maintech GmbH

Multi FM Modulator

User's Manual for Generator Software v2.61

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Contents

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1 Package Contents

Following parts are contained in the box:

(1) MultiFM Modulator Hardware
(2) 12-Volt power supply
(3) RJ45 network cable
(4) USB/RS232 service cable
(5) License sheet
(6) newest MultiFM Software from:

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

2 Starting up

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

1. Install MultiFM software on a computer (`http://www.maintech.de/multifm`)
2. Connect control computer and modulator (1) using the network cable (3) and switch them on
3. Start MultiFM 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)

You will find the software documentation (pdf) via Menu ⇒ Help ⇒ Documentation (Ctrl+H). 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

Modulator and MultiFM software communicate via Ethernet (UDP). Therefore, both devices must be assigned with IP addresses of the same segment. 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.

1. Start the MultiFM software
2. Connect service cable (4) to computer (USB) and modulator (RS232)
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"

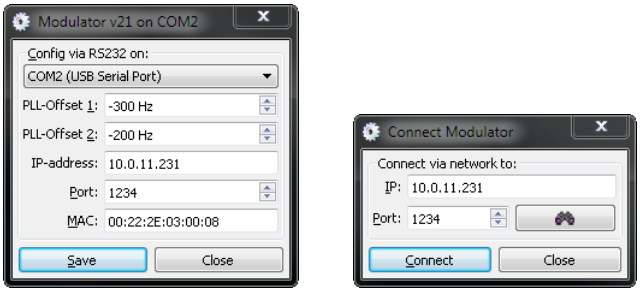

Figure 1: Building up a network connection with the Modulator

3.2 Connecting the Modulator via Network

1. Start the MultiFM 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 on 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 is also necessary to remove the absolute offset of the output frequencies. All devices are properly aligned during manufacturing and testing by maintech, but the process can be repeated by the customer if necessary.

To realign the PLLs, follow these steps:

1. Start Multi FM Software (see figure 2)
2. Connect service cable (4) 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. Choose Menu ⇒ Modulator ⇒ Config
5. Choose COM port; the MAC address will be displayed
6. Control 93 MHz deviation with a spectrum analyser (Center 93 Span 4 kHz)
7. Set PLL-Offset 1 for frequencies lower than 98 MHz
8. Confirm by "Save" or "Enter"; start again at step 6 if necessary
9. Control 103 MHz deviation with a spectrum analyser (Center 103 Span 4 kHz)
10. Set PLL-Offset 2 for frequencies above 98 MHz
11. Confirm by "Save" or "Enter"; start again at step 9 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 can be found in chapter 6.

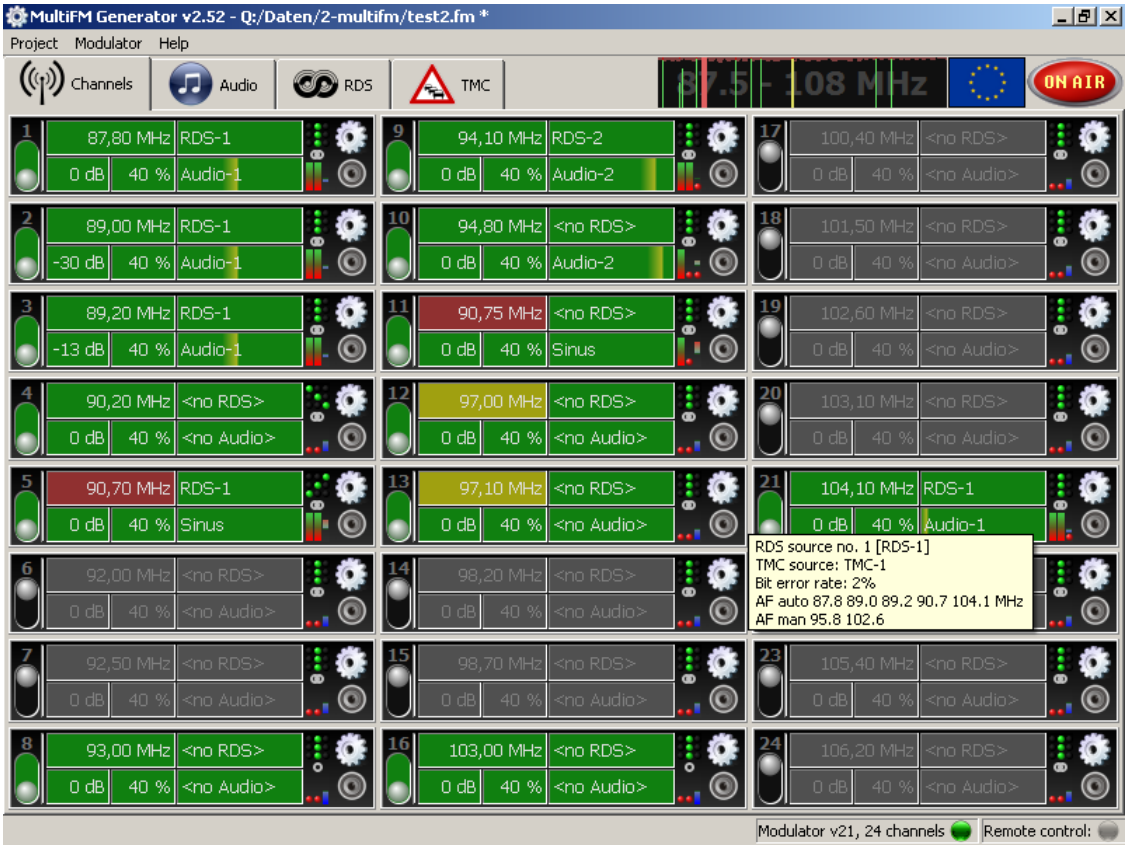

Figure 2: Multi FM channel overview

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`

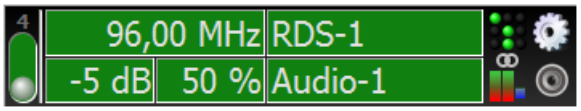

Figure 3: Channel status

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. To reach the intended frequencies as close as possible, it may be neccessary to calibrate 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

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.

