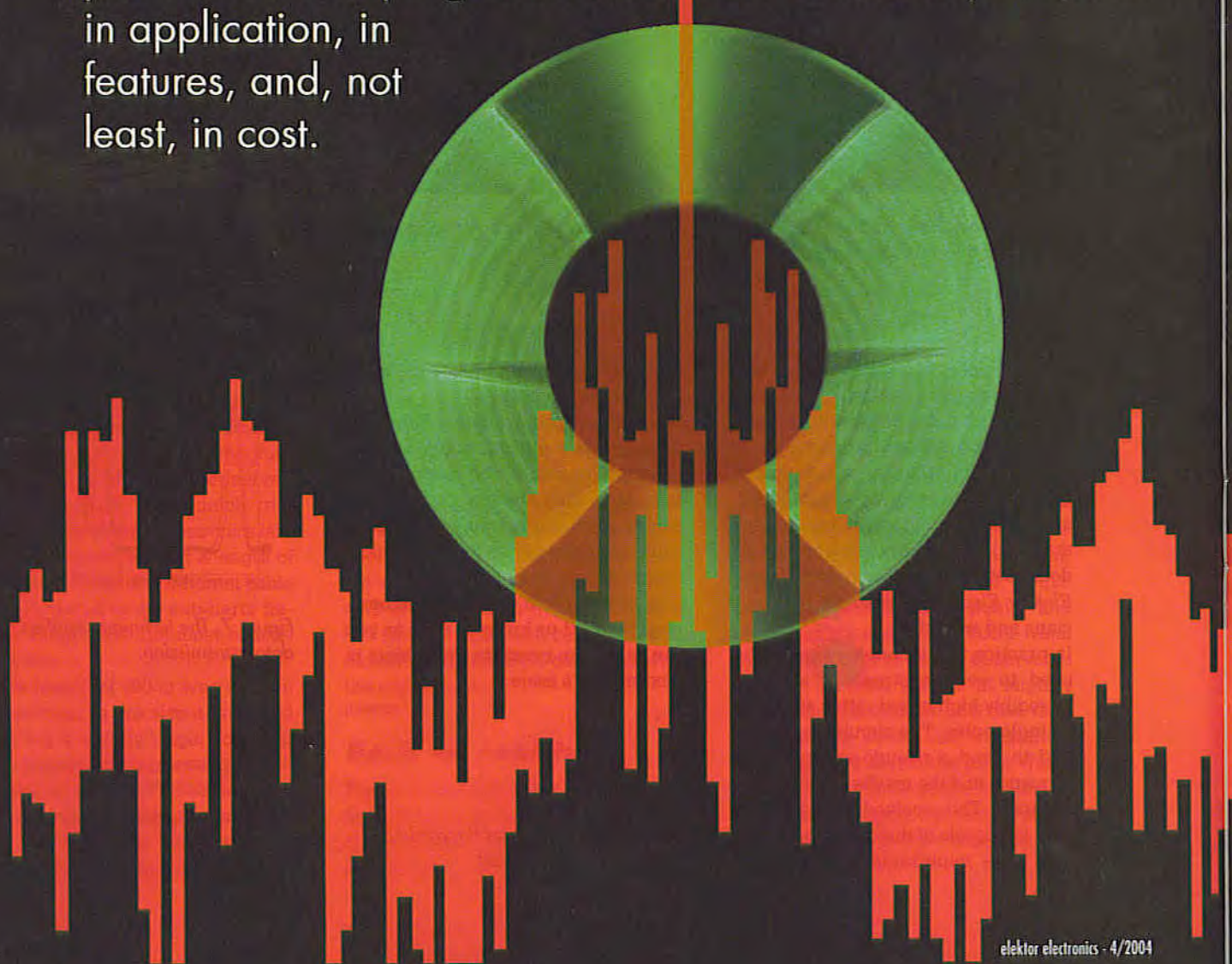
Burkhard Kainka

DREAM TEAM

Software DRM receiver

Low-cost digital radio receivers for short- and medium-wave are not yet on the market. There is, however, software available for processing DRM signals on a PC which can be used during the evaluation and changeover period. The two programs that have been developed differ in application, in features, and, not least, in cost.



