

Datasheet

CENTAURI 200

Product ID CT200 20

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TABLE OF CONTENTS

1 INTRODUCTION.....	5
1.1 PURPOSE.....	5
1.2 SCOPE.....	5
1.3 ACRONYMS & ABBREVIATIONS.....	5
1.4 REFERENCES.....	5
2 PRODUCT OVERVIEW.....	6
2.1 SYSTEM BLOCK DIAGRAM.....	8
2.2 FEATURES AND FUNCTIONALITY.....	8
3 MAJOR COMPONENTS ON CENTAURI 200.....	9
3.1 SECURE ELEMENT.....	9
3.2 WIRELESS CONNECTIVITY.....	10
3.3 WI-FI COMBO MODULE.....	10
3.4 POWER SUPPLY.....	11
4 PERIPHERAL INTERFACES.....	12
4.1 ETHERNET.....	12
4.2 IEEE FEATURES:.....	15
4.3 USB.....	15
4.4 DEBUG PORT.....	16
4.5 EMMC.....	17
4.6 DDR (DOUBLE DATA RATE) RAM.....	17
4.7 SWITCHES.....	17
4.8 LED'S.....	18
5 ELECTRICAL THERMAL & ANTENNA RANGE CHARACTERISTICS.....	19
5.1 RECOMMENDED OPERATING CONDITIONS.....	19
5.2 THERMAL ANALYSIS DATA.....	19
6 MECHANICAL DIMENSIONS.....	20
7 CERTIFICATION.....	22
7.1 FCC (FEDERAL COMMUNICATIONS COMMISSION) & IC (INDUSTRY CANADA).....	22
CONFORME À LA NORME NMB-003 DU CANADA.....	22
APPLICATION NOTES.....	22
SAFETY PRECAUTIONS.....	22
DESIGN ENGINEERING NOTES.....	22
STORAGE CONDITIONS.....	23
LIST OF FIGURES	
FIGURE 1 : CENTAURI 200 UNIT.....	6
FIGURE 2 : CENTAURI 200 PCBA.....	7
FIGURE 3 : CENTAURI 200 - SYSTEM BLOCK DIAGRAM.....	8

FIGURE 4 : CENTAURI 200 - BASE BOARD.....	9
FIGURE 8 : INTERFACES ON CENTAURI 200.....	12
FIGURE 9 : ETHERNET PORTS.....	12
FIGURE 10 : USB PORT SELECTION JUMPER.....	16
FIGURE 11 : DEBUG PORT.....	16
FIGURE 12 : USER CONFIGURABLE SWITCHES.....	17
FIGURE 13 : LED'S ON CENTAURI 200.....	18
FIGURE 14 : CENTAURI 200 DIMENSIONS TABLE TOP.....	20
FIGURE 15 : CENTAURI 200 DIMENSIONS WALL MOUNT.....	21

LIST OF TABLES

TABLE 1 : REVISION HISTORY.....	4
TABLE 2 : ACRONYMS & ABBREVIATIONS.....	5
TABLE 3 : REFERENCES.....	5
TABLE 4 : FEATURES AND FUNCTION.....	8
TABLE 6 : WI-FI RF CHARACTRICS.....	11
TABLE 7 : LED'S.....	18
TABLE 8 : RECOMMENDED OPERATING CONDITIONS.....	19
TABLE 9 : THERMAL ANALYSIS.....	19

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Revision History

Date	Version	Details of change	Author	Reviewers
5-Aug-19	1	Initial draft	JB	KB
8-Feb-20	2	<ul style="list-style-type: none"> - Updated the document as per the latest rev2.0 of the schematics and layout. - Removed “Regulatory Statements” section. - Updated the document with standard document template. 	SD	KB
19-Mar-20	2.1	<ul style="list-style-type: none"> - Updated all the tables, Images, added thermal & Range test data. 	YP	KB
25-06-20	2.2	<ul style="list-style-type: none"> - Updated PoE source specification in section 3.10 	SD	KB
03/02/2021	2.3	<ul style="list-style-type: none"> - Updated as per OCH certification 	YP	KB
10/02/2021	2.4	<ul style="list-style-type: none"> - Updated as per ZF certification 	YP	KB

Table 1 : Revision History

1 INTRODUCTION

1.1 Purpose

This document describes the VOLANSYS' Centauri 200 enterprise/industrial IoT Gateway. Targeted for multiple use cases in various segments of IoT such as Smart Home, Buildings and Industries. Core features are its Hardware Design with Multi-Radio Connectivity such as Wi-Fi, Zigbee®. Apart from multiple radio connectivity options.

This document mainly describes Centauri 200 from a Hardware point of view, there are separate software development manuals that can be also consulted.

For any further support contact Volansys support services at: centauri.support@volansys.com

1.2 Scope

The scope of this document is to detail out aspect of CT200 Gateway product design, specifications, Features etc.

This document, henceforth, is to be used as a direct reference by end customers that uses this product. CT200 Gateway team will also use this document to review, approve and accept the product design for showcase purpose.

1.3 Acronyms & Abbreviations

Terms	Definition
SoC	System on Chip
CPU	Central Processing Unit
IoT	Internet of things
RST	Reset
UART	Universal asynchronous receiver-transmitter
LED	Light Emitting Diode
GPIO	General Purpose Input/output
TBD	To Be Determined
Etc	Et Criteria

Table 2 : Acronyms & Abbreviations

1.4 References

Sr No	Reference Document Title	Provided by	Remarks
1	Schematics design	Volansys	Primary reference
2	Layout design	Volansys	N/A

Table 3 : References

2 PRODUCT OVERVIEW

Volansys' Centauri 200 is all-in-one gateway development kit, which is based on NXP's power efficient i.MX6ULL applications processor featuring ARM® Cortex®-A7 core CPUs.

Centauri 200 has a wide range of interfaces available like USB, Ethernet. It supports various wireless connectivity protocol as Zigbee®, Wi-Fi b/g/n. Centauri 200 has standard MikroBus compatible socket header which enables a user to use any standard MikroBus add on modules. The figure below shows the complete Centauri 200 unit and internal view depicting all its interfaces.

CENTAURI 200 IoT Gateway platform is specifically crafted to satisfy all the needs of the Enterprise/Industrial IoT Gateway Solution. Gateway is built on secure, power-efficient, and cost-optimized ARM® Cortex®-A7 based i.MX6ULL SoC. This enables a greater amount of flexibility in providing various RF connectivity and peripherals to make a tailor-made solution according to end-user needs. VOLANSYS also offers a CENTAURI Software Framework for all OEMs to quickly build applications. CENTAURI Gateway platform is pre-integrated with well-known cloud & app platform providers to help OEMs with faster application development. OEMs can build Zigbee gateway-based solution on the platform with any two radios supported at a time. CENTAURI Gateway platform is available under OEM offerings to reduce time to market so that you can focus more on creating values in end-user applications.



