Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: Supplemental Information for HBC

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Re:

Abstract: This document provides supplemental information for HBC.

Purpose: To present responses for regulation and transmission issues of HBC.

- Radio Spectrum Regulatory Summary
- Transmit Power Issues

RADIO SPECTRUM REGULATORY SUMMARY

USA (1/2)

- FCC Regulations for low-power, non-licensed transmitters
  - If a particular transmitter can comply with the general radiated limits (Section 15.209), and at the same time avoid operating in one of the restricted bands (Section 15.205), then it can use any type of modulation (AM, FM, PCM, etc.) for any purpose.
  - Section 15.209 contains general radiated emission (signal strength) limits that apply to all Part 15 transmitters using frequencies at 9 kHz and above. (see table below)
  - Section 15.205 lists a number of restricted bands in which low power, non-licensed transmitters are not allowed to operate. (see next slide)

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009–0.490	2400/F(kHz)	300
0.490–1.705	24000/F(kHz)	30
1.705–30.0	30	30
30–88	100**	3
88–216	150**	3
216–960	200**	3

**Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54–72 MHz, 76–88 MHz, 174–216 MHz or 470–806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§ 15.231 and 15.241.

USA (2/2)

- Restricted Bands (10 MHz ~ 50MHz) [Section 15.205]

MHz
12.290 ~ 12.293
12.51975 ~ 12.52025
12.57675 ~ 12.57725
13.36 ~ 13.41
16.420 ~ 16.423
16.69475 ~ 16.69525
16.80425 ~ 16.80475
25.55 ~ 25.67
37.5 ~ 38.25

MHz	MHz
0.090–0.110	16.42–16.423
[1]0.495–0.505	16.69475–16.69525
2.1735–2.1905	16.80425–16.80475
4.125–4.128	25.5–25.67
4.17725–4.17775	37.5–38.25
4.20725–4.20775	73–74.6
6.215–6.218	74.8–75.2
6.26775–6.26825	108–121.94
6.31175–6.31225	123–138
8.291–8.294	149.9–150.05
8.362–8.366	156.52475–156.52525
8.37625–8.38675	156.7–156.9
8.41425–8.41475	162.0125–167.17
12.29–12.293	167.72–173.2
12.51975–12.52025	240–285
12.57675–12.57725	322–335.4
13.36–13.41.	

[1] Until February 1, 1999, this restricted band shall be 0.490–0.510 MHz.
[2] Above 38.6

- Submitted an inquiry to FCC's Office of Engineering and Technology regarding the interpretation of Sections 15.205 and 15.209 for EFC (see next slide)

Office of Engineering and Technology

Tracking Number 767539

Inquiry:

We are submitting an inquiry to verify if our rules interpretations of FCC regulations are correct, and to request correct rules interpretation if we are wrong.

We are developing a connectivity technology based on the concept of capacitive coupling. Electric Field Communication (EFC), as we call it, detects the variation of electric field induced on the communication medium. The variation of electric potential at the transmitter electrode induces the receiver electrode's potential to vary, and by detecting this variation, the receiver receives the information being transferred. EFC can use air, water, human body, etc. as a communication medium, and the communication range (and performance) depends on the relative permittivity, ε_r, of the medium. The ε_r of air is 1 where the ε_r of human body is about 300~500, so EFC can communicate further if human body is used as a medium. If air is used as a medium, our device's transmission range is about 20cm. Our EFC's potential applications are similar to those of Near Field Communication (NFC).

Our EFC can operate from 10MHz to 50MHz, and needs a bandwidth of 4MHz. We have tested our prototypes at 16MHz and 24MHz. Our initial measurement values of radiation emission are well below the 30uV/m @ 30m requirement of Part 15.209 for 1.705~30.0MHz.

Can we get a certification as Low Power, Non-Licensed Transmitter under Part 15.209 if our final EFC product's radiation emission is well below 30uV/m @ 30m?

