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. The following test procedure was followed to demonstrate that the SAR results in this report represent the appropriate SAR test conditions. For bands with dynamic tuning implemented, SAR will be measured according to the required FCC SAR test procedures with the dynamic tuner active to allow the device to automatically tune to the antenna state for the respective RF exposure test configurations. Additional single point SAR time-sweep measurements will be evaluated for other tuner states to determine that the other tuner configurations would result in equivalent or lower SAR values.
3. The number of supported tune codes is different for each frequency band as shown in the following table.
4. Dynamic antenna tuning mechanism is available at Ant.0 for its < 3GHz LTE and NR band, details are illustrated in the operational description, all supported tuning states for each band are tested and it's verified that auto-tune state results in the highest SAR configuration.
5. The tuner state was established remotely through Wi-Fi so that the device is not moved for the entire series of single point SAR for the tuner states in each combination (band, mode, exposure conditions).
6. The auto-tune state determined by the device during normal SAR measurement has been verified immediately before and after each SAR measurement by reading the auto-tune state and confirm that they are the same and also listed alongside the reported SAR results in following table to facilitate comparing these with the single point SAR to be measured for the other tuner states.

Antenna	Band	Number of tune states
Ant 0 (LB)	LTE Band 12/17	12
	LTE Band 13	4
	LTE Band 14	3
	LTE Band 5/26	9
	LTE Band 71	9
	FR1 n12	12
	FR1 n14	3
	FR1 n5/n26	9
	FR1 n71	9

<Supplemental SAR result for Ant 0>
<Close Mode>

	RF exposure position											Average Value of Time Sweep Single Point SAR (W/kg)											
	Band	Mode	Channel		Setting	Test Position	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)	Default-Tuner (State)	Before Auto-Tuner (State)	After Auto-Tuner (State)	Auto-Tuner Single Point SAR (W/kg)	1	2	3	4	5	6	7	8	9	10	11	12
Head (Ant0)	LTE Band 12	10M_QPSK_1_0	Middle	23095	247	Right Cheek	0.199	0.287	5	5	5	0.247	0.188	0.179	0.155	0.001	0.227	0.125	0.146	0.001	0.201	0.132	0.134	0.001
	LTE Band 13	10M_QPSK_1_0	Middle	23230	247	Right Cheek	0.230	0.325	1	1	1	0.248	0.251	0.164	0.231	0.048								
	LTE Band 14	10M_QPSK_1_0	Middle	23330	247	Right Cheek	0.221	0.303	1	1	1	0.288	0.268	0.253	0.246									
	LTE Band 26	15M_QPSK_1_0	Middle	26865	247	Right Cheek	0.211	0.285	5	5	5	0.285	0.243	0.182	0.059	0.183	0.265	0.084	0.199	0.179	0.106			
	LTE Band 71	20M_QPSK_1_0	Middle	133297	247	Right Cheek	0.203	0.290	4	4	4	0.231	0.210	0.153	0.001	0.223	0.168	0.001	0.197	0.169	0.001			
	FR1 n12	15M_BPSK_1_1	Middle	141500	247	Right Cheek	0.180	0.252	5	5	5	0.235	0.183	0.161	0.140	0.001	0.210	0.112	0.139	0.001	0.195	0.113	0.141	0.047
	FR1 n14	10M_BPSK_1_1	Middle	158600	247	Right Cheek	0.200	0.277	1	1	1	0.274	0.252	0.237	0.242									
	FR1 n26	20M_BPSK_1_1	Middle	166300	247	Right Cheek	0.199	0.267	5	5	5	0.252	0.229	0.174	0.061	0.165	0.233	0.088	0.198	0.172	0.100			
	FR1 n71	20M_BPSK_1_1	Middle	136100	247	Right Cheek	0.158	0.227	4	4	4	0.199	0.138	0.108	0.001	0.189	0.117	0.001	0.144	0.107	0.001			

