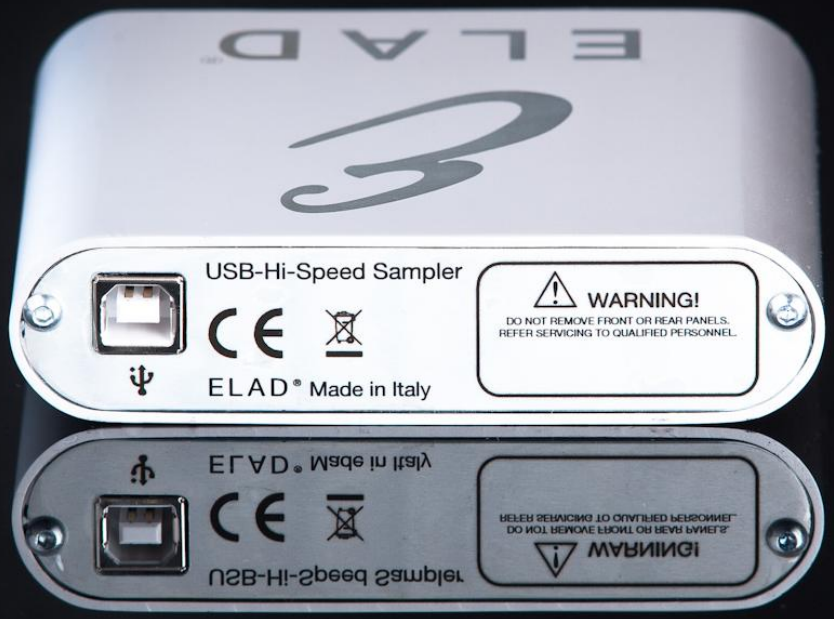
FDM-S1

Sampler or Receiver?

FDM-S1

FDM-S1


USB-Hi-Speed Sampler
WARNING!
DO NOT REMOVE FRONT OR REAR PANELS.
REFER SERVICING TO QUALIFIED PERSONNEL.
ELAD® Made in Italy

FDM-S1

- Direct sampling SDR Receiver
  - 200 MHz font end Bandwidth

- Small size and weight
  - 108 x 27 x 88 mm
  - 180 g

- Powered by USB connection
  - Low power consumption < 2.2 W

FDM-S1

ELAD FDM-S1
TECHNICAL SPECIFICATIONS

Rev. 4
18/06/2012

GENERAL	Frequency coverage:	20 kHz ÷ 30 MHz (up to 200 MHz in undersampling)
	Antenna connectors:	SMA (50 Ω) – SMA/BNC adapter included
	Temperature range:	0 ÷ 40 °C
	PC Interface	High-Speed USB 2.0 (480 Mbit/s)
	Power supply:	USB powered
	Power consumption:	Less than 2.2 W
	External I/O connector:	Female DB9 (mute control, I²C and SPI interface)
	Dimensions:	108 (W) x 27 (H) x 88 (D) mm
	Weight:	180 g
RECEIVER	Configuration:	Direct sampling
	A/D Conversion	61.44 MSPS @ 14 bit/sample
	Sensitivity:	Typical: -114 dBm (CW, BW 500 Hz, 10 dB (S+N)/N) -114,5 dBm (CW, BW 500 Hz, 10 dB S/N)
	3rd Oder Intercept Point:	> +25 dBm @ 14 MHz, Spacing 2 kHz, Input level -97 dBm, Low Pass Off, Attenuator Off
	Blocking gain compression:	> 100 dB @ 14 MHz, Spacing 2 kHz, CW, BW 500 Hz Typical: 108 dB @ 14 MHz, Spacing 2 kHz, CW, BW 500 Hz, Noise Reduction On
	Noise floor (MDS):	< -124 dBm @ 14 MHz, CW, BW 500 Hz Typical: -130 dBm @ 14 MHz, CW, BW 500 Hz, Noise Reduction On
	Attenuator:	0, 20 dB
	RF Preselection filter:	OFF (wide band), Low Pass (0 ÷ 30 MHz)

SW TECHNICAL SPECIFICATIONS

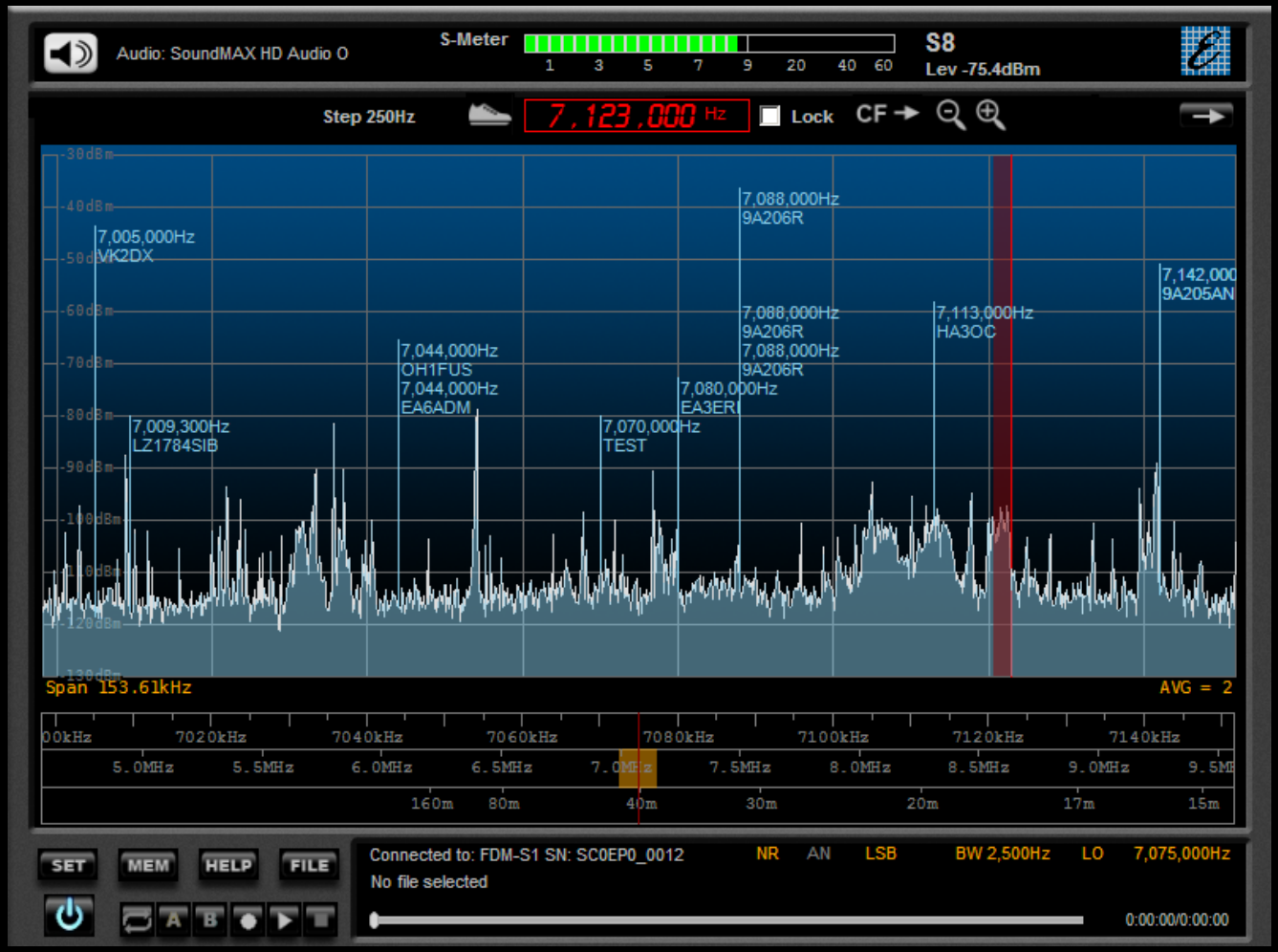
GENERAL	SW Name:	**ELAD FDM SW1**
	Mode:	CW, CW SH+, CW SH-, USB, LSB, DSB, AM, SYNC AM, FM, WB FM (Stereo + RDS decoder), DRM
	Memory:	User frequency database support (XML files based), EIBI database support (CSV import), DX Cluster spot visualization (Internet connection required)
	Digital USB Streaming Sampling Rate:	192, 384 ,768 and 1536 I/Q channels, 32 bit/sample
	Digital Filters:	Double IF notch filters, continuous variable band filter (Selectivity > 100 dB)
	Adaptive Filters	Powerful Noise-Reducer and Auto-Notcher
	Tuning:	Manual entry keys, triple tuning bar (patent pending), WoodBox Tmate & Tmate2 compatible, CAT, touch-screen (under development)
	Display:	Spectrum, Waterfall
	Recorder:	Recording and playback of IF data stream (automatic multiple files split feature)
	Minimum PC requirements:	Intel Atom N270, 1GB RAM Operating System: Windows XP, Windows Vista, W7, W8 (Apple virtual machine compatible – tested on VMware Fusion environment)
GENERAL	SW Name:	**ExtIO_ELAD_FDMS1 DLLs**
	Third Party Compatibility:	Studio1, Winrad, WrPLUS, HDSDR, digiRadio

All stated specifications and other product information provided in this document are subject to change without notice or obligation.

FDM-S1

L'FDM-S1 is provided with proprietary software

ELAD FDM-SW1



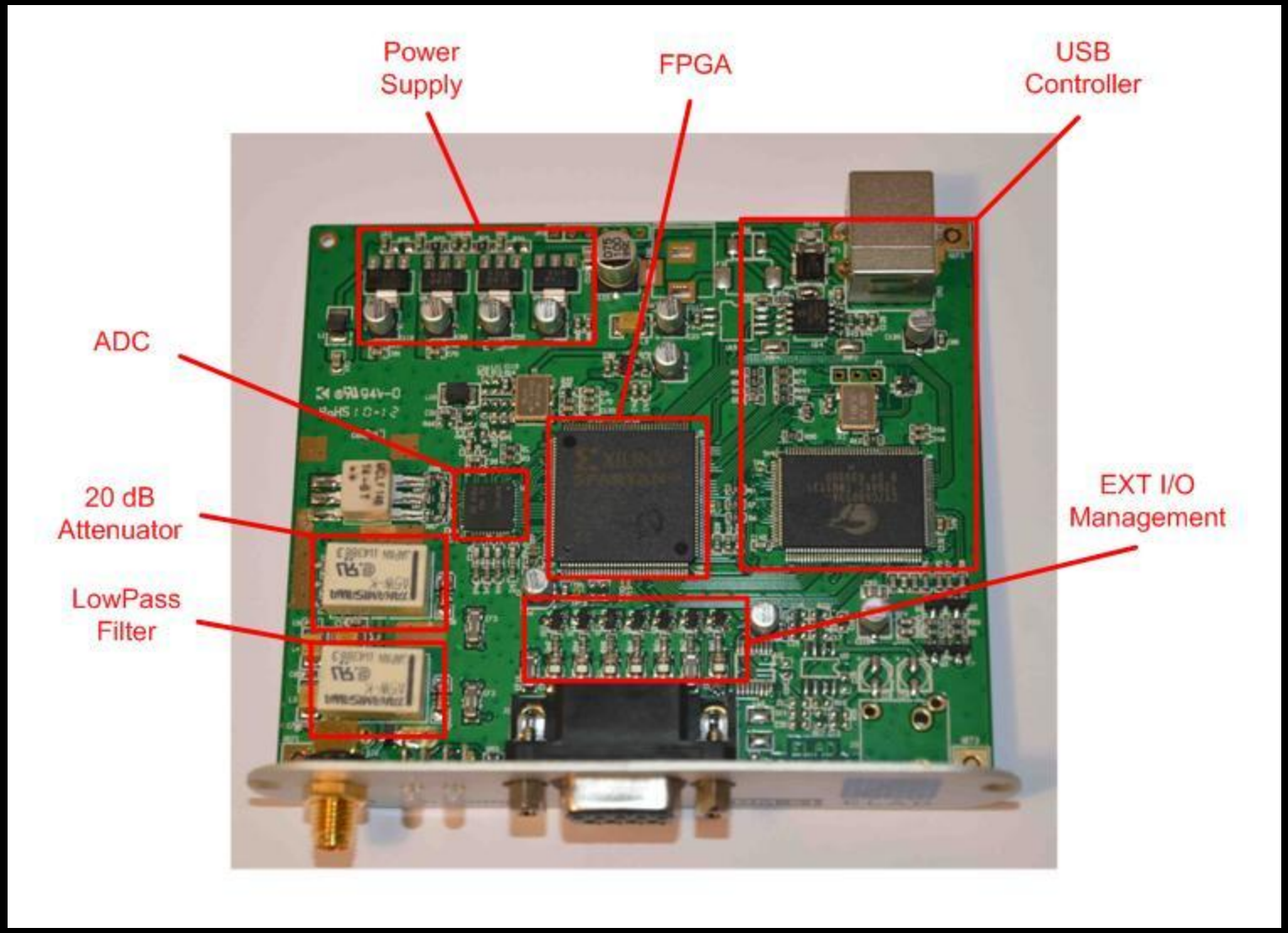
FDM-S1

- Tunable frequencies:

  Receiver Mode: 0 ÷ 30 MHz (Direct Sampling)

  Sampler Mode: 30 ÷ 200 MHz (Undersampling)

FDM-S1


Power Supply
FPGA
USB Controller
ADC
20 dB Attenuator
LowPass Filter
EXT I/O Management

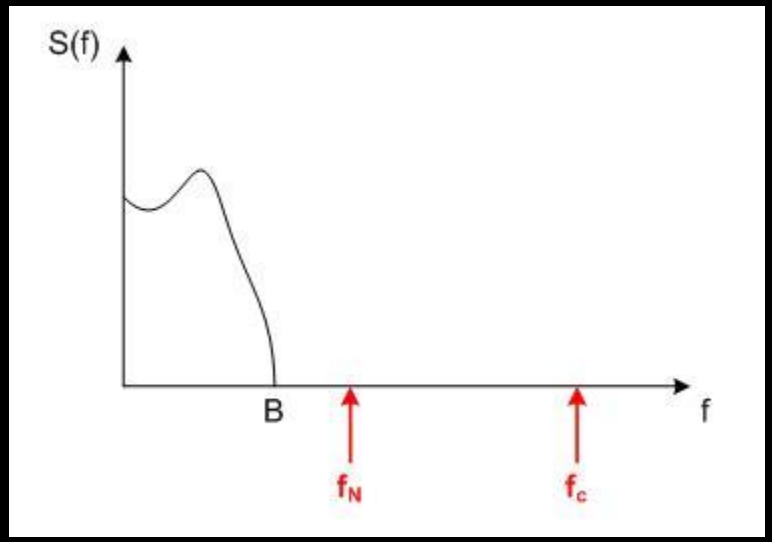
Sampling, Aliasing and Undersampling

Sampling theorem

The sampling theorem states that if a signal *s(t)* contains no frequencies higher than *B*

S(f)=0 per f>B

$f_c \geq 2B$



then it can be reconstructed <u>exactly</u> when it is sampled at a rate that is at least twice the maximum frequency component *B*.

