LoRa-FHSS-Spreading Factor 9

TEST RESULTS DATA
20dB and 99% Occupied Bandwidth and Hopping Channel Separation

Mod.	NTX	CH.	Freq. (MHz)	20db BW (MHz)	99% Bandwidth (MHz)	Hopping Channel Separation Measurement (MHz)	Hopping Channel Separation Measurement Limit (MHz)	Pass/Fail
SF9	1	1	902.2	0.145	0.126	0.184	0.145	Pass
SF9	1	65	915	0.150	0.132	0.193	0.150	Pass
SF9	1	129	927.8	0.149	0.132	0.229	0.149	Pass

TEST RESULTS DATA
Dwell Time

Mod.	CH.	DT On-time per hop (ms)	Total hops over 20sec	Dwell Time (sec)	Limits (sec)	Pass/Fail
SF9	hopping	178.039	1.00	0.18	0.4	Pass

TEST RESULTS DATA
Peak Power Table

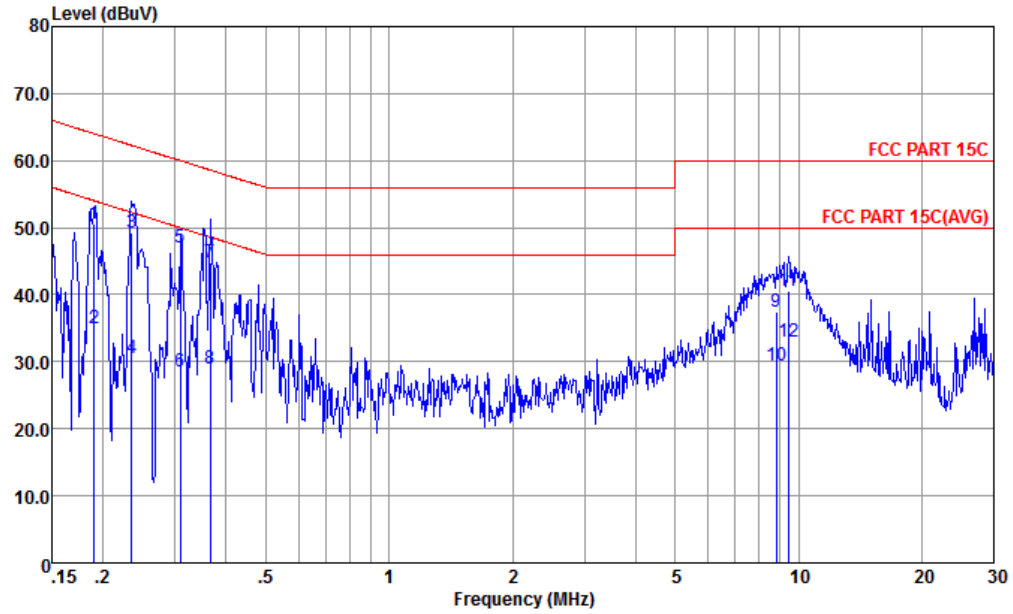
DH	Freq. (MHz)	NTX	Peak Power (dBm)	Power Limit (dBm)	Test Result
SF9	902.2	1	**21.99**	30.00	Pass
	915	1	21.95	30.00	Pass
	927.8	1	21.89	30.00	Pass

