Multi FM Modulator

User's Manual for Generator Software v2.27

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Contents

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Wir freuen uns über Ihre Rückmeldung! Wenn Sie einen Fehler gefunden haben oder der Meinung sind, dass etwas in größerer Ausführlichkeit erklärt werden sollte, dann zögern Sie nicht, uns darauf hinzuweisen.

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1 Package Contents

Included in the delivery of the Multi FM Modulator are:

- 1x Multi FM Modulator hardware (incl. power supply)
- 1x Multi FM generator software (download from `http://www.maintech.de/multifm`)
- 1x RJ45 network cable
- 1x USB/RS232 service cable

2 Starting up

For the initial start-up of the modulator please proceed as follows.

1. Install generator software on a computer (`http://www.maintech.de/multifm`)
2. Connect control computer and modulator using the network cable and switch them on
3. Start generator software on the control computer (icon on desktop)
4. Choose IP address of the modulator via RS232 (see chapter 3.1) and connect (Ctrl+O)
5. Enter licence key if existing (Ctrl+K)

Modulator and generator software communicate via Ethernet (UDP). Therefore, both devices must be assigned with IP addresses of the same segment (see chapter 3.1). Starting up has to be done only once; if you restart the software and switch the modulator on, the connection is reestablished automatically.

3 Hardware Settings

3.1 Configuring the Modulator's IP Address

1. Start the generator software
2. Connect service cable to computer and modulator
3. Choose Menu ⇒ Modulator ⇒ Config
4. Choose COM port; the MAC address will be displayed
5. Fill in host IP and port number for the modulator
6. Confirm by "Save" and "Close"

The IP address of the computer can be displayed on the command prompt with `ipconfig`. The modulator has to be assigned an IP address in the same network range.

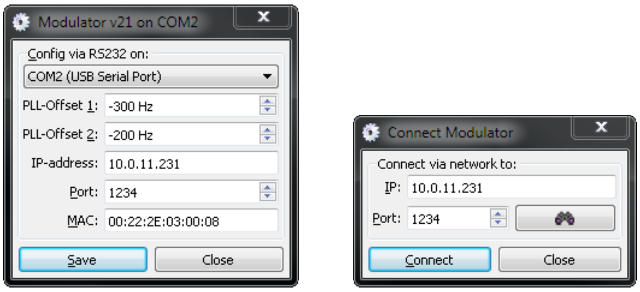


Figure 1: Building up a network connection with the Modulator

3.2 Connecting the Modulator via Network

1. Start the generator software
2. Choose menu ⇒ Modulator ⇒ Connect (or Ctrl+O)
3. Fill in host IP and port number of the modulator
4. Click "Search board" (button with binoculars icon) and choose the modulator with a double-click
5. Confirm the selection by "Connect" and "Close"

See figure 1 for examples of the "Connect"-Window.

3.3 Calibrating PLLs

The device design is based around two PLLs that are in charge of the lower and upper half of the output spectrum. To avoid a gap in the middle of the spectrum, these two PLLs have to be aligned to each other. This alignment also is necessary to remove the absolute offset of the output frequencies. All devices are properly aligned during manufacturing and testing by maintech, but it can be repeated by the customer if needed.

The realign the PLLs, follow these steps:

1. Start Multi FM Software (see figure 2)
2. Connect service cable to computer (USB) and modulator (RS232)
3. Configure the system to use the European FM frequencies and start two channels, one at 93 and one at 103 MHz, with the following parameters:
   - No audio
   - No RDS
   - Mono
   - 0 dB attenuation
4. Open the menu "Board" ⇒ Connect... (or press Ctrl+O)
5. Choose "Config via RS232"
6. Choose the correct COM port
7. Set PLL-Offset 1 for frequencies lower than 98 MHz
8. Set PLL-Offset 2 for frequencies above 98 MHz
9. "Save" the settings
10. Verify 93 MHz and 103 MHz with a spectrum analyser
11. Start again at step 7 if necessary

4 Multi FM Software

The Multi FM software is structured in four main categories: Channel overview, audio sources, RDS sources and TMC sources. The channel overview functions as distributing matrix for all channel settings (audio, RDS/TMC) and for the configuration of the HF parameters. As you can see in figure 2, you can switch between the different categories using the tabs in the upper part of the window.

Right next to the tabs a schematic representation of the output signal spectrum is shown (green lines) with the expected intermodulation products (red parts) and a display for the currently chosen VHF frequency range (Europe, Japan). On the right, you find the "On Air" button which enables or disables the HF signal at the output.

At the bottom of the window the status line displays the hardware status (green indicator for an existing network connection to the hardware, hardware version and number of activated channels). The status line also contains an indicator for remote control.

For every channel the main window contains a configuration panel. A detailed description of the configuration options is in chapter 6.

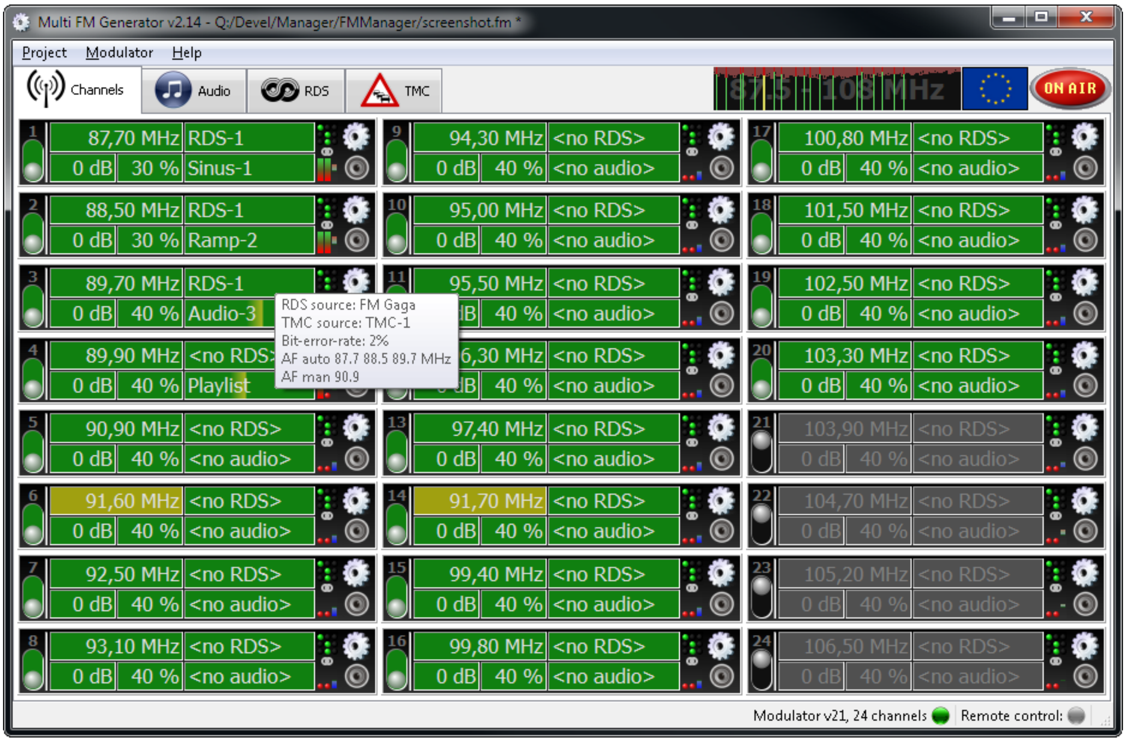


Figure 2: Multi FM channel overview

5 Project Settings

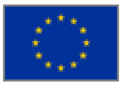
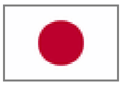
The Multi FM software manages all settings in a project that can be saved and reloaded. Thus it is possible to switch between complete sets of parameters and to prepare different test scenarios and process them systematically.

