FE5RW0D31

5G DSDA NAD Module

OEM Manual and User Guide v1

(For Use during Certification)

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Terms and Acronyms

BB	Baseband
DCM	Data Connectivity Module (also, "TCU")
DRX	Discontinuous Reception
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
HSIC	High Speed Inter-Chip
HU	Head Unit
LTE	Long Term Evolution
MP	Mass Production
NAD	Network Access Device
OEM	Original Equipment Manufacturer
PCB	Printed Circuit Board
PCIe	Peripheral Component Interconnect Express
PHY	Physical Layer
PMIC	Power Management IC
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
TSP	Telematics Service Provider
UMTS	Universal Mobile Telecommunication System
WCDMA	Wideband Code Division Multiple Access

FE5RW0D31 Module

1 FE5RW0D31 Module

The **FE5RW0D31** Module incorporates 5G New Radio technology with **Dual Sim Dual Access** 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).

Note: The FE5RW0D31 Module support the DSDA (Dual Sim Dual Access) feature in HW, but DSDA is disabled from SW config, so the FE5RW0D31 will behavior like a single SIM Module.

1.1 Key Features

1.1.1 Air Interface Support

- 5G NR: 3GPP Release 15
- Sub-6 Ghz 5G NR bands n77, n78
- LTE FDD/TDD: 3GPP Rel. 15 Category 15
- UMTS: HSUPA CAT6 (SIM1 only)
- GSM: EGPRS Rel-12
- VoLTE – HD Voice
- Embedded Qualcomm GNSS Sub-system
- High Precision GNSS
- SBAS supported: EGNOS/MSAS/QZSS/WAAS/GAGAN

1.2 Package

- 764-pin LGA module of size 52 x 60 x 3.1 mm

1.3 Band Configurations Supported

Table 1-1: FE5RW0D31 Band Configuration Support

Model	Region	5G NR Band (SIM1)	LTE (SIM1 and SIM2))	C-V2X Bands	UMTS Bands (SIM1)	GSM (SIM1 &2)	GNSS
FE5RW0D31	RW	n1, n3, n8, n20, n28, n77, n78, n79	1,2,3,4,5,7,8,9,18,19,20,25,26 ,28a,28b,32RX,34,38,39,40,41	---	1, 3, 5, 8,9, 19	2, 3, 5, 8	B1I, E1, G1, L1

Notes:

1.The module supports n77 U.S. band from 3700 to 3980 MHz

2.The module disables n78 via software

2 Regulatory Compliance Notes

2.1 Regulatory Compliance Notes

2.1.1 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-FE5RW0D31. Part 15 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.

2.2 Device Installation and User Manual

The FE5RW0D31 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 FE5RW0D31 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-FE5RW0D31".

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 FE5RW0D31 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, for all standalone NR/LTE/WCDMA/GSM operations the maximum antenna gain including cable loss shall not exceed the following values:

- GSM850: 4.5 dBi
- GSM1900: 2.5 dBi
- WCDMA Band V: 4.5 dBi
- LTE B2: 2.5 dBi
- LTE B4: 5.5 dBi
- LTE B5: 4.5 dBi
- LTE B7: 6 dBi
- LTE B25: 2.5 dBi
- LTE B26: 4.5 dBi
- LTE B38: 6 dBi
- LTE B41: 6 dBi
- NR Band n77: 6 dBi

This radio transmitter (FCC ID: LHJ-FE5RW0D31) has been approved by FCC to operate with the antenna types listed above 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: Module Label Example

5 NAD Module RF Characteristics

5.1 NAD Module RF Transmitter Output Power

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

GSM 850/900:	+32.5 dBm +1.0/-2.0 dB
GSM 1900/1800:	+29.5 dBm +1.0/-2.0 dB
EDGE 850/900:	+26.5 dBm +1.0/-2.0 dB
EDGE 1800/1900:	+25.5 dBm +1.0/-2.0 dB
WCDMA:	+ 23.5 dBm to +1.0/-2.0 dB
LTE:	+23 dBm +1.0/-2.0 dB
LTE B41 HPUE:	+26 dBm +1.0/-2.0 dB
5G NR FDD bands:	+23 dBm +1.0/-2.0 dB
5G TDD HPUE n77, n79:	+26 dBm +1.0/-2.0