TEST RESULTS DATA
Number of Hopping Frequency

Number of Hopping (Channel)	Limits (Channel)	Pass/Fail
129	> 50	Pass

Appendix B. AC Conducted Emission Test Results

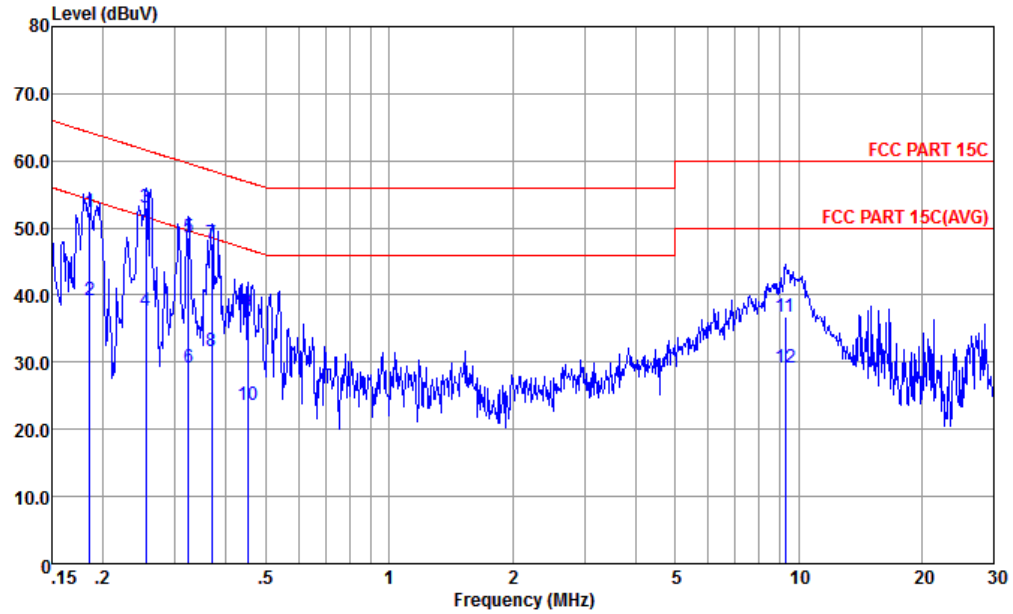
Test Engineer :	Amos Zhang	**Temperature :**	24.2~25.6℃
		Relative Humidity :	37~39%
Test Voltage :	120Vac / 60Hz	**Phase :**	Line



Site : CO01-KS
Condition : FCC PART 15C LISN-060105-L LINE

		Freq	Level	Over Limit	Limit Line	Read Level	LISN Factor	Cable Loss	Remark
		MHz	dBuV	dB	dBuV	dBuV	dB	dB	
1		0.190	50.62	-13.40	64.02	40.20	0.04	10.38	QP
2		0.190	35.02	-19.00	54.02	24.60	0.04	10.38	Average
3	*	0.235	49.29	-12.97	62.26	38.90	0.05	10.34	QP
4		0.235	30.59	-21.67	52.26	20.20	0.05	10.34	Average
5		0.308	46.97	-13.05	60.02	36.60	0.07	10.30	QP
6		0.308	28.57	-21.45	50.02	18.20	0.07	10.30	Average
7		0.365	44.86	-13.75	58.61	34.50	0.08	10.28	QP
8		0.365	28.86	-19.75	48.61	18.50	0.08	10.28	Average
9		8.822	37.34	-22.66	60.00	26.80	0.21	10.33	QP
10		8.822	29.34	-20.66	50.00	18.80	0.21	10.33	Average
11		9.451	40.45	-19.55	60.00	29.89	0.22	10.34	QP
12		9.451	33.05	-16.95	50.00	22.49	0.22	10.34	Average

Test Engineer :	Amos Zhang	Temperature :	24.2~25.6℃
		Relative Humidity :	37~39%
Test Voltage :	120Vac / 60Hz	Phase :	Neutral



