KA start-up procedure

Version 1.0

Update 2018-02-26

Radio Activity S.r.l.

Via De Notaris, 50 - 20128 Milano- Italy – email: comm@radioactivity-tlc.it - www.radioactivity-tlc.com
Tel. +39.02.36514205 - FAX/Voicebox +39.1782.242408 - CCIAA Milano N° 1728248 - VAT Id. 04135130963

Summary

REVISION HISTORY **3**

1 *INSPECTION AND TESTING AT THE PRODUCTION SITE* **4**

2 *SW LOADING, TRIMMING AND TESTING* **5**

2.1 *REQUIRED INSTRUMENTATION* 5

2.2 *LOADING OF THE IMAGE OF FW ONTO FLASH MEMORY* 5

2.3 *MANUAL SETTING OF HW TRIMMERS* 6

2.4 *AUTOMATIC SETTING OF SW TRIMMERS* 9

2.5 *TESTING* 10

3 BURN-IN STRESS TEST AND FINAL VERIFICATION **12**

4 PARAMETERS CONFIGURATION FOR SPECIFIC APPLICATION **12**

Revision History

Date	Version	Document	DMR	Brief description of changes
2018/02/26	1.0	KA start-up procedure	DMR Tier 2 and Tier 3	Description of the start-up procedure for Kairos.

KAIROS start-up procedure

This document describes the full start-up procedure of a Kairos: after the electronic assembly of the main board, a sequence of operations must be performed in order to have a product to sell and a set of tests are made at each step of the alignment, in order to have a reliable product to sell.

The Kairos has been designed in order to maximize the amount of automatic self-tests and to minimize the manual settings. Thus, the complete procedure may be divided into 4 steps:

- Testing of the electronic board after electronic assembly of the main board;
- Mechanical assembly, SW loading, trimming and testing;
- Burn-in stress test, final verification;
- Configuration of parameters for specific application.

In the following paragraphs, we will analyse step by step these items.

The described procedure is generally valid for every model of Kairos; if any difference is present for any model, it will be specified.

This document does not describe the architecture of the Kairos, nor the usage of any SW tool. Please, refer to the document ***KAIROS OPERATIONAL MANUAL 1v2*** *(or newer version)* and to ***ENB52 - KAIROS user manual 1v4*** *(or newer version)* for any information related to the SW tool and to Kairos usage respectively.

1 *Inspection and testing at the production site*

This paragraph is not intended for dealing with the electronic assembly procedure of the board, but for specifying the requested tests on the assembled boards before SW loading.

After assembling one lot of boards, the requested verifications must be performed on the boards by the EMS company directly:

- Visual inspection on each single board, in order to verify that each component has been correctly mounted; the inspection check for the correct positioning of the components and for the correct soldering of the pads. Automatic test is preferred because identification of many chips is also possible.
- XRAY inspection of BGA chips. This inspection is performed on 5% of the amount of boards of the lot, with minimum of 3; in case one or more boards are defective, the test must be performed on the complete set of produced boards.

The produced boards are ready for programming.

2 SW loading, trimming and testing

This paragraph describes the procedure for loading the FW onto Kairos, trimming manual parameters, performing automatic self-test.

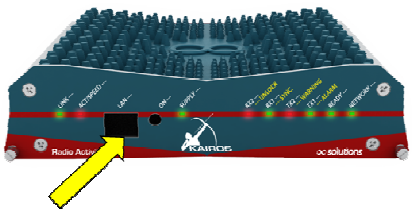
2.1 Required instrumentation

This procedure is performed by Factory and it requests the following instruments:

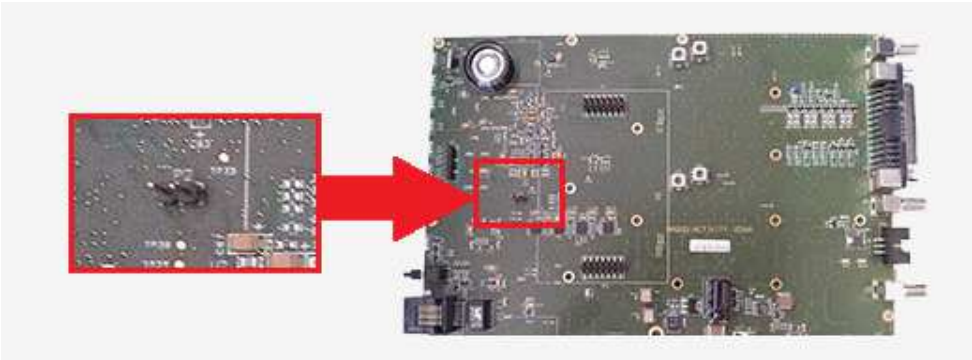
- A DC power supply, 13.2Vdc, 6A;
- A PC with Linux O.S. with the “System Development Kit” application for the loading the initial FW on the microprocessor;
- A PC with Windows O.S. with the “Kairos Manager” application for managing self-testing procedures and setting of parameters;
- A communication test set like for analog radio and/with a spectrum analyzer with embedded tracking functionality and the option for setting on offset of frequency between tracking output and analyzer input. For example HP8920;
- A High-impedance RF probe;
- A 50 ohm dummy load.