The frequency $f_N = f_C/2$ is called Nyquist frequency

Sampling theorem

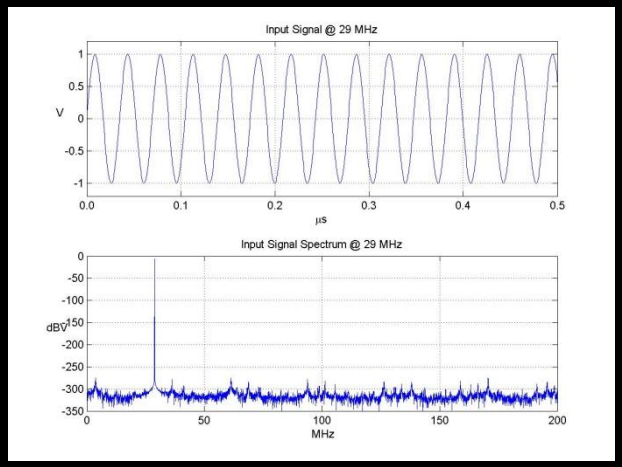
Example: FDM-S1

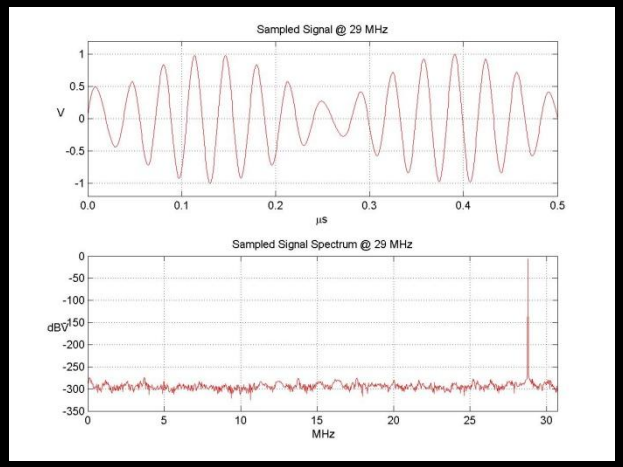
$f_c = 61.44$ MHz

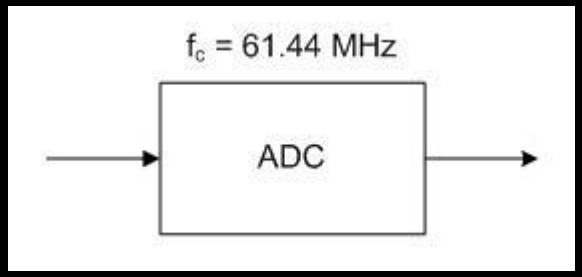
$f_n = B_{max} = f_c/2 = 30.72$ MHz

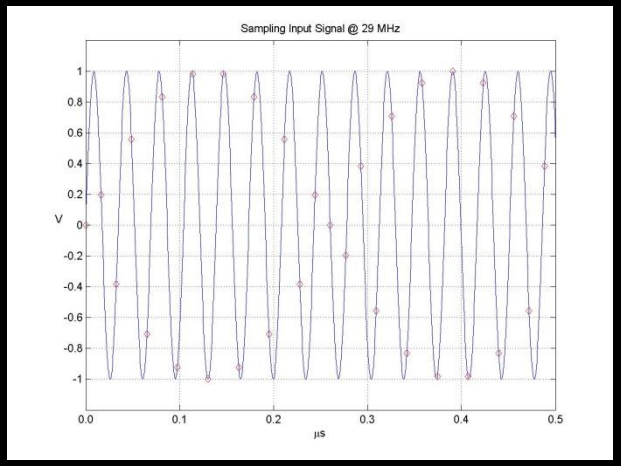
According to the sampling theorem, we are able to analyze signals that contain frequency components up to 30 MHz

Sampling theorem









What happens when we don’t comply with the sampling theorem?

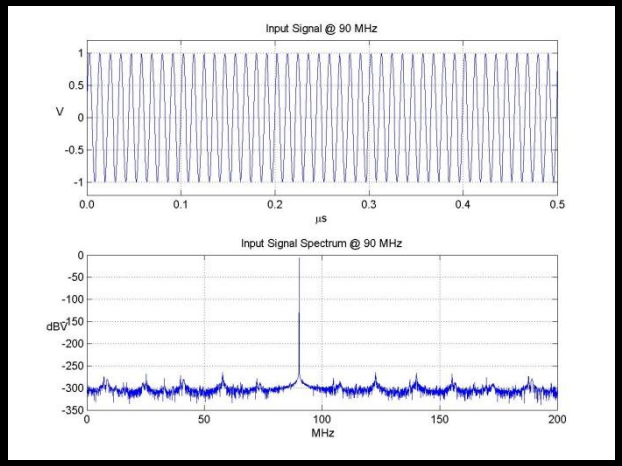
ALIASING

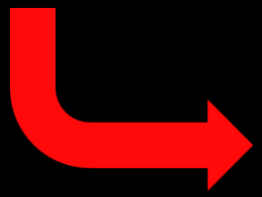
Aliasing

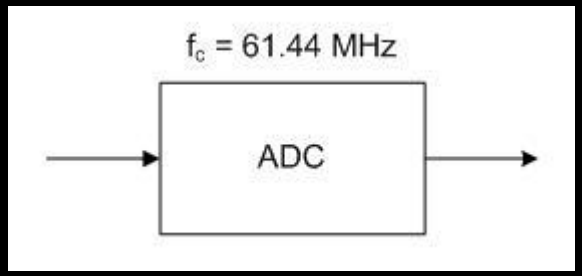
In the presence of Aliasing, given a sampled signal $s_c(nT_c)$ (where $T_c=1/f_c$ corresponds to the sampling interval), we are not able to know univocally the original signal s(t)

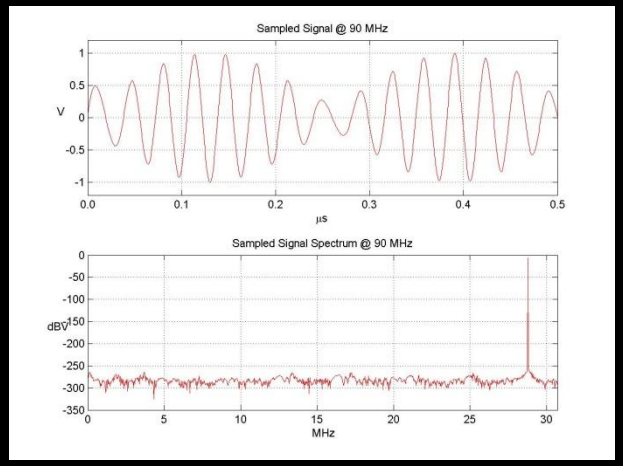
Every frequency component of the original signal that has frequency greater than f_N will be "confused" as a spectral component at frequency $0 \leq f \leq f_N$

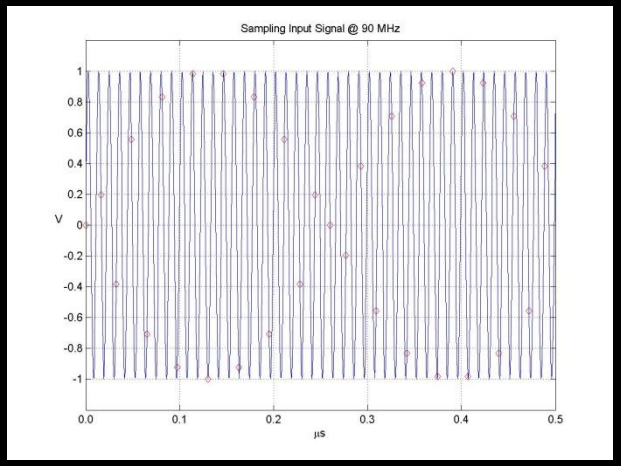
Aliasing


Input Signal @ 90 MHz
V
μs
Input Signal Spectrum @ 90 MHz
dBV
MHz




f_c = 61.44 MHz
ADC


Sampled Signal @ 90 MHz
V
μs
Sampled Signal Spectrum @ 90 MHz
dBV
MHz

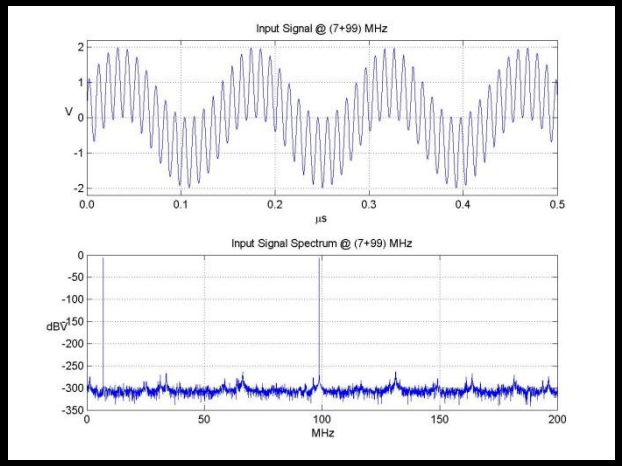

Sampling Input Signal @ 90 MHz
V
μs

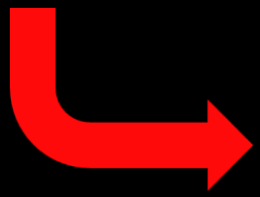
Aliasing

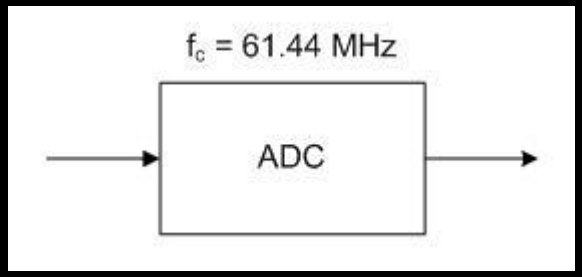
Due to the aliasing, in the $0 \leq f \leq f_N$ frequency range we will have the superposition of each frequency that falls within the bandwidth of the analog-to-digital converter

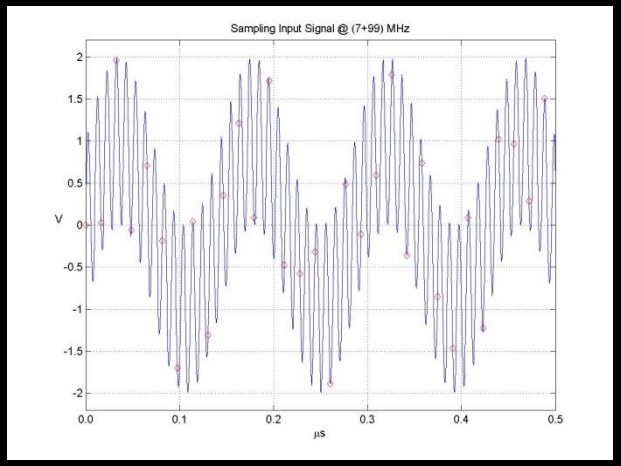
FDM-S1 front-end exhibits 200 MHz input bandwidth