5.1 Creating, Saving and Reloading Projects

- Choose project ⇒ New (or Ctrl+N) to set up a new empty FM project
- Save a project with Project ⇒ Save (Ctrl+S) under a new name
- Open an existing project with Project ⇒ Load (Ctrl+L)
- The last n projects (for $n \in \{1, \ldots, 9\}$) can be reopened with Ctrl+Shift+n

5.2 Switching Frequency Band (Europe, Japan)

The chosen frequency band can be changed by a click on the flag top right in the window or by pressing Ctrl+B:

 Europe: 87,50 to 108,00 MHz  Japan: 76,00 to 90,00 MHz

5.3 Stopping and Resuming Modulation

Clicking the 

button disables the RF output of the Multi FM hardware. Clicking again reenables the modulator.

6 Configuring Channels

You can configure up to 24 single carriers (depending on your licence) in the channel overview. Pressing key 1. . . 0 switches the modulation of channel 1. . . 10 on or out; pressing key Ctrl+1. . . 0 of channel 11. . . 20. See figure 3 for an example of the channel status.

The following information are displayed:

- Channel 4 is active (transmitting)
- Transmitting frequency is `96,00 MHz`
- Attenuation is `-5 dB`
- Audio volume is 50%
- Audio source is `Audio-1`
- RDS/TMC source is `RDS-1`

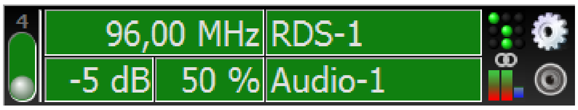


Figure 3: Channel status

6.1 Frequency, Attenuation, Volume

Clicking on the frequency opens the slider which sets the transmitting frequency of the channel. See figure 4 for an example.

Figure 4: Frequency setting

The frequency is changed by moving the red circle or by the keys +, -, Home, End, PageUp, PageDown or by the arrow keys. With the left/right arrow keys the frequency can be changed in kHz steps. The reach such destionation frequencies as close as possible it may be neccessary to do a calibration of the PLL units (s. chapter 3.3). It is also possible to enter 958 to set the frequency to 95.8 MHz directly.

The adjustments of attenuation and volume work correspondingly.

6.2 Choosing Audio and RDS Sources

6.2.1 Configuring the Signal Sources

Different channels are able to send the same audio or RDS data. Therefore, the software distinguishes different audio and RDS sources that refer to the channels in the channel overview. The mechanism is like a switching matrix which is able to route different input signals to the outputs.

Clicking the audio or RDS source of a channel opens a list of all available sources. The right mouse key opens a menu that allows a quick jump to the configuration page of the chosen source.

6.2.2 Replaying a RDS Log

Apart from generating a new RDS signal, you can select a recorded RDS log from a file for playout. All lines from this file are transmitted continually. After the last line, the playout restarts at the begin of the file. Paragraph 8.4.2 describes how to save a RDS log.

6.3 Status Icons, Muting, Channel Editor

Clicking the button with the loudspeaker symbol mutes the audio source temporarily – the RDS/TMC datastream is still transmitted which means that the HF channel stays active.

Clicking the button with the gearwheel symbol opens the channel editor (see figure 5). The channel editor allows the setting of preemphasis, frequency deviation, sample rate and mono/stereo mode. The frequency deviation can be chosen arbitrarily between 0 and 130 kHz.

The channel editor allows to copy the settings to all other channels or a selected range of channels.

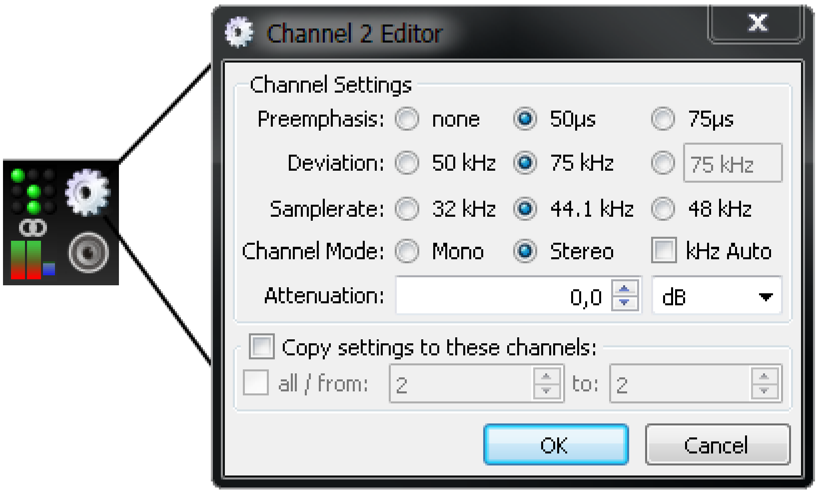


Figure 5: Status icons and channel editor

The green dots that are displayed in a 3x3 grid for each channel correspond to the settings in the channel editor. The dots and the stereo symbol can be clicked directly, switching the related setting. This way, settings can be changed faster than by opening the channel editor. When the mouse rests a moment on an option, the current value is displayed in a tooltip window.

Additionally, the channel overview displays three bargraphs representing the following values:

- On the left, the audio PCM fifo fill level is displayed (from red to green for empty to full)
- In the middle, the RDS/TMC fifo fill level is displayed (colors similar to audio)
- On the right, the multiplex power is displayd in dB (from blue to white)

The multiplex power depends on the audio source volume. Ideally, the volume should be chosen so that the value is about 0 dB.

7 Audio Sources

For audio sources the following signals can be generated:

- Constant sinus, seperately configurable for left and right channel
- Sinus sweep (ramp)
- A single MP3 or Ogg Vorbis file (.mp3 / .ogg)
- A playlist consisting of several MP3s and OGGs

See figure 6 for the configuration of the audio sources.

