

GPS/GNSSシンポジウム2025

ソフトウェア無線受信機

Pocket SDR ver. 0.15 の開発

Development of SDR-Receiver Pocket SDR ver. 0.15

Tomoji TAKASU

ttaka@gpspp.sakura.ne.jp, <https://gpspp.sakura.ne.jp>



2025-12-4 @TUMSAT, Tokyo, Japan

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Pocket SDR ver. 0.14

Pocket SDR

tomojitaku / PocketSDR

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tomojitaku Fixed #39. f9826b6 · last month 898 Commits

FE_2CH	Updated.	2 months ago
FE_4CH	Updated.	2 months ago
FE_8CH	Updated.	2 months ago
app	Fix segfault.	2 months ago
bin	Updated.	last month
conf	CRLF->LF.	2 months ago
doc	Updated.	2 months ago
driver	Updated.	4 months ago
image	Added.	2 months ago
lib	Updated.	last month
python	Fixed #39.	last month
sample	http -> https.	2 months ago
src	Fixed segfault for INT8X2 format input.	last month
test	CRLF->LF.	2 months ago

History

- 2021-10-20 (v0.1): Initial draft version.
- 2021-10-25 (v0.2): Added rebuild firmware and write firmware image to Pocket SDR.
- 2021-12-01 (v0.3): Added and modified Python scripts.
- 2021-12-25 (v0.4): Added and modified Python scripts.
- 2022-01-05 (v0.5): Fixed several issues.
- 2022-01-13 (v0.6): Added and modified Python scripts.
- 2022-02-15 (v0.7): Improved performance and added more Python scripts.
- 2022-07-08 (v0.8): Added C-version of pocket_acq.py and pocket_trk.py.
- 2024-01-03 (v0.9): Added C-version of pocket_snap.py. pocket_trk now supports multi-signal and multi-threading.
- 2024-01-12 (v0.10): Added support for NavIC L1-SPS-D, L1-SPS-P, GLONASS L1OCd, L1OCp, and L2OCp.
- 2024-01-25 (v0.11): Added support for decoding GLONASS L1OCd NAV data and NB-LDPC error correction for BDS B1C, B2a, and B2b.
- 2024-05-28 (v0.12): Performance optimizations. Added support for PVT generation, RTCM3, and NMEA outputs.
- 2024-07-04 (v0.13): Added GUI-based GNSS SDR receiver AP. Added support for macOS and Raspberry Pi OS.
- 2025-03-21 (v0.14): Added Pocket SDR FE 8CH. Fixed various issues.

README License

Pocket SDR - An Open-Source GNSS SDR, ver. 0.14

Overview

Pocket SDR is an open-source Global Navigation Satellite System (GNSS) receiver based on software-defined radio (SDR) technology. It consists of RF frontend devices named **Pocket SDR FE**, utilities for these devices, and GNSS SDR applications (APs) written in Python, C, and C++. It supports almost all signals for **GPS**, **GLONASS**, **Galileo**, **QZSS**, **BeiDou**, **NavIC**, and **SBAS**.

The Pocket SDR FE device includes 2, 4, or 8 RF frontend channels, supporting the GNSS L1 band (1525 - 1610 MHz) or L2/L5/L6 bands (1160 - 1290 MHz). For these signal bands, refer to [GNSS Signal Bands](#). Each RF channel of the Pocket SDR FE device provides IF (intermediate-frequency) bandwidth of up to 36 MHz. The ADC sampling rate can be configured up to 32 Msps (FE 2CH) or 48 Msps (FE 4CH and FE 8CH).

Pocket SDR also includes utility programs to configure the Pocket SDR FE devices, capture, and dump digitized IF data. Additionally, Pocket SDR provides GNSS SDR APs to display the PSD (power spectrum density) of captured IF data, search for GNSS signals, track these signals, decode navigation data, and generate PVT (position, velocity, and time) solutions. These utilities and APs are compatible with **Windows**, **Linux**, **Raspberry Pi OS**, **macOS**, and other environments.

The supported GNSS signals by Pocket SDR are as follows. For details on these signals and Pocket SDR signal IDs, refer to [GNSS Signals](#).

- GPS**: L1C/A, L1C-D, L1C-P, L2C-M, L5-I, L5-Q
- GLONASS**: L1C/A (L1OF), L2C/A (L2OF), L1OCd, L1OCp, L2OCp, L3OCd, L3OCp
- Galileo**: E1-B, E1-C, E5a-Q, E5b-I, E5b-Q, E6-B, E6-C
- QZSS**: L1C/A, L1C/B, L1C-D, L1C-P, L1S, L2C-M, L5-I, L5-Q, L5S-I, L5S-Q, L6D, L6E
- BeiDou**: B1I, B1C-D, B1C-P, B2a-D, B2a-P, B2I, B2b-I, B3I
- NavIC**: L1-SPS-D, L1-SPS-P, L5-SPS
- SBAS**: L1C/A, L5-I, L5-Q

These utilities and APs are written in Python, C, and C++ in a compact and modular way, making them easy to modify for adding custom algorithms.

Pocket SDR FE 2CH, 4CH

<https://github.com/tomojitaku/PocketSDR>

Open Source GNSS SDR

Software		GNSS-SDR	GNSS-SDRLIB	Pocket SDR
URL		https://gnss-sdr.org https://github.com/gnss-sdr	https://github.com/taroz/GNSS-SDRLIB	https://github.com/tomojitakasu/PocketSDR
GitHub Stars/Forks		☆ 2k / 668	☆ 517 / 182	☆ 421 / 139
Current Release		v0.0.20 (April 2025)	v2.0 Beta (Dec 2014)	ver. 0.14 (March 2025)
License		GPL-3.0	GPL-2 or later	BSD 2-clause
RF Frontends		USRP, UmTRX, HackRF One, Blade RF, RTL-SDR	SiGe GN3S sampler v2/v3, Stereo, Blade RF, RTL-SDR	Pocket SDR FE 2/4/8CH
Programming Language		C++, C	C, C++/CLI	Python 3, C++, C
OS		Linux, macOS	Windows, Linux	Windows, Linux, macOS, Raspberry Pi OS
Real-time		Yes	Yes	Yes
GNSS Signals	GPS	L1C/A, L2C, L5	L1C/A	L1C/A, L1C, L2C, L5
	GLONASS	L1C/A, L2C/A	L1C/A	L1C/A, L2C/A, L1OC, L2OC, L3OC
	Galileo	E1B/C, E5a, E5b, E6B	E1B	E1B/C, E5a, E5b, E6B/C
	QZSS	-	L1C/A, L1SAIF, LEX	L1C/A, L1C/B, L1C, L1S, L2C, ...
	BeiDou	B1I, B3I	B1I	B1I, B1C, B2I, B2a, B2b, B3I
	NavIC	-	-	L1-SPS, L5-SPS, S-SPS
	SBAS	-	L1C/A	L1C/A, L5
PVT		Single, PPP	-	Single
Output Format		KML, GeoJSON, GPX, RINEX, NMEA, RTCM3, Custom	RTCM3, RINEX	NMEA, RTCM3, CSV Log, Raw binary
External Libraries		GNU Radio, Boost, FFTW3, VOLK, Armadillo, LAPACK/BLAS, glog, gflags, matio, pugiXML, Protocol Buffers, OpenSSL, RTKLIB	FFTW3, LIBFEC, RTKLIB, libusb	FFTW3, LIBFEC, LDPC-codes, RTKLIB, CyAPI or libusb-1.0

