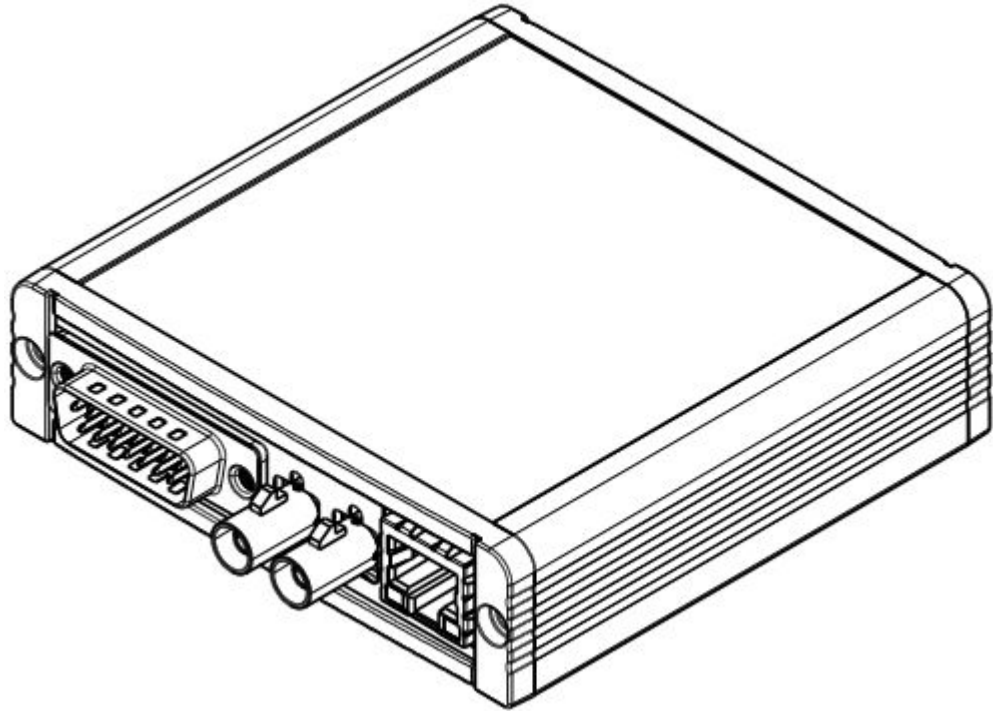


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## Technical description MX-4 V61



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# 1 General Description

## 1.1 Features

- ARM Cortex-A5 CPU, 500 MHz single core
- ARM Cortex-M4 CPU, 167 MHz single core
- 512 MB flash, 256 MB RAM
- Linux operating system
- 14.4 / 5.7 Mbit/s Five band 3G module (Optional: LTE)
- 1 x 10/100 Mbit/s Ethernet
- 1 x USB 2.0 high-speed host/device (auto detect)
- 3 x CAN 2.0 B
- 2 x LIN buses
- 4 x Digital inputs
- 4 x Digital outputs
- 1 x Start signal input (to boot the system using external signal)
- Start switch (to boot the system manually)
- $\mu$ SD-card interface
- Internal Lithium battery (optional)
- Super Capacitor
- Wide operating temperature: -40 to +85°C
- Wide input voltage range, 8-36 V
- Low power sleep mode

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## 1.2 Intended Use

Intended as a “black box” vehicle computer. Includes several different interfaces for communication with the vehicle, and several interfaces for communication with other equipment/systems. Can carry customer specific applications to suit specific needs.

## 2 Soft Deliverables

When you buy a MX-4 hardware from Host Mobility AB the following is included.

### 2.1 Platform

Host Mobility AB provides a complete Linux platform with driver support for all hardware interfaces and with a customizable distribution.

All hardware interfaces are accessible via well defined API's. We try to reuse the standard Linux way of doing things as much as we can. This way the platform environment is familiar to developers who has worked with embedded Linux in their past.

Main software components:

- Tool-chain
  - Tegra2: Linaro GCC 4.7-2013.09  
(<http://releases.linaro.org/13.09/components/toolchain/gcc-linaro/4.7>)
- Linux (Tegra2: 3.1.10)
- U-boot (Tegra2: 2011.06)
- Ångstrom distribution built with yocto (<https://www.yoctoproject.org/>)
- Co-processor firmware

### 2.2 Firmware Update

Host Mobility AB provides a simple method to update the firmware in the MX-4 hardware.

This method is based on a `hmupdate.img` which is able to update all software components (Linux kernel, u-boot, distribution, co-processor firmware).

This is easily done by placing an `hmupdate.img` in the root of a USB flash drive and simply restarting the MX-4 system with the USB flash drive plugged in.

The `hmupdate.img` can also be placed in the internal nand flash in `/boot` directory which will trigger an update as well. This method could be integrated in a customer application for over the air updates.