2.2 Loading of the image of FW onto flash memory

The first action to do consists in mounting the main boards onto their mechanical molded base. Then the board must be connected to the power supply.



Before supplying the Kairos, a jumper must be placed to the P2 connector inside Kairos, like the following picture shows:



Switch on Kairos and connect it via a LAN patch cable to a PC with Linux O.S. and with the "system development kit" environment installed. This application is customized for automatically loading the image of flash memory to target.

Launch the specific command of the application to load FW onto Kairos. After completing the loading, please wait for the automatic restart of the Kairos, that is shown by the frontal LED: the second LED flashes green, the third and the fourth LED flash red.

Then switch off the Kairos, disconnect jumper and LAN cable.

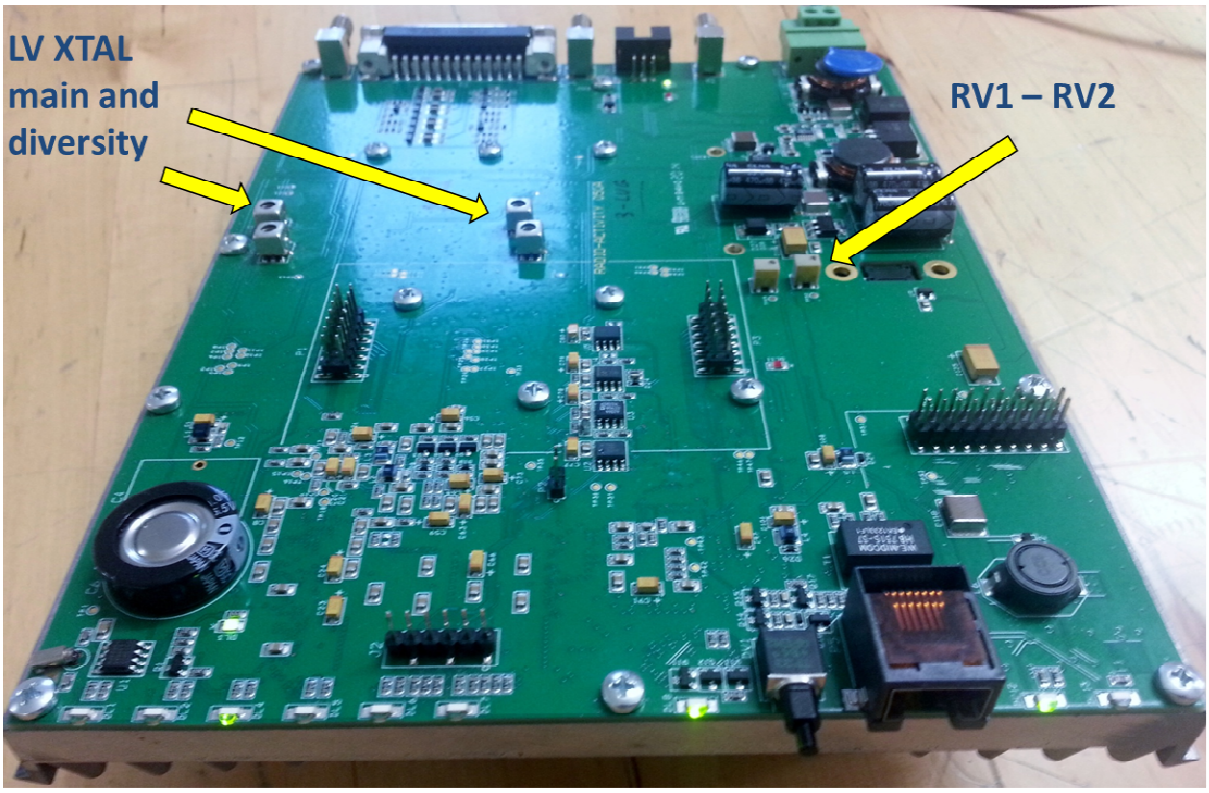
2.3 *Manual setting of HW trimmers*

The main board contains just 3 couples of trimmers:

- RV1 and RV2, that are intended to set the maximum biasing current of the RF driver and RF final amplifier;
- LV XTAL main, that are variable coils for tuning the head of the XTAL filters at IF frequency for the main receiver;
- LV XTAL diversity, that are variable coils for tuning the head of the XTAL filters at IF frequency for the diversity receiver.

