlé. Cet équipement doit être installé et utilisé à distance minimum de 20 cm entre le radiateur et votre corps.*

### 1.10 Warranty

For details on the MYNXG warranty policy, please visit our website [www.mynxg.com](http://www.mynxg.com).

### 1.11 Disposal of Sense MCE IBC – Save the Environment

The Sense MCE IBC does not contain hazardous materials or need any special handling at the end of its lifetime. Many components of the device can be recycled and should be disposed with respect to the local regulations. Feel free to send the unit back to us after sending a request (contact details given in the next chapter).



## 1.12 Behavior in Case of Malfunctions and Irregularities

The appliance may only be used in a flawless condition. If you notice irregularities, malfunctions, or damage, immediately take the appliance out of service and inform your supervisor (if any).

The user / owner of the Sense MCE IBC and associated accessories shall report all complaints about the system to any representative of MYNXG Product GmbH or directly to:

MYNXG Technology GmbH  
Neumeyerstrasse 28-34  
DE-90411 Nürnberg  
Germany

Phone: + 49 911-990876-0  
E-Mail: [service@mynxg.com](mailto:service@mynxg.com)



## 2 Construction and Description

The Sense MCE IBC (**Sense Mobile Cloud Explosive Intermediate Bulk Container**) is the Hazardous location sense device for the Internet of Things (IoT) produced by MYNXG Product GmbH.

The Sense MCE IBC is battery operated with wireless charging capabilities and designed to monitor and manage intermediate bulk containers (IBC). The location, quantity and conditions of the IBC liquids are measured with a non-intrusive sensor. The device comes in an ultra-safe housing (ATEX, NEC500/505) which protects against harsh climate conditions and daily operational handling like cleaning cycles and transport in hazardous environments. The Sense MCE IBC device is supporting LTE, WI-FI and Sub-1GHZ networks (ISM 868 MHz) and is supported through the MYNXG Sensor OS and is fully remote controllable through the MYNXG Cloud.

The Sense MCE IBC is intended for the following user scenarios (industrial applications):

- Digitalization of all IBCs via smart IBC solution
- Integrate a full sensorics profile that measures
  - fill-level of the IBC
  - location (indoor/outdoor)
  - movement
  - environment (light/air humidity /air temperature)
  - pressure (bulging)
- Integrate all data for people and systems to run core business processes
  - goods receipt, production and goods issues, inventory count, cleaning, filling/emptying
  - alerting and warning

The Sense MCE IBC is intended for operation in the following locations:

- Zone 1
  - NEC 505 Class I Zone 1 for Gas Groups
  - ATEX Group II, Equipment Category 2G
- Zone 2
  - NEC 500 Class I Division 2
  - NEC 505 Class I Zone 2
  - ATEX Group II, Equipment Category 3G

## 2.1 Product Number

The Product (Identification) Number (PN) is a unique identifier, assigned to each finished / manufactured product which is ready, to be marketed or for sale. The number is printed together with the serial number (SN) on a MYNXG label (see example given in Figure 1) which is placed on the Sense MCE IBC device.

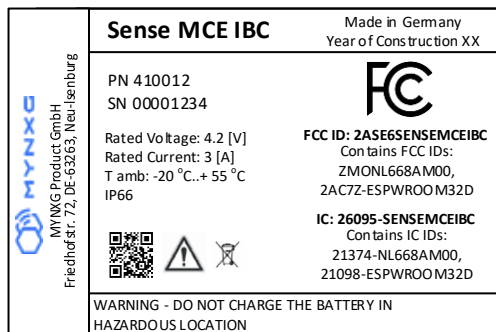


Figure 1: Sense MCE IBC identification label

The Sense MCE IBC has for North America the following product number:

- **410012** Operates in North America

## 2.2 Key Benefits

The key benefits of Sense MCE IBC are:

- Sense MCE IBC is a unique, battery operated, multi communication and secure device.
- Sense MCE IBC supports:
  - LTE / 3G (3GPP Modem) with push-pull MicroSIM holder
  - Wi-Fi 802.11 b/g /n
  - Sub-1GHz Network (ISM 915 MHz Bands)
- Piezo for ultrasonic sensing measurements of fill level
- Sense MCE IBC runs on ARM® Cortex®-M4 RISC Core
- MYNXG hardware-based security implemented Trusted Platform Module (highest level of security).

The Operating System (MYNXG SensorOS) is powering the Sense MCE IBC:

- MYNXG SensorOS is based on FreeRTOS™, an open-source operating system published under the MIT open source license, including:
  - Rich collection of MYNXG libraries optimized for highest performance.
  - Access to large application development community.
- MYNXG Over-The-Air (OTA) service support from the cloud for remote software updates including white-listing of the entire based software (secure signing).

## 2.3 User Group

The designated user group of the MYNXG Sense MCE IBC are professionals and technicians, who are familiar with the handling of radio devices and electrical equipment (low voltage devices). The device is designed for light industrial use.

## 2.4 Industrial Usage

The MYNXG Sense MCE IBC device shall be installed on an IBC. The Intermediate Bulk Containers (also known as: IBC tote, IBC tank, IBC or pallet tanks), are reusable, multi-use industrial-grade containers engineered for the mass handling, transport and storage of liquids, semi-solids, pastes, or solids. The two main categories of IBC tanks are flexible IBCs and rigid IBCs.

