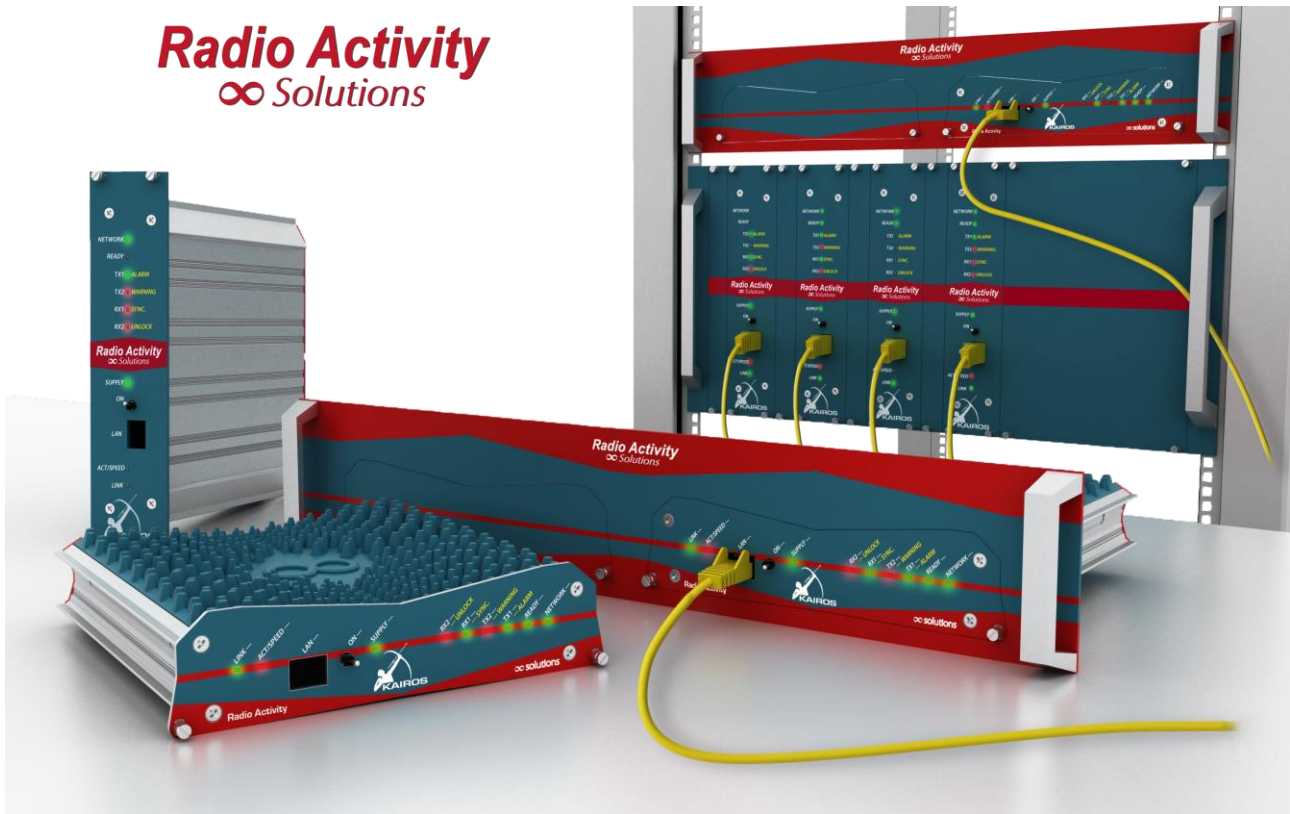




Radio Activity ∞ Solutions



KAIROS Family description

Version 1v2



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KAIROS

KAIROS coming out from the best Italian tradition, where all details, also the invisible ones, are important and need a care. Designing a mobile radio infrastructure is an art, that needs a complete knowledge of all the possible aspects to avoid unexpected situations. Our long experience in building infrastructure has generated this professional transceiver: the right building block for a number of applications ranging from a simple standalone repeater to a national wide system. We solved the complexity to ease your creativity.



1 Overview

KAIROS is a multi-protocol transceiver that implements all mo-demodulation and filtering processes via SW, following the “**soft radio**” concept. This technique assures repeatability and perfect matching between the base stations. It also allows to manage multiple protocols at the same time to perform, for example, a **multi-protocol** transceiver able to switch between analog and DMR automatically and in real time, according to the incoming radio (or IP) signals. Since a new protocol or a new standard is only a SW upgrade, the **investment is future proof**. Other protocols like P25 or old analog signalling or custom applications can be inserted in the large available space of its elaboration core.

KAIROS has got an effective SW and HW platform that realizes a powerful embedded workstation. Its **LINUX core**, thanks to the continuous upgrading from thousands of developers around the world, interfaces naturally IP devices and networks. It allows also a high level of customizations to satisfy the most exigent Customer’s needs, without troubles and reducing the development time.

The radio performances are at the top level in the market, because it is designed for infrastructure applications where radiofrequency pollution is a well-known problem. Excellent resistance to adjacent channel and blocking, noiseless transmitter and soft diversity reception reduce in-field troubles and give excellent coverage and clean communications.

The modular structure, for both HW and SW point of view, maximizes its flexibility and minimizes costs and physical dimensions. The **small size and extra-low power** consumption allow a number of uses and applications; for example a low cost repeater without the need of a shelter, can be realized simply fitting a **KAIROS** in a water-proof cabinet and adding a solar panel and a battery as supply. The basic model is equipped with a double receiver to counteract fading effects through **diversity space reception**. It can be configured as needed, buying only the required HW (e.g.: GPS receiver, DMR audio codec, USB and serial ports, ...) or the SW functional blocks (e.g.: simulcast kit, TIER 3 controller, SIP/RTP interface,...), to realize “*infinite solutions*” at reasonable price.

KAIROS supports extend IP communication and many synchronization sources to build a variety of radio networks. Such networks are easily expandable in size and upgradable to custom requirements or to

protocol extension. Its applicability spans from a simple standalone fixed station/repeater to a multi-frequency or simulcast multi-site system, operating in dedicated carriers (DMR TIER 2) or as trunking (DMR TIER3) system. A **KAIROS** based network allows the automatic multi-protocol analog/DMR functioning and is able to manage different types of communications paths between the base stations like microwave, narrowband VHF/UHF point to point radio links, fibre optics, 2/4 wire copper pairs and generic IP connections.

The main communication interface is a standard Ethernet port supporting TCP/UDP-IP, SIP/RTP-IP, SNMP and other IP protocols, compatible with the most diffused IP technologies. This interface supports not only voice and data traffic, but also a very powerful remote control management that allows: a complete monitor of the equipment and the network status, the modification all parameters, the down-load of the internal SW and configuration, the launch of the self-test and calibration functions, the use of the internal embedded function generators and software analysers. The remote control service can be performed also through a GSM modem or through another Radio Activity station using the narrowband radio channel.

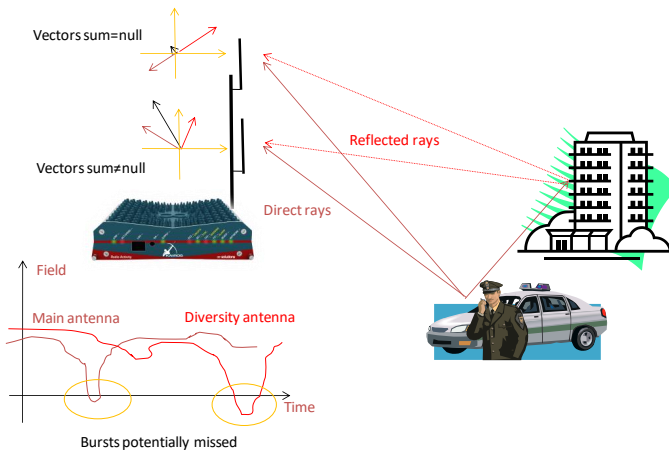
KAIROS can perform the audio trans-coding from DMR to PCM standard. This function permits to implement a Dispatching System with PC based operator desks. The main way to interfacing **KAIROS** to a Dispatching System is the VoIP RTP-IP port. The digital audio coming from DMR terminal is coded with the AMBE II+™ (Advanced Multi-Band Excitation) developed by Digital Voice Systems and is sent as a streaming to the SIP/RTP-IP port. At this port is available a standard VoIP streaming to create PC based dispatching system. These IP audio ports have similar functioning as the analog ones with more powerful features to allow a number of applications. Due to the full management of DMR protocol, **KAIROS** can open all communications of the radio network, including private. This feature is ideal for full recording purpose in most emergency situations. Alternatively, it is also possible to connect directly old analog consoles through the 4 wires ports.

The SIP protocol allows the direct connection to a SIP PABX. In this case user's terminals are registered to the SIP PABX/SERVER as local phone number, allowing direct phone↔radio communications. Connecting the SIP ports of different networks to a SIP SERVER, it is possible to joint all networks giving coverage over the whole area. Each radio communication, automatically, will remain within the same radio network or will involve more networks depending of the actual location of called users. This adds the "User Mobility" feature to group of different network/repeater.

2 Main features

2.1 Diversity space reception

One of the biggest problems that could arise when receiving digital signals is caused by “multipath fading”: in complex environments between transmitting and receiving antenna of a communication equipment more paths can be established for the signal, one direct and one or more reflected, each of them with a different amplitude and delay, that generally are time varying, especially with mobile systems.



Coming from different paths, signals sum together with different phases and amplitudes, not predictable in a deterministic way. If reflected paths have a delay equal to half a wavelength (180° signal phase difference) the sum of direct and reflected signals will be affected by disruptive interference and received signal can suffer from a very strong attenuation. Also a carrier cancellation can happen. Following

figure shows average and instantaneous power, as measured at receiver input, under multipath fading effect. The result, even if dealing with a particular realization, however shows a generally valid concept.

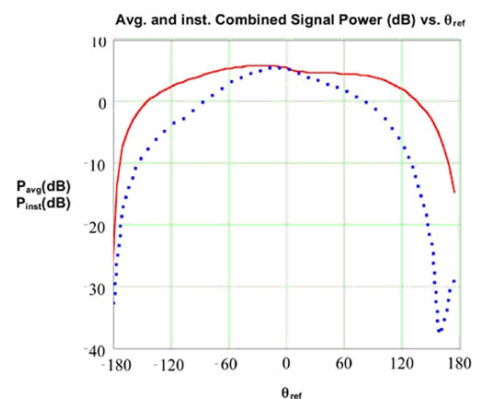
This phenomenon acquires increasing importance with decreasing of the received field, that is while approaching the edge of radio coverage. Although this is also for analogical communications, the phenomenon is much more significant with digital communications: in the first case in fact nulls of fields worsen the signal quality, but the content often remains intelligible; in the second case a B.E.R. increasing can cause the total loss of information.

KAIROS, thanks to the “soft radio” design, approaches this problem with the same techniques adopted in the most diffused digital communication systems like GSM, GPRS, TETRA, WiMAX, LTE, It is equipped of 2 coherent independent receivers that, connecting them to 2 different antennas, realizes a “soft space diversity” receiving system.

The soft diversity is a receiving technique based on the vector treatment of the incoming signals. The algorithm is based on the fact that the probability to have contemporary fading effects on both the antennas is very low if the antennas are far enough one from the other (typically at least 2 wavelengths) to let the signals be considered not correlated. By summing in phase received fields on the two antennas it is possible in case of fading over an antenna to have a good signal over the other one and to obtain a continuous and stable data flux at demodulation output.

The soft diversity reception gives a number of benefits on the receiver capability of the base station:

- ∞ it gives 3 dB more of sensitivity



- ∞ it contrasts the multipath fading
- ∞ it removes long interruptions in the digital communications
- ∞ it reduces the de-sensitivity effect in the repeater placed at high altitude
- ∞ it increases significantly the coverage area of a repeater

The diversity algorithms work properly in digital and in analog mode. For analog modulations, the obtained benefit by this technology is significant, but non determining, while for systems with digital modulation, it gives a great coverage capability.

2.2 Quality and reliability



KAIROS uses the latest RF hardware in conjunction with sophisticated algorithms for the digital processing of the signals. It maximizes the performances in terms of simplicity, flexibility, power consumption, reliability and cost. This base station is inherently digital specifically designed to achieve simulcast solutions. The strong investment made in the design of the equipment, the continuous hardware and software updating and our large in the field experience (**over 2000 installations**

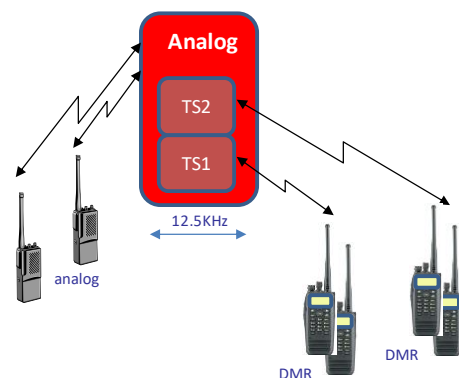
worldwide), guarantees the **highest quality and reliability** over time. **KAIROS** implements several automatic protections: power supply range and polarity detection, surge and transient suppression, soft start current, current limitation, RF power limiting when reverse PW or temperature cross the threshold. Most critical functions are automatically set-up by the equipments. This fact guarantees a drastic simplification in installation and maintenance operations that don't require any manual adjustment on the apparatus.

KAIROS, adding an RF Power divider or switch, supports the full 1+1 operation. The IP address of the assembly will remain the same independently from which one is active.

In network applications, **KAIROS** supports a smooth services degradation when failures happened. The system can integrate an "**Alias/backup Master**" station placed in different position respect to the main Master. The "Alias Master" operate normally as a Slave base station until the Main Master is present in the IP network. When the main Master disappears from the IP network, every base station change the registration to the "Alias Master" automatically restoring the network functionality. The network reacts, depending on events, re-directing the paths of the signals on the transport network, creating sub-autonomous networks, it turns an isolated base station as a simple repeater (local bridge) up to reduce the power consumption in over temperature events.

2.3 Multi-Protocol

The **KAIROS** transceiver is "**multi-protocol**" analog/digital with the automatic switch between the analog/DMR services. This functioning is assured also when the **KAIROS** is used as network repeater, giving to the whole network the multi-protocol operating and reducing the migration impact: the old analog terminals may operate with the new digital one through the same network.



For inter-operability analog/DMR, it is necessary to set a sub-audio tones squelch on the receiver of the terminals (it stops the noise in case of DMR signaling into the analog receivers).

When a DMR terminal accesses the network using the Timeslot TS1 or TS2, the other DMR terminals can hear him and the analog terminals don't listen noise. Enabling the scanning between analog and DMR on the same channel, both analog and DMR incoming communications are listened.