Supported GNSS Signals

Signal Options

System	Satellite No	GNSS Signals			
☒ GPS	1-32,35-37	☒ L1CA	☒ L1CD	☒ L1CP	☒ L2CM
		☒ L5I	☒ L5Q		
☒ GLONASS	-7-6/1-27	☒ G1CA	☒ G1OCD	☒ G1OCP	☒ G2CA
		☒ G2OCP	☒ G3OCD	☒ G3OCP	
☒ Galileo	1-36	☒ E1B	☒ E1C	☒ E5AI	☒ E5AQ
		☒ E5BI	☒ E5BQ	☒ E6B	☒ E6C
☒ QZSS	1-10	☒ L1CA	☒ L1CB	☒ L1CD	☒ L1CP
		☒ L1S	☒ L2CM	☒ L5I	☒ L5Q
		☒ L5SI	☒ L5SIV	☒ L5SQ	☒ L5SQV
		☒ L6D	☒ L6E		
☒ BeiDou	1-63	☒ B1I	☒ B1CD	☒ B1CP	☒ B2AD
		☒ B2AP	☒ B2I	☒ B2BI	☒ B3I
☒ NavIC	1-14	☒ I1SD	☒ I1SP	☒ I5S	☐ ISS
☒ SBAS	120-158	☒ L1CA	☒ L5I	☒ L5Q	

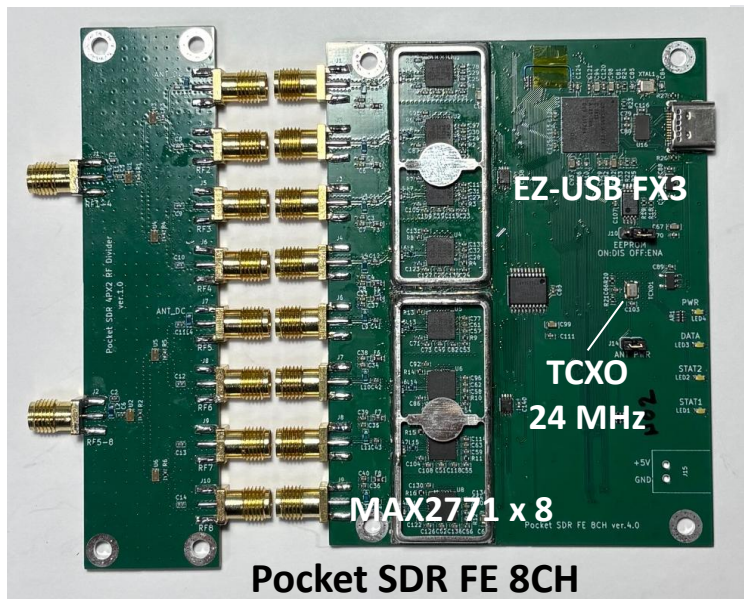
System	Signal	Signal ID	System	Signal	Signal ID
GPS	L1C/A	L1CA	QZSS	L1S	L1S
	L1C-D	L1CD		L2C-M	L2CM
	L1C-P	L1CP		L5-I	L5I
	L2C-M	L2CM		L5Q	L5Q
	L5-I	L5I		L5S-I	L5SI
	L5-Q	L5Q			L5SIV
GLONASS	L1C/A	G1CA		L5S-Q	L5SQ
	L1OCd	G1OCD			L5SQV
	L1OCP	G1OCP		L6D	L6D
	L2C/A	G2CA		L6E	L6E
	L2OCP	G2OCP	BeiDou	B1I	B1I
	L3OCd	G3OCD		B1C-D	B1CD
Galileo	L3OCP	G3OCP		B1C-P	B1CP
	E1-B	E1B		B2a-D	B2AD
	E1-C	E1C		B2a-P	B2AP
	E5a-I	E5AI		B2I	B2I
	E5a-Q	E5AQ		B2b-I	B2BI
	E5b-I	E5BI		B3I	B3I
QZSS	E5b-Q	E5BQ	NavIC	L1-SPS-D	I1SD
	E6-B	E6B		L1-SPS-P	I1SP
	E6-C	E6C		L5-SPS	I5S
	L1C/A	L1CA	SBAS	S-SPS	ISS
	L1C/B	L1CB		L1C/A	L1CA
	L1C-D	L1CD		L5-I	L5I
	L1C-P	L1CP		L5-Q	L5Q

PocketSDR-AFS: LANS (Lunar Augmented Navigation Service) AFS (Augmented Forward Signal) ^{*1*2}

^{*1} <https://github.com/osqzss/PocketSDR-AFS>

^{*2} R.Sobukawa and T.Ebinuma, Open-Source Real-Time SDR Platform for Rapid Prototyping of LANS AFS Receiver, Aerospace, 2025 ⁵

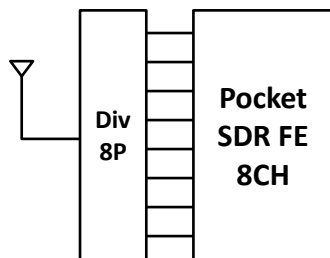
Pocket SDR FE



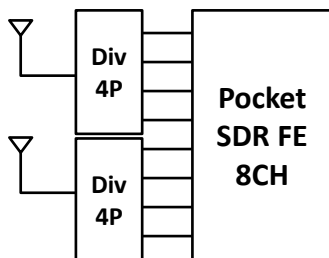
Pocket SDR FE 8CH



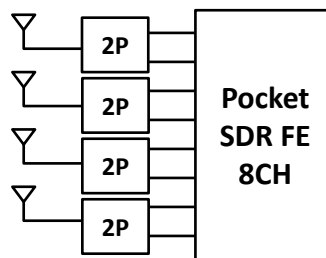
Pocket SDR FE 8CH-2ANT



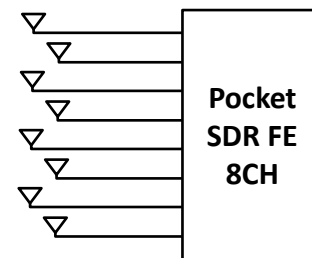
**All L-band GNSS receiver
(L1+B1+G1+L2+G2+L5+
E5b/B2+B3/L6)**