Part 15.205 permits only spurious emissions at several frequency bands. Those bands in 10~50MHz range are (in MHz) 12.290 ~ 12.293, 12.51975 ~ 12.52025, 12.57675 ~ 12.57725, 13.36 ~ 13.41, 16.420 ~ 16.423, 16.69475 ~ 16.69525, 16.80425 ~ 16.80475, 25.55 ~ 25.67, and 37.5 ~ 38.25. If a device's center frequency (f_c) is outside of these limited bands, does that device meet the requirement of Part 15.209?

If our EFC product operates with a center frequency (f_c) of 16MHz or 24MHz (with a bandwidth of 4MHz), does it meet Part 15.205? Can it be certified as Low Power, Non-Licensed Transmitter? Of course, this is assuming that our product?s emission is well below 30uV/m @ 30m.

Thank you very much.

Jahng Sun Park

Response:
Based on your description of the product, we agree that the device may be approved under Section 15.209

Japan (1/2)

- Regulation of the Extremely Low Power Radio Station
  - When the level of the electric field intensity (the strength of the radio wave) within 3 meters is below 500μV/m (f_c < 322MHz), there is no need for getting a license from the radio station.
  - Japan Radio Law Operation Regulation – Article 6, Section 1

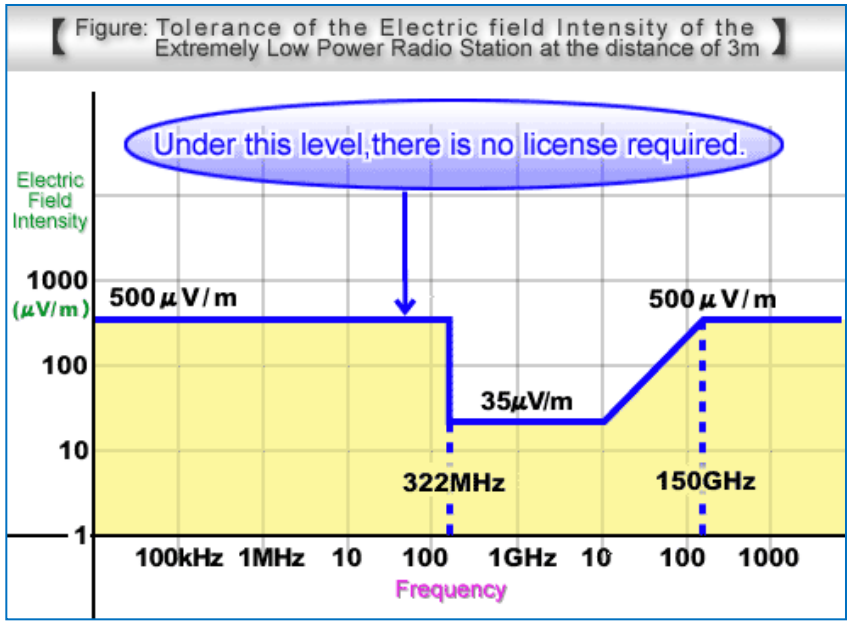
電波法施行規則抜粋

（免許を要しない無線局）

第６条　法第４条第一号に規定する発射する電波が著しく微弱な無線局を次のとおり定める。

一．当該無線局の無線設備から３メートルの距離おいて、その電界強度が、次の表の上欄の区分に従い、それぞれ同表の下欄に掲げる値以下であるもの

周　波　数　帯	電　界　強　度
３３２ MHz以下	５００μV/m
３３２ MHzを超え１０GHz以下	３５μV/m
１０GHzを超え１５０GHz以下	次式で求められる値（５００μV/mを超える場合は、５００μV/m） ３．５×F（μV/m） Fは、GHzを単位とする周波数とする。
１５０GHzを超えるもの	５００μV/m



Japan (2/2)

- Japan Radio Law – Article 4, Section 1

第四条　無線局を開設しようとする者は、総務大臣の免許を受けなければならない。ただし、次の各号に掲げる無線局については、この限りでない。

一　発射する電波が著しく微弱な無線局で総務省令で定めるもの

Article 4.