Site : CO01-KS
Condition : FCC PART 15C LISN-060105-N NEUTRAL

		Freq	Level	Over Limit	Limit Line	Read Level	LISN Factor	Cable Loss	Remark
		MHz	dBuV	dB	dBuV	dBuV	dB	dB	
1		0.185	52.30	-11.94	64.24	41.81	0.10	10.39	QP
2		0.185	39.30	-14.94	54.24	28.81	0.10	10.39	Average
3	*	0.255	53.03	-8.57	61.60	42.60	0.10	10.33	QP
4		0.255	37.63	-13.97	51.60	27.20	0.10	10.33	Average
5		0.323	48.60	-11.02	59.62	38.20	0.10	10.30	QP
6		0.323	29.20	-20.42	49.62	18.80	0.10	10.30	Average
7		0.369	47.58	-10.94	58.52	37.20	0.10	10.28	QP
8		0.369	31.68	-16.84	48.52	21.30	0.10	10.28	Average
9		0.452	37.46	-19.39	56.85	27.10	0.11	10.25	QP
10		0.452	23.66	-23.19	46.85	13.30	0.11	10.25	Average
11		9.302	36.76	-23.24	60.00	26.21	0.22	10.33	QP
12		9.302	29.16	-20.84	50.00	18.61	0.22	10.33	Average

Note:

1. Level(dBμV) = Read Level(dBμV) + LISN Factor(dB) + Cable Loss(dB)
2. Over Limit(dB) = Level(dBμV) – Limit Line(dBμV)

Appendix C. Radiated Spurious Emission

902~928MHz

LoRa FHSS SF=7 (Band Edge @ 3m)

	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Cable Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
		(MHz)	(dBµV/m)	(dB)	(dBµV/m)	(dBµV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
902.2MHz		902.03	118.35	-	-	116.88	29.06	4.78	32.37	200	0	P	H
		967.99	40.42	-13.58	54	36.64	30.49	4.96	31.67	200	0	P	H
		902.03	118.05	-	-	116.58	29.06	4.78	32.37	100	0	P	V
		981.57	40.95	-13.05	54	37.08	30.41	5	31.54	200	0	P	V
915MHz		914.64	118.06	-	-	116	29.47	4.82	32.23	100	0	P	H
		964.11	40.23	-13.77	54	36.49	30.51	4.94	31.71	100	0	P	H
		914.64	117.29	-	-	115.23	29.47	4.82	32.23	200	0	P	V
		985.45	40.73	-13.27	54	36.83	30.39	5.01	31.5	200	0	P	V
927.8MHz		928.22	117.87	-	-	115.2	29.91	4.85	32.09	100	0	P	H
		984.48	39.98	-14.02	54	36.1	30.39	5	31.51	100	0	P	H
		928.22	116.46	-	-	113.79	29.91	4.85	32.09	200	0	P	V
		982.54	39.14	-14.86	54	35.27	30.4	5	31.53	200	0	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line. 3. Non-restricted band limit is 100kHz-PSD down20dB.												

LoRa FHSS SF=7 (Harmonic @ 3m)

	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Cable Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
		(MHz)	(dBµV/m)	(dB)	(dBµV/m)	(dBµV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
902.2MHz		1801	38.74	-59.61	98.35	66.75	29.94	6.77	64.72	100	360	P	H
		2710	42.3	-31.7	74	66.58	32.44	8.38	65.1	100	360	P	H
		1804.4	38.63	-59.42	98.05	66.64	29.94	6.77	64.72	300	0	P	V
		2710	43.26	-30.74	74	67.54	32.44	8.38	65.1	300	0	P	V
915MHz		1828	33.65	-64.41	98.06	62.48	29.05	6.84	64.72	300	0	P	H
		2745	41.5	-32.5	74	67.14	31.04	8.43	65.11	300	0	P	H
		1828	35.48	-61.81	97.29	64.31	29.05	6.84	64.72	300	0	P	V
		2745	40.67	-33.33	74	66.31	31.04	8.43	65.11	300	0	P	V
927.8MHz		1855	34.76	-63.11	97.87	63.46	29.15	6.87	64.72	100	0	P	H
		2782	40.43	-33.57	74	66.05	31.01	8.49	65.12	100	0	P	H
		1855	35.87	-60.59	96.46	64.57	29.15	6.87	64.72	300	0	P	V
		2783.4	40.94	-33.06	74	66.56	31.01	8.49	65.12	300	0	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line. 3. Non-restricted band limit is 100kHz-PSD down 20dB.												