If no RDS source is chosen `<no RDS>`, no RDS carrier is sent on the channel. In all other cases, a RDS carrier is generated, as well in mono as in stereo mode.

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.

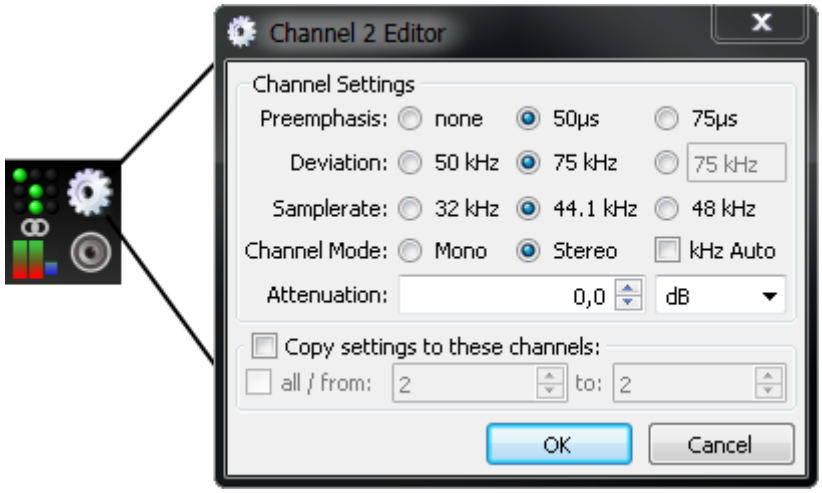

Figure 5: Status icons and channel editor

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 thus 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) with configurable time course
- A single audio file (ogg vorbis, flac, wav or mp3*)
- A playlist consisting of several audio files

* All audio files have to have a 16-bit, two channels 32, 44.1 or 48kHz sample rate. Some mp3 files may have unknown meta information (tags) so that they cannot be identified and played out correctly. If possible, these mp3 files should be converted into xiph formats OGG or FLAC, e.g. by foobar2000.org. Using this tool, you can also (re)set the tags, e.g. for RadioText+.

See figure 6 for the configuration of the audio sources.

