FE5NAR131

SA515 ReDTC NAD Module

OEM Manual and User Guide v1.0

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Terms and Acronyms

- BB — Baseband
- CA — Carrier Aggregation
- DCM — Data Connectivity Module (also, "TCU")
- DRX — Discontinuous Reception
- DRx — Diversity (2^{nd}/3^{rd}/4^{th}) Receive
- EN-DC — **E**-UTRAN **N**ew Radio – **D**ual **C**onnectivity (LTE and NR simultaneously)
- ES — Engineering Sample
- FDD — Frequency Division Duplex
- GLONASS — GLObalnaya NAvigatsionnaya Sputnikovaya Sistema
- GNSS — Global Navigation Satellite System
- GPIO — General Purpose Input Output
- GSM — Global System for Mobile
- HORXD — High Order RX Diversity (using 4 RX antennas)
- HSIC — High Speed Inter-Chip
- HB — Cellular High Band (~2.2 to 3GHz)
- HU — Head Unit
- LB — Cellular Low Band (~<1GHz)
- LTE — Long Term Evolution
- LTE_ANT — Cellular antennas (not only LTE, may also support 2G,3G & 5G)
- MB — Cellular Mid Band (~1 to ~2.2GHz)
- MP — Mass Production
- NAD — Network Access Device
- NR — New Radio (5G)
- NSA — Non-Stand-Alone 5G operation (also EN-DC)
- OEM — Original Equipment Manufacturer
- PC2 — Power Class 2 (also called "HPUE" nominally +26 dBm)
- PC3 — Power Class 3 (standard 3G/4G/5G, nominally +23 dBm)
- PCB — Printed Circuit Board
- PCIe — Peripheral Component Interconnect Express
- PHY — Physical Layer
- PMIC — Power Management IC
- PRx — Primary Receive
- SA — Stand-Alone 5G operation
- SIM — Subscriber Identity Module
- SoC — System-On-a-Chip (refers to the Qualcomm SA515M IC)
- TCU — Telematics Control Unit (also, "DCM")
- TDD — Time Division Duplex
- TRx — Transmit and Receive
- TSP — Telematics Service Provider
- UHB — Cellular Ultra-High Band (>3GHz)
- UMTS — Universal Mobile Telecommunication System
- WCDMA — Wideband Code Division Multiple Access

FE5NAR131 Module

1 FE5NAR131 Module

The FE5NAR131 Module incorporates 5G New Radio technology with available 1TX x 2RX Antenna technology. The NAD is part of a family of proprietary embedded 5G wireless modules designed by Continental Automotive Systems, Inc. The modules are intended to be integrated into Data Connectivity Modules (DCMs) or Head Units (HUs) designed and produced by Continental or by a 3rd party for use by automotive OEMs. DCMs will be installed into vehicles during the OEM's factory assembly process and will not be accessible without use of special tools. Primary use-cases are data-centric with data and voice connections to Telematics Service Providers (TSP).

1.1 Hardware Revision Notes

This document may contain details specific to only certain PCB revisions of the device. When detailing properties unique to one or more HW revisions, the specific revision will be identified, otherwise it is assumed to be applicable to the latest Hardware.

1.2 Key Features

1.2.1 Air Interface Support

- 5G NR: 3GPP Release 15
- Sub-6 Ghz 5G NR bands
- LTE FDD/TDD: 3GPP Rel. 15 Category 16
- UMTS: HSUPA CAT6, HSDPA CAT24 3GPP Rel. 9
- GSM: EGPRS Rel-12
- VoLTE – HD Voice
- Embedded Qualcomm GNSS Sub-system
- GNSS L1 Frequency Band: Beidou-B1I, GalileoE1, GLONASS-G1, GPS-L1 and SBAS-L1
- SBAS supported: EGNOS/MSAS/QZSS/WAAS/GAGAN