The areas in which the device can operate are:

- Harbor facilities
- Machine construction
- Process industry
- Transportation

The Sense MCE IBC is designed to fit a good combination of EU and US standard regulations with one product.

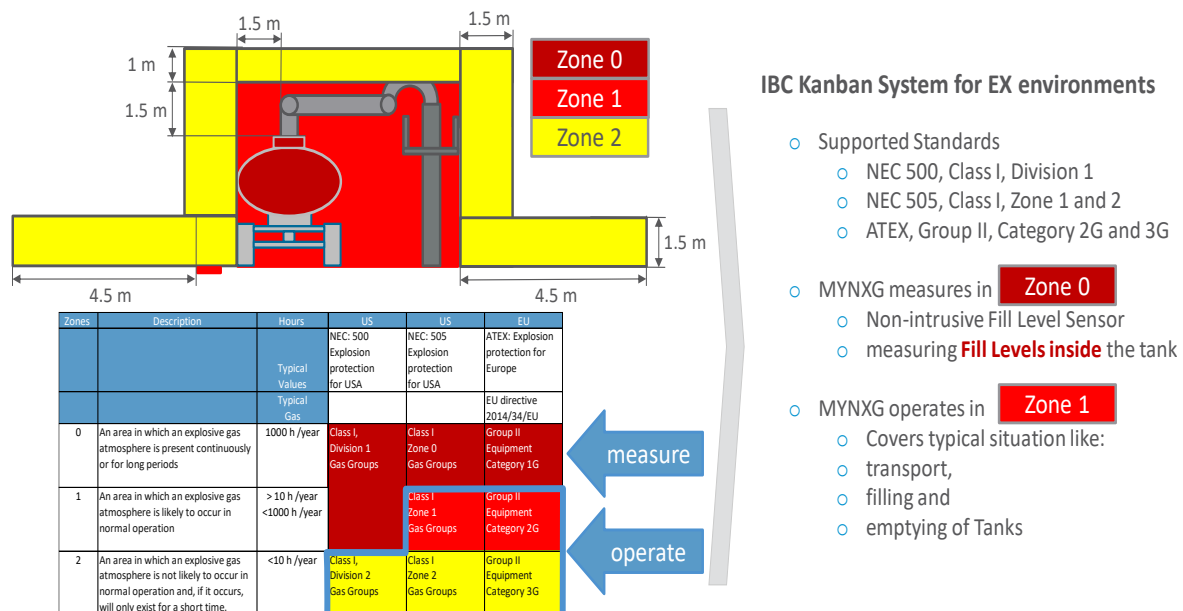


Figure 2 Solution Coverage of the Sense MCE IBC for Hazardous Environments

## 2.5 Industrial Design

The industrial design is based on the MYNXG customized Klippon POK (polyester empty enclosure) housing from Weidmueller and does have the following characteristics:

Parameter	Value
Dimensions	120mm x 122mm x 30mm (H x W x D)
Weight	1.6 kg (approx..)
IP Class	IP66



Figure 3: MYNXG Sense MCE IBC

## 2.6 Interfaces on the Sense MCE IBC

The Sense MCE IBC has only one external interface which is utilized by the cable of the Piezo sensor used for used for ultrasonic sensing measurements of the fill level.

- A non-armored M12 cable gland is holding the piezo cable (Figure 4)



Figure 4: Sense MCE IBC cable gland

## 2.7 EMC and ESD concept

The MYNXG Sense MCE IBC is designed to be compliant with the EU and North America regulations when installed per MYNXG Sense MCE IBC instructions.

The following components are shielded by itself:

- The LTE / 3G Modem is shielded, fully type approved and certified.
- The WI-FI module is shielded, fully type approved and certified.
- The Sub-1GHz Short Radio Device (SRD) is shielded and fully certified.
- The device is in line with the EMC Immunity and EMC Emission.

Furthermore, the PCB board design is done per the following principles:

- On Board EMC and ESD protection components per interface.
- All boards are in line with EMC Immunity Class B EN 61000-6-2.
- All boards are in line with Emission Class A EN 61000-6-3.
- All boards and all components are REACH<sup>1</sup> and RoHS<sup>2</sup> compliant with the respective EU regulations.

The Sense MCE IBC industrial is designed for indoor or outdoor applications and should be placed with a minimum distance of 50cm for a good radio performance.

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<sup>1</sup> Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) is a European Union regulation dating from 18 December 2006. REACH addresses the production and use of chemical substances, and their potential impacts on both human health and the environment.

<sup>2</sup> The Restriction of Hazardous Substances Directive 2002/95/EC, (RoHS 1), short for Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment. This directive restricts (with exceptions) the use of six hazardous materials in the manufacture of various types of electronic and electrical equipment.

## 2.8 Sense MCE IBC Security

Security is anchored inside the Sense MCE IBC via the Trusted Platform Module (TPM). The TPM is a special designed and crypto logical hardened HW, able to store secrets.

The communication between the MYNXG controller and

- the MYNXG Service and Transformation Layer is secured with TLS means,
- TLS encryption of all data for data protection
- the MYNXG communication with the sensors is protected through DTLS / TLS means.

