RTK-GPS with Openmoko Neo Freerunner

Decimeter-level accuracy with Free Software

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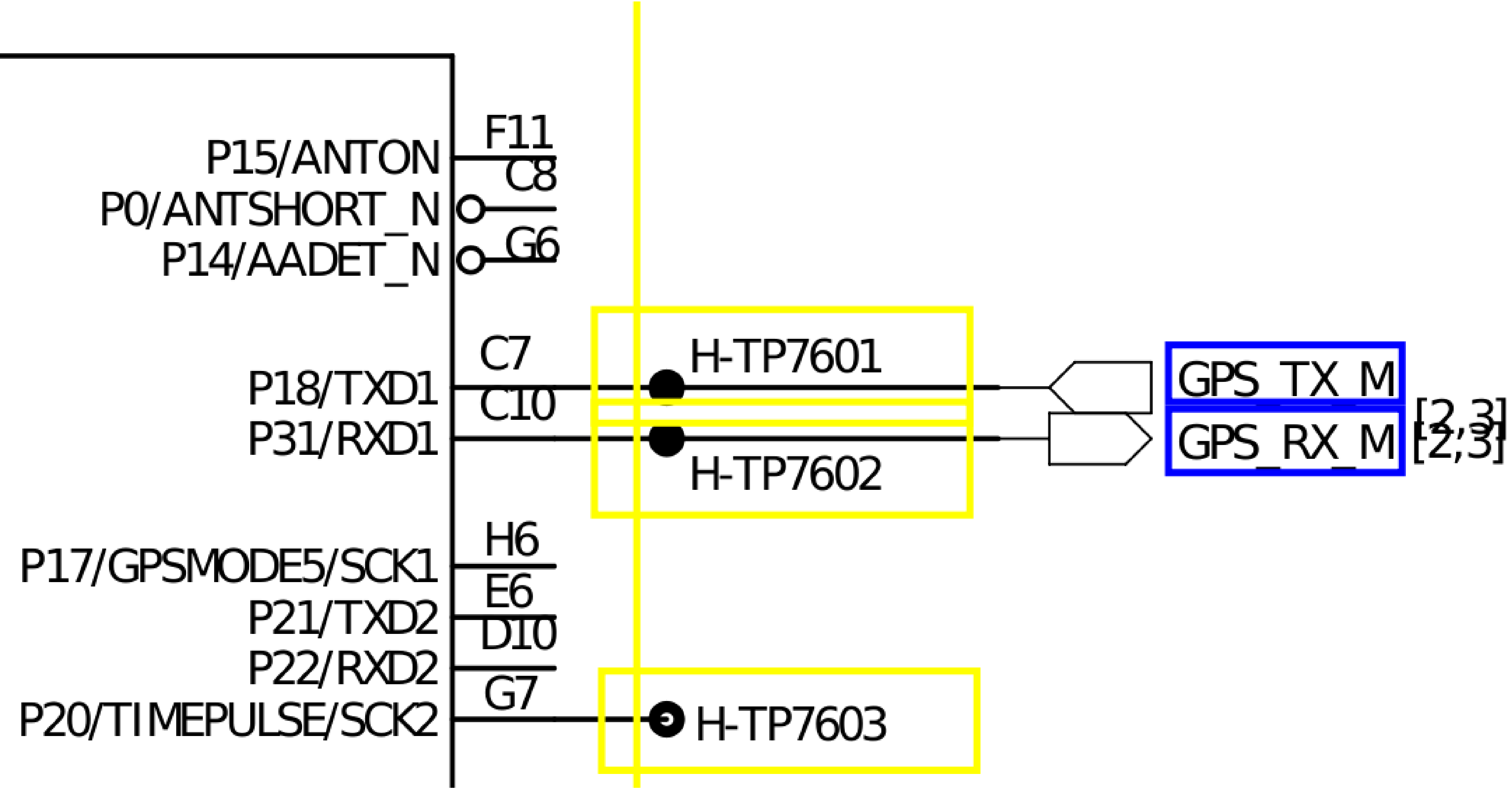
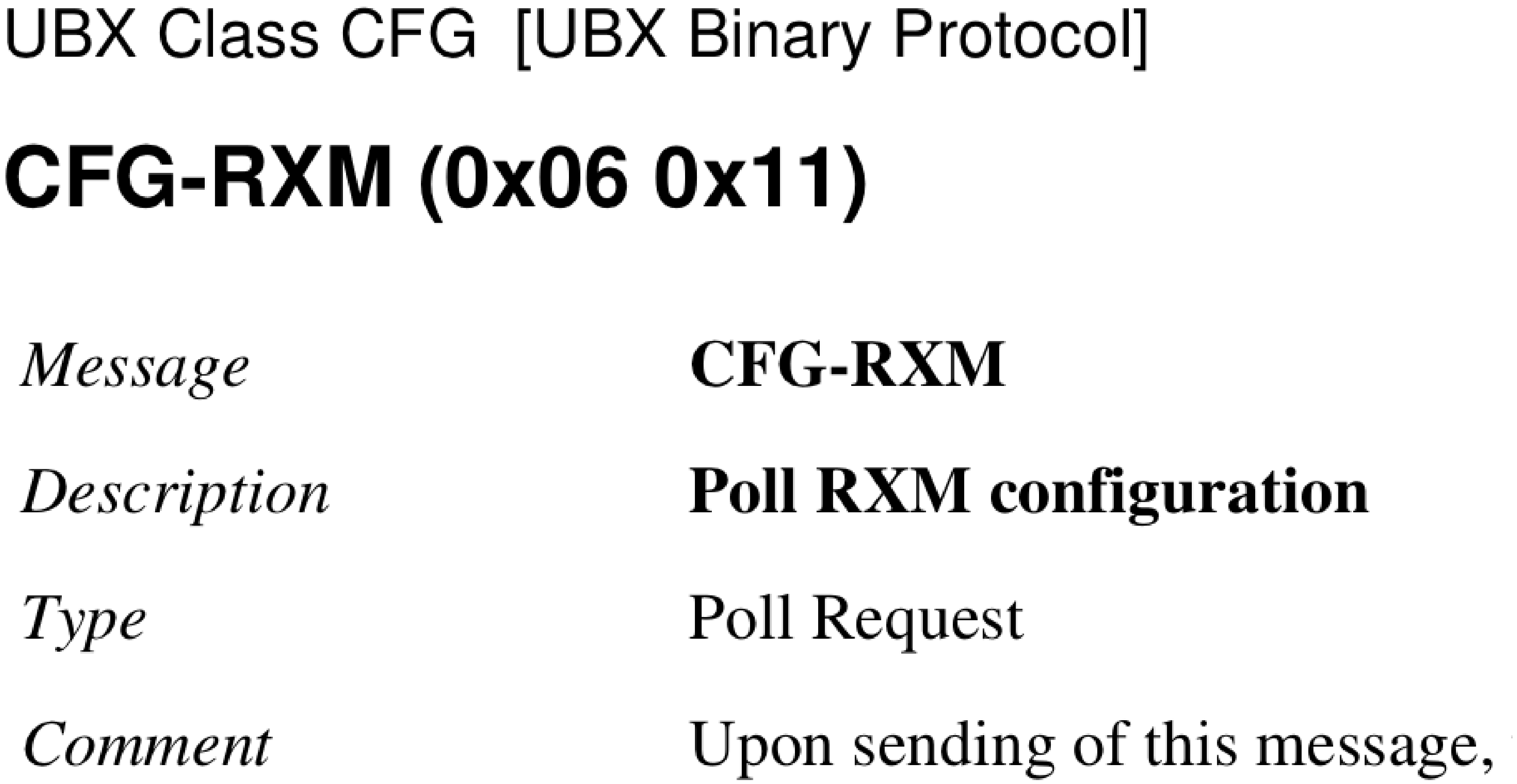
Finhack 2010



Schematics_Freerunner-GTA02_A5-A7cumulative_public_RC0.pdf

```
lindi@ginger:~$ om gps power 1
lindi@ginger:~$ cat /dev/gps
$GPTXT,01,01,02,u-blox ag - www.u-blox.com*50
$GPTXT,01,01,02,ANTARIS ATR062x HW 80040001*26
$GPTXT,01,01,02,ROM CORE      5.00    Jan 09 2006
12:00:00*76
$GPTXT,01,01,02,LIC 1EBF-BD07-E83D-6BE1-0F7A*50
$GPRMC,,V,,,,,,,,,,N*53
$GPVTG,,,,,,,,,N*30
$GPGGA,,,,,,0,00,99.99,,,,,,*48
$GPGSA,A,1,,,,,,,,,,,,,99.99,99.99,99.99*30
$GPGSV,1,1,00*79
$GPGLL,,,,,,V,N*64
$GPZDA,,,,,00,00*48
```