**GNSS-compass
(qual-freq.)**

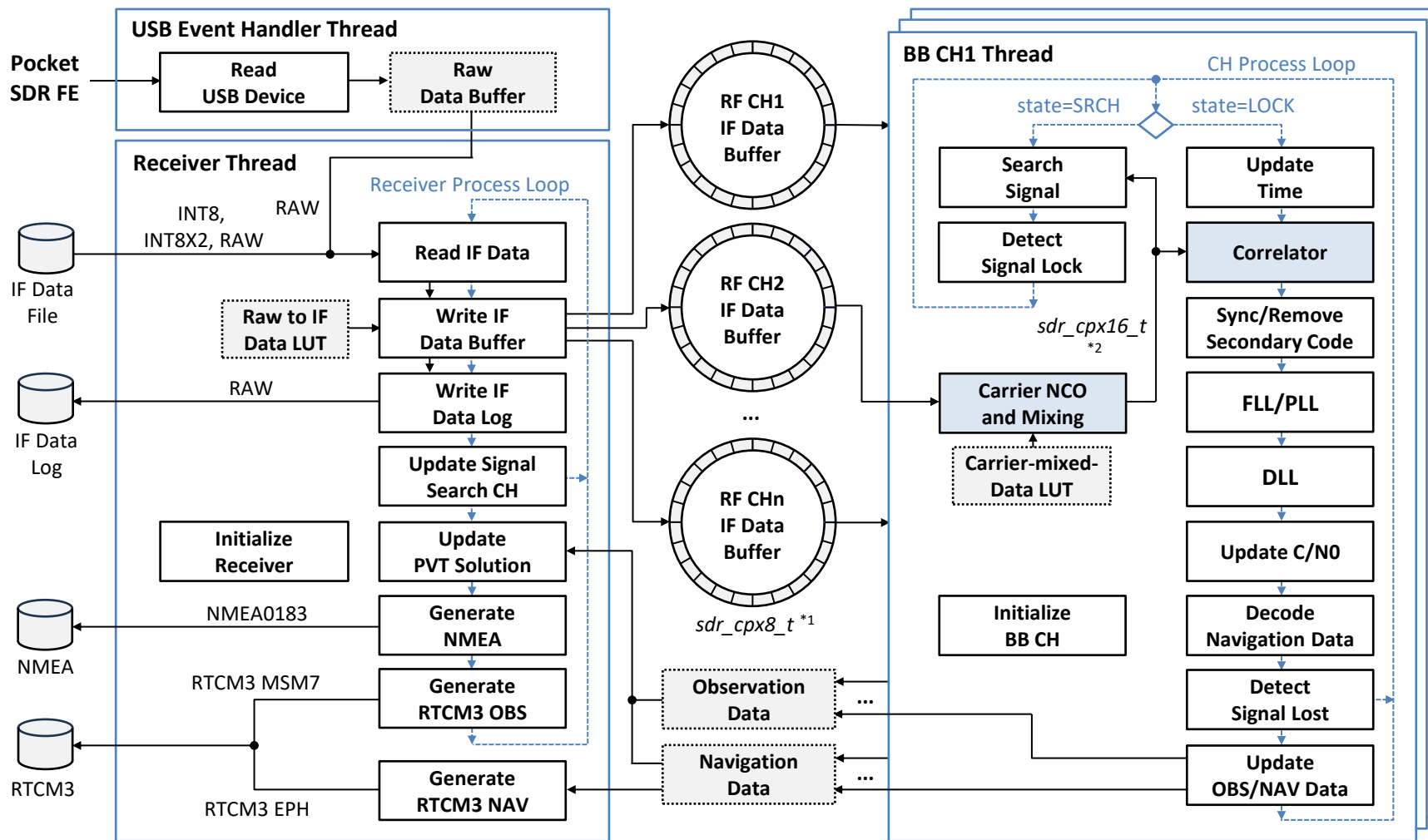


**4-elements
Antenna-array
(dual-freq.)**



**8-elements
Antenna-array
(single-freq.)**

Pocket SDR Receiver Structure

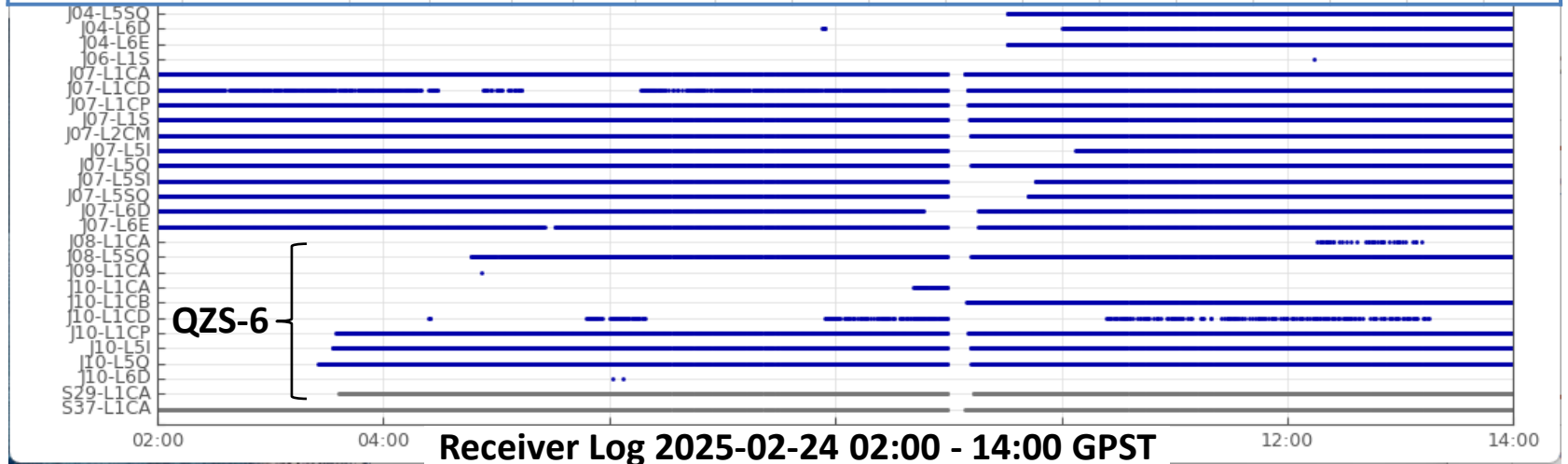


*1 int4 x 2 Fixed Point Complex

*2 int8 x 2 Fixed Point Complex

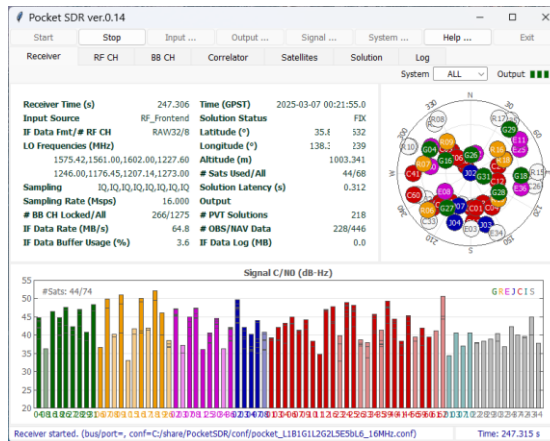
QZS-6 First Light

Satellite	Launch	Block	Orbit	SV No	SV ID	RINEX Sat ID	Signal and PRN Number										
							L1C/A	L1C	L1C/B	L1S	L1Sb	L2C	L5	L5S	L5SV	L6D	L6E
QZS-1	2010-09-11	I-Q	QZO	1	1	J01	193	193	-	183	-	193	193	-	-	193	(203)
QZS-2	2017-06-01	II-Q	QZO	2	2	J02	194	194	-	184	-	194	194	184	-	194	204
QZS-3	2017-08-19	II-G	GEO	3	7	J07	199	199	-	189	137	199	199	189	-	199	209
QZS-4	2017-10-09	II-Q	QZO	4	3	J03	195	195	-	185	-	195	195	185	-	195	205
QZS-1R	2021-10-26	IIA-Q	QZO	5	4	J04	196	196	(203)	186	-	196	196	(186)	186	196	206
QZS-5	2025-12-07	III-Q	QZO	6	5	J05	(197)	197	204	-	-	-	197	-	-	197	207
QZS-6	2025-02-02	III-G	GEO	7	8	J08	(200)	200	205	-	129	-	200	-	205	200	210
QZS-7	JFY2025	III-G	QGEO	8	9	J09	(201)	201	206	-	-	-	201	-	206	201	211
Non-Standard	-	-	-	-	-	J06	(198)	(198)	(198)	-	-	-	(198)	-	-	(198)	(208)
Non-Standard	-	-	-	-	-	J10	202	202	202	-	-	-	202	-	-	202	212



