SPECTRUM SENSING PROTOTYPE SOLUTIONS

IMEC SMART SYSTEMS

RECONFIGURABLE RADIO PROGRAM

OUTLINE

- Introducing the components
  - **SCA**lable ra**DIO** (SCALDIO)
  - **W**ireless open-**A**ccess **R**esearch **P**latform (WARP)
  - **DI**gital **F**ront-end **F**or **S**ensing (DIFFS)
  - **S**ensing **P**latform for **I**ntegration and **DE**monst**R**ation off DIFFS (SPIDER)
- Prototypes
  - Scaldio & DIFFS integrated on SPIDER (USB)
  - WARP & DIFFS integrated on SPIDER (USB)
- Software and interface
  - Sensing Engine HAL
  - Sensing Engine user API
  - DIFFS configuration GUI

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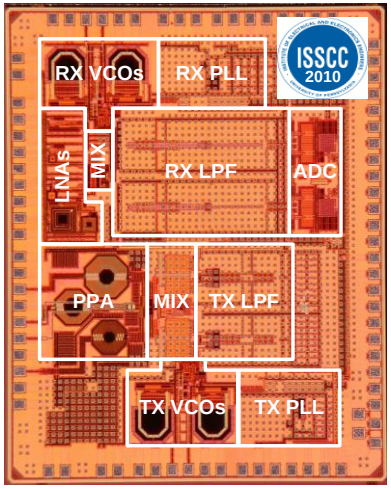
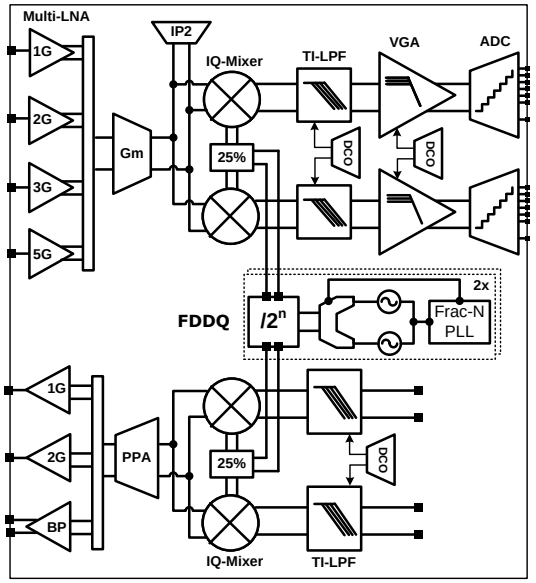
SCALDIO2B: FLEXIBLE AND LOW POWER TRANSCEIVER IN 40NM CMOS

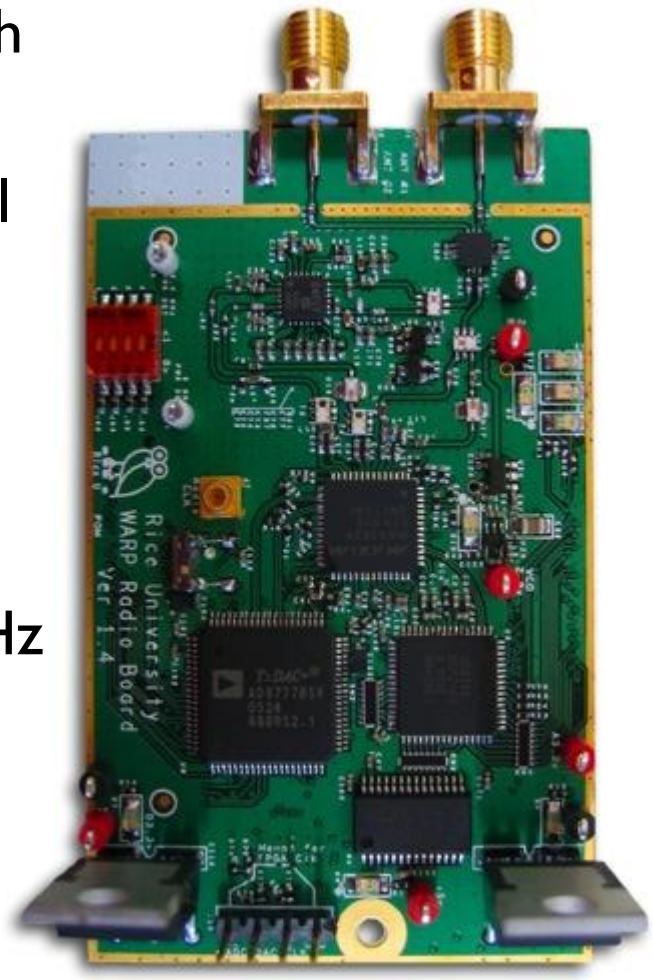
- 40 nm digital 1.1/2.5 CMOS TSMC technology
- Performance, power and area competitive with SotA single-mode radios
  - Area: 5mm^2 (incl. 2 freq synth. & ADC)
  - Power: 40 – 100 mW depending on mode
- Receiver incl. ADC
  - Good linearity
  - On-chip 10b 65MS/s SAR ADC
- Low Noise Direct Up-conversion full transmitter
  - Out-of-band noise floor compatible with SAW-less WCDMA/LTE requirements





