Features and Applications of the Adaptable Flexiband USB3.0 Front-end

ION GNSS+ 2014
September 8-12, 2014, Tampa Convention Center, Florida

Session A6: Simulation and Testing

Alexander Rügamer, Frank Förster, Manuel Stahl, Günter Rohmer

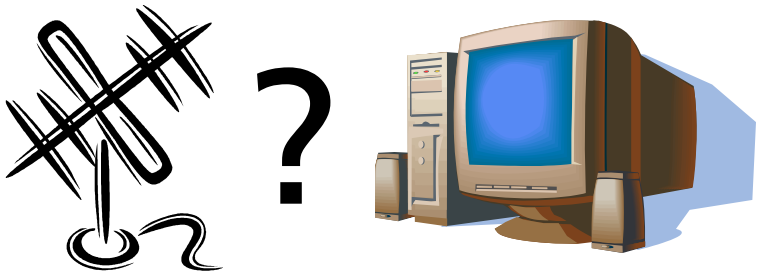
alexander.ruegamer@iis.fraunhofer.de
Fraunhofer IIS, Nuremberg, Germany

Contents

- Introduction
- Flexiband Hardware and Software
- Project Examples
  - Recording with Flexible Configurations
  - Interference Monitoring at German Reference Station
  - Interference Monitoring at Airport Graz, Austria
  - Array Post-Processing
- Conclusion

Introduction
Motivation and Applications for a USB Front-end

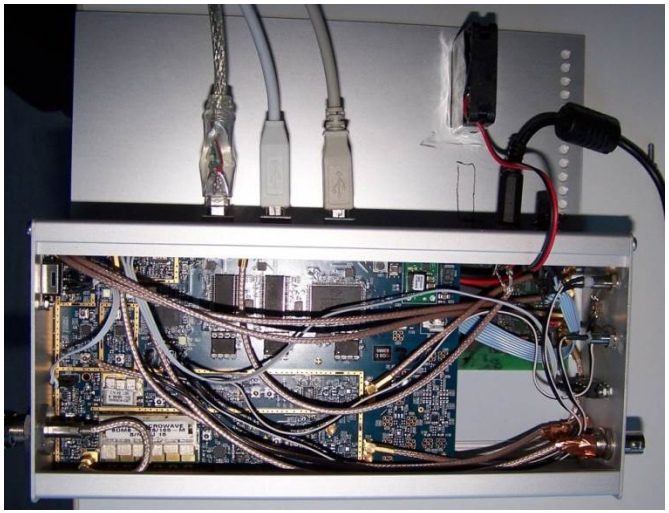
- Even a software receiver needs some hardware!
  - A front-end is required
  - USB is the most common standard PC interface



- Wide field of applications:
  - Get collection of real-world events to have controlled and reproducible data
  - Interference monitoring and detection
  - Array processing: beamforming / null-steering
  - Reflectometry applications
  - Multipath monitoring
  - Antenna comparisons

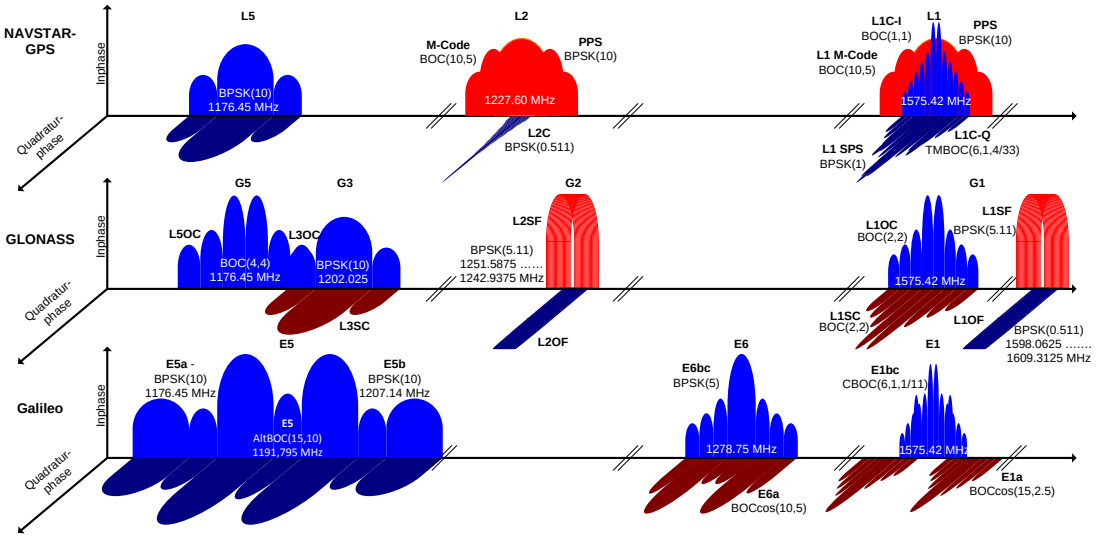
Introduction
Fraunhofer USB Front-ends

- L125 Triband USB Front-end (2006)
  - GPS L1/L2/L5
  - Two USB 2.0 data streams
  - Powered over USB
- RTKIII USB Front-end (2010)
  - Lower band: 1145-1310 MHz
  - Upper band: 1545-1630 MHz
  - 2x 410 MSPS ADCs
  - Flexible signal conditioning using an FPGA
  - Three USB 2.0 data streams



Introduction
Fraunhofer USB Front-ends

- "Flexiband" (2012)
- ION GNSS 2012
- Features
  - Portable
  - USB 3.0, USB2.0
  - Powered via USB
  - Futureproof (support all GNSS signals)
  - Flexibility for the user
  - Synchronization between different units
  - Multi antenna support
  - User friendly control GUI and API

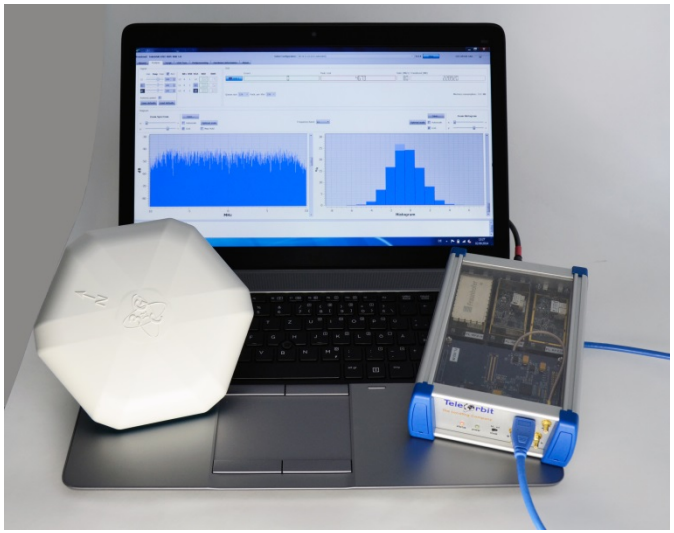


A. Rügamer, F. Förster, Frank, M. Stahl, G. Rohmer, "*A Flexible and Portable Multiband GNSS front-end System*," Proceedings of the 25th International Technical Meeting of The Satellite Division of the Institute of Navigation (ION GNSS 2012), Nashville, TN, September 2012, pp. 2378-2389.

Fraunhofer IIS

Introduction
Fraunhofer Flexiband ⇔TeleOrbit GTEC RFFE

- Since 2012, distributed via TeleOrbit
- ION GNSS+ 2014
  - At the booth of NavXperience
  - Flexiband together with Fraunhofer's 3G+C Antenna



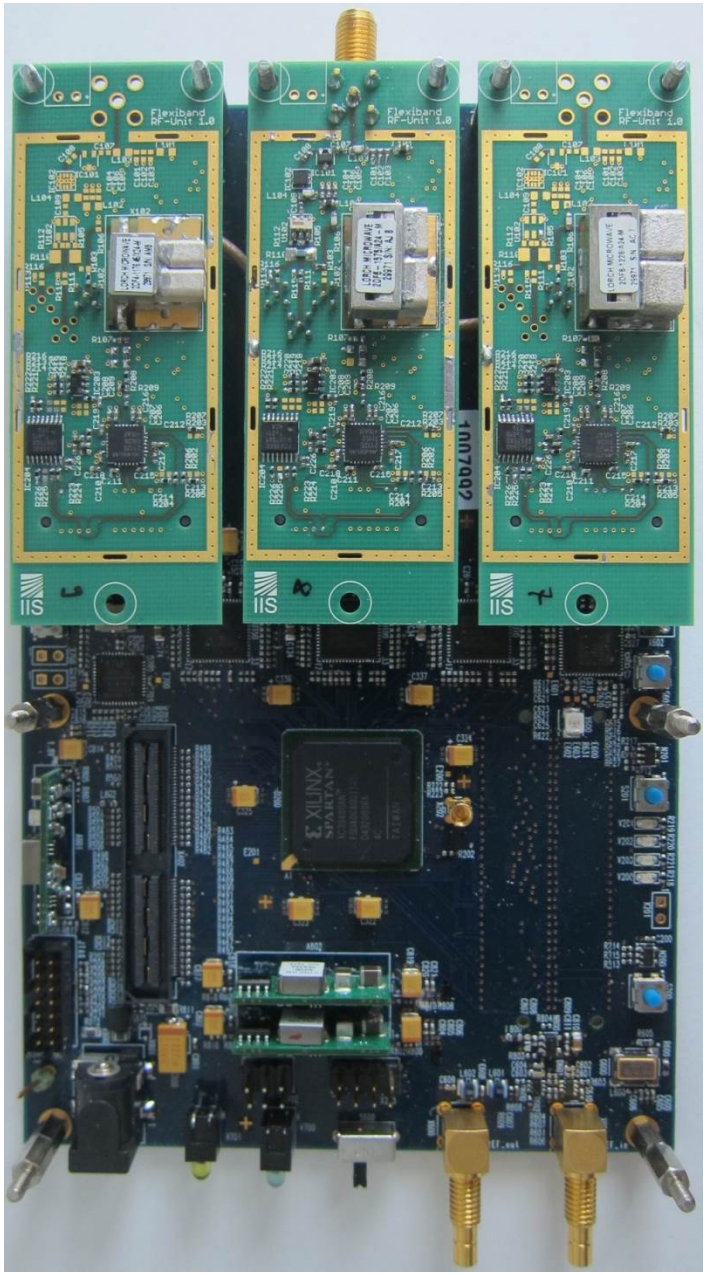
Fraunhofer IIS

Flexiband Hardware
Overview

- System architecture comprises four blocks:
  - RF modules
  - Baseband Unit
  - Interface Unit
  - Housing
- Integration
  - 188 x 125 x 50 mm^3
  - 0.8 kg weight
  - USB powered
  - Perfectly suited for mobile recording campaigns

Flexiband Hardware
RF Modules and Base Unit

- Carries up to 3 RF modules
  - 80 MHz RF bandwidth
  - Different filter types available
- Three Dual-Channel ADCs
  - Up to 80 Msps@8 bit I/Q
  - Coherent sampling
- FPGA
  - Digital filtering, mixing, multiplexing
  - Synchronization between different units
  - Embedding an error detection protocol
  - 67 GPIOs to e.g. embed digital sensor data in received raw GNSS data stream
- Clock generation and distribution unit
  - Onboard TCXO, External clock



Flexiband Hardware
USB3.0 Interface, Parallel Port

- USB 2.0 discontinued
- USB 3.0
  - Cypress EZ-USB FX3 controller
  - SuperSpeed USB3.0 – 5 Gbits/s
  - Power supply via 1x USB 3.0
  - Possibility to upgrade USB controller, microcontroller and FPGA firmware
- Parallel port interface
  - 24 bit data, 1 clk
  - LVCMOS 3.3V

