PEGATRON 和碩聯合科技

Antenna Proposal for ARRIS X504N Project (Apex)

2019-11-28

Contents

Reversion History

Rev	Date	Description
R000	2019-06-05	1’st release.
R001	2019-06-25	Improved isolation ~ -23dB
R002	2019-07-17	antenna frame changing verify
R003	2019-09-25	EPR2a for HSB and APEX verify
R004	2019-10-03	The APEX 5G1 on board antenna matching circuit comparison at page 32,33. Correct the scale at the page 17.
R005	2019-11-28	EPR2b For APEX verify

Contents

Introduction

- This report is based on EPR2b PCBA to verify antenna performance.

  Antenna solution:

  -Dual band off board antenna*2

  -5G on board antenna*1

  -5G off board antenna*1

- This report provides Passive Measurement results .(Return loss ,Isolation, Gain, Radiation Pattern)
  - The return loss and isolation are measured by Agilent E5071C.
  - The radiation pattern, antenna gain and efficiency are measured by Pegatron's SATIMO SG24 chamber as below picture.

Pegatron's SATIMO SG24 chamber

E5071C

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Antenna proposal Specification

Antenna Proposal	
Wireless Function	■Wi-Fi 2.4G antenna 2X2 ■Wi-Fi 5G antenna 4X4
Antenna type	■ Off board: Dual band antenna*2 ■ On board: 5G antenna*1 ■ Off board: 5G antenna*1
Specification and measurement data	
	Measurement data
Return loss	<-10 dB
Isolation	■ 2.4G antenna < -20dB ■ 5G antenna <-20 dB ■ 2.4G to 5G antenna < -20 dB
Peak Gain	■ 2.4G antenna: 3.72 dBi ■ 5G antenna:4.62 dBi
Antenna efficiency	■ 2.4G antenna > 62%. ■ 5G antenna > 64%

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Antenna proposal Specification

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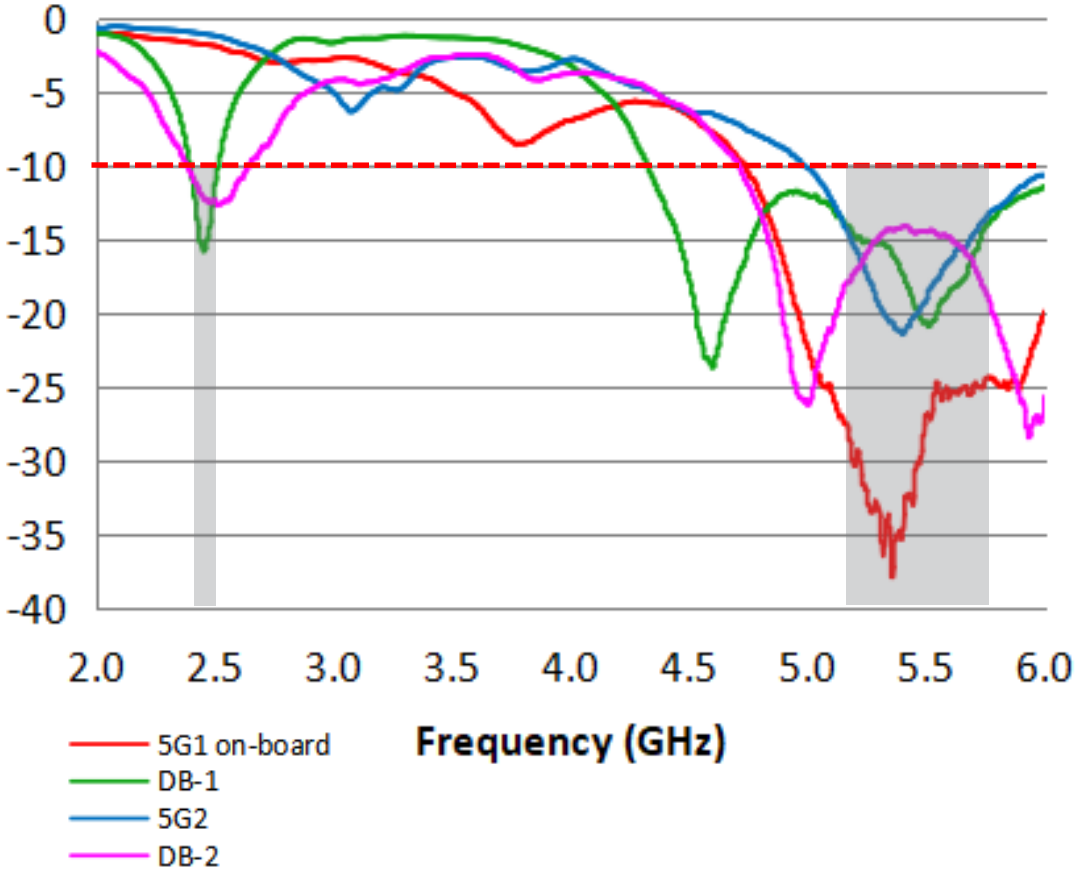
Measurement data

