P275
FM Broadcast Analyzer

User Manual

Firmware version 2.2c
Hardware version P275A

Product Site: https://pira.cz/fm_broadcast_analyzer/ Technical Support: https://pira.cz/forum/

Table of Contents

Related Documents

Visit the Website for the latest documentation version and the following additional documentation:

- FM Scope - User Guide (http://pira.cz/fm_broadcast_analyzer/fmscope.pdf)
- RDS Spy - RDS Decoder for Windows (http://rdsspy.com/download/mainapp/rdsspy.pdf)

Introduction

The P275 FM Broadcast Analyzer is a stand-alone compact solution for FM broadcast analysis. It provides complete FM modulation and basic AF spectrum measurements in FM radio band through the combined antenna and MPX input.
Built-in OLED display and control interface allows to measure and collect data directly in field without need of any PC computer. USB interface and the control software provide a possibility of remote control, data viewing and automated data logging.
This kind of analyzer is essential equipment for all FM radio stations to ensure compliance with basic technical broadcast standards and to accomplish the highest audio quality possible.

Main Highlights

- Stand-alone design, completely DSP based from IF to outputs
- Compliant with CEPT/ERC REC 54-01 E and ITU-R SM.1268
- Combined RF and MPX input via industry standard BNC connector
- Dual-conversion RF receiver
- Aluminum case, built-in OLED display and USB interface
- Pocket size, built-in replaceable LiPo cell
- Easy and fast to use

Measurements, Indications and Outputs

- Overall frequency deviation incl. histogram
- Modulation power (MPX power)
- Baseband spectrum, RF carrier spectrum
- Pilot deviation, RDS deviation
- Pilot-to-RDS phase difference
- FM carrier frequency offset
- Reception quality and signal strength
- Stereo balance meter
- MPX peak to peak voltage
- RDS/RBDS decoder

Typical Applications

- FM broadcast equipment installation, setup and maintenance
- Verification of compliance with related technical standards
- Diagnostics, repairing and development

Please read this entire manual and familiarize yourself with the controls before attempting to use this equipment.

The equipment has been thoroughly tested and found to be in proper operating condition when shipped. The manufacturer is not liable for any damages, including but not limited to, lost profits, lost savings, or other incidental or consequential damages arising out of the use of this product.

It is our intention to provide you with the best documentation possible to ensure successful use of the product. If you wish to provide your comments on organization, clarity, subject matter and ways in which our documentation can better serve you, please mail us your comments.
Information in this document is subject to change without notice.

Revision: 2024-05-04

Electromagnetic compatibility

CE

The manufacturer declares that the product complies with the essential requirements of applicable European Directives and carries the CE marking accordingly and in conformity with the following product standards:

EMC Standard	Test conditions	Notes
EN 55011:2009	Class B	
In line with EN 61326-1:2013:		
EN 61000-3-2:2014		1)
EN 61000-3-3:2013		1)
EN 61000-4-2:2009	Contact discharge ±4 kV Air discharge ±8 kV	
EN 61000-4-3:2006	3 V/m (80 MHz - 1 GHz) 3 V/m (1.4 GHz - 2 GHz) 1 V/m (2 GHz - 2.7 GHz)	
EN 61000-4-4:2012	L, N conductors ±1 kV Capacitive way (antenna cable) ±1 kV	1)
EN 61000-4-5:2006	L, N conductors ±0.5 kV	1)
EN 61000-4-6:2009	3 V, 150 kHz - 80 MHz	
EN 61000-4-11:2004	0% UT during half cycle 0% UT during full cycle 70% UT during 25 cycles short interruption: 0% UT during 250 cycles	1)

Test report no.: 414103294AE1
Issued by: Testing laboratory no. 1004.3, ITC, a.s., CZ
Date: 2016-10-25

Notes:
1) With standard power supply.

Technical Specifications

Parameter	Condition	Value

General

Supply voltage	USB	5.0 V DC ±10 %
Supply current (USB)	powered on	190 mA
	charging	220 mA
	powered on and charging	410 mA
Power supply connector		USB-B
Internal battery		3.7 V, 0.8 Ah LiPo cell, 2 hours of operation
CPU		70 MIPS DSP
Data connector		USB-B (FTDI based, virtual serial port)
Communication speed		115200 bps
Communication mode		1 stop bit, 8 data bits, no parity, (no flow control)
RX buffer length		40 bytes
Signal input		BNC type, combined antenna (RF) and MPX input with internal solid-state switch.
Case dimensions		12.5×8×3 cm
Weight	w/o accessories	280 g

Antenna (RF) Input

Recommended source impedance		50 Ω
Frequency range	guaranteed params	76.0 – 108.0 MHz
	extended	64.0 – 108.0 MHz
Tuning step		selectable 50 kHz or 100 kHz
Input sensitivity	S/N 26 dB	4 µV
	basic measurements	30 µV
	full measurements	70 µV
Maximum input level		1000 mV (20 mW)
Intermodulation immunity		basic (single input LC circuit with coil tap)
Intermediate frequency (IF)	1st IF	10.7 MHz
	2nd IF	0.325 MHz ± 0.005 MHz
Image rejection	+ 21.4 MHz	23 dB
IF bandwidth		280 kHz

Never connect RF power output from the transmitter directly to the device's antenna input!

Measurements

Frequency deviation range	min.	0 – 121 kHz
Frequency deviation error	1 kHz sine	< ± 1.5 kHz
	typical content	< ± 2 kHz
Modulation power range	min.	-12 – 14 dBr
Modulation power error	-6 – 6 dBr	± 0.2 dBr
Pilot deviation error	6.8 kHz	± 0.2 kHz
RDS deviation range		0.8 – 17.9 kHz, note 4
RDS deviation error	full signal	± 5% ± 0.5 kHz
Pilot-to-RDS phase difference error		± 4 deg.
Baseband frequency response flatness	10 Hz – 60 kHz	± 0.3 dB
Stereo balance error		± 0.5 dB
Signal level (RSSI) range		0 – 90 dBµV
Signal level (RSSI) error	60 dBµV	± 3 dBµV
	30 – 75 dBµV	± 5 dBµV
	0 – 90 dBµV	not specified
Ambient temperature		10°C – 40°C (50°F – 105°F)

MPX Input

Input impedance		2.3 kΩ
Recommended source impedance		600 Ω or less
Maximum MPX level	peak to peak	8.0 Vpp
Bandwidth	-1 dB	100 kHz
Vertical resolution		12 bits
Peak to peak voltage error	1 kHz sine	± 2% ± 0.010 Vpp
Pilot level range		0.010 – 2.250 Vpp
RDS level range		0.002 – 3.400 Vpp

Never use the equipment if there's any visible damage on its electrical parts! In that case disconnect all cables, remove accumulator and contact the vendor or manufacturer.