Figure 1: Centauri 200 Unit

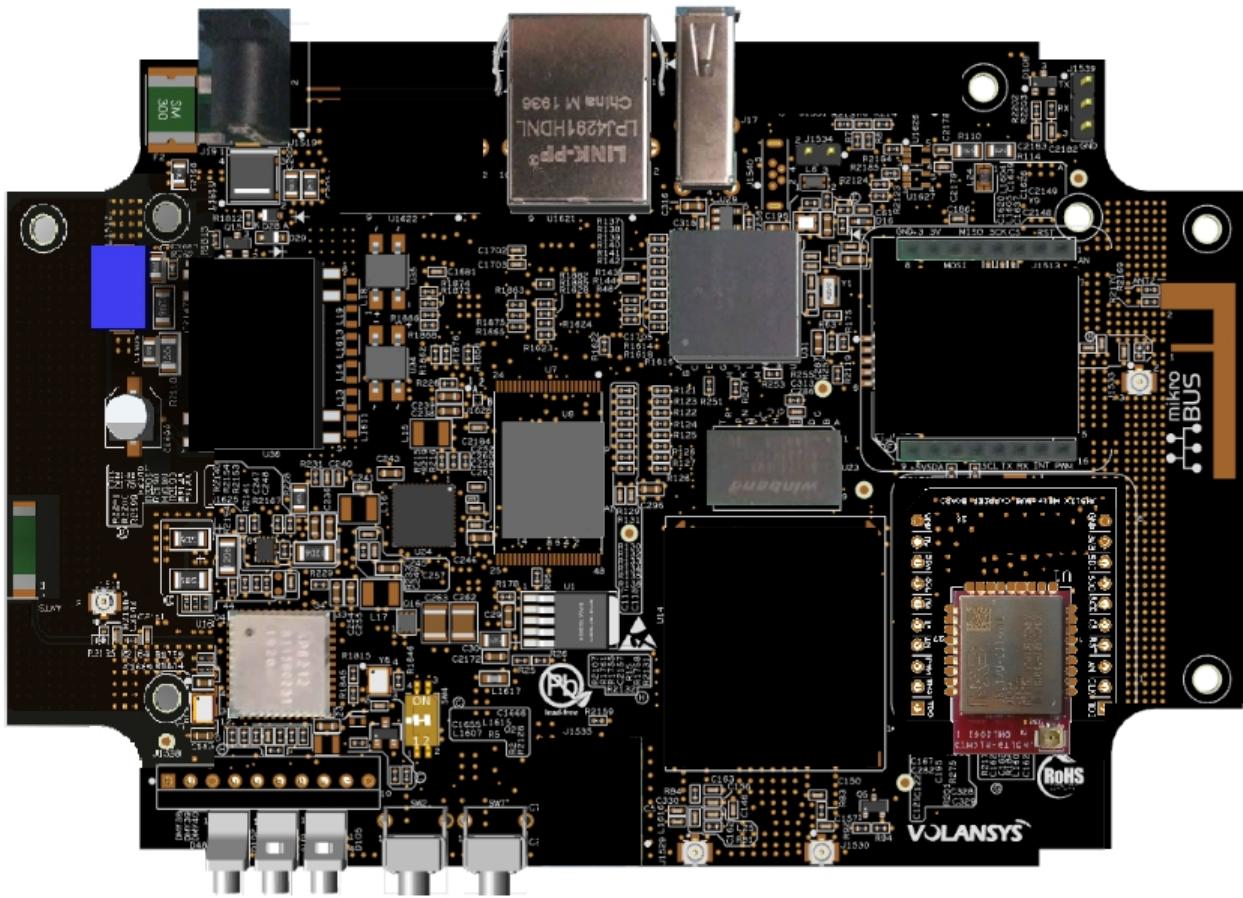


Figure 2: Centauri 200 PCBA

2.1 System Block Diagram

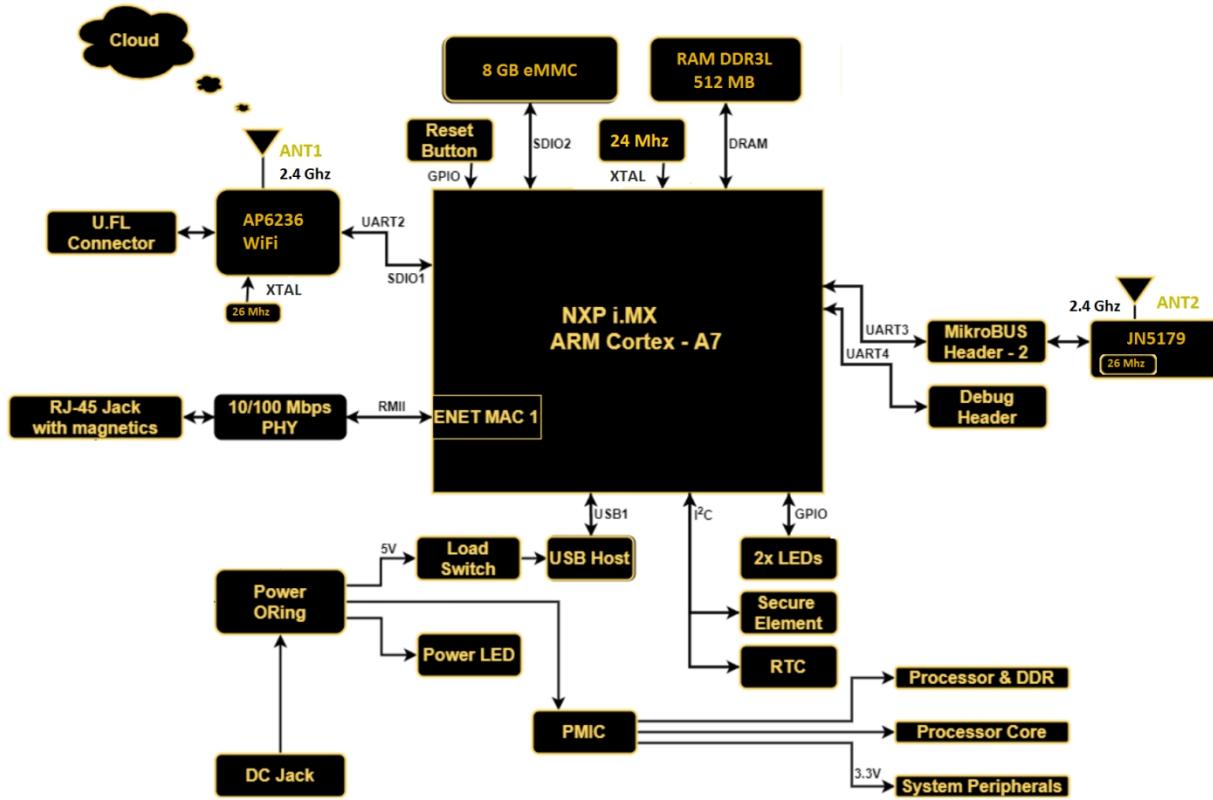


Figure 3: Centauri 200 - System Block Diagram

2.2 Features and Functionality

The table below lists major features and function of the Centauri 200.

