Leaving the dead-end street:
New ways for the digitisation of the VHF-FM sound broadcasting with DRM+

Part I
DRM+ Field Trial: Concept, Setup, and First Results

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I. INTRODUCTION

Digital Radio Mondiale™ (DRM) is a digital broadcasting system for the broadcasting bands below 30 MHz. It has been adopted by the ITU, and is standardised as ETSI ES 201 980 [1]. The DRM consortium is currently extending this system to the broadcasting bands up to 120 MHz. This system extension has the internal project name 'DRM+' and will be included as 'Mode E' in the DRM standard. DRM+ allows radio stations in 87.5 - 108.0 MHz frequency range to broadcast 'in digital'. **Tab. 1** summarises the key parameters of DRM+.

Tab. 1. Key parameters of DRM+ [2]

Modulation	COFDM
Sub-carrier modulation	4-QAM, 16-QAM
Number of sub-carriers	213
Sub-carrier spacing	444 Hz
RF bandwidth	96 kHz
OFDM symbol duration	2.5 ms
Guard intervall	0.25 ms
Net data rates	37 - 186 kBits/s
Audio coding	MPEG4-AAC+
Number of channels/services	1-4

Throughout March, April and May 2008, the University of Applied Sciences of Kaiserslautern has broadcast and received its experimental radio station across the southwest German city on 87.6 MHz using DRM+ in order to test compatibility with the analogue FM system as well as DRM+ coverage using the very first DRM+ receiver worldwide. Extensive field tests have been carried out to validate the trial in cooperation with Germany's Federal Network Agency (BNetzA), the German State Media Authorities of Rhineland-Palatinate (LMK) and North Rhine-Westfalia (lfm), and the Fraunhofer Institute for Integrated Circuits IIS (IIS).

This paper focuses on the field trial's concept, setup, components and measurement paradigms. Furthermore, results from the compatibility measurements as well as first estimates of DRM+ measured coverage are presented and discussed. Finally, an outlook on future work is given.

II. OBJECTIVE AND CONCEPT

The field trial mainly strived for two goals. The first objective was to verify and extend the results on system compatibility obtained for DRM+ from extensive laboratory measurements [3,4,5]. These results apply to compatibility between DRM+ and HD-Radio™ [6], respectively, into

- aeronautical radio services (VOR, VHF Omnidirectional Range and ILS (Instrument Landing System) 108.0 – 117.95 MHz),
- FM broadcasting (87.5 – 108.0 MHz), and
- narrowband FM BOS services (74.0 – 85.0 MHz).

Since the laboratory measurement procedures can not be translated into the real radio environment, DRM+ into FM compatibility is assessed by comparing the audio quality degradation perceived by an FM receiver being interfered by either DRM+ or conventional FM. Therefore, a hybrid transmitter capable of radiating either DRM+ or conventional FM was set up, cf. **Tab. 2**, denoted TX FH[1] and highlighted in red.

Tab. 2. TX characteristics.

TX name and geogr. location	FH ('Am Kaiserberg') 31 07E 46 49 / 49N 27 10 [PD] 260 m hasl, Antenne: 30 m agl		RB ('Rotenberg') 07E 46 19 / 49N 27 39 [PD] 260 m hasl, Antenne: 30 m agl
Licence period	1.3.2008 – 31.5.2008		13.3.2008 – 31.5.2008
Modulation	FM	DRM+	FM
RF carrier frequency	87.6 MHz	87.6 MHz	87.6 ... 88.1 MHz
Radiated power (RMS)	35 W (ERP)		35 W (ERP)
Antenna	ND		Directional (4-element Yagi) (Kathrein K 52 4017)
Polarisation	vertikal	vertikal	vertikal
Content	Test signals		Test signals

The schematic of the hybrid TX FH is shown in **Fig. 1**. In the context of compatibility DRM+ into FM, TX FH plays the role of the 'interfering' TX, i.e. it is used to produce a controlled 'interfering' signal. In **Fig. 2**, the characteristics of the DRM+ signal is shown. The power spectrum (**Fig. 2**a) complies with the ETSI TX spectrum mask [7]. The shoulder distance of the complex baseband signal at the input of the SMU200A is better than 75 dB. This distance goes down to 28 dB mainly due to

[1] TX location: Fachhochschule (TX FH), cf. **Fig. 6**.

saturation effects arising from amplification. Note that crest-factor (**Fig. 2**b) goes down from 11.0 dB to 6.5 dB for the same reason.