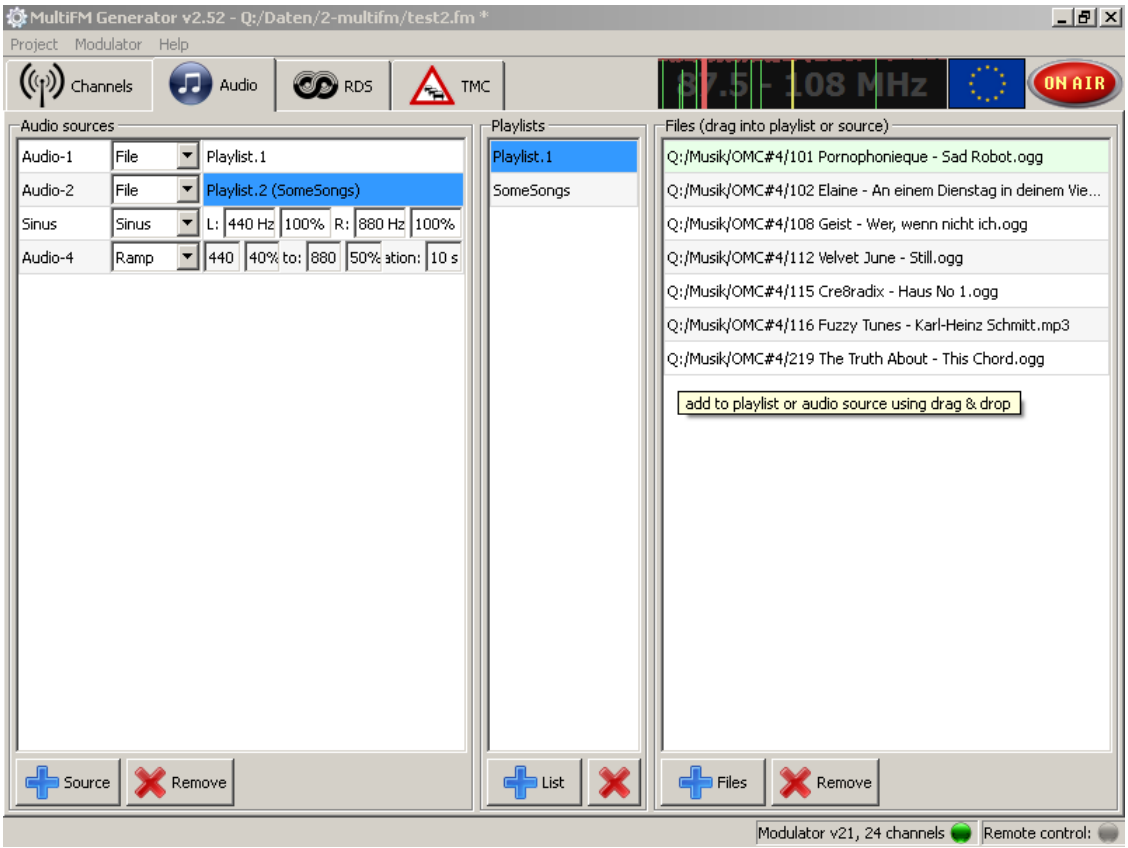

Figure 6: Audio sources

A correctly played out audio file is highlighted in green, a faulty or not playable file in red. When keeping the mouse pointer still upon the file name or upon the audio source in the channel overview, you will see the available tag information (artist, album) in a tooltip. In column "Audio sources", new sources can be set up or existing ones can be changed or deleted. A source's attributes are name, operation mode (sinus, ramp or file) and the related parameters. By drag&drop, the files are assigned to the playlists or sources.

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 continually 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 do 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 source type 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, drag the mouse arrow with pressed key onto the audio source until you see a "+"-symbol and drop it there.
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).

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.

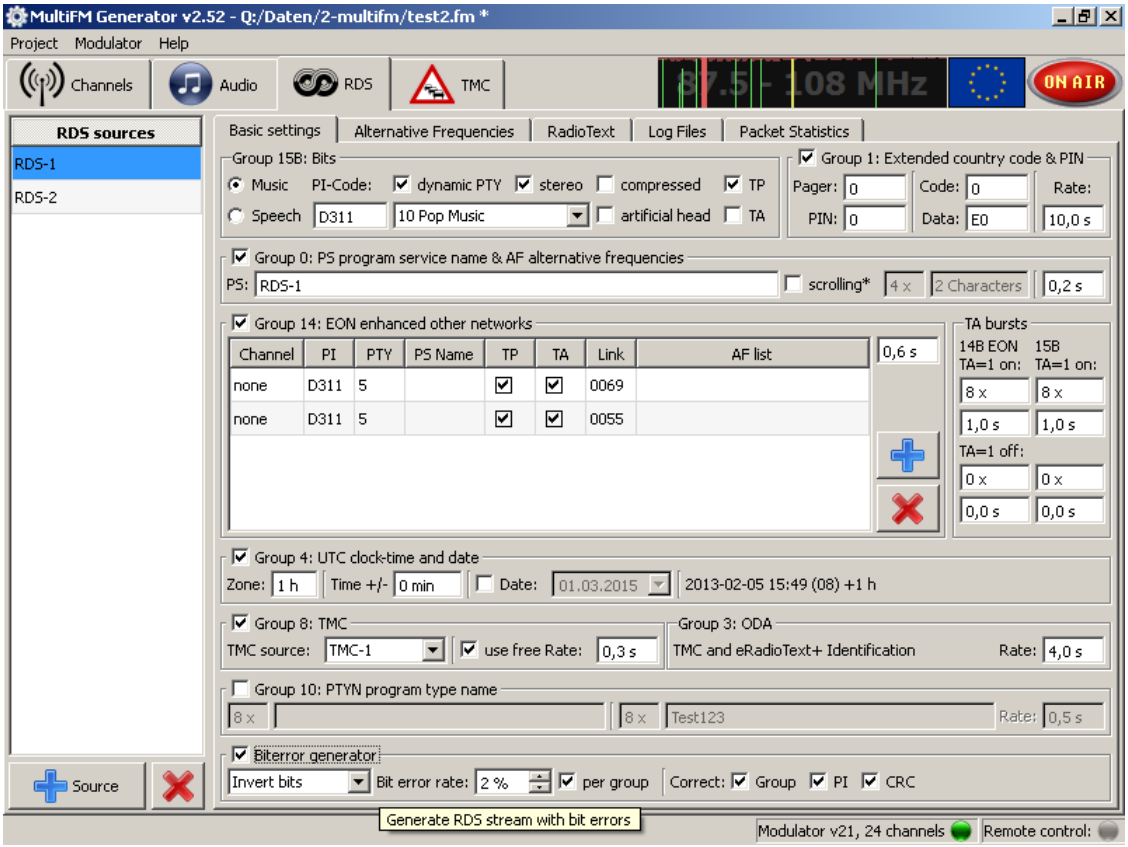

Figure 7: RDS sources

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
- Packet statistics

Each RDS source creates a defined bitstream that can be sent on several channels / frequencies independently. The channel tab shows which RDS bitstream is sent on which channel (see figure 2) and allows to set it (see paragraph 6.2). If no RDS source is chosen <no RDS>, no RDS carrier is sent on the channel. In all other cases, a RDS carrier is generated, as well in mono as in stereo mode.

The packet statistics allows analysis of the transmitted bitstream (blocks or groups depending on nomenclature). It also helps verify that 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 play it out without the need to rebuild the configuration etc.

8.1 Basic Settings, Group 15B

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).

If no further RDS groups are defined, only 15B groups are created in the bitstream.

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 or when no other groups are configured.

8.1.2 Group 0: PS, AF, TA (Program 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 for testing purposes. 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 has 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) signals 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 can fall 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, these 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 continually or set to 0 or 1 constantly. 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 finding software errors in decoder parts that get the data not until after the CRC check and therefore cannot receive data errors under normal conditions.

