



WT50NA01

User Manual v 3.0

(to be used for certification)

FCC ID: LHJ-WT50NA01

IC: 2807E-WT50NA01

Change History

Revision	Date	Change Description	Owner (s)
1.0	08-08-2018	Initial Release for certification, based on the HW Spec version 2.0	I. Shmagin
2.0	08-24-2018	Added Information about DC Voltages and Currents	I. Shmagin
3.0	08-30-2018	Updated Antenna Gains and pcb layout information	I.Shmagin

Terms and Acronyms

- CDMA Code Division Multiple Access
- DCM Data Connectivity Module
- DRX Discontinuous Reception
- ES Engineering Sample
- FDD Frequency Division Duplex
- GLONASS GLOBal'naya NAVigatsionnaya Sputnikovaya Sistema
- GNSS Global Navigation Satellite System
- GPIO General Purpose Input Output
- GSM Global System for Mobile
- HU Head Unit
- HSIC High Speed Inter-Chip
- LTE Long Term Evolution
- MP Mass Production
- NAD Network Access Device
- OEM Original Equipment Manufacturer
- PCB Printed Circuit Board
- PHY Physical Layer
- SIM Subscriber Identity Module
- TCU Telematics Control Unit
- TDD Time Division Duplex
- TSP Telematics Service Provider
- UMTS Universal Mobile Telecommunication System
- WCDMA Wideband Code Division Multiple Access

WT50NA01 Module

The WT50NA01 NAD is a proprietary modem module designed by Continental Automotive Systems, Inc. The modem will be integrated into Data Connectivity Modules (DCMs) or Head Units (HUs) designed and produced by Continental 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 Key Features

1.1 LTE CAT11 NAD Module

Air Interface Support

- LTE FDD/TDD: 3GPP Rel 12
- LTE FDD CAT11 (up to 75-Mbps UL/600-Mbps DL)
- UMTS: HSUPA CAT 6 (up to 5.76-Mbps), HSPA CAT14
- GSM: EGPRS Rel-10

2 Regulatory Compliance Notes

FCC:

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-WT50NA01. 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.

Industry of Canada:

This device complies with Industry Canada's license-exempt RSSs. 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 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 radio transmitter (2807E-WT50NA01) has been approved by 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.

« Le présent émetteur radio (2807E-WT50NA01) a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal. Les types d'antenne non inclus dans cette liste, et dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.».

3 Device Installation and User Manual

The WT50NA01 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.

- 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 ID. For example, the label can include text "Contains device with FCC ID: LHJ-WT50NA01 and IC: 2807E-WT50NA01".

4 Antenna requirements for use with WT50NA01 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.
- The WT50NA01 module is for use with external antennas ONLY.
- The maximum gain of the antenna path (cable loss + antenna gain) for all supported bands shall not exceed the following values:
 - GSM 850: 1 dBi
 - GSM 1900: 1 dBi

- WCDMA Band 2: 1 dBi
 - WCDMA Band 4: 5 dBi
 - WCDMA Band 5: 1 dBi
 - LTE Band 2: 1 dBi
 - LTE Bnad 4: 5 dBi
 - LTE Band 5: 1 dBi
 - LTE Band 7: 9 dBi
 - LTE Band 12: 5 dBi
 - LTE Band 13: 5 dBi
 - LTE Band 66: 5 dBi
- This radio transmitter (FCC ID: LHJ-WT50NA01; IC: 2807E-WT50NA01) 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.
- « Le présent émetteur radio (ID: LHJ-WT50NA01; IC: 2807E-WT50NA01) a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci-dessous et ayant un gain admissible maximal. Les types d'antenne non inclus dans cette liste, et dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.»

5 Instructions to OEMs:

Continental must instruct the automotive OEM and provide them to include the following information into the car user's manual:

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.

6 Layout and Routing Recommendations

6.1 Module Specific

The pad spacing of 1mm should allow the placement of a 600um finished VIA between pads, while maintaining a 200um Via- to-trace or Via-pad spacing, to facilitate the breakout of inner row signals. The 1mm spacing is also large enough to route two 200um (8 mil) traces between pads.

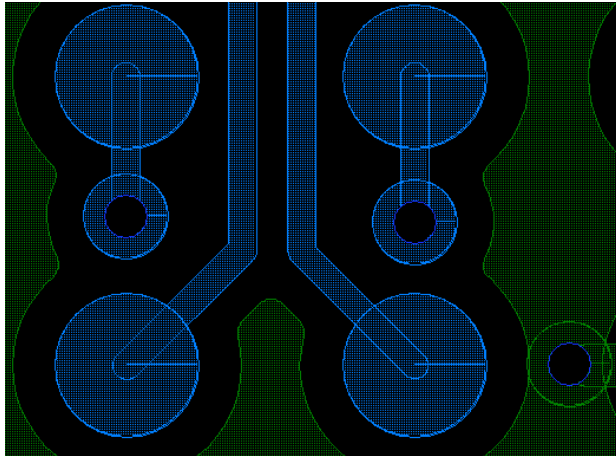


Figure 1 Vias placed between Pads

6.2 RF Traces for antennas

The NAD has five antenna pins.

