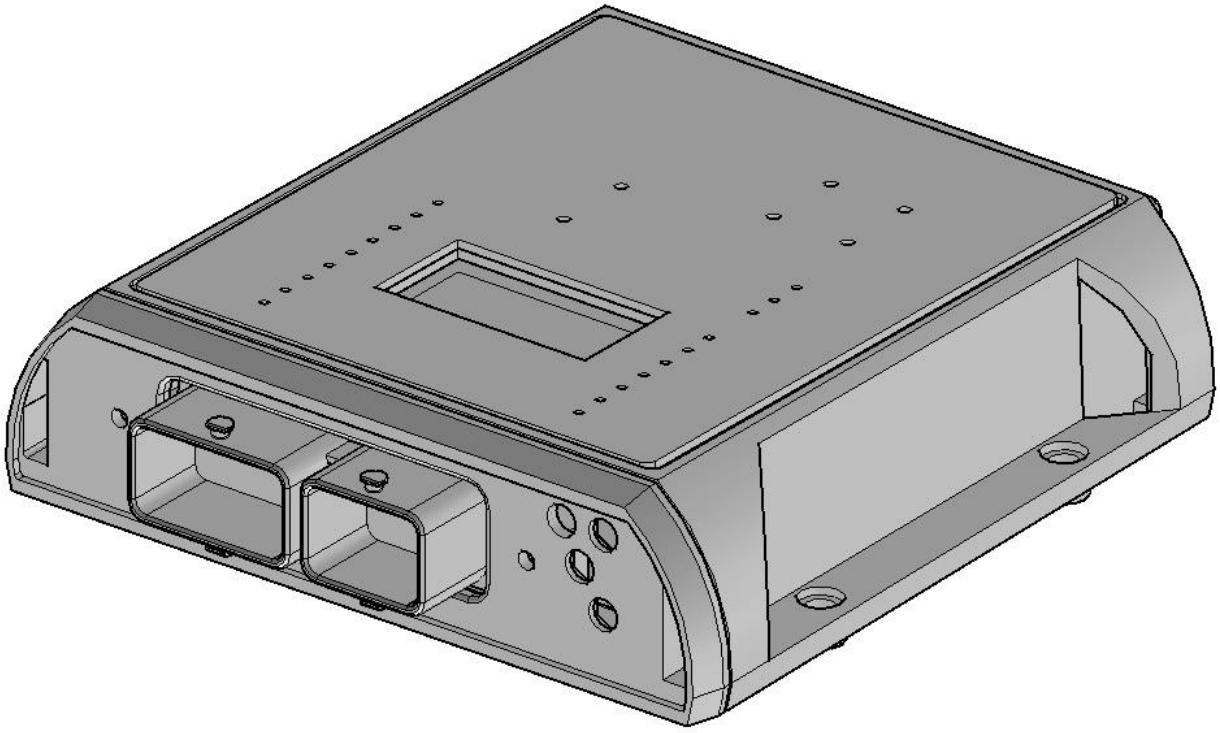
Technical Specification and Product Description

Product references
Product code: **Telemaco/RC2015/Ermete**
Product description: Telematics platform for localization and data acquisition “Telemaco/RC2015/Ermete”



Review	Editing	Check (DT)	Authorization (DG)	Date
1.7	F.Gallo	F. Gallo	S. De Micheli	16/10/2017

REVISIONS HISTORY				
Rev.	Date	Editing	Par. / Pag.	Description
0.1	20/10/12	F.Gallo	-	First draft
0.2	05/11/12	F.Gallo	-	General review
0.3	10/11/12	F.Gallo	-	Review based on customer spec. rev 1.1EN
0.4	15/01/13	Customer	-	Customer review
0.5	16/01/13	F.Gallo	-	First real design ideas
0.6	22/02/13	F.Gallo	-	General review
0.7	22/03/13	F.Gallo	-	General review
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1.0	10/06/13	A.Pizzato	-	General review
1.1	18/06/13	A.Pizzato	-	RC2-Core integration General review
1.2	21/06/13	A.Pizzato	-	General review
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1.6	14/07/17	M. Freguglia		Updated for RED
1.7	16/10/17	F.Gallo		Updated with LTE modules

Index

Index of figures

Index of tables

1. Document purpose

The purpose of this document is to define the characteristics of an electronic platform, hereinafter referred as "RC2", intended to be a reference in our AVL and AVM products. Evidence is given to the basic and complete configuration, and the management of possible expansions. The basic version is designed for all low-cost applications that require a reduced peripheral set, the full version provides the complete set of devices, while ensuring higher performance.

2. Product Description

2.1. Overview

The general characteristics of the product are as follows:

- processing unit based on Freescale Cortex A9 iMX6 up to 1GHz quad core
- DDR3 memory up to 4GB @ 64bit
- non-volatile eMMC memory on-board, for operating up to 64GB
- vehicle-side interfaces for monitoring, diagnostic and 3rd parts vehicle devices
  - 6 high speed CAN lines 1Mbps
  - 1 B-CAN lines,125kbps fault tolerant
  - 3 K lines
  - 1 RS232 complete line (8 wires)
  - 1 RS232 minimal line (2 wires)
  - 1 RS485 line
  - 1 serial line for tachograph
  - 8 configurable GPIO
  - 3 wake-up inputs
  - 2 high-side outputs
  - 1 microphone input or speaker output
  - 1 USB 2.0 host
  - 1 Ethernet 10/100
- user-side connector for maintenance and user interface connection
  - auxiliary power supply
  - 1 HDMI full-HD
  - 1 Ethernet Gigabit
  - 3 USB 2.0 host
  - 1 USB 2.0 OTG port optically isolated (used in device mode)
  - 1 Comm over Usb (used for debug console)
- communication interfaces for vehicle localization and other radio connections
  - GPS with dead-reckoning
  - UMTS and CDMA modem / LTE modem
  - WiFi
  - Bluetooth
  - Easy access to sim insertion and removal
- Internal peripherals for diagnostics and added value features:
  - digital accelerometer
  - digital Magnetometer
  - digital gyroscope
  - buzzer
  - uSD slot with easy access
- user diagnostic info trough a LED matrix and graphic display
- real time clock (RTC) with battery-powered backup
- connector for future expansion, with reconfigurable FPGA pins
- wake-up source management (GPIO, CAN, modem, RTC, accelerometer, tachograph, LAN)

- backup battery (500mAh min.) able to ensure the proper system shutdown
- non-isolated automotive power supply (8-36V) with auxiliary input
- operating temperature -20÷65°C
- moisture range 10÷90% non-condensing
- cooling system based on natural dissipation through the case (fanless)
- dedicated plastic/aluminum case
- all the system devices are in range industrial, or automotive where available

2.2. Regulations

Hereby, DMD Computers, declares that “Telemaco”, “RC2015” or “Ermete” system is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC and further modifications.

All the system is:

- Compliant to:

Riferimento n° *Reference n°*	**Titolo** *Title*
2011/65/CE *(D.Lgs. 4/3/2014, n. 27)*	**DIRETTIVA 2011/65/UE DEL PARLAMENTO EUROPEO E DEL CONSIGLIO sulla restrizione dell’uso di determinate sostanze pericolose nelle apparecchiature elettriche ed elettroniche (RoHS2)** *DIRECTIVE 2011/65/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS2)*
2014/30/UE *(D.Lgs.29/3/2014 n. 96)*	**DIRETTIVA 2014/30/UE DEL PARLAMENTO EUROPEO E DEL CONSIGLIO concernente l’armonizzazione delle legislazioni degli Stati membri relative alla compatibilità elettromagnetica** *DIRECTIVE 2014/30 / EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the harmonization of the Member States relating to electromagnetic compatibility*
2014/53/EU *(D.Lgs. 22/6/2016, n. 128)*	**Direttiva 2014/53/UE DEL PARLAMENTO EUROPEO E DEL CONSIGLIO del 16 aprile 2014 concernente l'armonizzazione delle legislazioni degli Stati membri relative alla messa a disposizione sul mercato di apparecchiature radio e che abroga la direttiva 1999/5/CE** *DIRECTIVE 2014/53/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC*
2006/28/CE *(D.Lgs. 24/10/2009, n. 248)*	**DIRETTIVA 2006/28/CE DELLA COMMISSIONE del 6 marzo 2006 che modifica, per adeguarle al progresso tecnico, la direttiva 72/245/CEE del Consiglio relativa alla soppressione delle perturbazioni radioelettriche (compatibilità elettromagnetica) dei veicoli.** *DIRECTIVE amending, for the purposes of their adaptation to technical progress, Council Directive 72/245/EEC of 20 June 1972 relating to the radio interference (electromagnetic compatibility) of vehicles.*