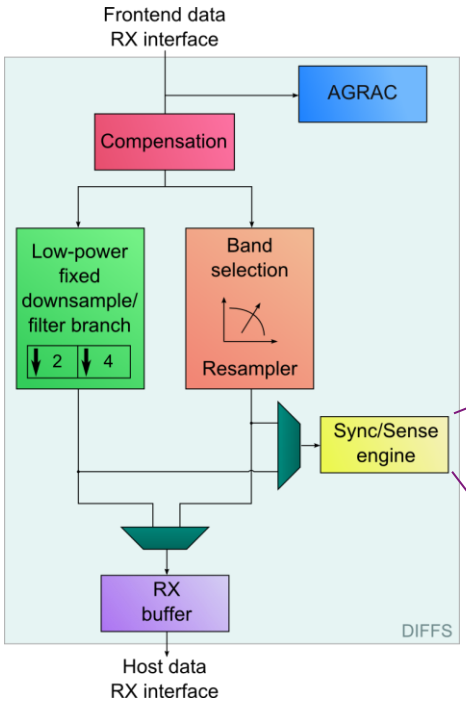
WARP RADIO BOARD - SOTA

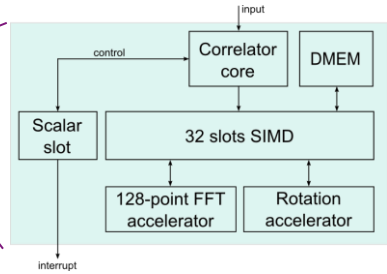
- **W**ireless open-**A**ccess **R**esearch **P**latform
- Single RF transceiver with digital baseband interface
- 2.4 & 5 GHz RF transceiver (Maxim2829)
- Dual 65MS/sec 14-bit ADC
- Flexible RX BW: ~7.5 – ~18 MHz
- Dual 125MS/sec 16 bit DAC
- 18 dBm power amplifier



DIFFS

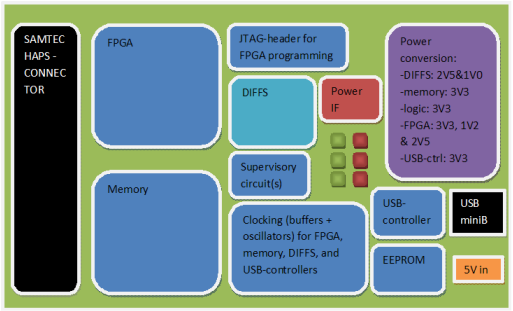
- **D**igital **I**nter**F**ace **F**or **S**ensing
- AGC/packet detection
- IQ imbalance/DCO compensation
- Flexible / fixed filter branch
- 32-slot SIMD processor with optimized instruction set (Coware toolflow)
  - Auto/Cross correlation and signal power
  - Parallel FFT (128 complex values)
  - Full-flexible rotator
  - Sensing & syncing @ same time
- 6.4 mm^2 - 65nm CMOS

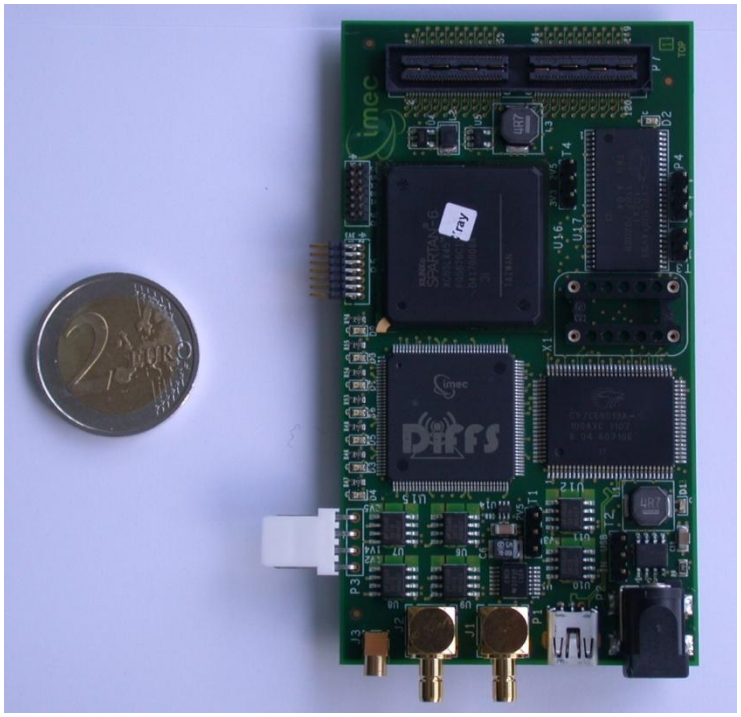




SPIDER

- **S**ensing **P**latform for **I**ntegration and **DE**monst**R**ation off DIFFS
- Xilinx Spartan FPGA to interconnect:
  - DIFFS chip
  - Cypress USB interface
  - 16 Mbit SRAM
  - SCALDIO or WARP board
- Clock generation
- Power generation





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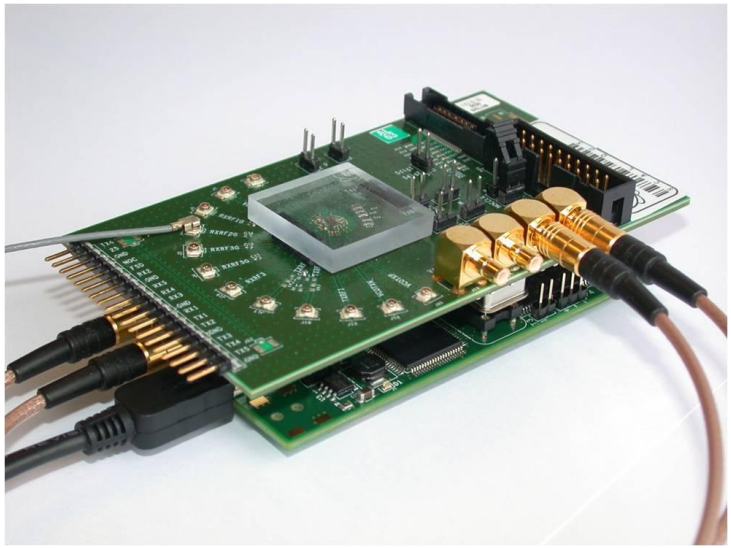
SCALDIO & DIFFS ON SPIDER