- PRIMARY_ANT
- DRX0_ANT
- DRX1_ANT
- DRX2_ANT
- GNSS_ANT

The figure below shows the general breakout of the module:

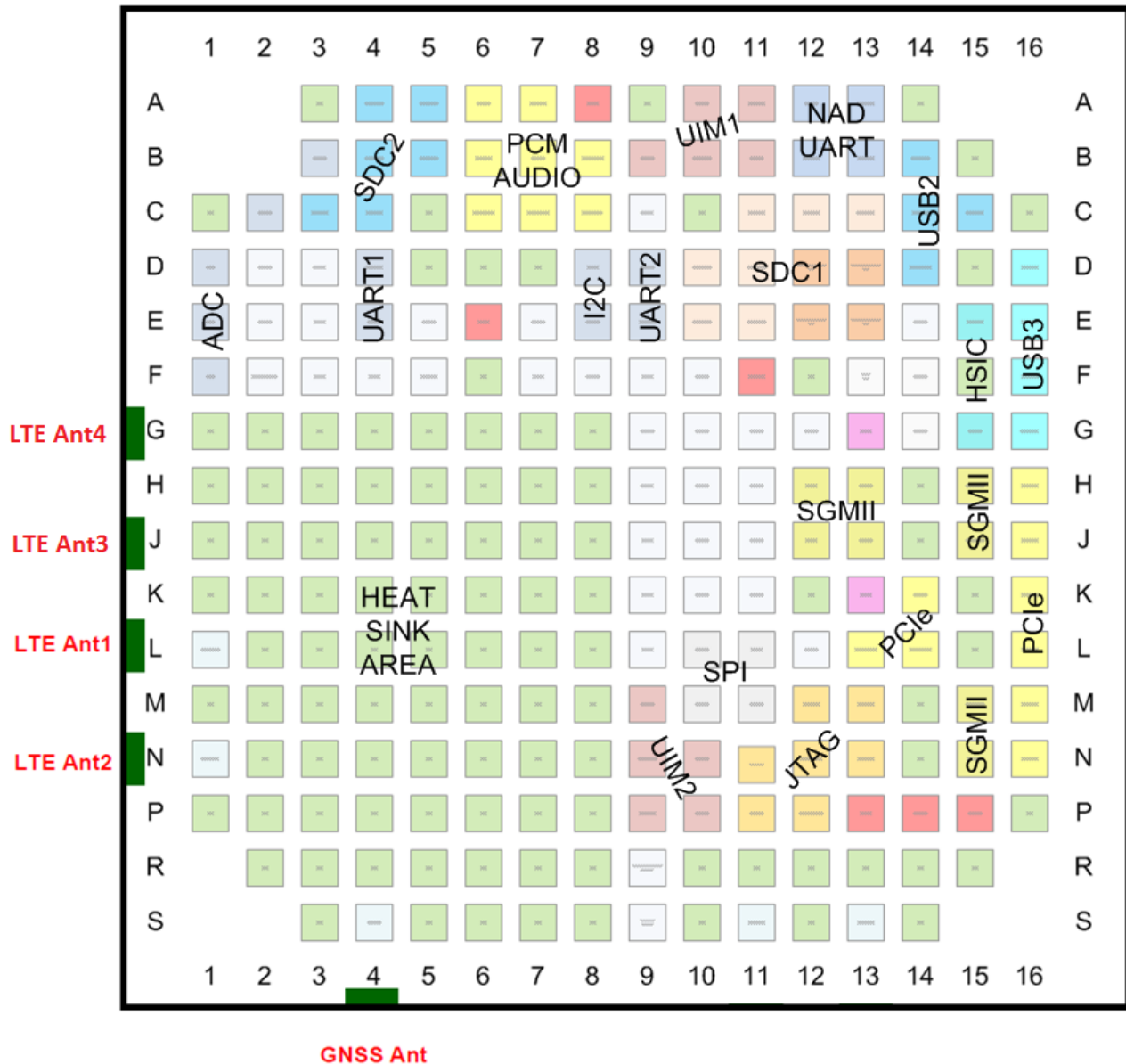


Figure 2: NAD Pin Breakout

The WT50NA01 NAD should be oriented on the main board to minimize the length of the PRIMARY_LTE antenna pin (LTE Ant1). This 50ohm line should be as short as possible to the external RF connector or internal antenna feed point.