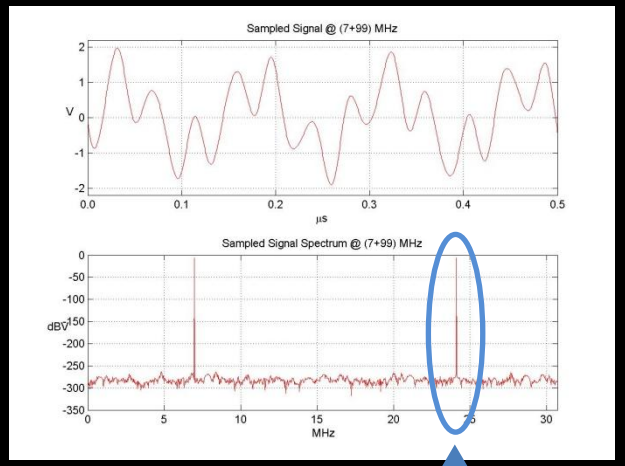
Aliasing

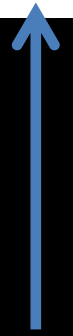












Aliasing

Aliasing

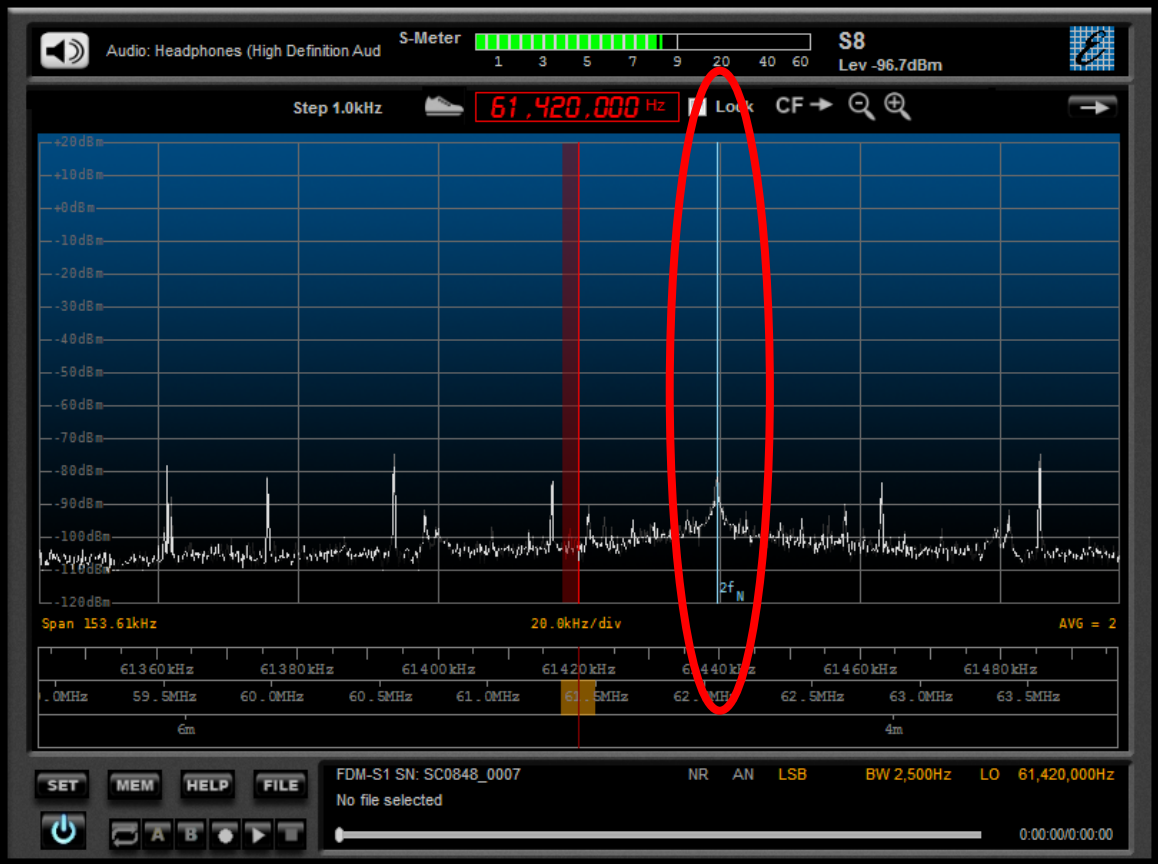
Example: aliasing caused by FM broadcasting (89 MHz)

Aliasing

Aliasing frequencies computation

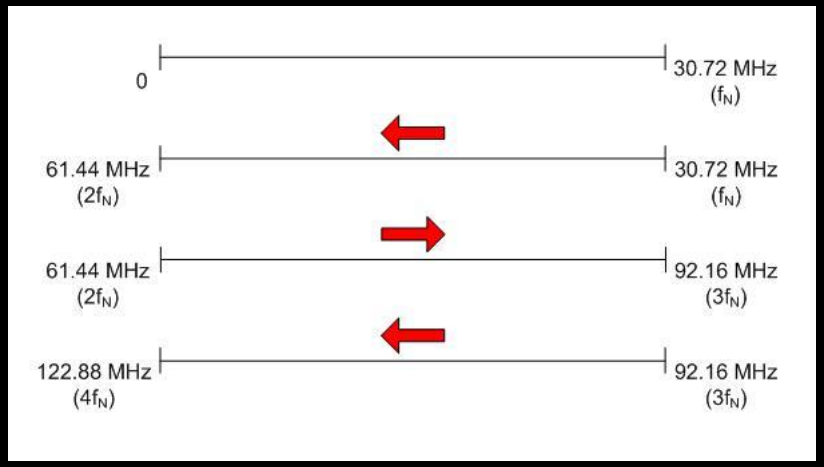
Aliasing

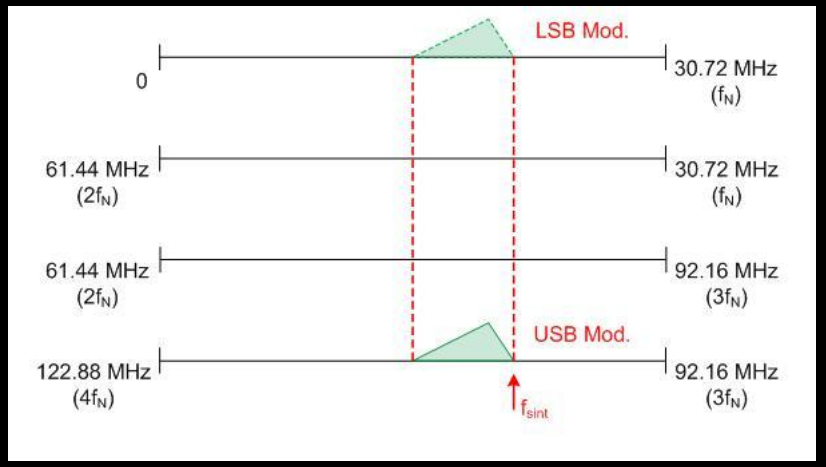
FDM-SW1 helps users highlighting frequencies that are multiples of the Nyquist frequency



Aliasing

Be careful to correctly understand the signals that I obtain in the presence of aliasing



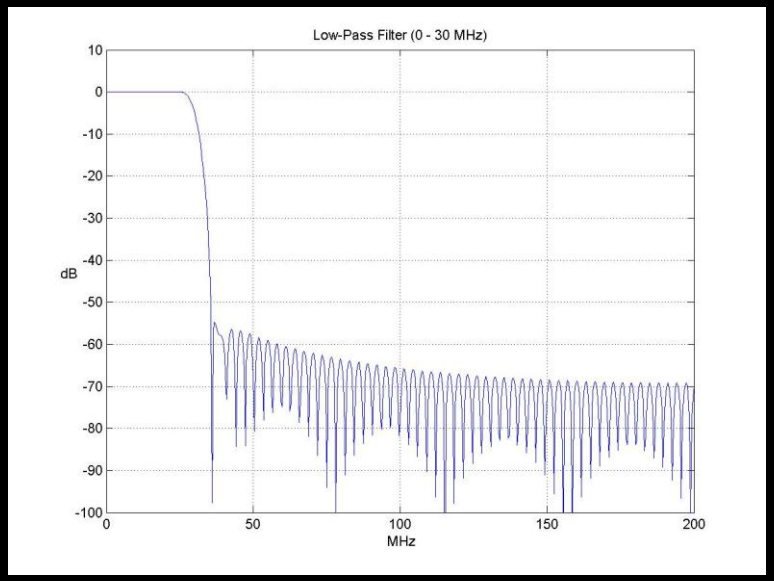


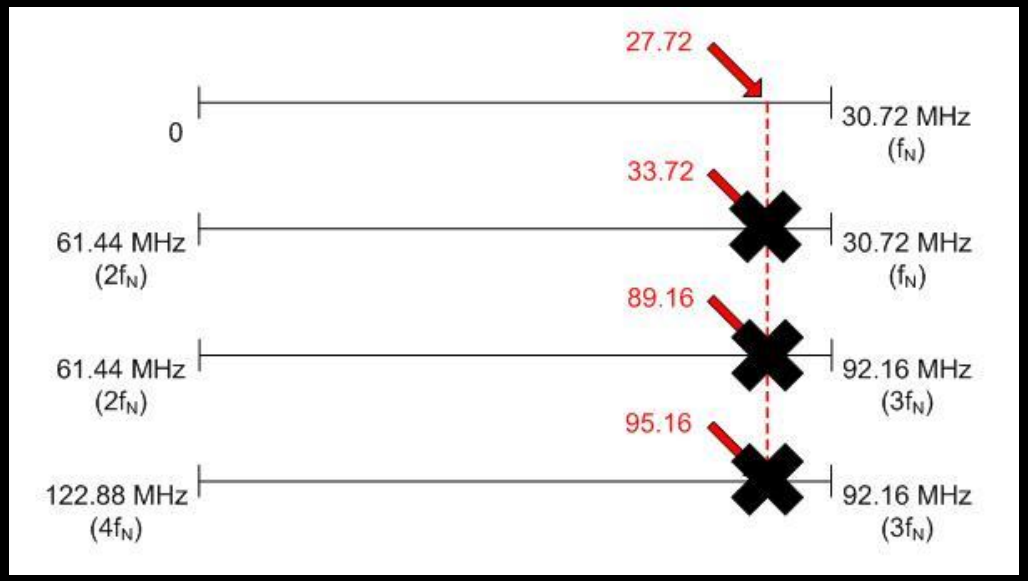
How can we avoid aliasing errors?

Anti-Aliasing Filter

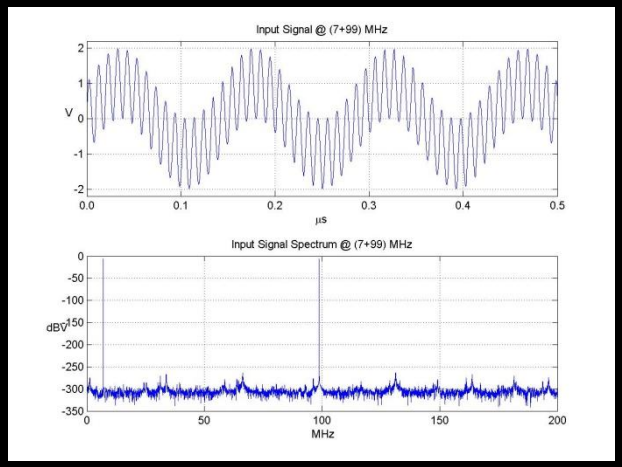
Anti-Aliasing Filter

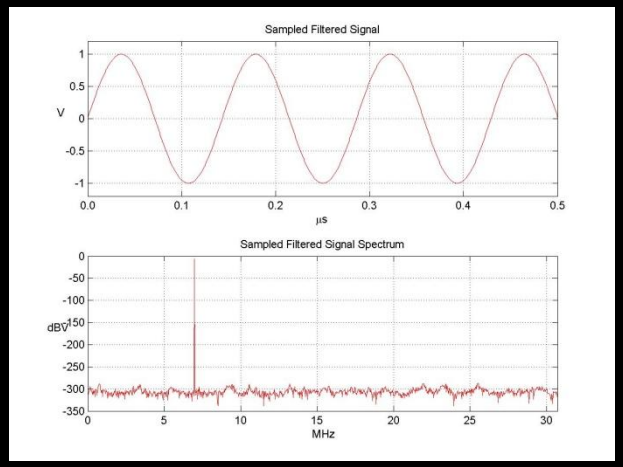
Filter which limits the bandwidth of the input signals cutting all the spectral components greater than the Nyquist frequency