Sr No	Block	Feature Parameter	Specification
1	CPU	Core & Frequency	i.MX 6ULL (528 MHz) ARM Cortex A7
2	Memory	RAM Memory Type	DDR3L
		RAM Size	512 MB
		EMMC	8 GB
3	Interfaces	Ethernet	1 x 10/100Mbps
		USB	1 x USB2.0 (Host/Device)
		Mikrobus header	1 x Zigbee Module
4	User Interface/ IO	Switch	2x user configurable switches
		LED's	1x power LED
			2x user configurable LED's
		Debug Port	1x UART port for debug

Table 4: Features and Function

3 MAJOR COMPONENTS ON CENTAURI 200

Below are some of major features and interfaces of Centauri 200 base board:

- 1x MikroBus Compatible Header. (Supports JN5179 Zigbee module)
- 1x Wi-Fi b/g/n module with U.FL connector to support external antenna.
- 1x JTAG header.
- 1x USB 2.0 port (host/device configurable).
- 1x 10/100 Ethernet port.
- 3x LED's (1x power + 2x user configurable).
- 2x user configurable switches.
- DC power jack (5V, 3A) or terminal block (9-27V).

Note: Other MikroBUS compatible modules can be added to the Centauri 200 via its MikroBUS compatible headers.

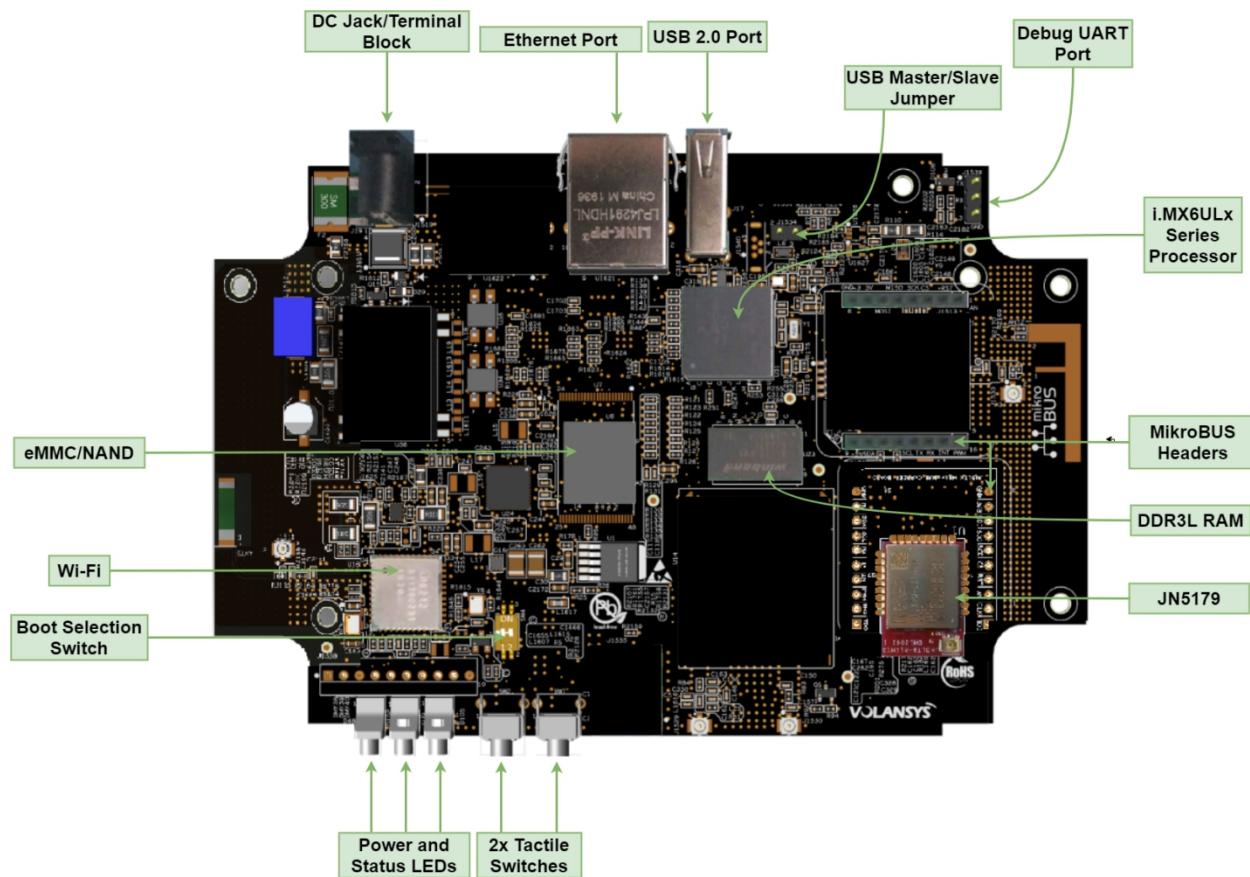


Figure 4 : Centauri 200 - Base Board

3.1 Secure Element

Centauri 200 has a built-in secure element IC providing device to device authentication, key storage and

data protection, etc features based on NXP's A71CH chip.

The A71CH is a ready-to-use solution providing a root of trust at the IC level and proven, chip-to-cloud security right out of the box. It is a platform capable of securely storing and provisioning credentials, securely connecting IoT devices to cloud services and performing cryptographic node authentication.

More information regarding this chip can be found at the link below:

<https://www.nxp.com/docs/en/data-sheet/A71CH-SDS.pdf>

3.2 Wireless Connectivity

Centauri 200 has on board AP6236 (WiFi), JN5179 (Zigbee) wireless modules. Below are major features of each wireless peripheral. More information regarding the wireless modules can be obtained from their respective websites and data-sheets.

