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Approved		Date	Rev	Reference
			PA3	

Technical description MX-4 T30 FR 4G EU

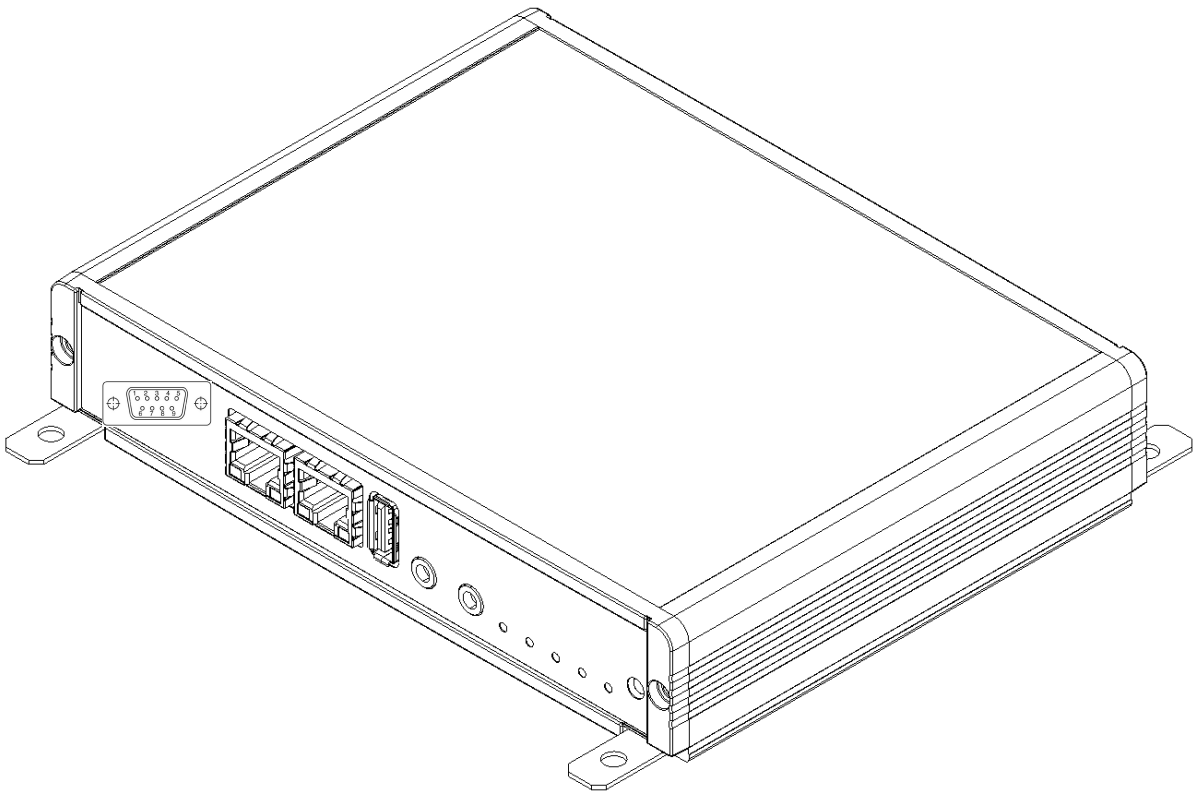

Table of Contents

1 General Description 2
2 Soft Deliverables 3
3 Connectors 4
4 Features 8
5 Power 20
6 LED Indicators 22
7 Enclosure 22
8 Mounting 23

9 Environment..... 23

1 General Description

1.1 Features

- ARM Cortex-A9 CPU, Up to 1.4 GHz, Quad Core
- 4 GB flash, 1 GB RAM
- Linux 3.1.10 operating system
- Analog stereo audio out and mono in (microphone) interface
- Penta Band LTE (4G) module
- 802.11 b/g/n WiFi
- 2 x 10/100 Mbit/s Ethernet
- 1 x USB 2.0 high-speed host
- 1 x USB 2.0 high-speed host/device (auto detect)
- 1 x Flexray 2.1 / 2.1RevA
- 6 x CAN 2.0 B
- 2 x LIN buses
- 6 x Digital inputs
- 6 x Digital outputs
- 1 x Tachometer input
- 1 x AUX Voltage output
- 1 x Start signal input (to boot the system using external signal)
- 2 x Analog inputs, 0–32 V (including the start signal)
- Start switch (to boot the system manually)
- Buzzer
- µSD-card interface
- Operating temperature: -40 to +85°C
- Internal Lithium battery: 1050mAh, -20 to +60°C (can be removable)
- Super Capacitor
- Low power sleep mode
- Input voltage range: 8–36 V

1.2 Intended Use

The MX-4 T30 FR is intended as vehicle telematics computer.
It includes a long range of automotive communication interfaces and it is able to carry a customer-specific diagnostics or fleet management application.

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
  - Tegra3: Linaro GCC 4.7-2013.09 (http://releases.linaro.org/13.09/components/toolchain/gcc-linaro/4.7)
- Linux (Tegra3: 3.1.10)
- U-boot (Tegra3: 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.

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.