### 2.3 Source Code

Host Mobility's provides read-only access to our software repositories hosted at <https://github.com/hostmobility>.

With this access you can fork the repository, create pull-requests, create issues and clone the repository and build the whole platform from scratch.

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## 2.4 Support

Host Mobility AB provides first class support.

We will help you get started with MX-4 development and once the initial steps are done we also provide tips and tricks to optimize your application to our platform.

Beside the documentation and wiki you can also contact Host Mobility developers directly with your questions. See <http://hostmobility.com> for contact information.

## 2.5 Wiki

<http://hostmobility.github.io/mx4/>

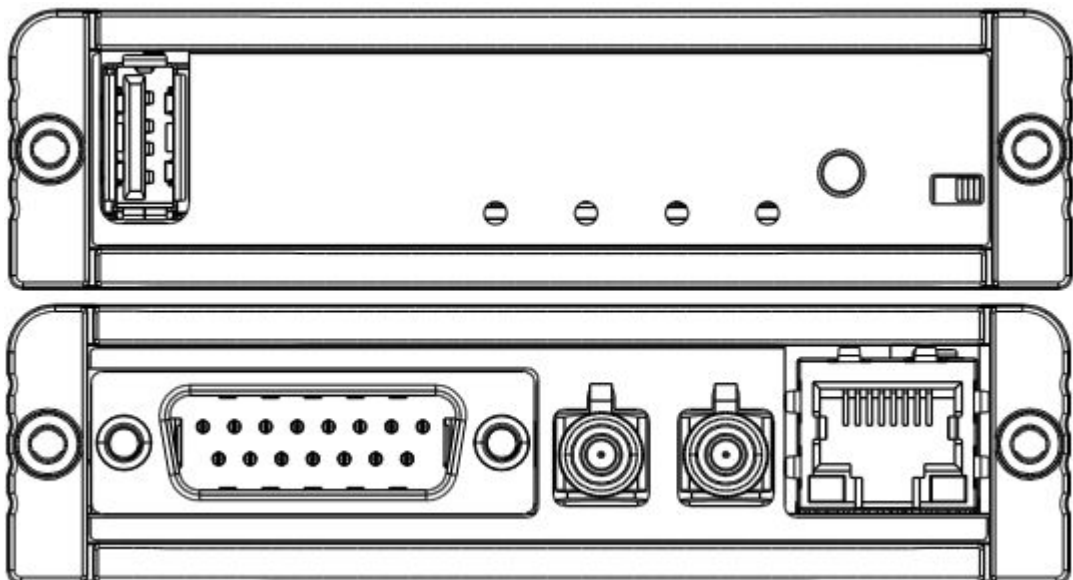
## 2.6 Build Server

Host Mobility AB provides access to our build server which is based on Jenkins software. Here you can download the latest and greatest software for your MX-4 platform.

It is also possible to setup a customer specific build job on request where one could integrate the customer application in the MX-4 platform build system or build a branch of the MX-4 platform repository.

## 3 Connectors

### 3.1 Connection Layout

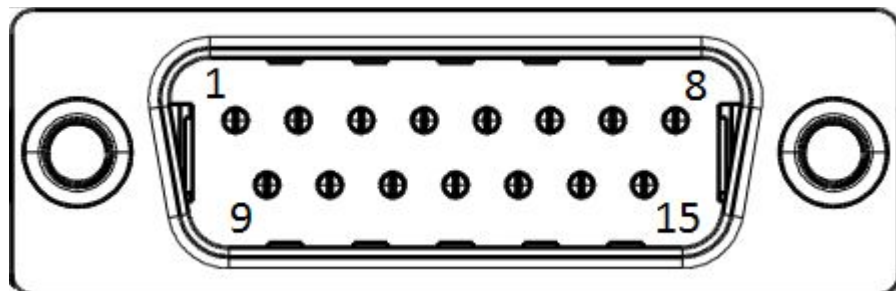


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### 3.2 Connector – PWR & CAN

Pin	Function	Comment
1	CAN-1-H	
2	CAN-1-L	
3	CAN-2-H	
4	CAN-2-L	
5	CAN-3-H	
6	CAN-3-L	
7	INPUT-POWER	Tied to pin 14
8	GND	Reference for INPUT-POWER
9	DIG-INPUT-3	Internal pull-down
9	DIG-OUTPUT-3	Sourcing current
10	LIN-1	LIN bus 1 input/output
10	DIG-INPUT-1	Internal pull-up
10	DIG-OUTPUT-1	Sinking current
11	DIG-INPUT-4	Internal pull-down
11	DIG-OUTPUT-4	Sourcing current
12	LIN-2	LIN bus 2 input/output
12	DIG-INPUT-2	Internal pull-up
12	DIG-OUTPUT-2	Sinking current
13	START-SIGNAL	Must be high for the unit to start
14	INPUT-POWER	Tied to pin 7
15	GND	Reference for INPUT-POWER
S	GND	The shield acts as a general purpose GND

\* Grey rows are secondary functions, selectable by software.