	RF exposure position											Average Value of Time Sweep Single Point SAR (W/kg)											
	Band	Mode	Channel		Setting	Test Position	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)	Default-Tuner (State)	Before Auto-Tuner (State)	After Auto-Tuner (State)	Auto-Tuner Single Point SAR (W/kg)	1	2	3	4	5	6	7	8	9	10	11	12
Body (Ant0)	LTE Band 12	10M_QPSK_1_0	Middle	23095	247	Back	0.202	0.291	5	3	3	0.384	0.241	0.218	0.361	0.272	0.224	0.143	0.342	0.261	0.232	0.144	0.345	0.265
	LTE Band 13	10M_QPSK_1_0	Middle	23230	247	Back	0.292	0.412	1	1	1	0.375	0.354	0.347	0.324	0.305								
	LTE Band 14	10M_QPSK_1_0	Middle	23330	247	Back	0.328	0.450	1	1	1	0.428	0.408	0.374	0.380									
	LTE Band 26	15M_QPSK_1_0	Middle	26865	247	Back	0.329	0.445	5	5	5	0.394	0.378	0.313	0.222	0.297	0.385	0.222	0.375	0.306	0.243			
	LTE Band 71	20M_QPSK_1_0	Middle	133297	247	Back	0.260	0.372	4	4	4	0.375	0.352	0.267	0.228	0.356	0.267	0.230	0.344	0.271	0.222			
	FR1 n12	15M_BPSK_1_1	Middle	141500	247	Front	0.224	0.314	5	5	5	0.385	0.355	0.285	0.250	0.110	0.379	0.189	0.248	0.087	0.359	0.226	0.248	0.092
	FR1 n14	10M_BPSK_1_1	Middle	158600	247	Back	0.326	0.451	1	1	1	0.482	0.444	0.393	0.415									
	FR1 n26	20M_BPSK_1_1	Middle	166300	247	Back	0.326	0.437	5	5	5	0.412	0.383	0.325	0.241	0.322	0.398	0.245	0.391	0.331	0.264			
	FR1 n71	20M_BPSK_1_1	Middle	136100	247	Back	0.273	0.393	4	4	4	0.385	0.357	0.269	0.219	0.361	0.262	0.232	0.354	0.259	0.214			

<Open Mode>

	RF exposure position											Average Value of Time Sweep Single Point SAR (W/kg)											
	Band	Mode	Channel		Setting	Test Position	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)	Default-Tuner (State)	Before Auto-Tuner (State)	After Auto-Tuner (State)	Auto-Tuner Single Point SAR (W/kg)	1	2	3	4	5	6	7	8	9	10	11	12
Head (Ant0)	LTE Band 12	10M_QPSK_1_0	Middle	23095	247	Left Cheek	0.150	0.216	5	6	6	0.172	0.115	0.171	0.152	0.108	0.158	0.186	0.127	0.101	0.132	0.167	0.138	0.106
	LTE Band 13	10M_QPSK_1_0	Middle	23230	247	Left Cheek	0.165	0.233	3	3	3	0.192	0.139	0.167	0.181	0.158								
	LTE Band 14	10M_QPSK_1_0	Middle	23330	247	Left Cheek	0.172	0.236	2	2	2	0.201	0.188	0.196	0.125									
	LTE Band 26	15M_QPSK_1_0	Middle	26865	247	Left Cheek	0.188	0.254	5	5	5	0.266	0.260	0.179	0.086	0.151	0.277	0.074	0.209	0.166	0.092			
	LTE Band 71	20M_QPSK_1_0	Middle	133297	247	Left Cheek	0.128	0.183	4	4	4	0.142	0.133	0.088	0.064	0.135	0.090	0.064	0.131	0.094	0.069			
	FR1 n12	15M_BPSK_1_1	Middle	141500	247	Left Cheek	0.143	0.200	5	6	6	0.176	0.099	0.157	0.123	0.089	0.145	0.167	0.151	0.108	0.150	0.150	0.140	0.097
	FR1 n14	10M_BPSK_1_1	Middle	158600	247	Left Cheek	0.164	0.227	2	2	2	0.225	0.201	0.216	0.142									
	FR1 n26	20M_BPSK_1_1	Middle	166300	247	Left Cheek	0.129	0.173	5	5	5	0.312	0.260	0.171	0.097	0.182	0.291	0.090	0.264	0.177	0.108			
	FR1 n71	20M_BPSK_1_1	Middle	136100	247	Left Cheek	0.138	0.199	4	4	4	0.143	0.152	0.114	0.071	0.154	0.104	0.074	0.135	0.098	0.076			

