C93-M8E

Application board

User guide

Abstract

This document describes the structure and use of the C93-M8E application board and provides information for evaluating and testing u-blox M8 Untethered Dead Reckoning (UDR) positioning technology.

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UBX-15031067 - R04

C1-Public

Document information

Title	C93-M8E	
Subtitle	Application board	
Document type	User guide	
Document number	UBX-15031067	
Revision and date	R04	6-Aug-2020
Disclosure Restriction	C1-Public	

Product status	Corresponding content status	
In development / Prototype	Objective specification	Target values. Revised and supplementary data will be published later.
Engineering sample	Advance information	Data based on early testing. Revised and supplementary data will be published later.
Initial production	Early production information	Data from product verification. Revised and supplementary data may be published later.
Mass production / End of life	Production information	Document contains the final product specification.

This document applies to the following products:

Product name	Type number	Hardware version	Firmware version	PCN reference	Product status
C93-M8E	C93-M8E-0-00	A	Flash FW 3.01 UDR 1.31 EVA	N/A	Early Production information

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Contents

1 Product description

1.1 Overview

Based on the EVA-M8E module, the C93-M8E application board enables immediate evaluation of u-blox's Untethered Dead Reckoning (UDR) technology in most vehicle applications. The C93-M8E includes the antenna, RTC and peripheral components that are required to complete an end-product design, all enclosed in a small case, ready for mounting in a vehicle application. The built-in USB interface provides both power supply and high-speed data transfer, and eliminates the need for an external power supply. The C93-M8E is compact, and ideally suited for use in laboratories and vehicles. It can be used directly with a PDA or a notebook PC via its USB interface. Schematics and layouts are available, allowing the C93-M8E to be used as a basis for customer designs.

1.2 C93-M8E package includes

- C93-M8E application board in clear plastic housing
- USB cable
- 18-mm patch type GNSS antenna

1.3 Evaluation software

The u-center software installation package for the C93-M8E can be downloaded from www.u-blox.com/en/evaluation-software-and-tools.

Once the .zip file is downloaded, extract the file contents in the Tools folder and double-click the extracted .exe file. The software components will be installed in your system and placed under the "u-blox" folder in the "Start > Programs" menu.

The u-center application is an interactive tool for configuration, testing, visualization and data analysis of GNSS receivers. It provides useful assistance during all phases of a system integration project. The latest version of the u-center should be used.

1.4 System requirements

- PC with USB interface
- Operating system: Windows Vista onwards (x86 and x64 versions)
- USB drivers are provided in the installed software

2 Specifications

Parameter	Specification
USB	1 micro USB V2.0
Extra connectors	connection pins for UART communication, 3.3 V
Dimensions	49 x 49 x 20 mm
Power supply	5 V via USB or external powered via extra power supply pin 1 (VCC) and common supply/interface ground pin 6 (GND)
Normal Operating temperature	-40 °C to +65 °C

Table 1: C93-M8E specifications

3 Device description

3.1 Interface connection and measurement

For connecting the application board to a PC, use the included USB cable or 6-pin connector. USB provides both power and a communication channel.

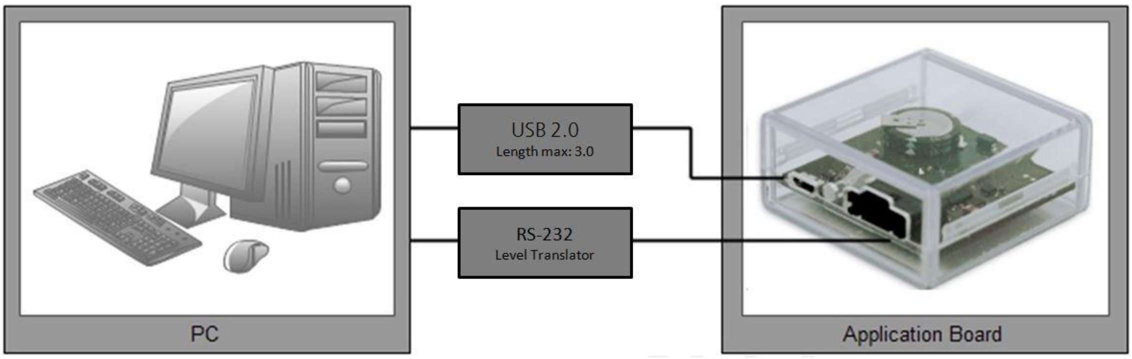

Figure 1: Connecting the unit for power supply and communication

3.2 Integrated GNSS antenna

The C93-M8E includes an 18-mm patch type GNSS antenna. The PCB design allows for patch antennas of up to 25 mm to be fitted (soldering required).

3.3 Evaluation unit

Figure 2 shows C93-M8E application board.

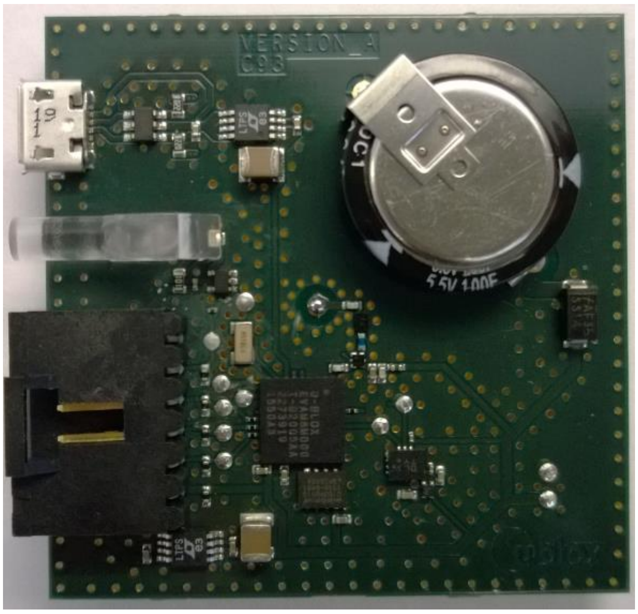

Figure 2: C93-M8E application board

3.3.1 USB

A micro USB V2.0 compatible port is featured for data communication and power supply.