1.2.2 Processing and Memory Support

• Apps Processor	• Cortex-A7 – 1.5 GHz • ARMv7 Instruction Set • 32-bit architecture • 32 KB L1 I/D Cache • 256 KB L2 Cache
• Modem Processor	• Hexagon QDSP6 – 1.5 GHz • 2MB L2 Cache • Low-Power Audio Post-Processing supported in the modem system
• AOSS (Always On Sub-System) • RPM	• Cortex M3 – 300 MHz • MPM is the only master • MPM coordinates shutdown/wakeup, clock rates, a VDDs
• Internal Memory	• 176 KB Boot ROM • 24 KB IMEM
• Module RAM	• 1x16 LPDDR4x – 1.8 GHz • 4 Gbit (512 MBytes) or 8Gbit (1024 MBytes)
• Module NAND	• 4Gbit (512 Mbytes) or 8Gbit (1024 Mbytes) • x8 SLC • Micron • 8/8 - MT29GZ6A6BPIET-53AAT.112 • JSC • 8/8 - JSFDDP5QHAFGF-405A(M)

1.2.3 Electrical Interface Support

• Antenna Ports	• 1TX 2RX • GNSS: GNSS_ANT1 (Internal diplexer for L1/L5)

• PCIe	• 2x Lane (Gen3) • End Point and Root Complex support
• Ethernet	• RGMII Integrated MAC • 4 Rx bits • 4 Tx bits • 1 Gbps
• USB	• 1 port • Supports USB3.1 or USB2.0
• QLINK	• QLINK 2.0 • 4 lanes • DL0, UDL0, UDL1, UL0
• I2S	• Up to two ports
• UIM	• 2 available UIM1/UIM2 • 1.8V/3V support
• BLSP Interfaces	• 4 BLSP Ports (I2C, SPI, UART) • 4 bits each; • Muxed serial interfaces • UART: 4 Mbps • I2C: Yes • SPI: Yes (Master)
• GPIOs	• Up to 29 free GPIO
• ADC	• 2 ADC ports

Note: The NAD supports interfaces to WLAN or Bluetooth ICs, but the NAD itself does not contain WiFi or Bluetooth ICs.

1.3 Package

- 585-pin LGA module of size 46 x 39 x 3.1 mm (with shield cover)

1.4 Band Support

1.4.1 RF Bands

Table 1-1: FE5NAR131 Bands in Hardware

Model	Region	NR (5G) Bands NSA or SA	LTE Bands (FDD + TDD)	C-V2X Bands	UMTS Bands	GSM	GNSS
FE5NAR131	NA	n2, n5, n25, n41, n66, n71, n77, n78	1, 2, 3, 4, 5, 7, 12, 13, 14, 17, 25, 26, 28A, 28B, 29Rx, 30Rx, 41, 66, 71	---	2, 4, 5	2, 5	B1I, E1, G1, L1

Notes:
1. The module supports n77 U.S. band from 3450 to 3550 and 3700 to 3980 MHz
2. The module disables n78 via software under U.S.A PLMN.
3. The module supports n78 from 3450 to 3800 MHz according to RSS-192
4. The module disables n77 via software under Canada PLMN.

1.4.2 5G ReDtc NAD Band Combinations (EN-DC and CA)

Where the required bands are supported in the hardware of a given variant, the 5G ReDtc NAD will support EN-DC and CA operation per the established in the PICs and the TRF files.

It should be noted that while the Hardware may be capable of supporting the stated Band Combinations (i.e. RF Configuration and relevant RF path calibration are present in the device), the delivered Software may not support such operation without an update.

2 Regulatory Compliance Notes

2.1 Regulatory compliance notes

2.1.1 FCC/IC

This device complies with Part 15, Part 22(H), Part 24(E) and Part 27 of the FCC Rules. The FCC ID for this device is LHJ-FE5NAR131.

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

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.

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. End user must follow the specific operating instructions for satisfying RF exposure compliance. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

2.1.2 Industry of Canada:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions:

(1) this device may not cause interference, and

(2) this device must accept any interference, including interference that may cause undesired operation of the device.

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 nedoit 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.

