

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	Setting	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	232	Right Cheek	0.697	0.932	2	0.770	1	0.711	3	0.722	2	0.755
Ant 2	LTE Band 7	20M_QPSK_1_0	21100	197	Right Edge	0.489	0.536	2	0.569	1	0.506	3	0.513	2	0.544
Ant 0	LTE Band 12	10M_QPSK_1_0	23095	363	Left Cheek	0.312	0.343	10	0.279	9	0.156	11	0.128	10	0.271
Ant 0	LTE Band 12	10M_QPSK_1_0	23095	363	Left Edge	0.516	0.567	10	0.772	9	0.492	11	0.396	10	0.769
Ant 0	LTE Band 13	10M_QPSK_1_0	23230	363	Left Cheek	0.395	0.444	6	0.415	5	0.298	7	0.311	6	0.402
Ant 0	LTE Band 13	10M_QPSK_1_0	23230	363	Left Edge	0.447	0.563	6	0.872	5	0.855	7	0.849	6	0.855
Ant 0	LTE Band 14	10M_QPSK_1_0	23330	363	Left Cheek	0.347	0.400	5	0.471	4	0.370	6	0.422	5	0.455
Ant 0	LTE Band 14	10M_QPSK_1_0	23330	363	Back	0.534	0.575	5	0.670	4	0.559	6	0.619	5	0.666
Ant 2	LTE Band 25	20M_QPSK_1_0	26340	360	Right Cheek	0.507	0.634	9	0.710	8	0.394	10	0.639	9	0.702
Ant 2	LTE Band 25	20M_QPSK_50_0	26340	204	Right Edge	0.380	0.481	9	0.703	8	0.446	10	0.656	9	0.688
Ant 0	LTE Band 26	15M_QPSK_1_0	26865	363	Left Cheek	0.341	0.405	14	0.391	13	0.388	15	0.387	14	0.388
Ant 0	LTE Band 26	15M_QPSK_1_0	26865	363	Back	0.570	0.590	14	0.811	13	0.667	15	0.655	14	0.803
Ant 2	LTE Band 30	10M_QPSK_1_0	27710	357	Right Cheek	0.347	0.466	4	0.484	3	0.222	5	0.138	4	0.477
Ant 2	LTE Band 30	10M_QPSK_1_0	27710	206	Right Edge	0.469	0.495	4	0.863	3	0.355	5	0.286	4	0.855
Ant 2	LTE Band 66	20M_QPSK_1_0	132322	360	Right Cheek	0.448	0.545	13	0.562	12	0.167	14	0.210	13	0.555
Ant 2	LTE Band 66	20M_QPSK_50_0	132322	212	Right Edge	0.403	0.452	13	0.624	12	0.192	14	0.203	13	0.612
Ant 0	LTE Band 71	20M_QPSK_1_0	133297	363	Left Cheek	0.284	0.309	11	0.257	10	0.169	12	0.118	11	0.244
Ant 0	LTE Band 71	20M_QPSK_1_0	133297	363	Left Edge	0.402	0.437	11	0.661	10	0.489	12	0.353	11	0.654
Ant 2	FR1 n7	50M_BPSK_135_68	507000	227	Right Cheek	0.792	0.928	9	0.959	8	0.784	10	0.755	9	0.933
Ant 2	FR1 n7	50M_BPSK_135_68	507000	190	Right Edge	0.390	0.509	9	0.730	8	0.700	10	0.680	9	0.710
Ant 0	FR1 n12	15M_BPSK_36_22	141500	363	Left Cheek	0.328	0.360	10	0.299	9	0.166	11	0.144	10	0.288
Ant 0	FR1 n12	15M_BPSK_36_22	141500	363	Left Edge	0.499	0.547	10	0.752	9	0.488	11	0.377	10	0.719
Ant 0	FR1 n14	10M_BPSK_1_1	158600	363	Left Cheek	0.365	0.414	5	0.433	4	0.414	6	0.188	5	0.411
Ant 0	FR1 n14	10M_BPSK_1_1	158600	363	Back	0.502	0.570	5	0.807	4	0.627	6	0.427	5	0.790
Ant 2	FR1 n25	40M_BPSK_108_54	376500	360	Right Cheek	0.546	0.697	9	0.733	8	0.433	10	0.644	9	0.721
Ant 2	FR1 n25	40M_BPSK_108_54	376500	205	Right Edge	0.439	0.524	9	0.742	8	0.492	10	0.689	9	0.733
Ant 0	FR1 n26	20M_QPSK_50_28	166300	363	Left Cheek	0.367	0.452	14	0.450	12	0.288	13	0.447	14	0.422
Ant 0	FR1 n26	20M_QPSK_1_53	166300	363	Back	0.546	0.655	14	0.656	12	0.529	13	0.313	14	0.622
Ant 2	FR1 n30	10M_BPSK_25_14	462000	357	Right Cheek	0.419	0.577	3	0.428	2	0.222	4	0.125	3	0.409
Ant 2	FR1 n30	10M_BPSK_1_1	462000	205	Right Edge	0.434	0.499	3	0.754	2	0.299	4	0.279	3	0.723
Ant 2	FR1 n66	40M_BPSK_108_54	349000	360	Right Cheek	0.405	0.489	9	0.511	8	0.444	10	0.405	9	0.503
Ant 2	FR1 n66	40M_BPSK_108_54	349000	203	Right Edge	0.334	0.408	13	0.600	12	0.185	14	0.222	13	0.588
Ant 0	FR1 n71	20M_BPSK_1_1	136100	363	Left Cheek	0.275	0.309	11	0.299	10	0.155	12	0.111	11	0.291
Ant 0	FR1 n71	20M_BPSK_50_28	136100	363	Left Edge	0.399	0.450	11	0.588	10	0.455	12	0.355	11	0.579