	RF exposure position											Average Value of Time Sweep Single Point SAR (W/kg)											
	Band	Mode	Channel		Setting	Test Position	Measured 1g SAR (W/kg)	Reported 1g SAR (W/kg)	Default-Tuner (State)	Before Auto-Tuner (State)	After Auto-Tuner (State)	Auto-Tuner Single Point SAR (W/kg)	1	2	3	4	5	6	7	8	9	10	11	12
Body (Ant0)	LTE Band 12	10M_QPSK_1_0	Middle	23095	247	Front	0.365	0.526	5	6	6	0.485	0.317	0.419	0.447	0.349	0.400	0.479	0.453	0.335	0.388	0.470	0.449	0.352
	LTE Band 13	10M_QPSK_1_0	Middle	23230	247	Front	0.454	0.641	3	1	1	0.712	0.689	0.393	0.647	0.340								
	LTE Band 14	10M_QPSK_1_0	Middle	23330	247	Front	0.458	0.628	2	1	1	0.588	0.592	0.559	0.410									
	LTE Band 26	15M_QPSK_1_0	Middle	26865	247	Front	0.384	0.519	5	7	7	0.598	0.482	0.399	0.284	0.376	0.483	0.278	0.585	0.384	0.298			
	LTE Band 71	20M_QPSK_1_0	Middle	133297	247	Front	0.354	0.506	4	7	7	0.501	0.486	0.364	0.235	0.190	0.361	0.258	0.488	0.354	0.253			
	FR1 n12	15M_BPSK_1_1	Middle	141500	247	Front	0.373	0.522	5	6	6	0.520	0.356	0.443	0.472	0.354	0.435	0.508	0.467	0.342	0.435	0.502	0.488	0.349
	FR1 n14	10M_BPSK_1_1	Middle	158600	247	Front	0.487	0.674	2	1	1	0.642	0.656	0.591	0.463									
	FR1 n26	20M_BPSK_1_1	Middle	166300	247	Front	0.251	0.336	5	7	7	0.655	0.502	0.417	0.313	0.414	0.496	0.304	0.621	0.415	0.330			
	FR1 n71	20M_BPSK_1_1	Middle	136100	247	Front	0.361	0.519	4	7	7	0.582	0.509	0.375	0.253	0.534	0.388	0.283	0.537	0.393	0.277			

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.

<Close Mode>

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 2	GPRS (4 Tx slots)	Bottom Side	25mm	-	810	1909.8	25.94	27.50	1.432			0.08	0.383	0.549
WCDMA II_Ant 2	RMC 12.2Kbps	Bottom Side	25mm	-	9262	1852.4	24.25	25.60	1.365			0.01	0.711	0.970
LTE Band 66_Ant 2	20M_QPSK_1_0	Bottom Side	25mm	-	132572	1770	24.71	25.60	1.227			0.03	0.651	0.799
FR1 n25_Ant 2	40M_BPSK_1_1	Bottom Side	25mm	-	376500	1882.5	24.20	25.30	1.288			-0.08	0.592	0.763
WLAN2.4GHz	802.11b 1Mbps	Top Side	25mm	Ant 4	6	2437	23.95	24.00	1.012	100	1.000	-0.08	0.227	0.230
WLAN5GHz	802.11a 6Mbps	Top Side	25mm	Ant 3+4(4)	149	5745	20.67	21.00	1.079	100	1.000	0.1	0.259	0.279
Bluetooth	1Mbps	Top Side	25mm	Ant 4	39	2441	19.46	19.50	1.010	77.10	1.080	-0.18	0.097	0.106

<Open Mode>

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 2	GPRS (4 Tx slots)	Front	25mm	-	810	1909.8	25.94	27.50	1.432			0.15	0.092	0.132
WCDMA II_Ant 2	RMC 12.2Kbps	Bottom Side	25mm	-	9262	1852.4	24.25	25.60	1.365			-0.12	0.709	0.967
LTE Band 25_Ant 2	20M_QPSK_1_0	Bottom Side	25mm	-	26140	1860	24.43	25.30	1.222			0.01	0.616	0.753
FR1 n25_Ant 2	40M_BPSK_1_1	Bottom Side	25mm	-	376500	1882.5	24.20	25.30	1.288			-0.06	0.603	0.777
WLAN2.4GHz	802.11b 1Mbps	Front	25mm	Ant 4	11	2462	23.95	24.00	1.012	100	1.000	-0.11	0.084	0.085
WLAN5GHz	802.11a 6Mbps	Top Side	25mm	Ant 3+4(4)	149	5745	20.67	21.00	1.079	100	1.000	0.09	0.146	0.158
Bluetooth	1Mbps	Front	25mm	Ant 3+4(4)	39	2441	19.46	19.50	1.010	76.86	1.301	-0.07	0.065	0.085