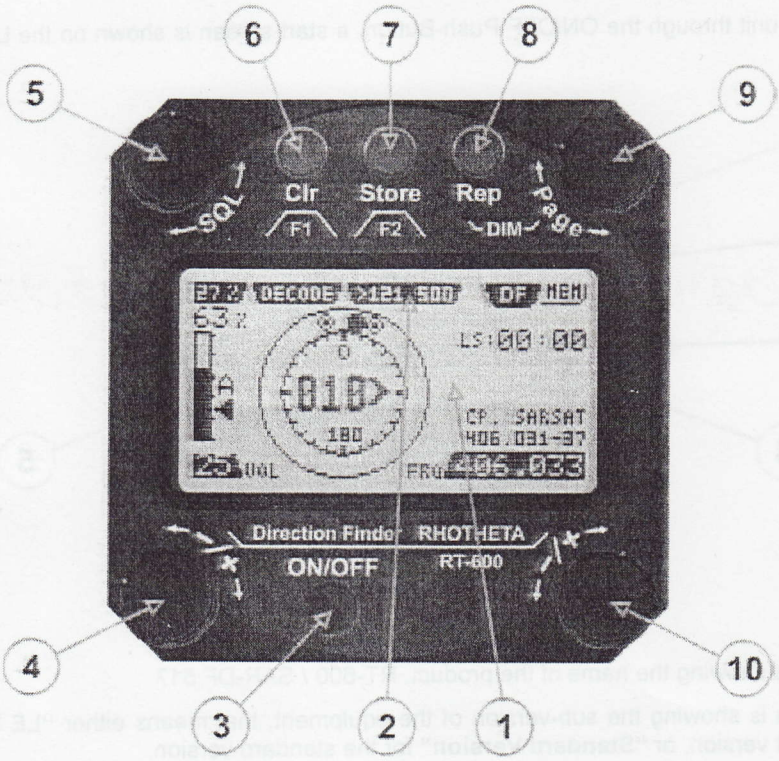
RT600

2 Operating

Operating the direction finder is deliberately very simple with its clearly arranged layout. Except the upper page rotary switch and the ON/OFF pushbutton, the function of the operating elements always depends on the active page. All relevant adjustments can be controlled on the display. Figure 1 shows the general layout of the Display Control Unit's surface.

2.1 General Operating Principles



Display Control Unit Overview

(1) **>LC Graphic Display<** (128 x 64 dots dot-matrix display, dark blue on yellow-green background) showing all relevant operational information depending upon the selected page.

(2) **>Menu<** options for rotary and push buttons: If a field with dark background and bright text is shown below a button or switch, the function described in this field may be selected through the operational element above or below this menu field. In case of the Page Menu, the active page is high-lighted with dark background, while the inactive page is in black letters.

(3) **>ON/OFF<** Push-button to switch on / off the system.

(4) **>Volume<** Rotary Switch, used, depending on the active page, to adjust the volume of the audio output or to select frequency values (MHz steps).

(5) **>SQL<** Rotary Switch, used, depending on the active page, to adjust the squelch function or to select specific functions on a page depending upon the interactive menu on the display.

(6) **>CLR / F1<** Push-button. If pushed for a short time, this button activates the function F1 described in the interactive menu on the display below. If pushed for a longer time (ca. 3 seconds), this button activates the CLEAR function.

(7) **>STORE / F2<** Push-Button. If pushed for a short time, this button activates the function F2 described in the interactive menu on the display below.

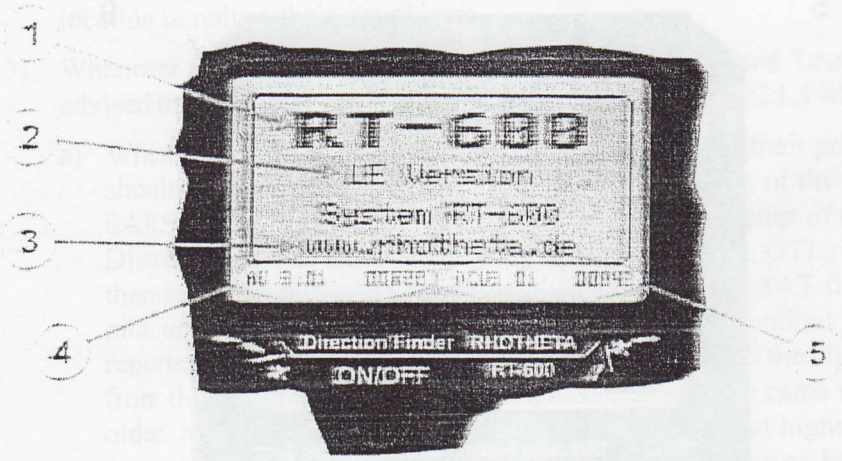
(8) >Rep / DIM< Push-Button. If pushed for a short time, this button activates the setup of the display dimming function. If pushed for a longer time (ca. 3 seconds), this button activates the repetition of the last valid bearing and signal level information.

(9) >Page< Rotary Switch to select displayed main pages ("DF" or "MEM"). Together with the DIM button, it is used to set the display brightness (dimming function).

(10) >Frequency< Rotary Switch to select frequencies.