3.3.2 Pin header

The C93-M8E application board includes a 6-pin latching connector from the TE Connectivity AMPMODU MTE series. Mating cable receptacles from this series include part numbers 5-103960-5 and 5-103957-5. The 6-pin header is assigned as listed in Table 2:

Pin no.	Assignment
1	VCC
2	TXD, GPS Transmit Data, serial data to DTE, 3 V logic level inverted
3	RXD, GPS Receive Data, serial data from DTE, 3 V logic level inverted
4	Connect to RESET pin of EVA-M8E
5	Connect to SAFEBOOT pin of EVA-M8E
6	GND

Table 2: Pin header description for C93-M8E

☞ Note that the UART signals are at 3 V logic levels, suitable only for direct connection to a host microcontroller. For connection to standard RS-232 level interfaces on PCs or other equipment, a separate inverting level-shifter buffer must be used (e.g. MAX3232).

3.3.3 LED

On the front panel of the unit, a single blue LED may be configured to follow the receiver time pulse signal using message UBX-CFG-TP5. The time-pulse may be configured so that the LED starts flashing at one pulse per second during a valid GNSS fix. If there is no GNSS fix, the LED will only be lit, without flashing. The time pulse is enabled by default in C93-M8E.

3.3.4 Backup battery

The unit includes a “Supercapacitor” type rechargeable backup battery. This is necessary to store calibration, dead-reckoning and orbital information between operations, and it also supports Real Time Clock (RTC) to enable immediate startup in DR mode and fast acquisition of GNSS signals. Once fully charged, the capacitor provides around 24 hours of backup supply.

3.3.5 GNSS configuration

The C93-M8E supports GPS, QZSS, GLONASS, Galileo and BeiDou.

The GNSS to be used can be configured on u-center (View > Messages View > UBX-CFG-GNSS). For more information, refer to the u-center User Guide [6] and the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [5].

4 Setting up

4.1 C93-M8E installation

The following sections describe the steps required to complete the C93-M8E hardware installation.

4.1.1 Mounting the C93-M8E

The C93-M8E application board should be firmly attached to the car body so as to avoid any movement or vibration with respect to the car body. The application board should not be attached to any “live” (unsprung) part of the vehicle’s suspension. Often it is enough to use strong double-sided tape or Velcro tape glued to the bottom of the C93-M8E casing. The C93-M8E must be secured against any change in position and particularly orientation with respect to the vehicle frame.

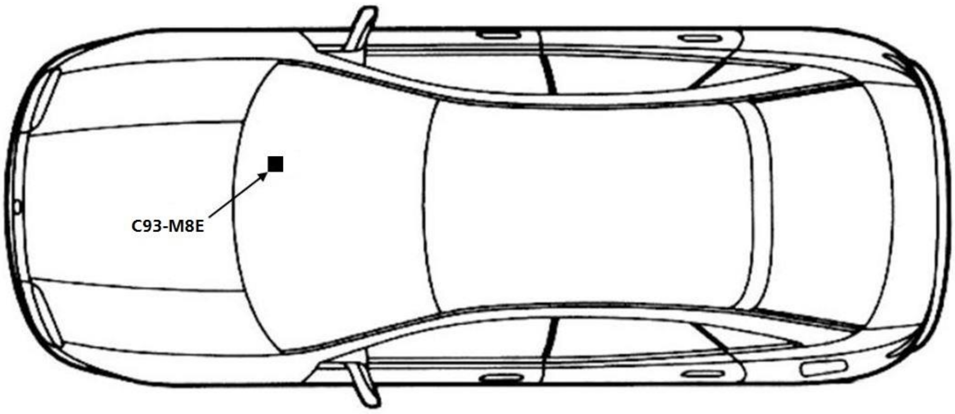

Figure 3: Example installation of the C93-M8E on car dashboard

☞ For best performance, the integrated antenna needs to have the best sky view possible in the car or outside of the car.

4.1.2 Connecting the cables

Rather than using USB alone, we recommend using the 6-pin latching receptacle recommended above because it locks securely to the front connector of the C93-M8E. Other 0.1" receptacles may be compatible. You will need to solder the necessary I/O cables to signal sources and outputs as shown in Table 3.

1. Connect the unit to a PC running Microsoft Windows by
   1.1. USB: Connect via USB port or
   1.2. UART: Connect via 6-pin header via an inverting RS-232 level shifter (e.g. MAX3232).
2. The device is powered either via USB or from a 5 V supply via pin no.1 of the 6-pin header.
3. Start the u-center GNSS Evaluation Software and select the corresponding COM port and baud rate.

☞ Refer to the u-center User Guide [6] for more information.

4.2 Recommended configuration

For an optimum navigation performance, the recommended configuration is as follows:

- Navigation rate: The default DR/GNSS-fused navigation solution update rate of 1 Hz is recommended. You can set the navigation update rate with the message UBX-CFG-RATE. (In this mode navigation rates of up to 30 Hz are also available from the UBX-HNR-PVT message.)
- Signal attenuation compensation: For installations where the signals are attenuated due to the C93-M8E placement, the signal attenuation compensation feature can be used to restore normal performance. There are three possible modes:
  - Disabled: no signal attenuation compensation is performed
  - Automatic: the receiver automatically estimates and compensates for the signal attenuation
  - Configured: the receiver compensates for the signal attenuation based on a configured value
- These modes can be selected using UBX-CFG-NAVX5 message.

☞ In the case of the "configured" mode, the user should input the maximum C/N0 observed in a clear-sky environment, excluding any outliers or unusually high values. The configured value can have a large impact on the receiver performance, so should be chosen carefully.

☞ For more information, refer to the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [5].