3.3 Wi-Fi Combo Module

The Centauri 200 uses an Ampak AP6236 Wi-Fi combo module. AP6236 is a single chip 2.4 GHz WLAN IEEE 802.11 b/g/n single band radio with integrated class 1.5 PA and Low Energy (LE) support. The Centauri 200 comes with two antenna options for the Wi-Fi viz. Internal PCB trace antenna and external high gain whip antenna.

Below image shows the RF specification of the Wi-Fi/BT module.

Sr	Feature	Description
1	WLAN Standard	IEEE 802.11b/g/n, WiFi compliant
2	Frequency Range	2.400 GHz ~ 2.4835 GHz (2.4 GHz ISM Band)
3	Number of Channels	2.4GHz: Ch1 ~ Ch14
4	Modulation	802.11b : DQPSK, DBPSK, CCK 802.11 g/n : OFDM /64-QAM,16-QAM, QPSK, BPSK
5	Output Power (Burst Average Power)	802.11b /11Mbps : 16 dBm ± 1.5 dB @ EVM -9dB 802.11g /54Mbps : 15 dBm ± 1.5 dB @ EVM -25dB 802.11n /65Mbps : 14 dBm ± 1.5 dB @ EVM -28dB
6	Receive Sensitivity (11n,20MHz) @10% PER	- MCS=0 PER @ -85 dBm, typical - MCS=1 PER @ -84 dBm, typical - MCS=2 PER @ -82 dBm, typical - MCS=3 PER @ -80 dBm, typical - MCS=4 PER @ -77 dBm, typical - MCS=5 PER @ -73 dBm, typical - MCS=6 PER @ -71 dBm, typical - MCS=7 PER @ -68 dBm, typical
7	Receive Sensitivity (11g) @10% PER	- 6Mbps PER @ -86 dBm, typical - 9Mbps PER @ -85 dBm, typical - 12Mbps PER @ -85 dBm, typical - 18Mbps PER @ -83 dBm, typical - 24Mbps PER @ -81 dBm, typical

		<ul style="list-style-type: none"> - 36Mbps PER @ -78 dBm, typical - 48Mbps PER @ -73 dBm, typical - 54Mbps PER @ -71 dBm, typical
8	Receive Sensitivity (11b) @8% PER	<ul style="list-style-type: none"> - 2Mbps PER @ -88 dBm, typical - 5.5Mbps PER @ -87 dBm, typical - 11Mbps PER @ -84 dBm, typical - 2Mbps PER @ -88 dBm, typical
		<ul style="list-style-type: none"> - 2Mbps PER @ -88 dBm, typical - 5.5Mbps PER @ -87 dBm, typical - 11Mbps PER @ -84 dBm, typical - 2Mbps PER @ -88 dBm, typical
		<ul style="list-style-type: none"> - 2Mbps PER @ -88 dBm, typical - 5.5Mbps PER @ -87 dBm, typical - 11Mbps PER @ -84 dBm, typical - 2Mbps PER @ -88 dBm, typical
		<ul style="list-style-type: none"> - 2Mbps PER @ -88 dBm, typical - 5.5Mbps PER @ -87 dBm, typical - 11Mbps PER @ -84 dBm, typical - 2Mbps PER @ -88 dBm, typical
9	Data Rate	802.11b : 1, 2, 5.5, 11Mbps
10		802.11g : 6, 9, 12, 18, 24, 36, 48, 54Mbps
11	Data Rate (20MHz ,Long GI,800ns)	802.11n: 6.5, 13, 19.5, 26, 39, 52, 58.5, 65Mbps
12	Maximum Input Level	802.11n : 7.2, 14.4, 21.7, 28.9, 43.3, 57.8, 65,72.2Mbps
13		802.11b : -10 dBm 802.11g/n : -20 dBm
13	Antenna Reference	Small antennas with 0~3.2 dBi peak gain

Table 6 : Wi-Fi RF Charactrics

3.4 Power Supply

The Centauri 200 has the following power options:

- **DC Jack:** Uses a 5V, 3A DC power adaptor.
- **Terminal Block:** Uses a 9-27V, 1.6-0.6A DC power adaptor

4 PERIPHERAL INTERFACES

This section describes interfaces of Centauri 200. Below figure shows the available interfaces of Centauri 200. Figure 5-1 describes the peripheral interfaces of Centauri 200 pictorially.