SDR Receiver

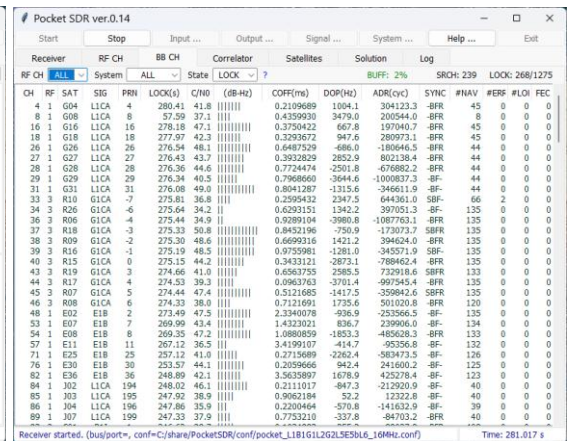
Receiver Tab



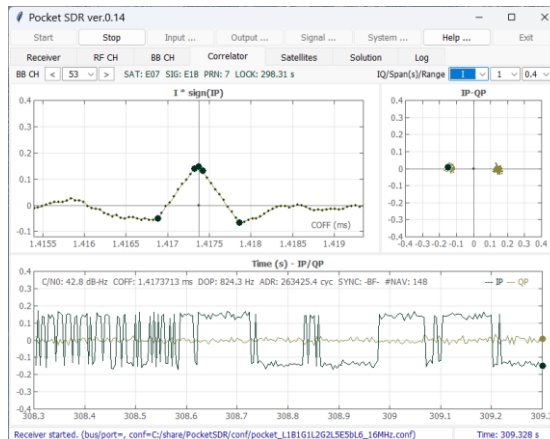
RF CH Tab



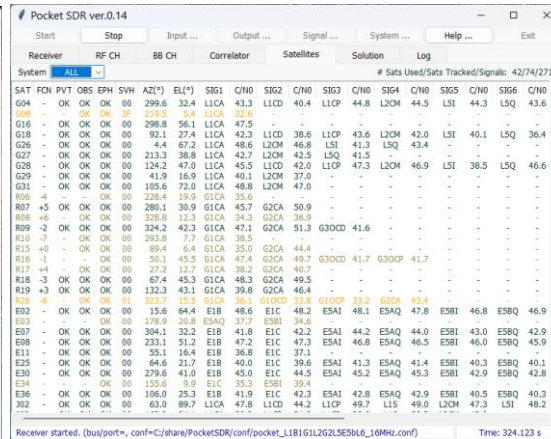
BB CH Tab



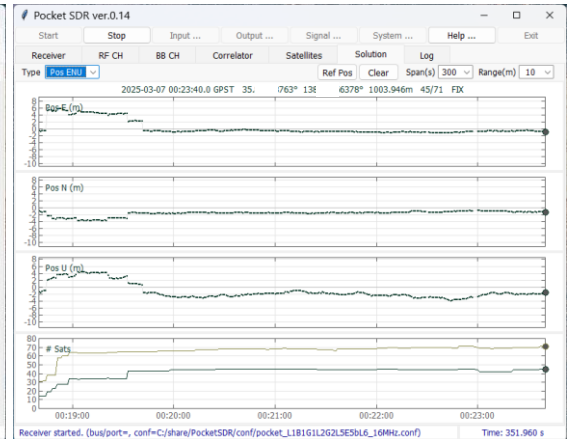
Correlator Tab



Satellites Tab



Solution Tab



Pocket SDR ver. 0.15

Alternative RF Frontends (1/3)

RF-frontend	Vendor	# of CH		# of PLL		RF Bands	Sampling Type/Rate	RF LSI	FPGA	Host I/F	Price	
		RX	TX	RX	TX							
USRP B210 ^[1]	Ettus Research, NI	2	2	1	1	70 MHz ~ 6 GHz	IQ, 12 bits ≤ 61.44 Msps	ADI AD9361	Spartan 6 XC6SLX150	USB 3.0	\$2,387	
SiGe GN3S Sampler ^[2]	GNSS Lab Univ Colorado	1	-	1	-	GPS L1	I or IQ, 2 bits ≤ 16.368 Msps	SiGe 4120	-	USB 2.0	\$496	
Stereo ^[3]	NSL	2	-	2	-	GNSS L1/L2/L5/L6	I+IQ, 2/3 bits 26 Msps	MAX2769B + MAX2112 + ...	Spartan-6	USB 2.0	\$800	
RTL-SDR ^[4]	RTLSDR.com	1	-	1	-	500 kHz ~ 1.75 GHz	IQ, 8 bits ≤ 2.56 Msps	R820T + RTL2832U	-	USB 2.0	\$20 - 50	
bladeRF ^[5]	NuBand	2	2	1	1	300 MHz ~ 3.8 GHz	IQ, 12 bits ≤ 40 Msps	Lime Micro. LMS6002D	Cyclone IV E	USB 3.0	\$520 (X40)	
LimeSDR ^[6]	Lime Microsystems	2	2	1	1	100 kHz ~ 3.8 GHz	IQ, 12 bits ≤ 61.44 Msps	Lime Micro. LMS7002M	Cyclone IV EP4CE40F23	USB 3.0	\$625 (USB)	
NUT4NT ^[7]	Amungo Navigation	4	-	2	-	GNSS L1/L2/L5/L6	I, 2 bits ≤ 99 Msps	NTLab NT1065	Lattice ECP5	USB 3.0	\$399	
PlutoSDR ^[8] (ADALM-PLUTO)	Analog Devices (ADI)	1	1	1	1	325 kHz ~ 3.8 GHz	IQ, 12 bits ≤ 61.44 Msps	ADI AD9363	Zynq Z-7010	USB 2.0	\$233	
Pocket SDR FE 2/4/8CH	-	2/ 4/ 8	-	2/ 4/ 8	-	GNSS L1/L2/L5/L6	I/IQ, 2/3 bits ≤ 32/48 Msps	MAX2771 x 2/4/8	-	USB 2.0/3.0	\$60/ \$130/ \$200 *	

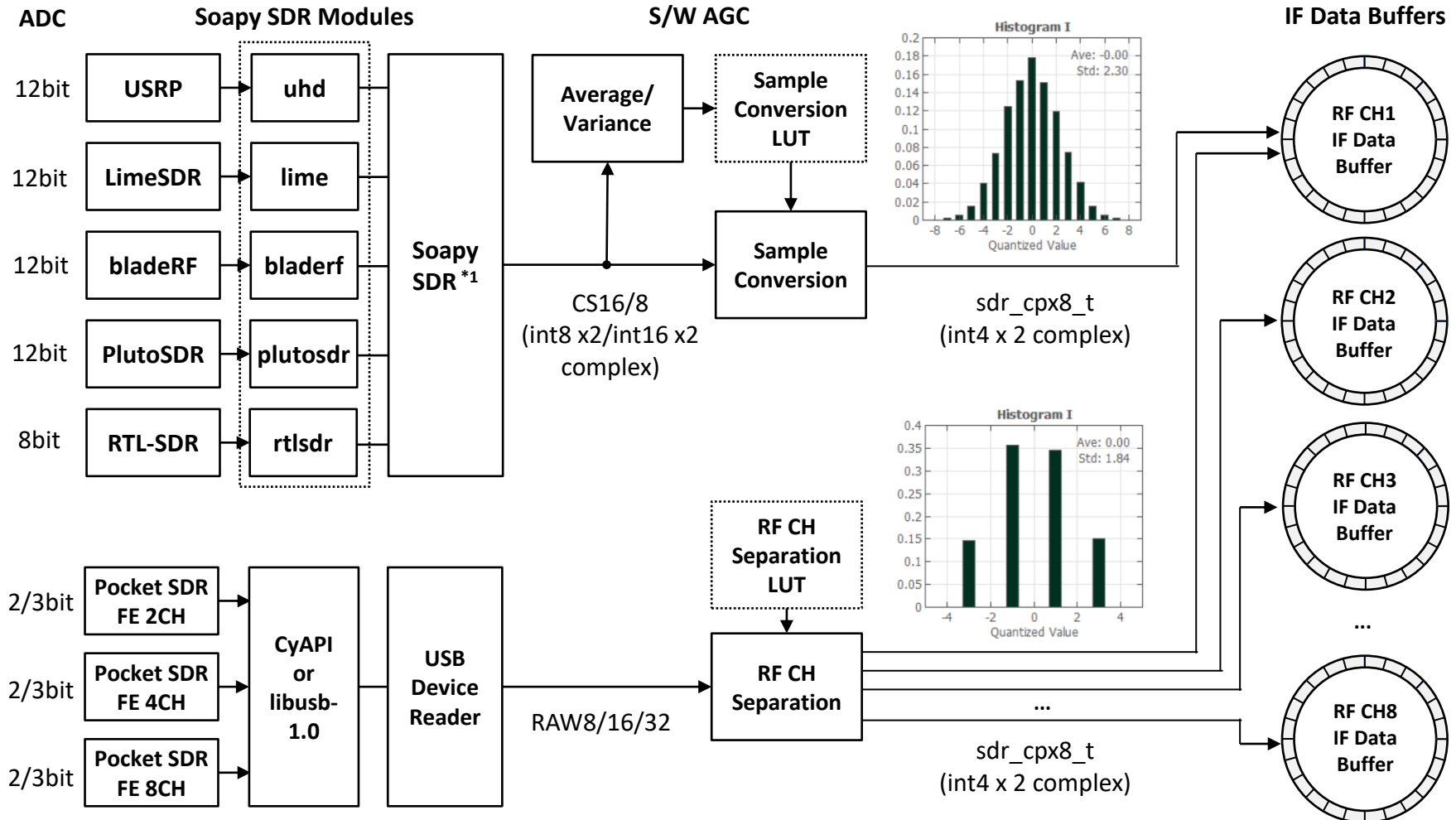
[1] <https://www.ettus.com/all-products/ub210-kit/>, [2] <https://ccar.colorado.edu/gnss/>, [3] <https://gmvnsl.com/advanced-gnss-hw-sw/>,