Allowance for reduction in maximum transmitter power is specified in the 3GPP standard for GPRS multi-slot operation. Per 3GPP TS 05.05, the following Maximum Output Power Reduction will be taken during Multi-slot GPRS operation (MSPP = 0):

- 0 dB back -off for 1TX slot
- 3 dB back-off for 2TX slots
- 4.5 dB back-off for 3TX slots
- 6 dB back-off for 4TX slots

Per 3GPP TS 05.05, the following Maximum Output Power Reduction will be taken during Multi-slot EDGE operation (MSPP = 0):

- 0 dB back -off for 1TX slot
- 2.0 dB back-off for 2TX slots
- 3.0 dB back-off for 3TX slots
- 4.0 dB back-off for 4TX slots

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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 low bands (800/900):	3GPP TS 51.010-1 Section 14.2
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
GNSS bands:	-163 dBm (in Out-Of-Service mode)

6 Mechanical Information

6.1 Module Exploded View

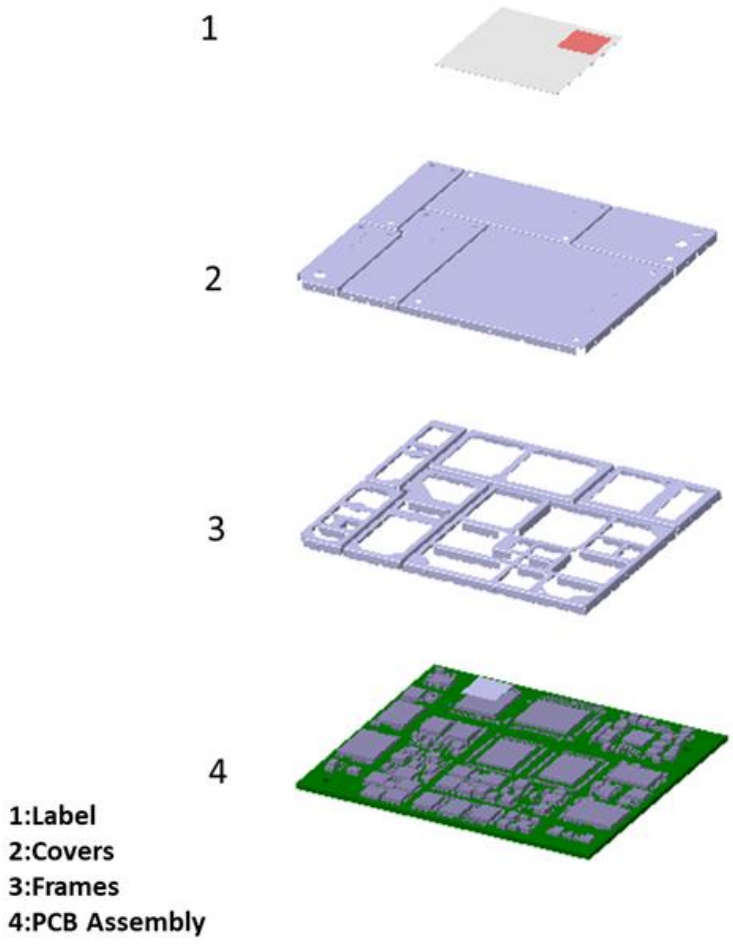


Figure 6-1: Module Exploded View

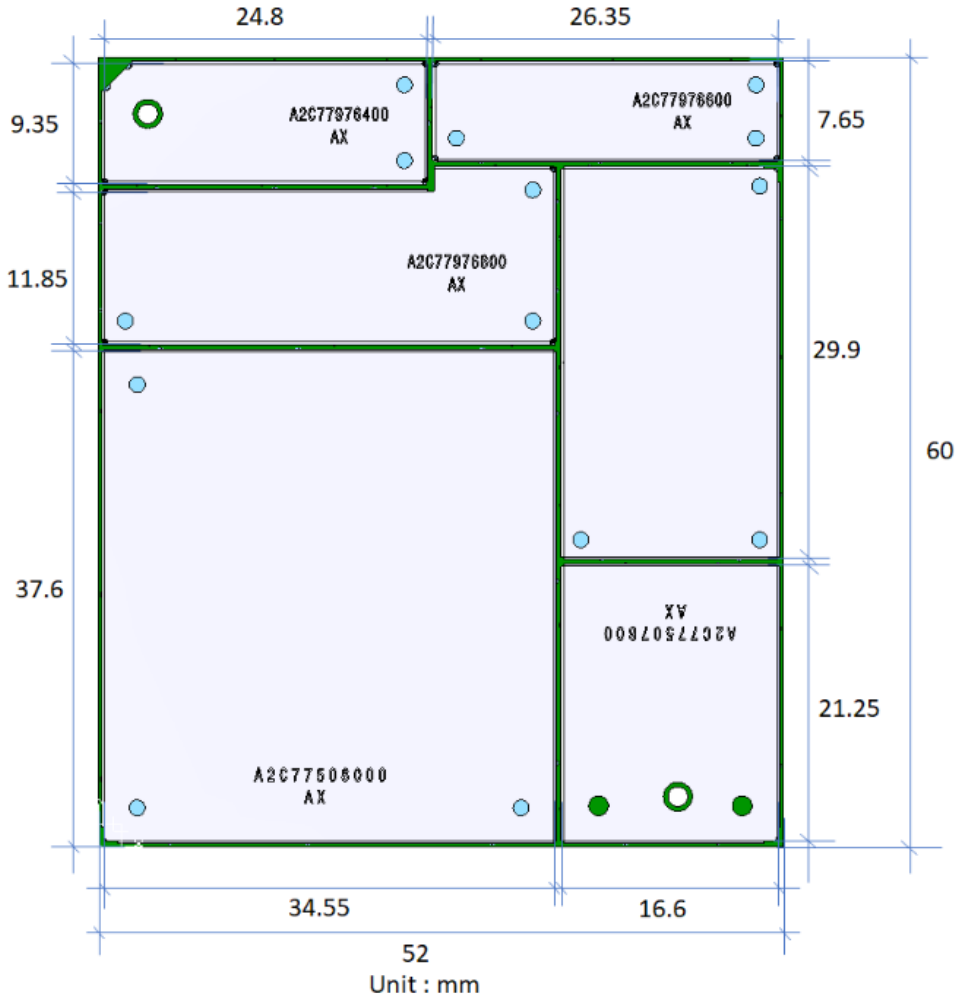
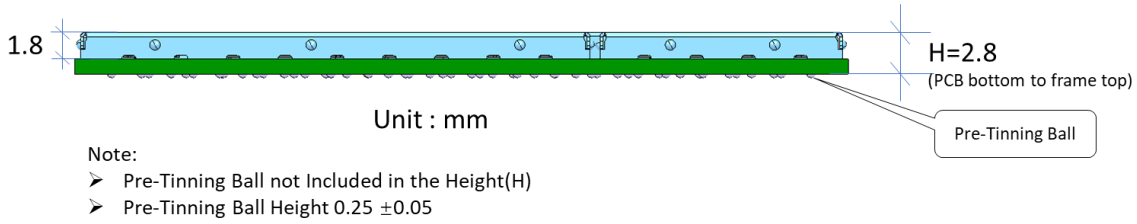


Figure 6-2: Module Top View

6.2 Module Side View



Note:
- Pre-Tinning Ball not Included in the Height(H)
- Pre-Tinning Ball Height 0.25 ±0.05

Figure 6-3 Module Side View

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)

This remainder of this section will be completed in a future release of this document.

