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LEA-4R / TIM-4R

System Integration Manual / Reference Design

Abstract

This document describes the features and specifications of the LEA-4R / TIM-4R low power DR GPS modules. It guides through a design in and provides information to get maximum GPS performance at very low power consumption.

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Manual

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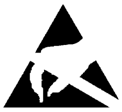	This is an Electrostatic Sensitive Device (ESD). Observe precautions for handling.

Preface

The LEA-4R / TIM-4R System Integration Manual provides the necessary information to successfully design in and configure these ANTARIS®4-based GPS receivers. This document specifically refers to the Dead Reckoning technology available in the LEA-4R and TIM-4R modules. It does not explain the ANTARIS®4 system. For detailed information regarding ANTARIS®4 technology, see the *ANTARIS®4 System Integration Manual [5].*

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Helpful Information when Contacting Technical Support

If you contact Technical Support please prepare the following information:

- Receiver type (e.g. LEA-4R / TIM-4R) and firmware version (e.g. V4.00)
- Receiver configuration, e.g. in form of a u-center configuration file.
- Clear description of your question or the problem together with u-center logfile.
- A short description of your application
- Your complete contact details

Contents

1 Dead Reckoning Fundamentals

1.1 Dead Reckoning enabled GPS (DR)

Dead Reckoning is a feature to make GPS more accurate and reliable in urban canyon environments and during GPS outages. It uses additional sensors to measure speed, heading and direction (forward / backward). Therefore a DR enabled GPS receiver consists of a GPS receiver, a turn rate sensor (gyroscope) and a speed indicator (odometer[1]). By combining the information of all sensors a position can be determined even if GPS positioning is degraded or impossible due to restricted sky view. This means that a DR enabled receiver continues to report positions when GPS signals are blocked, such as in tunnels or in heavy urban canyon environments.

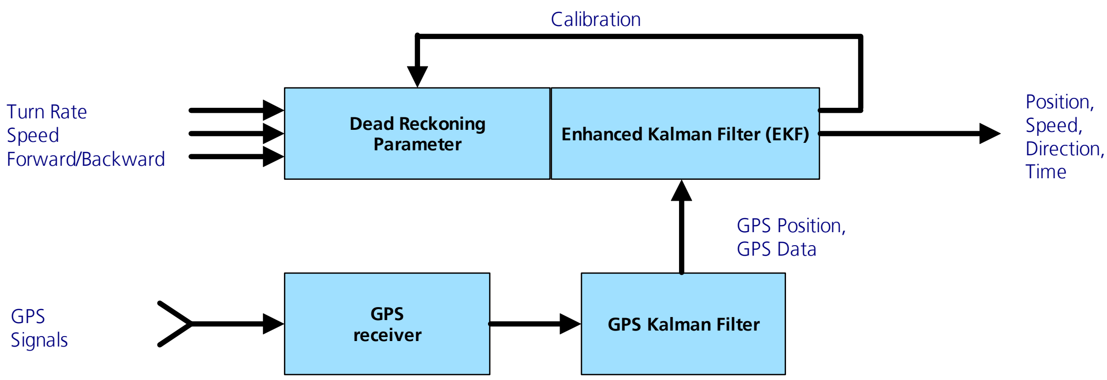


Figure 1: Dead Reckoning Block diagram

1.2 Dead Reckoning Principle

In contrast to GPS, which delivers absolute positions, Dead Reckoning is a relative method. The sensors give information for a defined measurement period, and the location is calculated relative to the previously known position. Therefore an absolute GPS position is required as a starting point, which is the last known GPS position.

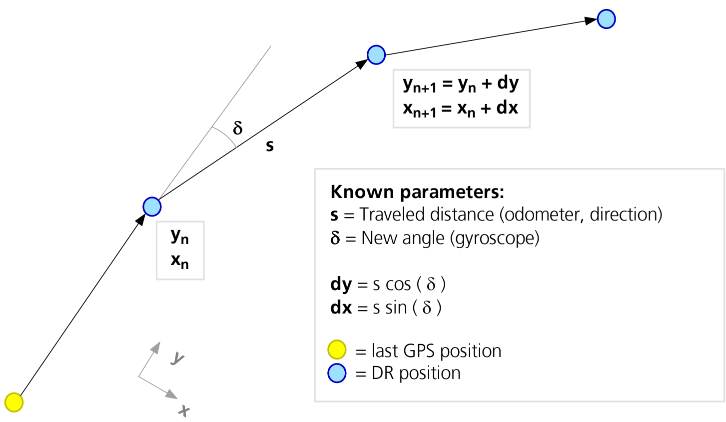


Figure 2: Dead Reckoning Principle

[1] An odometer is by definition a device, which measures linear distance traveled. GPS receivers can also include software (also known as an odometer) used to calculate this distance.

Parameters used for the relative position calculation are:

- **Distance travelled:** Odometer pulses
- **Direction:** Forward / backward indicator
- **Angular turn rate:** Gyroscope

1.3 Dead Reckoning Performance

As DR is an incremental algorithm, the quality of the DR position depends very much on the quality and stability of the sensors used. An accurate model, low tolerances and low thermal drifts are essential for reliable position output.

The performance figures of a DR system are always proportional to distance traveled or time.

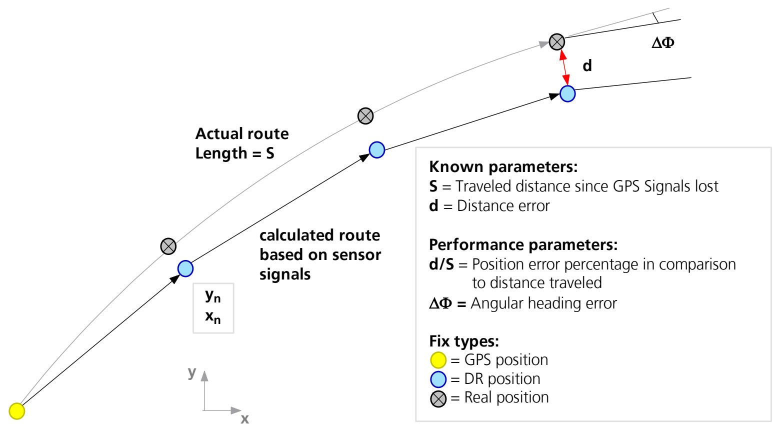


Figure 3: Dead Reckoning Performance Parameters

The seamless transition between absolute GPS positions and relative DR positions is advantageous in getting optimal performance from a DR enabled GPS receiver. ANTARIS®4 GPS Technology employs blended algorithms to obtain the optimum from both systems.

GPS Positioning is weighted more heavily as long as the GPS parameter (e.g. DOP, number of satellites, signal quality) indicates good and reliable performance. In situations, where the GPS signals are poor, reflected from buildings (multipath) or jammed the DR solution is used with a higher weighting.

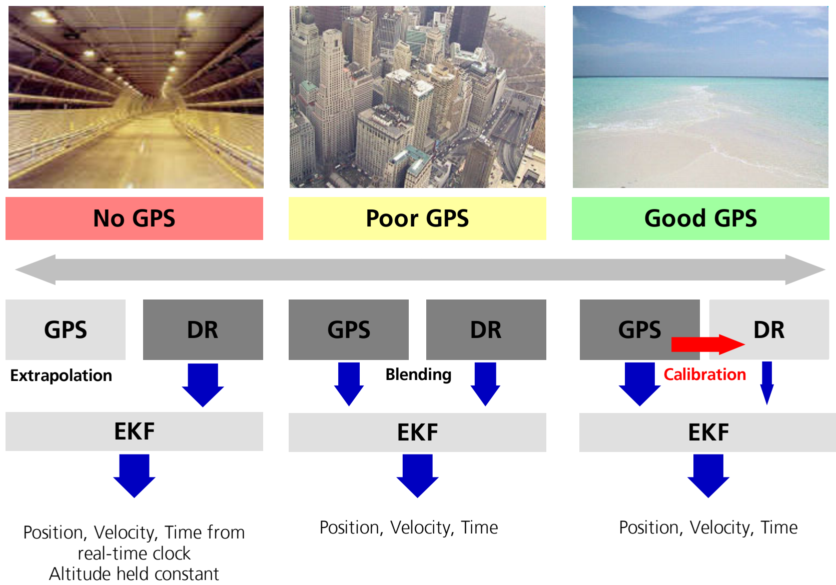


Figure 4: Dead Reckoning Blending

- **No GPS:** During GPS loss, only DR- (sensor based) positions are reported. The position is calculated based on the signals of the turn rate sensor and speed sensor, with reference to the last known GPS solution.
- **Poor GPS:** In urban canyons with fast changing sky visibility or during degraded GPS reception, the ANTARIS®4 DR Technology performs a calculation by blending the GPS and sensor based positioning.
- **Good GPS:** With good GPS performance and optimal sky view, the GPS position has a higher weight than the DR/sensor based position on the overall navigation solution. In this situation, the GPS position values are used to calibrate the DR sensors or to perform sensor integrity checks (to establish if the sensors are well calibrated).

2 Design-In

This section provides a Design-In Checklist as well as Reference Schematics for new designs with LEA-4R/TIM-4R. For migration of existing TIM-LR product designs to TIM-4R please refer to *Appendix 0*.

2.1 Schematic Design-In Checklist for LEA-4R/TIM-4R

Designing-in a LEA-4R/TIM-4R GPS receiver is easy, especially when a design is based on the reference design in *Appendix A*. Nonetheless, it pays to do a quick sanity check of the design. This section lists the most important items for a simple design check. The Layout Checklist in *Section 2.4* also helps to avoid an unnecessary respin of the PCB and helps to achieve the best possible performance.

! **Note** It's highly recommended to follow the Design-In Checklist when developing any ANTARIS®4 GPS applications. This can shorten the time to market and significantly reduce the development cost.

! **Note** For important information explaining the various aspects of this checklist see section 3 in the *Antaris®4 System Integration Manual [5]*

Check Power Supply Requirements and Schematic:

- ❑ Is the power supply within the specified range?
- ❑ Place any LDO as near as possible to the **VCC** pin of the module; if this is not possible design a wide power track or even a power plane to avoid resistance between the LDO/ power source and the GPS Module.
- ❑ Is the ripple on **VCC** below 50mVpp?

Backup Battery

- ❑ A backup battery is a must for DR enabled GPS receiver's designs.
- ❑ Make sure to connect a backup battery to **V_BAT**. LEA-4R/TIM-4R do not operate without a backup battery.
- ❑ When you connect the backup battery for the first time, make sure **VCC** is on or – if not possible – power up the module for a short time (e.g. 1s) ASAP in order to avoid excessive battery drain.
- ❑ While power off, make sure there are no pull-up or down resistors connected to the RxD1, RxD2, EXTINT0 and EXTINT1 as this could cause significant backup or sleep current (>25µA or more instead of 5µA).

Antenna

- ❑ Active antenna is supported.
- ❑ The total noise figure should be well below 3dB.
- ❑ If a patch antenna is the preferred antenna, choose a patch of at least 18x18mm (25x25mm is even better).
- ❑ Make sure the antenna is not placed close to noisy parts of the circuitry. (e.g. micro-controller, display, etc.)
- ❑ For active antennas add a 10R resistor in front of **V_ANT** input for short circuit protection or use the antenna supervisor circuitry.
- ❑ When migrating from TIM-LR reduce R5 of the Antenna Short and Open Supervisor circuit to 18k.
- ❑ Adapt the value of some of the resistors in the reference design to the 3.0 V voltage levels (see *Appendix A).*

Serial Communication

- ❑ Choose UBX for an efficient (binary) data handling or if more data is required than supported by NMEA.
- ❑ When using UBX protocol, check if the UBX quality flags (see *Section **4.1.9.2***) are used properly.
- ❑ Customize the NMEA output if required (e.g. NMEA version 2.3 or 2.1, number of digits, output filters etc.)

Schematic

- Leave the **RESET_N** pin open if not used. Don't drive it high!
- Leave **BOOT_INT** pin open if not used for firmware update.
- Plan use of 2[nd] interface for firmware updates or as a service connector.

2.2 TIM-4R/LEA-4R Design

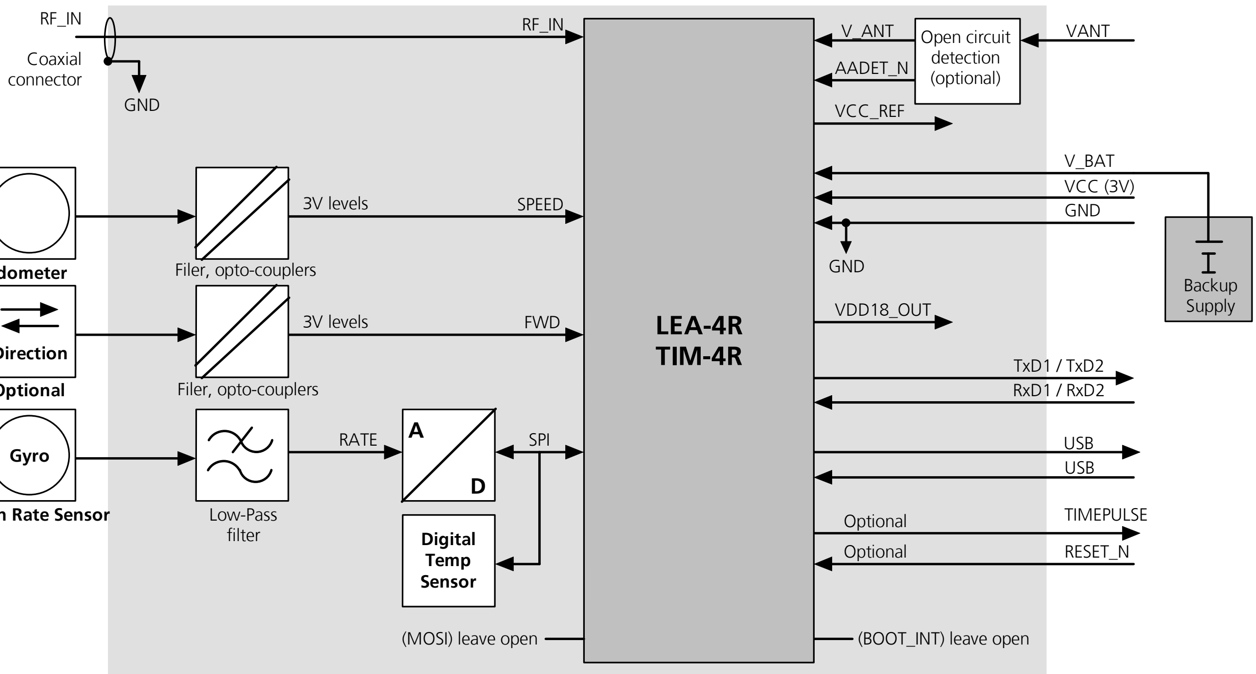


Figure 5: Block Schematic of a complete LEA-4R / TIM-4R Design

2.2.1 Forward / Backward Indication

Use of the forward / backward indication signal **FWD** is optional but strongly recommended for good dead reckoning performance. Connect to **VDD18_OUT** (1.8V) if not used.

You need to check the voltage levels and the quality of the vehicle signals. They may be of different voltage levels, for example 12V nominal with a certain degree of variation. Use of optocouplers or other approved EMI protection and filtering is strongly recommended.

2.2.2 Odometer / Speedpulses

DR receivers use signals from sensors in the car to establish the velocity and distance traveled. These sensors are referred to as the odometer and the signals can be designated odometer pulses, speedpulses, speed ticks, wheel pulses or wheel ticks. These terms are often used interchangeably which can sometimes lead to confusion. For the sake of consistency, in this document we will be referring to these signals as speedpulses.