The RF traces from the NAD antenna pins on the main board can be stripline or microstrip. For the stripline approach, vias should be placed to the NAD EDGE SIDE of the pins as close as possible to the NAD antenna pads to minimize any impedance discontinuity (see figure 38). For the microstrip approach, the PCB insertion loss will be less but the short route under the NAD MUST BE TREATED AS STRIPLINE SO IT WILL BE NARROWER UNDER THE NAD THAN THE MICROSTRIP LINE.

The NAD has ground cleared out under the RF antenna routes as shown below:

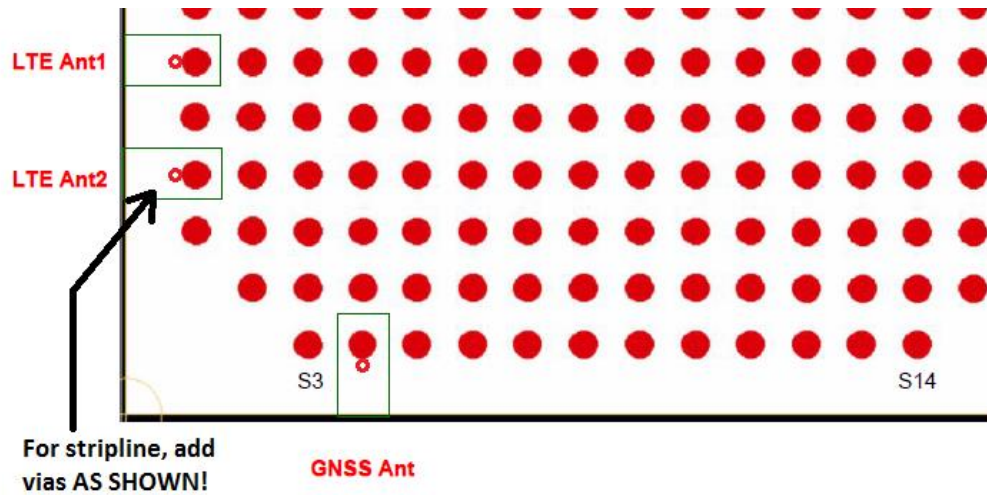


Figure 3: Antenna Pad Ground Cutout (Top View)

For routing microstrip lines UNDERNEATH the NAD on layer 1, these ground cutouts internal to the NAD need to be accounted for in the stripline calculation. The internal GND height and dielectric constant of the NAD board are shown below:

H = 19.3 mils (491 micron)
Dielectric Constant = 4.1

For example, consider the following stackup for a main PCB:

		Thickness in microns	Tolerance in microns	Thickness in mils
	Solder Mask	30 micron	+11 micron	1.17 mil
Plated 0.5oz Cu	ML1	49 micron	+/-10 micron	1.91 mil
7628 x 1+1080 x 1 Prepreg	DL1	253 micron	+/-38 micron	9.88 mil
1oz Cu	ML2	36 micron	+/-10 micron	1.41 mil
2116 x 2 Core	DL2	254 micron	+/-38 micron	9.92 mil
1oz Cu	ML3	36 micron	+/-10 micron	1.41 mil
2165 x 2 Prepreg	DL3	277 micron	+/-38 micron	10.82 mil
1oz Cu	ML4	36 micron	+/-10 micron	1.41 mil
2116 x 2 Core	DL4	254 micron	+/-38 micron	9.92 mil
1oz Cu	ML5	36 micron	+/-10 micron	1.41 mil
7628 x 1+1080 x 1 Prepreg	DL5	253 micron	+/-38 micron	9.88 mil
Plated 0.5oz Cu	ML6	49 micron	+/-10 micron	1.91 mil
	Solder Mask	30 micron	+11 micron	1.17 mil
Total board thickness:		1593 micron	+272 mu -250 mu	62.23 mil

Figure 4

Assume the main PCB above with a 6 layer stackup with ground cut away on layer 2 so the microstrip lines reference ground on layer 3. The dielectric thickness from L1 to L3 is 21.2 mils.