2.1.1 Power-On procedure

After switching on the unit through the ON/OFF Push-Button, a start screen is shown on the LC-Display for five seconds:



Power-On Screen

(1) **The upper line** is showing the name of the product, RT-600 / SAR-DF 517

(2) **The second line** is showing the sub-version of the equipment, that means either **"LE Version"** for the Law Enforcement version, or **"Standard Version"** for the standard version.

(3) **The fourth line** is showing the web address of the manufacturer, RHOTHETA Elektronik GmbH.

(4) **The lowest line** displays software version and serial number information for the antenna unit and (5) for the display control unit.

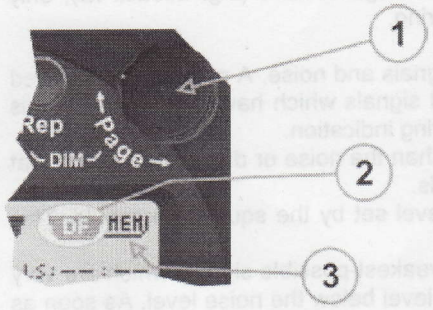
After five seconds, the equipment switches into the operational mode by displaying the last active main page before having been switched off, that means either the DF (Direction Finder) or the MEM (Memory) page.

2.1.2 Main Pages Selection

There are two main pages which can be selected:

The **DF** (Direction Finder) Page is the page in which all relevant operational information is shown, depending on the kind of signal which shall be received.

The **MEM** (Memory) Page is the page in which memorized operational frequencies can be modified.



Page Selection

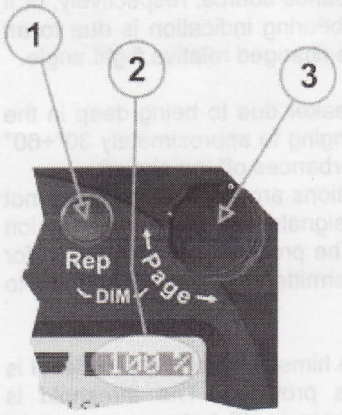
(1) The **>Page<** rotary switch is used to select the active page.

(2) The **active page** is highlighted with dark background

(3) The **inactive page**, which may be selected, is written in dark letters on bright background.

2.1.3 Dimming function

The background of the LC-graphic display is equipped with a LED-array, whose brightness may be adjusted continuously (from 5 to 100%). Dimming will be performed in an exponential curve, thus allowing very accurate adjusting under night-conditions



Dimming Setup

(1) Pressing the **>Rep/DIM<** button for a short time is activating the dimming setup mode.

(2) **Brightness** information, as percentage value from 5 % to 100 % in steps of 5 % is displayed instead of the "Page" field in the upper right corner of the display.

(3) The **>Page<** rotary switch can be used to adjust the display brightness. Right-hand turn will increase the value in steps of 5 percent, while a left-hand turn will reduce the value in steps of 5 percent.

After ca. 3 seconds of user inactivity, the display falls back into the prior main page. The adjusted brightness of the display will remain stored after switching off the unit.

Dimming of legends may be performed in two ways, using the internal dimming settings as for the LC-display itself, or using an external (remote) dimming voltage provided by the aircraft.

Internal dimming (on display unit) of legends:

Internal dimming is always active, if the external dimming input is not connected, or if applied voltage is below 1 V DC. (Refer to the wiring plan). The legends are dimmed in the same manner as the LC display.

External (remote) dimming of legends:

As soon as there's a voltage >1 V DC at the dimming input, the brightness of legends is controlled externally by an analog signal. (Refer to the wiring plan and to the operating/setup-menu description).

2.1.4 Squelch Operation

The main challenge in direction finder operations is to only use the signal transmitted by the destination for calculation of the bearing. Noise and other disturbances shall not cause misleading bearing indications.

In order to prevent the direction finder to calculate bearing results which are mislead due to noise and disturbances, several means are given:

If a signal can be distinguished from noise and other signals by its message content (e.g. LoJack ID), only transmissions containing the required message content are used for bearing.

In other cases, the squelch can be used to suppress unwanted weak signals and noise. A squelch level, called threshold, has to be set by the user or automatically by the system. All signals which have a level below this threshold value will be ignored. Signals above this level will cause a bearing indication.
As a result, a signal to be used for bearing has to be so much stronger than the noise or disturbing signals that the receiver can clearly distinguish between wanted and unwanted signals.
The result of this requirement is that the sensitivity is reduced to the level set by the squelch threshold. This results in a reduced maximum distance to the transmitter.
However, it might be desirable to achieve bearing information even for weakest-possible signals which are very close to the noise level. In this case, it is possible to reduce the squelch level below the noise level. As soon as the modulation of a signal can be heard in the loudspeaker, it can be expected that bearing is possible.

If the noise itself is a randomly distributed noise (so-called white noise), and there is no other signal receiver, the bearing indication itself will be randomly distributed. If the noise is not white noise but a disturbance, bearing will show to the source of the noise.