2.2.3 Power Supply for Gyroscope, Temperature Sensor and A/D Converter

The Gyro and the A/D-Converter are especially sensitive to voltage drop and ripple. Therefore a clean power supply must be designed, which is, for example, not affected from current spikes produced by the GPS module.

! **Note** For best DR performance it's recommended to design a separate (reference) 5V power supply for the gyro and the A/D converter.

2.2.4 SPI Interface for Gyroscope and Temperature Sensor

The LEA-4R/TIM-4R are configured as SPI masters. Following signals are used for the SPI interface:

Pin	Signal name	Direction	Usage
22	PCS2_N	Output	Selects A/D converter for gyro signal
9	PCS0_N	Output	Selects temperature sensor with SPI interface
23	SCK	Output	SPI clock
2	MISO	Input	Serial data (Master In / Slave Out)
1	MOSI	Output	Serial data (Master Out / Slave In), leave open

Table 1: SPI pin for LEA-4R

Pin	Signal name	Direction	Usage
24	PCS1_N	Output	Selects A/D converter for gyro signal
25	PCS0_N	Output	Selects temperature sensor with SPI interface
26	SCK	Output	SPI clock
27	MISO	Input	Serial data (Master In / Slave Out)
28	MOSI	Output	Serial data (Master Out / Slave In), leave open

Table 2: SPI Pin for TIM-4R

The following block schematic specifies the A/D converter and temperature sensor for the LEA-4R and TIM-4R. Please note that the National LM70-3 sensor functions at 3V. If the 5V version (LM70-5) is used, a level translation with open-drain buffers and pull-up resistors at the outputs is required.

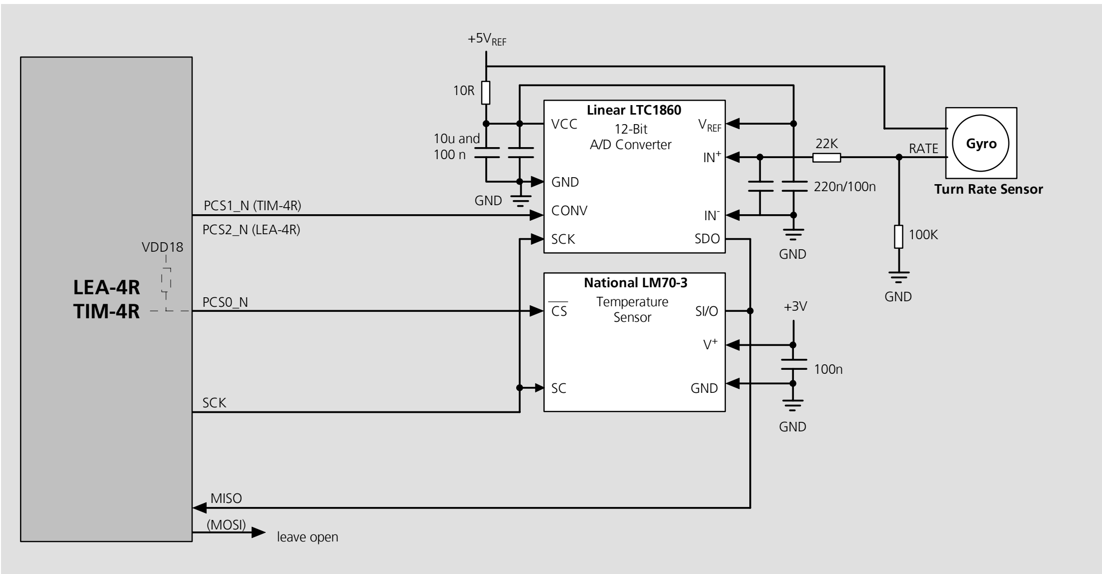


Figure 6: Attaching A/D converter and temperature sensor using SPI interface

For **PCS0_N,** a pull-up resistor is not required since this pin already has a pull-up resistor inside LEA-4R/TIM-4R.

For best results, supply the 5V voltage for the gyroscope through a low pass filter as illustrated. Provide a dedicated reference voltage line from the gyroscope supply pin to the VREF input of the A/D converter.

Add appropriate coupling capacitances according to the recommendations in the data sheets of the illustrated semiconductor products. All shown resistors shall have 5% accuracy or better. All shown capacitors (X7R types) shall have 10% accuracy or better.

! **Note** For correct operation with the LEA-4R/TIM-4R firmware, this circuit must be adopted without making any modifications such as, but not limited to, using different types of semiconductor devices and changing signal assignment.

2.3 Pinout tables

Pin	LEA-4R			TIM-4R		
	Name	I/O	Description	Name	I/O	Description
1	MOSI	O	SPI MOSI	VCC	I	Supply voltage
2	MISO	O	SPI MISO	GND	I	Ground
3	TxD1	O	Serial Port 1	BOOT_INT	I	Boot mode
4	RxD1	I	Serial Port 1	RxD1	I	Serial Port 1
5	VDDIO	I	Pad voltage supply	TxD1	O	Serial Port 1
6	VCC	I	Supply voltage	TxD2	O	Serial Port 2
7	GND	I	Ground	RxD2	I	Serial Port 2
8	VDD18OUT	O	1.8V output	FWD	I	Direction indication(1 = Forward)
9	PCS0_N	O	SPI Chip Select 0 (Temperature Sensor)	EXTINT1	I	External Interupt
10	RESET_N	I/O	Reset	VDD18_OUT	O	1.8V supply output
11	V_BAT	I	Backup voltage supply	GND	I	Ground
12	BOOT_INT	I	Boot mode	GND	I	Ground
13	GND	I	Ground	GND	I	Ground
14	GND	I	Ground	GND	I	Ground
15	GND	I	Ground	GND	I	Ground
16	RF_IN	I	GPS signal input	GND	I	Ground
17	GND	I	Ground	RF_IN	I	GPS signal input
18	VCC_RF	O	Output Voltage RF sect.	GND	I	Ground
19	V_ANT	I	Antenna Bias voltage	V_ANT	I	Antenna Bias voltage
20	AADET_N	I	Active Antenna Detect	VCC_RF	O	Output Voltage RF section
21	FWD	I	Direction Indication (1=Forward)	V_BAT[2]	I	Backup voltage supply
22	PCS2_N	O	SPI Chip Select 2 (A/D Converter)	RESET_N	I/O	Reset (Active low)
23	SCK	O	SPI Clock	SPEED	I	Speedpulses
24	VDDUSB	I	USB Supply	PCS1_N	O	SPI Chip Select 1 (A/D Converter)
25	USB_DM	I/O	USB Data	PCS0_N	O	SPI Chip Select 0 (Temperature Sensor)
26	USB_DP	I/O	USB Data	SCK	O	SPI clock
27	SPEED	I	Speedpulses	MISO	I	SPI MISO
28	TIMEPULSE	O	Time pulse (1PPS)	MOSI	O	SPI MOSI
29	-			TIMEPULSE	O	Timepulse signal
30	-			AADET_N [3]	I	Active Antenna Detect
Shaded pins relate to dead reckoning specific functionality.						

Table 4: Pinout LEA-4R/TIM-4R

[2] Battery backup voltage is necessary to memorize the last vehicle position and direction of the previous trip. This is particularly important when the previous trip ended in an obstructed place, for example a parking garage, and plausible dead reckoning navigation shall continue when driving again.

[3] AADET_N will only be operated as input pin if "Open Circuit Detection" for active antennas is activated or configured.

2.4 Layout Design-In Checklist for ANTARIS®4

Follow this checklist for your Layout design to get an optimal GPS performance.

Layout optimizations

- ❑ Is the GPS module placed according to the recommendation in *Antaris®4 System Integration Manual [5]*?
- ❑ Have you followed the Grounding concept?
- ❑ Keep the micro strip as short as possible.
- ❑ Add a ground plane underneath the GPS module to reduce interference.
- ❑ For improved shielding, add as many vias as possible around the micro strip, around the serial communication lines, underneath the GPS module etc.

Calculation of the micro strip

- ❑ The micro strip must be 50 Ohms and it must be routed in a section of the PCB where minimal interference from noise sources can be expected.
- ❑ In case of a multi-layer PCB, use the thickness of the dielectric between the signal and the 1st **GND** layer (typically the 2nd layer) for the micro strip calculation.
- ❑ If the distance between the micro strip and the adjacent **GND** area (on the same layer) does not exceed 5 times the track width of the micro strip, use the "Coplanar Waveguide" model in AppCad to calculate the micro strip and not the "micro strip" model.

2.5 Layout

Please refer to the *Antaris®4 System Integration Manual [5]* for layout recommendations.

3 Receiver Description

3.1 Dead Reckoning enabled GPS module (DR module)

3.1.1 Architecture

A Dead Reckoning enabled ANTARIS® 4 GPS Receiver contains an ANTARIS® 4 GPS module with the addition of an Enhanced Kalman Filter (*see Figure 7*). Connected to the DR module are a turn rate sensor (gyroscope) with a temperature sensor, odometer (speedpulse signal source) and a direction indicator (forward – backward.).

Similar to the ANTARIS® 4 GPS modules, the DR module supports active and passive antennas and has an optional antenna supervisor circuitry. Two serial ports are available for communication (see *Section on Serial Communication in Antaris®4 System Integration Manual [5]*) and are freely configurable for NMEA or u-blox proprietary protocols. It provides a TIMEPULSE signal for timing synchronization (see *Section on Timing in Antaris®4 System Integration Manual [5]*).

In order to store any DR specific data such as last position, current heading, calibration data, the temperature compensation table (TC) etc., a DR module requires a backup battery. Furthermore, these data are stored in Flash in repetitive intervals.

! **Note** Do not use any power saving modes (e.g. FixNow™ Mode) as the DR algorithm and power saving modes are incompatible.

3.1.1.1 Enhanced Kalman Filter (EKF)

The Enhanced Kalman Filter is the core of the ANTARIS® 4 DR Technology. It combines all the sensor signals (odometer, direction indicator, gyroscope, temperature), which are sampled with 40 Hz and combines them with the GPS solution.

The GPS Kalman Filter and the Enhanced Kalman Filter are tightly coupled to produce the best position solution from both, the GPS system and the sensor-based system. The weighting between both systems is controlled by GPS quality indicators (e.g. DOP values, number of SV, residuals etc.) and variances for all DR related parameters.

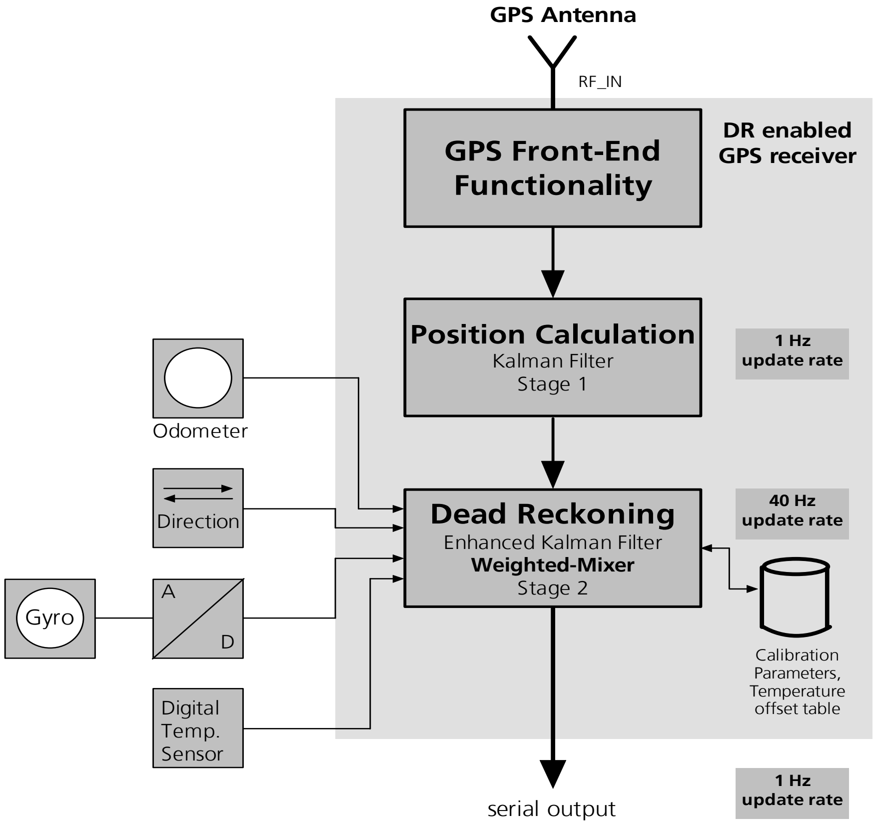


Figure 7: Enhanced Kalman Filter

3.1.1.2 Sensor Integrity Check

The Sensor Integrity Check monitors the quality of the attached sensors (gyro and odometer) and reports unexpected drifts, or malfunctions. As soon as the DR sensors are sufficiently calibrated the ANTARIS® DR Technology begins with sensor integrity checks.

If a sensor signal is out of range, an error message is produced via serial port and reported in NAV-EKFSTATUS. In this case the Enhanced Kalman Filter is switched off meaning that subsequently only GPS position solutions are reported.

To recover the system, the sensors have to be checked for mechanical failures, all calibration parameter (Sensor Calibration and Temperature Calibration) have to be reset and an initial calibration (see *Section3.1.4*) has to be done.

For short minimal errors the system is able to recover itself. In this case the error will be cleared and the DR module will report combined position solutions again.

! **Note** The INF message: "ERROR: EKF disabled. Gyro data inconsistent." indicates a shutdown of the DR algorithm due to inconsistency of the gyro signal. It happens if the gyro is defect or the system is miscalibrated. To recover, check the gyro and reset the receiver. If it happens again, reset all calibration data and repeat an initial calibration.

! **Note** The INF message: "ERROR: EKF disabled. Tick data inconsistent." indicates a shutdown of the DR algorithm due to inconsistency of the speedpulses/ odometer signal. It happens if the speed signal line or the sensor is broken. To recover, check the odometer signal and reset the receiver. If it happens again, reset all calibration data and repeat an initial calibration.

3.1.2 Input Signals/ Sensors

3.1.2.1 Turn rate sensor (Gyroscope)

The gyroscope indicates the turn rate of the device. The gyro output signal is connected via an A/D converter to the DR module and sampled at 40 Hz. The integration of the gyro signal over one measurement period is equal to the relative turn of the device during this period.

There are three major parameters of the gyroscope:

- **Gyro Bias**: Describes the offset of the gyro signal at a turn rate of 0 [deg/s]. +/-25.0 [deg/s] is the maximum allowed Gyro Bias Offset.
- **Gyro Scale Factor**: Describes the relation of the typical gyro sensitivity [V/(deg/s)] of the real measured output voltage [V] to the actual turn rate [deg/sec].
  This value has an upper limit of 1.2, and a lower limit of 0.8. This means that the implemented gyro can vary by +/- 20%, from the typical gyro sensitivity.
- **Gyro Bias as function of the temperature**:
  Any differences from the Gyro Bias Offset over the entire temperature range are stored in a lookup table, called Temperature Compensation Table (TC). This table covers a temperature range of –40 deg Celsius to +80 deg Celsius.

