

Appendix G. Supplemental Antenna Tuner Tests Results

General Note:

1. This device implements antenna tuning techniques in the several frequency band and list as below. SAR test proposal was measured according to the normally required SAR configurations with the tuner active and worst tune state (auto tune) was used for SAR testing and this design will provide the highest power at different user scenarios and would not influence to the antenna characteristics other than impedance matching.
2. Dynamic antenna tuning mechanism is available at Ant.0 / 2 for its < 3GHz LTE and NR band. The number of supported tune codes is different for each frequency band as shown in the following table. And it's verified that tune state results in the highest SAR configuration
3. The antenna tuner state shall be controlled remotely such that the DUT position is not moved during the series of single-point SAR measurements.
4. For each air interface, exposure condition, and antenna that supports dynamic antenna tuning (DAT), the following procedure shall be followed:
 - a. An area scan is performed with the DUT positioned for the exposure condition with auto-tuner enabled to determine the peak SAR location
 - b. A single-point SAR measurement (i.e., time sweep) is performed at the peak SAR location of step a (that is, with auto-tuner enabled). The auto-tuner state shall be recorded, after verifying that it is stable. If fluctuations occur, the scan procedure can be restarted, or the state with the highest SAR needs to be recorded
 - c. Without moving the probe, or introducing any other perturbation, the auto-tuner shall be disabled, and two other adjacent tune states shall be chosen by increasing and decreasing the state identification number by 1
 - d. A single point SAR measurement is then performed on both chosen adjacent states and compared with the value of step b. The measured SAR for auto-tuner disabled is expected to be less than or equal to the recorded SAR of step b. If the measured SAR is higher beyond documented tolerance, then the auto-tuning feature is not working as intended and is not suitable for compliance. DAT functionality shall be removed or adjusted by the manufacturer. If the measured SAR is higher than the value of step b but within tolerance, the next adjacent state(s) shall be chosen and the measure repeated until a lower SAR value can be shown; otherwise, the DAT is considered inoperative and shall be removed or adjusted by the manufacturer.
 - e. Repeat step b with auto-tuning enabled as a test for variability within tolerance: the previous measured value in step 2.2 shall be recovered. If the measured SAR is outside the expected tolerance, then the auto-tuning feature is considered not working as intended and not suitable for compliance. DAT functionality shall be removed or adjusted by the manufacturer
 - f. If any single-point SAR measurement result is >1.4 W/kg, then all tune states for that particular combination of air interface, exposure condition, and antenna selection shall be evaluated with single-point SAR measurements.

Antenna	Band	Number of tune states
Ant 0	LTE B5/26 NR n5/26	21
	LTE B12/17 NR n12	20
	LTE B13	17
	LTE B14 NR n14	12
	LTE B71 NR n71	20
	LTE B2/25 NR n2/25	27
	LTE B4/66 NR n66	19
	LTE B7 NR n7	15
	LTE B30 NR n30	9
	NR n70	16
Ant 2	LTE B2/25 NR n2/25	17
	LTE B4/66 NR n66	19
	LTE B7 NR n7	16
	LTE B30 NR n30	7