8 Part Reliability

This section will be completed in a future release of this document.

9 Layout and Routing Recommendations

9.1 ANTENNAS

The NAD has eight antenna pins.

- **LTE/5G NR:** LTE_ANT_1 – LTE_ANT_2
- **GNSS:** GNSS_ANT_1, GNSS_ANT_2
- **DSDA:** ANT5_DSDA, ANT6_DSDA

9.1.1 NAD Antenna Breakout

The FE5RW0D31 should be oriented on the main board to minimize the length of the primary Cellular TX/RX antenna (ANT1). This 50ohm line should be as short as possible to the external RF connector or internal antenna feed point.

The RF traces on the main board connecting from the NAD antenna pins can be either stripline or microstrip, but the microstrip routing must be on the layer opposite from the NAD, since the bottom layer of the NAD will be mostly ground and it would become a near RF short to any trace that runs on the main board's top layer, while still underneath the NAD. For a given line length, the stripline approach will tend to be more lossy, so it is generally not recommended. Thus, microstrip antenna lines are favored in most cases.

9.1.1.1 NAD Antenna Pad Ground Cutout

It is likely that the parent device's PCB will use only thru-hole vias, and so the antenna pads on the parent PCB may need to be offset slightly from their vias for manufacturability reasons. The NAD bottom layers have been designed to accomodate this need, and ground cutout in these layers has been extended to avoid shorting to those vias on the parent PCB's top layer, where it mates with the NAD. Figure 9-1 details the

ground cutout provided on the bottom six layers of the NAD. The PCB of the parent device should utilize this cutout area for placement of any thru vias which serve the antenna pads:

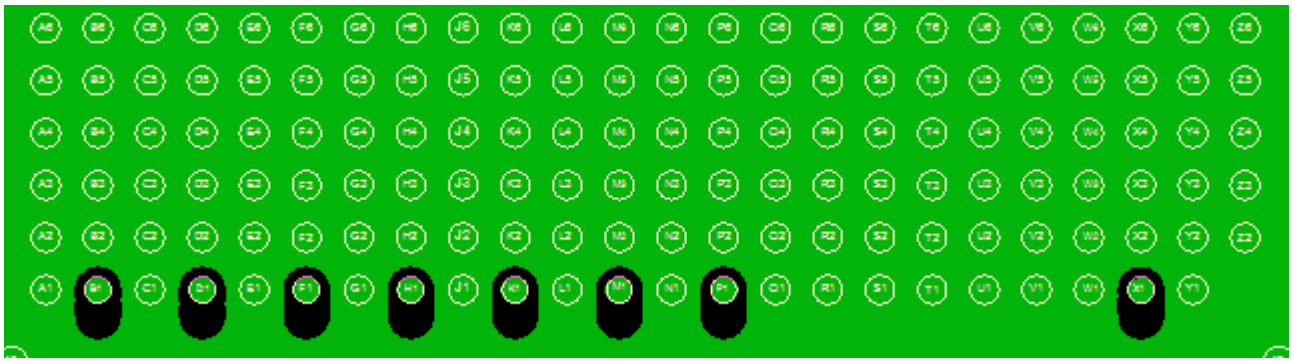


Figure 9-1: Antenna Pad Ground Cutouts (NAD bottom layer)

Figure 9-2 provides a more detailed view of the cutout around each antenna pad on the NAD PCB.