4.2.1 Serial port default configuration

Parameter	Description	Remark
UART Port 1, input	UBX and NMEA protocol at 9,600 Bd	
UART Port 1, output	UBX and NMEA protocol at 9,600 Bd	Only NMEA messages are activated
USB, input	UBX and NMEA protocol	
USB, output	UBX and NMEA protocol	Only NMEA messages are activated

Table 3: Default configuration

4.2.2 UDR configuration

By default, C93-M8E is ready to operate in UDR navigation mode. The following sections describe how to configure the parameters specific to the installations.

☞ The statuses of different modes of UDR receiver are output in the UBX-ESF-STATUS message.

4.2.2.1 Sensor/IMU mount angles configurations

Dead reckoning performance relies on accurate configuration of the sensor mount configuration angles. The angles may be measured and configured manually or established using the Automatic IMU-mount Alignment feature described below. In either case the configuration is made using message UBX-CFG-ESFALG.

If you do not know or are not completely certain how to measure the Sensor-mount Misalignment Angles correctly, enable the Automatic IMU-mount Alignment (see below). Click the **Send** button after selecting “Automatic IMU-mount Alignment”. The correct angles will then be determined automatically in Phase II of the calibration drive (see section 4.4).

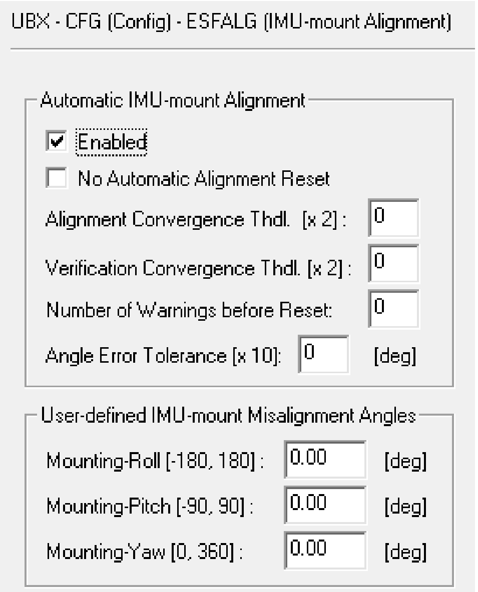

Figure 4: u-center showing how to enable Automatic IMU-mount Alignment with UBX-CFG-ESFALG

If you know the IMU-mount Misalignment Angles, enter those values into the UBX-CFG-ESFALG dialog shown in Figure 4. Make sure the "Automatic IMU-mount Alignment" is unselected. Click the **Send** button. For more information, refer to the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [5].

☞ Automatically determined IMU-mount Alignment angles do not survive a cold start (either by command or loss of the battery backup supply). If it is important that automatically determined angles continue to be used after the next cold start, follow the procedure in section 4.3.1.2.

☞ If the user reverts to factory defaults with UBX-CFG-CFG command, the UBX-CFG-ESFALG with correct configuration values (yaw, pitch, roll) shall be issued again.

4.2.2.2 Saving the configuration permanently

If, for example, automatically determined IMU mount angles should be used after the next cold start, they can be saved in the receiver's non-volatile memory and will be re-used until the automatic alignment feature is next enabled. Proceed as follows:

- When configuration is indicated as completed in the UBX-ESF-STATUS and UBX-ESF-ALG windows, copy the angles from UBX-ESF-ALG display to the UBX-CFG-ESFALG dialog. Unselect the "Automatic IMU-mount Alignment" in UBX-CFG-ESFALG dialog and click the **Send** button. Save the configuration as described below.

The entire current configuration of the receiver (including configuration data and all UDR parameters) can be saved to BBR and non-volatile memory (flash) by sending UBX-CFG-CFG command (see Figure 5 below).

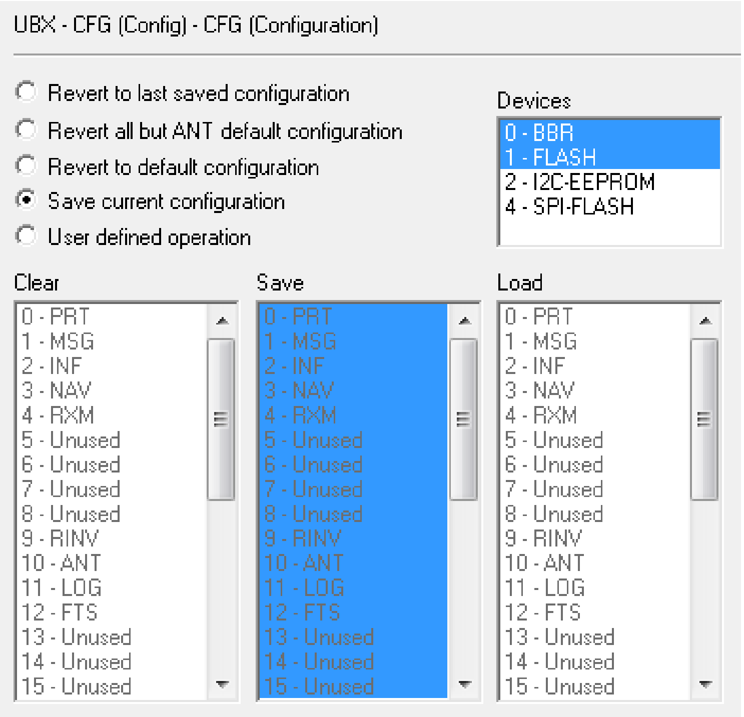

Figure 5: u-center showing how to save current configuration with UBX-CFG-CFG

4.3 UDR receiver operation

The sections below describe the UDR receiver operation modes.

4.3.1.1 Initialization mode

The purpose of the Initialization phase is to estimate all unknown parameters that are required for achieving fusion. In this case, the required sensor calibration status shows NOT CALIBRATED. Note that the initialization phase requires good GNSS signal conditions as well as periods during which vehicle is stationary and moving (including turns). Once all required initialization steps are achieved, fusion mode is triggered and the calibration phase begins.

