The launch of the FM broadcasting system in the middle of the 20th century constituted an enormous improvement compared to AM. Nevertheless it turned out that car radios cannot reach the performance level of stationary receivers. Therefore in Europe the RDS system has been developed. It provides among other features for increased convenience also specific functions to overcome the performance problems of car radios to a large extent.

RDS is the most complex technology to receive analog broadcasting stations. To use this technology to the full extent it requires a lot of know how about the specific reception problems in the field, RDS and reception technology in general. All this leads to a large and very complex software solution.

This paper describes the main reception problems of car radios. The basic features of RDS are explained shortly. The main part of this essay deals with the software and the required tools. It is shown, based on three key issues, how these problems can be solved with high sophisticated software. The tool for monitoring the behaviour in the field, dedicated for detailed analysis and evaluation, is explained in detail. At the end the results of different test drives show the evidence that this new RDS software developed by Technical Center Nuremberg has reached a performance which is state of the art.
RDS - Introduction.

Heavy distortion due to missing parts of the FM signal spectrum

Fluctuating noise occurring each time the signal level falls below the limiting threshold of the receiver

Periodical noise bursts (paling fence effect) in case the fading signal is dominated by two main paths with Doppler shift

The Radio Data System -RDS-

The RDS system is a digital audio broadcasting service that transmits data on a carrier frequency different from the audio frequency. It is used to broadcast information such as news, sports, weather, and traffic updates. The RDS system consists of a network of transmission stations that broadcast the RDS data over the FM radio spectrum. The data is transmitted in a structured format, allowing the receiver to extract the information and display it on the screen.

- Heavy distortion due to missing parts of the FM signal spectrum
- Fluctuating noise occurring each time the signal level falls below the limiting threshold of the receiver
- Periodical noise bursts (paling fence effect) in case the fading signal is dominated by two main paths with Doppler shift

The RDS system is a digital audio broadcasting service that transmits data on a carrier frequency different from the audio frequency. It is used to broadcast information such as news, sports, weather, and traffic updates. The RDS system consists of a network of transmission stations that broadcast the RDS data over the FM radio spectrum. The data is transmitted in a structured format, allowing the receiver to extract the information and display it on the screen.
2.1 Description of important group types
In all groups are available:

• uniquely identifies a program and the country in which the program is broadcast
• allows selection of a program independent of a frequency
• allows automatic frequency changes to frequencies transmitting the same or related programs.

<table>
<thead>
<tr>
<th>Group 0A</th>
<th>Group 2A, 2B</th>
</tr>
</thead>
</table>

2.2 How to perform sophisticated network following

The radio normally has different detectors for

• fieldstrength
• FM
• AM
• DAB

Additional detectors

• DAB
• FM

2.2.1 Fieldstrength:
2.2.2 Multipath:

2.2.3 USN:

Offset:

2.3 Conclusion

2.4 Traffic program and enhanced other networks (TP and EON)
The indication for the program is called TP (traffic program).

The indication for the announcement is called TA (traffic announcement).

3.1 NF-Following

The indication for the program is called TP (traffic program).

The indication for the announcement is called TA (traffic announcement).

RDS - The Software

3.2 The Improvements

- The indication for the program is called TP (traffic program).
- The indication for the announcement is called TA (traffic announcement).

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3.3 The tunnel situation

3.3.1 The Tunnel with AF

3.3.2 The tunnel without AF

3.4 EON - Enhanced Other Network
3.5 The Tool NF-Trace

The NF-Trace tool is designed to help users understand and improve the performance of their network. It allows for the capture and analysis of network traffic, providing insights into how data is transmitted and what might be causing delays or other issues.

To use NF-Trace, the tool needs to be installed on the network devices being monitored. Once installed, it begins to collect data on network activity. This data can then be analyzed to identify patterns and anomalies.

3.5.1 NF-Trace User Interface

The user interface of NF-Trace is intuitive and easy to use. It allows users to select the devices they want to monitor, and then to view various metrics such as network latency, packet loss, and bandwidth usage.

Additionally, NF-Trace provides a range of tools for troubleshooting network problems. These tools can help identify the cause of issues, such as slow performance or failed connections, and provide recommendations for solutions.

Overall, NF-Trace is a powerful tool for network monitoring and management, providing valuable insights into how data is transmitted and how network performance can be improved.
3.5.2 RDS Group Decoder

<table>
<thead>
<tr>
<th>PI</th>
<th>PSN</th>
<th>PTy</th>
<th>TP</th>
<th>TA</th>
<th>EON</th>
<th>EON Alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>D313</td>
<td>DAYERN3</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- **RI**: データシンベースオペレータとの通信
- **PSN**: データシンベースオペレータの識別
- **PTY**: プログラムの種類
- **TP**: データシンベースオペレータの頻度
- **TA**: データシンベースオペレータの周波数
- **EON**: エンターテイメントオペレータの識別
- **EON Alarm**: エンターテイメントオペレータの周波数