Headphones audio output

Audio channels		2 (left and right)
Output impedance	typ.	100 Ω
Output level	no load	adjustable 0.1 – 4.0 Vpp @ 75 kHz
Signal to noise ratio	75 kHz dev.	60 dB
Stereo decoder separation	1 kHz	>26 dB
Distortion	1 kHz	1 %

Internal RDS/RBDS Decoder

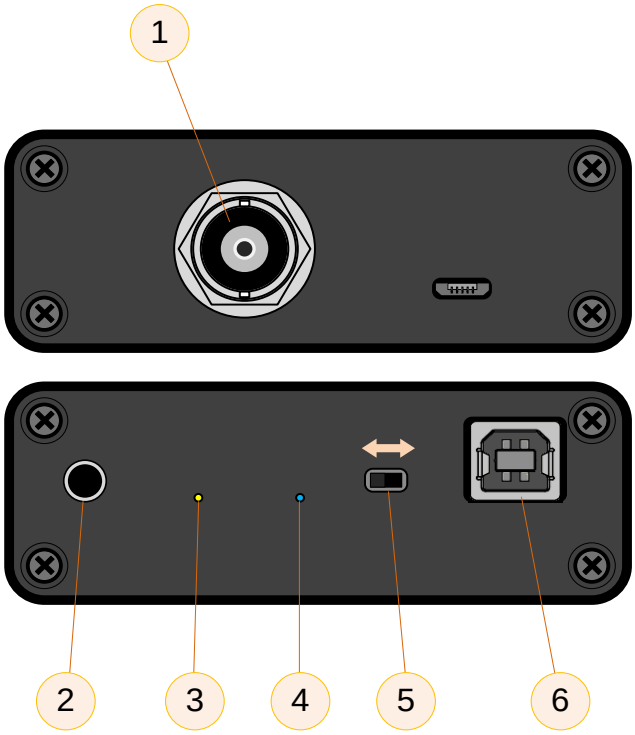
RDS filter and demodulator		DSP based
RDS source		Antenna (RF) or MPX input
RDS groups detected		All RDS groups 0A-15A, 0B-15B
RDS services supported		PS, PI, PTY, PTYN, TP, TA, M/S, DI, AF, EON, ECC, LIC, PIN, RT, CT, AID, RT+
RDS groups decoded		0A, 0B, 1A, 2A, 2B, 3A, 4A, 10A, 14A
Minimum RDS deviation (ΔF_{rds})	antenna (RF) input	1.0 kHz
Minimum RDS level	MPX input	4 mVpp
Antenna input sensitivity (average BER = 5 % or less, single station, no interference)	ΔF_{rds}=2.0 kHz	25 µV
	ΔF_{rds}=3.4 kHz	18 µV
	ΔF_{rds}=6.8 kHz	9 µV

Notes (Technical specifications):

1. pp = peak-to-peak value; BER = Block Error Rate
2. Due to inherent reception the unit may have reduced sensitivity at 102.4 MHz.
3. Very strong el. field intensity (above 130 dBµV/m) may cause additional measuring error or may disallow the measurement.
4. If pilot and RDS are not synchronized, the range reduces to 1.5 – 17.9 kHz. Spurious RDS detection may occur on stations without RDS if the station's signal is noisy or specific static sine tones are transmitted. If ARI system is used simultaneously with RDS on the same transmitter, the RDS deviation value should not be taken into consideration. Instead of this the Windows application and MPX spectrum graph gives an image about signal level of each component.

Side connectors and controls

While the main control interface covers the front side of the device, the connectors and other elements are accessible on the left and right side.



1	**Input**	BNC 50Ω input connector. Accepts RF as well as MPX signal. See section ‘Menu’ for details. See section ‘Antenna input’ and ‘MPX input’ for specifications.
2	**Headphones output**	2-channel audio output provided on 3.5mm Jack. See section ‘Headphones audio output’ for specifications.
3	**Charge LED**	Indicates the internal battery charging state.
4	**USB Power LED**	Indicates the USB 5V power.
5	**Power off/on**	Device power switch. The battery, if necessary, is charged regardless of the switch position.
6	**USB**	Allows connection of external 5V power supply or connection to a PC. See section ‘Power supply’ for details. See section ‘USB Port Communication’ for details.

There are no adjustable elements inside the equipment.

Power supply

Two power supply modes are provided: from the USB and from the internal battery. The Off/On switch applies to both modes.

USB-B connector

Use this connector for supplying the FM analyzer from a PC computer or 5V power supply (DC wall adapter). This connector is polarity protected for currents up to 2 A. In case of blackout (power failure), the device continues smoothly in operation from the internal battery.

Never exceed specified voltage value at the USB connector! It may cause permanent damage to the device! Do not let the cable to hang freely from tables or shelves!

The USB port should be rated to full **500 mA** current! When supplying the unit from USB bus, it is a better choice to connect the unit to the USB interface on the main board. Supplies for pocket USB hubs and for some USB interfaces of lap-top and desk top computers may not be sufficient.

Battery operation

The device is equipped with internal LiPo cell for independent operation and working in the field. The battery is charged whenever the USB power is connected. The charging is terminated automatically once the battery is in full state. You can still use the equipment for measurements while the battery is charging.

In the RF mode, the battery voltage is indicated on page 9. The device will turn off itself when the battery voltage drops below 3.0 V. In such case it is necessary to connect USB power supply as soon as possible, to charge the battery.

Charge the battery immediately if the battery is weak! Keep the battery charged.

If the device will not be in use for a longer time, always charge the battery.
Connect the device to USB power at least once per 3 months!

Never leave the device in direct sunlight!
Never leave the device unattended while the battery is charging!

Firmware updates

The FM analyzer has a firmware update capability. This allows easily implementing of new features. When a new firmware version is released, a special simple Windows application provides the firmware update. The firmware updates are provided at no additional costs.

1. Connect the FM analyzer to any local COM port or USB port.
2. Run the update utility, select the COM port and click Start! button.
3. Turn on the FM analyzer if not done yet.
4. The upgrade process is fully automated and takes about 1 minute.

Please refer to the web site for more information.

Don’t forget to download also latest control software and manual!

Operating Instructions

Power-up

On power-up, the device requires no heating time. After a few seconds the unit is ready for operate. The antenna, audio and data cables can be connected regardless of the operating state.

Control buttons

Button	Meaning
▲ ◯	Go to previous page or menu item, tune up, volume up.
▼ ◯	Go to next page or menu item, tune down, volume down.
☰ ◯	OK, enter the menu, confirm the option.

Menu

Navigation in the menu

- To enter the menu or submenu, press the OK button.
- To leave the submenu, go to the Return item, then press the OK button.
- To leave the menu entirely, select an option or go to the Return item, then press and hold the OK button.

List of menu items

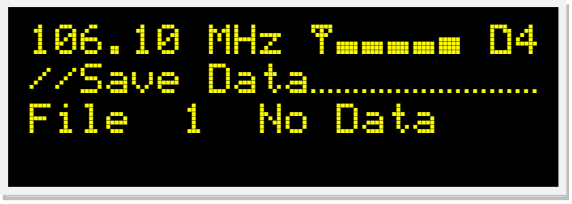
Menu item	Meaning
1 – Tune	Tune to a desired frequency in FM band (manual tuning) or select the MPX input.
2 – Scan	Tune using a scan mode (automatic tuning, stops on each station).
3 – Page Context	Items in this submenu appear depending on what page is being active.
MPX Spectrum FFT Show Peaks Histogram Data Set as Normal More RDS Data	Shows graphical representation of the MPX spectrum Selects between overall peak deviation and Pos/Neg representation. Show frequency deviation histogram values. Consider the 2nd IF as a normal (see Carrier frequency offset) Show more Radio Data System information.
4 – File	
Save Settings Load Data Save Data	Save settings (incl. current frequency tuned) Load measured data and RDS data from EEPROM. Save measured data and RDS data into EEPROM.
5 – Clear Data	Clear all measured values in operational memory.
6 – Settings	
Volume Force Mono MPX Input Corrections DIP Switches	Adjust audio volume in steps. Disable the stereo decoder. MPX options for correct voltage calculation: source impedance, load impedance Power supply ripple suppressing, audio output deemphasis etc. Further configuration options (frequency range etc.)
7 – Measuring	Enable/Disable the measuring.

Switching between antenna (RF) input and MPX input

The input connector is shared by two internal modules - the RF module and the MPX module.
To enable the MPX input, tune the frequency to **0.00 MHz** (following the end of the band in any direction).
The MPX label will appear instead of the signal quality indicator.

Where applicable, the device keeps all functionality for the MPX input (stereo decoder, audio output, RDS decoder) except that measurement of FM deviation in kHz is replaced by peak-to-peak voltage measurement.