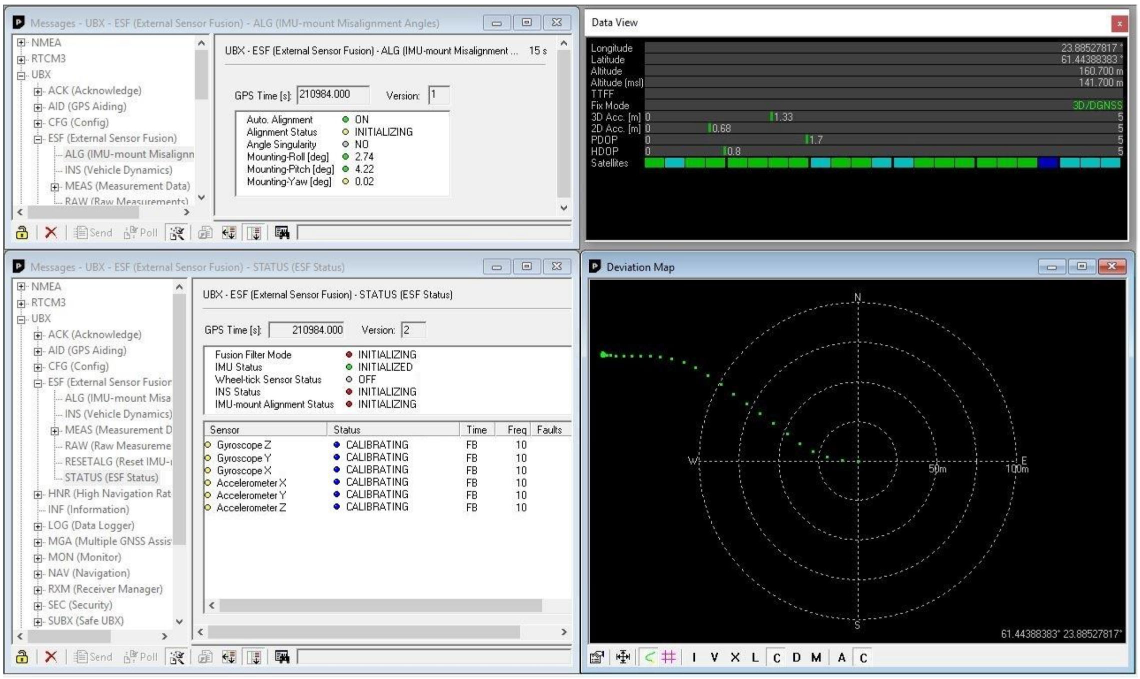

Figure 6: Screenshot of u-center showing the INITIALIZING mode in UBX-ESF-STATUS message

4.3.1.2 Fusion mode

Once the initialization phase is achieved, the receiver enters navigation mode and starts to compute combined GNSS/Dead-reckoning fixes and to calibrate the sensor required for computing the fused navigation solution. The sensor calibration status outputs CALIBRATING. As soon as the calibration reaches a status where optimal fusion performance can be expected, the sensor calibration status is flagged as CALIBRATED (see Figure 7).

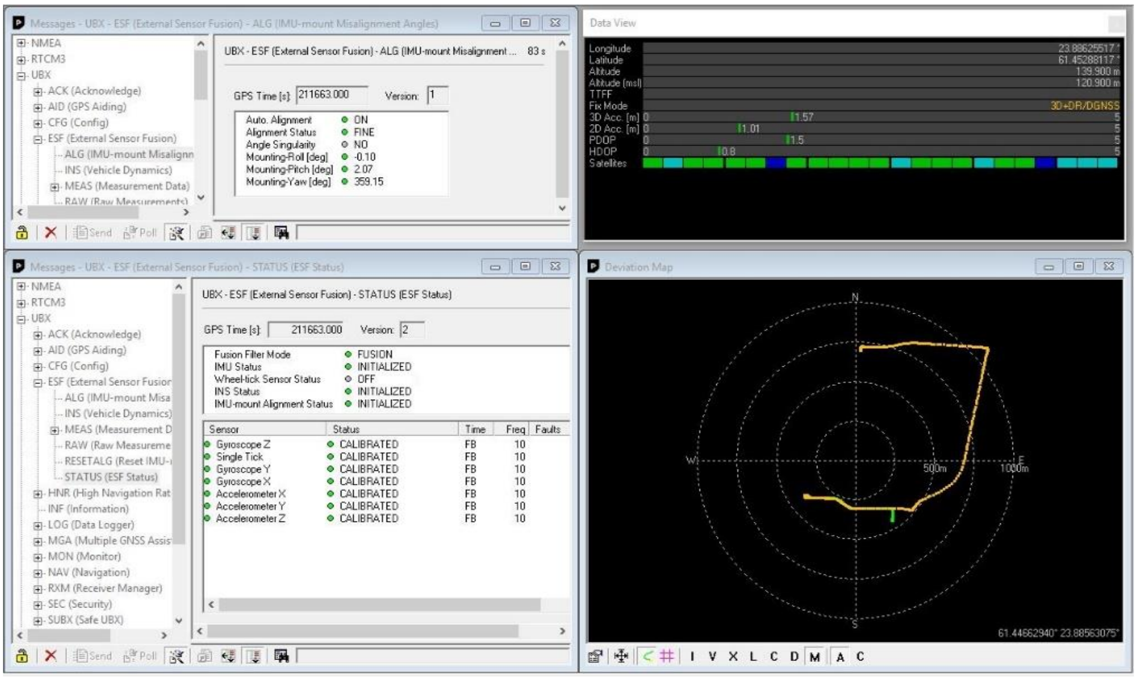

Figure 7: Screenshot of u-center showing the sensor calibration as CALIBRATED

4.4 Accelerated initialization and calibration procedure

This section describes how to perform fast initialization and calibration of the UDR receiver for evaluation purposes.