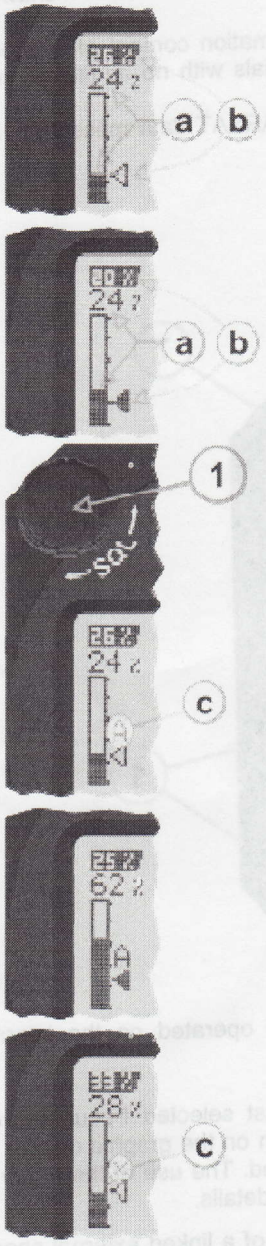
If there is a very weak signal "in the noise", this signal will produce a correct bearing indication thanks to sophisticated bearing technologies used in the RT-600 system. Fluctuations due to noise will be small even at low signal levels, however the reaction time of the bearing indication can increase.
To verify if a bearing indication is due to white noise or due to an internal disturbance source, respectively, or if it is due to a real receive signal, the aircraft should make a slow turn. If the bearing indication is due to an external signal, e.g. a SAR beacon, the bearing indication has to compensate the changed relative flight angle.

Example: Bearing indication is 30°. The signal is weakly audible in the loudspeaker due to being deep in the noise. The airplane makes a turn left by 60°. If the bearing indication is not changing to approximately 30°+60° = 90° after a few seconds, the bearing is likely to be due to noise or internal disturbances off the aircraft.
Note: The weaker a signal is, the longer it will take to change the bearing. Durations around 5 seconds are not unfamiliar in such cases. Therefore, it is not useful to use this procedure for signals with short transmission times and low transmit duty cycles, such as COSPAS-SARSAT transmission. The procedure is best suited for ELT transmission with a continuous signal and still well-suited for ELTs with intermittent transmission (down to 33%).

In cases where pulsed signals are to be received, the receiver is able to decide himself which squelch level is best-suited for normal operation. In such cases, an automatic squelch is provided. The threshold is automatically set to a value higher than the calculated noise level. The difference in dB between noise and threshold level can be defined in the Setup Menu. Refer to the chapter "Setup Page" for details. During automatic squelch operation, the user has the possibility to force the squelch into manual mode, but has to care about the operational limitations described in this chapter.

In cases where the Antenna Unit checks signal validity autonomously and without useful possibilities of user interaction, user interaction is not possible and the squelch purely follows internal rules appropriate to the kind of received signal.

Examples of different squelch settings:



Five Examples for Squelch operation

Without received signal, the noise level **(a)** is below the correctly chosen squelch level **(b)**. The receiver audio output remains quiet, and no bearing is indicated.

With the same received noise level **(a)**, but wrongly set squelch level **(b)**, there will be an erroneous, noisy bearing available if there is no receive signal available at that time.

If the squelch is operating in automatic squelch mode, this is indicated by a sign "A" **(c)** above the squelch level marker. Depending on the SN-Ratio Setup, the squelch level is set slightly higher than the noise level. Using the SQL rotary switch (1), the user would be able to force the squelch level to a manual setting. Automatic setting can be re-entered by setting the manual setting to < 0 % or > 60 %.

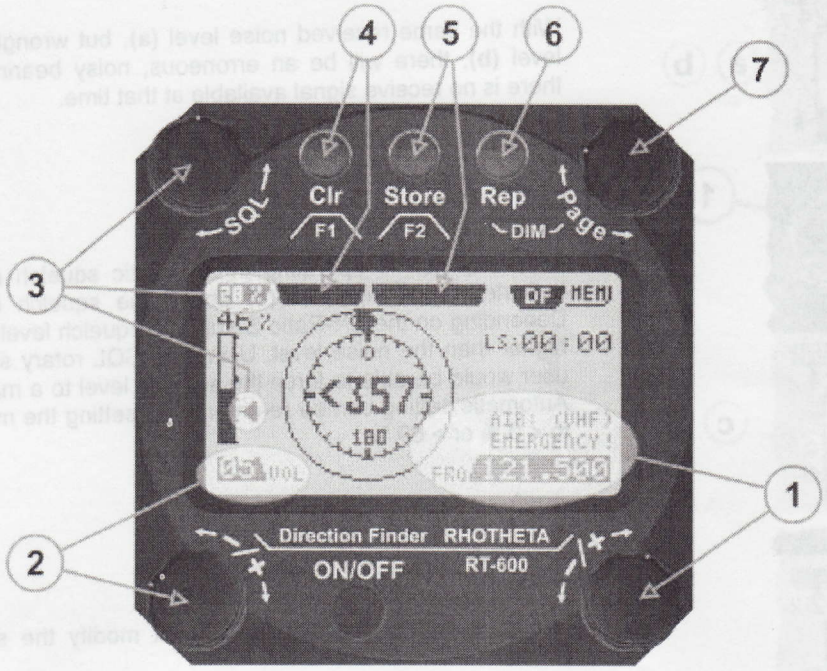
Strong, short receive signals will not modify the squelch level setting.