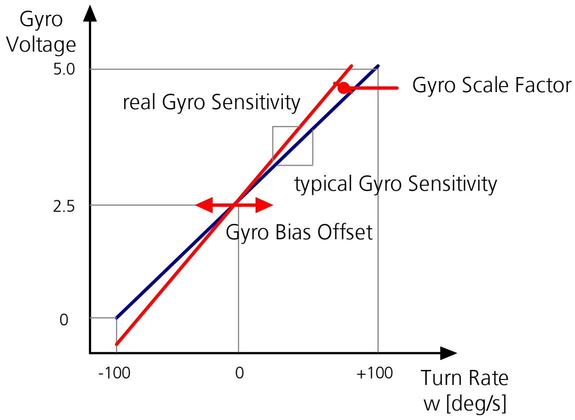


Figure 8: Gyroscope Signals

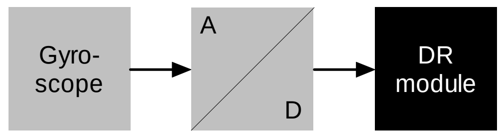


Figure 9: Gyroscope Signals Flow

! Note The mounting angle of the gyro influences its performance significantly. The angle of incline should not exceed the maximal value referring to the turn axis of the vehicle. Consult the datasheet of the gyro carefully to choose the appropriate mounting technique as well the right parameter settings (e.g. Gyro Sensitivity, Polarity, max angle of inclination etc.)

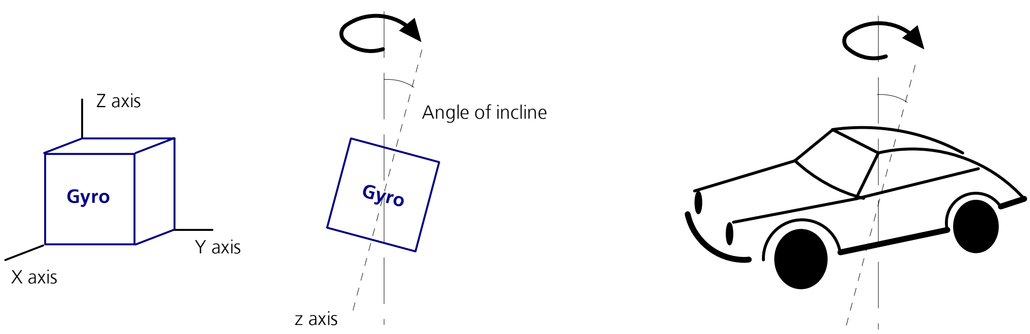


Figure 10: Mounting of the gyroscope

Refer to the LEA-4R/TIM-4R datasheets for recommendations about the selection of gyros.

! **Note** Please follow design recommendations from the gyroscope manufacturers for proper analog signal conditioning.

3.1.2.2 Temperature sensor

The Output of the Gyroscope (especially **Gyro Offset**) is very sensitive to temperature changes. Therefore ANTARIS® DR modules support an automatic temperature compensation against this effect.

To achieve reasonable performance of this compensation the temperature sensor has to have a moderate hysteresis and the environmental temperatures have to be reproducible by around 5 degrees Celsius.

! **Note** The temperature sensor has to be built in the Gyroscope or as near as possible to the Gyroscope to measure the temperature of the gyroscope.

Temperature compensation

To compensate the variation of the Gyro Offset with different temperatures, the ANTARIS® DR Technology maintains a **Temperature Compensation** table **(TC)**. The range is from –40 to +85 degrees Celsius. The table is continuously updated with new values as soon as the receiver is stationary (no odometer pulses at the input) for more than 3 seconds. This process allows the receiver to learn about the temperature characteristics of the individual gyro in its specific environment.

The TC stabilizes as more measurements are observed for the same temperature. For temperature ranges not measured yet the TC Bias Offset will be extrapolated from the available data.

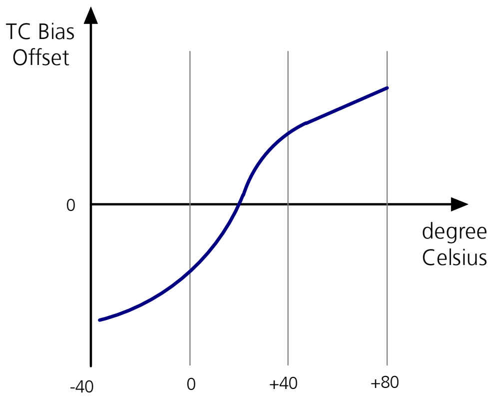


Figure 11: TC compensation graph

! **Note** The INF message: "WARNING: Discarded TC Measurement: RMS Gyro = xx.xxx mV" indicates that the gyro has a to high noise to measure it's offset values for temperature compensation. If this message appears regularly, the gyro might have a mechanical defect or is mounted at a place with too high vibrations.

3.1.2.3 Speedpulse Signal

The speedpulse signal required for DR modules must have a frequency range from 1 Hz to 5kHz (0 Hz is equal to a speed of 0 km/hour). The speedpulse signal must be linear to the driven speed.

The **Scale Factor** is the ratio between the frequency of the speedpulse signal and the real speed. It has a maximum range of 0.02 [m/pulse] to 1 [m/pulse] (i.e. from 50k pulses per km to 1000 pulses per km. If the **Scale Factor** exceeds the lower or upper limit, the output will be held at the limiting value.

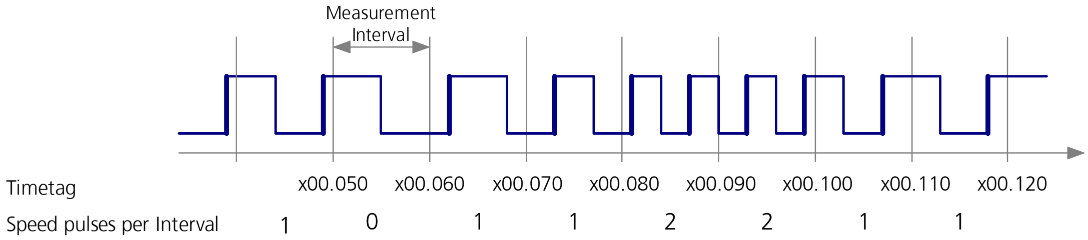


Figure 12: Speed signal

! **Note** Non-linearity of the speedpulse signal (e.g. no pulses below 5 km/h), may lead to wrong direction calculation and therefore wrong positioning.

! **Note** If the pulse frequency is below the minimum frequency (1Hz), speed will be set to 0 m/s and the position output is frozen at the last known position.

3.1.2.4 Direction (Forward/ Backward Signal)

The direction signal indicates whether the vehicle is moving forward or backward. If the signal is high, it indicates forward driving, but it can be configured vice-versa in UBX–CFG (Config) – EKF (EKF Settings).

It's recommended to use a direction indicator for best DR performance. If no direction signal is available, it's recommended to set the direction to forward.

Consequences if no direction signal is available:

Direction GPS coverage	Forward	Backward
Insufficient to determine a position (DR only)	The direction signal indicates the right direction ⇨ **Good DR performance, all position are valid**	The DR output will indicate a wrong direction (always forward). ⇨ **DR positions are wrong as the direction is wrong**
Good GPS coverage	The direction signal indicates the right direction ⇨ **Good DR performance**	For short distances the influence of the mismatching direction signal can be neglected (in order of meters, e.g. maneuvering a car into a parking lot). ⇨ For longer distances it might have significant **impact** to the **calibration parameter**.

Table 5: Consequences of a missing direction signal

! **Note** As the forward/backward direction signal is not available in all cars, try to make use of the reverse gear light.

3.1.3 DR specific Parameters

3.1.3.1 DR specific GPS configuration

As the GPS Kalman Filter and the Enhanced Kalman Filter are optimized by u-blox, do not change the Power Mode in UBX-CFG (Config) – RXM (Receiver Manager) or any of the UBX-CFG (Config) – NAV (Navigation) parameters!

3.1.3.2 DR Configuration Options

The following configuration options are available with the UBX –CFG (Config) - EKF (EKF Settings) message:

- The EKF can be enabled or disabled. When the EKF is disabled the module functions only in the GPS mode, there is no DR functionality available.
- It is possible to manage data and memory in the following ways. Please note that if the default settings are changed the maximum number of flash write/release cycles needs to be taken into account:
  - The Temperature Table and Calibration Data can be cleared. When this is the case the calibration begins again.
  - The interval to save the content of the temperature compensation table from the internal Battery Backup RAM to the Flash memory can be determined.
- The hardware interface can be configured in the following ways:
  - The Direction Pin Polarity can be set. The default is '0 – High = Forward'
  - The axis or the direction of rotation of the Gyro if the voltage output is positive can be set (default setting is '0 – Clockwise Rotation).
- The hardware can also be configured to simplify calibration. This does not, however, eliminate the need to perform a calibration.
  - The Odometer can be configured to set the number of speedpulses per kilometer (default value is 3500 [pulses/km]).
  - The nominal bias voltage and sensitivity of the Gyro can be set, as well as the maximum allowed RMS of the Gyro. This value is needed to control the quality of the measured Gyro offset to be saved in the temperature compensation table.

The DR Status is reported by the (PUBX,05/EKFSTATUS) message.

! Note For detailed information regarding the configuration of the messages please see the ANTARIS®4 GPS Technology Protocol Specifications [3].

3.1.3.3 DR Navigation Parameters (UBX – NAV (Navigation) – EKFSTATUS (Status))

Parameter	Description	Unit
Sensor Data		
Speed Pulses	Number of speed pulses in one measurement period	[Pulses/Period]
Period	Duration of one sensor measurement period	[ms]
Mean Gyro	Uncorrected Mean Value of the Gyro in the last period.	
Temperature	Measured temperature at the gyroscope	[°C]
Direction	Signal from the direction indicator	[forward/backward]

Parameter	Description	Unit
Filter Data		
Sensor data used	Sensor data used in the Enhanced Kalman Filter	None
Sensor failure	Reported sensor errors	None
GPS Data used	GPS data used	None
Scale Factor Pulses*)	Current scale factor of the speed pulses/ odometer (Calibration Value)	[Pulses/km]
Scale Factor Gyro*)	Current scale factor of the gyro (Calibration Value)	[-]
Bias Gyro*)	Current Gyro Bias Offset (Calibration Value)	[rad/s]

*) These Parameters have additional information about the calibration quality of the parameter (init, calibration, course calibration & fine calibration with a percentage indicator (0...100%). For further information refer to the DR calibration in *Section 3.1.4*.

Table 7: DR Navigation Parameter

! **Warning** **Do not change any navigation configuration (refer to Section 4) settings when using LEA-4R/TIM-4R, as it may influence the performance of the Enhanced Kalman Filter.**

3.1.4 DR Calibration

The calibration of the DR sensors is a transparent and continuously ongoing process during periods of good GPS reception:

- Gyroscope Bias — Voltage level of the gyroscope while driving a straight route or not moving
- Gyroscope Scale Factor — Adjusts of left and right turns; gyro sensitivity
- Speed Pulse Scale Factor — Used to calibrate odometer pulse frequency to GPS speed over ground
- Temperature Compensation — The gyroscope is a temperature-dependent device that requires temperature compensation

When a new GPS receiver is installed in a vehicle, the accuracy is only **moderately good** until sufficient **calibration** data has been collected, e.g. during a first drive. With time, continuous calibration results in continuous improvement of dead reckoning accuracy. Small discontinuities, like deviating wheel diameters after exchanging tires (summer vs. snow tires) or aging of the sensors, will be balanced out by ongoing automatic calibration.

Calibration parameters must be **reset**, if

- a DR module is transferred to a **different vehicle** and/or a **different gyroscope** is connected
- the sensor integrity check has reported any failure from the sensors and set itself into **GPS only mode**

Calibration can be reset with UBX message UBX – CFG (Config) – EKF (Enhanced Kalman Filter).

3.1.4.1 Initial Calibration Drive

For **optimum navigation performance** the system needs some learning time and distance for calibrating the various sensors inputs. The following driving directions are recommended to achieve an efficient calibration so dead reckoning yields high accuracy after the shortest possible period of time.

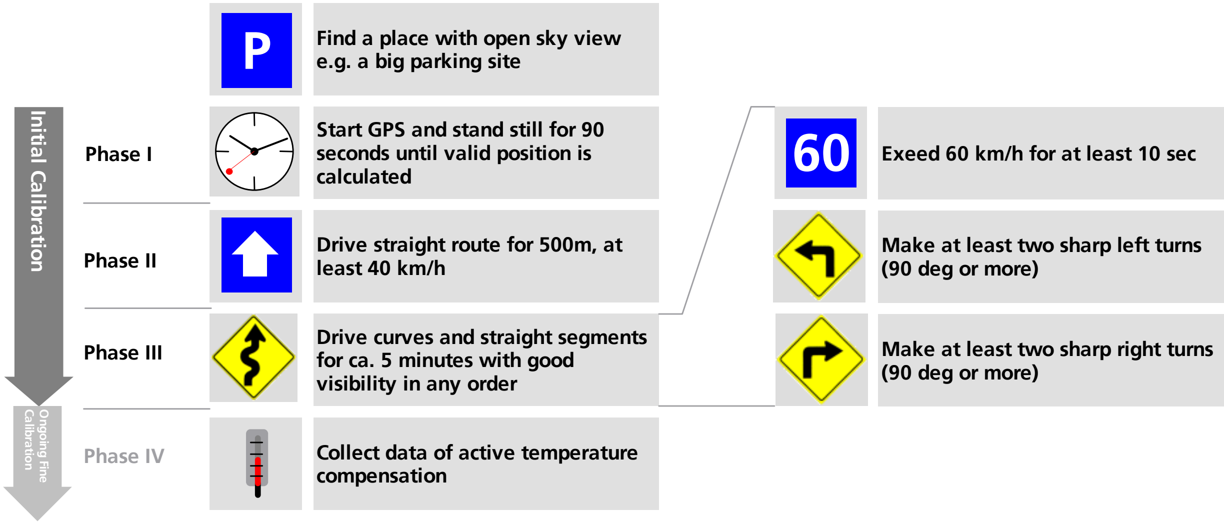


Figure 13: Initial EKF Calibration Drive

The mentioned distances and durations are typical values, a better indication are the quality indicators of the calibration values in UBX – NAV (Navigation) – EKF Status (Status). The Percentage values indicate clearly which phase of the initial calibration the receiver is in. In **Phase IV** good DR performance can already be expected, as all sensors are calibrated. Still further fine calibration will be ongoing with good GPS reception. .

! **Note** The above instructions result in a calibration status within the shortest period of time. Should traffic, road and regulatory conditions not allow such a calibration drive, the time until optimum calibration will increase. However navigation results are already satisfactory after a relatively short driving distance and time.

! **Warning The above instructions shall not be made a rule towards any end user. They shall only be applied in a testing environment where sufficient care is taken that these driving instructions can be carried out without creating any risk of accidents or violation of regulations.**

How to recognize a successful calibration

To see the progress of the DR calibration, the EKFSTATUS percentage values can help (compare with Figure 13).