Through the MYNXG public key infrastructure (PKI) the following functions are provided:

- Provisioning of Certificates
- Provisioning of permanently changing TLS secrets
- Provisioning of permanently changing DTLS secrets
- Secure SW Over The Air (OTA) downloads towards the
- Secure SW Over The Air (OTA) downloads to the sensor

### NOTICE

#### IMPORTANT NOTICE

The Sense MCE IBC is designed in line with the methods defined under ISO 27001. Security hardened boot sequence according to CC-EAL, and CC-EAL based security analysis and counteractions. Every cloud communication over 3GPP or Wi-Fi networks is encrypted at any time.

MYNXG development processes and the MYNXG products are designed in line with the methods defined under ISO 27001, MYNXG is audited through the TÜV Rheinland. MYNXG Digital Products and Digital Services are developed within a secured ISO 27001 compliant development environment.

MYNXG has implemented and is provisioning the entire needed infrastructure including:

- Certification Authority (CA) and PKI for the generation and distribution of secrets.
- Production environment for Gateways and Sensors.
- R&D environment to produce software and hardware in line with the ISO 27001.

The MYNXG architecture is compliant with the BSI recommended "Protection Profile for the Gateway of a Smart Metering System". The gateways are not security certified as they are delivered but contain all functions and features for the security.

## 2.9 Functional Block Diagram

A global overview of the Sense MCE IBC electronic is given in Figure 5 below, whereas some of the presented features are optional.

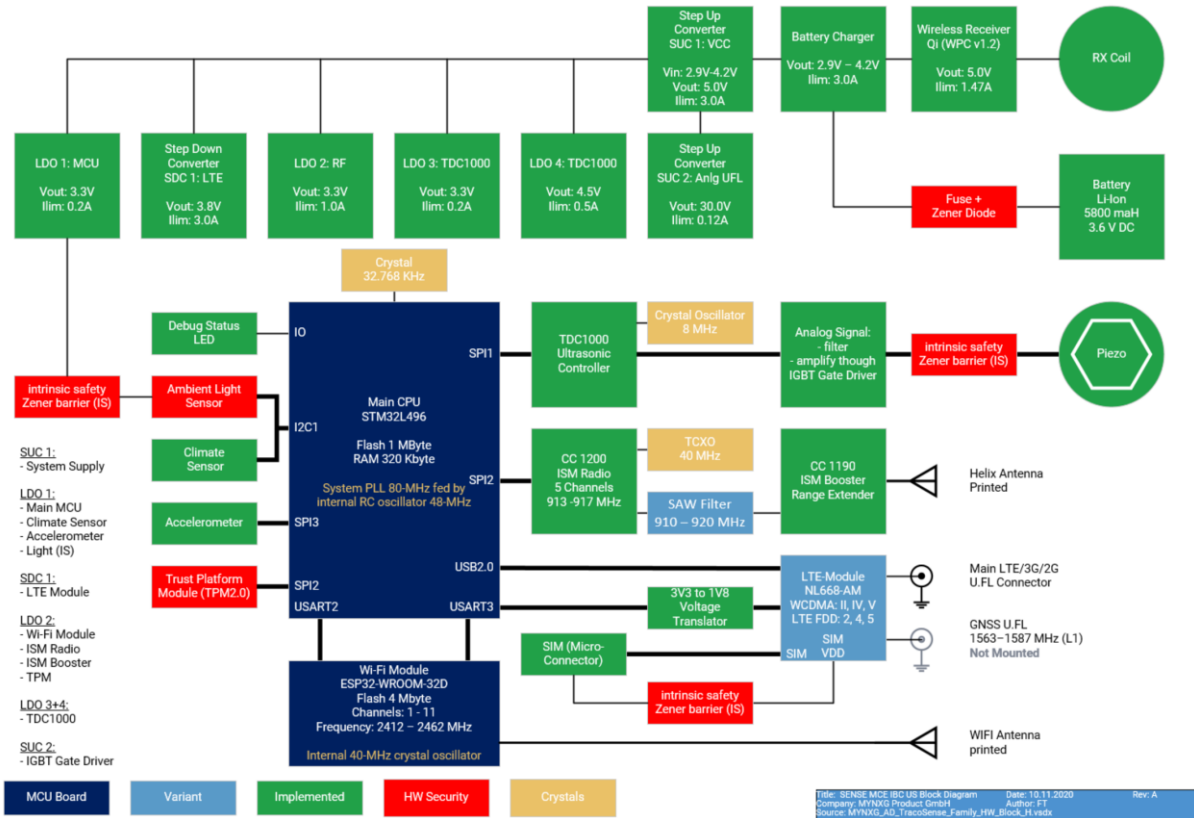


Figure 5: Functional Block Diagram

## 2.10 Typical Application

The Sense MCE IBC is fully controlled and configured from the cloud from trained users. The following steps are performed at first usage of the Sense MCE IBC:

1. The trained technician activates the device with a wireless charger
2. Trained technician installs the external sensors on the Sense MCE IBC
3. The device performs a Secure SW Over The Air (OTA) if applicable
4. The device reports the data to the cloud over LTE



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### 3 Installation

#### NOTICE

##### IMPORTANT NOTICE

The Sense MCE IBC shall not be installed on a place where it might be penetrated by mechanical stress above 7 J.

