COMPANY CONFIDENTIAL

U98Z058.02
USB WiFi Module
User Manual
Rev. 1.0

Prepared by	Reviewed by	Approved by
Hans Dang	Gallon Tao	

Index

1. Revision History

Date	Change Note	REV Note
2010-06-17	Initial Release	1.0

2. Introduction

Project Name: 802.11 b/g/n wireless card

This documentation describes the product specification of the 802.11b/g/n WiFi Module. It is Compliant with IEEE Std 802.11b-1999, IEEE Std 802.11g-2003 and IEEE Std 802.11n-2009. It is a confidential document of Foxconn.

2.1 Scope

This 802.11 b/g/n Module is available in the 2.4-GHz ISM band, it is compatible with the IEEE 802.11 b/g standard and the 802.11n standard. It allow user to switch to different vendors' Access Points through the wireless networks and to prevent from eavesdropping. The 802.11 g data rate provides for 54, 48, 36, 24, 18, 12, 9, 6Mbps, 802.11b data rate provides for 11, 5.5, 2, 1 Mbps, it can also support 11n high data rate up to MCS7 with PHY data rate to 135Mbps.

2.2 Function

- Single stream 802.11 support for both 20MHz and 40MHz (optional) channels provide PHY layer rates up to MCS7(150Mbps).
- Support IEEE 802.15.2 external 3-wire additional co-located wireless technologies such as Bluetooth, GPS, WiMax or UWB.
- Provides a small form factor solution and ultra low power consumption to support low cost requirement.
- Host interface supports USB, SDIO is not used in this product.

3. Product Specification

3.1 WiFi RF Specification

Wireless LAN Standards	IEEE 802.11 b/g/n standard
Operating Frequency	2.400 – 2.4835 GHz
WLAN Data Rate	802.11g: 54Mbps with fall back of 48, 36, 24, 18, 12, 9, 6Mbps. 802.11b: 11Mbps with fall back rates of 5.5, 2, and 1Mbps 802.11n: Data Rate (MCS0~MSC7) refer to Table A-1 and Table A-2
Modulation Schemes	802.11g: 64QAM (54Mbps, 48Mbps), 16QAM (36Mbps, 24Mbps), QPSK (18Mbps, 12Mbps), BPSK (9Mbps, 6Mbps) 802.11b: CCK (11 Mbps, 5.5Mbps), DQPSK (2 Mbps), DBPSK (1 Mbps) 802.11n: refer to Table A-1 and Table A-2

Table A-1 – rate dependent parameters for mandatory 20 MHz, N_{SS} =1 (N_{ES} = 1) modes

MCS Index	Modulation	R	N_{BPSC}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)	
								800ns GI	400ns GI[1]
0	BPSK	½	1	52	4	52	26	6.5	7.2
1	QPSK	½	2	52	4	104	52	13.0	14.4
2	QPSK	¾	2	52	4	104	78	19.5	21.7
3	16-QAM	½	4	52	4	208	104	26.0	28.9
4	16-QAM	¾	4	52	4	208	156	39.0	43.3
5	64-QAM	2/3	6	52	4	312	208	52.0	57.8
6	64-QAM	¾	6	52	4	312	234	58.5	65.0
7	64-QAM	5/6	6	52	4	312	260	65.0	72.2

Table A-2—Rate-dependent parameters for optional 40 MHz, N_{SS} = 1 (N_{ES} = 1) modes

MCS Index	Modulation	R	N_{BPSC}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	Data rate (Mbps)	
								800 ns GI	400ns GI
0	BPSK	½	1	108	6	108	54	13.5	15.0
1	QPSK	½	2	108	6	216	108	27.0	30.0
2	QPSK	¾	2	108	6	216	162	40.5	45.0
3	16-QAM	½	4	108	6	432	216	54.0	60.0
4	16-QAM	3/4	4	108	6	432	324	81.0	90.0
5	64-QAM	2/3	6	108	6	648	432	108.0	120.0
6	64-QAM	¾	6	108	6	648	486	121.5	135.0
7	64-QAM	5/6	6	108	6	648	540	135.0	150.0

* 40MHz bandwidth is optional for transmit and receive.

Transmitter AV Output Power

11b CCK: 17.5+/-1.5 dBm
11g OFDM: 14.0 +1/-2 dBm
11n MCS0~MCS7: 14.0 +1/-2 dBm

Receiver Sensitivity

Typical -87dBm @11Mbps (PER<8%)
Typical -75dBm @54Mbps (PER<10%)
Typical -70dBm @MCS7 (PER<10%)

3.2 Electrical Specification

Absolute Maximum Ratings

These specification indicate levels where permanent damage to the device can occur. Functional operation is not guaranteed under these conditions. Operation at absolute maximum conditions for extended can adversely affect long-term reliability of the device.

Rating	Symbol	Value	Unit
DC supply voltage for the device	VDD_USB	-0.5 to +4.1	V
Maximum chip junction temperature	Tj	125	ºC

Recommended Operating Condition

Element	Symbol	Value			Unit
		Minimum	Typical	Maximum	
DC supply voltage for the device	VDD_USB	3.0	3.3	3.63	V

Function operation is not guaranteed outside this limit, and operation outside this limit for extended periods can adversely affect long-term reliability of the device.

Current Consumption

Standby: typically 120mA @3.3V
Transmit:
802.11b: typically 320mA @3.3V (Tx Power=17.5dbm)
802.11g: typically 310mA@3.3V (Tx Power=14dbm)
802.11n: typically 315mA@3.3V (Tx Power=14dbm)
Receive: typically 220mA @3.3V

4. Product Requirements and Characteristic

4.1 Hardware Characteristic

Form factor	44.5x40(mm^2) module with 2x4 pin connector
Host Interface	USB 2.0
PCB	4-layer single side
Antenna &RF connector	Two printed Antenna, with one for diversity. One U.FL switched RF connector for testing and can be also used for external antenna

4.2 Hardware Architecture

This 802.11b/g/n device is operating at 2.4 GHz ISM band, it supports 20 MHz and 40 MHz (optional) channels.

The WiFi design is based on Broadcom BCM4319 chipset.

The Broadcom BCM4319 is a highly integrated single chip solution for 2.4GHz 802.11n-ready wireless local area network that enables a high performance 1X1 configuration for wireless station maximum throughput and range, it integrated a multi-protocol MAC, baseband processor, ADC and DAC converters, 1X1 radio transceiver, RF switch in all-CMOS device.

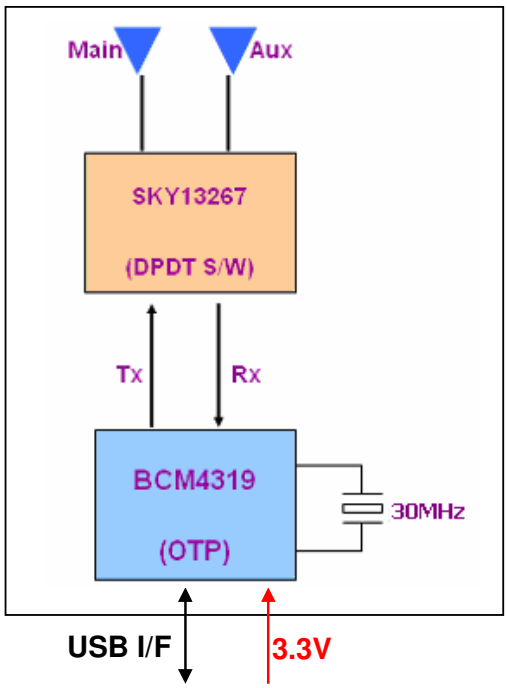
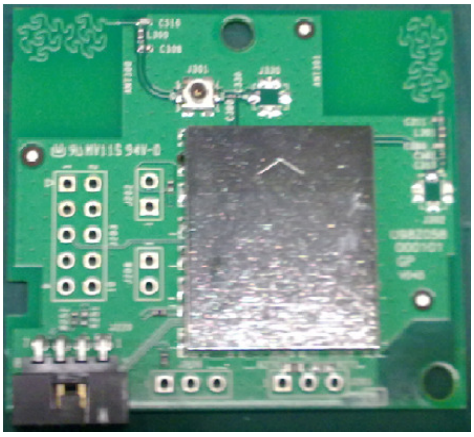


Figure 1 Functional Block Diagram

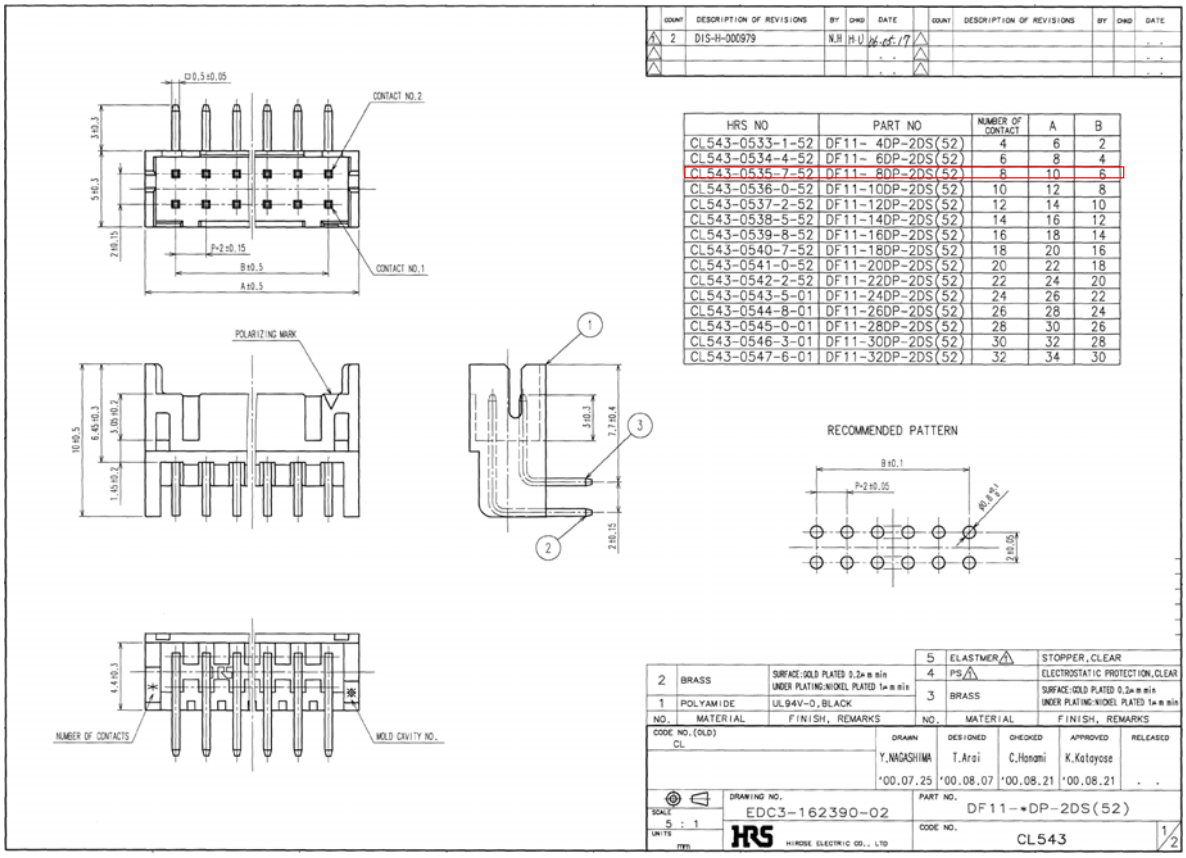


Top **Bottom**

Figure 2 Board Appearance (For reference)