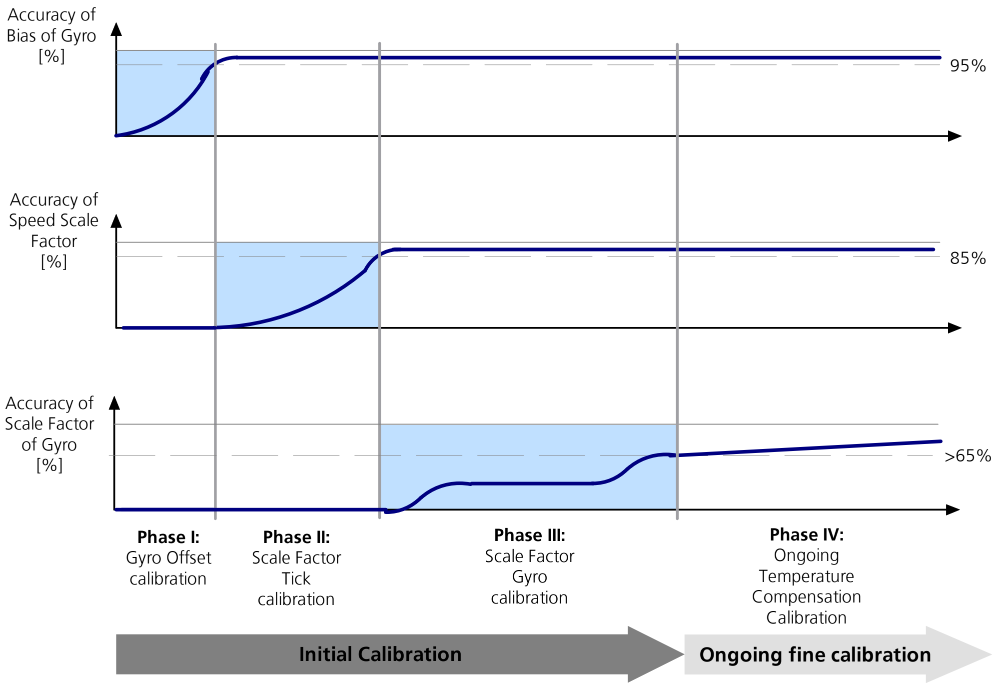


Figure 14: Phases of EKF calibration

! Note The values above do not tell anything about the quality of the calibration, but only about the progress of the calibration process.

Consequences of a bad/wrong calibration procedure

The ANTARIS® DR Technology needs well-calibrated sensors to have optimal performance. A poorly calibrated system will report wrong positions and headings during GPS loss. Also the performance is degraded during good GPS performance, as the position output with good GPS performance will be combined with the poor data from the sensors (refer to *Figure 4*).

As long as the miscalibration is minor (e.g. change of tires from summer to winter tires), the system will recover itself. If the miscalibration leads to a 'sensor integrity check error' (the receiver reports GPS only solutions/ see also *Section*3.1.1.2), a reset of the calibration data and new initial calibration is required.

3.1.5 Storage of Parameters

To maintain a high degree of dead reckoning navigation accuracy, all dynamic DR calibration parameters are saved in a common configuration section (see *Section on Receiver Configuration in Antaris®4 System Integration Manual [5]* for further information). These are:

- Gyro offset and scaling factor
- Gyro temperature compensation information
- Odometer scaling factor

All data is dynamically updated and stored periodically during periods of good GPS reception. In addition all data is stored to the non-volatile RAM, allowing continued dead reckoning when a vehicle has been parked and shut down at an obstructed site, for example an indoor or underground car park. At startup, the previously stored heading will be retrieved in order to continue accurate dead reckoning navigation in the right direction until sufficient number of satellites is visible again to calculate an absolute position fix.

All DR specific information is stored in 30-minute intervals into Flash EPROM. The interval is configurable in UBX – CFG (Config) – EKF (EKF Settings). If a backup supply voltage is applied to V_BAT pin, the information above is stored in 1s intervals into battery-backup RAM.

! **Note** Provision of a backup power supply to DR enabled GPS receivers (e.g. LEA-4R/TIM-4R) is required.

3.1.6 Static Position

When DR enabled receiver is not moving (i.e. it receives no pulses from the odometer), it will always **output DR Mode**, regardless of whether or not GPS coverage is available. In this case, position data will be kept constant (except altitude as this is a DR independent parameter).

During this time the **Gyro Bias** will be **calibrated**, as it is expected that the object is not moving.

! **Note** Do not confuse this with Static Hold Mode from the GPS Kalman Filter.

3.2 Power Saving Modes

Please note that FIXNOW is not supported by the LEA-4R/TIM-4R

3.3 Antenna and Antenna Supervisor

For information regarding the antenna and antenna supervisor please refer to the *ANTARIS®4 System Integration Manual [5].*

3.3.1 Open Circuit Detect

AADET_N is assigned to different pins for TIM-4R and the other variants of TIM-4x. On TIM-4x, AADET_N is assigned to pin 27. On TIM-4R, AADET is assigned to pin 30 since pin 27 is used for the SPI interface. In case of designs, where either a TIM-4x or a TIM-4R shall be populated, a layout for two optional 0-Ohm resistors to pin 27 and 30 shall be provided (see *Figure* 16).

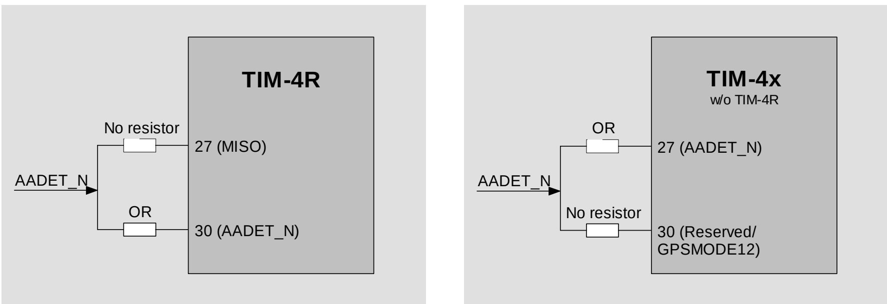


***Figure* 16: Connection of "Open Circuit Detection" signal to AADET_N input**

4 Navigation

Once the GPS receiver is tracking enough satellites, it uses the measurements to calculate the current position. This part of the code is called Navigation Solution.

The following section discusses mainly the usage of the UBX proprietary messages UBX – CFG (Config) – RATE (Rates), UBX – CFG (Config) – DAT (Datums) and UBX – CFG (Config) – NAV2 (Navigation2) to configure the Navigation Engine of the ANTARIS®4 GPS receiver. To get an optimal setting the application environment must be considered.

4.1.1 Overview

Parameter	Description
Navigation Output	The ANTARIS®4 GPS Technology outputs the navigation data in LLA (Latitude, Longitude and Altitude), ECEF coordinate frame or Universal Transverse Mercator (UTM) format. The LLA output can be configured to one out of more than 200 pre-defined datums, or to a user datum.
Map Datum	The ANTARIS®4 GPS Technology supports more than 200 different map datums (including one user specific datum) and Universal Transverse Locator (UTM)
Navigation Update Rate	The ANTARIS®4 GPS Technology supports navigation update rates higher than 1 update per second. For LEA-4R/TIM-4R the Navigation Update Rate is fixed at 1Hz.
Dynamic Platform Model	Dynamic models adjust the navigation engine, tuning the GPS performance to the application environment. Do not change for LEA-4R/TIM-4R
Allow Almanac Navigation	Enable Almanac Navigation (without ephemeris data) as a degraded mode to realize fast fixes with reduced position accuracy.
Navigation Input Filters	Applies a mask to the input parameters of the navigation engine to filter the input data. It screens potentially poor quality data preventing its use in the navigation engine.
Navigation Output Filters	Applies a mask to the position fixes to prevent poor quality from being output. Internally, the positions are still calculated to further track the SVs.
RAIM	Receiver Autonomous Integrity Monitoring
DGPS	Specific Differential GPS parameters

Table 9: Overview GPS Navigation Parameter

4.1.1.1 Navigation Output

The ANTARIS®4 GPS Technology outputs the navigation data in LLA (Latitude, Longitude and Altitude), ECEF (Earth Centered Earth Fixed) or UTM (Universal Transverse Mercator) format.

The LLA output can be configured to one out of more than 200 predefined datums or to a user datum. The default datum is WGS84. The altitude is available as height above ellipsoid (HAE). The height above mean sea level (MSL) is available if the default datum WGS84 is selected.

! **Note** Refer to the ANTARIS®4 System Integration Manual [5] for a list of all predefined datums.

4.1.2 Navigation Update Rate

The LEA-4R/TIM-4R supports only an update rate of 1 Hz.

4.1.3 Dynamic Platform Model

The LEA-4R/TIM-4R only supports the Automotive Platform.

4.1.4 Static Hold Mode

Do not use this mode with the LEA-4R/TIM-4R

4.1.5 Degraded Navigation

Degraded navigation describes all navigation modes, which use less than 4 satellites.

4.1.5.1 2D Navigation

If the GPS receiver only has 3 satellites to calculate a position, the navigation algorithm uses a constant altitude to make up for the missing fourth satellite. When losing a satellite after a successful 3D fix (min. 4 SV available), the altitude is kept constant to the last known altitude. This is called a 2D fix.

! **Note** The ANTARIS®4 GPS Technology does not calculate any solution with a number of SVs less than 3 SV. Only ANTARIS®4 Timing Receivers can calculate timing solution with only one SV.

! **Note** If the receiver makes initial 2D LSQ fixes during acquisition, the initial altitude is set to 500m. To change the initial altitude use UBX – CFG (Config) - NAV2 (Navigation 2) message.

4.1.5.2 Dead Reckoning/ extrapolating positioning

The implemented extrapolation algorithm kicks in as soon as the receiver does no longer achieve a position fix with a sufficient position accuracy or DOP value (can be configured in UBX-CFG-NAV2). It keeps a fix track (heading is equal to the last calculated heading) until the Dead Reckoning Timeout is reached. The position is extrapolated but it's indicated as "NoFix" (except for NMEA V2.1).

! **Note** For sensor based Dead Reckoning GPS solutions, u-blox offers Dead Reckoning enabled GPS modules (LEA-4R/TIM-4R). It allows high accuracy position solutions for automotive applications at places with poor or no GPS coverage. This technology relies on additional inputs from a turn rate sensor (gyro) and a speed sensor (odometer or wheel tick).

4.1.6 Almanac Navigation

The satellite orbit information retrieved from an almanac is much less accurate than the information retrieved from the ephemeris. If during a startup period, only almanac information is available, (e.g. while the ephemeris still is being downloaded) the receiver still is able to navigate based on almanac orbits.

With almanac navigation enabled, when a new satellite rises and its reception just has started, the receiver might use an almanac to use this satellite in the navigation solution until the ephemeris is fully retrieved. By disabling almanac navigation, the receiver does not use the almanac for navigation, but will always wait to collect the entire ephemeris information before including a satellite in the navigation solution.

With an almanac only solution the position will only have an accuracy of a few kilometers. Normal GPS performance requires at least 4 satellites included in the navigation solution, which have ephemeris information available.

Almanac navigation allows much faster start up, as there is no need to wait for the completion of the ephemeris download (>18s). This is useful whenever an inaccurate position is better than no position (e.g. emergency or security devices).

! **Note** The almanac information is NOT used for calculating a position, if valid ephemeris information is present, regardless of the setting of this flag. But the almanac information is needed to acquire the SV when there is no ephemeris data available.

4.1.7 Navigation Input Filters

The navigation input filters mask the input data of the navigation engine. These settings are optimized already. It is not recommended that changes to any parameters be made unless advised by u-blox support engineers.

Parameter	Description
Fix Mode	By default, the receiver calculates a 3D position fix if possible but reverts to a 2D position if necessary (**Automatic 2D/3D**). It's possible to force the receiver to permanently calculate 2D (**2D-only**) or 3D (**3D-only**) positions.
Fix Altitude	Initial altitude used for 2D navigation output The fix altitude is used if Fix Mode is set to **2D-only** or in case of a 2D fix after a Coldstart.
Min SVs	Restricts the navigation solution to be calculated with at least n satellites. This could be used to inhibit a solution with only 3 satellites. Set this value to 1 single satellite for timing applications (LEA-4T only).
Max SVs	Uses at most 'n' satellites for a navigation solution.
Initial Min SV	Minimum number of satellites, which must be available before the first position fix will be calculated.
Min C/No	A satellite with a C/N0 below this limit is not used for navigation.
Initial Min C/No	Minimum C/N0 for the initial fix. Only satellites exceed this threshold will be used for the calculation of the first position fix. This parameter may be set to a higher value than "Min C/No (Nav)" in order to achieve a higher confidence in the accuracy of the first position fix.
Min SV Elevation	Minimum elevation of a satellite above the horizon in order to be used in the navigation solution. Low elevation satellites may provide degraded accuracy, because of the long signal path through the atmosphere.
DR (Dead Reckoning) Timeout[4]	The time during which the receiver provides an extrapolated solution. After the DR timeout has expired no GPS solution is provided at all. Don not change for LEA-4R/TIM-4R.

Table 11: Navigation Input Filter parameters (UBX-CFG-NAV2)

4.1.8 Navigation Output Filters

Parameter	Description
PDOP Mask **P Accuracy Mask**	The PDOP and Position Accuracy Mask are used to determine, if a position solution is marked valid in the NMEA sentences or the UBX PosLimit Flag is set. A solution is considered valid, when both PDOP and Accuracy lie below the respective limits.
TDOP Mask **T Accuracy Mask**	The TDOP and Time Accuracy Mask are used to determine, when a Time Pulse should be allowed. The TIMEPULSE is disabled if either TDOP or the time accuracy exceeds its respective limit.

Table 13: Navigation Output Filter parameter

[4] Does not apply to DR enabled receivers (like TIM-LR)

4.1.9 Position Quality Indicators

4.1.9.1 NMEA Valid Flag (Position Fix Indicator)

A position fix is declared as valid if all of the conditions below are met:

- Position fix with at least 3 satellites (2D or 3D fix). In order to ensure a good accuracy, the ANTARIS®4 GPS Technology does not support 1D fixes.
- The '3D Position Accuracy Estimate' needs to be below the 'Position Accuracy Mask'
- The PDOP value needs to be below the 'PDOP Accuracy Mask'.

! Note The 'Position Accuracy Mask' and the 'PDOP Mask' are configurable. This allows customizing the behavior of the valid flag to application requirements (see *Section 4.1.8*).

Table 15 lists of the status fields (valid flags) for the different NMEA message for NMEA standard 0183 Version 2.3:

NMEA Message	Field	No Position Fix (after power-up, after losing Satellite lock)	Valid Position Fix but User Limits exceeded	Dead Reckoning (linear extra-polation)	EKF[5]	2D Position Fix	3D Position Fix	Combined GPS/EKF Position Fix
GGA	Status	0	0	6	6	1/2	1/2	1/2
		0=Fix not available/invalid, 1=GPS SPS Mode, Fix valid[6], 2=Differential GPS, SPS Mode, Fix Valid, 6=Estimated/Dead Reckoning						
GLL	Status	V	V	V	A[7]	A	A	A
		A=Data VALID, V=Data Invalid (Navigation Receiver Warning)						
	Mode Indicator	N	N	E	E	A/D	A/D	A/D
		N=No Fix, A=Autonomous GNSS Fix, D=Differential GNSS Fix, E=Estimated/Dead Reckoning Fix						
GSA	Nav Mode	1	1	2	2	2	3	3
		1=Fix Not available, 2=2D Fix, 3=3D Fix						
RMC	Status	V	V	V	A	A	A	A
		A=Data VALID, V=Data Invalid (Navigation Receiver Warning)						
	Mode Indicator	N	N	E	E	A/D	A/D	A/D
		N=No Fix, A=Autonomous GNSS Fix, D=Differential GNSS Fix, E=Estimated/Dead Reckoning Fix						
VTG	Mode Indicator	N	N	E	E	A/D	A/D	A/D
		N=No Fix, A=Autonomous GNSS Fix, D=Differential GNSS Fix, E=Estimated/Dead Reckoning Fix						

Table 15: NMEA Valid Flag (0183 Version 2.3)

[5] TIM-LR / DR enabled receivers only
[6] For DR enabled receiver a valid fix is always a combination of a GPS fix with a DR position based on the attached DR sensor (turn rate sensor, odometer)-
[7] For DR enabled receivers the EKF only fix is considered as valid as long as it's within the defined accuracy range.

