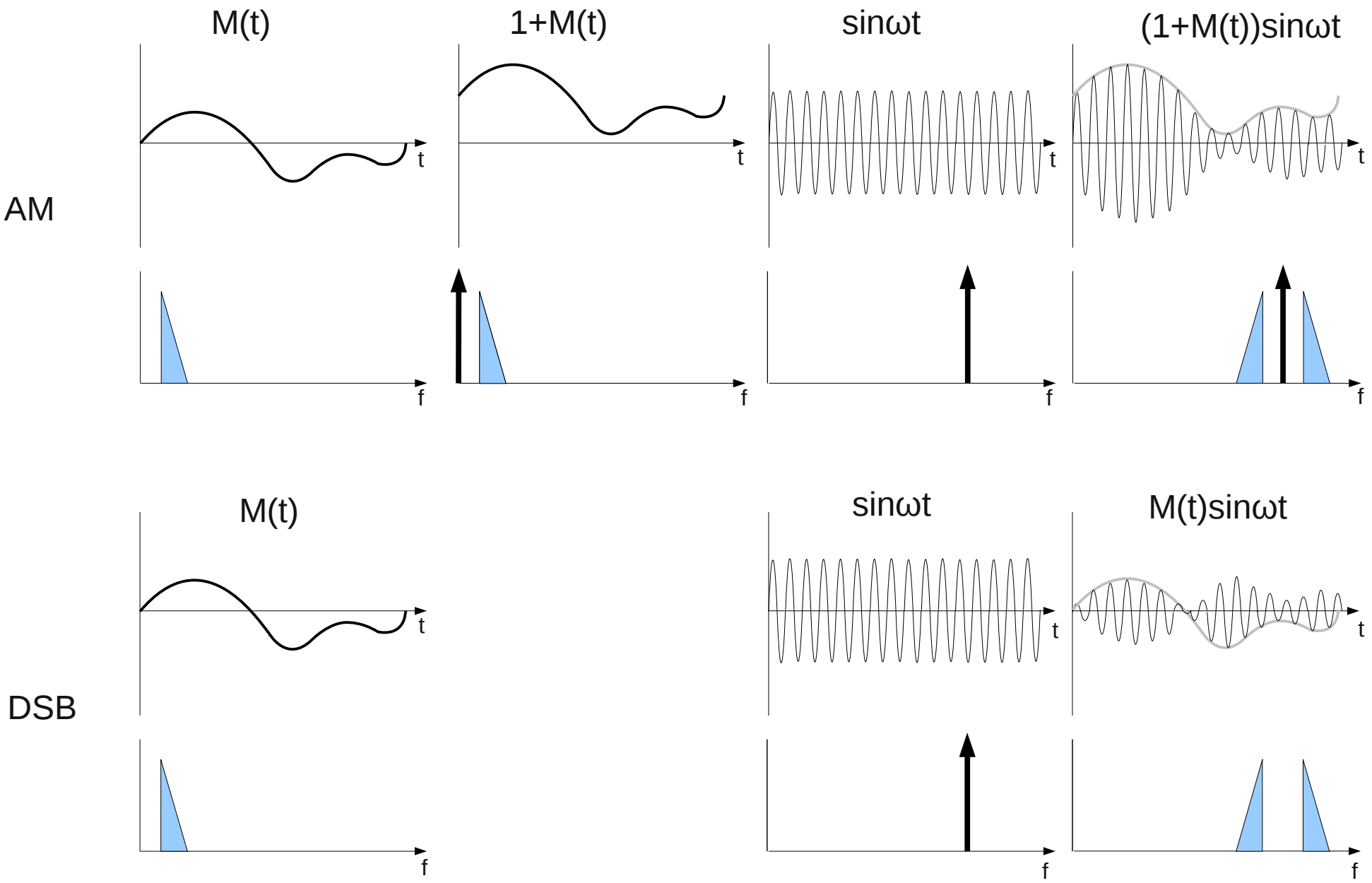
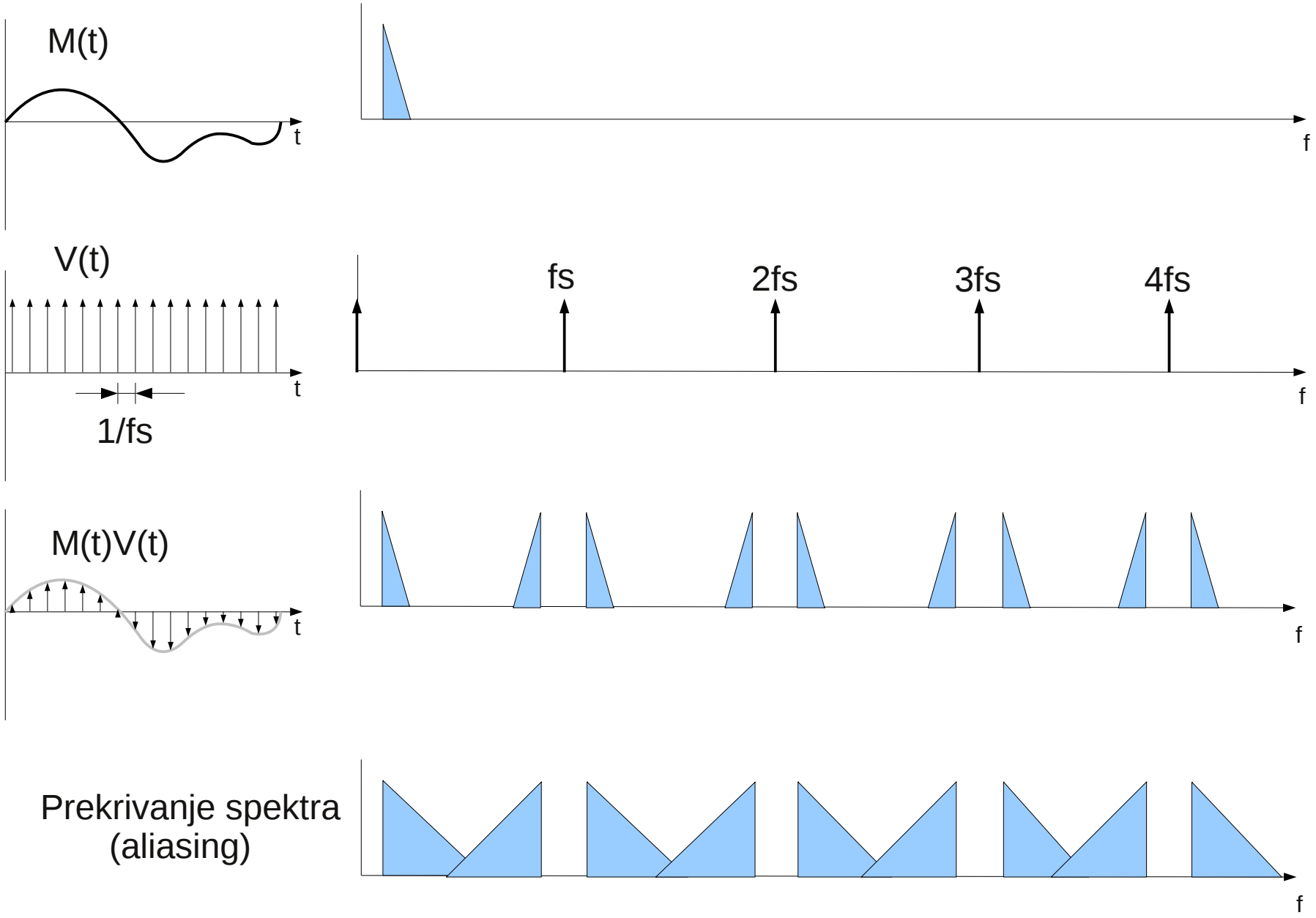
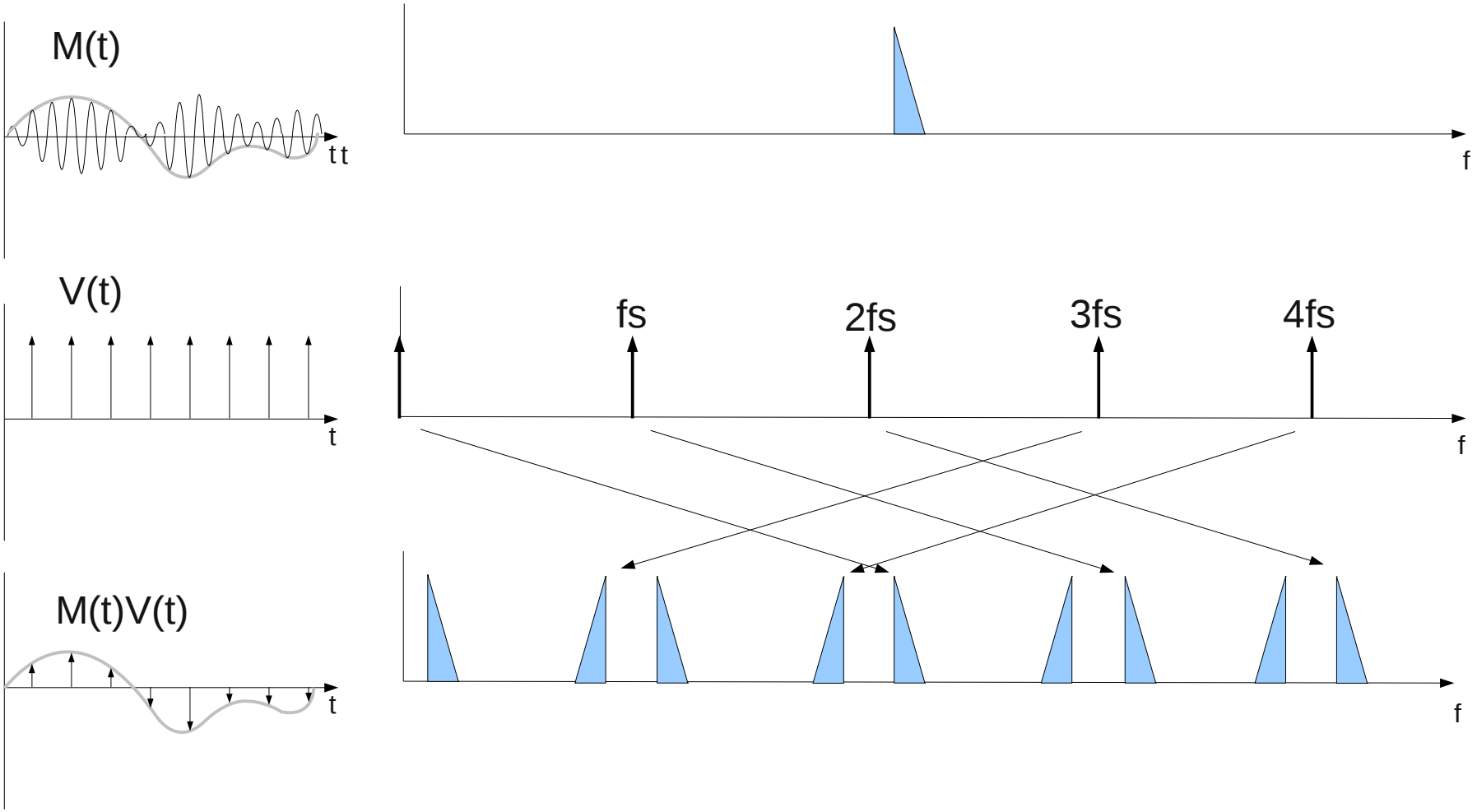
Nekaj malega o SDR