Mating connector: D-Sub 15-pin female  
 Connector on MX-4: D-Sub 15-pin male

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## 4 Features

### 4.1 Digital Inputs

There are four digital inputs available, two of which has internal pull-up, and two of which has internal pull-down. Two are also used for LIN, and all are also used for digital out. See “3.2 Connector – PWR & CAN”.

#### 4.1.1 Level Definitions for Inputs with Internal Pull-Up

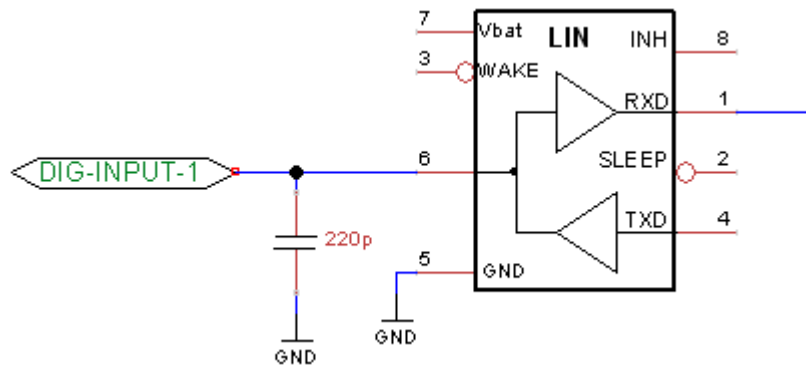
These pins also have LIN functionality and the inputs uses the LIN transceiver.

Negative going threshold:  $\text{Max } 0.4 * \text{INPUT-POWER}$

Positive going threshold:  $\text{Min } 0.6 * \text{INPUT-POWER}$

Input hysteresis:  $\text{Max } 0.175 * \text{INPUT-POWER}$

Internal pull-up: 20-47k ohm (typ 30k ohm)



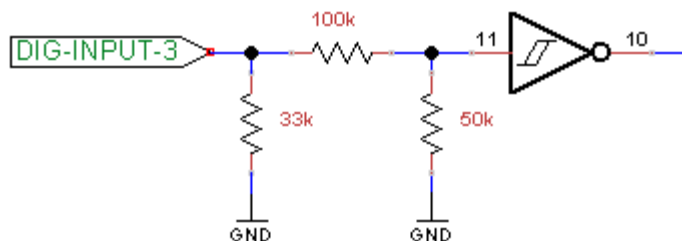
#### 4.1.2 Level Definitions for Inputs with Internal Pull-Down

Negative going threshold:  $\text{Min } 1.8 \text{ V}$

Positive going threshold:  $\text{Max } 7.1 \text{ V}$

Hysteresis:  $\text{Min } 0.9 \text{ V}$

Internal pull-down: 33k ohm (see schematic below)



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## 4.2 Digital Outputs

There are four digital outputs available, two of which can source current, and two of which can sink current. See “3.2 Connector – PWR & CAN” and “4.1 Digital Inputs”.

### 4.2.1 Level Definitions – Sourcing Outputs

Output high min: INPUT-POWER – 1.5V

Internal pull-down: 33 k ohm

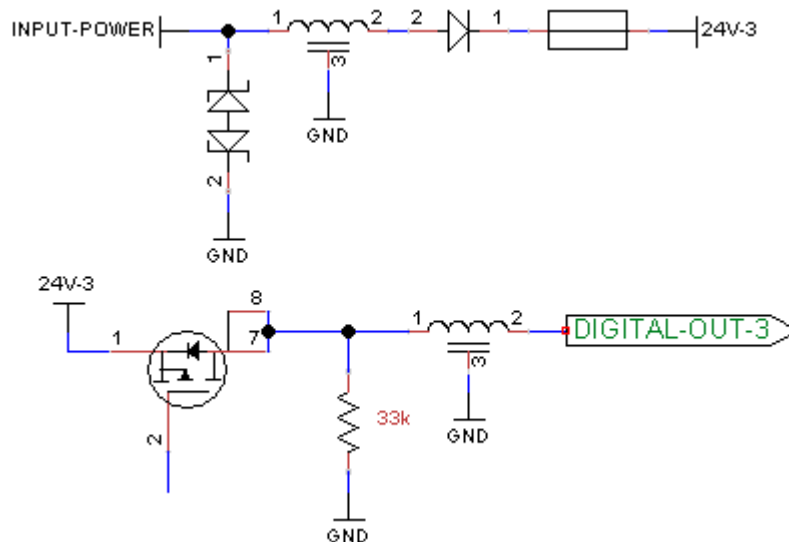
The two current sourcing digital outputs share the same over current protection fuse. The fuse is automatically resettable and limits the current in a short circuit or over current situation. The fuse will reset as soon as the combined current on both outputs drops down to normal. When the fuse has tripped, the voltage on the digital outputs will be limited and will depend on the current.

