# AFMS F-CHLC

## Airplane Flight Manual Supplement

**- Radio KRT2**

**- Flarm**

# Annexe 1

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RÉPUBLIQUE FRANÇAISE

Cet intercalaire doit obligatoirement être inséré devant la page de garde d'un manuel de vol en langue anglaise

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Référence : Instruction du 13/11/2009 relative à la langue des manuels de vol

# KRT2

## VHF Communication Transceiver

### Standard, Landscape, Portrait


Part No 285942 = KRT2-S (Standard)
Part No 285945 = KRT2-L (Mini Landscape)
Part No 286048 = KRT2-P (Mini Portrait)
Part No 285946 = KRT2-RC (Remote Control)

# Operation- and Installation Manual

# Record of Revisions

| Revision | Date | Chapter(s) | Topic |
|---|---|---|---|
| 0100 | 24.03.2017 | all | Initial Release |
| 0101 | 16.01.2018 | 6.3, 7.1 | FCC supplements, chap. 7.1 (periodic maintenance) amended |
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Table 1: Record of Revisions

# Service Bulletins (SB)

Service Bulletins must be inserted in the manual and added to this table.

| No SB | No Rev. | Release date | Date added | Name |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

Table 2: Service Bulletins

## Table of Contents

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# 1. GENERAL

This manual contains information about the physical, mechanical and electrical properties as well as a description for the operation and installation of the VHF airborne transceiver KRT2.

## 1.1 Symbols

| | |
|---|---|
|  | WARNING<br>Non-compliance may cause personnel injury due to radiation or fire. |
|  | CAUTION<br>Non-compliance may cause damage or incorrect operation of the transceiver. |
|  | INFORMATION |

## 1.2 Acronyms

| Abbreviation | Description | Definition |
|---|---|---|
| BAT | Battery (Electrical) | Check DC source |
| DIM | Dimming | Display brightness setting |
| EXT | Exterior / External | External Audio input level setting |
| INT | Intercom level | Intercom volume level setting |
| PTT | Push-To-Talk | Transmitter activation |
| RC | Remote control | KRT2-RC remote control for KRT2 |
| SQ | Squelch | Squelch setting |
| VOX | Voice operated intercom | Voice level setting for intercom activation |

Table 3: Acronyms

## 1.3 Customer Service

In order to process returned units most expeditiously, please use the email support.krt@tq-avionics.com on the website www.tq-avionics.com

| | |
|---|---|
|  | Suggestions which will improve this manual are very much appreciated at: info@tq-avionics.com. |

| | |
|---|---|
|  | Information concerning software updates is available under support.krt@tq-avionics.com. |

## 1.4 KRT2 Transceiver properties

- VHF airborne transceiver
- Frequency range 117.975 to 137.000 MHz
- Channel spacing 8,33 / 25 kHz (2278 channels)
- Fast channel selection
- 2 separate microphone inputs (standard or dynamic)
- Audio-input for other audio devices
- Installation: Standard panel cut-out (57 mm)
- Integrated Intercom
- 100 user definable frequencies with up to 8 character/spaces identifiers

| | |
|---|---|
|  | Continuous transmissions will be turned off after 2 minutes.<br>(Stuck microphone function) |

## 2. Installation limitation

The conditions and tests required for (E)TSO approval of this article are minimum performance standards. It is the responsibility of those installing this article either on or within a specific type or class of aircraft to determine that the aircraft installation conditions are within the (E)TSO standards. (E)TSO articles must have separate approval for installation in aircraft.

### 2.1 Installation

For installation hints, data, electrical connections and mounting instructions please see section 6 “Installation”.

### 2.2 Aircraft Radio

The KRT2 was designed as a closed unit for installation in a cockpit environment of the general aviation with the following limitations:

Installation must be in accordance with the applicable EASA or FAA requirements.
The classification of the software approval is suitable for aircraft type.

The failure classification identified in accordance with FAA AC 23.1309-1D is:

**MINOR**

The Software level is:

**LEVEL D**

### 2.3 Quantitative safety objective identification

In accordance with EASA regulations, the goal is a safety objective for the VHF COM radio in the KRT-2 VHF Communication Transceiver System of 1 x 10E-4 per flight hour for Class I airplanes and 1 x 10E-5 per flight hour for Class II Airplanes.