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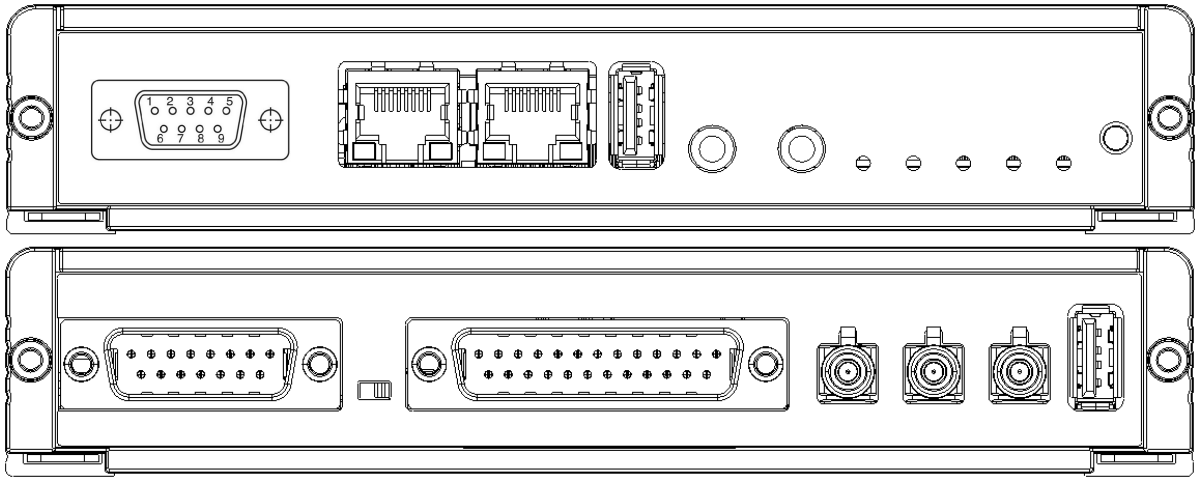
3 Connectors

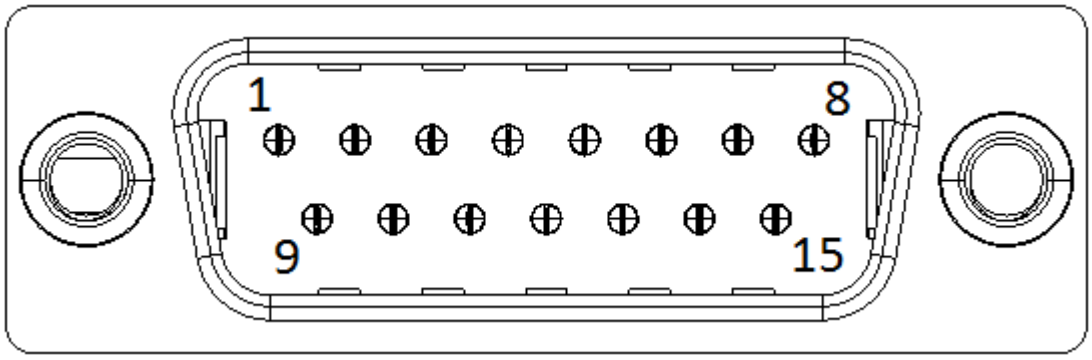
3.1 Connection Layout



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	CAN-4-H	
10	CAN-4-L	

11	CAN-5-H	
12	CAN-5-L	
13	START-SIGNAL	Must be high for the unit to start, tied to pin 23 in other D-sub
14	INPUT-POWER	Tied to pin 7
15	GND	Reference for INPUT-POWER
SH	GND	Shield is also connected to the common GND



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

3.3 Connector – I/O & LIN

Pin	Function	Comment
1	GND	Reference for all I/O and communication buses
2	CAN-6-H	
3	CAN-6-L	
4	DIG-INPUT-1	Internal pull-up
5	DIG-INPUT-2	Internal pull-up
6	DIG-INPUT-3	Internal pull-up
7	DIG-INPUT-4	Internal pull-up

8	DIG-INPUT-5	Internal pull-down
9	DIG-INPUT-6	Internal pull-down
10	PULSE-COUNTER	Input for tachometer
11	DIG-OUTPUT-5V	Digital 5V output, for peripherals
12	GND	Reference for all I/O and communication buses
13	GND	Reference for all I/O and communication buses
14	LIN-1	LIN bus 1
15	LIN-2	LIN bus 2
16	DIG-OUTPUT-1	Sourcing current
17	DIG-OUTPUT-2	Sourcing current
18	DIG-OUTPUT-3	Sourcing current
19	DIG-OUTPUT-4	Sourcing current
20	DIG-OUTPUT-5	Sinking current
21	DIG-OUTPUT-6	Sinking current
22	ANALOG-IN-1	0-32 V input
23	START-SIGNAL	Must be high for the unit to start, tied to pin 13 in other D-sub
24	VOLTAGE-OUTPUT	Outputs the input voltage, not controllable, current limited
25	GND	Reference for all I/O and communication buses
SH	GND	Shield is also connected to the common GND

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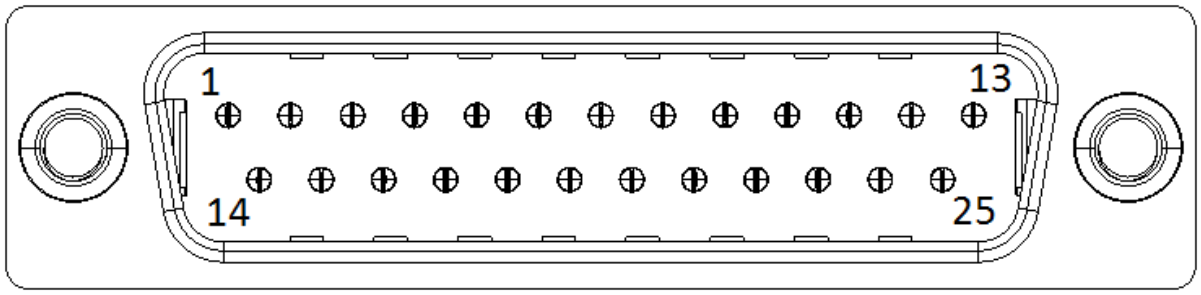
		1/1301-HMP075/4		
Approved		Date	Rev	Reference
			PA3	