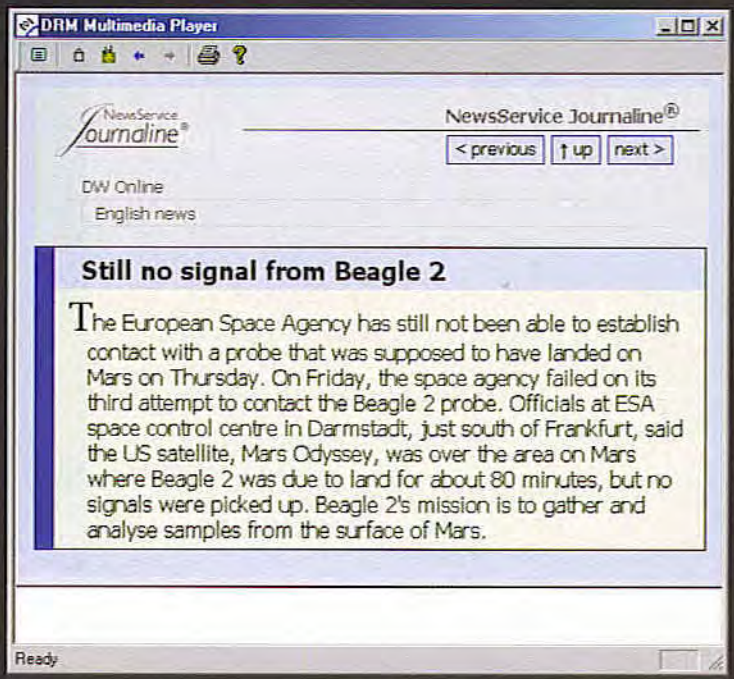


Figure 1. DRM can also carry text and images. Here is a example from the Deutsche Welle (German world service) news service, displayed using the DRM Software Radio program via a multimedia player.

Whether you use a modified world radio or the *Elektor Electronics* DRM receiver to surf the digital wave, you will need a software decoder running on a PC. This program takes the signal input to the sound card and decodes the data stream from it, which it returns as audio data to the sound card for output. There are at the moment two programs available: the 'DRM Software Radio' developed by Fraunhofer IIS, and the open source project 'DREAM', run by Volker Fischer and Alexander Kurpiers of the Communications Technology Institute at the University of Darmstadt.

A significant difference between the two programs lies in the requirements on the input signal. The standard intermediate frequency used is 12 kHz, putting the 10 kHz-wide band of the DRM signal between 7 kHz and 17 kHz. The DRM Software Radio allows a maximum deviation in the intermediate frequency of 500 Hz, whereas DREAM can decode DRM signals anywhere in the range from 0 kHz to 24 kHz.

DRM with text and images

'DRM Software Radio' is a commercial program and can be ordered online from www.drmrx.org for about 60 Euros. Each user is given their own software key and is automatically registered. The user can then take part in the DRM field trials and send in reception reports. Reception reports, especially from Europe, can certainly influence broadcasters' plans. The DRM Software Radio homepage gives information as to which stations can be received in which areas.

The function of the software as a DRM demodulator and decoder has already been described in the article 'Build your own DRM Receiver' project in the previous (March 2004) issue of *Elektor Electronics*.

DRM can carry more than just speech and music. As well as the 'audio service', information such as the name of the station and news headlines is also broadcast: these can be viewed as a scrolling or as a steady display. Some broadcasters also transmit images or other information using a format similar to the World Wide Web. The DRM Software Radio program makes these additional services available via a multimedia player. When a particular service is available, a click in the corresponding area in the window starts the player. After a delay while the requested data is collected, it is displayed. In this way, for example, the Deutsche Welle (German world service) transmitter in Jülich on 6140 kHz has recently started an additional service called 'Journaline', carried alongside the audio signal. A click in the audio window opens the multimedia player; in the background news summary information (in both English and German) is collected, and, after a delay, the pages of news can be viewed. This service works even when reception conditions mean that the audio signal breaks up: the news text still gets through, although it may take a little longer. **Figure 1** shows an example from the English-language 'Journaline' service.

Open Source Project

In contrast to tahe 'ready to run' DRM Software Radio, the DREAM open source project requires a little preparatory work. The authors have made the program available only as C++ source code (http://sourceforge.net/projects/drm/). Distributing the compiled version DREAM.EXE is not possible for copyright reasons, as patent-protected components are used. We shall look at these components individually, and present a step-by-step guide to compiling the project yourself, written by Thorsten Godau DL9SEC.

The complete project, along with advice on compilation and on the additional libraries required, can be found at www.tu-darmstadt.de/fb/et/uet/fguet/mitarbeiter/vf/DRM/DRM.html and at http://www.tu-darmstadt.de/fb/et/uet/drm.html.