❖ S-parameter : Return loss



	5G1 on-board	DB-1	5G2	DB-2	spec.
2.4GHz	-	-10.08	-	-10.38	
2.45GHz	-	-15.43	-	-11.98	
2.5GHz	-	-12.23	-	-12.28	
5.15GHz	-27.13	-13.68	-13.78	-18.51	< -10 dB
5.35GHz	-35.67	-15.73	-20.58	-14.28	
5.47GHz	-30.15	-20.10	-19.90	-14.45	
5.725GHz	-24.86	-15.64	-14.32	-17.19	
5.85GHz	-25.08	-12.63	-12.28	-23.07	Unit: dB

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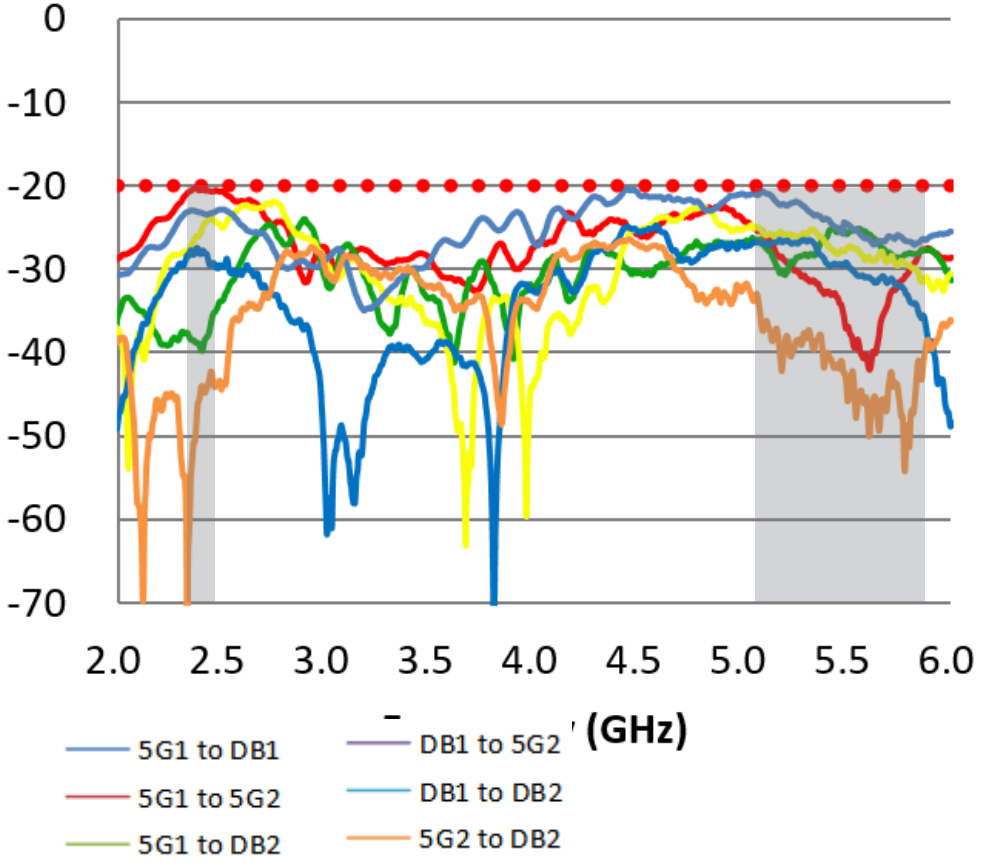
Measurement data