Current must be held lower than 260 mA in total on both outputs, over the entire temperature span. If the temperature is below +40 °C, the outputs can source 400 mA in total.

Actual current limiting starts at 1 - 1.5 A

The outputs can withstand short current spikes of up to 1 A without limiting the current.

The voltage after the fuse can be read by software to determine if the fuse limits the output voltage.



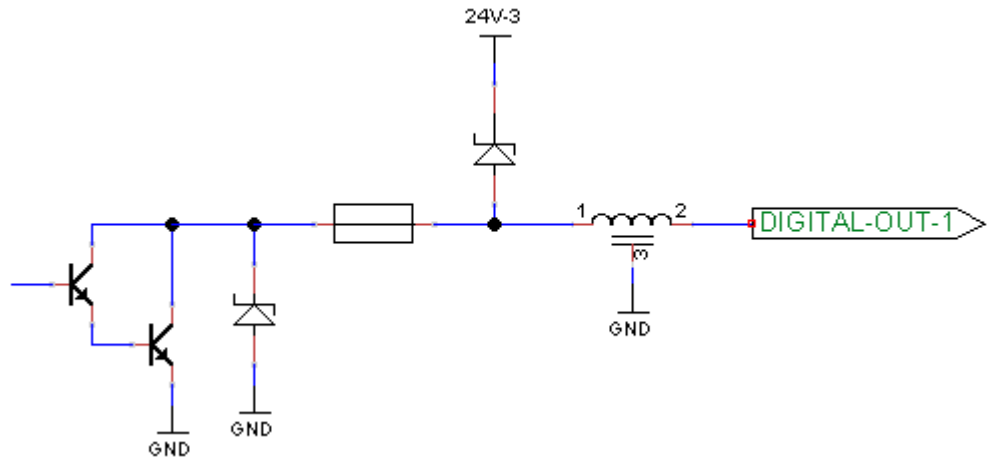
### 4.2.2 Level Definitions – Sinking Outputs

Sinking current: Max 100 mA

Output low: Max 1 V @ 100 mA

Max voltage: 32 V or INPUT-POWER, whichever is lowest.

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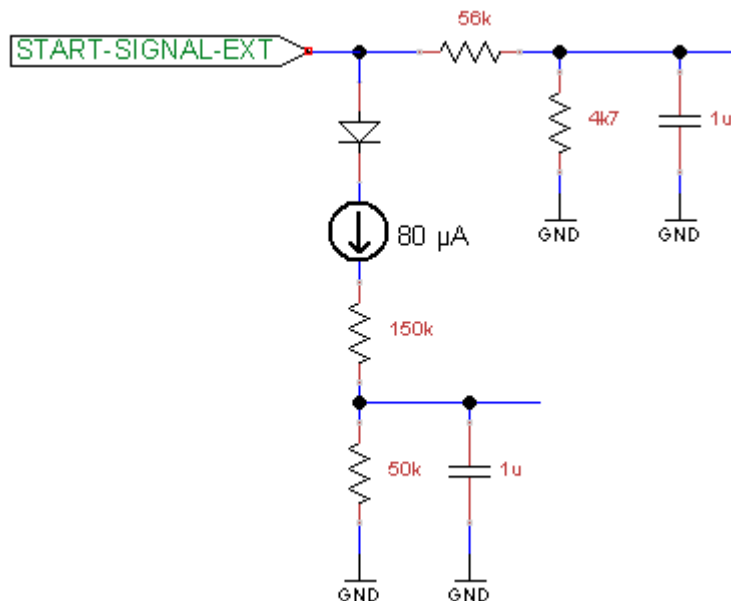
### 4.3 Start Signal

For the unit to boot, this input (START-SIGNAL) must be high if the “Start Signal Slide Switch” is set to “EXT”. After unit has booted, the signal can go low without the unit shutting down.

This input can be read from software, just like ANALOG-IN-1.

The same input is found in both connectors, and are only separated using two diodes. Therefore, if one of the to pins are high, the state of the other pin doesn't matter.

If START-SIGNAL is low, a software shutdown will put the unit in CUT OFF mode (see “Power Modes”). When START-SIGNAL goes low, the system will operate as before until your application decides to initiate a software shutdown into CUT OFF mode.