The aim of the project was to develop an installable DRM software receiver with basic functionality. The project, in C++, was begun in June 2001 and version 1.0, which supports

Onward with fewer bits

Progress in digital audio

MP3

Way back in 1987 researchers at the Fraunhofer Institute started to develop an audio encoding method that made use of psycho-acoustic effects. The result was called **ISO-MPEG Audio Layer 3**, a.k.a. MP3 — and it became the standard for the 1990s. MPEG Layer 3 achieves CD quality in stereo at a data rate of **112-118 kbit/s**.

the new DRM standard using the FAAD2 library, has been available since 17 December 2003.
Although the software can be freely distributed under the GNU General Public Licence (GPL), that is not to say that there are no third-party rights attached to it. In certain countries use of the software by be in breach of patent law. The project is intended for those who want to find out how the DRM data stream is decoded, to learn about the software algorithms used, and then help to improve the software. If you only want to evaluate the quality of DRM transmissions, the authors recommend installing the commercial DRM Software Radio.

Microsoft Visual C++ V6.0 Service Pack 4 or Service Pack 5 is required for compilation, along with Trolltech QT 2.x. The following libraries are needed: FFTW, Qwt and FAAD2. We shall now look at these components in more detail:

Qwt (Qt Widgets for Technical Applications) is a library of GUI components, including graph plotting and controls. The entire C++ source code is independent of the underlying operating system and is used so that DREAM can run under Windows as well as under Linux. The library can be downloaded from http://qwt.sourceforge.net/.

FFTW (the Fastest Fourier Transform in the West) was developed at MIT by Matteo Frigo and Steven G. Johnson. The package can be downloaded from http://www.fftw.org/.
DREAM uses the fast Fourier transform to analyse the individual carriers in the DRM signal in terms of amplitude and phase. The data obtained from these carriers is assembled to form the complete data stream, which includes both audio and multimedia components.

FAAD2, by the Dutch company AudioCoding.com, includes the DRM-specific algorithms for decoding the received digital data. AAC (Advanced Audio Coding) is the ISO high quality audio coding algorithm developed by leading companies AT&T, Dolby Laboratories, Fraunhofer IIS and Sony, which is also used in the Fraunhofer IIS DRM Software Radio. MPEG-2 and MPEG-4 AAC are also implemented. Version 2 also implements decoding of HE (High Efficiency) AAC streams. FAAD2 may be installed for private and scientific use under the GNU General Public Licence, although of course any patent restrictions must be observed. This is one of the reasons that a compiled version DREAM.EXE cannot be distributed without restriction. It is also not certain whether free use of FAAD2 will still be permitted as DRM is developed further. We should nevertheless warmly welcome this opportunity for those interested in DRM to gain access to this new technology.

Here are Thorsten Godau's comments on how to proceed.

The first requirement for compiling the DREAM source code for Windows is a working installation of:

– Microsoft Visual (Studio) C++ V6.0, and **either**
– Visual C++ Service Pack 4 and Processor Pack for SP4, **or**
– Visual C++ Service Pack 5 and Processor Pack for SP5

Then proceed as follows:

– **Download** the non-commercial version of QT (QT-Win V2.3 NC) from Trolltech at http://www.trolltech.com/download/qt/download_noncomm.html and install it (use the standard paths).

– **Download** the source code of DREAM V1.0 (or higher) from http://prdownloads.sourceforge.net/drm/drm_1_0.zip?download (select one of the mirrors).

– **Download** the precompiled FFTW package from http://www.tu-darmstadt.de/fb/et/uet/fguet/mitarbeiter/vf/DRM/download/WinFFTWInst.zip.

– **Download** the precompiled Qwt package from http://www.tu-darmstadt.de/fb/et/uet/fguet/mitarbeiter/vf/DRM/download/WinQWTInst.zip.

– **Download** the FAAD2 package from http://www.tu-darmstadt.de/fb/et/uet/fguet/mitarbeiter/vf/DRM/download/WinFAAD2SBRNewInst.zip.