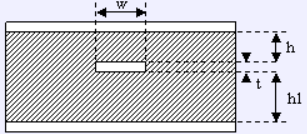
Using an online impedance calculator, the line width under the NAD for a 50 ohm line is 16.9mils (433micron) shown below:

Asymmetric Stripline Impedance Calculator

Note: valid for (w/h) from 0.1 to 2.0 and (t/h) less than 0.25

Dimensional units: ☐ mm ☒ mils

w (trace width) =	16.9
t (trace thickness) =	1.91
h (smaller dielectric thickness) =	21.21
h1 (larger dielectric thickness) =	21.6
er (relative dielectric constant) =	4.2



Calculate

Zo (Impedance, Ohms) =	49.988
Propagation Delay, Tpd (ps/inch) =	173.50
Inductance, L (nH/in) =	8.673
Capacitance, C (pF/in) =	3.47078

Note: 1oz = 1.4mils = 0.03556mm

$$Z_0 = \frac{80}{\sqrt{\epsilon_r}} \ln \left(\frac{1.9(2h+t)}{(0.8w+t)} \right) \left(1 - \frac{h}{4h_1} \right) \quad T_{pd} = 3.333 \sqrt{\epsilon_r} \left(\frac{ns}{meter} \right)$$

BL

Figure 5

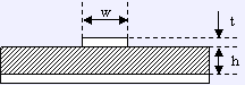
The calculation for the microstrip line width outside the NAD is 37.7mils (967micron) shown below:

Microstrip Impedance Calculator

Note: valid for (w/h) from 0.1 to 3.0

Dimensional units: ☐ mm ☒ mils

w (trace width) =	37.7
t (trace thickness) =	1.91
h (dielectric thickness) =	21.21
er (relative dielectric constant) =	4.3



Calculate

Zo (Single Ended Impedance, Ohms) =	50.060
Propagation Delay, Tpd (ps/inch) =	139.43
Inductance, L (nH/in) =	6.980
Capacitance, C (pF/in) =	2.78522
DC Resistance, Rdc (mOhm/in) =	9.404

Note: 1oz = 1.4mils = 0.03556mm

$$Z_0 = \frac{87}{\sqrt{\epsilon_r + 1.41}} \ln \left(\frac{5.98h}{(0.8w+t)} \right) \quad T_{pd} = 3.333 \sqrt{0.475 \cdot \epsilon_r + 0.67} \left(\frac{ns}{meter} \right)$$

Figure 6

Due to the nature of the weave chosen for each PCB, the dielectric constant of the NAD board is 4.1 while the main board is 4.3. A dielectric constant of 4.2 was chosen in the stripline calculation, while 4.3 was used for the microstrip calculation.

Main board stack up may vary so these line widths may need to be recalculated. IT IS HIGHLY RECOMMENDED TO USE A SIMILAR STACKUP AS SHOWN IN FIGURE 39 WITH MICROSTRIP ROUTING AND GND CUTS ON LAYER 2 WITH GND REFERENCE ON LAYER 3. THERE SHOULD BE NO ROUTING ON L2 AND SOLID GND ON L3 UNDERNEATH THESE ANTENNA LINE MICROSTRIP TRACES.

The antenna traces need to be routed STRAIGHT OUT OF THE NAD TO THE NEAREST NAD EDGE. The lines need to be tapered from 433micron to the 967micron width gradually but quickly.

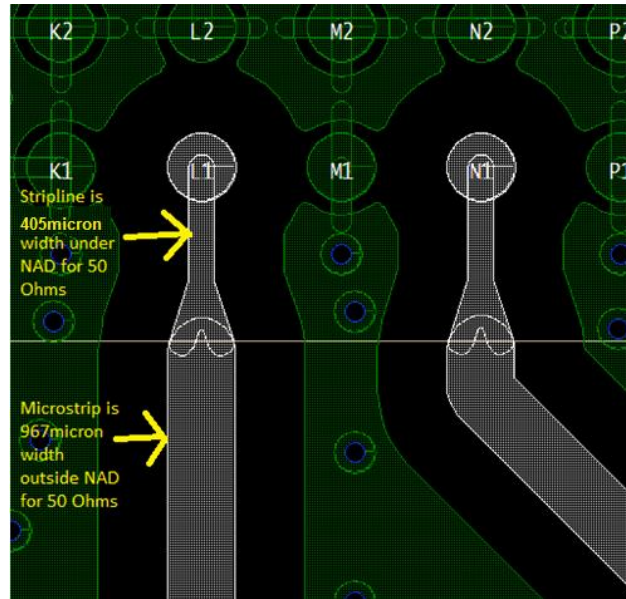


Figure 7

These line widths may vary depending on the stackup selected for the main board.

6.3 RF Antenna Layout Parameters

Type of Guidance	Requirement
Trace impedance	50-Ohms $\pm$ 10% single-ended
Total route length	<100-mm
Ground between signals	> 3 x line width of ground trace between, stitched VIA to ground
Spacing to other signals	< 3:1

- Signals should be routed along similar route path but separated by ground trace.
- Trace impedances should match the table, either as microstrip or stripline.
- Total length for both signals should match the table.
- Spacing to ground or other signals on outside of bundled signals should match the table.