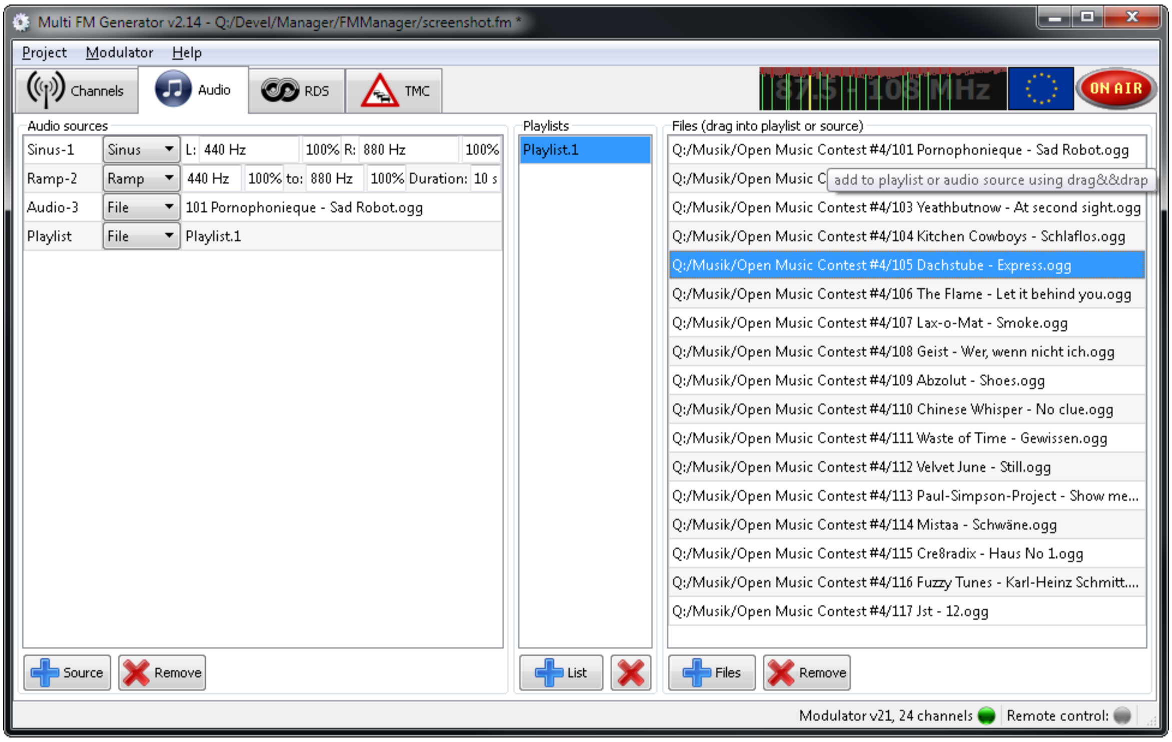


Figure 6: Audio sources

You can set up new sources, change or delete existing ones in the column "Audio Sources". A source consists of a name, mode of operation and the relating parameters.

7.1 Constant Sinus

You can set frequency and volume separately for the left and right channel. If you choose "mono", both frequencies are transmitted on both L/R channels (mixed).

7.2 Sinus Sweep (Ramp)

You can set starting frequency, end frequency, volume and period between start and end. The ramp is repeated repeatedly on both L/R channels.

7.3 Audio Files and Playlists

A playlist contains a list of audio files that are played back successively. When the end of the playlist is reached, playback starts again with the first entry.

To create a new playlist and assign it to an audio source, you have to execute the following steps:

1. Create a new playlist in column "Playlists" with the plus list button
2. Change the name of the playlist if necessary (doubleclick the name or press the F2 key)
3. Add several files to the playlist in the right column ("Files") with the plus files button
4. To assign a playlist to an audio source, you have to change the type of the source to "File". Then, the playlist has to be dropped on the parameter field of the source by drag&drop: Press the left mouse key on the name of the playlist und drag the mouse arrow with pressed key onto the audio source until you see a "+"-symbol.
5. If you want only a single file on the playlist to be played in a loop, you can pull the file name directly onto the audio source.
6. You can copy selected files by drag&drop to other playlists.
7. Finally, you should ensure that the newly created audio source is assigned to an RF channel: The audio source must be chosen for at least one channel of the channel overview (see paragraph 6.2.1).

8 RDS sources

The RDS generator implements the RDS standard according to DIN EN 62106. Understanding the configurable parameters requires an understanding of the standard and a detailed explanation of the values and of their function would go beyond the scope of the manual. Therefore, it is assumed that the user of the Multi FM Modulator is well acquainted with the RDS standard.

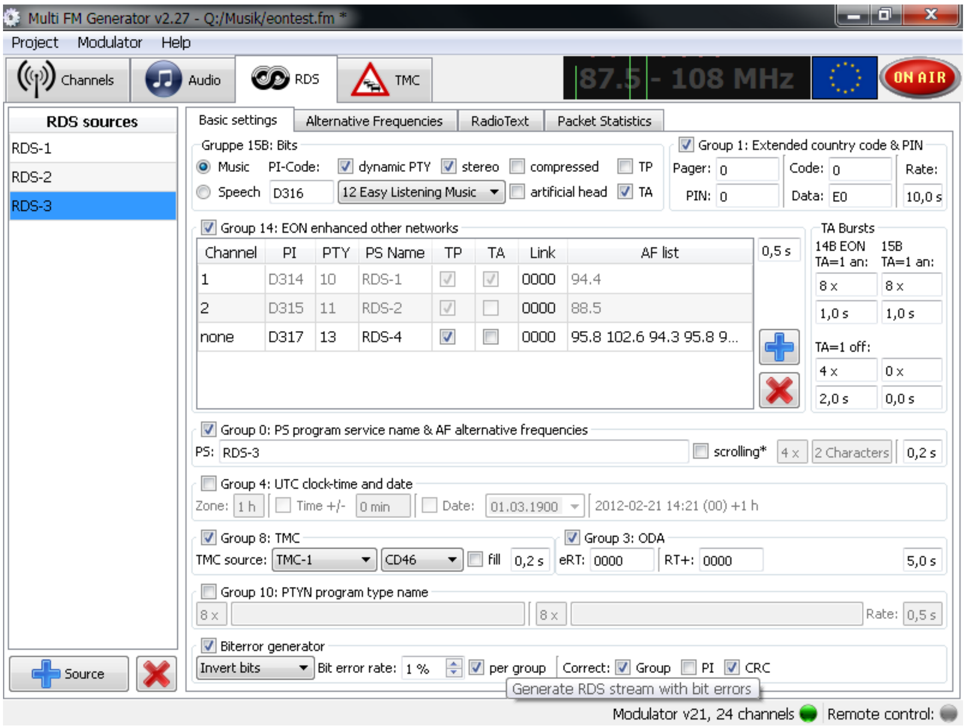


Figure 7: RDS sources

The RDS source configuration consists of several parts. Each of them has its own tab in the window:

- Basic settings with options like PI, PTY, PS etc.
- Alternative Frequencies
- RadioText
- Package statistics

The package statistics allows analysis of the transmitted bitstream (blocks or groups depending on nomenclature). It also helps verify that the the information really arrives at the RF signal at the necessary rate. Apart from that, you can save the created datastream in a file to analyse it with an alternative software or to replay it out without the need to rebuild the configuration etc.

8.1 Basic Settings

The basic settings in figure 7 include the most commonly used flags, RDS groups and an error generator that generates intentional bit errors in the created RDS data stream (e.g. for fuzzing).

8.1.1 Group 0/15B: Flags, PI Code and PTY

The flags set several bits for music/speech, traffic program (TP), traffic announcement (TA) and the decoder information. Changing a flag or other parameters immediately affects all channels transmitting this RDS source. Setting e.g. the TA flag makes a compliant FM radio switch to the "traffic announcement" mode.

These flags are transmitted in groups 0A, 0B and 15B.

The PTY (program type) defines the kind of content as a value between 0 and 31. PTY and TP are always transmitted in the second block of *each* RDS group. You will find a table with the meanings of the different values for the PTY in the RDS standard. The PI code (program identification) is sent in the first block (two bytes) of *each* RDS group.

When switching the TA bit, a burst of 15B groups can be sent. The number of the groups and their duration can be set for TA=1 and TA=0. If the number is set to 0, no burst will be sent. If the duration is 0 or too low to transmit the number of burst groups in time, no other groups will be sent between the burst groups.

15B groups are also transmitted as filling groups when the set sending rates of all other groups would produce gaps in the RDS data stream.

8.1.2 Group 0: PS, AF, TA (Programme Service)

In group 0, program service name (PS) and alternative frequencies (AF) are configured (0A/0B) and the flags music/speech and TA are transmitted. The code for PS is defined in table E.1 of annex E in the standard. Characters can be created directly by "#xx" from a Hex value xx: "Hello#21" creates a "Hello!", 0x21 is the hex value for the exclamation mark.

All in all, four 0-groups are necessary to transmit the PS name (8 characters) completely. At least two 0-groups per second should be sent which means that the sending rate should be less or equal to 0,5 seconds.

According to the standard, scrolling PS is not allowed and RadioText should be used instead. Nevertheless, the RDS generator features this function. To create a scrolling PS, the PS has to be longer than 8 characters. Additionally, you have to set how often a PS segment (8 characters) is repeated and by how many characters the text is advanced afterwards. When the PS is sent completely, it starts from the beginning again.