<Antenna tuner Verification result>

Config Tx 0	RF exposure position													
	Band	Mode	Channel	Test Position	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)	Auto-tuner enable_Initial		Auto-tuner disabled Verify adjacent tuner				Repeat Auto-tuner enable	
							State	Single Point SAR (W/kg)	State	Single Point SAR (W/kg)	State	Single Point SAR (W/kg)	State	Single Point SAR (W/kg)
Ant 2	LTE Band 7	20M_QPSK_1_0	20850	Right Cheek	0.578	0.708	9	0.850	8	0.505	10	0.128	9	0.850
	LTE Band 7	20M_QPSK_1_0	21100	Right Edge	0.434	0.521	29	0.868	28	0.561	30	0.866	29	0.867
Ant 0	LTE Band 12	10M_QPSK_1_0	23095	Left Cheek	0.205	0.235	39	0.227	38	0.022	40	0.021	39	0.222
	LTE Band 12	10M_QPSK_1_0	23095	Left Edge	0.439	0.503	39	0.519	38	0.065	40	0.061	39	0.506
Ant 0	LTE Band 13	10M_QPSK_1_0	23230	Left Cheek	0.259	0.279	4	0.300	3	0.095	5	0.081	4	0.295
	LTE Band 13	10M_QPSK_1_0	23230	Left Edge	0.412	0.512	4	0.873	3	0.358	5	0.312	4	0.865
Ant 0	LTE Band 14	10M_QPSK_1_0	23330	Left Cheek	0.268	0.301	27	0.247	26	0.098	28	0.100	27	0.247
	LTE Band 14	10M_QPSK_1_0	23330	Left Edge	0.388	0.498	27	0.761	26	0.364	28	0.376	27	0.764
Ant 2	LTE Band 25	20M_QPSK_1_0	26340	Right Cheek	0.317	0.443	30	0.543	29	0.107	31	0.275	30	0.533
	LTE Band 25	20M_QPSK_50_0	26340	Right Edge	0.447	0.525	30	0.824	29	0.188	31	0.444	30	0.822
Ant 0	LTE Band 26	15M_QPSK_1_0	26865	Left Cheek	0.221	0.269	29	0.212	28	0.101	30	0.155	29	0.203
	LTE Band 26	15M_QPSK_1_0	26865	Bottom Edge	0.471	0.573	29	0.692	28	0.158	30	0.577	29	0.677
Ant 2	LTE Band 30	10M_QPSK_1_0	27710	Right Cheek	0.455	0.583	38	0.632	37	0.402	39	0.569	38	0.622
	LTE Band 30	10M_QPSK_1_0	27710	Right Edge	0.304	0.358	38	0.509	37	0.347	39	0.482	38	0.501
Ant 2	LTE Band 41	20M_QPSK_1_0	40620	Right Cheek	0.327	0.406	19	0.531	18	0.526	20	0.380	19	0.522
	LTE Band 41	20M_QPSK_1_0	40620	Right Edge	0.402	0.494	19	0.859	18	0.858	20	0.573	19	0.851
Ant 2	LTE Band 66	20M_QPSK_1_0	132322	Right Cheek	0.306	0.411	11	0.431	10	0.190	12	0.189	11	0.431
	LTE Band 66	20M_QPSK_50_0	132322	Right Edge	0.304	0.390	11	0.584	9	0.255	10	0.511	11	0.578
Ant 0	LTE Band 71	20M_QPSK_1_0	133297	Left Cheek	0.141	0.159	20	0.174	19	0.048	21	0.006	20	0.170
	LTE Band 71	20M_QPSK_1_0	133297	Let Edge	0.285	0.322	20	0.388	19	0.103	21	0.013	20	0.388
Ant 2	FR1 n7	50M_BPSK_135_68	507000	Right Cheek	0.614	0.700	29	0.346	28	0.222	30	0.215	29	0.333
	FR1 n7	50M_BPSK_135_68	507000	Right Edge	0.382	0.468	29	0.855	28	0.533	30	0.811	29	0.846
Ant 0	FR1 n12	15M_BPSK_36_22	141500	Left Cheek	0.199	0.233	39	0.311	38	0.055	40	0.052	39	0.303
	FR1 n12	15M_BPSK_36_22	141500	Let Edge	0.470	0.550	39	0.566	38	0.060	40	0.059	39	0.543
Ant 0	FR1 n14	10M_BPSK_25_14	158600	Left Cheek	0.254	0.300	27	0.299	26	0.085	28	0.111	27	0.299
	FR1 n14	10M_BPSK_1_1	158600	Let Edge	0.555	0.567	27	0.774	26	0.377	28	0.376	27	0.764
Ant 2	FR1 n25	40M_BPSK_108_54	376500	Right Cheek	0.314	0.413	30	0.317	29	0.062	31	0.159	30	0.302
	FR1 n25	40M_BPSK_108_54	376500	Right Edge	0.398	0.474	30	1.279	29	0.293	31	0.687	30	1.200
Ant 0	FR1 n26	20M_BPSK_50_28	166300	Left Cheek	0.250	0.294	29	0.254	28	0.052	30	0.209	29	0.251
	FR1 n26	20M_BPSK_1_1	166300	Bottom Edge	0.523	0.610	29	0.507	28	0.112	30	0.414	29	0.500
Ant 2	FR1 n30	10M_BPSK_25_14	462000	Right Cheek	0.436	0.502	38	0.310	37	0.188	39	0.201	38	0.302
	FR1 n30	10M_BPSK_25_14	462000	Right Edge	0.263	0.307	38	0.518	37	0.350	39	0.493	38	0.510
Ant 2	FR1 n41	100M_BPSK_1_1	518598	Right Cheek	0.569	0.710	18	1.108	17	1.065	19	1.079	18	1.088
	FR1 n41	100M_BPSK_1_1	518598	Right Edge	0.470	0.498	18	1.000	17	0.918	19	0.985	18	0.991
Ant 0	FR1 n66	40M_BPSK_108_54	349000	Right Cheek	0.270	0.340	11	0.312	10	0.133	12	0.144	11	0.298
	FR1 n66	40M_BPSK_108_54	349000	Right Edge	0.366	0.438	11	0.953	10	0.457	12	0.415	11	0.941
Ant 0	FR1 n71	20M_BPSK_1_1	136100	Left Cheek	0.120	0.139	20	0.233	19	0.085	21	0.022	20	0.225
	FR1 n71	20M_BPSK_1_1	136100	Left Edge	0.312	0.362	20	0.471	19	0.129	21	0.016	20	0.461