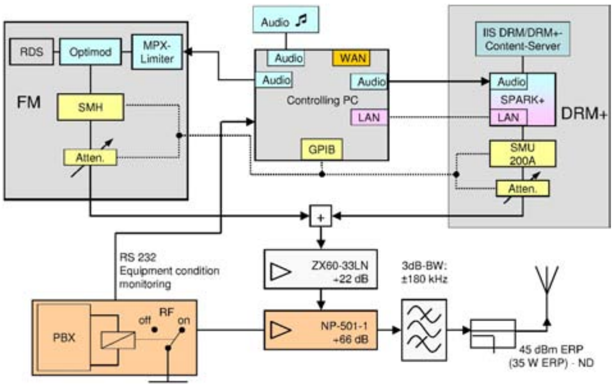
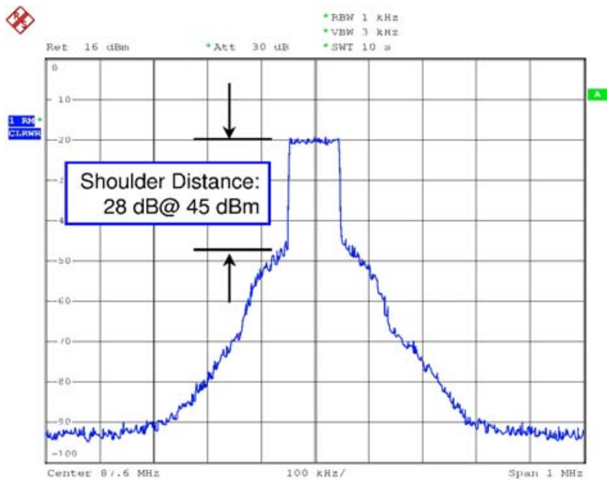


Fig. 1. Schematics of the hybrid TX FH.

The conventional FM signal - carrying audio test signals to rate the demodulated LF[2] audio quality - is generated by TX RB[3], cf. Tab. 2, highlighted in green. Thus, dealing with compatibility DRM+ into FM, TX RB acts as 'victim' TX, i.e. it delivers the signal whose quality is intentionally degraded by the interfering signal – originating from TX FH - at the receiving location. The measurement principle applied for DRM+ into FM compatibility measurements, some results obtained, and conclusions to be drawn thereof are discussed a section III.



(a)

(b)

Fig. 2. (a) PDS and (b) CCDF of DRM+ signal.

[2] The term 'LF' (Low Frequency) is used rather than 'AF' (Audio Frequency)

[3] SWR TX location: 'Am Rotenberg' (TX RB), cf. **Fig. 6**.

The second objective was to get first ideas of DRM+ coverage. The very first complete functional prototype RX for DRM+ worldwide was designed, assembled and put into operation at the end of the trial period. This prototype decodes the DRM+ signal in real-time and can deliver any MSC data via the RSCI interface to applications. Furthermore, a monitoring software allows for examining the receiver status, e.g. coded bit error rates based on PRBS in synchronous or asynchronous mode. **Fig. 3** shows the schematics of the DRM+ prototype RX.

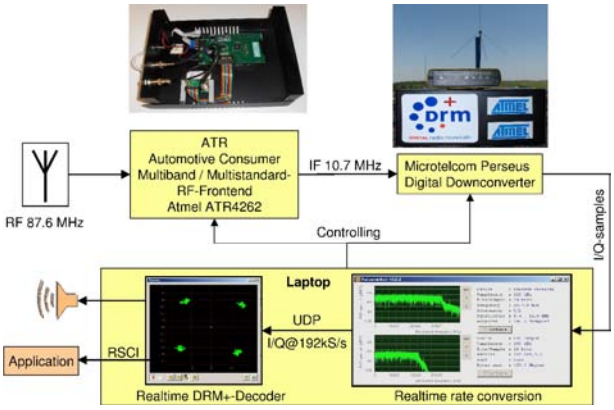


Fig. 3. Schematics of DRM+ prototype RX.

The DRM+ prototype RX consists of the Atmel ATR 4262 RF frontend [8], a Microtelecom Perseus DDC [9] which delivers the I/Q stream via USB to a state-of-the-art laptop. The latter runs the real-time sampling rate conversion software followed by the IIS prototype real-time DRM+ decoder software. Some first results on measured DRM+ coverage using this prototype are presented later on in section IV.

III. DRM+ INTO FM COMPATIBILITY

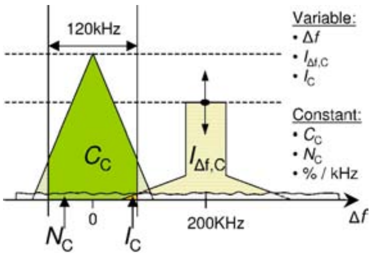
III.1. Measurement paradigm

As already stated in section II, the ITU measurement recommendations for determining protection ratios in the laboratory [10] are not applicable in the real environment. Furthermore, the well known conventional procedures of verifying nominal FM coverage as stated in [11] – often implemented in specialised measurement vans - can not be applied since these procedures

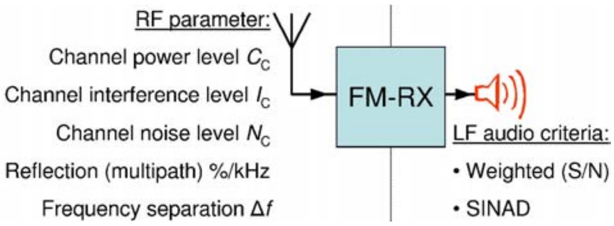
- exclusively rely on measured RF powers in a given nominal bandwidth, e.g. 100 or 120 kHz, and
- are based on FM into FM protection ratios [11].