LoRa FHSS SF=8 (Band Edge @ 3m)

	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Cable Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
		(MHz)	(dBµV/m)	(dB)	(dBµV/m)	(dBµV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
902.2MHz		902.03	118.65	-	-	117.18	29.06	4.78	32.37	200	0	P	H
		962.17	41.05	-12.95	54	37.32	30.52	4.94	31.73	200	0	P	H
		902.03	118.15	-	-	116.68	29.06	4.78	32.37	100	0	P	V
		992.24	41.38	-12.62	54	37.43	30.35	5.03	31.43	100	0	P	V
915MHz		914.64	117.25	-	-	115.19	29.47	4.82	32.23	100	0	P	H
		985.45	40.1	-13.9	54	36.2	30.39	5.01	31.5	100	0	P	H
		914.64	116.69	-	-	114.63	29.47	4.82	32.23	200	0	P	V
		985.45	40.4	-13.6	54	36.5	30.39	5.01	31.5	200	0	P	V
927.8MHz		927.25	117.43	-	-	114.8	29.88	4.85	32.1	200	0	P	H
		969.93	39.37	-14.63	54	35.58	30.48	4.96	31.65	200	0	P	H
		927.25	115.61	-	-	112.98	29.88	4.85	32.1	100	0	P	V
		965.08	40.3	-13.7	54	36.54	30.51	4.95	31.7	100	0	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line. 3. Non-restricted band limit is 100kHz-PSD down 20dB.												

LoRa FHSS SF=8 (Harmonic @ 3m)

	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Cable Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
		(MHz)	(dBµV/m)	(dB)	(dBµV/m)	(dBµV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
902.2MHz		1801	34.85	-63.8	98.65	63.94	28.86	6.77	64.72	300	0	P	H
		2706.6	39.99	-34.01	74	65.66	31.07	8.35	65.09	300	0	P	H
		1801	34.24	-63.91	98.15	63.33	28.86	6.77	64.72	100	0	P	V
		2706.6	41.66	-32.34	74	67.33	31.07	8.35	65.09	100	0	P	V
915MHz		1828	34.24	-63.01	97.25	63.07	29.05	6.84	64.72	100	0	P	H
		2745	40.07	-33.93	74	65.71	31.04	8.43	65.11	100	0	P	H
		1828	34.25	-62.44	96.69	63.08	29.05	6.84	64.72	300	0	P	V
		2745	40.42	-33.58	74	66.06	31.04	8.43	65.11	300	0	P	V
927.8MHz		1855	34.46	-62.97	97.43	63.16	29.15	6.87	64.72	300	0	P	H
		2783.4	40.79	-33.21	74	66.41	31.01	8.49	65.12	300	0	P	H
		1855	34.65	-60.96	95.61	63.35	29.15	6.87	64.72	100	0	P	V
		2783.4	40.17	-33.83	74	65.79	31.01	8.49	65.12	100	0	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line. 3. Non-restricted band limit is 100kHz-PSD down 20dB.												

LoRa FHSS SF=9 (Band Edge @ 3m)

	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Cable Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
		(MHz)	(dBµV/m)	(dB)	(dBµV/m)	(dBµV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
902.2MHz		902.03	119.03	-	-	117.56	29.06	4.78	32.37	200	0	P	H
		984.48	41.86	-12.14	54	37.98	30.39	5	31.51	200	0	P	H
		902.03	118.84	-	-	117.37	29.06	4.78	32.37	100	0	P	V
		978.66	40.98	-13.02	54	37.13	30.43	4.99	31.57	100	0	P	V
915MHz		914.64	119.43	-	-	117.37	29.47	4.82	32.23	200	0	P	H
		978.66	39.84	-14.16	54	35.99	30.43	4.99	31.57	200	0	P	H
		914.64	115.75	-	-	113.69	29.47	4.82	32.23	100	0	P	V
		967.99	41.09	-12.91	54	37.31	30.49	4.96	31.67	100	0	P	V
927.8MHz		927.25	119.21	-	-	116.58	29.88	4.85	32.1	200	0	P	H
		991.27	38.97	-15.03	54	35.04	30.35	5.02	31.44	200	0	P	H
		927.25	114.32	-	-	111.69	29.88	4.85	32.1	100	0	P	V
		985.45	39.38	-14.62	54	35.48	30.39	5.01	31.5	100	0	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line. 3. Non-restricted band limit is 100kHz-PSD down 20dB.												