8.2 Alternative Frequencies (AF)

If activated, AFs are transmitted in 0A groups together with PS.

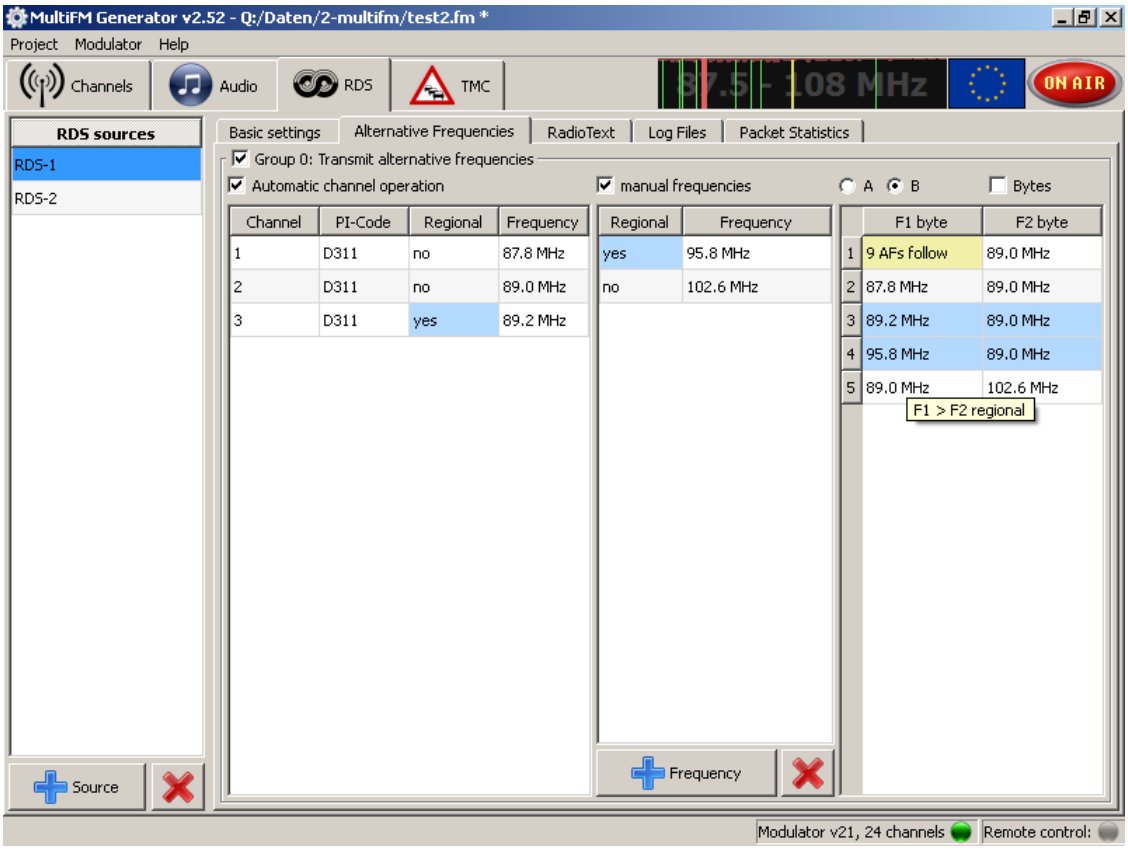

Figure 8: Alternative frequencies in RDS

8.2.1 Channel Automatic

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).

Double-clicking the Regional-field changes between yes and no. Regional programs can only be sent with procedure B.