* Parts only

[4] <https://rtl-sdr.com/>, [5] <https://www.nuand.com/bladeRF-1/>, [6] <https://limemicro.com/products/boards/limesdr/>, [7] <https://www.amungo-navigation.com/>,

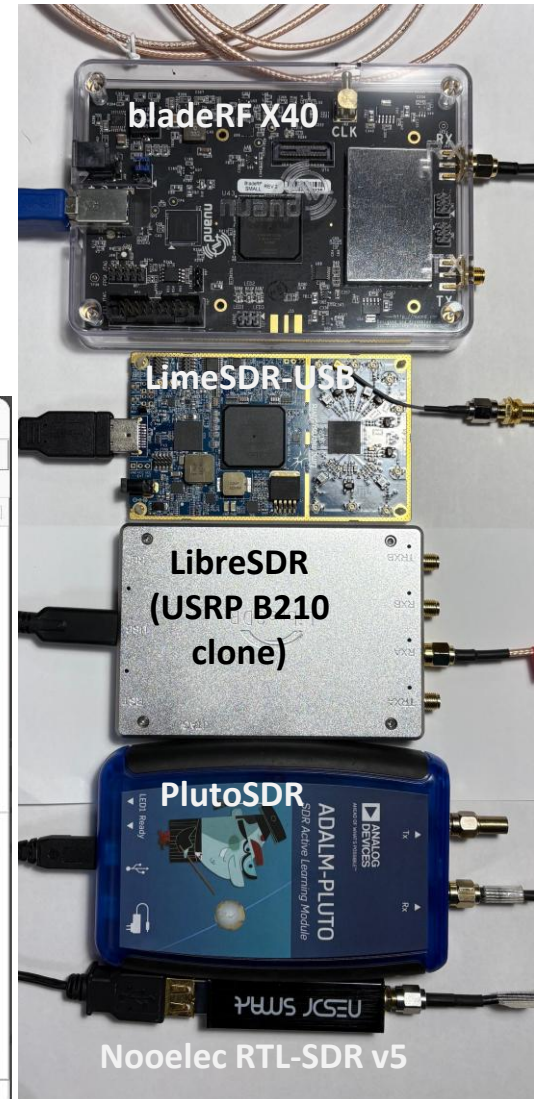
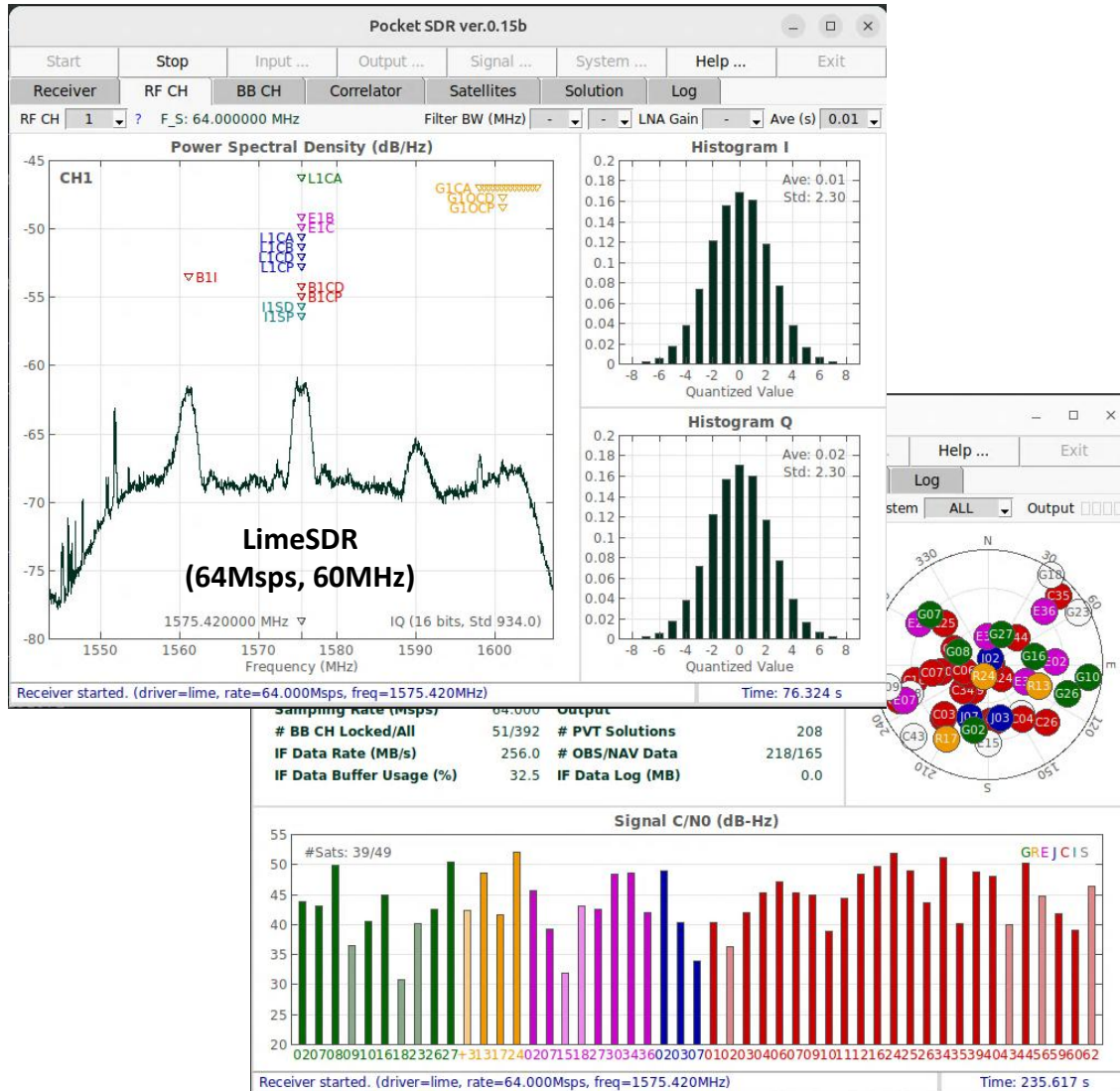
[8] <https://www.analog.com/en/resources/evaluation-hardware-and-software/evaluation-boards-kits/adalm-pluto.html>

Alternative RF Frontends (2/3)