#### CAUTION

##### CAUTION

Ensure that the location where the device is placed meets the specified environmental conditions concerning temperature and humidity. Do not cover the device and keep at least 20cm space around for air circulation.

#### CAUTION

##### CAUTION

The cable of the pre-assembled piezo is already connected to the Sense MCE IBC. Ensure that the cable is handled carefully in order to prevent any kind of damage.

#### NOTICE

##### IMPORTANT NOTICE

- Do not place the device close to high power / high frequency cable tacks that might have an influence on the device – minimum distance 50cm.
- Do not place the device below ground level or inside rooms with concrete walls (bunker like environments).

### 3.1 Delivery and Unpacking

The Sense MCE IBC is delivered in a carton enclosure which also includes the (optional) mounting plate. The device is already pre-assembled and personalized, i.e. ready for use after waking up.

#### NOTICE

##### IMPORTANT NOTICE

Please check packaging and delivery immediately after receipt regarding damages and completeness. Do not throw away the packaging – it can be used for storage or sending the device back to MYNXG in case of service needed.

#### CAUTION

##### CAUTION

Devices on which moisture has developed because of temperature changes must not be used unless they have been completely dried.

#### CAUTION

##### CAUTION

The SENSE MCE IBC shall not be used when damages or technical defects are visible or recognized.

### 3.2 Placing the Sense MCE IBC

Rating the cellular radio network and Wi-Fi quality prior placing the Sense MCE IBC is recommended to avoid bad signal qualities and transmission issues. Appropriate test software for mobile devices like shown in Figure 6 can be found in the internet.



Figure 6: Wi-Fi Analyzer App

### 3.3 Installation Instructions

Figure 7 shows the principle of the installation of the Sense MCE IBC and the connected piezo sensor. The piezo disc is glued directly onto the bottom side of the IBC. For a good functioning of the measuring method a high quality of the bonding is crucial to ensure, on one hand a good measurement and on the other hand a long stability and durability of the bonding.

A possible placement of the Sense MCE IBC is on the top side of the IBC, via suitable adhesive materials. The Sense MCE IBC and the piezo sensor are connected with a cable of suitable length. The cable is shielded coaxial to reduce potential electromagnetic interferences.

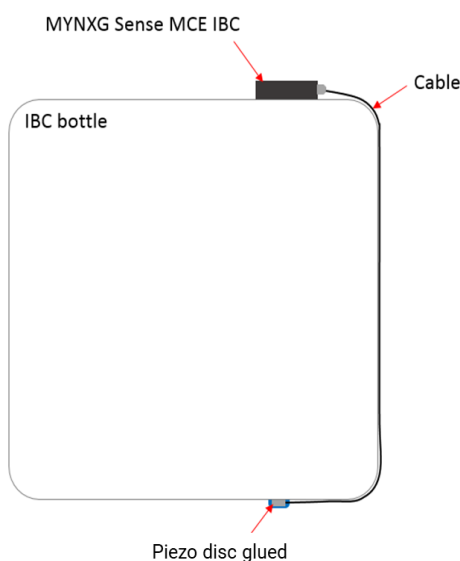


Figure 7: Principle of installation of Sense MCE IBC and connected piezo disc on IBC.

**CAUTION****CAUTION**

Ensure that all instructions of the adhesive materials are followed. Special care should be taken care regarding the temperature during application and the time needed until full cure.

All steps necessary for the installation are described further below

1. Prepare Bottom Side:
  - a. Identify the area (square, size around 60x60 mm) on the bottom side, where the piezo sensor shall be attached. For the area it is important to ensure that it is completely horizontal when the IBC is stored in a horizontal position, otherwise the TOF measurement will not work properly
  - b. Do a first cleaning of this area with a lint-free cloth soaked with alcohol (isopropanol).
2. Mount Piezo Sensor:
  - a. The pre-assembled piezo should be cleaned with alcohol (isopropanol) using a lint-free cloth.
  - b. Glue should be applied on the piezo disc, using provided glue pack
  - c. The piezo assembly should be pressed on the IBC surface, by making sure that the piezo disc itself is located in the specified area
  - d. Hold the pressure for 30 seconds
  - e. The bonding reaches stability after 5 min, final strength of the bonding is reached after 24 hours.
3. Mount Sense MCE IBC
  - a. The surface of the IBC, where the box shall be located, should be clean and dry before applying the provided glue
  - b. Guide the cable from the piezo towards the specific area
  - c. Attach at least five self-adhesive tie sockets to the side of the IBC in equal distances.
  - d. Use cable ties to attach the cable at the self-adhesive tie sockets.
  - e. Apply the bonding material
  - f. Press the mounting plate on the surface of the IBC
  - g. Press for 10 seconds with firm pressure.
  - h. Click the sensor box on the mounting plate, by making sure that all notches are inserted on the housing.



### 3.4 Antennas

The MYNXG Sense MCE IBC is delivered with already pre-assembled antennas. There are three antennas in the device.