8.3 RadioText

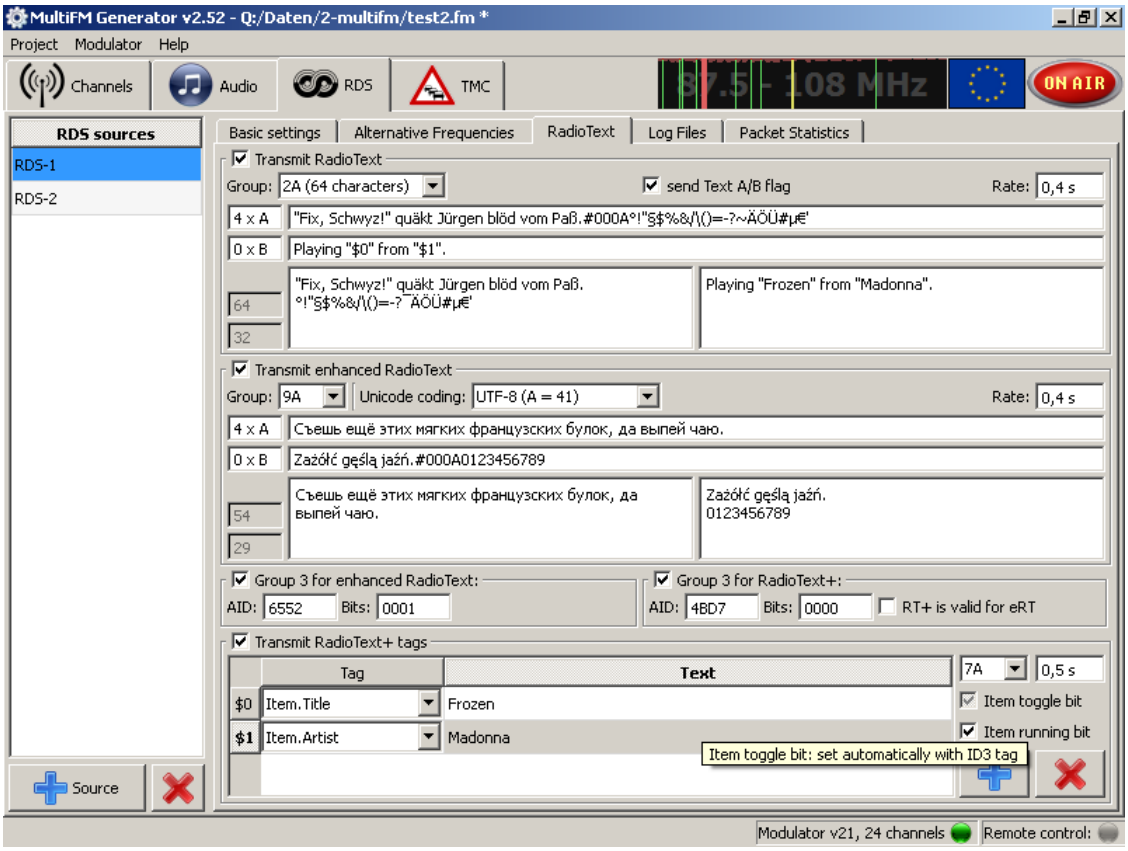

Figure 9: RadioText configuration in RDS

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. The different coding and/or texts can cause different position and length specifications of the RT+ tags; therefore it has to be set if the RT+ applies for RadioText or Enhanced RadioText. This is signalled with a bit in ODA group 3 of the RT+.

The groups for eRT and RT+ transmission have to be selected differently. They are transmitted as ODA with the AID identification in 3A groups (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.

If Text A/B is activated, the Text-A/B-bit will be toggled each time the RadioText changes. This can happen when changing from Text A to Text B or by filling a tag information from a new playing audio file.

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".

With `"RadioText+ applies to eRT"` the RT/eRT-Flag in group 3A can be set. If set, the tags from RT+ are valid for the enhanced RadioText; if not, for the standard RadioText in group 2.

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 Play Back RDS Log Files

Instead of generating a new RDS signal, it is possible to play a recorded RDS log from a file. The requested files have to be added in the "Log files" tab. All lines from all files are sent continually. After the last line of the last file, the playout starts with the beginning of the first file again. Paragraph 8.5.2 describes how to save an RDS log file.

To create faulty CRCs too, there is a special format:
`ABCD D314 1592 6535 8979`
If there is a 0 in the place of A,B,C or D, the correct CRC for the relevant block is computed and inverted.

In Raw format, the CRC values can be set directly (13 bytes, of these 4 x 10 bits CRC).

8.5 Packet Statistics

8.5.1 General

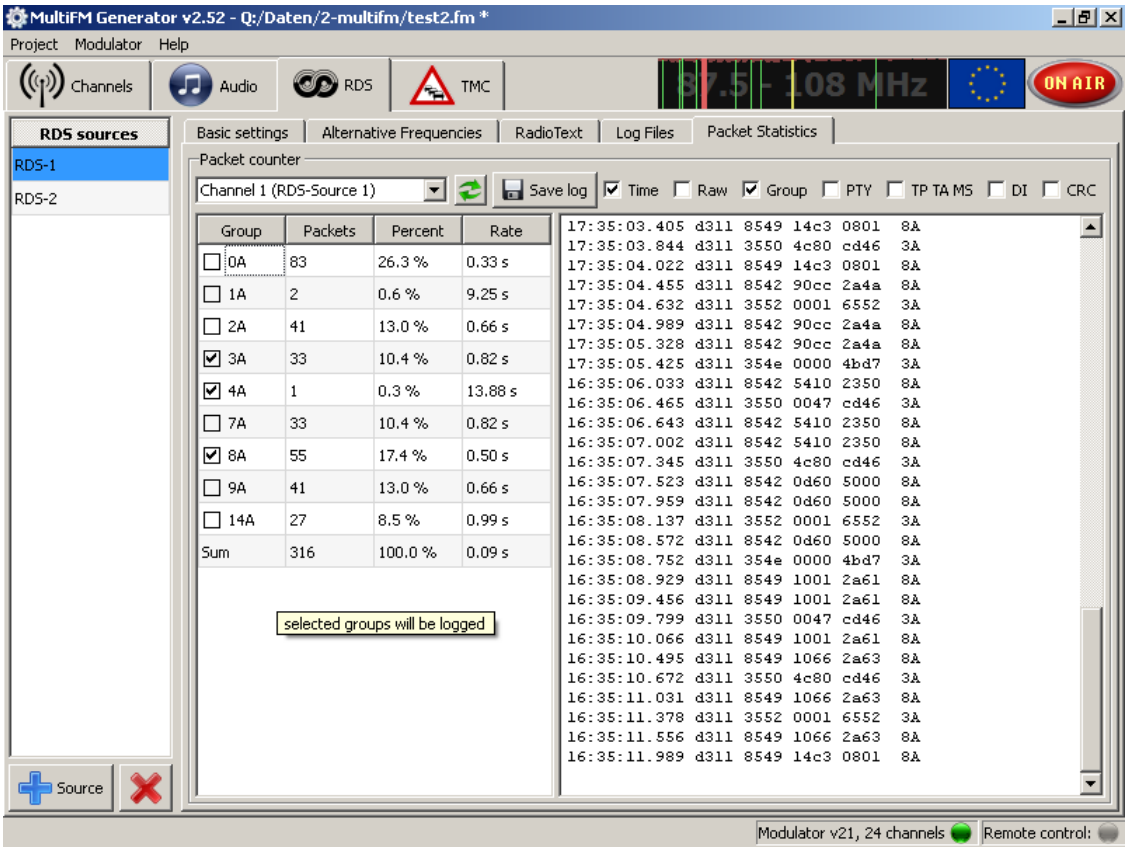

Figure 10: Packet statistics

The packet statistics display the sent RDS packets, itemized in groups for one channel at a time using the currently chosen RDS source. The log can be filtered by choosing several groups.