❖ Antenna isolation



	5G1 to DB1	5G1 to 5G2	5G1 to DB2	DB1 to 5G2	DB1 to DB2	5G2 to DB2	SPEC
2.4GHz	-20.5	-39.7	-25.6	-23.2	-28.2	-44.2	
2.45GHz	-20.7	-36.1	-23.9	-23.3	-29.6	-42.4	
2.5GHz	-20.7	-33.8	-24.9	-22.9	-29.6	-44.5	
5.15GHz	-27.4	-28.8	-26.0	-21.6	-26.8	-38.0	<-20 dB
5.35GHz	-31.6	-28.3	-25.5	-23.6	-27.2	-38.8	
5.47GHz	-34.2	-25.1	-27.8	-25.4	-29.4	-41.2	
5.725GHz	-32.5	-28.8	-29.1	-26.4	-31.6	-43.8	
5.85GHz	-28.0	-28.0	-31.2	-26.8	-35.6	-41.9	

Unit: dB

Measurement data

- Radiation pattern - DUT orientation setting
- 2D Radiation pattern – Dual Band 2.45GHz
- 2D Radiation pattern – 5.47GHz

Please refer to the file antenna information page 2~4.

Measurement data

❖ Gain table: 5G1

Frequency (MHz)	XZ plane		YZ plane		XY plane		E-total (dBi)	Efficiency (%)
	Peak Gain (dBi)	Average Gain (dBi)	Peak Gain (dBi)	Average Gain (dBi)	Peak Gain (dBi)	Average Gain (dBi)		
5150	0.37	-2.91	3.05	-1.45	3.09	-1.2	3.87	68%
5350	-1.31	-5.08	3.5	-1.96	3.35	-1.57	4.21	65%
5470	-0.96	-5.13	3.2	-2.53	3.96	-1.69	4.30	71%
5725	-0.46	-5.01	3.24	-2.73	3.8	-0.91	4.14	69%
5850	0.09	-4.9	2.71	-3.18	3.82	-0.91	4.09	68%

Measurement data

❖ Gain table: 5G2

Frequency (MHz)	XZ plane		YZ plane		XY plane		E-total (dBi)	Efficiency (%)
	Peak Gain (dBi)	Average Gain (dBi)	Peak Gain (dBi)	Average Gain (dBi)	Peak Gain (dBi)	Average Gain (dBi)		
5150	1.97	-1.64	1.5	-1.14	-0.78	-4.06	3.88	66%
5350	3.63	-0.99	1.83	-0.45	0.78	-2.91	3.78	68%
5470	3.76	-1.35	1.98	-0.38	1.39	-2.64	4.00	70%
5725	3.3	-2.62	2.53	0.01	2.2	-2.3	3.58	71%
5850	2.55	-2.95	3.39	0.08	2.28	-2.36	3.59	68%

Measurement data

❖ Gain table: DB1

Frequency (MHz)	XZ plane		YZ plane		XY plane		E-total (dBi)	Efficiency (%)
	Peak Gain (dBi)	Average Gain (dBi)	Peak Gain (dBi)	Average Gain (dBi)	Peak Gain (dBi)	Average Gain (dBi)		
2400	2.77	-1.92	1.98	-3.98	3.06	-3.46	3.57	63%
2450	3.34	-1.24	2.46	-3.73	3.49	-3.13	3.72	67%
2500	3.09	-1.61	2.1	-3.74	3.5	-3.2	3.52	62%
5150	3.95	-1.61	3.95	-1.04	1.12	-3.46	3.95	66%
5350	4.3	-1.57	4.3	-1.18	-0.09	-3.92	4.35	68%
5470	4.08	-1.98	4.24	-1.33	0.73	-4.2	4.41	71%
5725	4.49	-2.82	4.62	-1.84	-0.79	-5.68	4.62	67%
5850	4.2	-2.54	4.42	-1.85	-2.4	-5.72	4.44	64%

Measurement data

❖ Gain table: DB2

Frequency (MHz)	XZ plane		YZ plane		XY plane		E-total (dBi)	Efficiency (%)
	Peak Gain (dBi)	Average Gain (dBi)	Peak Gain (dBi)	Average Gain (dBi)	Peak Gain (dBi)	Average Gain (dBi)		
2400	0.63	-3.53	2.4	-3.13	2.3	-0.06	3.33	63%
2450	0.54	-3.81	2.31	-3.09	2.79	0.16	3.12	66%
2500	0.62	-3.72	2.28	-3.33	2.6	0.06	3.03	65%
5150	1.23	-2.95	2.92	-2.18	3.61	0.28	3.83	68%
5350	1.09	-3.18	3.08	-2.07	3.81	0.45	3.92	71%
5470	0.79	-4	3.15	-2.68	2.94	-0.3	3.55	72%
5725	0.07	-5.53	3.58	-3.84	2.91	-0.82	4.00	70%
5850	0.63	-5.25	3.94	-3.56	3.42	-0.54	4.41	68%

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Measurement data

- Radiation pattern - DUT orientation setting
- 2D Radiation pattern – Dual Band 2.45GHz
- 2D Radiation pattern – 5.47GHz

Please refer to the file antenna information page 2~4.