Save Data



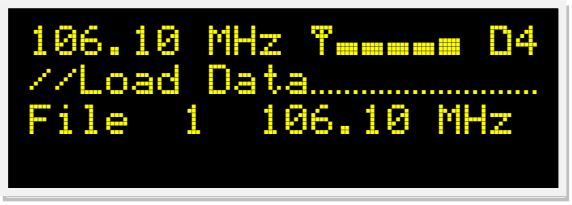
The FM analyzer can store data from up to 30 measurements into internal EEPROM memory. This memory does not lose the data after power-off.

Select the Save data menu item and choose unused file position (or rewrite any existing position).

In addition, current frequency and these RDS information are saved: PS, PI, PTY, TP, TA, M/S, RT, EON, AF, DI, group statistics.

The Save Data feature also supplies a preset memory function for tuning frequencies.

Load Data



Select the Load data menu item and choose the file required. The data are identified by the frequency.

To use the file as a frequency preset:

- Make sure the Measuring option in the menu is enabled
- Load the file

To use the file for the purpose of reading all stored data:

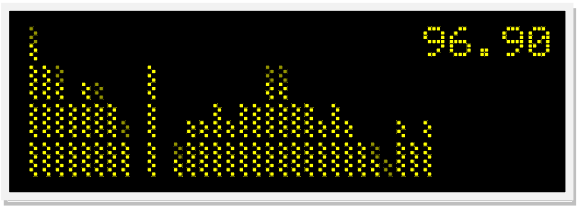
- Disable (uncheck) the Measuring option in the menu
- Load the file
- You may browse the data, send them via serial port or continue in measurement by enabling the Measuring option.

Headphones output volume

The menu item Volume allows adjusting of audio volume in steps. The volume can be set separately for the antenna (RF) input and for the MPX input.

Note: The headphones output is not suitable for rebroadcast or streaming purposes.

MPX Spectrum FFT



The FFT screen covers frequency range from 0 to 80 kHz and signal levels between -10 and -50 dB. By pressing Up or Down, the display will show the axis description.

The FFT is available in both the RF and MPX mode. Detailed spectrum is accessible via the FM Scope software.

Screen saver

If the user does not press any button for more than 30 minutes, the screen saver will activate. This is necessary to protect the OLED display and increase its lifetime.

The screen saver shows current frequency at different positions which change each second. The screen saver can be deactivated by pressing any button or by sending `*0` command via the data interface.

RF Measurements

Signal quality

The signal quality indication does not reflect the signal strength directly. It's a result of the following input parameters and influences:

- Noise level (measured in baseband above 100 kHz)
- Multipath propagation
- Intermodulation
- Amplitude ripple (AM modulation)
- 2nd IF frequency (frequency offset) – "in-channel" check

The essential condition for the measurement is enough signal level on the antenna input and sufficient frequency spacing between the stations. Not all signals that you can listen can be also measured. The following scale illustrates it and it's valid in general:

Signal level	1 µV	10 µV	100 µV	1000 µV
Reception on typical receiver	Mono only	Poor quality stereo	High quality stereo	
Measurement ability	Not possible	Basic	Full	

The basic measurement includes modulation power, pilot level and RDS decoding. The full measurement includes overall frequency deviation and RDS level. In noisy environment or in a location with many strong stations the minimum signal level may increase.

It's possible to say that optimal signal strength range and reception conditions for full measurement coincide with the requirements placed on high quality stereo reception. This rule determines the demands closely.

Signal reception quality table:

Signal	**Meaning**
T	No signal.
T▂	Weak signal detected.
T▂▂	Signal still unusable for measurement.
T▂▂▂	Poor signal. Basic measurement is possible with reduced accuracy for RDS level. Full measurement is not possible.
T▂▂▂▂	Good signal. Full measurement is possible with partially reduced accuracy.
T▂▂▂▂▂	Excellent signal.

Note: For proper measurement of modulation characteristics, internal bandwidth for RF signal is fixed at 280 kHz. In locations where stations are present in 200 kHz or even 100 kHz spacing, the device may indicate insufficient signal quality unless signal of the adjacent stations is rejected enough by positioning of the receiving antenna.

Following tables illustrate approximate max. measuring distance as a result of transmitter's ERP power and measuring conditions:

Estate housing, telescopic antenna:

ERP	Max. distance
1 W	300 m
10 W	800 m
100 W	3 km
1 kW	8 km
10 kW	20 km
100 kW	40 km

Open space, hill, Yagi antenna:

ERP	Max. distance
1 W	800 m
10 W	3 km
100 W	7 km
1 kW	20 km
10 kW	50 km
100 kW	100 km

Recommended operating conditions

- Stable dipole or better antenna, in the desired transmitter site direction
- 60 dBµV level of the signal being measured
- Strongest station on the FM band not exceeding the signal being measured by more than 30 dB
- At least 0.4 MHz spacing from other stations, if these have higher level than the signal being measured.

Selecting an antenna

There is no general choice for the antenna.
The requirements for the antenna differ with local conditions and kind of use.

The essential condition for the measurement is enough signal level of the desired station on the antenna input. Not all signals that you can listen on any conventional radio receiver can be also measured. It's possible to say that optimal signal strength range for full measurement coincides with the range which is required for high quality stereo reception. If we apply this rule, it's clear that simple telescopic or whip antennas are not enough for many applications. On the other hand special calibrated antennas for EMI and RF field applications have no reason for FM modulation measurements.

In the transmitter's near field (up to 1 km distance from the transmitter) any piece of wire connected to the antenna input should be sufficient. When measuring other than only local stations or where number of stations reaches a couple of tens, a single dipole or 3-element Yagi antenna will give considerably better results, compared to simple telescopic or whip antenna. In many cases this kind of antenna must allow positioning in horizontal plane in order to boost signal of stations being measured and suppress signal of all other stations.

Always make sure there is no pulse interference source near the antenna. These sources especially include computers, cars, electric motors, PWM regulators, high voltage lines etc. Assure stable antenna position during the measurement so the device can examine the signal characteristics reliably. Especially the frequency deviation should not be measured in motion like in ridden car.

Hint: Keep on mind that with fixed omni-directional antenna, the number of stations with excellent reception (full measurement ability) usually does not exceed 15, regardless of how many strong stations are on air overall in the location. This may be caused due to multipath propagation of many station signals, as well as by the receiver's limited selectivity (restricted by requirement of proper FM deviation measurement) and intermodulation predisposition of the receiver's simple front-end. If the station of interest is 30 dB or more below the strongest stations, finding the best antenna position may be necessary to reduce this ratio and to ensure full measurement ability.

Measurement using the transmitter's test RF output

Many FM broadcast transmitters are equipped with a test RF output. This output is primarily not intended for modulation characteristics measurement using an analyzer based on a receiver like the P275. In most cases the RF test output can be used for this purpose but this usually does not bring any advantage.

Special care is required before connecting the analyzer to this output. Make sure the output signal power does not exceed 20 mW (13 dBm). In some cases the test RF output gives 30 dBm (1 W) or more. That signal must be attenuated to less than 20 mW before connecting to the analyzer!