8.5.2 Save RDS-Log File

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 send this file repeatedly (see paragraph 8.4).

In Raw format, the CRC values are also stored (13 bytes = 8 databytes + 4 x 10 bits CRC).

9 TMC Sources

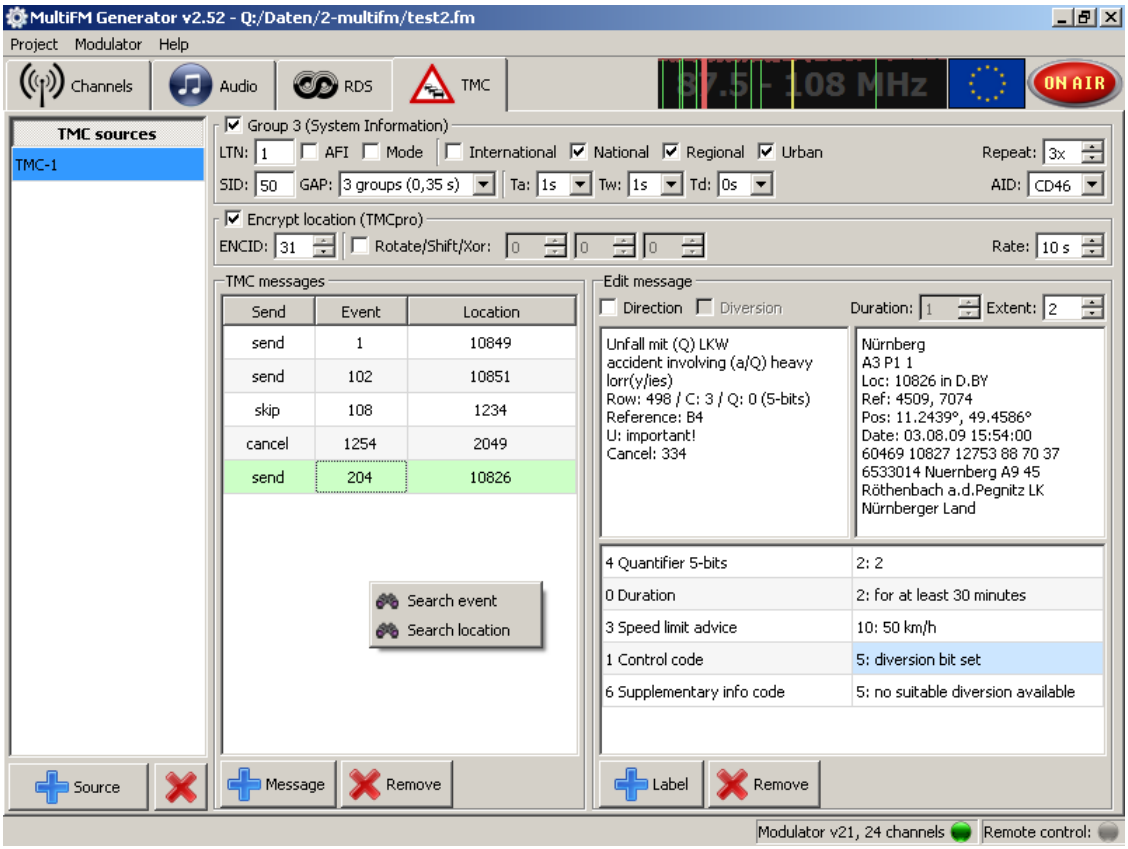

Figure 11: TMC generator

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

Adding labels changes a single-group traffic message into a multi-group traffic message.

9.1 Preconditions

Setting	**Reason**
activate group 8	Traffic messages (Alert-C) will be sent in RDS group 8A
activate group 4	some receivers need a local time stamp to work
activate group 3	ensure TMC detection in the receiver (System Information ODA)
choose source	link a TMC source to all desired RDS sources in the basis settings
set CC	with the country code (first letter in PI) the correct LTN for that country is assigned; if not, receivers may discard the messages for unknown countries. Germany uses D or 1
set ECC	the extended CC can be sent in group 1. Germany uses E0 as ECC
TMCpro	TMCpro receivers have decryption keys for some sets of CC/SID/LTN. A known set for germany is CC=D, SID=50, LTN=1, ENCID=31

TMC announcements are coded according to the Alert-C Standard (ISO 14819-1..6). For a detailed explanation of the following parameters, please refer to this standard.

9.2 System Information

The TMC system information (SI) consists of Location Table Number (LTN), Service Identifier (SID), GAP Parameter, Timings (Active, Window, Delay), Alternate Frequency Indicator (AFI) and Message Geographical Scope (MGS) Bits International, National, Regional, Urban (INRU).

This SI is sent alternating with the TMC Application ID (AID), usually 0xCD46, in RDS group 3A. Thus, the TMC service is signalized to the receiver by the ODA mechanism (Open Data Applications).