Config Tx 1	RF exposure position													
	Band	Mode	Channel	Test Position	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)	Auto-tuner enable_Initial		Auto-tuner disabled Verify adjacent tuner				Repeat Auto-tuner enable	
							State	Single Point SAR (W/kg)	State	Single Point SAR (W/kg)	State	Single Point SAR (W/kg)	State	Single Point SAR (W/kg)
Ant 0	LTE Band 7	20M_QPSK_1_0	21100	Left Cheek	0.102	0.133	24	0.147	23	0.105	25	0.137	24	0.140
	LTE Band 7	20M_QPSK_1_0	21100	Bottom Edge	0.624	0.838	24	1.140	23	0.778	25	0.961	24	1.050
Ant 0	LTE Band 25	20M_QPSK_1_0	26340	Left Cheek	0.070	0.093	29	0.066	28	0.063	30	0.062	29	0.064
	LTE Band 25	20M_QPSK_50_0	26340	Bottom Edge	0.577	0.782	29	0.925	28	0.888	30	0.899	29	0.911
Ant 0	LTE Band 30	10M_QPSK_1_0	27710	Left Cheek	0.088	0.117	27	0.138	26	0.127	28	0.129	27	0.129
	LTE Band 30	10M_QPSK_25_0	27710	Bottom Edge	0.524	0.766	33	0.933	32	0.766	34	0.921	33	0.922
Ant 0	LTE Band 41	20M_QPSK_1_0	40620	Left Cheek	0.061	0.078	23	0.131	22	0.112	24	0.077	23	0.122
	LTE Band 41	20M_QPSK_1_0	40185	Bottom Edge	0.700	0.847	23	1.330	22	1.110	24	1.010	23	1.320
Ant 0	LTE Band 66	20M_QPSK_1_0	132322	Left Cheek	0.040	0.053	30	0.090	29	0.028	31	0.065	30	0.088
	LTE Band 66	20M_QPSK_1_0	132072	Bottom Edge	0.564	0.834	6	0.964	5	0.454	7	0.843	6	0.955
Ant 0	FR1 n7	50M_BPSK_135_68	507000	Left Cheek	0.084	0.105	24	0.111	23	0.099	25	0.103	24	0.103
	FR1 n7	50M_BPSK_1_1	507000	Bottom Edge	0.575	0.807	24	1.100	23	0.743	25	1.050	24	1.050
Ant 0	FR1 n25	40M_BPSK_1_1	376500	Right Cheek	0.056	0.070	29	0.066	28	0.058	30	0.052	29	0.063
	FR1 n25	40M_BPSK_108_54	376500	Bottom Edge	0.539	0.779	29	0.888	28	0.811	30	0.833	29	0.881
Ant 0	FR1 n30	10M_BPSK_25_14	462000	Left Cheek	0.082	0.112	27	0.133	26	0.125	28	0.111	27	0.130
	FR1 n30	10M_BPSK_25_14	462000	Bottom Edge	0.453	0.679	27	0.811	26	0.799	28	0.785	27	0.802
Ant 0	FR1 n41	100M_BPSK_1_1	518598	Left Cheek	0.098	0.125	23	0.155	22	0.144	24	0.133	23	0.150
	FR1 n41	100M_BPSK_1_1	518598	Bottom Edge	0.637	0.840	23	1.330	22	1.210	24	0.988	23	1.310
Ant 0	FR1 n66	40M_BPSK_1_1	349000	Left Cheek	0.053	0.068	30	0.101	29	0.089	31	0.085	30	0.099
	FR1 n66	40M_BPSK_1_1	349000	Bottom Edge	0.543	0.748	30	1.180	29	0.459	31	0.951	30	1.100