Before starting the tuning procedure, RV1 and RV2 must be set to their minimum value by turn them clockwise (10 rounds each) by a small flat screwdriver.

The following picture shows the position of the 3 couples of trimmers.



Switch on the Kaiors and connect the LAN patch cable to a PC with Windows O.S. and “Kairos Manager” application installed. At power on, four of the frontal LED are flashing back and forth, red in one direction and green in the opposite one; when this effect stops, the Kairos is ready for hosting an external connection.

Launch Kairos Manager and set the IP address 172.33.16.140 for accessing the Kairos.

Open the menu Kairos→Configurations→Main setup and enable the layers “TRX” and “Base station” (check the boxes “Run TRX layer” and “Run Base Station Layer”; push the write button).

Open the menu Kairos→Configurations→Channel table; double click on the default/working channel and set the power of the TX to 1W.

Open the menu Kairos→Controls→Kairos overall status; check the boxes “Inhibit TX LNA” and “Start transmission”; push the “Set” button. This command activates the RF power amplifier, but without any signal to its input port; no RF signal is present at the TX output port, thus no dummy load is requested. In these conditions, the maximum bias current of driver amplifier and of final amplifier must be set.

The first trimmer to set is RV1 and the second is RV2:

- Turn RV1 counterclockwise, until the supplied current by the DC power supply increases of 10mA;
- Turn RV2 counterclockwise, until the supplied current by the DC power supply increases of 100mA.

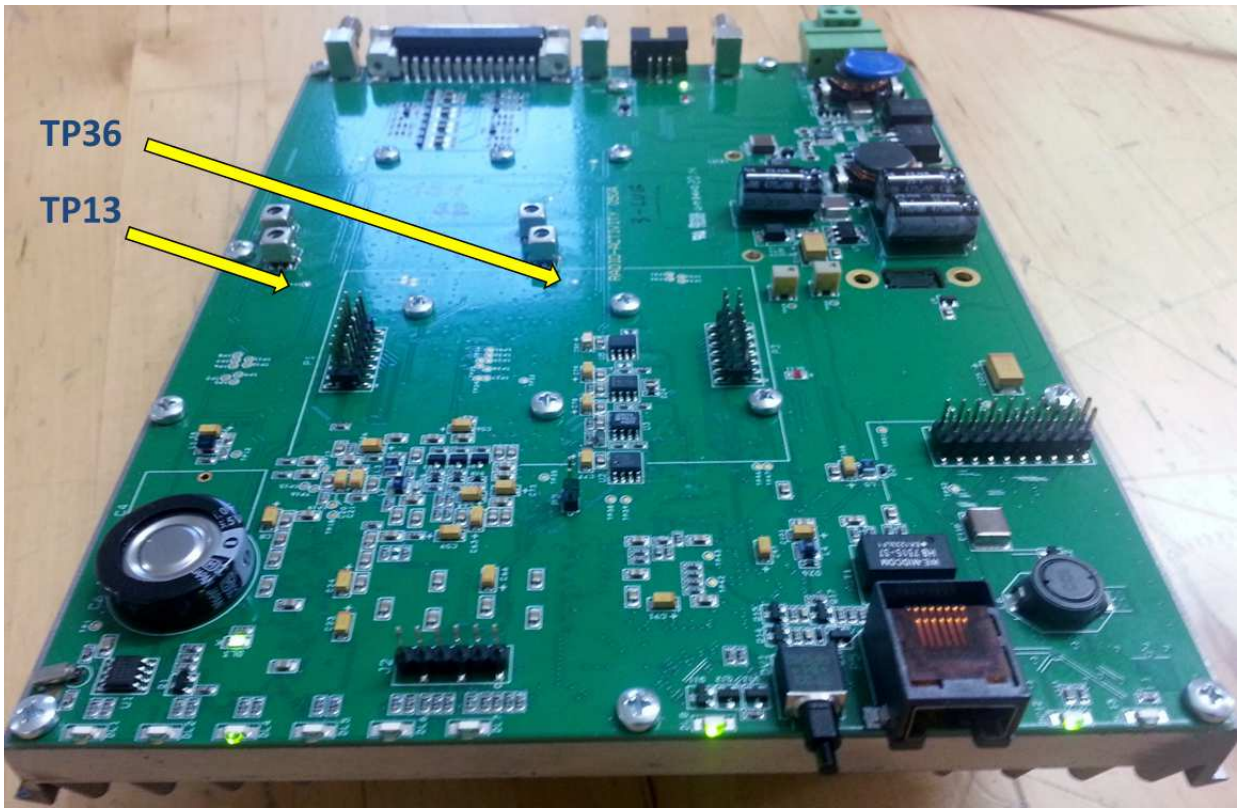
Now the biasing currents are correctly set. Uncheck the boxes “Inhibit TX LNA” and “Start transmission” and push the “Set” button.