Any person who wishes to establish a radio station shall obtain a license from the Minister of Public Management, Home Affairs, Posts and Telecommunications. This shall not apply to:

i) Radio stations operating with extremely low power of emission as specified in the applicable ministerial ordinance of the Ministry of Public Management, Home Affairs, Posts and Telecommunications #.

Korea (1/2)

- Regulation of the Extremely Low Power Radio Station (ELPRS)
  - When the level of the electric field intensity within 3 meters is below 500μV/m (f_c < 322MHz), there is no need for getting a license from the radio station.
  - Same as Japan

- Radio Station Law
  - Article 97
  - Except in the restricted bands listed in Attached Table 95 (see next page)

- Contacted Radio Research Agency (certification body of KCC) ➔ EFC device should be able to operate as ELPRS

제97조(미약 전계강도 무선기기) 미약 전계강도 무선기기의 기술기준은 다음 각 호와 같다.

1. 해당 무선기기로부터 3m의 거리에서 측정한 전계강도는 다음의 조건에 적합하여야 한다.

주파수	전계강도
322㎒ 미만	500㎶/m 이하. (15㎒ 이하에서는 측정값에 6π/λ를 곱하여 적용한다. 이 경우 λ는 측정주파수의 파장임)
322㎒ 이상 10 ㎓ 미만	35 ㎶/m 이하
10㎓ 이상 150 ㎓ 미만	3.5f ㎶/m 이하(다만, 500㎶/m를 초과하는 경우에는 500㎶/m로 한다). 이 경우 f는 ㎓를 단위로 한 주파수로 한다.
150㎓ 이상	500㎶/m 이하

2. 기본파의 주파수가 별표 95에 명시된 '미약전파무선국으로 운용할 수 없는 주파수대역'에 포함되지 않아야 한다.
3. 불요발사 전계강도는 기본파의 전계강도보다 낮아야 한다.

Korea (2/2)

- Restricted Bands (10 MHz ~ 50MHz)

MHz
12.51975 ~ 12.52025
12.57675 ~ 12.57725
16.69475 ~ 16.69525
16.80425 ~ 16.80475
25.550 ~ 25.670
27.819 ~ 27.823
37.50 ~ 38.25

[별표 95]

미약전파무선국으로 운용할수 없는 주파수대역

(제97조제2호 관련)

주파수대역	주파수분배표 주석 (Footnote)
kHz	
485 ~ 526.5	- 긴급통신(5.82)
2089.5 ~ 2092.5	- 조난·긴급·안전(K16)
2173.5 ~ 2190.5	- 조난·호출(5.108, 5.109, 5.110)
4177.25 ~ 4177.75	- 국제조난(5.110)
4207.25 ~ 4207.75	- 국제조난(5.109)
6267.75 ~ 6268.25	- 국제조난(5.110)
6311.75 ~ 6312.25	- 국제조난(5.109)
8376.25 ~ 8386.75	- 국제조난(5.110)
8414.25 ~ 8414.75	- 국제조난(5.109)
12519.75 ~ 12520.25	- 국제조난(5.110)
12576.75 ~ 12577.25	- 국제조난(5.109)
13360 ~ 13410	- 전파천문(5.149)
16694.75 ~ 16695.25	- 국제조난(5.110)
16804.25 ~ 16804.75	- 국제조난(5.109)
25550~25670	- 전파천문(5.149)
27819 ~ 27823	- 조난·안전·긴급(K47)
MHz	
37.5 ~ 38.25	- 전파천문(5.149)
73.0 ~ 74.6	- 전파천문(5.149)

EU

- Regulation of Short Range Devices (SRDs) [ETSI EN 300 330]
  - SRD is defined as the radio transmitter which provide either unidirectional or bi-directional communication and which have low capability of causing interference to other radio equipment
  - For SRDs, individual licenses are normally not required
  - No restricted bands unlike USA, Korea, and Japan

	Frequency Band	Power / Magnetic Field	Spectrum access and mitigation requirement	Channel spacing
a	6765-6795 kHz	42 dBμA/m at 10m	No requirement	No spacing
b	13.553-13.567 MHz	42 dBμA/m at 10m	No requirement	No spacing
c	26.957-27.283 MHz	42 dBμA/m at 10m 10 mW e.r.p	No requirement	No spacing
d	40.660-40.700 MHz	10 mW e.r.p.	No requirement	No spacing