Table 17 lists the status fields (valid flags) for the different NMEA message for NMEA standard 0183 Version 2.2 and smaller:

NMEA Message	Field	No Position Fix (after power-up, after losing Satellite lock)	Valid Position Fix but User Limits exceeded	Dead Reckoning (linear extra-polation)	EKF[8]	2D Position Fix	3D Position Fix	Combined GPS/EKF Position Fix
GGA	Status	0	0	1	1	1/2	1/2	1/2
		0=Fix not available/invalid, 1=GPS SPS Mode, Fix valid[9], Estimated/Dead Reckoning,2=Differential GPS, SPS Mode, Fix Valid						
GLL	Status	V	V	A	A[10]	A	A	A
		A=Data VALID, V=Data Invalid (Navigation Receiver Warning)						
	Mode Indicator	Not available in this NMEA version						
GSA	Nav Mode	1	1	2	2	2	3	3
		1=Fix Not available, 2=2D Fix, 3=3D Fix						
RMC	Status	V	V	A	A	A	A	A
		A=Data VALID, V=Data Invalid (Navigation Receiver Warning)						
	Mode Indicator	Not available in this NMEA version						
VTG	Mode Indicator	Not available in this NMEA version						

Table 17: NMEA Valid Flag (0183 Version 2.2 and smaller)

4.1.9.2 UBX Valid Flag (Position Fix Indicator)

UBX protocol provides status information in abundance. Table 19 lists the position fix flags:

Status Field	Message	Enumeration	Description
GPSfix	NAV-STATUS NAV-SOL	0x00 0x01 0x02 0x03 0x04	No Fix Dead Reckoning only 2D-fix 3D-fix GPS + Dead Reckoning combined
Flags	NAV-STATUS NAV-SOL	0x01 0x02 0x04 0x08	GPS fix OK (i.e. within PDOP & Position Accuracy Masks) DGPS used Week Number valid Time of Week valid

Table 19: UBX Valid Flags (Position Fix Indicator)

A position fix shall be treated as valid, if 'GPSfix' reports either a '2D-fix' or a '3D-fix' and 'Flags' indicates 'GPS fix OK'.

For DR enabled receivers a position fix shall be treated as valid if 'GPSfix' reports either a 'GPS + Dead Reckoning combined' or 'Dead Reckoning only' and 'Flags' indicates 'GPS fix OK'.

[8] TIM-4R / DR enabled receivers only
[9] For DR enabled receiver a valid fix is always a combination of a GPS fix with a DR position based on the attached DR sensor (turn rate sensor, odometer)-
[10] For DR enabled receivers the EKF only fix is considered as valid as long as it's in the defined accuracy range.

4.1.9.3 UBX Status Information

Additional status and accuracy information is available in the UBX protocol:

Status Field	Message	Enumeration / Unit	Description
calib_status acc_pulse_scale acc_gyro_bias acc_gyro_scale	NAV-EKFSTATUS		Sensor Integrity Calibration Status
Pacc	NAV-SOL NAV-POSECEF	cm	3D Position Accuracy Estimate
SAcc	NAV-SOL NAV-VELECEF NAV-VELNED	cm/s	Speed Accuracy Estimate
CAcc	NAV-VELNED		Course / Heading Accuracy Estimate
Hacc		cm	Horizontal Accuracy Estimate
Vacc		cm	Vertical Accuracy Estimate
TAcc	NAV-TIMEGPS NAV-TIMEUTC	ns	Time Accuracy Estimate
PDOP	NAV-SOL NAV-DOP	-	Position DOP
numSV	NAV-SOL	-	Number of SVs used in Nav Solution
DiffS	NAV-STATUS		Bits [1:0] - DGPS Input Status • 00: none • 01: PR+PRR Correction • 10: PR+PRR+CP Correction • 11: High accuracy PR+PRR+CP Correction
TTFF	NAV-STATUS	ms	Time to first fix (millisecond time tag)
MSSS	NAV-STATUS	ms	Milliseconds since Startup / Reset
Valid (Time)	NAV-TIMEGPS NAV-TIMEUTC	0x01 0x02 0x04	Valid Time of Week Valid Week Number Valid UTC (Leap Seconds known)

Table 21: Status Information in UBX Protocol

4.1.10 DGPS (Differential GPS)

For information about the RTCM protocol refer to *ANTARIS®4 System Information Manual [5]*.

4.1.11 SBAS (Satellite Based Augmentation Systems)

- Please note that the LEA-4/TIM-4R does not support SBAS.

4.1.12 RAIM (Receiver Autonomous Integrity Monitoring)

RAIM is a process where the GPS unit itself uses various techniques to monitor the signals it is receiving from the satellites, ensuring that the information used in the navigation solution is valid. Four SVs are required for a 3D navigation solution. The presence of one bad SV could be detected if five SVs were available. A bad SV could be identified and eliminated from the solution if six or more SVs are available (Fault Detection and Exclusion (FDE)).

The ANTARIS®4 Technology supports RAIM and has the ability to enable/disable this feature using software commands. RAIM can only function with sufficient SV visibility and acceptable DOP geometry. RAIM is activated by default and it is recommended to have it enabled at all times.

The status of the RAIM system is reported in the NMEA – GPGBS (GNSS Satellite Fault Detection) message.

5 Product Testing

5.1 u-blox In-Series Production Test

u-blox focuses on a high quality of its products. To achieve a high standard it’s our philosophy to supply fully tested units. Therefore at the end of the production process, every unit will be tested. Defective units will be analyzed in detail to improve the production quality.

This is achieved with automatic test equipment, which delivers a detailed test report for each unit. The following measurements are done:

- Digital self-test (Software Download, verification of FLASH firmware, etc.)
- Measurement of voltages and currents
- Measurement of RF characteristics (e.g. C/No)

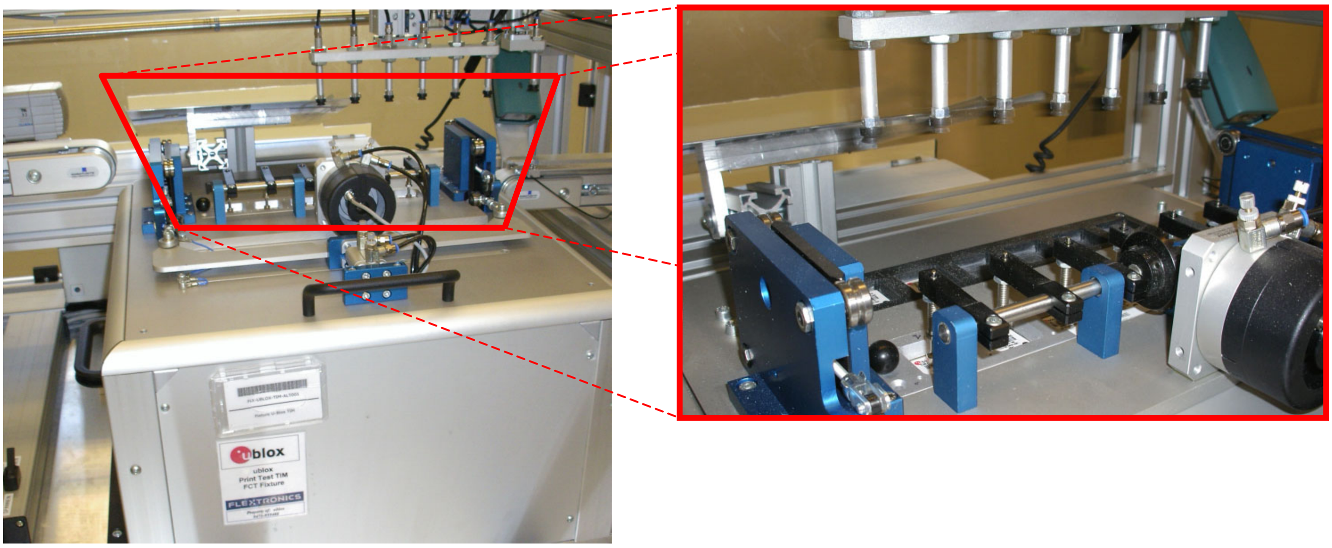


Figure 17: Automatic Test Equipment for Module Tests

5.2 Test Parameters for OEM Manufacturer

Based on the test done by u-blox (with 100% coverage), it is obvious that an OEM manufacturer doesn’t need to repeat firmware tests or measurements of the GPS parameters/characteristics (e.g. TTFF) in his production test.

An OEM Manufacturer should focus on

- Overall sensitivity of the device (including antenna, if applicable)
- Communication to a host controller

5.3 System Sensitivity Test

The best approach to test the sensitivity of a GPS device is the use of a 1-channel GPS simulator. It assures reliable and constant signals at every measurement.

Figure 18: 1-channel GPS simulator

u-blox recommends the following Single-Channel GPS Simulator:

- Spirent GSS6100
  Spirent Communications Positioning Technology
  (previously GSS Global Simulation Systems) www.positioningtechnology.co.uk

5.3.1 Guidelines for Sensitivity Tests

1. Connect a 1-channel GPS simulator to the OEM product
2. Choose the power level in a way that the "Golden Device" would report a C/No ratio of 45 dBHz
3. Power up the DUT (Device Under Test) and allow enough time for the acquisition
4. Read the C/No value from the NMEA GSV or the UBX-NAV-SVINFO message (e.g. with u-center AE)
5. Reduce the power level by 10dB and read the C/No value again
6. Compare the results to a "Golden Device" or an ANTARIS®4 GPS EvalKit.

5.3.2 'Go/No go' tests for integrated devices

The best test is to bring the device to an outdoor position **with excellent visibility** (HDOP < 3.0). Let the receiver acquire satellites and compare the signal strength with a "Golden Device".

! **Note** As the electro-magnetic field of a redistribution antenna is not homogenous, indoor tests are in most cases not reliable. This kind of tests may be useful as a 'go/no go' test but not for sensitivity measurements.

5.4 Testing of LEA-4R/TIM-4R Designs

The GPS functionality should be checked as outlined in *Section 5.3*.

! **Note** When testing the design ensure that no GPS signals are being received. Failure to do so can eventually result in operation errors.

5.4.1 Direction Signal

This input shall be set once to high level and once to low level. In both states the software parameters are read back with the UBX-NAV-EKFSTATUS. The direction flag shall read FWD_HIGH = 1 (forward) for a high level at the FWD input and FWD_LOW = -1 (backward) for a low level at the FORWARD input.

5.4.2 Speedpulse Signal

A rectangular waveform with 2kHz frequency shall be fed into the SPEED input. The result can be read back with the UBX-NAV-EKFSTATUS message. The number of speed pulses during the last update period divided by the duration of the last update period shall correspond to the input signal frequency.

$$f_{in} = \frac{\text{Speedpulses}}{\text{Period}}$$

5.4.3 Gyroscope (Rate) Input

Three different DC voltages 1.0 V, 2.5 V and 4.0 V shall be applied to the rate input (input of the A/D converter) and the measurements will be read out with the UBX-NAV-EKFSTATUS message. The voltage applied to the rate input can be measured using the 'mean gyro' value from the UBX-NAV-EKFSTATUS message multiplied with 5 V/(2^{16}-1) = 76.2951e^{-6} V or read directly from the message output.

$$V_{gyro} = mean\_gyro * 76.2956 \mu V$$

! **Note** The rate input can only be tested if an A/D converter is connected to LEA-4R/TIM-4R.

5.4.4 Temperature Sensor

The temperature measured by the temperature sensor connected to the LEA-4R/TIM-4R shall be read with the UBX-NAV-EKFSTATUS message. The measurement tolerance is in the order of about ±5°.

5.4.5 Erase Calibration

To erase the calibration send a CFG-EKF command.

6 PC Support Tools

For information on various PC Support Tools for the LEA-4R/TIM-4R please see the *ANTARIS®4 System Integration Manual [5]*.

A Migration from TIM-LR to TIM-4R

- TIM-LR and TIM-4R have the same pin-out.
- With the TIM-4R the voltage levels of TIMEPULSE, MOSI, SCK, PCS0_N and PCS1_N are changed to VCC. With the TIM-LR they had levels of 1.8 V. Please verify that this doesn't cause any problems with your circuitry.

! **Note** If you have followed our TIM-LR reference design, it is advisable to change the value of some resistors (see) Please see the reference schematics in Appendix A for positioning of the resistors.

Resistor	TIM-4R	TIM-LR
R14	18k	47k
R32	OR[11]	47k
R36	5k6	47k
R39	OR[12]	47k

Table 23: Resistor values by migration from TIM-LR to TIM-4R

- The UBX-CFG-NAV message (TIM-LR only) has been replaced by the UBX-CFG-NAV2 message (TIM-4R)

[11] 0Ω Resistor
[12] 0Ω Resistor

A.1 Migration from TIM-LR to TIM-4R pin out

The pin-outs of TIM-LR and TIM-4R modules do not differ significantly. *Table 26* compares the modules and highlights the differences to be considered.