Compliant to :

Harmonized standards.	*Title*	Essential requirements reference
EN 60950-1:2006 + A1:2010 + A 11:2009 + A 12:2011	Information technology equipment— Safety — Part 1: general Requirement	Art. 3.1 (a) (Directive 2014/53/EU)
EN 62311:2008-01	Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz)	
EN 301 489-1 V.2.2.0 (2017-03)	Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment; Part 1: Common technical requirements.	Art. 3.1(b) (Directive 2014/53/EU)
EN 301 489-17 V3.2.0 (2017-03)	Part 17: Specific conditions for Broadband Data Transmission Systems	
EN 301 489-19 V2.1.0 (2017-03)	Part 19: Specific conditions for Receive Only Mobile Earth Stations (ROMES) operating in the 1,5 GHz band providing data communications and GNSS receivers operating in the RNSS band (ROGNSS) providing positioning, navigation, and timing data;	
EN 301 489-52 V1.1.0 (2017-03)	Part 52: Specific conditions for Cellular Communication Mobile and portable (UE) radio and ancillary equipment;	
EN 300 328 V.2.1.1 (2016-11)	Data transmission equipment operating in the 2,4 GHz ISM band and using wide band modulation techniques;	
ETS 300 440 V.2.1.1 (2017-03)	Short range devices; Radio equipment to be used in the 1 GHz to 40 GHz frequency range;	Articolo 3, paragrafo 2 (Directive 2014/53/EU)
EN 301 908-1 V.11.1.1 (2016-07)	IMT cellular networks; Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 1: Introduction and common requirements	
EN 301 908-2 V.11.1.1 (2016-07)	IMT cellular networks; Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 2: CDMA Direct Spread (UTRA FDD) User Equipment (UE)	
EN 301 908-15 V.11.1.2 (2017-01)	IMT cellular networks; Harmonized Standard covering the essential requirements of article 3.2 of the Directive 2014/53/EU; Part 15: Evolved Universal Terrestrial Radio Access (E-UTRA FDD) Repeaters	
EN 301 511 V.12.1.10 (2016-12)	Global System for Mobile communications (GSM); Mobile Stations (MS) equipment;	

Harmonized standards.	*Title*	
EN 50155, EN 61373 (EN 60068-2)	Railway applications - Rolling stock equipment - Shock and vibration tests	
EN 60529	Specification for degrees of protection provided by enclosures	
EN 50155 (EN 68068-2)	Thermal tests on electronic equipment used on rolling stock for railway applications	

CE

2.3. System architecture and configurations

The RC2 equipment consists of:
- a "core module" containing the processing unit
- a "module carrier" implementing
  - all basic devices
  - the automotive power supply
  - the connections with the outside world, both vehicle and operator side
- a "communication module" integrating all radio interfaces (modem, GPS, BT, WiFi)
- a "diagnostic module" integrating a set of LEDs and a display
- an "expansion module" for future additions
- The plastic/aluminum case

In the following paragraphs the possible configurations of each module are shown.

2.3.1. Core module configurations

- processing unit based on Freescale Cortex A9 iMX6
  - Single-core 1GHz in the basic version
  - Quad-core 1.2GHz in the full version
- DDR3 memory on-board
  - 1GB in the basic version, with 32bit bus length
  - 2GB in the full version, with 64bit bus length
- non-volatile eMMC memory on-board, for operating system and data
  - 4GB in the basic version
  - 64GB in the full version

2.3.2. Communication module configurations

All devices require dedicated communication channels; this means that you can set up custom solutions that use only the devices strictly necessary, allowing a cost reduction.

Below are listed the devices present on communication module:
- GPS module with dead-reckoning (Ublox NEO6V); it requires 1 channel USB 2.0
- UMTS and CDMA module (Cinterion PXS8) or LTE module; it requires 1 channel USB 2.0
- BT module (Bluegiga BT111); it requires 1 channel USB 2.0
- WiFi b/g/n module (Bluegiga WF111); it requires 1 channel SDIO

The GPS, WiFi and UMTS modules use an external antenna trivalent.

The BT module uses an external antenna.

NOTE: BT and WiFi module are only supported under linux distribution while they are not supported in Windows EC7 operating system.

2.3.3. Diagnostic module configurations

The module itself is optional.
When mounted, it can be provided with the graphic display or only with led support.

2.3.4. Configuration summary

The following table represents the possible configurations:

TLMC/RC2015/ERMETE-CRFFMDWBLC				
C	CPU	Q=Quad	D=Dual	S=Solo
R	RAM	1=1G,2=2G, etc.		
FF	FLASH	04=4G,08=8G,16=16G,….28=128G		
M	Modem	H=HSPA		0= NO Modem
		L=LTE		
D	GPS	D=DeadReckoning,G=Glonass 0=NO GPS		
W	Wi-Fi	W=Present		0= NO WiFi
B	BlueTooth	B=Present		0=NO B.T.
L	DISPLAY OLED	L=Present		0=NO LED
C	Carrier Mount Version	1,2,3 etc		

3. Power management and backup battery

The system turns on following the activation of any of the following signals/wake-up events:

- 1 CAN line
- modem ring
- 3 digital inputs
- tachometer
- accelerometer
- Ethernet line on vehicle side
- Real Time Clock

In case of power supply failure, the system is equipped with a rechargeable backup battery; this battery is able to ensure the proper system operation for sufficient time to save data; in addition, it allows the correct operating system shutdown. Monitoring the power supply voltages, the power management processor is constantly informed of the possible impending power supply failure.

Since the power supply from the external battery may present a relatively short transient phenomena (for example voltage drops or load-dump), the power management processor is able to monitor the power supply and measure the duration of these events. If the phenomena are transient and have a duration less than a "reasonable time" then we can assume that no shutdown procedure should be initiated and the system is temporarily powered by internal battery backup, else the shutdown will start automatically.

The BSP must ensure that all applications are killed, but the file system is synchronized and unmounted properly before turning off the core module.

4. Connectors

4.1. Vehicle-side connector

The vehicle-side connector is qualified automotive; the associated “plug”, which owns the wiring, has a high retention clamp structure. The connector is divided into two adjacent sections; the assignment of the signals on the pins is performed so that the full version uses both sections while the basic version uses only one, thus ensuring a simplification of the wiring.

Below are listed the interfaces and devices present on the vehicle-side connector:

- 2 inputs for the main power supply from vehicle battery.
- 6 high-speed CAN lines (1Mbps) and 1 B-CAN line (125kbps). All lines are protected against short-circuits. On one high-speed CAN line is scheduled a wake-up function. All the CAN lines are not terminated, it is possible to insert the termination by manual override (spot weld).
- 3 K lines. If the vehicle battery is 24V, the pull-up on each line is 1kΩ, if the vehicle battery is 12V, the pull-up is 500Ω, and the selection is done automatically by the power-management processor. On each line is also available the "boost" function, which allows to achieve a higher communication speed (up to 250kbps). All lines are protected against short-circuits.
- 1 tachometer line. It consists of a high-frequency and high-impedance input (without pull-up) and it is managed directly by the power-management processor, which allows to manage the wake-up function from tacho; this processor also manages the "data buffering" immediately following the wake-up and until the core module is not ready to acquire them. The line is protected against short-circuits. It is possible to insert a pull-up by manual override (spot weld), in order to ensure compatibility with different tachographs.
- 1 microphone line. This input is not protected against short-circuits.
- 2 serial lines RS232 and 1 line RS485. One RS232 is complete (8 wires) and one is minimal (2 wires). These serial lines are not protected against short-circuits.
- 3 digital inputs. They are active high and with wake-up capabilities, managed directly by the power management processor. These inputs are protected against short-circuits.
- 8 digital Input/Output. They are configurable via the mounting plane. The default configuration provides 2 inputs, TTL-compatible but able to operate up to the external battery voltage, and 6 outputs, capable of delivering 5V-15mA each. If the current draw is excessive, a protection automatically reduces the voltage and current supplied.
- 2 digital outputs. They are high-side connected to the vehicle battery. These outputs are protected against overcurrent by 500mA resettable fuses.
- 1 USB 2.0 host channel. This line is not protected against short-circuits.
- 1 Ethernet 10/100 channel. This line is galvanically isolated and managed by the FPGA.