UK

- Licence Exempt Short Range Devices
  - UK Interface Requirement 2030
  - The UK Interface Requirement defines the radiation level for the use of Licence Exempt Short Range Devices in the specified bands
  - No restricted bands
  - In the case of general non-specific short range devices (section 3)

category	Frequency / Band	Radiated Level
i	6765 - 6795 kHz	42 dBuA/m at 10 m
ii	13.553 - 13.567 MHz	42 dBuA/m at 10 m
iii	26.957 - 27.283 MHz	10 mW e.r.p. 42 dBμA/m @ 10 m
iv	40.66 - 40.70 MHz	10 mW e.r.p.
v	49.82 - 49.98 MHz	10 mW e.r.p.
vi	49.82 - 49.98 MHz	10 mW e.r.p.
vii	40.66 - 40.7 MHz	10 mW e.r.p.

Australia

- Regulation of Short Range Devices (SRDs)
  - Radiocommunications (Low Interference Potential Devices) Class Licence 2000
  - The class license authorizes a person to operated the transmitter which does not exceed the maximum EIRP and spurious emissions (Section 4, Schedule 1)
  - No restricted bands

Row	Class of transmitter	Permitted operating frequency band (MHz) (lower limit exclusive, upper limit inclusive)	Maximum EIRP	Transmitter spurious emissions (EIRP)
9	All transmitters	13.553 to 13.567	100 mW	1μW
10	All transmitters	24 to 24.89	10 mW	0.1μW
11	All transmitters	26.957 to 27.283	1 W	2.5μW
12	All transmitters	29.7 to 29.72 30 to 30.0625 30.3125 to 31 36.6 to 37 39 to 39.7625 40.25 to 40.66	100 mW	5μW
13	All transmitters	40.66 to 41	1W	5μW
14	All transmitters	54 to 56	2.5 mW	0.1μW

* For equipment operation on frequencies below 470 MHz, the spurious emissions should be measured over the frequency range 25 MHz to 4 GHz.