8.1.3 Group 1: ECC and PIN

In Group 1, the extended country code (ECC) can be transmitted. First, set `Code = 0` and then set `Data` to the ECC. The first character of the PI code is the country code (CC). The settings for Germany are: ECC = 0xE0 and CC = D or 1.

The program item number (PIN) contains the scheduled transmission start (5-bit day of the month 1-31, 5-bit hour 0-23 and 6-bit minute 0-59) of the currently sent program segment. Month = 0 (e.g. PIN = 0) tells the decoder that the PIN is not set.

8.1.4 Group 4: Date and UTC Time

In this group, date and time can be sent. Time is sent once every full minute, and the receiver receives the message at second 0. Reference time is the current time of the computer running the software. When noticing discrepancies, you should check the Windows system time.

8.1.5 Group 8: TMC (Traffic Message Channel)

In Group 8 TMC messages are sent if a TMC source has been chosen. Apart from that, you can configure the applications identification (AID) that is transmitted in group 3.

With "`fill`", you can use free groups for TMC if the maximum sending rate for RDS is not used up by the other groups. With `fill` active, the sending rate go below the configured setting for TMC. Otherwise, the free groups are filled up with 15B groups (quick info).

8.1.6 Group 3: ODA (Open Data Applications)

ODA groups announce the existence of open data applications that are not defined in the RDS standard. Among others those are TMC, enhanced RadioText (eRT) and RadioText Plus (RT+). If no group 3 is sent, it is possible that the receiver cannot recognise TMC even if TMC is transmitted in group 8. Transmitting group 3 should be always activated when using ODA for TMC.

8.1.7 Group 14: EON (Enhanced Other Networks)

TP=0 (off) and TA=1 (on) signals that EON information that refer to at least one other program with traffic information are transmitted. Thus, RDS receivers can recognize traffic announcements in other programs.

RDS sources with TP=0 and TA=1 have to refer to a program with TP=1 in at least one EON group.

In the EON list, all data have to be entered either manually (channel=0), or the number of another transmitting channel (program) is entered into the channel field. In that case, the data is taken automatically from the RDS source of the other channel. If the TA flag of the RDS source in the referenced channel is set to TA=1, a burst will be generated (14B groups) and the receiver should tune to this channel until TA=0 is recognized again.

The number of burst groups (14B) and their duration can be set separatly for TA=1 and TA=0. If the number is set to 0, no burst will be sent. If the duration is 0 or too low to transmit the number of burst groups in time, no other groups will be sent between the burst groups.

A burst can be triggered by toggling the TA flag of the RDS source in the linked channel or, if no channel is given (=0), directly by the TA entry in the EON table row.

8.1.8 Error Generator

The error generator creates intentional bit errors in the transmitted RDS data stream. This function enables the simulation of difficult receiving conditions in the lab. According to the configured error rate, bits are either inverted or set to constant 0 or 1. If the error rate is set to "per group", the same number of bits are changed in every RDS group. One RDS group consists of 104 bits, so an error rate of 1% means about one bit per group.

After the bit errors have been inserted, certain parts of the RDS group can be rectified again. These parts are the PI code, the current group and the CRC. This way, one can transmit incorrect data with correct CRC to the group-related receiver parts as a test. This possibility should help in finding software errors in decoder parts that get the data only after the CRC check and therefore cannot receive data errors under normal conditions.

8.2 Alternative Frequencies (AF)

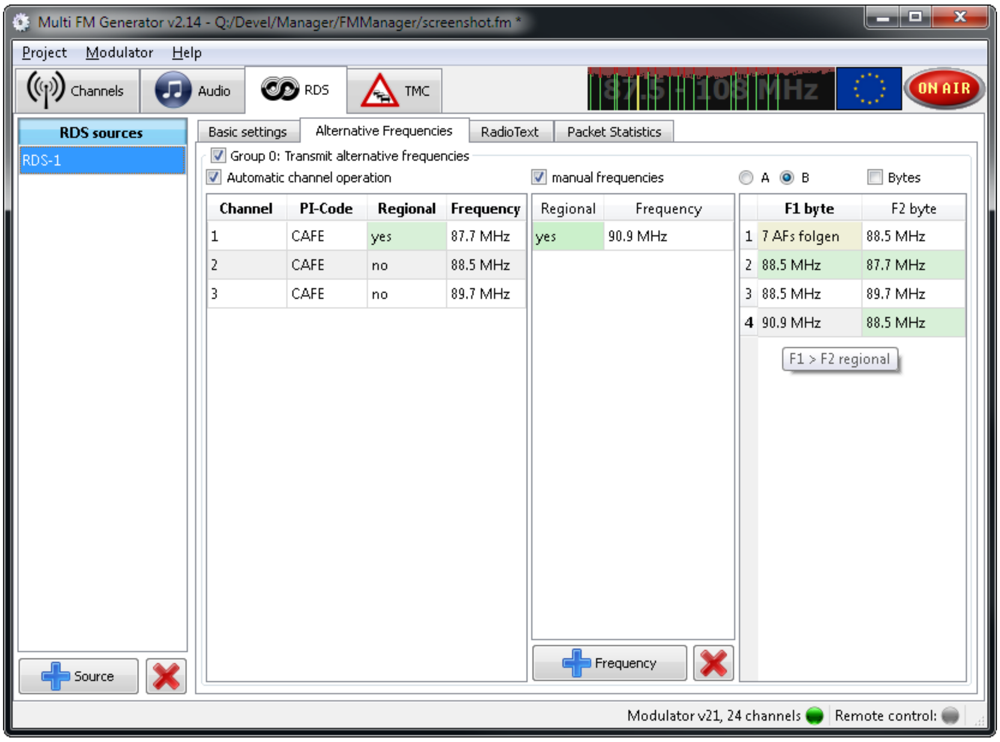


Figure 8: Alternative frequencies in RDS

8.2.1 AF Basics

When activated, AFs are sent together with the PS in 0A groups.

The channel automatic mode finds the frequencies of all channels using the same RDS source. This means that all frequencies that belong to a certain transmitting station (same PI/PS) are used. All these channels are transmitting the frequencies of the other channels automatically in the AFs in group 0.

Additionally, one can add frequencies manually even if they are not transmitted by the FM modulator, e.g. to include the frequencies of transceivers with a different PI.

8.2.2 Method A/B

The standard defines two methods for the encoding of the AF. Procedure A transmits a list with up to 25 AFs. Procedure B can be used for bigger lists, or when it is necessary to mark regional stations (similar programs with different PI).