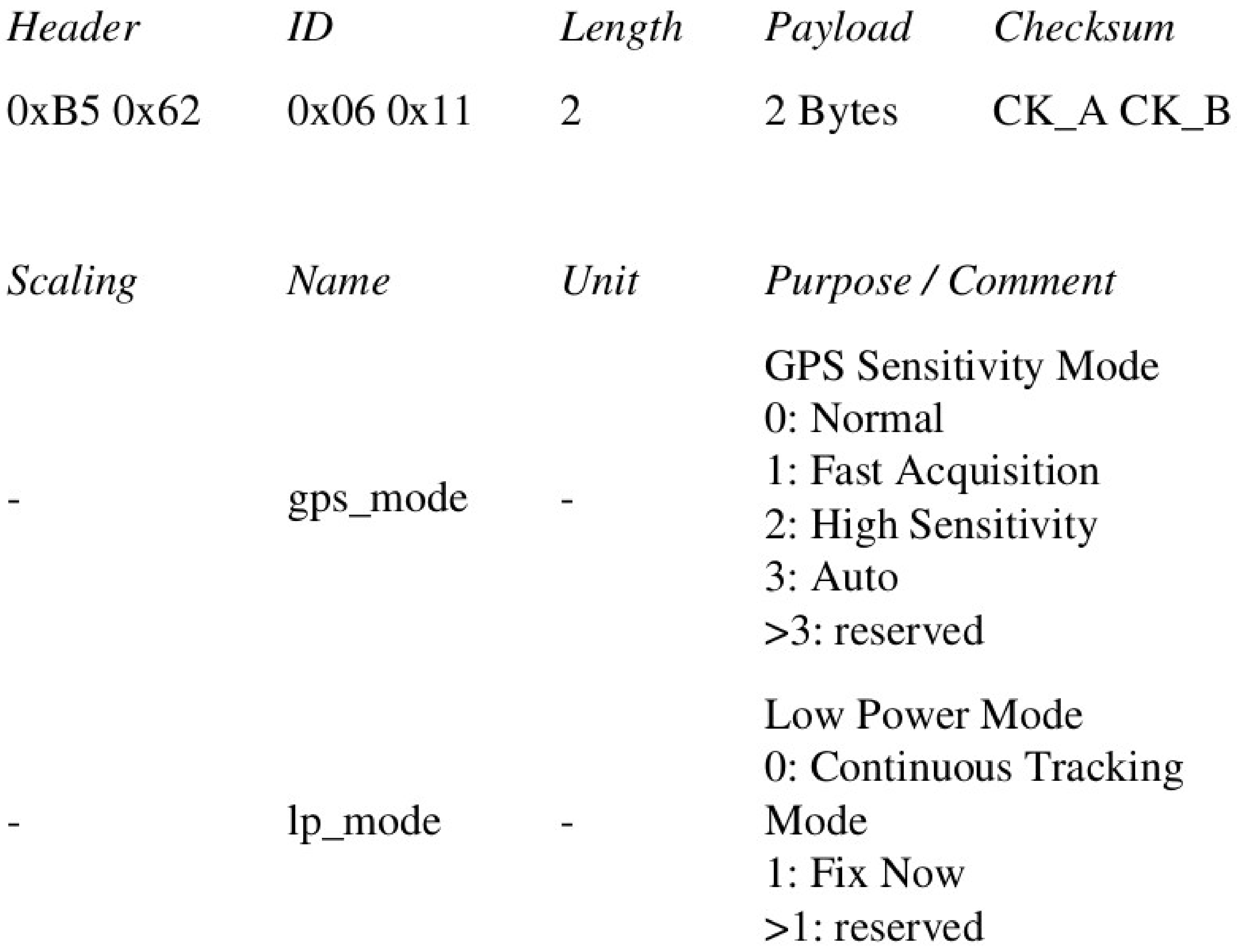


UBX Class CFG [UBX Binary Protocol]

CFG-RXM (0x06 0x11)

Message	**CFG-RXM**
Description	**Poll RXM configuration**
Type	Poll Request
Comment	Upon sending of this message,

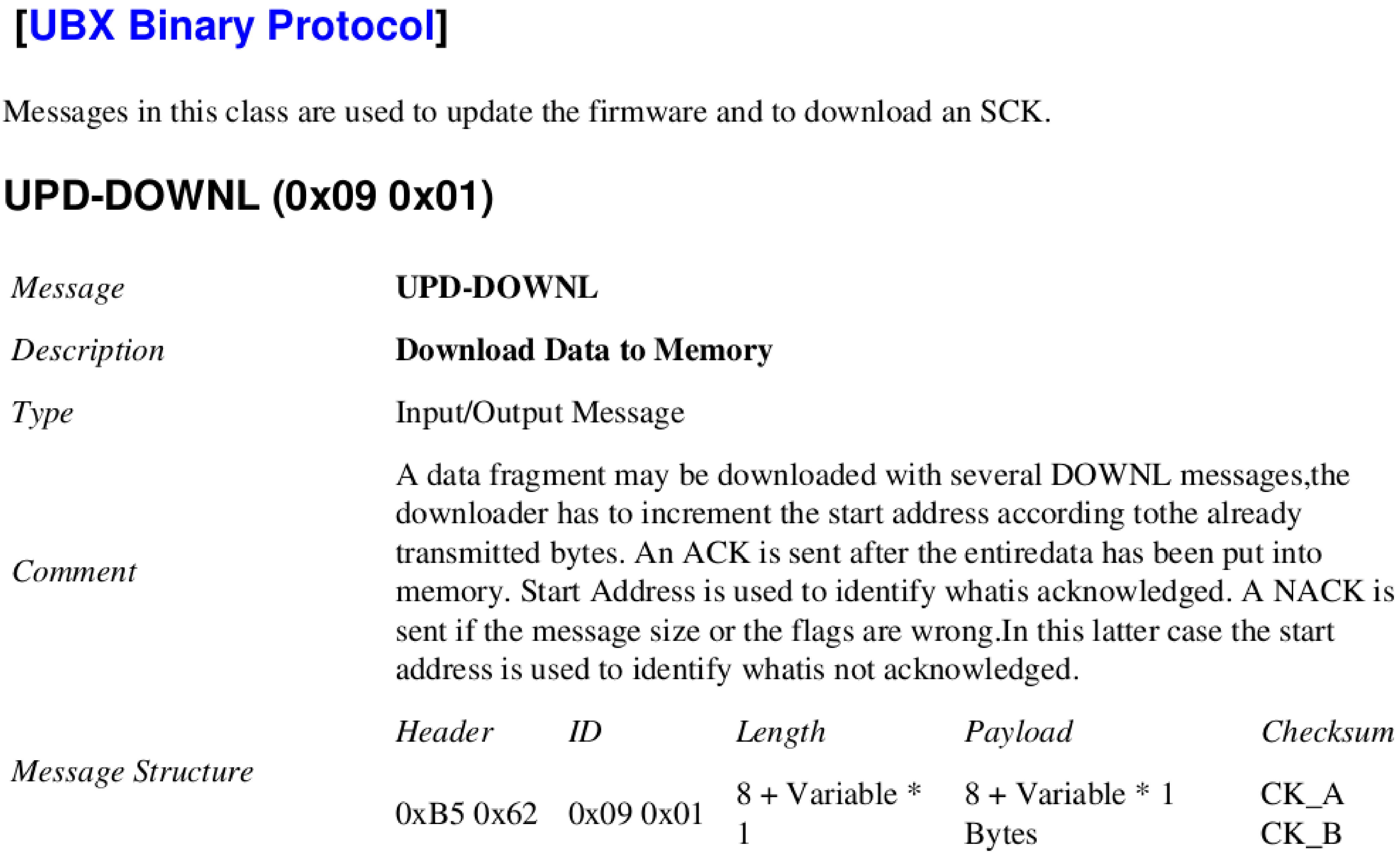
ANTARIS_Protocol_Specification(GPS.G3-X-03002).chm



Header	*ID*	*Length*	*Payload*	*Checksum*
0xB5 0x62	0x06 0x11	2	2 Bytes	CK_A CK_B

Scaling	*Name*	*Unit*	*Purpose / Comment*
-	gps_mode	-	GPS Sensitivity Mode 0: Normal 1: Fast Acquisition 2: High Sensitivity 3: Auto >3: reserved
-	lp_mode	-	Low Power Mode 0: Continuous Tracking Mode 1: Fix Now >1: reserved

ANTARIS_Protocol_Specification(GPS.G3-X-03002).chm



[UBX Binary Protocol]