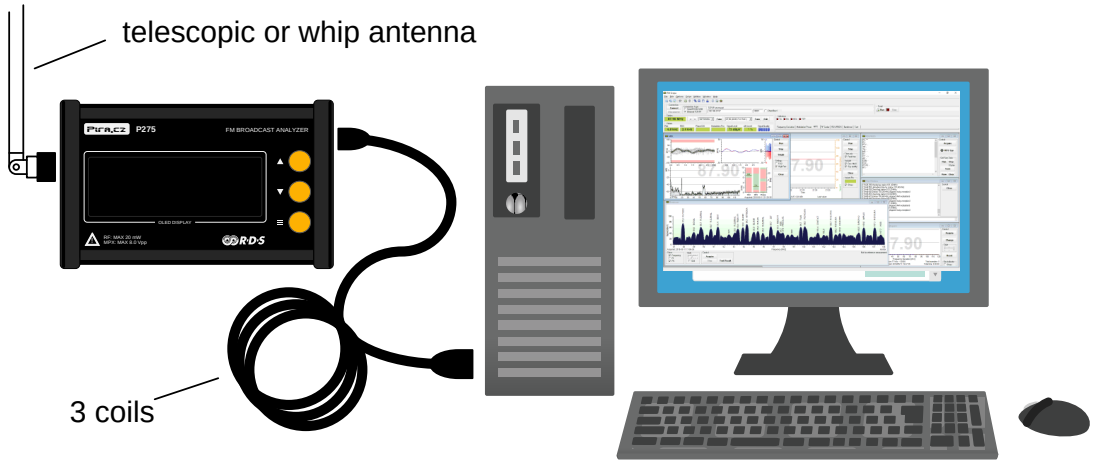
It is sometimes better not to use the test output and get the signal "from air". The modulation characteristics are not affected in near field. Another recommended way is to connect only the transmitter's and analyzer's ground (shielding).

On the transmitter sites where many transmitters are operating the user may be forced to find one of the methods mentioned that gives full quality result. It's due to intermodulations caused by many strong signals and their harmonics that are present in this environment.

Measuring when connected to a PC

Personal computer (PC) is a strong source of unwanted RF signals which may cause interference with the signal being measured. Sometimes, when using telescopic aerial, the reception quality may decrease once a 'live' data cable (USB or RS-232) is connected to the FM analyzer. This phenomenon does not occur when using external antenna because well symmetrized antenna suppresses this kind of interference. However, a telescopic aerial is not symmetrized, thus the device case as well as outer side of the data cable effectively becomes a part of the receiving antenna, bringing all unwanted RF signals from the PC.

The solution is usually simple. Make a few coils on the data cable to cut off the RF path between the device and the interference source:



Measuring of stations carrying HD Radio (United States only)

The HD Radio (IBOC FM) spectrums partially overlap with the original FM channel. That overlap is almost inaudible but makes impossible to measure the FM parameters in the required (full bandwidth) quality. The P275 detects increased noise floor and hides the values which are potentially affected.

For adjusting or measuring the FM parameters, the HD Radio channels must be temporarily switched off.

Overall frequency deviation (peak frequency deviation)

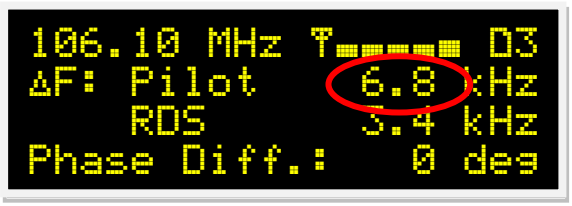
Frequency deviation (ΔF) is used in FM radio to describe the maximum (peak) instantaneous difference between an FM modulated carrier frequency, and the nominal carrier frequency.

The overall peak frequency deviation shall not exceed **75 kHz**.

The peak hold values of the deviation are taken during a measuring time of 50 ms, 20 times per one second. From this sequence of values the MAX, AVE and MIN values are calculated and showed. These values represent signal characteristics in previous second. The measurement is fully **continuous** over the signal, without any gaps. Moreover, MIN Hold and MAX Hold functions are provided. The MAX Hold value represents the maximum deviation found in last 10 seconds. Since it may be affected by pulse interference, interpret it very carefully. **Remember that any "Hold" or "MAX" function based on a single number cannot fully and adequately describe the FM modulation characteristics as the histogram function can (described thereinafter).**

Pilot deviation

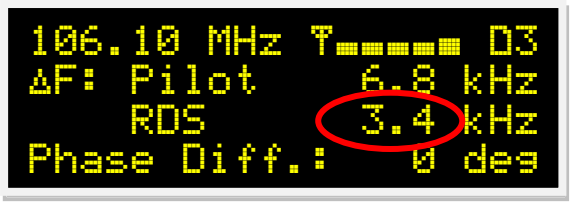
In FM stereo broadcasting, a pilot tone of 19 kHz indicates that there is stereophonic information. The receiver uses the pilot tone as a phase reference to demodulate the stereo information. The (L+R) main channel signal is transmitted as baseband audio in the range of 30 Hz to 15 kHz. The (L-R) subchannel signal is modulated onto a 38 kHz subcarrier occupying the baseband range of 23 to 53 kHz.



The deviation range of the FM carrier caused by pilot tone is from **6.0 kHz** to **7.5 kHz**. The recommended value is **6.8 kHz**.

RDS deviation

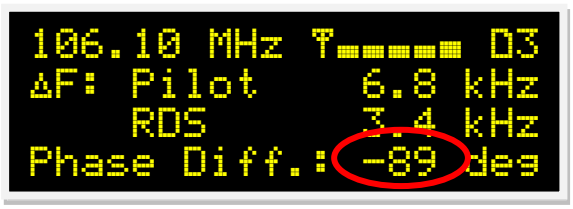
Radio Data System (RDS), is a standard from the European Broadcasting Union for sending small amounts of digital information using conventional FM radio broadcasts. Radio Broadcast Data System (RBDS) is the official name used for the U.S. version of RDS. The two standards are nearly identical, with only slight differences. Both use a 57 kHz subcarrier to carry data.



The deviation range of the FM carrier caused by RDS/RBDS is from **1.0 kHz** to **7.5 kHz**. The most used value is around **3.0 kHz**. This value should be considered as a minimum if dynamic PS or TMC service is being broadcasted.

Pilot-to-RDS phase difference

The 57 kHz for RDS subcarrier was chosen for being the third harmonic of the pilot tone for FM stereo, so it would not cause interference or intermodulation with it. The amount by which RDS subcarrier and third harmonic of pilot tone are out of step with each other can be expressed in degrees from 0° to 360°. Since the RDS signal is based on its carrier phase alternating, the full angle reduces to straight angle and we can equate 90 degrees = -90 degrees.



During stereo broadcasts the RDS subcarrier will be locked either in phase (**0 degrees**) or in quadrature (**90 or -90 degrees**) to the third harmonic of the pilot-tone. The tolerance on this phase angle is **±10 degrees**.

A value out of the specification is however not to be considered as a critical failure, i.e. there's no need to solve that situation promptly.

If no value is given, the RDS and pilot are not in stable phase relation. In that case check if pilot or MPX signal is connected to the RDS encoder input and external synchronization is enabled. Follow the instructions supplied with your broadcast equipment.

Set the phase difference when the broadcast equipment works under common conditions and after enough time of warm-up. The phase difference depends a little on the broadcast equipment temperature and other physical quantities.

Modulation power (MPX power, P_m)

The modulation power is a relative power of the MPX signal averaged over 60 seconds according to the formula:

modulation power = $10 \log \{(2/60\ s) \int(\Delta f(t)/19\ kHz)^2\ dt\}$ [dBr]

0 dBr corresponds to an average power of a signal equivalent to the power of a sinusoidal tone which causes a peak deviation of 19 kHz.

Intensive audio dynamics compression as well as increasing overall peak deviation causes the modulation power to rise.

The modulation power limit, if defined in your country, is usually **0 dBr** or **+3 dBr**. Please refer to your local communications authority for more information.

Since the modulation power is averaged over last 60 seconds, first value can appear after one minute from power-up or tuning to a new frequency. However the analyzer reduces this time using estimation method during first minute so it shows an estimated value of the modulation power almost immediately, saving considerably the operator's time but still keeping compliance with standards. This is indicated by the 'Pm:' symbol blinking. Relevancy and accuracy of the modulation power value increases with each second. After the first minute elapses, the value is accurate from that moment and the 'Pm:' symbol stops blinking.

The measurement should represent typical modulation of the programme material of the broadcasting station. The observation time should be at least 15 minutes or in some cases one hour may be required to be sure to measure representative programme material.