If the squelch functionality is controlled by the system, without user interactions being allowed, this is indicated by a "X" sign **(c)** above the squelch level marker.

2.2 Direction Finder Mode

Generally, the direction finder mode is used to track bearing information towards a transmitter. It shows all basic information depending of the kind of signal to be tracked.
Mainly, differences in how information is displayed are related to the information content of tracked signals. Basic information and basic operational possibilities are applicable for signals with no additional information content, such as 121.500 MHz sweep-tone modulated SAR beacon signals.
In case of signals with additional information content, such as COSPAS-SARSAT data messages, additional sub-pages may be activated.

2.2.1 Operating Elements in Bearing Mode



Operational Elements in Bearing Mode

The picture above shows the state of the display while the equipment is operated on the international emergency frequency 121.500 MHz with an active signal being received.

(1) >**FREQUENCY**< Rotary switch selecting the active frequency. The last selected frequency remains stored after switching off/on the device. The selected frequency is shown on the graphic display bottom right. Above, additional information for the selected frequency is displayed. The use of the rotary switch activates a sub-page. Please refer to the Frequency Selection section for details.

(2) >**VOLUME**< Rotary switch to adjust the audio output level. The volume of a linked external speaker or amplifier can be adjusted in a range from 0 (off) to 99 (maximum loudness). The selected volume is shown in the bottom left corner of the graphic display. The volume remains stored after switching off/on the device.

(3) **>Squelch Level<** adjusts the squelch level. The squelch level has to be above the receiving level without signal (noise). Only signals above the squelch level are audible in the loudspeaker and used by the direction finder for bearing indication. The **>SQL<** rotary switch allows to select the squelch threshold, i.e. a minimum signal strength of an incoming signal to be processed. The current settings on a signal level scale from 0 % to 60 % is shown in bright letters on dark background below the SQL rotary switch and as an arrow beside the signal Strength Bar-Graph.

(4) The **>CLR**< Push-button is used for erasing the internal bearing value averaging store and the Last Signal Timer. To activate this function, the push-button has to be hold down for a minimum of circa three seconds. The sophisticated averaging store increases bearing precision and enables at all an usable bearing display in case of bad receiving signals (if there is a far away transmitter and/or temporary complete loss of a receiving signal). Caused by the averaging procedure, a drag error may occur, which

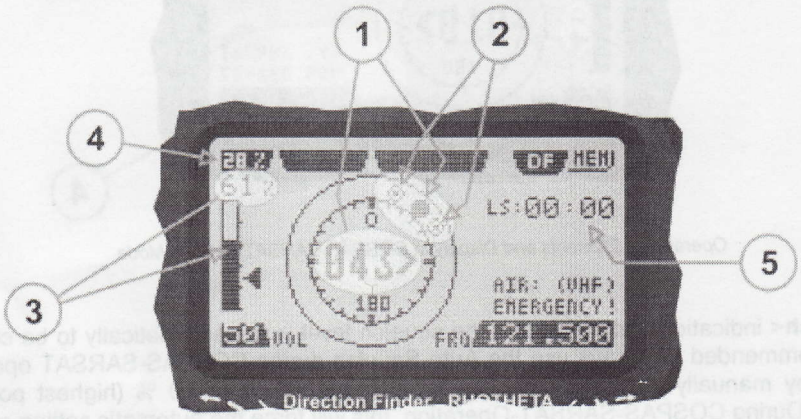
might be disturbing the bearing indication after a quick change of course of the aircraft or vehicle. In this case, the indicated bearing value lags by the real bearing value for about two seconds (for very weak signals even longer). By pressing this push-button after a quick change of course, the display will show the new bearing value without drag error. Additionally, the CLR Push-Button is used to activate specific functions high-lighted in the menu below the button:

(5) >**STORE**< push-button: Without function except if a special function is high-lighted in the menu line of the display.

(6) >**REPEAT**< Push-button, when pressed, showing the last valid bearing value with corresponding receiving level.

(7) **>PAGE<** Rotary switch to leave the DF mode in order to switch to the MEMORY (MEM) Page / Mode.

2.2.2 Standard Display in Bearing Mode



Display in Bearing Mode

(1) >**Relative Bearing value**<, by means of a sophisticated averaging procedure, a steady display is accomplished, either as graphic display or as text in the range of 0°... 359°. (0° corresponds to bearing direct ahead).

(2) >**Spread**<, maximum deviation of un-averaged bearing values. This is an indicator of bearing quality. The wider the range between the directions of maximum deviation, the worse the received signal is. As a result of the excellent averaging procedure, even with a spread of 45°, good bearing results are achieved.

(3) >**Receiving level**< (field strength) of the signal as a relative percentage value, visualized as bar-graph indication and as decimal value. Even without a received signal a certain noise level may be displayed.