4.3. Connector information

Connector: 2x4P, T/H, Male, Right Angle, 2mm pin pitch.
Hirose P/N: DF11-8DP-2DS (52)



HRS NO	PART NO	NUMBER OF CONTACT	A	B
CL543-0533-1-52	DF11- 4DP-2DS(52)	4	6	2
CL543-0534-4-52	DF11- 6DP-2DS(52)	6	8	4
CL543-0535-7-52	DF11- 8DP-2DS(52)	8	10	6
CL543-0536-0-52	DF11-10DP-2DS(52)	10	12	8
CL543-0537-2-52	DF11-12DP-2DS(52)	12	14	10
CL543-0538-5-52	DF11-14DP-2DS(52)	14	16	12
CL543-0539-8-52	DF11-16DP-2DS(52)	16	18	14
CL543-0540-7-52	DF11-18DP-2DS(52)	18	20	16
CL543-0541-0-52	DF11-20DP-2DS(52)	20	22	18
CL543-0542-2-52	DF11-22DP-2DS(52)	22	24	20
CL543-0543-5-01	DF11-24DP-2DS(52)	24	26	22
CL543-0544-8-01	DF11-26DP-2DS(52)	26	28	24
CL543-0545-0-01	DF11-28DP-2DS(52)	28	30	26
CL543-0546-3-01	DF11-30DP-2DS(52)	30	32	28
CL543-0547-6-01	DF11-32DP-2DS(52)	32	34	30

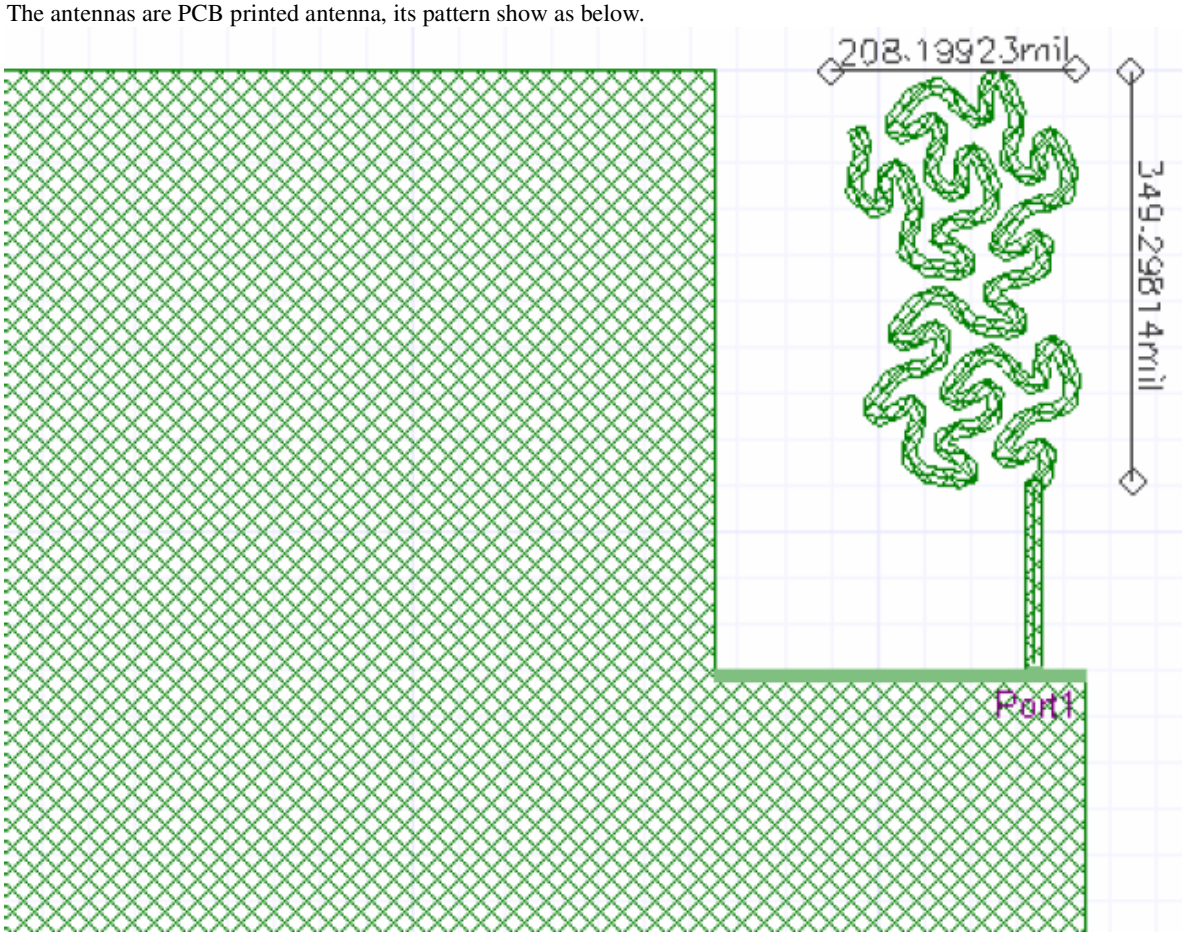
4.4 Connector Pin Assignment

Pin No.	Pin Name	Description	Pin No.	Pin Name	Description
1	VDD_USB	Power supply for the device, 3.3 typically.	2	VDD_USB	Power supply for the device, 3.3 typically.
3	GND	Ground	4	GND	Ground
5	USB_DP	USB differential positive	6	USB_DM	USB differential negative
7	WL_REG_ON	Enable/disable power the internal regulators	8	GND	Ground

Notice:
WL_REG_ON is used by PMU to enable/disable power the internal regulators, ViH=1.6V, maximum=3.6V.
When WL_REG_ON is low (<1.2(1-20%)=0.96V) or the voltage at VDDIO is less than 0.96V, all six internal regulators are powered down.
When WL_REG_ON is high (>1.6V) and the voltage at VDDIO is greater than 1. 6V, the CBUCK, LDO2p5V, CLDO, and LNLDO1 regulators are powered on default.
The voltage at WL_REG_ON should not exceed 3.6V.
There's a 200KΩ internal pull-down on WL_REG_ON.
In normal operation mode, WL_REG_ON is pulled-high to 3.3V; and when the device is not needed in the system, WL_REG_ON should be driven low while VDDIO remains powered, which is called Low-Power shutdown mode.

5. Antenna Specification

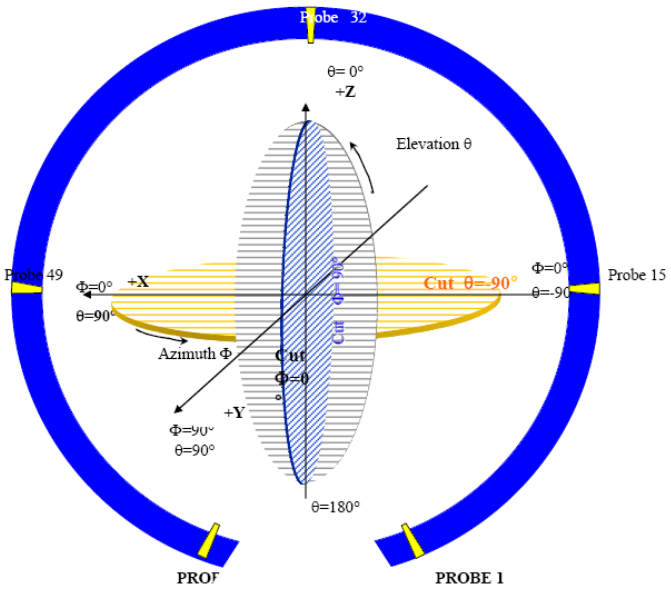
The antennas are PCB printed antenna, its pattern show as below.