2.2 Device Installation and User Manual

The 5G ReDtc NAD module is a proprietary product designed and manufactured by Continental Automotive Systems, Inc. for integration into Telematics control units manufactured by Continental Automotive Systems, Inc. for automotive OEMs.

i. The module is limited to installation ONLY in an integrated device manufactured by Continental Automotive Systems, Inc.
ii. During manufacturing process of the integrated device, the module is soldered onto the PCB of the integrated device.
iii. The integrated device must provide RF connectors to external antennas or RF traces to connect the WT50NA01 modules to antennas inside the integrated device. The typical reference design for the RF trace layout, including PCB stack-up and trace length is described in Section 6 of this document.
iv. Automotive OEM is responsible for ensuring that the end-user has no manual instructions to remove or install module.
v. The module is limited to installation in mobile applications, according to Part 2.1091(b).
vi. No other operation configurations are allowed.
vii. Changes or modifications to this system by other than a facility authorized by Continental could void authorization to use this equipment.
viii. The module must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operate in conjunction with any other antenna or transmitter.

ix. The integrator is responsible for fulfilling FCC and IC requirements for the integrated device.

If Continental chooses to re-use modular approval, then the TCU shall be clearly labeled with an external label containing the integrated modem's FCC IC ID. For example, the label can include text "Contains device with FCC ID: LHJ-FE5NAR131 and IC: 2807E- FE5NAR131".

2.3 Antenna requirements for use with module:

The module must be installed to provide a separation distance of at least 20cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter. Additional testing and certification for SAR will be required if the distance limitation cannot be met.

The FE5NAR131 NAD module does not contain internal antennas and external antenna must be provided by the integrator or OEM. Based on FCC OET Bulletin 65 Supplement C and 47 CRF §2.1091 and on RSS-102 Issue 5, for all standalone NR/LTE/WCDMA/GSM operations the maximum gain of the antenna path (cable loss + antenna gain) shall not exceed the following values.

	FCC	IC
GSM850:	7.10 dBi	3.42 dBi
GSM1900:	2.50 dBi	2.50 dBi
WCDMA Band II:	9.00 dBi	9.00 dBi
WCDMA Band IV:	6.00 dBi	6.00 dBi
WCDMA Band V:	10.42 dBi	7.13dBi
LTE B2:	9.00 dBi	9.00 dBi
LTE B4:	6.00 dBi	6.00 dBi
LTE B5:	10.41 dBi	7.12dBi
LTE B7:	9.00 dBi	9.00 dBi
LTE B12:	9.70 dBi	6.64 dBi
LTE B13:	10.16 dBi	6.96 dBi
LTE B14:	10.23 dBi	7.00 dBi
LTE B17:	9.74 dBi	6.66 dBi
LTE B25:	9.00 dBi	9.00 dBi
LTE B26:	10.36 dBi	7.12 dBi
LTE B41:	6.00 dBi	6.00 dBi
LTE B66:	6.00 dBi	6.00 dBi
LTE B71:	9.48 dBi	6.49 dBi
NR Band n2:	9.00 dBi	9.00 dBi
NR Band n5:	10.42 dBi	7.13 dBi
NR Band n25:	9.00 dBi	9.00 dBi
NR Band n41:	9.00 dBi	9.00 dBi
NR Band n66:	6.00 dBi	6.00 dBi
NR Band n71:	9.48 dBi	6.49 dBi
NR Band n77:	3.00 dBi	/
NR Band n78:	/	3.00 dBi

This radio transmitter (FCC ID: LHJ-FE5NAR131; IC: 2807E- FE5NAR131) has been approved by FCC and Industry Canada to operate with the antenna types listed below with the maximum permissible gain

indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

2.4 Instructions to OEMs:

Continental must instruct the automotive OEM and provide them to include the following information into the car user's manual (i.e., for the DCM):

1. End-users must be provided with transmitter/antenna installation requirements and operating conditions for satisfying RF exposure compliance:
2. A separate section should clearly state "FCC RF Exposure requirements:"
3. Required operating conditions for end users.
4. The antenna used with this device must be installed to provide a separation distance of at least 20cm from all persons, and must not transmit simultaneously with any other transmitter, except in accordance with FCC multi-transmitter product procedures.
5. The Maximum ERP/EIRP and maximum antenna gain required for compliance with Parts 15, 22H, 24E, and 27.
6. Clear instructions describing the other party's responsibility to obtain station licensing.