(predvsem o hardveru)

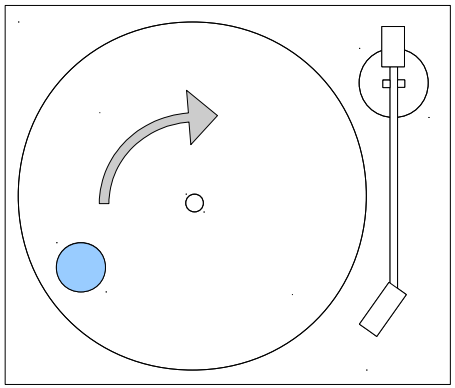
Marko Cebokli S57UUU

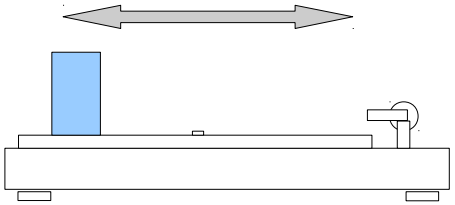

AM
M(t)
1+M(t)
sinωt
(1+M(t))sinωt
t
f
DSB
M(t)
sinωt
M(t)sinωt
t
f

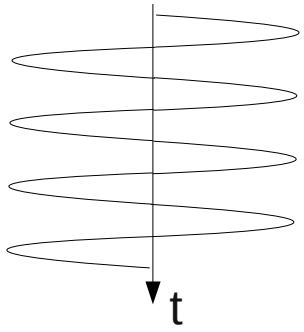

M(t)
t
f
V(t)
t
1/fs
fs
2fs
3fs
4fs
f
M(t)V(t)
t
f
Prekrivanje spektra
(aliasing)
f