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

9.3 Traffic Announcements

Each line in the table is equate to one traffic announcement. This consists of at least one event and one location. To search for a location or event, click the right mouse button for a search dialog.

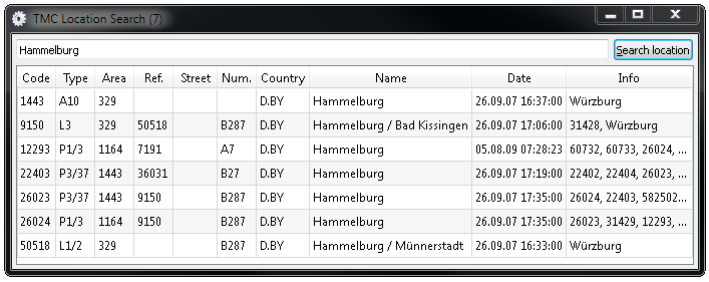

Figure 12: TMC location search

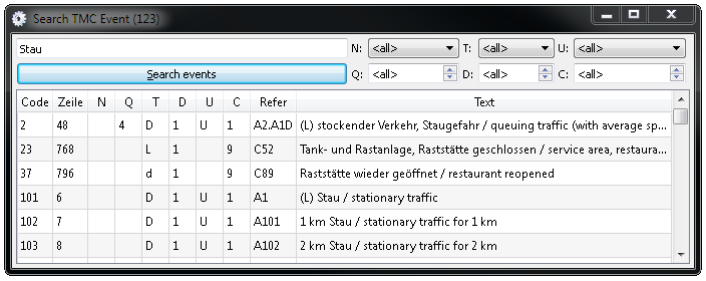

Figure 13: TMC event search

A search for the event "stationary traffic" should produce 116 matches. A code can be moved from the search dialog to the event or location field using drag&drop.

The sending state of each message can be switched between *send, cancel, skip* by double clicking the field. By cancelling, the corresponding cancel event from the same update class of the event is sent instead. The receiver should delete the message then. The event 2047 (Null-Message) with the special Location Code 65535 can by used to delete all messages of the current service.

9.4 Additional Content

By adding some labels (additional message content), a single-group traffic message becomes a multi-group message. Up to five RDS 8A groups are allowed per message. That means 5*28 = 140 bits are available for additional content. The diversion bit and the duration are directly sent within single-groups. In multi-groups they have to be added as optional content with Label 1 (Control Code) with value 5 (diversion bit set) and Label 0 (duration).

Label (4-bits)	**Description (0..16-bits)**
0 Duration	depends on (last) event, value 0 not allowed
1 Control code	value between 0..7, f.i. 5 for diversion bit set
2 Length of route affected	0..31, f.i. 5 for 5 km
3 Speed limit advice	0..31, f.i. value 10 means 50 km/h
4 Quantifier 5-bits	0..31, depends on (last) event
5 Quantifier 8-bits	0..255, event specifies which Q is used
6 Supplementary code	0..255, see supplementary info code table in ISO 14819-2
7 Explicit start time	0..255, f.i. 40 for 10:00 am
8 Explicit stop time	0..255
9 Additional event	11-bit event code
A Diversion instruction	16-bit location code from same LTN
B Destination	16-bit location code
C Reserved/Precise Location	16-bit
D Cross link problem source	16-bit location code
E Separator	0-bit (no value), separate Label 2 and 3, group Label A
F Reserved	

10 Remote Control

Remote controlling the MultiFM 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`.
`ADD key value`	Add a list entry
`DEL key`	Delete list entry or complete list
`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.

Command	Description
`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
`get channel.1`	list all values of channel 1
`get channel.1-3.*`	list all values of channels 1, 2 and 3
`dir`	lists all project files in the current directory
`help channel.1.volm`	show a short description about this key: `channel.1.volm channel audio pcm volume (linear) [0-100] %`

If an unknown command is entered, a list of all commands will be shown:
`valid commands: REG UNR GET SET ADD DEL 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 and their description 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 List Management

The commands ADD, SET and DEL are used to manage lists.

List (Key)	Description
`playlist.N.#`	song list for playlist N
`rds.N.af`	sent AF list of RDS-Source N (read only)
`rds.N.afs`	manual AF (Alternative Frequencies) list entries
`rds.N.afr`	regional AF entries (within manual AFs)
`rds.N.eon.#`	EON value list
`rds.N.eon.af`	AF list of an EON entry
`rds.N.rttag.#`	RadioText+ tag list
`rds.N.files`	list of RDS log files to play out (instead of using the generator)
`tmc.N.#`	TMC message list of TMC-Source N

Example	Description
`get rds.1.eon`	list all EON entries
`add rds.1.eon 0 d311 1 2 3 4`	add one EON entry
`set rds.1.eon.2 0 d311 5 6 7 8`	change EON entry 2 (if existing)
`del rds.1.eon.2`	remove EON entry 2 (if existing)
`set rds.1.eon.0.af 958 1030`	set AF to 95.8 and 103.0 MHz for EON entry 0
`add rds.1.eon.0.af 1026`	add 102.6 to AF list of EON entry 0
`del rds.1.eon.*`	remove complete EON list
`del rds.1.afs`	remove all manual set AFs
`set rds.1.afs 958 1026`	set two manual AFs (95.8 and 102.6 MHz)
`set rds.1.afr 958`	mark AF 95.8 MHz as regional
`add tmc.1 1 2 3 4`	add one TMC message in TMC-Source 1
`del tmc.1.*`	remove all TMC messages in TMC-Source 1

10.2 Channel Info, RDS-Log

In the channel information, status changes of the channels #1...24 are displayed. These values can be read only, but cannot be set.