The duration of the initialization phase mostly depends on the quality of the GNSS signals and the dynamics encountered by the vehicle. Therefore the car should be driven to an open and flat area such as an empty open-sky parking area. The initialization and calibration drive should contain phases where the car is stopped during a few minutes (with engine turned-on), phases where the car is doing normal left and right turns, and phases where the speed is above 30 km/h under good GNSS reception conditions.

☞ Note that the calibration status of some used sensors might fall back to CALIBRATING if the receiver is operated in challenging conditions. In such cases, the quality of the fused navigation will be degraded until optimal conditions are again available for re-calibrating the sensors.

☞ For more information, refer to the u-blox 8 / u-blox M8 Receiver Description including Protocol Specification [5].

5 Test drives

We recommend recording and archiving the data of your test drives. You can enable additional debug messages by clicking the **Debug** button, and then clicking the **Record** button (see Figure 8). When prompted to poll for configuration, click **Yes** (see Figure 9).

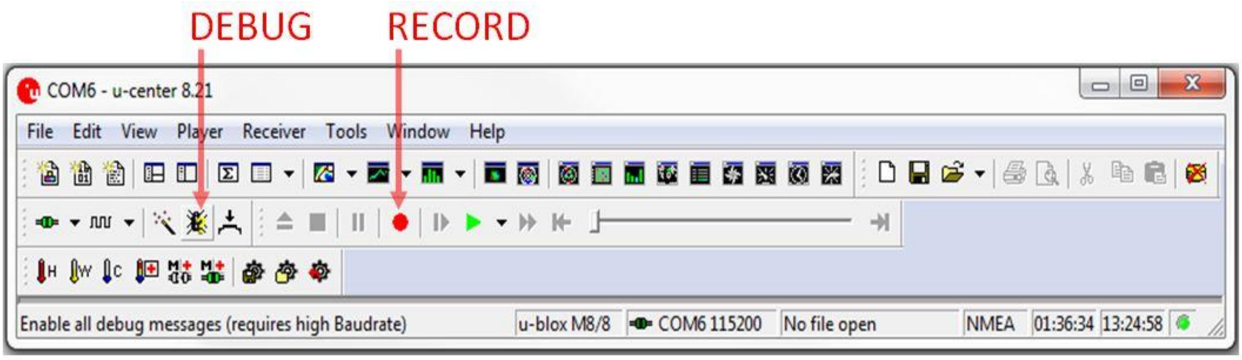

Figure 8: The Debug and Record buttons are used for extra messages and debugging / post-analysis

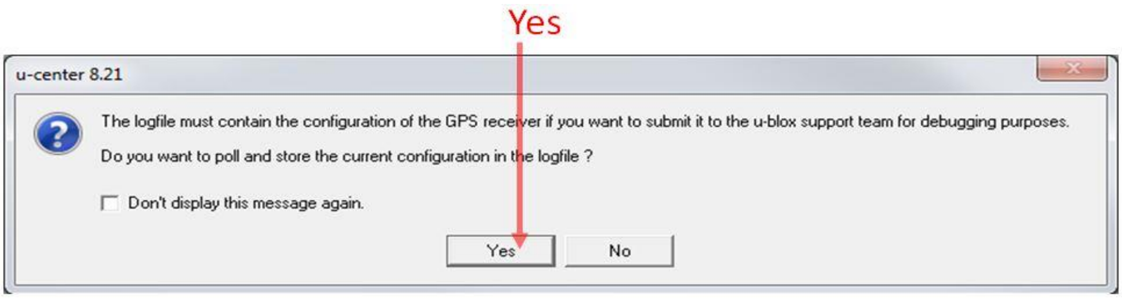

Figure 9: Allow polling and storing of the receiver configuration into log file

6 Block diagram

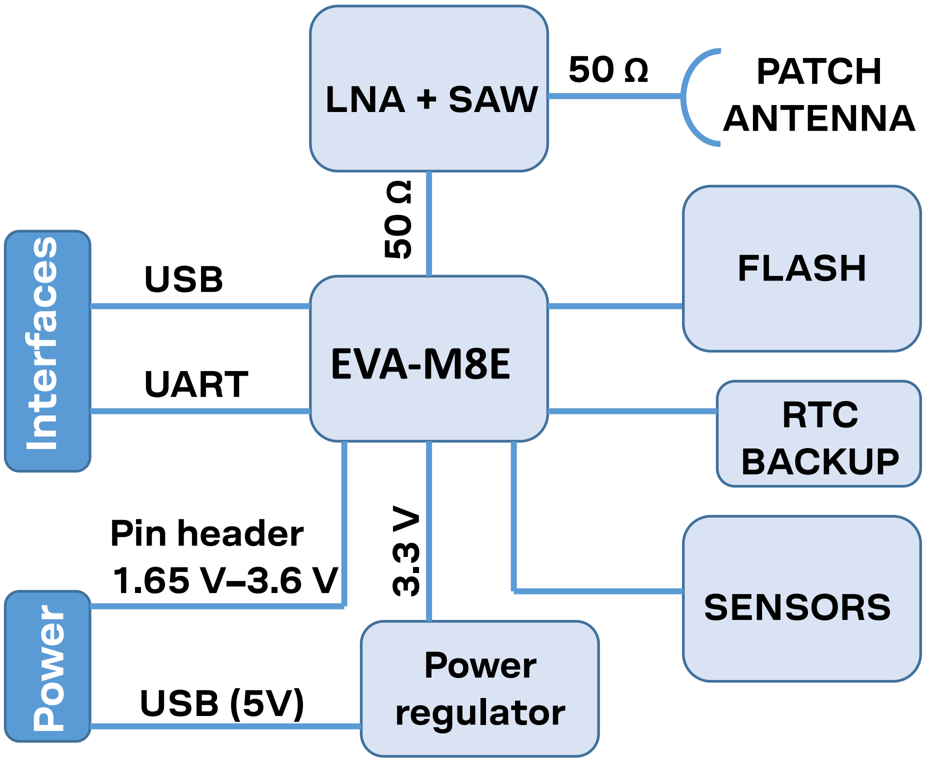

Figure 10: C93-M8E block diagram

7 Board layout

Figure 11 shows the C93-M8E board layout. See Table 4 for the application board component list.