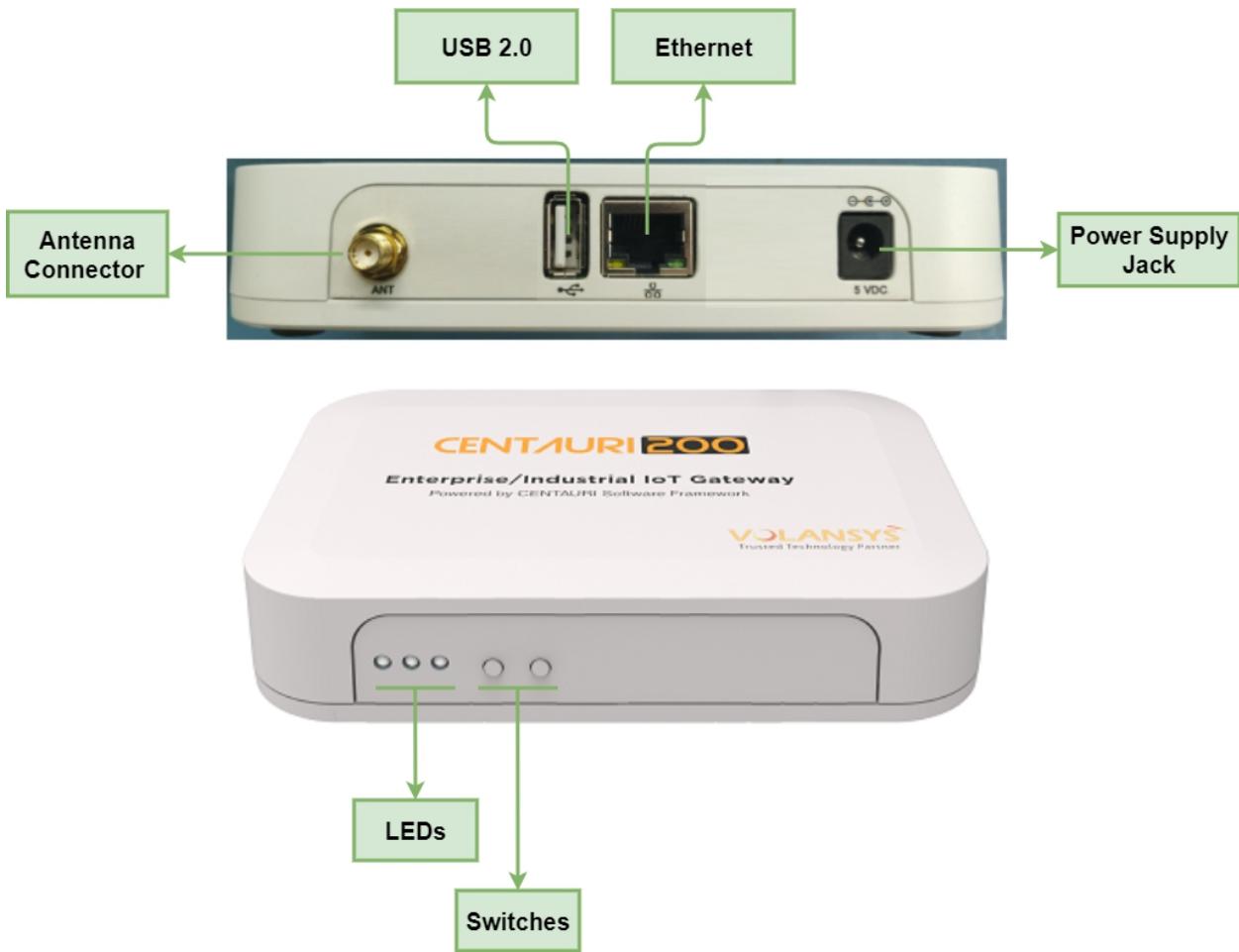


Figure 8 : Interfaces on Centauri 200

4.1 Ethernet

The Centauri 200 has 1 x 10/100Mbit/s Ethernet ports.

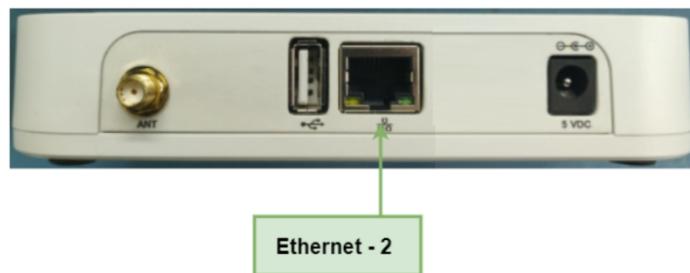


Figure 9 : Ethernet Ports

Ethernet MAC features:

- Implements the full 802.3 specification with preamble/SFD generation, frame padding generation, CRC generation and checking, supports zero-length preamble.
- Dynamically configurable to support 10/100-Mbit/s operation.
- Supports 10/100 Mbit/s full-duplex and configurable half-duplex operation.
- Compliant with the AMD magic packet detection with interrupt for node remote power management.
- Seamless interface to commercial Ethernet PHY devices via one of the following:
 - A 4-bit Media Independent Interface (MII) operating at 2.5/25 MHz.
 - A 4-bit non-standard MII-Lite (MII without the CRS and COL signals) operating at 2.5/25 MHz.
 - A 2-bit Reduced MII (RMII) operating at 50 MHz.
 - Simple 64-Bit FIFO user-application interface.
- CRC-32 checking at full speed with optional forwarding of the frame check sequence(FCS) field to the client.
- CRC-32 generation and append on transmit or forwarding of user application provided FCS selectable on a per-frame basis.
- In full-duplex mode:
 - Implements automated pause frame (802.3 x31A) generation and termination, providing flow control without user application intervention.
 - Pause quanta used to form pause frames — dynamically programmable.
 - Pause frame generation additionally controllable by user application offering flexible traffic flow control.
 - Optional forwarding of received pause frames to the user application.
 - Implements standard flow-control mechanism.
- In half-duplex mode: provides full collision support, including jamming, back-off, and automatic re-transmission.
- Supports VLAN-tagged frames according to IEEE 802.1Q
- Programmable MAC address: Insertion on transmit; discards frames with mismatching destination address on receive. (except broadcast and pause frames)

- Programmable promiscuous mode support to omit MAC destination address checking on receive.
- Multicast and uni cast address filtering on receive based on 64-entry hash table, reducing higher layer processing load.
- Programmable frame maximum length providing support for any standard or proprietary frame length.
- Statistics indicators for frame traffic and errors (alignment, CRC, length) and pause frames providing for IEEE 802.3 basic and mandatory management information database (MIB) package and remote network monitoring (RFC 2819).
- Simple handshake user application FIFO interface with fully programmable depth and threshold levels.
- Provides separate status word for each received frame on the user interface providing information such as frame length, frame type, VLAN tag, and error information.
- Multiple internal loop back options.
- MDIO master interface for PHY device configuration and management supports two programmable MDIO base addresses, and standard (IEEE 802.3 Clause 22) and extended (Clause 45) MDIO frame formats.
- Supports legacy FEC buffer descriptors.
- Interrupt coalescing reduces the number of interrupts generated by the MAC, reducing CPU loading.

IP protocol performance optimization features:

- Operates on TCP/IP and UDP/IP and ICMP/IP protocol data or IP header only, enables wire-speed processing. Supports IPv4 and IPv6.
- Transparent passing of frames of other types and protocols.
- Supports VLAN tagged frames according to IEEE 802.1q with transparent forwarding of VLAN tag and control field.
- Automatic IP-header and payload (protocol specific) checksum calculation and verification on receive.
- Automatic IP-header and payload (protocol specific) checksum generation and automatic insertion on transmit configurable on a per-frame basis.
- Supports IP and TCP, UDP, ICMP data for checksum generation and checking.
- Supports full header options for IPv4 and TCP protocol headers.
- Provides statistics information for received IP and protocol errors.
- Configurable automatic discard of erroneous frames.

- Configurable automatic host-to-network (RX) and network-to-host (TX) byte order conversion for IP and TCP/UDP/ICMP headers within the frame.
- Configurable padding removes for short IP datagrams on receive.
- Configurable Ethernet payload alignment to allow for 32-bit word-aligned header and payload processing.
- Programmable store-and-forward operation with clock and rate decoupling FIFOs.

4.2 IEEE features:

- Supports all IEEE 1588 frames.
- Allows reference clock to be chosen independently of network speed.
- Software-programmable precise time stamping of ingress and egress frames.
- Timer monitoring capabilities for system calibration and timing accuracy management.
- Precise time stamping of external events with programmable interrupt generation.
- Programmable event and interrupt generation for external system control.
- Supports hardware- and software-controllable timer synchronization.
- Provides a 4-channel IEEE 1588 timer. Each channel supports input capture and output compare using the 1588 counter.