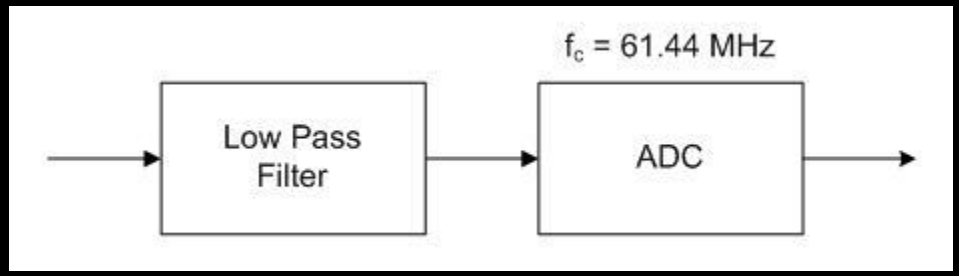


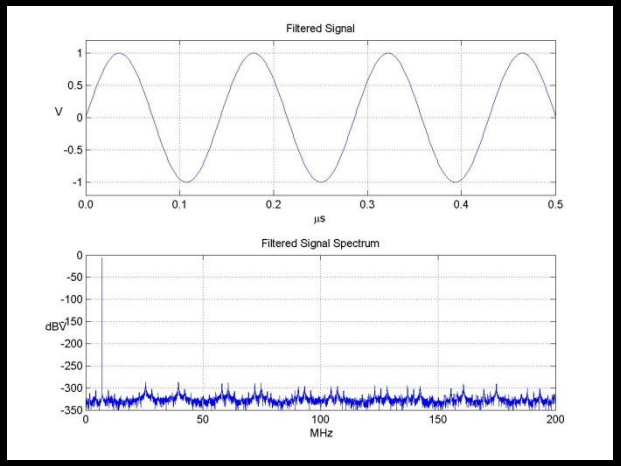


Anti-Aliasing Filter



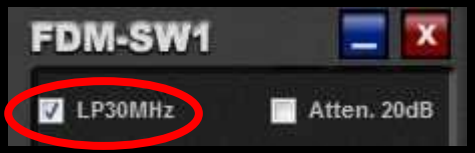


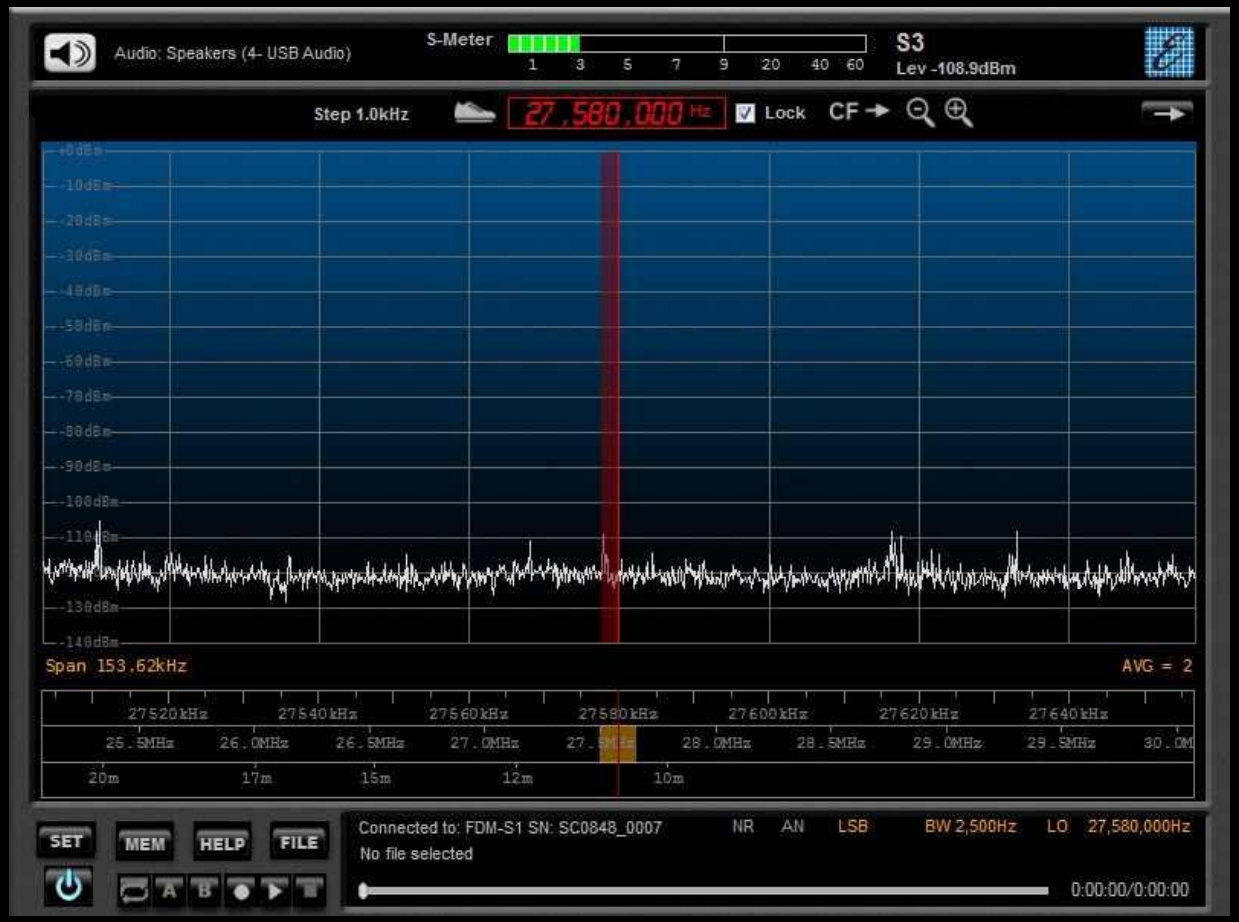




Anti-Aliasing Filter

FDM-S1 has 30 MHz anti-aliasing filter





Is Aliasing always a bad issue?

NO!!!

We can take advantage of it

UNDERSAMPLING

Undersampling

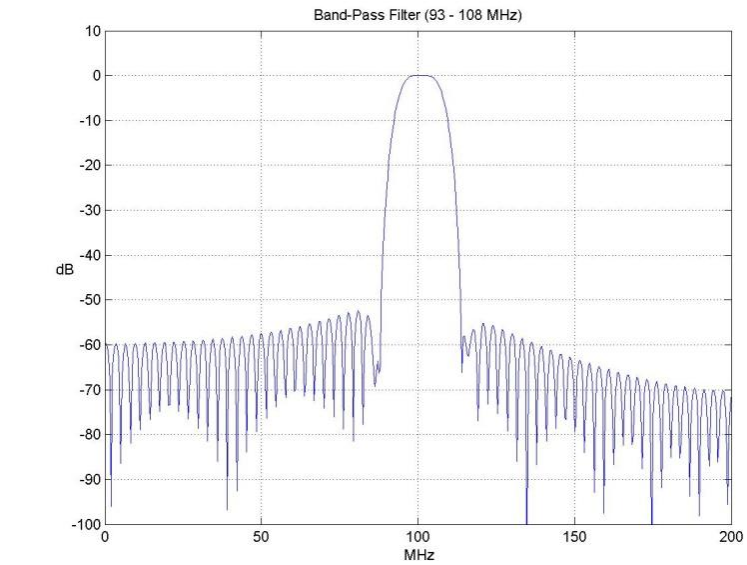
Undersampling technique uses the Aliasing phenomenon to realize a digital mixer

Undersampling is commonly implemented in several types of digital receiver, e.g. mobile phones

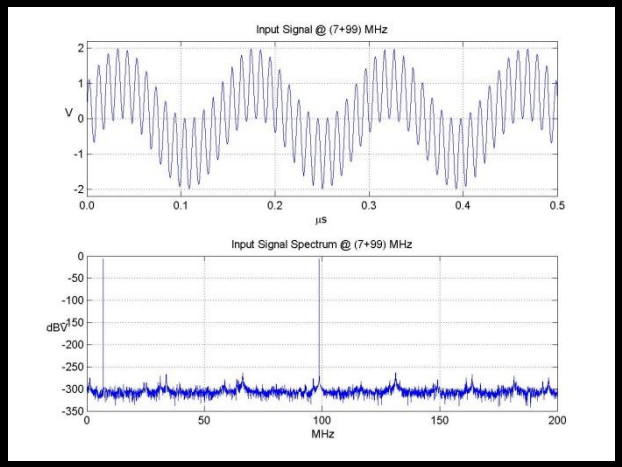
Using undersampling technique, we are able to convert within the analysis band ($0 \leq f \leq f_N$) portions of the spectrum that are located at higher frequencies

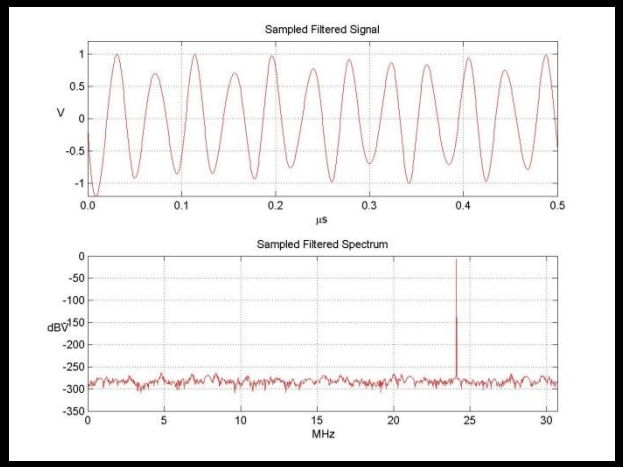
Undersampling

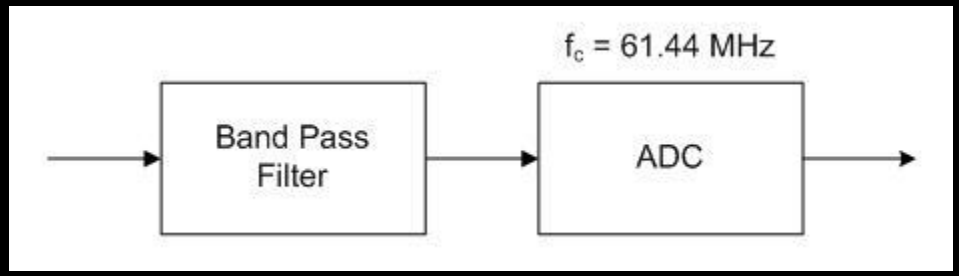
To avoid the superposition we must use preselection filters (band pass)