4.1.1. Pinout

shows the front view of the connector on the vehicle side. The left section, with pin 48, and the right one, with 32 pin, are visible.

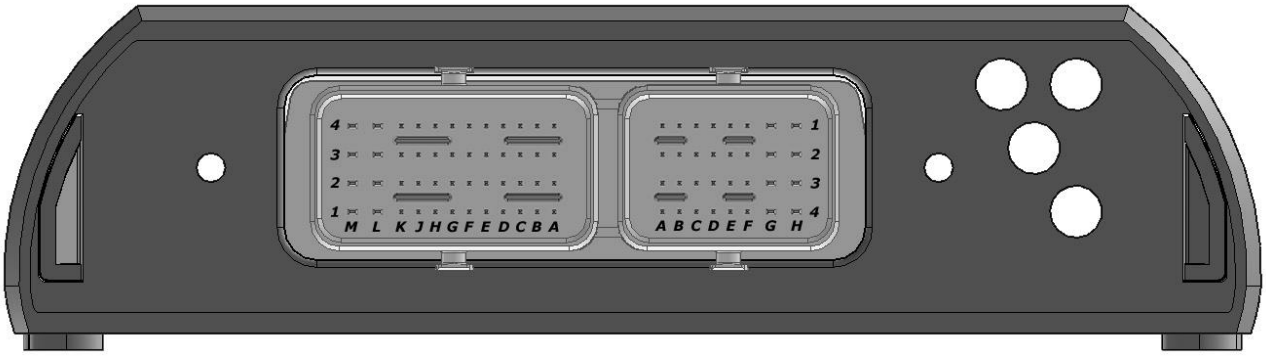


Figure 1: vehicle-side connector pinout

ATTENTION to the pin numbering: from bottom to top and from right to left for the 48-pin section, from top to bottom and from left to right to the 32-pin section.

For the left section (48 pin), the pin assignment is summarized in .

Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
1A	GND_RF	2A	LAN_RX-	3A	GND	4A	WU_IN1
1B	GND	2B	LAN_RX+	3B	RS232c_RI	4B	DIG_IO8
1C	CAN4H	2C	LAN_TX-	3C	RS232c_DCD	4C	DIG_IO7
1D	CAN4L	2D	LAN_TX+	3D	RS232c_CTS	4D	DIG_IO6
1E	CAN3H	2E	USB_GND	3E	RS232c_RX	4E	DIG_IO5
1F	CAN3L	2F	USB_DM	3F	RS232c_DTR	4F	DIG_IO4
1G	CAN1L	2G	USB_DP	3G	RS232c_RTS	4G	DIG_IO3
1H	CAN1H	2H	USB_VCC	3H	RS232c_TX	4H	DIG_IO2
1J	CAN2H	2J	RS485_N	3J	RS232c_DSR	4J	DIG_IO1
1K	CAN2L	2K	RS485_P	3K	GND	4K	GND
1L	MIC_GND	2L	DIG-OUT2	3L	WU_IN2	4L	WU_IN3
1M	MIC_IN	2M	DIG-OUT1	3M	PWR	4M	PWR_GND

Table 1: vehicle-side connector pinout – 48 pin section

On this section of the connector are present:

- 4 CAN lines (CAN1÷4 – 8 pins)
- 1 microphone input (MIC – 2 pins)
- 1 Ethernet vehicle-side (LAN – 4 pins)
- 1 USB host vehicle-side (4 pins)
- 1 RS485 serial line (2 pins)
- 2 digital output high-side (DIG-OUT – 2 pins)
- 1 RS232 serial line (complete, 8 pins)
- 3 digital input with wake-up capabilities (WU_IN – 3 pins)
- 8 digital IO (DIG_IO – 8 pins)
- the main power supply (PWR and PWR_GND – 2 pins)
- all the other pins are reference ground (4 pins)

For the right section (32 pin), the pin assignment is summarized in .

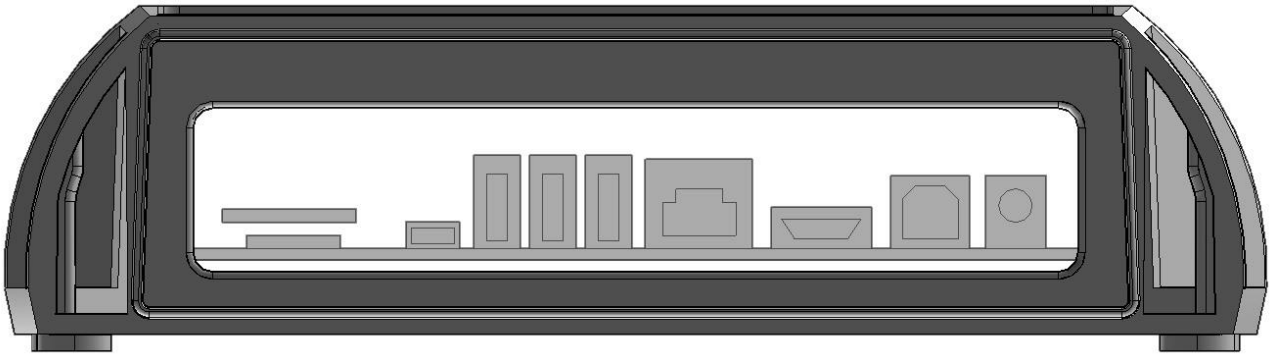
Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
1A	EXP_1	2A	EXP_9	3A	RS232r_TX	4A	CAN5L
1B	EXP_2	2B	EXP_10	3B	RS232r_RX	4B	CAN5H
1C	EXP_3	2C	EXP_11	3C	GND	4C	CAN6L
1D	EXP_4	2D	EXP_12	3D	K1	4D	CAN6H
1E	EXP_5	2E	EXP_13	3E	K2	4E	CANBH
1F	EXP_6	2F	EXP_14	3F	K3	4F	CANBL
1G	EXP_7	2G	EXP_15	3G	EXP_17	4G	GND
1H	EXP_8	2H	EXP_16	3H	EXP_18	4H	TACHO

Table 2: vehicle-side connector pinout – 32 pin section

On this section of the connector are present:
- 1 RS232 serial line (minimal, 2 pins)
- 3 K lines (3 pins)
- 3 CAN lines (CAN5÷6, CANB – 6 pins)
- 1 input tachograph (1 pin)
- 18 pins for future expansions(EXP – 18 pins)
- all the other pins are reference ground (2 pins)

4.2. User-side connectors

The user-side connector consists of a set of different connectors dedicated to the various sections. Since this side provides dedicated interfaces, non-automotive and high speed, it is obviously impossible to condense all the signals in a single connector. In addition, it is absolutely more practical to connect external devices with their respective standard connectors.



Below are listed the interfaces and devices present on the user-side connector:
- 1 bipolar jack, for the auxiliary power supply;
- 3 USB 2.0 host channels.
- 1 USB OTG optoisolated channel, used in device mode.
- 1 HDMI channel
- 1 Ethernet 10/100/1000 channel.
- 1 COMM2USB for debug console
- 1holder for microSD (optional)

The communication module is oriented so that the SIM holder is accessible on the same side where all the user connectors are.

5. Case

The product is housed in a plastic case with IP54 protection.
The dimensions approximately are 18x18x4cm and will be able to accommodate all of the modules (core, carrier, communication, expansion and diagnostic).

The connectors for the antennas are close to the vehicle side connector.