The value in (...) is a linear representation of the modulation power, 0 dBr = 1.00.

Frequency deviation histogram

To provide more information the deviation is better represented by histogram rather than only displaying the highest value in over a certain period of time. In this device the histogram of frequency deviation is processed as follows:

a) Obtain **N peak hold values (samples)** of the deviation, each taken during a measuring time of **50 ms**. The measuring time has influence on the distribution plot and hence must be standardised in order to ensure repeatability. The 50 ms ensures that the peak values of the deviation are captured even at modulating frequencies as low as 20 Hz.

b) Discard the samples that have been taken in presence of noise or interference.

c) Divide the range of frequency deviation of interest (0 – 120 kHz) into 1 kHz resolution to give relevant number of bins.

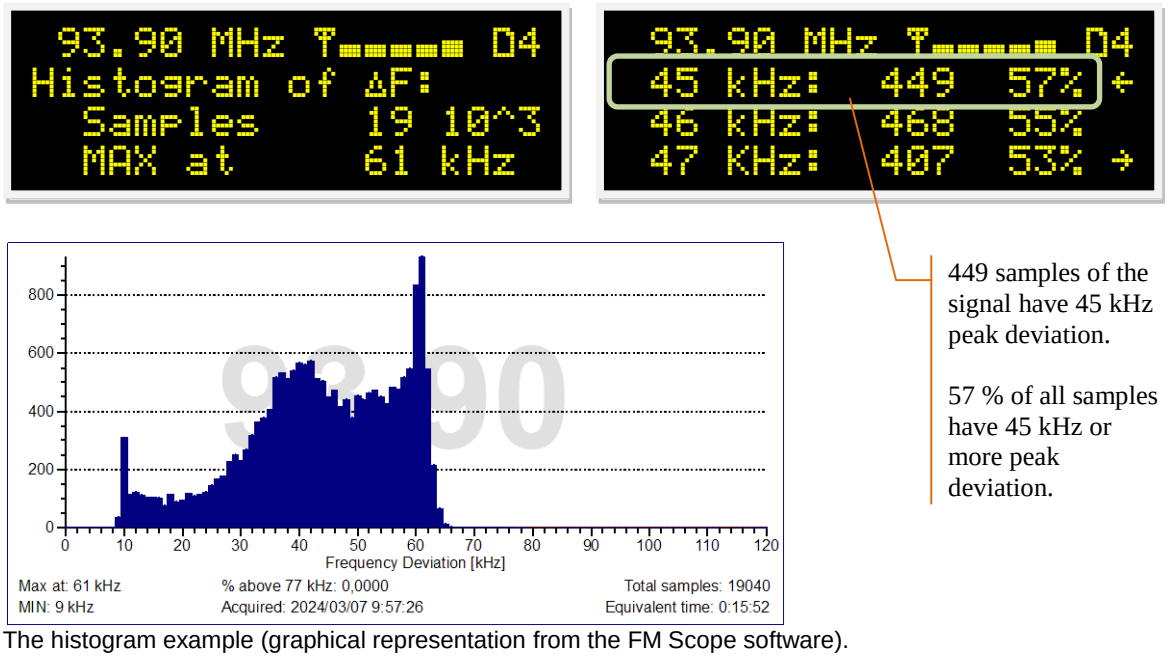
d) For each bin, count the number of samples which have a value within the bin. The result is a distribution plot of the deviation – frequency deviation histogram (see the figure below).

e) Add counts in each bin from left to right and normalise by N. The result is a plot of the accumulated distribution which starts with a probability of 100 % from the lowest deviation and will finish with a probability of 0 % at the highest deviation.

The measurement should represent typical modulation of the programme material of the broadcasting station. The observation time should be at least 15 minutes or in some cases one hour may be required to be sure to measure representative programme material.

Note: Samples associated with the deviation of 121 kHz represent all values above 120 kHz.

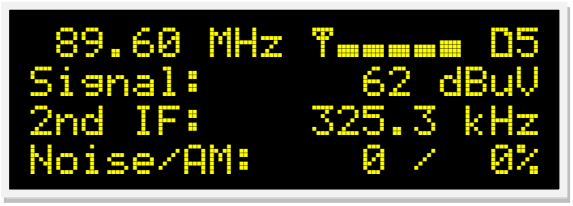
Note: Samples are added to the histogram only when the signal quality ensures that the values measured have a sense. This extends the histogram readability in the cases the reception quality is not good enough.



The histogram example (graphical representation from the FM Scope software).

Service details

Several service values are provided on page 5:



The Signal represents real signal strength on the device input in dBµV unit. The Signal value main reason is to find the best antenna position (strongest signal) resulting in the best suppression of pulse interference (as recommended for peak deviation measurements).

Use of the 2nd IF parameter is described on following page.

The Noise Level value is proportional to the noise voltage behind the FM demodulator. It's used as a main indicator of the signal quality. The user should consider this value as dimensionless variable. The value does not evaluate the original signal but it reflects only the reception quality in the current place and using current antenna and equipment.

There's an additional peak amplitude modulation indicator. The AM on the received signal may occur for various reasons, including but not limited to transmitter failure, broadcast antenna coupler, motion, interference, multipath propagation and other characteristics of the environment.

In general the AM modulation of the signal is undesirable. Thus whenever possible the user should choose such antenna placement and direction that maintains a low or zero AM level. AM below 15 % has usually no significant effect on the measurement.

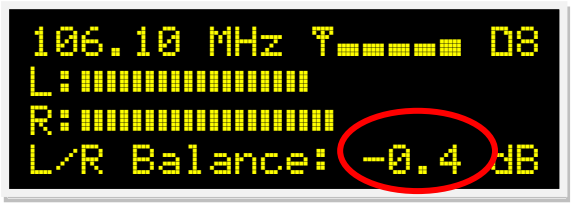
The AM indication is available only for a limited range of input signal strength and its accuracy is not specified.

Simple stereo balance meter

To show the stereo balance meter, navigate to page 8. The stereo decoder must be enabled (in submenu 'Settings' uncheck the menu item 'Force mono').

The simple stereo balance meter helps to maintain the same peak signal level in both right and left audio channels if stereo encoder is present in the transmission chain. The best value is around 0 dB (1:1).

No special audio signal is required to be broadcasted but it’s preferable to use a sample with no stereo information.

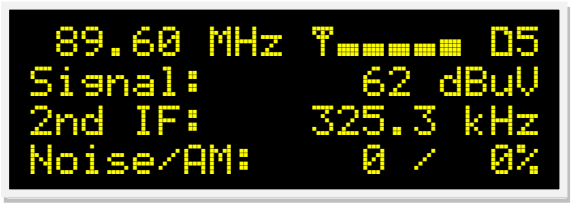


Carrier frequency offset

The unit can provide a relative carrier frequency offset from the nominal frequency. Although there is no calibrated frequency normal included for this purpose, it can be simply found in the band. If any station can be considered as a frequency etalon, the device can be used to adjust correct carrier frequency on the transmitter with 0.1 kHz precision.