- Cellular / LTE rigid fiberglass internal antenna (Figure 8)
- Wi-Fi printed antenna (Figure 9)
- Sub-1GHz SRD printed antenna (Figure 10)



Figure 8: Antennas for LTE and WCDMA Networks with U.FL connector



Figure 9: Wi-Fi on module printed antenna

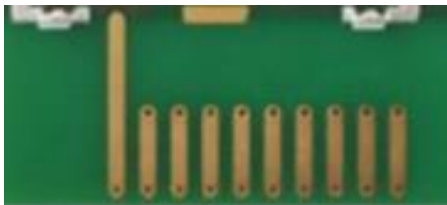


Figure 10: Sub-1GHz SRD printed antenna

#### CAUTION

#### CAUTION

Please note: The LTE antennas have a U.FL connector and shall be placed only on U.FL sockets (Figure 8).

### 3.5 Electrical Power

The Sense MCE IBC is only battery operated.

#### ⚠ WARNING

#### WARNING

The Sense MCE IBC battery is fully compliant under IEC 62133 2nd. Ed. No other battery except the one approved and assembled is allowed to be used.

## 4 RF Interfaces

In the Sense MCE IBC edge computing device three fixed internal for Wi-Fi, LTE and sub-1GHz networks are pre-installed.

The device is using national roaming and all available 3GPP technologies to guarantee the best possible network connections. The Quality of Service is measured by indicators and the quality is reported towards the cloud to analyse potential conflicts at mitigation paths.

Only one RF interface can be active each time. No simultaneous transmissions are supported by the SW.

### 4.1 Wi-Fi Interfaces

Wi-Fi antenna for HOST communication (for Wi-Fi HOST interface) or for primary user equipment (UE) communication (for Wi-Fi UE interface):

- Printed Antenna is optimized for 2.4GHz WI-FI operations.
- Main Wi-Fi - RX / TX antenna is pre-assembled.

#### NOTICE

#### IMPORTANT NOTICE

- The Wi-Fi HOST interface is used to connect the Sense MCE IBC to an external WI-FI hotspot for WLAN and Internet connectivity towards host systems.
- The Wi-Fi UE enables mobile phones and tablets to directly connect to and interact with the Sense MCE IBC as part of the MYNXG BYOD<sup>3</sup> / CYOD<sup>4</sup> concept.

### 4.2 LTE Interfaces

One LTE Internal antenna is pre-assembled to the main RX /TX antenna U.FL connector of the 3GPP LTE (4G) / WCDMA (3G) modem.

#### 4.2.1 SIM-Card

A Micro SIM card is needed for the operation of the LTE modem. Push the Micro SIM card into the slot until you hear the click. To remove the Micro SIM card push it and it will pop out.

### 4.3 Sub-1GHZ Network Interfaces

Sub-1GHz radio technologies are currently using single antennas for RX / TX without diversity:

- One printed antenna is used for Sub-1GHz technology.

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<sup>3</sup> Bring Your Own Device

<sup>4</sup> Choose Your Own Device



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## 5 Electrical Standards and Specifications

### NOTICE

#### IMPORTANT NOTICE

Absolute Maximum Ratings are those values within damages on the device will not occur. Any operation outside these maximum ratings may cause damages on the device. Recommended Operating Conditions are conditions under which operations of the device are intended to be functional. Typically, values correspond to temperature  $T_J = 25\text{ }^\circ\text{C}$ . Unless otherwise stated, the following conditions apply for supply voltage:  $V_{in} = 5\text{ VDC}$  through Wireless Charger.

### 5.1 Recommended Operating Conditions

The recommended operating conditions specify the values under which the device operationally meets the specifications (Table 1). The battery can provide continuously 3A or 10A for less than 2ms in temperatures below  $45\text{ }^\circ\text{C}$ .

### CAUTION

#### CAUTION

Battery discharge in ambient temperatures lower than  $0\text{ }^\circ\text{C}$  will result in limited performance in current output and usable capacity.

Table 1: Recommended operating conditions.

Symbol	Parameter	Min.	Typ.	Max.	Unit
Vbat	Battery Voltage on the battery connector	3.0	3.7	4.2	V
Ibat	Battery maximum continuous discharge current		0.44	3 <sup>5</sup>	A
Ibatpk	Battery maximum peak discharge current			10 <sup>6</sup>	
Vchg	Wireless Charger Voltage	4.5	4.9	5.0	V
I <sub>max</sub>	Wireless Charger maximum current			1.20	A
T <sub>discharge</sub>	The continuous discharging temperature (limited by the connector in maximum value)	-20	-	55	$^\circ\text{C}$
T <sub>charge</sub>	The continuous charging temperature (limited by the connector in maximum value)	0	-	35	$^\circ\text{C}$

<sup>5</sup>  $-20\text{ }^\circ\text{C} < T < 55\text{ }^\circ\text{C}$  (limited by connector).

<sup>6</sup>  $0\text{ }^\circ\text{C} < T < 35\text{ }^\circ\text{C}$  for time period  $< 2\text{ms}$

## 5.2 Power consumption

The power consumptions of the different elements according to the datasheets are listed in Table 2.