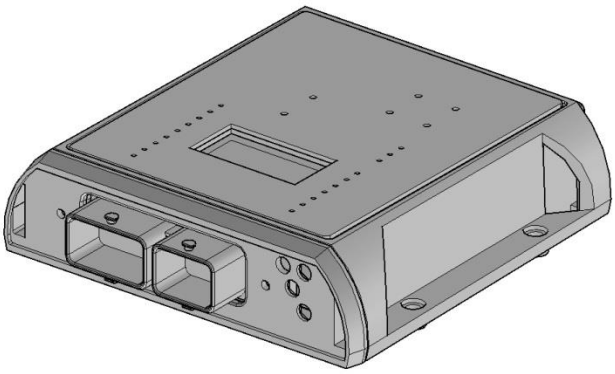
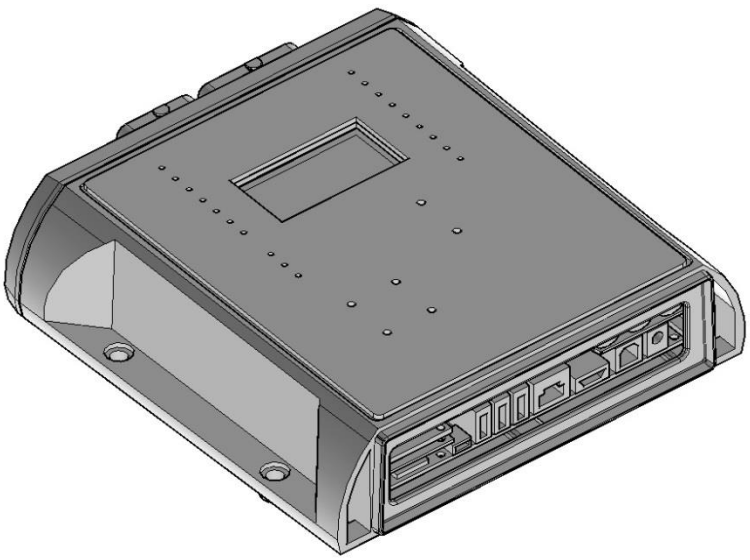


Figure 2: “tubular" case

The system is mechanically fixed to the front panel (via the vehicle-side connector) and is surrounded by a "tubular" case. In the opposite side is provided an aperture for access to the user connectors; a dedicated lid is required for cover this aperture.



6. Software

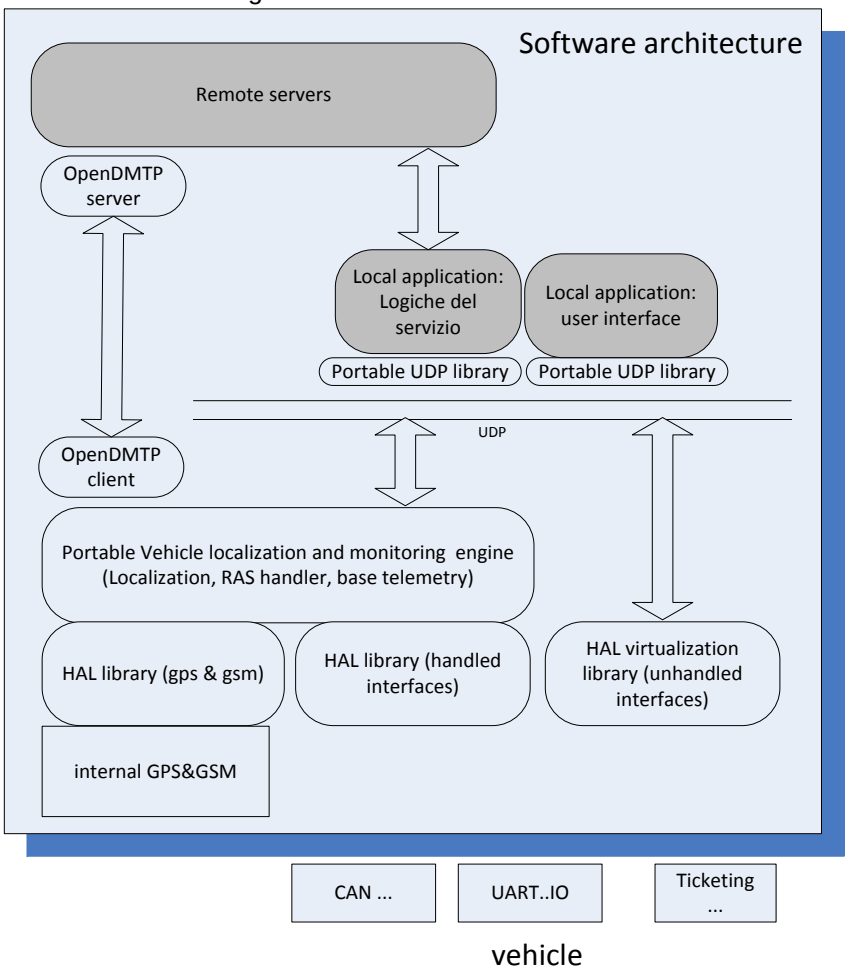
6.1. Linux

A BSP based on Linux Kernel 3.0 is supplied with the system (the distribution is curated by DMD). All device drivers and non-standard features, not currently provided by the operating system, will be made by DMD.
Note that the Linux distribution, both for the standard and non-standard functionality, is curated directly by DMD; therefore the functionality of the product RC2 can be guaranteed for the entire life of the same. DMD will provide a plan for the security patches update.

6.2. SDK and library

DMD provides a portable and scalable library to handle two types of task:

- Hardware virtualization
- High level services and engines



All the library are realized with a resident server on the RC2 which listen on standard UDP ports and waits for connections.
On the customer side a portable library written in C++ for linux allows easy integration of the device's peripherals in customer's application.
A backward compatible device driver, for application that used the old "DMD1:" device, is under development.

The base HAL library handles:

- I/O management

- Power management
- Non volatile data area for identification and configuration info
- CAN / UART virtualization over RFC2217 standard
- User graphic display management

The enhanced services at now available are:

- Localization service. It handles GPS (both power management and NMEA parsing) and provides “android like “ information such as position, time, fix quality
- Tracking/diagnostic service. It handles GPS and GPRS and vehicle telemetry under I/O, CAN, Serial line. It provides both local information or it is able to manage an open GST server.

7. Options and expansions

The following paragraphs describe the most common options required by specific installations.

7.1. Trivalent antenna

The tri-functional external antenna (UMTS + GPS + WiFi) can be supplied in two configurations:

- wall screw mounting
- adhesive fixing

The external antenna has degree of protection IP65.

7.2. BT antenna

A single BT antenna can be provided.

8. Modules specification

8.1. Core module

This chapter defines the characteristics of a device, hereinafter referred as "core logic" or “core module”, intended to provide an embedded platform based on iMX6 Freescale ARM processor.
This platform integrates the processor, the DDR3 volatile memory bank, the on-chip MMC non-volatile memory bank for storage and the "physical layer" Ethernet for LAN connection. There is also a PMIC for the intelligent management of power supplies and operating states (off, sleep, idle, run).
All peripherals of the processor, described below, are available on 3 high density and high speed connectors.

8.1.1. Overview

The core logic is basically a PC-embedded.
The processing unit is an iMX6 Freescale ARM processor. Around it, there are:
- a volatile bank of RAM (expandable up to 4GB);
- a non-volatile bank of storage memory (used for operating system, programs and data) based on MMC on-chip (expandable up to 64GB);
- an interface for the LAN connection, compatible with the standard 10/100/1000Gb.

The core logic is powered by a PMIC used for the proper management of all internal voltages. This circuit requires a single external supply voltage.

The core logic is a multicore platform and on the same PCB can be used quad/single cores.

The RAM memory can be selected from a minimum of 1GB up to 4GB simply changing the chip part-number.
The MMC memory can be selected from a minimum of 4GB up to 64GB simply changing the chip part-number.

The core provides a large set of peripherals, allowing connection to a wide set of devices.

From the point of view of graphics, these interfaces are available:
- HDMI
- LVDS
- Native 24-bit RGB

With regard to high-speed serial connections, these interfaces are available:
- PCI-express
- SATA
- Ethernet
- SD-card
- USB host and OTG

With regard to standard connections, these interfaces are available:
- UART
- I^2C
- SPI
- CAN

At the end, these interfaces are available:
- a stereo audio channel
- some dedicated signals (eg. system reset)
- a large set of digital inputs and outputs for generic use

The above interfaces are spread across 3 high density and high speed connectors.

Being a core logic, in order to use the available resources, a support board (carrier board) is needed; this board allows the mechanical fixing, provides the supply voltage and includes all external devices and connectors.