### 2.4 Deviations

None

# 3. CONTROL general

## 3.1 Control elements overview

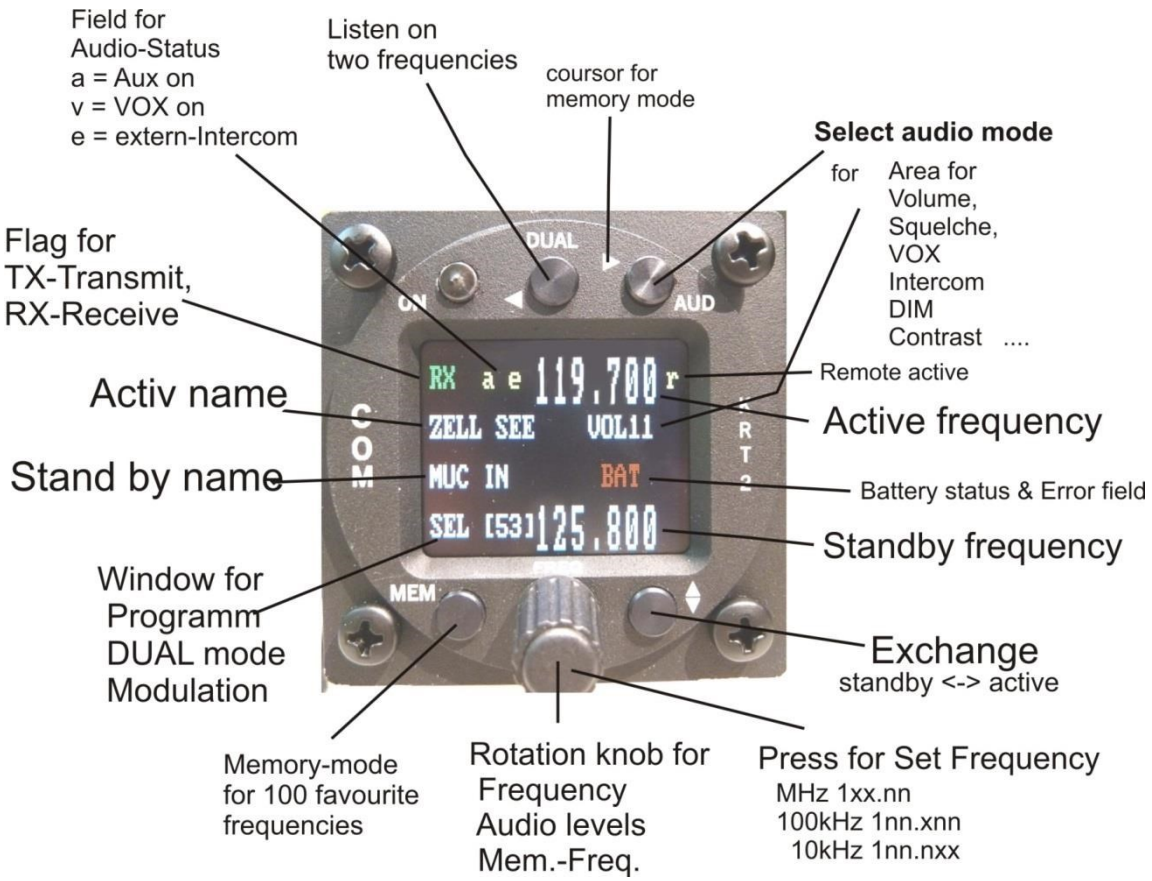



Figure 1: KRT2-S Front View

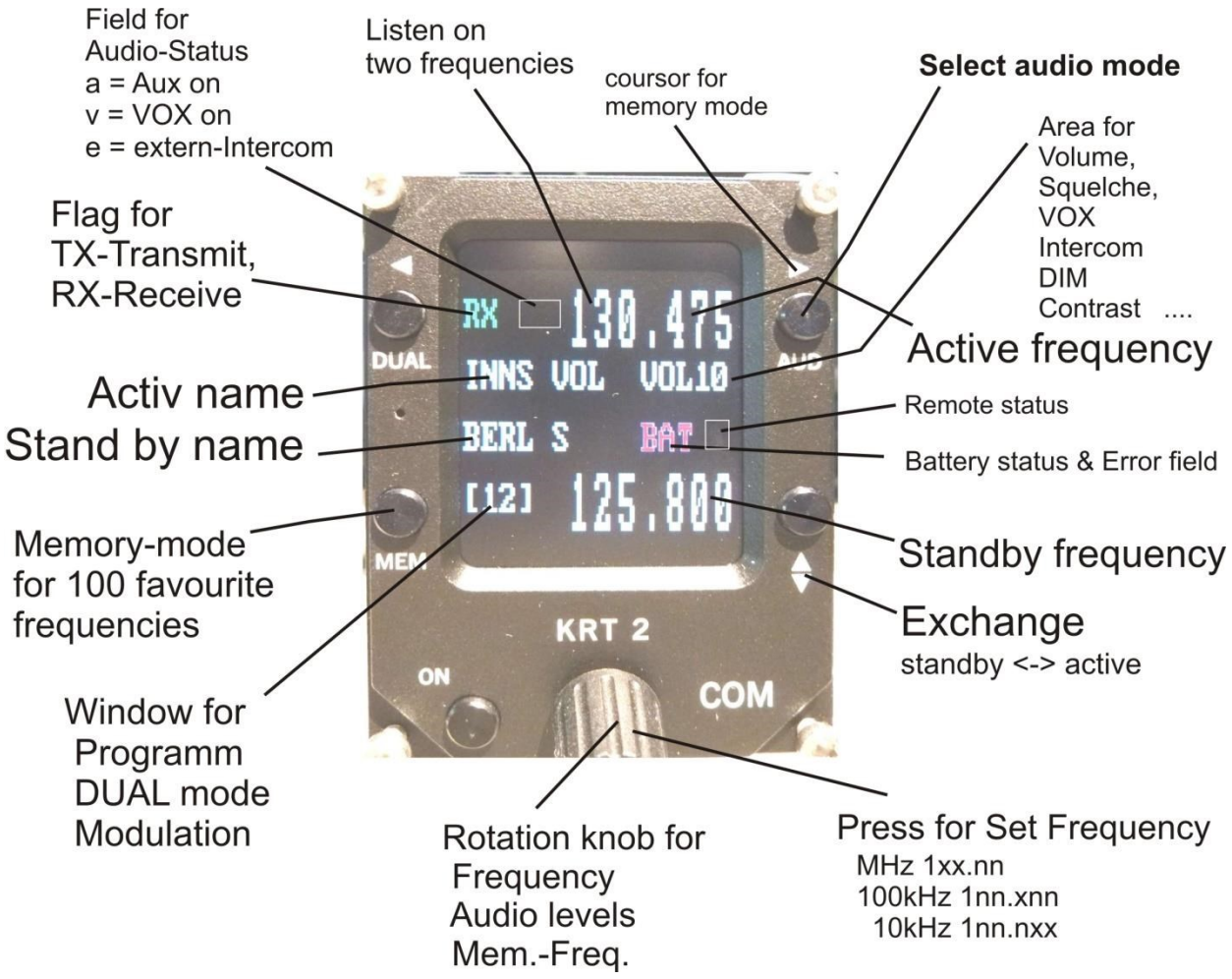



Figure 2: KRT2-P front view

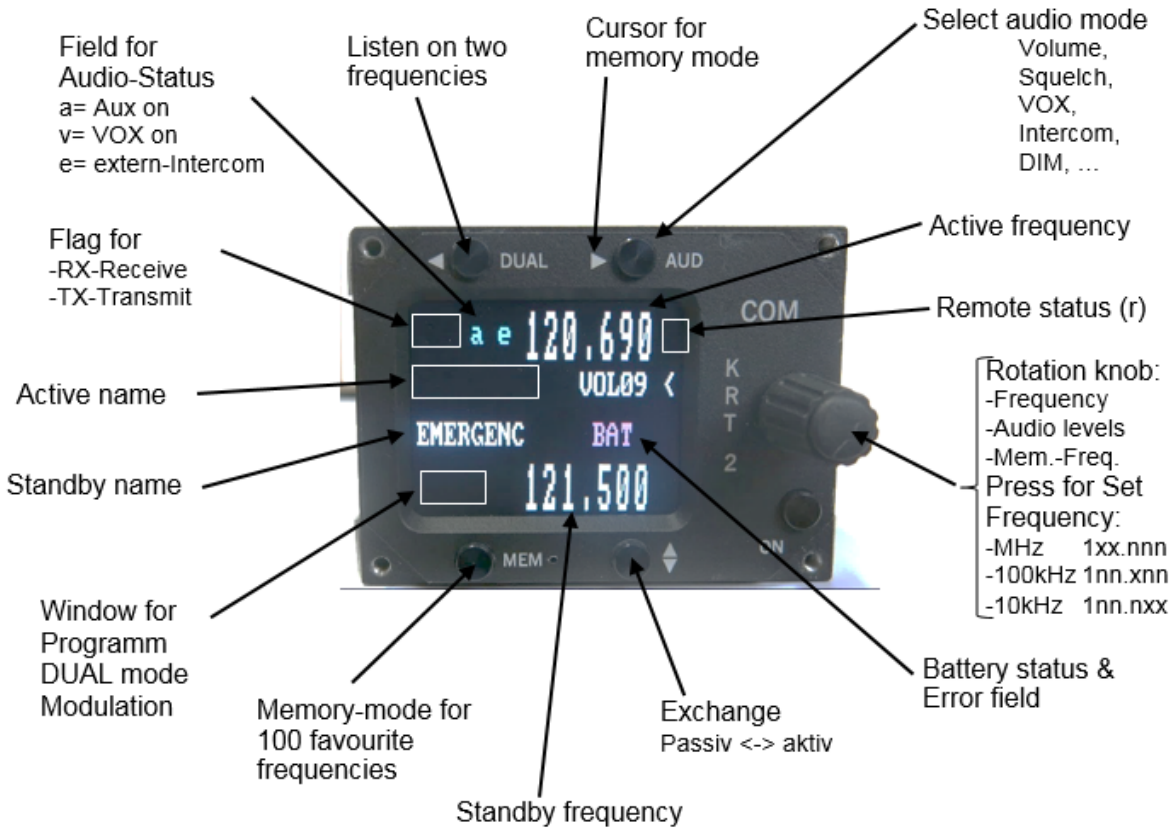



Figure 3: KRT2-L front view

All functions and performances of the normal size unit (57mm round) and the Portrait format (Mini) are identical.

The only differences are the text areas on the display Compare Figure 2: KRT2 Front view and Figure 3: KRT2 Mini Front view for more details.

| Button | Function | Usage |
|---|---|---|
|  | ON / OFF | Self-locking switch |
|  | DUAL WATCH | 1. Scanning between the Active and Standby frequencies<br>2. Positioning cursor to the left when programming the station identifier |
|  | AUDIO SELECT | 1. Stepping through the audio menus<br>2. VOL SQ VOX TX INT EXT DIM CON SIT and MIC<br>3. Positioning cursor to the right when programming the station identifier |
|  | FAVORITES | 1. Frequency and identifier selection from the favourites list<br>2. Programming of favourites (frequency and identifier) |
|  | EXCHANGE | Exchange of the Active and Standby frequencies |
|  | TURNING KNOB | Pressing for Selection of the frequency range to: MHz, 100kHz, 10kHz<br>Toggles between frequency and identifier when programming the favourites<br>Sets all variable values in any menu<br>• Volume setting of headsets and speakers<br>• MHz/kHz selection of the standby<br>• frequency in 3 different ranges<br>• Favourite selection<br>• Alpha character selection when programming favourites<br>• Change of microphone settings |

Table 4: KRT2 Controls

## 3.2 Display

| Indication | Meaning | Remark |
|---|---|---|
| RX | Reception | RX is displayed during reception (squelch opened) |
| TX | Transmission | Transmitter operates normally |
| Te | Transmitter was turned off automatically after 2 min continuous operation | |
| 119.700 | Frequency | |
| ZELL SEE | Frequency station identifier | Displayed when frequency and identifier are stored in the favourite list |
| MUC IN | Standby frequency station identifier | Displayed when frequency and identifier are stored in the favourite list |
| VOL …… | Receiver volume level (default after a certain time delay) | When AUD is pressed the corresponding Audio Menu item and setting is displayed |
| DUAL | DUAL function is activated | DUAL function is deactivated by DUAL, FREQ or MEM |
| [03] (MEM) | Favourite list index (0-99) | When frequency and identifier are stored at this index ex:[03] they are displayed |
| 125.100 upper | Active frequency | Displayed in large fonts. |
| 125.800 lower | Standby/DUAL - frequency | Displayed in large fonts. |
| < | The pointer indicates what the turning knob will change VOL SQ VOX…..etc. Standby frequency | Arrow is positioned according to the button pressed (AUD or FREQ) |
| BAT | Supply voltage is low <10,5V | Low or defective battery / generator. |
| A-match | Antenna error | Bad antenna match |
| a v e | Status of certain Audio menu functions | a = AUX. Input active<br>v = VOX active<br>e = external Intercom switch active |

Table 5: KRT2 Display

## 3.3 Menu levels

| Displayed | Signification | Remark |
|---|---|---|
| VOL | Volume | Default |
| SQ | Squelch | |
| VOX | Voice operated | Voice operated intercom |
| DIM | Display brightness | |
| BAT(tst) | DC source check | |
| INT | Intercom - Volume | |
| EXT | Volume of external devices | |
| TX(m)** | PTT button selection | Left/Right/Both |
| SIT | Side tone | During transmitter operation |
| MIC | Setup-Menu for Microphones | Service-Menu without radio opera-tion. |

Table 6: KRT2 Menu Levels

## 3.4 Self-test error reports

| Display | Meaning | Remark |
|---|---|---|
| Er_PLL | Internal error, no transmission | Return the transceiver for maintenance |
| Er_ADC | Internal error, operation limited | Return the transceiver for maintenance |
| Er_FPA | Internal error;  unit not usable | Return the transceiver for maintenance |
| Er_I2C | Internal error; unit not usable | Return the transceiver for maintenance |
| Er_D10 | Internal error; reception corrupt | Return the transceiver for maintenance |
| Error_3V3 | Internal error; unit not usable | Return the transceiver for maintenance |
| Key_Block | Internal error; unit not usable | Return the transceiver for maintenance |

Table 7: KRT2 Built In Tests (BIT)

# 4. OPERATION

## 4.1 General

In the normal operating mode in which the turning knob always is connected to the volume (VOL). The normal operating mode can be left by pressing the AUD, FREQ or MEMORY button.