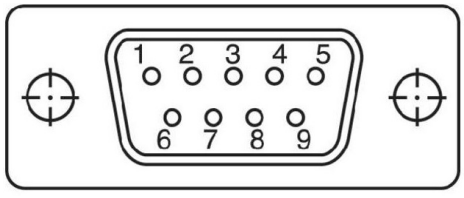


Mating connector: D-Sub 25-pin female

Connector on MX-4: D-Sub 25-pin male

3.4 Connector – FlexRay

Pin	Function	Comment
1	NC	Not connected
2	FRAY1-BM	
3	GND	
4	FRAY2-BP	Not activated
5	NC	Not connected
6	NC	Not connected
7	FRAY1-BP	
8	FRAY2-BM	Not activated
9	NC	Not connected

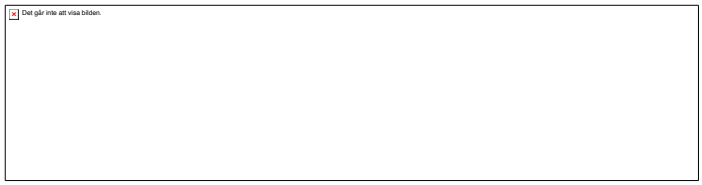


Mating connector: D-Sub 9-pin female

Connector on MX-4: D-Sub 9-pin male

3.5 Connector – Audio Output

Pin	Function	Comment
Tip	AUDIO-OUT-L	Linux platform audio output, left
Ring	AUDIO-OUT-R	Linux platform audio output, right
Sleeve	GND-A	Reference for audio interface

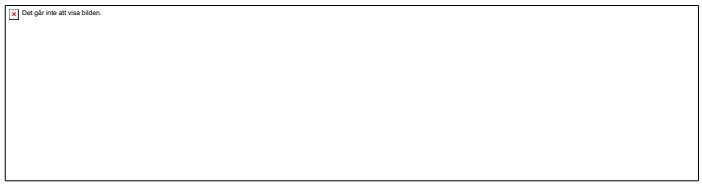


Mating connector: 3.5 mm stereo phone plug (male)

Connector on MX-4: 3.5 mm stereo phone jack (female)

3.6 Connector – Audio Input

Pin	Function	Comment
Tip	AUDIO-IN-L	Linux platform audio input, left, biased to 3.3V for microphone.
Ring	N/A	N/A
Sleeve	GND-A	Reference for audio interface



Mating connector: 3.5 mm stereo phone plug (male)

Connector on MX-4: 3.5 mm stereo phone jack (female)

4 Features

4.1 Digital Inputs

There are six digital inputs available, four of which has internal pull-up, and two of which has internal pull-down. See “3.3 Connector – I/O & LIN”.