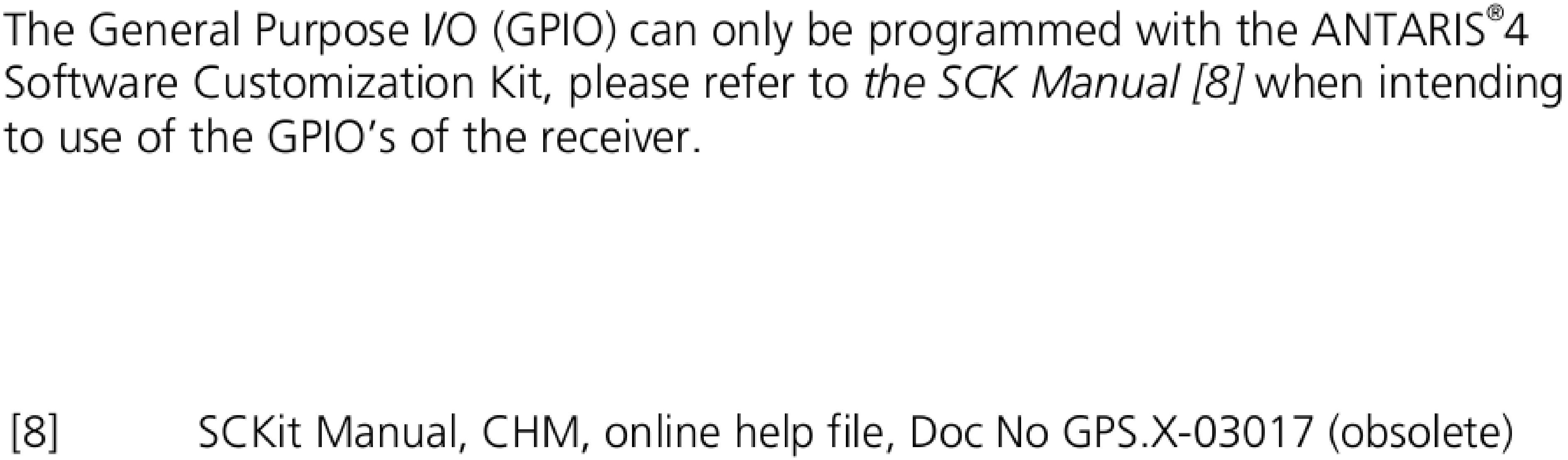
Messages in this class are used to update the firmware and to download an SCK.

UPD-DOWNL (0x09 0x01)

Message	**UPD-DOWNL**
Description	**Download Data to Memory**
Type	Input/Output Message
Comment	A data fragment may be downloaded with several DOWNL messages,the downloader has to increment the start address according tothe already transmitted bytes. An ACK is sent after the entiredata has been put into memory. Start Address is used to identify whatis acknowledged. A NACK is sent if the message size or the flags are wrong.In this latter case the start address is used to identify whatis not acknowledged.

	Header	*ID*	*Length*	*Payload*	*Checksum*
Message Structure	0xB5 0x62	0x09 0x01	8 + Variable * 1	8 + Variable * 1 Bytes	CK_A CK_B

ANTARIS_Protocol_Specification(GPS.G3-X-03002).chm



The General Purpose I/O (GPIO) can only be programmed with the ANTARIS®4 Software Customization Kit, please refer to *the SCK Manual [8]* when intending to use of the GPIO's of the receiver.

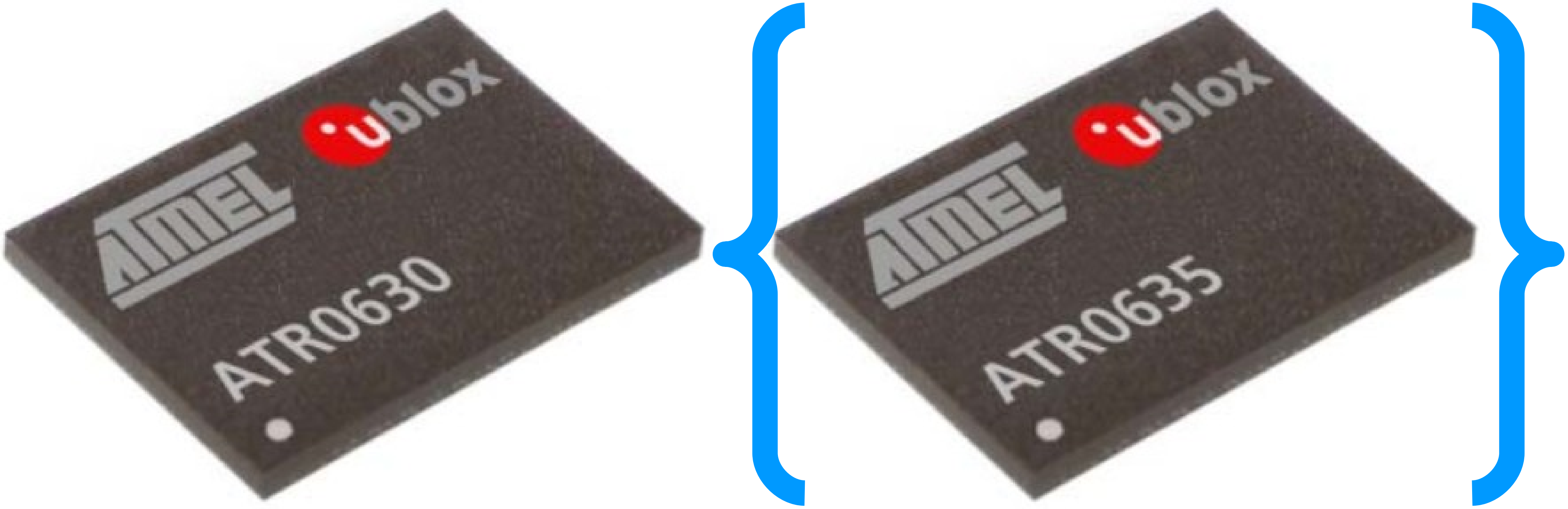
[8] SCKit Manual, CHM, online help file, Doc No GPS.X-03017 (obsolete)