- DIFFS mounted directly on SPIDER
- SCALDIO2B PCB connect to SPIDER via SAMTEC connector
- DIFFS connected to SCALDIO2B via Xilinx Spartan FPGA
- PC connection via USB



WARP & DIFFS ON SPIDER

- DIFFS mounted directly on SPIDER
- WARP PCB connect to SPIDER via HIROSE connector board
- DIFFS connected to WARP via Xilinx Spartan FPGA
- PC connection via USB

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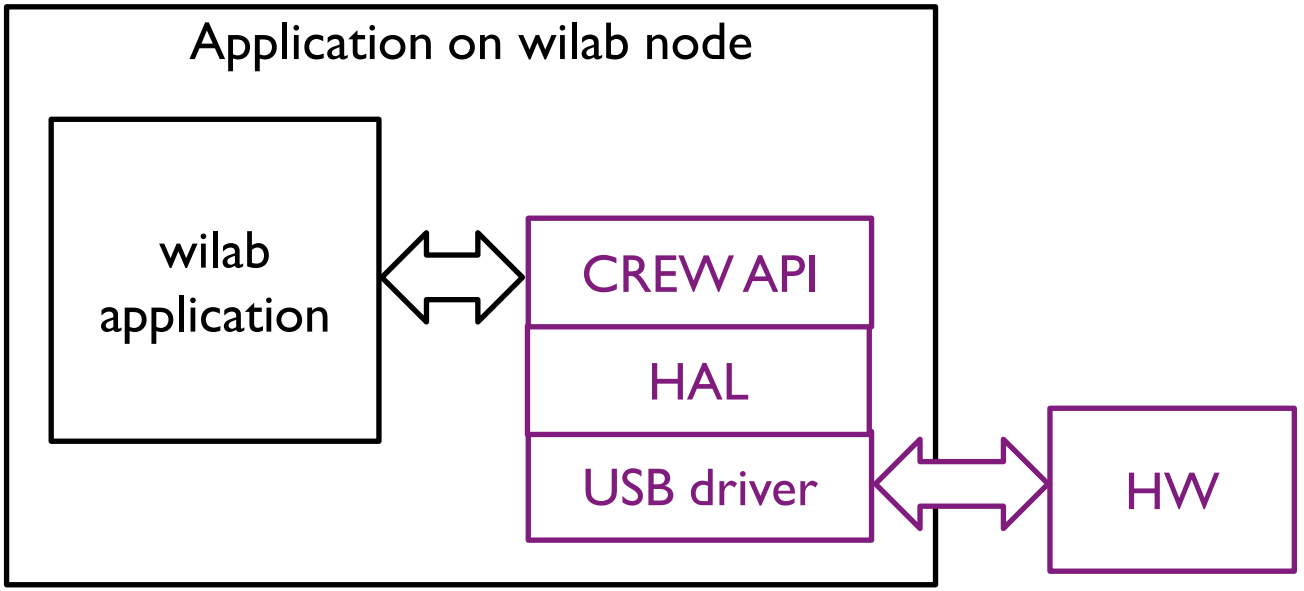
CREW USE CASE

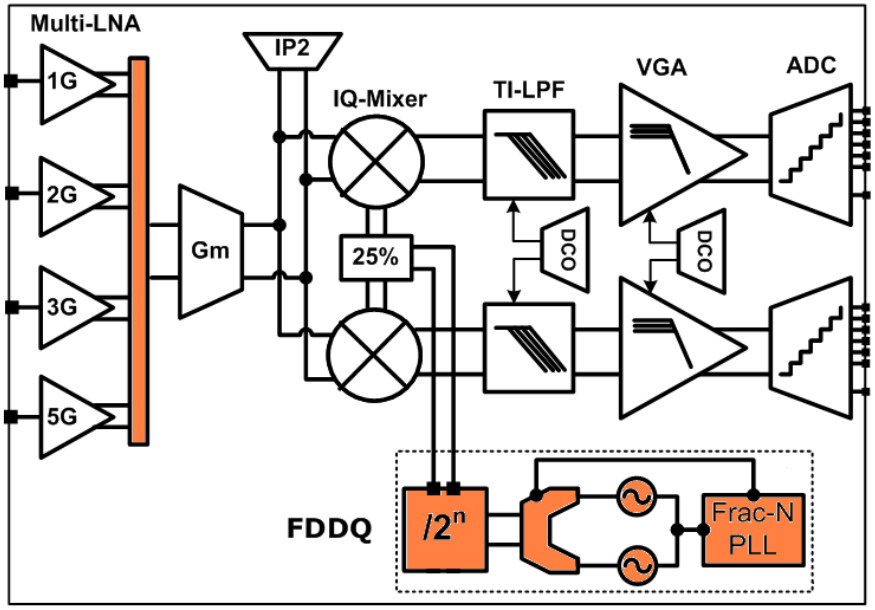


HAL: FUNCTIONS AND PARAMETERS

- Functions
  - id = se_open
  - se_config(id, RF struct, DIFFS struct)
  - se_start_measurement(id,pointer_to_result)
  - se_stop_measurement(id)
  - se_close(id)
- RF - struct containing:
  - RF: integer => range 0 to 6000 (MHz)
  - BW: integer => range 1 to 40 (MHz)
  - GAIN: integer => range 0 to 100 (dB)
- DIFFS – struct containing:
  - identifier pointing to AGRAC firmware
  - identifier pointing to SENSEPRO firmware
  - struct containing settings for all blocks in the DATAPATH