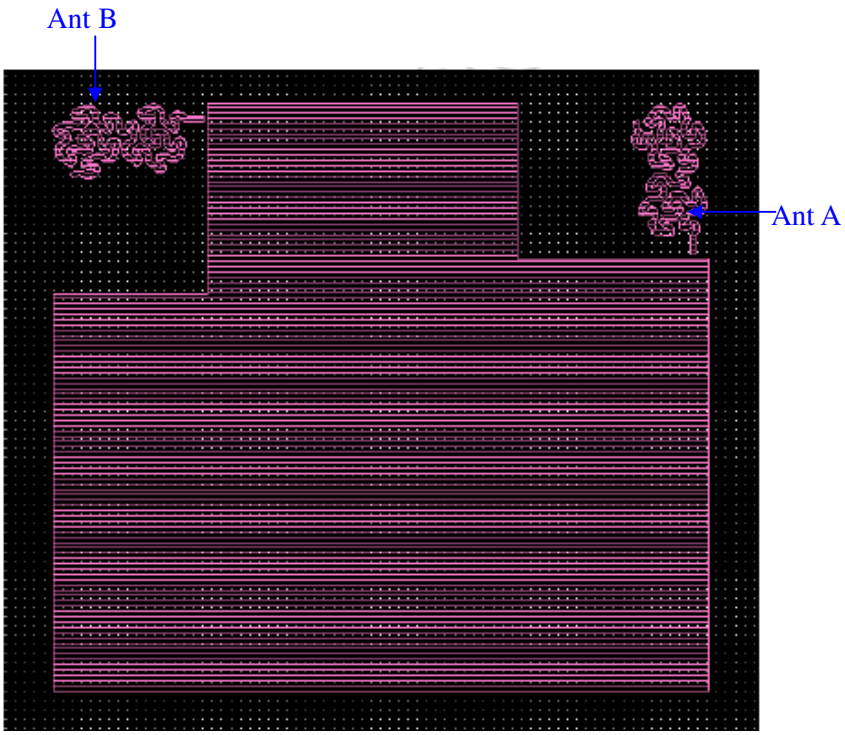


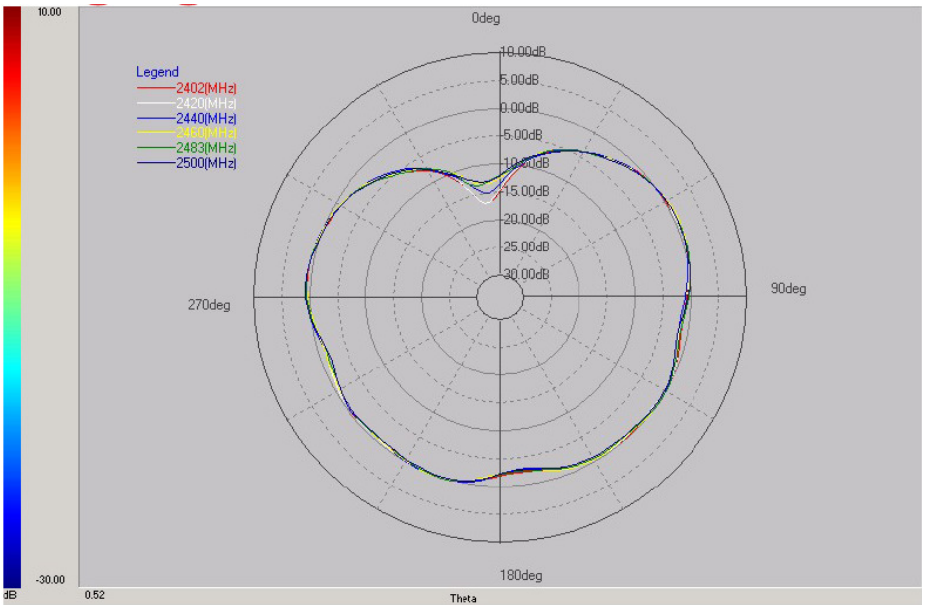
Features：
2.4 to 2.5 GHz operation
VSWR better than 2:1
Efficiency >72%