8.1.2. Architecture

summarizes graphically the architecture of the core logic.

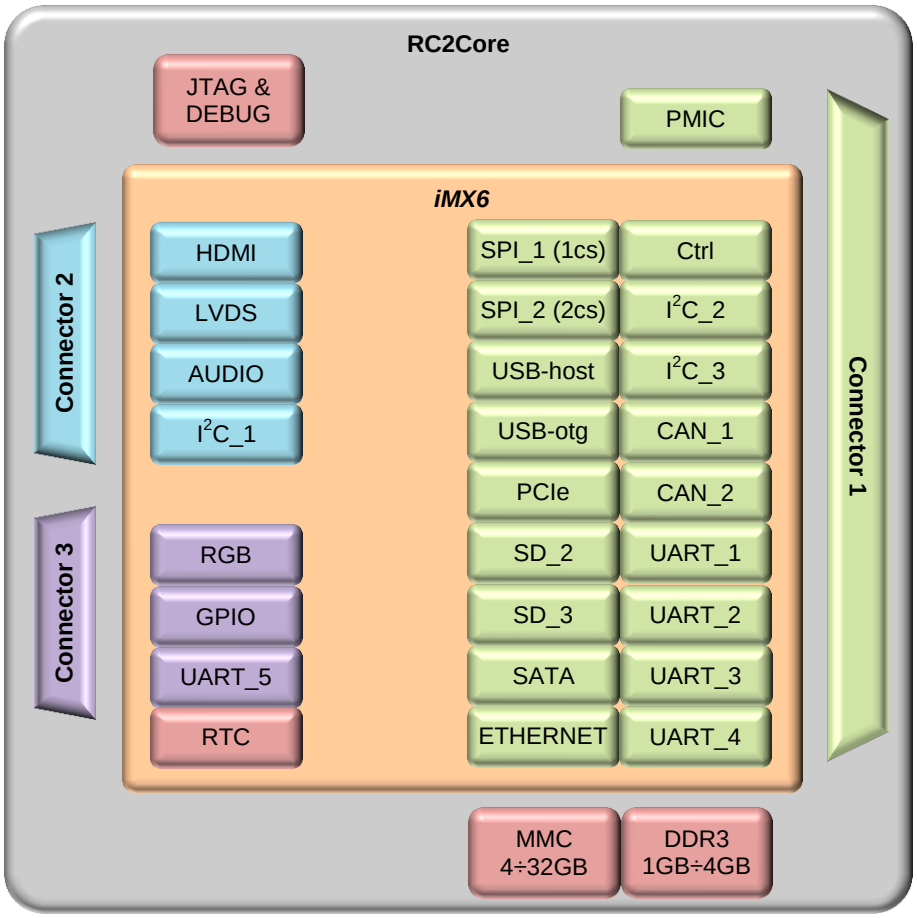


Figure 3: RC2-core system architecture

Most of the interfaces is available on the connector 1:

- 2 SPI channels with 3 chip-selects,
- 2 I^2C channels,
- 1 USB host channel,
- 1 USB OTG channel,
- 2 CAN channels,
- 4 UART channels,
- 2 SD channels,
- 1 SATA channel,
- 1 Ethernet channel.

The connector 1 also provides the global power supply, managed by the PMIC, and some control signals for the management of the standby and power-off.
The connector 2 provides audio/video channels and 1 I2C channel.
The connector 3 provides the parallel video channel and the 5th UART channel.
All non-differential interfaces, if not used, can be converted into general purpose I/O.

8.1.3. Power supply

The core logic power supply is fully managed by the Power Management Integrated Circuit. This device, member of PFUZE100 Freescale PMIC family, integrates:

- 6 buck switching regulators
- 1 boost switching regulators
- 6 linear regulators

It requires only a single power supply voltage available on connector 1.

Within certain limits, all voltage supplies are programmable; it is also possible to program the timeline. This programmability is managed by the processor via I^2C interface. The PMIC also manages the supply for the Real Time Clock and the operating modes (on, off and standby).

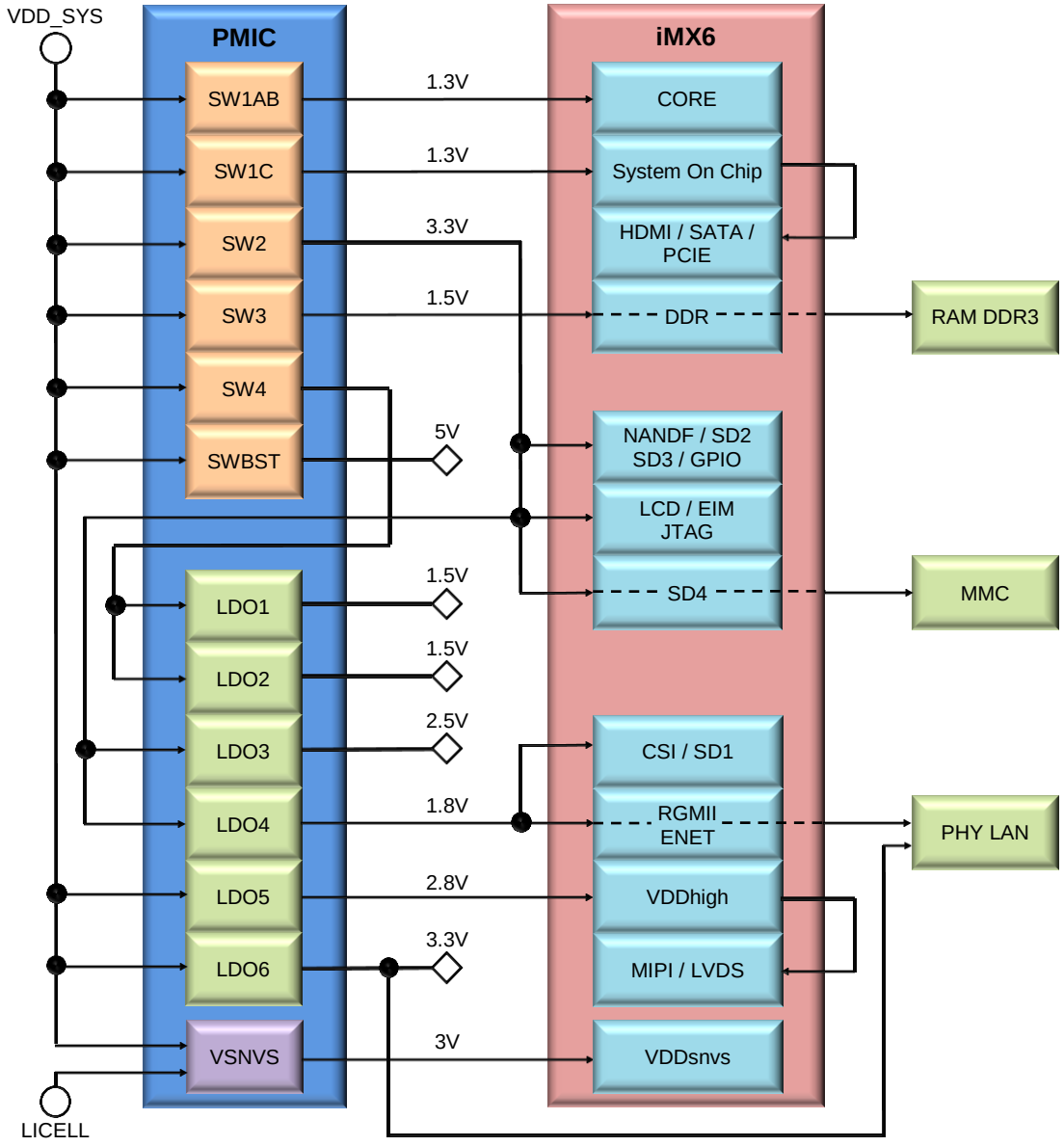


Figure 4: RC2-core power supply

shows the distribution of power supplies:

- SW1AB provides power to the processor cores;
- SW1C provides power to the system-on-chip, that is the high-speed interfaces (HDMI, SATA, PCIe);
- SW3 provides power for DDR3 memory;
- SW2 generates the 3.3V voltage used by most devices, including MMC memory;
- SW4 generates power for LDO1 and LDO2, but they are not used;
- SWBT provides the 5V voltage required by HDMI interface;
- LDO3 is not used;
- LDO4 and LDO6 provide the power for the network interface.