ANTARIS4_Modules_SIM(GPS.G4-MS4-05007).pdf

ATR0630, ATR0635
ANTARIS 4 GPS Single Chips

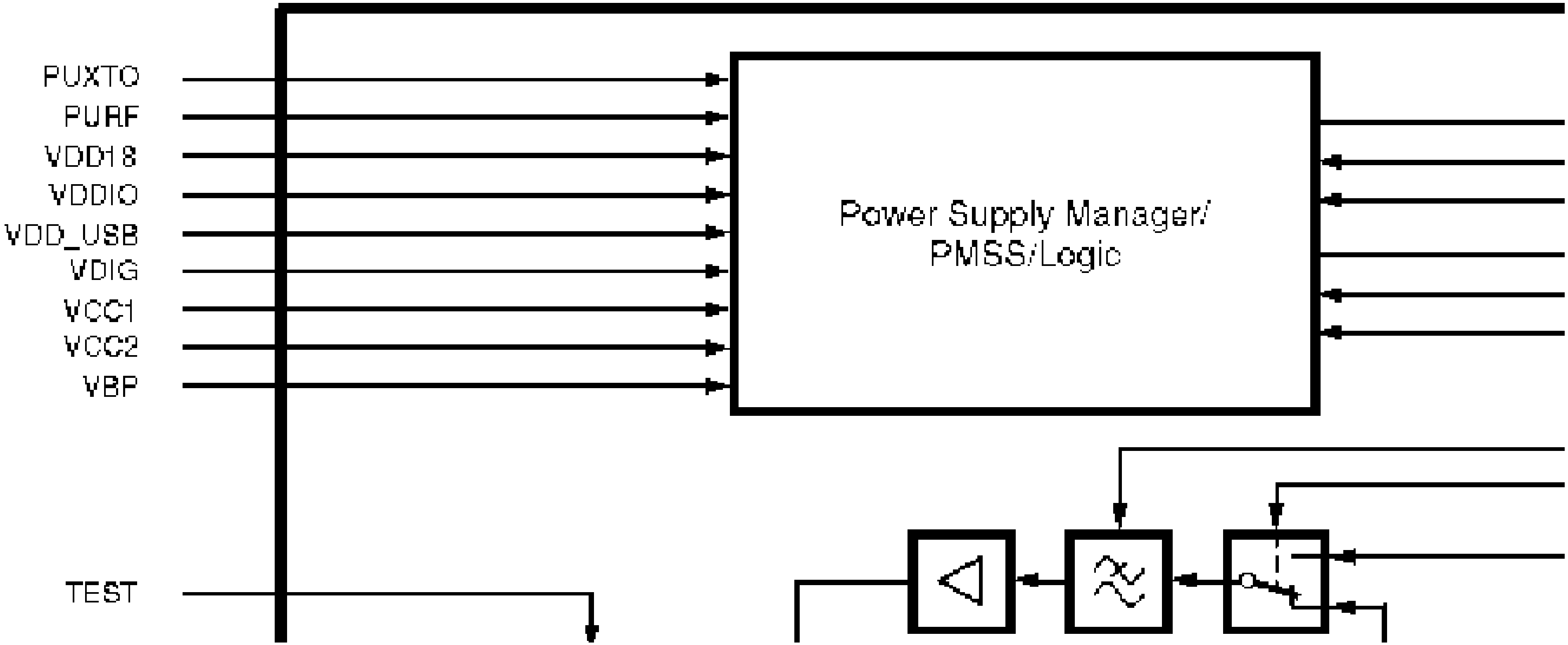
Data Sheet

PRELIMINARY



ATR0630_35_SglChip_Data_Sheet(GPS.G4-X-06009).pdf

Block Diagram



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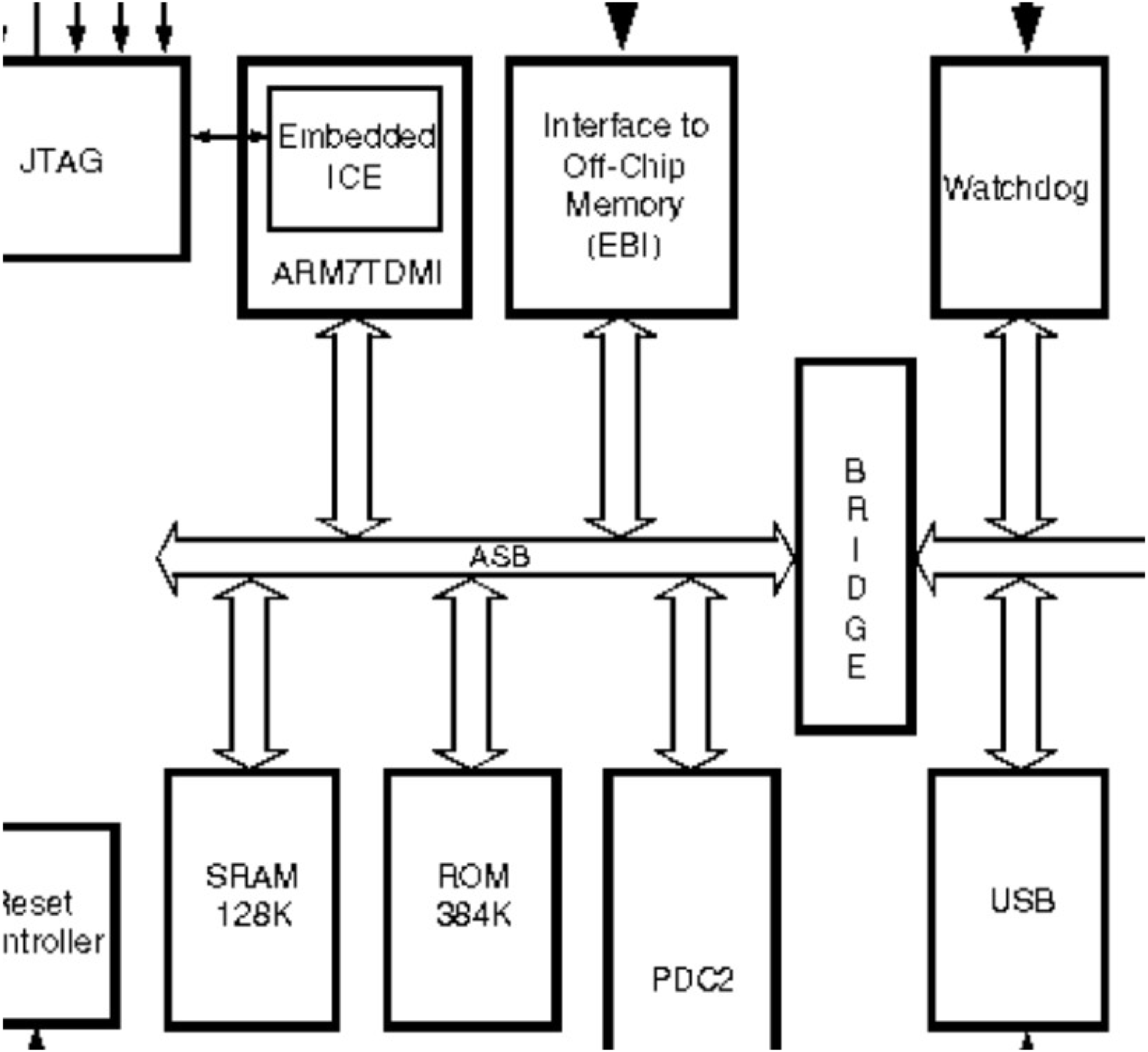

ATR0630_35_SglChip_Data_Sheet(GPS.G4-X-06009).pdf

Development of the low-cost RTK-GPS receiver with an open source program package RTKLIB

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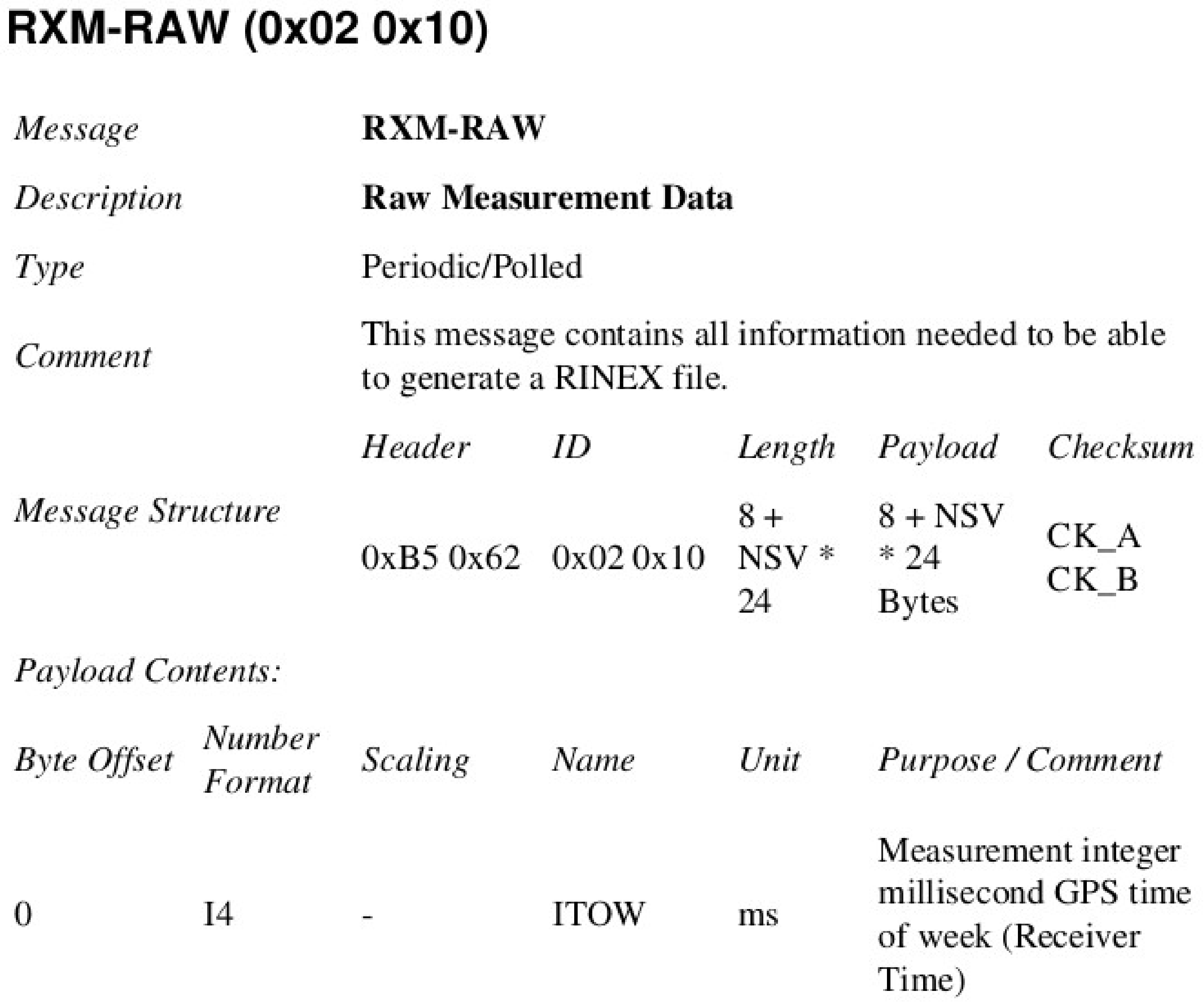
Abstract: RTKLIB is an open source program package for RTK-GPS developed by the authors. RTKLIB is a compact and portable program library written in C to provide a standard platform for RTK-GPS applications. The library implements fundamental navigation functions and carrier-based relative positioning algorithms for RTK-GPS with integer ambiguity resolution by LAMBDA. RTKLIB also supports data communication via serial I/O, TCP/IP connection and NTRIP, and various data formats including RTCM 2.3, RTCM 3.1 and proprietary raw messages for some GPS receivers. By supporting RTCM and NTRIP, NRTK (Network RTK) service can be used with RTKLIB. From the version 2.2.0, RTKLIB has been distributed under the GPLv3 license. RTKLIB was originally implemented on Windows PC. In this study, we port RTKLIB to a small and compact single-board computer BeagleBoard and construct a low-cost RTK-GPS receiver with RTKLIB. BeagleBoard has 600MHz ARM Cotex-A8 core CPU and supports embedded Linux environment. In order to acquire and track GPS signals, we employ a single-frequency GPS receiver module LEA-4T provided by u-blox AG. The RTK-GPS server running on BeagleBoard inputs the u-blox raw binary data messages. The server also inputs the base-station data via a serial port or USB network device and computes RTK-GPS solution in real-time. The total cost of the developed RTK-GPS receiver was about $400. To demonstrate and verify the performance of the low-cost RTK-GPS receiver, we made some field tests. In these tests, CPU/memory usage, accuracy of solutions and fixing ratio were evaluated. According to the test results, even with such a low-cost RTK-GPS receiver, we can obtain reasonable performance in company with RTKLIB.