The multi-protocol operation is supported also in the SIP/RTP-IP ports, allowing a complete solution from the Dispatching Center to user's terminals.

2.4 LINUX core

Communication and control functions are demanded to an integrated computer that manages the communications between the external world and the radio part. This processor use the open source operative system LINUX in the "full" version, where were developed all the SW applications for the local and remote control and managing of the radio. This operative system allows to operate on the physical level of the elaboration device giving "stability" of performances difficult to perform in a Windows or proprietary operative systems. Integrating a real computer in the base station allows to easy implement a number of applications for audio and data communications and for control purpose. Using internal IP ports for data and events notifications, a Qualified Partner can develop its own application directly in the user resource space of O.S.



2.5 IP native

The use of LINUX in the "full" version allows a strong flexibility and it is the best solution in every IP based application. Thanks to the LINUX core, the **KAIROS** is an "IP native" transceiver target for high level of performance in a distributed elaboration system. The main control and communication interface is a standard IP Ethernet, one of the most common and cheap in the telecommunications world. A **KAIROS** is seen in the IP network as a peer with its own IP address and with many IP communication ports. Thanks to the "IP native" approach, the bandwidth requirement on the IP backbone is very low due to the packet protocol. Differently from an E1/G703 based solutions that requires a constant link presence, each base station sends packets in the backbone in the case of valid signals only. When no traffic is present in the network, the bandwidth used by the base stations goes down to 1Kb/s or less. In a radio system few base stations contemporary may receive an access signal, therefore the bandwidth (and cost) requirement is a fraction of the E1 based solution.



2.6 Built-in algorithms

The **KAIROS** has got embedded all the necessary algorithms (32x3 CH voting system, automatic digital equalization, protocol coherence, ...) to ensure a perfect operation in any network geometry and on any carrier transportation media (IP, SDH/PHD on fiber optic or microwave link, XDSL modem on copper pair, VHF/UHF narrowband, ...).

The **KAIROS** is able to manage many different timing/synchronization systems based on GPS, Precision Time Protocol (PTP/IP) over IP, OCXO, digital radio signals correlation, super-audio tone, digital strings, external clock, with automatic selection of the best source. The precision in timing and synchronization, the

high performance graphic equalization and the built-in algorithms guarantee an **optimal functionality even in simulcast overlap areas.**

2.7 Supported radio communication signalling and protocols

KAIROS is a synthesis of more than 20 years of experience and develops in radio communication. Most of the protocols or signaling system developed in the past, for example the analog selective call, are still present in the radio. **KAIROS**, in analog mode, is able to manage DTMF, ZVEI I and ZVEI II, CCIR, EIA and EEA tone signaling, coming from the radio or lines path. Others tones with 1Hz of resolution from 1 Hz to 7KHz can be defined for special purposes like PTT activation, super-audio burst key, carrier synchronization, end communication advise and custom application.



KAIROS has got two synchronized CTCSS and DCS codec to allow coexistence of different fleet of users under the same repeater. It performs also the “squelch tail” cutting to avoid annoying noise at the end of each communication. On request it is possible to use for special purpose the internal 1200/2000 bps FFSK modem and also the DSC (maritime signaling standard) modem.

KAIROS is able to generate a variety of analog signaling, very useful in the setup phase of a new network, like sinusoidal sweep, single tone, pulsed tone and high self correlation pattern for fine delay measurement.



When operates in digital, **KAIROS** manages the 4FSK modulation (it is the DMR and P25 standard modulation) and can also manage, on request, the GMSK constellation (**Automatic Identification System AIS** in maritime applications) and

many generic FSK standards compatible with the channel bandwidth like the **Post Office Code Standardization Advisory Group (POCSAG) 512/1200/2400 bps.**

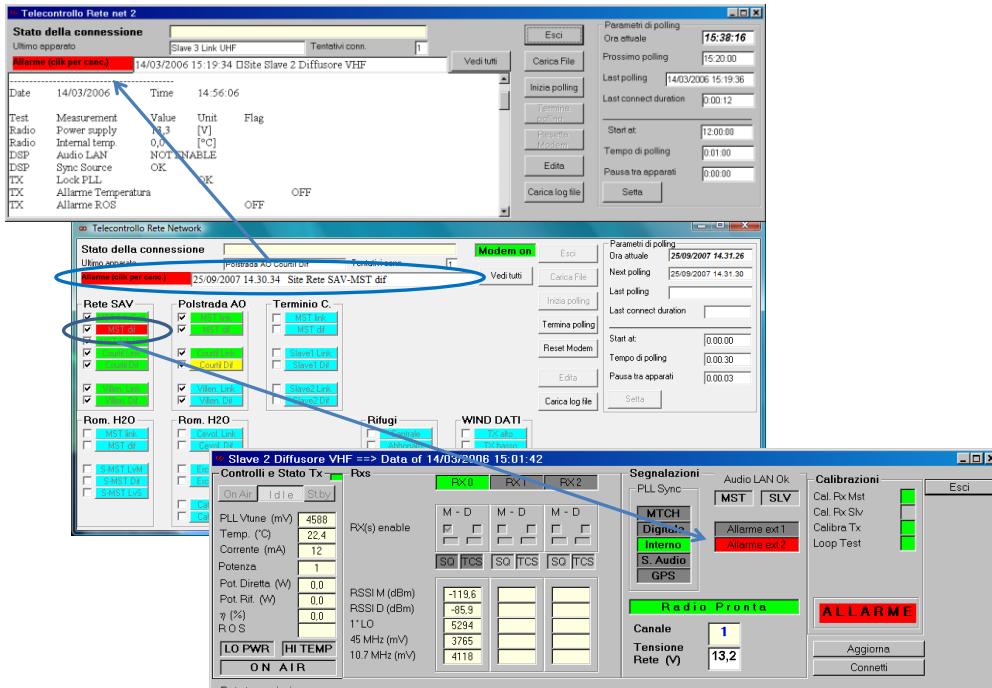
Operating in DMR, **KAIROS** manages the TIER 2 and TIER 3 (trunking) protocols. All data communication, like GPS positioning, raw data communication (for SCADA or AVM applications), text messages, alarm notifications etcetera, are available at a specific IP port.



KAIROS can run, up to medium size network, the TIER 3 Controller tasks on its internal LINUX without the need of an external device.

2.8 Powerful remote control

The powerful remote control tools gives a real full control of the base station and of the entire radio system. The features offered by the remote control are extremely large. The same features may be available from the User or the local Technical Assistance or from the Factory directly. In fact Radio Activity sends its products over the world, in many cases placed in very uncomfortable site, therefore the possibility to control, observe, correct and modify parameters or the internal SW is a must.



All the setup (and SW develop tools also!) operations are available from remote. The remote control system, in addition to the classic change of radio and IP networking parameters and the diagnostic services as audio and RF loop tests, allows also **full software remote upgradability** (LINUX applications, DSP applications, setup

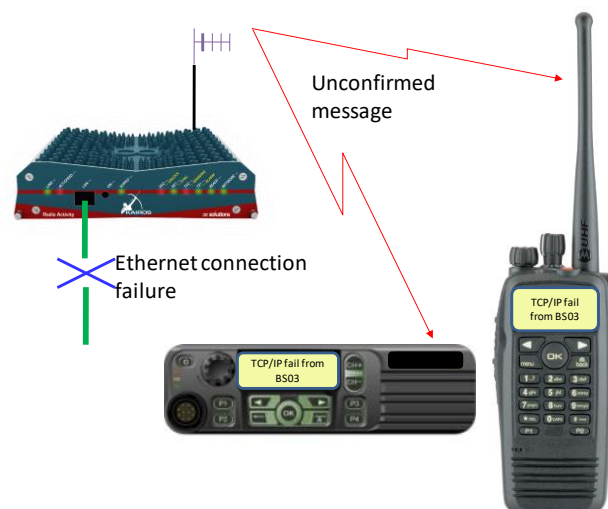
data and FPGA Firmware). It can use multiple connection routes (Ethernet IP, USB GSM/GPRS modem, external modem, DMR embedded, ...) with back up of each another. Through remote you can change in just a few minutes the structure of the network by creating autonomous sub-networks at the level of a province or even at the level of a single valley, and changing, if required, the channel operation. This simplifies and speeds up operations for placing into service and maintenance of the network.

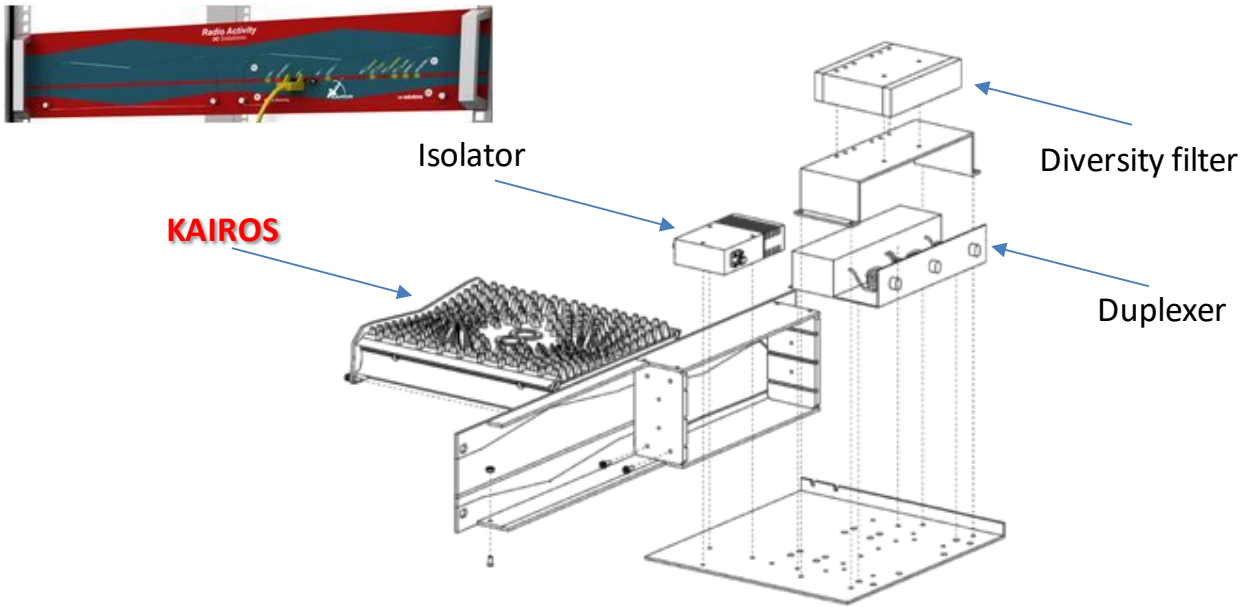
In addition to the Radio Activity very deep Remote Control tools, **KAIROS** manages also **SNMP traps** to a general purpose Surveillance Server. The major events will be notified, in real time, to the Server(s).

2.9 Designed to simplify use and operation

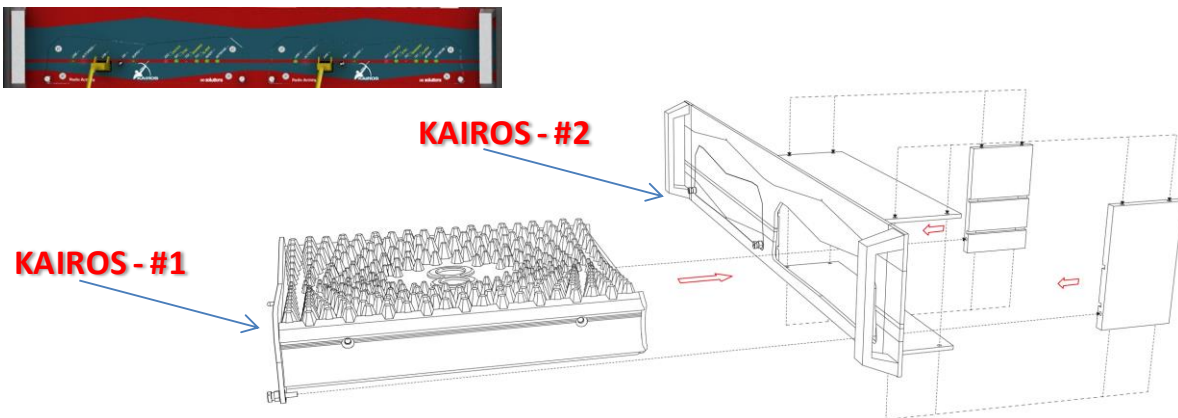
Many events, internal or user defined, can be set as alarms. **When such alarm occurs, the base station sends automatically a DMR text message** to inform about its state. This feature is particularly useful because allows the user to receive on his mobile terminal (or on a group of user terminals) short text messages at the occurrence of certain events. So, a continuous monitoring of the Remote Control utility is no more needed: the events will be dispatched in real time, even if the user is kept busy in other activities.