The PMIC uses the power supplies VDD_SYS and LICELL, taken from connector J2; these supplies must be stabilized and provided by the carrier board. The VDD_SYS is the main power supply and, starting from it, all the other supplies are generated. The LICELL only serves to keep alive the section of the processor that manages the stand-by.
The power supplies generated by the PMIC, also if present on the connectors, cannot be used to power external devices mounted on the carrier board; these devices must have dedicated - and compatible - power supply. The carrier board must be designed to ensure that an external device is never supplied if the corresponding interface on the core logic is not powered, and vice versa.

8.2. Carrier module

This chapter defines the characteristics of a device, hereinafter referred as "carrier module", intended to provide the support base and all the connectivity for the "core logic" to the external world.

8.2.1. Overview

The carrier module provides mechanical support to all the other modules and provides the output connectors, both for vehicle and user side. It contains the following components:

- automotive power supply
- power supply for the core module
- power supply for the carrier and communication modules
- charger for backup-battery
- power-management controller
- vehicle connector, and all associated devices:
  - 6 CAN lines, 1Mbps
  - 1 B-CAN lines,125kbps fault tolerant
  - 3 K lines
  - 1 RS232 complete line (8 wires)
  - 1 RS232 minimal line (2 wires)
  - 1 RS485 line
  - 1 serial line for tachograph
  - 8 configurable GPIO
  - 3 wake-up inputs
  - 2 high-side outputs
  - 1 microphone input
  - 1 USB 2.0 host
  - 1 Ethernet 10/100
- user connector, and all associated devices:
  - 1 HDMI full-HD
  - 1 Ethernet Gigabit
  - 3 USB 2.0 host
  - 1 USB 2.0 OTG port optically isolated (used in device mode)
  - 1 Serial over usb connector (for debug console)
- connector for communication module
- connector for expansion module
- connector for diagnostic module (led-matrix and display)
- all on-board peripherals
  - gyroscope
  - accelerometer
  - magnetometer
  - analog channels for diagnostics
  - wake-up circuits
  - buzzer
- programmable logic circuit (FPGA), which allows the management of multiple devices, " virtualized " on PCIe channel of core module.

8.2.2. Architecture

The architecture of the carrier module is shown in .
The main features are as follows:

- all USB 2.0 lines are generated via hub; this hub reply the USB host channel of the core module into 7 channels; 3 channels converge on the connector user, 1 channel on the vehicle connector and 3 channels on the communication module;
- all user-specific interfaces available on the user connector (opto-isolated USB device, HDMI, Ethernet and, optional, µSD) are obtained directly from the core module;

- all communication lines (CAN, K-line, RS232 and RS485), the IOs and the Ethernet present on the vehicle connector are managed by the programmable logic; all these interfaces are "mapped" on the PCIe bus;
- accelerometer, gyroscope and magnetometer digital communicate directly with the core module via I^2C bus;
- the tachometer input, to ensure its complete "buffering", is handled by the power-management processor;
- all wake-up signals (1 CAN, GSM, 3 digital inputs, vehicular Ethernet and accelerometer) are handled by the power-management processor;
- the power-management processor and the core module exchange data between them via 2 dedicated serial lines;
- the diagnostic module is managed by the programmable logic;
- the microphone input on the vehicle connector is managed via a sound chip, directly from the core module;
- not used pins of the vehicle connector are available to an internal connector for future expansions; these expansions are managed by the programmable logic.

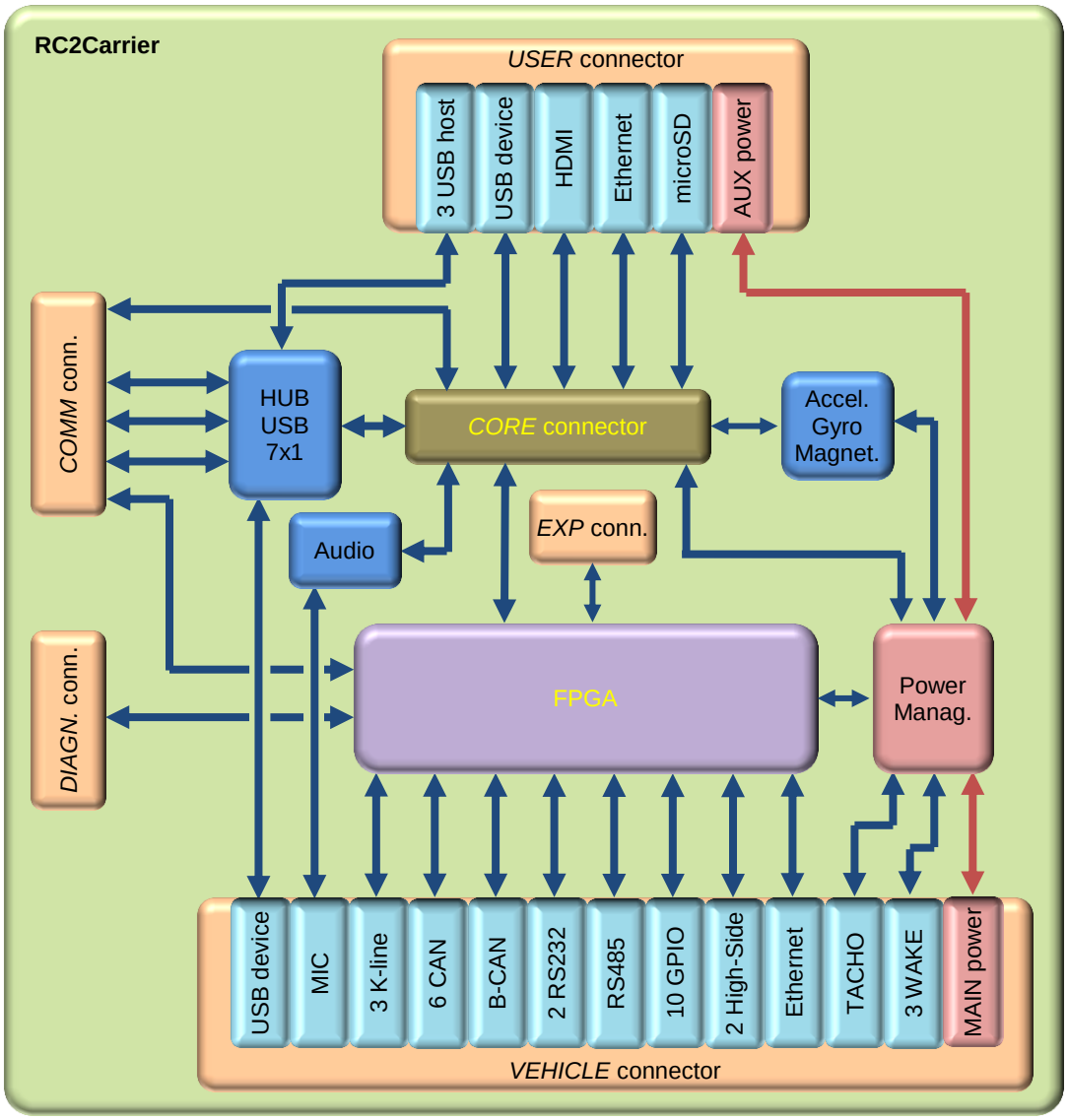


Figure 5: RC2-carrier system architecture

All the interfaces available on the vehicle connector are referred to the vehicle battery ground.
All the interfaces available on the user connector are referred to the vehicle battery ground, except for the USB device, which is optically isolated for electrical safety issues when connecting to an external PC.
The two Ethernet lines are isolated by its own transformers.

8.2.3. Power supply

summarizes the distribution of power supply on the module carrier. For completeness, the communication devices, present on the communication module, are shown.