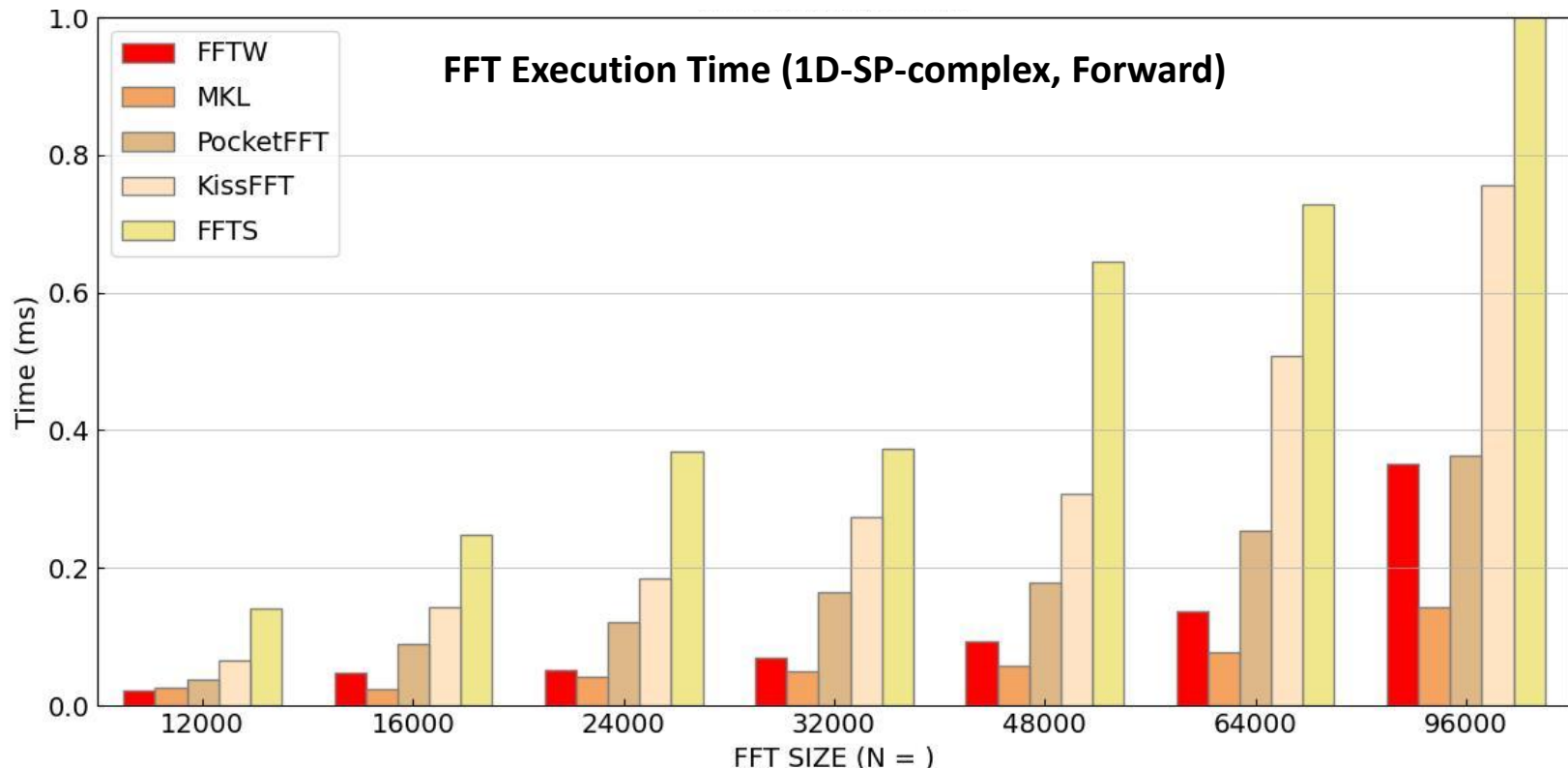
*1 <https://github.com/pothosware/SoapySDR>

Alternative RF Frontends (3/3)



Alternative FFT Library

ver.0.14 Issue: License Conflict between Pocket SDR and FFTW3 (GPLv2)



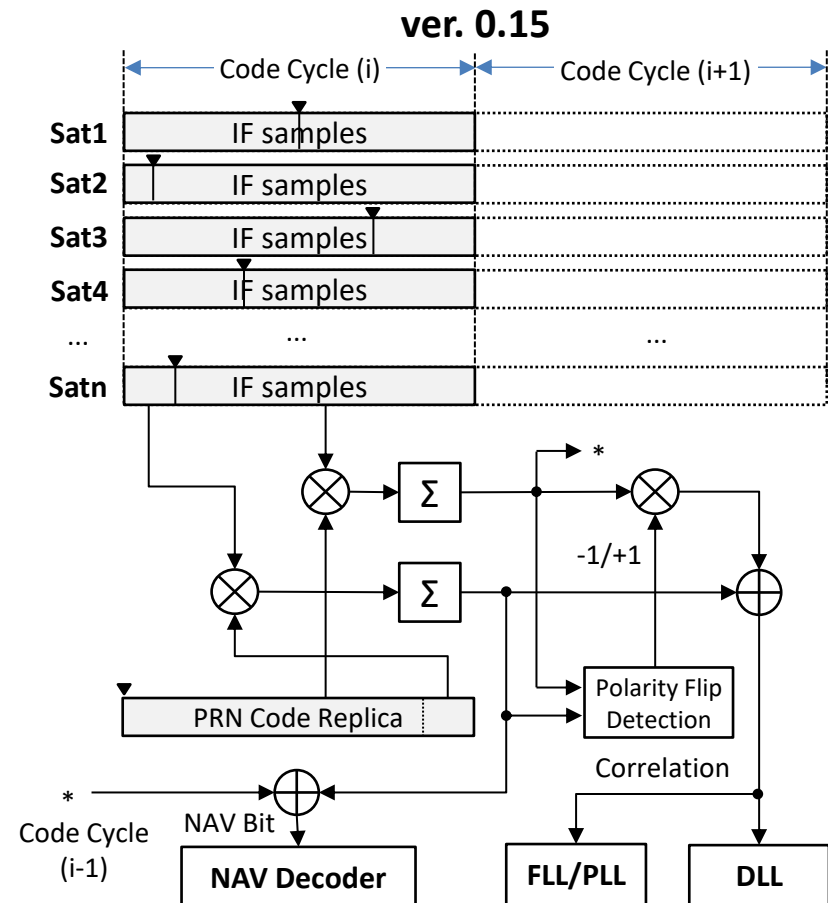
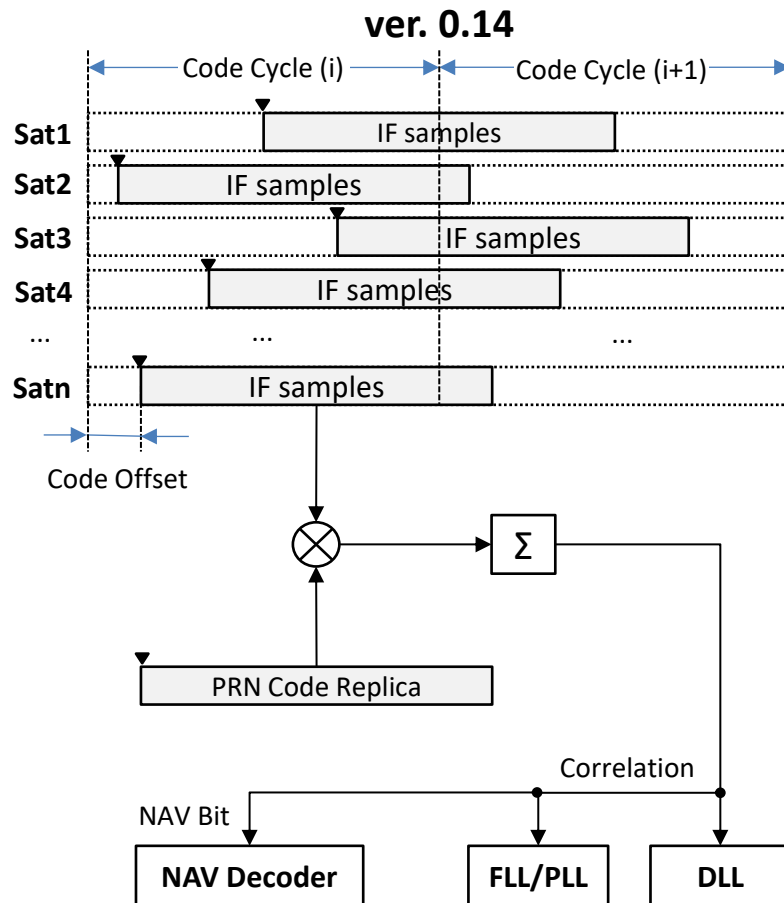
→ **PocketFFT: Binary AP/shared Library** → **MKL and FFTW3: User build options**

FFTW: 3.3.4, <https://www.fftw.org>, MKL: 2025.3, <https://www.intel.com/content/www/us/en/developer/tools/oneapi/onemkl.html>,
PocketFFT: <https://github.com/hayguen/pocketfft>, KissFFT: <https://github.com/mborgerding/kissfft>, FFTS: <https://github.com/anthonix/ffts>