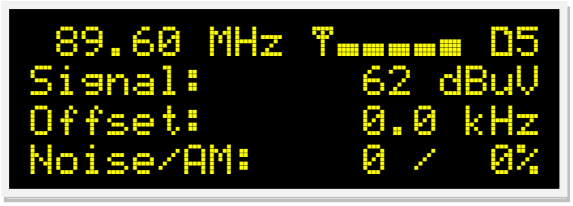
To determine the carrier frequency offset

Under normal conditions the page 5 shows second IF frequency:

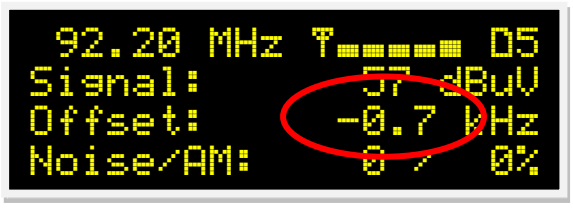


Now select menu item 'Set IF as Normal' in 'Page Context' submenu:

The Offset value appears which is 0.0 on the station selected as Normal:



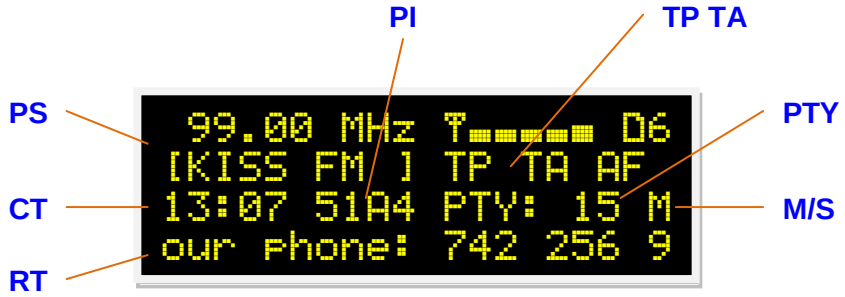
Now tune to any other station:



Still not sure how to read the result of this example? If real frequency of the station at 89.6 MHz is exact, real frequency of the station at 92.2 MHz has -0.7 kHz offset so its exact value is 91.1993 MHz

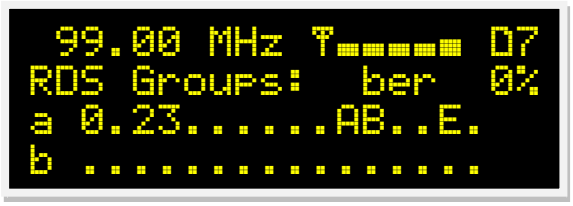
Radio Data System decoding

If RDS is being broadcast by the station or it is present in the input MPX signal, page 6 shows the basic RDS information:

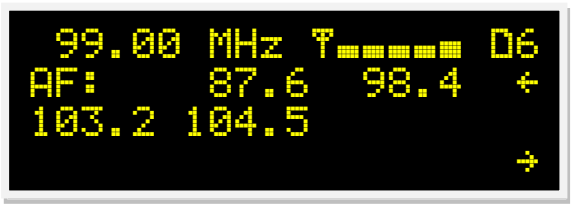


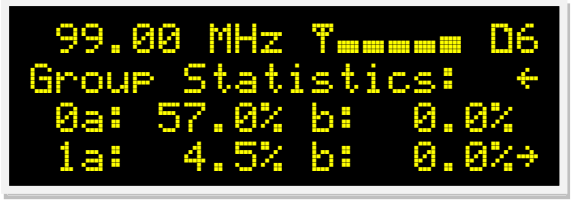
If RT+ service is being broadcast, the RT line contains [ ] symbols indicating begin and end of each RT+ tag in the text. More information is provided on RDS sub-pages 15 to 17.

When the RDS decoder is active, page 7 shows block error rate (ber) and indicates RDS groups that are being received. This gives quick survey of the RDS services present in the RDS stream. The group numbers are in hexadecimal representation:



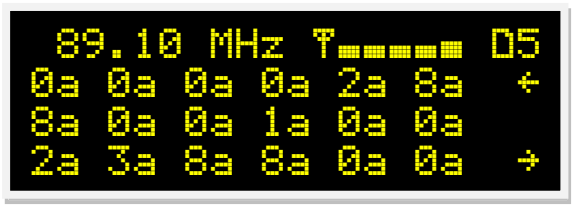
Detailed RDS information is accessible from page 6 or 7 under the menu item Page Context/More RDS Data. Total 50 sub-pages are provided. Last 32 sub-pages are reserved for group content viewer.





Group order viewer

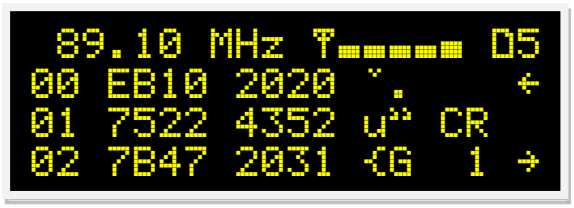
When you access the Group order sub-page, internal group order buffer starts filling. The group order buffer capacity is 18 groups. The group order is showed after about 2 seconds and locked for viewing.

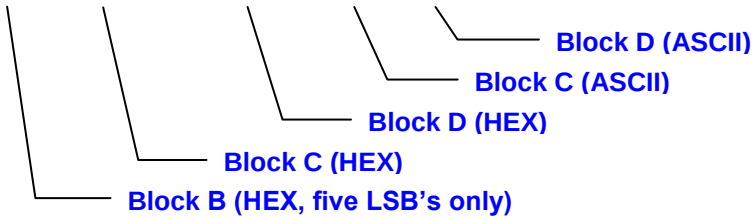


Read the group order line per line from left to right. To view current group order again, go to previous or next sub-page and then back.

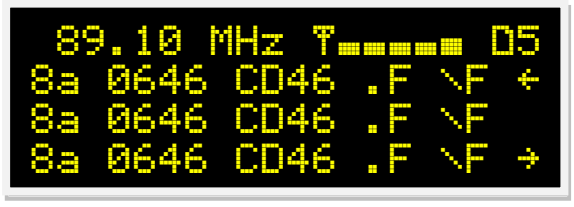
Group content viewer

When you access any Group content sub-page, the group content is showed on each error-less reception of the group type desired. After reception of 3 groups the process is locked for viewing. To view current group content of the desired group type again, go to previous or next sub-page and then back. The content does not stay in memory, a new content is received instead.





Special case is group type **3a** (ODA AID) where application group type is directly showed:



More RDS Data summary

Sub-page	Service / Function
1	Detailed PTY, PTYN
2	EON (PI of other networks), ECC, LIC
3	RT type (A/B), latest RT
4	DI
5-7	AF list
8-13	Group statistics
14	CT, PIN
15	Static PS, current RT+ markers (running, toggle, type1, start1, length1, type2, start2, length2)
16-17	RT+ tag 1/2 class name and content
18	Group order (sequence)
19	Group content 0a
20	Group content 0b
...	...
25	Group content 3a (ODA AID)
...	...
50	Group content 15b

List of RDS services

RDS Service	Decoded by the device	RDS Groups
PI (Program Identification)	yes	All
PTY (Program Type)	yes	All
TP (Traffic Program)	yes	All
TA (Traffic Announcement)	yes	0a, 0b, 15b
M/S (Music/Speech)	yes	0a, 0b, 15b
DI (Decoder Identification)	yes	0a, 0b, 15b
PS (Program Service)	yes	0a, 0b
AF (Alternative Frequencies)	yes	0a
ECC (Extended Country Code)	yes	1a
LIC (Language Identification Code)	yes	1a
RT (Radiotext)	yes	2a, 2b
CT (Clock-Time and date)	yes	4a
PTYN (Program Type Name)	yes	10a
EON (Enhanced Other Networks)	yes (PI)	14a, 14b
AID (Application Identification)	yes	3a
RT+ (Radiotext Plus)	yes	3a, 2a, 2b (note 1)
TDC (Transparent Data Channels)		5a, 5b
IH (In-house Applications)		6a, 6b
RP (Radio Paging)		7a, 13a
TMC (Traffic Message Channel)		3a, 8a (note 2)
EWS (Emergency Warning Systems)		9a

Notes:
1) Plus appropriate ODA groups.
2) This is the most frequent group type used for TMC. An indication in the AID group 3a is decisive.