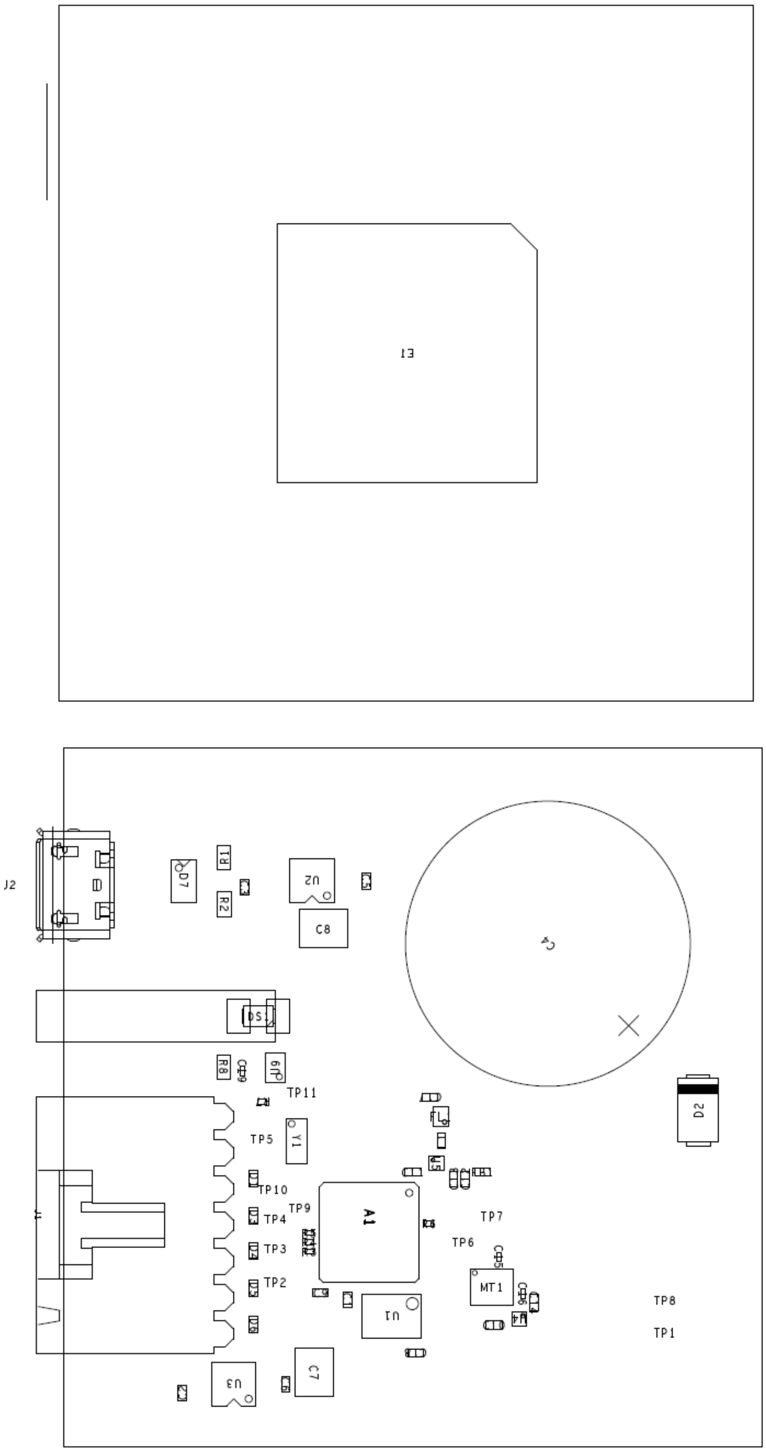

Figure 11: C93-M8E layout: top and bottom

PART	DESCRIPTION
A1	GPS RECEIVER U-BLOX EVA-M8E QFN36 -40/+85 °C
C1, C2, C3, C10, C14 C18	CAP CER X5R 0402 1U0 10% 6.3 V
C4	CAP ELECTRIC DOUBLE LAYER THT PANASONIC SERIES SG 1F 30% 5.5 V
C5, C6	CAP CER X7R 0402 10N 10% 16 V
C7, C8	CAP CER X5R 1210 10U 10% 10 V
C9	CAP CER X5R 0402 2U2 20% 6.3 V
C11	CAP CER COG 0402 1P8 +/-0.1P 25 V
C12	CAP CER COG 0402 22P 5% 25 V
C13	CAP CER X7R 0402 1N0 10% 16 V
C15, C16, C19	CAP CER X5R 0201 100N 10% 6.3 V
C17	CAP CER COG 0402 47P 5% 25 V
D1, D3, D4, D5, D6	VARISTOR BOURNS MLE SERIES CG0402MLE-18G 18 V
D2	SURFACE MOUNT SCHOTTKY BARRIER RECTIFIER SS14 1A -55/+125 °C
D7	USB DATA LINE PROTECTION ST USBLC6-2SC6 SOT23-6
DS1	LED OSRAM HYPER MINI TOPLED LB M673-L1N2-35 BLUE 0.02 A
E1	ANTENNA PATCH THT 18MM X 18MM X 4MM TAOGLAS 1561MHZ,1575MHZ,1602MHZ -40/+85 °C
FB1	FERRITE BEAD MURATA BLM15HD 0402 1000R@100 MHZ
FL1	SAW FILTER FOR GPS/GLONASS/BEIDOU TST TA1343A -40/+85°C
J1	6PIN 90\xB0 2.54MM PITCH DISCONNECTABLE CRIMP CONNECTOR -40/+85°C
J2	CON USB RECEPTACLE MICRO B TYPE SMD - MOLEX 47346-0001 - TID60001597 30V 1 A
L1	IND MURATA LQW15A 0402 8N7 3% 0.54A -55/+125 °C
MT1	SMAL, LOW POWER INERTIAL MEASUREMENT UNIT BMI160 BMI160 3.6V -40/+85 °C
R1, R2	RES THICK FILM CHIP 0603 22R 5% 0.1W -55/+125 °C
R3, R4, R5, R6	RES THICK FILM CHIP 0201 220R 5% 0.05 W
R7	RES THICK FILM CHIP 0201 1K0 5% 0.05 W
R8	RES THICK FILM CHIP 0603 100R 5% 0.1 W
U1	WINBOND W25Q16DVZPIG 16MBIT SERIAL QUAD I/O SPI FLASH MEMORY 2.7 - 3.6 V USON8 3.6V -40/+85 °C
U2, U3	LOW DROPOUT REGULATOR LINEAR LT1962 MS8 3.3V 0.3 A
U4	LOW DROPOUT REGULATOR MICREL MIC5503 1.8V 0.3A -40/+125 °C
U5	LOW NOISE AMPLIFIER GAAS MMIC 1.575 GHZ 1.5V-3.6V JRC EPFFP6-A2 3.6V -40/+85 °C
U9	TINY LOGIC UHS BUFFER OE_N ACTIVE LOW FAIRCHILD NC7SZ125 SC70
Y1	CRYSTAL CL=7PF MICRO CRYSTAL CC7 GOLD TERMINATION 32.768KHZ 100PPM -40/+85 °C