Appendix G. Supplemental SAR Tests Results

SAR test result

1. The test data is selected according to the worst case SAR configuration per cellular technology.
2. The test data is to demonstrate the device is in compliance with FCC requirements at 25mm when all power reduction mechanisms are OFF. The worst case body SAR at 10mm was used for simultaneous transmission SAR analysis since they are more conservative than the 25mm SAR.

Band	Mode	Test Position	Gap (mm)	Antenna	Power Index	Ch.	Freq. (MHz)	Average Power (dBm)	Tune-Up Limit (dBm)	Tune-up Scaling Factor	Duty Cycle %	Duty Cycle Scaling Factor	Power Drift (dB)	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)
GSM1900_Ant 0	GPRS (4 Tx slots)	Bottom Edge	25mm	-	1	512	1850.2	25.61	27.20	1.442	-	-	-0.04	0.337	0.486
WCDMA II_Ant 0	RMC 12.2Kbps	Bottom Edge	25mm	-	1	9262	1852.4	23.82	24.70	1.225	-	-	0	0.545	0.667
LTE Band 66_Ant 0	20M_QPSK_1_0	Bottom Edge	25mm	-	1	132322	1745	23.44	24.70	1.337	-	-	0.02	0.353	0.472
FR1 n25_Ant 0	40M_BPSK_1_1	Bottom Edge	25mm	-	1	376500	1882.5	23.72	24.70	1.253	-	-	0	0.468	0.586
WLAN2.4GHz	802.11b 1Mbps	Left Edge	25mm	Ant 3	0	6	2437	22.39	22.50	1.026	100.00	1.000	-0.16	0.127	0.130
WLAN5GHz	802.11a 6Mbps	Back	25mm	Ant 3+4(3)	0	149	5745	19.04	21.00	1.570	99.51	1.005	0.17	0.173	0.273
WLAN5GHz	802.11a 6Mbps	Back	25mm	Ant 3+4(4)	0	149	5745	20.93	21.00	1.016	99.51	1.005	0.17	0.169	0.173
Thread	250K	Left Edge	25mm	Ant 3	0	25	2475	20.96	22.00	1.269	89.87	1.001	-0.1	0.083	0.105