8.3 RadioText

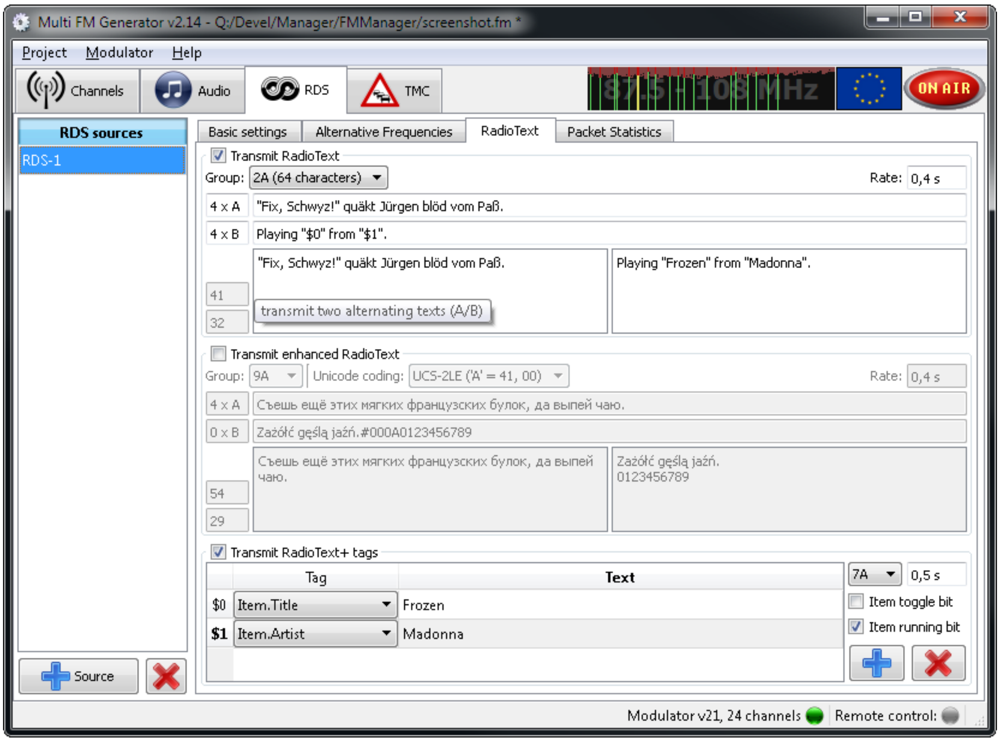


Figure 9: RadioText configuration in RDS

RadioText can be transmitted as normal RadioText in group 2 or as enhanced RadioText (eRT) in the ODA extension of the RDS standard with the possibility of using Unicode characters.

It is possible to transmit both versions simultaneously with different texts, but it is uncommon because of the limited bandwidth of RDS. Apart from that, the RadioText+ tags effect only eRT in that case as there can be different position and length specifications of the RT+ tags because of the different coding.

The ODA groups for eRT and RT+ have to be selected differently. The identification is transmitted in group 3 (see paragraph 8.1.6).

8.3.1 Standard RadioText (Group 2)

Normal RadioText is transmitted in group 2. Up to 64 characters can be transmitted in 2A groups, up to 32 characters in 2B groups. The coding refers to table E.1 of the RDS standard. "#xxxx" creates a single character from the hex value xxxx: "#0021" becomes "!", "#000A" a line break.

8.3.2 Enhanced RadioText (Unicode)

There are 3 Unicode variants available. Depending on the chosen variant the encoded byte string for character 'A' looks as follows:

- UTF-8: 0x41

- UCS-2LE: 0x41, 0x00 (little endian)
- UCS-2BE: 0x00, 0x41 (big endian)

The description in the RDS standard doesn't state explicitly which of both UCS-2 codings (table E.2) has to be used. Therefore, the software features both formats.

Correspondingly to normal RadioText, one can create a Unicode character directly with "#xxxx".

8.3.3 RadioText Plus (RT+)

Using RT+ one can mark certain areas in RadioText and use them as data fields (position, length). A possible application is e.g. signalling the position of the componist's name or the song title in the text.

With each line, a tag is defined and numbered consecutively with $n. The RadioText "You hear $0 from $1" includes the references $0 and $1. In the first line ($0), the tag "Item.Title", in the second line ($1) the tag "Item.Artist" is chosen. If a Vorbis file with ID3 tags is played as the audio source of the channel, the RT+ tags from the ID3 tags are transferred automatically. Otherwise, the text deposited in the table is used for the tags.

8.4 Package Statistics

8.4.1 General

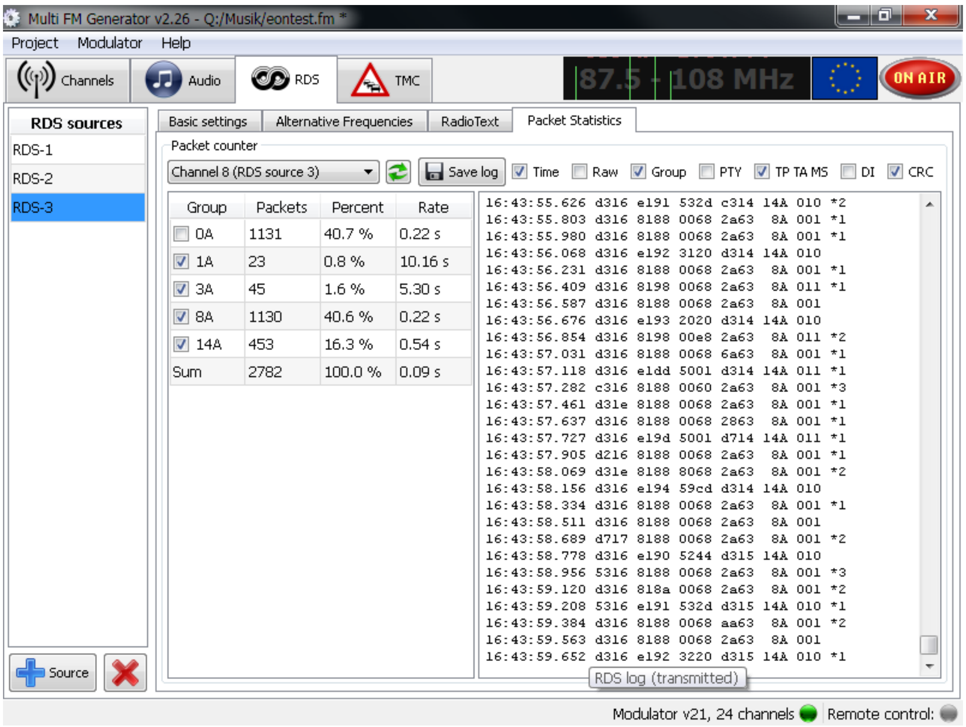


Figure 10: Package statistics

After a channel is selected, the corresponding RDS source is analyzed and the packet count, share of bandwith and transmission rate are calculated. It is also possible to start a log of the transmitted raw data.

8.4.2 Save Log File

The log can be filtered by choosing several groups. Additional information – e.g. timestamp, group or number of CRC errors – can be displayed and logged, too. The log can be saved as text file; afterwards, you can use this file as RDS source of a channel and send it repeatedly (see paragraph 6.2.2).

9 TMC Sources

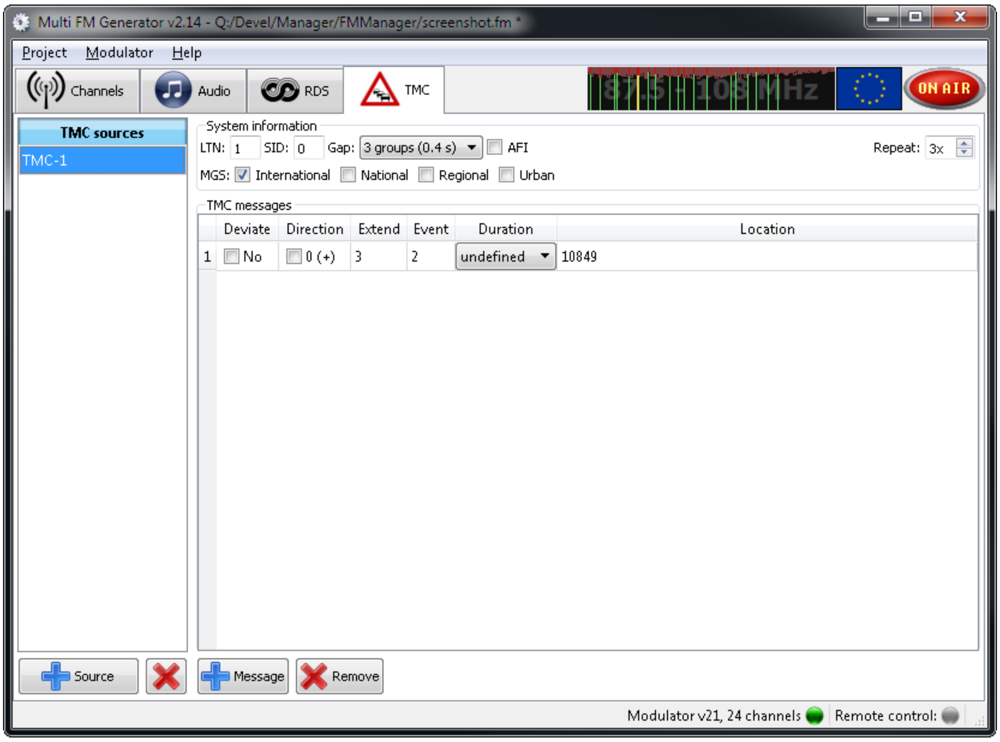


Figure 11: TMC generator

The window is built analogously to the RDS sources: On the left one can add new sources or delete them, on the right a currently chosen source is edited.