(4) >**Squelch level**< (independently adjustable and stored for each frequency). Squelch level is indicated as marker at the Signal Strength Bar-Graph or as direct relative level value. A usable bearing analysis can only be achieved if the squelch level is above the noise level (without received signal). If the antenna unit is placed close a heavily disturbing electronic devices, the squelch level has to be raised, thus making the direction finder being less sensitive. In receive modes where the squelch level is set automatically, an "A" above the marker indicates the "Autosquelch" functionality.

(5) **>Last Signal<** timer showing the time since a signal has been received for the last time (i.e. since a signal has been stronger than the squelch level). Values are "minutes:seconds".

2.2.3 Special Options in COSPAS-SARSAT Bearing mode

Especially for the use together with beacons transmitting a data signal according to COSPAS-SARSAT specifications in the 406-MHz-Band, special functionalities and pages are being provided.

After selection of a COSPAS/SARSAT Frequency (Refer to the chapter "Frequency selection Page"), the bearing page provides additional information and operating options.

Operational Elements and Display in COSPAS-SARSAT Bearing Mode

(1) >**Auto Squelch**< indication, indicating that the squelch level is set automatically to be close to the noise floor. It is recommended to always use the Auto Squelch during COSPAS-SARSAT operation. This can be achieved by manually selecting 0 % (lowest possible value) or 60 % (highest possible value) as squelch level. During COSPAS-SARSAT-Operation, this will force the automatic setting of the level.

(2) **>Decode<** menu option, allows to open the COSPAS/SARSAT Decode sub-page by shortly pushing the F1 push-button above the menu option.

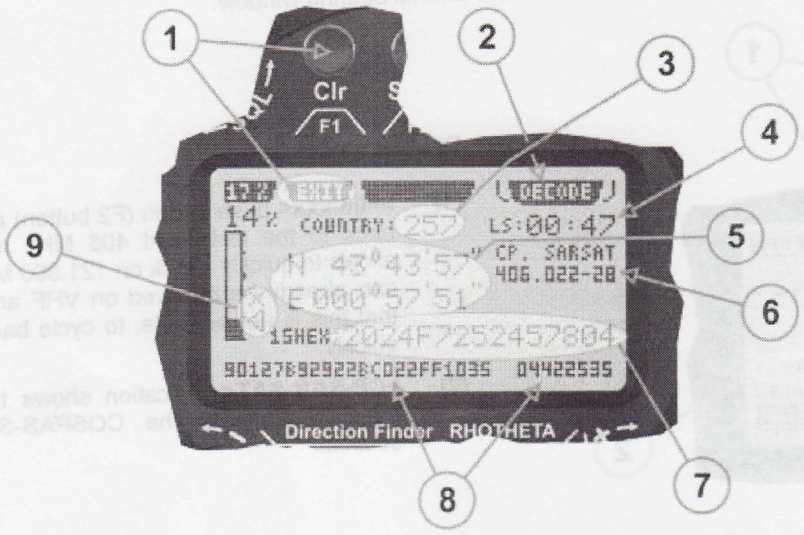
(3) **>>121.500<** menu option. The COSPAS-SARSAT signal in the 406 MHz band is transmitted only every 50 seconds in form of a short data burst of 440 or 520 ms. Approaching the transmitter, it will be received earlier than the 121.500 MHz continuous signal due to its high transmitter power. However, in a lower distance to a transmitter, bearing on 121.500 MHz is faster thanks to the continuous or rapidly intermittent signal. The 121.500 MHz menu option allows a direct switch-over to 121.500 MHz. Direct return back from 121.500 to the COSPAS-SARSAT band is possible from the 121.500 MHz bearing Window in COSPAS-SARSAT mode. Please refer to the chapter "121.500 MHz bearing Window in COSPAS-SARSAT mode" for details.

(4) **>Frequency range<** indication. COSPAS-SARSAT is using a channel spacing of 3 kHz for its beacons. Due to the internal architecture of the direction finder, it is possible to receive more than one channel in the same time. Thus, frequency steps of the direction finder are 8.33 kHz instead of 3 kHz. The receive frequency covered by the current receive frequency setting is shown in the display line above the receive frequency indication.

Important:
If the exact frequency of the COSPAS-SARSAT beacon is unknown, it is strongly recommended to use the COSPAS-SARSAT scanning functionality for detecting the correct frequency (Refer to the chapter "Frequency selection Page" & "COSPAS-SARSAT Scan Mode")

2.2.4 COSPAS-SARSAT Decode Window

The COSPAS-SARSAT Decode Window allows decoding incoming COSPAS-SARSAT data messages.



COSPAS-SARSAT Decode Window

(1) **>Exit<** push button (F1 button) allows to leave the decode window and to go back to the COSPAS-SARSAT bearing mode window.

(2) **>Decode<** in the upper right corner of the display indicates that the decode function is activated.

(3) **>Country<** displays the COSPAS-SARSAT Country Code coded into the received data message.

(4) **>Last Signal<** time since the last COSPAS-SARSAT message has been received in minutes:seconds format.

(5) **>Position<** field showing, in case of location protocols being used by the beacon, the encoded GNSS position data (latitude / longitude) transmitted by the beacon.

(6) **>Range<** field showing the range of COSPAS-SARSAT channels covered by the actual receive frequency setting.