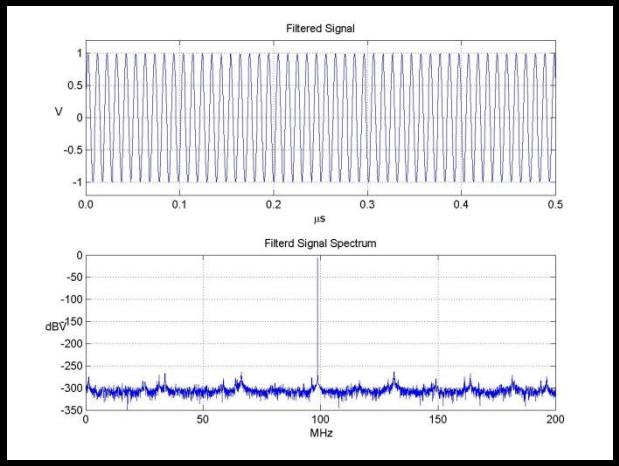


Undersampling

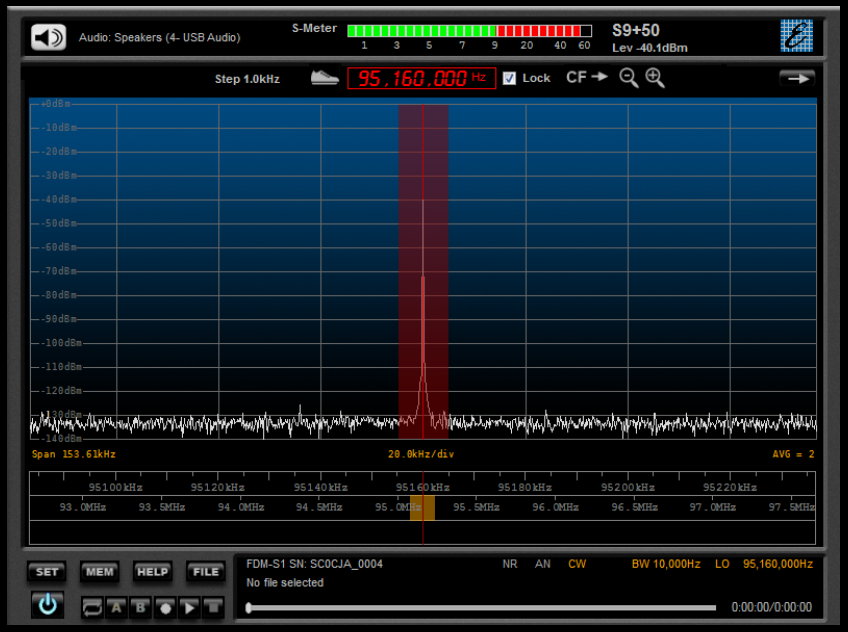








Undersampling with Preselector



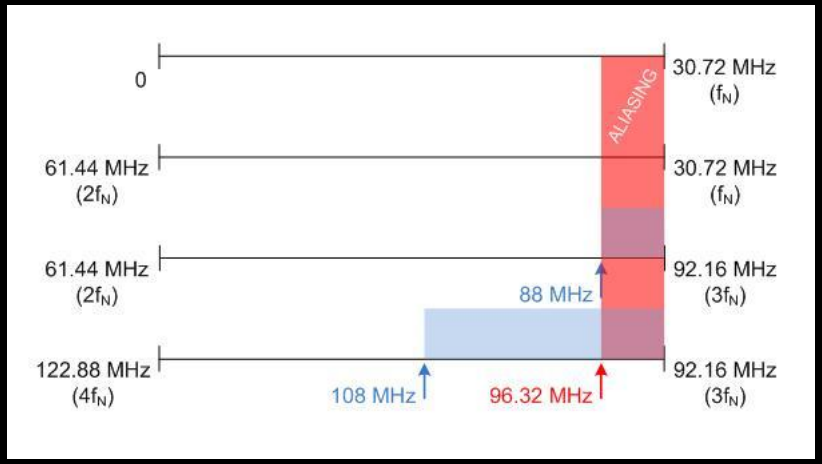
Undersampling

N.B.: preselection filter's bandwidth must satisfy the following rule

$$N*f_N \leq B \leq (N+1)*f_N$$

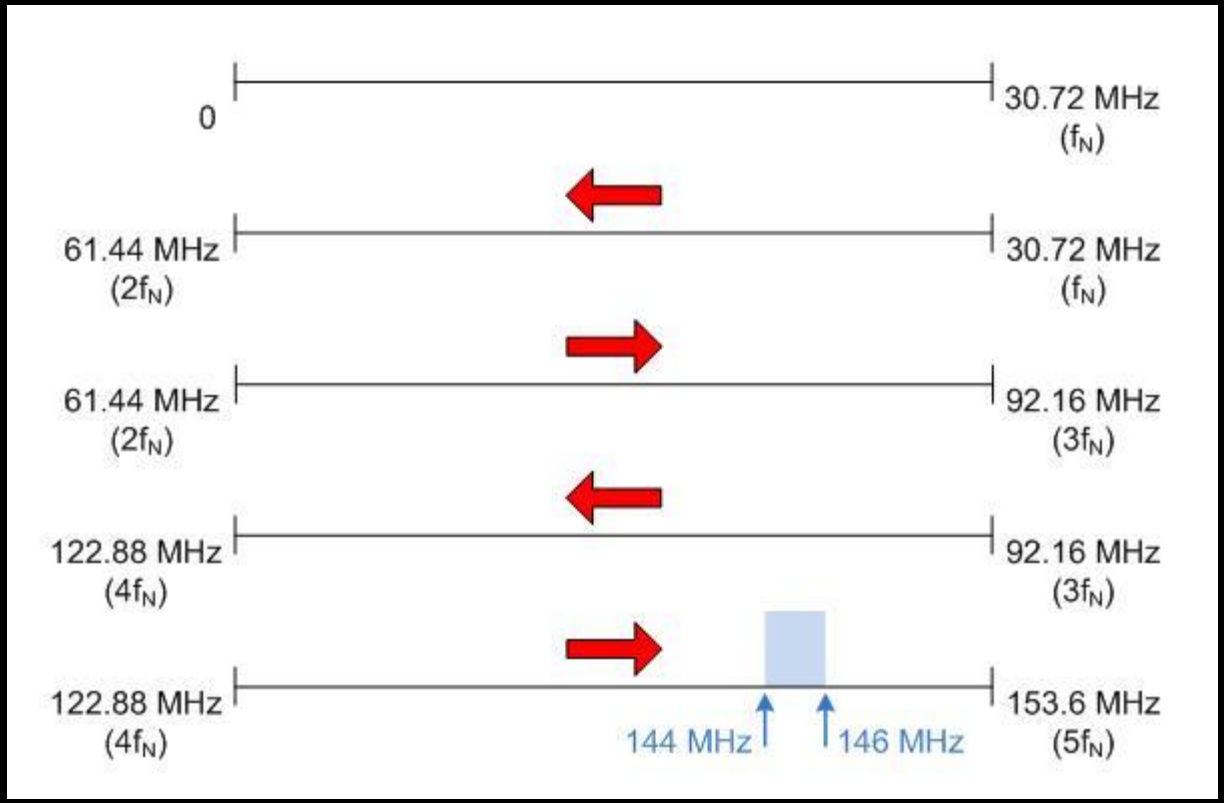
otherwise we will obtain aliasing again

Example: filter for the FM 88 ÷ 108 MHz band



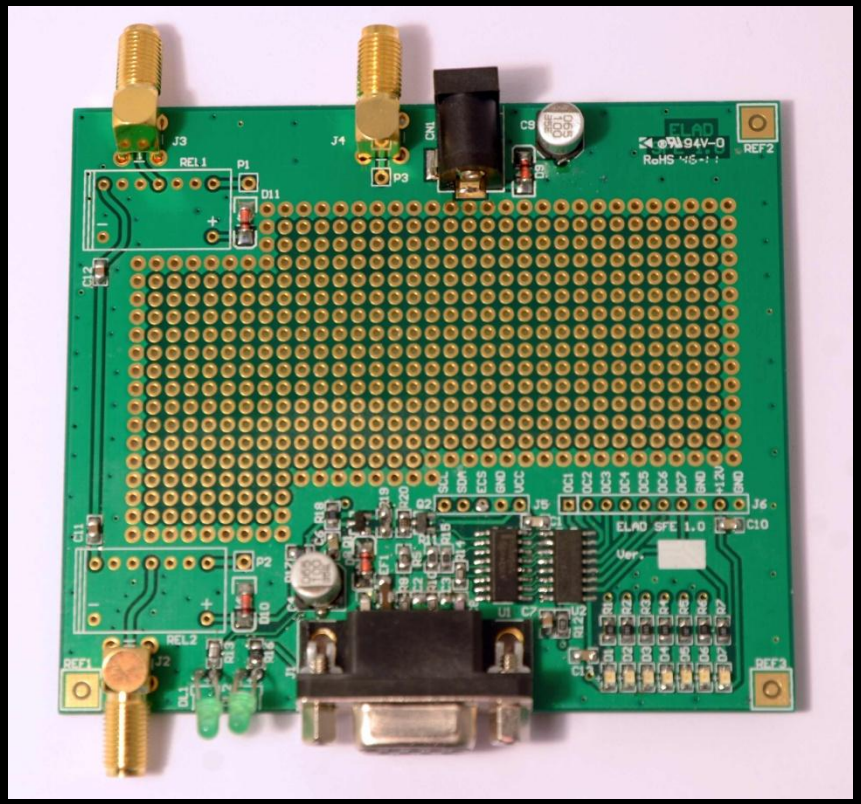
Undersampling

No problem with the 144 ÷ 146 MHz band



Undersampling

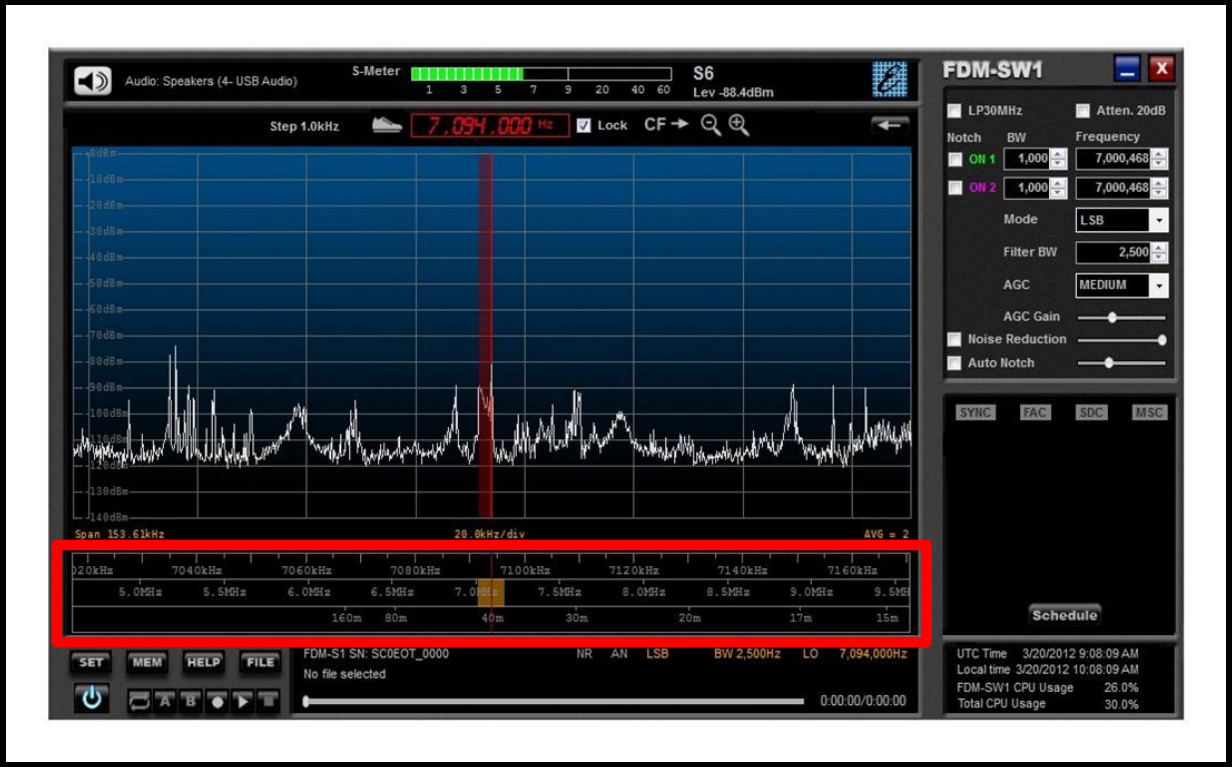
Elad will commercialize a partially mounted developing board (controlled by SW) to help users to develop custom preselection filters



FDM-SW1 Features

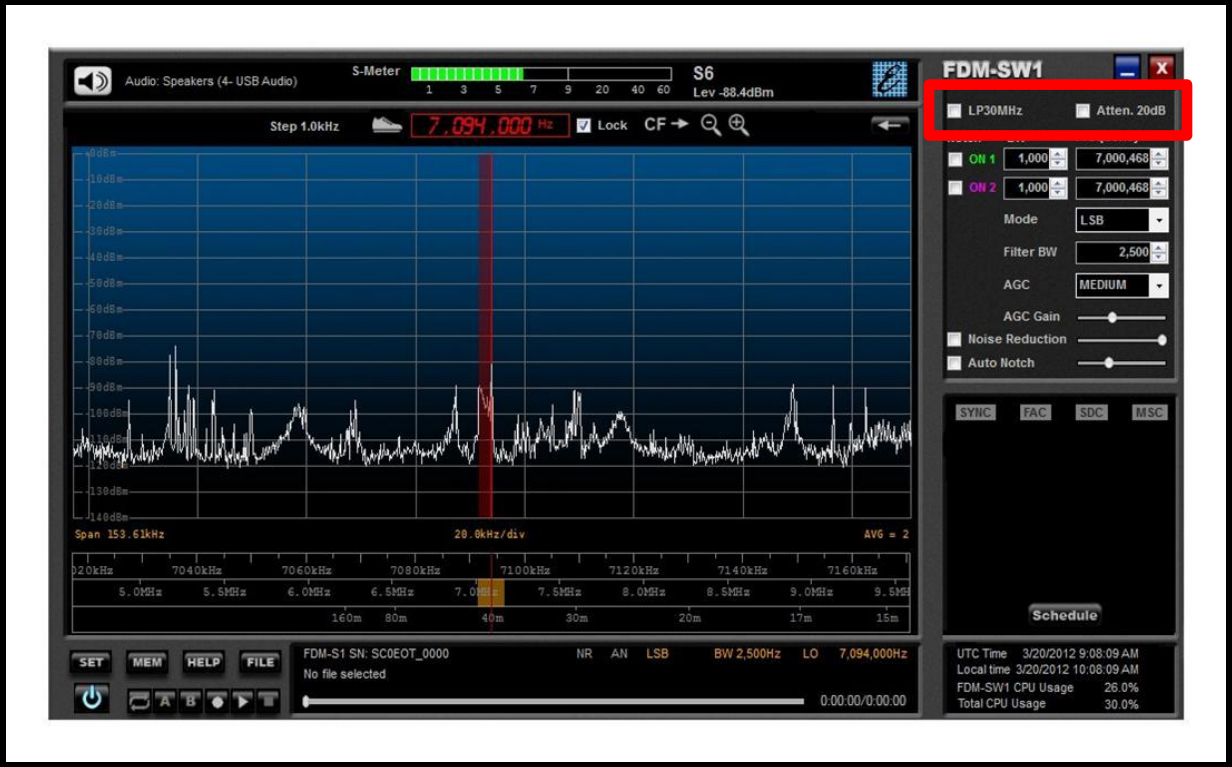
FDM-SW1 Features

- Innovative multi-level tuning bars
  - Fast tuning on the whole spectrum
  - Configurable span for “Middle” e “Band” bars
  - Patent Pending



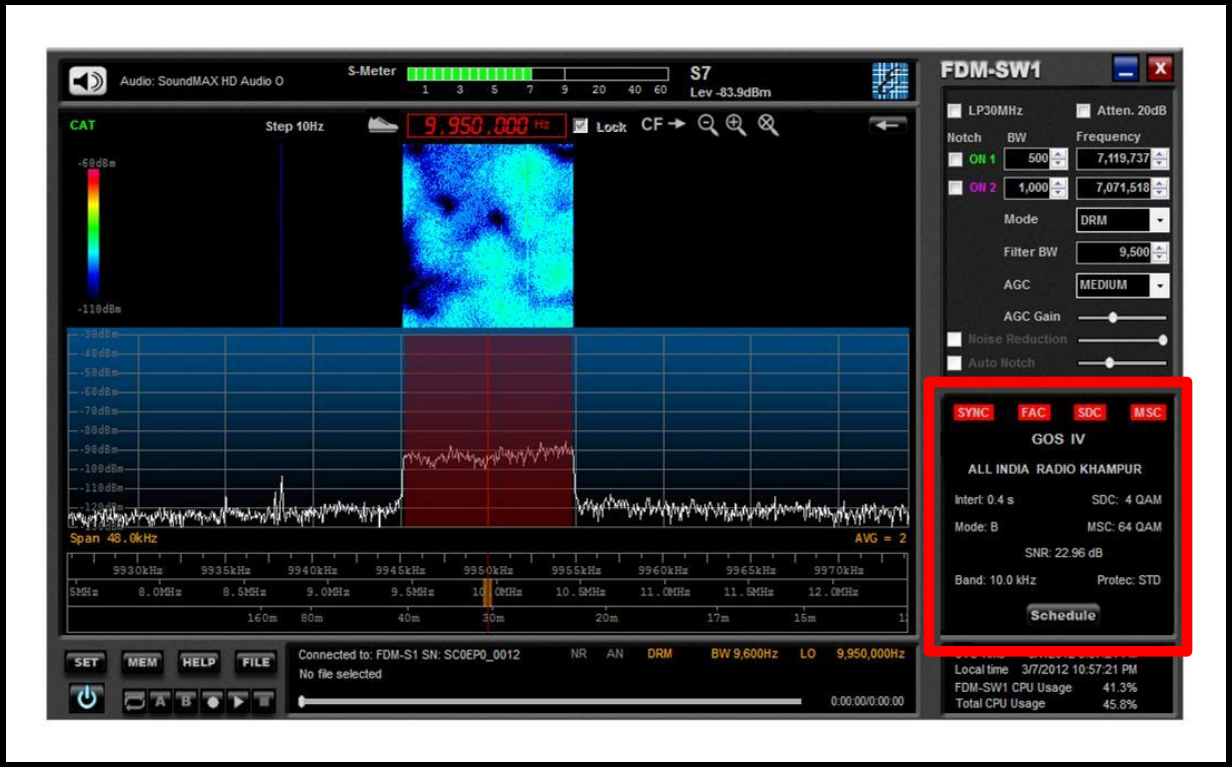
FDM-SW1 Features

- 20 dB attenuator
- Anti-aliasing filter (30 MHz Low-Pass)