4.3 USB

Centauri 200 has one USB 2.0 Type A port on back side and is configured as a host device by default. Below are major features of USB interface:

- High-Speed/Full-Speed/Low-Speed support.
- High Speed, and Full Speed operation in Peripheral mode (with UTMI transceiver).
- Hardware support for OTG signaling, session request protocol, and host negotiation protocol.
- Up to 8 bidirectional endpoints.
- Low-power mode with local and remote wake-up capability.
- Serial PHY interfaces configurable for bidirectional/unidirectional and differential/single ended.
- Embedded DMA controller.

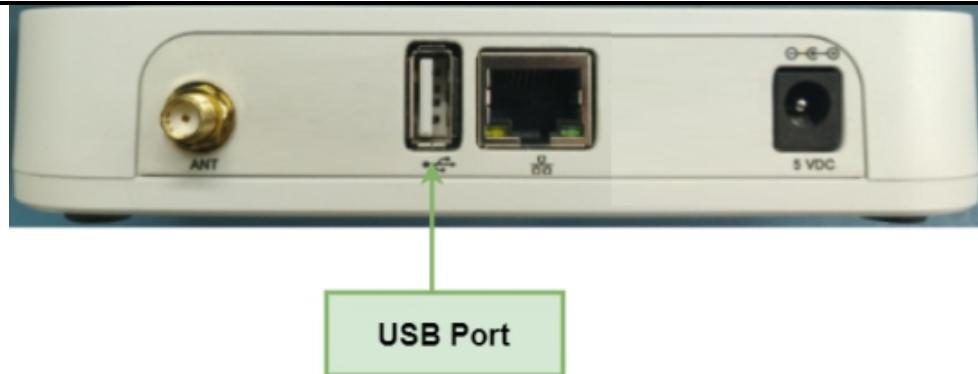


Figure 10 : USB Port Selection Jumper

The Centauri 200 can also be configured as a USB slave device. This is done by closing the selection jumper using a jumper shunt. The location of the selection jumper is on the Centauri 200 PCBA. Figure 5-3 shows the jumper on a Centauri 200 PCBA.

4.4 Debug Port

The Centauri 200 has an inbuilt debug UART port with three pins. Debug is only possible if the user can access Centauri 200 PCBA. It is to be noted that the UART signaling occurs at 3.3V logic levels and the pins are not 5V tolerant. A user can enter the debug prompt on a PC/Mac using a normal 3.3V logic USB to UART converter.

These are the parameters to establish debug UART connection with Centauri 200:

- Baud rate: 115200
- Data bits: 8
- Parity: None
- Stop bits: 1
- Flow control: None



Figure 11 : Debug Port

4.5 eMMC

For storage of data, Centauri 200 utilizes eMMC/NAND. Note that Centauri 200 also has an option of using NAND instead of eMMC as per the variant. The table below describes eMMC/NAND storage densities possible on Centauri 200.

Sr No	Memory	Density
1	eMMC	Standard - 8 GB

Table 17: Storage Options

4.6 DDR (Double Data Rate) RAM

The Centauri 200 uses a DDR3L memory operating at 1866 MT/s. The standard density of the DDR RAM for Centauri 200 is 512 MB. The table below shows the possible densities possible with Centauri 200.

Sr No	Memory	Density
1	DDR RAM	Standard configuration - 512 MB

Table 18: DDR Options

4.7 Switches

The Centauri 200 has two tactile switches on the front panel. These switches are completely user configurable and users can use it as per their use case. Figure 5-6 describes switches on Centauri 200.

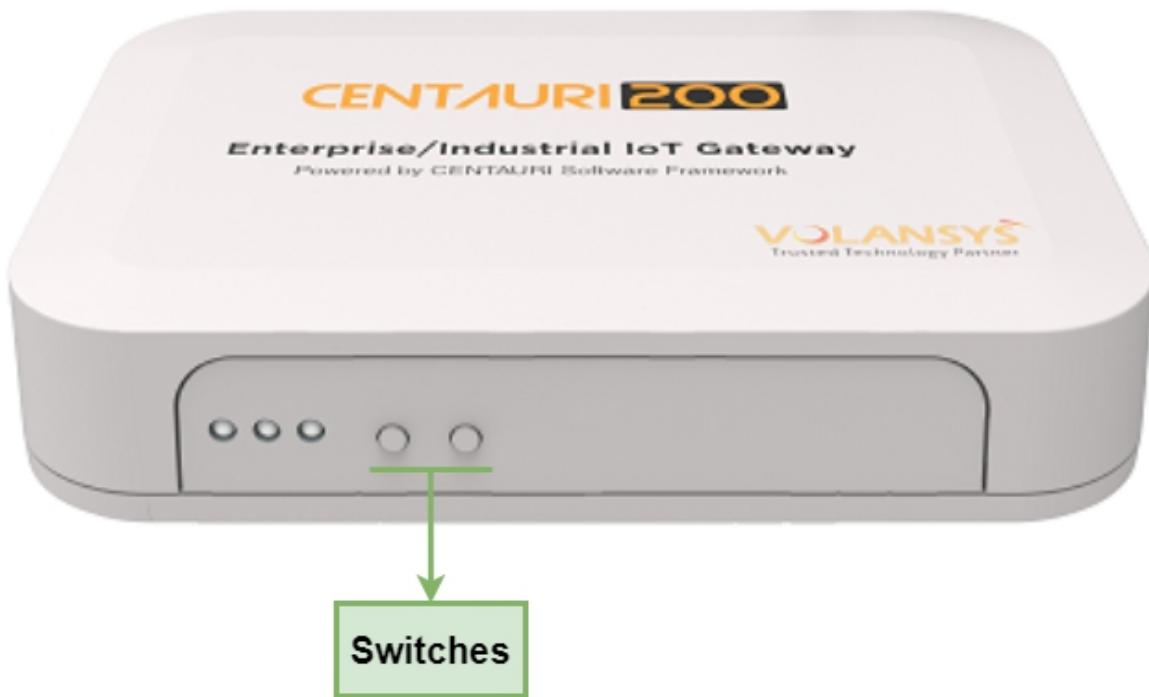


Figure 12 : User Configurable Switches

4.8 LED's

The Centauri 200 has three inbuilt LED's. One LED is used to indicate whether the Centauri 200 is powered ON or OFF and the remaining two are user configurable. The user can use these two LED's as per their use case. Figure 5-7 shows the location of these LED's on the Centauri 200.