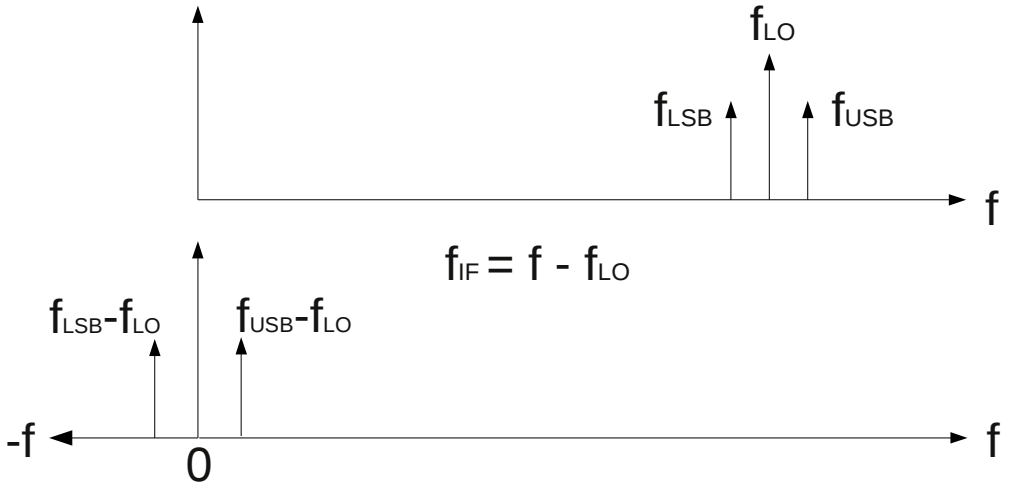

M(t)
t t
f
V(t)
t
fs
2fs
3fs
4fs
f
M(t)V(t)
t
f

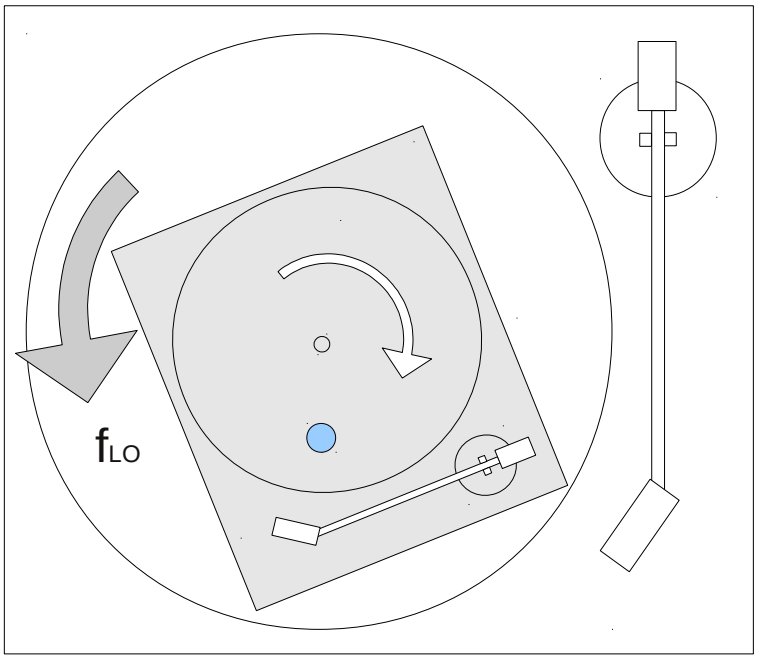
Negativne frekvence

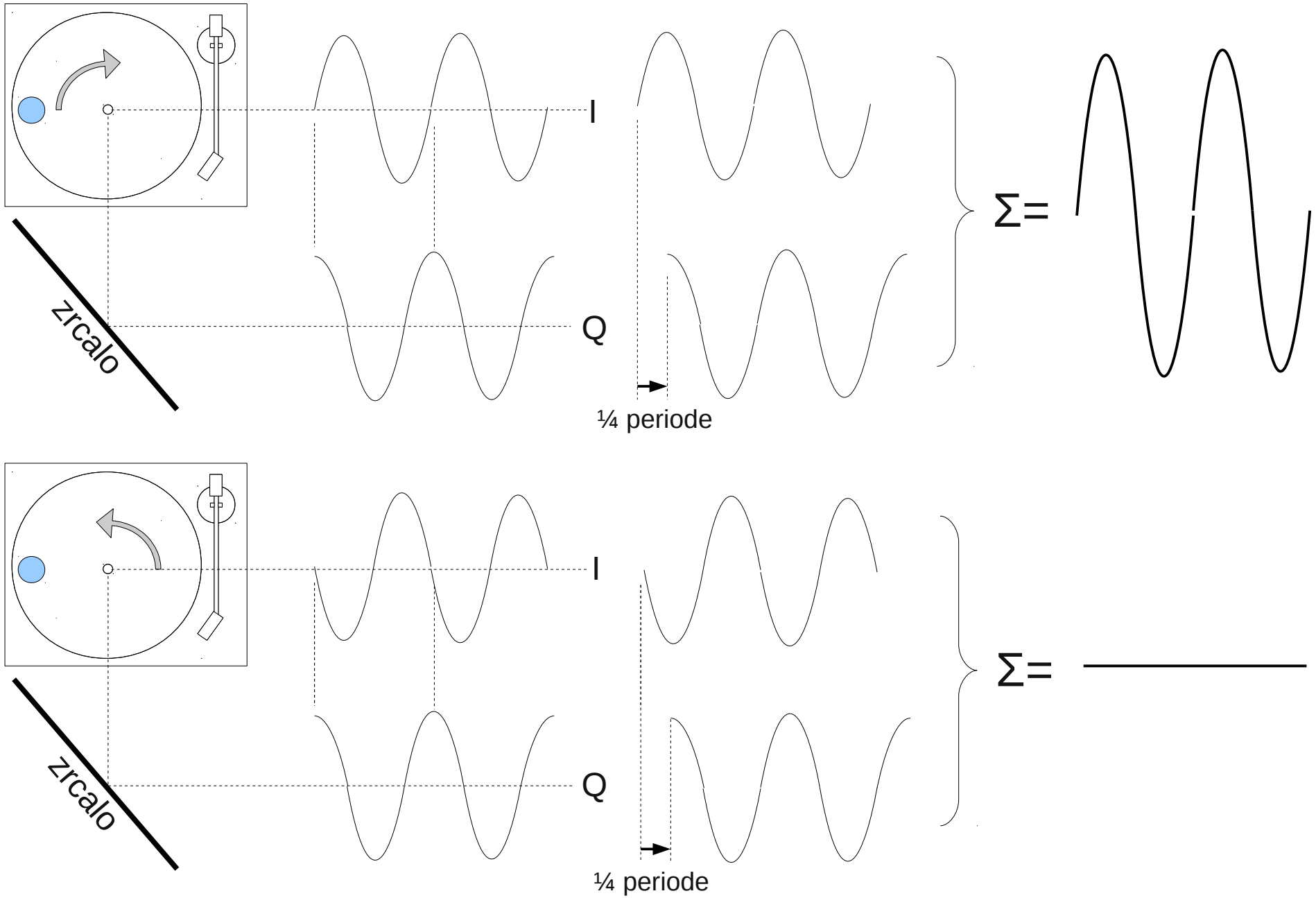




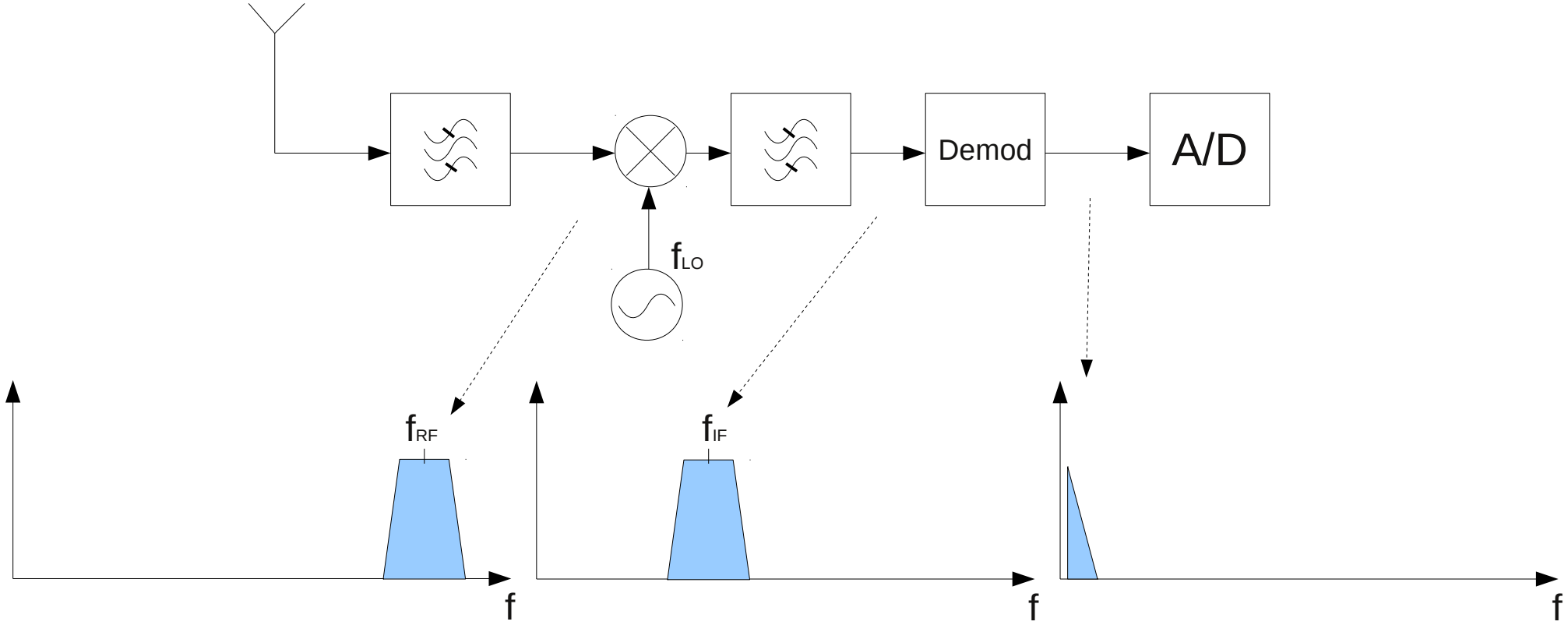




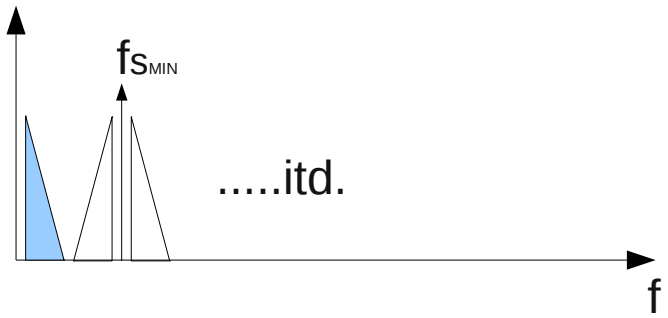



I
Q
zrcalo
Σ=
¼ periode
I
Q
zrcalo
Σ=
¼ periode

Vzorcenje v osnovnem pasu (po demodulaciji)

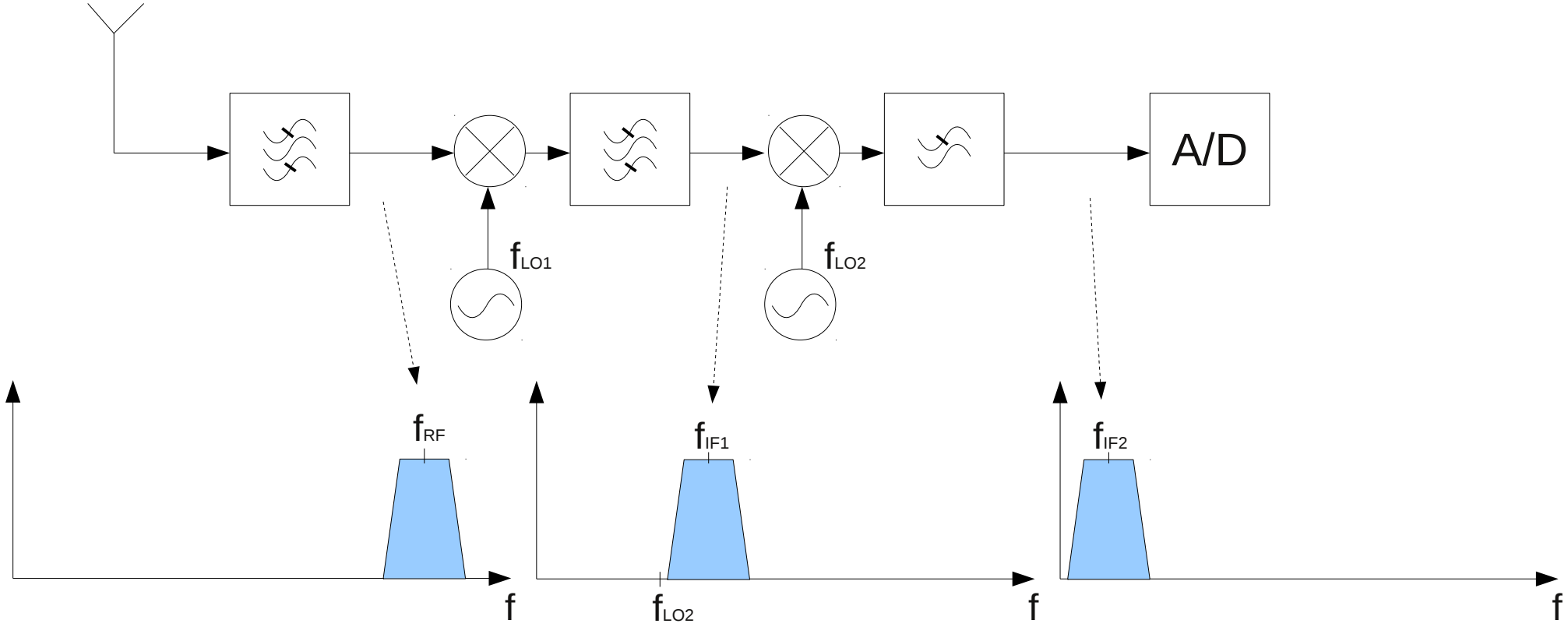


Prakticni primer:
AFSK, APT...
(S53MV DSP racunalnik)

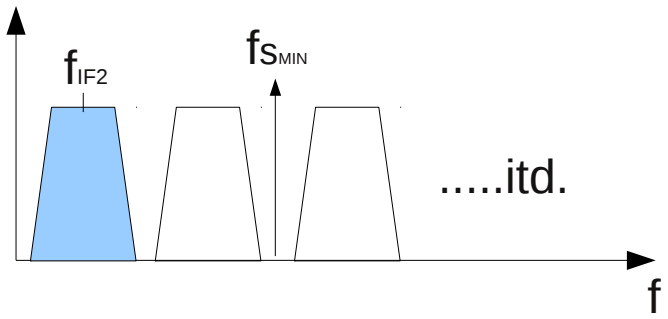


Vzorcenje nizke medfrekvence (SSB)

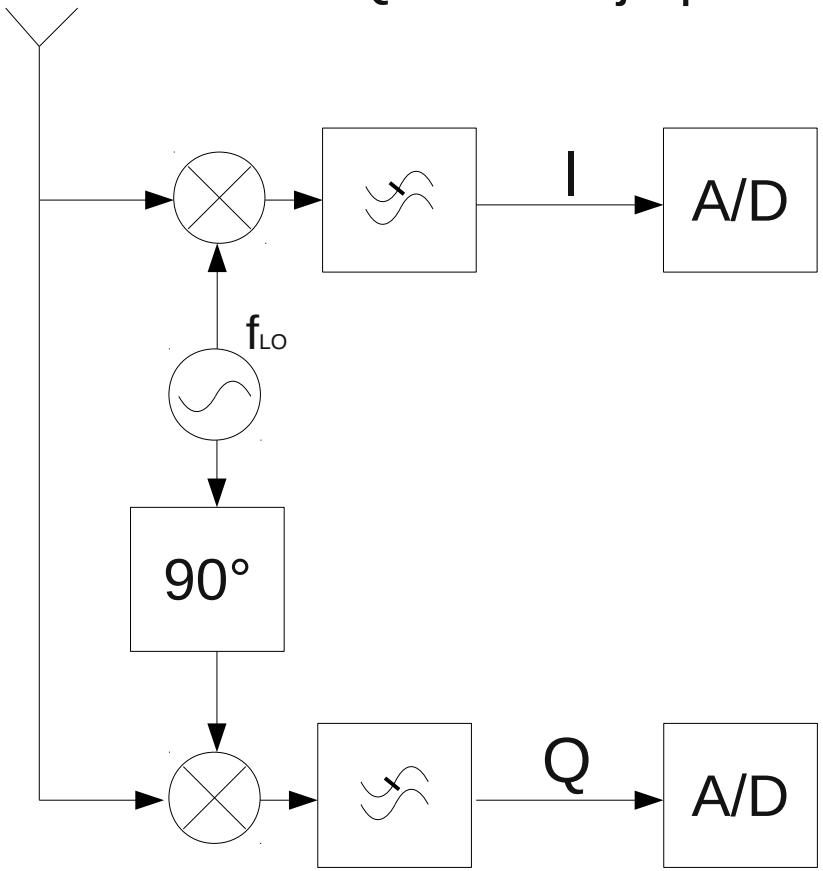
"offset baseband"