When not in the normal mode and there is no pilot action for more than 10 seconds the unit returns to the normal mode.

## 4.2 ON / OFF switching

ON / OFF switching is done by pushing the self-locking switch.

After power up the following display will be displayed:


Device-name
KRT2

Software Version e.g. V8.6

(Example)

The unit starts in the normal operating mode using and displaying the data last used.

### 4.3 Frequency selection

There are two different frequency selection methods:

- Direct Input
- Selection from the favourite list (index 0-99)

#### 4.3.1 Direct frequency selection


The Standby-Frequency is set with the turning knob in 3 different ranges. The selected range is highlighted and can be changed with the FREQ button. Frequency ranges are:

1xx.nnn

1nn.xnn

1nn.nxx

Press the FREQ button once or several times until the desired frequency range is highlighted. The unselected digits are displayed as dotted digits.


When the pointer is not next to the Standby Frequency window, it will be repositioned with the first pressing of the FREQ button.


Exchanges the Active and Standby frequencies.

When the Exchange button is not pressed, the Standby frequency display will return to its normal appearance after 20 seconds.

### 4.3.2 Frequency selection from favourites list

By pressing 

and operating the turning knob a specific favourite list position can be accessed [xx] (xx = index 0 … 99). When frequency and station identifier have been defined, they will be displayed in the Standby and station identifier windows.

The favourite identifiers list can be sorted in alphabetic order (see 4.3.3 Storing and Editing Favourites).

To exit this menu, press the  key.

The selection procedure can be terminated with either the AUD or FREQ buttons. Without pressing any of these buttons the unit will return to its normal operating mode after about 15 seconds.

### 4.3.3 Storing and editing favourites

Any displayed Standby Frequency can be associated with an identifier and both can be stored as favourites in the favourite list. The frequency and identifier of a favourite can be edited.

First press the 

button and go to the desired favourite list position to be edited using the turning knob (index [00 …99]).

Press the MEMORY button a second time and „–EDIT--„ will show up in the program window.


In the identifier window a blinking cursor will show up under the extreme left character.

The turning knob selects the desired character.

The AUD button positions the curser one character to the right. The DUAL button positions the cursor one character to the left and simultaneously erases this character.

The station identifier can consist of a maximum of 8 characters/spaces.

To change frequency just press the FREQ button and follow the normal direct input procedure to edit the frequency, see “4.3.1 Direct Frequency Selection”.

To quit the frequency input press the MEMORY button again in order to go to the station identifier window for editing the identifier if required. Using the buttons FREQ and MEMORY it is possible at any time to toggle between identifier and frequency inputs.

Keep in mind the watch dog timer which will terminate the input mode after 15 sec.

**Termination and Save**

To save the entered identifier, press the  key as the cursor is on the station name, “SAVE” will appear and the system will go back to the favourite selection.

A **sorting process** can be activated by pressing the “MEM” button again from the EDIT-mode.

“SORT?” will be displayed for 20 seconds and it should be activated with  or skipped with “MEM”.
When activated all 99 favourites will be sorted in alphabetical order and the process can take several minutes.

During the sorting procedure “RUN nn“ is displayed in the program window, with nn being the running index.
After a 6 seconds time out or by ending the sort, the transceiver resumes its normal operating mode.

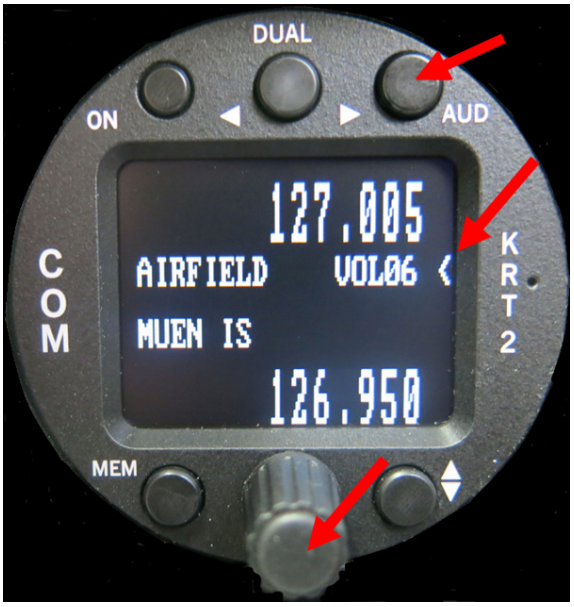
When the “MEM” button is pressed at the time “RUN nn“ is displayed, the sorting procedure is terminated. The favourite list is then partially sorted and the transceiver resumes its normal operating mode.

Example:

1. Button MEM -> SEL [23] = Select location
2. Button MEM -> -EDIT- = Input of name
   Rotation knop to select the characters
   For cursor use (AUD) (DUAL)
   Frequency setting -> press rotating button
   Use button MEM to go back to -EDIT-
3. Button  -> shortly SAVE -> back to 1.) (do nothing = cancelling)
4. Button MEM -> question for “SORT?” Yes =  , No = MEM or do nothing.

If the function is abandoned before completion, it will be exited after a 6 seconds time out with no activity. The data will not be saved.

## 4.4 AUD – Audio menu




Any action in the Audio Menu requires the pointer (<) to be next to the Audio menu window (see picture). When the pointer is next to the Standby frequency window, the pointer can be repositioned by pressing the AUD button once.

VOLnn is the Audio menu default display. No action on any control for more than 10 seconds will result in the VOLnn being displayed.

Audio Menu items can be accessed in the following order by repeatedly pressing the AUD button.

VOL (default), SQ, VOX, TXm**, INT, EXT, DIM, BATtst, SIT, MIC

### 4.4.1 VOL – Volume

Turning the turning knob changes the receiver volume.

**VOLnn** Range: 01 – 20

| | |
|---|---|
|  | The VOL setting only concerns the receiver and not the intercom system. Intercom volume values are set in the INT audio menu. |

### 4.4.2 SQ – Squelch

Pressing the AUD button once enables the turning knob to change the squelch level values.

**SQnn** Value range: 01 – 10

The Squelch setting is depending on several factors.

For engine driven airplanes an initial setting of 3-5 is recommended. For gliders a setting of 2 is recommended. The lower the Squelch level value the higher is the input sensitivity. A high sensitivity setting is susceptible to noise from other sources like ignition strobe-lights etc.

| | |
|---|---|
|  | Standard SQ-level is 3...5. Higher setting will suppress weaker input signals. 01 = Squelch off, 02 = for long range. Squelch does not influence the intercom system. |

### 4.4.3 VOX – Intercom voice trigger level setting

Pressing the AUD button twice enables the turning knob to change the voice level which triggers the intercom.

The intercom voice trigger level must be set to a value which prevents normal cockpit noise from being heard in the earphones. The intercom system should only be activated when talking at a normal voice level into the microphone.

The higher the trigger level the louder the voice must be in order to trigger the intercom system.
VOX on condition is indicated by flag “v”.
VOXnn Range: 01 – 10

| | |
|---|---|
|  | The larger the value, the louder one must speak in order to activate the Intercom connection.<br>VOX on condition is indicated by flag “v”.<br>For installation with loudspeakers set VOX to 10 to switch it off. |

### 4.4.4 Manual Intercom

With cockpit loud background noise or with uncompensated microphones the Intercom can be controlled manually by using an external switch. Therefore the VOX system must be activated permanently by selecting VOX: 01.
To turn off the Intercom the talk switch (default closed) must be opened, which will be indicated by “e”.

Deactivation of the intercom is done with an opened external microphone button (Ground connection to pin 12), this is indicated with an “e” on the display.

This mode only works with a deactivated external audio input (see “4.4.7 EXT – External Audio Input Volume”).

In gliders the VOX has to be set to 10 in order to disable the speaker control.

### 4.4.5 TXm – PTT switch selection

Pressing the AUD button three times enables the turning knob to enable certain PTT switches.

On transmission the microphone which is related to the PTT-L/R will be enabled. The equivalent indication is TX (TXm**), TX1 (TXm*-) TX2 (TXm-*).
On transmission the PTT-L/R related microphone will be the only one activated.

**TXm**** *- Left / -* Right / ** Both

### 4.4.6 INT – Intercom volume

Pressing the AUD button four times enables the turning knob to set the intercom volume.

**INTnn** Range: 1 – 9

### 4.4.7 EXT – External audio input volume

Pressing the AUD button five times enables the turning knob to set the external audio input volume. External audio inputs can be audio alarms, voice alarms, Vario, etc. The required level is 200mVpp (6Vpp max).
Activation occurs for settings >00 and will be indicated by “a”.

