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Indoor and Outdoor Reception Performance Evaluation of Digital Radio Techniques in Field Trials

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In-band	HD Radio	DRM+	, out-of-band	DAB/DAB+/T-DMB
가	19	test point	가	test bed
가	ATT			

Abstract This paper provides field test results to confirm and compare the receiving characteristics of digital radio in various environments. HD Radio and DRM+ was used for the in-band method, while DAB/DAB+/T-DMB were used for the out-of-band method. To run field tests for digital radio, a transceiver test bed was constructed in a region in Korea selected as suitable for the testing, and indoor and outdoor reception tests were conducted by selecting 16 test points with different levels of multipath. Not only was the receivability tested at the test point, but ATT margin was also applied, in order to derive the minimum reception level. Through various analyses, the findings obtained through the field tests can aid in the setting of a standard for determining the method of digital radio transmission to ensure a smooth reception environment for consumers.

Key Words : DAB, Digital Radio, DMB, DRM+, Field Trial, HD Radio

1. 가 '90 가 2013 / 가 [3][4]. [1][2]. 2014 Audio USAC (Universal Speech and Audio Codec) 2009 [5][6]. 2010 2

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TV , 가 [7]. 가

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2.1

DAB(digital audio broadcasting), DAB+, T-DMB(terrestrial digital multimedia broadcasting) Audio, HD(High Definition) Radio, DRM+(digital radio mondiale)



1.

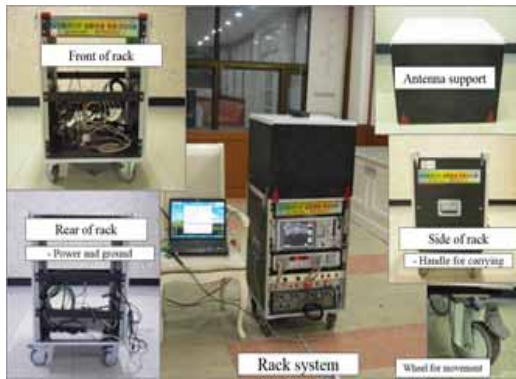
Fig 1. Area of field and transmitter antenna

(dBV/m), (dBm), (dBm), (dBV/m)

1.

Table 1. Parameters for Transmitter Features

항목	값	
지역	37°42'29.81"N, 129°00'0.62"E	
고도	325 m	
송신탑 높이	40 m	
주파수	DAB/DAB+/T-DMB	195.008 MHz
	HD Radio	103.5 MHz
	DRM+	103.1 MHz 103.3 MHz
송신 파워	DAB/DAB+/T-DMB	100W
	HD Radio	MP3 : 1kW MP5 : 100W
	DRM+	100W



2.

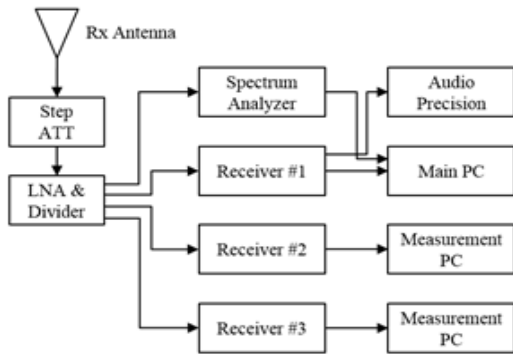
Fig 2. Reception system details

2

Evaluation method Methodology 3

, 4

5



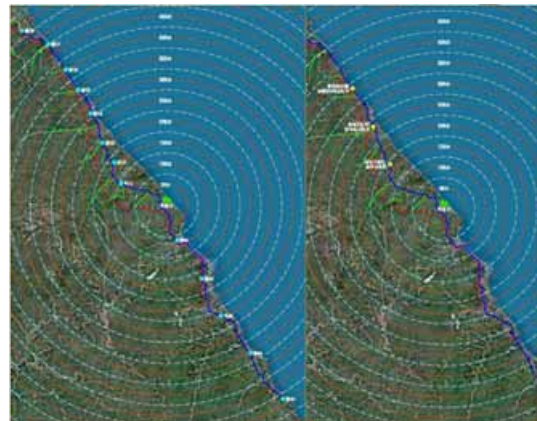
3. Fig 3. Composition of the measurement system

ToA(Threshold of Audibility)