3.5.3 The Stream Decoder

3.5.4 The actual frequency

<table>
<thead>
<tr>
<th>Freq</th>
<th>FS</th>
<th>Offs</th>
<th>USN</th>
<th>Mpath</th>
<th>Stereo</th>
<th>BWCtrl</th>
<th>SBlend</th>
<th>HiCut</th>
<th>SMute</th>
<th>RDSSync</th>
<th>RDSQual</th>
</tr>
</thead>
<tbody>
<tr>
<td>97900</td>
<td>46</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>84</td>
<td>99</td>
<td>98</td>
<td>255</td>
</tr>
</tbody>
</table>

3.5.5 The Alternative Frequency List

- **Freq**: アルタルテイオン周波数
- **FS**: アルタルテイオン周波数の設定
- **Offs**: アルタルテイオン周波数のオフセット
- **USN**: アルタルテイオン周波数の識別
- **Mpath**: アルタルテイオン周波数のマップ
- **Stereo**: ステレオモード
- **BWCtrl**: ブロードキャストコントロール
- **SBlend**: サブレンジモード
- **HiCut**: ハイカットモード
- **SMute**: スマットモード
- **RDSSync**: RDS同期
- **RDSQual**: RDS品質
Alternative Frequency List

<table>
<thead>
<tr>
<th>Freq</th>
<th>PH</th>
<th>Exp</th>
<th>Ngh</th>
<th>FS</th>
<th>NS</th>
<th>MP</th>
<th>FFS</th>
</tr>
</thead>
<tbody>
<tr>
<td>97900</td>
<td>+</td>
<td>0</td>
<td>46</td>
<td>0</td>
<td>0</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>99300</td>
<td>+</td>
<td>0</td>
<td>10</td>
<td>3</td>
<td>3</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>94400</td>
<td>??</td>
<td>1</td>
<td>20</td>
<td>3</td>
<td>2</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>94700</td>
<td>??</td>
<td>1</td>
<td>12</td>
<td>3</td>
<td>3</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>99800</td>
<td>??</td>
<td>1</td>
<td>10</td>
<td>3</td>
<td>3</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>99400</td>
<td>??</td>
<td>1</td>
<td>10</td>
<td>3</td>
<td>3</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>99500</td>
<td>??</td>
<td>1</td>
<td>10</td>
<td>3</td>
<td>3</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>99600</td>
<td>??</td>
<td>1</td>
<td>10</td>
<td>3</td>
<td>3</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>97600</td>
<td>??</td>
<td>1</td>
<td>10</td>
<td>3</td>
<td>3</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>95800</td>
<td>??</td>
<td>1</td>
<td>59</td>
<td>0</td>
<td>0</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>95300</td>
<td>??</td>
<td>1</td>
<td>11</td>
<td>3</td>
<td>2</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>98300</td>
<td>??</td>
<td>1</td>
<td>10</td>
<td>3</td>
<td>3</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>98500</td>
<td>??</td>
<td>1</td>
<td>10</td>
<td>3</td>
<td>3</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

3.7 Evaluation

The table above shows the alternative frequency list for the RDS system. Each row represents a possible frequency with its associated parameters. The columns indicate the frequency, phase (PH), exponential (Exp), number of phases (Ngh), signal strength (FS), noise strength (NS), modulation type (MP), and FFS result. The FFS result indicates whether the frequency is suitable for transmission, with 'ok' indicating a suitable frequency.

3.6 Analysis

The analysis section provides a detailed examination of the frequencies listed above. It discusses the suitability of each frequency for transmission based on various factors, such as signal strength, noise level, and modulation type. The analysis evaluates the performance of each frequency and suggests recommendations for optimal transmission.

The evaluation focuses on the following key points:

- Signal strength: The signal strength is a critical factor in determining the effectiveness of the frequency. Frequencies with higher signal strength are generally preferred.
- Noise level: A low noise level indicates a more reliable transmission. Frequencies with lower noise levels are recommended for higher quality transmission.
- Modulation type: The type of modulation used affects the efficiency and robustness of the frequency. Frequencies that support a higher modulation type are preferable.

The analysis also considers the impact of environmental factors on frequency selection, such as distance from the transmitter and local interference. It concludes with recommendations for optimal frequency selection based on the analysis.

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**Test Drives Results**

4.1 How to score?

<table>
<thead>
<tr>
<th>Mute and check PI code</th>
<th>NF (network following - switch to an alternative frequency)</th>
<th>If PI code is wrong switch back miss change appears.</th>
<th>If mute or miss change appears please note how often, how long.</th>
</tr>
</thead>
</table>

4.2 Dedicated test drive results.

4.2.1 Forchheim

Test Items: Sound, Noise, Multipath, Adjacent, Mute / Miss Changes and Network following.

4.2.2 Bacharach

Test items: Ultra weak signal, Mute / Miss Changes, Noise
4.2.3 Austria, Tauern motorway
Test items: Tunnel network following, Multipath, Network following

4.2.4 UK EON Network following.
Test Items: EON
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