Table 2: Power consumption according to datasheets

Hardware	Min.	Typ.	Max.	Unit	Conditions
ARM® Cortex®-M4	0.001	0.1	0.3	W	
LTE Operation	1.6	2.4	3.0	W	Continuous transmission
3G Operation	2.3	2.6	2.9	W	Continuous transmission
Wi-Fi Operation	1.0	1.1	1.2	W	Continuous transmission
Sub-1GHz (SRD)	0.3	0.5	0.8	W	Continuous transmission
Fill Level measurement	0.4	1.0	2.0	W	Continuous measurement
Battery Charging	0.7	3.5	5	W	Only charging active
Peak Use Case	-	3.7	5.3	W	No battery charging
Wireless charging and peak use case	-		6.1	W	Battery charge, measure and transmit

Peak use cases are defined by continuous measuring the fill level and send the values over LTE interface. This combination of usage is only possible with the LTE / 3G HSUPA operation with bit rates of 42Mbps or higher.

The 3GPP Modem may reach a transient peak current 1.3 A (average current 1.1 A), when the module works at LTE/3G mode (the module transmits at the maximum power) and the power consume may reach for extreme short times a peak value of 8.25W.

## 5.3 LTE and WCDMA Module Specifications

The 4G (LTE) / 3G (WCDMA) module, further reference as LTE module, supports one RF connector used for external antenna connection and is used to receive and transmit RF signals. The LTE module adopts standard LLC module RF connectors and uses U.FL connector.

There is a second position for placing a U.FL connector, reserved for GPS / GLONASS / BeiDou. The GPS / GLONASS / BeiDou functionalities are not supported with the current device.



### 5.3.1 LTE and WCDMA Operating Bands

The following LTE / 3G bands might be used for the operation of the Sense MCE IBC. Some of the bands are optional, other will be supported always. Operational bands in North America are marked **BOLD** in Table 3:

Table 3: Operating bands.

Operating Band	Description	Mode	Tx (MHz)	Rx (MHz)
<b>Band 2</b>	<b>PCS 1900MHz</b>	<b>LTE FDD / WCDMA</b>	<b>1850 - 1910</b>	<b>1930 - 1990</b>
<b>Band 4</b>	<b>AWS-1 1700MHz</b>	<b>LTE FDD / WCDMA</b>	<b>1710 - 1755</b>	<b>2110 - 2155</b>
<b>Band 5</b>	<b>CLR 850MHz</b>	<b>LTE FDD / WCDMA</b>	<b>824 - 849</b>	<b>869 - 894</b>
<b>Band 12</b>	<b>LSMH (Blocks A/B/C)</b>	<b>LTE FDD</b>	<b>699 - 716</b>	<b>729 - 746</b>
<b>Band 13</b>	<b>USMH (Block C)</b>	<b>LTE FDD</b>	<b>777 - 787</b>	<b>746 - 756</b>
<b>Band 17</b>	<b>LSMH (Blocks B/C)</b>	<b>LTE FDD</b>	<b>704 - 716</b>	<b>734 - 746</b>
Band 66	Extended AWS-1 (Blocks A-I)	LTE FDD	1710 - 1780	2110 - 2200
Band 71	US 600	LTE FDD	663 - 698	617 - 652

### 5.3.2 LTE and WCDMA Receiver Sensitivity

For the receiver performance of the LTE Module are the conducted receive sensitivity and the conducted transmit power important parameters. Receiver sensitivity is the lowest power level at which the receiver can detect an RF signal and demodulate data. The typical values are listed below in Table 4.

Table 4: Conducted Rx sensitivity.

Mode	Band	3GPP Requirement (dBm)	Rx Sensitivity (dBm) Typical	Note
WCDMA	Band II	-106.7	-109.0	BER < 0.1%
	Band IV	-106.7	-109.5	BER < 0.1%
	Band V	-104.7	-111.0	BER < 0.1%
LTE FDD	Band 2	-94.3	-97.8	10MHz Bandwidth
	Band 4	-96.3	-97.8	10MHz Bandwidth
	Band 5	-94.3	-99.0	10MHz Bandwidth
	Band 12	-93.3	-98.0	10MHz Bandwidth
	Band 13	-93.3	-97.0	10MHz Bandwidth
	Band 17	-93.3	-98.0	10MHz Bandwidth
	Band 66	-95.8	-97.8	10MHz Bandwidth
Band 71	-93.3	-98.0	10MHz Bandwidth	



### 5.3.4 LTE and WCDMA Transmit Power

The conducted transmit power is the maximum power that the module, tested at the antenna port, can transmit. The 3GPP protocol requires different transmit power levels for each power class. Table 5 lists the required and the tested values of the transmit power.

Table 5: Conducted Tx power specifications.