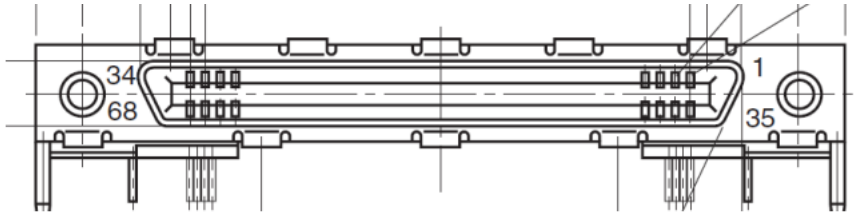
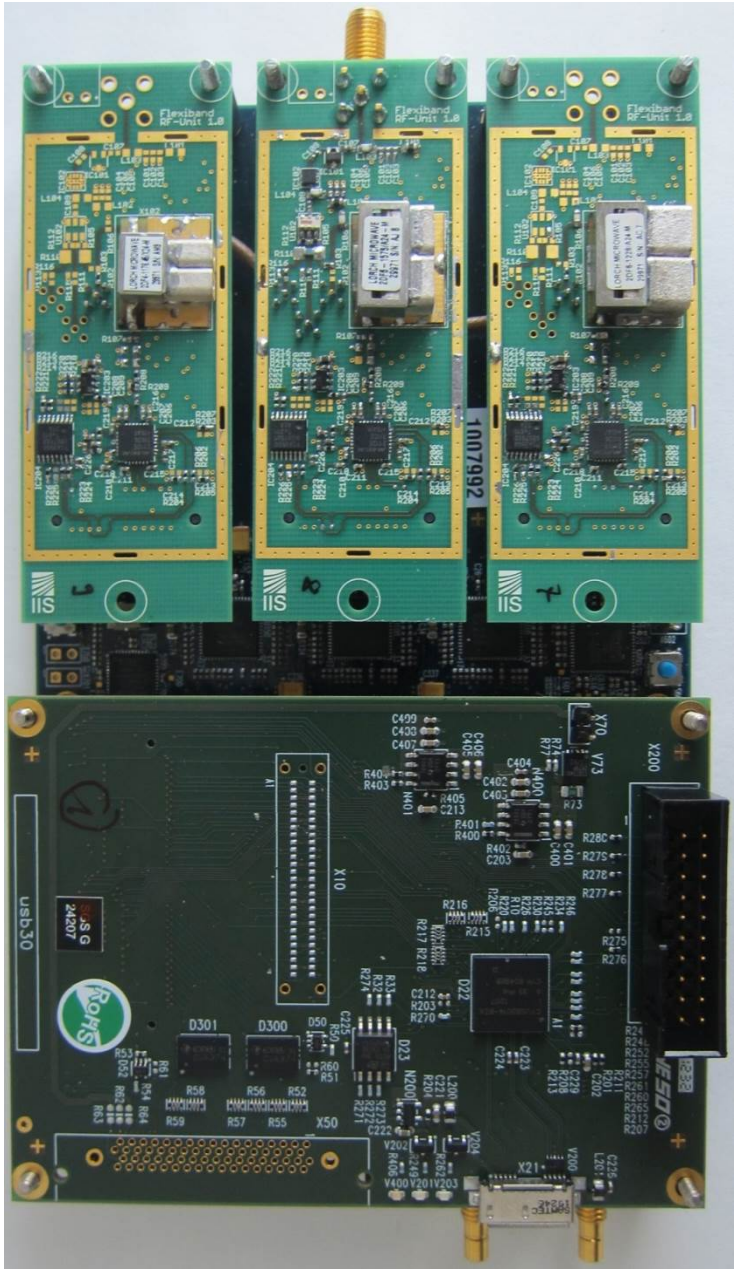


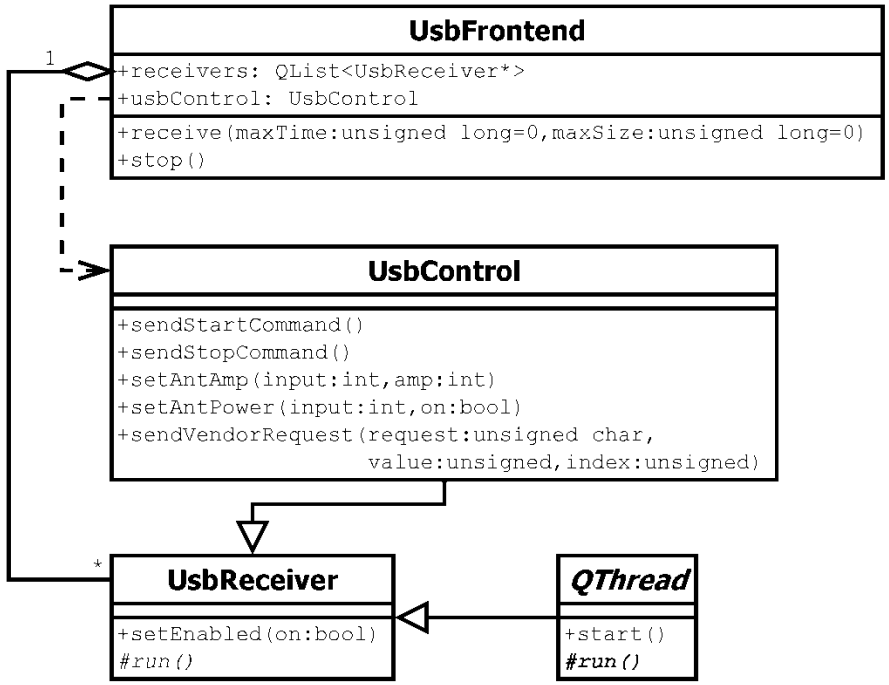
Figure 2: Honda connector layout (commonly used for SCSI-bus systems)



Fraunhofer IIS

Flexiband Software
Architecture

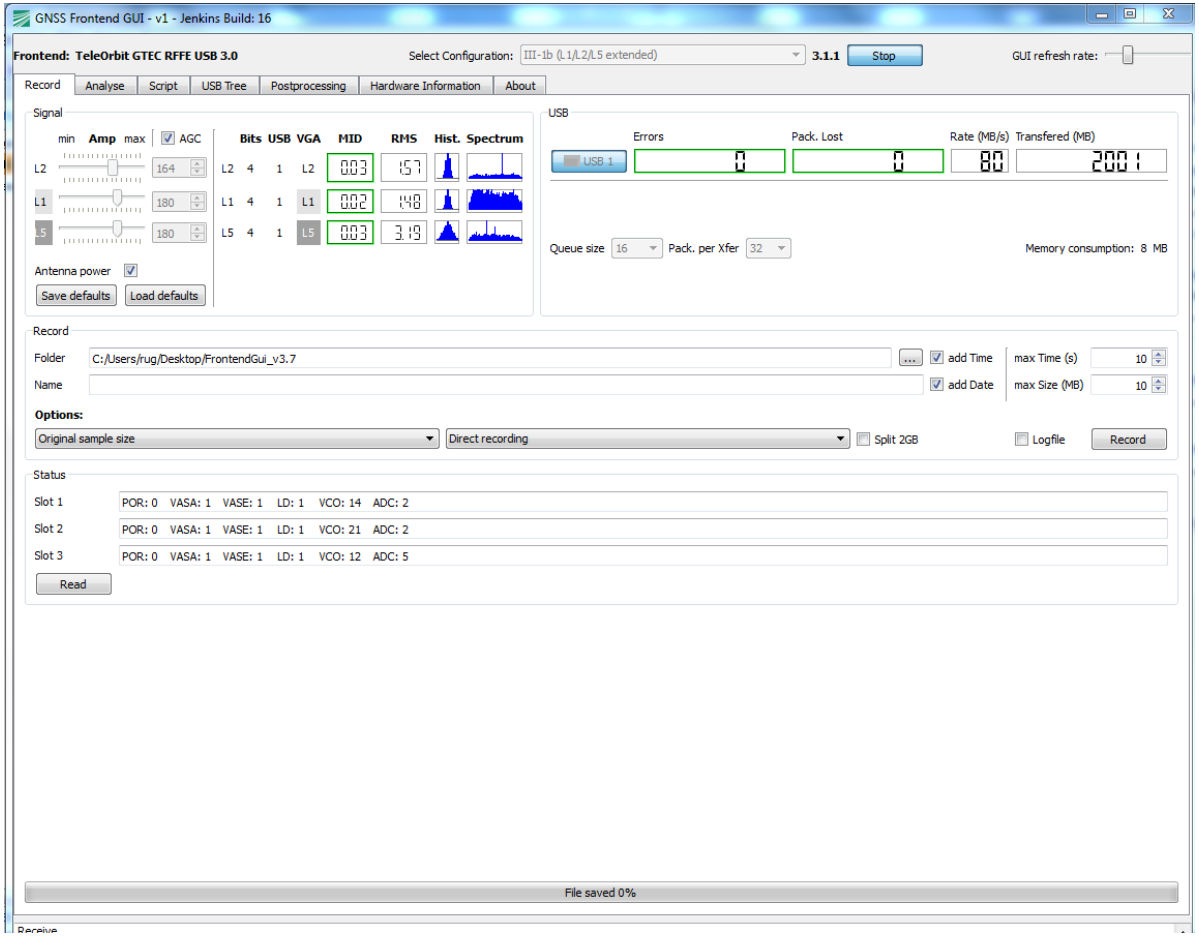
- Flexiband software components
  - USB-driver
  - Application programming interface (API)
  - Visualization and recording software (Qt)
    ➔ FlexibandGUI
  - Console Version
    ➔ FlexibandCLI
- Available for Windows and Linux



Flexiband Software

Flexiband GUI – Recording tab

- Manual / Automatic Gain Control (AGC)
- Error visualization
- Recording modes
  - Original samples
  - 8 bits/sample
  - Matlab
- Recording methods
  - Direct recording
  - RAM buffered
  - Round robing (infinite recording time, overwrites oldes files)