List of ODA applications

AID	Application name
125F	I-FM-RDS for Fixed and Mobile devices
1C68	ITIS In-vehicle database
4BD7	RT Plus
5757	Personal weather station
6552	Enhanced RadioText / eRT
7373	Enhanced early warning system
C350	NRSC Song title and artist
C3B0	iTunes tagging
C3C3	Traffic Plus
C4D4	eEAS
C737	Utility Message Channel
CD46	TMC
E123	APS Gateway
E1C1	Action code
E411	Beacon downlink

Notes:
This is not a complete ODA registration list reference.
Some applications are special purpose only or are used very rarely and may require special receiver.

The most frequent RDS setting errors

Error	Implication	Solution
First PI digit is 0 (zero).	RDS is not working on some receivers.	First PI digit can't be 0. It should be set in accordance with the country where the station is located.
Two different stations have the same last two PI digits, for example 5AFF and 51FF.	Car radios switch between different stations oneself.	Stations that carry different program entire day must be unambiguously identified by the last two PI digits.
AF list contains more frequencies but second PI digit is 0, for example 603B.	Many receivers ignore the AF list and listener must tune manually to the strongest frequency.	The second PI digit can't be 0 if the station has more transmitters listed in AF.
The station uses only single transmitter but second PI digit is not 0, for example FFFF.	Car radios search for another frequency using PI seek, this takes up to one minute, of course without any result.	The second PI digit must be 0 if the station has only single transmitter (local station).

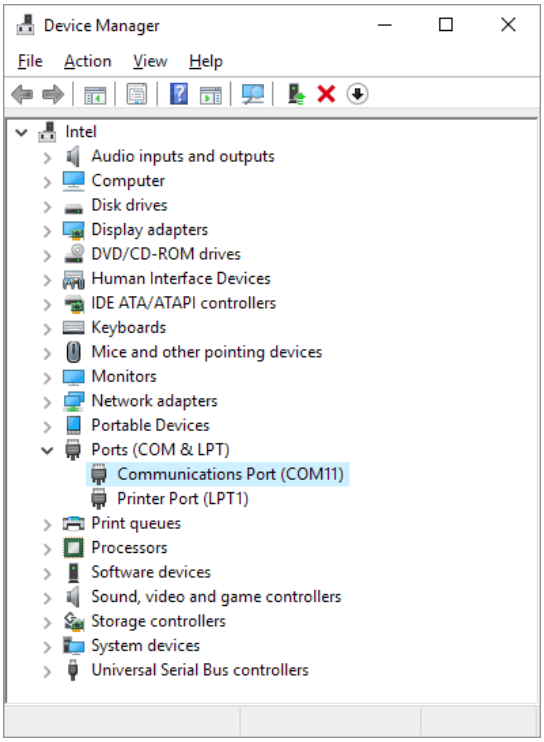
USB Port Communication

Connecting the FM analyzer to a PC

For configuration and control requirements the FM analyzer can be connected to a PC via standard USB cable A-B.

USB driver must be installed prior to start communicating. Some Windows versions are already supplied with the driver. Virtual COM port feature provides seamless compatibility with all software.

After successful installation a new COM port will appear in Windows Control Panels – Device Manager ►



To change the assigned COM port number, double-click on the line and go to Port Settings – Advanced.

Note: Latest USB drivers are available at https://ftdichip.com/drivers/vcp-drivers/

In the control software, fill the communication parameters as follows:

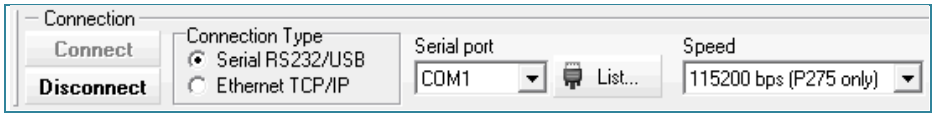
Communication speed	115200 bps
Data bits	8
Parity	None
Stop bits	1
Flow control	None

Note: Depending on the software version, some parameters may not be available.

FM Scope setup

The FM Scope application is free for download at https://www.pira.cz.

In the Connection field, select ‘Serial RS232/USB’ connection type. Select the COM port assigned to the device by the system. Select 115200 bps communication speed. Finally click on Connect.



The application status bar at the bottom indicates the connection status. Verify the function by selecting a local station and clicking on Tune.

In Options – Preferences – General – Application Settings select the option Online update of deviation and signal.

Finally tune the frequency of interest and if necessary, adjust the antenna position for getting full (5/5) signal quality.

As a next step, follow the FM Scope user manual.

To store the settings to a non-volatile EEPROM memory, use the button in the tool bar.

P275 Communication protocol

Following section is intended for software engineers. It described the way how the device communicates with the PC computer. Using this guide, a custom control routine can be created.

Control commands

Note 1: There is no need to validate the commands by any additional character or key, such as <Enter>.
Note 2: Some commands have their equivalent in the FM analyzer's menu.

Command	Meaning
*+	Tune up (one step)
*-	Tune down (one step)
*P	Switch on the modulation power sending
*p	Switch off the modulation power sending
*M	Switch on the MAX value sending
*m	Switch off the MAX value sending
*R	Switch on RDS groups content sending
*r	Switch off RDS groups content sending
*F	Tune to a frequency entered in kHz. Example (tune to 96.2 MHz): 096200*F
*S	Save settings to EEPROM, incl. DIP switches and alarm registers
*E	Enable the measuring mode
*L	Load station data saved in EEPROM memory. Example (load file 3): 03*L
*C	Clear data
*B	Enables internal stereo decoder
*b	Disables internal stereo decoder (force mono)
RESET*X	Hardware reset
DIPx:y*X	Set DIP switch. Example (set tuning step to 100 kHz): DIP2:1*X
MEM xxxx:yyyy*X	Write value yyyy to memory address xxxx. Hexadecimal format. Reserved for special purposes.
*1 to *9	Switch the OLED view to page 1 to 9
*0	Deactivate screen saver, clear the screen saver counter

Commands returning a value

Command	Meaning
?B	Return all basic data
?F	Return current receiver's frequency
?R	Return the RDS deviation value
?L	Return the pilot deviation value
?P	Return modulation power value
?M	Return frequency deviation MAX value
?A	Return frequency deviation AVE value
?N	Return frequency deviation MIN value
?O	Return frequency deviation MIN Hold value
?Q	Return the signal quality (0-5)
?D	Return RDS data
?T	Return RDS group statistics
?E	Return the pilot-to-RDS phase difference
?G	Return the signal information (strength, IF, noise)
?H	Return the frequency deviation histogram data
?I	Return the 2nd IF
?C	Return the channel balance (Hz*100/Hz*100, stereo mode only)
?c	Return the channel balance (fast variant with 50 ms hold time)
?X	Return frequency deviation MAX Hold value
?s	Return latest FFT data
?U	Return signal level
?V	Return firmware version. D: version 2.2c
?a	Return memory content in ASCII format. * Syntax: (address),(length)?a Example (return latest radiotext): 19C,040?a
?h	Return memory content in HEX format. * Syntax: (address),(length)?h Example (return PI): 032,002?h
?v	Return address content in HEX format. Syntax: MEM xxxx?v Reserved for special purposes.