Mode	Band	3GPP Requirement (dBm)	Tx Power (dBm) Typical	Note
WCDMA	Band II	24+1.7 / -3.7	23.5±1	-
	Band IV	24+1.7 / -3.7	23.5±1	-
	Band V	24+1.7 / -3.7	23.5±1	-
LTE FDD	Band 2	23±2.7	23±1	10MHz Bandwidth, 1 RB
	Band 4	23±2.7	23±1	10MHz Bandwidth, 1 RB
	Band 5	23±2.7	23±1	10MHz Bandwidth, 1 RB
	Band 12	23±2.7	23±1	10MHz Bandwidth, 1 RB
	Band 13	23±2.7	23±1	10MHz Bandwidth, 1 RB
	Band 17	23±2.7	23±1	10MHz Bandwidth, 1 RB
	Band 66	23±2.7 / -3.2	23±1	10MHz Bandwidth, 1 RB
	Band 71	23±2.7	23±1	10MHz Bandwidth, 1 RB

## 5.4 Wi-Fi Specifications

The output power and the receive sensitivity for the different wireless-networking standards, the available data rates for each used IEEE 802.11 network PHY standard and the modulation techniques are listed in the Table 6.

Table 6: Wi-Fi specifications.

Technical Specifications											
<b>Output power</b>	802.11b:		18.5dBm ± 1.5dBm @ 11Mbps								
	802.11g:		13dBm ± 1.0dBm @ 54Mbps								
	802.11gn HT20:		13dBm ± 1.0dBm @ MCS7								
	802.11gn HT40:		12dBm ± 1.0dBm @ MCS7								
<b>Receive Sensitivity</b>	802.11b:		-89dBm ± 2dBm @ 11Mbps								
	802.11g:		-74dBm ± 2dBm @ 54Mbps								
	802.11gn HT20:		-71dBm ± 2dBm @ MCS7								
	802.11gn HT40:		-69dBm ± 2dBm @ MCS7								
<b>Standards</b>	IEEE 802.11b	11 Mbps	5.5 Mbps	2 Mbps	1 Mbps						
	IEEE 802.11g	54 Mbps	48 Mbps	36 Mbps	24 Mbps	18 Mbps	12 Mbps	9 Mbps	6 Mbps	Auto.	
		Fallback to 5.5Mbps, 2Mbps, 1Mbps									
	IEEE 802.11n	20MHz	65Mbps @ 800GI, 72.2Mbps @ 400GI (Max.)								
40MHz		135Mbps @ 800GI, 150Mbps @ 400GI (Max.)									
<b>Channel Number</b>	1	2	3	4	5	6	7	8	9	10	11
<b>Frequency (MHZ)</b>	2412	2417	2422	2427	2432	2437	2442	2447	2452	2415	2462
<b>Modulation Techniques</b>	OFDM: BPSK, QPSK, 16 QAM, 64QAM DSSS: DBPSK, DQPSK, CCK										

### 5.4.1 Wi-Fi Channels 802.11b/g/n-HT20

Table 7: Wi-Fi channels for 20MHz band width

Channel	Frequency (MHz)
1	2412
2	2417
3	2422
4	2427
5	2432
6	2437
7	2442
8	2447
9	2452
10	2457
11	2462
12 <sup>7</sup>	2467

### 5.4.2 Wi-Fi Channels 802.11b/g/n-HT40

Table 8: Wi-Fi channels for 40MHz band width

Channel	Frequency (MHz)
3	2422
4	2427
5	2432
6	2437
7	2442
8	2447
9	2452
10 <sup>8</sup>	2457

<sup>7</sup> Canada Only

<sup>8</sup> Canada Only

## 5.5 ISM Sub-1GHz Band

For the ISM Sub 1-GHz band signal generation and transmission, a low-power, high-performance RF Transceiver from Texas Instruments (CC1200) is used. The transmitted and the received signals are amplified with an RF Front End also from Texas Instruments, which can be operated at 850 – 950 MHz (CC1190).

To get an increased ISM maximum output power of 23 dBm, a transmitted power level of -1.5 dBm is amplified with an analog front end in the output amplifier stage. With a gain of 24.5 dB (High Gain Mode) and a noise figure of 2.9 dB the maximum power level is achieved in consideration of the board losses (approximately 1.1 dB). This is the gain going out of the Power Amplifier without calculating the peak gain of the printed antenna of peak gain of 0 dBi (average gain of the printed antenna -6 dBi).

Table 9 shows the transmit power levels, receiver sensitivity and current consumption for each used frequency at 915 MHz.

Table 9: RF specifications and current consumption

Parameter	Min	Typ.	Max	Unit	Conditions
Transmit Power	3	16	23	dBm	
Receiver Sensitivity	-	-115	-	dBm	100-kbps 2-GFSK, DEV=175 kHz, CHF=514.423 kHz <sup>9</sup>
Current Consumption	-	220	-	mA	Output power of 23 dBm
Current Consumption	-	160	-	mA	Output power of 16 dBm

<sup>9</sup> GFSK is short for the frequency modulation Gaussian Frequency Shift Keying, DEV is short for deviation, CHF is short for Channel Filter Bandwidth



### 5.5.1 ISM Sub-1GHz Band (Frequencies North America)

The frequencies used for Sense MCE IBC for ISM communication are shown in Table 10:

Table 10: RF channels for North America

Channel Number	Frequency (MHz)	Average EIRP Power (dBm) <sup>10</sup>	PSD in any 3KHz band (dBm)	Occupied Bandwidth (kHz)
1	913.0	16	7.02	514.4231
2	914.0	16	7.27	514.4231
3	915.0	15	7.62	514.4231
4	916.0	15	7.68	514.4231
5	917.0	15	7.76	514.4231

**Software or system compliance:** Sense MCE IBC is utilizing the following network assignment technologies in line with the above directive:

- Polite Spectrum Entrance using collision detector
- Sense MCE IBC always transmit below the duty cycle due to limited usage to safe power for the sensor.