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### 4.3.1 Start Signal Slide Switch

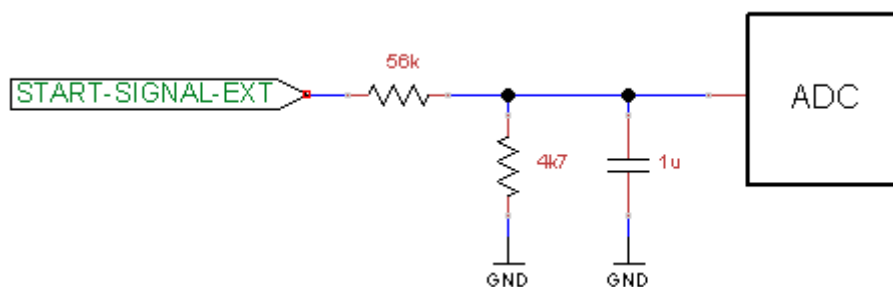
Using a Slide Switch which is reachable externally, the external START-SIGNAL can be overridden. This enables the unit to boot even without the start signal attached, but prohibits the unit from entering CUT OFF mode when the input voltage is connected. See “Power Modes”.

### 4.4 Analog inputs

There are no dedicated analog inputs in MX-4 V61, but the START-SIGNAL can measure voltage in the range 0 – 32 V.

This analog input is connected to the 12 bit ADC through a voltage divider which translates to ~8 mV per bit.

The tolerance in resistors used for the voltage divider can be compensated for by calibration in software.



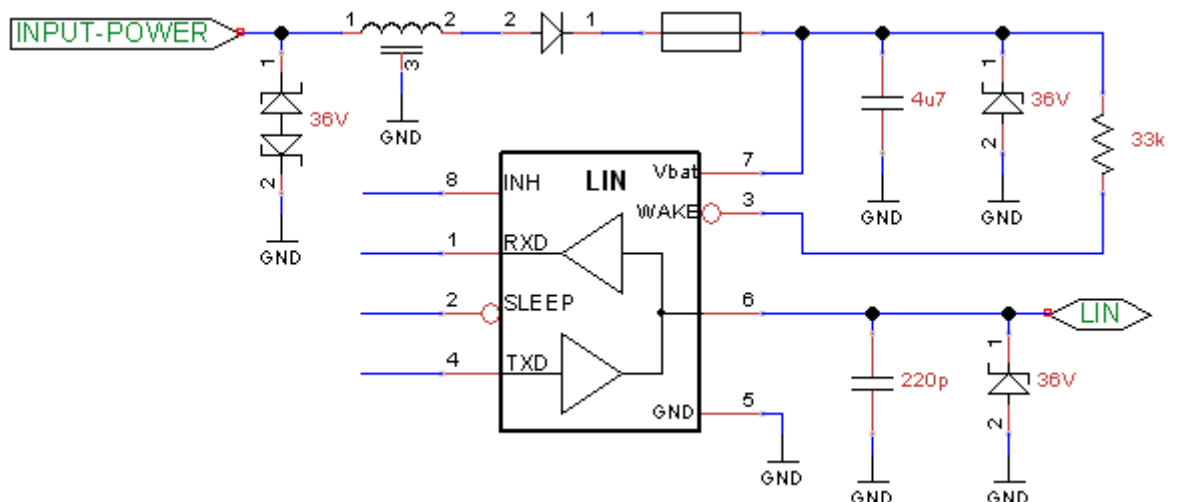
### 4.5 LIN

Up to 20 kBd.

There isn't a LIN master resistor included in the product, so if the LIN should be operated in master mode, this resistor has to be connected externally.

The LIN interfaces support Master mode and listen only mode.

LIN can be used as a wake-up source from sleep mode.



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## 4.6 Ethernet

Standard Ethernet connector with two LEDs to indicate communication, see “LED indicators” for more information.

10/100 Mbit/s Full-duplex Ethernet controller.

## 4.7 CAN

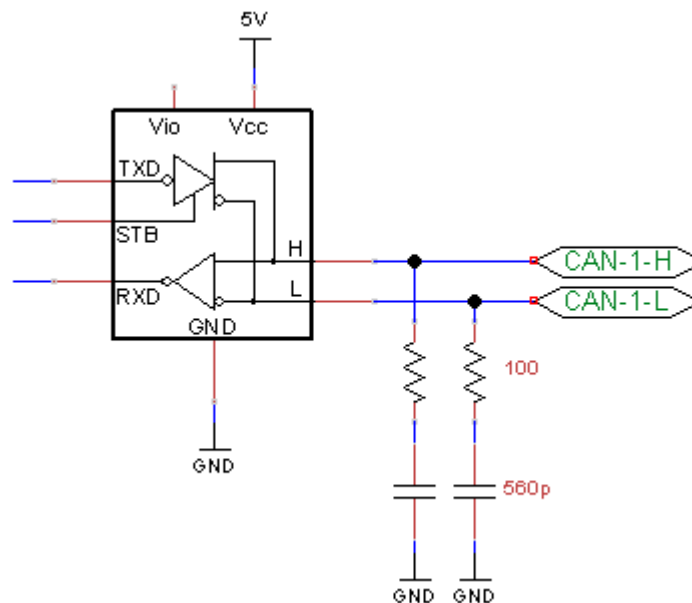
CAN 2.0B, ISO11898, capable of running 1 Mbit/s.