4.1.1 Level Definitions for Inputs with Internal Pull-Up

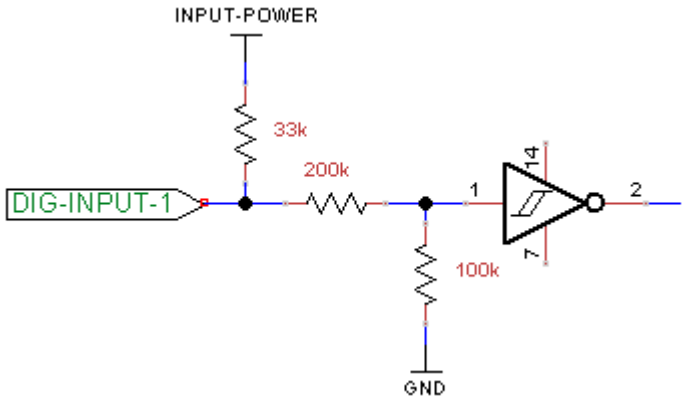
Negative going threshold: Min 1.8 V

Positive going threshold: Max 7.1 V

Hysteresis: Min 0.9 V

Internal pull-up: 33k ohm

Internal pull-up will pull input high if input voltage is > 8 V

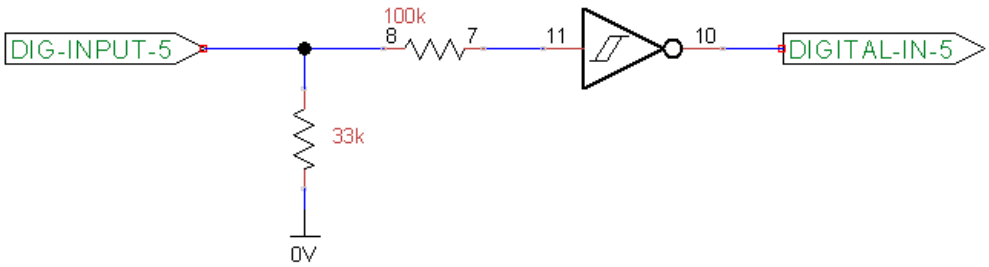


4.1.2 Level Definitions for Inputs with Internal Pull-Down

Negative going threshold: 0.6V – 1.5V, Nominal 1.0 V

Positive going threshold: 1.2V-2.4V, Nominal 1.8 V

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



4.2

4.3 Pulse Counter Input

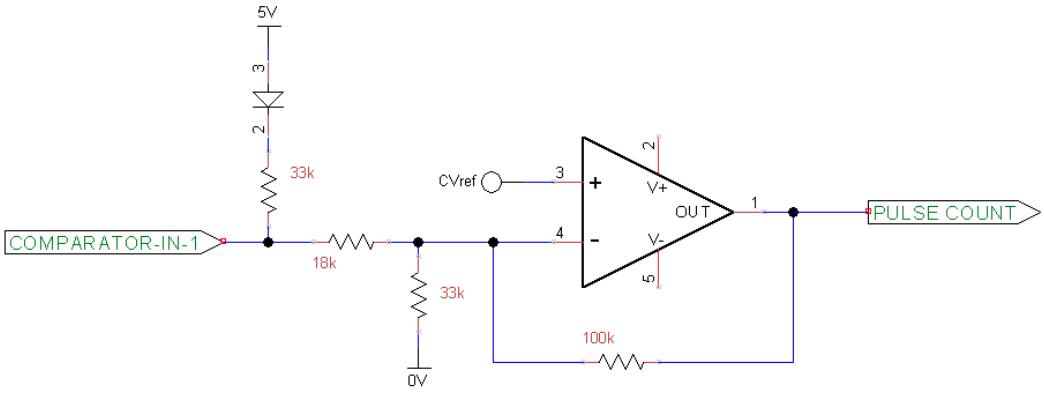
This input is intended to be used with a tachometer output. The number of pulses registered on this input is counted by the micro-controller and is made available to the system.

The CVref is set in the micro-controller firmware and can be changed by Host Mobility.

Cvref: ~1.05 V

Negative going threshold: 1.2V

Positive going threshold: 1.8V



4.4 Digital Outputs

There are six digital outputs available, four of which can source current, and two of which can sink current. See “3.3 Connector – I/O & LIN”.

4.4.1 Level Definitions – Sourcing Outputs

Output high min: INPUT-POWER – 1.5V

Internal pull-down: 33 k ohm

The four 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

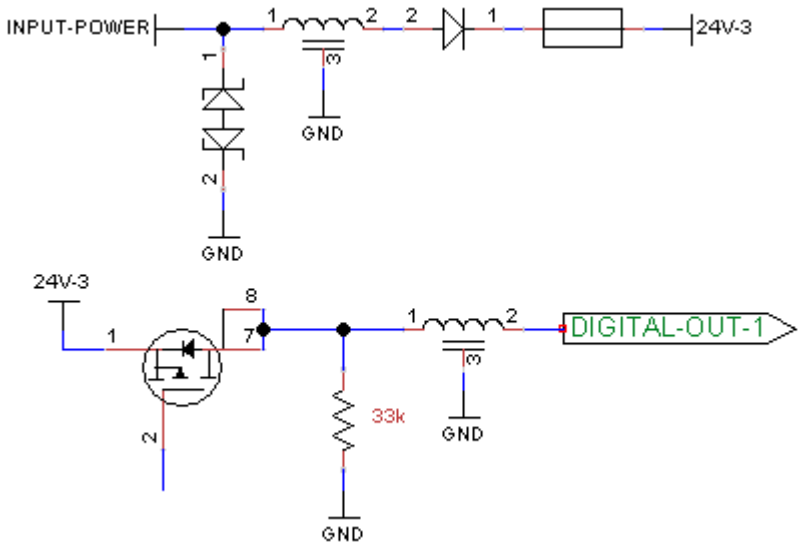
situation. The fuse will reset as soon as the combined current on all four outputs drops down to normal. When the fuse has tripped, the voltage on the digital outputs will be limited and will depend on the current.

Current must be held lower than 260 mA in total on all four 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.



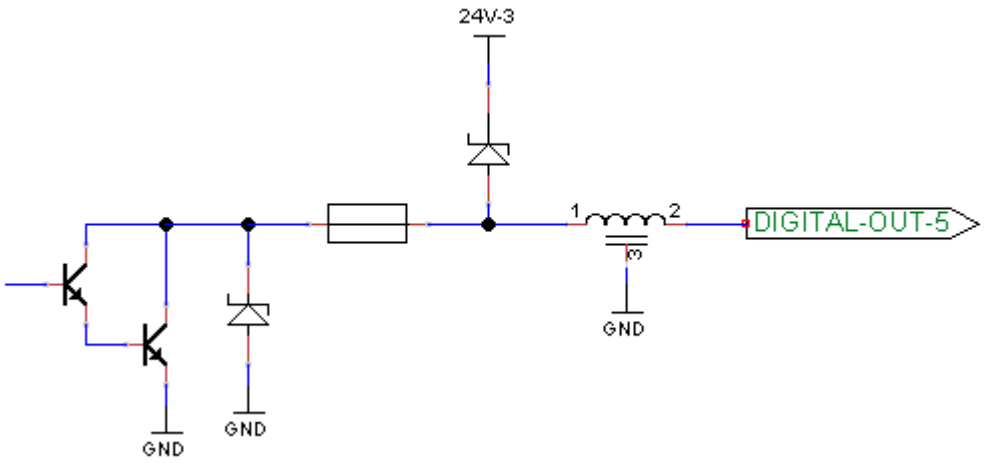
4.4.2 Level Definitions – Sinking Outputs

Sinking current: Max 100 mA

Output low: Max 1 V @ 100 mA

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

Prepared (also subject responsible if other)		No.		
		1/1301-HMP075/4		
Approved		Date	Rev PA3	Reference

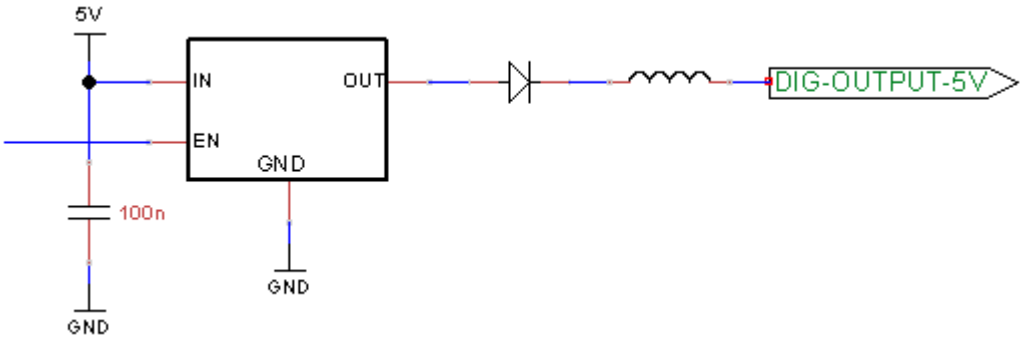


4.5 *Digital 5V Output*

This digital output can supply 5V to peripherals so that they don't need to include an advanced power supply. Current limited to 0.7 - 1.3 A