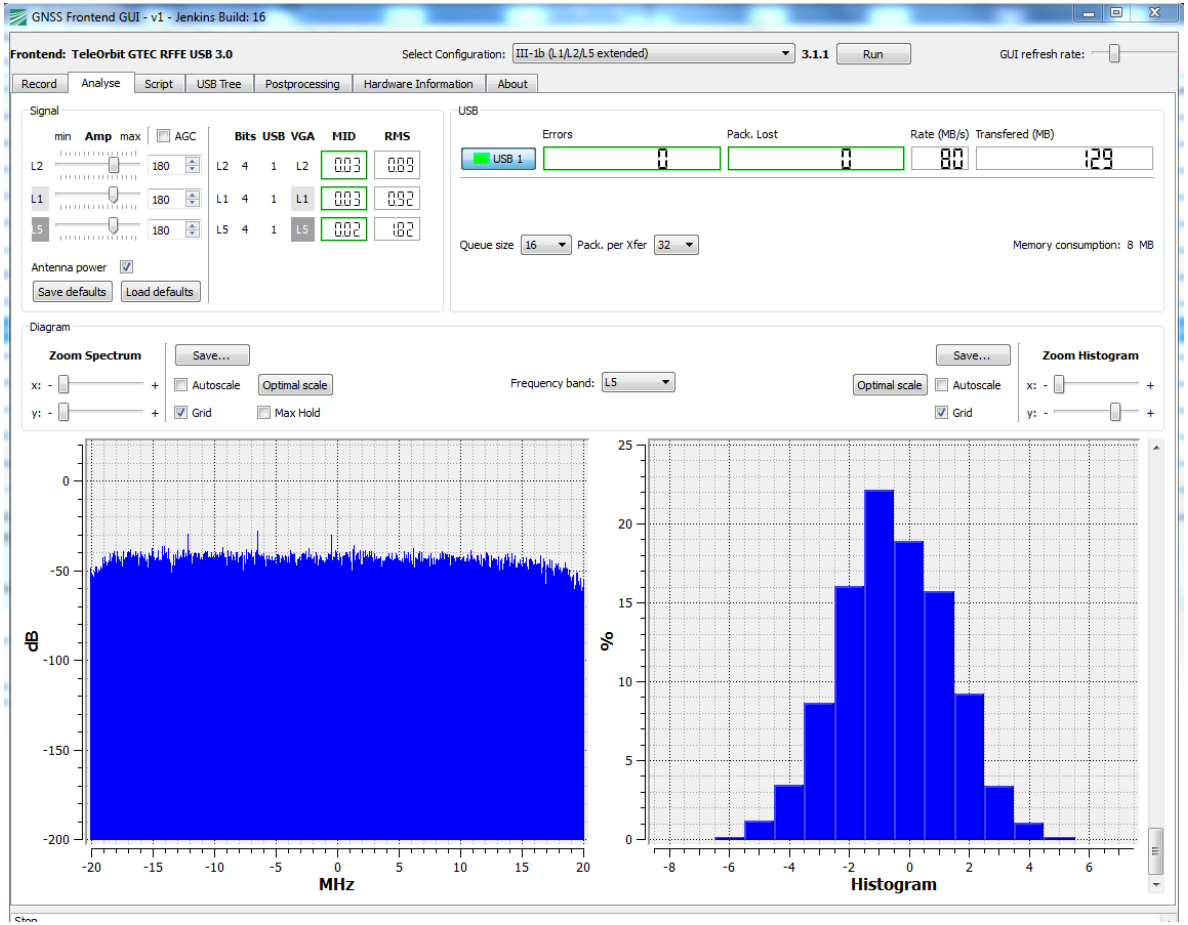


Fraunhofer IIS

Flexiband Software

Flexiband GUI – Analyze tab

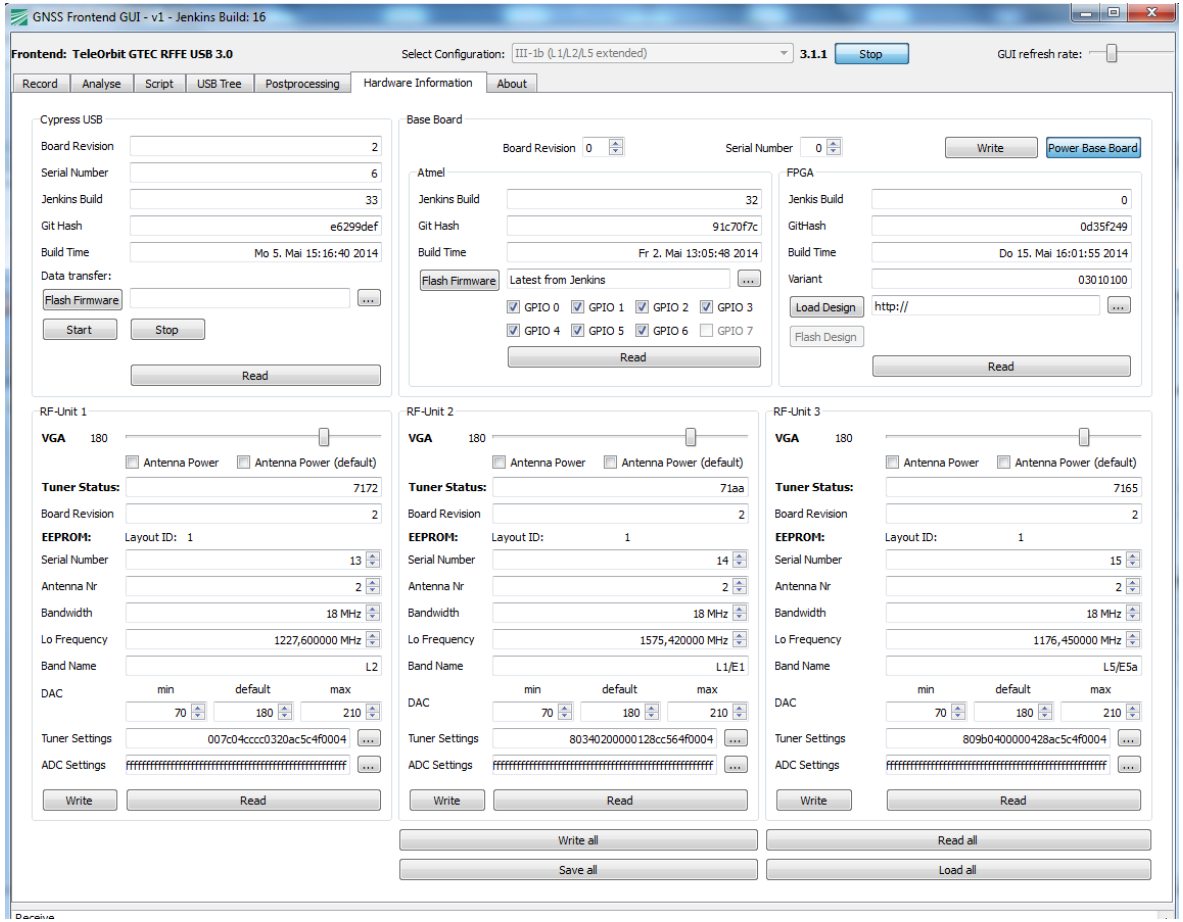
- Manual / Automatic Gain Control (AGC)
- Error visualization
- Complex Spectrum visualization of selected band
  - Identify e.g. CW-interference
- ADC histogram view
  - Check antenna and gain settings



Flexiband Software

Flexiband GUI – Hardware Information/Configuration

- "Expert control"
- Board revisions
- Status of Firmware
  - USB
  - Microcontroller
  - FGPA
- Settings of RFICs
  - Analog bandwidth
  - Analog local oscillator
- Compensation of ADC DC-offset



Flexiband Software
Flexiband CLI

- All configuration parameters are stored in config.ini file
- Usage:
  FrontendCLI [-i INI_FILE] [--help|-h]
- Default ini-file:
- Advantages
  - No user interaction to configure/start recording necessary
  - Suited for automatic recordings e.g. from triggered events

```
[directories]
# File path
recordPath=.
# Base filename without file extension
recordFile=test
[receive]
# Maximal record time (s) and size (MB)
maxTime=0 # Not properly working yet
maxSize=100
# Split data in 2 GB files
split=false
# record mode
# 0: Direct recording
# 1: RAM buffered recording
# 2: Round robin recording
bufferMode=0
# Data conversion after recording
# 0: No convertion
# 1: 8 Bit/sample
# 2: Matlab
fileFormat=0
# Add date/time tag to filename
addTime=true
addDate=true
# Time tag
# h   : the hour without a leading zero (0 to 23 or 1 to 12 if AM/PM display)
# hh  : the hour with a leading zero (00 to 23 or 01 to 12 if AM/PM display)
# m   : the minute without a leading zero (0 to 59)
# mm  : the minute with a leading zero (00 to 59)
# s   : the second without a leading zero (0 to 59)
# ss  : he second with a leading zero (00 to 59)
# z   : the milliseconds without leading zeroes (0 to 999)
# zzz : the milliseconds with leading zeroes (000 to 999)
# AP  : use AM/PM display. AP will be replaced by either "AM" or "PM".
# ap  : use am/pm display. ap will be replaced by either "am" or "pm".
timeFormat="hh-mm-ss_"
# Date tag
# d    : the day as number without a leading zero (1 to 31)
# dd   : the day as number with a leading zero (01 to 31)
# ddd  : the abbreviated localized day name (e.g. 'Mon' to 'Sun')
# dddd : the long localized day name (e.g. 'Monday' to 'Sunday')
# M    : the month as number without a leading zero (1-12)
# MM   : the month as number with a leading zero (01-12)
# MMM  : the abbreviated localized month name (e.g. 'Jan' to 'Dec')
# MMMM : the long localized month name (e.g. 'January' to 'December')
# yy   : the year as two digit number (00-99)
# yyyy : the year as four digit number
dateFormat="yyyyMMdd_"
# Create a file with the current recording settings
logFile=true
# RAM buffer:
# Values: 16, 32, 64, 128, 256, 512, 1024
# 16 kB * queuesize * pktPerXfer
# e.g.: 16 kB * 256 * 128 = 512 MB
queuesize=16
pktPerXfer=16
# Amplification for each band
amp1=180
amp2=180
amp3=180
# USB device enabled
# Flexiband: Only usbEnabled1 is used
usbEnabled1=1
usbEnabled2=0
usbEnabled3=0
# Enable AGC -> if '1' then amp[1..3] is not used
agc=0
[dialog]
# Flexiband variant:
configSelect=3
```

Project Examples
Recording with Flexible Configurations

- Once the analog front-end hardware is chosen the digital signal conditioning on the FPGA can be used to realize flexible settings
- FPGA development kit for experienced users
  - Generate own bit-files for FPGA to
    - Configurable, complex FIR filter
    - Sampling rate decimation (80MSPS / *n* with configurable *n*)
    - Configurable digital mixer for IF setting
- Different FPGA configurations
  - Changing the signal selection and conditioning „on-the-fly“
  - From a single band to a triple band with one mouse click

Project Examples
Recording with Flexible Configurations

Configuration	Frequency band	Bandwidth [MHz]	Center frequency [MHz]	Intermediate frequency [MHz]	Sampling rate [MHz]	Sample bit width	USB data rate [MBit/s]	USB type 3.0	Remarks
Single band front-end									
I-1a	L1/E1abc/B1	38	1.575,420	B1: -14,322	40	2x8 (complex)	640	USB3.0	Interference Monitoring
I-1b	L1/E1abc/B1	38	1.575,420	B1: -14,322	40	2x4 (complex)	320	USB3.0	
I-1c	L1/E1bc	18	1.575,420	0,000	20,25	2x8 (complex)	324	USB3.0	
I-1d	L1/E1abc/G1/B1	60	1.587,000	L1: -11,58 G1: 15,00	64	2x8 (complex)	1.024	USB3.0	
I-2a	L2/G2	50	1.238,000	L2: -10,40 G2: 8,00	60	2x8 (complex)	960	USB3.0	
I-2b	tbd								
I-2c	L2/L2C	18	1.227,600	0,000	20,25	2x8 (complex)	324	USB3.0	
I-3a	L5/E5/B2	68	1.191,795	L5/E5a: -15,345 E5b: 15,345	80	2x8 (complex)	1.280	USB3.0	
I-3b	E5b/B2	38	1.207,140	0,000	40	2x4 (complex)	320	USB3.0	
I-4a	E6abc/B3	38	1.278,750	0,000	40	2x8 (complex)	640	USB3.0	
I-5a	L1/E1abc/G1/B1	68	1587,000	L1: -11,58 G1: 15,00	80 / N	2x 8 (complex)	1.280 / N	USB3.0	Mixer, Filter and N configureable
I-6a	L5/E5/B2	68	1191,795	L5/E5a: -15,345 E5b: 15,345	80 / N	2x 8 (complex)	1.280 / N	USB3.0	
Dual band front-end									
II-1a	L1/E1ab	18	1.575,420	0,000	20	2x8 (complex)	640	USB3.0	Interference Monitoring
	L1/E1ab	18	1.575,420	0,000	20	2x8 (complex)			
II-1b	L5/E5a	18	1.176,450	0,000	20	2x8 (complex)	640	USB3.0	Interference Monitoring
	L5/E5a	18	1.176,450	0,000	20	2x8 (complex)			
II-1c	L1/E1ab	18	1.575,420	0,000	20	2x8 (complex)	640	USB3.0	Interference Monitoring
	L5/E5a	18	1.176,450	0,000	20	2x8 (complex)			
II-2a	L1/E1abc	18	1.575,420	0,000	20,25	2x8 (complex)	648	USB3.0	Interference Monitoring
	L2/L2C	18	1.227,600	0,000	20,25	2x8 (complex)			
II-2b	L1/E1abc/B1/G1	54	1.585,000	L1: -9,58 G1: 17,00	81	2x4 (complex)	972	USB3.0	L1/L2 GPS, GLO, GAL, BEI
	L2/L2C/G2	38	1.235,000	L2: -7,40 G2: 11,00	40,5	2x4 (complex)			
II-3a	L1/E1abc/B1	38	1.575,420	B1: -14,322	40	2x4 (complex)	640	USB3.0	Galileo / Beidou
	E5b/B2	38	1.207,140	0,000	40	2x4 (complex)			
II-3b	L1/E1abc/B1	38	1.575,420	0,000	40	2x8 (complex)	1.280	USB3.0	Extended E1/E5
	L5/E5/B2	52	1.191,795	L5/E5a: -15,345 E5b: 15,345	80	2x4 (complex)			
II-3d	L1/E1abc/B1	38	1.575,420	0,000	40	2x4 (complex)	960	USB3.0	Wideband E1/E5
	L5/E5/B2	52	1.191,795	L5/E5a: -15,345 E5b: 15,345	80	2x4 (complex)			
II-4a	L1/E1bc	18	1.575,420	0,000	30	2x4 (complex)	720	USB3.0	Extended E1/E5
	L5/E5/B2	52	1.191,795	L5/E5a: -15,345 E5b: 15,345	60	2x4 (complex)			
II-4b	L1/E1abc/B1	38	1.575,420	L1/E1: 0,000 B1: -14,322	40	2x8 (complex)	1.280	USB3.0	Galileo PRS
	E6abc/B3	38	1.278,750	E6: 0,000 B3: -10,230	40	2x8 (complex)			
II-5a	G1	18	1.602,000	0,000	20	2x4 (complex)	320	USB3.0	Standard G1/G2
	G2	18	1.246,000	0,000	20	2x4 (complex)			
II-6a	L1/E1abc/G1/B1	68	1587,000	L1: -11,58 G1: 15,00	80 / N	2x 4 (complex)	1.280 / N	USB3.0	Mixer, Filter and N configureable
	L5/E5/B2	68	1191,795	L5/E5a: -15,345 E5b: 15,345	80 / N	2x 4 (complex)	1.280 / N		
II-7a	L1/E1bc/G1	38	1587,000	L1: -11,58 G1: 15,00	40	2x 4 (complex)	640	USB3.0	GPS + GLONASS
	L2/G2	38	1230,000	L2: -2,40 G2: 16,00	40	2x 4 (complex)			
II-8a	B1	18	1561,098	0,000	20	2x 4 (complex)	320	USB3.0	Standard B1/B2/B3
	B2	18	1207,140	0,000	20	2x 4 (complex)			