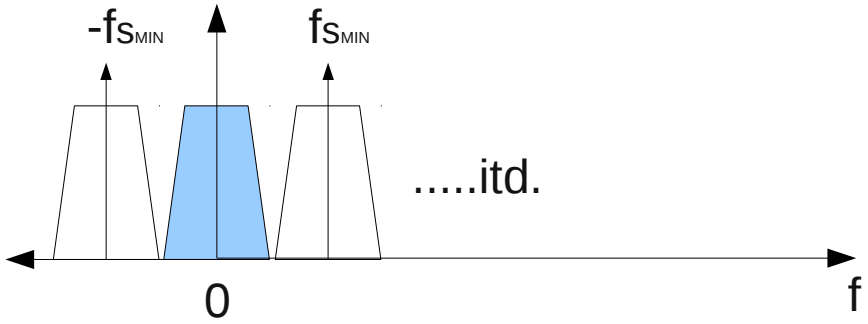


Prakticni primeri:
DRM, RTTY,
PSK31, WSJT



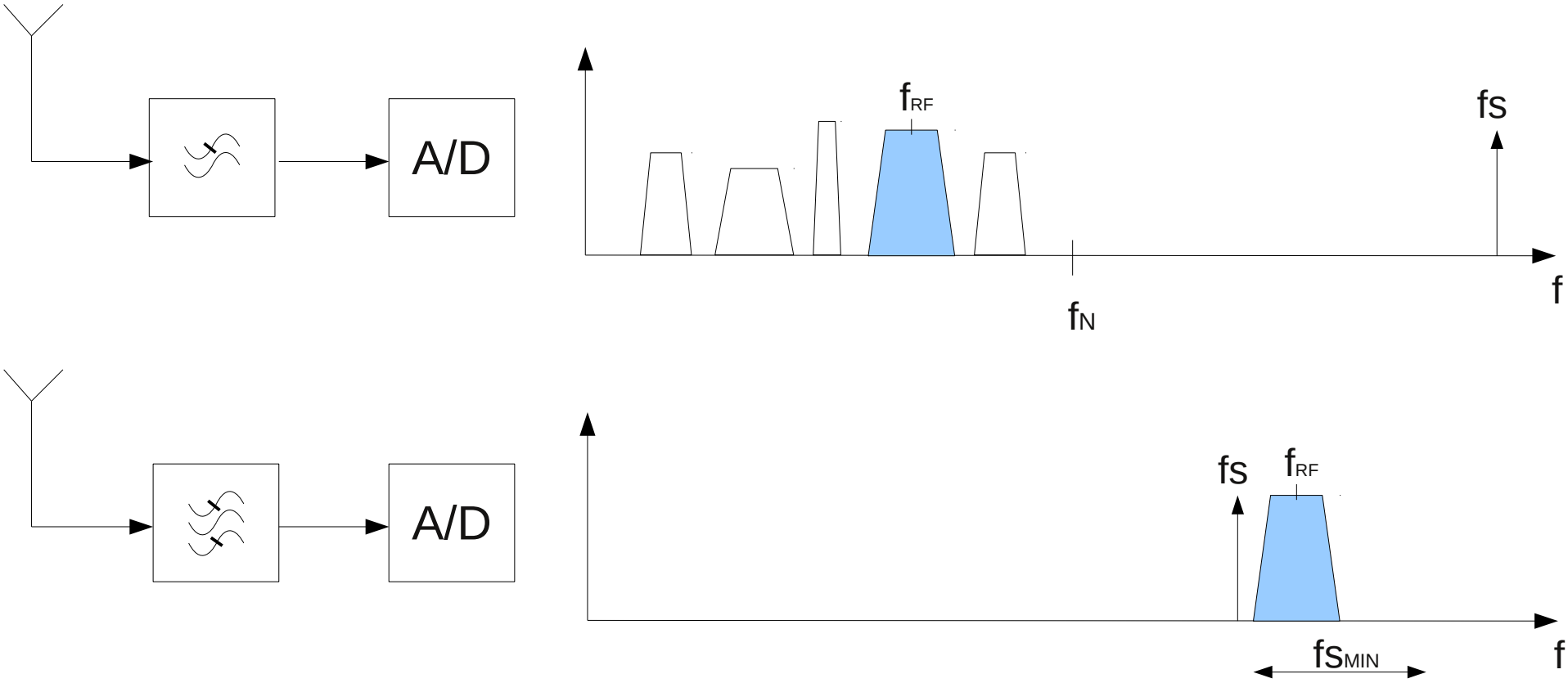
I/Q vzorcenje po direktni konverziji (zero IF)





Prakticni primeri:
GSM, GPS,
Softrock, SDR-1000, LINRAD

Direktno vzorcenje



Prakticni primeri:
Zvocna kartica: VLF (spectran)
USRP, QS1R do 2m

Nekaj A/D pretvornikov

Tip	Vzorcenje	Dinamika	Cena
Analog AD1974	24 bit 192 kHz	cca 105 dB	RS Comp: 8 eur DigiKey: 8 usd
Linear LT2379-18	18 bit 1.6 MHz	cca 100 dB	@1000 cca 30 usd
Analog AD6644	14 bit 65 MHz	cca 75 dB	RS Comp: 99 eur DigiKey: 67 usd
Linear LTC2208	16 bit 130MHz	cca 80 dB	RS Comp: 120 eur DigiKey: 130 usd
National ADC12D1800	12 bit 3.6GHz	cca 60 dB	DigiKey: 160 usd

Zmogljivosti nekaterih popularnih vmesnikov

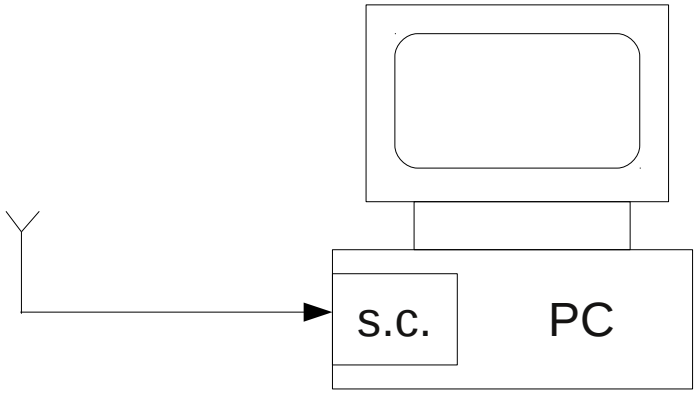
Vmesnik	bitov / sek	fs za 16 bitne vzorce
Serijski (COM port)	1M bruto	cca 40k
Paralelni (LPT port)	2.4M neto	150k
Zvocna kartica	1.5M neto	2x48k
HP-IB (IEEE 488)	8M neto	500k
USB 1.1	12M bruto	cca 600k
SCSI	40M bruto	cca 2M
Ultra wide SCSI	320M bruto	cca 15M
Firewire (IEEE1394)	400M / 800M bruto	cca 20M / 40M
USB 2.0	480M bruto	cca 20M
1000baseX Ethernet	1G bruto	cca 60M
PCI	cca 1G neto	cca 60M
SATA	1.5G / 3G / 6G	90M / 180M / 370M
USB 3.0	5G bruto / 3.2G neto	cca 200M
PCIe V2.0 16x	64G	4G

Zmogljivosti procesorjev

	mnoz/sek (max)	fs za 4xFFT1024	mnoz/vz @ fs=48kHz	mnoz/vz @ fs=60MHz	opomba
M68000, 12MHz	300k	1 kHz	6	/	INT
Pentium 3GHz, SSE	12G / jedro	40 MHz	250k	200	FLOAT
GPGPU	>10G	>33 MHz	>208k	>166	FLOAT
TMS320C476x	10G / jedro	33 MHz	208k	166	INT MACs
FPGA XILINX Spartan 6	60G	200 MHz	1.25M	1k	INT MACs
FPGA XILINX Virtex 6	1T	3.3 GHz	20M	16k	INT MACs

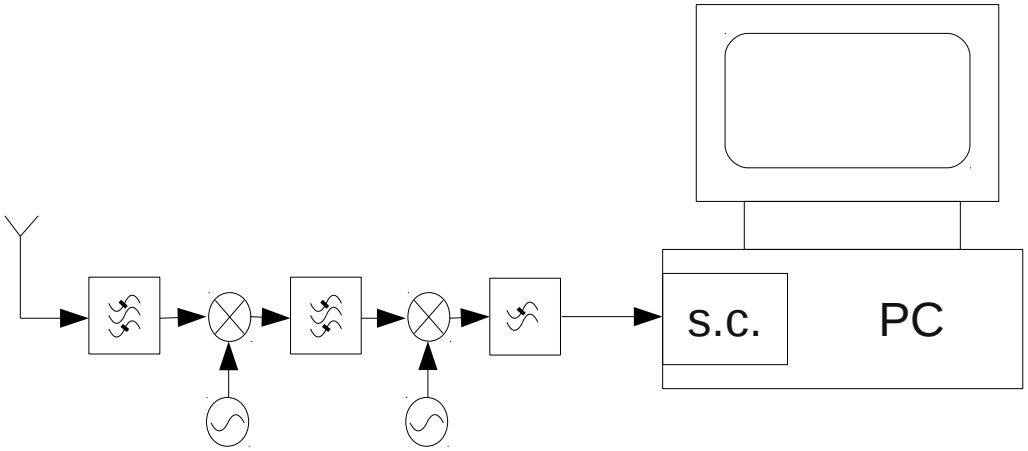
Stevilke so ZELO optimisticne!

SDR z zvocno kartico



VLF monitoring (SID)

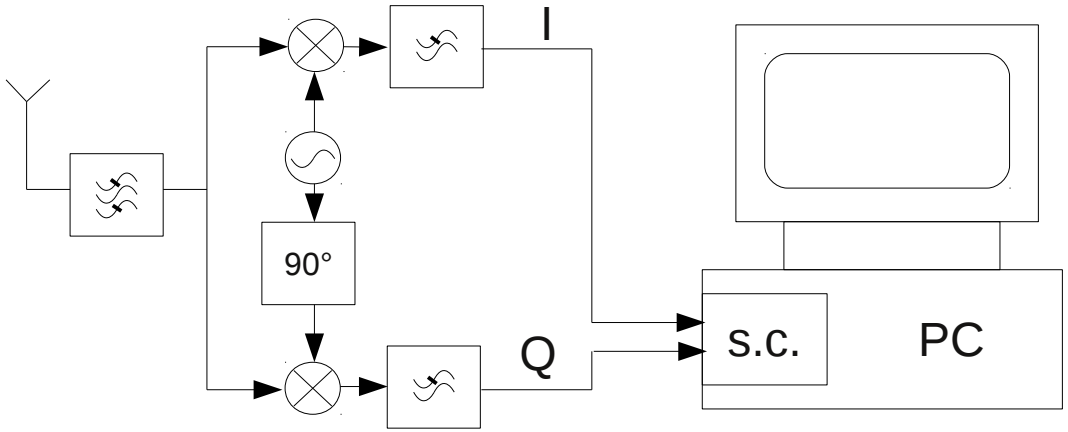
Detektor strel



Razni DRM sprejemniki

PSK31, WSJT

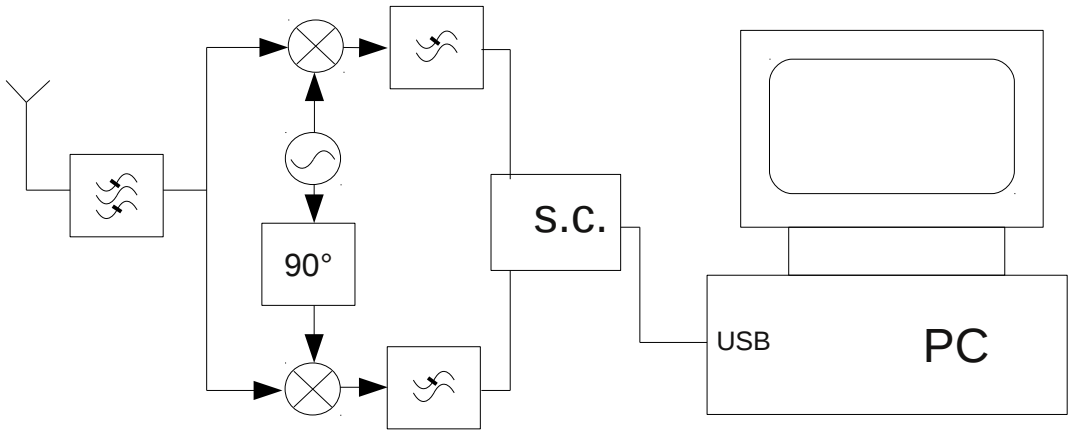
SDR z zvocno kartico



LINRAD+WSE Originalno za EME, Poudarek na max dinamiki

SOFTROCK Minimalisticen, single band RX fixwd Xtal LO, napajan iz USB (USB je samo za napajanje)