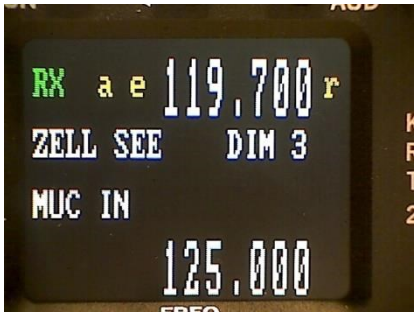
- 00 = turning off,
- 01 = lowest gain without threshold
- 09 = highest gain with interference suppression threshold.

**EXTnn** Range: 0 - 9

### 4.4.8 DIM – Display brightness

Pressing the AUD button six times enables the turning knob to set the display brightness.

**DIMnn** Range: 01 – 16





The display consumption at 12V is between 10mA und 70mA. In addition the battery voltage in Volts is indicated.

### 4.4.9 BAT – Battery test

Pressing the AUD button seven times enables the turning knob to display the battery voltage.


### 4.4.10 SIT – Side tone

Pressing the AUD button eight times enables the turning knob to set the side tone volume (for gliders has to be set to 01).

**SITnn** Range: 1 – 9

### 4.4.11 MIC – Setup

This mode is for microphone setup and test only without using the PTT. It is a service mode and it is not designed for normal operation.

Each of the two microphone input channels can be configured individually, which enables different microphone types to be used.

A maximum of two microphones of same type may be connected to each microphone input channel (see chapter 6.6.1 Microphone-Connection).

The MIC – Setup is the last item of the Audio menu and can be accessed by pressing the AUD button nine times.


By pressing the DUAL button repeatedly L, R and AUTO can be selected (Left “L” in the example).

L: Left = Left microphone.

R: Right = Right microphone.

AUT: Auto mode.

**Menus L and R:**

By means of the turning knob the displayed microphone input channel amplifier gain (MIC-level 01 = low gain, 09 =high gain) can be selected individually. The microphone signal level is dynamically displayed with a bar and a numeric value.

The initial MIC-level should be 0,5; the engine should be running, use a headset or earphone and speak at a normal voice level to fine-tune the MIC-level. Whenever a new MIC level is selected, the dynamic bar indicator should then be at about 50%.

**Special hint:**

**During MIC-Setup activation, the speaker state will be taken into account (SQU on/off), if the state is active an acoustic feet-back may be heard.**

The range of the MIC-level for standard microphones is 1 to 9.

MIC levels 10 and 11 are special settings for low microphone levels like dynamic micro-phones often used in gliders.

- Level 10 is used for non-amplified Electret microphones with an 8 volt supply voltage.
- Level 11 is for dynamic microphones only.

For high gain selection (> 9) the use of side tone can lead to a feedback at transmission. In that case the side tone should be set to SIT=01.

The new values will be stored upon exiting the microphone setup menu. AUTO must be selected in order to activate the AUTO menu, else use L or R to activate the Left and & Right microphone menu.

**Menu Auto**

In the AUTO mode only the left microphone impedance is measured. When a dynamic microphone is recognized, the left channel is switch to 11, the right channel is unaffected. When returning to the standard configuration, the original L and R values are restored.

| | |
|---|---|
|  | A simultaneous operation on Electret and Dynamic microphones is not possible (there is just one DC source for both ports). For dynamic mode this source must be turned off automatically. |

The display of microphone type (lower right side) is done upon activation of the microphone menu.
When an Electret microphone is recognized, the values used are the one that were saved upon leaving the menu.


The MIC submenu is terminated by pressing the AUD button.

**Additional indications**

Additional indications for test purposes:

- RxS : RF receiver input level (from Automatic Gain Control)
- Ext : External audio input voltage
- Mic : d (dynamic) or s (standard)

The microphone type is displayed when the microphone menu is entered.

This Symbol  appears on right side of STBY Frequency in AUTO-mode if the dynamic microphone has been recognized and activated after transmission. In that case the intercom voice triggering level VOX is set to 10 (switched off).

To reactivate the intercom after a microphone change, a short press of the PTT is required.

### 4.4.12 Menu lock

For school operation the menus area TXm to MIC-setup can be locked.

To lock or unlock the button combination AUD & FREQ has to be pressed simultaneously for > 2 seconds.

In lock condition there will be displayed an “L” at the right end of the third line.
To store those condition the setting of SQnn should be changed before turning off.

| VOL | SQ | VOX | TXm | INT | EXT | DIM | CON | SIT | MIC |
|---|---|---|---|---|---|---|---|---|---|
| Available | | | Locked and not available | | | | | | |

Table 8: KRT2 Menu Lock

## 4.5 DUAL watch

Because the communication transceiver KRT2 contains only one receiver, DUAL watch is achieved by alternating between the Active and Standby frequencies.

The DUAL button activates and deactivates the dual watch function. Deactivation also can take place by pressing either the FREQ or MEMORY buttons.
The frequencies to be watched should be selected prior to the DUAL watch selection.

The frequencies to be used must be selected before using dual watch and the squelch level SQ must be set to 02 or more in order to eliminate noise. Scanning Frequencies is only possible when differentiating between radio noise and radio transmissions.

| | |
|---|---|
|  | There must be radio noise suppression in order to recognize reception. The squelch level SQ must be set to 02 or higher. |

When DUAL watch is activated, “DUAL“ is displayed on the lowest line. The pointer next to the DUAL display indicates the frequency on which there is reception.
The Active frequency always has priority and the receiver remains on the active frequency as long as there is reception on this frequency.
When there is no reception on both the Active frequency and the Standby frequency the receiver scans both frequencies 5 times per second.

When reception is detected on the Active frequency the reception on the standby frequency is interrupted until the end of the reception.

When a reception is detected on the Standby frequency the receiver stays on the Standby frequency, however it switches to the Active frequency every 2 seconds for a duration of 0.3 seconds. If a signal is detected on the active frequency the reception will be switch to that frequency.
The pointer next to the DUAL display indicates on which frequency there is reception.

Figure 4: KRT2 active & standby frequencies

Standby and Active frequencies can be exchanged when in the DUAL mode. The transmitter operates on the Active frequency only.

Summary:

- Select the Standby frequency to be monitored in addition to the active frequency.
- With the AUD button and turning knob set SQnn to 2 or higher.
- With the DUAL button activate the DUAL watch function.
- When there is no reception on both the Active frequency and the Standby frequency the receiver scans both frequencies.
- When scanning the Active frequency always has priority.
- Deactivate the DUAL watch function with the DUAL, FREQ or MEMORY buttons.

### 4.6 Transmitter Operation

The unit transmits on the active frequency (upper line) as long as a PTT (press to talk) switch is pressed.


Transmission Reception

Figure 5: KRT2 TX & RX operations

“TX“ indicates normal transmitter operation.
“RX“ indicates a receiver operation.

In the lower left corner of the display the carrier modulation is dynamically displayed. It corresponds to the side tone which is not available on gliders when no earphones are in use.

In order to avoid the blocking off of the frequency by unintentional long transmissions (stuck microphone) the transmitter is switched off after two minutes and the display changes from „TX“ to „Te“. To resume transmission the PPT switch first must be released and then be pressed again.

While transmitting the external audio input will be turned off automatically and the microphone input, selected during the pre-setting in the TXm-menu, will be selected.

The differential speaker output will be turned off to prevent an audio feedback to the microphone. For the same reason; the speaker is turned off when the intercom (VOX) is active.
The output for the headset will carry the side tone.

### 4.6.1 Two PTT configuration

There are two different PTT assigned for each of the left and right side microphones. This enables the deactivation of the unused one preventing additional noise and unintentional talking on transmission.

In case there is just one PTT and multiple headsets in use both the PTT-L and PTT-R must be tied together, see chapter “4.4.5 TXm – PTT Switch Selection”.

### 4.6.2 Self-Test monitor

Software diagnostics operate continuously in the background in order to test the system.

The field for battery status & error (see Control Elements Overview) is used to display warnings and in case of hardware failure, different error reports will be displayed here.

The warnings are:

**BAT** **L**ow battery voltage (becomes active < 10,5V)

At transmission

**A-match** Bad antenna match or defective antenna.

Also while transmitting the TX-flag (left top) will change to:

**Te** if transmission time has exceeded (> 2 minutes).

All other reports starting with Er_…. Indicating a major hardware failure and consequently the radio has to be returned to the factory.

### 4.6.3 Optical side tone

Especially when used in gliders, where headsets are generally not worn and thus no side tone is heard, it is very helpful to see if the microphone is operating properly.

At left lower side, there is a modulation indicator that depicts the voice level. When there is no modulation it becomes a small dot approximately in the centre.

Also if it lays far off centre, it indicates that there is bad antenna matching.

## 4.7 Resetting to factory settings

Returning to the factory settings can only be initiated during power-up.

To do this, during power-up the MEM and DUAL buttons must be pressed simultaneously and the display will show “SET DEFAULTS”. When the buttons are released the resetting to the factory settings takes place. When resetting is completed “DONE” is displayed.

## 4.8 SET UP - Menu

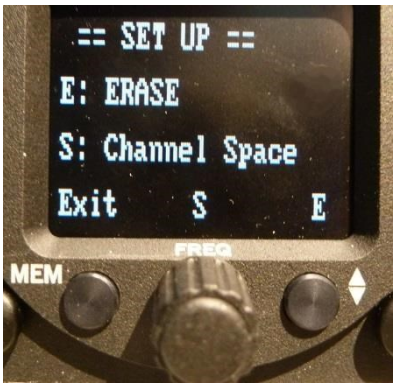
During power-up the MEM button must be pressed.