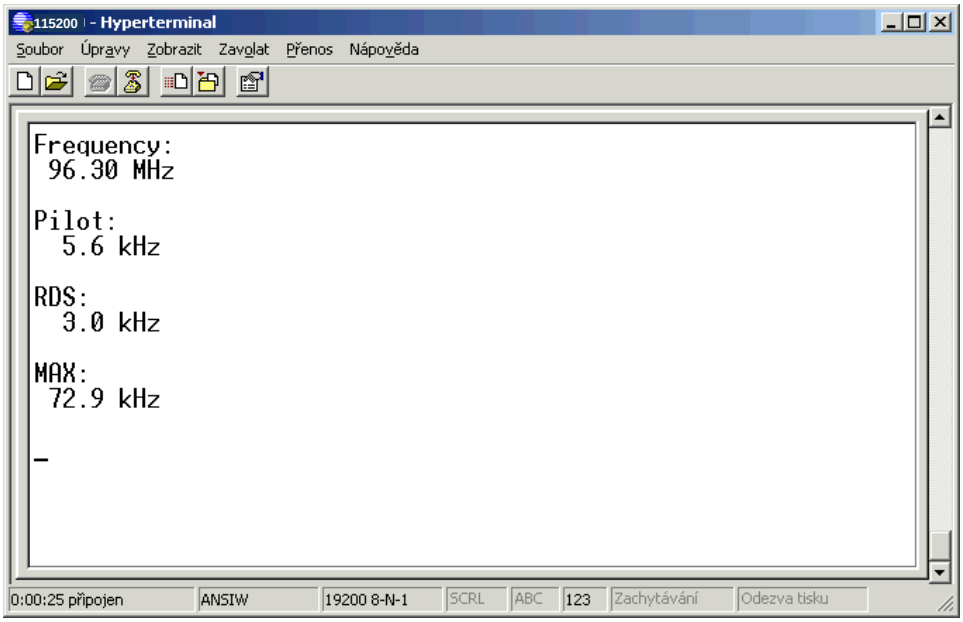
Note:
* See Annexes for commented memory map.

Data format

The format of all data returned by the device is defined as follows:

key+":"+Chr(13)+Chr(10)+Chr(13)+Chr(10)
(if return value is empty)

key+":"+Chr(13)+Chr(10)+**value**+Chr(13)+Chr(10)+Chr(13)+Chr(10)
(otherwise)



Example of the outputs when using Windows HyperTerminal. Local echo is off.

DIP switches

	Meaning	0	1		Meaning	0	1
DIP0	(reserved)			**DIP1**	(reserved)		
DIP2	Tuning step	50 kHz	100 kHz	**DIP3**	Scan sensitivity	Low	High
DIP4	(reserved)			**DIP5**	(reserved)		
DIP6	Noise cancellation between stations	Off	On	**DIP7**	Frequency range [MHz]	Standard 87.5 to 108.0	Extended 64.0 to 108.0
DIP8	MPX filter bandwidth for FM deviation measurements	70 kHz	90 kHz				

Note: By default, all DIP switches are set to 0 except for DIP2.

List of keys

Key	Invoked by	Key	Invoked by
Frequency	?F	Pilot	?L
G	*R	RDS	?R
PS	?D	RDS Group Statistics	?T
PI	?D	MAX	?M or *M
RT	?D	AVE	?A
LTO	?D	MIN	?N
CT	?D	IF	?I
PTY	?D	ASCII	xxx,yyy?a
MS	?D	HEX	xxx,yyy?h
TP	?D	FV	?V
TA	?D	Signal Quality	?Q
AF	?D	Fast Signal Info	?G
DI	?D	Modulation Power	?P
EON	?D	Pm	*P
ECC	?D	RDS Phase Difference	?E
LIC	?D	Histogram Data	?H
PTYN	?D	FFT	?s
PIN	?D	MAX Hold	?X
R/L	?C	Level	?U
Fast R/L	?c	Carrier Offset	?f

Annexes

Memory map

Address	Length	Content	Unit
01A	002	Current receiver's frequency raised by 1065	kHz*10
020	002	DIP switches (bit 0 = DIP0)	-
024	002	Pilot deviation	Hz*10
026	002	RDS deviation	Hz*10
028	002	Pilot to RDS phase difference	deg.
02A	002	ΔF MAX	Hz*10
02C	002	ΔF AVE	Hz*10
02E	002	Modulation power (linear)	1/100
030	002	ΔF MIN Hold	Hz*10
032	002	RDS PI	-
034	008	RDS static PS	-
03C	001	RDS PTY	-
03E	002	RDS status bits, bit 10: CT indicator, bit 9: RT indicator, bit 8: RT Type (A/B), bit 7: AF indicator, bit 6: TP, bit 5: TA, bit 4: MS, bits 3 to 0: DI.	-
040	020	RDS group counters (0a, 0b, 1a, 1b, ... 15b)	-
060	01A	RDS AF list	channel No.
07A	008	RDS EON PI (up to 4)	-
082	001	Signal quality	-
088	002	ΔF MAX Hold	Hz*10
08E	001	Amplitude modulation (0xFF = not available)	%
144	002	ΔF in last 50 ms time period (0xFFFF = not available due to noise)	Hz*10
146	002	Noise level averaged over 1 sec.	-
19C	040	RDS RT	-
1DC	008	RDS PTYN	-
1E4	001	RDS CT Hour	-
1E6	001	RDS CT Minute	-
1EA	003	RDS MJD	-
1EE	001	RDS RT+ group type	-
1EF	001	RDS RT+ status	-
1F0	001	RDS RT+ item 1 type	-
1F1	001	RDS RT+ item 1 start	-
1F2	001	RDS RT+ item 1 length	-
1F3	001	RDS RT+ item 2 type	-
1F4	001	RDS RT+ item 2 start	-
1F5	001	RDS RT+ item 2 length	-
1F8	001	RDS PIN day	-
1F9	001	RDS PIN hour	-
1FA	001	RDS PIN minute	-
1FB	001	RDS LIC	-
1FC	001	RDS ECC	-
1FD	001	RDS CT local time offset	half of hour

48C	002	Instant Modulation power (linear)	1/2503
4CE	001	Alarm - Silence detector ΔF AVE minimum	kHz
4CF	001	Alarm - Overmodulation ΔF MAX Hold maximum	kHz
4D0	001	Alarm - Overmodulation Histogram MAX At maximum	kHz
4D1	001	Alarm - Overmodulation ΔF AVE maximum	kHz
4D2	001	Alarm - Pilot minimum	kHz/10
4D3	001	Alarm - Pilot maximum	kHz/10
4D4	001	Alarm - RDS minimum	kHz/10
4D5	001	Alarm - RDS maximum	kHz/10
4D6	001	Alarm - Signal lost time duration	s*10
4D7	001	Alarm - Silence time duration	s*10
4D8	001	Alarm - Overmodulation time duration	s*10
4D9	001	Alarm - Pilot or RDS error time duration	s*10
4DA	001	Alarm - Alarm time hysteresis	s
572	0F4	ΔF Histogram	-

Important notes:
Lower byte is carried first (higher byte is placed at Address+1 for 2-bytes variables).
The Address and Length values are in HEX format.

Device differences

Feature	**P275 FM Analyzer 2015-2023**	**P275 FM Analyzer 2024 onwards**
Operation from AA cells	✓	×
Built-in LiPo cell	×	✓
Alarm outputs	✓	×
RS-232 connection	✓	×
USB connection	USB Micro	USB B
Display type	LCD	OLED

Features which are not listed are common to both device variants. Both variants use the same firmware and Windows control software.

Schematic diagram of internal I/O board

B1, B2, B3	1241.1614
C1, C2, C7	100n
C3, C4, C5, C6, C8, C9, C10, C11	4µ7
R1, R3, R4	1k
R2, R8, R9, R14	2k
R5	2R2
R6, R7	220R
R11	5k1
R12, R13	47k
U1	FT232RN
U2	MCP73831-2
U3, U4	MAX40203
Q1	IRLML2244
D1	KPA-2106SYCK
D2	OSB50802C1E
D3, D4	OF-SMD2012Y
D5, D6, D7, D8, D10, D11, D12, D13	1N5819HW-7-F
D9	SMBJ5.0A
F1	0ZCG0110AF2C
FB1	BLM21PG600SN1D
SB1	Solder bridge (open)
SB2	Solder bridge (short)
J11	MX-67068-8000
J15 (OLED display)	WEH002004A LPP5N00010
J16 (LiPo cell)	LP453350
SW1	OS102011MA1QN1