As a consequence, analysis will always yield the same outcome regardless of modulation, RF amplitude variations e.g. of any interfering signal as long as its measured power remains the same. Thus, no information about the perceived LF audio quality can be deduced from this kind of measurement. This leads to the following problem: A DRM+ interferer and an FM interferer with equal received powers result in the same measurement finding, albeit the LF audio quality might differ significantly.

To overcome the obvious lack of applicable measurement procedures and to implement an objective assessment of the LF audio quality, the measurement principle outlined in the sequel was adopted: At a given test location, the signal at the RX input is modelled as being made up of three uncorrelated components: The 'victim' signal, radiated by the 'victim' TX, the 'interfering' signal, coming from the 'interfering' TX, and the inevitable background noise, which accounts for co-channel interferers and other components. Their respective RMS powers, measured in a bandwidth of 120 kHz, are denoted as C_C, I_C, and N_C, respectively, cf. **Fig. 4**a. The frequency separation Δf takes on integer multiple values of 100 kHz according to the European frequency grid defined for the 87.5 – 108.0 MHz frequency range.



(a)



(b)

Fig. 4. (a) Power definitions (b) RF and LF parameters.

In order to assess LF audio quality in an objective way, two well known absolute measures were used:

- Psophometrically weighted (S/N) [12], and
- SINAD [12].

Both absolute measures express audio quality; the higher the value, the better the quality. Typically, these figures are given in dB units. For example, FM protection ratios are based on a pshophometrically weighted (S/N) of 50 dB [10]. The properties of the FM receivers are described [13], but a physical implementation of a reference receiver does not exist. Therefore, audio quality depends on the concrete receiver used, which is in some way 'unaesthetic' because 'the' complete 'receiver universe' is difficult to cover. But, since the focus lies on compatibility established between coverage areas[4], planned according [10], a receiver whose (S/N) sensitivity performance fairly matches the underlying protection radio curves was used for all results shown in this paper.

III.2. Stationary reception

Compatibility was determined for two types of receiving conditions, namely stationary and mobile reception. First, the stationary measurements carried out with the BNetzA are presented and discussed. The underlying measurement paradigm for stationary reception is as follows: In a test location, the (S/N) and SINAD values were recorded for both DRM+ and FM while maintaining the RF parameters, cf. **Fig. 4**b, constant. Thus, the difference between $(S/N)_{FM}$ and $(S/N)_{DRM+}$ or $SINAD_{FM}$ and $SINAD_{DRM+}$ reveals the difference in interference potential of the interferer's modulation, provided that the multipath component of received 'victim' signal can be neglected. Therefore, all stationary measurements were carried out using a directional antenna in 10 m height above ground level, oriented towards the 'victim' TX RB. This situation is by far not the typical receiving situation, but it 'isolates' the effect of interferer modulation onto LF audio quality. This isolation gets the better, the bigger I_C as compared to N_C. Care was taken that the multipath component for stationary measurements was significantly below 2%/kHz. Inspecting the so derived difference in audio quality allows for rating the compatibility of DRM+ into FM relative to the one obtained for FM into FM in a real FM environment.

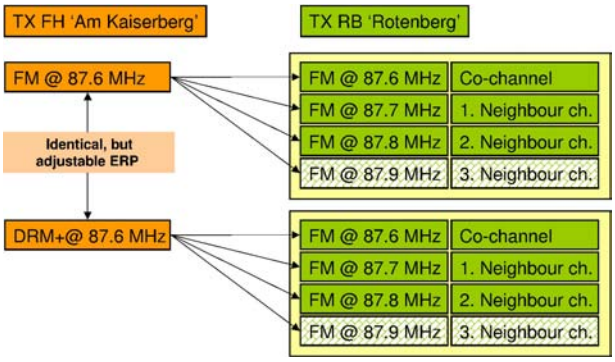


Fig. 5. Frequency constellations for compatibility measurements.

The frequency constellations used for compatibility measurements are shown in **Fig. 5**. TX RB is tuned to a frequency, e.g. 87.8 MHz, and then interfered by TX FH either in DRM+ or FM mode. Note that measurements on 87.9 MHz are only partially conclusive since a very strong FM station (SR 1, Göttelborner Höhe, 100 kW) broadcasts on 88.0 MHz in about 40 km as the crow flies.

18 locations have been chosen for stationary measurements as representative test points, cf. **Fig. 6**, based on a sequel of orienteering measurement runs. As an instructive example for the evaluation of the measurement data, test location 7 will be discussed, cf. **Fig. 7**. For a detailed presentation and discussion of all measurements the reader is referred to [14].

In **Fig. 7**, curves of similar colour denote similar Δf of the interfering signal with power I_C originating from TX FH. The interfering modulation can be distinguished by the symbols ◆ (FM) und ▲ (DRM+). For each curve, the lowest value for SINAD corresponds to the maximum interfering TX power of +45 dBm, which was lowered in 5 dB steps whilst keeping the victim TX power (TX RB) constant. In **Fig. 7**a, the rightmost point of each curve describes the 'non-interfered' case, i.e. TX FH switched off, whereas in Fig 6b, the leftmost point is valid for the

[4] Note the subtle difference between '*coverage area*' as a well defined technical spatial measure ('planned world') and '*subjective coverage*', i.e. area in which a station can be received with a given receiver ('real world'). Today, in almost all cases, the latter is by far bigger than the planned world.