2.2

4

(GTB) 1
 가
 가
 가
 가
 가
 , DAB, DAB+,
 T-DMB 195.008MHz
 HD-Radio DRM+ 103.5MHz



4. Fig 4. Test point with reception coverage into consideration

2. Table 2. Summary of indoor and outdoor fixed measurement points

측정 유형	지점 수	지형	측정 지점
실외	13	산악지형	S1~S5
		평야지형	N1~N8
실내	3	평야지형	R1~R3

3 RF

PC

. RF

0.1dB

(Radial) 10km S1 S5
 5 DAB, DAB+, T-DMB
 5km N1 (가 / 가)
 N8 8 3 MSC(Main Service Channel) CER
 (Character Error Rate) [8]
 R1 R3 가 CER
 () 가
 가 TOA

3.

3.1 DAB/DAB+/T-DMB

MSC CER
 3 DAB, DAB+,
 T-DMB MSC CER

가
 가 ToA

(1)

3. DAB, DAB+, T-DMB

Table 3. Criteria for Determining Reception Error Rate in DAB, DAB+, T-DMB Methods

방식	파라미터 및 측정값 기준	성능 평가
DAB	CER < 0.060	수신 가능으로 판단
	CER ≥ 0.060	수신 불가능으로 판단
DAB+	CER < 0.084	수신 가능으로 판단
	CER ≥ 0.084	수신 불가능으로 판단
T-DMB	CER < 0.090	수신 가능으로 판단
	CER ≥ 0.090	수신 불가능으로 판단

$$\begin{aligned} \text{수신전계강도 (dB}\mu\text{V/m)} &= 107 \\ &+ \text{수신채널과워 (dBm)} + \text{시스템손실 (dB)} \\ &- \text{시스템이득 (dB)} + \text{안테나팩터 (dB)} \end{aligned} \quad (1)$$

가

3.2 HD Radio

4. HD Radio 가

Table 4. Criteria on HD-Radio Measurement Evaluation

모드	측정 파라미터	측정값	성능 평가
MP3(Hybrid)	Blending Point	7, 5	Digital 신호 수신양호
		3, 1, 0	Analog 신호로 전환
MP5 (All Digital)	Blending Point	7, 5	Digital 신호 수신양호
		3, 1, 0	Digital 신호 수신불가
Only FM (Analog)	THD	< 1.8	수신양호
		≥ 1.8	잡음발생

HD-Radio FM

MP3

MP5

5. DRM+ 가
Table 5. Criteria on DRM+ Measurement Evaluation

측정 파라미터	측정값	성능평가	비고
Audio CRC	0	수신양호	
	1 이상	수신불가	Error 발생
	"-" (음수)	수신불가	음영 지역

HD-Radio 4 DAB
iBiquity (Blending Point)
Radio MP3 MP5 FM only
MP3
-10dB -20dB

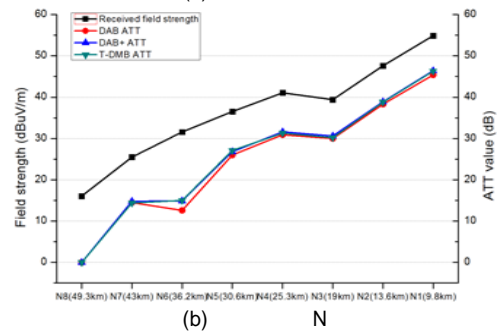
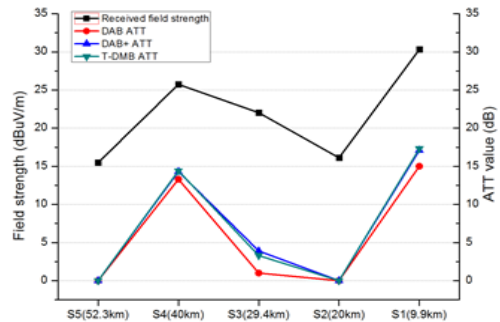
3.3 DRM+