The transceiver has a **very compact size**, like a vehicular station, and the mounting accessories set simplifies its hosting in many applications. Three different solution are available for 19" rack installation: single transceiver in a 19"/2TU panel, two transceivers in a 19"/2TU panel and up to six transceivers in a 19"/5TU sub-rack:





2TU/19" frontal panel mounting: Single assembly with branching

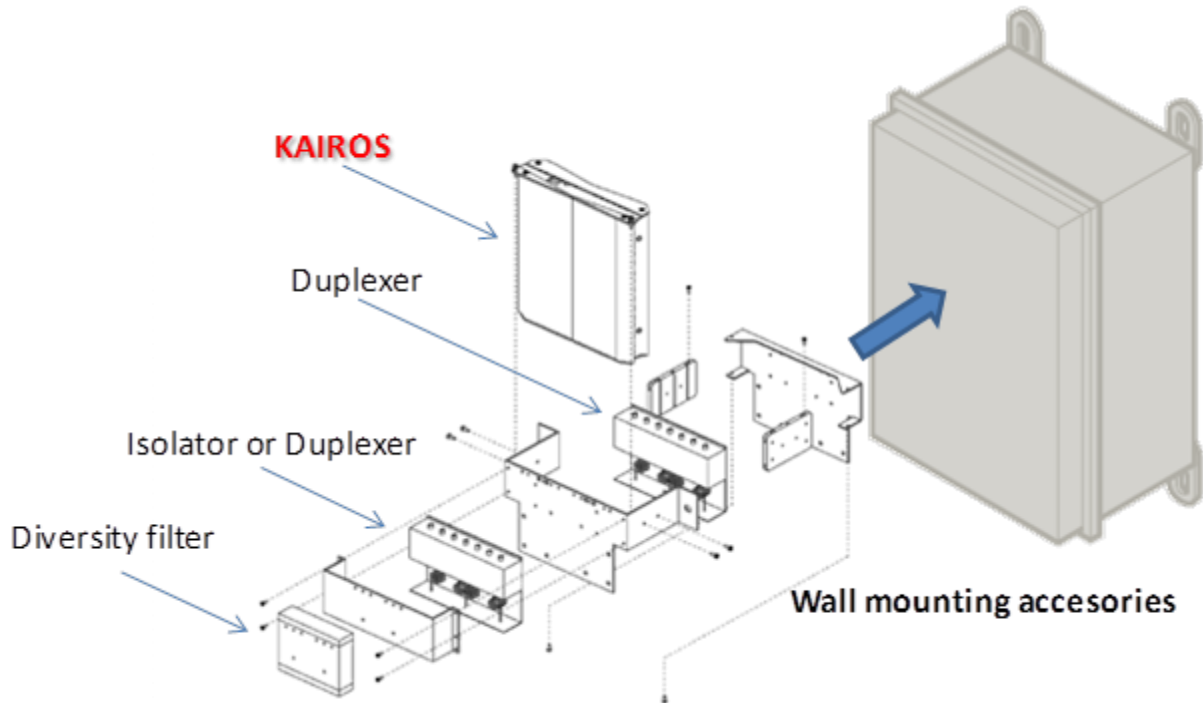


2TU/19" frontal panel mounting: double assembly without branching

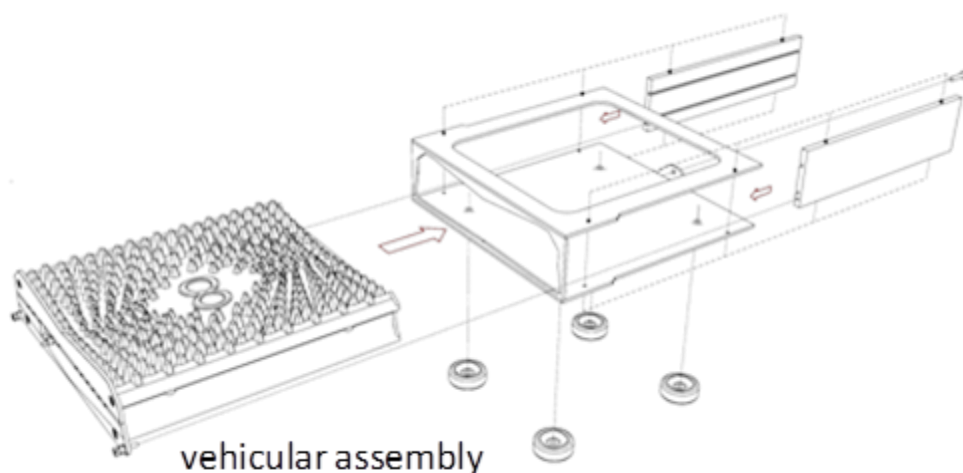


5TU/19" sub-rack multicarrier assembly (up to 6 KAIROS)

KAIROS well performs also in low cost realization. The wall mount accessories helps to assembly compact solutions in a small size cabinet. The very low power requirement in conjunction with its low dissipation, allows **KAIROS**, fitted in a waterproof cabinet and powered from a small solar panel with a backup battery, to realize a repeater station without the cost of a conventional site.



KAIROS is a great solution also in mobile applications, for example when it is request to manage duplex communications. **KAIROS** is able to operate in duplex mode, both in FDMA with a duplexer or in TDMA using “not aligned” timeslots for TX and RX. Typical application are mobile repeaters/trasponders, CAB radios (trains communication system) and AVM. The following figure illustrate a possible installation of **KAIROS** in such application.



2.10 SIP/RTP Gateway

KAIROS can run a “DMR Gateway” agent to interface Analog and DMR radio systems to several external networks, allowing radio users to easily communicate and interoperate with:

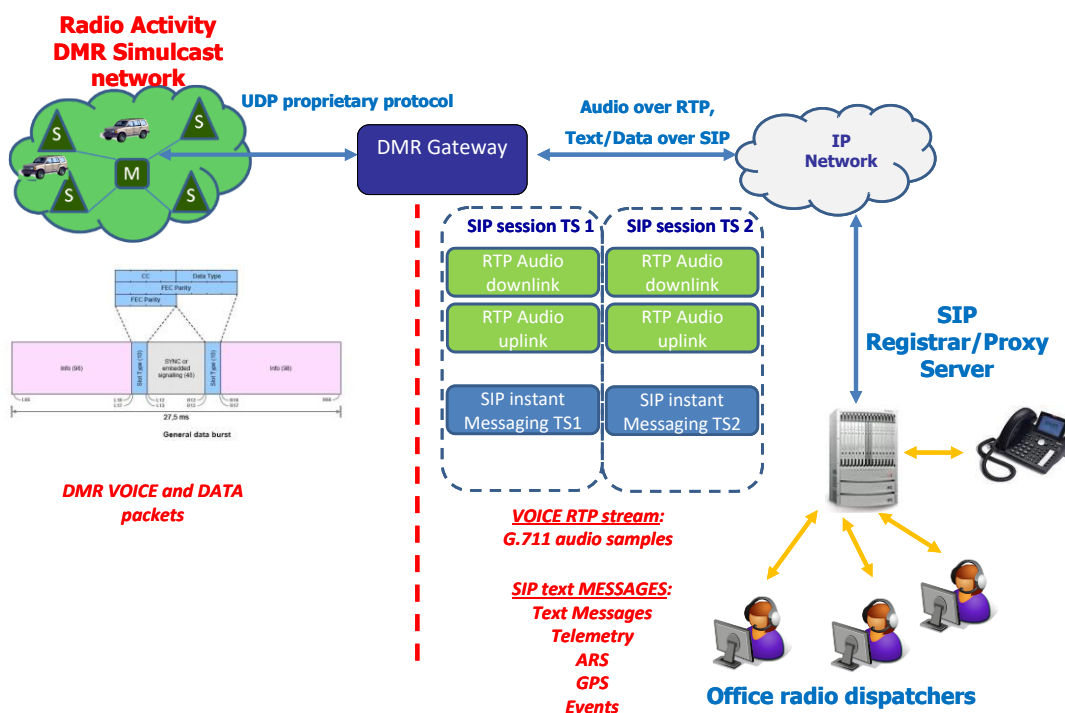
- ∞ External telephone applications like conventional PSTN equipments and VoIP systems (SIP PABX, SIP Hardphones, Softphones, Open Source SIP platforms).
- ∞ Dispatching systems and control room applications like analog *4-wire + E&M* consoles, RTP based consoles, SIP based dispatching systems for control room applications, to connect a Base Station (or a radio network) to a local operator desk.
- ∞ Other users under different radio networks/repeater (Wide Area Mobility).

The DMR Gateway Agent translates Voice (full duplex audio streams from/to DMR coded audio to *G.711 μ-law* or *a-law*) and Data streams, along with the associated signalings (for example *SIP Requests* ↔ DMR or *DTMF* ↔ DMR) to provide the interconnection between these communication systems.

The DMR Gateway Agent runs into the **KAIROS** engine without the need of an external PC. This Agent is compatible with the DTI/DMR Gateway module of the **RA-XXX** family of DMR Base Station (blue series) and can be used in the same system.

These Agent manages two DSP processor for audio encoding/decoding (vocoders). A lot of applications may be available by using the extremely compact coded bandwidth and the powerful built-in functionalities. The applications are targeted to the DMR radio communication Dispatching Room.

This audio can be easily managed using standard audio program and application on a PC. Radio Activity will provide the protocol descriptions to allow his partners to develop their own applications. The layer borders between Radio Activity and the partners SW applications is shown in the following figure.



3 Configuration

3.1 Basic features

The standard configuration of **KAIROS** includes:

HW units:

1. Soft diversity RX; this feature was an option in the RA-XXX base station family.
2. Multiple channelization; this mean that the equipment can be programmed in any of the following channelization bandwidth: 25/20/12,5/6,25 KHz. Note that DMR operation requires 12,5KHz of channelization. This feature was an option in the RA-XXX base station family.
3. Ethernet port for communication and control purposes.
4. 2x balanced 2/4 wire audio ports
5. 8x digital output pins and 8x digital input pins. The I/O output pins are open collector type able to switch up to 20mA/40Vdc. The I/O input pins are internally pull-upped to the 3.3V, they switch on closing it to GND. For more information about the use of these pins, please see the related chapter in this manual.
6. 1x analog Voltage (10KOhm / 0..24V referred to ground) input pin for general purpose remote measurements.
7. Environmental monitor; it surveys and remotes many measurements: the power supply input voltage, the internal mean temperature, the RF power amplifier temperature, the direct and reflected RF power, the current consumption of the RF power amplifier, all VCO tuning voltages and many other internal signals.

SW functions:

1. IP based, multi-protocol, radio network capability; it includes the 32CH Voter system, the IP link managing between repeaters and the basic synchronization.
2. Each repeater can be set as Master, Secondary Master, Alias/Backup Master or Slave. The Master and Alias/Backup Master were options in the RA-XXX base station family.
3. SNMP alarms; **KAIROS** manages SNMP traps to a general purpose Surveillance Server. The major events will be notified, in real time, to the Server(s).
4. SW upgrading from the remote control tools
5. Managing of analog selective call and tone signaling/decoding in DTMF, ZVEI I and ZVEI II, CCIR, EIA and EEA, coming from the radio or lines path. Others tones with 1Hz of resolution from 1 Hz to 7KHz can be defined for special purposes like PTT activation, super-audio burst key, carrier synchronization, end communication advise and custom applications.
6. Two synchronized CTCSS and DCS codec to allow coexistence of different fleet of users under the same repeater.
7. "Squelch tail" cutter to avoid annoying noise at the end of each analog communication.

3.2 Options

KAIROS can be upgraded with the following options:

HW modules:

1. GPS receiver; this module allows to synchronize the repeater for simulcast operation or for special purposes.
2. AMBE CODEC; this module “translate” the DMR coded audio into a standard analog audio. It can be ordered for 1 or 2 contemporary communications and can include also the GPS receiver
3. USB port
4. RS232 port
5. Half – duplex operation; this option must be specified in the ordering phase.

Internal SW modules:

1. DMR operation; it allows the multi-protocol DMR/Analog functioning, also in the IP linked radio network.
2. DMR TIER 3 protocol; **KAIROS** can run, up to medium size network, the TIER 3 Controller tasks on its internal LINUX without the need of an external device.
3. Simulcast operation; it includes the DMR TIER 3 module. It requires the GPS module.
4. POCSAG protocol; normally it requires also simulcast operation.
5. SIP/RTP Gateway; it requires the AMBE module.
6. Custom SW modules.

External units and accessories:

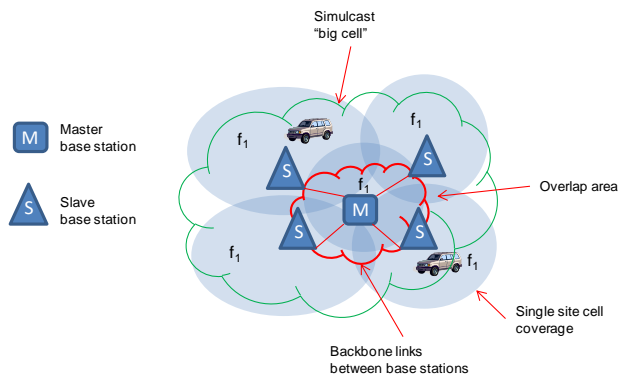
1. Remote Control SW tools; it runs in a Windows PC (not included)
2. GPS antenna
3. Duplexer
4. Diversity RX filter
5. RF Circulator/Isolator
6. Amplified and filtered RX multi-coupler; it allows to divide the signal from one antenna to up to 8 RXs in the Master/Sub Master station of a UHF linked network.
7. 1+1 switch module; it switches automatically the active TX port to the duplexer input connector. It includes a low pass filter to eliminate spurious emissions.

Note 1: please, contact Factory to check the availability of options you need for your own application.

Note 2: due to the very large applications capability of **KAIROS** and the number of parameters to set, it is very suggestible that the setup and programming activities were performed in Factory. Simple adjustments like IP address, RF frequencies, Colour Code/TCS frequency are easily modifiable by the user.

4 Main applications

KAIROS, since the most part of functionalities are SW defined, performs a very large variety of applications, ranging from a standalone fixed station up to a simulcast TIER3 network. The same HW, in the case adding some SW licence or an internal option board, supports near all configurations. This gives to the customer the possibility to increase at any time the size or the performances of the radio system as he needs.



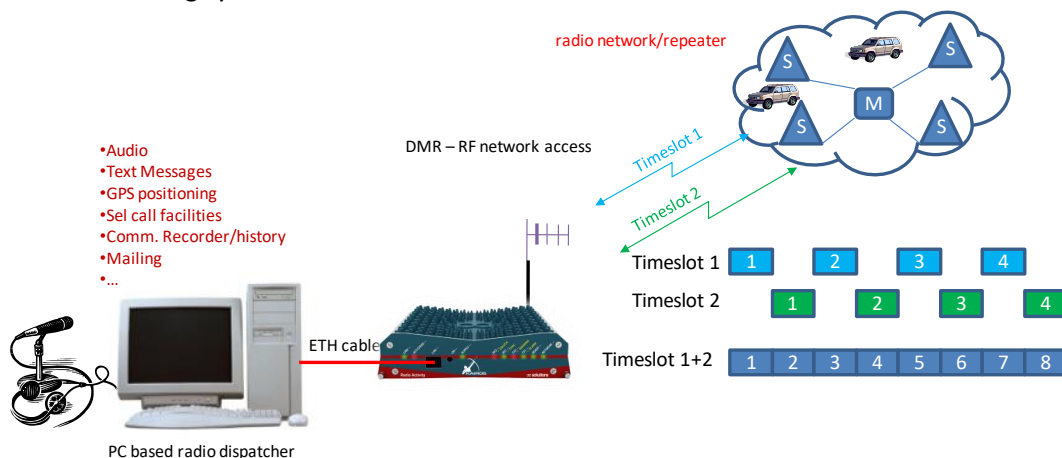
A multi-site radio network based on **KAIROS** can realize both a multi-frequency or a **simulcast** solution. Migration from multi-frequency to simulcast require only to add a GPS antenna and the simulcast SW license. Simulcast type networks operate on the same radio channel on the whole coverage area. The network will make the automatic selection of accessing terminals and will broadcast the signal on the same frequency throughout the coverage area. So the

terminals are served regardless of their position as if they were covered by a single repeater (intrinsic handover and roaming). The high quality synchronism request from a simulcast can be recovered from the internal GPS receiver or from other sources like Precision Time Protocol over IP (TPT), external reference, copper pair,... The algorithms inside the base station perform all the needed functions (Voting, equalization, synchronization) for the best quality simulcast system.