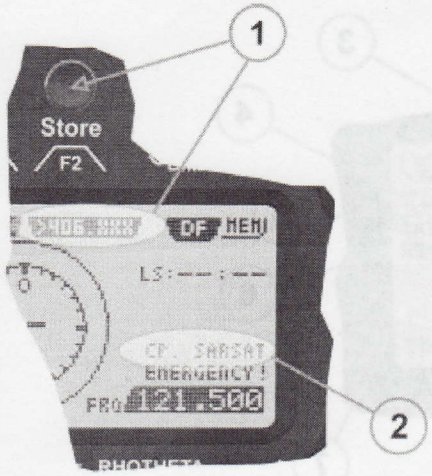
(7) **>15-HEX-ID<** 15-HEX-ID of the beacon in hexadecimal format.

(8) **>Data string<** of the bits 25 to 112 of the COSPAS-SARSAT data burst in case of short messages, and bits 25 to 144 in case of a long message format. The last 8 Hex Values are separated by a blank. Bit- and Frame-synchronization hex values (Bits 1 to 24) are suppressed to increase the readability of the data message.

(9) **>X<** sign to indicate that the Squelch is controlled by the antenna unit for optimum sensitivity. The user has no access to the Squelch setting.

2.2.5 121.500 MHz bearing Window in COSPAS-SARSAT mode

While being in the 121.500 MHz bearing window activated through the COSPAS-SARSAT Bearing Mode sub-page, the bearing window is slightly different to the normal bearing window:



121.500 MHz Bearing Window in COSPAS-SARSAT Mode

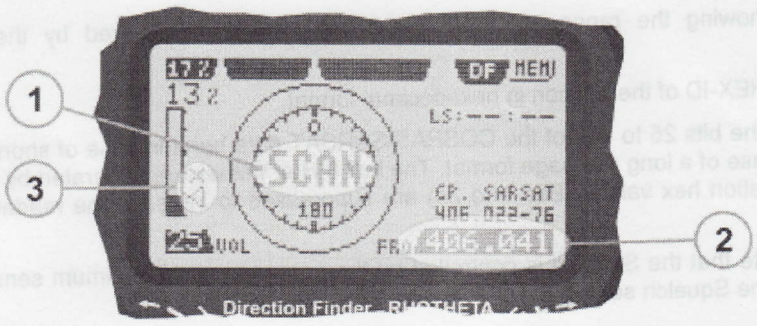
Differences are:

(1) **>406.xxx<** push button (F2 button) allows to switch back to the last used 406 MHz frequency. This allows to quickly check on 121.500 MHz if a beacon can already be received on VHF and, in the case that this is not possible, to cycle back to 406 MHz quickly.

(2) **>CP-SAR-SAT<** indication shows that the actual page belongs to the COSPAS-SARSAT page section.

2.2.6 COSPAS-SARSAT Scan Mode

If the COSPAS-SARSAT scan mode has been selected, the COSPAS-SARSAT channels, as selectable manually from the Frequency Selection Page, are scanned. After reception of a valid COSPAS-SARSAT Signal, the COSPAS-SARSAT bearing mode is activated. Due to the fast scanning – the complete COSPAS-SARSAT sub-band is scanned within less than 400 ms – detection of a receivable COSPAS-SARSAT signal is possible within one COSPAS-SARSAT repetition cycle.



Display in COSPAS-SARSAT Scan Mode

(1) **>SCAN<** flashing indication notifying the user that the equipment is operating in scan mode.

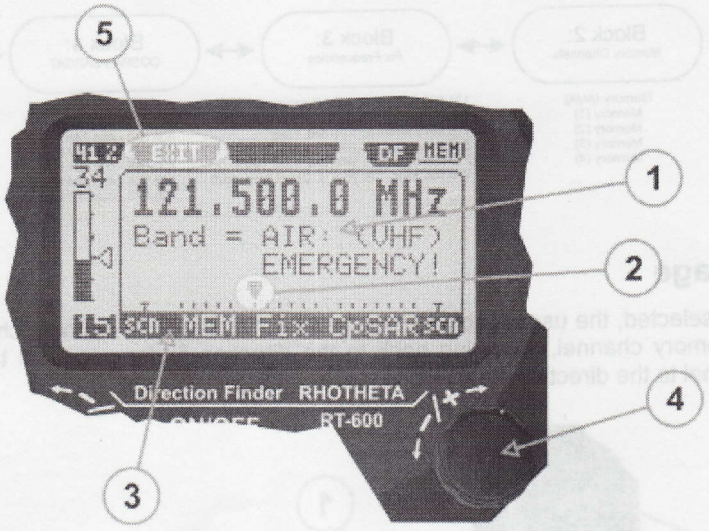
(2) **Frequency** display indicating the COSPAS-SARSAT scanning frequency range.

(3) **>X<** sign showing that squelch settings are controlled autonomously by the receiver.

Scan mode can be left by entering a new frequency through the frequency or memory setup.

2.4 Frequency Selection Page

If the frequency selection page has been activated by using the frequency selection rotary switch, the frequency selection page opens. The frequencies which can be selected consist of several frequency blocks: Memory Channels, Special Application Frequencies, COSPAS-SARSAT frequencies, and scan modes.