Measurement data

❖ Gain table: correlated 2GHz

Frequency (MHz)	XZ plane		YZ plane		XY plane		3D Peak Gain (dBi)	3D Average Gain (dBi)
	Peak Gain (dBi)	Average Gain (dBi)	Peak Gain (dBi)	Average Gain (dBi)	Peak Gain (dBi)	Average Gain (dBi)		
2400	4.24	0.92	2.51	-0.20	5.49	2.08	5.54	0.41
2450	4.81	1.24	2.62	0.00	5.72	2.42	5.73	0.67
2500	4.84	1.20	3.20	-0.07	5.93	2.31	5.95	0.64

Measurement data

❖ Gain table: uncorrelated 2GHz

Frequency (MHz)	XZ plane		YZ plane		XY plane		3D Peak Gain (dBi)	3D Average Gain (dBi)
	Peak Gain (dBi)	Average Gain (dBi)	Peak Gain (dBi)	Average Gain (dBi)	Peak Gain (dBi)	Average Gain (dBi)		
2400	1.39	-1.74	0.13	-2.68	2.50	-0.78	2.57	-2.16
2450	1.93	-1.42	0.04	-2.46	2.75	-0.42	2.80	-1.88
2500	1.93	-1.52	0.44	-2.54	2.94	-0.52	2.97	-1.94

Measurement data

❖ Gain table: correlated 5GHz

Frequency (MHz)	XZ plane		YZ plane		XY plane		3D Peak Gain (dBi)	3D Average Gain (dBi)
	Peak Gain (dBi)	Average Gain (dBi)	Peak Gain (dBi)	Average Gain (dBi)	Peak Gain (dBi)	Average Gain (dBi)		
5150	6.00	3.65	7.02	4.54	6.74	3.55	7.16	4.06
5350	5.97	3.80	6.98	4.86	6.72	3.86	7.39	4.36
5470	5.32	3.08	6.52	4.46	6.41	3.35	7.11	3.97
5725	4.64	2.49	6.19	4.23	6.27	3.25	6.54	3.56
5850	4.42	2.52	6.19	4.24	6.60	3.50	6.71	3.53

Measurement data

❖ Gain table: uncorrelated 5GHz

Frequency (MHz)	XZ plane		YZ plane		XY plane		3D Peak Gain (dBi)	3D Average Gain (dBi)
	Peak Gain (dBi)	Average Gain (dBi)	Peak Gain (dBi)	Average Gain (dBi)	Peak Gain (dBi)	Average Gain (dBi)		
5150	1.08	-1.68	0.95	-0.93	0.62	-2.17	1.19	-1.41
5350	1.10	-1.85	0.95	-0.78	0.52	-2.12	1.31	-1.31
5470	0.59	-2.27	0.62	-0.98	0.20	-2.33	1.21	-1.56
5725	0.26	-3.06	0.44	-1.08	0.46	-2.48	1.29	-2.01
5850	-0.02	-2.98	0.60	-1.10	0.77	-2.26	1.08	-2.01

Contents

Summary

- The return loss of all antenna can meet -10 dB spec.
- The efficiency of all antenna can meet 60% spec.
- The isolation of all antenna can meet -20 dB spec.
- For certification, We used the formulas as below which is based on FCC document 662911 to calculate directional gain.

(i) If transmit signals are *correlated*, then

Directional gain = 10 log[$(10^{G_1/20} + 10^{G_2/20} + \ldots + 10^{G_N/20})^2$ /N_{ANT}] dBi [Note the "20"s in the denominator of each exponent and the square of the sum of terms; the object is to combine the signal levels coherently.]