3 Recommended NAD Interfaces

Integrators are strongly recommended to provide access to the following NAD communication ports to be used for debugging, certification, or other developmental activity.

- HS-USB 2.0
- 2-wire UART
- JTAG
- **RF Ports:** If any on-board antennas are used by the product, provisions should be made to support conducted RF measurements on all antenna interfaces
- **SIM Interface:** Electrical performance of the SIM interface is always evaluated during certification testing of the final product. Product teams should insure that the SIM interface can be accessed for testing without degrading its integrity.

4 Example of NAD Module Label

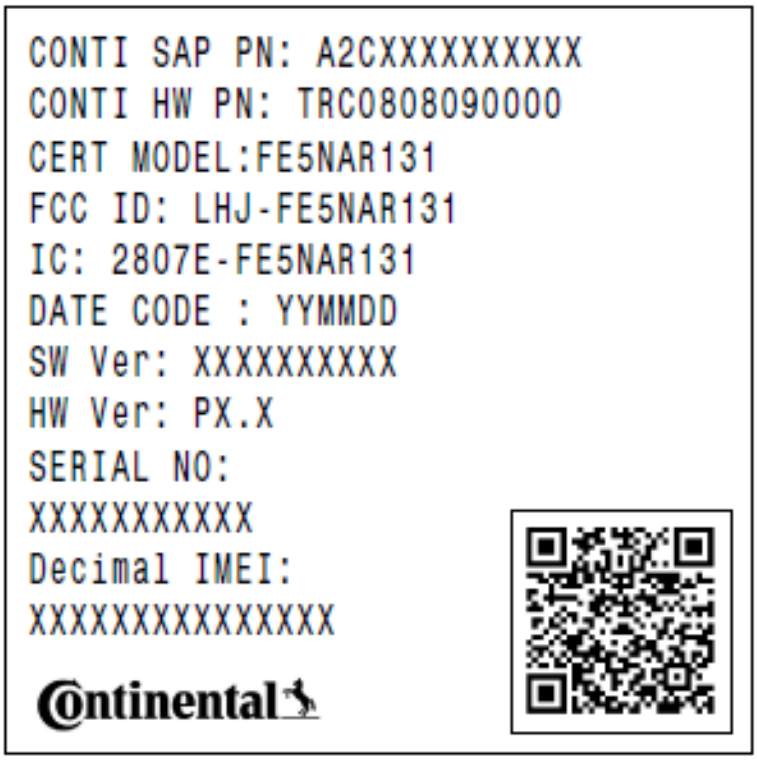


Figure 4-1: NAD Label Example

5 NAD Module RF Characteristics

All RF parameters are referenced at the antenna terminals *of the NAD*. The RF performance of the parent device (i.e. TCU) can differ depending on the additional line losses – as well as the impedance match – presented to each of the NAD's antenna terminals.

5.1 NAD Module RF Transmitter Output Power

The Transmitter Power at the NAD antenna terminal (not the RF connector of the evaluation board or the Telematics/parent module) at Room Temperature:

- GSM low bands (800/900): +32.5 +1.0/-2.0 dBm
- GSM hi bands (1800/1900): +29.5 +1.0/-2.0 dBm
- EDGE low bands (800/900): +26.5 +1.0/-2.0 dBm
- EDGE hi bands (1800/1900): +25.5 +1.0/-2.0 dBm
- WCDMA bands: +23.0 +1.0/-2.0 dBm
- LTE bands (PC3): +23.0 +1.0/-2.0 dBm*
- LTE bands (PC2): +26.0 +1.0/-2.0 dBm**
- 5G NR bands (PC3): +23.0 +1.0/-2.0 dBm*
- 5G NR bands (PC2): +26.0 +1.0/-2.0 dBm**

* For most bands. Some exceptions exist, based on 3GPP standard.