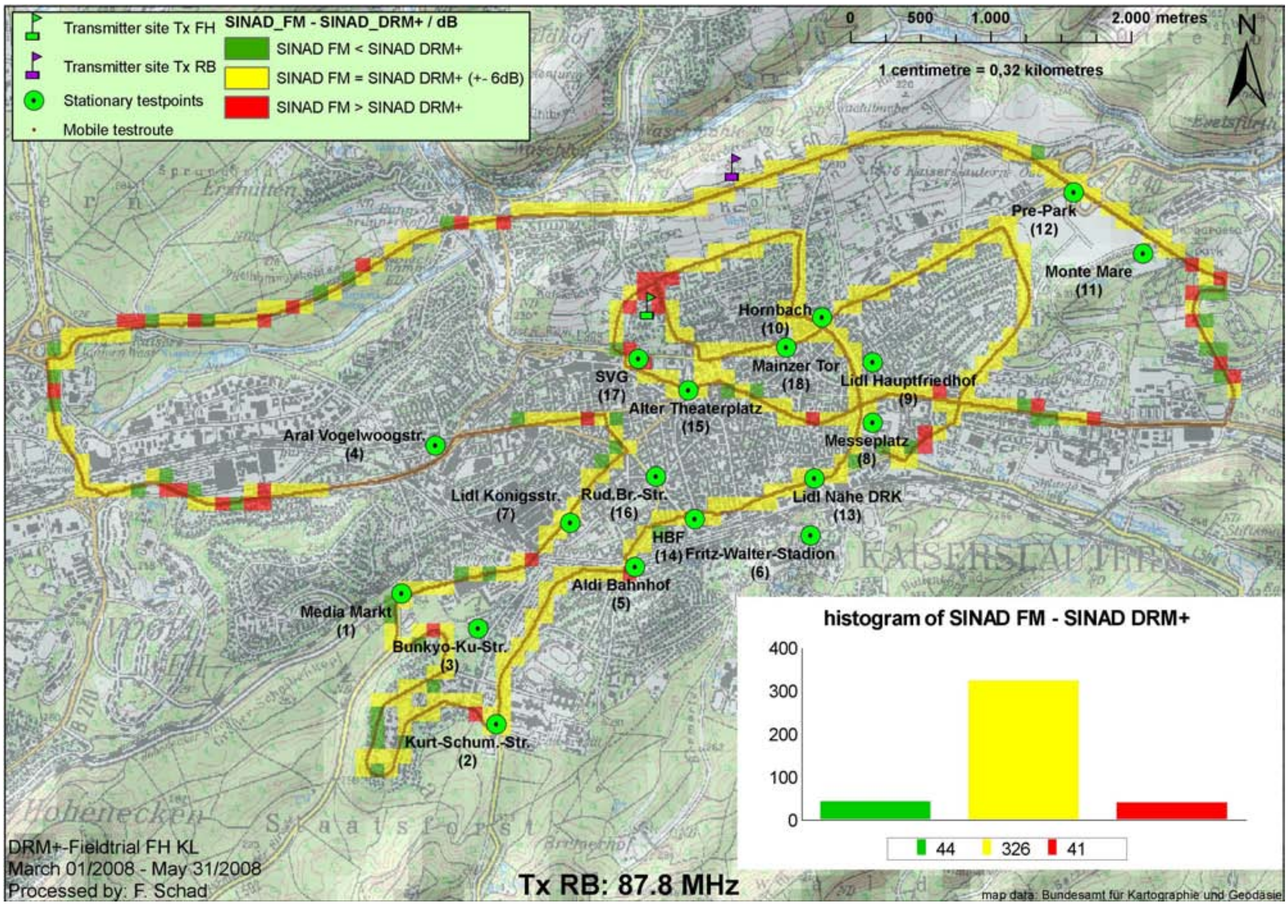


Fig. 6. TX locations, measurement routes, and $SINAD_{FM} - SINAD_{DRM+}$

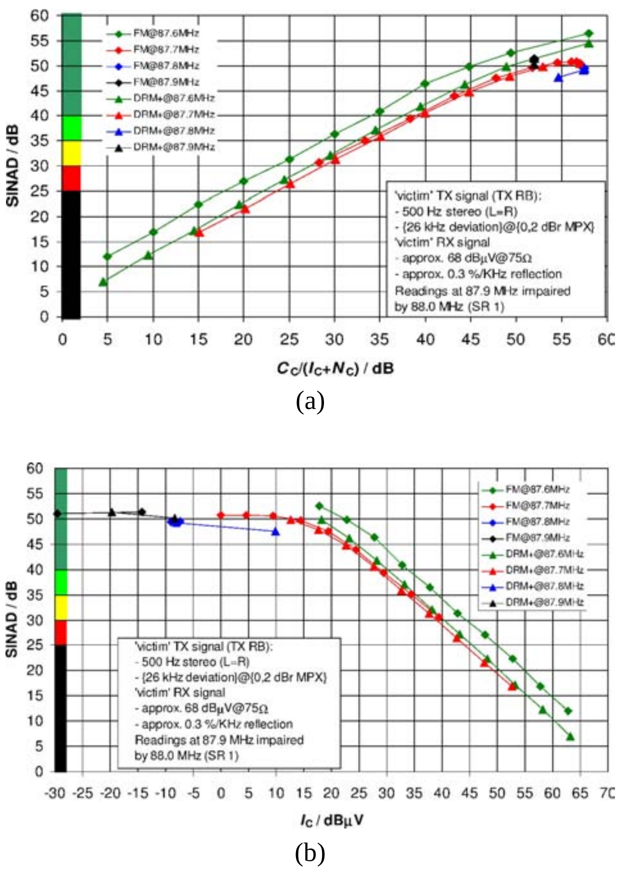


Fig. 7. (a) SINAD vs. $C_C/(I_C+N_C)$ (b) SINAD vs. I_C.

lowest interfering TX power of 0 dBm. The colour bar depicted at the ordinate represents the authors subjective rating of audio quality as follows: black: not acceptable, red: hardly tolerable, yellow: acceptable, light green: good, dark green: very good.

Inspecting **Fig. 7** suggests that SINAD is governed by two effects (as to be expected):

- The maximum is reached for minimum I_C and vice versa (that is, SINAD increases with decreasing I_C), and it's upper limit is defined by 'background noise', typically interference from other surrounding FM stations,
- since I_C denotes the interference power measured in the 120 kHz bandwidth around the 'victim' RX frequency, its influence on SINAD decreases with increasing Δf.

From the curves shown in **Fig. 7** it follows that DRM+ has a slightly higher interference potential as FM in the co-channel (green curves). For a given SINAD value, I_C can be higher for FM than for DRM+. The converse also holds: For a given $C_C/(I_C+N_C)$, FM yields a better SINAD than DRM+. Note that the two green curves are not congruent; this discrepancy clearly indicates the influence of difference in modulation. The FM modulated interfering signal shows no significant amplitude variations, but the DRM+ interfering signal does, cf. **Fig. 2**b: The received signal fluctuates more in the DRM+ case and, consequently, can produce more intermodulation in the receiver when being shifted to the IF domain.

Inspecting the first neighbour channel (red curves) shows that SINAD curves run higher as compared to the co-channel case, but DRM+ shows a higher interference potential as compared to FM. Two things might serve as explanation. First, it is noteworthy that the curves of DRM+ and FM seem to be more or less congruent – in contrast to the co-channel case. This suggests that mainly power, not modulation, determines the achievable SINAD. Second, the interference is not symmetric to the 'victim' signal, producing even higher amplitude and phase variations in the receiver as compared to the co-channel case since the interfering signal falls into the slope of the IF filter[5]. This means that DRM+ power needs to be even more reduced as compared to the symmetric (co-channel) case to result in the same SINAD value as FM. This could explain why the relative difference between FM and DRM+ in terms of achievable SINAD is bigger than in the co-channel case. This difference decreases with decreasing I_C, i.e. with increasing SINAD.