Pin	TIM-LR		TIM-4R		Remarks
	Pin Name	Typical Assignment	Pin Name	Typical Assignment	
1	**VCC**	2.70 – 3.30V	**VCC**	2.70 – 3.30V	No difference
2	**GND**	GND	**GND**	GND	No difference
3	**BOOT_INT**	NC	**BOOT_INT**	NC	No difference
4	**RXD1**	3.0V in; pull up to VCC if not used	**RXD1**	1.8 - 5.0V in	Do not add an external pull up resistor; there is one built-in to **V_BAT18**. Leave open if not used.
5	**TXD1**	3.0V out	**TXD1**	3.0V out	No difference
6	**TXD2**	3.0V out	**TXD2**	3.0V out	No difference
7	**RXD2**	3.0V in; pull up to VCC if not used	**RXD2**	1.8 - 5.0V in	Do not add an external pull up resistor; there is one built-in to **V_BAT18**. Leave open if not used.
8	**FWD**	1.8V I/O (LP: 3.0V), not connected	**FWD**	3.0V I/O	Apply direction signal
9	**STATUS**	1.8V I/O (LP: 3.0V), not connected	**EXTINT1**	3.0V I/O, not connected	Status Pin not available anymore; No difference otherwise.
10	**VDD18_OUT**	Not connected	**VDD18OUT**	Not connected	No difference
11 to 16	**GND**	GND	**GND**	GND	No difference
17	**RF_IN**	RF_IN	**RF_IN**	RF_IN	No difference
18	**GND**	GND	**GND**	GND	No difference
19	**V_ANT**	3.0V -5.0V	**V_ANT**	3.0V -5.0V	No difference
20	**VCC_RF**	VCC - 0.1V	**VCC_RF**	VCC - 0.1V	No difference
21	**V_BAT**	1.95 – 3.6V	**V_BAT**	1.50 – 3.6V	Wider voltage range. Uncritical for migration.
22	**RESET_N**	(1.8V)input	**RESET_N**	1.8V	No difference. Don't drive high. Refer to ANTARIS®4 System Information Manual [5] for more information.
23	**EXTINT0**	Not connected	**EXTINT0**	Not connected	No difference
24	**PCS1_N**	1.8V I/O	**PCS1_N**	3.0V I/O	Different voltage level
25	**PCS0_N**		**PCS0_N**		
26	**SCK**		**SCK**		
27	**MISO**	Not connected	**MISO**	Not connected	
28	**MOSI**	1.8V I/O (LP: 3.0V)	**MOSI/ P24**	3.0V I/O	
29	**TIMEPULSE**	1.8V out (LP: 3.0V)	**TIMEPULSE**	3.0V out	Same functionality but different output voltage.
30	**AADET_N**	1.8V I/O (LP: 3.0V), not connected	**AADET_N**	3.0V I/O, not connected	Different voltage level

: Pins to be checked carefully

Table 26: Pin-out comparison TIM-LR vs. TIM-4R

[13] 0Ω Resistor
[14] 0Ω Resistor

B Default Settings

B.1 Hardware

Antenna Configuration (UBX – CFG – ANT)

Parameter	Default setting	Unit	Range/Remark
Enable Control Signal	Enabled		Enabled - Disabled
Enable Short Circuit Detection	Enabled		Enabled - Disabled
Enable Short Circuit Power Down logic	Enabled		Enabled - Disabled
Enable Automatic Short Circuit Recovery	Disabled		Enabled - Disabled
Enable Open circuit detection	Disabled		Enabled - Disabled

Table 28: Antenna settings

B.2 Navigation

Datum (UBX – CFG – DAT)

Parameter	Default setting	Unit	Range/Remark
Datum	0 – WGS84		Refer to *Appendix 0*

Table 30: Datum default settings

Navigation (UBX – CFG – NAV2)

Parameter	Default setting	Unit	Range/Remark
Dynamic Platform Model	3-Automotive		1-Stationary; 2- Pedestrian; 3-Automotive; 4-Sea; 5-Airborne <1g; 6-Airborne <2g; 7-Airborne <4g
Allow Almanac Navigation	Disabled		Enabled - Disabled
Static Hold Threshold	0.00	m/s	
Navigation Input Filters			
Initial Min SV	3	#	3..16
Min SV's	3	#	3..16
Max SV's	16	#	3..16
Initial Min C/N0 (Fix)	24	dBHz	Standard GPS
Min C/NO	20	dBHz	Standard GPS
Min SV Elevation	5	deg	
DR Timeout	0	s	
Navigation Output Filters			
PDOP Mask	25	-	
TDOP Mask	25	-	
P Accuracy	100	m	
T Accuracy	300	m	
Fix Mode	Auto 2D/3D	#	Auto 2D/3D – 2D only – 3D only
RAIM	Enabled		Enabled - Disabled; DO NOT DISABLE!
DGPS Timeout	60	s	
Fixed Altitude	500	m	

Table 32: Navigation default settings

NMEA Protocol (UBX – CFG – NMEA)

Parameter	Default setting	Unit	Range/Remark
Enable position output even for invalid fixes	Disabled		Enabled - Disabled
Enable position even for masked fixes	Disabled		Enabled - Disabled
Enable time output even for invalid times	Disabled		Enabled - Disabled
Enable time output even for invalid dates	Disabled		Enabled - Disabled
Version	2.3		
Compatibility Mode	Enabled		Enabled – Disabled (Compatible to TOM-TOM, NOKIA etc)

Table 34: NMEA Protocol default settings

Output Rates (UBX – CFG – RATE)

Parameter	Default setting	Unit	Range/Remark
Time Source	0 – UTC		0 – UTC1 - GPS
Measurement Period	1000	ms	
Measurement Rate	1	Cycles	

Table 36: Output Rates default settings

Receiver Manager (UBX - CFG – RXM)

Parameter	Default setting	Unit	Range/Remark
GPS Mode	Normal		Auto; Normal; Fast Acquisition; High Sensitivity
Low Power Mode	0 – CTM		0 - CTM; 1 - FXN

Table 38: Receiver Configuration default settings

B.3 Power Saving Modes

FixNOW™ Mode (UBX - CFG – FXN)

Parameter	Default setting	Unit	Range/Remark
On/ off time – Timeout			
Use on/off time	Enabled		Enabled - Disabled
T_on	36	s	
T_off	1800	s	
Absolute align	Disabled		Enabled - Disabled
Base TOW	0	s	
Startup – Timeout			
T_acq	120	s	
T_acq_off	600	s	
Last Fix – Timeout			
T_reacq	120	s	
T_reacq_off	600	s	
System Mode	Sleep		On; Sleep; Backup

Table 40: FixNOW™ default settings

B.4 Communications Interface

Port Setting (UBX – CFG – PRT)

Parameter	Default setting	Unit	Range/Remark
USART1 (TARGET1)			
Protocol in	0+1+2 – UBX+NMEA+RTCM		None; 0 – UBX; 1 – NMEA; 2 – RTCM; 12 – USER0; 13 – USER1; 14 – USER2 ; 15 – USER3
Protocol out	0+1 – NMEA + UBX		None; 0 – UBX; 1 – NMEA; 2 – RTCM; 12 – USER0; 13 – USER1; 14 – USER2 ; 15 – USER3
Baudrate	9600	baud	8 bits, no parity bit 1 stop bit
Autobauding	Disabled		Enabled - Disabled
USART2 (TARGET2)			
Protocol in	0+1+2 – UBX+NMEA+RTCM		None; 0 – UBX; 1 – NMEA; 2 – RTCM; 12 – USER0; 13 – USER1; 14 – USER2 ; 15 – USER3
Protocol out	0+1 – UBX+NMEA		None; 0 – UBX; 1 – NMEA; 2 – RTCM; 12 – USER0; 13 – USER1; 14 – USER2 ; 15 – USER3
Baudrate	57600 / 38400[15]	baud	8 bits, no parity bit 1 stop bit
Autobauding	Disabled		Enabled – Disabled

Table 42: Port default settings

[15] 57600 Baud: LEA-4P, LEA-4H, LEA-4t, TIM-4P, TIM-4H
38400 Baud: LEA-4S, LEA-4A, TIM-4A, TIM-4S

B.5 Messages (UBX – CFG – MSG)

UBX

Message	Type	USART1 (TARGET1[16])	USART2 (TARGET2)	USB (TARGET3)	Range/Remark
NAV-POSECEF	Out				
NAV-POSLLH	Out		1		
NAV-STATUS	Out		1		
NAV-DOP	Out				
NAV-SOL	Out		1		
NAV-POSUTM	Out				
NAV-VELECEF	Out				
NAV-VELNED	Out				
NAV-TIMEGPS	Out				
NAV-TIMEUTC	Out				
NAV-CLOCK	Out				
NAV-SVINFO	Out		1		
NAV-DGPS	Out				
NAV-SBAS	Out				
NAV-EKFSTATUS	Out		1		
RXM-RAW	Out				
RXM-SFRB	Out				
RXM-SVSI	Out				
RXM-RTC	Out				
RXM-ALM	Out				
RXM-EPH	Out				
MON-SCHD	Out		1		
MON-IO	Out		1		
MON-IPC	Out				
MON-MSGPP	Out				
MON-RXBUF	Out				
MON-TXBUF	Out		1		
MON-HW	Out				
MON-EXCEPT	Out		1		
MON-VER	Out				
AID-ALM	In/Out				
AID-EPH	In/Out				
AID-HUI	In/Out				
AID-INI	In/Out				
TIM-TP	Out				
TIM-TM	Out				

Table 44: UBX output rate default settings

[16] The Number entered under Target1 – Target2 defines the output cycle: 1 means every measurement cycle, 2 every 2nd measurement etc.

NMEA

Message	Type	USART1 (TARGET1[17])	USART2 (TARGET2)	USB (TARGET3)	Range/Remark
NMEA - DTM	Out				
NMEA - GBS	Out				
NMEA - GGA	Out	1		1	
NMEA - GLL	Out	1		1	
NMEA - GSA	Out	1		1	
NMEA - GSV	Out	1		1	
NMEA - RMC	Out	1		1	
NMEA - VTG	Out	1		1	
NMEA - GRS	Out				
NMEA - GST	Out				
NMEA - ZDA	Out	1		1	
NMEA – PUBX,00	Out				
NMEA – PUBX,01	Out				
NMEA – PUBX,03	Out				
NMEA – PUBX,04	Out				
NMEA – PUBX,05	Out				
NMEA – PUBX,06	Out				

Table 46: NMEA enabled output msg

B.6 Messages (UBX – CFG – INF)

UBX

Message	Type	USART1 (TARGET1[18])	USART2 (TARGET2)	USB (TARGET3[18])	Range/Remark
INF-Error	Out	1			
INF-Warning	Out	1			
INF-Notice	Out	1			
INF-Test	Out				
INF-Debug	Out				
INF-User	Out	1			

Table 48: UBX default enabled INF msg

NMEA

Message	Type	USART1 (TARGET1[19])	USART2 (TARGET2)	USB (TARGET3)	Range/Remark
INF-Error	Out	1		1	
INF-Warning	Out	1		1	
INF-Notice	Out	1		1	
INF-Test	Out				
INF-Debug	Out				
INF-User	Out	1		1	

Table 50: NMEA default enabled INF msg

! **Note** For further information about the UBX messages, refer to the ANTARIS®4 Protocol Specifications in *ANTARIS®4 System Information Manual [5]*

[17] The Number entered under Target1 – Target2 defines the output cycle: 1 means every measurement cycle, 2 every 2nd measurement etc.
[18] The Number entered under Target1 – Target2 defines the output cycle: 1 means every measurement cycle, 2 every 2nd measurement etc.
[19] The Number entered under Target1 – Target2 defines the output cycle: 1 means every measurement cycle, 2 every 2nd measurement etc.

B.7 Timing Settings

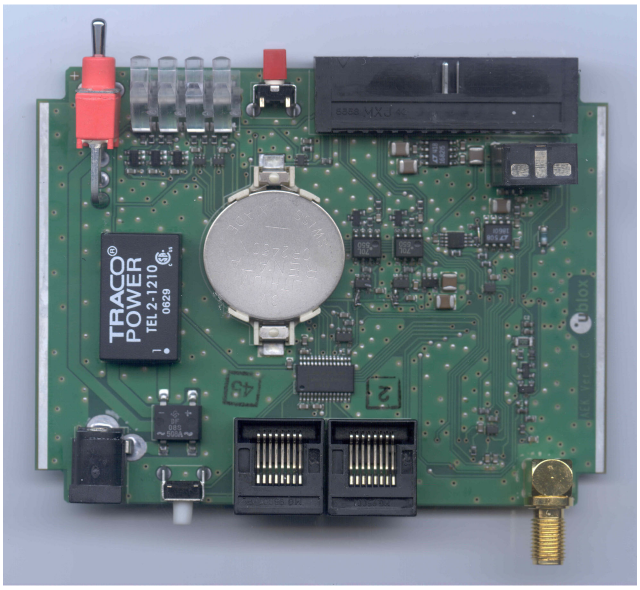
Timepulse (UBX – CFG – TP)

Parameter	Default setting	unit	Range/Remark
Pulse Mode	+1 - rising		+1 – rising; 0 – disabled; -1 - falling
Pulse Period	1000	ms	1 … 60'000
Pulse Length	100	ms	1us … (Pulse Period – 0.250 us)
Time Source	1 – GPS time		0 – UTC time; 1 – GPS time
Cable Delay	50	ns	± $2x10^9$ us
User Delay	0	ns	± $2x10^9$ us

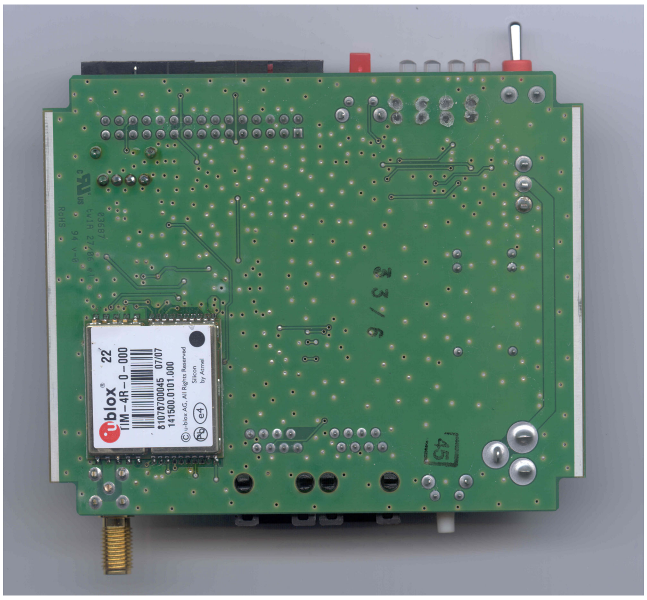
Table 52: Timepulse default settings

C Reference Design for TIM-4R

The TIM-4R Reference Design in this section is based on the *ANTARIS®4 Evaluation Kit for Dead Reckoning*. This is derived from an older TIM-LR design and is more complicated than necessary with Antaris®4 technology. Some of the components can be omitted.



AEK-4R top view



AEK-4R bottom view

Figure 19: Antaris®4 Evaluation Kit AEK-4R

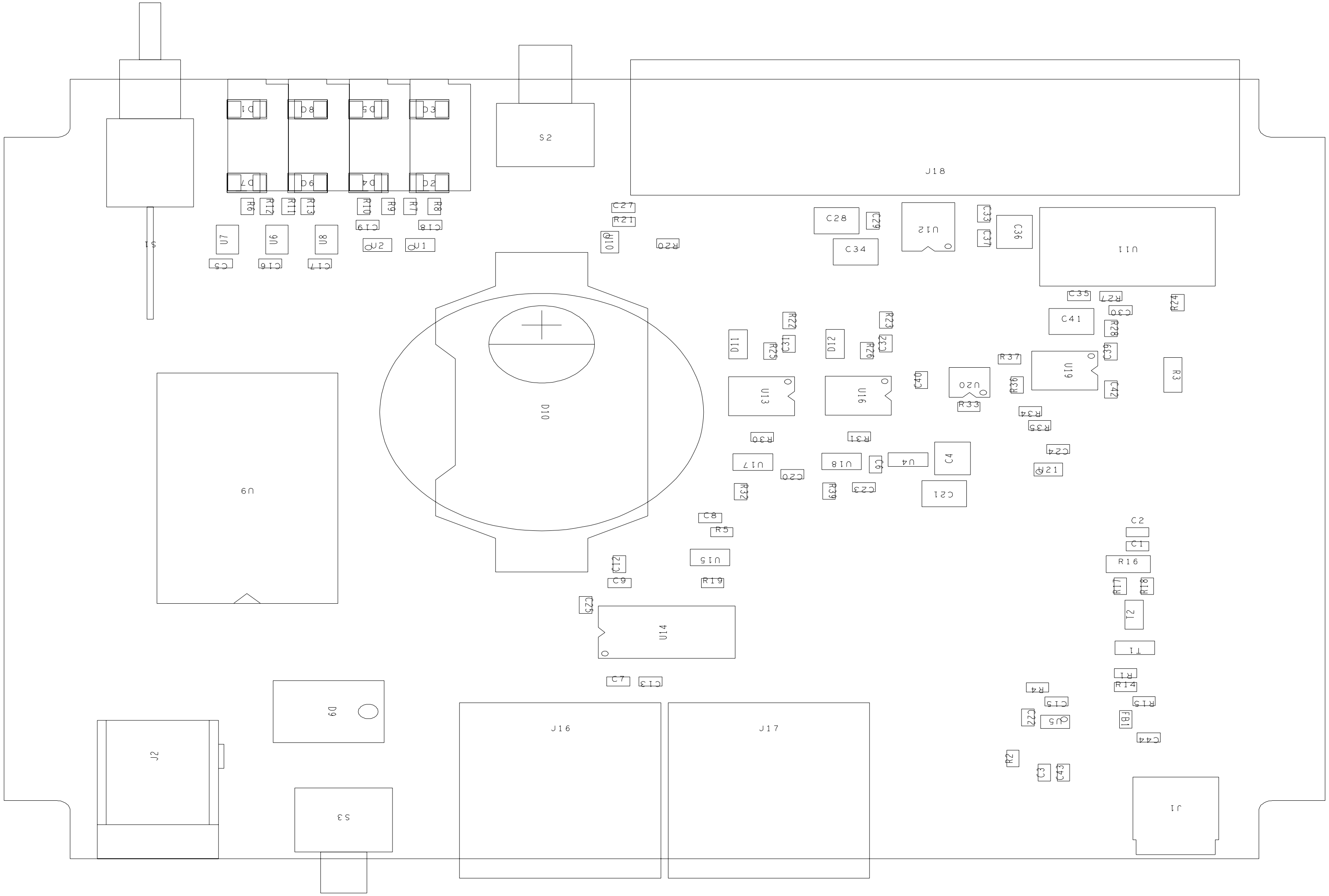


Figure 20: TIM-4R Reference Design (not to scale)