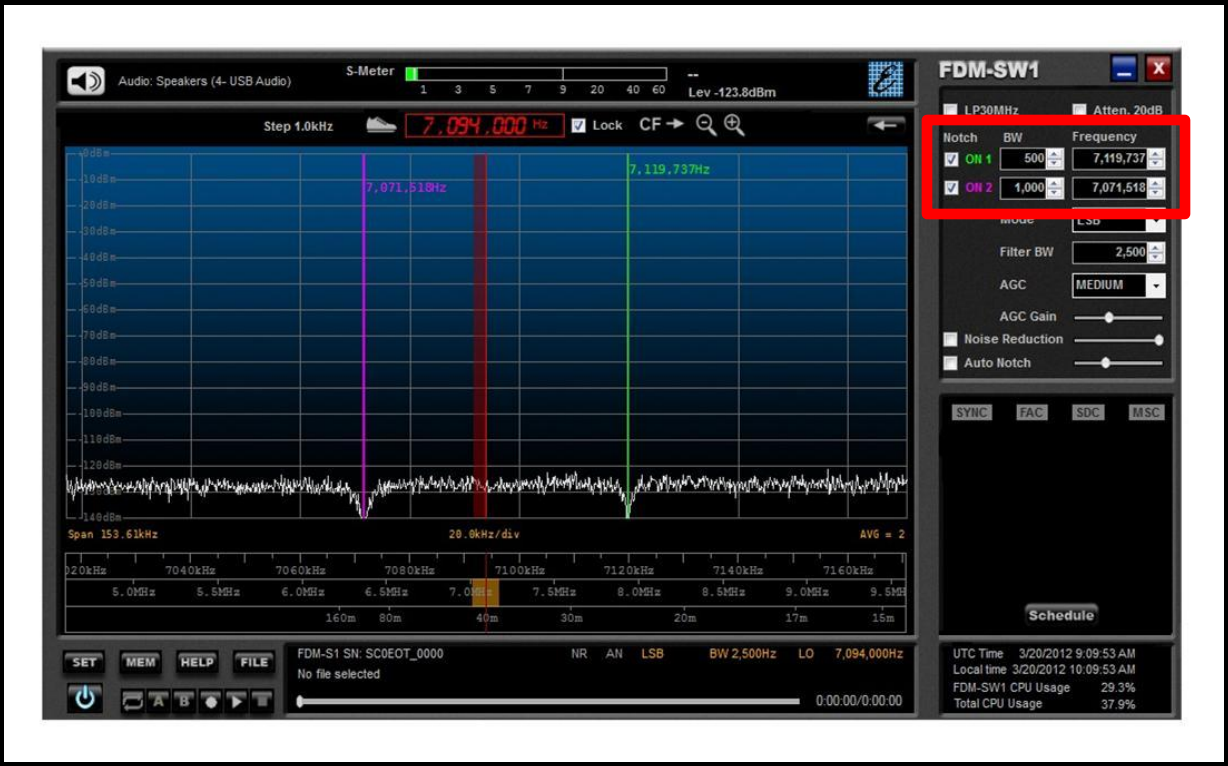
FDM-SW1 Features

- Demodulation modes:
  - CW, CW SH+, CW SH-, USB, LSB, DSB
  - AM, SAM,FM, WB FM (Stereo + RDS)
  - DRM



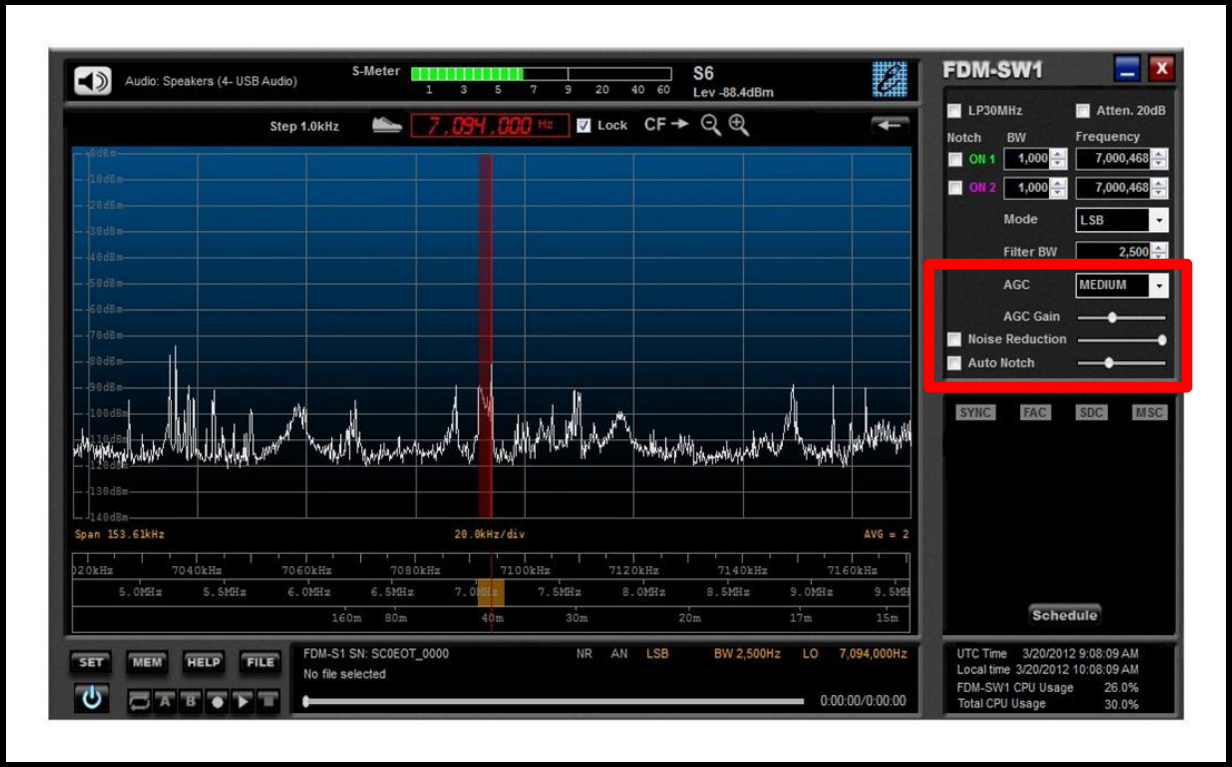
FDM-SW1 Features

- Two Notch filters at IF stage



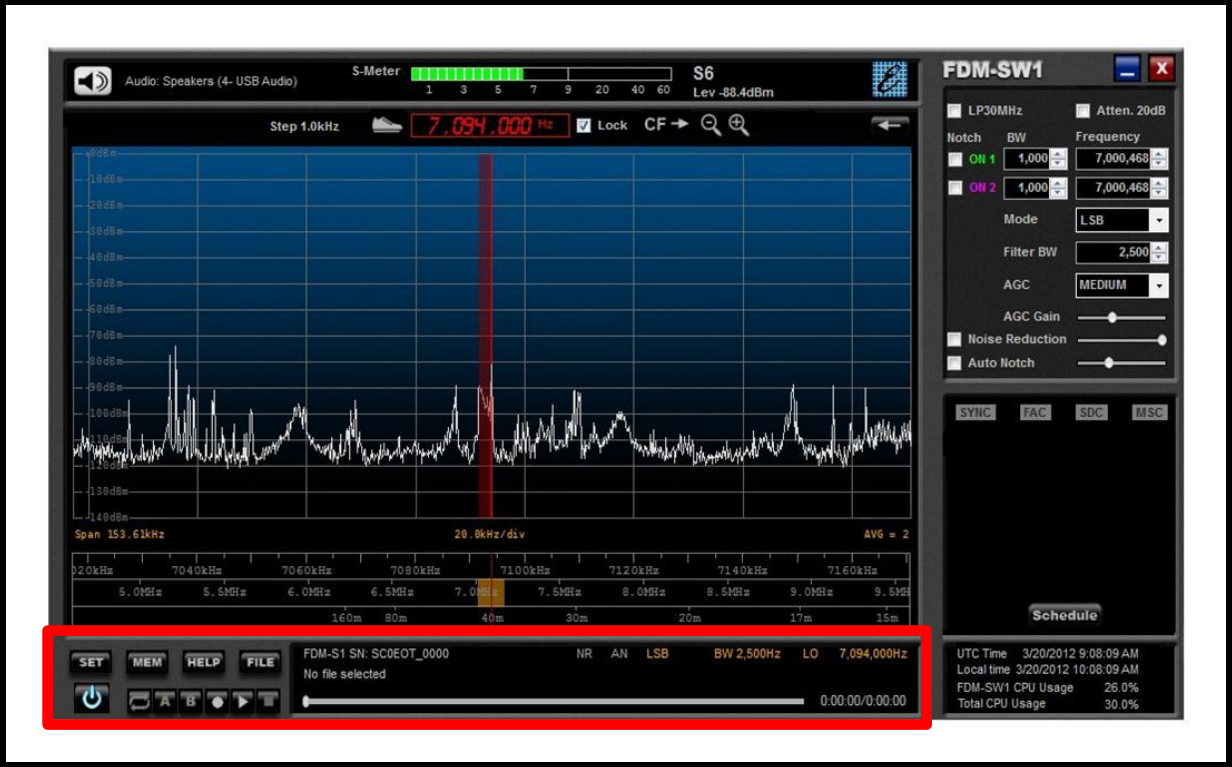
FDM-SW1 Features

- Adaptive De-Noiser (Audio)
- Adaptive Auto-Notch (Audio)
- Automatic Gain Control (Audio)
  - Slow, Medium, Fast and Manual



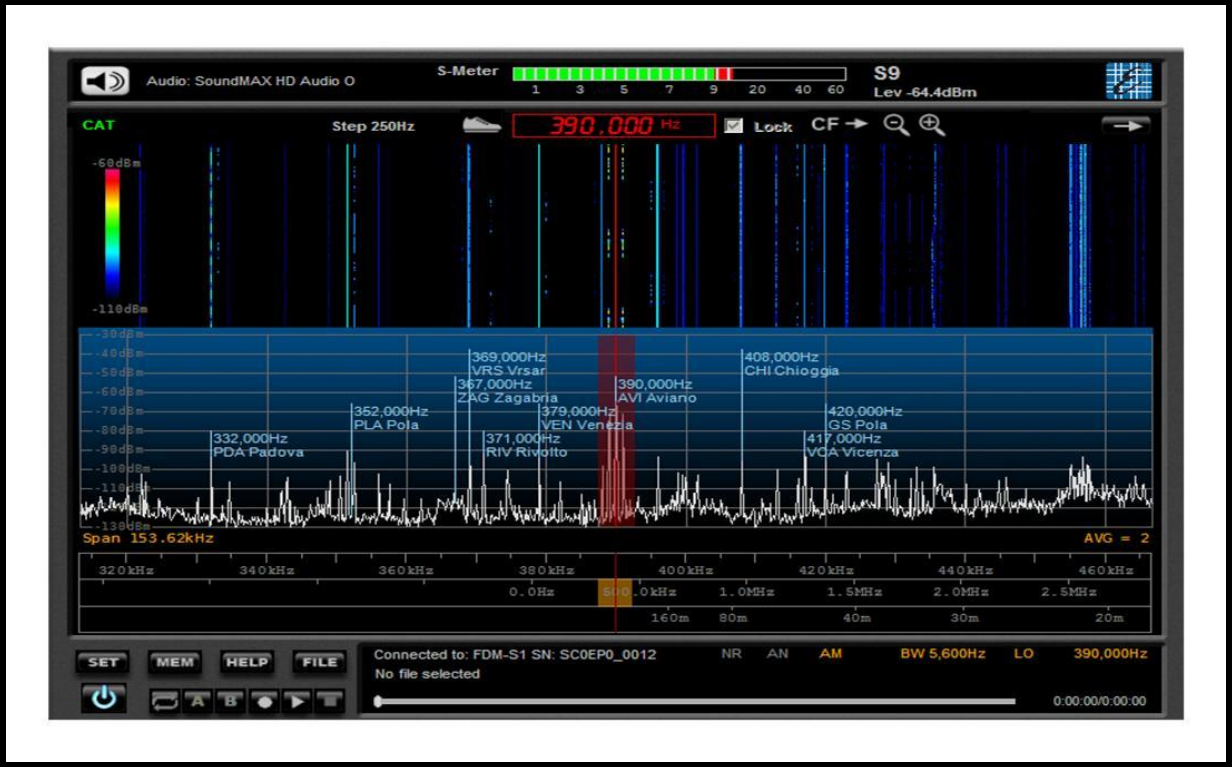
FDM-SW1 Features

- Advanced file recording/playback:
  - Fast file positioning using scrolling bar
  - Programmable recording
  - Settings memorization in the file's header