Antennas orientation. SMA connectors looking at the floor

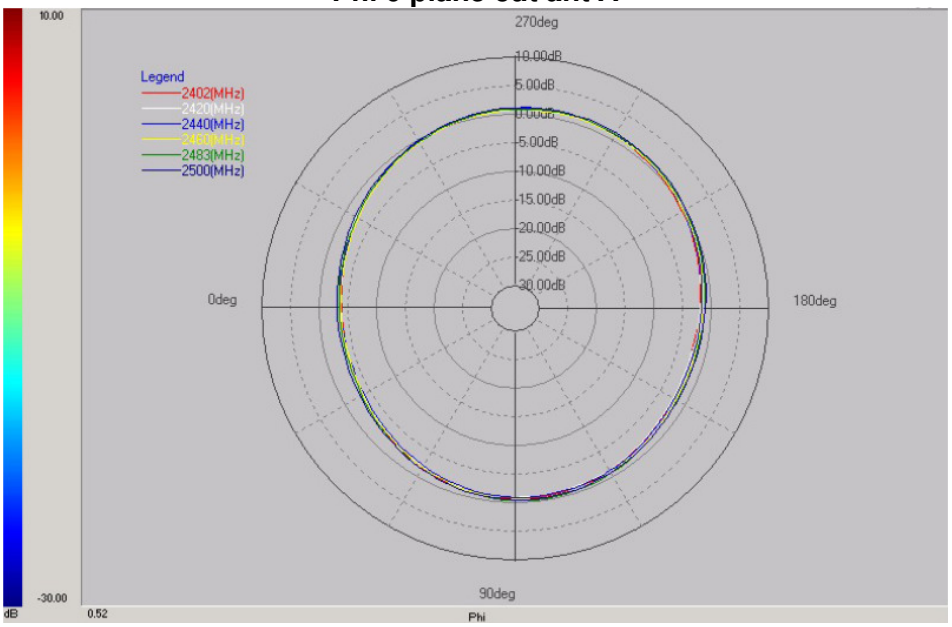
Satimo Chamber Coordinate System



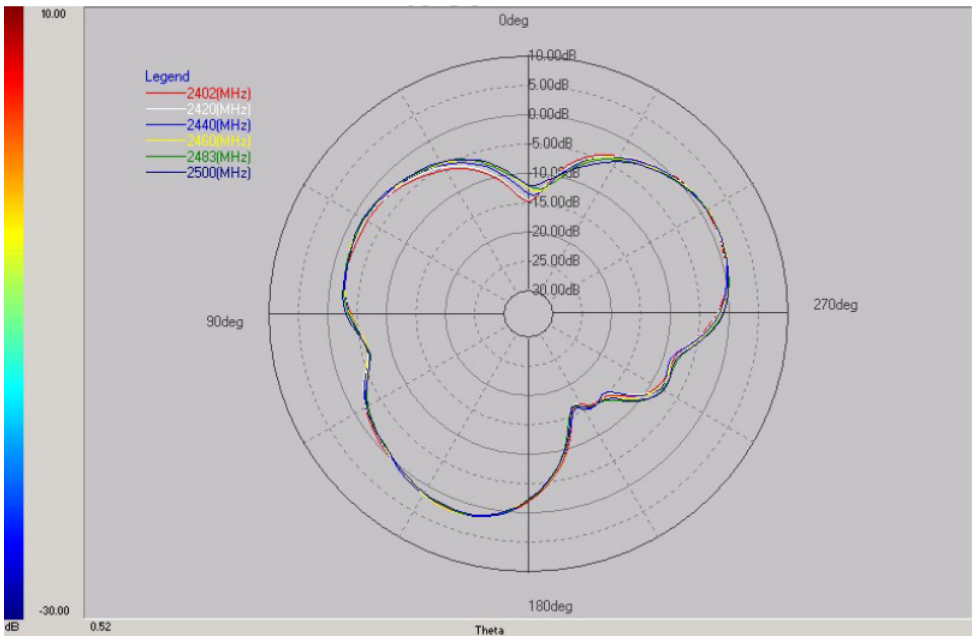




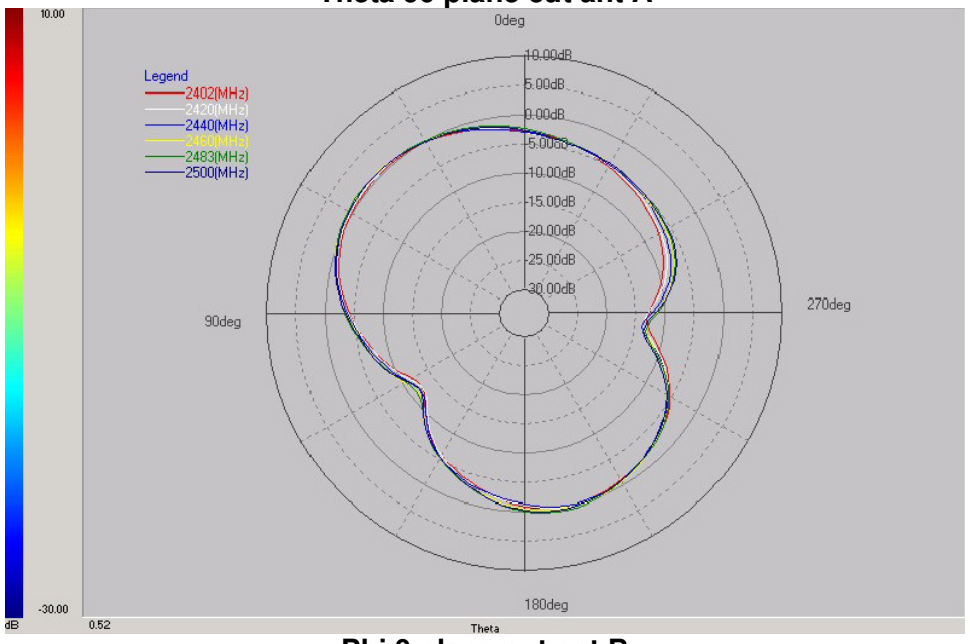
Phi 0 plane cut ant A



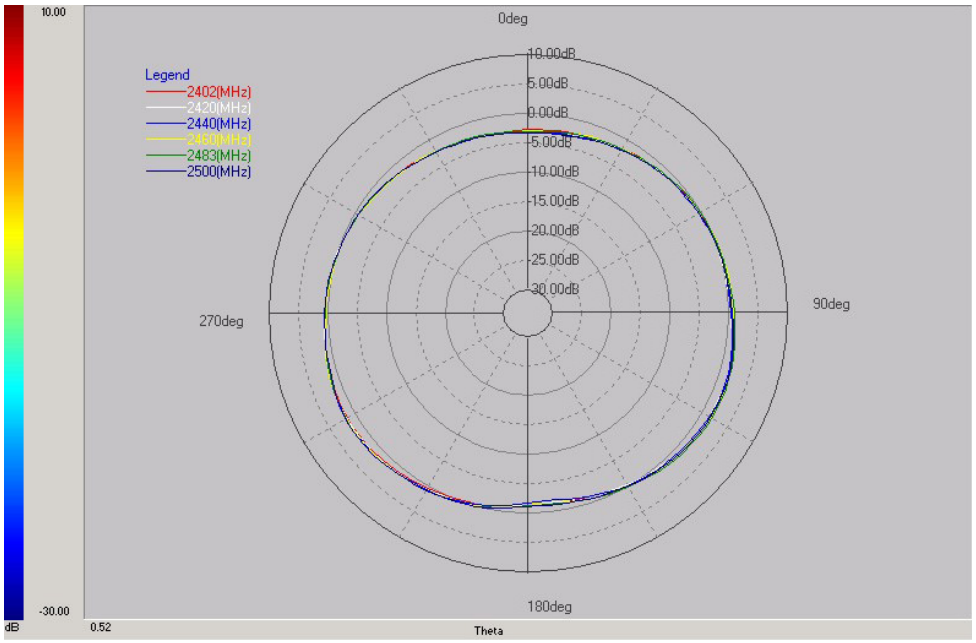
Phi 90 plane cut ant A



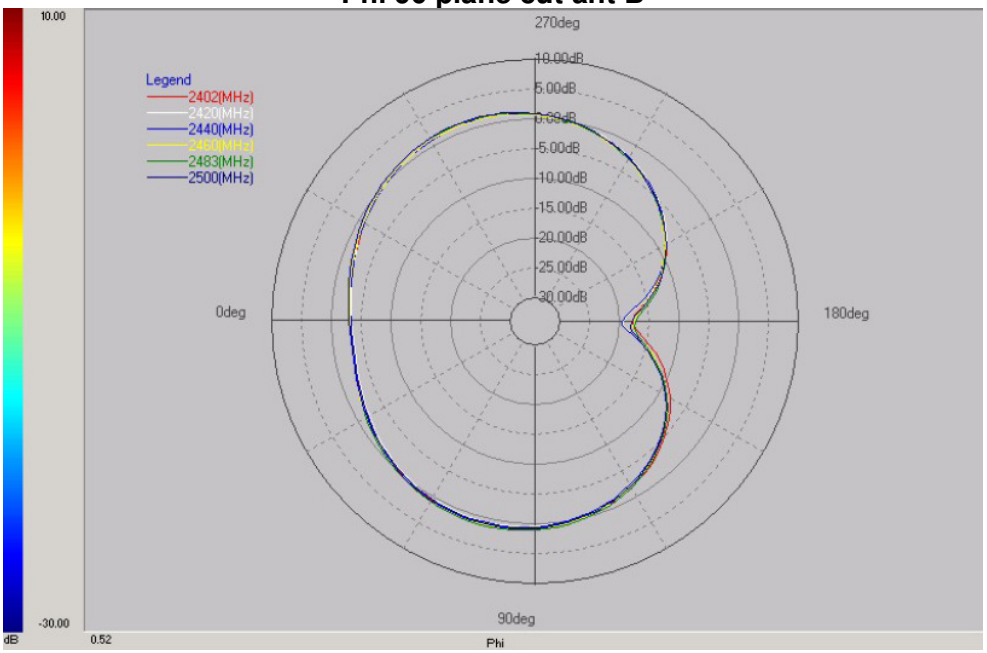
Theta 90 plane cut ant A



Phi 0 plane cut ant B

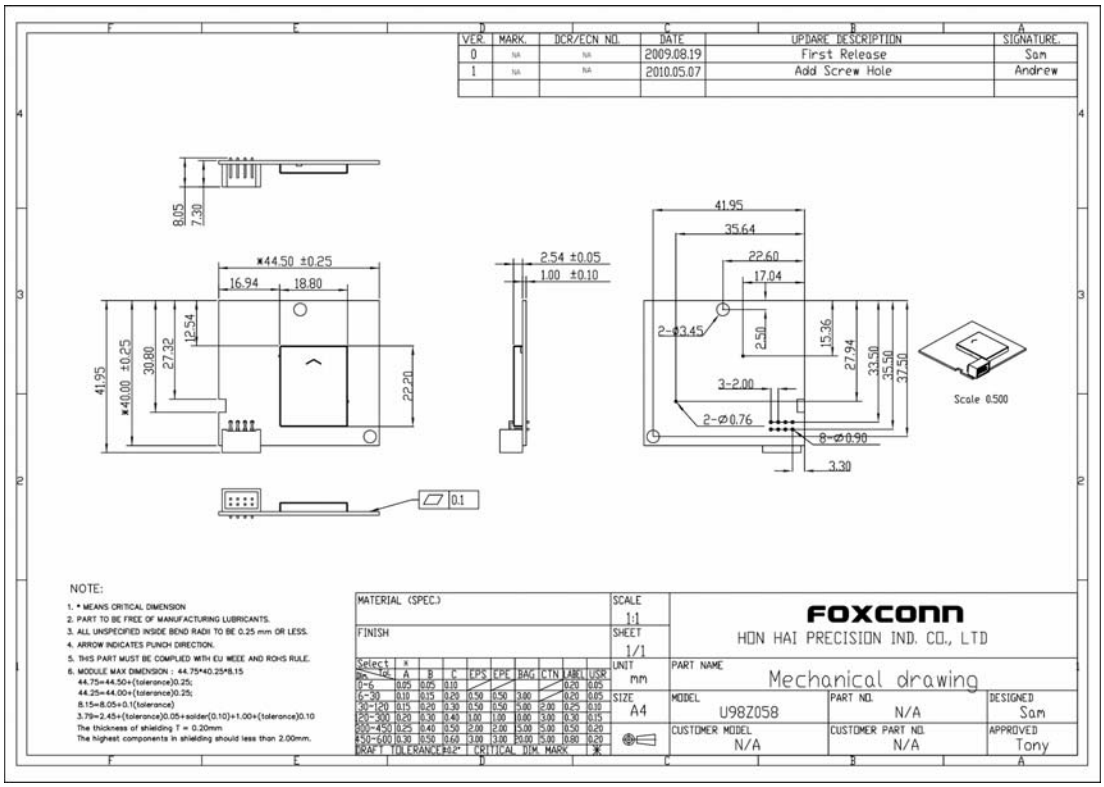


Phi 90 plane cut ant B

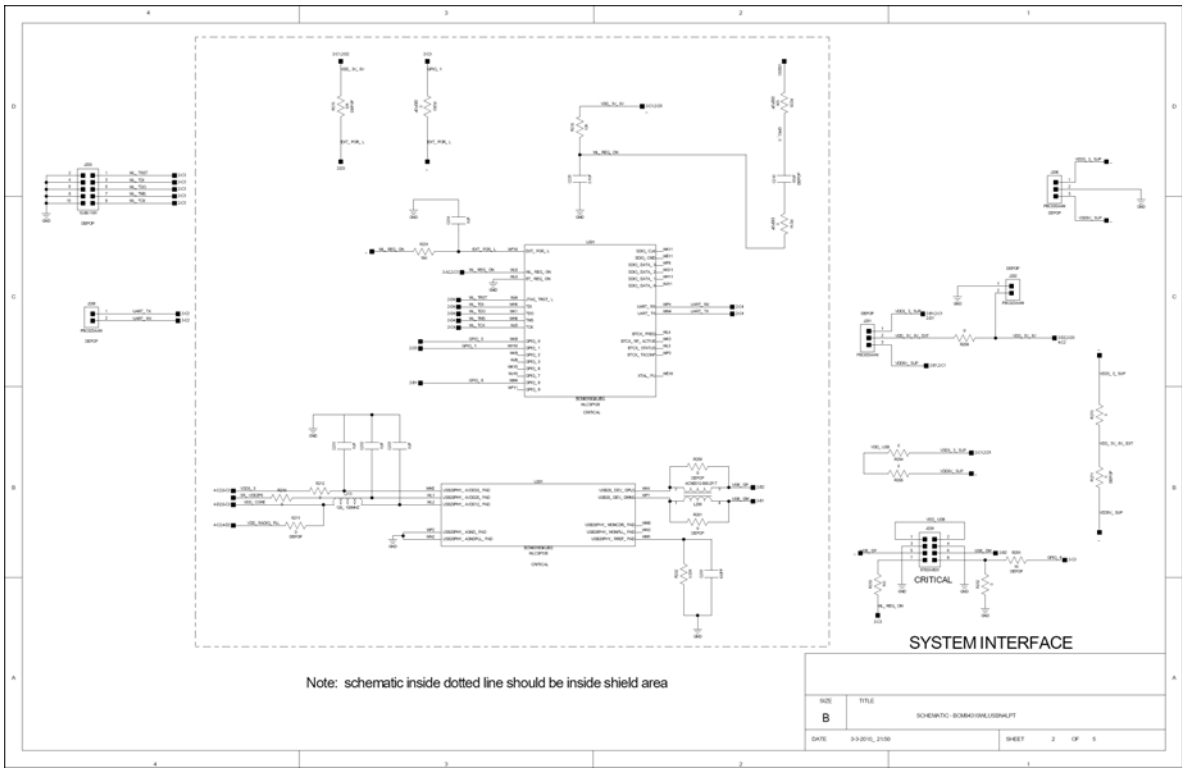


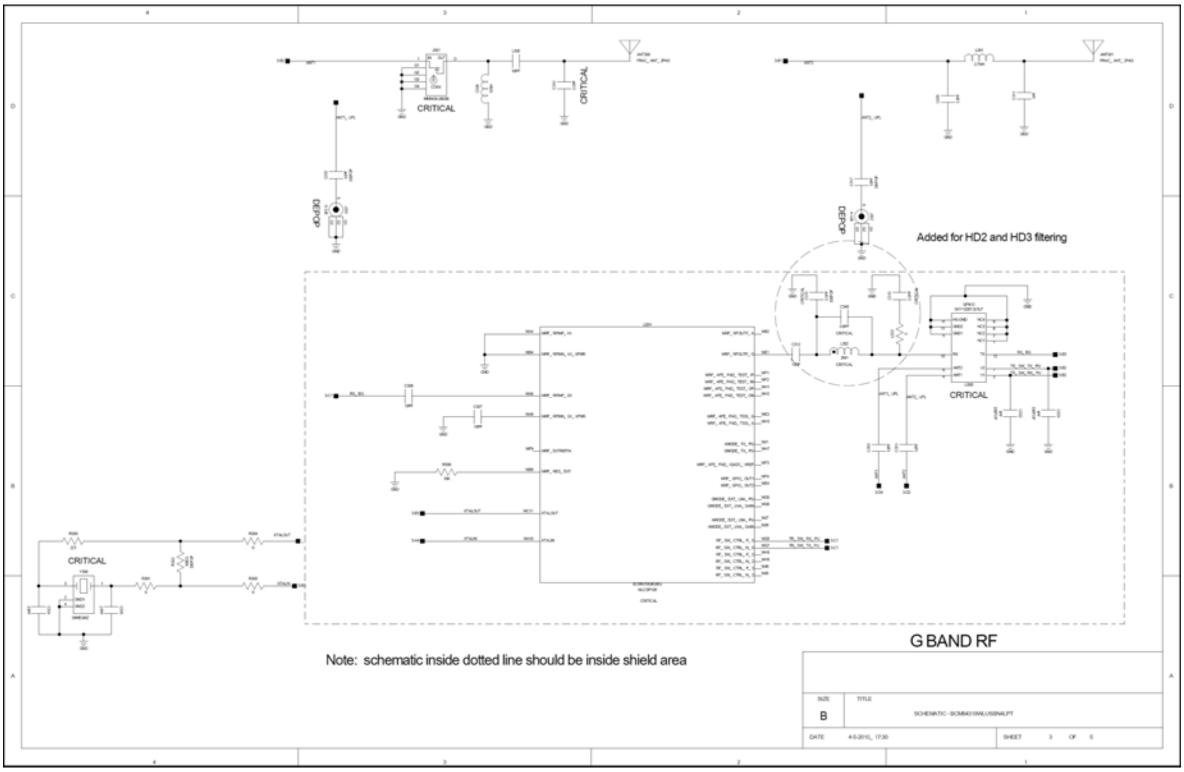