Next step consists in setting up the channel XTAL filters at intermediate frequency for both main and diversity receiver. The procedure consists in applying a RF signal at the RX input port and to track the output of the XTAL filters at IF frequency. Because of the difference between RX input frequency and IF output frequency, a spectrum analyzer with embedded tracking with the possibility to set an offset between input and output frequency is requested. An example is HP8920.

Connect the RX input of Kairos (main and diversity) to the tracking output; set the instrument as it follows:

- Generated RF power=-50dBm
- Frequency span=50kHz
- Vertical scale=2dB/square
- Output (generated) frequency= RX frequency as per channel table
- Enable tracking functionality
- Input frequency (of the analyzer)=45MHz for all models, except KA-900, which requires 70MHz.

Connect the high-impedance probe to the RF input of the analyzer and check the RF signal on the test point TP36 (for RX main) and TP13 (for RX diversity) just after the IF XTAL filters.



Tune the variable coils pairs (LV XTAL), in order to have the “head” of the XTAL filters the most flat, symmetrical and with the less insertion loss as possible.

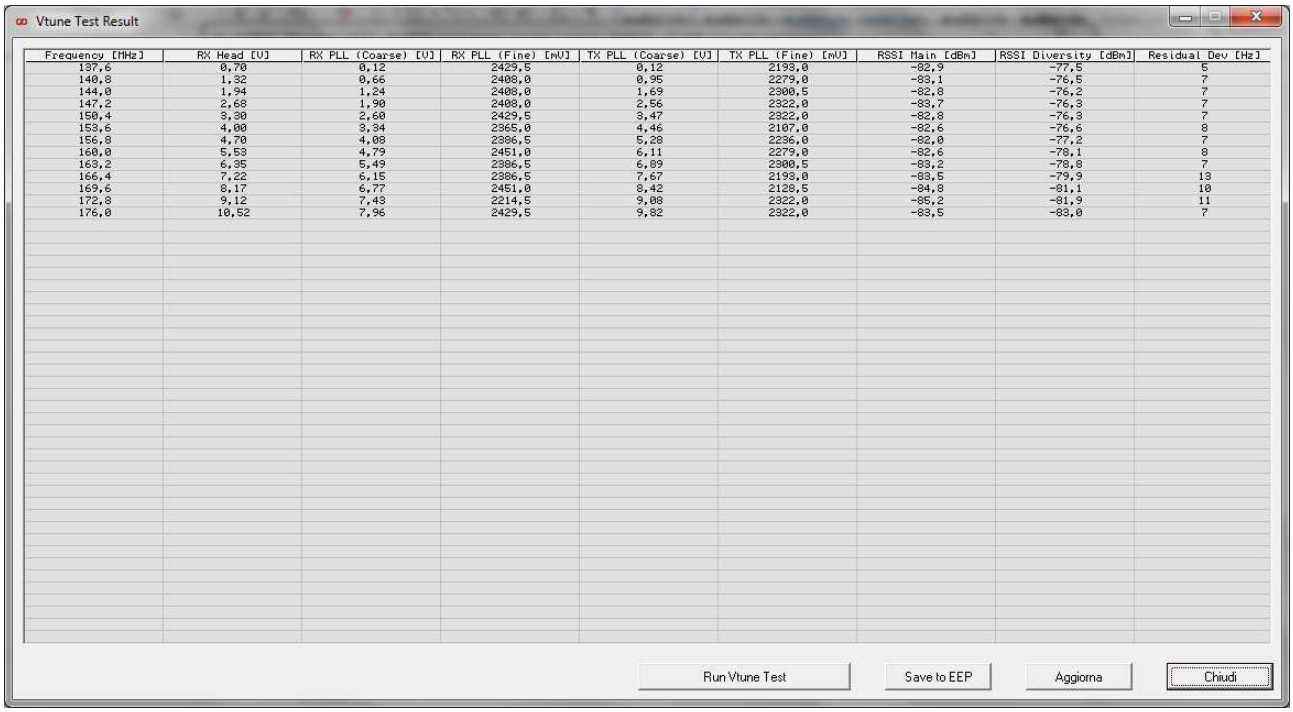
These are the only HW trimmers to be set. The remaining parameters of the board are automatically tuned by SW.