Note that all applications described in the following benefit of **KAIROS** features (e.g.: soft diversity reception, multi-protocol operation DMR/Analog, SIP/RTP-IP capability, remote control, LINUX user's application space, ...).

4.1 Double timeslot fixed station

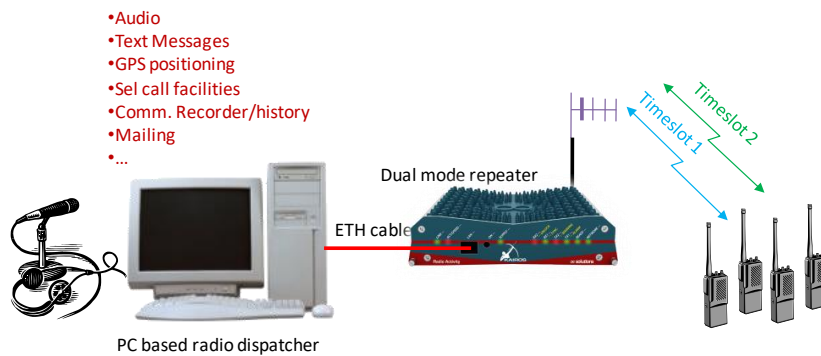
KAIROS can manage the 2 DMR timeslots at the same time using a single antenna. In a Dispatching point, it can be configured to supply the access to an external radio network. A single **KAIROS** replaces 2 vehicular station and the branching system.



Note that, in this application, it is requested a half-duplex version of **KAIROS**. The half-duplex functioning must be requested in the order phase to Factory to fit in the RF switch.

4.2 Repeater station with Dispatcher

KAIROS, simply adding a duplexer, can act as a repeater controlled by the dispatcher.

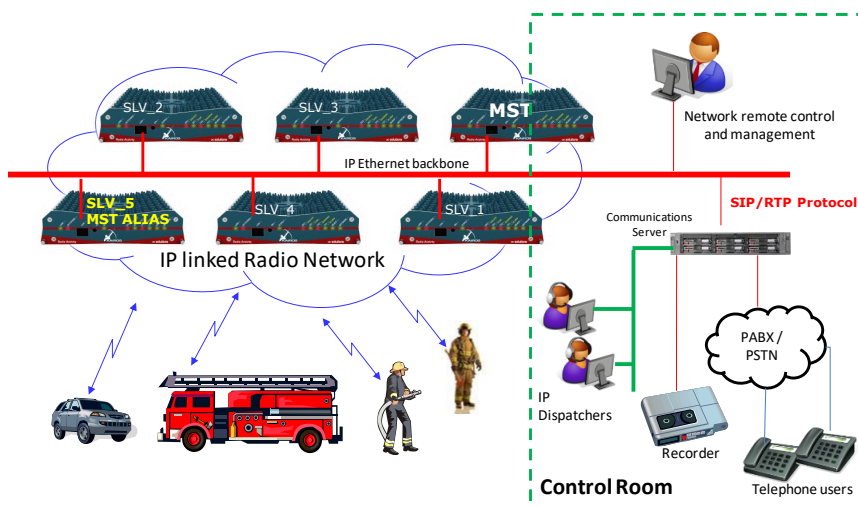


This application is very useful in small realization, like a radio coverage for a local Police department of a small town/plant.

4.3 IP-linked Base Stations

KAIROS supports IP connections among the base stations to realize multisite hierarchical systems. The role of each device can be set as Master, Secondary Master, Slave or Backup Master. A Master manages up to 32 Slaves/Secondary Master, allowing to realize radio networks of unlimited dimension.

The IP based network is the ideal solution when an affordable IP backbone is available. This is the most common network application of **KAIROS**. Generally speaking, in a IP network there is no central switch, thus eliminating a critical point of potential failure. Instead, full signalling is made by IP (Internet Protocol) network technology to provide reliable data routing between network components. This combination of IP technology and the advanced DMR communication standard produces a feature-rich solution with a surprising degree of flexibility and resilience. Every base station runs in a full LINUX operative system that allow a very powerful and stable connections to a LAN backbone network through the local Ethernet port. Communications between mobile terminals and the Dispatcher can be duplex, half-duplex and simplex.

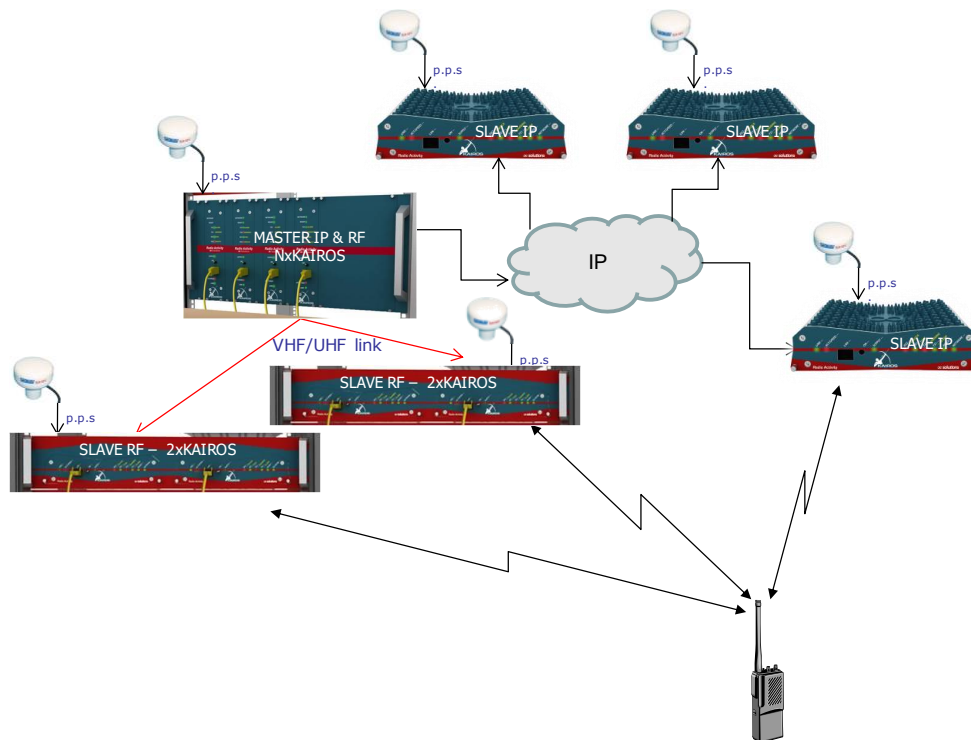


The master station performs the voting process that is the method by which the best signal received from each base stations of the network is continuously selected. In analog mode the Master station evaluate the S/N ratio of each signal received from RBS and select the best one in real time (every 30ms). In Digital mode (DMR) every timeslot received from all the base stations is selected to found the error free timeslot or the maximum likelihood one in absence of CRC (e.g. voice). In case of use the same access frequency or a simulcast solution, this high performance, real time voting system performs a “very large diversity reception” over all the base stations involved in the call.

The best signal (analog or digital) is sent back to all slave base stations for broadcasting in IP “multicast or unicast” mode. Multicast reduces significantly the bandwidth required to the backbone interconnection network.

4.4 RF-linked Base Stations

In this kind of network the connections between the base stations are made by point to point narrowband radio links between Master and Slaves, with the ability to route through Secondary Masters. **KAIROS** can be configured as “LAN extender” supporting the RF narrowband connection between different sites. The resultant network is multi-protocol DMR/Analog and can operate in simulcast adding only a GPS antenna and the SW license.



As drawn in the figure below, it is possible to realize also simulcast/multicast radio networks with some base station connected through IP backbone (fibre optic or radio) and some other connected with narrowband radio links.

The use of narrowband radio link allows to realize networks when the distance to connect is very large (100Km or more) or when the radio path isn't in direct visibility.

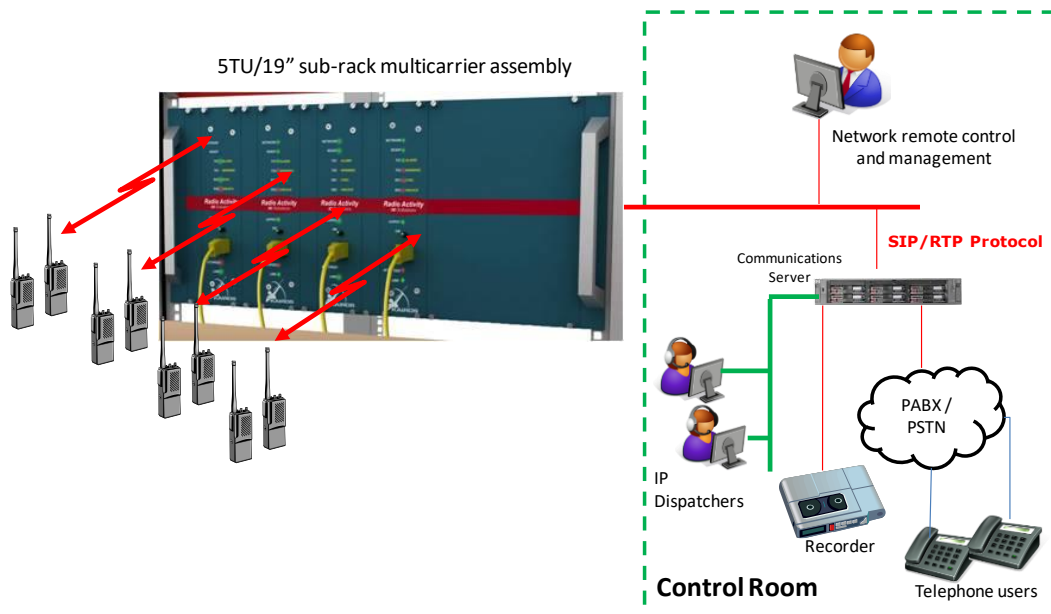
The radio stations are very compact, making audio connections between link and local transceivers directly in a 4Mb/s digital format. All required functions (Voting, compensation for delays, synchronization) are integrated in the station.

The standard configuration is a star networks with Master station in the centre links with the Slave ones implemented by radio devices in the UHF range integrated in the same radio assembly. The Master station uses multiple receivers array (one receiver each Slave/Sub-Master to manage) and a single transmitter to send back to the Slaves the best signals.

4.5 Single site TIER 3 trunking system

In a trunked radio system the number of available channels is much smaller than the total number of potential users, and the traffic(payload) channels are only assigned as the need arises. Payload channels are allocated and released on a call-by-call basis.

Adding a TIER3 Controller Agent into a group of **KAIROS**, the channels can be efficiently shared between all users according to the ETSI standard TIER3 Trunking protocol.



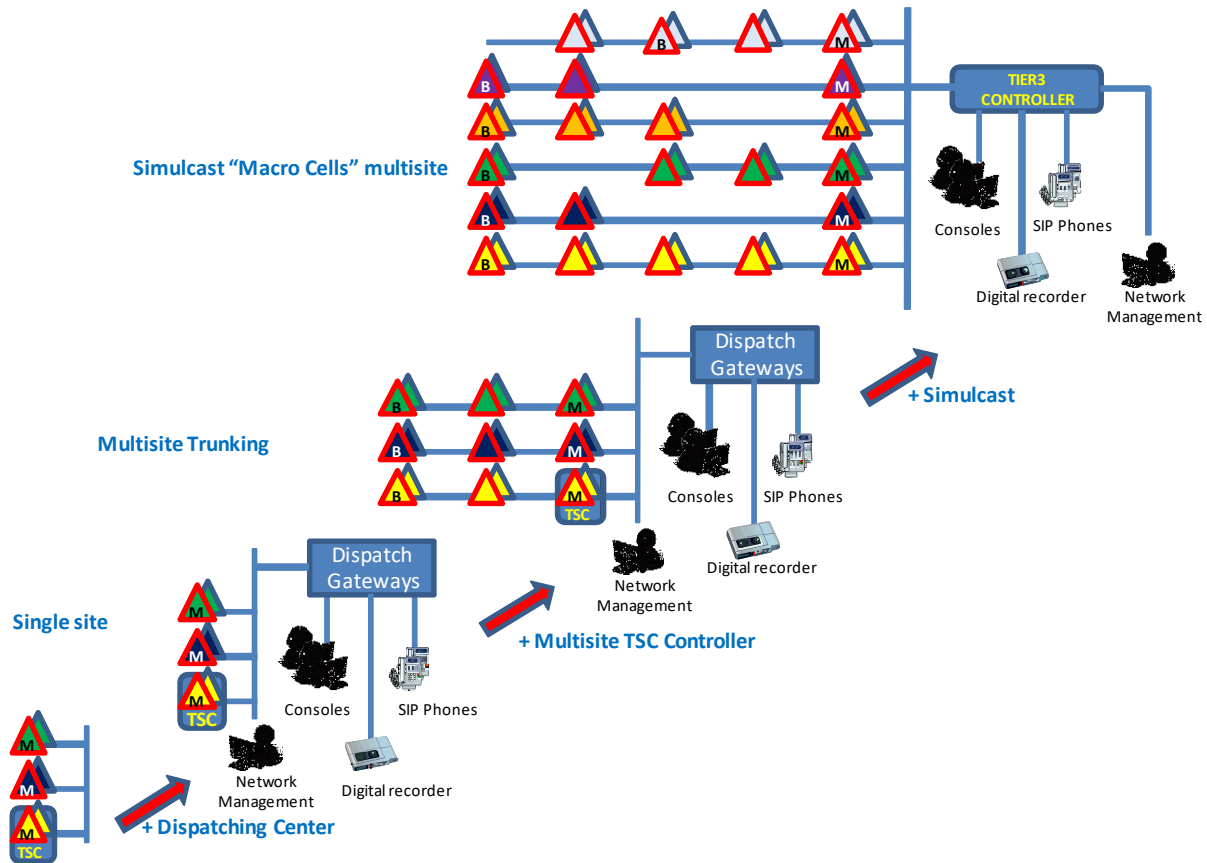
The user does not need to manually select channels. Each subscriber will register itself via the Control Channel to inform the system about its presence. The system will accept the registration after a check of the validity of the DMR ID. To make a call, each subscriber shall request a communication resource to the system. A control channel (TSCC) is dedicated to the channel access regulation. The subscribers listen to the Control channel when not involved in a call.