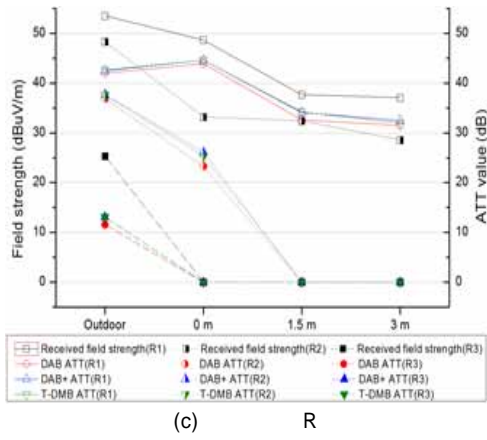
DRM+
FM 150kHz, 200kHz, 400kHz
QPSK 0.41 0.5 16QAM
DRM+ (가 / 가)
5 Audio CRC (Cyclic Redundancy Check) error
CRC error Audio Unit CRC
1 가 가
Audio CRC error 0 가
OFDM error (-) 가
Audio CRC

4.

4.1 DAB/DAB+/T-DMB

5 (a) S
S
N-LOS
S1
10km
가 ToA
가
S2 S5
가 가 , S4 S
가
DAB+ T-DMB DAB
1~2.9 dB





5. DAB/DAB+/T-DMB

Fig 5. Field test results of DAB/DAB+/T-DMB

5 (b) N

7 N

LOS 가 가

가 가

가 가

N3

N4 가 1.6dB μ V/m

N3 가

DAB+

T-DMB DAB

0.2~2.4dB 가

5(c) N

R1 10.25km

1 가

가

가

가 0m 1.5m

가 10.9dB μ V/m

가 1.5m 3m

0.6dB μ V/m

R1

가 1m, 1.5m, 3m

R2

22.15km

2

가

가

1.5m 0.7dB μ V/m

가 1.5m 3m

3.8dB μ V/m

가 1m, 1.5m, 3m

R3

32.5km

2