Theta 90 plane cut ant B

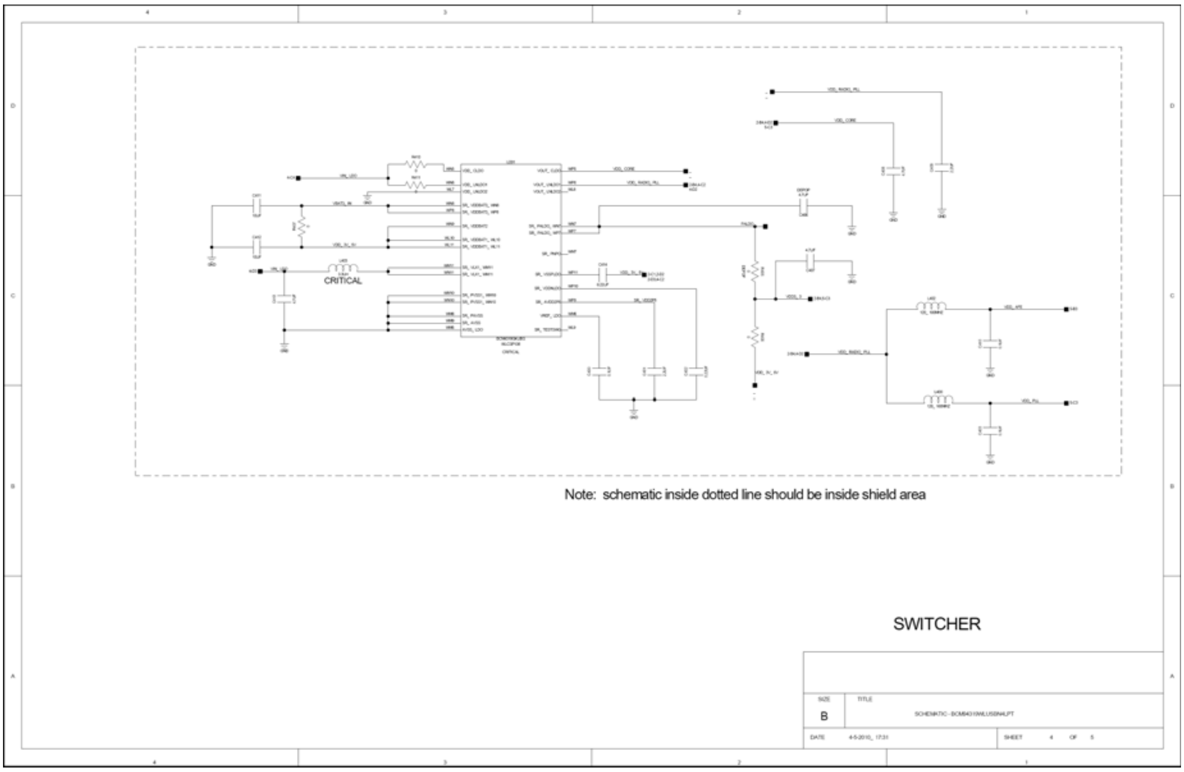
6. Mechanical Drawing

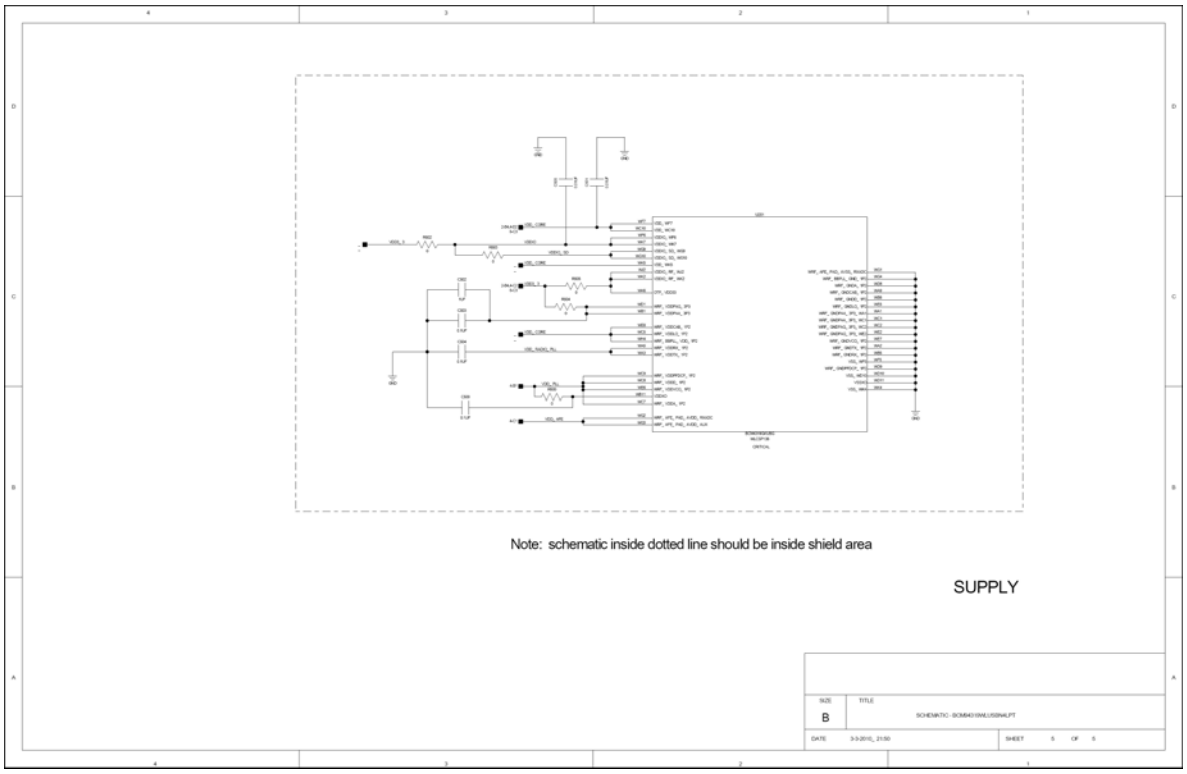


7. Schematic




CRITICAL
CRITICAL
DEPOP
DEPOP
Added for HD2 and HD3 filtering
CRITICAL
CRITICAL
G BAND RF
Note: schematic inside dotted line should be inside shield area
B


CRITICAL
Note: schematic inside dotted line should be inside shield area
SWITCHER
B



8. BOM List

HON HAI PRECISION IND.CO.,LTD.

Date : 2010/04/14 [Material List] Manuf. Limit : GP
Product : U98Z058.02 EMS(Wireless) Unit : EA BOM Usage : 1 Revision : 02