A random access protocol defined in the TIER 3 standard allows a subscriber to request a communication channel to the Controller of the system. The system, if there is at least one free channel, will accept the request, assigning a channel for such communication. Then, each user involved in the call will move to the assigned channel and it can start the communication. At the end of a communication (e.g.: timeout or a specific command), the channel will change its status informing the TSC (Trunking System Controller) about its availability.

Note that this solution, due to the DMR digital protocol, has got some limitations in multi-protocol functioning.

4.6 Multisite multi-frequency/simulcast TIER 3 trunking system

The previous application “Single site TIER 3 trunking system” can be expanded to a multisite multicarrier (simulcast or multi-frequency) system as explained in the following figure.



The complete description of a multisite trunking system would require a lot of space and it is out of the scope of this document. A more extended information is available in the technical document “*DMR TIER 3 System Specifications*” written by Radio Activity. In the present document we only underline the benefit of using **KAIROS** that allows simulcast operation.

Using **simulcast** channels in a trunking system guarantees a real time, automatic and continuous hand over and roaming over all the coverage area. Simulcast assures the hand-over also during transmission and reduce the probability of call loss due to the scanning process. The voting based access selection gives the advantage of macro-diversity reception: the network selects burst by burst the best signal because they are at the same frequency.

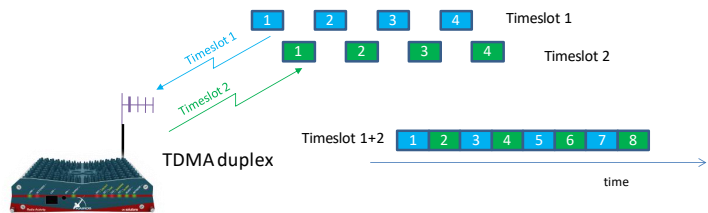
The overall system efficiency is the same or near the same of a multicast solution because, in the real case, the most part of the communications are group ones. A group communication requires a dedicated channel in each site therefore simulcast doesn't reduce the availability of the communication resources.

Simulcast gives unsurpassed spectrum efficiency and often is the unique way to build up a trunking system in congested areas.

4.7 Duplex TDMA/FDMA Mobile station

KAIROS can be used as (duplex) mobile transceiver in special applications. It is able to operate in two duplex mode:

- ∞ **FDMA**; the transceiver receives and transmits on different frequencies as a conventional duplex fixed station. An external duplexer filter is needed to allow contemporary operation in TX and RX. The modulation can be analog, DMR on a single (aligned) timeslot or on both timeslots for special applications that require a large data communication capability.
- ∞ **TDMA**; the transceiver alternates continuously the TX and RX operation using one timeslot in the uplink (TX) and the other in the downlink (RX). Thanks to the high speed of switching, the audio communication is continue. The TDMA duplex access, allows under the same DMR channel, 2 contemporary mobile to Dispatcher/Phone communication or 1 duplex communication between mobiles.

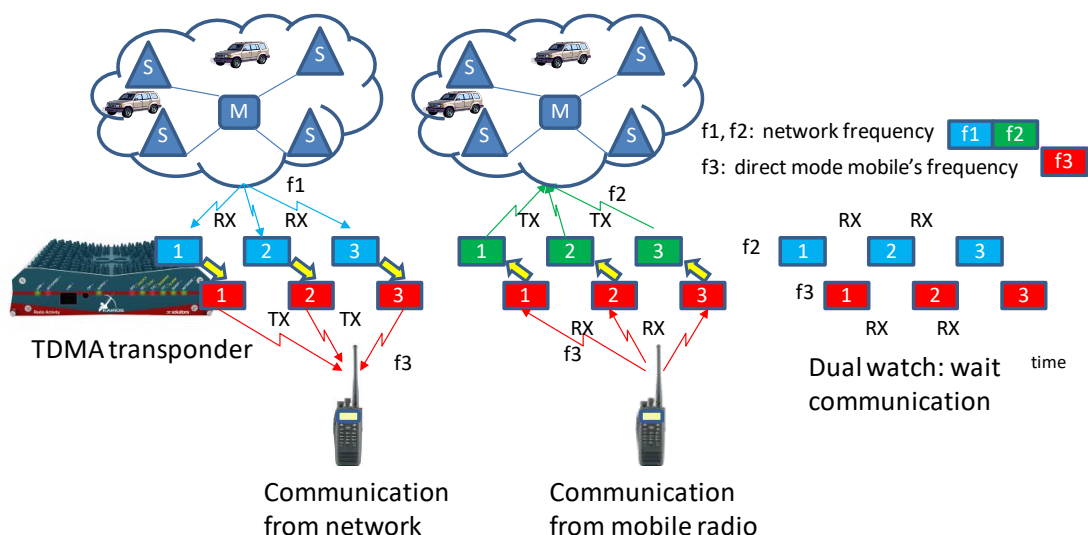


TDMA has the advantage respect to the FDMA of saving the duplexer filter but can't perform dual timeslot (high data rate) communication.

KAIROS should be integrated a front panel/monitor to realize the desired man-machine interface for dispatching. This device can be connected to **KAIROS** via RTP-IP and/or 4 wires interface.

4.8 Mobile communication extender

This application is very useful when it's needed a temporary coverage extension, for example a rescue team that has to operate in a tunnel or in a building where there is no network coverage. **KAIROS** allows the use as TDMA duplex transponder with frequency offset. It forwards the Timeslot_1 on f1 of the network to the Timeslot_2 on f3 of the direct mode channel and vice versa. The figure below illustrates the functioning.



During a communication from the network, **KAIROS** receives the Timeslot_1 payload at frequency_1 (network output) then re-send it at frequency_3 (direct mode with H/H) to the local rescue team's terminals. The fast switching between RX and TX allow such transition.

A communication coming from the local mobile at frequency_3 on Timeslot_2 will be re-direct at frequency_2 (network access) on Timeslot_1.

In absence of communication **KAIROS** monitors alternatively the Timeslot_1 payload at frequency_1 (network output) and the Timeslot_2 at frequency_3 (local rescue team's terminals TX/RX) searching a new communication. This operating mode is called "dual watch".

4.9 Paging simulcast networks

KAIROS includes all of Paging functions: IP interface, LINUX core, precise digital modulator, 0 to 5 KHz modulation bandwidth, synchronization algorithms, RX monitor, low power RF amplifier (up to 25W), GPS receiver. An external power amplifier can be added for high power applications.

KAIROS, as SW option, is able to perform different paging protocols: analog tone based (ZVEI, CCIR, ...), digital based on direct FSK like POCSAG at 512, 1200 and 2400 bps.

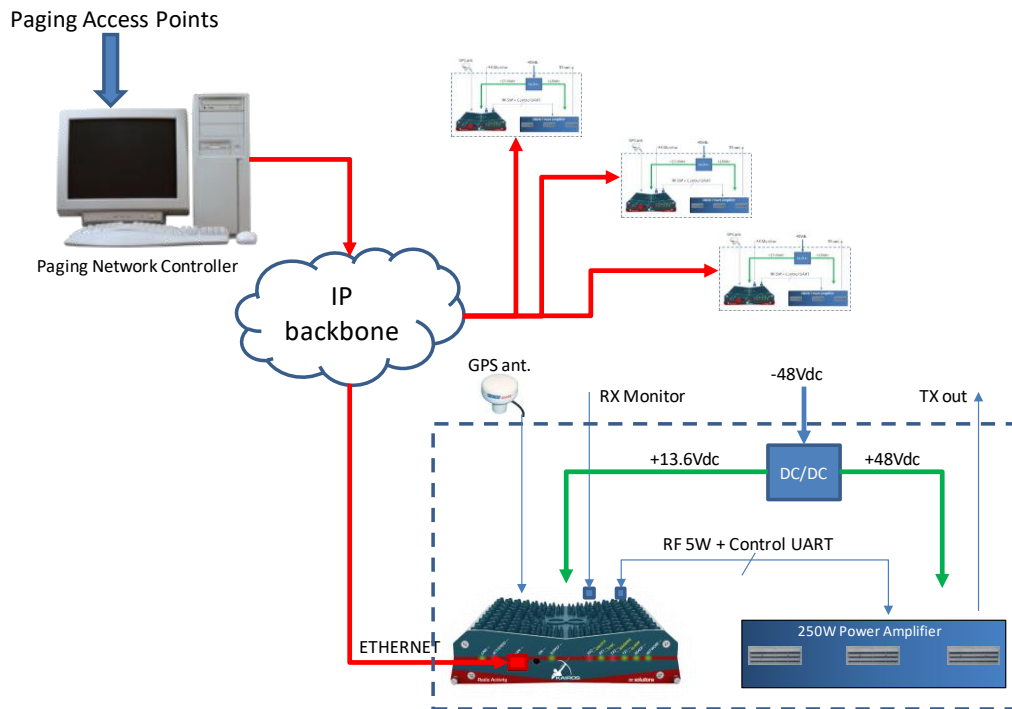
The use of **KAIROS** allows to implement in the same radio network both services, the DMR for voice/data and the Paging one. Since in many applications the Paging traffic is very low, this solution can save a lot of costs with small impact in the communications capability.

In Paging applications all benefits of **KAIROS** like remote control, synchronization, 1+1 assembly, ... are available, giving an excellent paging solution.

In Paging only network, the receiver channel can be used as monitor to have a overall feedback about the correct functioning of the site. The integrated receiver allows also:

- ∞ To receive an acknowledge message from the destination of the paging message (e.g. in case of DMR based paging)
- ∞ To implement mesh network that receives and retransmits synchronously the same messages to cover large land areas

Therefore its application as Paging Transmission Equipment can follow the same roles of the other simulcast networks already described in the precedent paragraphs. The whole Paging system block diagram including a 250W power amplifier and a 48V DC/DC assembly may be:



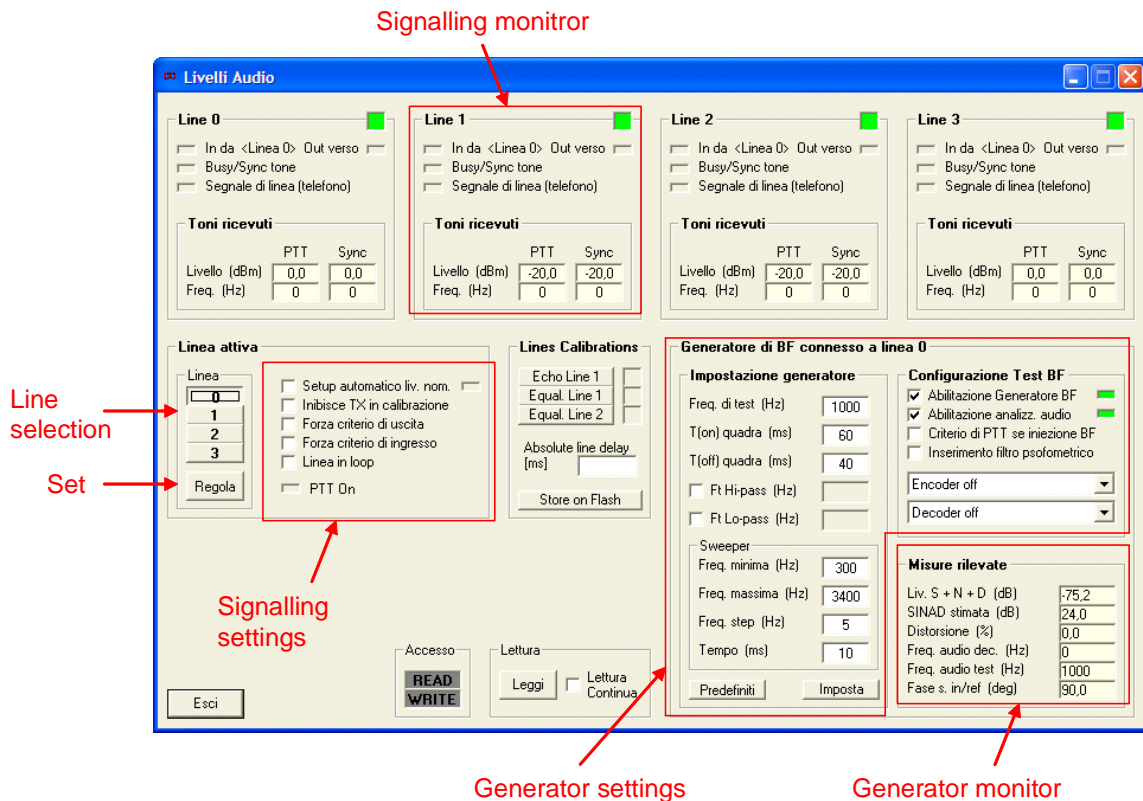
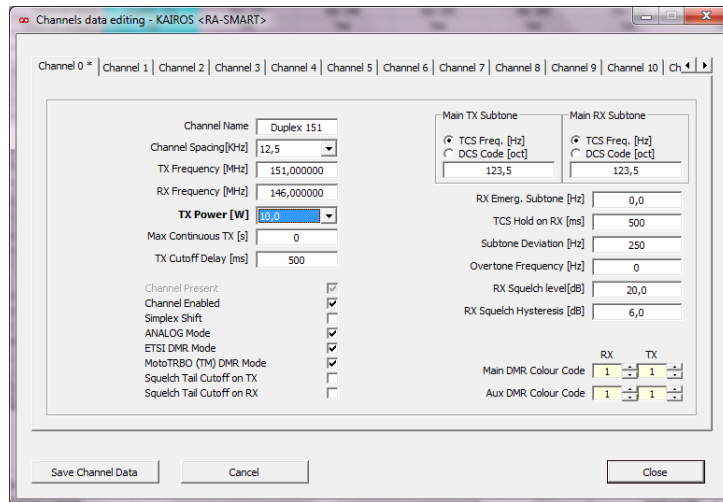
The Paging Network Controller receives the Paging requests from some Paging Access Points that may vary application by application. The Paging Network Controller sends the PAGING message in a IP packet to all the Paging Transmission Equipment that are implemented with **KAIROS**. This protocol will be available on request to allow independent develop of Paging Control Room respect to the radio network.