## 5.6 Ultrasonic Fill level measurement

The fill level is measured using the piezo sensor for ultrasonic sensing measurements. More information regarding the fill level measurements, are shown in Table 9:

Table 11: Fill level measurement parameters

Parameter	Min	Typ.	Max	Unit
Transmit frequency		1		MHz
Number of TX pulses	0	-	31	-
Power Amplifier Gain	0	-	21	dB
Power Amplifier step size		3		dB
Low Noise Amplifier Gain		20		dB
Received signal level	35	-	1500	mV

<sup>10</sup> The EIRP Power includes the Tx power of the transceiver and the maximum antenna gain (0 dBi)

## 5.7 LTE and WCDMA Antenna Specifications

The modem uses one internal LTE antenna which is already pre-mounted in the housing. The characteristics are shown in Table 12.

Table 12: LTE and WCDMA antenna specifications

Parameter	Value	Unit
Connector	U.FL Standard	-
Frequency	700 - 2600	MHz
V.S.W.R.	< 2.1:1	BW
Peak Gain (698 - 960 MHz)	0.3	dBi
Peak Gain (1710 - 2170 MHz)	1.5	dBi
Peak Gain (2500 - 2700 MHz)	2.8	dBi
Average Gain (698 - 960 MHz)	-3.5	dB
Average Gain (1710 - 2170 MHz)	-3.3	dB
Average Gain (2500 - 2700 MHz)	-3.1	dB
Impedance	50	$\Omega$
Polarization	Linear	-
Radiation Pattern	Omni-directional	
Max Input Power	25	W
Material	Rigid Fiberglass	-
Length	89.7	Mm
Width	14.1	Mm
Height	0.8	Mm
Cable Length	100	Mm
Cable Type	1.37 Mini-Coax Standard	Mm
Mounting Type	Adhesive Mount	
Adhesive Type	3M 467	
Operating Temperature	-40 - +85	$^{\circ}\text{C}$
Environmentally Friendly	RoHS Compliant	-



## 5.8 Wi-Fi Antenna Specifications

The Wi-Fi antenna is printed on the module and the characteristics are shown in Table 13.

Table 13: Wi-Fi antenna specifications

Parameter	Value	Unit
Connector	Permanently attached antenna	-
Frequency	2.4 – 2.4835	GHz
V.S.W.R.	< 2.0:1	BW
Max Gain	3.7	dBi
Impedance	50	$\Omega$
Polarization	Linear	-
Max Input Power	25	W
Operating Temperature	-40 - +85	$^{\circ}\text{C}$
Environmentally Friendly	REACH / RoHS Compliant	-

## 5.9 Sub-1GHz (SRD) Specifications

The Sub-1GHz antenna is printed on the PCB and the characteristics are shown in Table 14.

Table 14: Sub-1GHz antenna specifications

Parameter	Value	Unit
Connector	Permanently attached antenna	-
Frequency	860 – 920	MHz
V.S.W.R.	< 2.0:1	BW
Max Gain	0.0	dBi
Efficiency	65.55	%
Impedance	50	$\Omega$
Polarization	Linear	-
Max Input Power	25	W
Operating Temperature	-40 - +85	$^{\circ}\text{C}$
Environmentally Friendly	REACH / RoHS Compliant	-



## 6 Annex: Troubleshooting

Symptom	Solution
Getting Alarm from Cloud that Sense MCE IBC communication is interrupted	In case that you do not get data from the Sense MCE IBC displayed in your application, do the following steps: <ol style="list-style-type: none"> <li>1. Ensure that communication to cloud is established</li> <li>2. Ensure that communication chain from cloud to Sense MCE IBC is established (router, repeater, etc.)</li> </ol>
The LTE SIM card is inserted but the Sense MCE IBC does not connect to the network.	<ol style="list-style-type: none"> <li>1. Check that Sense MCE IBC reports to the cloud</li> <li>2. Check that the inserted SIM card is from our supported provider</li> <li>3. Check on the cloud that there is no tamper event</li> </ol>
Wi-Fi is not accessible when LTE is enabled	Only one radio interface is active at a time. Please configure from the cloud if you need to use Wi-Fi instead of LTE network.
The Sense MCE IBC is shown offline in the cloud	<ol style="list-style-type: none"> <li>1. Check the battery level reported on the last message</li> </ol>



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## 7 Annex: Supported & Unsupported Features

Feature	Supported <sup>11</sup>
Attach a 5W Qi (WPC 1.2) compliant wireless charger	Yes
Attach a 10W Qi (WPC 1.2) compliant wireless charger	Yes
Open the lid	Yes <sup>12</sup>
Insert SIM card from a different supplier	No
Attach external antenna	No
Attach internal antenna from different supplier	No
Change the battery	No

<sup>11</sup> 'Yes' = equipment is recognized and usable when connected to the Sense MCE IBC prior to system boot-up.

<sup>12</sup> Make sure that you have followed the procedure to open the lid. If not a tamper event will occur and the device will not be functional unless it is cleared.



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