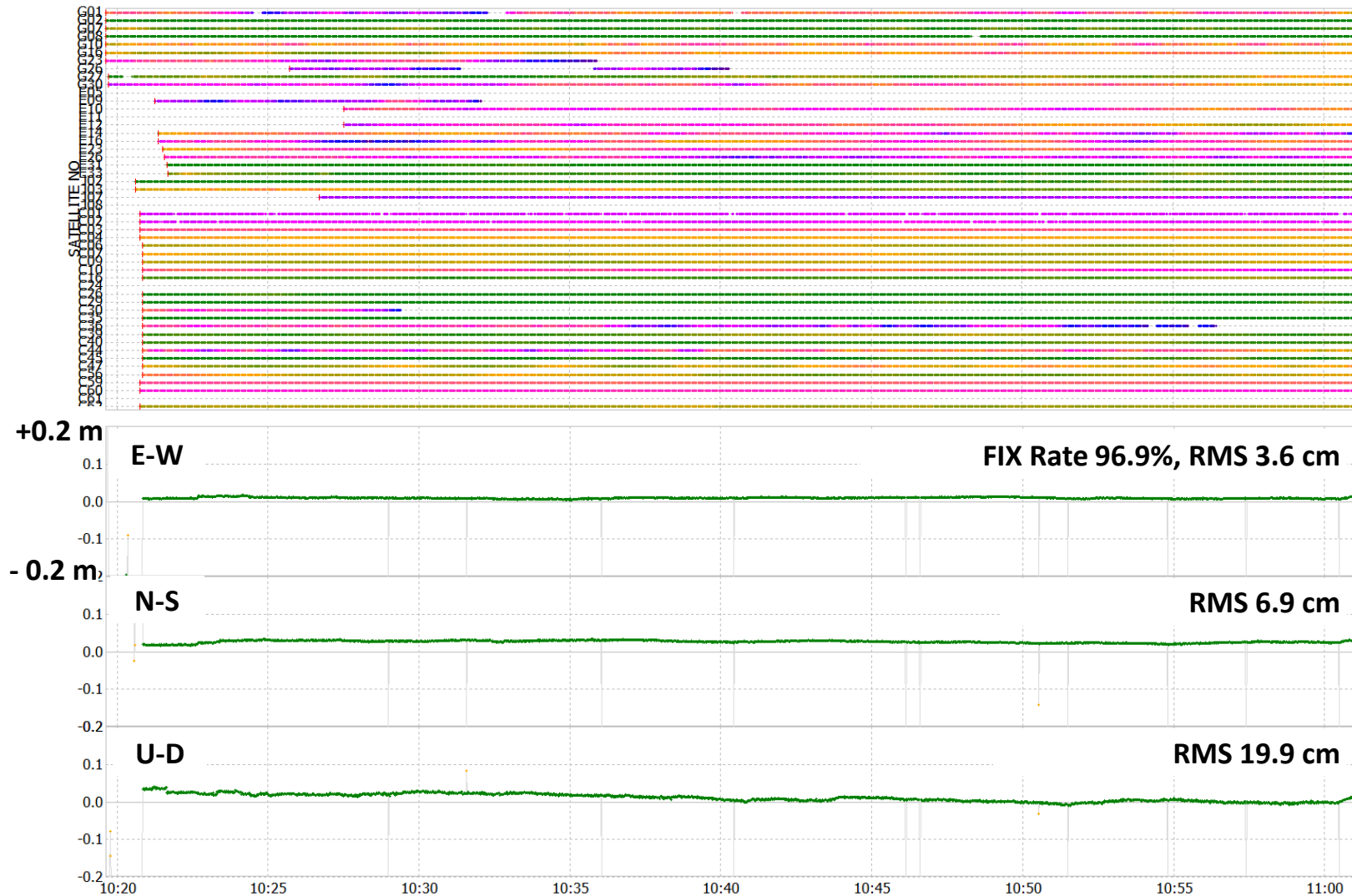
Carrier-Phase Generation (1/2)

ver.0.14 Issue: Unable to Fix Ambiguities for RTK

Change of Correlator Logic



Carrier Phase Generation (2/2)

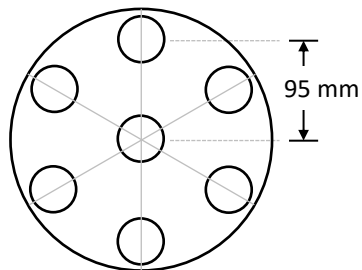
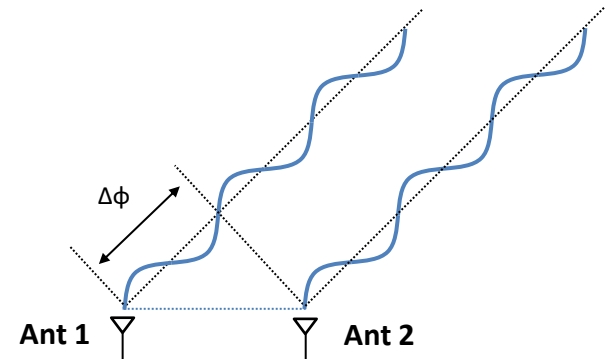
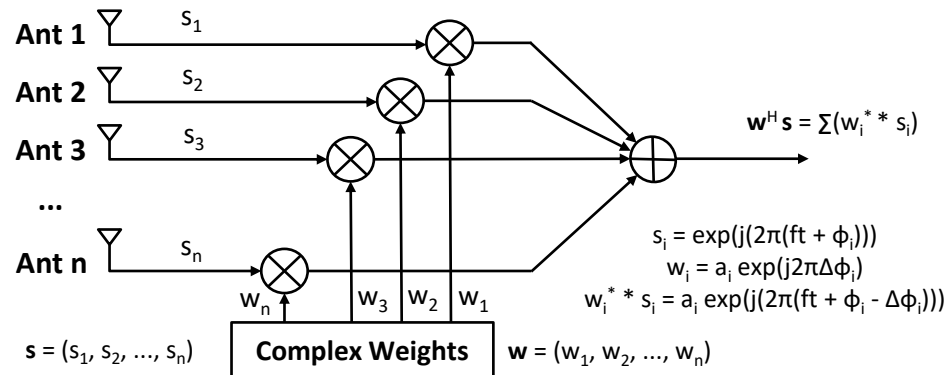


PPK Solution by Pocket SDR ver. 0.15, 2025-11-16 10:19-11:00 (BL=6.3 km)

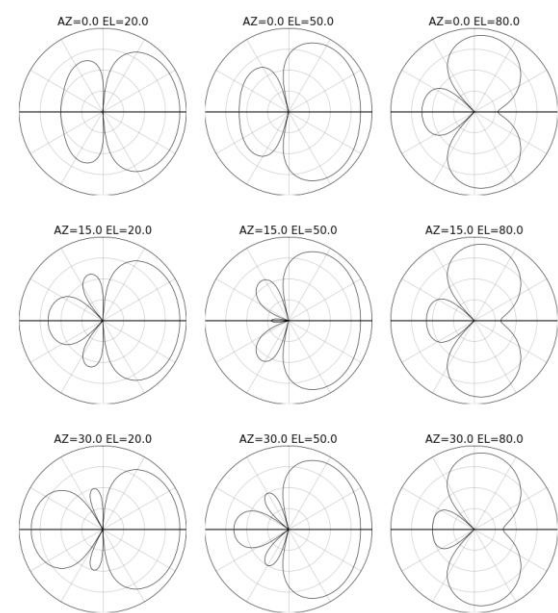
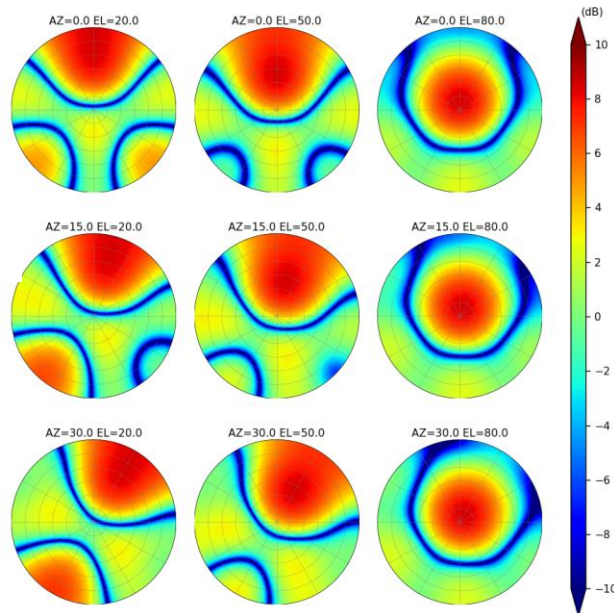
RTKPOST 2.4.3 b35, GPS, GAL, QZS, BDS, L1+L2+L5, EL Mask=20deg, AR=Instantaneous