Output voltage: ~4.6 V

Output current: Up to 500 mA



Prepared (also subject responsible if other)		No. 1/1301-HMP075/4		
Approved		Date	Rev PA3	Reference

4.6 Voltage Output

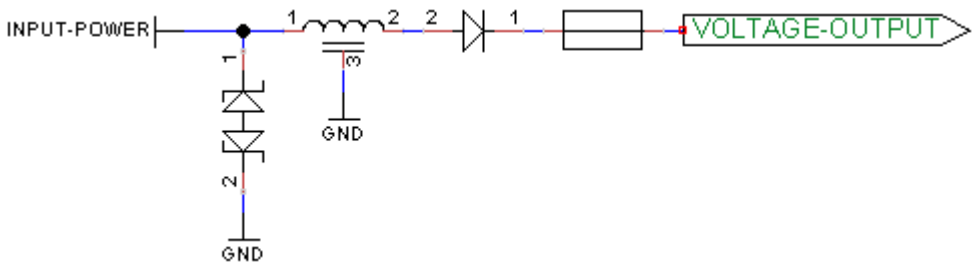
The voltage output pin (VOLTAGE-OUTPUT) is connected to the input voltage through an automatically resettable fuse which limits the current in a short circuit or over current situation. The fuse will reset as soon as the current drops down to normal.

Current must be held lower than 260 mA, over the entire temperature span. If the temperature is below +40 °C, this output can source 400 mA.

This output is non-controllable and is always available if the unit is powered through the input voltage pin. It cannot output any voltage if the unit is only powered by the internal lithium battery.

This output can be used to power peripherals or be connected to the START-SIGNAL by external logic to boot the unit.

Output voltage min: INPUT-POWER – 1.5V



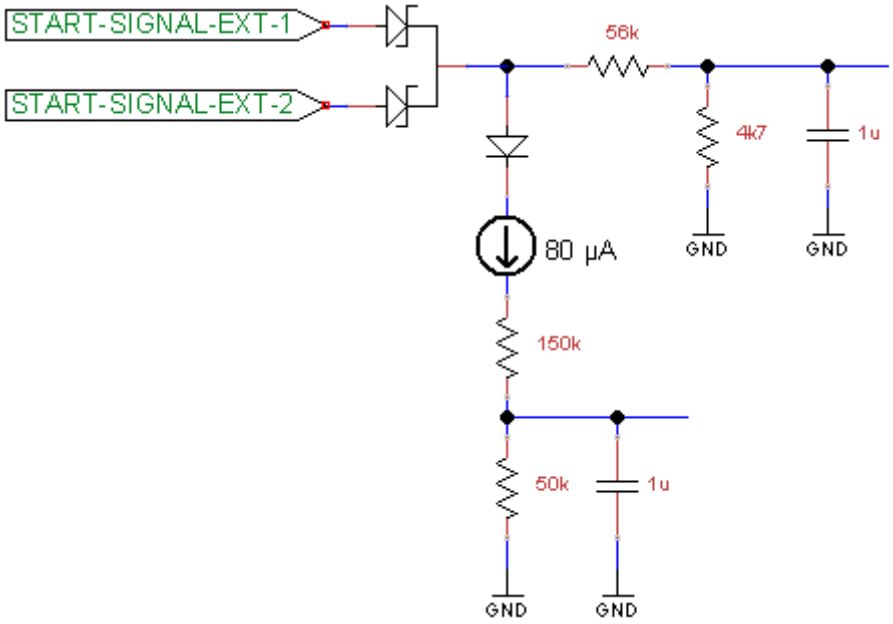
4.7 Start Signal

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.



4.7.1 Start Signal Slide Switch

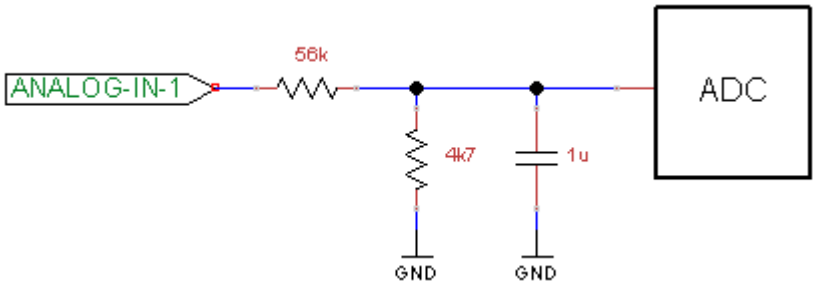
Using a Slide Switch which is reachable externally, the external START-SIGNAL can be overridden. This enables the unit to boot even without the start signal attached, but prohibits the unit from entering CUT OFF mode when the input voltage is connected. See “Power Modes”.

4.8 Analog inputs

There are two analog inputs on this board. Both the START-SIGNAL and the ANALOG-IN-1 can measure voltage in the range 0 – 32 V.

The analog inputs are connected to the 12 bit ADC trough 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.