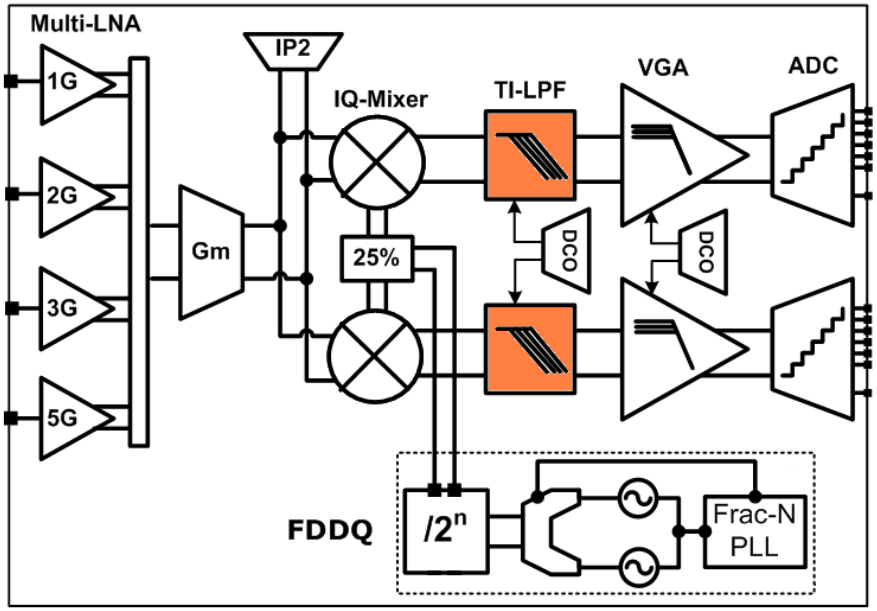
SCALDIO: CARRIER FREQUENCY

- Carrier frequency
  - Integer-N
    - 6 – 12 GHz (spacing 40 MHz) / [2/4/8/32/64]
  - Fractional-N – Currently not supported
    - 6 – 12 GHz / [2/4/8/32/64]



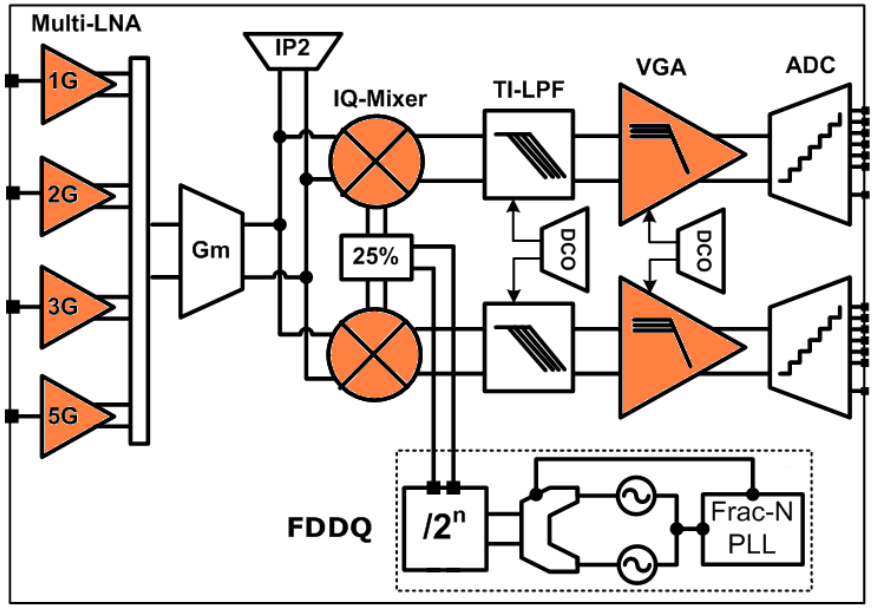
SCALDIO: CHANNEL BANDWIDTH

- BW settings
  - GSM
  - BlueTooth
  - DVB-H
  - UMTS
  - WLAN 802.11a/g
  - WLAN 802.11n