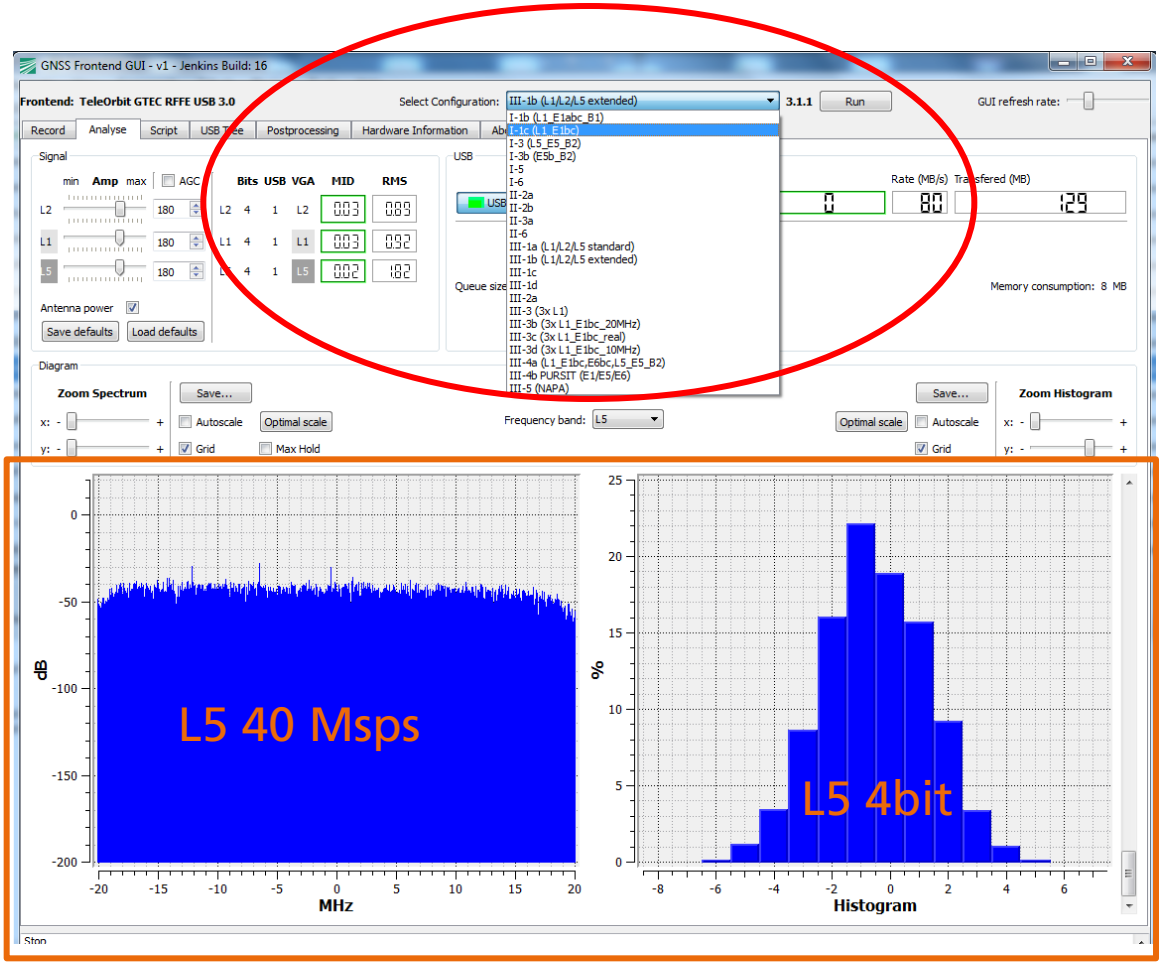
Triple band front-end									
III-1a	L1/E1bc	18	1.575,420	0,000	20	2x2 (complex)	320	USB3.0	Standard L1/L2/L5
	L2/L2C	18	1.227,600	0,000	20	2x2 (complex)			
	L5/E5a	18	1.176,450	0,000	20	2x4 (complex)			
III-1b	L1/E1bc	18	1.575,420	0,000	20	2x4 (complex)	640	USB3.0	Extended L1/L2/L5
	L2/L2C	18	1.227,600	0,000	20	2x4 (complex)			
	L5/E5a	38	1.176,450	0,000	40	2x4 (complex)			
III-1c	L1/E1bc	18	1.575,420	0,000	20,25	2x4 (complex)	648	USB3.0	Extended L1/L2/L5; other mixer freq.
	L2/L2C	18	1.227,600	0,000	20,25	2x4 (complex)			
	L5/E5a	38	1.176,450	0,000	40,5	2x4 (complex)			
III-1d	L1/E1bc	6	1.575,420	0,000	10	2x4 (complex)	320	USB3.0	GPS, GAL, GLO long time recording
	L2/L2C/G2	38	1.227,600	L2: -7,40 G2: 11,00	40	2x2 (complex)			
	L5/E5a	18	1.176,450	0,000	20	2x2 (complex)			
III-1e	L1/E1bc	18	1.575,420	L1/E1: -2.086,637 KHz (inv.)	20	2x4 (complex)	640	USB3.0	Extended L1/L2/L5
	L2/L2C	18	1.227,600	L2: +933,333 KHz (reg.)	20	2x4 (complex)			
	L5/E5a	38	1.176,450	L5/E5a: +449,965 KHz (reg.)	40	2x4 (complex)			
III-2a	L1/E1abc/B1/G1	54	1.585,000	L1: -9,58 G1: 17,00	81	2x2 (complex)	810	USB3.0	L1/L2/L5 GPS, GLO, GAL, BEI
	L2/L2C/G2	38	1.235,000	L2: -7,40 G2: 11,00	40,5	2x2 (complex)			
	L5/E5/B2	50	1.192,500	L5/E5a: -16,050 E5b: 14,640	81	2x2 (complex)			
III-2b	L1/E1abc/B1	38	1.585,000	L1: -9,58 G1: 17,00	40,5	2x4 (complex)	972	USB3.0	L1/L2/L5 GPS, GLO, GAL, BEI
	L2/L2C/G2	38	1.235,000	L2: -7,40 G2: 11,00	40,5	2x4 (complex)			
	L5/E5/B2	38	1.192,500	L5/E5a: -16,050 E5b: 14,640	40,5	2x4 (complex)			
III-2c	L1/E1abc/B1	38	1.585,000	L1: -9,58 G1: 17,00	40,5	2x4 (complex)	1296	USB3.0	L1/L2/L5 GPS, GLO, GAL, BEI
	L2/L2C/G2	38	1.235,000	L2: -7,40 G2: 11,00	40,5	2x4 (complex)			
	L5/E5/B2	50	1.192,500	L5/E5a: -16,050 E5b: 14,640	81	2x4 (complex)			
III-3a	L1/E1bc/G1	38	1.587,000	L1: -11,58 G1: 15,00	41	2x4 (complex)	984	USB3.0	Beamforming, Heading, etc.
	L1/E1bc/G1	38	1.587,000	L1: -11,58 G1: 15,00	41	2x4 (complex)			
	L1/E1bc/G1	38	1.587,000	L1: -11,58 G1: 15,00	41	2x4 (complex)			
III-3b	L1/E1bc	18	1.575,420	0,000	20,25	2x8 (complex)	972	USB3.0	Beamforming, Heading, etc.
	L1/E1bc	18	1.575,420	0,000	20,25	2x8 (complex)			
	L1/E1bc	18	1.575,420	0,000	20,25	2x8 (complex)			
III-3c	L1/E1bc	18	1575,420	-10,830	40,5	8 (real)	972	USB3.0	Beamforming, Heading, etc.
	L1/E1bc	18	1575,420	-10,830	40,5	8 (real)			
	L1/E1bc	18	1575,420	-10,830	40,5	8 (real)			
III-3d	L1/E1bc	8	1575,420	0,000	10	2x 8 (complex)	480	USB3.0	GPS C/A and Galileo OS BOC(1,1)
	L1/E1bc	8	1575,420	0,000	10	2x 8 (complex)			
	L1/E1bc	8	1575,420	0,000	10	2x 8 (complex)			
III-3e	L1/E1bc	8	1575,420	0,000	10	2x 4 (complex)	240	USB3.0	GPS C/A and Galileo OS BOC(1,1)
	L1/E1bc	8	1575,420	0,000	10	2x 4 (complex)			
	L1/E1bc	8	1575,420	0,000	10	2x 4 (complex)			
III-4a	L1/E1bc	18	1.575,420	0,000	30	2x4 (complex)	960	USB3.0	Galileo CS, QZSS, etc.
	E6bc	18	1.278,750	0,000	30	2x4 (complex)			
	L5/E5/B2	52	1.191,795	L5/E5a: -15,345 E5b: 15,345	60	2x4 (complex)			
III-4b	L1/E1abc	38	1.575,420	0,000	40	2x4 (complex)	1280	USB3.0	Extended Galileo CS, QZSS, etc.
	E6abc	38	1.278,750	0,000	40	2x4 (complex)			
	L5/E5/B2	68	1.191,795	L5/E5a: -15,345 E5b: 15,345	80	2x4 (complex)			
III-5a	G1	18	1.602,000	0,000	20	2x4 (complex)	640	USB3.0	Extended G1/G2/G3
	G2	18	1.246,000	0,000	20	2x4 (complex)			
	G3	38	1.202,025	0,000	40	2x4 (complex)			
III-6a	B1	18	1.561,098	0,000	20	2x4 (complex)	640	USB3.0	Standard B1/B2/B3
	B3/E6	38	1.268,520	0,000	40	2x4 (complex)			
	B2/E5b	18	1.207,140	0,000	20	2x4 (complex)			

- From single-band to triple-band
- From 320 to 1280 Mbit/s [40 to 160 Mbyte/s]
- Over 43 defined configurations available
- Customized configurations available, too