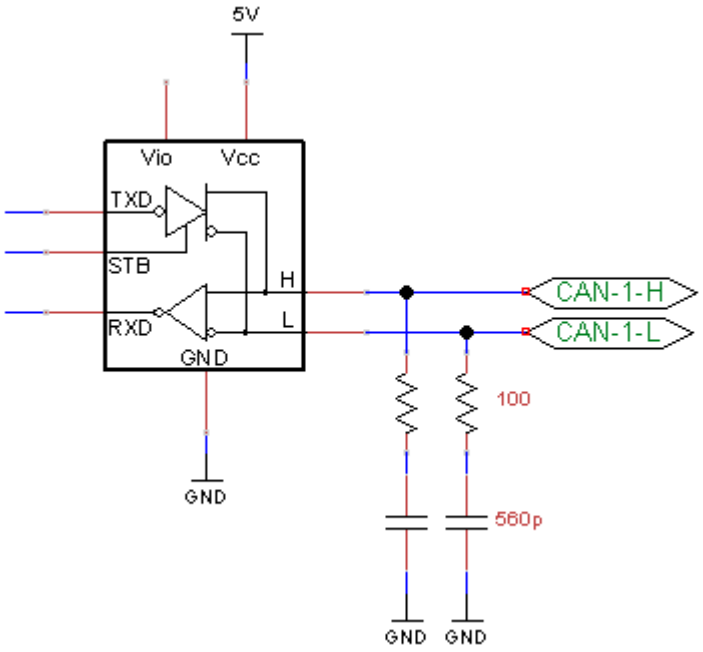
4.9 CAN

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 six 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”.



4.9.1 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 µs, which means that one will get a CAN frame time-stamp that has a 15-30 µs offset.

4.9.2 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).

4.10 Flexray

Conformance with FlexRay protocol specification v2.1

Bosch E-Ray IP core

Data rates up to 10Mbit/s

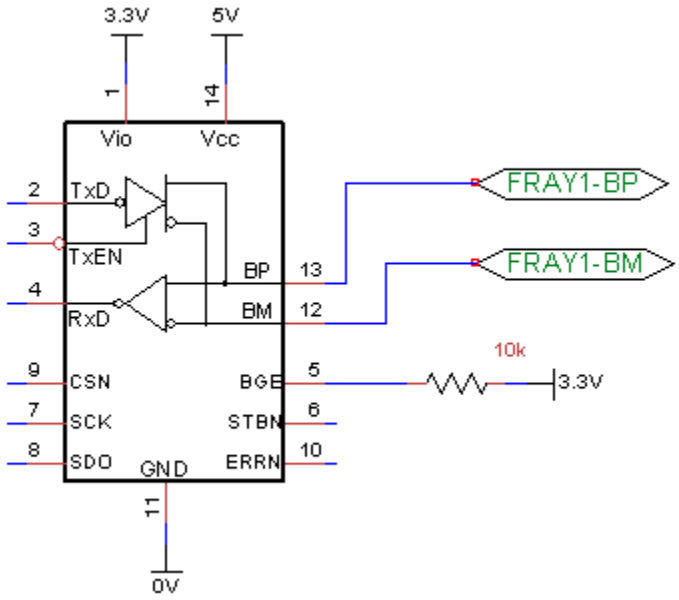
Supports dual channels, only 1 is activated.

Listen only

Can not act as a cold start device

NCV7383 FlexRay bus driver

Internally an ethernet interface is used for communication with the module.



4.10.1 Frame timestamps

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

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

FlexRay BUS → FlexRay controller → Ethernet interface → Linux kernel driver → Network stack → User application.

Linux kernel driver is where the frame will get a time-stamp. The delay from FlexRay controller to Linux kernel driver is below 100 µs, which means that one will get a FlexRay frame time-stamp that has a maximum 100 µs offset.

4.11 Accelerometer

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

4.12 µSD-Card

It's possible to extend the flash memory using a µSD memory card.

The µSD card is only accessible internally, the front gable (with Ethernet and audio connectors) must be removed for the µSD card to be accessible.

4.13 UPS

4.13.1 System Battery

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.

Battery is mounted by default. If applications do not take advantage of running on system battery and can handle loss of power with Super Capacitor only, the system battery can be removed to increase full temperature range.

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.
- The non controllable VOLTAGE-OUTPUT will go low when there is no input voltage.

4.13.2 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.

4.14 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.

4.15 Console

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

Prepared (also subject responsible if other)		No. 1/1301-HMP075/4		
Approved		Date	Rev PA3	Reference