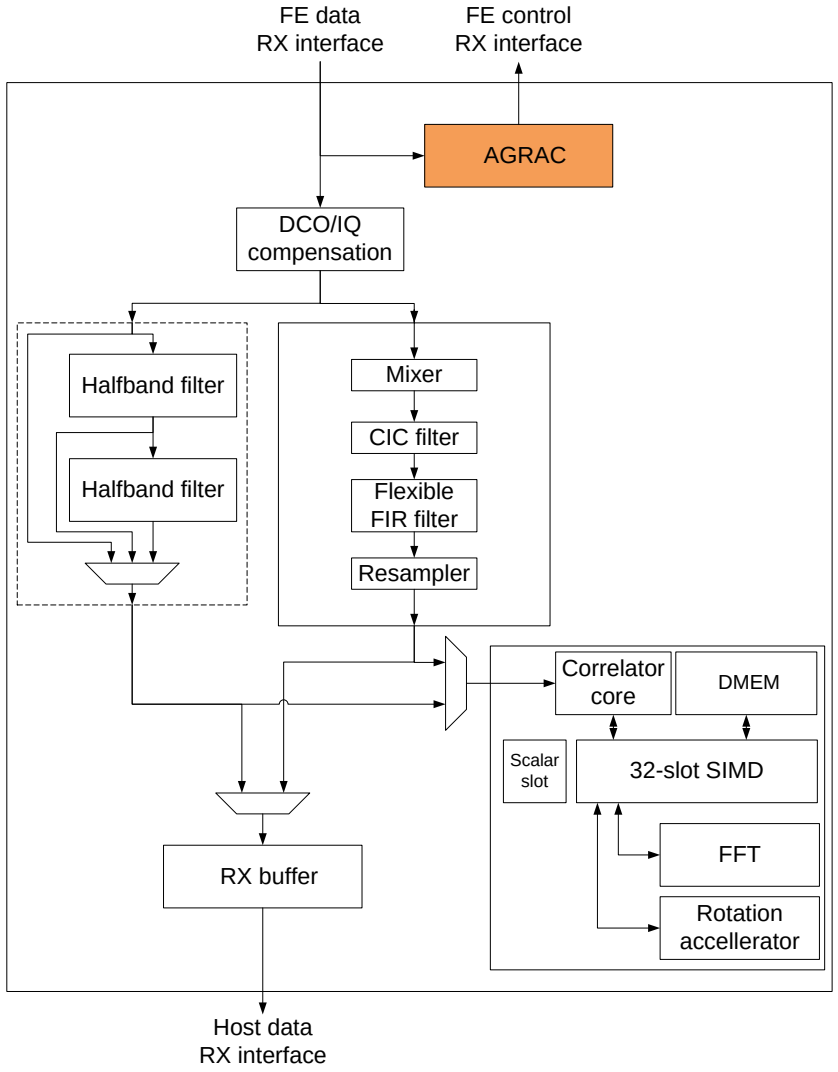
SCALDIO: GAIN SETTINGS

- GAIN configuration
  - Depending on BW selected (BB settings)
  - Depending on RF selected (LNA settings)