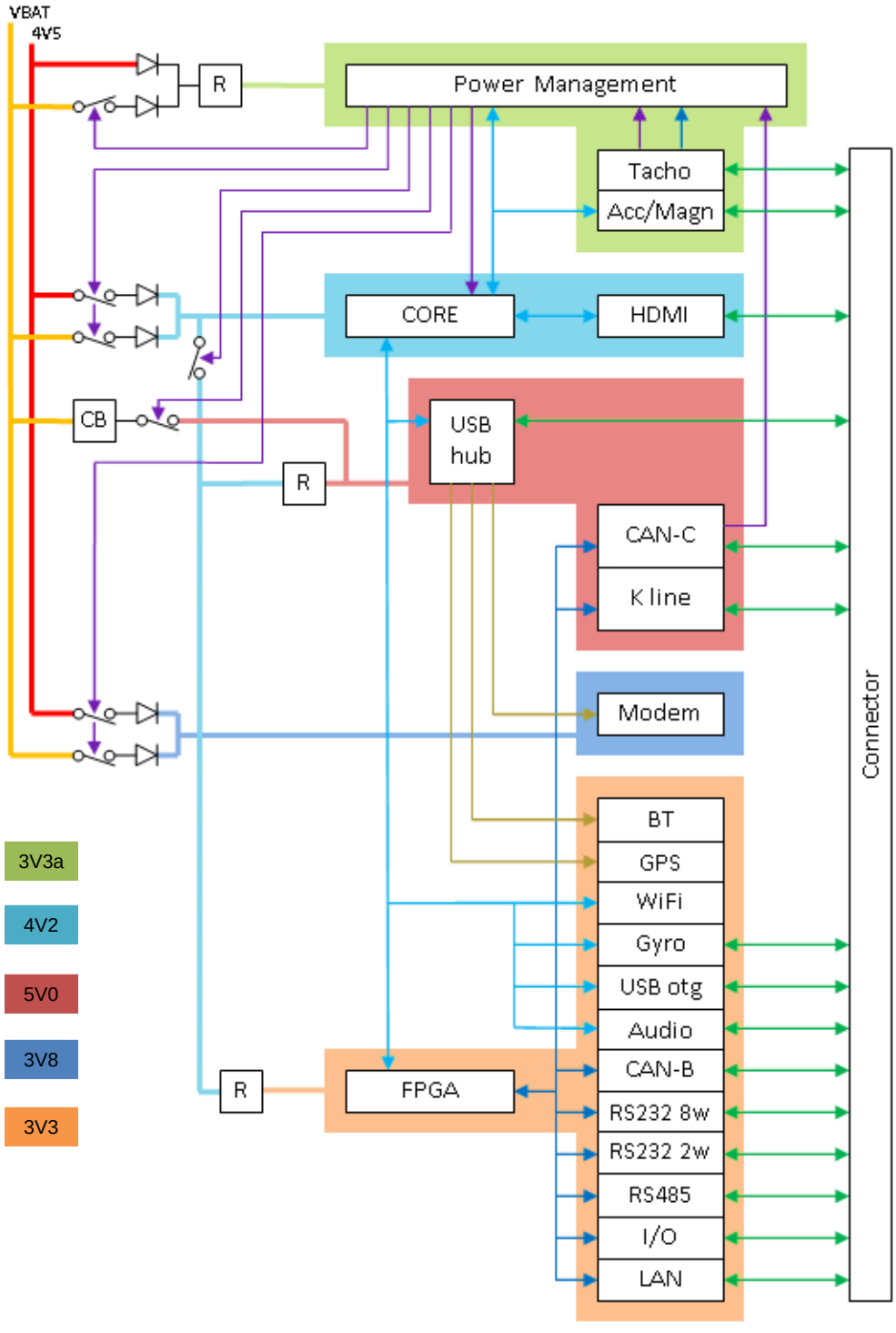


Figure 6: RC2-carrier power supply

The automotive power supply, starting from the external vehicle battery or, alternatively, from the auxiliary power supply, generates a 4.5V "system supply". This power, together with the internal backup battery, allows to manage the "power supply" of the whole system.
The power management is handled by a dedicated processor (Freescale Kinetis); this processor monitors the voltage of the external battery, the voltage of the backup battery and all the wake-up signals in order to manage the system state machine. The power management is powered by a dedicated 3.3V voltage (named as 3V3a) which is obtained directly from the external battery or, in the absence of this, form the backup battery. If the system is disconnected for a long time from the vehicle battery and the backup battery discharges too, then the power management release itself form the power sources and execute a complete auto shut-off.
The core module requires a 4.2V power supply; the modem requires a 3.8V power supply; these voltages are derived from the system supply or from the backup battery.
Starting from the 4.2V power supply, a 5V and 3.3V supplies are derived, for all devices of the system and for the programmable logic. Although not explicitly indicated, the LAN on vehicle side has a dedicated 3.3V power supply, arrangements needed to manage the wake-up from network.
Starting from the 5V power supply, a charger for the backup battery is implemented. Charging is typically enabled only when the vehicle is running.
All voltages above described are handled by the power management processor.

The automotive power supply accepts input voltages in the range 8÷36V; it is protected against reverse battery and load-dump and is capable of operating up to 100V persistent; under 8V the circuit does not guarantee its proper operation; between 36 and 100V a protection circuit decouples the power supply from external battery and the system is therefore powered by the backup battery.

On the user side, there is an auxiliary connector, compatible with the power jack of the laptop PC, which allow to power the system without being connected to the vehicle battery.
CAUTION: the implementation of a protection system able to handle, in total safety, a possible ground-shift between the two power supplies is too costly in terms of area occupied on the module; consequently the main power and auxiliary supplies are connected together via a simple protection circuit implemented by resettable fuses; is therefore strongly recommended to connect the auxiliary power supply only for use at the lab and do not connect anything to the auxiliary power supply if the system is already connected to the vehicle battery.

Due to the integrated temperature sensor, the power-management processor allows to monitor the system temperature.

8.2.4. Communication module connector

The connector for the communication module provides power supply and devices needed for communication with devices on the module itself.

Below are listed the interfaces present on the communication module connector:
- 1 USB 2.0 channel for the GPS module with *dead-reckoning* (Ublox NEO6V);
- 1 USB 2.0 channel for the UMTS e CDMA module (Cinterion PXS8);
- 1 USB 2.0 channel for the BT module (Bluegiga BT111);
- 1 SDIO channel WiFi module (Bluegiga WF111);
- 2 serial channels able to guarantee the use of another communication module integrating on board devices different from those listed above.

The connector also provides some signals able to turn on/off the various modules and the wake-up signal form modem.

8.2.5. Diagnostic module connector

The connector for the diagnostic module provides the power supply for the LED matrix and display, needed to provide diagnostic information of the system.

In order to reduce the dimensions of this connector, the philosophy adopted is to realize the diagnosis module with a small processor on-board; this processor communicates with the FPGA, through the connector, and manages the matrix of LEDs and the display; in this way, all diagnostic messages are encoded and communicated via a serial line.

The matrix of LEDs on the module diagnosis is used to highlight the behavior of the various elements in the system. In particular will be highlighted:

- the activity on the CAN and K lines;
- the activity on the Ethernet of the vehicle side;
- the activities of the modem, WiFi and BT;
- the GPS fix;
- the power supply status and its possible failure.

In the full version, an alphanumeric display allows to add additional details and additional information.

8.2.6. Expansion module connector

The pins on the vehicle-side connector currently free are available on an internal connector, some free signals of the FPGA are connected to another connector: this allows to realize a possible expansion module to add specific functionality to the system.

8.2.7. On-board peripherals

The carrier module integrates, directly on the board, a gyroscope, a magnetometer and an accelerometer (this with ability to wake up the system). Also a buzzer is available.

8.3. Communication module

The choice to realize a communication module stand-alone comes from requirements:

- the communication devices typically have a life time reduced compared to that of the entire system; their replacement will require consequently only the redesign of the module;
- the chosen devices, having regard to the required characteristics (dead reckoning for GPS and CDMA+UMTS for the modem), are relatively expensive; any applications that do not require these particular features can be made using less expensive devices; therefore, also in this case, the redesign of the module is a benefit to the economy of the whole system.

8.3.1. Overview

All devices require dedicated communication channels; this means that you can set up custom solutions that use only the devices strictly necessary, allowing a cost reduction.

Below are listed the devices present on communication module:

- GPS module with dead-reckoning (Ublox NEO6V); it requires 1 channel USB 2.0
- UMTS and CDMA module (Cinterion PXS8); it requires 1 channel USB 2.0
- BT module (Bluegiga BT111); it requires 1 channel USB 2.0
- WiFi b/g/n module (Bluegiga WF111); it requires 1 channel SDIO

The GPS, WiFi and UMTS modules use an external antenna trivalent.