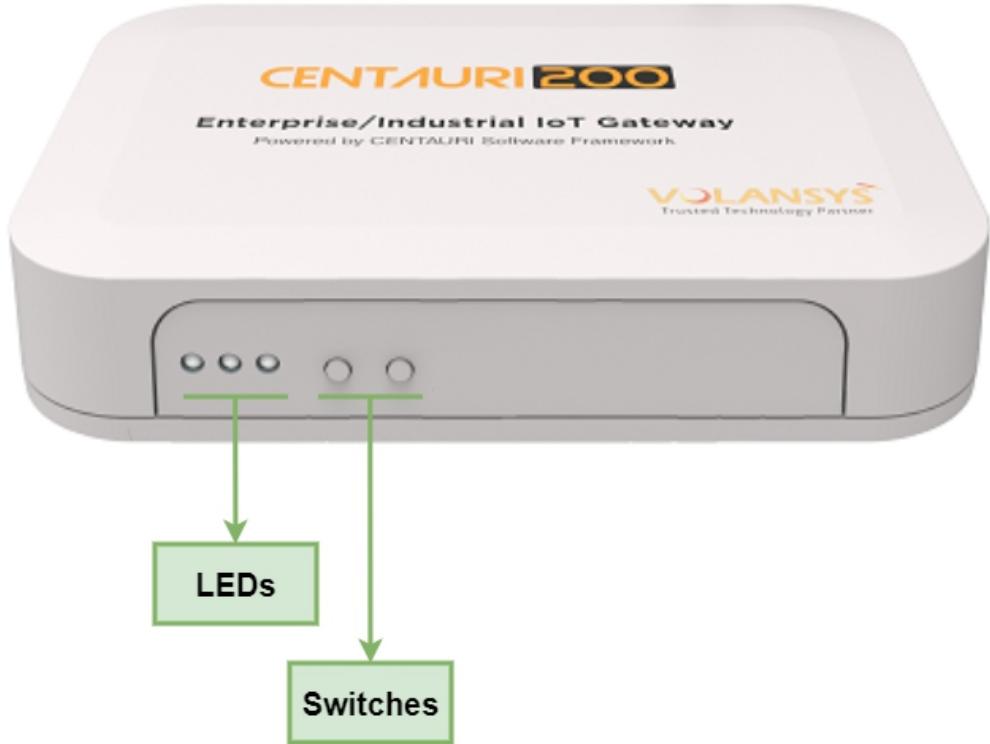


Figure 13 : LED's on Centauri 200

Sr No	LED	LED Colour	Function
1	PWR	Green	ON: Centauri 200 powered ON
			OFF: Centauri 200 powered OFF
2	LED1 & LED2	Bi-colour	Status: User configurable

Table 7: LED's

5 ELECTRICAL THERMAL & ANTENNA RANGE CHARACTERISTICS

5.1 Recommended Operating Conditions

Sr No	Description	Value			Unit
		Minimum	Typical	Maximum	
1	Operating voltage	4.75	5	5.5	V
2	Current consumption	-	-	3	A
3	Operating temperature range (ambient)	-10	25	65	°C

Table 8: Recommended Operating Conditions

5.2 Thermal Analysis data

Thermal analysis of CT200 was done with 4 different configuration as per below table.

Sr. No.	Objective	Processor Temperature	Ambient Temperature
1	CPU Runs in normal Condition	81 °C	65 °C
2	CPU run at 33%	84 °C	65 °C
3	CPU run at 66%	86 °C	65 °C
4	CPU run at 100%	92 °C	65 °C

Table 9 : Thermal Analysis

Note : The CPU threshold limit of the processor is 100 °C. As CPU temperature increased to 100 °C then processor will shutdown the PMIC and all the interfaces are down till the temperature reaches to 25 °C.

6 MECHANICAL DIMENSIONS

The table top dimensions of Centauri 200 are 100 x 150 x 30 mm (L x W x H). Figure 7-1 shows the dimensions in more detail.

Note: All dimensions are in millimetre (mm), unless otherwise specified.

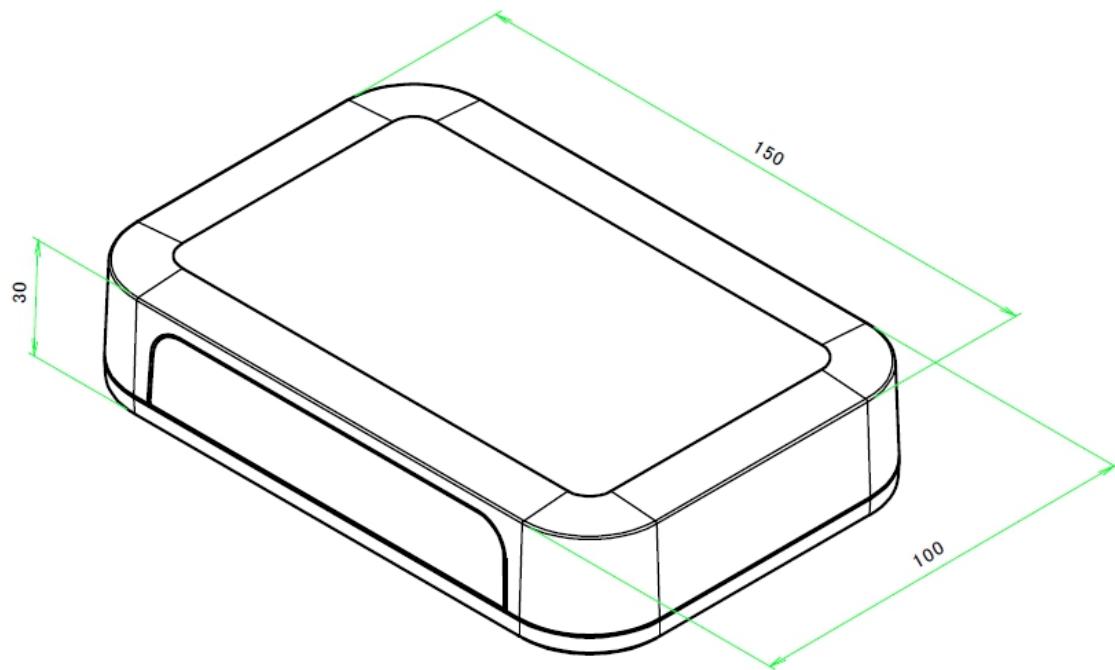


Figure 14 : Centauri 200 Dimensions table top

The table wall mount dimensions of Centauri 200 are 180 x 100 x 30 mm (L x W x H). Figure 7-1 shows the dimensions in more detail.