The situation in the second neighbour channel (blue curves) and third neighbour channel (black curves) is mainly determined by power since the respective curves coincidence, too. But, taking a SINAD of 40 dB as criterion for compatibility, then, in this case, both the DRM+ and FM interferer are to be considered compatible with the 'victim' TX at this test point. Taking the psophometrically weighted (S/N) as criterion, the results and curves obtained are similar to those presented in **Fig. 7** though, the above discussion qualitatively applies to (S/N), too.

III.3. Mobile reception

As mentioned before, mobile reception was the second receiving scenario under investigation. The measurements described hereafter were carried out together with the lfm using the lfm's measuring van. The measuring route, cf. **Fig. 6**, was also chosen to represent the RX conditions met in the coverage area of TX RB. As for the stationary case, the frequency constellations from **Fig. 5** were measured along the route. The route comprises a highway section as well as inner city parts incl. traffic lights and passes as many stationary test locations as possible. The speed of the van varied from 0 km/h to 120 km/h, depending on traffic situation. A $\lambda/4$ dipole mounted on the roof of the van was used as receiving antenna. Along the route, two measurement systems were used in parallel. The first system records and evaluates FM quality in an automated fashion (Audemat measurement system with software Golden Ear [15]), the second determines the SINAD value. Both systems store the data along with a geographical reference based on GPS, so that it can be analysed and cartographically displayed with any appropriate GIS software.

In what follows, one result will be presented and discussed as being representative for lots of measurements and subsequent analyses [14]. Referring to **Fig. 6**, the green, yellow and red pixels along the route denote the difference of SINAD values, $SINAD_{FM} - SINAD_{DRM+}$, quantised as follows: (-∞...-6 dB [green]], (-6 dB ... +6 dB [yellow]], (+6 dB ... ∞ [red]). The results given in **Fig. 6** describe the situation encountered along the route when the 'interferer' TX FH operates at 87.6 MHz and 'victim' TX RB at 87.8 MHz, both radiating with full power, i.e. +45 dBm. As can be seen from **Fig. 6**, again, DRM+ and FM seem to be equivalent in terms of interference potential since the yellow pixels clearly dominate along the route. An exception is the vicinity of the interfering TX FH, where the dominating interfering signal is very strong as compared to background noise ($I_C >> N_C$) and the DRM+ amplitude variations result in a lower SINAD value as compared to FM.