Fraunhofer IIS

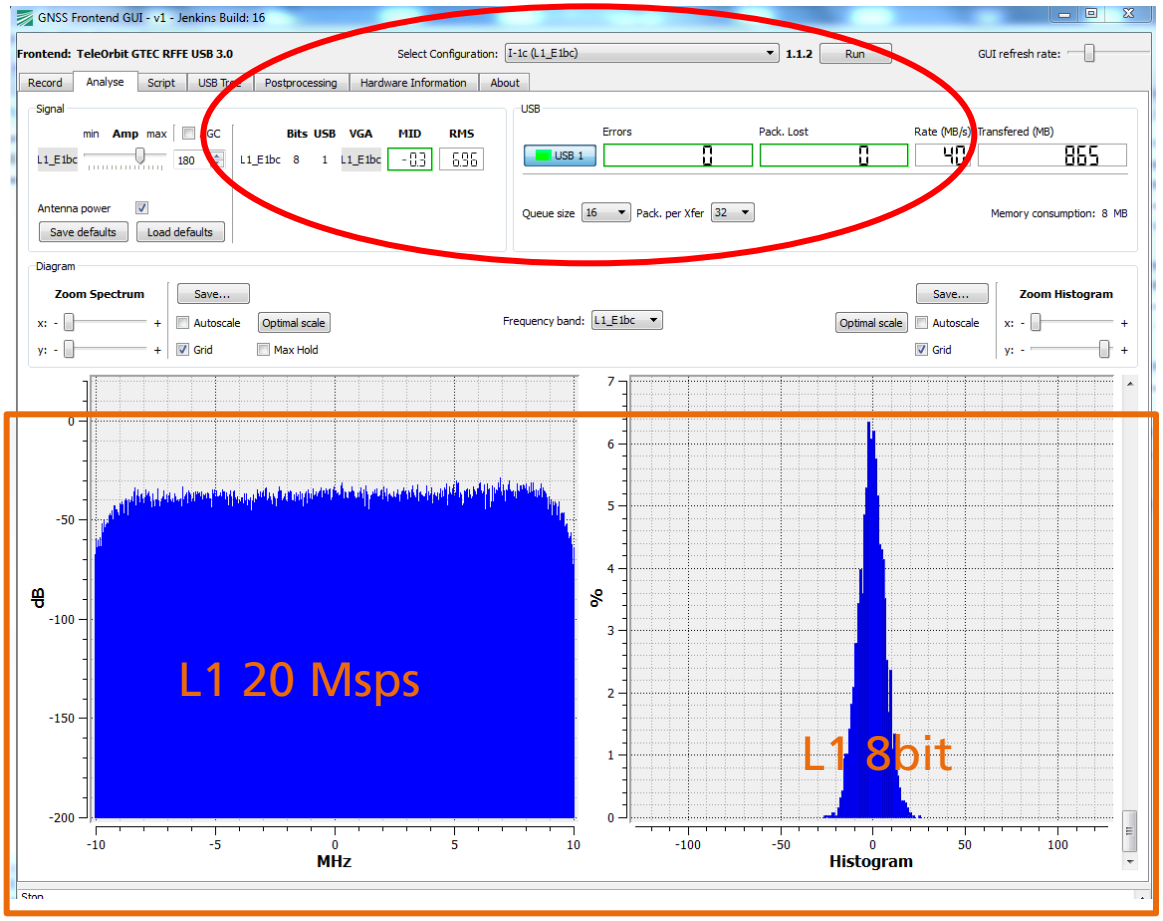
Project Examples
Recording with Flexible Configurations

- Select Configuration FPGA bit-File
- From a triple band III-b:
  - L1 20Msps@4bit I/Q
  - L2 20Msps@4bit I/Q
  - L5 40Msps@4bit I/Q
  - With overall 640 Mbit/s (80 Mbyte/s)



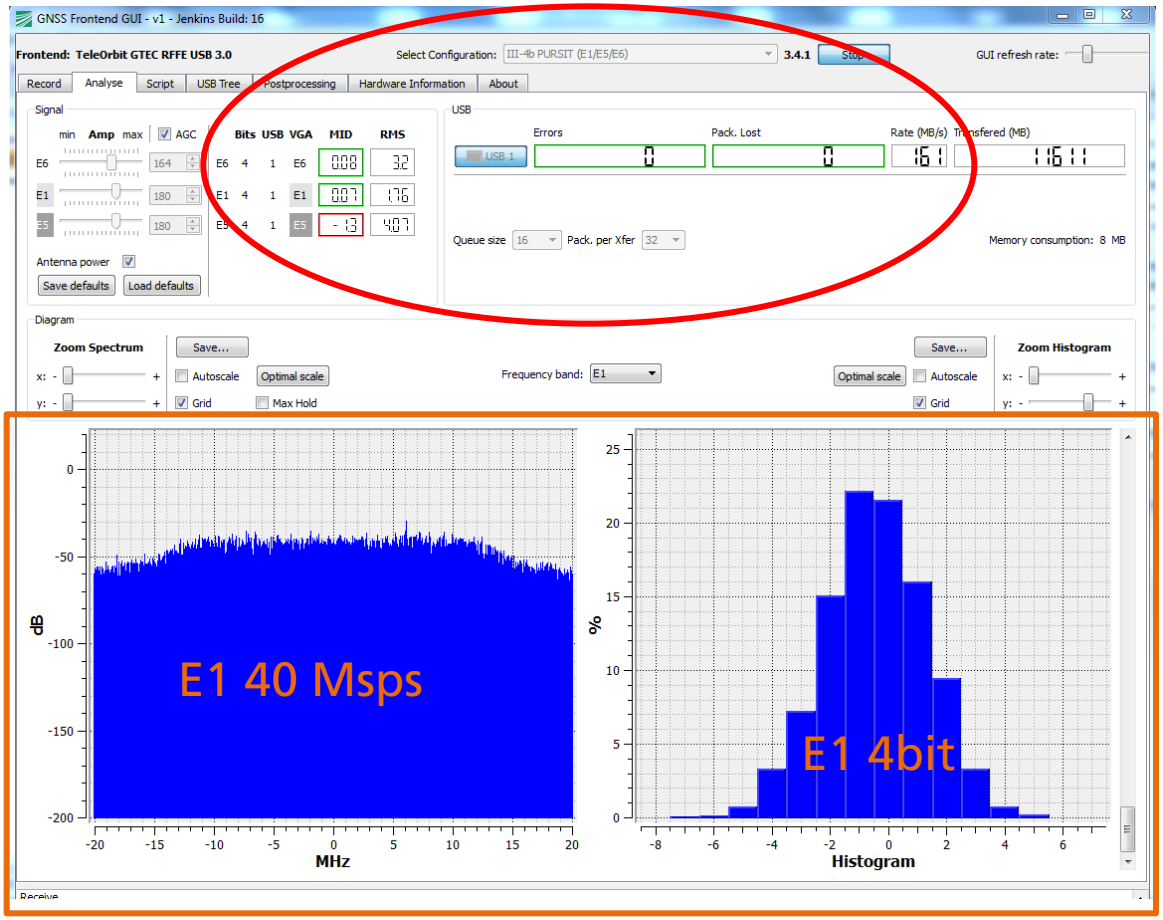
Project Examples
Recording with Flexible Configurations

- To a new single band configuration I-1c:
  - L1 20Msps@8bit I/Q
  - With overall 320 Mbit/s (40 Mbyte/s)



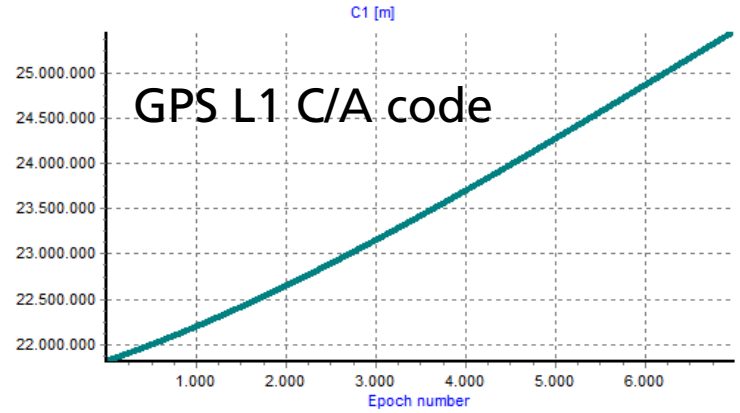
Project Examples
Recording with Flexible Configurations

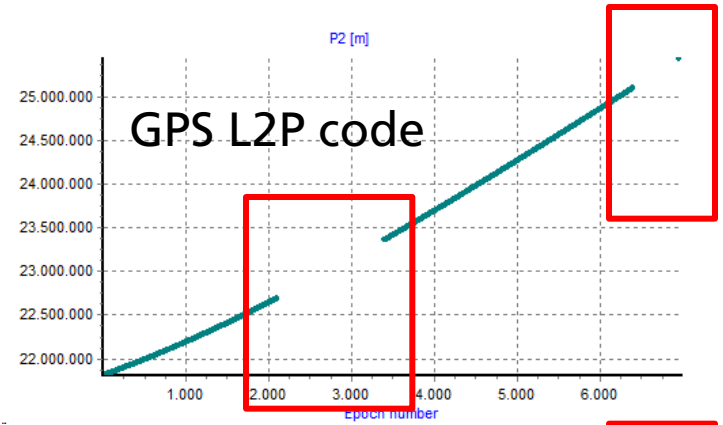
- Or to an extended triple band configuration III-4b:
  - E1 40Msps@4bit I/Q
  - E6 40Msps@4bit I/Q
  - E5 80Msps@4bit I/Q
  - With overall 1280 Mbit/s (160 Mbyte/s)