TRANSMIT POWER ISSUES

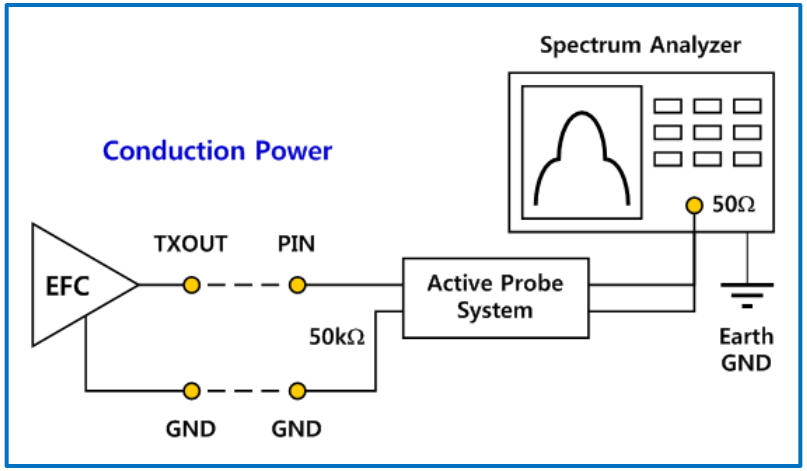
TX Radiation Power

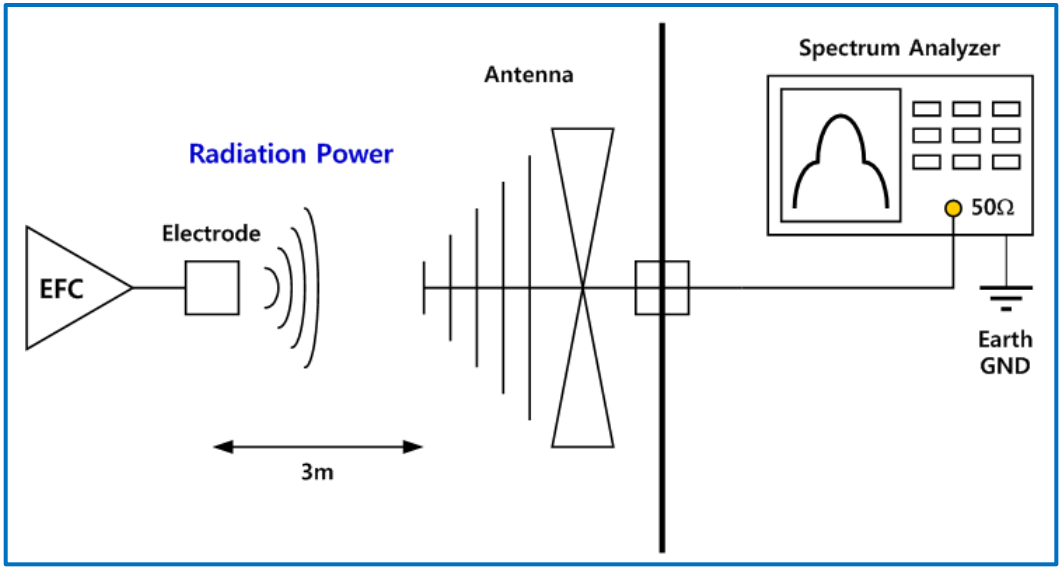
$$EIRP = G_T \cdot P_T \qquad P_D = \frac{E^2}{Z_0} = \frac{EIRP}{4\pi d^2} \qquad EIRP = 4\pi \cdot \frac{(E \cdot d)^2}{Z_0}$$

- **Radiation Power**
  - Measured Electric Field Intensity (E) @ 3m (d) = 42 dBμV/m (in RE Chamber)
  - Characteristic Impedance (Z_0) = 377 Ω
    → Radiation Power$_{(\text{single tone})}$ @ 16MHz → EIRP = **-53 dBm**
  - Transmit Power (P_T) = Conduction Power @ 16MHz$_{(\text{single tone})}$ = -26 dBm
    → (equivalent) TX Antenna Gain (G_T) = -27 dBi
  - Radiation Power$_{(14\sim18\text{MHz})}$ = EIRP + 14 dB = **-39 dBm**
    Conduction Power$_{(14\sim18\text{MHz})}$ = P_T + 14 dB = -12 dBm
  - Conduction Power @ 16MHz$_{(\text{single tone})}$
    - Single Tone Power @ 16MHz = TX Band Power$_{(14\sim18\text{MHz})}$ – 14 dB
    - TX Band Power$_{(14\sim18\text{MHz})}$ @ 50kΩ = -12 dBm (measured w/SA Equipment)
      ➔ Conduction Power @ 16MHz Single Tone = -26 dBm

Measurement Setup

- **Conduction Power Measurement**
  - Use of common GND between TX device and earth-grounded SA equipment
- **Radiation Power Measurement**
  - Use of TX GND separated from earth-grounded SA equipment
  - Weak condition for capacitive return path