Create directories and copy in the precompiled files:

– **Create** a directory called, for example, C:\vcprojects
– **Open** drm_1_0.zip and unpack it into subdirectories of C:\vcprojects.
– **Open** WinFFTWInst.zip. Copy the files libfftw.lib, fftw.h and rfftw.h from the subdirectory \lib into the directory

AAC
In 1997 the cooperation between the Fraunhofer Institute and large companies like AT&T, Sony and Dolby culminated in the **MPEG-2 Advanced Audio Coding** (AAC) method. AAC achieves high quality thanks to 1-48 audio channels and sampling rates between 8 kHz and 96 kHz.

mp3PRO
Using **Spectral Band Replication Technology** (SBR) developed by Coding Technologies the data reduction efficiency can be doubled without loss of quality. mp3PRO is the **MP3-compatible** implementation of SBR. It is for available as a plug-in for the current version of the famous Nero Burning ROM software.

aacPLUS/MPEG-4 HE AAC
The combination of AAC with bandwidth-extended SBR was originally marketed as **aacPLUS** by Coding Technologies. Having been standardised by MPEG as a one of the MPEG-4 audio profiles, the system became known as **MPEG-4 High Efficiency** (HE-AAC). This recently introduced standard allows full CD quality in stereo at 48 kbit/s, very good stereo quality at 32 kbit/s and 'parametric' stereo in FM-radio quality at just 20 kbit/s. The latter is employed for DRM since December 2003.
MPEG-4 HE AAC is also available as a plug-in for Nero Burning ROM.

C:\vcprojects\drm\libs.
- **Open** WinQWTInst.zip. Copy all the files (.lib und .h) from the subdirectory \lib into the directory C:\vcprojects\drm\libs.
- **Open** WinFAAD2SBRNewInst.zip and unpack it into subdirectories of C:\vcprojects.

Compile the FAAD2 package:
- Go to the directory C:\vcprojects\faad2\libfaad and double-click on libfaad.dsw (if Visual Studio is correctly installed the Visual C++ IDE will now open).
- In the IDE, select 'Build/Set Active Configuration' and in the window that appears select 'libfaad - Win32 Release', and then click 'OK'.
- In the IDE, select 'Build/Rebuild All'. Compilation begins, and should complete with 43 warnings, but no errors.
- Now, go to the directory C:\vcprojects\faad2\libfaad\Release and copy libfaad.lib into the directory C:\vcprojects\drm\libs. Likewise, copy faad.h from c:\vcprojects\faad2\include into the directory C:\vcprojects\drm\libs.

Build the QT MOC files:
- Go to the directory C:\vcprojects\drm\windows and double-click on MocGUI.bat to launch it. A number of files will automatically be created in the directory C:\vcprojects\drm\windows\moc.

Compile DREAM:
- Go to the directory C:\vcprojects\drm\windows and double-click on FDRM.dsw (if Visual Studio is correctly installed the Visual C++ IDE will now open).
- In the IDE, select 'Build/Set Active Configuration' and in the window that appears select 'FDRM - Win32 Release', and then click 'OK'.
- In the IDE, select 'Build/Rebuild All'. Compilation begins, and should complete with one linker warning, but no errors.

Run DREAM:
- Go to the directory C:\vcprojects\drm\windows\Release. Copy DREAM.EXE from here to a newly-created directory C:\Program Files\Dream.
- If DREAM.EXE is to be run on a computer where QT is not already installed, first copy the file qt-mt230nc.dll from the directory C:\qt\bin into C:\Program Files\Dream. Then run DREAM.EXE.

It's as simple as that.

Results

A click on DREAM.EXE starts the program. Once the receiver has been tuned to a suitable frequency, an audio signal will be produced after a short delay. The station being received and transmission information will be displayed on the screen (**Figure 2**).

Further information is available under 'View/Evaluation Dialogue'. This mode (**Figure 3**) shows the DRM spectrum and a large quantity of additional information including the current signal-to-noise ratio (SNR), the bandwidth, and the operating mode. It is also possible to experiment with a range of software options. A broken red line indicates the measured centre frequency of the DRM signal, which simplifies calibrating the receiver. DREAM is not restricted to a 12 kHz fre-

Figure 2. DREAM receiving RTL DRM.

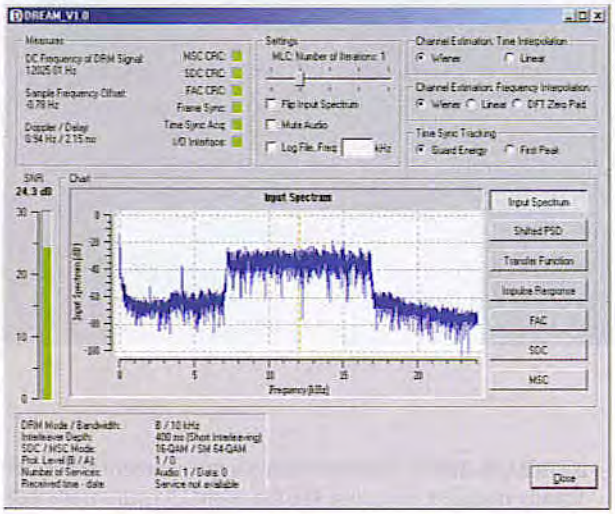


Figure 3. The DREAM evaluation dialogue displays the most important parameters.