Item	Level	Component	Description	Valid From	Valid To	Unit	Quantity	Ref. Doc.
1.	1	510.00130.005	CN-GP BAG PE 70*50mm REV.1 GP/HF U98035.00	2008/12/08		EA	1.000000	
2.	1	522.00181.005	CN-GP PAPER BOARD 383*475mm REV.0.0 U98H03	2008/12/08		EA	0.005926	
3.	1	522.00180.005	CN-GP PARTITION 475*383*50mm REV.0.0 U98H0	2008/12/08		EA	0.004444	
4.	1	520.00164.005	CN-GP CARTON 500*400*195mm REV.0.0 U98H035	2008/12/08		EA	0.001481	
5.	1	503.00098.005	CN-GP LABEL BLANK 100*50mm REV.0.0 WHITE G	2008/12/08		EA	0.001481	
6.	1	527.00011.005	CN-GP PALLET 1000*1200*120mm REV.2 GP/HF	2008/12/08		EA	0.000035	
7.	1	503.00089.005	CN-GP LABEL PACKING 110*36mm REV.1 K02I036	2008/12/08		EA	0.000071	
8.	1	522.00023.005	CN-GP PAPER BOARD BEZEL 950*50*50mm REV.0.	2008/12/08		EA	0.000141	
9.	1	522.00035.005	CN-GP PAPER BOARD BEZEL 1200*50*5mm REV.A	2008/12/08		EA	0.000141	
10.	1	U98Z058D00	GP EMS(Wireless)	2010/02/08		EA	1.000000	
12.	..3	531552-02H	GP CON,HDR,T/H,M,R/A,2*4P,2mm,GOLD,SHRO	2010/02/08		EA	1.000000	J220
13.	..3	502857-00H	GP CAP,CER,0402,100pF,20%,50V,C0G	2010/02/08		EA	1.000000	C200
14.	..3	533662-00H	GP CAP,CER,0402,1uF,10%,6.3V,X6S/X5R	2010/02/08		EA	4.000000	C201 C202 C203 C204
15.	..3	502363-00H	GP CAP,CER,0603,10uF,20%,6.3V,X5R	2010/02/08		EA	2.000000	C411 C412
16.	..3	502151-00H	GP CAP,CER,0201,0.1uF,10%,6.3V,X5R	2010/02/08		EA	4.000000	C220 C500 C503 C504
17.	..3	533925-00H	GP CAP,CER,0201,10pF,5%,25V,C0H	2010/02/08		EA	5.000000	C300 C301 C306 C307 C312
18.	..3	500198-00H	GP CAP,CER,0402,33pF,5%,50V,NP0/C0G	2010/02/08		EA	1.000000	C304
19.	..3	500647-00H	GP CAP,CER,0402,27pF,5%,50V,NP0/C0G	2010/02/08		EA	1.000000	C305
20.	..3	539179-00H	GP CAP,CER,0402,1pF,0.1pF,50V,NP0	2010/02/08		EA	1.000000	C311
21.	..3	541818-00H	GP CAP,CER,0201,0.5pF,0.1pF,25V,C0G	2010/04/14		EA	2.000000	C313 C340
22.	..3	500206-00H	GP CAP,CER,0402,0.1uF,20%,16V,X7R	2010/02/08		EA	3.000000	C400 C403 C410
23.	..3	530568-00H	GP CAP,CER,0402,2.2uF,20%,6.3V,X5R	2010/02/08		EA	1.000000	C401
24.	..3	531978-00H	GP CAP,CER,0402,0.22uF,10%,10V,X5R	2010/02/08		EA	2.000000	C402 C414
25.	..3	501058-00H	GP CAP,CER,0603,4.7uF,20%,6.3V,X5R	2010/02/08		EA	3.000000	C407 C408 C413
26.	..3	503302-00H	GP CAP,CER,0402,2.2uF,20%,6.3V,X5R	2010/02/08		EA	1.000000	C409
27.	..3	501099-00H	GP CAP,CER,0402,10pF,5%,50V,NP0	2010/02/08		EA	1.000000	L300
28.	..3	501089-00H	GP CAP,CER,0402,0.01uF,10%,16V,X7R	2010/02/08		EA	2.000000	C501 C505
29.	..3	500686-00H	GP CAP,CER,0402,1uF,10%,6.3V,X6S/X5R	2010/02/08		EA	1.000000	C502
30.	..3	541547-00H	GP CON,COAX,SMT/2,F,STR,1PORT,50 OHM,Au	2010/04/14		EA	1.000000	J301
31.	..3	532162-00H	GP IND,COM,0805,90 OHM,400mA,190mOHM,50	2010/02/08		EA	1.000000	L200
32.	..3	500264-00H	GP IND,FB,0402,120,25%,500mA,250mOHM	2010/02/08		EA	3.000000	L213 L400 L402
33.	..3	534006-00H	GP CAP,CER,0402,1.5pF,0.1pF,50V,NP0	2010/02/08		EA	1.000000	C309
34.	..3	541819-00H	GP IND,FXD,0201,2nH,0.1nH,220mA,180mOHM	2010/04/14		EA	1.000000	L302
35.	..3	528227-00H	GP RES,THK,0201,0,5%,50mW	2010/02/08		EA	1.000000	L303
36.	..3	541820-00H	GP IND,PWR,SMT,3.3uH,20%,870mA,140mOHM,	2010/04/14		EA	1.000000	L403

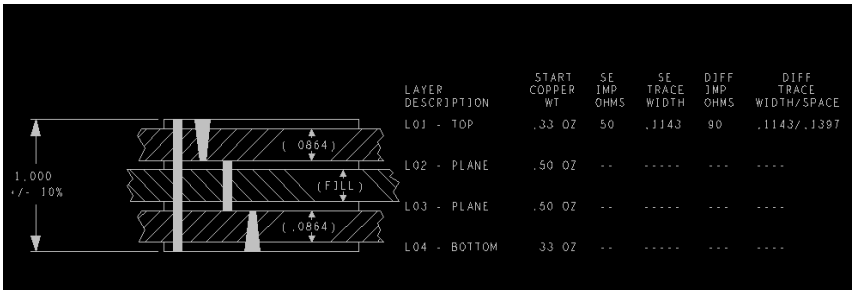
HON HAI PRECISION IND.CO.,LTD.

Date : 2010/04/14 [Material List] Manuf. Limit : GP
Product : U98Z058.02 EMS(Wireless) Unit : EA BOM Usage : 1 Revision : 02

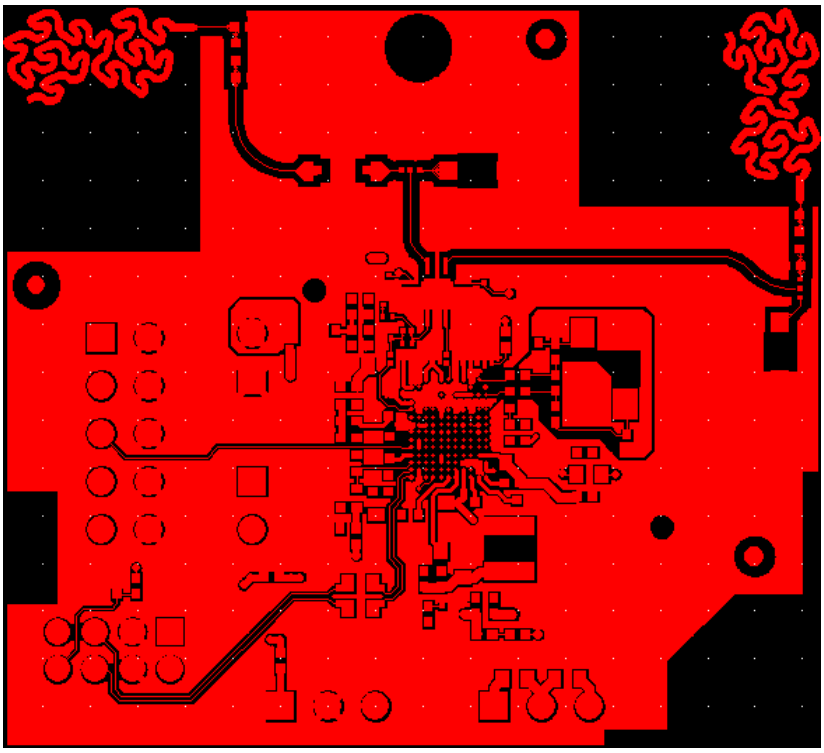
Item	Level	Component		Description	Valid From	Valid To	Unit	Quantity	Ref. Doc.
37.	..3	533909-00H	GP	RES,THK,0402,4.02K,1%,63mW	2010/02/08		EA	1.000000	R202
38.	..3	500225-00H	GP	RES,THK,0402,0,5%,63mW,50V	2010/02/08		EA	18.000000	R204 R205 R206 R210 R212 R301 R304 R305 R406 R407 R410 R411 R500 R502 R503 R504 R505 R252
39.	..3	530909-00H	GP	RES,THK,0402,12K,5%,63mW	2010/02/08		EA	1.000000	R215
40.	..3	500700-00H	GP	RES,THK,0402,15K,5%,63mW,50V	2010/02/08		EA	1.000000	R231
41.	..3	520163-00H	GP	RES,THK,0402,100,5%,63mW	2010/02/08		EA	1.000000	R253
42.	..3	500300-00H	GP	RES,THK,0603,0,5%,100mW	2010/02/08		EA	1.000000	R270
43.	..3	500267-00H	GP	RES,THK,0402,221,1%,63mW,50V	2010/02/08		EA	1.000000	R300
45.	..3	4319GKUBGP20S	GP	Single Chip USB, SDIO,150 Wafer Leve	2010/02/08		EA	1.000000	U201
46.	..3	541997-00H	GP	IC,SWH,QFN12,DPDT,0.7/1.2dB,3V,6GHz,	2010/04/14		EA	1.000000	U300
47.	..3	541821-00H	GP	XTL,FXD,SMT,30.000MHz,10PPM,20pF,FUN	2010/04/14		EA	1.000000	Y300
48.	..3	541815-00H	GP	IND,FXD,0402,12nH,5%,300mA,410mOHM	2010/04/14		EA	1.000000	C308
49.	..3	591.00007.005	CN-GP	SOLDER PASTE S3X58-M406H GP/HF	2010/02/08		G	0.150000	
50.	..3	300.00101.055	EU-GP	PCB HDI 4L SILVER REV.055 12PCS GP 4	2010/04/14		EA	1.000000	
51.	..3	535710-00H	GP	IND,FXD,0402,2.7nH,0.3nH,400mA,150mO	2010/02/08		EA	1.000000	L301
52.	..3	503.00653.005	EU-GP	LABEL BLANK 18*20mm REV.0 WHITE GP/H	2010/02/08		EA	1.000000	
53.	..3	426.00627.005	EU-GP	SHIELD COVER 22.2*18.8*2.54mm REV.1	2010/02/08		EA	1.000000	
54.	..3	541816-00H	GP	CAP,CER,0402,0.5pF,0.05pF,25V,NP0,HI	2010/04/14		EA	1.000000	C310
55.	..3	503.00039.015	CN-GP	LABEL BLANK 19.05*5mm REV.2 WHITE GP	2010/04/14		EA	0.083334	

9. PCB Layout

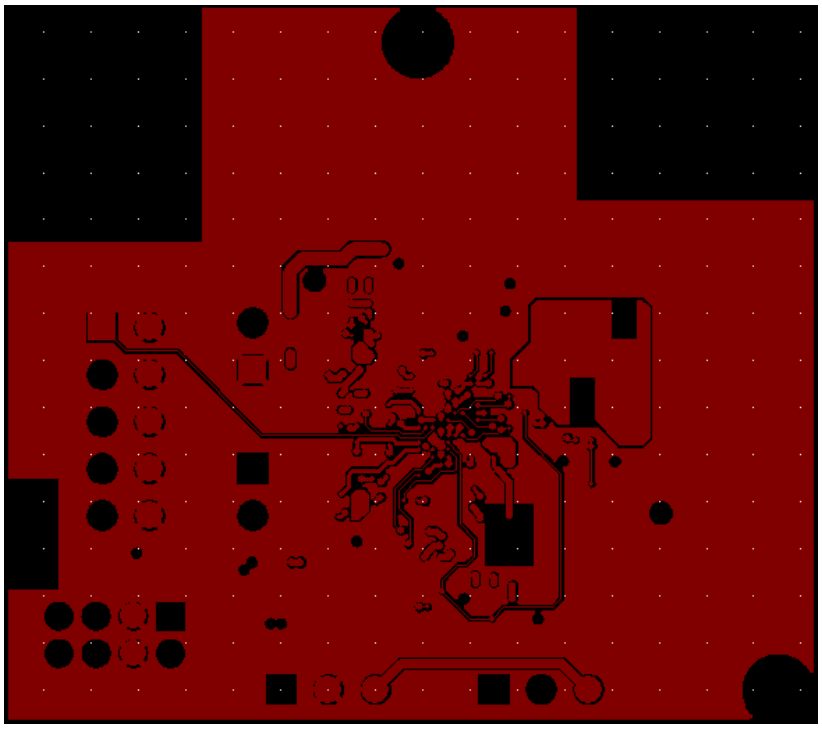
U98Z058.02 PCB is a 4-layer, HDI design, its surface finish is Immersion Silver.