Keywords: RKTLIB, Open Source Software, Low-Cost RTK-GPS Receiver, BeagleBoard



RXM-RAW (0x02 0x10)

Message	**RXM-RAW**
Description	**Raw Measurement Data**
Type	Periodic/Polled
Comment	This message contains all information needed to be able to generate a RINEX file.

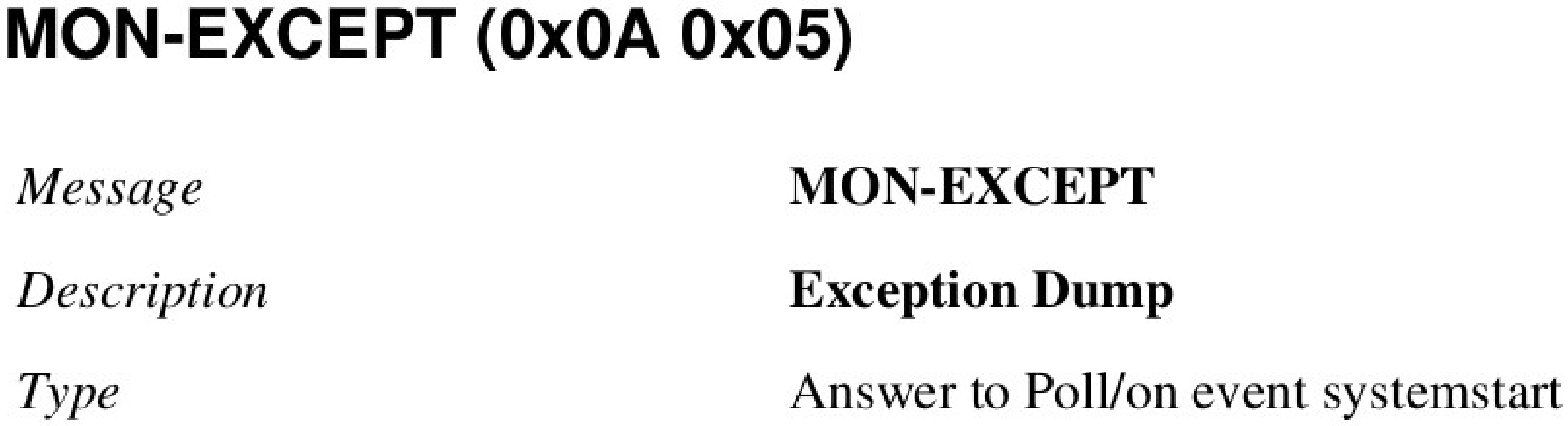
	Header	*ID*	*Length*	*Payload*	*Checksum*
Message Structure	0xB5 0x62	0x02 0x10	8 + NSV * 24	8 + NSV * 24 Bytes	CK_A CK_B

Payload Contents:

Byte Offset	*Number Format*	*Scaling*	*Name*	*Unit*	*Purpose / Comment*
0	I4	-	ITOW	ms	Measurement integer millisecond GPS time of week (Receiver Time)

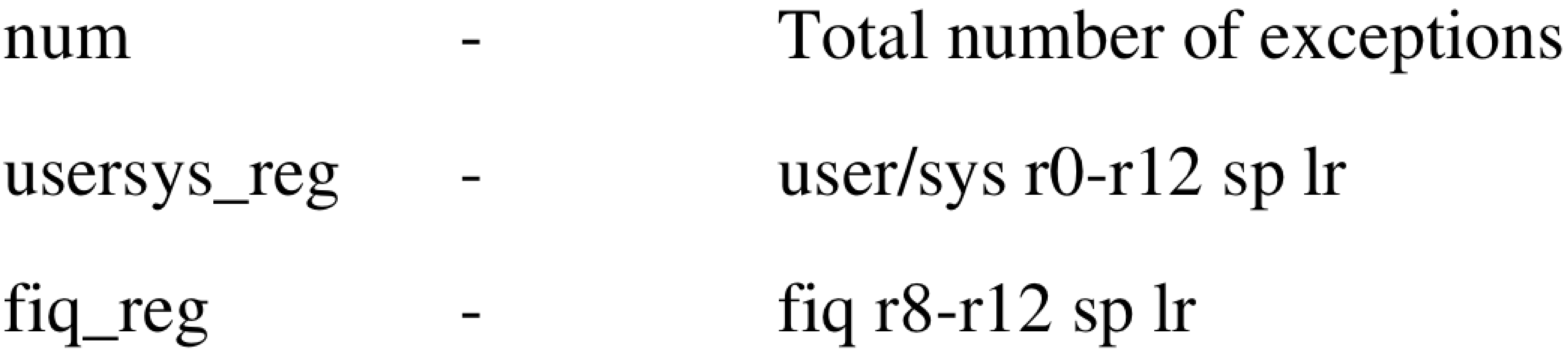
ANTARIS_Protocol_Specification(GPS.G3-X-03002).chm

4	I2	-	Week	weeks	Measurement GPS week number (Receiver Time).
6	U1	-	NSV	-	"sm3">7
Start of repeated block (NSV times}					
8 + N*24	R8	-	CPMes	cycles	Carrier phase measurement [L1 cycles]
16 + N*24	R8	-	PRMes	m	Pseudorange measurement [m]
24 + N*24	R4	-	DOMes	Hz	Doppler measurement [Hz]
28 + N*24	U1	-	SV	-	Space Vehicle Number
29 + N*24	I1	-	MesQI	-	Nav Measurements Quality Indicator: >=4 : PR+DO OK >=5 : PR+DO+CP OK <6 : likely loss of carrier lock in previous interval
30 + N*24	I1	-	CNO	dbHz	Signal strength C/No. (dbHz)
31 + N*24	U1	-	LLI	-	Loss of lock indicator (RINEX definition)



MON-EXCEPT (0x0A 0x05)

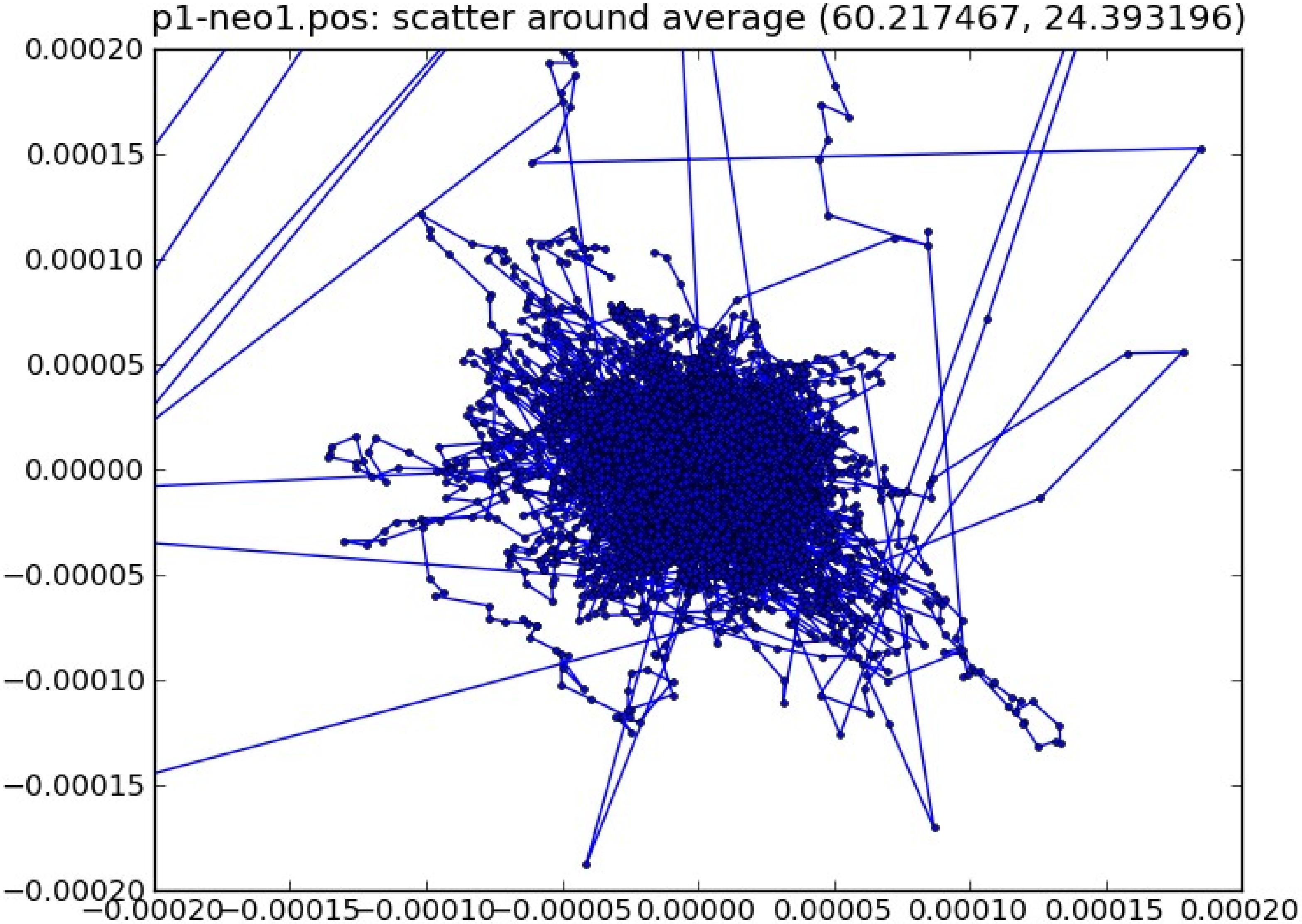
Message	**MON-EXCEPT**
Description	**Exception Dump**
Type	Answer to Poll/on event systemstart