Antenna Array (1/3)

CRPA (Controlled Reception Pattern Antenna)

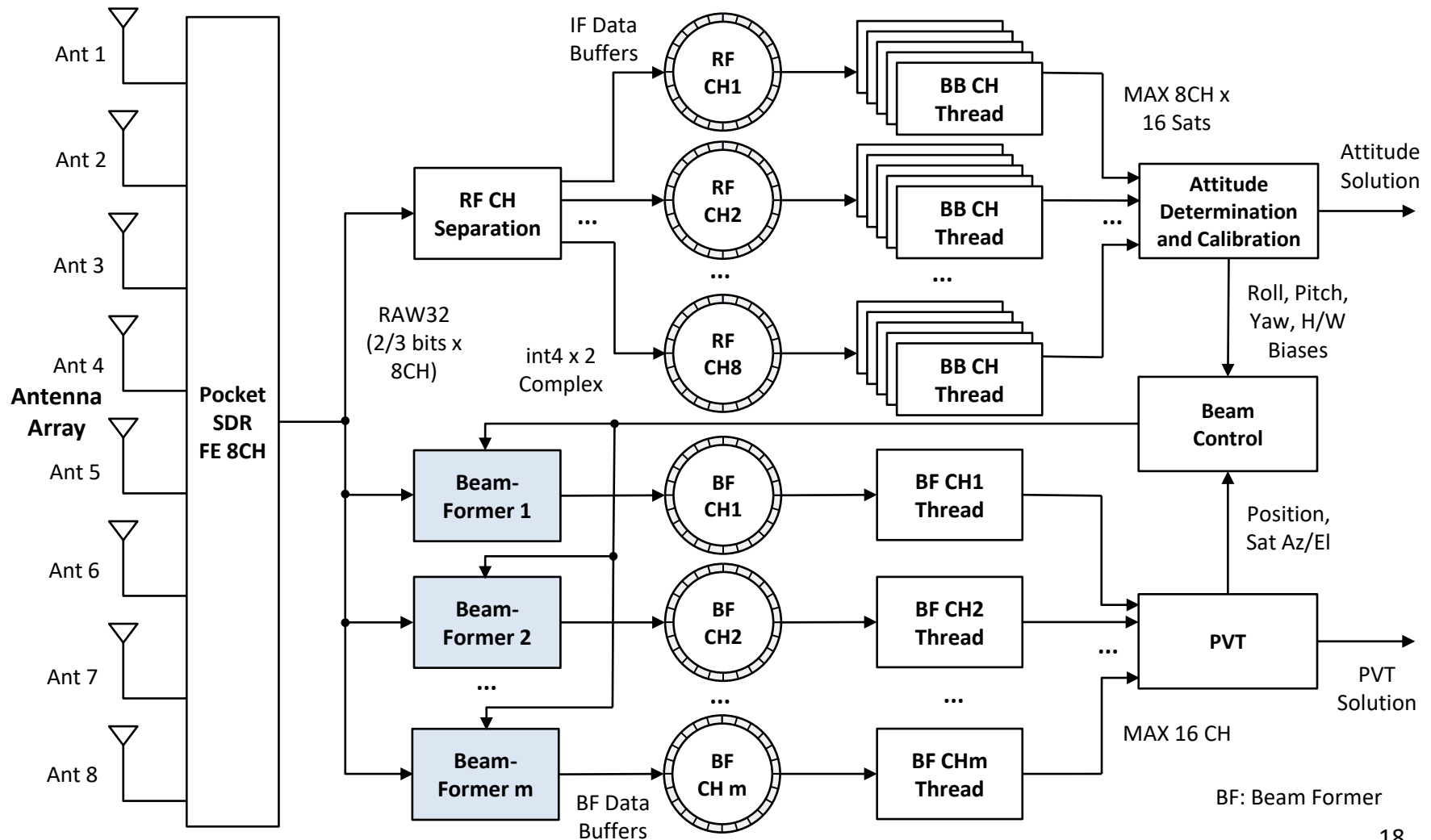


**L1 7-Elements
Antenna Array**



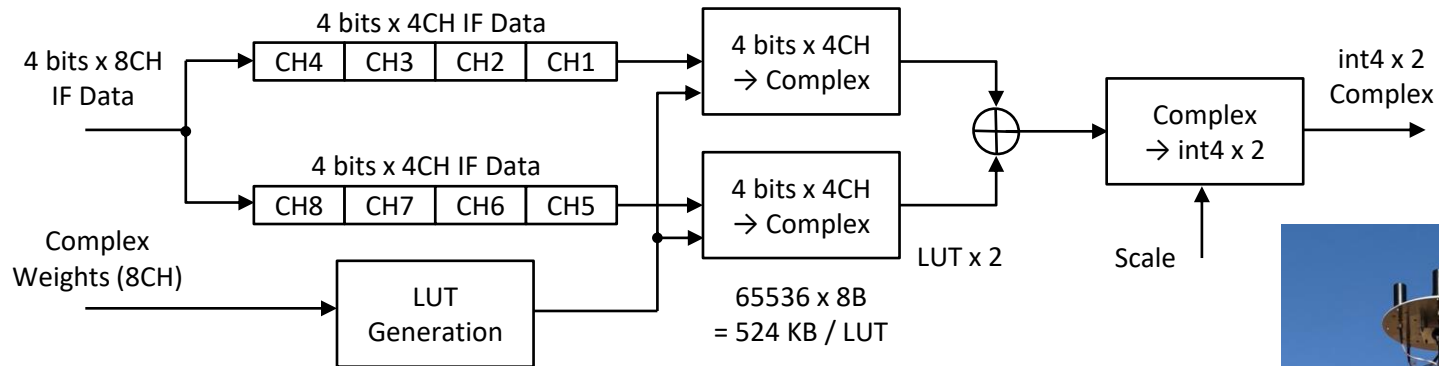
Antenna Array (2/3)

Pre-Correlation Beamforming $\leftrightarrow$ Post-Correlation Beamforming

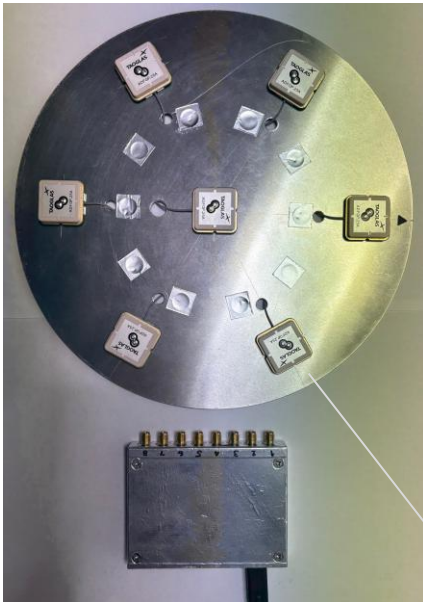


Antenna Array (3/3)

Pre-Correlation Beam-Former Design



Antenna Array Experiment Snapshots



Taoglas ADFGP.25A Embedded D



Pocket SDR FE 8CH



Summary

- **Pocket SDR ver. 0.14**
 - Most of L-band GNSS signals are already supported
 - Reconfigurable 8 CH RF frontends (Pocket SDR FE)
 - Over 300 CH signals can be tracked real-time by highly optimized codes
- **Pocket SDR ver. 0.15**
 - Alternative RF frontends are supported
 - FFT library is changed
 - Carrier-phase quality is improved to enable RTK or PPP
 - Codes for antenna-array (CRPA) are planned
- **Release of ver. 0.15**
 - in March 2026 (planned)
 - <https://github.com/tomojitakasu/PocketSDR>

Please Push ☆



Fork 137



Star 417