2.4 *Automatic setting of SW trimmers*

The Kairos embeds a DSP based algorithm for self-tuning the input filters of the main and diversity RX, the coarse control voltage of the local VCOs of TX and RX and for self-testing the overall performances of the synthesizer and receiver. This test is performed by internally connecting the output of the synthesizer to the input of the RX and by comparing the transmitted pattern to the received one.

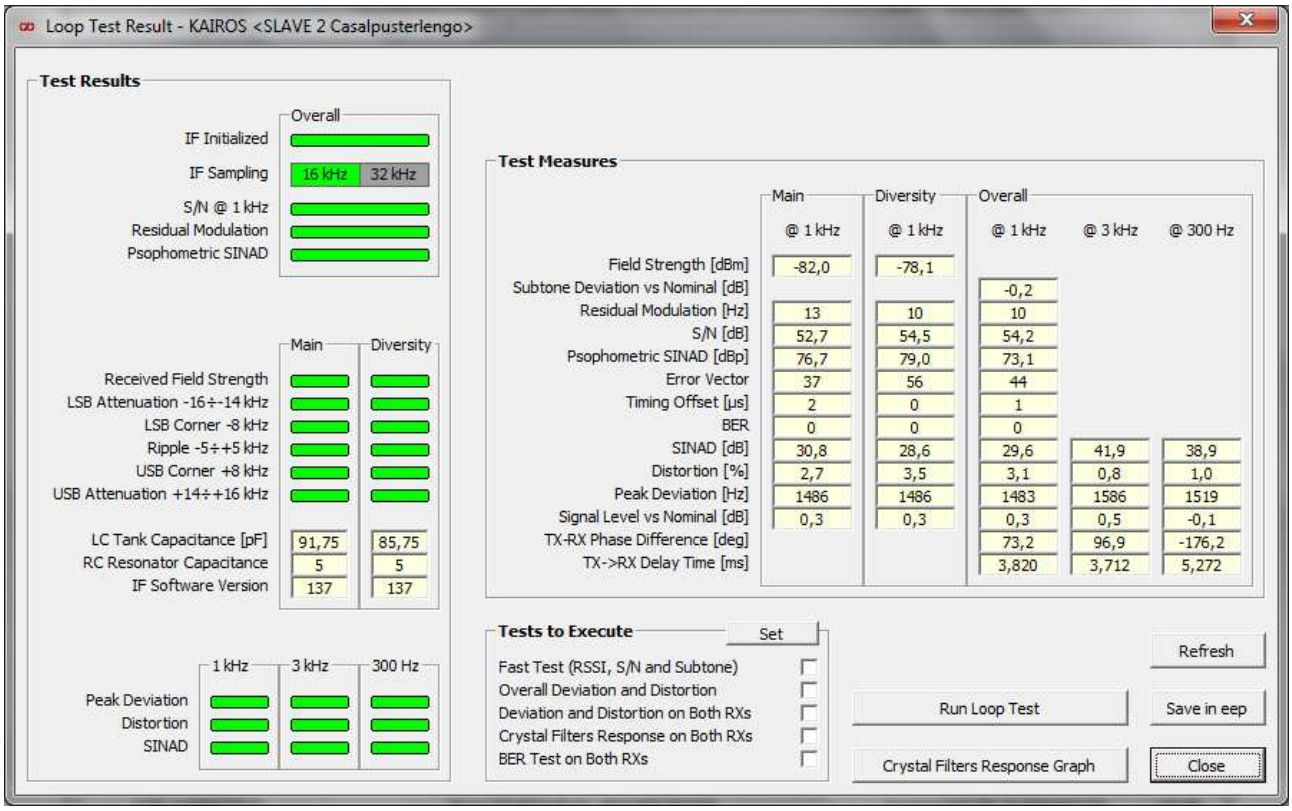
To make this test, if the Kairos is in UHF band connect a 50 ohm dummy load to the input of diversity RX; else if the kairos is in VHF band, leave the RX input open.

Open the menu Kairos→Controls→Vtune test result; push the button "Run Vtune test"; wait the end of the test and "save to EEP". During this test the Kairos fills in a lookup table with the tuning voltage (as a function of the frequency) of the RX input filters and the coarse control voltage of the VCOs. This test is performed by Factory just once during the life of the equipment, because every slight change during aging will be compensated by internal fine tuning.