Table 4: C93-M8E component list

8 Schematic

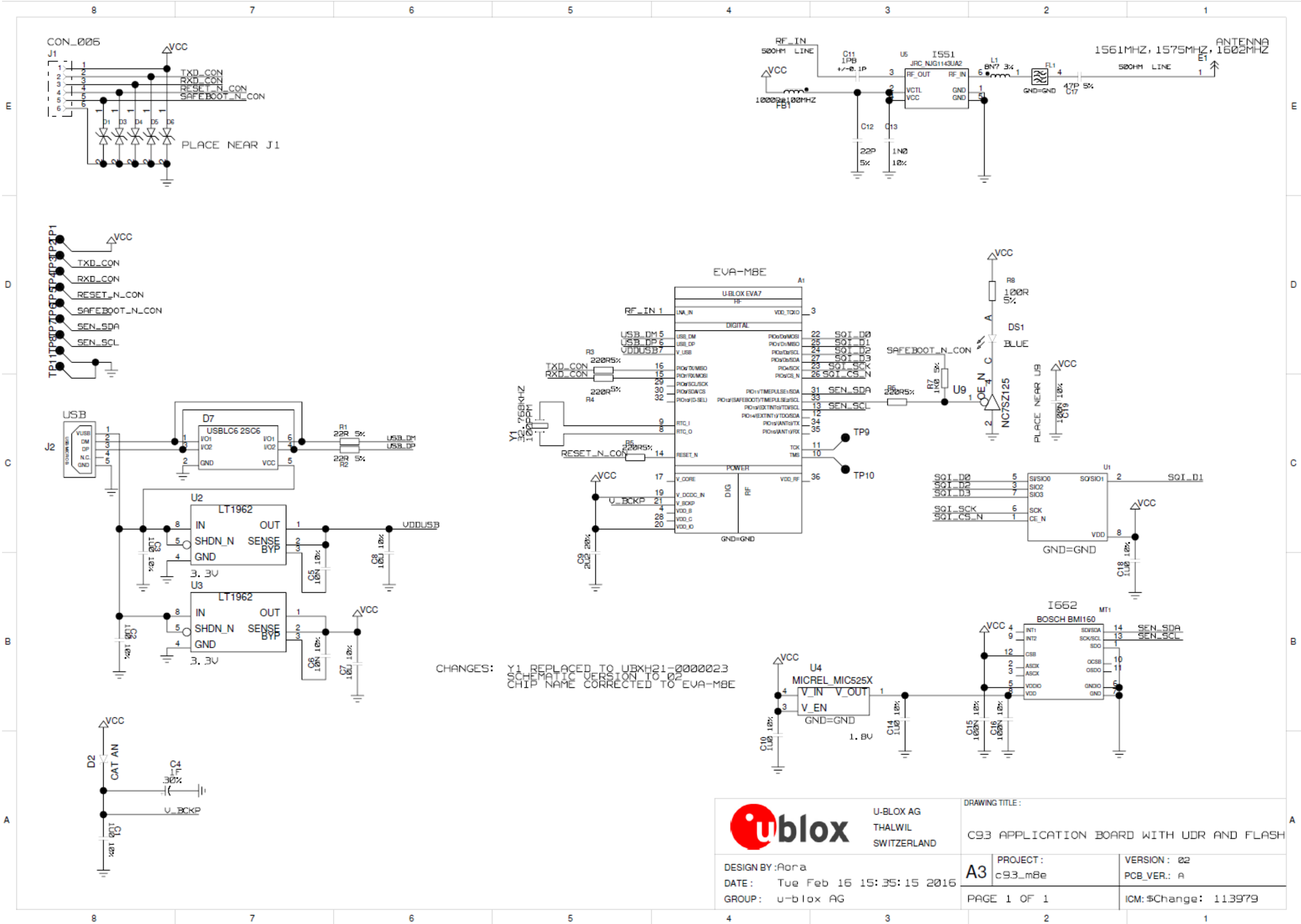

Figure 12: Schematic C93-M8E

9 Troubleshooting

My application (e.g. u-center) does not receive anything

Check whether the blue LED on the application board is blinking. Also make sure that the USB cable is properly connected to the application board and the PC. By default, the application board outputs NMEA protocol on Serial Port 1 at 9600 Bd, or on the USB.