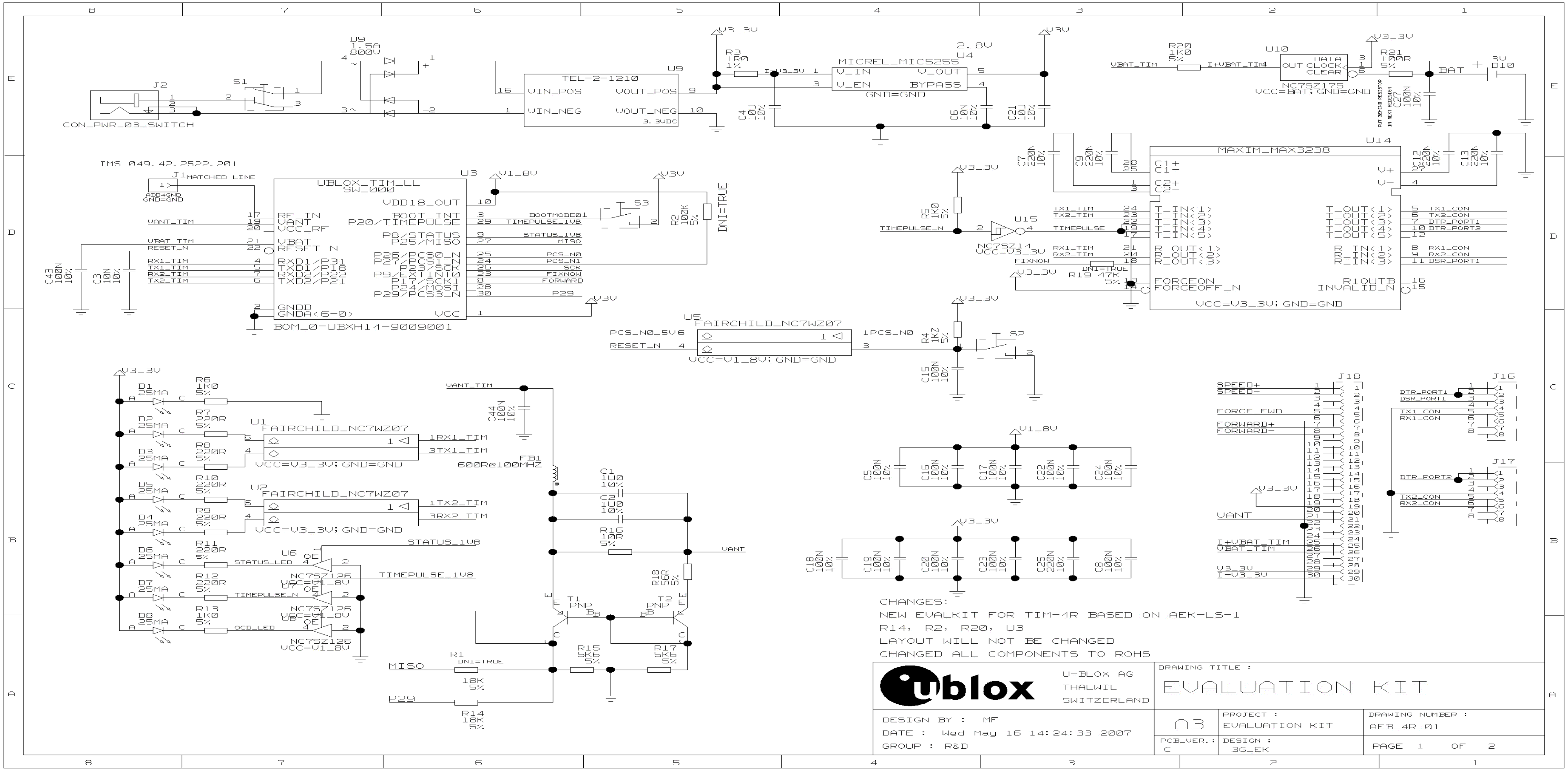


Figure 21: Reference Schematic (Evaluation Kit)

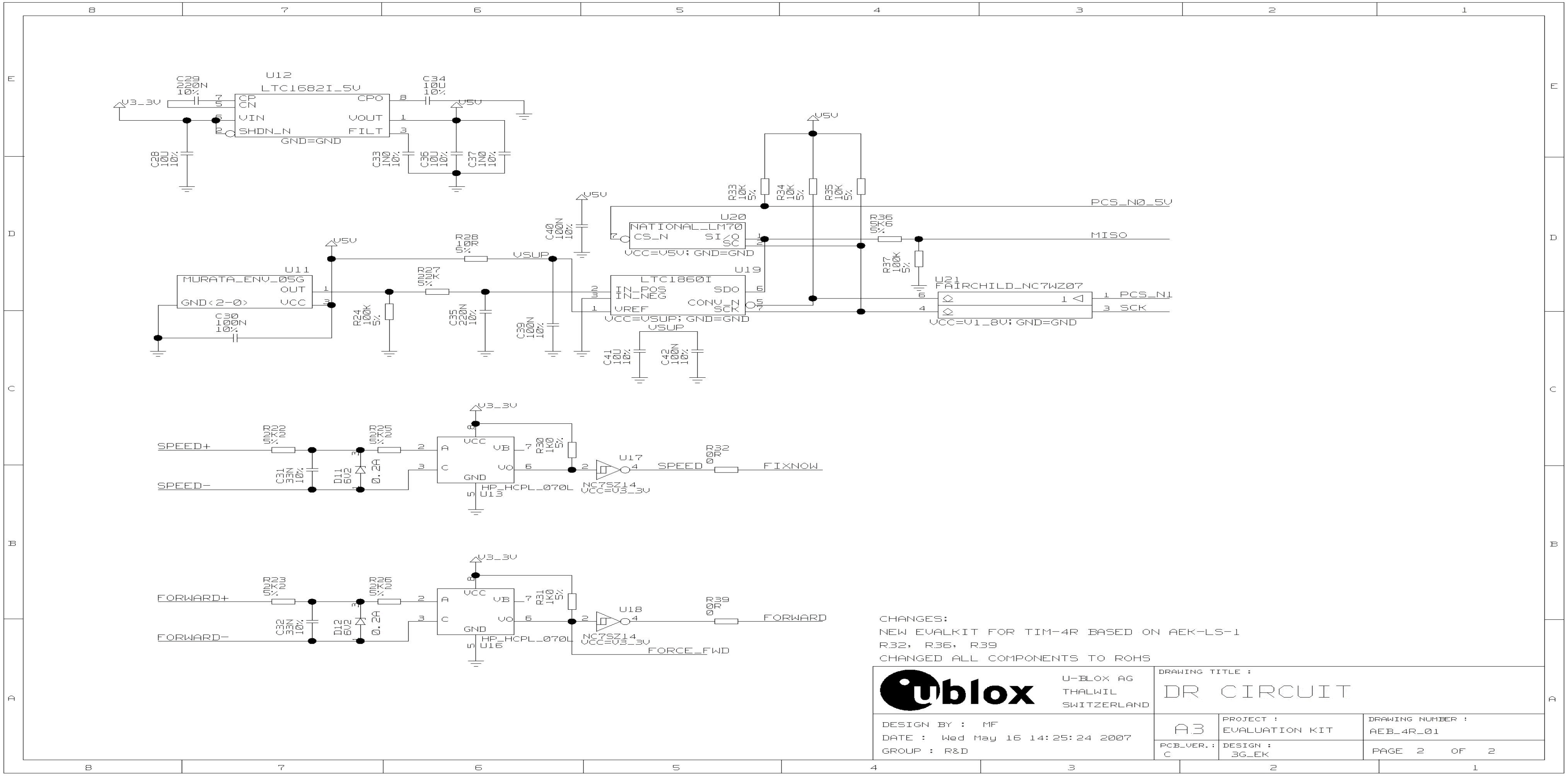


Figure 22: Figure 22: TIM-4R Reference Schematic (DR Circuit)

C.1 Bill of Material[20]

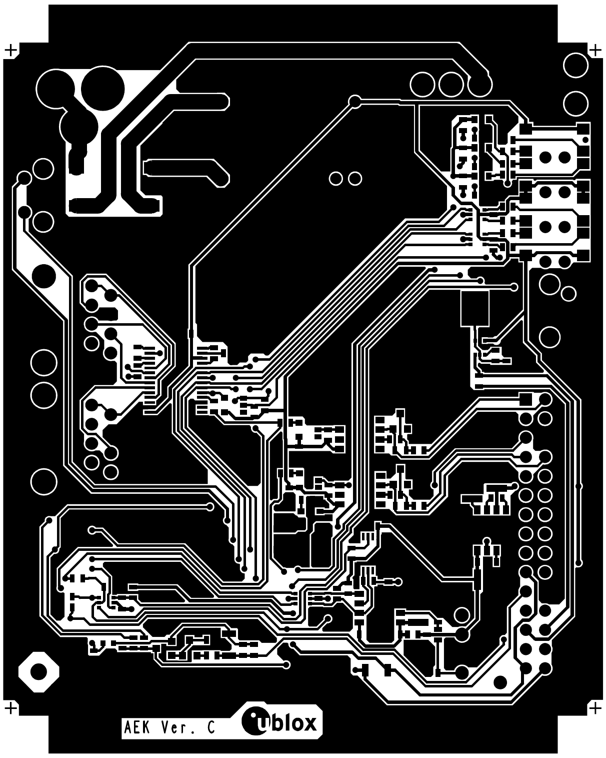
#	Ref. Design	Description	Selection List
2	C1 C2	CAP CER X5R 0603 1U0 10% 6.3V ROHS	GRM188R60J105KA01 - MURATA
7	C12 C13 C25 C29 C35 C7 C9	CAP CER X7R 0603 220N 10% 10V ROHS	GRM188R71C224KA01 - MURATA
18	C15 C16 C17 C18 C19 C20 C22 C23 C24 C27 C30 C39 C40 C42 C43 C44 C5 C8	CAP CER X7R 0603 100N 10% 10V ROHS	GRM188R71C104KA01 - MURATA
6	C21 C28 C34 C36 C4 C41	CAP CER X5R 1210 10U 10% 10V ROHS	GRM32ER61A106KA01 - MURATA
2	C3 C6	CAP CER X7R 0603 10N 10% 25V ROHS	GRM188R71E103KA01 - MURATA
2	C31 C32	CAP CER X7R 0603 33N 10% 25V ROHS	GRM188R71E333KA01 - MURATA
2	C33 C37	CAP CER X7R 0603 1N0 10% 25V ROHS	GRM188R71E102KA01 - MURATA
2	D1 D8	LED ALGAAS RED ALGAAS RED 25MA ROHS	597-3111-507F - DIALIGHT
1	D10	BATTERY HOLDER RENATA TYP CR2450N ROHS	SMTU2450N-LF - RENATA
2	D11 D12	VOLTAGE REGULATOR DIODE FAIRCHILD BZX84 SOT23 6V2 0.2A ROHS	BZX84C6V2 - FAIRCHILD
5	D2 D3 D4 D5 D7	LED YELLOW YELLOW 25MA ROHS	597-3401-507F - DIALIGHT
1	D6	LED GREEN GREEN 25MA ROHS	597-3301-507F - DIALIGHT
1	D9	RECTIFIER BRIDGE FAIRCHILD DF SERIES 800V 1.5A ROHS	DF08S - FAIRCHILD 449-5070 - FARNELL
1	FB1	FERRITE BEAD MURATA BLM18HD 0603 600R@100MHZ ROHS	BLM18HD601SN1 - MURATA
1	J1	SMA CONNECTOR THT RIGHT ANGLE JACK 10.8MM ROHS	049.42.2522.201 - IMS
2	J16 J17	RJ45 THT RIGHT ANGLE JACK ROHS	67 40 68 - DISTRELEC 0950012881 - MOLEX
1	J18	2-ROWS TH-PCB CONNECTOR 100MIL GRID 30PINS RIGHT ANGLE 10.2MM ROHS	39-28-5304 - MOLEX
1	J2	POWER CONNECTOR 2.1MM ROHS	DC10A - CLIFF
6	R10 R11 R12 R7 R8 R9	RES THICK FILM CHIP 0603 220R 5% 0.1W ROHS	RC0603JR-07220RL - YAGEO
7	R13 R20 R30 R31 R4 R5 R6	RES THICK FILM CHIP 0603 1K0 5% 0.1W ROHS	RC0603JR-071KL - YAGEO
1	R14	RES THICK FILM CHIP 0603 18K 5% 0.1W ROHS	RC0603JR-0718KL - YAGEO RK73B1JTTD183J - KOA
3	R15 R17 R36	RES THICK FILM CHIP 0603 5K6 5% 0.1W ROHS	RC0603JR-075K6L - YAGEO
1	R16	RES THICK FILM CHIP 1206 10R 5% 0.25W ROHS	RC1206JR-0710RL - YAGEO
1	R18	RES THICK FILM CHIP 0603 56R 5% 0.1W ROHS	RC0603JR-0756RL - YAGEO
1	R21	RES THICK FILM CHIP 0603 100R 5% 0.1W ROHS	RC0603JR-07100RL - YAGEO
4	R22 R23 R25 R26	RES THICK FILM CHIP 0603 2K2 5% 0.1W ROHS	2322_702_81222_L - YAGEO
2	R24 R37	RES THICK FILM CHIP 0603 100K 5% 0.1W ROHS	RC0603JR-07100KL - YAGEO RK73B1JTTD104J - KOA
1	R27	RES THICK FILM CHIP 0603 22K 5% 0.1W ROHS	2322_702_81223_L - YAGEO
1	R28	RES THICK FILM CHIP 0603 10R 5% 0.1W ROHS	RC0603JR-0710RL - YAGEO RK73B1JTTD100J - KOA
1	R3	RES THIN FILM MELF 0204 1R0 1% 0.25W ROHS	MMA0204-50_1%_B1_1R0 - BEYSCHLAG
2	R32 R39	RES THICK FILM CHIP 0603 0R 0.1W ROHS	RC0603JR-070RL - YAGEO
3	R33 R34 R35	RES THICK FILM CHIP 0603 10K 5% 0.1W ROHS	RC0603JR-0710KL - YAGEO
1	S1	SWITCH ON ON ROHS	1MS1T2B4M7RE - MULTICOMP AE101MD1AV2Q04 - TYCO
1	S2	SWITCH SPST ON 1POL OMRON ROHS	B3F-3150 - OMRON
1	S3	SWITCH SPST ON 1POL TYCO ROHS	FSMRA6J - TYCO
2	T1 T2	PNP SILICON TRANSISTOR BC856B SOT23 ROHS	BC856B - PHILIPS
4	U1 U2 U21 U5	TINY LOGIC UHS DUAL BUFFER OPEN DRAIN OUTPUTS FAIRCHILD NC7WZ07 SC70 ROHS	NC7WZ07P6X_NL - FAIRCHILD
1	U10	TINY LOGIC UHS D-FLIP-FLOP ASYNCHRONOUS CLEAR FAIRCHILD NC7SZ175 ROHS	NC7SZ175P6X - FAIRCHILD
1	U11	SUPPORT SENSOR FOR CAR NAVIGATION SYSTEMS ENV-05G ROHS	ENV-05G - MURATA
1	U12	DOUBLER CHARGE PUMPS WITH LOW NOISE LINEAR REGULATOR 5V IND. TEMP. SO8 ROHS	LTC1682IS8-5#PBF - LINEAR TECHNOLOGY
2	U13 U16	LOW INPUT CURRENT HIGH GAIN LVTTL/LVCMOS COMPATIBLE 3.3V OPTOCOUPLER SO8 HCPL-070L-000E ROHS	HCPL-070L-000E - AVAGO
1	U14	RS-232 TRANSCEIVER MAXIM MAX3238 IND. TEMP. SO28 WIDE ROHS	MAX3238EAI+ - MAXIM
3	U15 U17 U18	TINY LOGIC UHS INVERTER WITH SCHMITT TRIGGER FAIRCHILD NC7SZ14 SOT23-5 ROHS	NC7SZ14M5X - FAIRCHILD
1	U19	12 BIT ANALOG-TO-DIGITAL CONVERTER LT LTC1860 IND. TEMP. SO8 ROHS	LTC1860IS8#TRPBF - LINEAR TECHNOLOGY LTC1860IS8#PBF - LINEAR TECHNOLOGY
1	U20	DIGITAL TEMPERATURE SENSOR 10BIT NATIONAL LM70 5V MSOP8 ROHS	LM70CIMMX-5/NOPB - NATIONAL SEMICONDUCTOR
1	U3	GPS RECEIVER U-BLOX TIM-4R-0-000 ROHS	TIM-4R-0-000 - U-BLOX
1	U4	LOW DROPOUT REGULATOR MICREL MIC5255 2.8V 150MA SOT23 ROHS	MIC5255-2.8YM5 - MICREL
3	U6 U7 U8	TINY LOGIC UHS BUFFER OE ACTIVE HIGH FAIRCHILD NC7SZ126 SOT23-5 ROHS	NC7SZ126M5X_NL - FAIRCHILD
1	U9	9-18V TO 3.3V 500MA DC/DC CONVERTER 2WATT ROHS	TEL 2-1210 - TRACO