Frequency [MHz]	RX Head [V]	RX PLL (Coarse) [V]	RX PLL (Fine) [mV]	TX PLL (Coarse) [V]	TX PLL (Fine) [mV]	RSSI Main [dBm]	RSSI Diversity [dBm]	Residual Dev [Hz]
137,6	0,70	0,12	2429,5	0,12	2193,0	-82,9	-77,5	5
140,8	1,32	0,66	2408,0	0,95	2279,0	-83,1	-76,5	7
144,0	1,94	1,24	2408,0	1,69	2300,5	-82,8	-76,2	7
147,2	2,68	1,90	2408,0	2,56	2322,0	-83,7	-76,3	7
150,4	3,30	2,60	2429,5	3,47	2322,0	-82,8	-76,3	7
153,6	4,00	3,34	2365,0	4,46	2107,0	-82,6	-76,6	8
156,8	4,70	4,08	2386,5	5,28	2236,0	-82,0	-77,2	7
160,0	5,53	4,79	2451,0	6,11	2279,0	-82,6	-78,1	8
163,2	6,35	5,49	2386,5	6,89	2300,5	-83,2	-78,8	7
166,4	7,22	6,15	2386,5	7,67	2193,0	-83,5	-79,9	13
169,6	8,17	6,77	2451,0	8,42	2128,5	-84,8	-81,1	10
172,8	9,12	7,43	2214,5	9,08	2322,0	-85,2	-81,9	11
176,0	10,52	7,96	2429,5	9,82	2322,0	-83,5	-83,0	7

Remove the dummy load. Open the menu Kairos→Controls→Loop test result. This menu allows to check the overall performances of synthesizer and of RX. Check all the boxes about "Test to execute"; push "set" button and then "Run loop test". At the end of the test the table with the measurements is filled in and the corresponding flags are green if the test is positive, or red if the test is negative. In this case, depending on the red flags, it is possible to identify the possible cause of the problem.



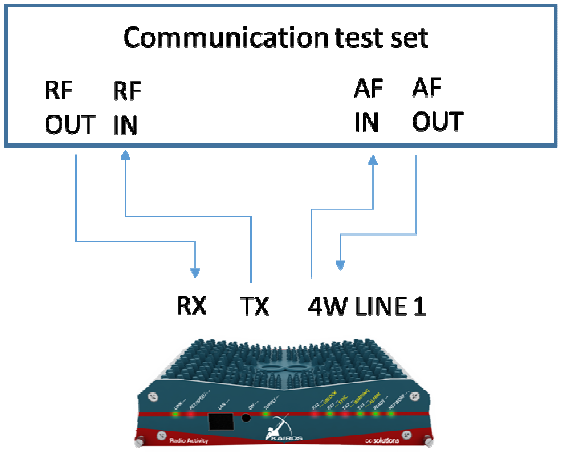
Please make sure that no signal is applied to the RX input while performing this test, else some wrong results are possible.

At the end, save the results by pushing the “Save on EEP” button.

The tuning of Kairos is completed. The self-test is able to check every parameter of the modulator and of the demodulator, except for the TX output power and the RX sensitivity, which should be tested by external devices.

2.5 *Testing*

To complete the testing of the Kairos, it is necessary to check the TX output power and the RX sensitivity. These measurements require an external instrument and a cable for connecting the 4 wire line interface of the 25 poles connector to the AF interface of the external instrument. Please refer to Kairos user manual for pinout definition.



TX output power measurement

Connect a communication test set to the TX output connector and to the AF input line of the Kairos.

Set the instrument for generating an audio tone with:

- Frequency=1kHz
- Amplitude=-10dBm

Close the PTT/E contact on the DB-25 connector of Kairos and check the generated power on the instrument. The test must be done at the minimum and maximum power, that is 1W and 25W respectively.

ATTENTION: the measured power can be slightly different from the expected one (+/-1dB). A fine-tuning of generated power is possible by manually tuning some SW defined trimmers, when the Kairos is configured for selling.

RX sensitivity measurement

Connect a communication test set to the RX input connector and to the AF output line of the Kairos. (Repeat this test both both main and diversity RX)

Set the instrument for generating a RF signal with:

- Frequency= RX frequency, as per channel table
- Modulation=1kHz, with 1.5kHz of deviation (for 12.5kHz of channel spacing)
- TCSS= as per channel table
- Amplitude=-80dBm

Set the CCITT/psophometric fiter on the AF input line of the instrument and read the SINAD of the received audio tone. Reduce the amplitude of the generated RF signal until the SINAD reached 20dBp. The value of the generated signal is the sensitivity of the RX. It is better than -113dBm, typically -115dBm.

ATTENTION: the SINAD is automatically measured by Kairos also (menu Kairos→Controls→Kairos overall status); the estimated value can be slightly different from the measured one by instrument. A fine-tuning of the SINAD is possible by manually tuning some SW defined trimmers, when the Kairos is configured for selling.

3 Burn-in stress test and final verification

As any possible manufacturing fault appears in the first working days of the equipment with a very high probability, it is very important to let the equipment work for some days before selling them.