My application (e.g. u-center) does not receive all messages

When using UART, make sure the baud rate is sufficient. If the baud rate is insufficient, GNSS receivers based on u-blox M8 GNSS technology will skip excessive messages. Some serial port cards/adapters (i.e. USB-to-RS232 converter) frequently generate errors. If a communication error occurs while u-center receives a message, the message will be discarded.

My application (e.g. u-center) loses the connection to the GNSS receiver

u-blox M8 positioning technology and u-center have an autobauding feature. If frequent communication errors occur (e.g. due to problems with the serial port), the connection may be lost. This happens because u-center and the GNSS receiver both autonomously try to adjust the baud rate. Do not enable the u-center autobauding feature if the GNSS receiver has the autobauding flag enabled.

The COM port does not send any messages

Be sure that the slide switch at the front side is set to RS232 and not USB. In USB Mode the RS232 pins on the DB9 connector are switched off.

Some COM ports are not shown in the port list of my application (e.g. u-center)

Only the COM ports that are available on your computer will show up in the COM port drop down list. If a COM Port is gray, another application running on this computer is using it.

The position is off by a few dozen meters

u-blox M8 GNSS technology starts up with the WGS84 standard GNSS datum. If your application expects a different datum, you will most likely find the positions to be off by a few dozen meters. Do not forget to check the calibration of u-center map files.

The position is off by hundreds of meters

Position drift may also occur when almanac navigation is enabled. The satellite orbit information retrieved from an almanac is much less accurate than the information retrieved from the ephemeris. With an almanac-only solution, the position will only have an accuracy of a few kilometers but it may start up faster or still navigate in areas with obscured visibility when the ephemeris from one or several satellites has not yet been received. The almanac information is NOT used for calculating a position if valid ephemeris information is present, regardless of the setting of this flag.

In NMEA protocol, position solutions with high deviation (e.g. due to enabling almanac navigation) can be filtered with the Position Accuracy Mask. UBX protocol does not directly support this since it provides a position accuracy estimation, which allows the user to filter the position according to his requirements. However, the “Position within Limits” flag of the UBX-NAV-STATUS message indicates whether the configured thresholds (i.e. P Accuracy Mask and PDOP) are exceeded.

TTFF times at startup are much longer than specified

At startup (after the first position fix), the GNSS receiver performs an RTC calibration to have an accurate internal time source. A calibrated RTC is required to achieve minimal startup time.

Before shutting down the receiver externally, check the status in MON-HW in field “Real Time Clock Status”. Do not shut down the receiver if the RTC is not calibrated.

The C93-M8E does not meet the TTFF specification

Make sure the C93-M8E has a good sky view. An obstructed view leads to prolonged startup times. In a well-designed system, the average of the C/No ratio of high elevation satellites should be in the range of 40 dBHz to about 50 dBHz. With a standard off-the-shelf active antenna, 47 dBHz should easily be achieved. Low C/No values lead to a prolonged startup time.

C93-M8E does not preserve the configuration in case of removed power

u-blox M8 GNSS technology uses a slightly different concept than most other GNSS receivers do. Settings are initially stored to volatile memory. In order to save them permanently, sending a second command is required. This allows testing the new settings and reverting to the old settings by resetting the receiver if the new settings aren't good. This provides safety, as it is no longer possible to accidentally program a bad configuration (e.g. disabling the main communication port).

10 Common evaluation pitfalls

- A parameter may have the same name but a different definition. GNSS receivers may have a similar size, price and power consumption but can still have different functionalities (e.g. no support for passive antennas, different temperature range). Also, the definitions of hot, warm and cold start times may differ between suppliers.
- Verify design-critical parameters; do not base a decision on unconfirmed numbers from data sheets.
- Try to use identical or at least similar settings when comparing the GNSS performance of different receivers.
- Data that has not been recorded at the same time and the same place should not be compared. The satellite constellation, the number of visible satellites and the sky view might have been different.
- Do not compare momentary measurements. GNSS is a non-deterministic system. The satellite constellation changes constantly. Atmospheric effects (i.e. dawn and dusk) have an impact on signal travel time. The position of the GNSS receiver is typically not the same between two tests. Comparative tests should therefore be conducted in parallel by using one antenna and a signal splitter; statistical tests shall be run for 24 hours.
- Monitor the Carrier-To-Noise-Ratio. The average C/No ratio of the high elevation satellites should be between 40 dBHz and about 50 dBHz. A low C/No ratio will result in a prolonged TTFF and more position drift.
- When comparing receivers side by side, make sure that all receivers have the same signal levels. The best way to achieve this is by using a signal splitter. Comparing results measured with different antenna types (with different sensitivity) will lead to incorrect conclusions.
- Try to feed the same signal to all receivers in parallel (i.e. through a splitter); the receivers will not have the same sky view otherwise. Even small differences can have an impact on the accuracy. One additional satellite can lead to a lower DOP and less position drift.

Related documents

[1] EVA-M8E Data sheet, UBX-15028061
[2] EVA-M8E Hardware integration manual, UBX-15028542
[3] NEO-M8U Data sheet, UBX-15015679
[4] NEO-M8U Hardware integration manual, UBX-15016700
[5] u-blox 8 / u-blox M8 Receiver Description including Protocol Specification (Public version), UBX-13003221
[6] u-center User Guide, UBX-13005250

☞ For regular updates to u-blox documentation and to receive product change notifications, register on our homepage (www.u-blox.com).

Revision history

Revision	Date	Name	Comments
R01	07-Jun-2016	njaf	Advance Information.
R02	24-Apr-2018	pmcm	Firmware Update.
R03	12-Dec-2018	njaf	Update to Early Production Information.
R04	06-Aug-2020	njaf	Update the firmware version to UDR1.31 Added 4.2.2.1 about IMU alignment configurations

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