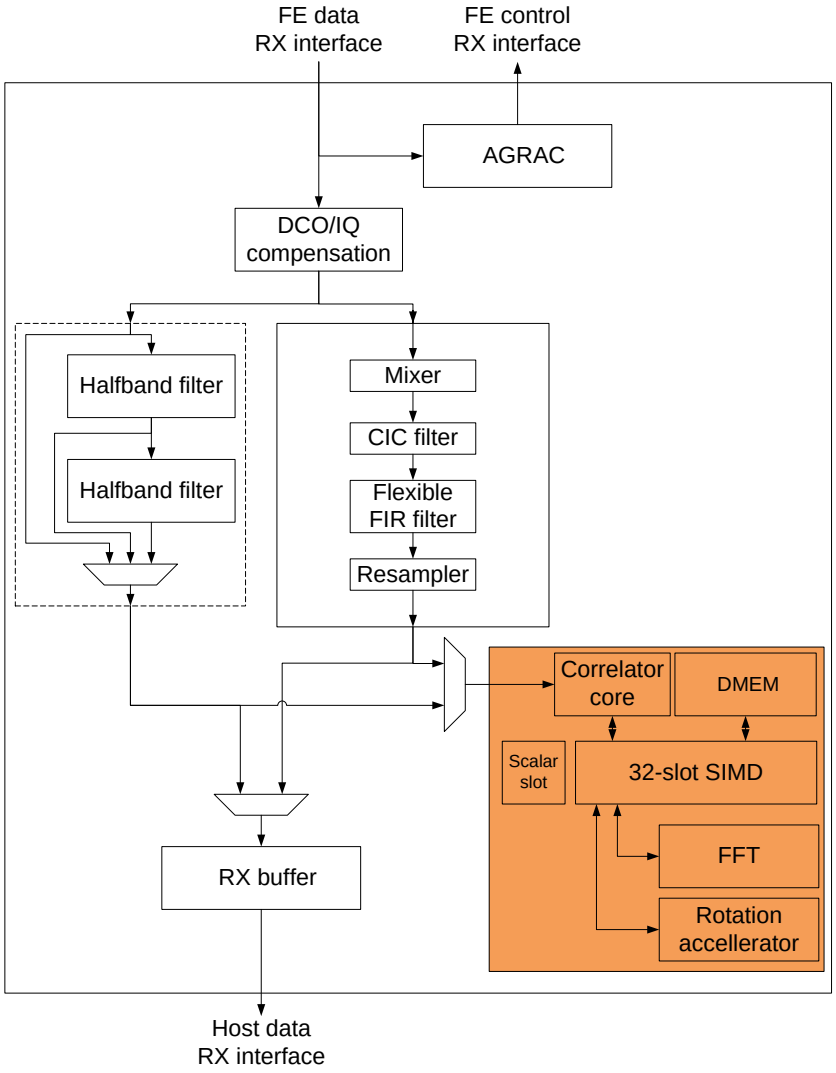
DIFFS AGRAC CONFIG

- Fixed gain
- AGC
  - Free running
  - Coupled with sync



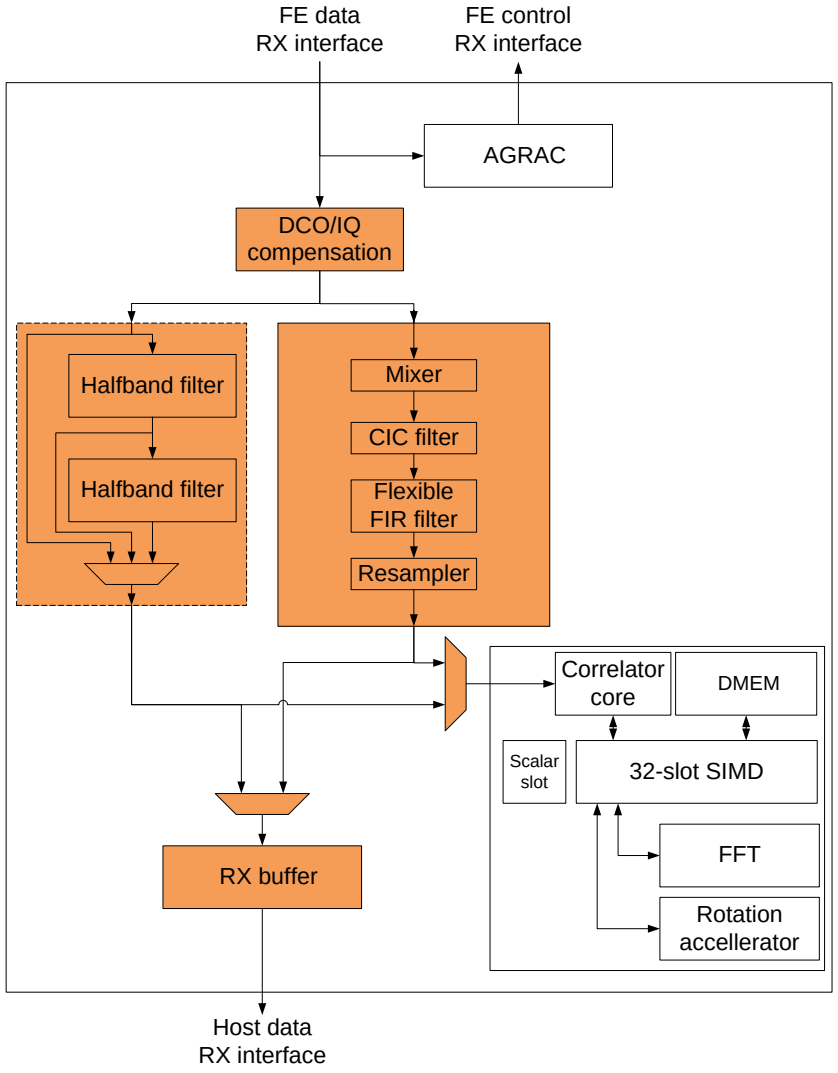
DIFFS SENSEPRO CONFIG

- Sync algorithm selection
  - WLAN
  - LTE
  - DVB-T
  - ...
- Sensing algorithm selection
  - Cyclo (DVB-T)
  - FFT
  - LTE multiband energy
  - ...



DIFFS DATAPATH CONFIG

- DCO and IQ mismatch compensation
- Filter branch selection
  - Fixed filter branch
    - # half-band filter stages
  - Flexible filter branch
    - Frequency shift
    - # stages CIC filter
    - Flexible FIR filter coefficients
    - Re-sampler coefficients



USER API FUNCTIONS: CREW

- id = crew_open
- crew_ism_channel
  (id, mode,channel,detector,pointer_to_result)
- crew_ism_sweep(id,detector, pointer_to_result)
- crew_dvb_sweep(id,detector, pointer_to_result)
- crew_close(id)

- single run
- blocking

USER API PARAMETERS: WARP

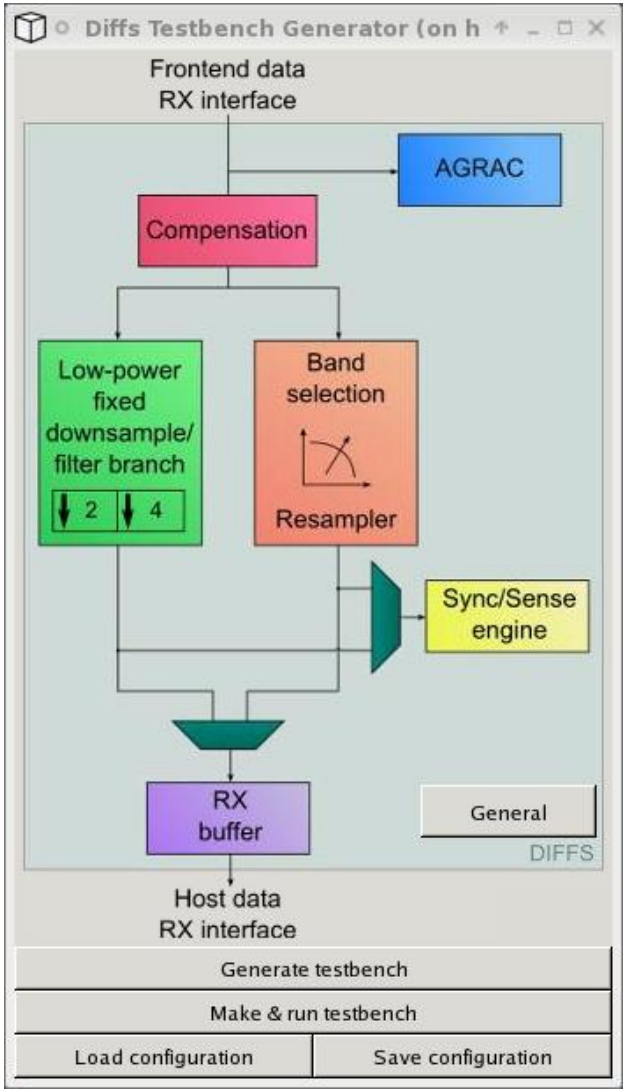
- Detector
  - Algorithm
    - Power (vs threshold)
    - FFT (vs threshold) / [32/64/128 bins]
  - Gain config
    - AGC / fixed gain
- Mode / Channel
  - BlueTooth / 1 .. 80
  - ZigBee / 1 .. 16
  - WLANg / 1 .. 13
  - WLANa / 1 .. TBC