Traffic announcements are sent in group 8 of the RDS data stream. Accordingly, the corresponding TMC source has to be chosen in the RDS source. Apart from group 8, group 3 should be also active; otherwise, the TMC detection in the receiver is not ensured.

It is advisable to set the relevant country code for the RDS source; if not, many TMC receivers will discard the announcements. For Germany, for example, PI codes should with D, and the enhanced country identification in group 1 is 0xE0.

Some receivers also need the clock included in the RDS stream to decode TMC if it is not provided by other means like GPS. If needed, it can be enabled in group 4.

TMC announcements are coded according to the Alert-C Standard (ISO 14819). For a detailed explanation of the following parameters, please refer to this standard.

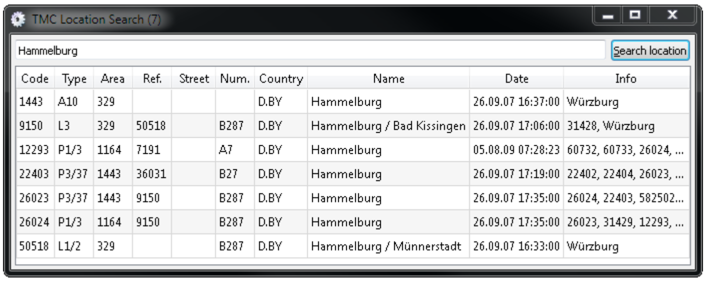
9.1 System Information

The TMC system information (SI) consists of Location Table Number (LTN), Service Identifier (SID), Gap Parameter, Alternate Frequency Indicator (AFI) and Message Geographical Scope (MGS) Bits. This SI is sent alternating with the TMC Application ID (AID), usually 0xCD46, in RDS group 3A.

The repeat field configures, how often each traffic announcement is repeated in direct succession. The announcements are transmitted consecutively in RDS group 8A.

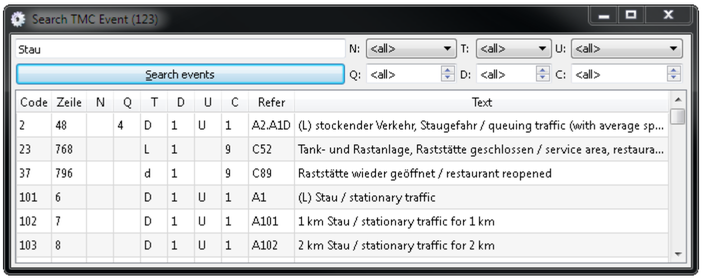
9.2 Traffic Announcements

At the moment, only single group messages are sent – each line in the table corresponding to one traffic announcement. To search fot a code or event, click on either using the right mouse button and select search from the appearing context menu. A search for the event "Stau" (meaning "traffic jam" in German) should produce 123 matches. A code can be moved from the search dialog to the event or location field using drag&drop.



Code	Type	Area	Ref.	Street	Num.	Country	Name	Date	Info
1443	A10	329				D.BY	Hammelburg	26.09.07 16:37:00	Würzburg
9150	L3	329	50518		B287	D.BY	Hammelburg / Bad Kissingen	26.09.07 17:06:00	31428, Würzburg
12293	P1/3	1164	7191		A7	D.BY	Hammelburg	05.08.09 07:28:23	60732, 60733, 26024, ...
22403	P3/37	1443	36031		B27	D.BY	Hammelburg	26.09.07 17:19:00	22402, 22404, 26023, ...
26023	P3/37	1443	9150		B287	D.BY	Hammelburg	26.09.07 17:35:00	26024, 22403, 582502...
26024	P1/3	1164	9150		B287	D.BY	Hammelburg	26.09.07 17:35:00	26023, 31429, 12293, ...
50518	L1/2	329			B287	D.BY	Hammelburg / Münnerstadt	26.09.07 16:33:00	Würzburg

Figure 12: TMC location search



Code	Zeile	N	Q	T	D	U	C	Refer	Text
2	48		4	D	1	U	1	A2.A1D	(L) stockender Verkehr, Staugefahr / queuing traffic (with average sp...
23	768			L	1		9	C52	Tank- und Rastanlage, Raststätte geschlossen / service area, restaura...
37	796			d	1		9	C89	Raststätte wieder geöffnet / restaurant reopened
101	6			D	1	U	1	A1	(L) Stau / stationary traffic
102	7			D	1	U	1	A101	1 km Stau / stationary traffic for 1 km
103	8			D	1	U	1	A102	2 km Stau / stationary traffic for 2 km

Figure 13: TMC event search

10 Remote Control

Remote controlling the Multi FM Generator software is possible by connecting to TCP port 1248. With a simple Telnet program (e.g. Putty in Telnet mode) one can send commands and monitor events. On request, a more comfortable client software with a simple command history and event management is available.

The following commands are implemented:

Command	**Description**
`HELP key`	Show information about a `key`, e.g. `help rds.1.pty`.
`REG key`	Register events for a `key`, i.e. adjustments are monitored.
`UNR key`	Do not monitor events for a `key` any more.
`GET key`	Output the value of a `key`.
`SET key value`	Set the value of a `key` on the new value `value`.
`DEL key`	Delete the `key` (only for playlists).
`NEW file`	Create a new, empty project with the name `file`.
`DIR path mask`	List files in directory `path`, e.g.: `dir . *.fm`.
`LOAD file`	Load project with the name `file`.
`SAVE file`	Save project under the name `file`.
`VER`	Show the versions of software (generator) and hardware.

A key always has the format `g.#.w` with g=group, #=number or range n-m (0<n<m<25) and w=value.

Kommando Beispiele	**Bechreibung**
`get channel.1.freq`	show frequency of channel 1
`get audio.2.file`	show file or playlist name of Audio-Source
`get rds.3.ps`	show Program Service Name of RDS-Source 3
`set channel.1,3-5.used 1`	turns the channels 1, 3, 4 and 5 on
`get *`	lists all currently available groups (sources) with numbers
`dir`	lists all project files in the current directory
`set rds.1.eon.0.af 958 1030`	set AF 95.8 and 103.0 MHz for EON 1st entry
`del rds.1.eon.1`	removes the 2nd EON entry
`get rds.1.eon`	list all EON entries
`help channel.1.volm`	show a short description about this key:
	`channel.1.volm channel audio pcm volume (linear) [0-100] %`

If a unknown command is entered, a list of all commands will be shown:
`valid commands: REG UNR GET SET NEW LOAD SAVE DIR HELP VER`

If a parameter of a command is missing a short description will be shown, f.i. for SET
`set key data example: SET channel.1.freq 88`

For a list of all available parameters see chapter 12.