** For antenna ports that are HPUE capable on specific LTE and 5G NR bands.

Allowance for reduction in maximum transmitter power is specified in the 3GPP standard for GSM multi-slot operation (MSPP=0). The SA515 ReDtc NAD adjusts the GSM maximum TX power in these cases per Table 5-1.

Table 5-1: GSM Multi-slot power reduction

Band	GSM/EDGE Multi-slot maximum output power reduction		
	2 slots	3 slots	4 slots
GSM	3.0 dB	4.5 dB	6.0 dB
EDGE	2.0 dB	3.0 dB	4.0 dB

5.2 NAD Module RF Receiver Sensitivity

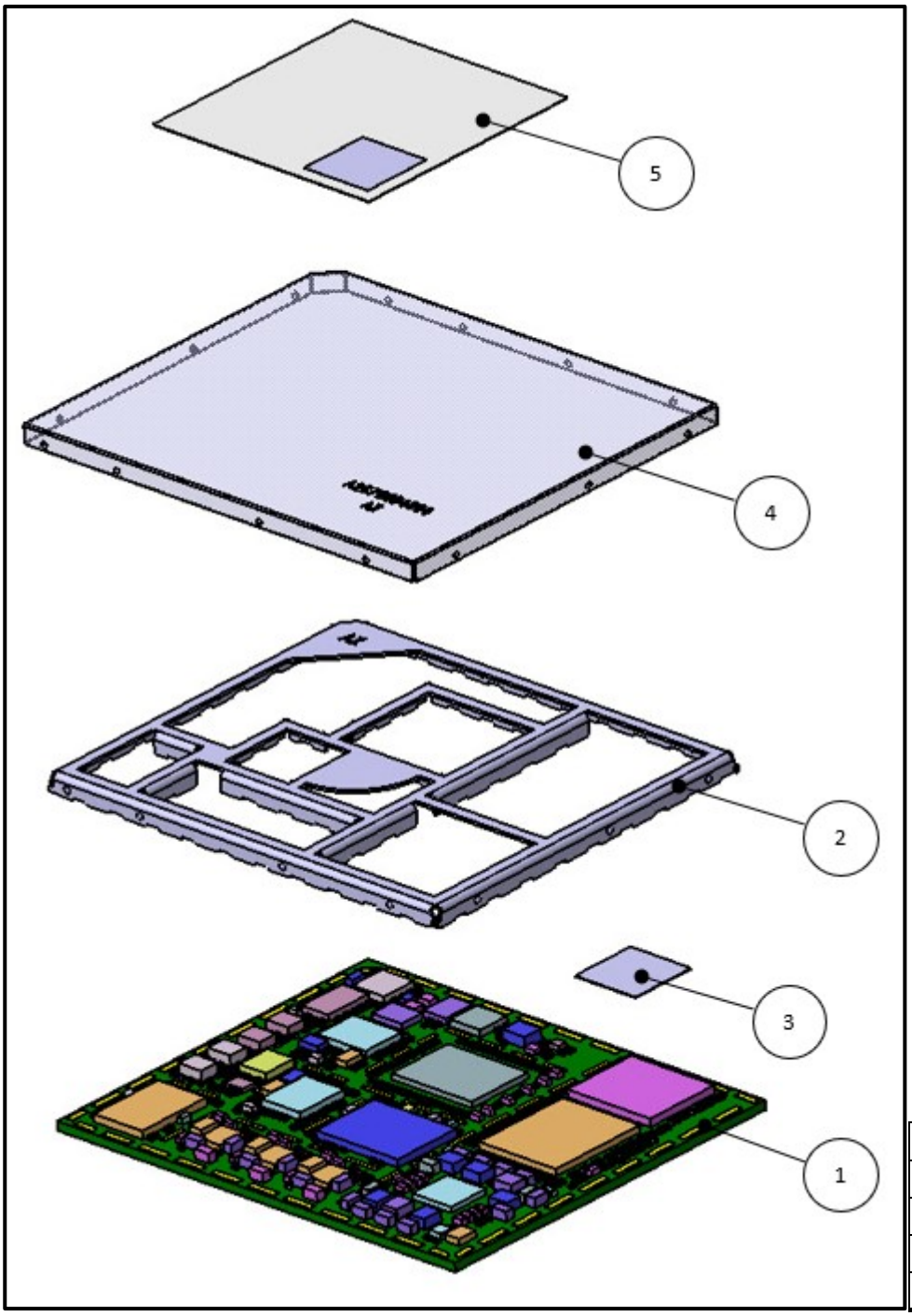
The Receiver Sensitivity at the NAD antenna terminal (not the RF port of the evaluation board or the Telematics/parent module) at Room Temperature:

- GSM lo bands (800/900): 3GPP TS 05.05 Section 6.2
- GSM hi bands (1800/1900): 3GPP TS 05.05 Section 6.2
- WCDMA bands: 3GPP TS 34.121-1 Section 6.2
- LTE bands: 3GPP TS GPP 36.521 Section 7.3
- 5G NR bands: 3GPP TS GPP 38.521 Section 7.3
- C-V2X bands: 3GPP TS GPP 36.521 Section 7.3G
- GNSS bands: -163 dBm (in Out-Of-Service mode)[1]

1) The NAD is designed to be paired with an external active GNSS antenna system having 17 to 20 dB of net gain and noise figure <=2.5 dB. The NAD by itself is not expected to achieve the stated RF sensitivity on the GNSS bands.

6 Mechanical Information

6.1 Module Exploded View



1	PCB
2	Shield Frame
3	QR Code Label
4	Shield Cover
5	NAD Label

Figure 6-1: Module Exploded View

6.2 Module Top View

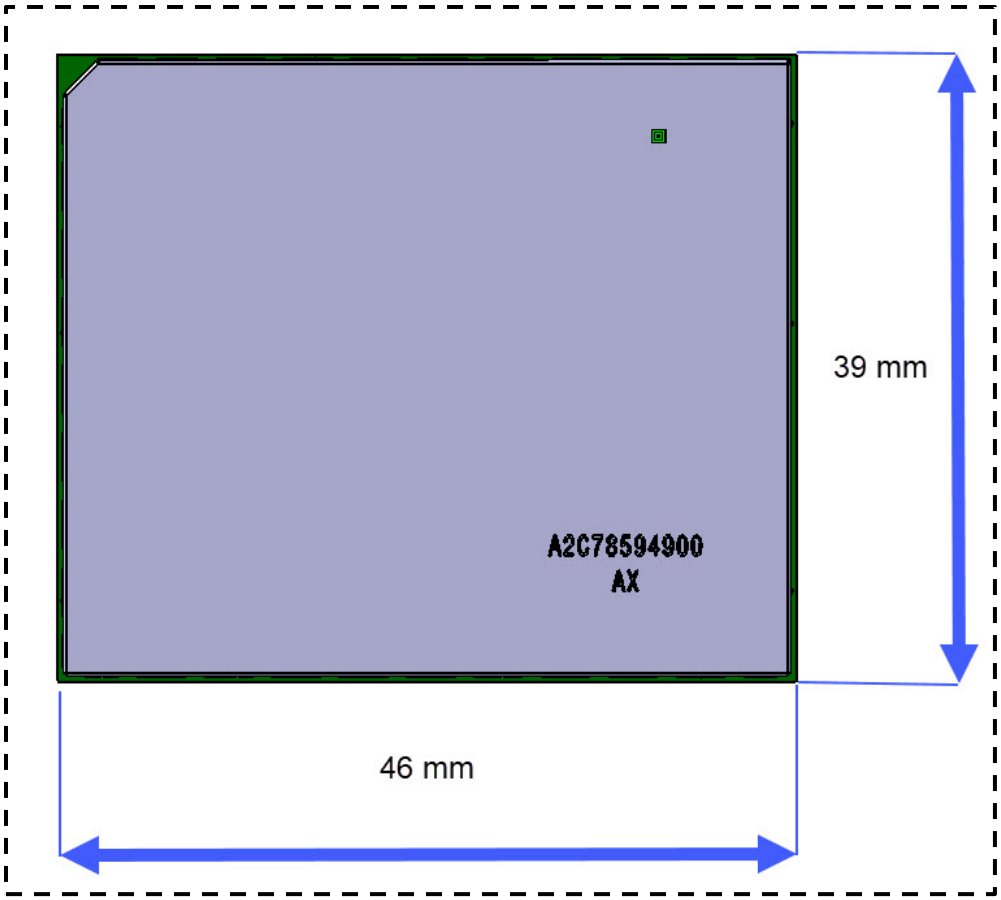


Figure 6-2: Module Top View

All dimensions are in mm.

6.3 Module Side View

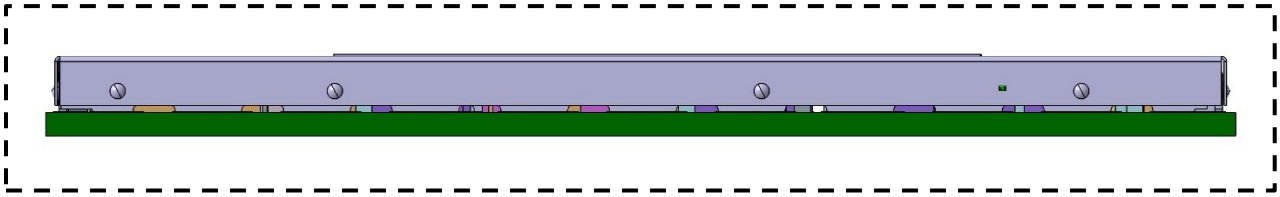


Figure 6-3: Module Side View

6.4 Module Height and Tolerance

Figure 6-4 Shows a top view of the NAD, highlighting a portion whose cross-section is expanded in detail in Figure 6-5.