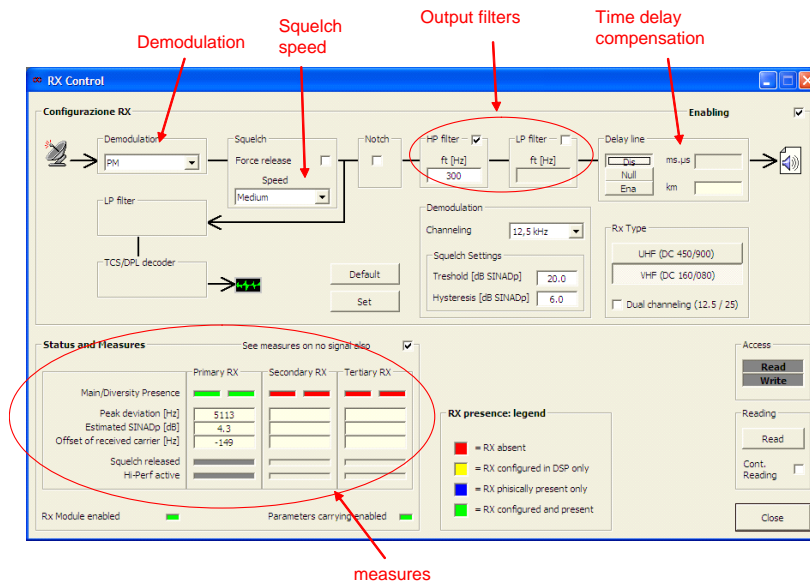
KAIROS collects a number of alarms and diagnostic parameters like effective RF power, temperature, received field and quality, current consumption, GPS status, LAN status, These information are remotely available through the Radio Activity remote control/surveillance tool or through SNMP traps. Anyway, a subset of such information could be useful to present to the Paging User Interface as immediate feedback about the equipment status.

5 Parameters configuration and remote control

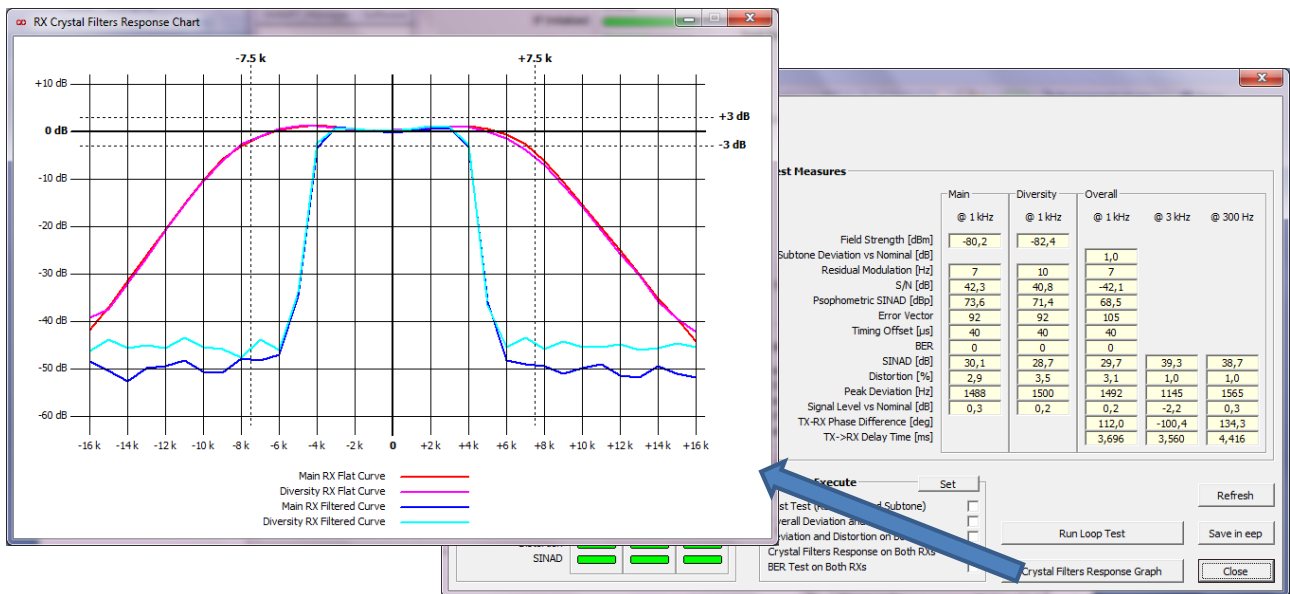
5.1 Setup tools

All parameters of the station are completely programmable through a SW package and a PC connection. The visible (and programmable) parameters set is very wide and extends from radio channel setting to tuning voltage measure of each local oscillator. Here following are shown only few examples of the more than 40 available masks for configure/check **KAIROS**.

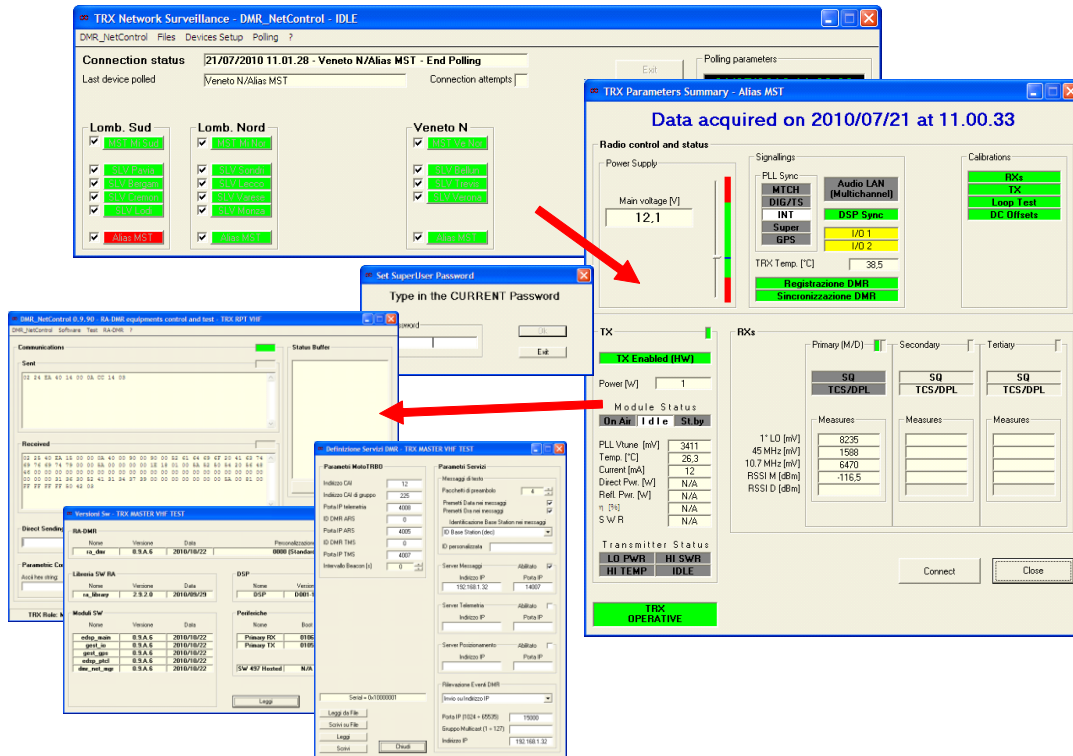




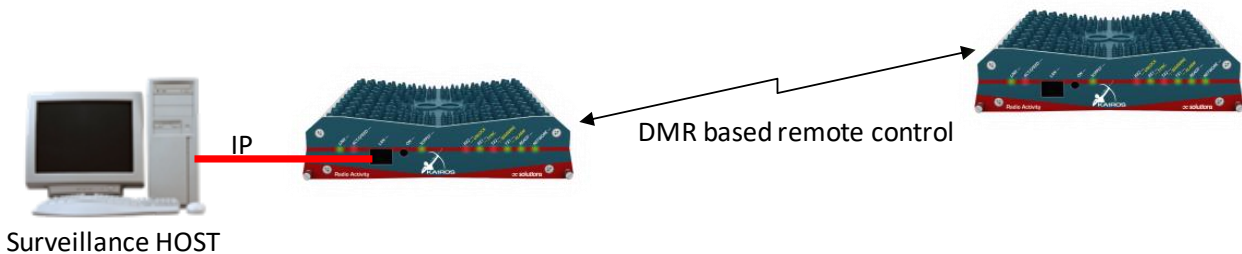
Remote diagnostic from PC towards radio stations can be performed through station Ethernet line remote. This interface is absolutely standard and very diffused, so relatively simple to remote. Connecting from remote it is possible to survey and check **KAIROS** deeply in detail as the loop test (TX=>RX) masks explain:



KAIROS can be equipped with an external GSM modem which will provide remote access to the station, provided service coverage. From remote each operation can be performed, exactly the same as in local connection, including FW down-loading, configuration Down-loading and up-loading, station check, parameters changing.



Remote equipment can be monitored by PC via radio channel also, by enabling the internal embedded modem, realized in DSP technology, provided the targeted equipment is reachable through radio link from a similar equipment, which is in turn connected through Ethernet to the PC. The connection between PC and remote equipment can be implemented according to the following scheme:

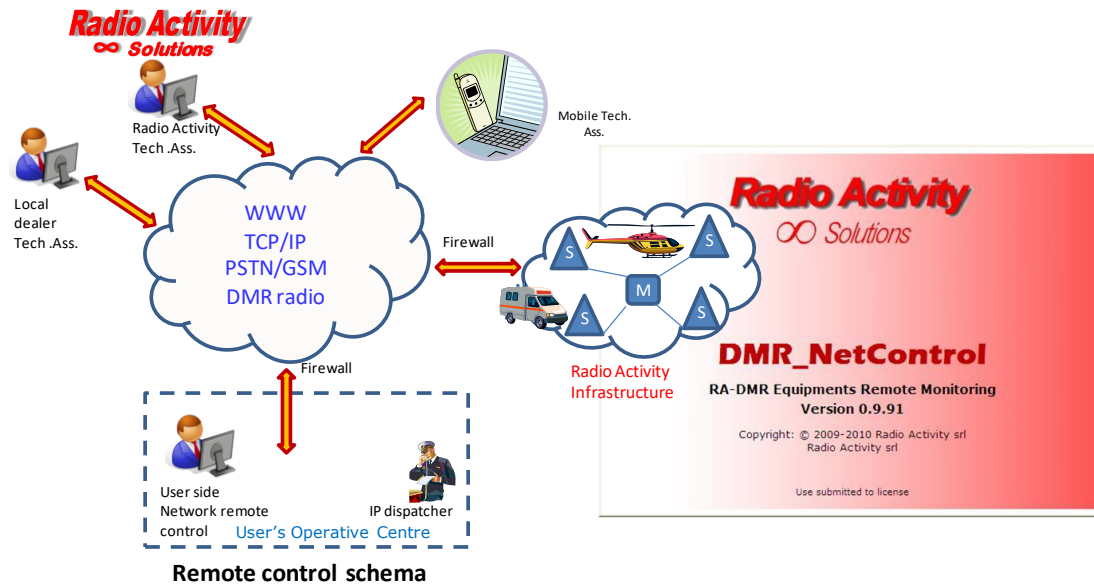


Communication and supervision unit spontaneously transmits a diagnostic message if “self-alarmed” defined events happen. If required by Control Centre, working parameters of RBS are sent to Supervisor Server for events collection and analysis.

5.2 Remote support from Factory

To help users that approach for the first time a **KAIROS** based infrastructure or to maintain, upgrade, detect failure and repair the network, Radio Activity, on demand, can supply a remote assistance from Factory.

These operations can be requested when an access port is granted from the IP backbone network and the Internet or when it is available a GSM/GPRS access.



The communication between Radio Activity and the radio infrastructure depends on the IP backbone configuration:

1. Infrastructure directly accessible via Internet (firewalled): each base station can be accessed directly from the Factory. It is the best case allowing good connection bandwidth.
2. Infrastructure IP connected to the local User's Control Room: to access a base station from Factory it is needed that the Remote Control Tools is running on the User's PC and that PC must allow an access from Internet.

The Radio Activity Technical Assistance Centre may be able to make a precise remote diagnosis of the network status; then it could solve problems (if possible) or it could drive the Local Service Maintenance during system recovery. On site operation can be performed by technical staff not specifically trained in RBS knowledge which are considerably complex machines. Once on site, the operator will be led by the Radio Activity Technical Assistance Centre to replace failed unit with spare one. The failed unit will be repaired or replaced by the factory to restore the stocks. The remotely SW up-grading function is useful for new features addition or to update the capabilities with new versions developed in Factory. This feature is particularly crucial and it is suggested to do it under the supervision of the Radio Activity Technical Assistance Centre only.

Contact your Reseller or Factory for these services.

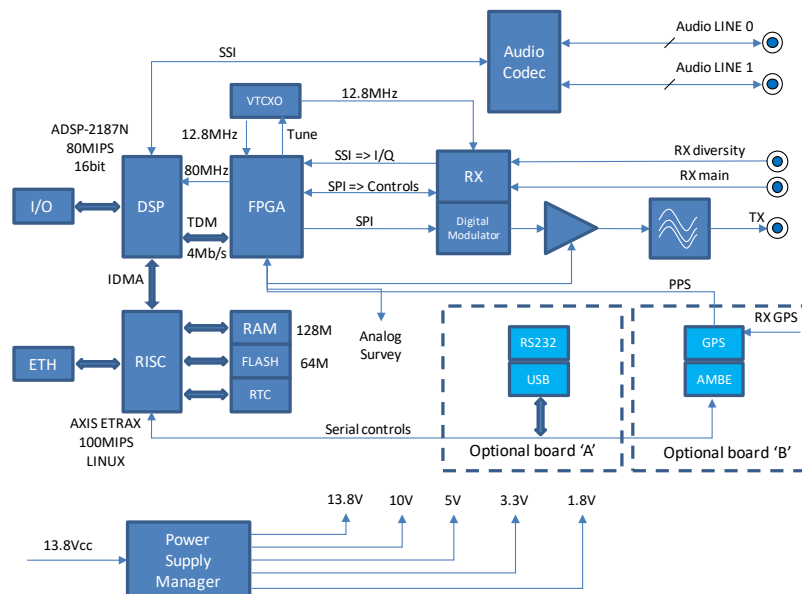
6 KAIROS Transceiver



KAIROS is a compact transceiver block realized with surface mounting components (SMD) and housed in a shielded aluminium case. That case is designed to maximize the dissipation in every position, vertical or horizontal mounting. It includes the following subsystems:

- ∞ power supply manager
- ∞ risk processor running LINUX O.S.
- ∞ Digital Signal Processor [D.S.P]
- ∞ Field Programmable Gate Array [F.P.G.A]
- ∞ Two digital receivers (Main and Diversity)
- ∞ Transmitter
- ∞ Two Audio codec
- ∞ I/O interfaces
- ∞ Real time clock
- ∞ Antenna switch (for simplex half-duplex operation only)
- ∞ GPS receiver (option)
- ∞ Two AMBE Codec (option)
- ∞ Serial ports USB-RS232 (option)

The following blocks schema gives an overview of **KAIROS**.



6.1 Power supply manager

The equipment is powered by nominal 13,2Vdc from battery with negative shorted to ground and with a maximum current absorption of 5 A.