Analysing and comparing stationary and mobile reception results shows that the conclusions drawn from the stationary scenarios can be applied to the mobile scenario.

IV. DRM+ COVERAGE

Since the very first DRM+ prototype receiver worldwide - briefly sketched in section II - was operational in May 2008, only first rudimental tests and measurements for DRM+ coverage could be made to get a very first, probably incomplete picture of achievable DRM+ coverage. Nevertheless, these first impressions are presented and discussed shortly in the sequel. A proper definition of suitable DRM+ quality measures, of methods to compare DRM+ quality with FM quality as well as a systematic measurement campaign is planned, but still outstanding, cf. section VI.

In order to get an impression of DRM+ coverage, the roles of the TX need to be interchanged: The hybrid TX FH now serves as 'victim' TX, whereas TX RB acts as 'interfering' TX radiating FM modulated signals. This change allows for direct comparison of FM and DRM+ coverage in a given location, just by altering the modulation of TX FH. The receivers (FM and DRM+) were installed in the FH's measurement van. A $\lambda/4$ dipole mounted on the roof of the van served as receiving antenna.

Two types of preliminary coverage tests were performed:

- The coded bit error rate based on asynchronous PRBS mode (4 QAM) was recorded, and
- a subjective comparison of perceived audio quality (HE AAC and FAAC vs. moderately compressed FM stereo) was made.

These tests were done for stationary as well as for mobile reception. **Fig. 8** shows an example of the first DRM+ coverage tests. In Fig. 8, the colour of each point indicates the measured FM SINAD quality: grey: no reception; red: 6 – 25 dB; yellow: 26 – 34 dB; green: 35 – 50 dB.

[5] Cf. the 'classical' FM to AM conversion using the rising half of the frequency characteristics of a tuned circuit.