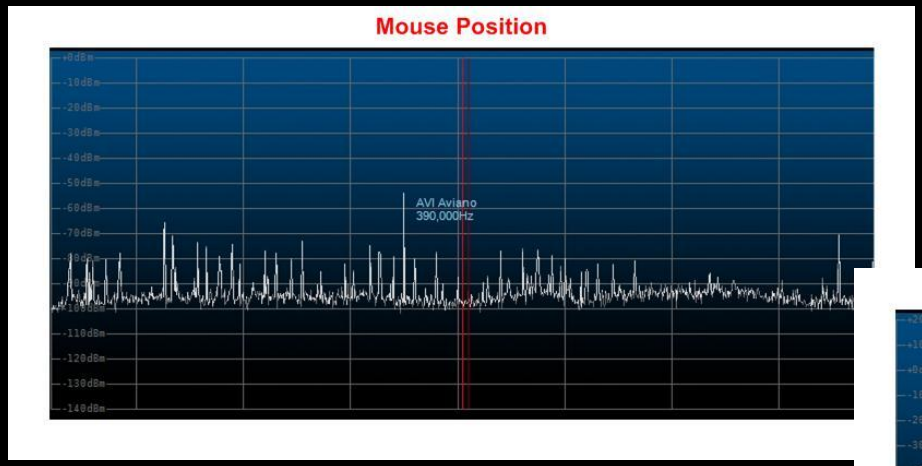
FDM-SW1 Features

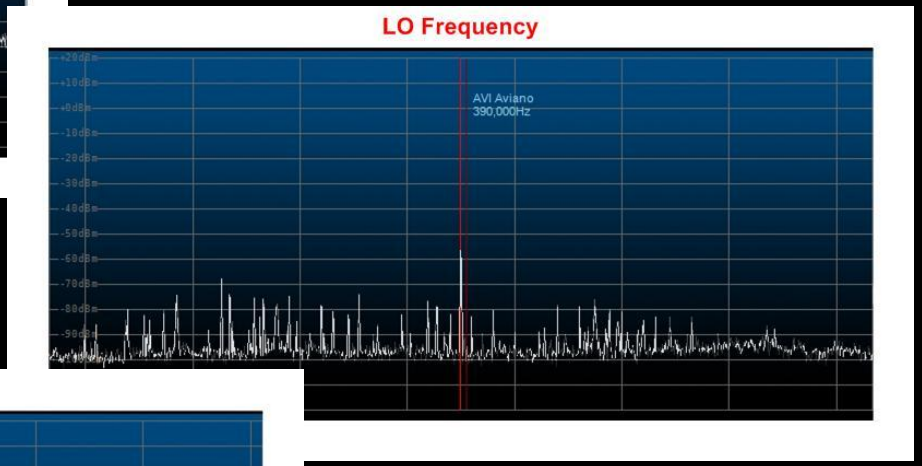
- User station memory (file .xml)
- EIBI database support
- Memories visualization on the spectrum

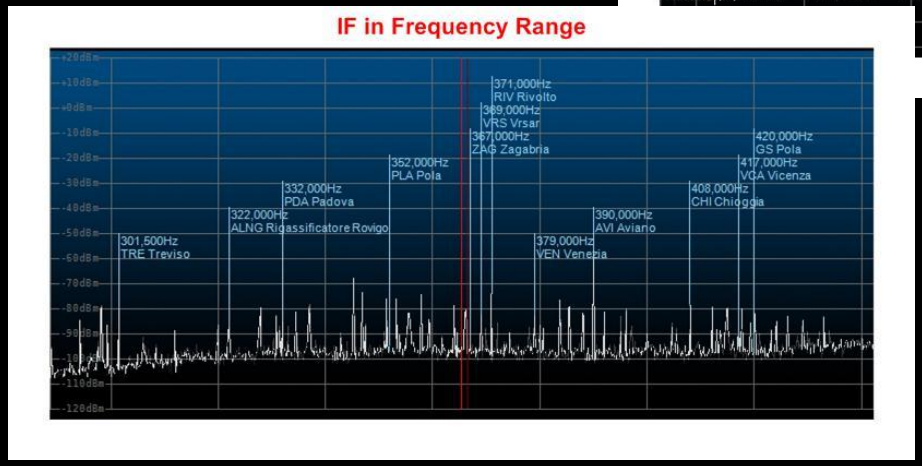


FDM-SW1 Features

- 3 types of memories visualization





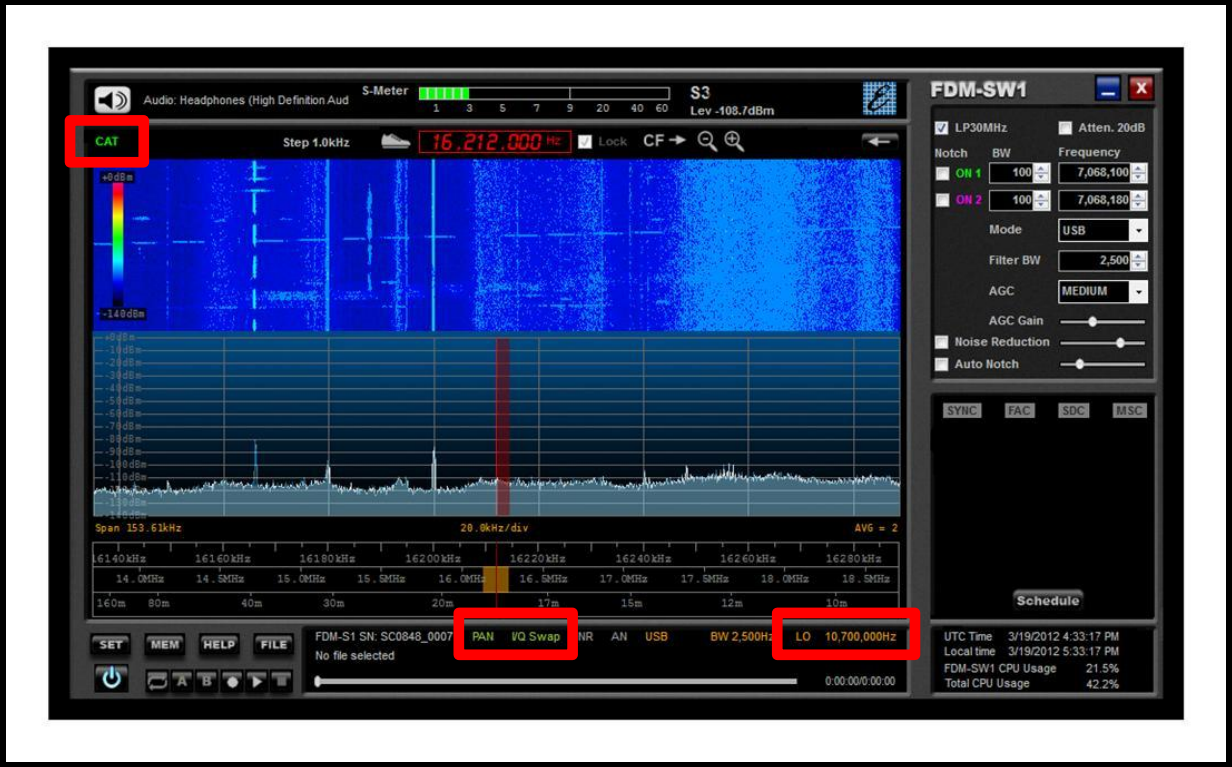


FDM-SW1 Features

- DX-Cluster connection and visualization of the connected users on the spectrum
- 3 types of visualization (same ways as memories)

FDM-SW1 Features

- Panadapter function
  - Configurable IF freq. and amplitude offset
  - Spectrum flip
  - CAT protocol (SW master or slave)



FDM-SW1 Features

• Possibility of using different USB sample rate (192, 384, 768, 1536 e 3072 kHz, canali I/Q, 32 bit/sample)

•Possibility of using two soundcards

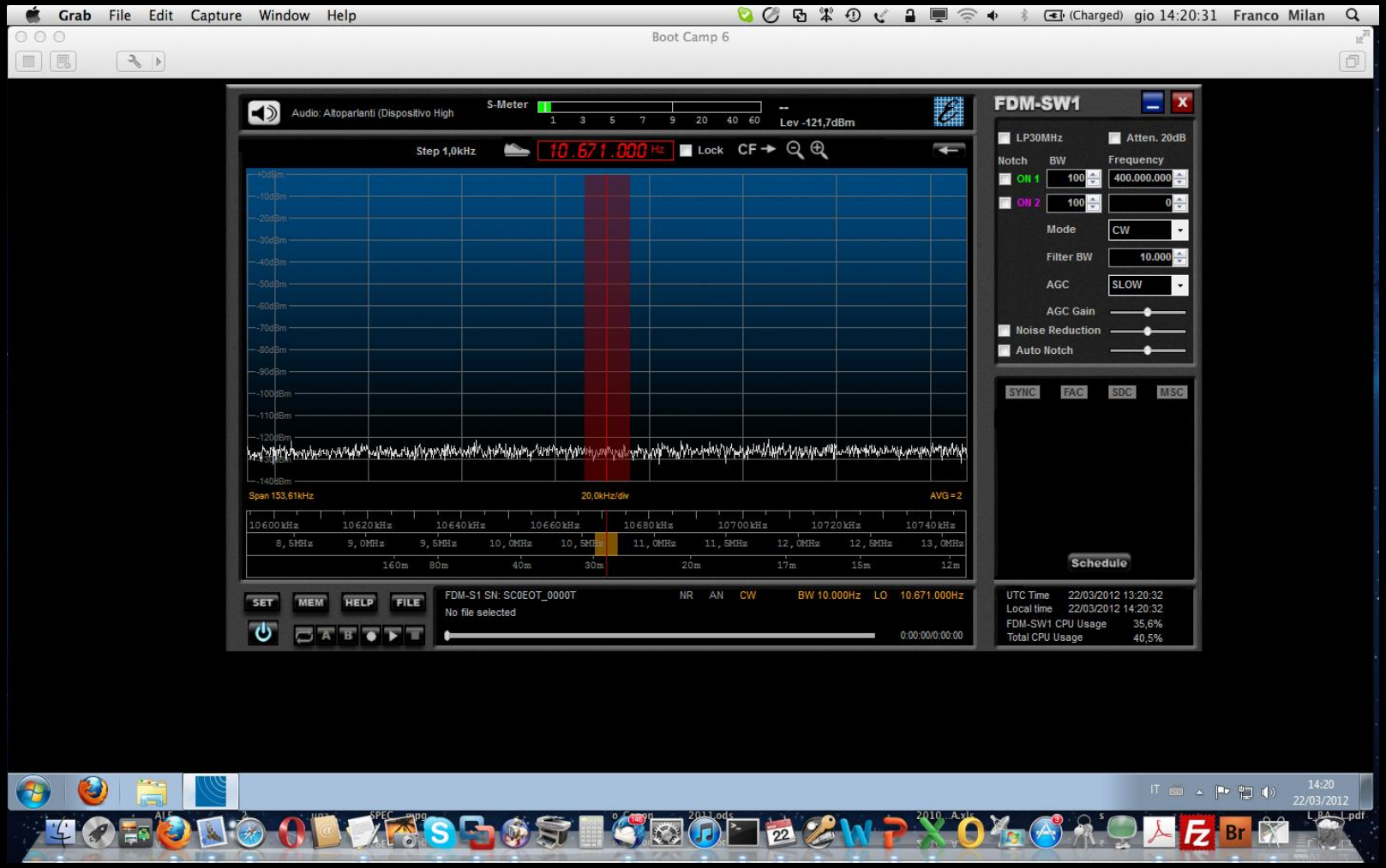
• Configurable presets
  - Frequency Step
  - Filter Bandwidth

• Possibility of using configurable default settings (mode, bandwidth, Att, LP30, etc) within user-defined frequency ranges

• Tmate and Tmate2 interface
  - Configurable function buttons

FDM-SW1 Features

- Apple virtual machine compatible (tested on VMware Fusion environment)