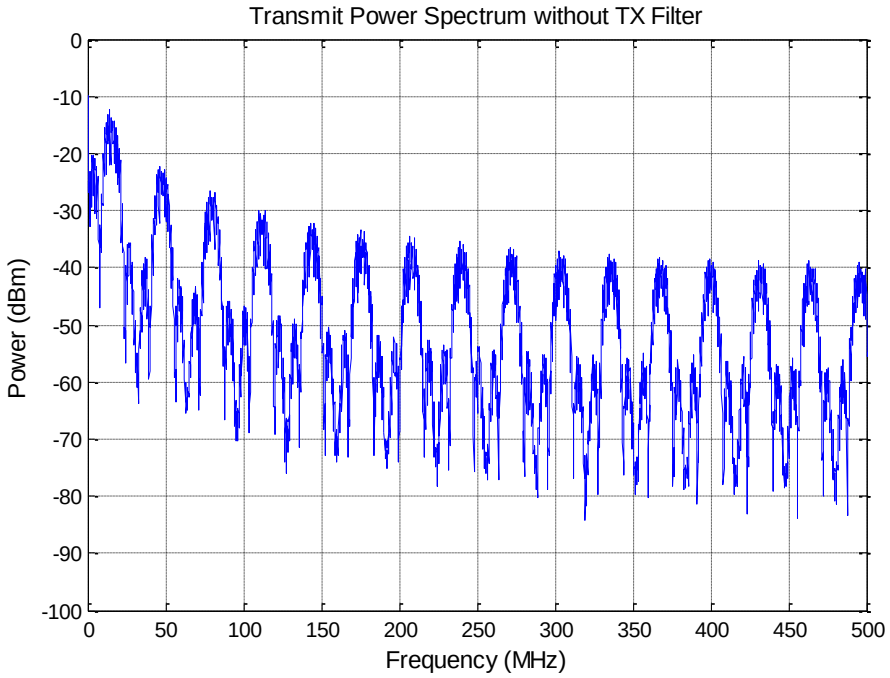


Conduction Power Measurement

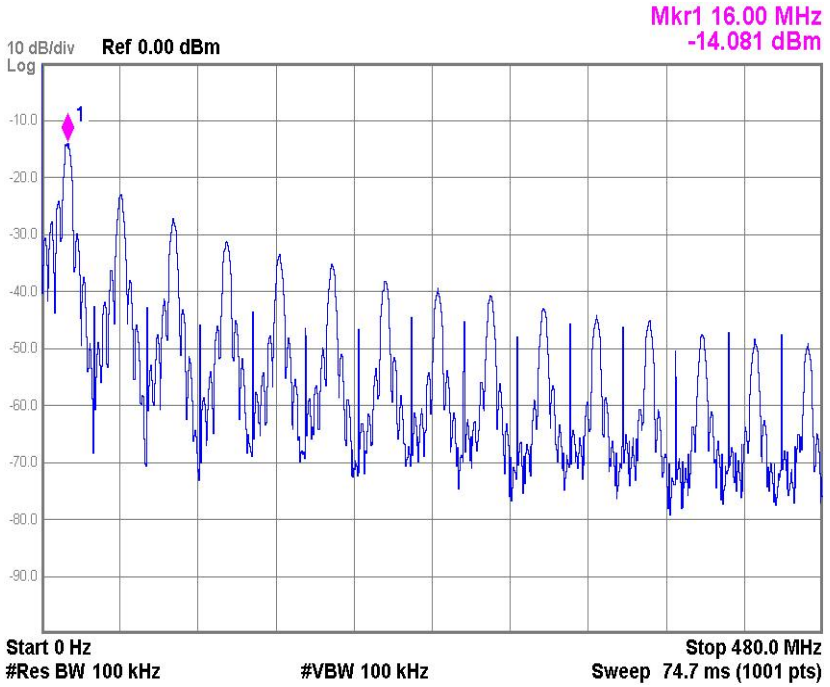
Radiation Power Measurement

Transmit Power Spectrum

- Without TX Filter
- SPAN: 0 ~ 500MHz



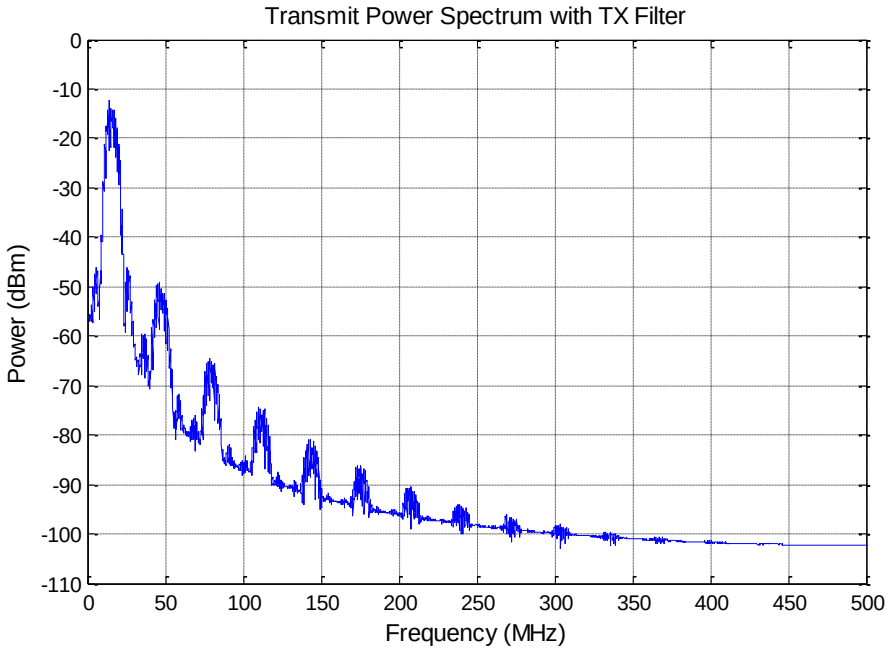
Simulation Result



Measured Data

Transmit Power Spectrum