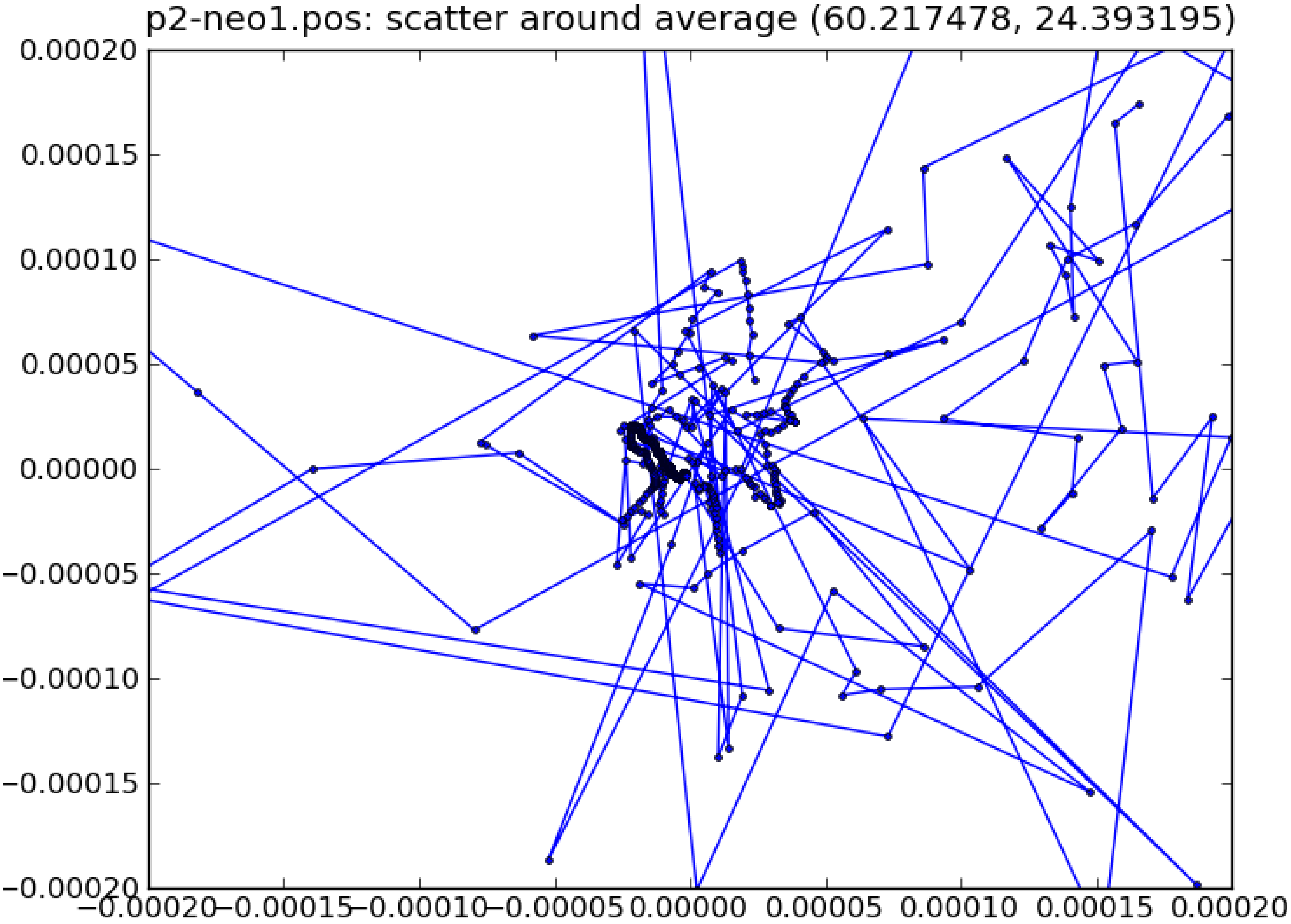


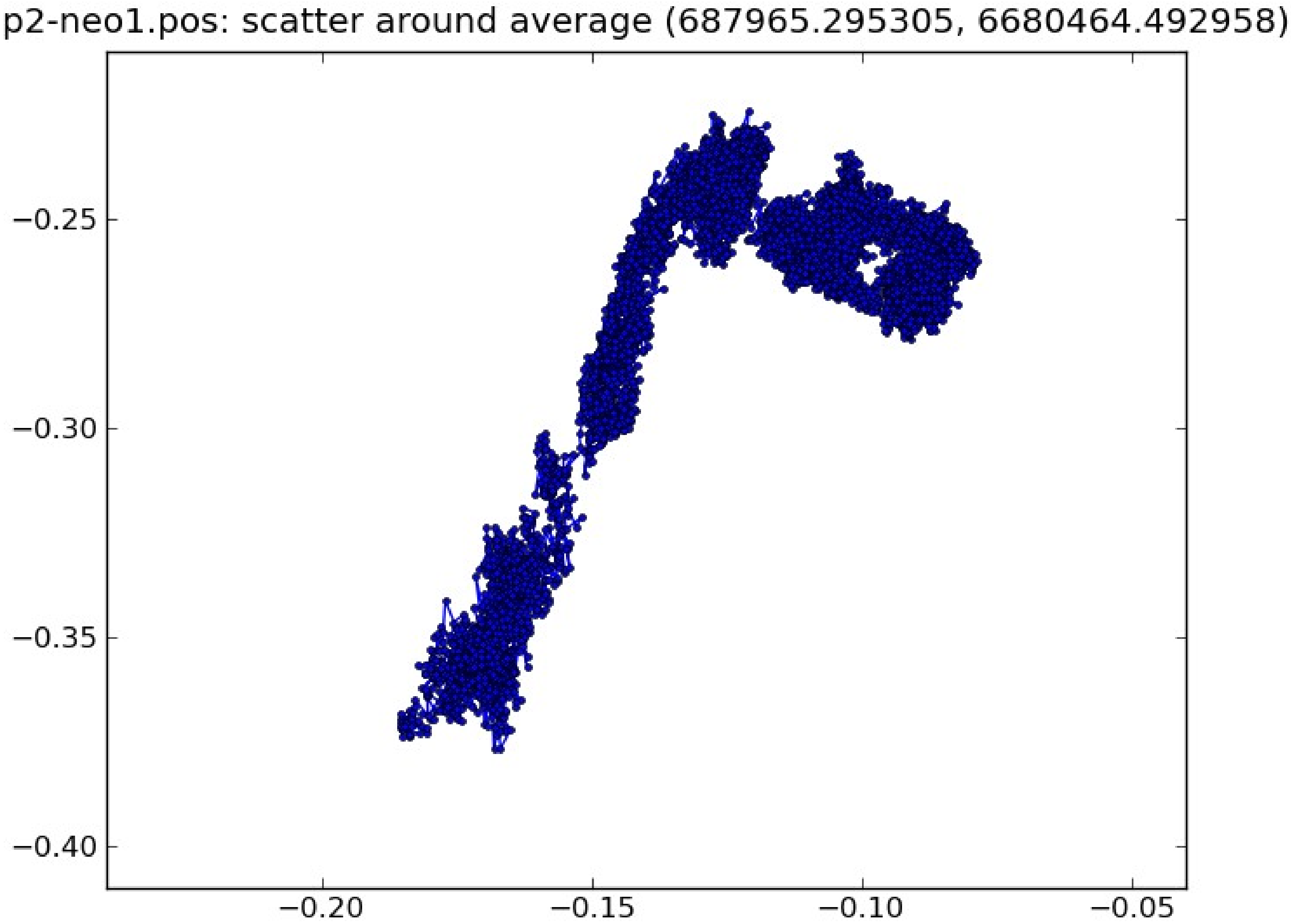
num	-	Total number of exceptions
usersys_reg	-	user/sys r0-r12 sp lr
fiq_reg	-	fiq r8-r12 sp lr