가

가

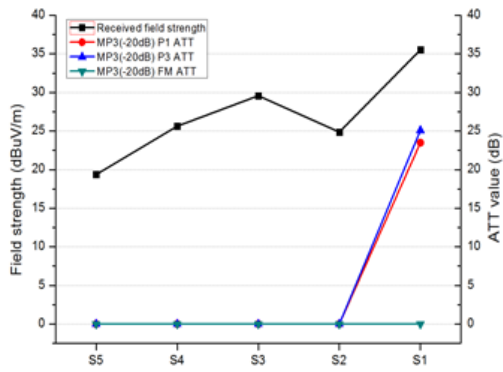
가

DAB, DAB+, T-DMB

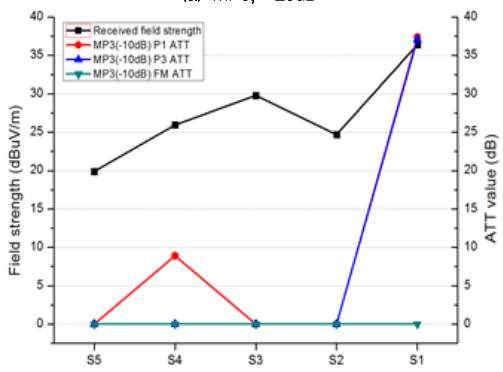
DAB+ T-DMB DAB

R1 0.5~1.6dB R2

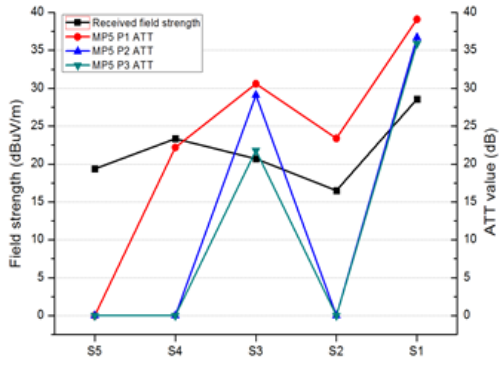
2~2.8dB 가



(a) MP3, -20dB



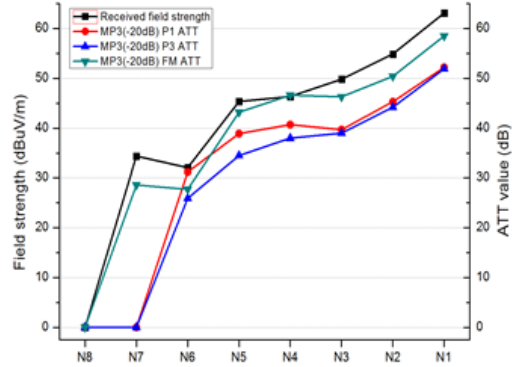
(b) MP3, -10dB



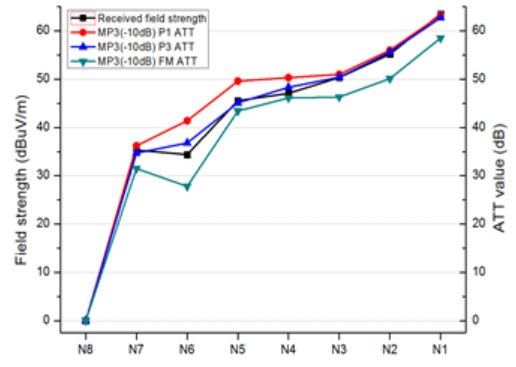
(c) MP5

6. S HD Radio
Fig 6. Field test results of HD Radio in route S

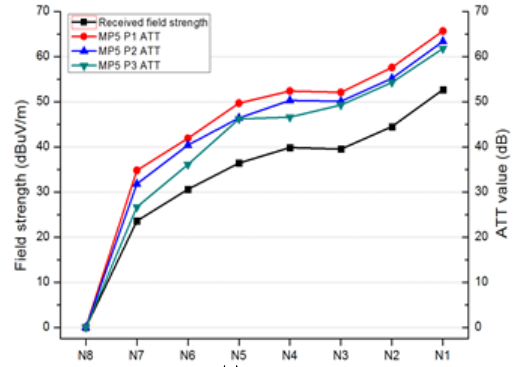
4.2 HD Radio 측정 결과



(a) MP3, -20dB

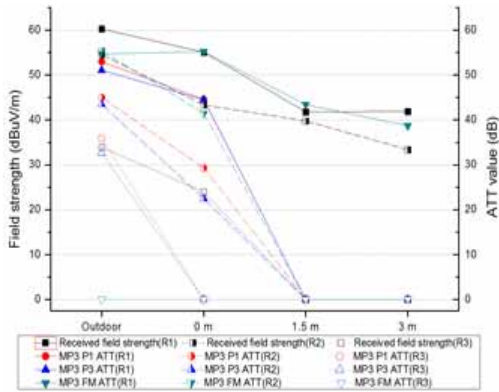


(b) MP3, -10dB

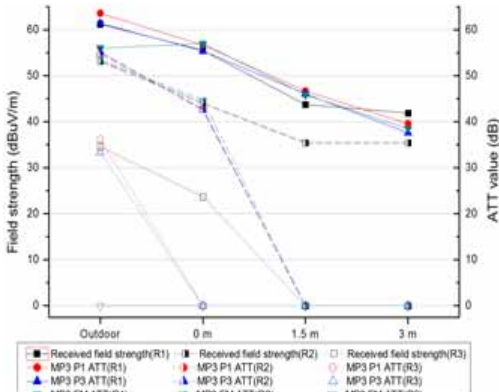


(c) MP5

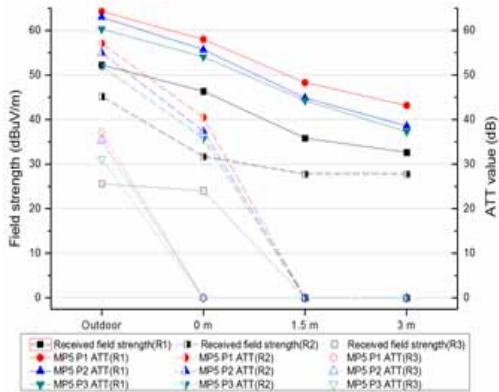
7. N HD Radio
Fig 7. Field test results of HD Radio in route N