The on/off switch is managed by the FPGA device that surveys the power supply events. The FPGA memorize the last on/off state and automatically powers on/off **KAIROS** according with the last state.

An I/O placed in the back of the equipment allows to switch off **KAIROS** from an external push-button (e.g.: for mobile applications).

The Power Supply subsystem protects the equipment from:

- ∞ Polarity inversion
- ∞ Over voltage: the equipment switch off when the power supply exceeds 15.6V. This may be useful in solar panel powered applications or in mobile applications
- ∞ Under voltage: equipment switch off when the power supply drops 10.8V. This saves an external lead acid battery that could be damaged from an excessive discarding
- ∞ Current limiting: an internal short circuit doesn't destroy the equipment or fuse the power supply cable
- ∞ Transient voltage: a double protection, one fast and resettable combined with another one relatively slow but able to absorb more energy, automatically stops transient in the power supply
- ∞ Soft start/inrush current: when the equipment is connected to the power supply, this circuit limit the maximum current during the charging of the internal capacitors

The Power Supply subsystem gives the following secondary voltages:

- ∞ 13.6V unregulated for the RF power amplifier
- ∞ 13.6V limited at 400mA for a general purpose external device (available in I/O connector in the back side)
- ∞ 10V linear regulated for the Voltage Controlled Oscillators of RX and TX
- ∞ 5V switching regulated for low noise amplifiers, PLL and some logics
- ∞ 3.3V switching regulated for DSP, FPGA, Risk processor, IF, Ethernet device and other logics
- ∞ 1.8V switching regulated for DSP and Risk processor

The efficiency of the power supply is very high so the standby power requirement of **KAIROS** is less than 5W.

6.2 D.S.P.

The core of system "physical layer" is this unit which via software performs every function of signal processing into radio station. What other equipments implement by adding boards (like synchronizers, phase and amplitude equalizers, signal decoders, modem, etc.), here are implemented by routines which can be freely matched, down-loaded and with superior performance.

The DSP is a low power/high performances fixed point 80MIPS device, that can process contemporary up to 2 analog duplex signals ensuring 70 dB of SNR, 2 digital receivers and 1 digital modulator.

Communication and control functions of the unit are entrusted to the Risk Processor which manages communications with external world and with other equipment modules. The FPGA device provides the necessary signals to glue the DSP to the Risk. The DSP program is downloaded directly from the Risk at every restart.

Main performed functions are the following:

- ∞ Analog and digital mo-demodulation
- ∞ Soft diversity reception
- ∞ Time and frequency synchronism recovery to synchronize the entire station upon an internal (VCTCXO 0.5 ppm) or external time reference (pps)
- ∞ RF output power control
- ∞ Fast managing of the PLLs and IF devices
- ∞ DMR protocols management
- ∞ Audio frequency lines management
- ∞ RX frequency self-tuning
- ∞ PLLs frequency self-tuning
- ∞ TX=>RX Loop self-calibration and test

6.3 Risk processor

The LINUX operative system is based on a powerful risk processor Axis ETRAX 100LX with 128M RAM and a 64M Flash disk. It manages an autosensing LAN Ethernet 10/100 interface, supporting the Precision Time Protocol over IP (standard 1588v2).

The risk processor is equipped with 4 serial ports to manage GPS, AMBE Codec, external hosts and auxiliary devices; it is equipped also with a Real Time Clock with tampon battery.

The microprocessor manages the SW of the entire radio apparatus and external communication; cooperates with the DSP to perform complex data management and synchronization. It stores all the setup configurations and programs of DSP and FPGA devices.

6.4 FPGA

The Field Programmable Gate Array [FPGA] is an high speed device that:

- ∞ integrates the glue logic of the DSP and the Risk Processor
- ∞ integrates the A/D and D/A converters for internal monitoring
- ∞ realizes the front-end communication with the digital IF
- ∞ performs the digital modulation
- ∞ manages the pps sources to recover time and frequency synchronization
- ∞ integrate many PLLs to supply the clocks to all internal logic devices
- ∞ interfaces all RF devices with the DSP
- ∞ manages the power supply events
- ∞ manages I/O

The FPGA is integrates a large number of gates and is capable to operate up to 180MHz. All function are defined via SW and can be downloaded from remote.

6.5 Receiver system

The receiver system is composed by two separate receivers matched to obtain a soft space diversity reception. Main and diversity receiver channels are completely independent and coherent (sharing the

same local oscillators) and they are designed according to a double conversion heterodyne structure, with 45 (or 70) MHz first IF and 1.5 MHz digital conversion to base-band.

The channel bandwidth is 25/20/12.5/6.25 KHz selectable per each channel via SW. The selectivity is assured by a filter electronically tuned at the desired receiver frequency, an XTAL filter at the IF frequency and a digital filters implemented in the IF device, in the FPGA and in the DSP.

The signals from the receivers are sent in digital vector format to the DSP. These vectors represent the electromagnetic field vectors, as received from antennas, before any demodulation. By this way the DSP can sum, with the appropriate phases, the received signals to obtain a “soft diversity” reception. This corresponds to an electronic antennas alignment in order to receive the maximum available information along the incoming signal direction.

A further input (TX Test input), common for both receivers (main and diversity) is available, for the receiver and modulator self-test purpose. Through a DSP command, the receiver can switch its input onto test signal generated inside transmission synthesizer module. That signal, amplitude calibrated by Factory, is modulated at receiving frequency and received by DSP. A fundamental test loop is close by this way.

6.6 Transmitter

The transmitter subsystem is realized by three cascaded stages. The RF output power regulation (between 1 and 25W) is implemented by controlling the gates voltages of MOSFET amplifier stages. The power amplifier works in C class and ensures a very high efficiency, lowering the needed power from supply system and lowering the thermal dissipation inside the cabinet. Direct and reflected output power are measured by an internal directional coupler through two “true RMS” sensors. The power control circuit acts in a closed loop and keeps constant the total power at MOSFET drain.

A thermal sensor is hosted in the near proximity of the final MOS stage for temperature monitoring. The internal Risk Processor, if the temperature rises over 85°C, enables the command for air forced cooling fan of the cabinet (this command is placed in the 25pin D-SUB connector). Anyway, if the reflected power or the MOSFET temperature exceeds protection threshold, regulation circuit will lower output power up to safe levels for transmitter.

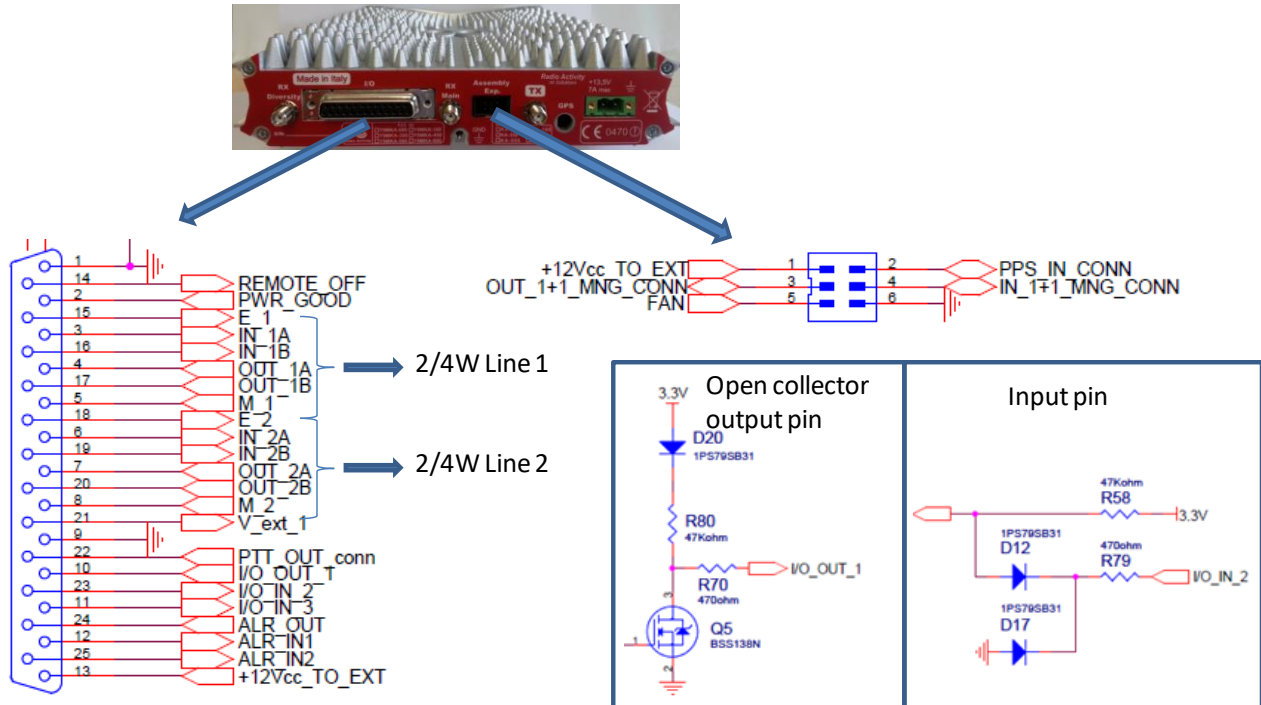
The current flowing into final amplifier transistor is continuously monitored by Risk Processor to verify the correct functioning and to reveal an eventual efficiency degradation.

The transmitter ended with an harmonic filter to lower spurious emissions under required levels by existing regulations.

An internal TX/RX switch can be enabled for simplex/half duplex applications. This switch must be requested directly in phase of order of the equipment, due to isolation reasons, it is not possible to enable this function via SW.

6.7 I/O ports

KAIROS provides some I/O ports fitted into the 25 pin D-SUB connector and the 6 pins connector placed in the back. Some of these I/O are specialized (e.g.: PTT_out or ALRM_out) but can be re-defined for special applications.



6.7.1 Digital I/O

The I/O output pins (PWR_GOOD, M_1, M_2, PTT_OUT_conn, I/O_OUT_1, ALR_OUT, FAN, OUT_1+1_MNG_CONN) are open collector type able to switch up to 20mA/40Vdc. A 470 Ohm resistor limits the maximum current and a 47K resistor refers the output to the internal 3.3V.

The I/O input pins (REMOTE_OFF, E_1, E_2, I/O_IN_2, I/O_IN_3, ALR_IN1, ALR_IN2, PPS_IN_CONN) are internally pull-upped to the 3.3V. A pair of diodes protect the input from voltage below zero. This input switch on closing it to GND.

The function of such pins are:

REMOTE_OFF : [IN] it is equivalent to push the on/off button in the front of the equipment. When **KAIROS** is in on condition, closing this pin to GND for at least 3 seconds produces a switch off condition. When in off condition, closing this pin to GND for at least 250 milliseconds produce a switch on.

PWR_GOOD : [OUT] it is closed to GND when the equipment is regularly switched on

E_1, E_2 : [IN] closing them to GND advise the equipment that a valid audio signal is incoming from the Line (like a PTT signal)

M_1, M_2 : [OUT] they are closed to GND when a valid audio signal is sent to the Line (like a SQUELCH advise)

I/O_IN_2, I/O_IN_3 : [IN] general purpose inputs; they can be used in special applications that need to acquire external status like: opening cabinet detection, opening site door, main power supply presence (with external switch)

I/O_OUT_1 : [OUT] general purpose output; it can be used in special applications that need to set an external device/relays

ALR_IN1, ALR_IN2 : [IN] alarm input; closing them to GND produces an alarm advise to the Supervisor Centre. Each alarm can be configured via the setup tool; it is possible to define a DMR TXT message or a SNMP trap for the 0 to 1 transition and for the 1 to 0. Typical application is the open site/cabinet event.

ALR_OUT : [OUT] it is open from GND when the equipment detects an alarm condition. Power off is an alarm condition.

FAN : [OUT] it is closed to GND when the temperature of the internal RF power amplifier rises above the threshold (typ 65°C). It can be used to switch on cooling fans in a cabinet.

PTT_OUT_conn : [OUT] it is closed to GND when the transmitter goes on air. It is possible to insert a pre-time to allow the right switching on time to an external RF power amplifier.

PPS_IN_CONN : [IN/OUT] this pin supports an external PPS signal or can share the internal PPS (from GPS receiver or from the PTP or from other sourced synch). A bus connection between different co-located **KAIROS** realises a multiple GPS reception with automatic backup. This pin can also be configured to accept an external synchronous clock. See the User Manual for further details.

IN/OUT_1+1_MNG_CONN : [IN/OUT] these pins support a simple protocol to allow two **KAIROS** to functioning as 1+1 (main and spare) equipment.

V_ext_1 : [IN analog] not isolated inputs for voltage sensing (10KOhm / 0..24V referred to ground); the value of this voltage can be seen via the remote control tool.

+12Vcc_TO_EXT : [OUT aux supply] this pin provides 13.8V limited at 400mA to supply a general purpose external device

6.7.2 Audio I/O

KAIROS provides two 2/4 wires + E&M balanced interface for external audio devices like consoles or phone lines.

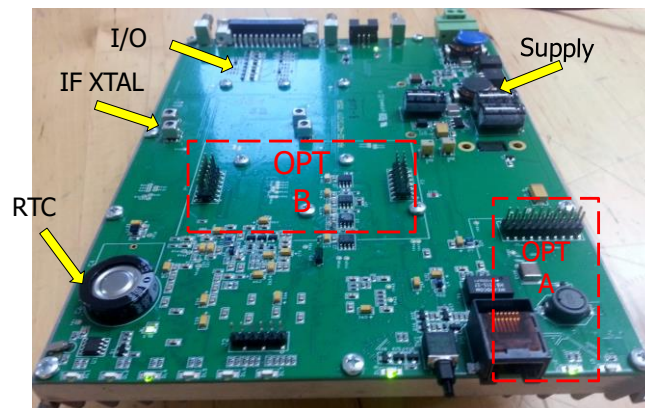
The inputs are IN_1A/IN_1B for the Audio Line 1 and IN_2A/IN_2B for the Audio Line 2 ($Z_{in} = 20K\Omega$ differential / $10K\Omega$ single ended). The outputs are OUT_1A/ OUT_1B for the Audio Line 1 and OUT_2A/ OUT_2B for the Audio Line 2 ($Z_{out} = 600\ \Omega$ differential / $300\ \Omega$ single ended). These IN/OUT ports are balanced and ground referred (**NOT FLOAT!** don't apply to these pins more than 20Vdc).

They can be used as balanced (suggested method) or as single ended using only one of the IN/OUT pin. The nominal level of the audio signal in/out can be regulated via setup tool between -20 and 0 dBm (-14 to -6dBm in single ended).