ANTARIS_Protocol_Specification(GPS.G3-X-03002).chm

```
$ git clone http://iki.fi/lindi/git/ubx.git/
$ cd ubx # Tested with version d7248036be5
$ ./set-nmea.py off
$ ./enable-raw.py
$ ./set-periodic-raw-logging.py on
$ ./interactive1.py
...
DEBUG:root:Got UBX packet of type RXM-RAW:
[{'Week': 1602, 'ITOW': 66579999, 'NSV': 2},
{'MesQI': 7, 'DOMes': -1576.923095703125, 'SV':
3, 'LLI': 0, 'CPMes': 114344156.38026848, 'CNO':
45, 'PRMes': 21758970.603088412}, {'MesQI': 7,
'DOMes': 4864.97314453125, 'SV': 11, 'LLI': 0,
'CPMes': 117594760.17341611, 'CNO': 38,
'PRMes': 24176304.105351221}]
```

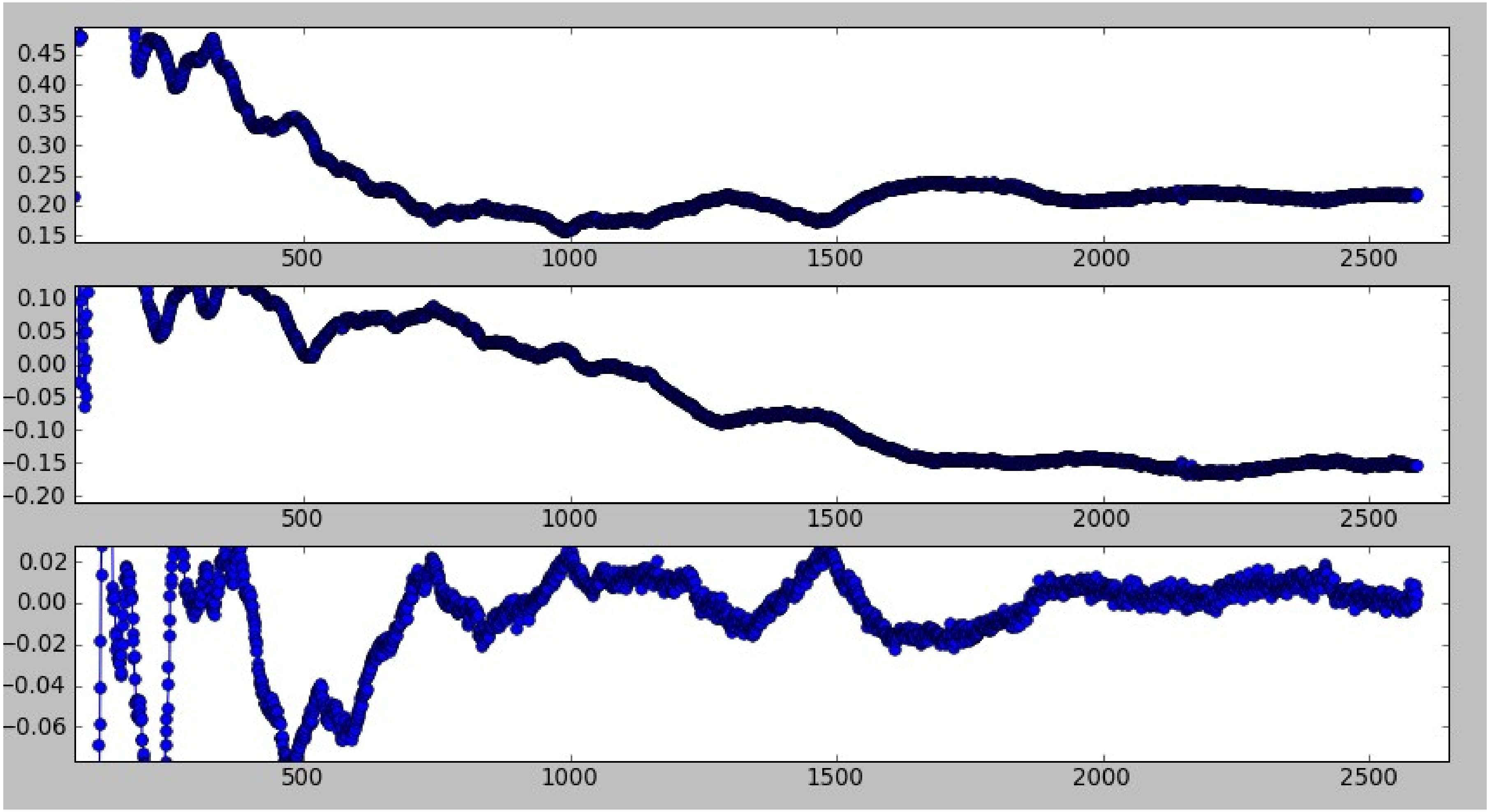

p1-neo1.pos: scatter around average (60.217467, 24.393196)
0.00020
0.00015
0.00010
0.00005
0.00000
−0.00005
−0.00010
−0.00015
−0.00020
−0.00020
−0.00015
−0.00010
−0.00005
0.00000
0.00005
0.00010
0.00015
0.00020

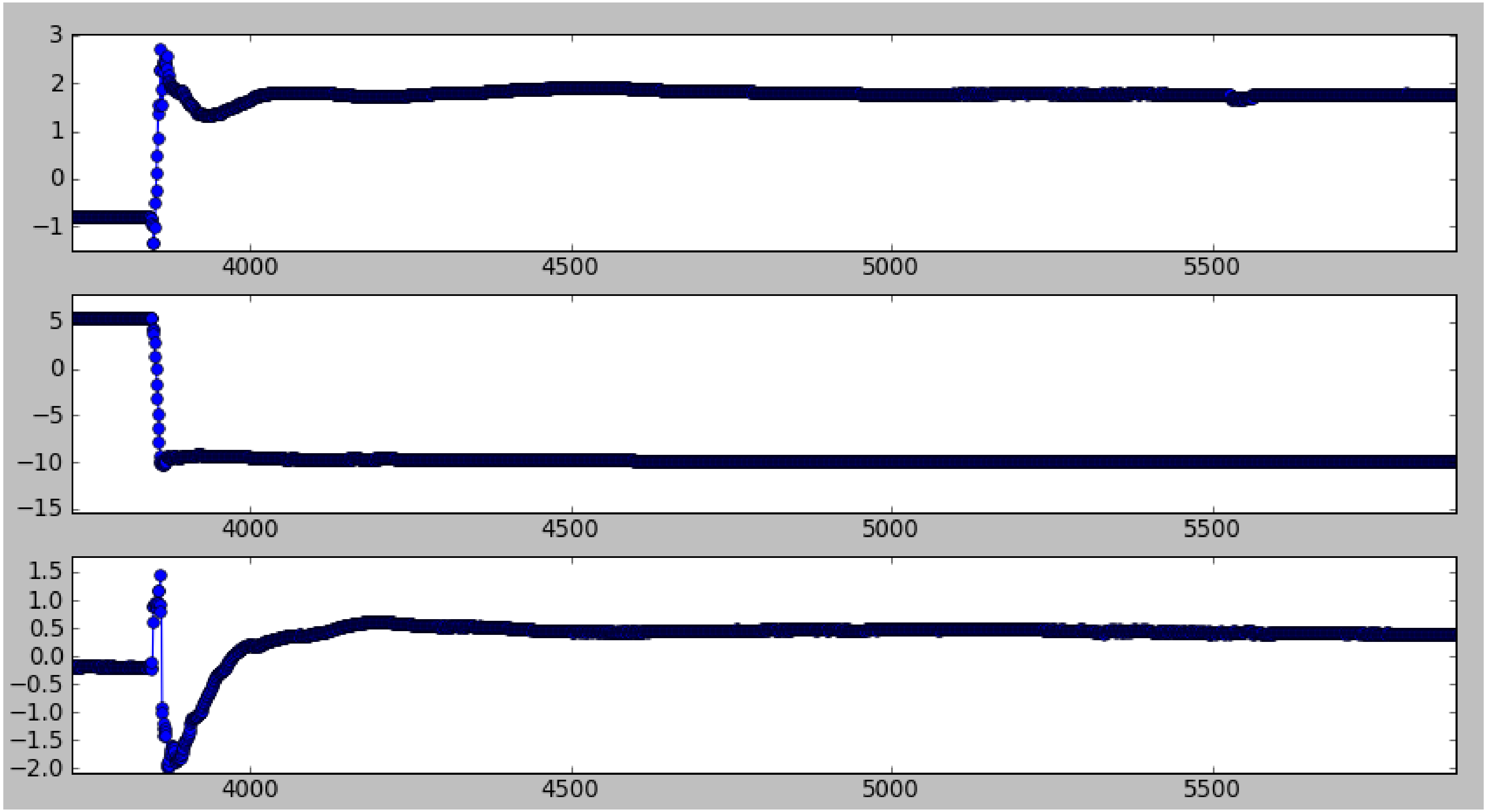

p2-neo1.pos: scatter around average (60.217478, 24.393195)
0.00020
0.00015
0.00010
0.00005
0.00000
−0.00005
−0.00010
−0.00015
−0.00020
−0.00020
−0.00015
−0.00010
−0.00005
0.00000
0.00005
0.00010
0.00015
0.00020