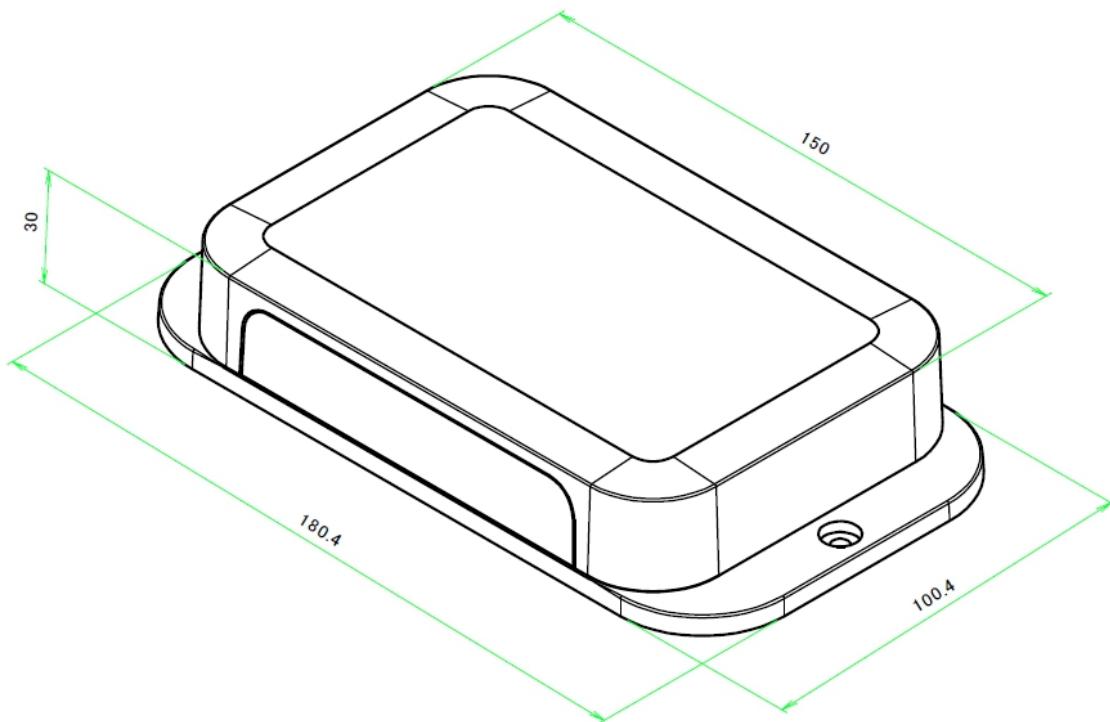


Figure 15 : Centauri 200 Dimensions wall mount

7 CERTIFICATION

7.1 FCC (Federal Communications Commission) & IC (Industry Canada)

This equipment complies with FCC and IC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 20 cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

This device complies with part 15 of the FCC rules and RSS-247 of Industry Canada. 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.

Le présent appareil est conforme aux CNR d'Industrie 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'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

This Class B digital apparatus complies with Canadian ICES-003. Cet appareil numérique de la classe B est conforme à la norme NMB-003 du Canada.

APPLICATION NOTES

Safety Precautions

These specifications are intended to preserve the quality assurance of products as individual components.

Before use, check and evaluate the module's operation when mounted on your products. Abide by these specifications when using the products. These products may short-circuit. If electrical shocks, smoke, fire, and/or accidents involving human life are anticipated when a short circuit occurs, then provide the following fail safe functions as a minimum:

1. Ensure the safety of the whole system by installing a protection circuit and a protection device.
2. Ensure the safety of the whole system by installing a redundant circuit or another system to prevent a single fault causing an unsafe status.

Design Engineering Notes

1. Heat is the major cause of shortening the life of the modules. Avoid assembly and use of the target

equipment in conditions where the product's temperature may exceed the maximum allowable.

2. Failure to do so may result in degrading of the product's functions and damage to the product.
3. If pulses or other transient loads (a large load applied in a short time) are applied to the products, before use, check and evaluate their operation when assembled onto your products.
4. These products are not intended for other uses, other than under the special conditions shown below. Before using these products under such special conditions, check their performance and reliability under the said special conditions carefully, to determine whether or not they can be used in such a manner.
5. In liquid, such as water, salt water, oil, alkali, or organic solvent, or in places where liquid may splash. In direct sunlight, outdoors, or in a dusty environment. In an environment where condensation occurs. In an environment with a high concentration of harmful gas (ex. salty air, HCl, Cl₂, SO₂, H₂S, NH₃, and NO_x).
6. If an abnormal voltage is applied due to a problem occurring in other components or circuits, replace these products with new products because they may not be able to provide normal performance even if their electronic characteristics and appearances appear satisfactory.
7. Mechanical stress during assembly of the board and operation must be avoided.
8. Pressing on parts of the metal cover or fastening objects to the metal cover is not permitted.

Storage Conditions

1. The module must not be stressed mechanically during storage.
2. Do not store these products in the following conditions or the performance characteristics of the product, such as RF performance, may well be adversely affected:
 - Storage in salty air or in an environment with a high concentration of corrosive gas, such as Cl₂, H₂S, NH₃, SO₂ or NO_x.
 - Storage (before assembly of the end product) for more than one year after the date of date of delivery even if all the above conditions have been met, should be avoided.

FCC regulatory conformance:

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.
- (2) This device must accept any interference received, including interference that may cause undesired operation.

NOTE: 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 or more 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

NOTE: The manufacturer is not responsible for any radio or TV interference caused by unauthorized modifications to this equipment. Such modifications could void the user's authority to operate the equipment.

RF Exposure

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 20 cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

IC regulatory conformance

This device complies with CAN ICES-003 (B)/NMB-003(B).

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

- (1) This device may not cause interference.
- (2) This device must accept any interference, including interference that may cause undesired operation of the device.

Cet appareil est conforme à la norme CAN ICES-003 (B)/NMB-003 (B).

Cet appareil contient des émetteurs / récepteurs exempt (s) de licence qui sont conformes aux RSS exemptes de licence d'Innovation, Sciences et Développement économique Canada. Son fonctionnement est soumis aux deux conditions suivantes:

- (1) Cet appareil ne doit pas provoquer d'interférences.
- (2) Cet appareil doit accepter toute interférence, y compris les interférences susceptibles de provoquer un fonctionnement indésirable de l'appareil.

RF Exposure

This equipment complies with IC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance of 20 cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Cet équipement est conforme aux limites d' exposition aux rayonnements de la IC établies pour un environnement non contrôlé. Cet équipement doit être installé et fonctionner à au moins 20cm de distance d'un radiateur ou de votre corps.