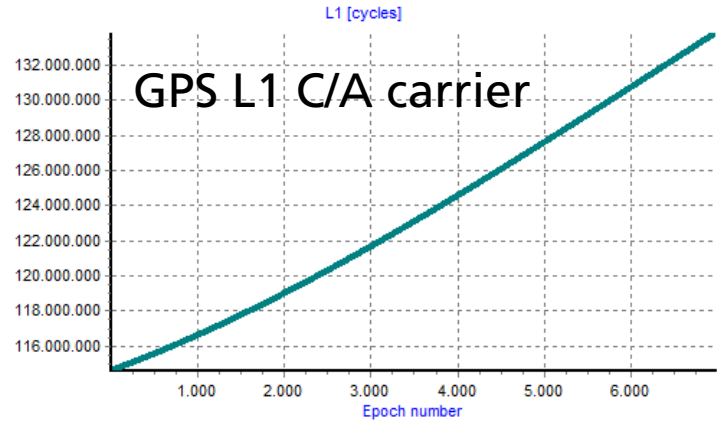


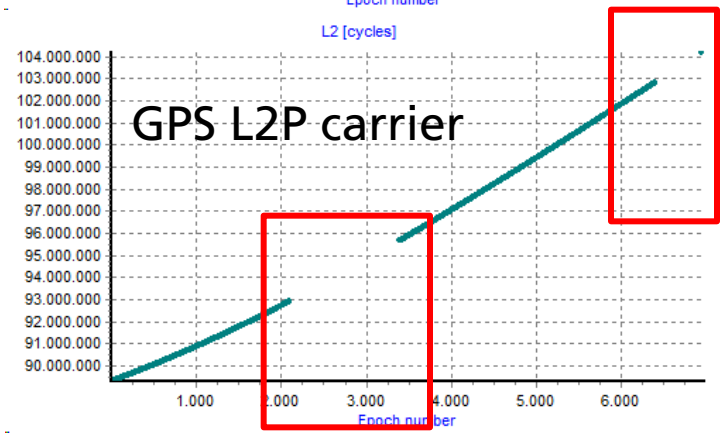
Project Examples

Interference Monitoring at German Reference Station





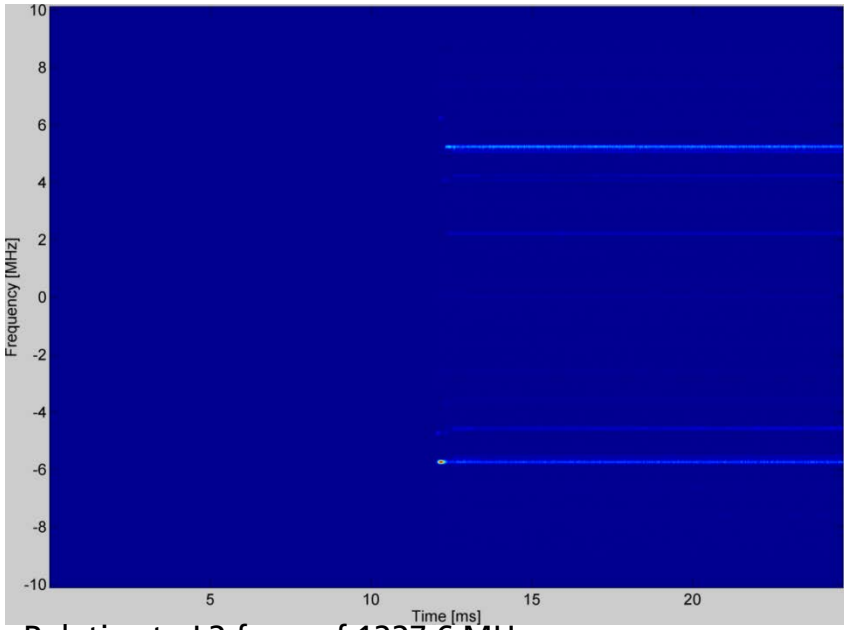




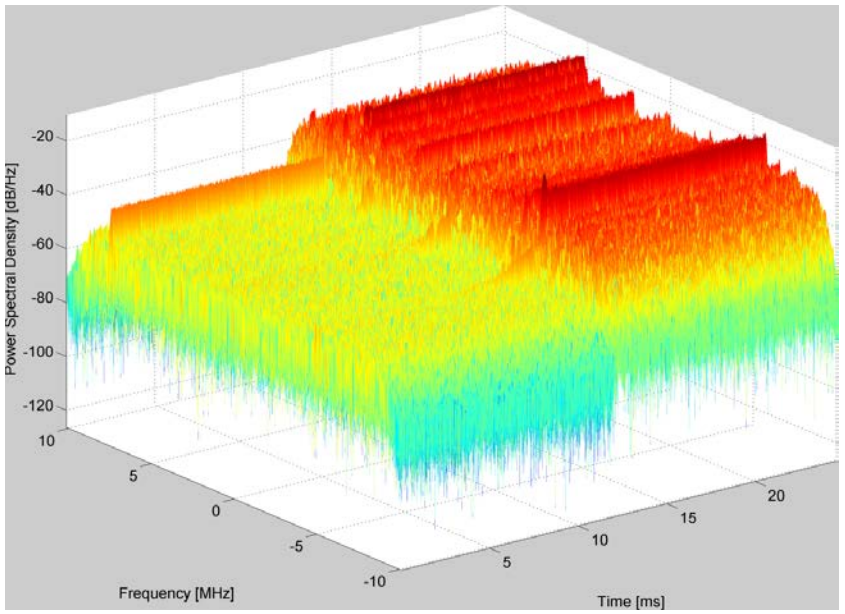
Fraunhofer IIS

Project Examples
Interference Monitoring at German Reference Station

- HAM Radio FM-Relais, 1242.650 MHz with approx. 9 Watt output power
- Even a power reduction to 300 mW is clearly visable (not shown here)
- Flexiband with antenna splitter at reference station



Relative to L2 freq. of 1227.6 MHz

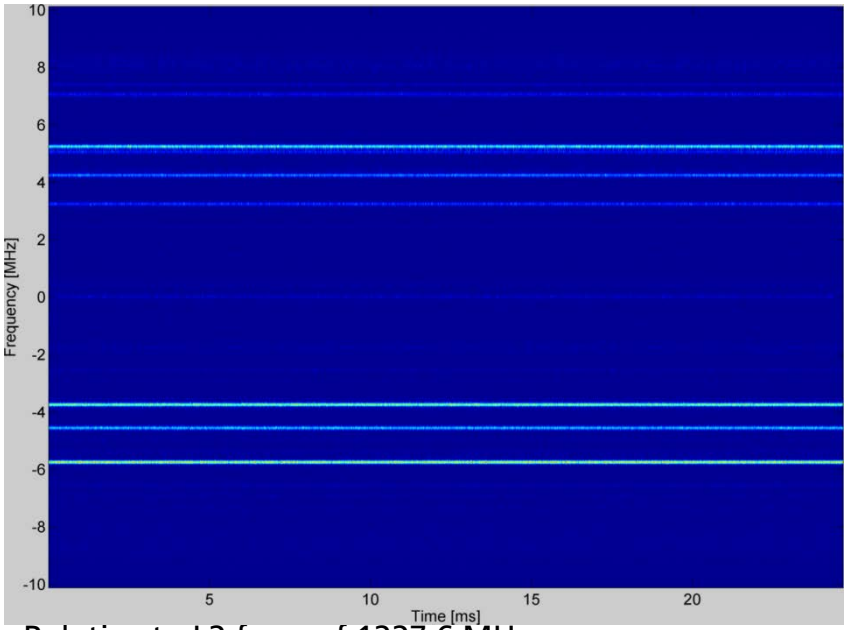


Relative to L2 freq. of 1227.6 MHz

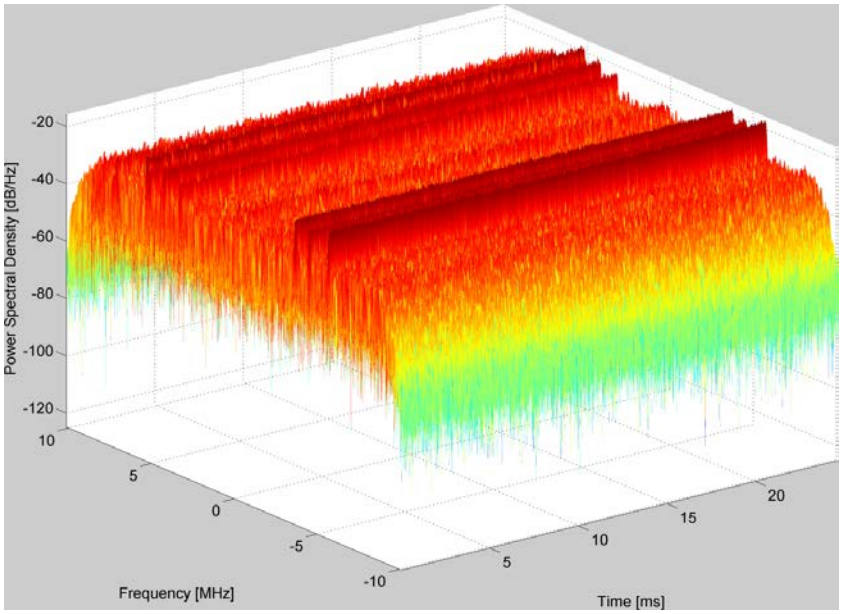
Fraunhofer IIS

Project Examples
Interference Monitoring at German Reference Station

- HAM Radio FM-Relais, 1242.650 MHz with approx. 9 Watt output power
- Even a power reduction to 300 mW is clearly visable (not shown here)
- Flexiband with antenna splitter at reference station