The message "protect mode" is displayed, just wait until it changes.

There are two functions available within the Set-up menu:

- ERASE – Erasing of the favorites (frequency and identifier)
- Channel Spacing – 25kHz / 8,33kHz

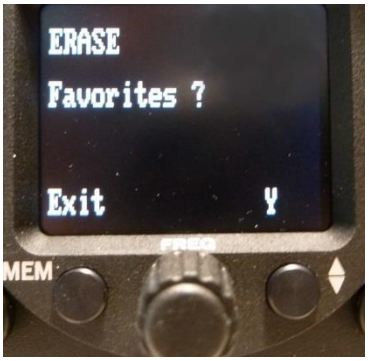
Programming of the Set-up is done with the lower 3 buttons next to the symbols (Exit, S, E). Their function is described on the display.




To exit the SET-UP menu, use the MEM button. The unit remains powered and the normal operating mode is resumed.

### 4.8.1 ERASE – erasing of favourites list

When in the SET UP – Menu select the “ERASE“ sub-menu with the buttons next to the symbols (Exit, Y).




Erasing the favourites (frequency and identifier) starts after the  button has been pressed again. This procedure may last a few minutes during which time the message “ERASING“ is displayed.

All INFO frequencies and identifiers that were stored on delivery are lost and all favourite index positions (01 to 99) are available to the user.

### 4.8.2 Channel spacing

When in the SET UP – Menu pressing the FREQ (S) button will change the KRT2 into the Channel Space submenu.


The desired channel spacing then can be selected and the (X) then indicates the actual channel spacing.

## 5. Remote Control

Tandem-seat airplanes can be equipped with the KRT2RC Remote Control Unit. The remote control unit is connected to RS232 serial interface and enables selection of the most common settings like frequency, volume, squelch, VOX, display contrast and brightness. In addition the unit has an independent memory for the favourites (frequency and identifier).

Transmission error messages are displayed in the error window in the third line:

- R_Time = Time-out transmission error
- R_ChkS = Checksum error
- R_Cmd = Unknown command
- R_Char = Data error
- R_Freq = Wrong Frequency

The error message disappears when a valid command or a new frequency has been input, or after 5 seconds.

Remote control unit errors do not interfere with the KRT2 transceiver operation.

Data transmission between the transceiver KRT2 and the remote control unit (KRT2-RC) is checked once a minute. An “r” in the upper right corner is displayed when there is no malfunction.

The KRT2-RC can also operate the KRT2 in a fully stand-alone mode such and allow the KRT2 to be installed anywhere in the aircraft, and be operated remotely by the KRT2C. This feature will be useful in tandem aircraft, or aircrafts with very little space behind the instrument panel.

# OPERATING MANUAL
# FLARM COLLISION WARNING UNIT



Status
Software Version 5.00 (March 01, 2011)

*This is a translation of the German manual.*


Baar-Switzerland
www.flarm.com
info@flarm.com

# 1. Welcome to the FLARM user community

Thank you for purchasing FLARM, a modern low-cost collision-warning unit for sailplanes and light aircraft. The main task for FLARM is to support the pilot, while he scans the airspace ahead with his own eyes. FLARM is simple to use and does not distract the pilot from the main business in hand.

Sport flying is an activity that is associated with considerable risks for crew, passengers, third parties and other objects. **In order to make full and safe use of FLARM, it is absolutely essential to be fully aware of the risks, operating conditions, restrictions and limitations associated with the use of FLARM, ensure a proper installation and do regular software updates. This includes familiarity with and observance of this Operating Manual and the Installation Manual.** Additional configuration information can be found in the 'Data Port Specifications' document, e.g. how to suppress additional data at the serial port what might be required in international championships.

We welcome user feedback and reports, suggestions for improvements, and pictures that will help us make further improvements to FLARM. Feedback reports should give a detailed description of the situation, quoting the Hardware and Software versions used, plus the flight data records in IGC format with short time recording intervals.

The latest version of this handbook and other related documents can be found at the Website www.flarm.com. This Website also has answers to Frequently Asked Questions.

This Website also carries announcements when new software versions or functions become available. If you enter your name on the mailing list, you will automatically receive notification of changes as and when they happen: https://lists.flarm.com/mailman/listinfo/user-list_flarm.com

To use existing devices in March 2011 or later, it is required to update the software to version 4.00 or higher. Use the free PC installation software available at www.flarm.com. You need a PC with Windows 98 / ME / 2000 / XP with a serial port or a suited USB-serial converter plus a data-power cable like the one used for most IGC flight recorders. This cable connects the PC to FLARM and supplies FLARM with power. Ensure you have configured the correct PC COM-port, only use the Power/Data-port on FLARM (not the Extension-port) and know the printed device serial number. After completion of the software update, use the same PC software to load the most recent obstacle file to FLARM; this file is available on www.flarm.com as well. Then use the PC software to configure the flight recording functionality accordingly. In case of questions, contact your FLARM dealer.

Software-Versions 5.x must not be used after **March 01, 2015**. Before this date, you must update the device in order to use it in the air.

# 2. How it works

FLARM receives position and movement information from an internal 16 channel GPS receiver with an external antenna. A pressure sensor[1] further enhances the accuracy of position measurements. The predicted flight path is calculated by FLARM and the information - including a unique identifier - transmitted by radio as low-power digital burst signals at one-second intervals. Provided they are within receiving range, the signals are almost at the same time received by further aircraft also equipped with FLARM. The incoming signal is compared with the flight path predicted by calculation for the second aircraft. At the same time, FLARM compares the predicted flight path with known data on obstacles, including electric power lines, radio masts and cable cars.

If FLARM determines the risk of dangerous proximity to one or more aircraft or obstacles, the unit gives the pilot warning of the greatest danger at that moment. The warning is given by a whistle sound (beep) and bright light emitting diodes (LED). The display also gives indication of the threat level, plus the horizontal and vertical[1] bearing to the threat. During circling flight different methods of calculation are employed to those used during straight flight.

The GPS and collision information received from other aircraft can also be made available for third party equipment (e.g. external display, speech synthesizer, PDA) via a serial data output. Such equipment is available from a number of manufacturers.

[1] Requires Hardware Version 2 or higher. However, the vertical bearing on the serial data output is also available to third-party equipment on Hardware Version 1.

The operating range is very dependent upon the antenna installation in the aircraft. The normal range is about 2 km. In individual cases the range may be up to 5 km, which can be valuable for fast sailplanes with a speed of up to 250 kt, providing the pilots in both aircraft with a warning enabling visual identification and reaction to the potential hazard. The effective range can easily be verified with an online tool[2]. Warnings are given in order of the time remaining before a potential collision, not the geometrical distance. The first warning level for another aircraft or an obstacle is delivered when less than 18 seconds remain to the possible collision; the second warning level is delivered when less than 13 seconds remains; the third level when less than 8 seconds remains.

The warnings continue as long as FLARM calculates a threat of collision. The warning level may decline or be cancelled, depending upon the prediction. The warnings are selective; they are only issued if the calculation reveals a high probability of collision in the near future. The alarm sensitivity can be configured with the PC.

In addition, FLARM operates as an IGC-file compatible flight recorder including the G-record. Flight logs can be read out either via the SD-card or via the data port and a suitable cable. The SD card does not need to be carried on during the flight. FLARM is optionally also available as diamond-level IGC-*approved* Flight Recorder, optionally with Engine Noise Level sensor (ENL).

With the standard April 2008 obstacle databank there is memory for more than 50 hrs of flight recording at a 4s interval. Use the free PC-software to download flights to your PC and to properly configure your device for flight recording. Flight recording automatically starts when the aircraft is moving and ends when the unit is switched off. Switching off the device during the flight for a longer period results in separate flight record files. Allow at least 2 minutes (if the interval is 4s, our recommended value) after landing before you switch off the device else you loose the last part of the flight. Allow more time after landing if the interval is higher. When the memory is full, the oldest data is overwritten. Always download you flight data before you update the obstacle databank or the software.

FLARM applies for the radio communication between the units a proprietary patent- and copyright-protected protocol. It is not public, but FLARM Technology offers a license contract where it is accessible in the form of a compatible core design ready for integration into 3rd party systems. These systems are officially declared as FLARM-compatible. Any non-licensed use, dissemination, copying, implementation or reverse engineering of the FLARM radio communication protocol, the FLARM hardware and software or parts of it is forbidden by law and will be prosecuted. FLARM is a registered trademark and can not be used without license.

## 3. General Advice on Operation

This Manual must be carried on board the aircraft. When permanently installed in an aircraft, the 'AFM Supplement' must also be carried in the aircraft.

In flight the pilot must have direct sight of and immediate access to a switch or circuit breaker that disconnects FLARM from the aircraft electrical power supply, without affecting other essential aircraft systems. This might be necessary if the pilot suspects that FLARM may be interfering with another on-board system, the suspected presence of smoke, the smell of smoke, or flying in a country where the use of FLARM is not permitted.

FLARM must not be operated at night or with night vision systems.

FLARM will not operate without adequate GPS signal strength. Correct antenna installation has a great effect on the transmission/receiving range.