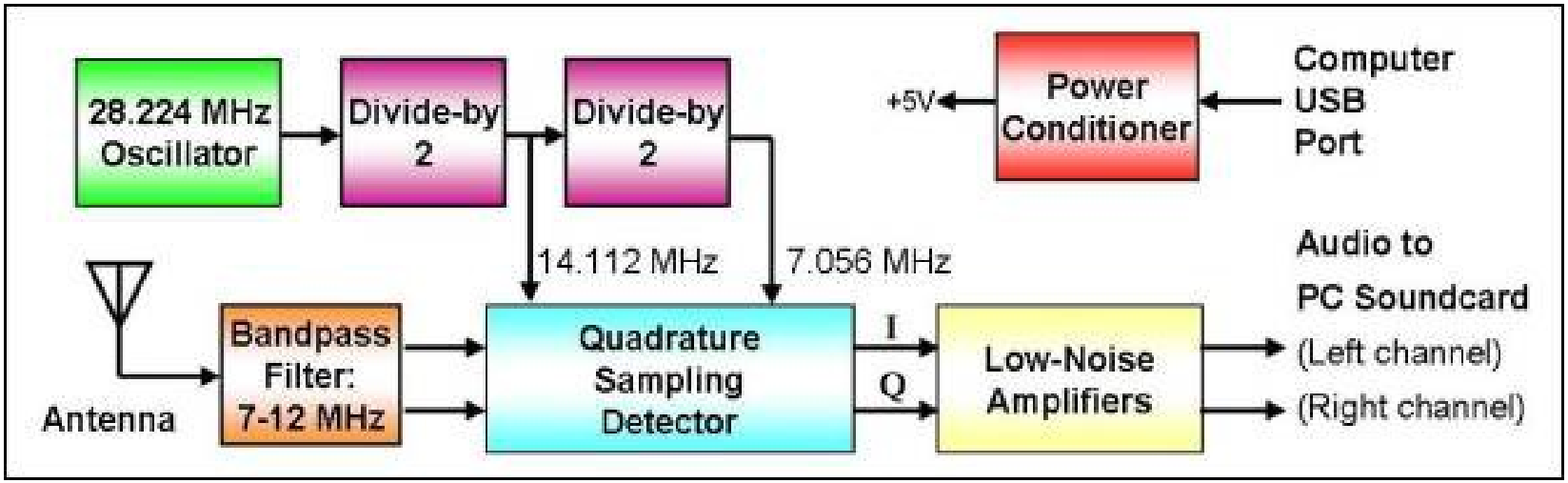
SDR-1000 12kHz-60MHz, RX/TX, 6x preselector, DDS LO upravljan preko LPT porta. Vgrajen predojacevalec, mocnostni ojacevalec, itd

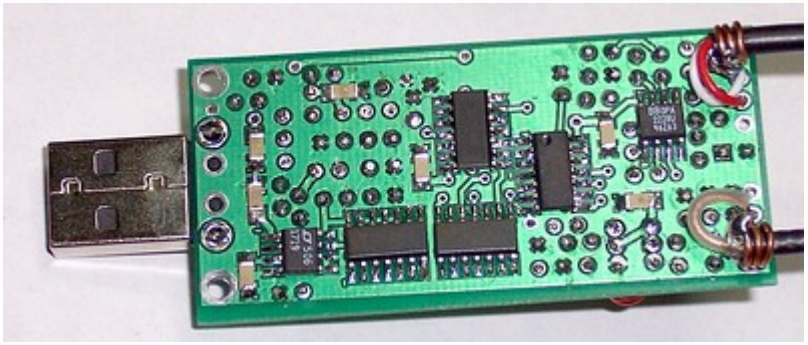


FLEX-1500 Podoben SDR-1000

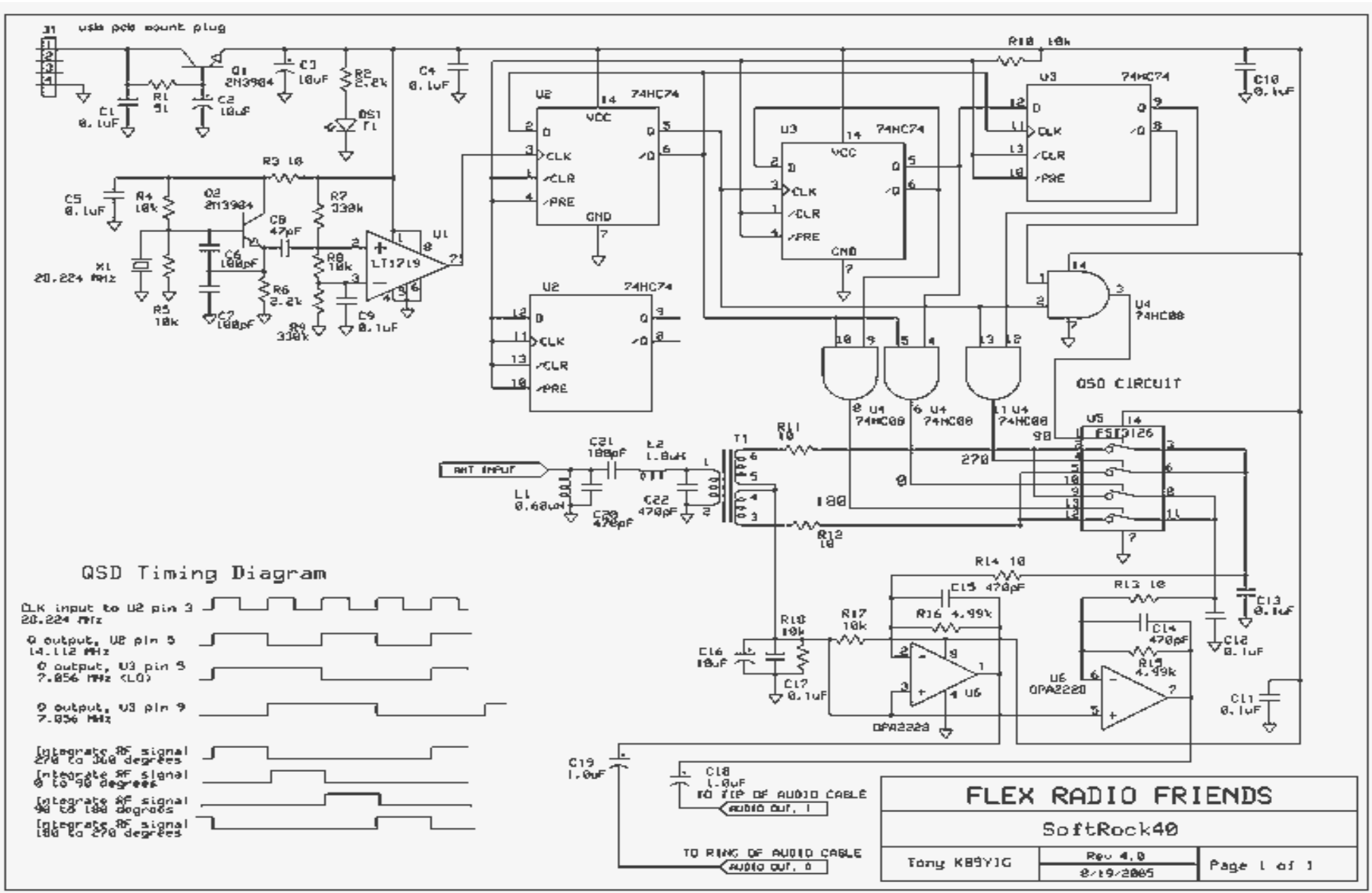
FUNCUBE 64MHz-1.7GHz, RX “USB dongle” AMSAT closed design?