Config Tx 1	RF exposure position														
	Band	Mode	Channel	Setting	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	361	Left Cheek	0.139	0.169	9	0.111	8	0.101	10	0.102	9	0.105
Ant 0	LTE Band 7	20M_QPSK_1_0	21100	180	Bottom Edge	0.609	0.827	11	1.390	10	0.074	12	0.622	11	1.330
Ant 0	LTE Band 25	20M_QPSK_1_0	26340	360	Left Cheek	0.057	0.066	13	0.092	12	0.051	14	0.053	13	0.090
Ant 0	LTE Band 25	20M_QPSK_1_0	26340	172	Bottom Edge	0.658	0.823	13	1.120	12	0.814	14	0.788	13	1.010
Ant 0	LTE Band 30	10M_QPSK_1_0	27710	357	Right Cheek	0.050	0.074	6	0.090	5	0.019	7	0.022	6	0.080
Ant 0	LTE Band 30	10M_QPSK_25_0	27710	185	Bottom Edge	0.559	0.819	6	1.381	5	0.768	7	0.792	6	1.330
Ant 0	LTE Band 66	20M_QPSK_1_0	132322	360	Left Cheek	0.076	0.082	9	0.106	8	0.040	10	0.050	9	1.010
Ant 0	LTE Band 66	20M_QPSK_1_0	132322	175	Bottom Edge	0.540	0.772	9	1.049	8	0.442	10	0.566	9	1.020
Ant 0	FR1 n7	50M_BPSK_135_68	507000	361	Left Cheek	0.174	0.212	11	0.226	10	0.103	12	0.111	11	0.215
Ant 0	FR1 n7	50M_BPSK_1_1	507000	175	Bottom Edge	0.534	0.646	11	1.110	10	0.452	12	0.422	11	1.030
Ant 0	FR1 n25	40M_BPSK_108_54	376500	360	Left Cheek	0.044	0.049	13	0.078	12	0.033	14	0.041	13	0.071
Ant 0	FR1 n25	40M_BPSK_1_1	376500	168	Bottom Edge	0.604	0.832	13	0.845	12	0.322	14	0.411	13	0.833
Ant 0	FR1 n30	10M_BPSK_1_1	462000	357	Right Cheek	0.051	0.078	6	0.098	5	0.021	7	0.035	6	0.091
Ant 0	FR1 n30	10M_BPSK_1_1	462000	189	Bottom Edge	0.566	0.833	6	1.391	5	0.805	7	0.722	6	1.320
Ant 0	FR1 n66	40M_BPSK_1_1	349000	360	Right Cheek	0.087	0.089	9	0.114	8	0.003	10	0.002	9	0.103
Ant 0	FR1 n66	40M_BPSK_108_54	349000	176	Bottom Edge	0.605	0.803	9	1.178	8	0.488	10	0.496	9	1.120
Ant 0	FR1 n70	15M_BPSK_36_22	340500	357	Right Cheek	0.087	0.098	5	0.088	4	0.082	6	0.046	5	0.083
Ant 0	FR1 n70	15M_BPSK_1_1	340500	176	Bottom Edge	0.600	0.802	5	0.962	4	0.959	6	0.438	5	0.955

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	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	-	661	1880	25.97	26.60	1.156	-	-	-0.09	0.445	0.514
WCDMA IV_Ant 0	RMC 12.2Kbps	Bottom Edge	25mm	-	1413	1732.6	23.89	24.30	1.099	-	-	-0.01	0.482	0.530
LTE Band 25_Ant 0	20M_QPSK_1_0	Bottom Edge	25mm	-	26340	1880	23.49	24.10	1.151	-	-	-0.07	0.566	0.651
FR1 n25_Ant 0	40M_BPSK_1_0	Bottom Edge	25mm	-	376500	1882.5	23.66	24.10	1.107	-	-	-0.04	0.564	0.624
WLAN2.4GHz	802.11b 1Mbps	Left Edge	25mm	Ant 3	11	2462	22.36	22.50	1.033	100	1.000	0.02	0.039	0.040
WLAN5GHz	802.11a 6Mbps	Left Edge	25mm	Ant 3+4(3)	165	5825	20.30	21.00	1.175	99.63	1.004	-0.07	0.310	0.366
WLAN5GHz	802.11a 6Mbps	Left Edge	25mm	Ant 3+4(4)	165	5825	20.80	21.00	1.047	99.63	1.004	-0.07	0.001	0.001
Thread	250K	Left Edge	25mm	Ant 3	18	2440	20.65	22.00	1.363	89.95	1.001	-0.11	0.108	0.147