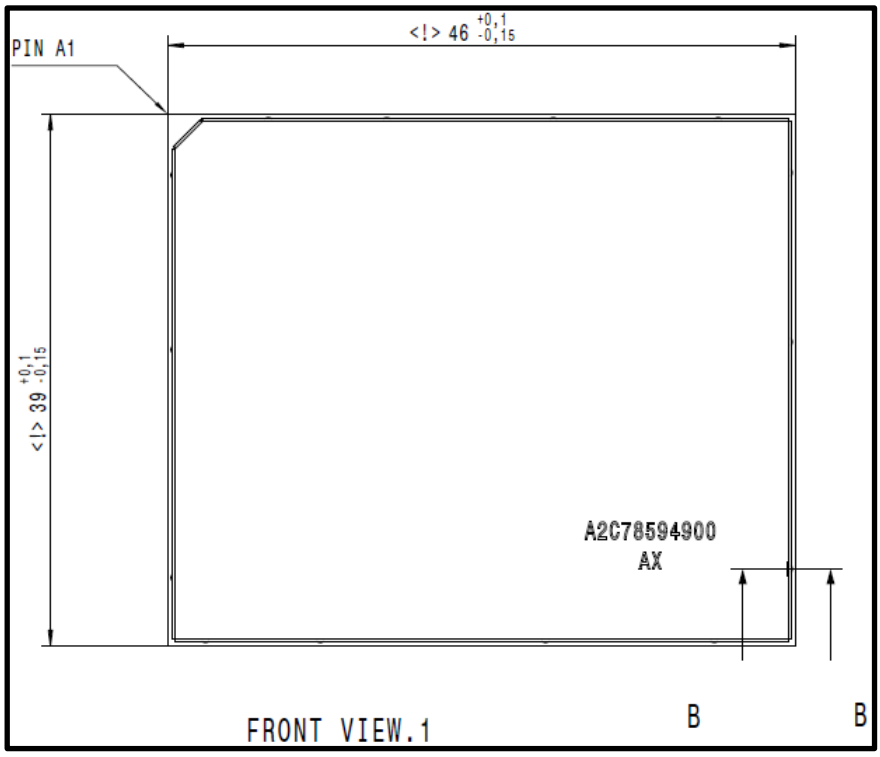


Figure 6-4: Top View with Component Thickness detail location

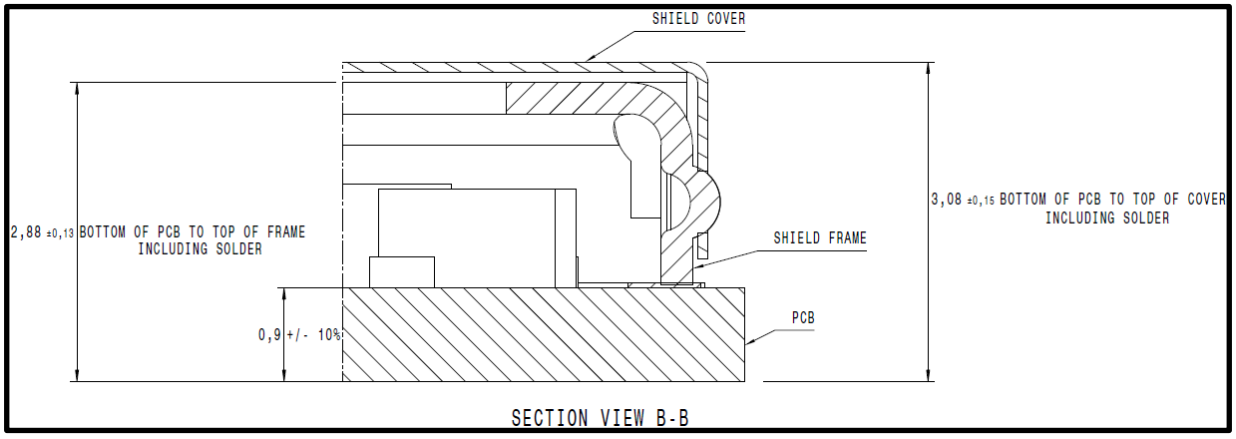


Figure 6-5: Component Thicknesses and Tolerances (no pre-tinning)

Table 6-1 explicitly lists the dimensions and tolerances of the NAD module, and the individual components contributing to its overall thickness.

Table 6-1: Component Thicknesses and Tolerances

Thickness Parameter Description	value	tolerance	units
NAD PCB (no pre-tinning)	0.9	+/-10%	mm
NAD with Shield Frame only (no pre-tinning)	2.88	+/-0.13	mm
NAD with Shield Cover placed (no pre-tinning)	3.08	+/-0.15	mm

7 Storage and Handling

7.1 Moisture Sensitivity Level (MSL)

All NAD modules are moisture sensitive and should be kept in their sealed moisture resistant bags until ready for assembly onto the DCM via the soldering process. Any parts that are not used immediately should be properly resealed in the same moisture resistant bag using appropriate equipment or placed into a dry box until they are needed again. The moisture sensitivity level (MSL) shown below is the amount of time the NAD modules may be exposed before this action must be taken. If the allowed MSL time elapses, the NAD modules must be baked per standard protocol to remove moisture.

Moisture Sensitivity Level: MSL Level 3 (1 Week)

7.2 Electrostatic Discharge

The NAD is generally well-protected from ESD by conductive full shielding when mounted on the parent device where adequate protections have been taken at the NAD electrical interfaces.

As a stand-alone device, such protection is absent, and care must be taken to protect the NAD from ESD during handling prior to placement onto the parent device.

8 Material Statement:

The End-of-Life Vehicle Directive (EVL) must be applied to the FE5NAR131 module. This means that the component is included into the overall vehicle (since it is permanently installed) and if the explanation of the materials used and, if applicable, disposal descriptions from the vehicle manufacturer.