(ii) If all transmit signals are *completely uncorrelated*, then

Directional gain = 10 log[$(10^{G_1/10} + 10^{G_2/10} + \ldots + 10^{G_N/10})$/$N_{ANT}$] dBi

U-NII Directional Gain Results

The following are the position & data which yielded the worst-case calculated directional gain:

Frequency	Position (θ,Φ)	Polarization	Gain at Position (dBi)				Calculated Directional Gain* (dBi)
			DB1	DB2	5G1	5G2	
5150~5250 MHz U-NII-1	(76 ,110)	H+V	2.15	0.15	2.55	-0.71	7.16
5250~5350 MHz U-NII-2A	(-64 , 54)	H+V	0.43	3.57	2.81	-2.6	7.39
5470~5725 MHz U-NII-2C	(106 , 100)	H+V	2.67	-0.2	-0.33	1.82	7.11
5725~5850 MHz U-NII-3	(96 , 98)	H+V	4.2	-5.69	-1	2.26	6.71

Frequency (MHz)	3D Directional Gain table							
	Uncorrelated gain				Correlated gain			
	WiFi 2G antenna		WiFi 5G antenna		WiFi 2G antenna		WiFi 5G antenna	
	Peak Gain	Average Gain	Peak Gain	Average Gain	Peak Gain	Average Gain	Peak Gain	Average Gain
2400	2.57	-2.16	-	-	5.54	0.41	-	-
2450	2.80	-1.88	-	-	5.73	0.67	-	-
2500	2.97	-1.94	-	-	5.95	0.64	-	-
5150	-	-	1.26	-1.52	-	-	7.16	4.06
5350	-	-	1.65	-1.17	-	-	7.39	4.36
5470	-	-	1.22	-1.54	-	-	7.11	3.97
5725	-	-	1.23	-1.88	-	-	6.54	3.56
5850	-	-	1.28	-1.85	-	-	6.71	3.53

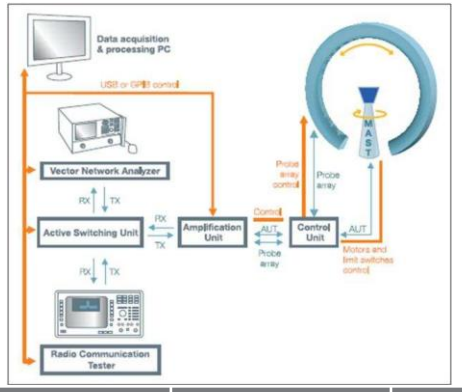
unit: dB

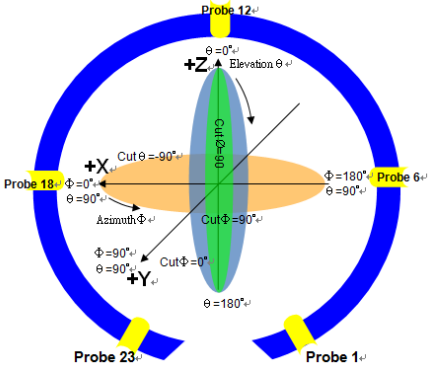
Antenna Vendor Info & Measurement Setup

- Antenna Vendor: Pegatron
- Test Date: 20191125
- Test Engineer :Angus Huang
- Measurement Setup:
  - Reflection Coefficient Measurement:
    1. Network Analyzer (Keysight Agilent E5071C)
    2. Setup:
       -calibrate the Network Analyzer by one port calibration using 85033E calibration kit.
       -connect the antenna under test to the Network Analyzer.
       -measure the S11 (return loss)& S12(isolation)

  - Pattern & Gain measurement:
    1. Satimo chamber (SG24)
    2. Satimo program (wave studio)
    3. system overview :

  - Test Item
    1. Antenna passive test 400MHz~6GHz





Description Manufacturer	Model No.	Serial No.	Calibrated Date	Calibrated Until
OTA Chamber	Satimo SG24	MVG/HKG0147S	2019/09/16	2020/09/15
Network Analyzer	Keysight E5071C	MY46212481	2019/05/16	2020/05/15

Test Procedure

a) sub-divide the whole sphere surface into many 2x2 degreeΦθ subsection.
b) Measure the gain contributed from each antenna within each subsection position.
c) Apply the KDB 662911 D01 correlated directional gain formula to calculate directional gain for each subsection.
d) After all subsections have been evaluated, the largest calculated value among all positions evaluated is picked as the worst-case directional gain for the system and used in RF/EMC test report.