The paths for the commands `DIR, NEW, LOAD, SAVE` can be set absolutely (C:/Users/...) or relatively (./fmfiles/...) to the open project file.

Important: All character strings have to be sent as UTF-8 code.

10.1 Channel Info, RDS-Log

In the channel information, status changes of the channels #1…24 are displayed. These are as follows:

- playlist position [0..1000]: `chinfo.#.playpos`
- currently played song: `chinfo.#.playing`
- current samplerate: `chinfo.#.playrate`
- minimum distance in MHz to the next sending channel: `chinfo.#.dist`
- RDS-Log: `chinfo.#.rdslog.#n` with #n = RDS source number
- number of sent RDS blocks (13 Bytes): `chinfo.#.rdscount.#n`

These values can be read only, but cannot be set.

Example: To get the playlist position of a song from 0 (start) to 1000 (end): `REG chinfo.1.playpos`
Example: To monitor song changes of all channels: `REG chinfo.*.playing`
Example: To get the RDS-Log of channel 1: `REG chinfo.1.rdslog`

The RDS-Log can be configured with `SET rdslog time raw data group`.
`time` is the time stamp,
`raw` are the complete 13-Bytes of an RDS block with CRCs,
`data` are the 8-Bytes RDS data without CRCs and
`group` is the data-extracted RDS group.

10.2 Modulator Status

All commands (apart from HELP, GET and VER) produce an "OK" in case of success or an "Error". If you get neither "OK" nor "ERROR", you have to assume that the UDP package is lost. The command has to be repeated.

Starting from an empty (NEW) or a pre-defined (LOAD) project, the status of the modulator is always known to the remote control.

Please note: If you make alterations in the generator's GUI simultaneously to the remote controlling, the related events have to be registered by the remote control (REG) for their recognition.

11 Application Examples

The following examples provide a step by step explanation on how to create different FM projects.
All examples can be downloaded from the following URL:

`http://www.maintech.de/multifm`

11.1 Sending two Sinusoidal Tones on 100 MHz

In this example, two sinusoidal tones (110 and 220 Hz) are sent on channel.1 on 100 MHz.

Via remote control, the following commands are performed consecutively:

Command	**Description**
`new 11-1_remote.fm`	Start new empty project
`set audio.1.used 1`	Add and activate audio source
`set channel.1.idaudio 1`	Choose audio source
`set channel.1.freq 100`	Set channel to 100 MHz
`set channel.1.used 1`	Activate channel, sinus should be audible
`set audio.1.frq1 220`	Change frequency for the left channel
`set audio.1.frq2 110`	Change frequency for the right channel
`set audio.1.name Sinus-1`	Change name of the audio source
`set channel.1.mono 1`	Set channel to mono (channels are mixed)
`get channel.1`	Display values (optionally)
`get audio.1`	Display values (optionally)

In the generator software, you will get the same result doing the following:

1. Choose menu Project ⇒ New (or Ctrl+N) and choose a new project name.
2. Choose "Audio Sources" and add a new source with the button "+ Source".
3. Set the frequencies to L: 220 Hz (left) and R: 110 Hz (right).
4. Edit the source name from "Audio-1" to "Sinus-1"
5. Choose the "Channel" index.
6. Activate channel 1 by pressing the "1" button or press key 1.
7. Click the frequency and set 100.00 MHz with the slider.
8. Set the audio source for channel 1 from "none" to "Sinus-1".
9. Click the displayed stereo symbol to switch to mono.

The status display for channel 1 should be similar to 14; using a receiver, both tones should be audible.

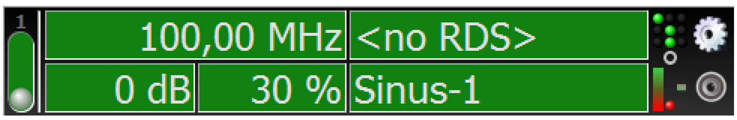


Figure 14: Channel 1 with sinusoidal tones

You can open the created project with a text viewer. It should contain the following content:

```
[channel.1]
freq=100
gain=0
volm=60
idaudio=1
used=1
mono=1

[audio.1]
used=1
frq1=220
frq2=110
name=Sinus-1
```

11.2 Sending Three Different Audio Files on Three Channels

In this example, different music tracks are played on three different channels.

Execute the following step:

1. Choose menu project ⇒ New (or Ctrl+N) and choose a new project name.
2. Choose "Audio Sources" and add **three** sources with the button "+ Source".
3. Set all channels to "File".
4. Add at least three MP3s or Ogg-Vorbis files (*.ogg) with "+ Files".
5. **Drag&Drop** each one of the files into one of the audio sources.
6. Choose the "Channel" tab.
7. Activate channel 1, 2 and 3 with the mouse or by pressing the keys 1, 2 and 3.
8. Set the audio source of channel 1 to "Audio-1", of channel 2 to "Audio-2" and of channel 3 to "Audio-3".

When you check with a receiver, each of the frequencies (see 15) should play the selected audio file. The tracks are repeated continually.

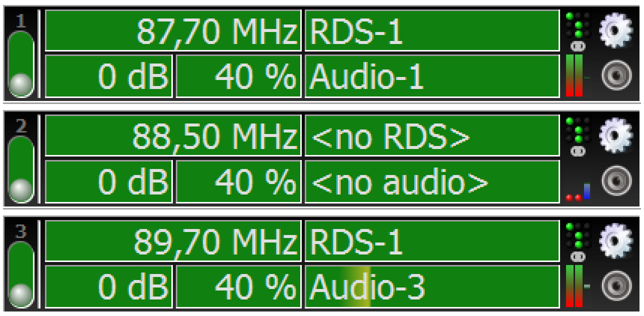


Figure 15: Play out three audio files on three channels

11.3 Automatic Change of channel via AF

Alternatice Frequencies are transmitted in the RDS signal of a channel. In this example, the automatic change to a stronger channel is simulated. For this, the example from paragraph 11.2 is extended. An RDS source that transmits the AFs of the other channels is added to the three channels. When the tuned signal is attenuated, an AF-enabled receiver should switch to another (stronger) channel.

Open the example from paragraph 11.2 and do the following steps:

1. Choose "RDS Sources" and add a source with "+ Source".
2. Change to tab "Alternative Frequencies".
3. Activate "Send AF in Group 0" and "Channel Automatic" (see paragraph 8.2.1).
4. Activate "Group 0" in "Basic Settings".
5. Choose the "Channel" tab.
6. Set the RDS sources for the channels 1-3 to "RDS-1".
7. Check the currently set receiver frequency (or the music track).
8. Attenuate the signal of this frequency gradually with the attenuation slider.

At a certain signal level, the receiver should switch to one of the stronger channels. You can observe this change in the played music or in the frequency displayed by the receiver. Attenuate and amplify the signal level of all three channels and observe the receiver performance. At which attenuation (-n dB) does it change the channel? Is there a hysteresis (in dB)?

11.4 Enhanced RadioText with RadioText+

In this example a RadioText is configured and sent with additional RT+ tags.

1. Create a new project with one channel and one RDS source.
2. Activate in "RDS Sources", part "RadioText" ⇒ "Send RadioText".
3. Enter "You're hearing $0 by $1." in the first line.
4. Activate "Send RadioText+ Tags".
5. Add two lines with the tags "Item.Title" and "Item.Artist".
6. Enter ⇒ "a track" for "Item.Title".
7. Enter ⇒ "an artist" for "Item.Artist".

Now you should see the following RadioText in the receiver: `"You're hearing a track by an artist."`

If you play out tracks with ID3 tags, the RadioText will change, e.g.: `"You're hearing Pass This On by The Knife."`

Repeat the same with enhanced RadioText:

1. Deactivate "Send RadioText" and activate "Send enhanced RadioText".
2. Enter "You're hearing $0 by $1." in the first line.
3. Activate "Group 3" in the RDS "Basic Settings".