6.8 Option boards

KAIROS has got two internal connectors for placing option boards. The main option boards are:

- ∞ *GPS receiver*: embedded receiver for GPS/GLONASS service, with high precision Pulse Per Second (PPS) output function in order to synchronize the station. Only an external active antenna is required. This option is required for simulcast and special operations.
- ∞ *AMBE codec*: two DSP, one per timeslot, perform the cross-coding of linear audio (mu-law coded) to a DMR audio and vice versa. This option is required for SIP/RTP-IP and local audio applications.
- ∞ *USB port*: it allow to connect to **KAIROS** standard USB devices like Flash Keys and the remote control modem.
- ∞ *RS232 port*: it allow to connect to **KAIROS** standard RS232 serial devices like external data logger.



7 Engineering specifications

7.1 KAIROS vs RA-XXX comparison

The main differences between the RA-XXX and the **KAIROS** families are:

	KAIROS	RA-XXX
Mechanic	Single module	Multi module assembly
Weight	1,3 Kg	6 Kg
Operative System	LINUX	LINUX
Internal Memory (RAM/FLASH)	128Mbyte/64Mbyte	32Mbyte/32Mbyte
Diversity RX	Always present	Option
Power supply	13,6Vdc (11 to 15,5V)	12Vdc; 24 – 48 Vdc as option
RX power consumption	<5W	<8W
TX Power	25W (15W at 900MHz band)	25W
Simulcast	Yes (as option)	Yes (as option)
Channelization	25/20/12,5/6,25 KHz	12,5 KHz; 25/20 KHz as option
Bands	66-88; 136-174; 350-410; 400-470; 450-520; 860-927 MHZ	68-88; 146-174; 400-470 MHZ
Multi-protocol DMR/Analog	Yes (as option)	Yes
DMR TIER 3	Yes (as option)	Yes (as option)
Operation	FDMA duplex / half duplex / Direct mode (2TS)/TDMA duplex	FDMA duplex / half duplex (as base station)
Vehicular/mobile repeater	Yes	No
Built in audio lines	2 (Timeslot 1 and 2 DMR)	1
User I/O	4 not insulated	4 insulated
Internal GPS Receiver	Option	Option
Internal GSM for remote Control	No	Option
SIP/RTP Gateway	Internal Option or external DTI module	external DTI module needed
1+1 (Main/Spare) operation	Yes (as option)	Yes (as option)
RS232 Serial port	Yes (as option)	Yes (included in the I/O module)
USB Port	Yes (as option)	No
Design year	2014	2007

7.2 Radio frequency

Radio Transceiver model KA080, KA160, KA350, KA450, KA500, KA900, typical values.

7.2.1 Transmitter

Output power at the connector	1/5/10/15/20/25 W
Connector	SMA
RF final transistor protection to high temperature	85°C +/- 5°C progressively reducing the RF power
Available modulation	FM, PM, GFSK, 4FSK, 2DFSK
Modulation bandwidth	0 .. 5000 Hz
Synthesis step	50 Hz
Transmitting duty cycle	Continued 100%
ROS protection	Min.10' in short circuit as well as in open circuit
Adjacent channel noise	-75 dBc @25KHz / -65 dBc @12.5KHz
FM distortion	< 1.5 %
Noise	-56 dBp @25KHz / -50 dBp @12.5KHz
Frequency stability (without GPS)	0.5 p.p.m. (without digital correction)
Max reverse input signal	-20dBm to avoid intermodulation products +20dBm no damage

7.2.2 Receiver

Maximum sensitivity	-116 dBm @20 dBp SINAD -118dBm @5% BER without diversity -121dBm @5% BER with diversity
Operating maximum input	-10 dBm
Maximum input without permanent damages	+10 dBm
Reception mode	Vector I & Q
Received signal band	0..5000 Hz
Synthesis step	50 Hz
Co-channel protection	8 dB @25 KHz / 12 dB @12.5KHz
Adjacent channel selectivity	73 dB @25 KHz / 65 dB @12.5 KHz
Blocking protection	80 dB
Intermodulation protection	75 dB
Intercept 3° order IP3in	+15 dBm
Distortion	<2 % @1KHz
Noise	-53 dBp @25 KHz / -47 dBp @12.5 KHz
Frequency stability	0.5 p.p.m. (without digital correction)

7.3 IP interfacing

7.3.1 LAN protocols

Protocols for voice packets	<p><u>Proprietary between base stations or Audio Gateway (RA-TI-XXX):</u> UDP/IP (ipv4), unicast (from Slave or RA-TI-XXX to master) and selectable from multicast/unicast/broadcast (from master to Slave or RA-TI-XXX), with DSCP set to "EF" (<i>Telephony service class</i>), according to RFC 4594</p> <p><u>Between the Audio Gateway and SIP/Dispatching applications:</u> RTP (Real Time Protocol) according to RFC 3550</p>
Protocols for BS "internal" network control	UDP/IP (ipv4), unicast and multicast, with DSCP set to "CS6" (<i>Network Control service class</i>), according to RFC 4594
Protocols for remote control, setup and surveillance	UDP/IP and TCP/IP (ipv4) unicast and broadcast with DSCP set to "AF13" (<i>High-Throughput Data service class</i>), according to RFC 4594
PTP Precision Time Protocol over IP	It delivers the highest level of precision clock synchronization for real time industrial connectivity based on the IEEE 1588 standard
Audio format between Master and Slaves or RA-TI-XX	Analog: 64 kb/s – 8 bit x 8 KHz selectable linear or mu-law coded DMR: AMBE II+™ (Advanced Multi-Band Excitation)
Audio frame block net payload	Analog: 60 ms – 480 bytes/samples DMR selectable single/double timeslot: 60 ms – 27 bytes each timeslot
Audio format between RA-TI-XX and PC/SIP application	RTP 64 kb/s – 8 bit x 8 KHz selectable A or mu-law coded
Messaging format between RA-TI-XX and PC/SIP application	variable length RTP for text messaging according to RFC 4103

7.3.2 Ports and connectors

UTP LAN Port	Ethernet 10BT/100TX (auto MDI/MDI-X) on an RJ45 socket
Optical LAN Port (option)	Ethernet 100FX on SC-SC socket (not yet available)
Serial control Port	RS232 V.24 asynchronous 600 ÷ 115200 bps (optional)
USB control Port	(optional)

7.3.3 LAN requirements

Jitter (deviation of averaged packet time delay)	The Base Station is able to compensate Jitter delay up to 200 ms. The total delay averaged + jitter must not exceeds 400ms (each way)
Maximum delay	The Base Station is able to compensate round trip delay less then 900ms (jitters included)
Packet loss	< 0.1 %
Minimum bandwidth (network signaling and remote control polling inclusive)	<p>SLAVE or RA-TI-XX: 70 kb/s in analog to/from Master 24 kb/s in DMR to/from Master (both timeslots)</p>
	<p>MASTER to serve N SLAVES or RA-TI-XX (both timeslots): Using multicast (preferred method) or broadcast: 70 kb/s in analog to Slaves, 70 kb/s x N from Slaves 24 kb/s in DMR to Slaves, 24 kb/s x N from Slaves Using unicast: 70 kb/s x N in analog to Slaves, 70 kb/s x N from Slaves 24 kb/s x N in DMR to Slaves, 24 kb/s x N from Slaves</p>

7.3.4 Codec VoIP

Uncoded audio source	64 kbps – 8bitx8KHz
Net bit-rate (1CH)	2450 bps
FEC Coded bit-rate (1CH)	3600 bps
Audio frame block	20ms
Coder algorithm	AMBE II+™ (Advanced Multi-Band Excitation)
DMR compatibility	Motorola (Mototrbo series), Hytera, Sepura

7.3.5 SNMP protocol

Version compatibility	2.0
Maximum number of managed server ports	8
Traps description	On MIB file included in the standard SW package

7.4 GPS/GLONASS antennas

7.4.1 GPS/GLONASS antenna requirements

Connector (RF + remote power supply)	SMA
Impedance	50 Ohm
Sensitivity Tracking	up to -159 dBm
Antenna gain	From 20 to 45 dB, depending on cable length, to obtain a total gain between 12 dB and 26 dB (assumes a 3 dBi patch antenna). A typical value of 25 dB is best in most cases.
Frequency band	GPS L1 1575.42 +/- 10 MHz
Maximum Noise Figure	< 2.5 dB including pre-selector
DC Voltage	5Vcc @ max 100mA superimposed into the SMA RF connector
Out of Band Rejection	-60 dB @ +/- 50 MHz off center frequency
Lightening Protection	90 V, 20 kA, 8/20 -S
Suggested model	GPS-TMG-SP-40N from PCTEL Broadband Technology

Note: It is necessary only 1 antenna per site independently from the number of base stations. The pps signal received from one base station can be shared to the other ones in the same cabinet via the 6-pins bus on the back of **KAIROS**.

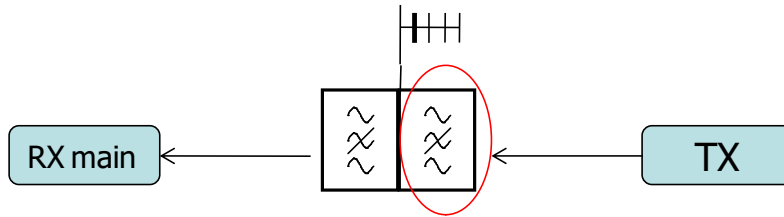
7.5 Frequency bands

Model	Frequency band
KA-900	UHF – HH => 865-941 MHz
KA-500	UHF – H => 450-527 MHz
KA-450	UHF – M => 400-470 MHz
KA-350	UHF – L => 350-410 MHz
KA-160	VHF – H => 136-174 MHz
KA-080	VHF – L => 68-88 MHz
KA-040*	VHF – LL => 30-40 MHz

* please, ask to Factory the availability

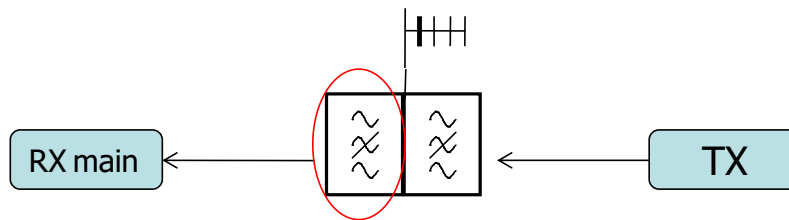
7.6 Branching requirements

7.6.1 TX to antenna duplex isolation requirements @10W TX RF power



Band	+/-40MHz	+/-9MHz	+/-4.5MHz	+/-3MHz	+/-1.5MHz	+/-0.8MHz
UHF – HH	75dB					
UHF – H/L	75dB	76dB				
VHF – H	75dB	75dB	76dB	78dB	81dB	85dB
VHF – L	75dB	75dB	75dB	75dB	78dB	81dB

7.6.2 Suggested RX max input limits on unwanted signals



Band	+/-1MHz	+/-500KHz	+/-100KHz	+/-50KHz	+/-25KHz	+/-12.5KHz
UHF – HH	-32dBm	-43dBm	-45dBm	-47dBm	-49dBm	-58dBm
UHF – H/L	-32dBm	-41dBm	-43dBm	-44dBm	-48dBm	-56dBm
VHF – H	-32dBm	-40dBm	-42dBm	-43dBm	-47dBm	-54dBm
VHF – L	-32dBm	-36dBm	-38dBm	-40dBm	-43dBm	-50dBm

7.7 Other specifications

7.7.1 Environmental parameters

Operating Temperature	-30 ÷ +60 °C
Storage Temperature	-40 ÷ +70 °C
Relative Humidity	Max 80% not condensed

7.7.2 Power supply

Input Voltage	10.8 – 15.6 Vcc, neg. ground, Nominal 13.2V
Max ripple	30 mVpp
Polarity reversal protection	up to -70 V
Power supply protections	Electronic protection with automatic restore for <u>overvoltage</u> and <u>undervoltage</u> events
Short-circuit protection	Electronic protection with automatic restore
Power supply connector	3 pole model Phoenix Contact
Ground connections	A Ø5MA nut on the rear side of the base station The central contact on the power supply connector
Power consumption	TX: 60 W @25W RF RX: 4.5 W (with both RX main and diversity enabled)

7.7.3 Mechanical characteristics

Dimensions (including connectors)	48 x 197x 220 mm
19" Rack mount assembly for up to 2 transceivers	87 (2TU) x 426 x 220 mm
19" Rack mount assembly for up to 6 transceivers	215 (5TU) x 426 x 220 mm
Weight (1 transceiver)	1.350 g

7.7.4 Audio balanced interfaces

Interface type	2x 2/4 wires isolated balanced line
Line isolation	25 V / (1500V with external phone line interface)
Used audio bandwidth	300÷3400 Hz
Input/output Impedance	600 Ohm
Side tone reflection	< - 20 dB
Output nominal level	-20 .. 0 dBm
Input nominal level	-20 .. 0 dBm
Level adjust	software by 0.1dB step
Ring detect (with external phone line interface)	60..120 Vpp @25Hz
Release tone detection(with external phone line interface)	3 pulses of 425Hz @50% duty 250ms/250ms

8 REGULATIONS COMPLIANCE

KAIROS is compliant with the existing regulations, in particular:

- ∞ **EN 300 086-2**: Technical characteristics and test conditions for radio equipment for analogue speech.
- ∞ **EN 300 113-2**: Technical characteristics and test conditions for non speech radio equipment for the transmission of data.
- ∞ **FCC**: Part 90; subpart I
- ∞ **IC**: RSS119
- ∞ **ETSI TS 102361 (part 1;2;3)**: Electromagnetic compatibility and Radio spectrum Matters (ERM); Digital Mobile Radio (DMR) Systems. The equipment is able to manage OSI stack layers 1–2–3 of the DMR protocol, offering an active interaction with mobile terminals.
- ∞ **EMC** : EN 301489-1; EN 301489-5
- ∞ **EMF**: EN50385
- ∞ **EMC for bus & train**: EN 50498; EN 50121-3-2; EN 50155
- ∞ **Safety** : EN 60065 A1

The product is conformed to the Directive 1999-5-CE.

The product is conformed to the Directive 2002/95/CE - RoHs (“ro-has”). It doesn’t contain concentrations exceeding the permitted limits for the following substances:



- ∞ Lead (Pb)
- ∞ Mercury (Hg)
- ∞ Cadmium (Cd)
- ∞ Hexavalent chromium (Cr (VI))
- ∞ Polybrominated biphenyls (PBB)
- ∞ Polybrominated diphenyl ethers (PBDEs)

The use of this equipment may be subject to the specific authorization by the national authority responsible for spectrum management, and it should operate under the local government laws.