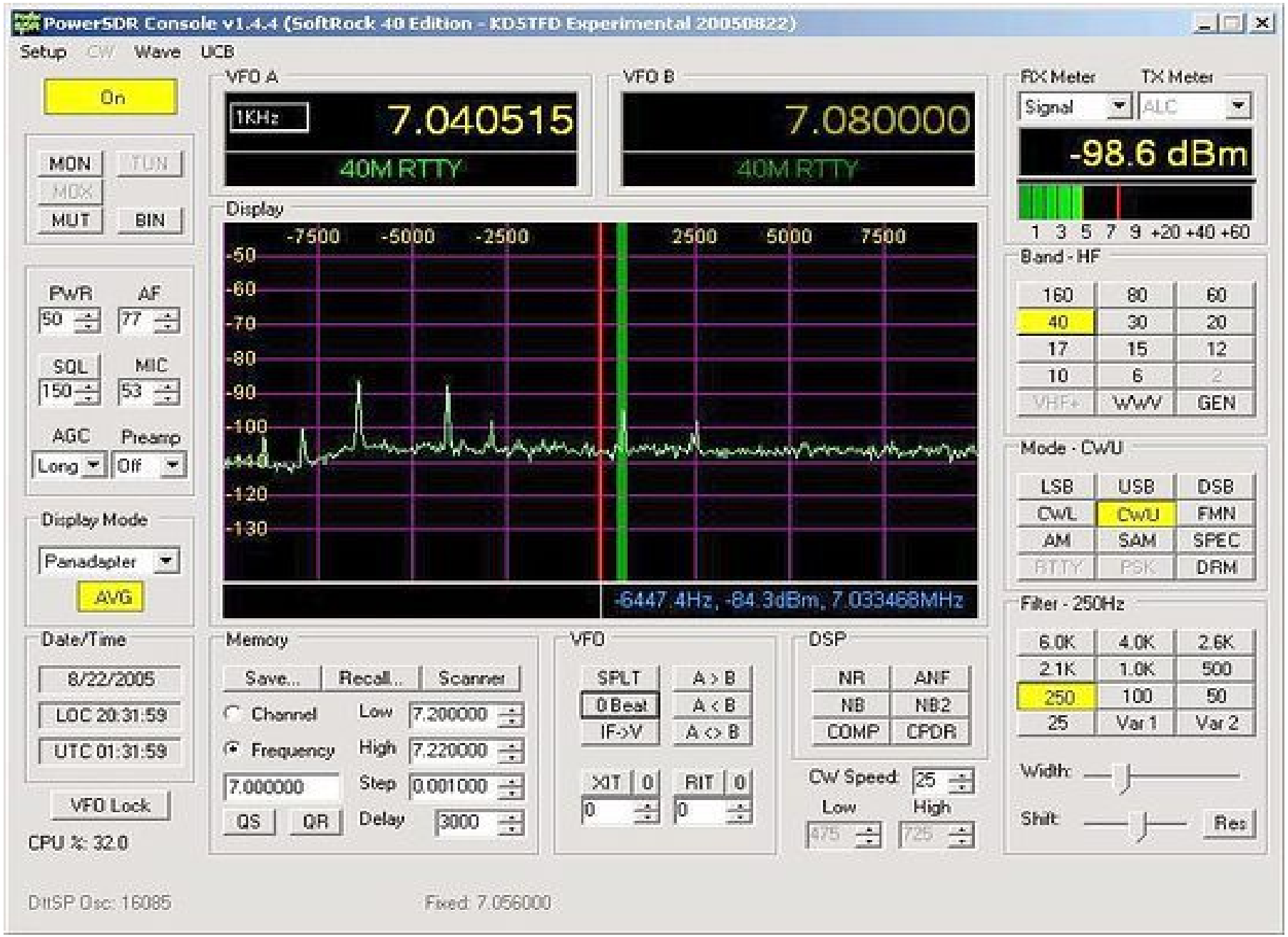
Softrock 40


28.224 MHz Oscillator
Divide-by 2
Divide-by 2
+5V
Power Conditioner
Computer USB Port
14.112 MHz
7.056 MHz
Audio to PC Soundcard
Antenna
Bandpass Filter: 7-12 MHz
Quadrature Sampling Detector
I
Q
Low-Noise Amplifiers
(Left channel)
(Right channel)

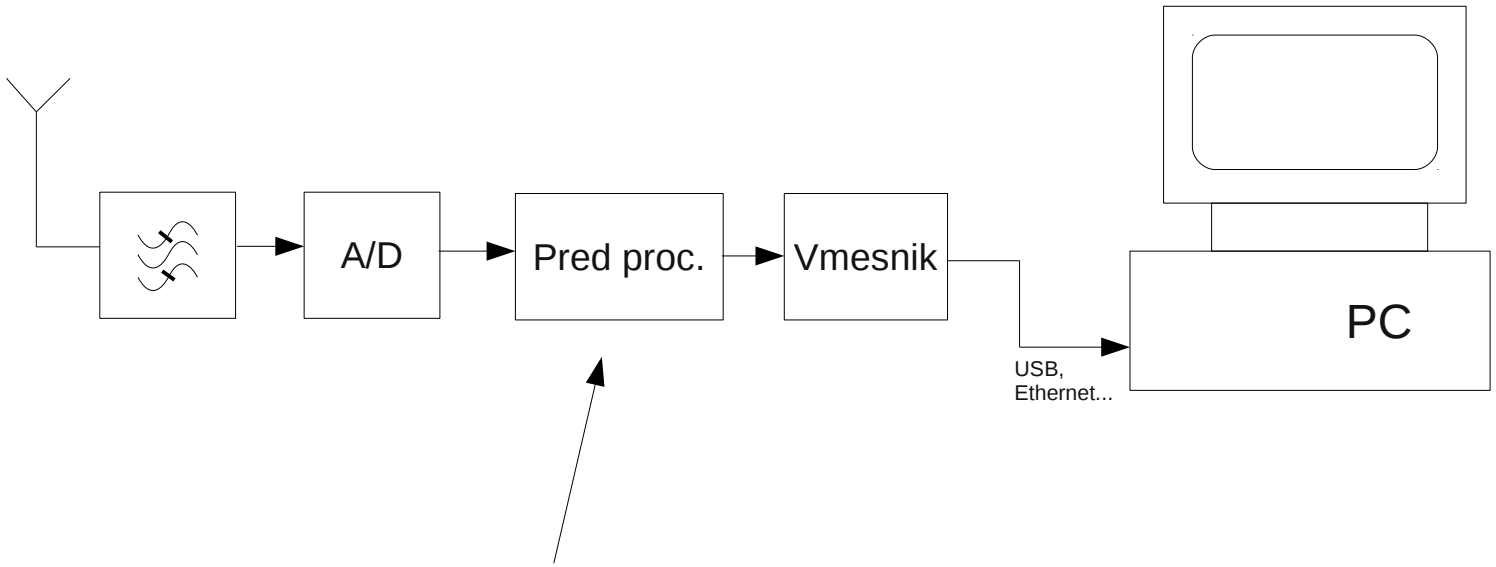



SoftRock40_v4.0


J1 usb pcb mount plug
Q1 2N3904
C3 10uF
R2 2.2k
C4 0.1uF
C1 0.1uF
R1 51
C2 10uF
DS1 F1
R3 10
C5 0.1uF
R4 10k
Q2 2N3904
R7 330k
C8 47pF
U1 LT1219
X1 20.224 MHz
C6 100pF
R8 10k
R5 10k
R6 2.2k
C7 100pF
R9 330k
C9 0.1uF
U2 74HC74
VCC
GND
D
CLK
/CLR
/PRE
Q
/Q
U3 74HC74
R10 10k
C10 0.1uF
U4 74HC08
QSD CIRCUIT
U5 FSD126
270
0
180
90
C21 100pF
L2 1.8uH
T1
ANT INPUT
L1 0.68uH
C20 470pF
C22 470pF
R11 10
R12 10
R14 10
C15 470pF
R13 10
R16 4.99k
R18 10k
R17 10k
C16 10uF
C17 0.1uF
U6 OPA2220
C14 470pF
R15 4.99k
C13 0.1uF
C12 0.1uF
C11 0.1uF
C19 1.0uF
C18 1.0uF
TO TIP OF AUDIO CABLE
AUDIO OUT, I
TO RING OF AUDIO CABLE
AUDIO OUT, Q
QSD Timing Diagram
CLK input to U2 pin 3
20.224 MHz
Q output, U2 pin 5
14.112 MHz
Q output, U3 pin 5
7.056 MHz (LO)
Q output, U3 pin 9
7.056 MHz
Integrate RF signal
270 to 360 degrees
Integrate RF signal
0 to 90 degrees
Integrate RF signal
90 to 180 degrees
Integrate RF signal
180 to 270 degrees
FLEX RADIO FRIENDS
SoftRock40
Tony KB9YIG
Rev 4.0
8/19/2005
Page 1 of 1


PowerSDR Console v1.4.4 (SoftRock 40 Edition - KD5TFD Experimental 20050822)
Setup
CW
Wave
UCB
On
MON
TUN
MOX
MUT
BIN
PWR
50
AF
77
SQL
150
MIC
53
AGC
Long
Preamp
Off
Display Mode
Panadapter
AVG
Date/Time
8/22/2005
LOC 20:31:59
UTC 01:31:59
VFO Lock
CPU %: 32.0
VFO A
1KHz
7.040515
40M RTTY
VFO B
7.080000
40M RTTY
Display
-7500
-5000
-2500
2500
5000
7500
-50
-60
-70
-80
-90
-100
-120
-130
-6447.4Hz, -84.3dBm, 7.033468MHz
FDX Meter
Signal
TX Meter
ALC
-98.6 dBm
1 3 5 7 9 +20 +40 +60
Band - HF
160
80
60
40
30
20
17
15
12
10
6
2
VHF+
WWV
GEN
Mode - CWU
LSB
USB
DSB
CWL
CWU
FMN
AM
SAM
SPEC
RTTY
PSK
DRM
Filter - 250Hz
6.0K
4.0K
2.6K
2.1K
1.0K
500
250
100
50
25
Var 1
Var 2
Width
Shift
Res
Memory
Save...
Recall...
Scanner
Channel
Frequency
7.000000
QS
QR
Low
7.200000
High
7.220000
Step
0.001000
Delay
3000
VFO
SPLT
0 Beat
IF->V
A > B
A < B
A <> B
XIT
0
RIT
0
DSP
NR
ANF
NB
NB2
COMP
CPDR
CW Speed
25
Low
475
High
725
DttSP Osc: 16085
Fixed: 7.056000

SDR s hitrim A/D in predprocesiranjem



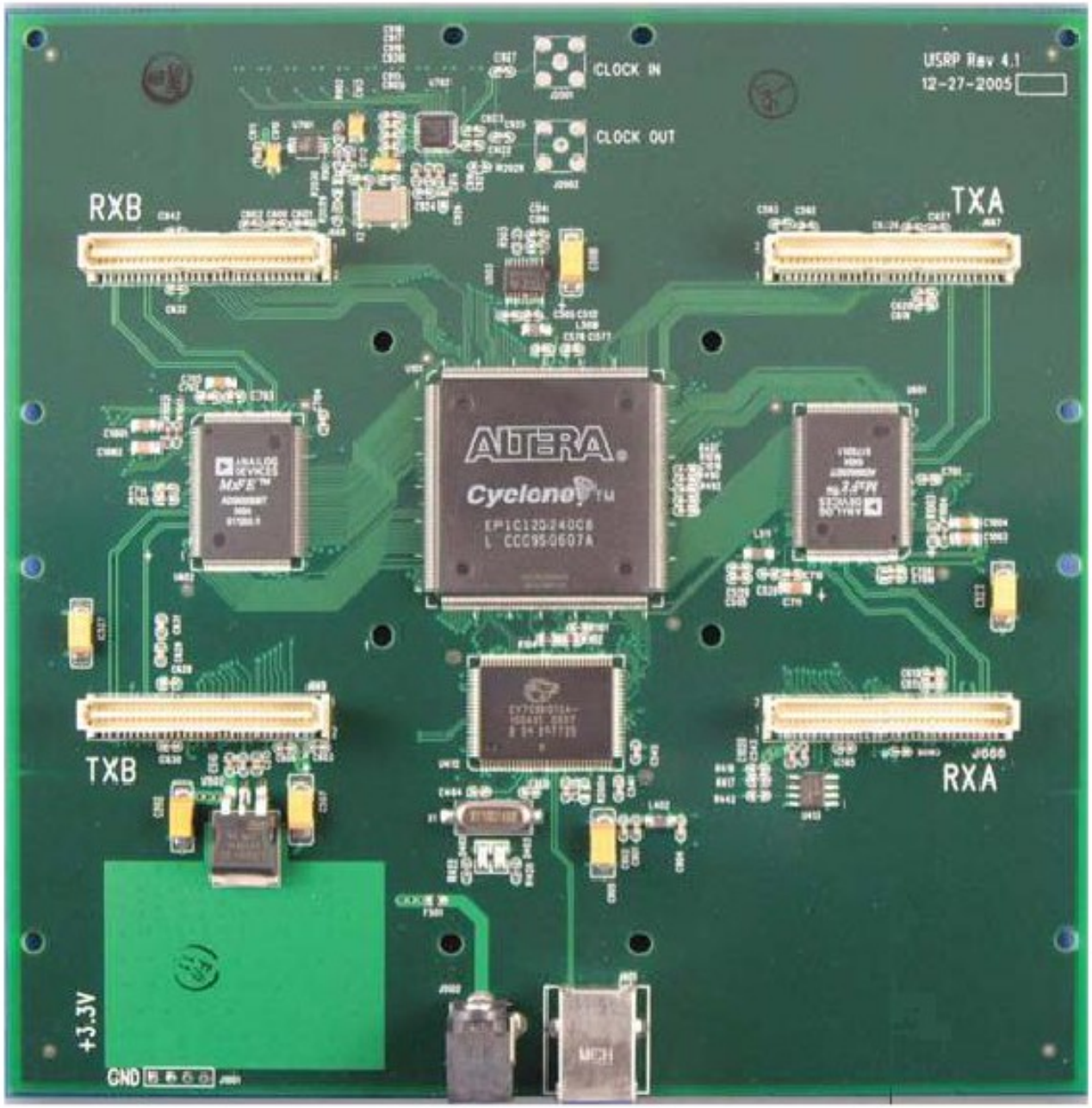
Predprocesiranje:
- ponavadi na FPGA
- digitalni oscilator + mesanje
- pasovno / nizko sito
- decimacija
- I/Q detekcija
....