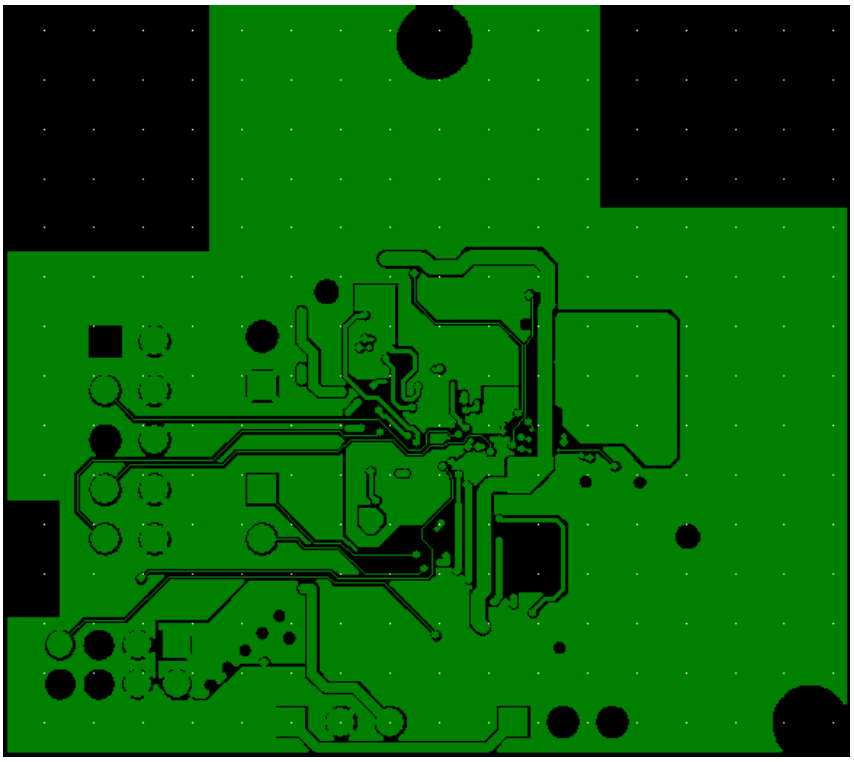
Stack-up



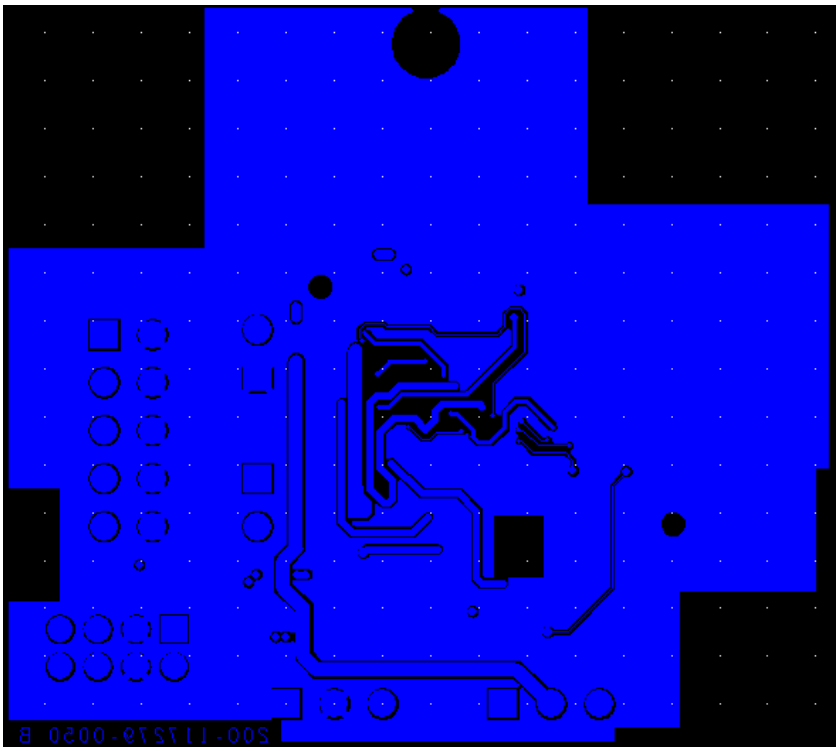
Top Layer



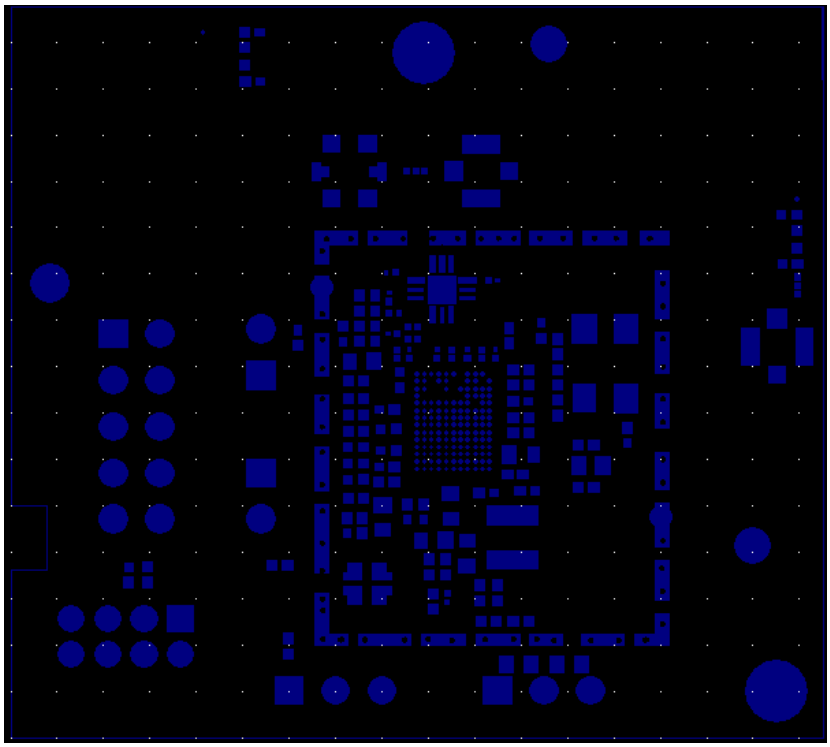
Layer 2



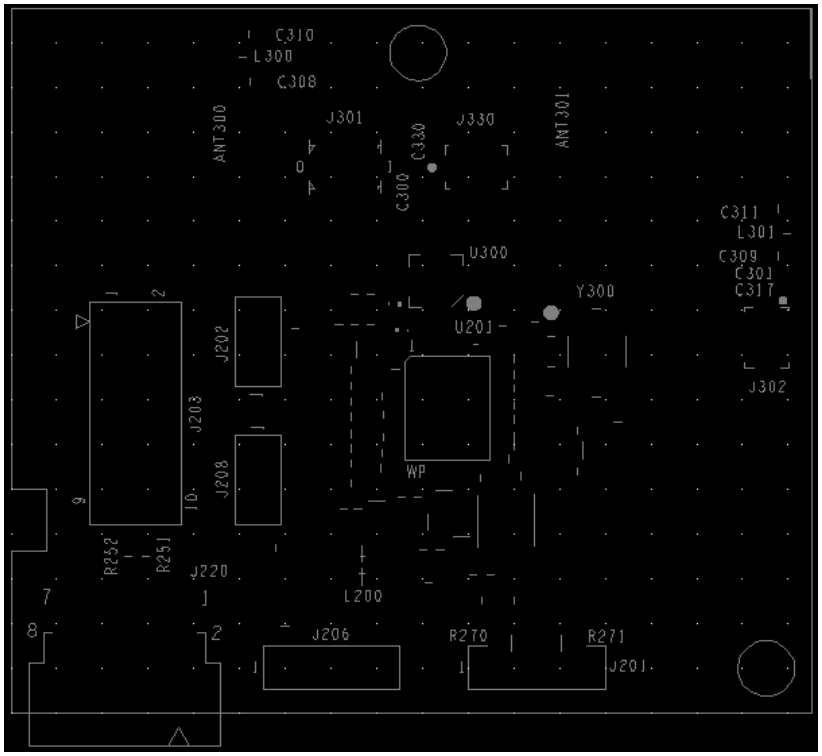
Layer 3



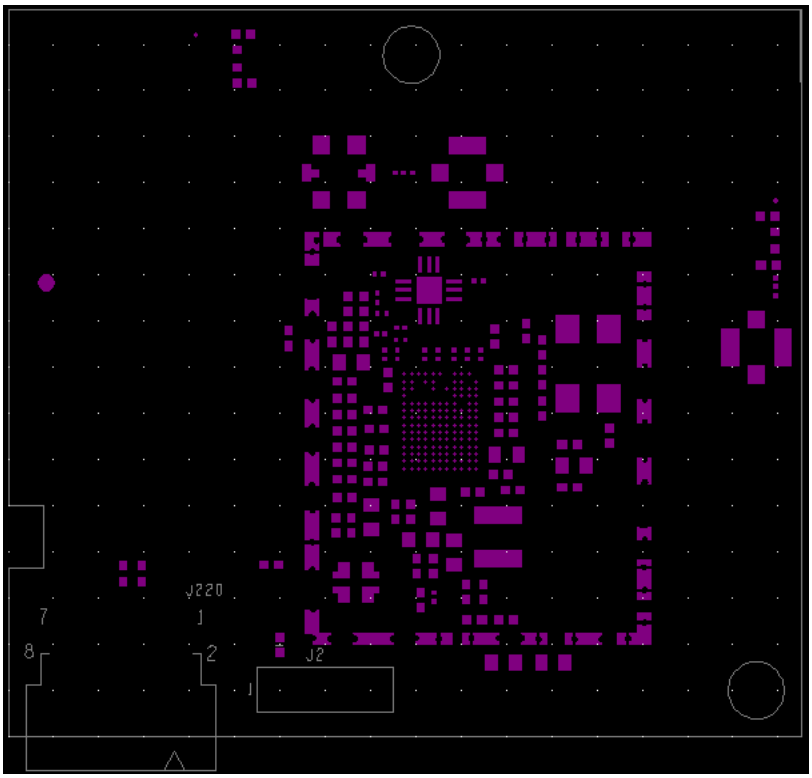
Bottom Layer



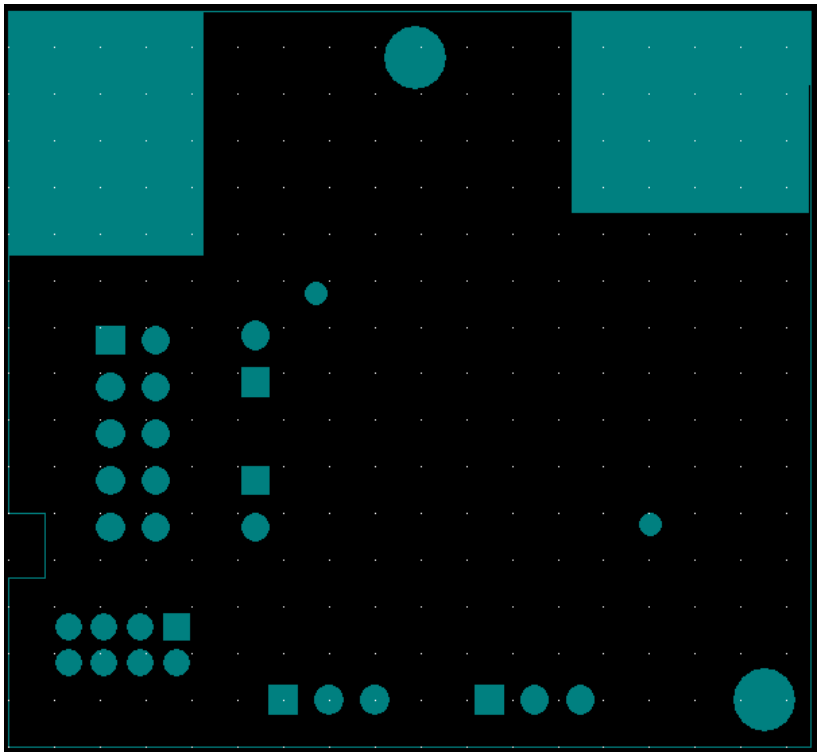
Top Side Solder Mask



Top Side Silk Screen



Top Side Paste Mask

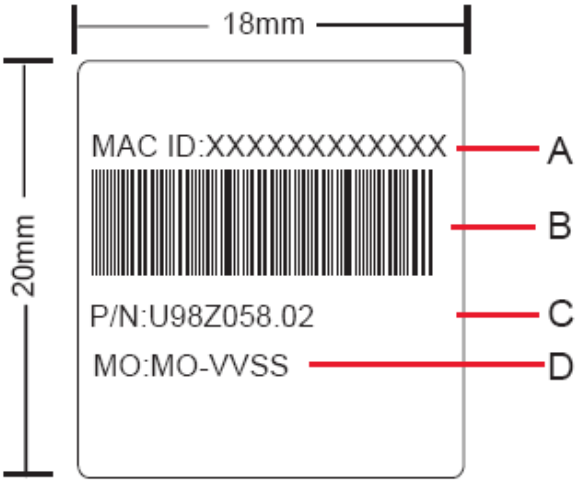


Bottom Side Solder Mask

10. Packing

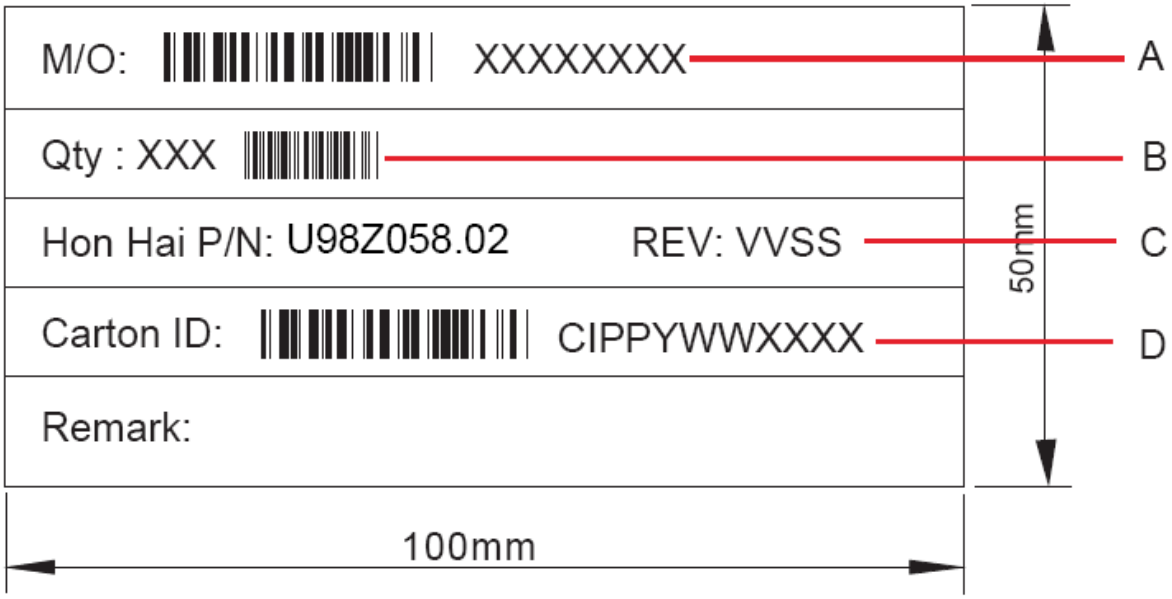
10.1 Label

10.1.1. MAC ID label: P/N:503.00653.005……1 MAC ID/product



Human readable:
A.MAC ID:XXXXXXXXXXXX
MAC ID Barcode, follow Foxconn standard.
C.P/N:U98Z058.02
D.MO: MO-VVSS
a. First MO: is letter
b. Second MO is Foxconn MO, follow Foxconn standard
c. VV: The engineering version
d. SS: The version of A300/A400 product
Barcode content:
XXXXXXXXXXXX
MAC ID Barcode, follow Foxconn standard
Barcode type: code39, height: 4mm

10.1.2. Carton label: P/N:503.00098.005



A.XXXXXXXX: the Foxconn MO
B. Qty: XXX
XX: The quantity of product in carton
Barcode content: The quantity of product in carton
C.REV: VVSS
VV: The engineering version
SS: The version of A300/A400

D.CIPPYWWXXXX
Carton ID Text Definition:
C - Carton
I - Production Location Code
PP - Production Line Identity
Y-year code: 2010 AD
WW - The products are built in the 14th week
XXXX - The four decade serial numbers

10.1.3 Pallet label: P/N:503.00089.005

Pallet ID Text Definition：
PIPPYWWXXXX
P - Pallet
I - Production Location Code
PP - Production Line Identity
Y-year code: 2010 AD
WW - The products are built in the 14th week
XXXX - The four decade serial numbers

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.

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.

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.

IMPORTANT NOTE:
FCC 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 & your body.
This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

IEEE 802.11b or 802.11g operation of this product in the U.S.A. is firmware-limited to channels 1 through 11.
This device is intended only for OEM integrators under the following conditions:
1) The antenna must be installed such that 20 cm is maintained between the antenna and users, and
2) The transmitter module may not be co-located with any other transmitter or antenna,
3) For all products market in US, OEM has to limit the operation channels in CH1 to CH11 for 2.4G band by supplied firmware programming tool. OEM shall not supply any tool or info to the end-user regarding to Regulatory Domain change.
As long as 3 conditions above are met, further transmitter test will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