FLARM is not able to measure its own RF-receiver sensitivity. When the pilot detects that other aircraft are received only when very close or not at all and when the RF-antenna's positioning is clearly not the cause of it, the device must be checked by the manufacturer.

[2] www.flarm.com/support/analyze

Installation and operation must be on the basis of non-interference with and no hazard to the existing suite of other certified equipment necessary for safe flying operation, or installed to comply with official requirements. Installation and operation must comply with official regulations and requirements. It is recommended that the FLARM, GPS and radio antennae are all installed as far away as practicable - but at least 25 cm from - susceptible aircraft systems such as GPS antennae and the magnetic compass.

The unit must be protected from solid particles or liquids, should not be exposed in use to temperatures below –10℃ or above +60 ℃ , or stored at temperat ures –20℃ or above +70 ℃, because this may cause irreparable damage. On the ground, the unit should be protected from exposure to long periods of direct sunlight, because it is likely to be overheated. Also avoid static discharges to the radio antenna.

Details on correct installation will be found in the Installation Manual.

## 4. Operating Modes

FLARM operates in two modes, *Nearest* and *Collision*. The change from one mode to the other is effected by a two-second push on a button followed by a brief visual confirmation from the unit. After the change has been signalled, the current mode selected is not displayed. When switched on, the unit is in *Nearest* mode.

The warnings given are identical in both modes, and generally relate to an immediate threat to which the pilot should make an immediate and appropriate reaction. The assumption has been made that following a warning it will take up to 12.5 seconds from the time that the other aircraft is seen, until a change in flight path has removed the threat[3].

When operating in the *Nearest* mode, the unit also reports the presence of other aircraft operating in the vicinity, even though calculations indicate that they do not represent a threat. The information displayed is limited to a configurable radius (default is three kilometres) and a vertical separation of 500 m. When no aircraft was displayed so far but one is received now, this is signalled with a click-sound. Only one single aircraft is indicated, with Hardware Version 3 or later in green. The optical signal is static (no flashing); the threat intensity is not indicated and there is no sound warning. As soon as FLARM detects the risk of a collision it automatically switches to *Collision* mode, followed by automatic reversion to *Nearest*. The choice of mode is presented, such that immediately after pressing the key, the display presents a diverging pattern (Hardware Version 1 and 2: ←→ ; version 3: ).

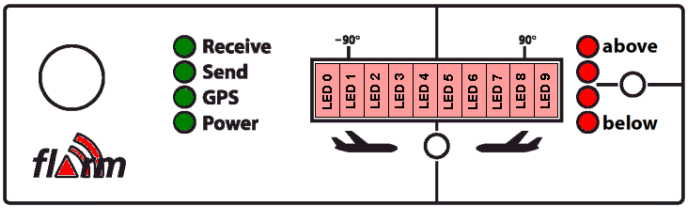
When operating in the *Warning* mode a red LED lights up only if the calculation predicts a threat. Warnings are always shown by flashing LEDs, the threat level being shown by the number of LEDs illuminated, by the frequency of flashes, and the simultaneous sound signal (beep). Selection of this mode is indicated by a upwards converging pattern (Hardware Version 1 and 2: →← ; Version 3: ) immediately after pressing the selector key.

In both modes the pilot can **suppress the display and the acoustic warning**: after a double push FLARM will suppress all visual and acoustic signals relating to traffic, obstacles or other threats. The act of selecting suppression is followed by a descending tone. A further double-push reinstates the *Collision* mode at once and is followed by a rising tone. While warnings are suppressed, FLARM nevertheless continues to transmit signals for reception by other aircraft.

[3] These times were published in 1983 FAA Advisory Circular 90-48-C and were based on military data. They relate to fast jet pilots with no on-board warning systems for other traffic and hazards. The assumption was made that only one aircraft takes avoiding action. Of the 12.5 seconds, five seconds were to recognise the threat of collision and four seconds were required to decide upon avoiding action. No information is available as to whether these times are applicable to light aircraft, sailplanes or helicopters, when using a warning system.

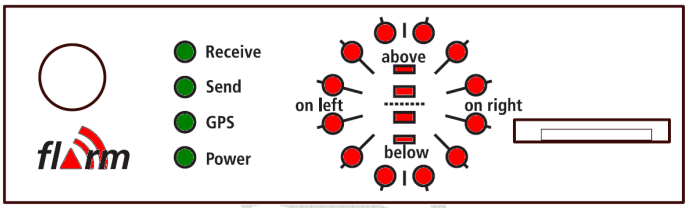
## 5. Front Panel

The dark grey front panel of Hardware Versions 1 and 2 has a push-button, four green Status-LEDs, ten red collision warning LEDs and four red LEDs for vertical[1] position indication.




Push-button | 4 green LED (Status) | 10 red LED (horizontal) | 4 red LED (vertical[1])

The front panel of Hardware Version 3 has a push-button, four green Status-LED, twelve bicolour LED for horizontal and four bicolour LED for vertical position indication. Depending on the threat caused by other aircraft or obstacles the LED show up red or green. Also included is a microSD-reader which can be used for updates, downloads and configurations. microSD cards are not included, but widely available in electronic and mobile phone shops.



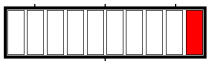

Push-button | 4 green LED (Status) | 12 LED (horizontal) 4 LED (vertical) all bicolor | microSD reader

# 6. Start-Up

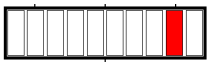
FLARM is always switched on if the unit is connected to an adequate power supply.

Immediately after it has been switched on there follows a one-second long beep while a start-up pattern might be shown on the LED, followed by a binary presentation of the Hardware-Version installed during the system self-test. The self-test mode lasts around 8 seconds, depending upon the size of the obstacle data bank.

`0x01` Hardware Version 1 (only red)



`0x02` Hardware Version 2 (only red)

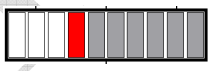


This is followed by another one-second beep, followed by a binary presentation of the Software-Version:

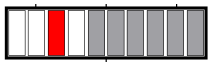
- Hardware Versions 1 and 2: LED0 to LED3 represent the major versions, LED4 to LED9 the minor versions. Everything is shown in red.

If the Software Version is not indicated and the beep sound is not emitted, the unit is not ready for operation.

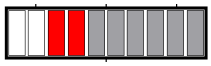
*Software Version 1.xx (operational only to April 2005)*



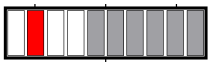
*Software Version 2.xx (operational only to Feb 2006)*



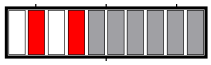
*Software Version 3.xx (operational only to March 2008)*



*Software Version 4.xx (operational only to Feb 2011)*



Software Version 5.xx (till March 01, 2015)

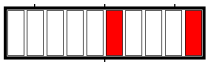
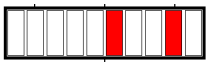
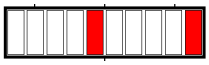
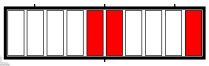
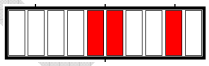
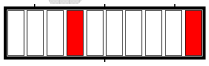
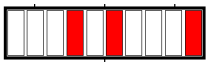
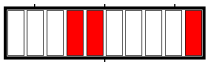
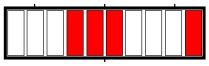
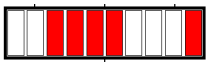
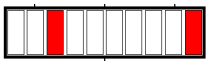
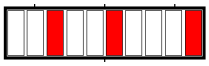
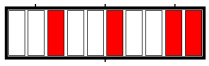
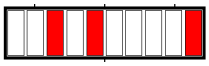


Then FLARM shifts to normal operation and waits until it has acquired an adequate GPS position fix. When switching on, this procedure can take *several minutes*. Without a proper GPS position fix, the unit is not ready for operation. **Before departure the pilot must ensure that at least the Power-, GPS- and Send-LED are all continuously on**. This state must be preserved during the whole flight to ensure correct operation.

## 7. Fault Finding

If a fault should occur during start-up self-test or subsequent operation, then all four green status LEDs will flash in unison for 30 seconds, while the red collision LEDs will give a binary indication of the most serious fault. The fault display can be stopped before 30 seconds has elapsed by pushing the button.

For safety reasons FLARM will not start up if there is a fault. FLARM may not be used if a fault has been reported or indicated. Limited operation is possible if there is an indication of a problem with the obstacle data bank or data recorder.

| | | | |
|---|---|---|---|
| 0x11 | Fault: Software out of date<br>(needs GPS reception) | *No operation* |  |
| 0x12 | Fault: Software integrity violation<br>(only IGC-units on F5) | *No operation* |  |
| 0x21 | Fault: Low Voltage | *No operation* |  |
| 0x31 | Fault: Internal GPS communication | *No operation* |  |
| 0x32 | Fault: Faulty GPS configuration | *No operation* |  |
| 0x41 | Fault: Internal radio communication | *No operation* |  |
| 0x51 | Fault: General internal communication | *No operation* |  |
| 0x61 | Fault: Flash memory | *No operation* |  |
| 0x71 | Fault: Pressure sensor | *No operation* |  |
| 0xF1 | Fault: Other fault | *No operation* |  |
| 0x81 | Indication: No obstacle data bank | Operation possible |  |
| 0x91 | Indication: Flight recording not possible | Operation possible |  |
| 0x93 | Indication: ENL recording not possible<br>(only IGC-units on F5) | Operation possible |  |
| 0xA1 | Indication: Error with SD-card configuration file | Operation possible |  |

The communications faults itemised above indicate if internal modules within FLARM are not communicating correctly with each other. For reasons associated with the system, reduced radio range cannot be detected by a single unit alone.