SDR-14
SDR-IQ
SDR-IP
Perseus
QS1R
HPSDR
USRP
USRP-2
USRP-N200
...

SDR vmesniki za PC s hitrimi A/D pretvorniki In predprocesiranjem

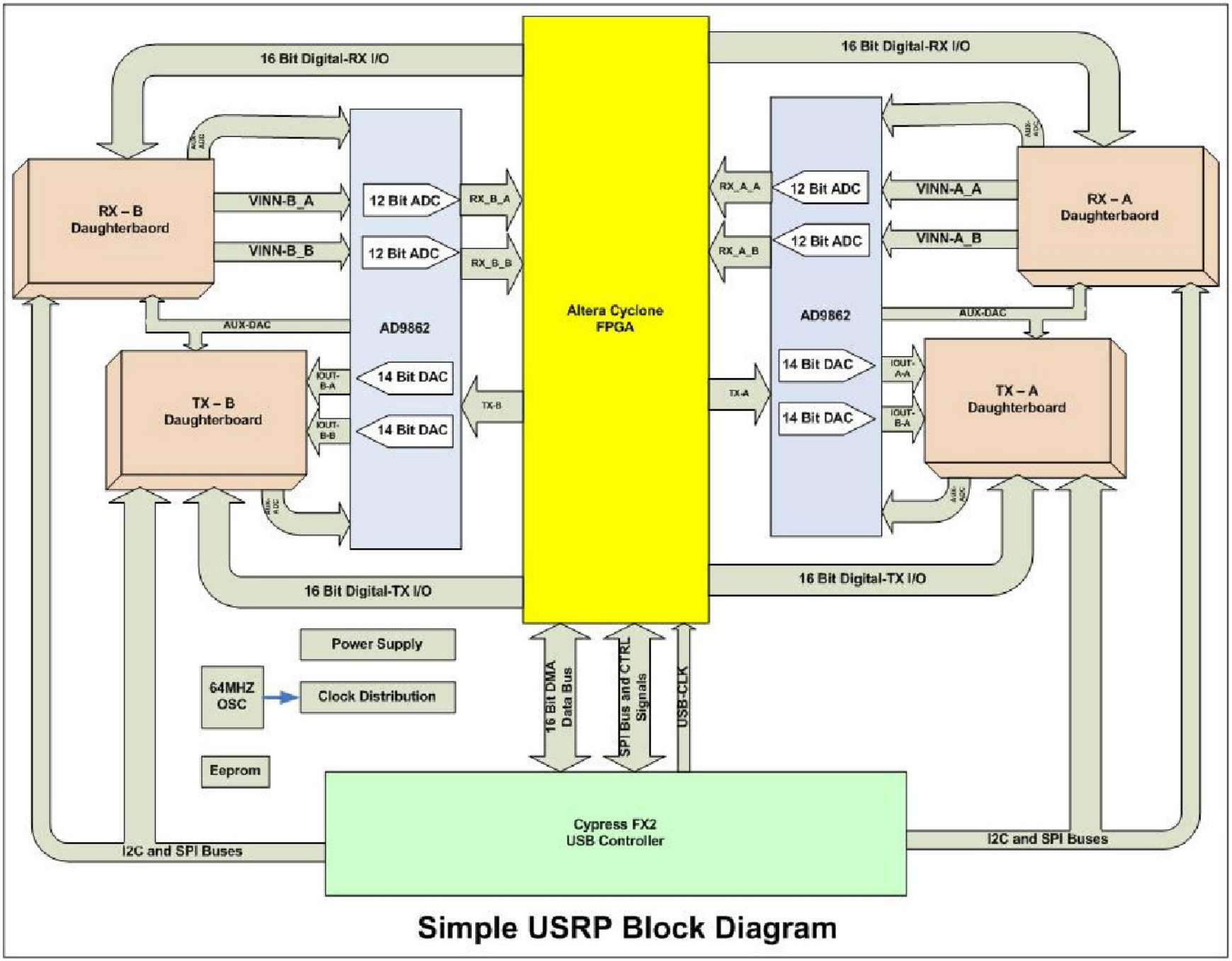
	Vhodi	Izhodi	BW na PC	CIP	Vmesnik	Preselekt.	opombe
SDR-14	1x 14bit @ 66MHz	ne	192kHz	?	USB2 ?	da, +att	
Perseus	1x 14bit @ 80MHz LTC2206	ne	1MHz	Spartan 3 XC35250 12 mnoz.	USB2	da	
QS1R	1x 16 bit @ 130MHz LTC2208	ne		Cyclone 3 EP3C25 66 mnoz.	USB2	ne	1000 USD "SEMI OPEN"
HPSDR	16 bit @ 130MHz LTC2208	da	200k	Cyclone 3 EP3C25 66 mnoz.	"atlas"	ne *	OPEN, kompliciran (vec ploscic)
USRP	2x (4x) 12bit @ 64MHz AD9862	2x (4x) 14 bit @ 128 Mhz AD9862	8MHz	Cyclone EP1C12Q240 0 mnoz.	USB2	ne **	700 USD OPEN
USRP-2	2x 14 bit @ 100MHz	2x 16bit @ 400MHz	25MHz	Spartan 3 XC3S2000	Ethermet 1000	ne **	1000 USD OPEN