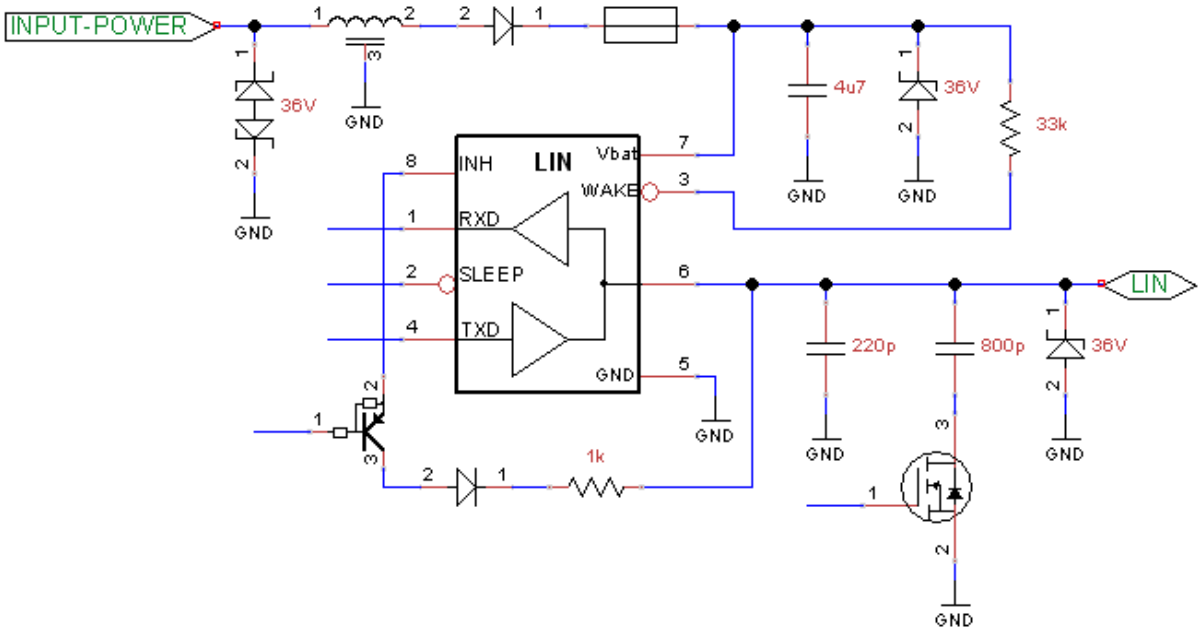
4.16 LIN

Up to 20 kBd.

LIN Master Resistor and Capacitor is connected by software when the LIN interface is set to master mode.

The LIN interfaces support Master mode and listen only mode.

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



4.17 Ethernet

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

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

4.18 USB

The unit has one dedicated USB Host port and one selectable USB host/device port.

Both connectors are standard type A connectors, but with high retention for a secure connection in automotive environment.

Both ports support USB 2.0 High Speed (480 Mbit/s).

The host/device port is placed by the Ethernet ports, and the dedicated host port is placed

next to the system connectors.

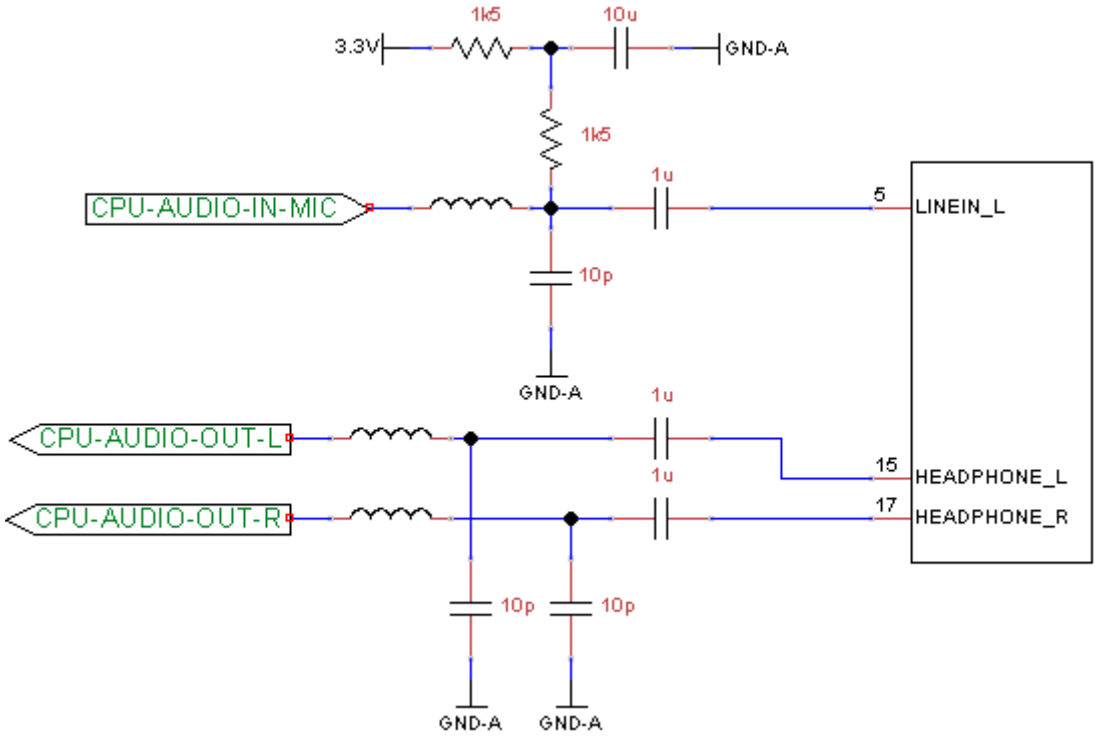
When the system is booted, the host/device port will enter device mode if a cable is connected between this port and a powered USB port of a computer or similar.

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

4.19 Platform Audio

The main CPU has an audio interface available in two standard audio connectors (3.5 mm stereo phone jack, female). Analog stereo out and analog mono in is referenced to GND-A in the same connectors.

The analog mono in is biased to 3.3V for it to be able to accept a microphone. Both the input and the outputs are single ended with a series capacitor to remove DC component.



4.20 GSM/GPRS/3G/4G

SIM card type: NanoSIM

Gemalto PLS8-E. Only one external antenna.

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

Antenna connector: FAKRA Code D (Bordeaux)

LTE: Five band, 800 (Bd20) / 900 (Bd8) / 1800 (Bd3) / 2100 (Bd1) / 2600MHz (Bd7)

UMTS/HSPA+: Triple band, 900 (BdVIII) / 1800(BdIII) / 2100MHz (BdI)

GSM/GPRS/EDGE: Dual band, 900/1800MHz

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.

4.21 GPS/GLONASS

Gemalto PLS8-E. 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.

4.22 WLAN

Texas Instruments WL1837MOD. Only external antenna.