LoRa FHSS SF=9 (Harmonic @ 3m)

	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Cable Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
		(MHz)	(dBµV/m)	(dB)	(dBµV/m)	(dBµV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
902.2MHz		1801	33.03	-66	99.03	62.12	28.86	6.77	64.72	100	0	P	H
		2706.6	36.39	-37.61	74	62.06	31.07	8.35	65.09	100	0	P	H
		1801	33.51	-65.33	98.84	62.6	28.86	6.77	64.72	300	0	P	V
		2706.6	35.97	-38.03	74	61.64	31.07	8.35	65.09	300	0	P	V
915MHz		1828	35.11	-64.32	99.43	63.94	29.05	6.84	64.72	300	0	P	H
		2745	39.78	-34.22	74	65.42	31.04	8.43	65.11	300	0	P	H
		1828	34.1	-61.65	95.75	62.93	29.05	6.84	64.72	100	0	P	V
		2745	39.96	-34.04	74	65.6	31.04	8.43	65.11	100	0	P	V
927.8MHz		1855	34.96	-64.25	99.21	63.66	29.15	6.87	64.72	100	0	P	H
		2783.4	39.97	-34.03	74	65.59	31.01	8.49	65.12	100	0	P	H
		1855	34.61	-59.71	94.32	63.31	29.15	6.87	64.72	300	0	P	V
		2783.4	40.31	-33.69	74	65.93	31.01	8.49	65.12	300	0	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line. 3. Non-restricted band limit is 100kHz-PSD down 20dB.												

Note symbol

*	**Fundamental Frequency** which can be ignored. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.
!	Test result is **over limit** line.
P/A	**P**eak or **A**verage
H/V	**H**orizontal or **V**ertical

A calculation example for radiated spurious emission is shown as below:

BLE	Note	Frequency	Level	Over	Limit	Read	Antenna	Path	Preamp	Ant	Table	Peak	Pol.
				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
		(MHz)	(dBµV/m)	(dB)	(dBµV/m)	(dBµV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
BLE CH 00 2402MHz		2390	55.45	-18.55	74	54.51	32.22	4.58	35.86	103	308	P	H
		2390	43.54	-10.46	54	42.6	32.22	4.58	35.86	103	308	A	H

1. Path Loss(dB) = Cable loss(dB) + Filter loss(dB) + Attenuator loss(dB)
2. Level(dBµV/m) =

Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBµV) - Preamp Factor(dB)

3. Over Limit(dB) = Level(dBµV/m) – Limit Line(dBµV/m)

For Peak Limit @ 2390MHz:

1. Level(dBµV/m)

= Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBµV) - Preamp Factor(dB)

= 32.22(dB/m) + 4.58(dB) + 54.51(dBµV) – 35.86 (dB)

= 55.45 (dBµV/m)

2. Over Limit(dB)

= Level(dBµV/m) – Limit Line(dBµV/m)

= 55.45(dBµV/m) – 74(dBµV/m)

= -18.55(dB)

For Average Limit @ 2390MHz:

1. Level(dBµV/m)

= Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBµV) - Preamp Factor(dB)

= 32.22(dB/m) + 4.58(dB) + 42.6(dBµV) – 35.86 (dB)

= 43.54 (dBµV/m)

2. Over Limit(dB)

= Level(dBµV/m) – Limit Line(dBµV/m)

= 43.54(dBµV/m) – 54(dBµV/m)

= -10.46(dB)

Both peak and average measured complies with the limit line, so test result is “PASS”.