Frequency Selection Page and Operating Elements

(1) **>Frequency<** information field, showing all necessary information on the selected frequency such as frequency in MHz, memory channel (in case of memory frequencies), purpose of the selected frequency.

(2) **>Marker<** showing the currently chosen frequency on the frequency scale

(3) **>Frequency scale<** on which a frequency can be chosen. The frequency scale is organized in frequency blocks. The name of the frequency block is indicated below the frequency scale. They are:

- Law Enforcement scanning frequencies (Law Enforcement version only)
- Memory Channels
- Fix pre-programmed frequencies
- COSPAS-SARSAT frequencies
- COSPAS-SARSAT scanning frequencies.

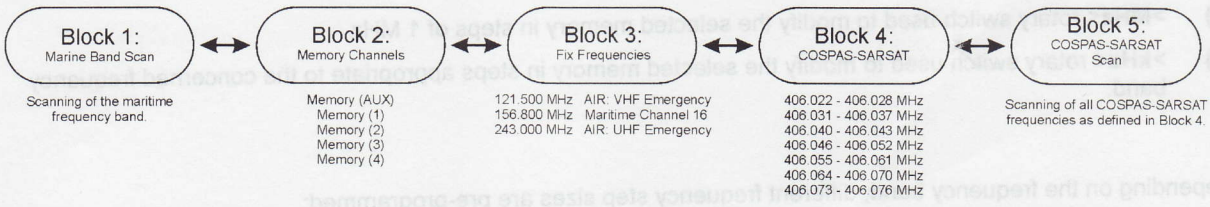
(4) **>Frequency selection<** rotary switch allowing to select a frequency by moving the marker along the frequency scale.

(5) **>Exit<** hotkey (F2 push-button) allowing to directly switch back to the normal operating mode on the currently selected frequency. If the exit hotkey is not pressed, the direction finder will fall back into the operating mode automatically after ca. 5 seconds of user inactivity.

2.4.1 Frequency Selection Page, Standard Version

In the standard version of the equipment, the frequency selection page offers a set of 17 different choices, organized in 4 blocks, which can be selected by the user.

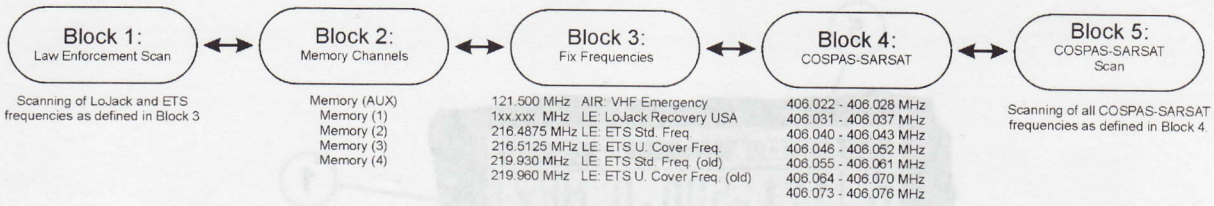
Frequency selection options for the standard version of the RT-600:



2.4.2 Frequency Selection Page, Law Enforcement Version

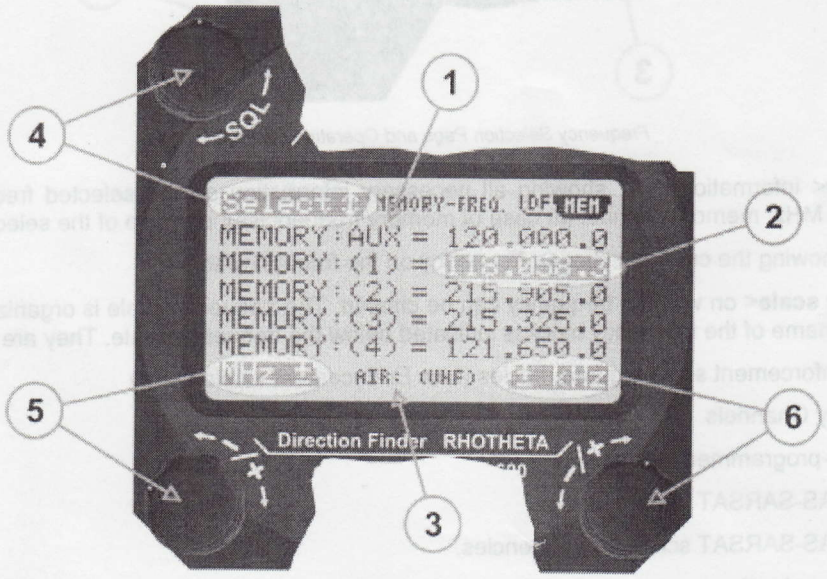
In the law enforcement version of the equipment, the frequency selection page offers a set of 20 different choices, organized in 5 blocks, which can be selected by the user.

Frequency selection options for the law enforcement version of the RT-600:



2.5 Memory Page

If the memory page is selected, the user is able to program the five available memory channels. After selecting and/or modifying a memory channel, switching back to the direction finder page will take over the currently selected memory channel to the direction finder mode.



Memory Page

(1) **>Channel Name<** field: indicates the name of the channel, which is re-used in other displays as name of the currently used frequency: AUX, (1) ... (4).