The BT module uses an external antenna, and optionally can use an indoor antenna or a shared-antenna with WiFi modules. If will be necessary to realize a case non-transparent to RF (for EMC emission problems) then an internal antenna will not be usable. The BT and WiFi modules are also connected in order to use a shared antenna, but at the moment this feature is not yet established by the manufacturer of the two modules.

The antennas are available on the front of the case through pigtail solder, since the experience has shown retention problems using the connectors normally present on the modules. The frontal connectors are SMA type, in a configuration that makes impossible to cross the antennas; in addition, they are highlighted with colored rings for the identification, compatible with the Facra colors.

8.3.2. Architecture

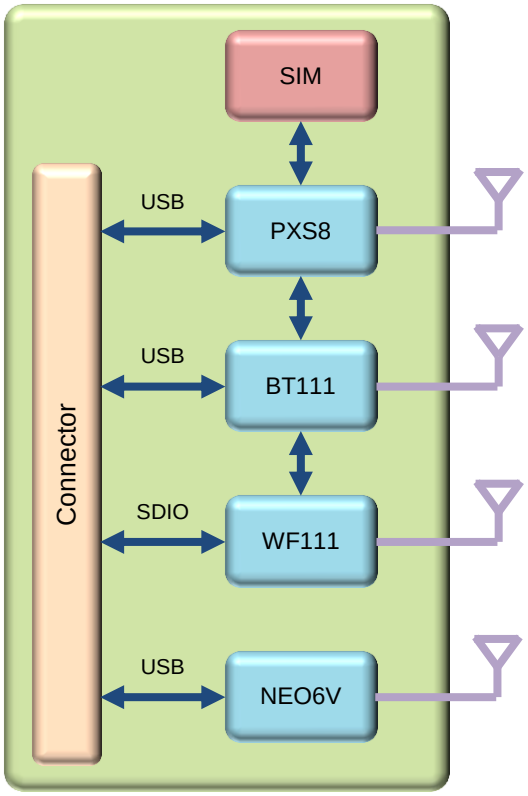
The architecture of the communication module is shown in .

The BT module is connected to the modem via a digital PCM channel, allowing the eventual audio management between the modem and a wireless headset. In addition, it is also connected to the WiFi module through a set of dedicated signals that allow the possible antenna sharing.

8.3.3. Power supply

The architecture of the communication module is shown in .

In addition to the dedicated communication channels, for each device a dedicated supply system is provided; this allows to completely turn off the device when not in use and/or to save energy.



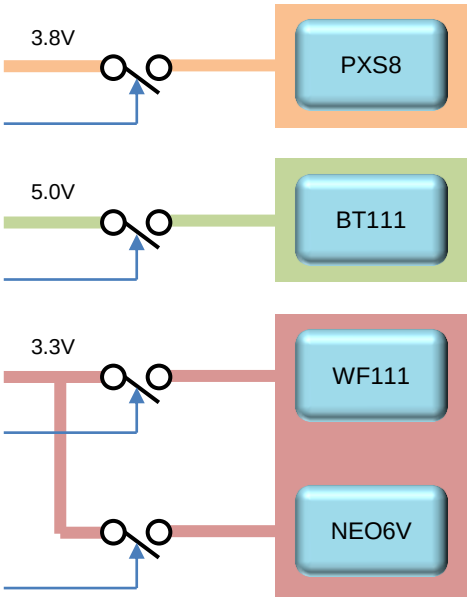


Figure 7: RC2-comm system architecture (left)
Figure 8: RC2-comm power supply (right)

8.3.4. GPS

The requirement of dead-reckoning, beyond the higher cost, limits the choice of a few GPS manufacturers. The choice, at this time, is mandatory for the Ublox NEO6V device.

To realize the dead-reckoning functionality, the GPS must be updated with other information, which must be sent from the core module through the dedicated USB channel:

- odometer pulse (available from the CAN line),
- gyroscope data,
- driving direction (optional).

The dead reckoning functionality is not available without the information of the distance traveled; this means that the gyroscope must be installed on the carrier module.

8.3.5. UMTS and CDMA modem

Modules supporting both standards are much less common, and more expensive, than single-standard, however is preferred to make a communication module with a single modem that supports all the required standards. It was therefore identified the module Cinterion PXS8.

Main characteristics are:

Frequency bands: GSM/GPRS/EDGE: Quad band, 850/900/1800/1900MHz
UMTS/HSPA+: Five band, 800/850/900/1900/2100MHz
CDMA: Triple band (BC0/BC1 and BC10 subclass 2+3), 800/1900MHz
GSM class Small MS

Output power
(according toRelease 99)
Class 4 (+33dBm ±2dB) for EGSM850
Class 4 (+33dBm ±2dB) for EGSM900
Class 1 (+30dBm ±2dB) for GSM1800
Class 1 (+30dBm ±2dB) for GSM1900
Class E2 (+27dBm ± 3dB) for GSM 850 8-PSK
Class E2 (+27dBm ± 3dB) for GSM 900 8-PSK
Class E2 (+26dBm +3 /-4dB) for GSM 1800 8-PSK
Class E2 (+26dBm +3 /-4dB) for GSM 1900 8-PSK
Class 3 (+24dBm +1/-3dB) for UMTS 2100, WCDMA FDD BdI
Class 3 (+24dBm +1/-3dB) for UMTS 1900,WCDMA FDD BdII
Class 3 (+24dBm +1/-3dB) for UMTS 900, WCDMA FDD BdVIII
Class 3 (+24dBm +1/-3dB) for UMTS 850, WCDMA FDD BdV
Class 3 (+24dBm +1/-3dB) for UMTS 800, WCDMA FDD BdVI

Power supply: $3.3V < V_{BATT+} < 4.2V$

Operating temperature
(board temperature) Normal operation: -30°C to +85°C
Restricted operation: -40°C to +95°C

All hardware components fully compliant with EU RoHS Directive

CDMA features: 3GPP2 CDMA2000
EV-DO Rev.A data rates:
FL max. 3.1Mbps, RL max. 1.8Mbps
1xRTT Advanced data rates:
FL max. 307.2kbps, RL max. 307.2kbps

HSPA features: 3GPP Release 6, 7
DL 14.4Mbps, UL 5.7Mbps
UE CAT. 1-12 supported
Compressed mode (CM) supported according to 3GPP TS25.212

UMTS features: 3GPP Release 4
PS data rate – 384 kbps DL / 384 kbps UL
CS data rate – 64 kbps DL / 64 kbps UL

GSM / GPRS / EGPRS features:

Data transfer GPRS:
- Multislot Class 12
- Full PBCCH support
- Mobile Station Class B
- Coding Scheme 1 – 4

EGPRS:
- Multislot Class 12
- EDGE E2 power class for 8 PSK
- Downlink coding schemes – CS 1-4, MCS 1-9
- Uplink coding schemes – CS 1-4, MCS 1-9
- SRB loopback and test mode B
- 8-bit, 11-bit RACH
- PBCCH support
- 1 phase/2 phase access procedures
- Link adaptation and IR
- NACC, extended UL TBF
- Mobile Station Class B

CSD:
- V.110, RLP, non-transparent
- 14.4kbps
- USSD

SMS:
Point-to-point MT and MO
Cell broadcast
Text and PDU mode

8.3.6. BT and WiFi

The BT and the WiFi modules are BT111 and WF111 from Bluegiga.

BlueTooth Transmit power: +8dBm
Wi-Fi Transmit power: +16dBm

8.3.7. LTE Modules

We can provide the communication module to support LTE network using PLS62 and PLS8 family of Gemalto LTE modules. In the table we provide the main data declared by Gemalto. The revised board provide sim on chip support too.

	PXS8	PLS62-W	PLS8-E	PLS8-J	PLS8-X
Regional focus	Global	Global	Emea	Japan	NordAm
Bands	3G 2G	LTEcat1 3G 2G	LTEcat3 3G 2G	LTEcat3 3G	LTEcat3 3G
Operator		AT&T, Vodafone		Docomo	AT&T Verizon
Data rate DL/UL (Mbit/s)	7,2/5,6	10,3/5,2	100/50	100/50	100/50