IMPORTANT NOTE: In the event that these conditions can not be met (for example certain laptop configurations or co-location with another transmitter), then the FCC authorization is no longer considered valid and the FCC ID can not be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

End Product Labeling

This transmitter module is authorized only for use in device where the antenna may be installed such that 20 cm may be maintained between the antenna and users. The final end product must be labeled in a visible area with the following: “Contains FCC ID: MCLU98Z058”.

Manual Information To the End User

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module.
The end user manual shall include all required regulatory information/warning as show in this manual.

Industry Canada Statement

This device complies with RSS-210 of the Industry Canada Rules. 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

IMPORTANT NOTE:

IC Radiation Exposure Statement:

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

This device is intended only for OEM integrators under the following conditions:

1. The antenna must be installed such that 20 cm is maintained between the antenna and users, and
2. The transmitter module may not be co-located with any other transmitter or antenna,
3. For all products market in CANADA, OEM has to limit the operation channels in CH1 to CH11 for 2.4GHz band by supplied firmware programming tool. OEM shall not supply any tool or info to the end-user regarding to Regulatory Domain change.

As long as 3 conditions above are met, further transmitter test will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

IMPORTANT NOTE: In the event that these conditions can not be met (for example certain laptop configurations or co-location with another transmitter), then the IC authorization is no longer considered valid and the IC ID can not be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate IC authorization.

End Product Labeling

The final end product must be labeled in a visible area with the following: “Contains TX IC : 2878D-U98Z058”.

Manual Information That Must be Included

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user's manual of the end product which integrates this module.

The end user manual shall include all required regulatory information/warning as show in this manual.

subjected to relative humidity in the range of 10% and 90% non-condensing.

12.2.2 Non-Operating Humidity conditions

The product shall not be damaged nor shall the performance be degraded after exposure to relative humidity ranging from 5% to 95% non-condensing.