The CAN controllers are exposed via the standard Linux SocketCAN API.

CAN bus terminated according to SS-ISO15765-4:2011(E) part 12.4.2.3.3. This is a termination method called AC termination, used for diagnostic tools which are connected to a stub on the CAN bus. Since the CAN bus already has two endpoints with resistor terminations, it's not allowed to terminate the CAN bus in MX-4 with a resistor.

The three CAN channels can be configured individually as wake-up sources from sleep or deep sleep. If a CAN channel is configured for wake-up, the unit will wake up as soon as any communication takes place on the CAN channel. See “Power Modes”.

Please note that the first two CAN channels are high performance, but the third CAN channel is somewhat limited in performance and might miss frames on a CAN bus with heavy load.



### 4.7.1 Frame timestamps

Every CAN frame received is timestamped in the lowest possible level.

A can frame has the following flow up to the application:

CAN BUS → CAN controller → Linux kernel driver → Network stack → User application.

Linux kernel driver is where the frame will get a time-stamp. The delay from CAN controller to Linux kernel driver is 15-30  $\mu$ s, which means that one will get a CAN frame time-stamp that has a 15-30  $\mu$ s offset.

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#### 4.7.2 System load when logging CAN

Since the device will be mostly used to log CAN data it makes sense to write down the performance limits.

The most crucial job the main CPU has is to empty out CAN data from the CAN controllers. Since the external CAN controllers do not have any significant buffer space the CAN data needs to be read-out immediately otherwise we would get overflows in the controller. Thankfully we have a dual-core 1 GHz CPU which manages to do this job without exhausting all the CPU resources.

We will define the worst case scenario as 90 % buss-load on 6 CAN channels at 1 Mbit/s.

The worst case scenario will produce an interrupt load on the CPU which takes approximately 30 % off one CPU core. That means we have 170 % of CPU resources left for applications and other kernel services. So clearly the CPU speed is not a problem here.

There is one limitation observed when testing the worst case scenario. If we are to dump all the CAN data from the worst case example to a SD card there is chance that we will drop/miss frames. It is not the SD card write speed that is the limitation but the system latency created when writing to SD card. Latency can be defined as the elapsed time (delay) between the generation of an event (hardware interrupt) and its realization. This limitation has not been observed when storing the data on the integrated flash storage or at lower speeds (e.g. 500 Kbit/s).

#### 4.8 Accelerometer

Freescale MMA8452Q connected to main CPU. Can be used as a wake-up source in sleep mode.

#### 4.9 $\mu$ SD-Card

It's possible to extend the flash memory using a  $\mu$ SD memory card.

The  $\mu$ SD card is only accessible internally and the PCB has to be removed from the aluminum profile for the  $\mu$ SD card to be accessible.

#### 4.10 Console

UART with TTL levels available internally. Used for development only. Cable can be supplied by Host Mobility.

#### 4.11 USB

The unit has one selectable USB host/device port.

The connector is a standard type A connector, but with high retention for a secure connection in automotive environment.

The port supports USB 2.0 High Speed (480 Mbit/s).

When the system is booted, the host/device port will enter device mode if a cable is connected between this port and a powered USB port of a computer or similar.

When the system has booted, the port can be reconfigured to host or device by software.

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#### 4.12 GSM/GPRS/3G

Gemalto PHS8-P. Only external antenna.

The MX-4 can be equipped with a LTE module instead of 3G. In this case the Gemalto PHS8-P is changed to a PLS8-E or PLS8-US module instead.

Antenna connector: FAKRA Code D (Bordeaux)

Five Bands UMTS/HSPA+: 850/800, 900, 1900 and 2100 MHz

Quad-Band GSM: 850/900/1800 and 1900 MHz

HSDPA Cat. 10 / HSUPA Cat.6

Data rates: max. 14.4 Mbps DL, max. 5.76 Mbps UL

Internally a USB interface is used for communication with the module. The co-CPU controls and monitors the module, but communication over USB is directly between the main CPU and the module.

#### 4.13 GPS/GLONASS

Cinterion PHS8-P. Only external antenna.

Antenna connector: FAKRA Code C (Blue)

Frequency GPS: 1575.42 MHz

Frequency GLONASS: 1601.72 MHz

Tracking Sensitivity (Open sky): -159 dBm

Acquisition Sensitivity (Open sky): -149 dBm

Cold Start sensitivity: -145 dBm

Channels: 40

Internally a USB interface is used for communication with the module.

#### 4.14 UPS

**NOTE!** When the battery is connected the super capacitor is disabled. This is to prevent current loads between these two since they are on the same voltage rail.

##### 4.14.1 System Battery

Battery is **NOT** mounted by default.

Lithium battery 3.7 V 1050 mAh.

This battery is always being charged if the unit is powered and START-SIGNAL is high, or if the system has booted. The only exception is if the unit is set to a mode where no current shall be consumed from the vehicle (but instead from the battery), even though the unit is powered.