A cyclic test of transmission/reception with a duration of 15minutes+15minutes is a good stress test for Kairos, in order to highlight any possible manufacturing fault. This test causes a fluctuation of the temperature of the internal board: any soldering problem or defective component will appear after few cycles.

To set the test:

- Set the TX power to 1W (this is enough for heating the board because the TX has the minimum efficiency and it allows to avoid mounting a dummy load)
- select the menu Kairos→factory test→burn-in test, enable the test with a period of 15 minutes

This command will enable the TX with a duty cycle of 50% and a period of 30 minutes. Keep the test going for at least 3 days and then power off the Kairos.

A final verification of performances is necessary to compare the results with the ones before the burn-in test.

Power on the Kairos and make the following verifications:

- open the menu Kairos→Controls→Loop test result and make sure that all the flags are green;
- check for the power output of the TX (as per the previous paragraph);
- check for the sensitivity of the RX (as per the previous paragraph).

Now Kairos can be placed in storage room; it is recommended to keep the humidity as low as possible and in any case it is mandatory to avoid condensation.

4 Parameters configuration for specific application

Kairos is configured by default as a stand-alone repeater with a default channel, at minimum TX power, without vocoder, without GPS; nevertheless, the main role of Kairos is a block for building radio networks, thus a specific configuration must be programmed on each Kairos in order to set its specific function inside its network.

The **hardware** of a Kairos is always the same, apart from the following options:

- GPS receiver: it must be added for synchronizing Kairos with 1PPS signal by GPS;
- Vocoder board: it must be added to Kairos, which interfaces with dispatcher only.

The **firmware** of a Kairos is always the same, apart from the following options:

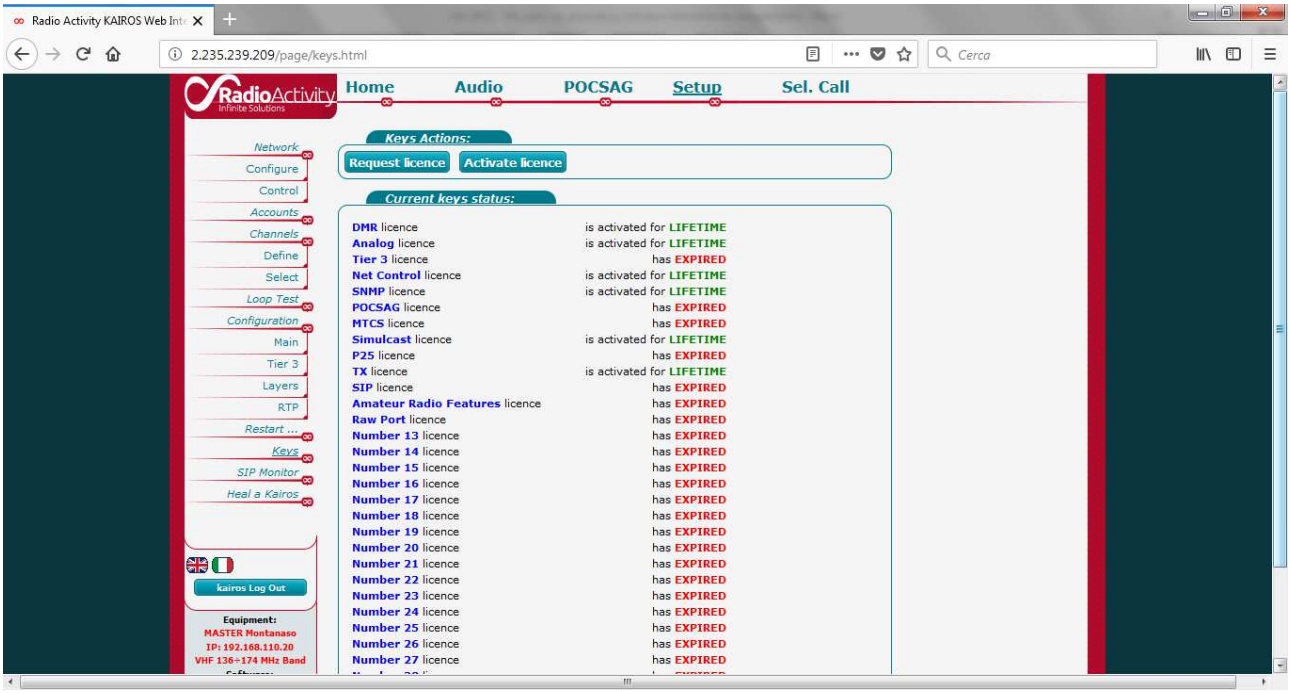
- SIP server application: it can be uploaded to Kairos if a SIP connection is needed with an extrenal SIP device;
- TSC (trunking system controller) application: it can be uploaded to Kairos if Tier 3 mode is needed.