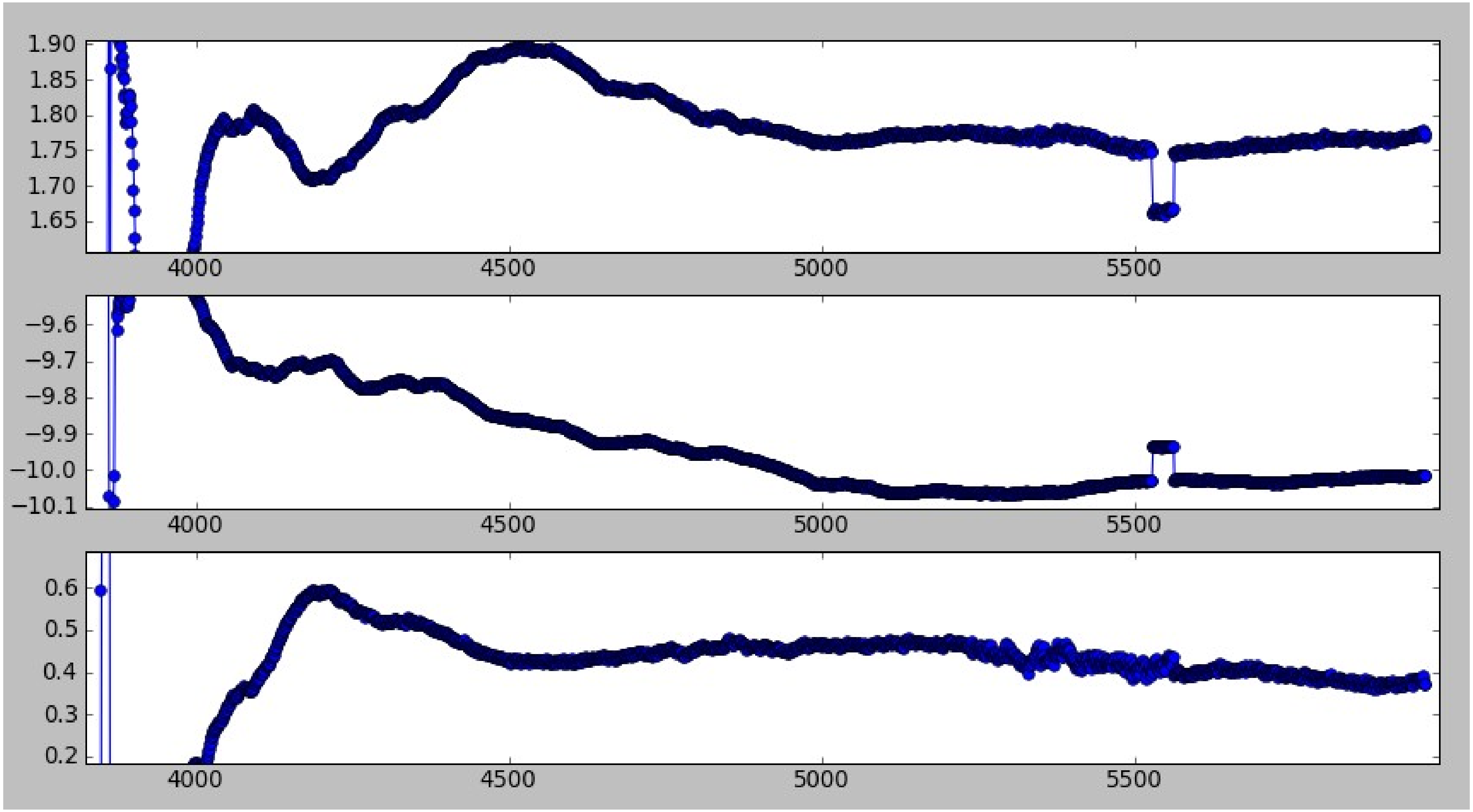

p2-neo1.pos: scatter around average (687965.295305, 6680464.492958)
−0.25
−0.30
−0.35
−0.40
−0.20
−0.15
−0.10
−0.05

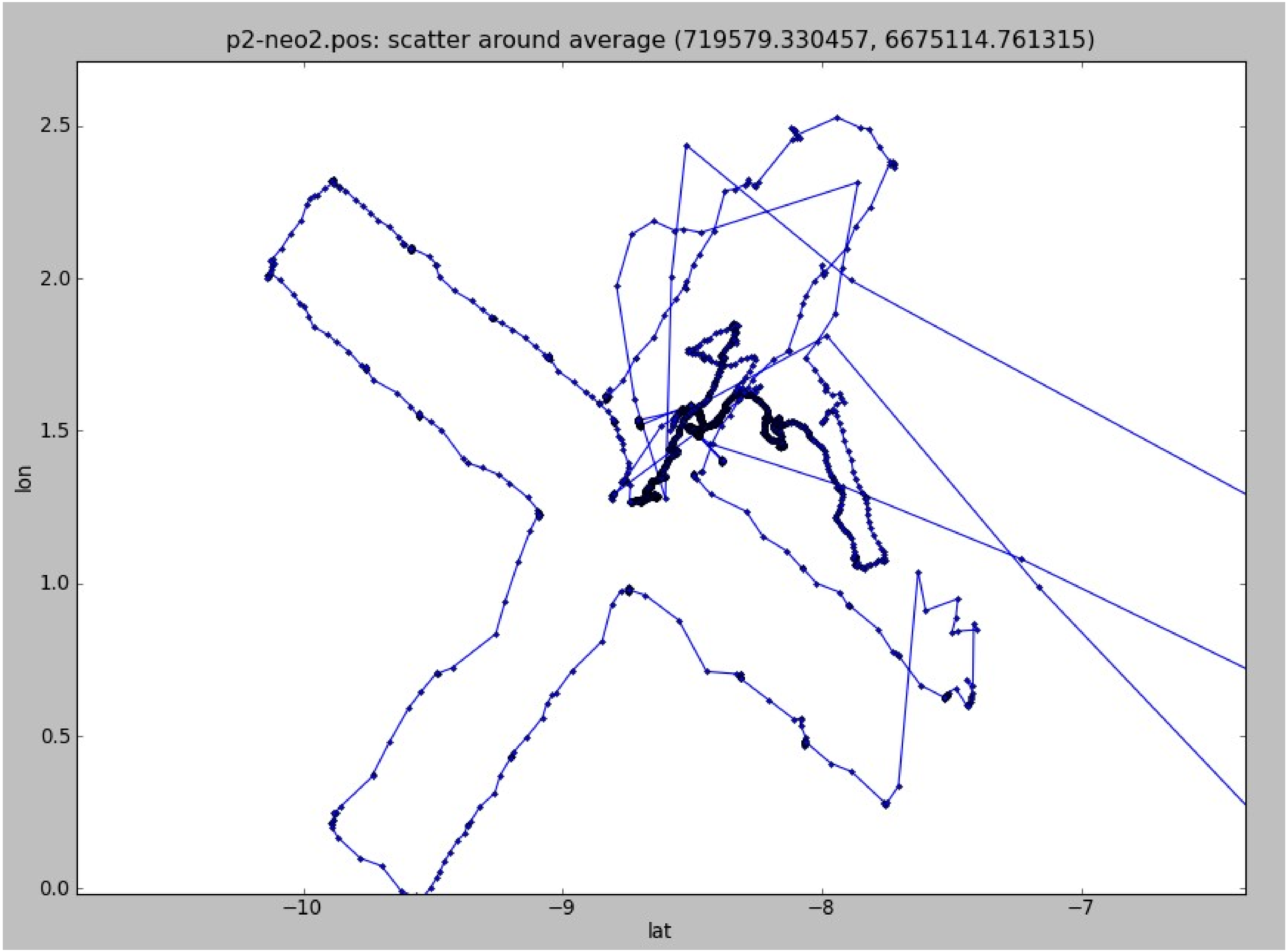
```
# deb-src http://lindi.iki.fi/lindi/debian destructive main
# apt-get –build source rtklib

wget -c http://iki.fi/lindi/gps/experiment/4/base.ubx
wget -c http://iki.fi/lindi/gps/experiment/4/rover.ubx
rtklib-convbin base.ubx
rtklib-convbin rover.ubx
rtklib-rnx2rtkp -p 2 \
 -l 60.153676211111 24.9567319 32 \
 rover.obs base.obs base.nav > rover.pos
```


0.45
0.40
0.35
0.30
0.25
0.20
0.15
500
1000
1500
2000
2500
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
500
1000
1500
2000
2500
0.02
0.00
-0.02
-0.04
-0.06
500
1000
1500
2000
2500


3
2
1
0
−1
4000
4500
5000
5500
5
0
−5
−10
−15
4000
4500
5000
5500
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
4000
4500
5000
5500


1.90
1.85
1.80
1.75
1.70
1.65
4000
4500
5000
5500
−9.6
−9.7
−9.8
−9.9
−10.0
−10.1
4000
4500
5000
5500
0.6
0.5
0.4
0.3
0.2
4000
4500
5000
5500


p2-neo2.pos: scatter around average (719579.330457, 6675114.761315)
lon
2.5
2.0
1.5
1.0
0.5
0.0
lat
−10
−9
−8
−7