The unit is fully functional when the input power is disconnected if the internal lithium battery is charged, with a few exceptions listed below.

- The current sourcing digital outputs and LIN communication will not be functional since these rely on the input voltage.

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#### 4.14.2 Super Capacitor

A super-cap is used for short term power loss protection. A capacitor of 2.5 F is connected to the 4V power rail. The super-cap is slow charged through a current limiter so that the current consumption of the unit is limited to a reasonable level during boot. Once an appropriate charge level has been reached, it is brought online on the 4V power rail and the protection is active. This is designed to give at least 500 ms power interrupt protection.

The super-cap must be charged for 30-35 s before it can be connected to the 4V power rail, which means that it won't help during a power loss if the power loss takes place within 30-35 s after the unit has been powered.

If a Lithium battery is connected, the charging of the super-cap is deactivated. This is a safety mechanism to ensure that the super-cap won't cause an inrush current to the battery when input power is lost. This means that as long as a lithium battery is connected, the super-cap is deactivated and doesn't help during power loss.

#### 4.15 RTC/GPS Backup Battery

Standard CR1225 Battery 3V 48 mAh 12x2.5 mm

The battery ensures that the system time is maintained during power loss. Empheris data and time/date of the GPS is also backed up, which helps the GPS receive a fix position much quicker if the power loss is less than about two weeks.

The battery is not rechargeable, but is only in use when the unit isn't powered. If the unit is placed on a shelf for a long time, the battery will discharge and needs to be changed.

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## 5 Power

### 5.1 Input Voltage

Input voltage range: 8 – 36 V DC

8-30 V is the recommended input voltage, but MX-4 can withstand up to 40 V continuously without breaking. MX-4 can also withstand transients of much higher voltage.

### 5.2 Battery Powered

Battery is **NOT** mounted by default.

The unit is fully functional when the input power is disconnected if the internal lithium battery is charged, with a few exceptions. The current sourcing digital outputs and LIN communication will not be functional since these rely on the input voltage.

There is a software configuration which enables the unit to run on battery overriding input voltage.

### 5.3 Reset

The unit has a reset button which can be reached from outside of the enclosure through a small hole using a pen or similar can be used to reset the unit.

### 5.4 Power Modes

There are six power modes:

- **RUNNING** – CPU resources and communication interfaces are being used.
- **IDLE** – CPU resources are not being used (CPU in idle) and no communication interfaces are being used.
- **SLEEP** – Main CPU is suspended to RAM, micro-controller runs on 32 kHz and is in cyclic sleep, some internal power rails are turned off. Fast resume of operation.
- **DEEP SLEEP** – Most internal power rails are turned off, including power rail to the main CPU. Cold boot on wake-up.
- **CUT OFF** – Everything is turned off on the board. The unit can only wake-up (boot) using the START-SIGNAL and/or “Start Signal Slide Switch”.
- **BATTERY** – Fully running, but consuming current from the internal battery instead of INPUT-POWER. If INPUT-POWER is connected, the current sourcing digital outputs, LIN communication and non controllable VOLTAGE-OUTPUT will be functional, but their current will be consumed from INPUT-POWER, despite the chosen operating mode.

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## 5.5 Wake-Up Sources

The different operating modes are controlled by software. The following wake-up events are supported (these apply to SLEEP and DEEP SLEEP modes).

- Digital inputs
- Accelerometer interrupt (motion, orientation, transient or tap event). (\*)
- RTC
- GSM/GPRS/3G Ring or SMS
- Low input voltage
- Analog input
- CAN traffic
- LIN traffic

(\*) – Accelerometer can not be used to wake-up from DEEP SLEEP mode.

## 5.6 Current Consumption

Mode	Consumption
RUNNING (*)	Avg = TBD mA @ 24 V Max = TBD mA @ 24 V Avg = TBD mA @ 12 V Max = TBD mA @ 12 V
IDLE	52 mA @ 24 V 95 mA @ 12 V
SLEEP	7.0 mA @ 24 V 9.8 mA @ 12 V
DEEP SLEEP	1.6 mA @ 24 V 2.5 mA @ 12 V
CUT OFF	0.3 mA @ 24 V 0.2 mA @ 12 V
Before first boot	2.1 mA @ 24 V 1.3 mA @ 12 V

(\*): In running mode with 100 % CPU load, Ethernet and modem where transmitting.

## 6 LED Indicators

Three green/orange biLEDs.

- **PWR**. Indicates the current operating mode.
- **GSM**. General purpose, intended to show connectivity of 3G-modem.
- **GPS**. General purpose, intended to show status of the GPS.

And one green/red biLED.

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- **FUNC.** General purpose, intended to show status of the unit.

There is also two LEDs on each of the two RJ45 Ethernet connectors.