Antenna connector: FAKRA Code I (Beige)

WiFi modes: Station (STA) and AccessPoint (AP) infrastructure mode

Standard: IEEE Std 802.11a, 802.11b, 802.11g, and 802.11n

Chipset: WL1837MOD

Transmit Power 2.4GHz: 16.5 dBm

Receive Sensitivity 2.4GHz: -95 dBm @ 6Mbps

Transmit Power 5GHz: 18 dBm

Receive Sensitivity 5GHz: -92.5 dBm @ 6Mbps

Encryption: Hardware-based encryption-decryption using 64-, 128-, and 256-bit WEP, TKIP, or AES keys

Authentication: WPS, WEP, WPA, WPA2

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

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

If battery installed, 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. Also, note that the non controllable VOLTAGE-OUTPUT will go low when there's no 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.

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

All measurements are without battery, otherwise battery will add a charge current in all modes except CUT OFF

Mode	**Consumption**
RUNNING (Average)	275 mA @ 24 V 560 mA @ 12 V
SLEEP	24mA @ 24V 46mA @ 12V

DEEP SLEEP	2.6mA @ 24V 4.0mA @ 12V
CUT OFF (*)	2.4mA @ 24V 1.4mA @ 12V

(*) Subject to further testing

6 LED Indicators

Four green/orange biLEDs.

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

And one green/red biLED.

- **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: 127x166x32 mm

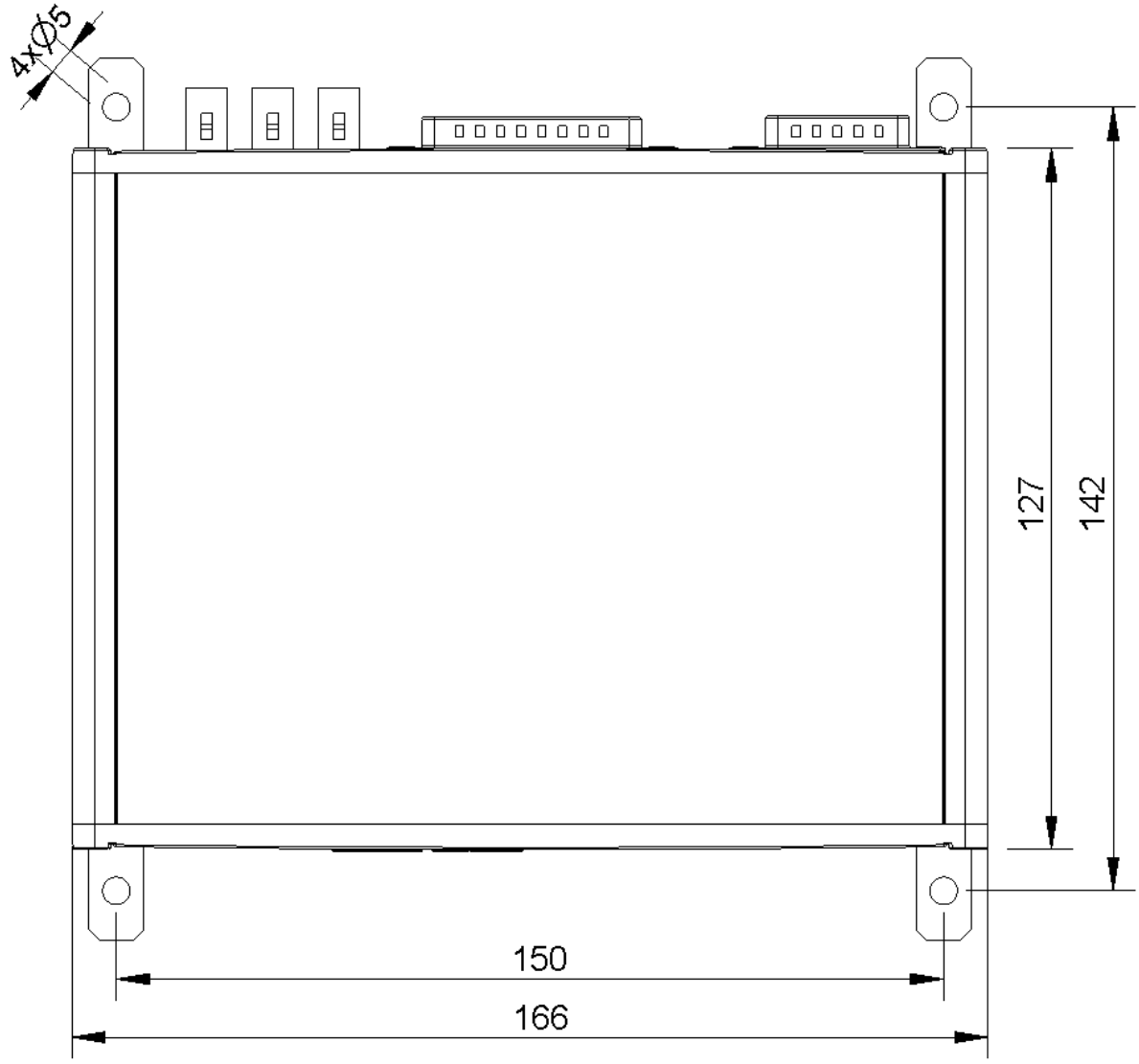
Weight: 456 g

IP-class: IP30

8 Mounting

The MX-4 is designed to withstand vibrations and shocks in a vehicle environment. Two mounting shackles supplied by Host Mobility should be used for a secure mounting.

Prepared (also subject responsible if other)		No.		
		1/1301-HMP075/4		
Approved		Date	Rev	Reference
			PA3	



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. The WiFi module is only specified to

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Approved		Date	Rev	Reference
			PA3	

+80 °C.

The main CPU will shut down in a controlled manner at +105 °C. There are several different temperature sensors available internally which the software has access to. A configurable thermal throttling mode can be used to lower the units self heating.