Software-Versions 5.x must not be used after March 01, 2015. Before this date, you must update the device in order to use it in the air. An update with the same functionality can be downloaded free of charge. Users will be able to load the software with the aid of a suitable power supply/data cable (not supplied). This operation requires the user to have the unit Serial Number to hand. Software validity has to be time-limited to ensure that all FLARM units are mutually compatible and that updates include the latest obstacle data.

## 8. Status-Display

The green Status Display LEDs operate as follows; normal operating mode is underlined:

- **Receive**: Lights up when a signal is detected from another aircraft less than the configured range (default is 3 km) away, with a height separation of less than 500 m; otherwise the LED is dark. If the warning is temporarily suppressed (see below) but signals are still received from other aircraft, then the LED flashes.
- **Send**: Lights constantly during operation and indicates that the on-board FLARM is transmitting. Transmission requires GPS reception.
- **GPS**: Lights constantly during operation (with very brief interruptions once per second). If the LED is constantly dark and flashes briefly once per second, then there is no GPS reception. When switching on this condition can take several minutes.
- **Power**: Lights constantly during operation. If the LED flashes, then the power supply has dropped below 8 V. FLARM will not operate below 8 V DC.

The 'Receive' and 'Send' LEDs give no indication of FLARM's transceiver range.

## 9. Push Button[4]

The push button can be used to select the following functions:

- **Brief Push** (<0.8 s) changes the volume from <*loud*> to <*medium*> to <*quiet*> to <*silent*> (and <*loud*> again). A short sound is emitted at the new volume selected. The default setting is <*loud*>.
- **Longer Push** (2 s) changes mode between <*Nearest*> and <*Collision*> when airborne. Visual confirmation. Default setting <*Nearest*>.
- **Longer Push (5 - 8 s, only on the ground)** activates the receiver self-test: Two seconds after the button is released, FLARM will show how many other FLARM are received with reduced sensitivity (50% of the normal range). It will then emit a long beep and light one vertical LED for every 10 and a short beep and one horizontal LED for every single received aircraft (e.g. 14 received FLARM is: "beeeeep bep bep bep bep", with one vertical and 4 horizontal LED's). After the self-test, FLARM switches back to normal operations. Note that for other units to be displayed these must be running.
- **Double Push** suppresses optical and acoustic warnings for five minutes. Suppression is followed by declining melody, normal setting followed by a rising melody. A double push terminates the suppressed operation at once.
- **Long Push** (>8 s): Re-boot. This procedure is recommended if a fault is apparent. No confirmatory sound signal.
- **Very long push** (>20 s) brings FLARM back to the factory settings. The very long push deletes all configurations that have been loaded by the user. No confirmatory sound signal.

[4] Activate the external display update by pushing the button four times in rapid succession. For details see the Installation Manual.

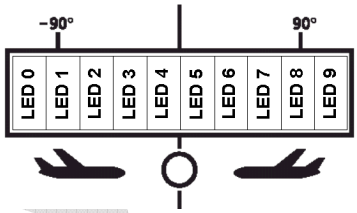
## 10. Aircraft Anti-Collision Warnings

An illuminated red LED indicates the approximate bearing to an aircraft currently posing the biggest threat of collision. The bearing is *relative to the track*. This indication is inaccurate if there is a strong wind, if the aircraft is in a sideways yaw, or if ground speed is very low (e.g. when a helicopter is in the hover). The display is refreshed every second.

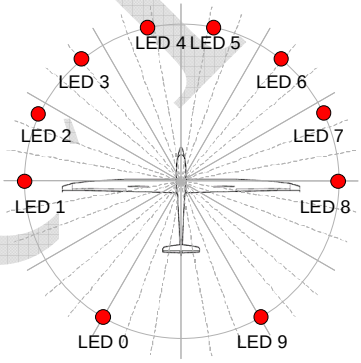
The unit emits an audio warning (beep) tone at the same time as the flashing red optical warning. The time between the warning and possible collision is brief, just a few seconds. Warnings of fixed obstacles are given slightly earlier.

### Horizontal bearing indicated on Hardware Versions 1 and 2

Each red LED is allocated to a sector of sky around the aircraft horizontal plane in a side view. The aircraft centreline is indicated by a white line above and below the mid point (between LED4 and LED5). A short white line is located above LED1 and LED8, marking 90° left and right.




- LED 0 ~210° quadrant rear left
- LED 1 270° hard left 9 o'clock
- LED 2 296° left 10 o'clock
- LED 3 321° left 10-11 o'clock
- LED 4 347° front left 11-12 o'clock
- LED 5 13° front right 12-1 o'clock
- LED 6 39° right 1-2 o'clock
- LED 7 64° right 2 o'clock
- LED 8 90° hard right 3 o'clock
- LED 9 ~150° quadrant rear right

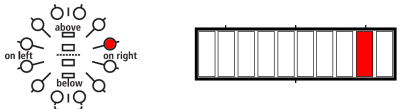
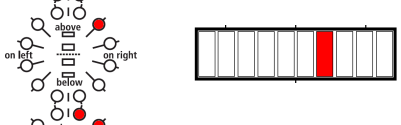
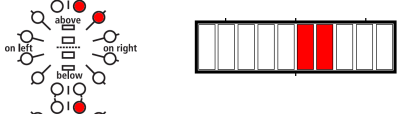
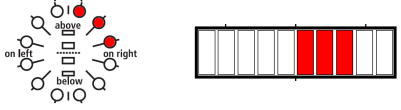



### Horizontal bearing indicated on Hardware Version 3 and later

The twelve bicolour LED show a compass rose, i.e. the birds view on the traffic situation. 'Top' is track-up according the own aircraft. Each LED covers an equal-sized horizontal sector of 30°.

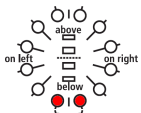
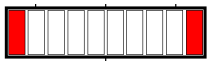
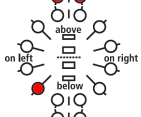
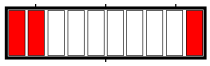
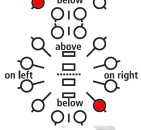
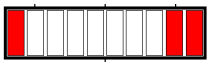
### Danger from the front or side

If the threat of collision with another aircraft is from the front or side, but not from the rear, then the threat level will be flagged up by the display. If the threat is moderate (less than 18 seconds to possible collision), a single LED lights up; in the case of a medium threat (less than 13 seconds) then two diodes light up; if the threat is imminent (less than 8 seconds) three LEDs. The threat is at the centre of the illuminated block. The flash and beep frequency increases with the threat.

| | | |
|---|---|---|
| Moderate threat from ca. 3 o'clock<br>(less than 18 seconds to calculated collision) | Slow flash at 2Hz |  |
| Moderate threat from 1 to 2 o'clock<br>(less than 18 seconds) | Slow flash at 2Hz |  |
| Medium threat from 1 o'clock<br>(less than 13 seconds) | Medium flash at 4Hz |  |
| Immediate threat from 1 to 2 o'clock<br>(less than 8 seconds) | Rapid flash at 6Hz |  |

### Danger from the rear

If the threat is from behind, then the threat level on Hardware Version 1 and 2 is given only by the frequency of LED flashes, not the number of LEDs activated.

| | | | |
|---|---|---|---|
| Danger from the rear, 5 to 7 o'clock | Flashing<br>*(H/W Version 3 example shows medium threat from 6 o'clock)* |  |  |
| Danger from the rear left, 8 to 7 o'clock | Flashing |  |  |
| Danger from the rear right, 4 to 5 o'clock | Flashing |  |  |

### Vertical indication

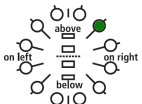
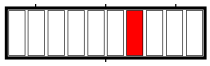
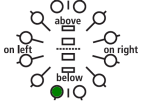
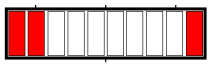
The vertical bearing is indicated by a vertical[1] line of four red LEDs and show the bearing relative to a horizontal plane. This is independent of the aircraft's climb angle. The uppermost or lowest LEDs illuminate when the bearing exceeds 14°. The LED flash frequen cy is identical and synchronous with that of the horizontal display.

H/W Version 3

H/W Version 2

### Traffic indication (only in Nearest-mode)

In Nearest-mode the closest aircraft is shown as long as no warning is necessary. Traffic indications don't flash, there is no sound and the distance is not shown. Hardware Version 3 and higher show traffic indications in green.

| | | | |
|---|---|---|---|
| Traffic around 2 o'clock | No flashing |  |  |
| Traffic around 7 o'clock | No flashing |  |  |

## 11. Obstacle Warnings

The standard obstacle data bank (as of Feb 2011) has about 35,000 coordinates locating about 11,000 Alpine obstacles[5]. This data bank is loaded by FLARM at manufacture; subsequently the user may upload but not alter up-dated information via a PC. Special data banks, corrections and amendments can be reported to us.