Table 54: Bill of Material of the TIM-4R Reference Design

! Note Some of the components used for the TIM-4R Reference Design do not fully comply with the industrial temperature range (i.e. the optocoupler). You will need to replace these components should your design require an industrial temperature range.

[20] This Bill of Material does not include any mechanical parts or battery.

C.2 Reference Layout



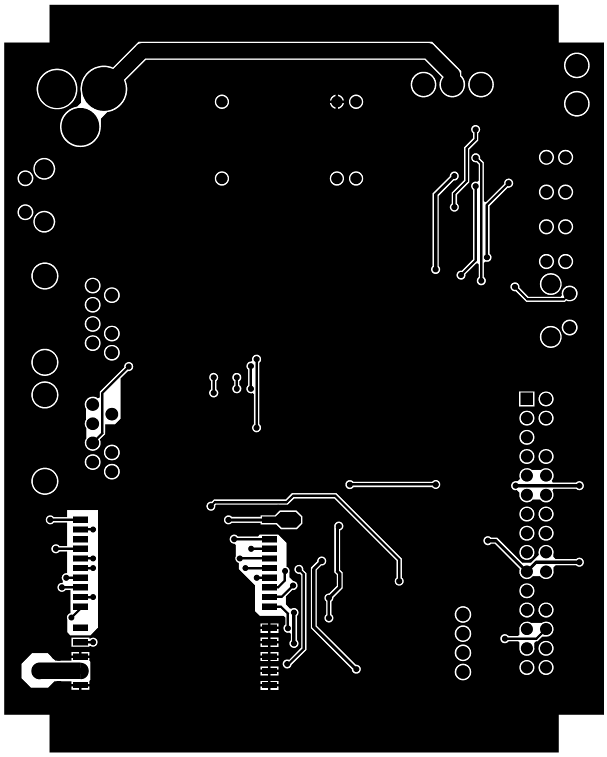


Figure 23: TIM-4R Reference Layout

! **Note** **Place the temperature sensor as close to the gyro as possible**

D Mechanical Dimensions

D.1 Dimensions

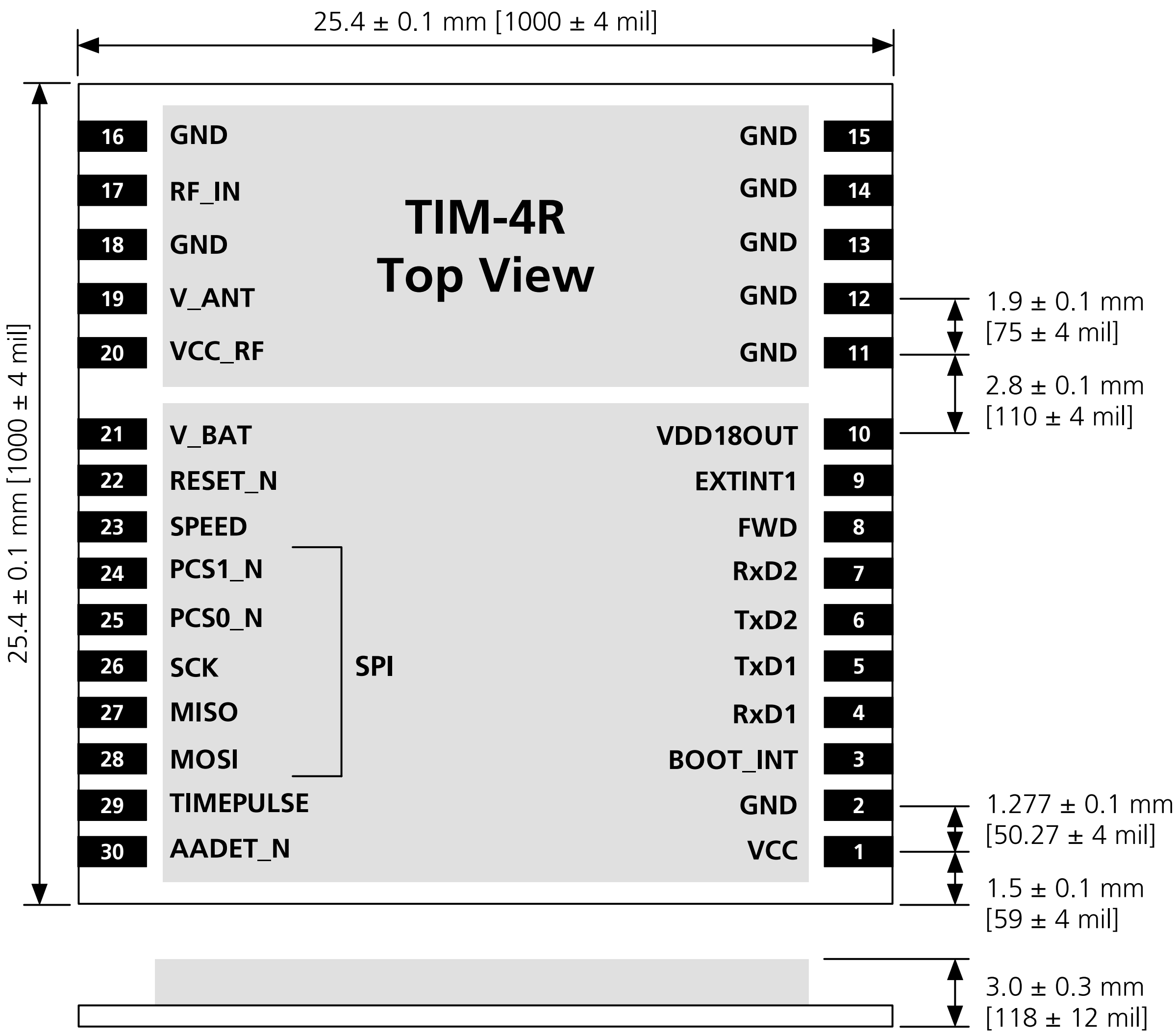


Figure 24: TIM-4R Dimensions

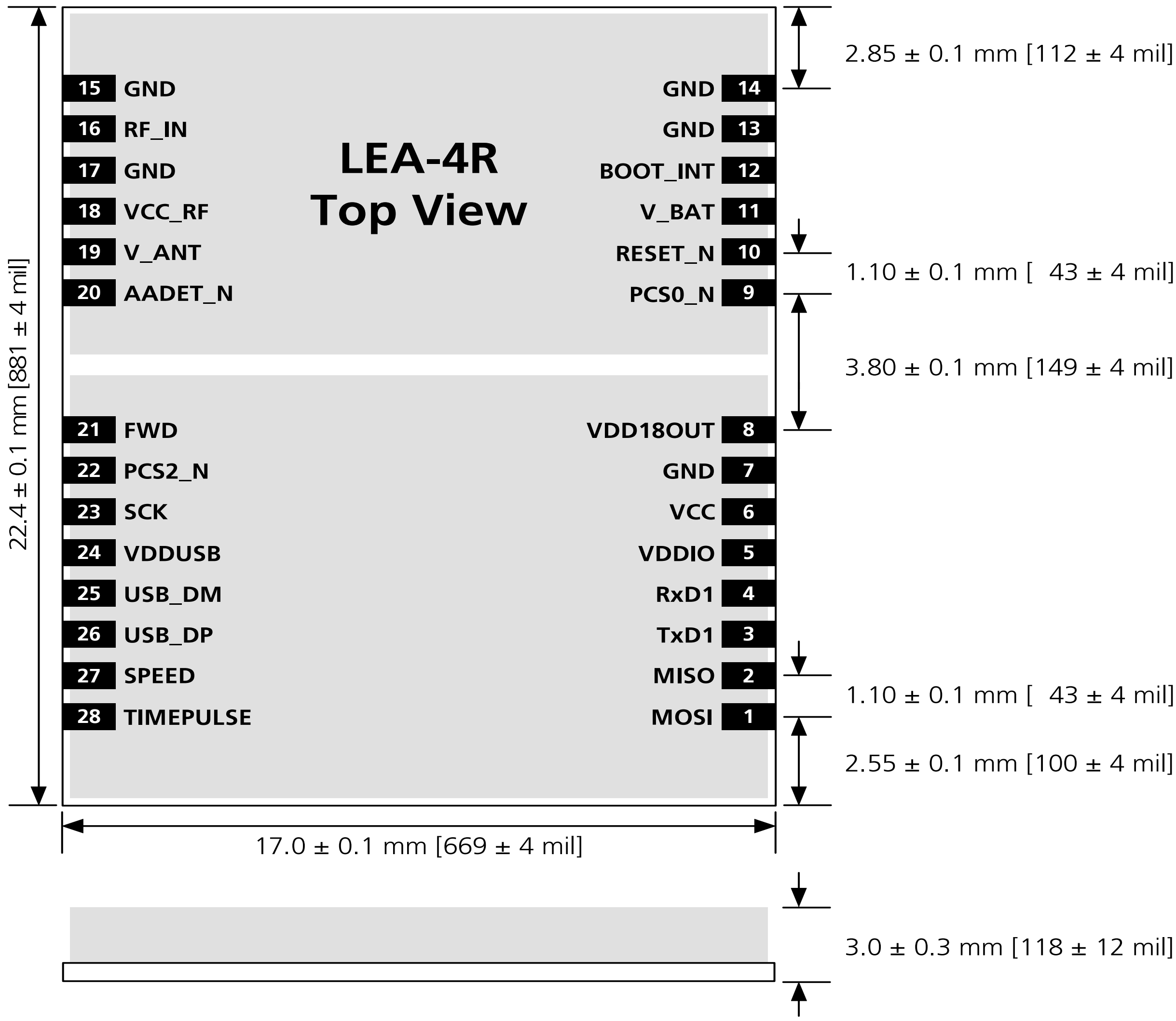


Figure 25: LEA-4R Dimensions

D.2 Specification

Parameter	Module	Specification
Length	LEA-4R TIM-4R	22.4±.1mm [881 ±4mil] 25.4±.1mm [1000 ±4mil]
Width	LEA-4R TIM-4R	17.0±.1mm [669 ±4mil] 25.4±.1mm [1000 ±4mil]
Thickness	LEA-4R TIM-4R	3.0 ±0.3mm [118 ±12mil] 3.0 ±0.3mm [118 ±12mil]
Pitch RF pins	LEA-4R TIM-4R	1.9±0.1mm [75 ±4mil] 1.9±0.1mm [75 ±4mil]
Pitch Digital pins	LEA-4R TIM-4R	1.277±0.1mm [50 ±4mil] 1.277±0.1mm [50 ±4mil]
Weight	LEA-4R TIM-4R	2.1g 3g

Table 55: Mechanical Specification LEA-4R/TIM-4R

Glossary

API	Application Programming Interface
APM	Autonomous Power Management
BBR	Battery backup RAM
CTM	Continuous Tracking Mode, operation Mode of the u-blox GPS receiver technology
DR	Dead Reckoning
ECEF	Earth Centered Earth Fixed
EKF	Enhanced Kalman Filter
ESD	Electro Static Discharge
FixNOW™	Operation Mode of the u-blox GPS receiver technology, initiates fix.
FXN	FixNOW™, operation Mode of the u-blox GPS receiver technology, initiates PVT fix.
HAE	Height Above WGS84-Ellipsoid
LLA	Latitude, Longitude and Altitude
LNA	Low Noise Amplifier
LOS	Line of sight,
MSL	Height above Mean Sea Level or Orthometric Height
NMEA 0183	ASCII based standard data communication protocol used by GPS receivers.
PUBX	u-blox proprietary extension to the NMEA protocol
PVT	Position, Velocity, Time
SA	Selective Availability
SBAS	Satellite Based Augmentation Systems
TIM-4x	Placeholder for all ANTARIS®4 GPS modules
UBX	File extension for u-center log file or short form for the UBX protocol
UBX Protocol	A proprietary binary protocol used by the ANTARIS® GPS technology
UTM	Universal Transverse Mercator
u-center AE	u-center ANTARIS® Edition

Related Documents

[1] GPS Basics, Introduction to the system – Application overview, Doc No GPS-X-02007

[2] u-blox' GPS Dictionary, Doc No GPS-X-00001

[3] ANTARIS®4 GPS Technology Protocol Specifications, Doc No GPS.G3-X-03002

[4] TIM-4x Datasheet, Doc No GPS.G4-MS4-07013

[5] ANTARIS® 4 System Integration Manual, Doc No GPS.G4-MS4-05007-A

All these documents are available on our homepage (http://www.u-blox.com).

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