API PARAMETERS: SCALDIO

- Detector
  - Algorithm
    - Power (vs threshold)
    - FFT (vs threshold) / [32/64/128 bins]
    - LTE multiband energy detection
    - Cyclostationairy [2k-8k] / Guard Interval [1/4-1/8-1/16-1/32]
  - Gain config
    - AGC / fixed gain
- Mode / Channel
  - BlueTooth / 1 .. 80
  - ZigBee / 1 .. 16
  - WLANg / 1 .. 13
  - WLANa / 1 .. TBC
  - LTE
  - DVB-T / 16 .. 66

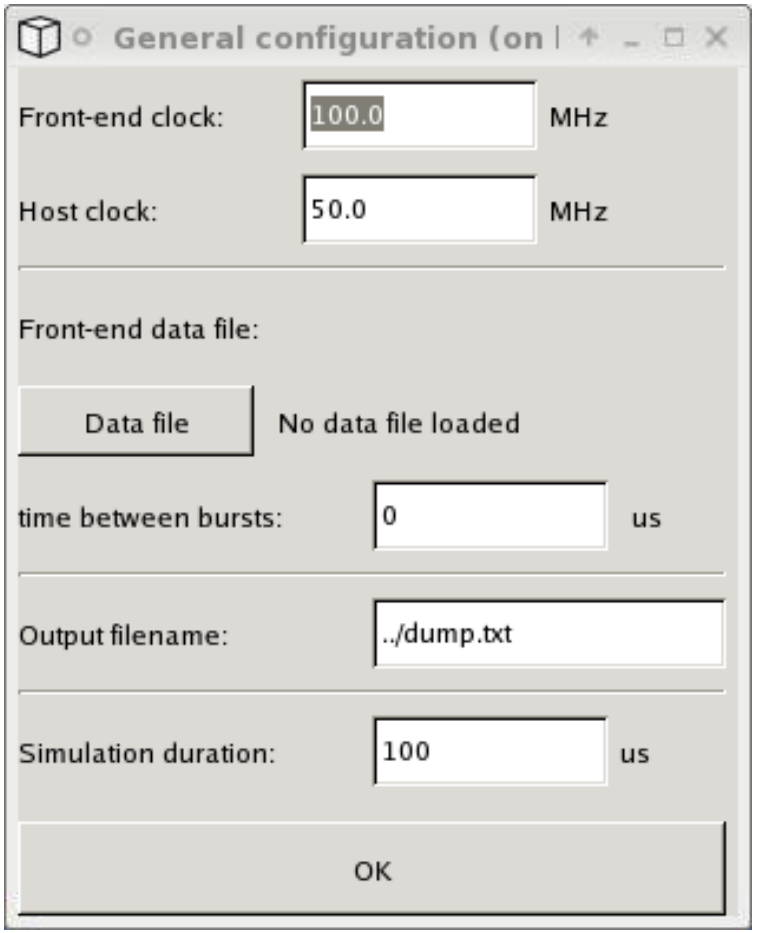
DIFFS CONFIGURATION TOOL

- Configuration of DIFFS chip via GUI
- Generates configuration file to download to chip
- Runs on Linux



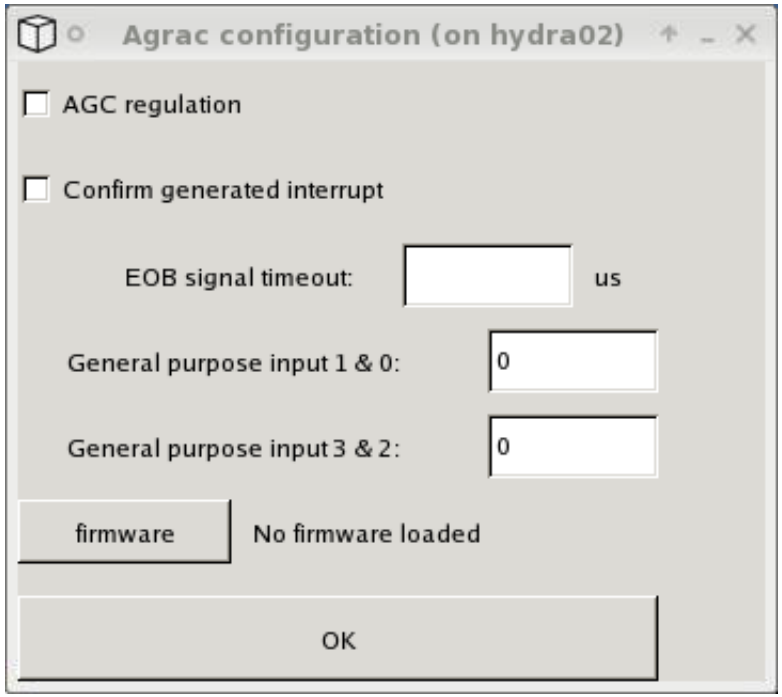
GENERAL CONFIGURATION (TESTBENCH ONLY)

- Clock configuration
- Stimuli file selection
- Output file selection
- Simulation time