The **configuration** of a Kairos depends on many parameters and it allows a great deal of functionalities. Please refer to "Kairos operational manual" for further information about the configuration of a Kairos.

Main features of the FW depend on **licenses**, which can be enabled by Factory via a dedicated application, based on a specific algorithm.

The web interface of each Kairos allows the management of the licenses:

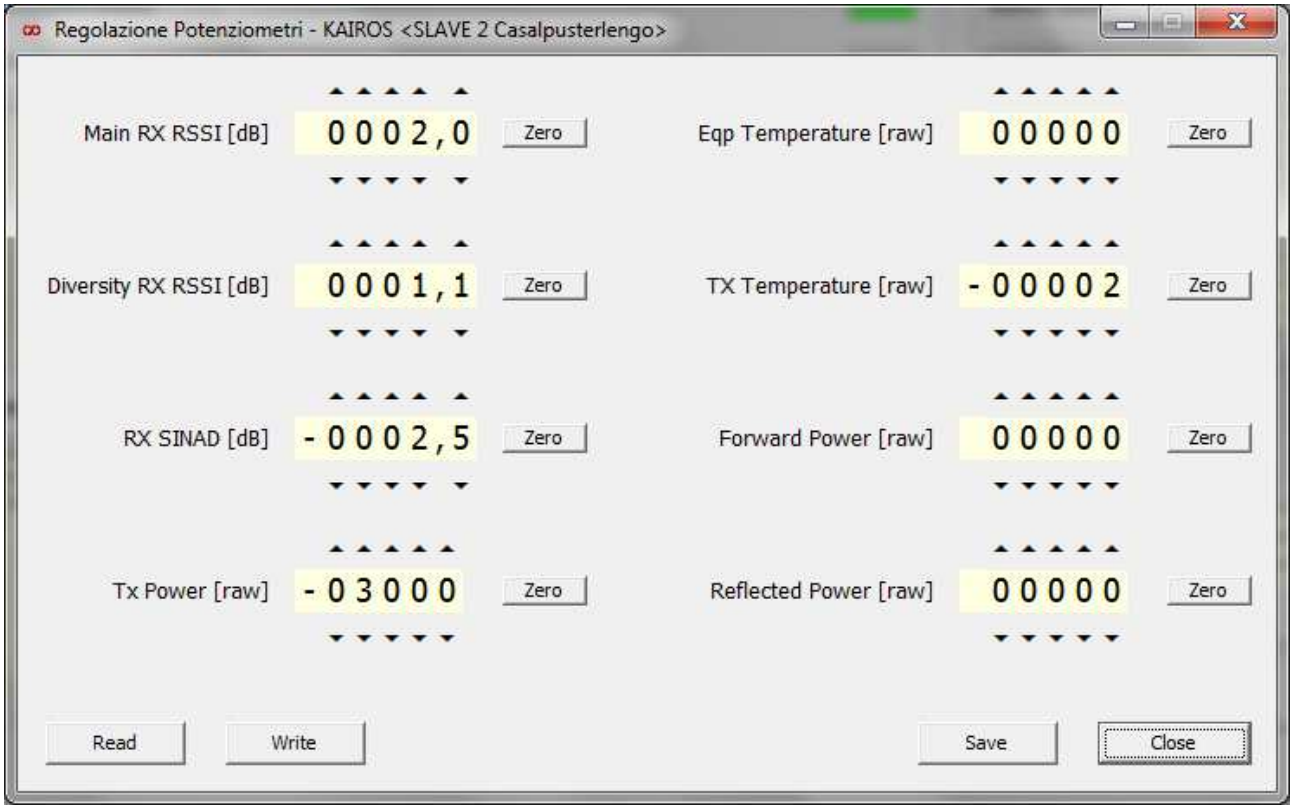
- Launch "Mozilla Firefox" and connect to the IP address of Kairos (the default one is 172.33.16.140)
- Open the page "Setup→Keys": the list of licenses appears; two buttons are present for requesting and for activating any license.



After configuring all the parameters, a fine-tuning of the following measurements may be done for getting precise values:

- RSSI for main and diversity RX
- RX SINAD
- TX power output
- Temperature of equipment and of TX
- Forward and reflected power

Launch Kairos Manager, open the menu Kairos→factory test→potentiometers set-up and tune the SW trimmers to get on the menu Kairos→Controls→Kairos overall status the same values as the corresponding ones on an external instrument. Then push "Save" button to store them on flash memory.



ATTENTION: some values of potentiometers are frequency depending. Without setting up potentiometers the maximum error is minimized all over the tuning bandwidth; in case of tuning, error is cleared at the working frequency, but increased at other frequencies.