If you can see no RadioText anymore, please change the Unicode coding until the receiver displays the text (see paragraph 8.3.2).

11.5 Sending Hex Signs with RadioText

In this example, any desired hex sign is sent in the RadioText. Therefore, a new project is created and saved; afterwards, the RadioText is changed continually.

The following commands are performed consecutively:

Command	Description
`new 11-5_radiotext.fm`	Create a new empty project
`set channel.1.idrds 1`	Choose RDS source
`set channel.1.freq 100`	Set channel 1 to 100 MHz
`set channel.1.used 1`	Activate channel 1
`set rds.1.used 1`	Activate RDS source 1
`set rds.1.rtxt 1`	Activate Standard RadioText
`set rds.1.rta #41#42#43`	Create RadioText ABC of hex signs
`set rds.1.2 4`	Set sending rate of RadioText group 2 (**important!**)
`save 11-5_radiotext.fm`	Save project
`get channel.1`	Display values (optionally)
`get rds.1`	Display values (optionally)

Afterwards, you can create freely chosen RadioText with `set rds.1.rta #nn#mm...`
For example, `set rds.1.rta #48#41#4C#4C#4F#20#57#4F#52#4C#44` creates ⇒ HALLO WORLD.

11.6 Generating two TMC Congestion Announcements

In this example, two TMC congestion announcements are configured and sent.

- Create a new project with one channel, one RDS and one TMC source.
- Acticate "Group 8" and "Group 3" in the RDS "Basic Settings".
- In "Group 8", choose "TMC-1" as TMC source.
- Set the "PI Code" to "D314" (see notice in paragraph 9).
- Add two traffic announcements in index "TMC Sources".
- Open menu "Search Event" (right mousekey in the traffic announcements).
- Search for "Stau".
- Pull or enter codes "101" and "352" into the event fields.
- Open menu "Search Location".
- Search for "Kist".
- Pull or enter codes "10849" and "10851" into the location fields.
- Activate an channel and choose"RDS-1" as RDS source.

Configure your receiver to display traffic announcements. It may be necessary to connect an GPS antenna to your receiver.

12 Parameter List

The following parameters can be changed via the GUI or via remote control.
The parameters are separated into groups:

Groups	Name	Description
channel.#	Channels	# = 1..24 channel number
chinfo.#	Channel information	# = 1..24 channel number (read only)
audio.#	Audio-Sources	# number of the Audio-Source
playlist.#	Playlists	# number of the Playlist
tmc.#	TMC-Sources	# number of the TMC-Source
rds.#	RDS-Sources	# number of the RDS-Source

To set and get a parameter the number # must be provided.

Parameter	Range	Description
channel.used	0/1	toggle channel on/off
channel.freq	87,5..108 MHz	transmission frequency, japan 76..90
channel.gain	-60..0 dB	gain from 0 (full power) to -60 (noise-floor)
channel.volm	0..100 %	audio pcm volume (linear)
channel.mute	0/1	mute audio
channel.mono	0/1	channel is 1=mono or 0=stereo
channel.devi	0..130 kHz	deviation
channel.emph	0/1/2	preemphasis 0=none, 1=50, 2=75 μs
channel.rate	Hz	sample rate (32000, 44100 or 48000 Hz)
channel.auto	0/1	auto sample rate change on song change
channel.aof	-1000..1000 dB	atttenuation offset
channel.att	string	atttenuation unit
channel.rds	string	rds file to replay
channel.idrds	link rds.#	used rds source id
channel.idaudio	link audio.#	used audio source id
chinfo.playpos	0..1000	current playback position
chinfo.playing	string	current playing song (filename)
chinfo.playrate	Hz	current samplerate
chinfo.dist	MHz	minimum distance in MHz to next transmitting channel
chinfo.rdslog.#	string	transmitted RDS-Log of RDS-Source number #
chinfo.rdscount.#	int	number of transmitted RDS blocks (one block = 13 bytes)

Parameter	Range	Description
audio.used	0/1	audio source enabled/disabled
audio.name	string	audio source name
audio.type	0/1/2	audio type 0=sinus, 1=ramp, 2=file or playlist
audio.frq1	10..22000 Hz	first frequency for sinus/ramp
audio.frq2	10..22000 Hz	second frequency for sinus/ramp
audio.vol1	0..100 %	first volume for sinus/ramp
audio.vol2	0..100 %	second volume for sinus/ramp
audio.time	0..60 s	ramp duration
audio.file	string	file/playlist name
playlist.name	string	playlist name
playlist.#	string list	playlist file names

Parameter	Range	Description
rds.used	0/1	rds source enabled/disabled
rds.name	string	rds source name
rds.ps	string	program service name
rds.pi	0..0xffff	program identifier
rds.tp	0/1	traffic program bit
rds.ta	0/1	traffic announce bit
rds.ms	0/1	music speech bit
rds.pty	0..31	program type
rds.dec	0..3	decoder bits 3:dynPTY 2:compressed 1:artific 0:stereo
rds.rttag.#	list 2	radio text tag (2 values)
rds.rta	string	radio text A (group 2)
rds.rtb	string	radio text B (group 2)
rds.rtc	string	enhanced radio text C
rds.rtd	string	enhanced radio text D
rds.pn1	string	program type name 1
rds.pn2	string	program type name 2
rds.tmcai	0..0xffff	tmc application id (should be 0xCD46 or 0x0D45)
rds.tmcsi	link tmc.#	used tmc source id
rds.rtgrp	0..255	radio text plus ODA group
rds.rtbit	0..65535	radio text plus message bits
rds.rtitm	0..255	radio text plus items bits
rds.rtxt	0..255	radio text mode &1=radio text, &2=enhanced radio text, (≫2)&3=unicode mode
rds.ertg	0..255	enhanced radio text group
rds.ertb	0..65535	enhanced radio text message bits
rds.pss	0..255	ps scroll mode &8=scroll ≫4+1=repeat &7=rate
rds.afu	0..31	af bits, 1=use, 2=auto, 4=manual, 8=A/B, 16=bytes
rds.rpa	0..255	radio text A repeat
rds.rpb	0..255	radio text B repeat
rds.rpc	0..255	radio text C repeat
rds.rpd	0..255	radio text D repeat
rds.rp1	0..255	program type 1 repeat
rds.rp2	0..255	program type 2 repeat
rds.zone	-12..12 h	group 4 UTC zone hour offset, &32 mins, &64 days
rds.mins	-960..960 min	group 4 minute offset
rds.days	days	group 4 fix date (days since 1.3.1900)
rds.err	0..255	error generator 0=invert, 1=set to 0, 2=set to 1, &128=on
rds.ber	0..100 %	bit error rate for error generator
rds.fix	0..255	fix bits 1=crc, 2=group, 4=pi, &128=exact ber bits per group
rds.eon.#	hex list 6	eon data of exact 6 hex values: Channel PI PTY TP TA Link
rds.eon.ps	string	eon program service name
rds.eon.af	list 876..16100	eon alternate freq list ∗10 (876 = 87,6 MHz, 16100 = 1610 kHz)
rds.#	0..6000 dsec	group #=0..15 transmission rate (set to 4 to send group each 0,4 seconds)
tmc.used	0/1	tmc source enabled/disabled
tmc.name	string	tmc source name
tmc.ltn	1..63	location table number
tmc.sid	0..63	service identification
tmc.gam	0..255	bits &192=GAP mode, &32=AFI, &15=MGS
tmc.rpt	2..10	immediate group repeat
tmc.#	list 4	table entry of four values: duration extent event place