The FLARM display flashes when there is warning of obstacles. The warning always relates to obstacles straight in-line with the current flight heading. In other words there is no horizontal or vertical bearing given to the obstacle. The threat level depends upon the time remaining to impact; the flash and beep frequency increases with reducing distance from the obstacle. The display is refreshed every second.

A warning is given if an aircraft flies under a cable or power line.

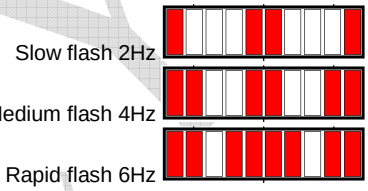
An acoustic warning (beep) is given at the same time as the flashing fixed obstacle warning. The time between warning and possible collision is brief, just a few seconds. However, warnings are given of fixed obstacles earlier than those for other aircraft.

Hardware Versions 1 and 2 show obstacles as follows:

Moderate threat
(less than 18 seconds to calculated collision)

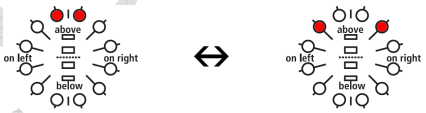
Medium threat
(less than 13 seconds)

Immediate threat
(less than 8 seconds)




Hardware Versions 3 and later show obstacles as follows:

A toggling pair of two LED's is shown, with the toggle frequency depending on the threat.




[5] For details on the data sources and status, consult the ‚Obstacle Data Format Specifications' manual.
**Neither FLARM Technology nor these organisations accept any responsibility for the accuracy, completeness or up-to-date status of the data or any direct or indirect damage resulting from using such data. Official data sources only collect data which have been reported by those who own, construct or operate constructions which represent an obstacle, and do not check these reports.**

## 12. Operating Limitations

FLARM is designed and built as a non-essential 'situation awareness only' unit to only support the pilot, and cannot always provide reliable warnings. In particular, FLARM does not give any guidance on avoiding action. Under no circumstances should a pilot or crewmember adopt different tactics or deviate from the normal principles of safe airmanship. Even with FLARM installed, you remain responsible for flying the aircraft and ensure the safety of passengers and other traffic. The use of FLARM is solely at the discretion of the commander and his delegated crew member. Operation must be preceded by thorough familiarisation by the commander or his delegated crew member with the Operating Manual.

FLARM will only give warnings of other aircraft that are likewise equipped with a compatible unit. FLARM does *not* communicate with Mode A/C/S transponders and is not detected by ACAS/TCAS/TPAS or Air Traffic Control. Likewise FLARM does not communicate with FIS-B, TIS-B or ADS-B.

Compatible FLARM units must be within range in order to provide a warning. The range is very much determined by the type, installation and position of the radio antennae, plus the relative positions of the two aircraft. Under *optimum* conditions the internal antennae can give a head-on range of up to 5 km; normally, range is about 2 km, which is adequate for light aircraft and sailplanes. The radio signals can only be received by *line of sight*. There is no FLARM signal between two aircraft on opposite sides of the same mountain.

FLARM has to know its *current* position in order to operate. For this reason, FLARM will only operate in the presence of good quality three-dimensional GPS reception. GPS reception is greatly influenced by the installation and position of the antenna, and aircraft attitude; furthermore, it requires that the US-american GPS-system is fully operational. This is particularly true during turns, when flying close to mountain slopes and in areas known for poor reception. If the installation is poor the GPS signal quality may be reduced. In particular, there can be rapid degradation of height calculations. FLARM resumes operation as soon as the GPS reception quality is adequate.

Movements calculated by the GPS relate to a fixed system of *terrestrial* coordinates. In strong wind there may be a substantial difference between aircraft heading and track, leading to a distortion of the threat bearing. If the wind speed is one third of True Airspeed (TAS) and the yaw-free aircraft Heading is 90° out of wind, then the threat indication displayed has an error of about 18°. If the wind is very strong, the Track can deviate up to 180° from Heading. Under such circumstances and when circling, the calculation and warnings given are unusable.

When close up, when two aircraft are at the same or similar height, or GPS reception is poor, the vertical bearing indication is imprecise and fluctuates.

FLARM calculates the predicted flight path of the aircraft to which it is fitted for less than the next 20 seconds. This prediction is based on immediate past data, current position- and movement data, plus a movement prediction model that is *optimised for the respective user*. This forecast is associated with a number of uncertainties that increase with an extension of the forecast time. There is no guarantee that an aircraft will actually follow the predicted flight path. For this reason, the warning issued will not be accurate in all cases. In sport flying flight path predictions of more than 30 seconds are *unusable*. This is particularly true for sailplanes and hang gliders. For this reason, the radio range is generally adequate.

Warnings are given at *very short notice*, i.e. the warning is given within a time frame of from a few seconds to 18 seconds, depending upon the closest predicted proximity, as calculated. The threat intensity (pitch of the warning tone, LED block width, flash interval) flags up the threat (collision time point), but not the geometric distance. FLARM only issues a warning if the calculation forecasts a *considerable* threat. For this reason, it is usual - depending upon the mode selected - that no warning is given about the presence of other aircraft, in spite of the fact that signals have been correctly received.

When a number of moving threats or fixed objects are within range, then FLARM gives warning *only* of the most dangerous *in accordance with the threat calculation algorithm.* The pilot is unable to confirm receipt of this warning, nor is he able to call for presentation of further threats. In spite of the warning issued for one other aircraft or fixed objects, it is quite possible that there are several further aircraft or fixed objects that represent a greater threat than that which has been signalled. When the unit simultaneously detects a threat from moving and fixed obstacles, then the warning issued relates to the earliest likely collision.

FLARM indicates the rough position of the aircraft or obstacle that currently represents the biggest threat, in accordance with the algorithmic calculation; FLARM Hardware Version 2 (and onwards) also displays a vertical bearing. In the case of fixed obstacles, the unit does not signal a bearing. FLARM does not indicate where the closest proximity may occur, nor does it signal avoiding action. Whether and how avoiding action is taken is solely a matter for the pilot, who must base his decision on his own observation of the airspace. In taking his decision, he must comply with the Rules of The Air and ensure that no additional hazard is caused by his action. Depending upon the phase of the flight, FLARM uses different forecasting methods, movement models and warning calculations, to provide the pilot with the best possible support without causing a distraction. For example, when a sailplane is circling, the system sensitivity is reduced. These models and processes are optimised, but are nevertheless a compromise. As seen by the pilot these models are the source of 'false alarms'; i.e. FLARM would give warnings of 'threats' that would not subjectively be regarded as a real danger. It is quite possible that FLARM will not give warning of the highest threat, or will give any warning at all.

Obstacle warnings (e.g. cables, antenna masts, cable cars, avalanche dynamite wires, power lines) are dependent on the information having been stored *correctly* in the internal data bank. The unit cannot give warning of any fixed object that has either been incorrectly stored, or not stored at all. No data bank is complete, up-to-date and correct. Obstacle information stored has usually been simplified; for example, FLARM assumes that a power wire is slung absolutely straight between two fixed points with no sag. Likewise, data for power lines and cable cars does not include all intermediate masts. In addition, FLARM data does not include terrain data and no such warnings are possible.

FLARM radio communications take place in a license-free band in which there is general freedom to transmit and receive. This means that the band is also available to a number of other uncoordinated users. FLARM has no exclusive right to the use of this band and there is no guarantee that FLARM will not be subject to interference by third parties.

There are national differences in frequency allocation and operating conditions between countries. The aircraft commander and user are solely responsible for ensuring that their use of FLARM conforms with local regulations. No radio licence is required for FLARM in Switzerland, Germany and France.

The radio transmission protocol employed places *no limit* on the number of units that may be operated within a given range. However, an increasing number of units within range is associated with a reduction in the probability that a single coded signal will be received ('graceful degradation'). The probability is small that subsequent signals will not be received from the same transmitter. FLARM is designed to receive and process signals from up to 50 aircraft within range. A high number of FLARM units within range has no effect on range.

The transmitter has ***no effect*** on what the receiver in the other aircraft does with the data. It is possible that this data may be captured and stored by other aircraft, or by ground stations, or used for other purposes. This opens up a range of possibilities, some of which may be in the pilot's own interest, (e.g. automated generation of an sailplane launch logging system, aircraft tracking, last position recovery), while others may not be (e.g. detecting tailing of other aircraft, airspace infringements, failure to take avoiding action prior to a collision). When FLARM makes a transmission, the signal also bears a unique identification code that can trace to the pilot or aircraft registration. The user can - even though this is not recommended - configure the unit so that identification is generated randomly and alters at one-minute intervals, making a back-trace difficult.

Operation of FLARM is limited to non-commercial day VFR flights. FLARM may not be used for navigational purposes or aerobatics.

At present FLARM has not been certified or tested in line with the usual aviation procedures (e.g. DO-160E). The FLARM software development is *roughly* in-line with Level E of DO-178B; i.e. a partial or total failure of FLARM will have no effect upon the safe operation of the aircraft, nor does it increase crew workload.

Operation of FLARM is forbidden in the USA or Canada or in aircraft registered in the USA or Canada.

The association FLARM Technology, FLARM Technology GmbH, its associates, owners, staff, management, development team, suppliers, manufacturers and data suppliers accept no responsibility for any damage or claims that may arise from use of FLARM.