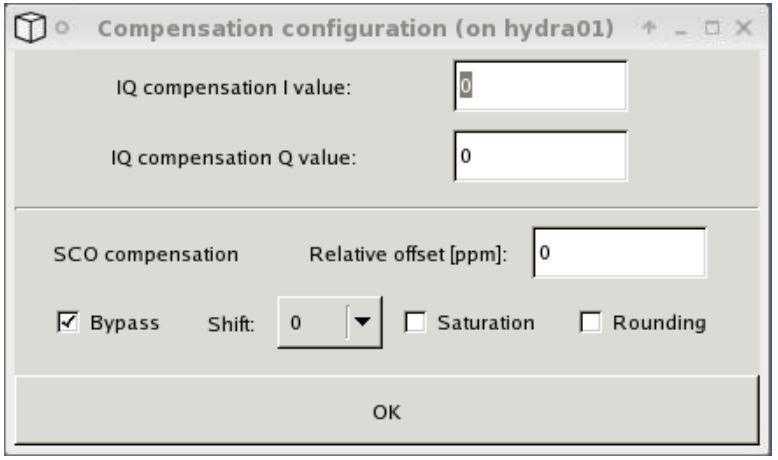
AGRAC CONFIGURATION

- Enable/disable automatic gain control
- Specification end-of-burst time
- Configuration of general purpose IO pins
- Selection of firmware (AGC algorithm) to be loaded into the PIC controller



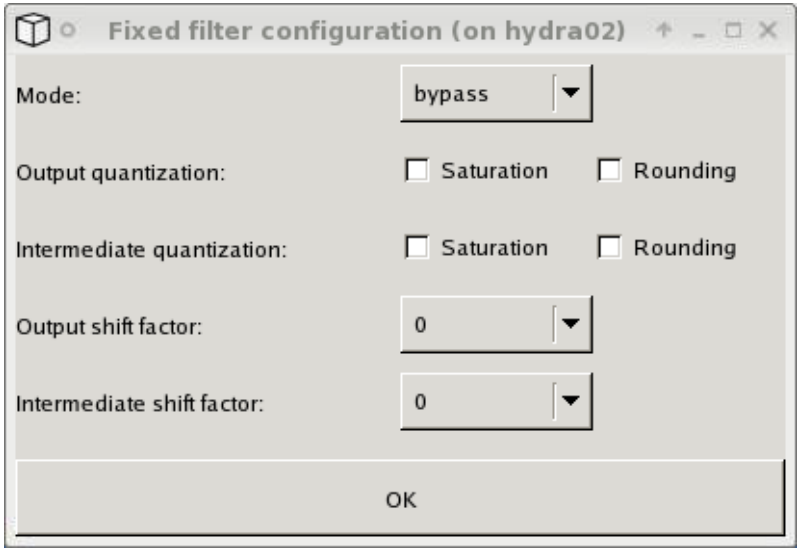
COMPENSATION CONFIGURATION

- IQ imbalance compensation values
- Sample Clock Offset compensation
- Signal scaling and rounding / saturation



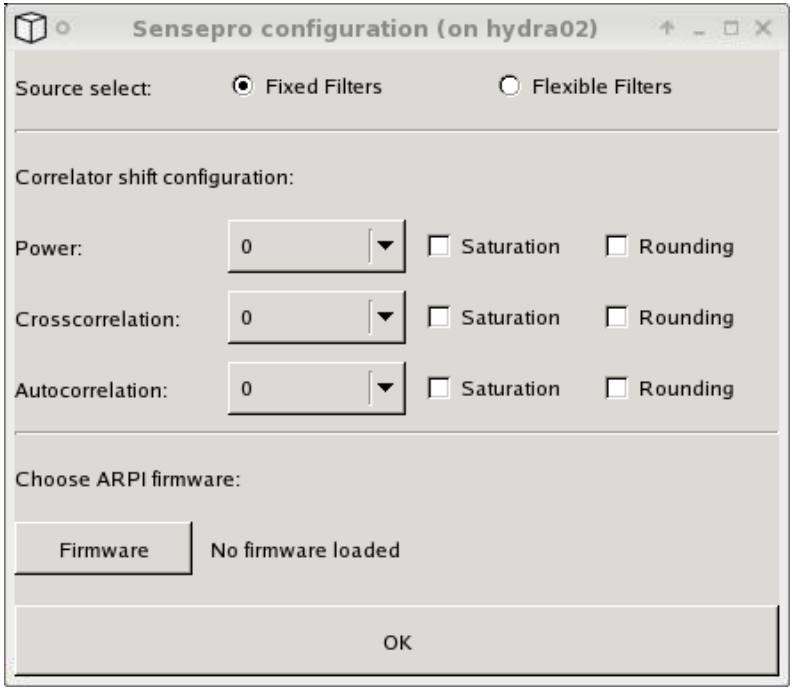
FIXED FILTER CONFIGURATION

- Enable/disable fixed filter
- Select rounding options
- Select shift factors



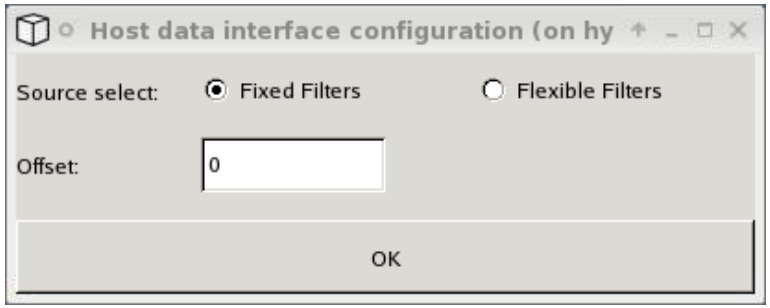
SENSEPRO CONFIGURATION

- Input datapath selection
- Correlator configuration
- Firmware selection for the SIMD processor



RX BUFFER CONFIGURATION

- Select datapath
- Configure offset



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