(a) MP3, -20dB



(b) MP3, -10dB



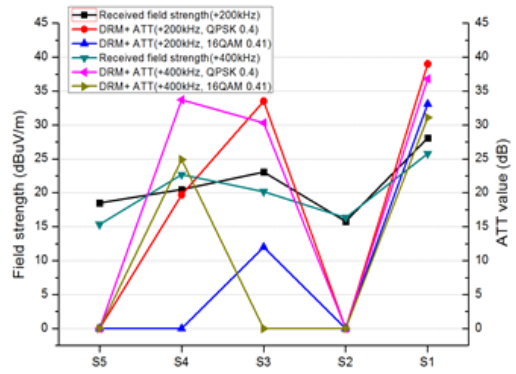
(c) MP5

8. R HD Radio

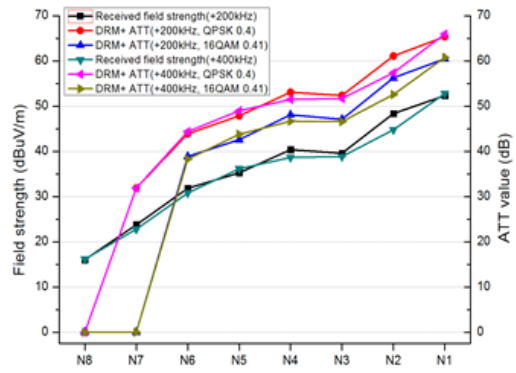
Fig 8. Field test results of HD Radio in route R

6 S HD Radio S

가
 . S2 S5
 가 가
 , S4
 가
 가 MP3 -20dB MP5
 14~16dB
 7 N
 가 가
 가
 . N3 N4
 가 1.6dB μ V/m
 가
 가



(a) 측정 루트 S

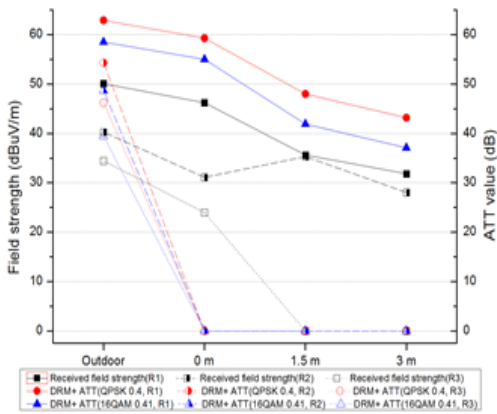


(b) 측정 루트 N

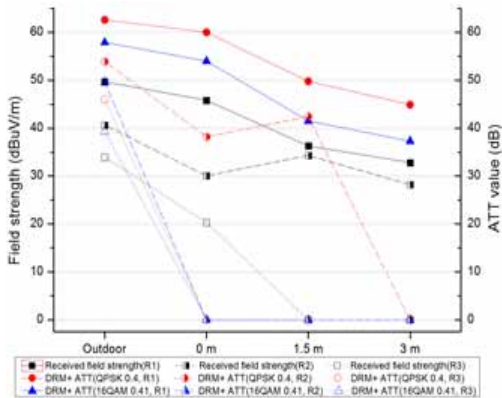
9. S N DRM+

Fig 9. Field test results of DRM+ in route S and N

8 N
 5~10dB μ V/m
 , 가
 1.5m 3m 1.5m
 가



(a) +200kHz



(b) +400kHz

10. R DRM+
 Fig 10. Field test results of DRM+ in route R

R1 R2 -20dB
 MP3 가
 가 가
 R3 가 가
 -10dB MP3 MP5 R1

가 10~15dB
 가 가 R2 가
 가 -20dB
 MP3 가 R3
 가

4.3 DRM+

9 (a) DRM+ FM
 200kHz, 400kHz
 QPSK(0.4), 16QAM(0.41) S

DRM+ S1 10km
 , S2 S5 가 가 가
 S 가 가 S4

9 (b) N

가 가 가
 가 가
 N3 N4 가 1.6dB
 μ V/m 10 N
 가
 1.5m 3m 가
 가 1m, 1.5m, 3m

가 R3
 32.57km 2
 , 가 가

가 가
 가

5.

ATT

Out of Band 가 DAB/DAB+/T-DMB Audio
 DAB+ T-DMB Audio
 가 DAB
 In Band HD Radio

DRM+ Multipath가

DRM+ Mutlipath가 가 HD Radio

DRM+, HD Radio, T-DMB 가 가
 50%

DAB, DAB+, T-DMB Audio,
 HD Radio, DRM+

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(Joo-Seok Kim)



- 2007 2 : ()
- 2009 2 : ()
- 2015 2 : ()
- 2014 5 ~ :

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(Myung-Sun Back)

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- 2005 2 :
- 2009 2 :
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(Kyung-Seok Kim)

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5G Massive-MIMO,
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DTV, DMB,