- **RJ45-Left.** On when a connection is established on the Ethernet interface. Blinking when communication takes place.
- **RJ45-Right.** On when the Ethernet controller is connected to a 100Base-TX network. Off if connected to a 10Base-T network, or not connected at all. If this LED is off, but the left LED is on or blinking, the network is a 10Base-T network.

## 7 Enclosure

Material: Alumina body with plastic sides.

Coating: Black powder coating

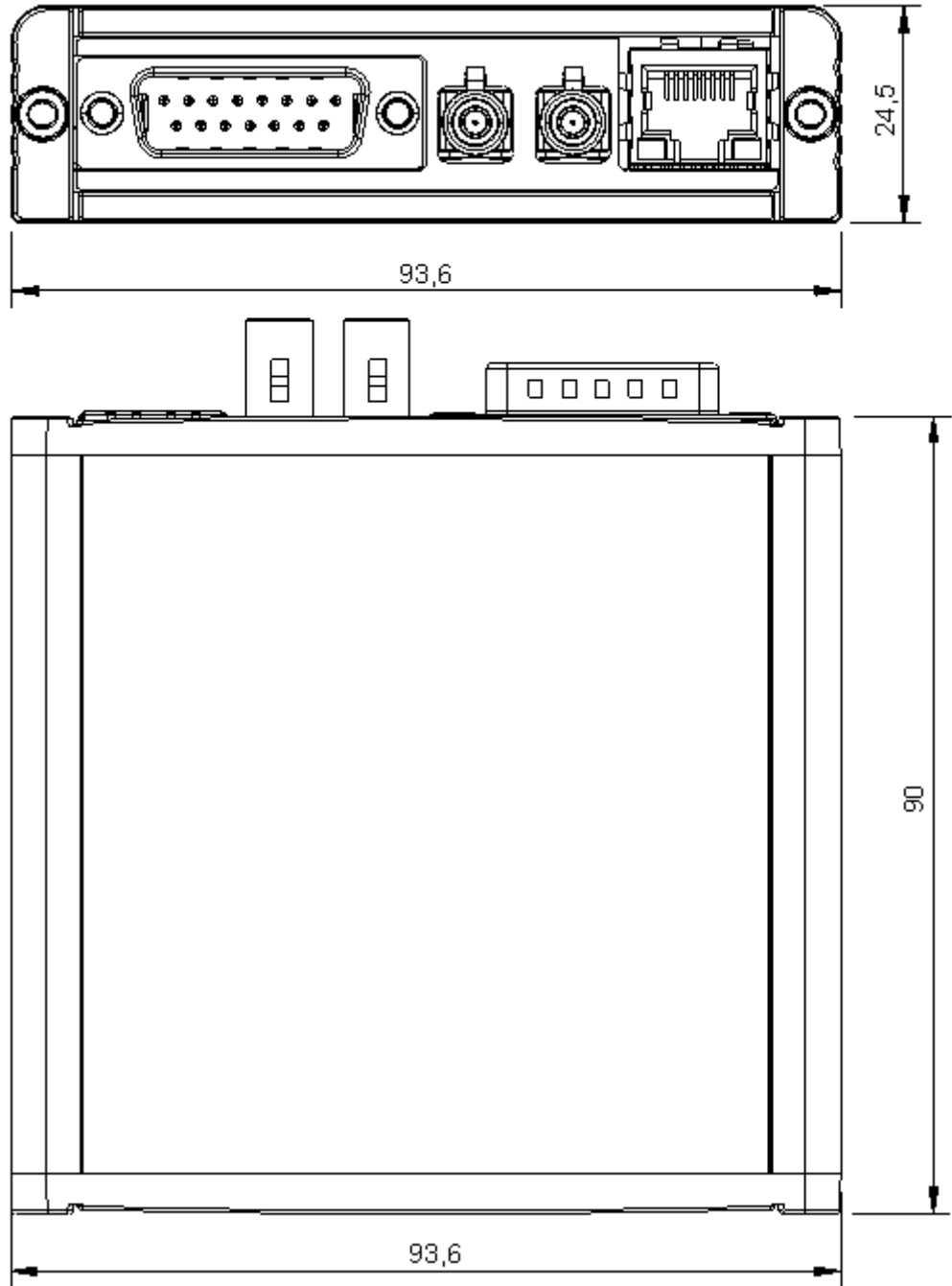
Dimensions: 93.6x90x24.5 mm

Weight: TBD g

IP-class: IP30



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**8 Mounting**

The unit is designed to withstand vibrations and shocks in a vehicle environment. A mounting shackle supplied by Host Mobility should be used for a secure mounting.

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## 9 Environment

### 9.1 Operating Temperature

Parameter	Min	Max	Unit
Operating temperature range (*)	-40	+85	° C

(\*) Note: The modem will only function at -40 °C for a short while. It will eventually shut down if temperature is below -30 °C or above +85 °C.