Relative to L2 freq. of 1227.6 MHz

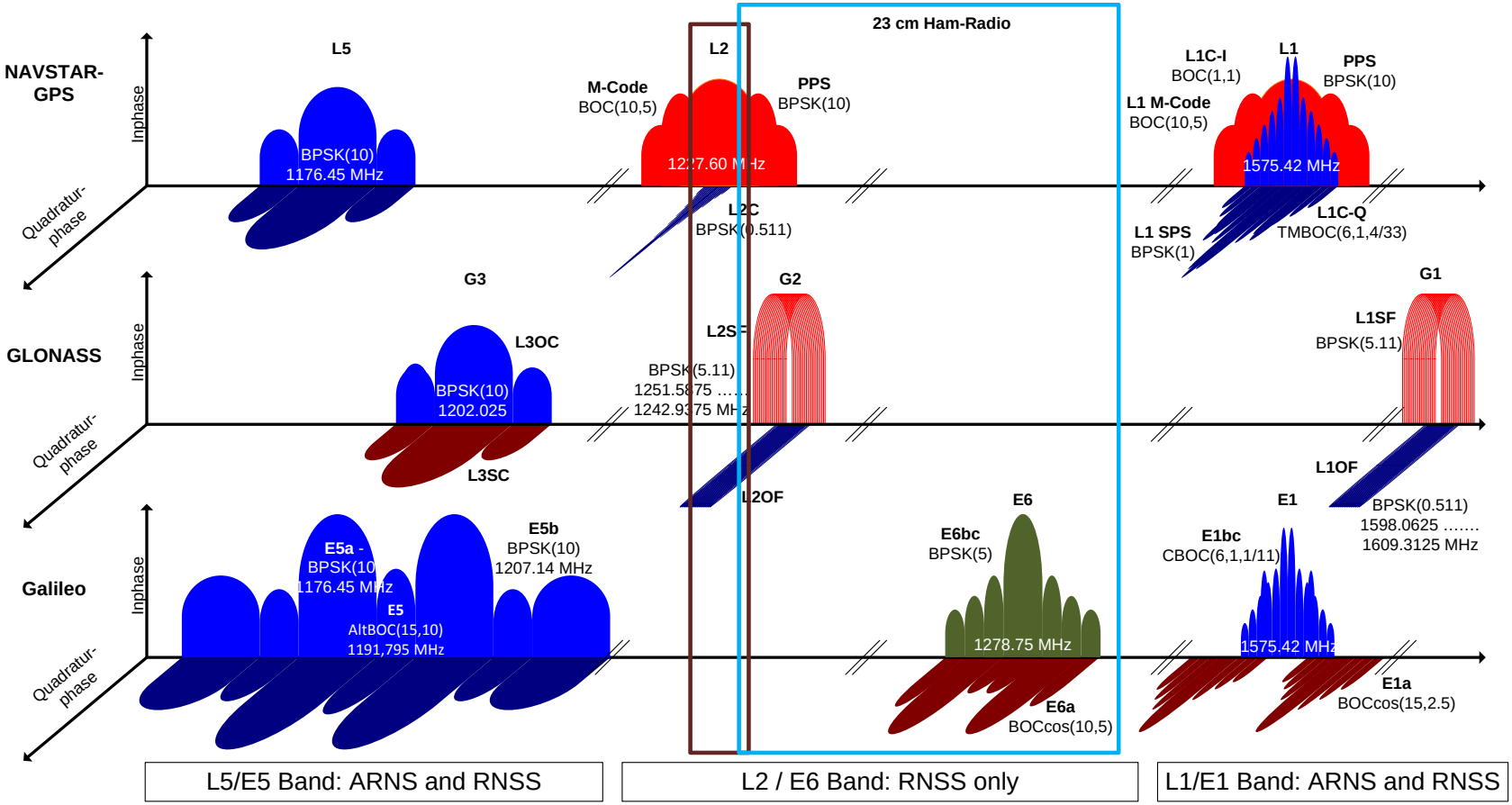


Relative to L2 freq. of 1227.6 MHz

Fraunhofer IIS

Project Examples

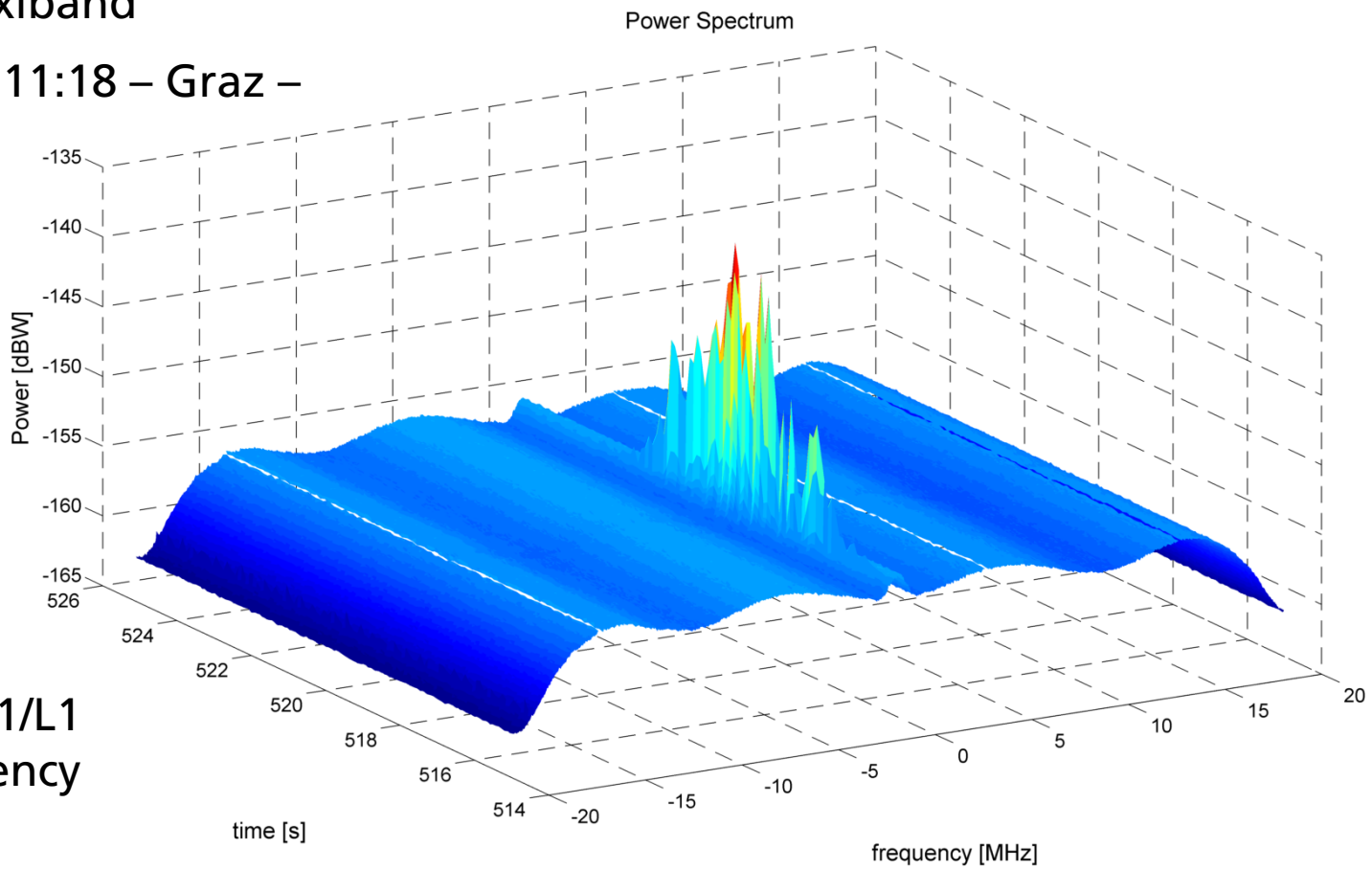
Interference Monitoring at German Reference Station



Fraunhofer IIS

Project Examples
Interference Monitoring at Airport Graz, Austria

- GNSS Airport Interference Monitoring System (GAIMS)* using the Flexiband
- 2014-08-19 – 11:18 – Graz – Vicinity of Airport Graz Thalerhof
- Jammer at E1/L1 center frequency

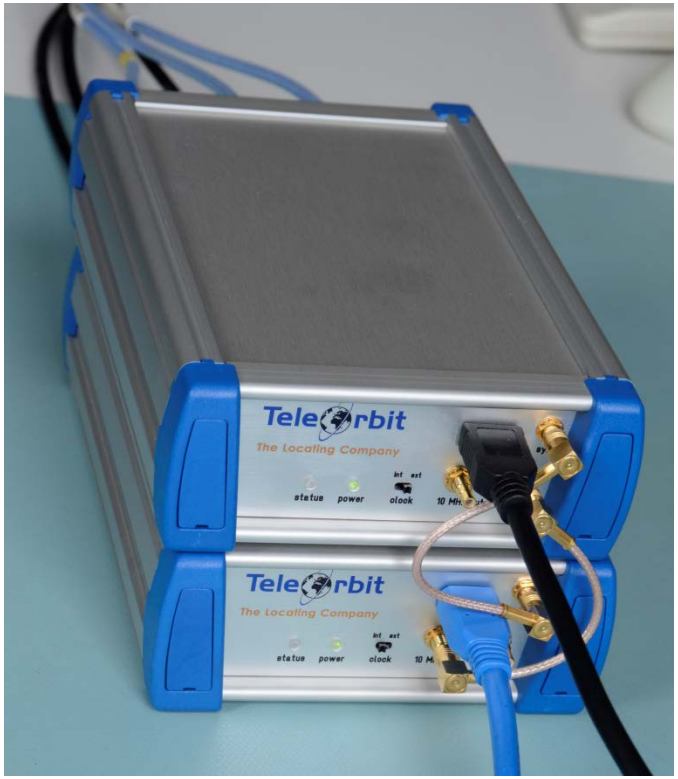


* Provided by TeleConsult Austria GmbH
P. Berglez and S. Hinteregger

Fraunhofer IIS

Project Examples
Mobile Array Recording Platform

- Several Flexiband units can be synchronized
- Sharing the same reference clock (internal one or external)
- Synchronization link necessary
  - Wired OR-connection: all units stay in reset till recording is triggered on all units
  - Used for asynchronous FPGA reset (and its counter values)
  - Preamble and counters guarantee data sync

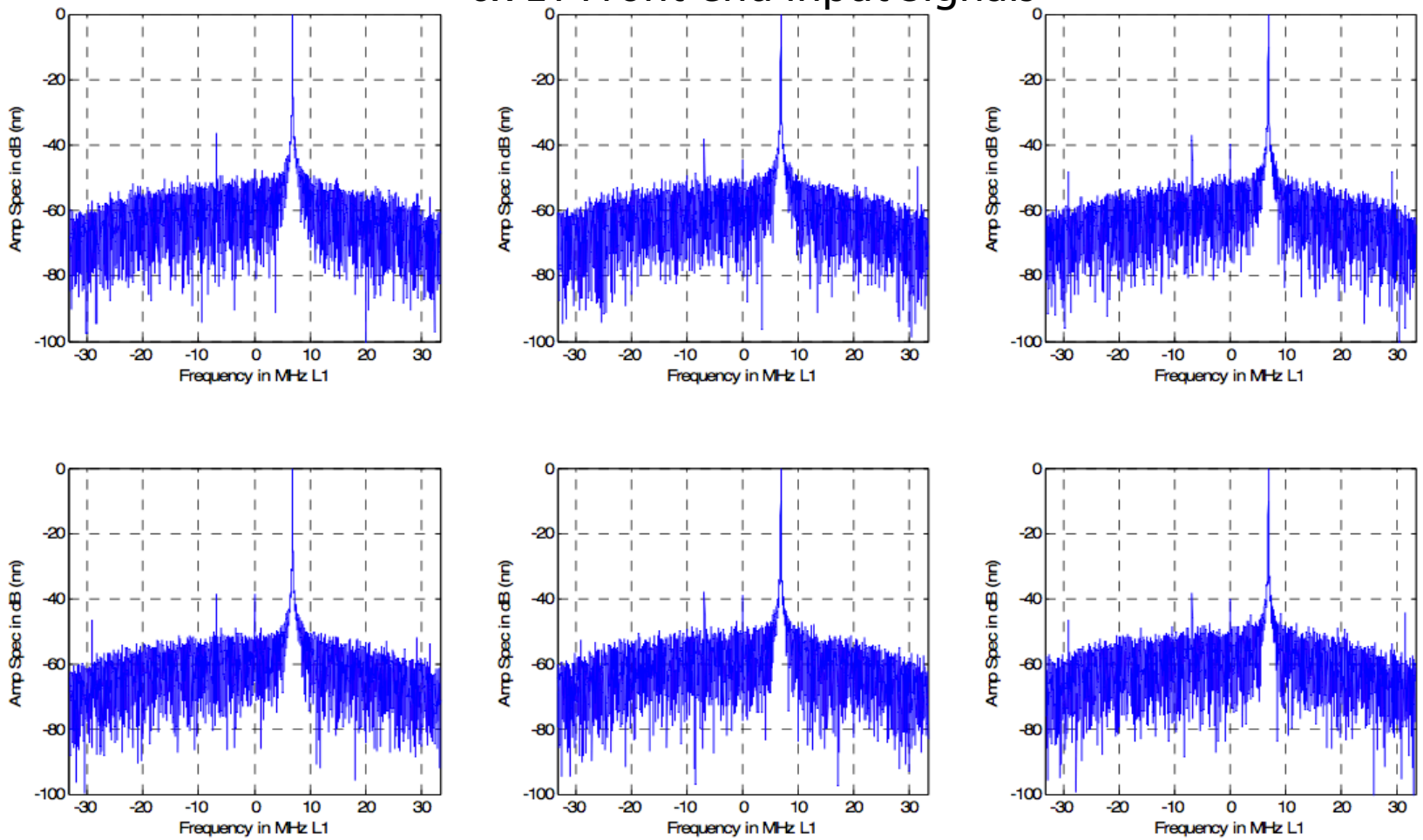


Project Examples
Mobile Array Recording Platform

- Recording of the array antenna elements for offline data analysis and beamforming / nullsteering
- With coupling two Flexiband units up to 6 antenna inputs possible
- Advantages
  - Not external power supply necessary (power via USB)
  - On-field selection of different recording configurations, e.g.
    - 6x L1/E1, 18 MHz BW, 20 MSPS I/Q, 8 bit = 960 Mbit/s per unit
    - 6x L1/E1, 8 MHz BW, 10 MSPS I/Q, 8 bit = 480 Mbit/s per unit

Project Examples
Mobile Array Recording Platform

6x L1 Front-end input Signals

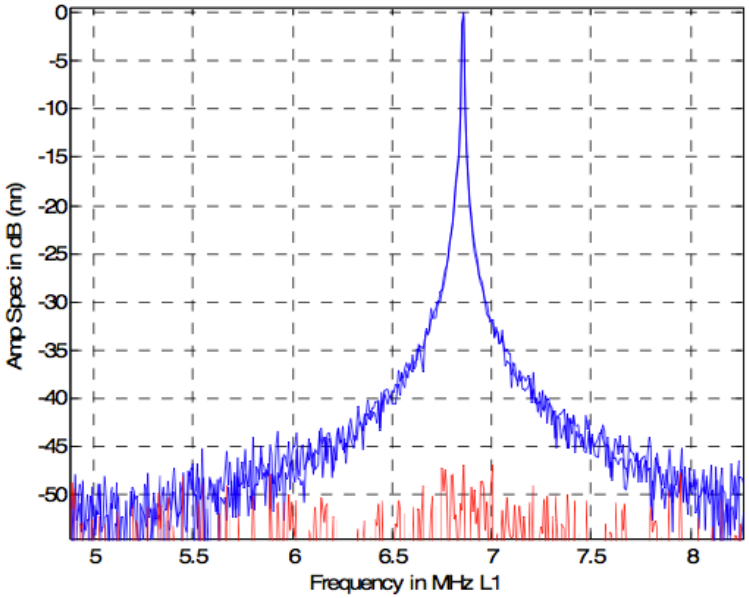


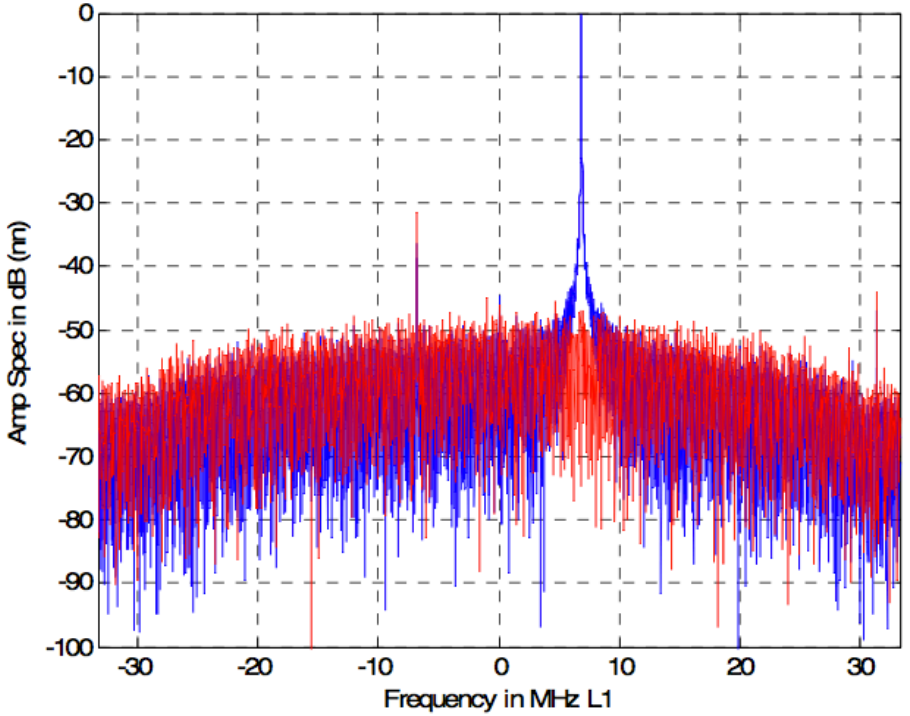
Project Examples
Mobile Array Recording Platform