quency band, but rather accepts the entire input band between 0 kHz and 24 kHz. This relaxes the constraints on the receiver and allows the receiver to be detuned by a few kilohertz, for example to avoid an unwanted interfering carrier on the image frequency.

AM reception

The receiver option Settings/Receiver mode/AM (analogue) allows DREAM to receive amplitude-modulated signals from normal AM broadcasters. DREAM looks for a strong carrier in the input spectrum and subtracts its frequency from the upper sideband of the received signal. The receiver thus operates as a single sideband (SSB) receiver. This allows both SSB, CW and utility signals such as weather fax and RTTY to be decoded.

In order to receive an AM station, first ensure that the frequency band to be received sits in the middle of the filter bandwidth around 12 kHz. Use DRM mode to search for the AM station: the carrier should stand out clearly from the spectrum at 12 kHz. Then switch to AM mode. In the evaluation dialogue the broken red line again indicates the detected carrier frequency at around 12 kHz. This setting remains fixed as long as AM mode is active. The receiver can therefore be retuned freely to bring in other stations.

The single sideband demodulation process gives a number of advantages over the conventional envelope detector. Selective fading normally causes severe distortion if the carrier is significantly attenuated. DREAM, however, can offer trouble-free reception in these conditions, although the sound quality may vary slightly. Also, DREAM includes a very good low-pass filter. The input signal is analysed by an FFT, the upper sideband moved down to zero frequency, and then the audio sig

nal re-synthesised by an inverse FFT covering the band from 0 kHz to 5 kHz. When the result compared with a conventional short-wave radio tuned to the same frequency, the delay introduced by the digital processing and data buffering is clearly apparent.

Single-sideband (SSB) reception also offers the possibility of obtaining better reception from severely distorted AM stations. Since short-wave broadcast channels are at multiples of 5 kHz, it is often the case that there are pairs of stations just 5 kHz apart: the upper sideband of one then completely overlaps the lower sideband of the other. With DREAM it is possible to receive only the undistorted sideband. In some cases this will mean inverting the input spectrum (option 'Flip Input Spectrum' in the evaluation dialogue). This is also required in order to receive an SSB transmission using the lower sideband. When the *Elektor Electronics* DRM receiver is being used, fine adjustment of its intermediate frequency is possible using the program DRM.EXE. Reception results are better than when using direct conversion, since the software completely discards the unwanted sideband.

Conclusions

DREAM_V1.0 is certainly a serious alternative to the DRM Software Radio. The program is absolutely stable in use and requires less processor power than the earlier versions. It is possible to receive images, and the program can create a log file with reception results. As already noted, DREAM is very tolerant of the position of the DRM baseband signal within its input bandwidth, scanning the entire range from 0 kHz to 24 kHz. It also offers an analogue AM reception mode, allowing it to be used with the *Elektor Electronics* DRM receiver for standard broadcasts.

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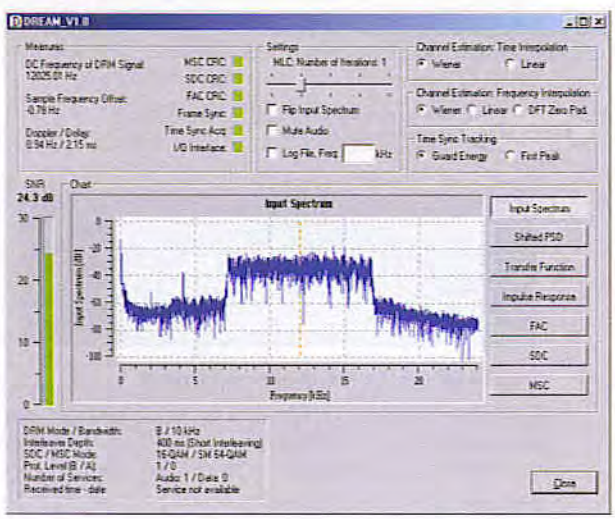

Figure 4. In contrast to the DRM software radio, DREAM can also demodulate normal AM transmissions on the PC.