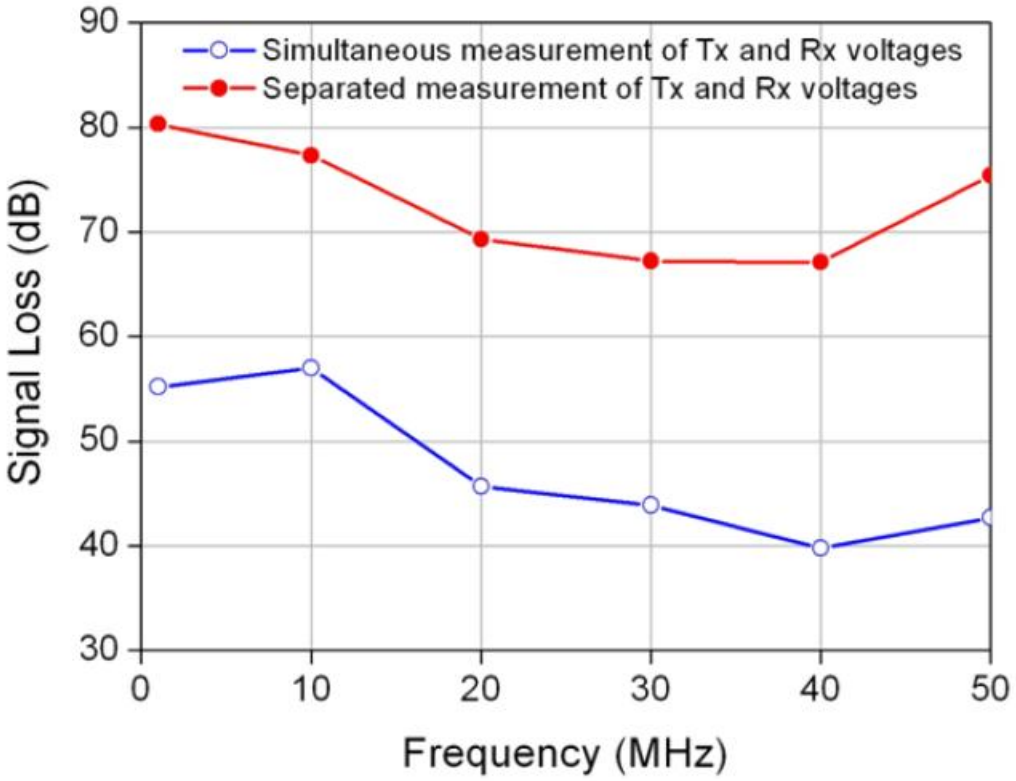
- With TX Filter
- SPAN: 0 ~ 500MHz



Simulation Result

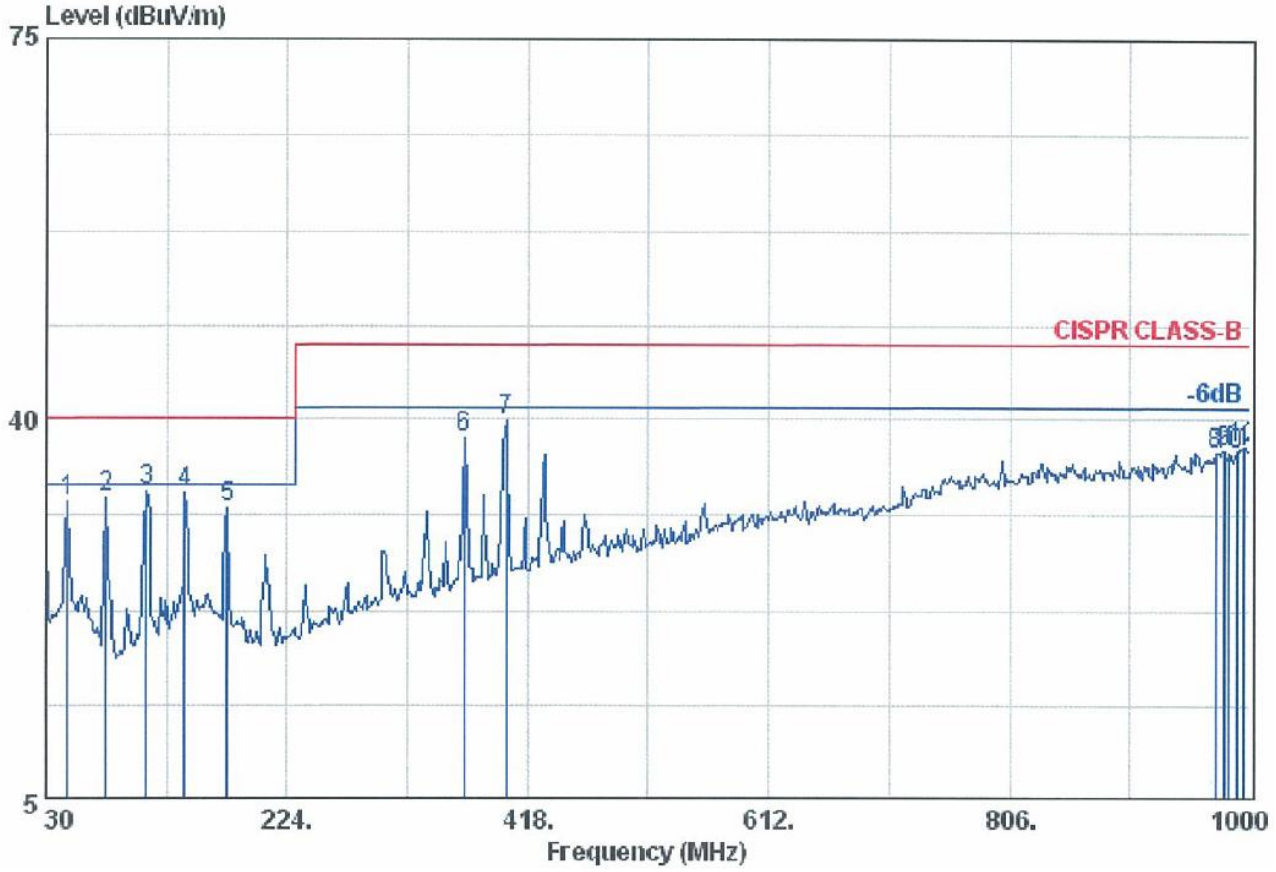
Back-Up Data

- Measured Signal Loss for Two GND Conditions
  - Shared GND and separated GND between TX and RX devices



Measured Data

- EMI Measurement without TX Filter (CISPR Class-B 3m)
  - The EMI values will be much lower with TX Filter



	Freq.(MHz)	Level (dBμV/m)
1	47.46	32.44
2	78.50	32.82
3	110.51	33.53
4	141.55	33.36
5	175.50	31.94
6	366.59	38.37
7	400.54	39.82
8	971.87	37.03
9	978.66	37.25
10	983.51	37.07
11	990.30	37.24
12	995.15	37.63