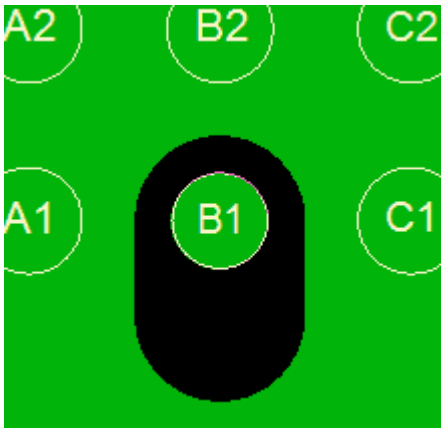


Figure 9-2 Antenna Pad Ground Cutout x8 (detail view)

9.1.1.2 Parent PCB Antenna Pad Design Recommendation

The main board on which the FE5RW0D31 will be mounted should have ground cut out under the RF antenna pins of the NAD as shown in Figure 9-3 and Figure 9-4:

Figure 9-3: Antenna Pad Ground Cutout Recommended (Main Board, top layer/NAD side)

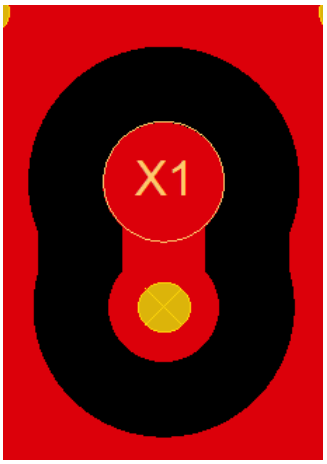


Figure 9-4 Antenna Pad Ground Cutout x8 (detail view)

The dimensions of the RF trace on the Main Board will be dependent on the layer stack-up of the board, their thicknesses and how many layers are used. As an example, the main PCB shown in Figure 9-5 is a 6 layer stack up with Ground cut out on layer 5 so the microstrip lines on the bottom (layer 6) reference Ground on layer 4. For this example, the dielectric thickness from L6 to L4 is 21.2 mils.

			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 9-5: Recommended PCB Stack-up

Using an online microstrip impedance tool, the calculation resulting in microstrip line width [w] of 37.7mils (967micron).

The line width will of course vary, depending on the stack up and use of layers on the main board. In the end, the characteristics of the RF traces connecting to the NAD on the main board should remain within the guidelines of Table 9-1.

Table 9-1: RF Antenna Layout Parameters

Type of Guidance	Requirement
Trace impedance	50±10% Ohms, single-ended
Total route length	< 100 mm
Ground between signals	> 1 x [RF line width] with stitched VIA to ground layer
Spacing to other signals	> 3 times RF line width, to any non-RF traces
VSWR for Cellular Antenna ports	< 3:1

- Trace impedances apply to either microstrip or stripline.
- Length for all antenna traces should be kept to a minimum, with priority on cellular antenna 1.

9.1.2 Integrated Device RF Insertion Loss

The integrated device TX and RX performance must comply with 3GPP and MNO RF requirements at the RF connectors. In addition, in some use cases, such as on-board antenna, TRP and TIS performance requirements must be met. It is a Product Team's responsibility to insure the integrated device complies with these requirements.

The Insertion Loss between NAD's RF and the parent module antenna terminal (RF Connector of the evaluation board or the Telematics/parent module) must be kept at minimum and not to exceed these values:

- RF Loss < 0.6dB from 700 - 1000MHz
- RF Loss < 1.2dB from 1.7 - 2.7GHz
- RF Loss < 2.5dB from 2.7 – 6.0GHz

9.2 SDC / eMMC Routing

Table 9-2: SDC / eMMC Layout Parameters

Type of Guidance	Requirement
Trace impedance	50-Ohms ± 10% single-ended
Total route length	< 50-mm recommended, but 75-mm is acceptable
Trace matching (SDC application)	< 1.6-mm
Trace matching (eMMC application)	< 5 - mm
Trace spacing	> 0.508-mm / > 20-mils
Number of vias per trace	< 5
Spacing to other signals	>= 2 times line width

- Trace impedances should follow table, either as microstrip or stripline.
- Trace lengths should follow table.
- Number of vias per trace should follow table.
- No stubs allowed on traces.
- No test points allowed on traces.
- Trace lengths should follow table.
- Spacing to ground or other signals on outside of bundled signals should follow table.