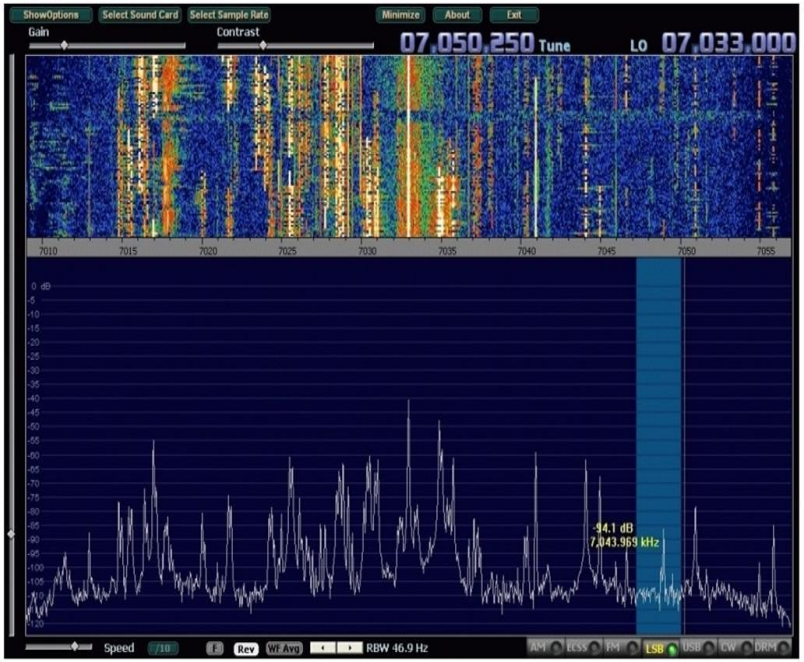
FDM-S1
Alternative Software

Alternative Software

Thanks to a dll interface, FDM-S1 can be used with third party software

STUDIO UNO

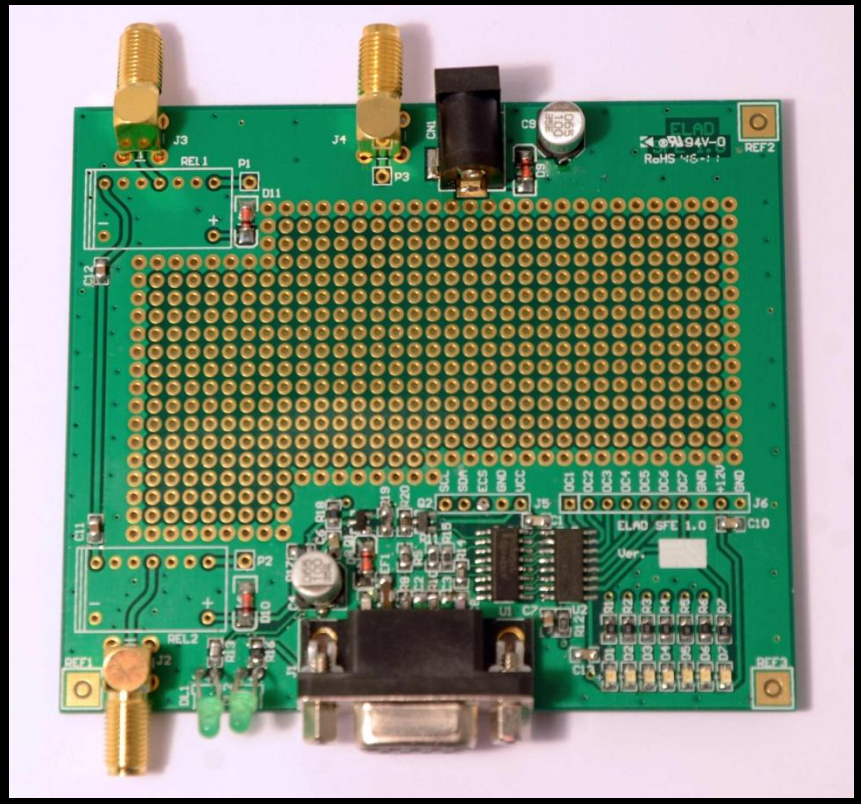
WINRAD



FDM-S1
Homebrew Radio Support

Homebrew Radio Support

Users could improve the performances of FDM-S1 realizing custom filters on a developing board controlled by software (FDM-SW1 or third party)



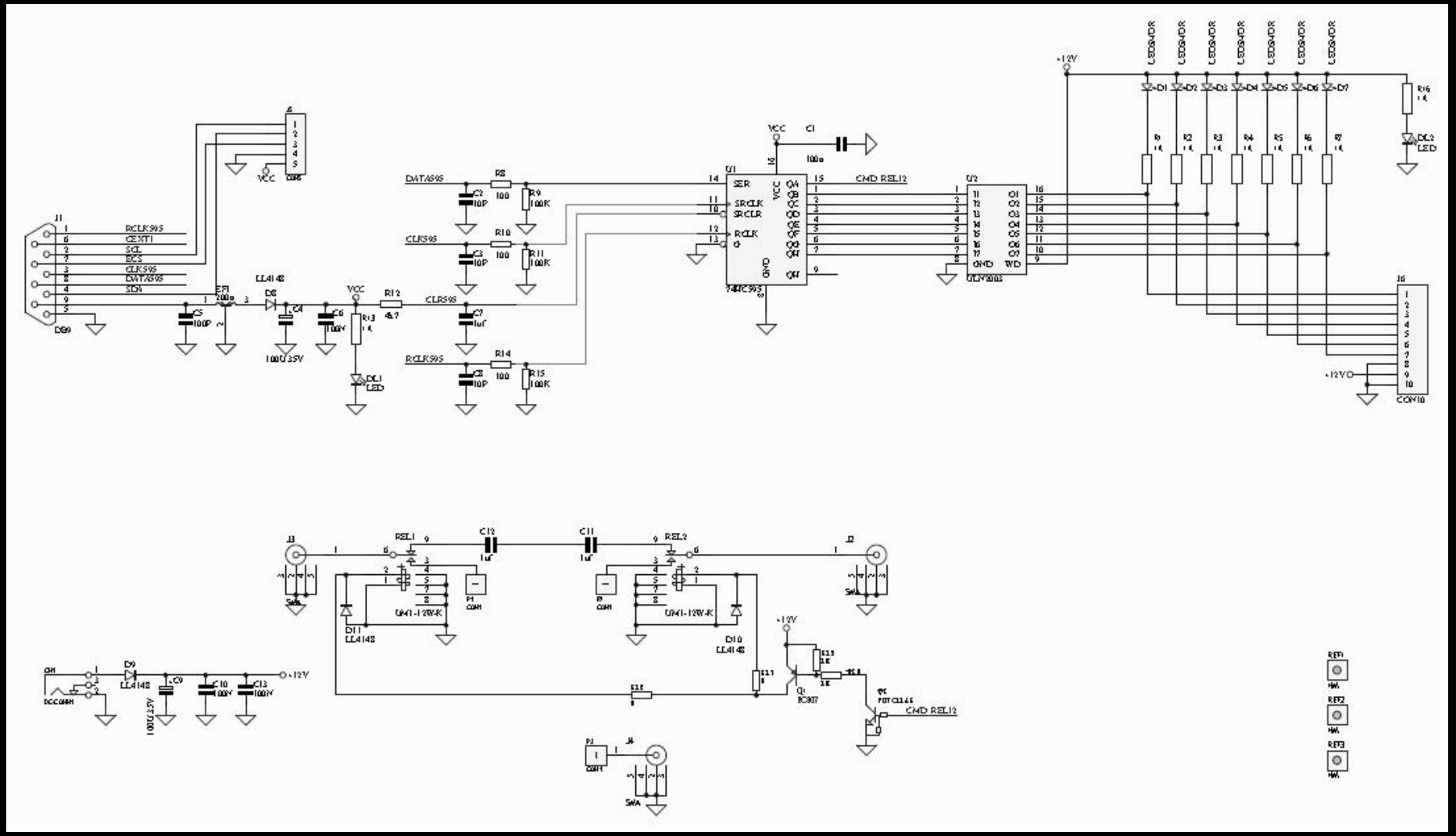
Homebrew Radio Support

- SFE 1.0 board

  -DB9 interface between FDM-S1 and SFE board
  - 2 antenna input (SMA)
  - Possibility of switching 7 relays
  - 7 Led monitor for the 7 External I/O
  - 2 Led monitor for 5V from FDM-S1 and 12V Ext
  - Possibility of switching 1 bypass relay

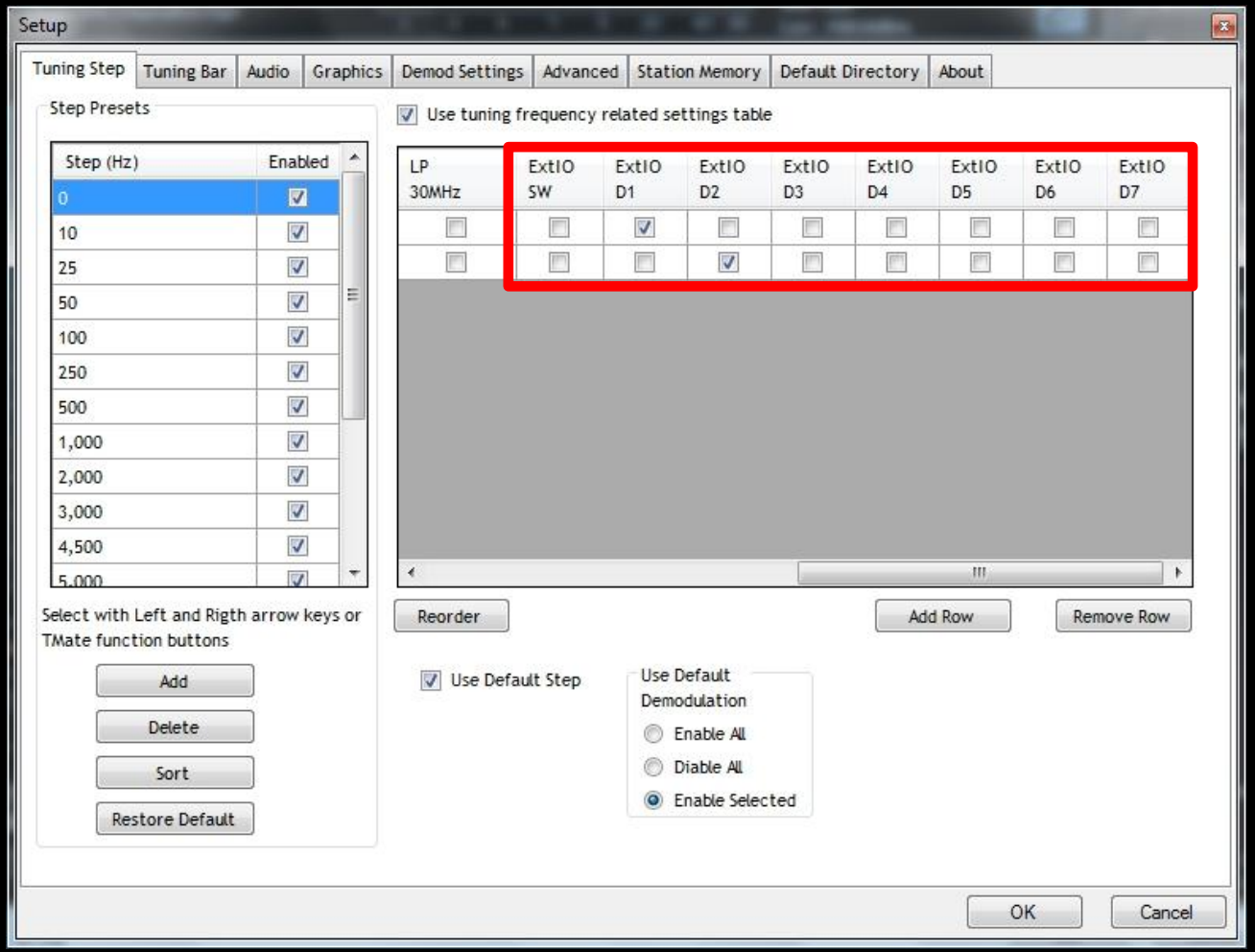
Homebrew Radio Support

SFE 1.0 schematic



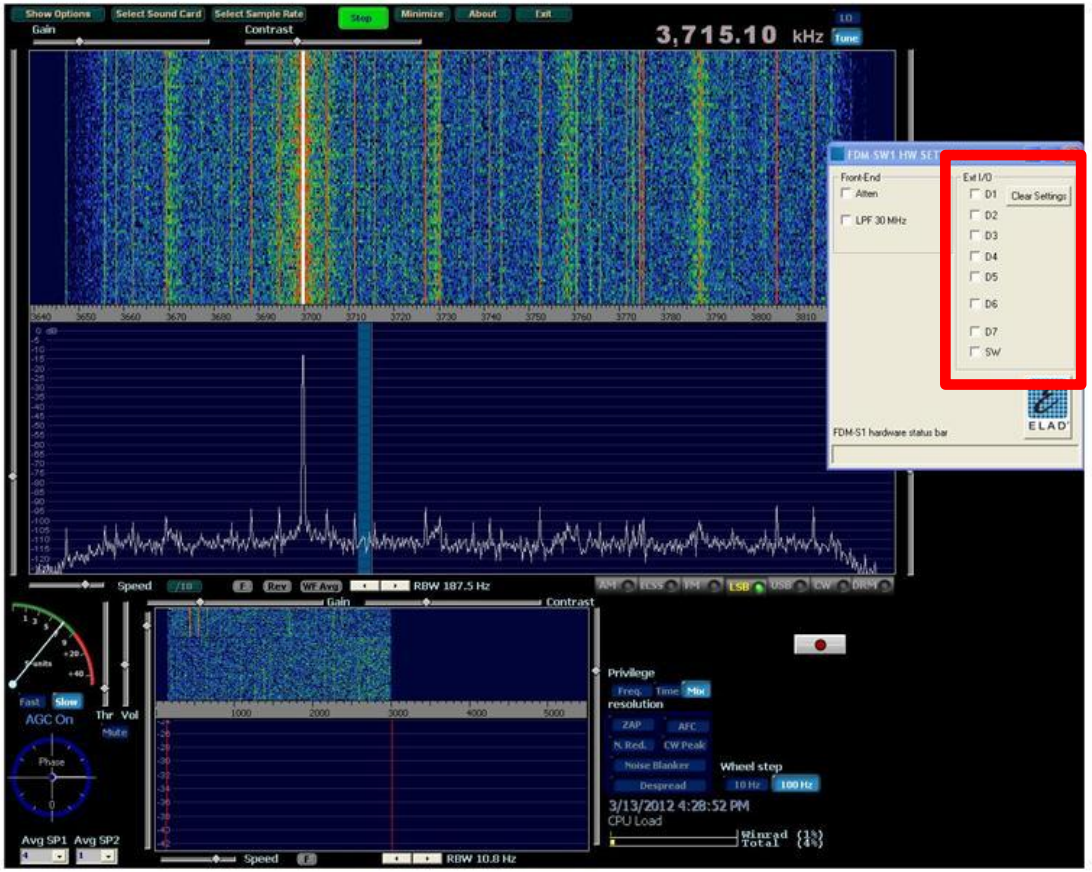
Homebrew Radio Support

SFE 1.0 setting using FDM-SW1



Homebrew Radio Support

SFE 1.0 setting using third party software



ELAD Sales Network

- Sales of FDM-S1 are assigned only to EQP (Elad Qualified Partner)

  Woodbox Radio is EQP for Europe
  www.woodboxradio.com

- For professional uses and customizations, please contact directly ELAD company
  www.eladit.com

Thanks

Elad Team