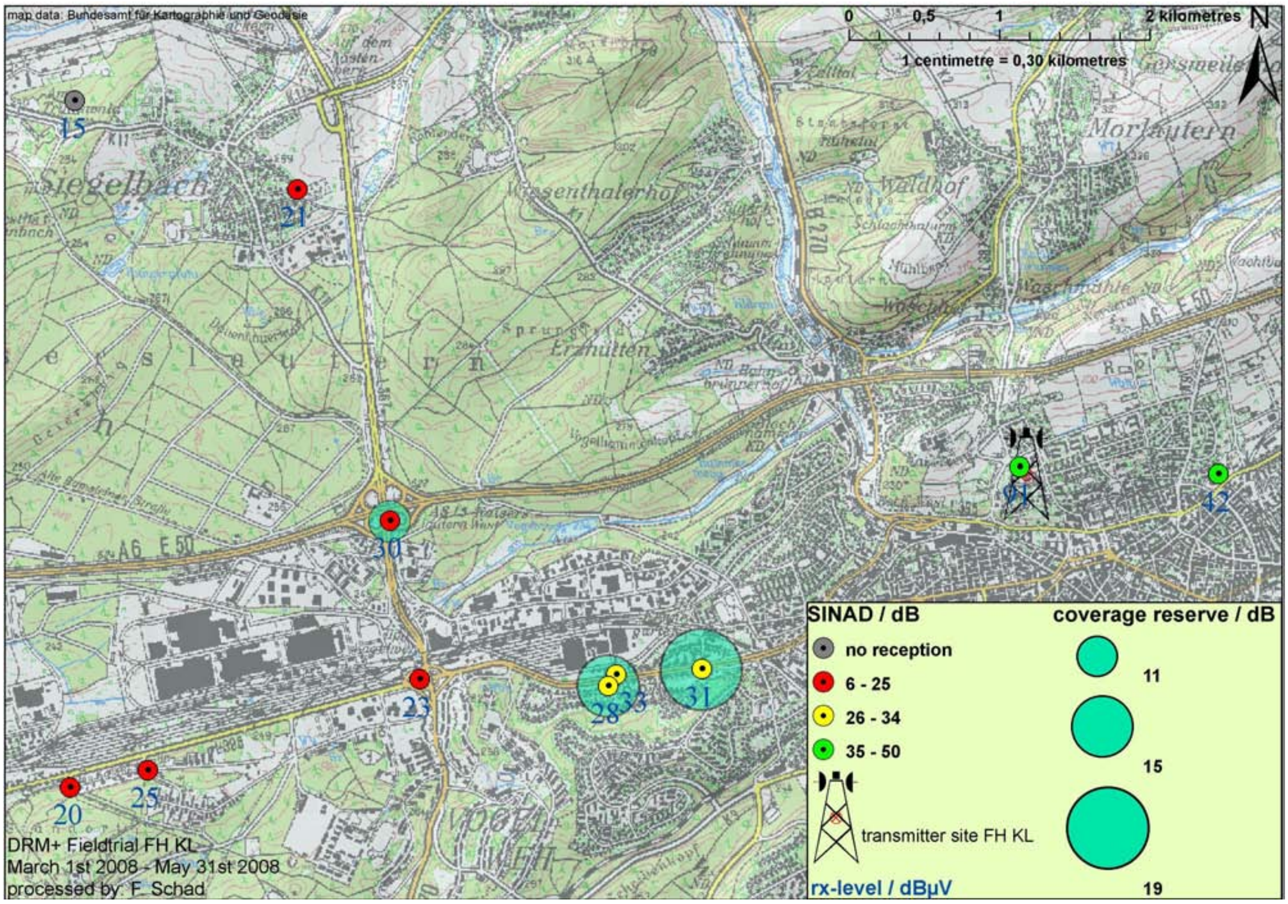


Fig. 8. First DRM+ coverage results.

The figures nearby each point give the received voltage in dBµV, which is the same for FM and DRM+ since both signals originate from TX FH. Note that in one location (upper left point in Fig. 8, 15 dBµV) the FM receiver did not demodulate the signal. In contrast, reception of the MSC (4 QAM, robustness mode medium) for each point in Fig. 8 was stable. In order to get a feeling of DRM+ 'coverage reserve', the following procedure was applied in some locations:

(1) TX FH radiates FM with full power;

(2) TX power is reduced until the demodulation of the signal breaks down ($TX_{FM,LIMIT}$);

(3) TX FH is switched to DRM+ and set to full power;

(4) TX power is reduced up to the point where the DRM+ decoding stops ($TX_{DRM+,LIMIT}$).

The difference $\Delta_{CR} = TX_{DRM+,LIMIT} - TX_{FM,LIMIT}$ is a rough measure of 'coverage reserve'. In Fig. 8, the figures associated with the green circles indicate the Δ_{CR} observed in three locations (11 dB, 15 dB, 19 dB). Note that in all receiving conditions a positive Δ_{CR} was obtained, even far out of the 'nominal' FM coverage area of TX FH.

V. CONCLUSIONS

Based on all present findings on compatibility of DRM+ into FM, the following conclusions seem to be obvious:

- As compared to the outcomes of the laboratory measurements, compatibility of DRM+ into FM is much easier to achieve in real world reception conditions. This phenomena arises from the fact that
  - the background noise limits the RF dynamics (and thus LF quality),
  - the received signal is made up of many statistically independent signal components of different power levels (not only two, i.e. the 'victim' and the 'interferer') which help to reduce the influence of the fast amplitude variations of the DRM+ signal on quality.
- DRM+ signals feature a higher crest factor than FM signals (6 … 12 dB, cf. **Fig. 2**b as compared to 3 dB), leading to a higher intermodulation potential in typical FM receivers, resulting in a higher degradation of perceived LF quality. This means that a DRM+ signal has an inherently higher absolute interference potential as compared to FM as long as it not filtered out before the first mixer stage.
- The pshophometrically weighted (S/N) of 50 dB, which is the basis for the planning standards for FM sound broadcasting networks, is merely achieved in real world reception conditions, irrespective of whether the receiver has this sensitivity or not. This is

due to the inevitable background noise (i.e. co-channel interference) as already stated before.

- Provided proper bandpass filtering at the TX output, cf. **Fig. 1**, the field trial outcomes propose that – as compared to FM to achieve compatibility - for
  - Δf = 0 kHz (i.e. the co-channel case) the DRM+ power needs to be lowered by about 5 dB,
  - Δf = ±100 kHz the DRM+ power needs to be lowered by about 5 … 15 dB, depending on the absolute value of the interference power (a high interference power means higher reduction),
  - Δf = ±200 kHz the DRM+ power needs to be lowered, too, but the LF quality achieved is already good,
  - Δf > ±200 kHz compatibility is not an issue.
- In the vicinity of a DRM+ TX, where the DRM+ signal typically dominates the received signal, the interference potential of DRM+ is generally higher as compared to FM.

The first steps undertaken to assess DRM+ coverage as compared to FM propose the following:

- In locations, where FM can be demodulated with 'tolerable' quality, DRM+ can be decoded.
- DRM+ seems to have a greater coverage area than FM. But, since reception is often interference limited (and not noise limited), and the coverage area of DRM+ will probably be higher than the one of FM, and it is likely that DRM+ has – within the coverage area – a higher coverage reserve, see also the discussion in Part II of this paper [16].

To summarise: DRM+ and FM could coexist in the 87.5 – 108.0 MHz frequency band, provided that - inter alia - the completely outdated planning criteria [11] are revised, cf. section VI.2.

VI. OUTLOOK

VI.1. Kaiserslautern

Just when passing this paper to press, the trial license for the setup described in section II has been renewed until 31 December 2008. Therefore, the topic of evaluating practical DRM+ coverage can be examined more systematically. Another issue which could be investigated is 'real' compatibility FM into DRM+ (i.e. the inverse to the situation discussed in section III). Prior to these field investigations,

- the complete DRM+-chain should be gauged with respect to linearity, phase noise, noise figure and decoder performance,
- appropriate performance measures for DRM+ decoding should be identified, e.g. RX sensitivity, resulting error rates (MSC, audio frame CRC), 'Out-of-Service' criteria, and,
- the laboratory protection ratios FM into DRM+ should be measured.