Channel Info	Description
`chinfo.#.playpos`	current playback position [0..1000]
`chinfo.#.playing`	current song (filename)
`chinfo.#.playrate`	current samplerate
`chinfo.#.dist`	minimum distance in MHz to next transmitting channel
`chinfo.#.rdslog.#n`	transmitted RDS-Log with #n = RDS source number
`chinfo.#.rdscount.#n`	number of transmitted RDS blocks (13 Bytes)

Examples	Description
`REG chinfo.1.playpos`	monitor playlist position of a song from 0 (start) to 1000 (end)
`REG chinfo.*.playing`	monitor song changes of all channels
`REG chinfo.1.rdslog`	monitor RDS-Log of channel 1
`SET rdslog time raw data group`	configure RDS-Log: `time` is the time stamp `raw` are the 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.

10.3 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 packet 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.

10.4 RDS Remote Control

The Multi FM Software receives on TCP ports 4001 to 4024 line by line the RDS data to be sent out over channels 1 to 24. All formats that can be created in the packet statistics as RDS-Log (s. 8.5.2) can be used here.

The reply consists of a *counter* and the current buffer *fill state* of the RDS queue. The counter gives the number of packets received for the current connection. A fill state 0 means that there are no more packets to send. The internal buffer of the modulator hardware can hold 19 packets (that means less than two seconds sending time). A higher fill state means that there are more packets waiting in the software to be sent to the hardware.

An error will be signalled with *fill state -1*, the RDS packet with number *counter* was discarded.

Operation	**Text**
`Send`	D314 1234 5678 9ABC
	d361d283634e4d361398c4830b 0B
	Test Test
`Reply`	425 51 *(counter = 425, fill state = 51)*
	426 52
	427 -1 51 noRDS

The example Client software can open an RDS-Log file and send it to any port for demonstration purpose.

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 MultiFM 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.

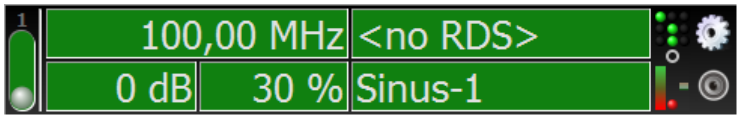

Figure 14: Channel 1 with sinusoidal tones

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.

Do the following steps:

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 audio files with "+ Files".
5. Drag&Drop each 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 (Figure 15) should play the selected audio file. The tracks are repeated continually.

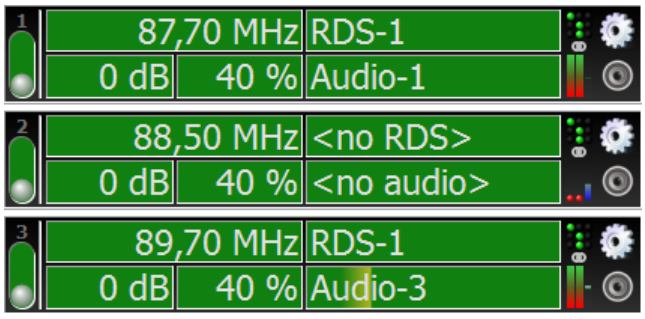

Figure 15: Play out three audio files on three channels

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, hex signs are 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 and start transmission
`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	attenuation offset
channel.att	string	attenuation 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 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.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=use radio text, &2=use enhanced radio text (≫2)&3=unicode mode, &16 toggle AB-Bit, &32 group 2B, &192 group 3
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..15	af bits, 1=use, 2=auto, 4=manual, 8=A/B
rds.af	int list	automatic af list (* 0.1 = MHz/kHz) read only
rds.afs	int list	876..16100 manual af list (* 0.1 = MHz/kHz)
rds.afr	int list	876..16100 rds regional af list (for method B)
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.date	0/1	group 4 use 0=date of today, 1=fix date from days
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.page	0..255	group 1 radio paging (5 bits)
rds.slow	0..65535	group 1 slow labeling code
rds.pin	0..65535	group 1 program item number
rds.fused	0/1	play log files on/off
rds.files		play log file list
rds.#	0..6000 dsec	group #=0..15 transmission rate (set to 4 to send group each 0,4 seconds)

Parameter	Range	Description
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.eoc1/2	0..100	eon ta on/off burst count
rds.eot1/2	0..100	eon ta on/off burst time in dsec
rds.buc1/2	0..100	group 15B ta on/off burst count
rds.but1/2	0..100	group 15B ta on/off burst time in dsec
tmc.used	0/1	tmc source enabled/disabled
tmc.name	string	tmc source name
tmc.flag	int	enable &1=group3 &2=tmcpro &4=skt
tmc.ltn	1..63	location table number LTN
tmc.sid	0..63	service identification SID
tmc.aid	hex	tmc AID application id (usually CD46)
tmc.gam	0..255	bits &192=GAP mode &32=AFI &16=Mode &15=MGS INRU
tmc.awd	int	timing active window delay for Mode=1
tmc.rpt	1..50	immediate group 8A repeat
tmc.rate	1..255	ENCID group 8A sending rate in seconds
tmc.enc	0..31	ENCID encryption id to use for TMCpro
tmc.skt	hex list	service key table for encryption
tmc.#	int list	duration extent event place send [multigroup labels...]