(2) **>Frequency<** field: shows the frequency currently stored for each channel. The memory channel currently selected for modification or for transfer to the direction finder mode is highlighted by dark background and bright ciphers on the frequency field.

(3) **>Application Information<** field showing to which frequency band and application a frequency belongs to.

(4) **>Channel selection<** rotary switch used to select which memory channel shall be active for modification or transfer into direction finder mode.

(5) **>MHz<** rotary switch used to modify the selected memory in steps of 1 MHz

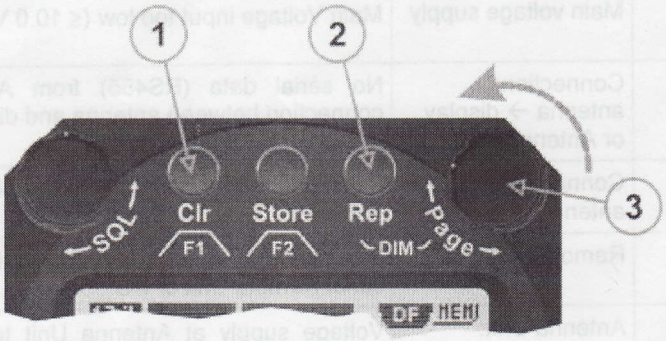
(6) **>kHz<** rotary switch used to modify the selected memory in steps appropriate to the concerned frequency band.

Depending on the frequency band, different frequency step sizes are pre-programmed:

Frequency Range	Step Size	Application Band	Applicable for:
118.000 – 123.975 MHz	8.33 kHz	Air VHF	Standard Version Law Enforcement Version
156.025 – 162.995 MHz	25 kHz	Maritime VHF	Standard Version Only
164.000 – 174.000 MHz	12.5 kHz	LE: LoJack	Law Enforcement Version Only
201.000 – 215.995 MHz	5 kHz	Med Track	Law Enforcement Version Only
216.000 – 218.9875 MHz	12.5 kHz	LE: ETS	Law Enforcement Version Only
219.000 – 220.000 MHz	10 kHz	LE: ETS	Law Enforcement Version Only
240.000 – 246.000 MHz	8.33 kHz	Air UHF	Standard Version Only
400.000 – 410.000 MHz	8.33 kHz	CP-SAR-SAT	Standard Version Law Enforcement Version

2.6 Setup Page

System setup functions are available in the setup page. The functions described in this section should be used by trained personal only.

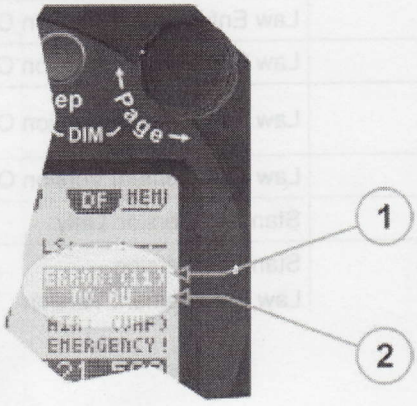


Accessing Setup Page

The setup page can be accessed by holding down the **>CLR< (1)** and **>REP< (2)** buttons simultaneously and, in the same time, performing a left-hand turn on the **>Page<** rotary switch **(3)**.

3 Error messages

If an internal error of the device is recognized, a corresponding, flashing error message will be shown in the DF pages:



Error Message

(1) **Error** message including **error code** (in brackets)

(2) **Short description** of the indicated error.

In case of coincidence of various errors, the error with the highest priority will be displayed.

Error message	Error, location	Reason
Error: (12) VOLT.DU	Main voltage supply	Main Voltage input too low (≤ 10.0 V)
Error: (11) NO AU	Connection: antenna → display or Antenna Unit	No serial data (RS485) from Antenna Unit. No or damaged connection between antenna and display, or damaged antenna unit.
Error: (10) BAD AU	Connection: antenna → display	Incompatibility or bad data connection between display and antenna.
Error: (9) BAD RU	Remote Unit:	Incompatibility or bad data connection between display and external serial Remote Unit or PC
Error: (8) VOLT.AU	Antenna Unit:	Voltage supply at Antenna Unit too low (≤ 9.0 V). Main voltage supply too low or considerable drop of voltage between display and antenna.
Error: (7) BAD DCU	Connection: Display → Antenna	Incompatibility or bad data connection between antenna and display.
Error: (6) NO DCU	Connection: Display → Antenna	No serial data from Display Control Unit to Antenna Unit.
Error: (5) PLL ERR	antenna	Error in synthesizer-oscillator of receiver in Antenna Unit.
Error: (4) FRQ+OFS	received transmitter	Received frequency too high (more than 6 KHz / error of transmitter)
Error: (3) FRQ-OFS	received transmitter	received frequency too low (more than 6 KHZ / error of transmitter)
Error: (2) DECODE	radio distance: transmitter ⇔ DF	Data Bits of decoded signal (COSPAS-SARSAT or LoJack) defective
Error: (1) DATARNG	Incompatibility of: data DCU ⇔ AU	Protocol data bytes out of valid range.
Error: (0) NO REC	Antenna Unit: receiver	Receiver board defective