Based on this work, systematic field measurement campaigns should be defined, carried out, and analysed.

VI.2. Consortium

In order to proceed in the DRM matter, the authors recommend submitting a DRM-standard proposal which includes Mode E (DRM+) as 'DRM+ Release 1.0' to ETSI for adoption as soon as possible. This finalises the first standardisation step and allows for introducing first releases of DRM+ into potential markets.

Since further studies are necessary to guarantee smooth introduction and/or migration of DRM+ in the VHF Band II in those places where analogue FM sound broadcasting is so widespread that the available spectrum is scarce, release 1.0 should depict a roadmap for future releases of DRM+[6]. The release roadmap extends DRM+ Release 1.0 to cope with the scenario depicted above.

To allow testing, reference implementations of soft- and hardware for both TX and RX need to be built up as a complete test floor, enabling system testing, evaluation, and validation.

As for future releases, the following items should be carefully investigated, as e.g.:

- Definition and validation of
  - methods/algorithms to reduce crest factor on TX side,
  - methods/algorithms to guarantee a smooth degradation in audio quality[7], by e.g. suitably combining audio coding, channel coding and hierarchical subcarrier modulation, or by other means,
  - DRM+/FM hybrid mode for flexible simulcast operation [16], which is a technical USP as compared to HD-Radio™ .
- Laboratory measurements and field trials
  - with SFN networks,
  - simulcast operation, and
  - high power operation (up to 1 kW RMS)

In order to create a litigable basis for DRM+ - which is the prerequisite of all licensing for *regular* operation - adaptations and/or modifications to ITU-recommendations should be tackled, e.g.:

- [10] describes a procedure for the identification of interference between FM signals. An extension for the determination of interference experienced by digital systems and originating from digital systems is necessary. The FM audio criterion used to determine the protection ratio does neither produce audible interference nor reflect today's FM broadcasting reality. It should be modified in such a way that audible interference is evaluated, e.g., based on SINAD (c.f. e.g. SINAD's application in narrowband FM radio systems [17]). In addition, this value should be defined for typical FM receivers, e.g. portable devices, automotive devices etc.

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[6] Cf. the UMTS standardisation process.

[7] Listeners are unaccustomed to 'all of the sudden' audio outage, a typical problem of all today's digital transmission schemes.

- [11] prescribes a planning procedure which accounts neither for today's FM receiving scenarios nor for today's FM receiver technologies. As a consequence, the predicted TX coverage areas do – by far – not coincidence with those areas where FM reception is actually possible. New and/or modified FM protection ratios (modified ITU-R BS.641) need to be defined, and protection ratios for digital into analogue scenarios and vice versa must be included.
- [13] defines a reference receiver which is not representative for today's receiver universe. The technical parameters should be revised. In addition, new reference receivers should be defined for different receiving scenarios. Digital reference receivers should be included.
- [18] suggests a measuring procedure to assess the interference potential of FM broadcasting services into aeronautical radio services above 108.0 MHz. New protection ratios based on digital systems as interferer must be included.
- [19] only describes DAB, ISDB und HD-Radio. DRM+ needs to be included.

Last but not least, scenarios for introduction and deployment of DRM+, especially for local and regional coverage scenarios, need to be developed.

VI.3. A non technological remark

The authors are aware of the fact that, besides technical items, other activities, especially commercial and marketing ones, need to be intensified, too. Based on Bill Clinton, one could say '*It's the content, stupid*'. This provoking statement applies to *all* digital broadcasting schemes, not only to DRM+. This attractive content must be such that it can not be broadcast to the listeners with analogue technology. Furthermore, the famous chicken egg problem - no attractive content means no business and listeners, but without business and listeners, there is no interest in investing in digital broadcasting technology - is to be solved. Otherwise, frustrated technophile pioneers will soon 'bury' DRM and DRM+ as being 'yet another unsuccessful expensive try', like some of them obviously already did for DAB by redictating DAB as Dead And Buried [20].

ACKNOWLEDGEMENTS

The authors would like to thank the following companies/institutions/authorities/… for their valuable material and/or technical support: Federal Network Agency (BNetzA), Robert Bosch GmbH, Deutsche Flugsicherung GmbH, Südwestrundfunk (SWR), Dolby Germany GmbH, ARD.ZDF medienakademie, LfM Nordrhein-Westfalen, Ruoss AG, LfK Baden-Württemberg, Microtune Inc., Radio RPR, BMW, Media Broadcast GmbH, PURE digital, NP Technologies Inc., Institute for Communications Technology at the University of Hannover, ATMEL Germany GmbH. Note that the enumeration does not reflect *any* whatsoever weight.

Special thanks goes to Rohde & Schwarz Vertriebs-GmbH for materially supporting all our work done for DRM+ up to now by lending outstanding equipment, e.g. the vector signal generator SMU200A or the audio analyser UPV.

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