Power Minimisation Technique (Minimum Variance Beamforming)

Blue: one input signal with interference

Red: output signal after MMSE





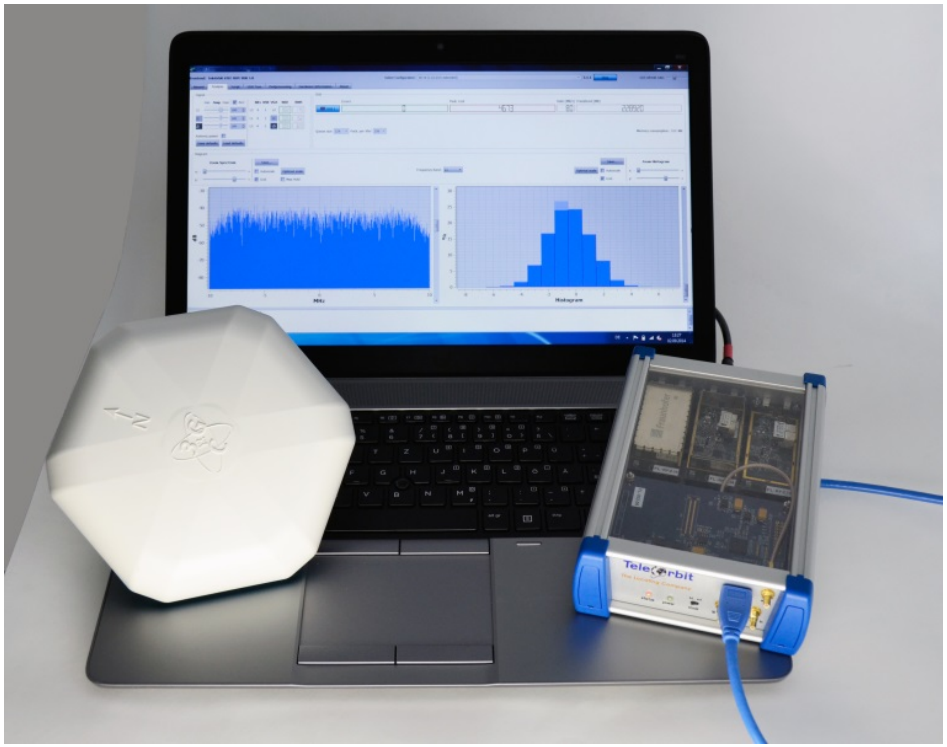
Fraunhofer IIS

Conclusion

- Flexiband provides a future proof, flexible, portable and user friendly GNSS recording solution
  - Powerful Flexiband recording software
  - USB 3.0 is current baseline interface,
    Parallel port, USB2.0 also available
  - Powered via USB ➔ perfectly suited for mobile recording campaigns
  - User changeable sampling rate, resolution and IF with different FPGA configurations
  - Synchronization of different units
  - Multi antenna support
- Digital replay solution planned for 2015
- User feedback, new feature suggestions, ideas welcome!

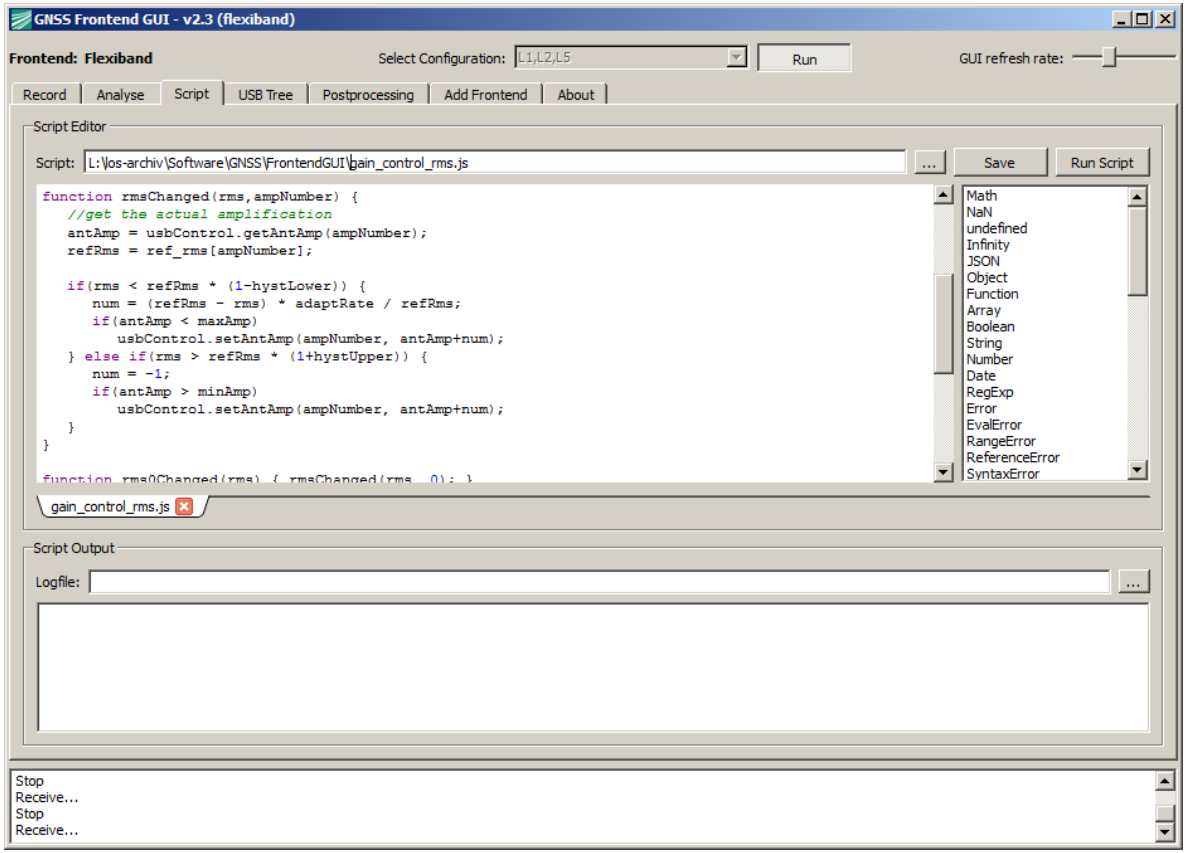
Questions?

alexander.ruegamer@iis.fraunhofer.de



Backup
Flexiband GUI – Script tab

- Scripting language ECMAScript
- Similar to JavaScript
- User can easily implement his own functions
- E.g. user defined automatic gain control (AGC) could implemented here



Backup
Flexiband technical parameters

Feature	Range
Dimensions (length*width*height) [mm]	188*125*50
Power supply	5V / 900 mA via 1x USB 3.0
Max. RF input power	0 dBm
Operating temperature	0-55°
Relative humidity	0-95 %
Storage temperature	-55° to 125°

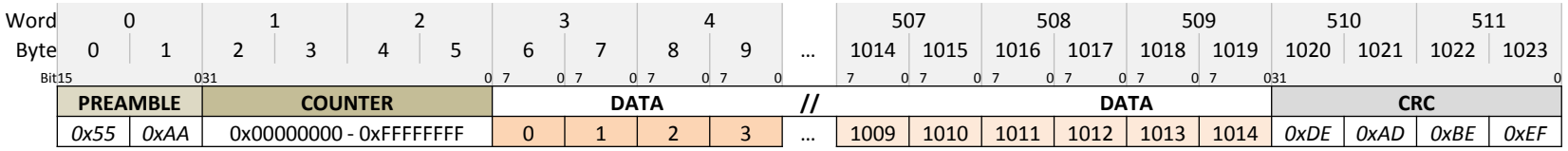
Band	Nominal Centre Frequency [MHz]	Digital IF [MHz]	RF-Band-width [MHz]	Comple x signal	IF spectrum orientation
L1/E1	1,575.420	0	up to 60	Yes	non flipped
L2/L2C	1,227.600	0	up to 50	Yes	non flipped
E6/B3	1,278.750	0	up to 50	Yes	non flipped
L5/E5	1,176.450	0	up to 68	Yes	non flipped

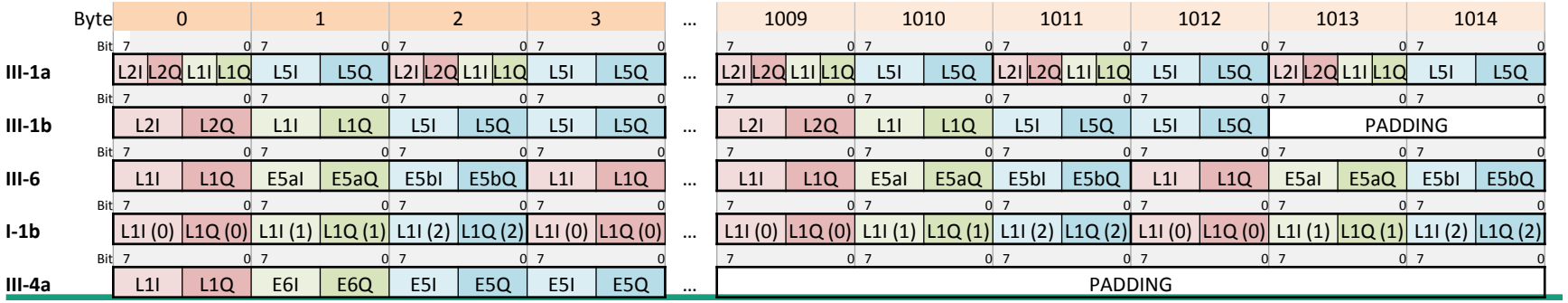
Label	Con.-Type	Description
Antenna	SMA	antenna connector (1 to 3 possible)
10 MHz in	SMB	input for an external reference clock, signal
10 MHz out	SMB	sinusoidal output of the internal 10MHz reference clock
USB	USB 3.0 Micro-B	data interface to the PC and power supply
Digital output	Honda E68-LFD	optional parallel output of the data stream
Sync	SMB	optional connector for synchronization of two front ends

Backup

Multiplexer Example for different triple band config

- III-1a: L1 20MSPS@2bit I/Q; L2 20MSPS@2bit I/Q; L5 20MSPS@4bit I/Q
- III-1b: L1 20MSPS@4bit I/Q; L2 20MSPS@4bit I/Q; L5 40MSPS@4bit I/Q
- III-6: L1 20MSPS@4bit I/Q; L5 20MSPS@4bit I/Q; E5b 20MSPS@4bit I/Q
- I-1b: L1 20MSPS@2bit I/Q; L2 20MSPS@2bit I/Q; L5 40MSPS@4bit I/Q
- III-4a: L1 20MSPS@2bit I/Q; L2 20MSPS@2bit I/Q; L5 40MSPS@4bit I/Q





Fraunhofer IIS