USRP

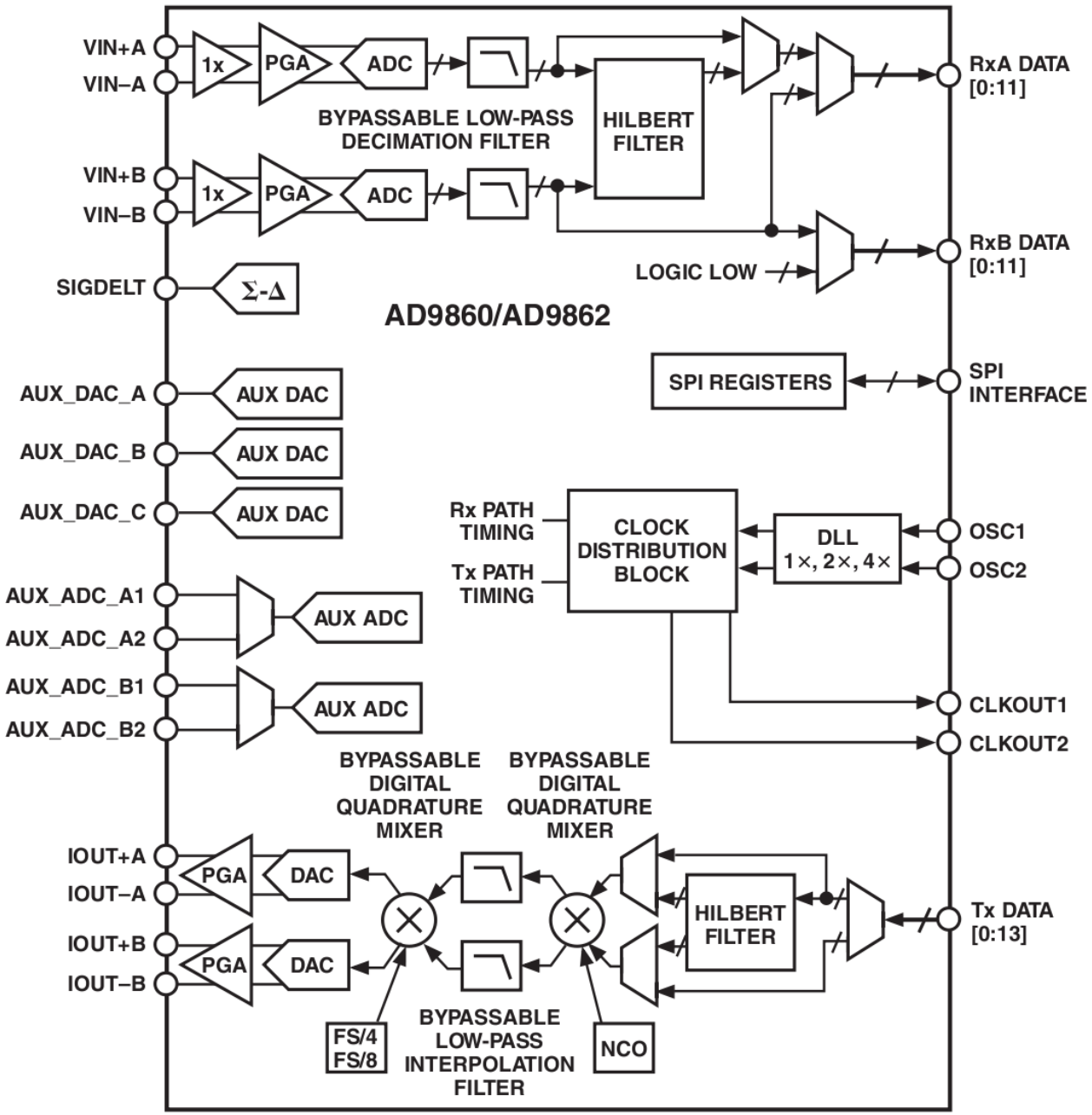


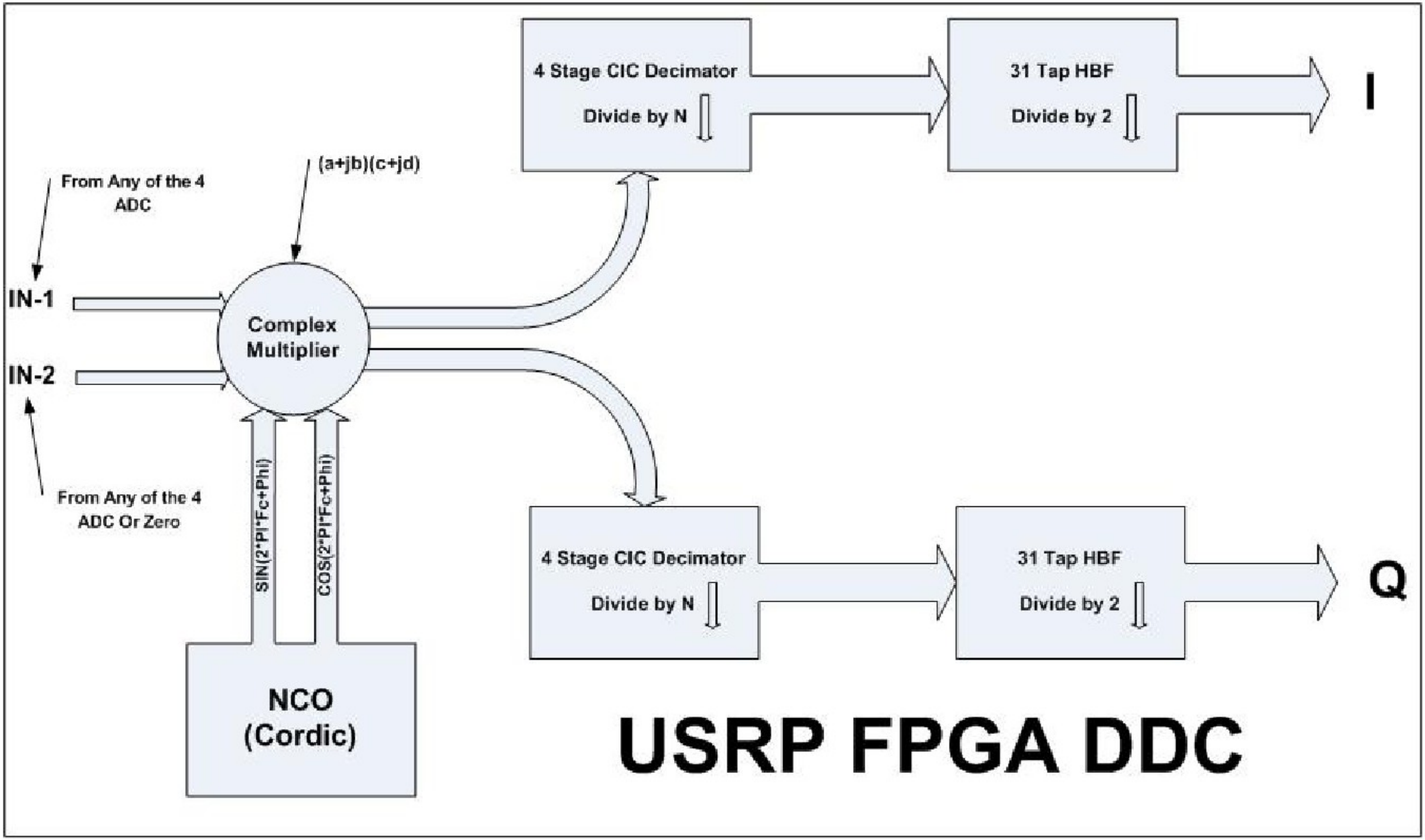
USRP Motherboard

USRP


16 Bit Digital-RX I/O
16 Bit Digital-RX I/O
RX – B
Daughterbaord
VINN-B_A
VINN-B_B
12 Bit ADC
12 Bit ADC
RX_B_A
RX_B_B
AD9862
AUX-DAC
TX – B
Daughterboard
14 Bit DAC
14 Bit DAC
TX-B
Altera Cyclone
FPGA
RX_A_A
RX_A_B
12 Bit ADC
12 Bit ADC
AD9862
14 Bit DAC
14 Bit DAC
TX-A
VINN-A_A
VINN-A_B
RX – A
Daughterbaord
AUX-DAC
TX – A
Daughterboard
16 Bit Digital-TX I/O
16 Bit Digital-TX I/O
Power Supply
64MHZ
OSC
Clock Distribution
Eeprom
16 Bit DMA
Data Bus
SPI Bus and CTRL
Signals
USB-CLK
Cypress FX2
USB Controller
I2C and SPI Buses
I2C and SPI Buses
Simple USRP Block Diagram

USRP: AD9862


VIN+A
VIN–A
1x
PGA
ADC
BYPASSABLE LOW-PASS DECIMATION FILTER
HILBERT FILTER
RxA DATA [0:11]
VIN+B
VIN–B
RxB DATA [0:11]
LOGIC LOW
SIGDELT
Σ-Δ
AD9860/AD9862
SPI REGISTERS
SPI INTERFACE
AUX_DAC_A
AUX_DAC_B
AUX_DAC_C
AUX DAC
Rx PATH TIMING
Tx PATH TIMING
CLOCK DISTRIBUTION BLOCK
DLL 1×, 2×, 4×
OSC1
OSC2
AUX_ADC_A1
AUX_ADC_A2
AUX_ADC_B1
AUX_ADC_B2
AUX ADC
CLKOUT1
CLKOUT2
BYPASSABLE DIGITAL QUADRATURE MIXER
IOUT+A
IOUT–A
IOUT+B
IOUT–B
DAC
Tx DATA [0:13]
FS/4 FS/8
BYPASSABLE LOW-PASS INTERPOLATION FILTER
NCO


4 Stage CIC Decimator
Divide by N
31 Tap HBF
Divide by 2
I
From Any of the 4 ADC
(a+jb)(c+jd)
IN-1
IN-2
Complex Multiplier
From Any of the 4 ADC Or Zero
SIN(2*PI*Fc+Phi)
COS(2*PI*Fc+Phi)
4 Stage CIC Decimator
Divide by N
31 Tap HBF
Divide by 2
Q
NCO (Cordic)
USRP FPGA DDC

Samostojni SDR (vgrajen racunalnik)

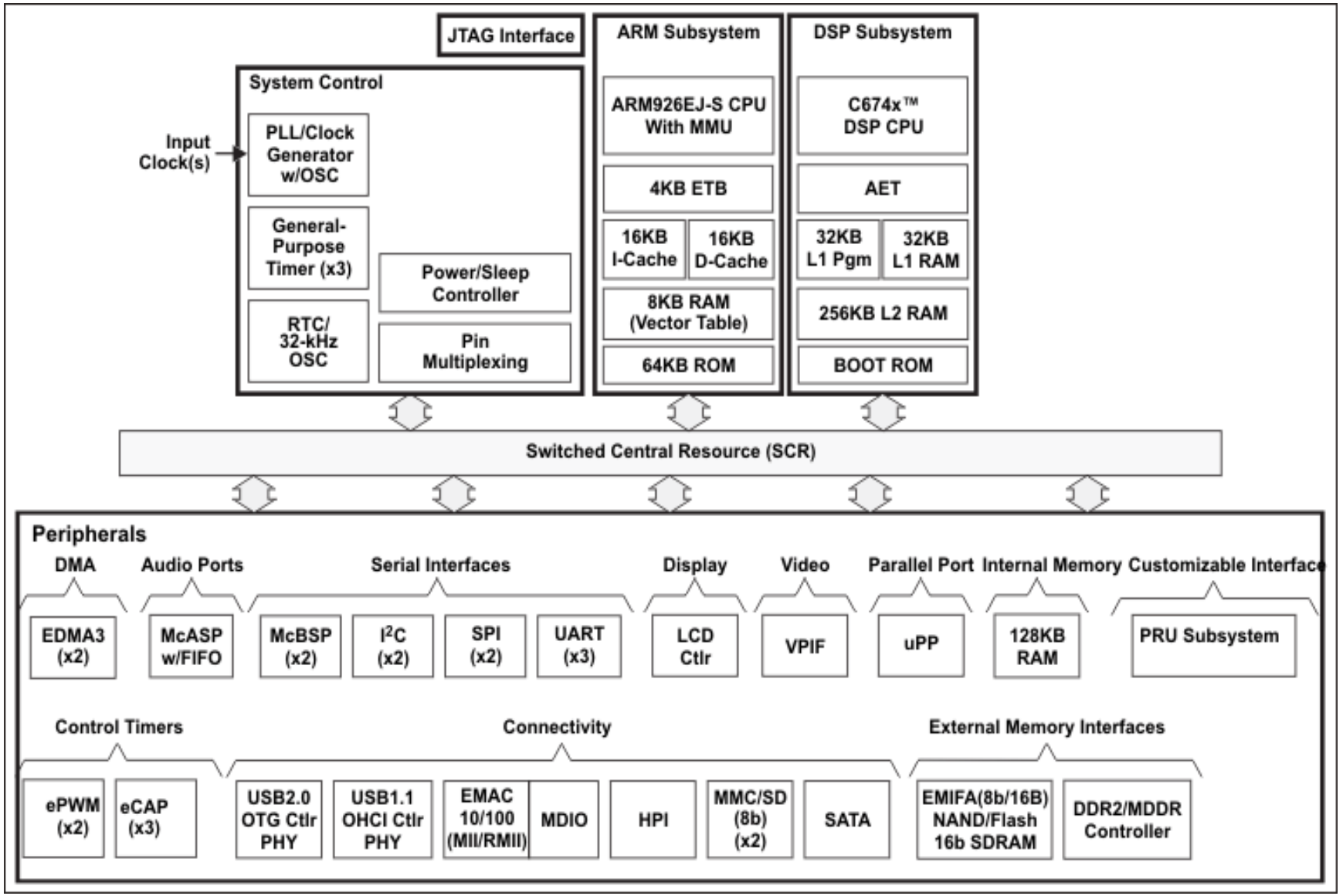
FLEX-5000C

Vgrajen mini-ITX PC racunalnik Intel core 2 duo
Windows XP
192 kHz vzorcenje
kompleten Rx/TX z analognim delom (100W TX)
cca 4000 USD ??

USRP E100

Vgrajen OMAP3 (ARM cortex A8 + TI C64x+ DSP)
ARM LINUX
2X 12bit 64MHz vhod
2X 14 bit 128MHz izhod
Spartan 3A-DSP1800 FPGA
1300 USD

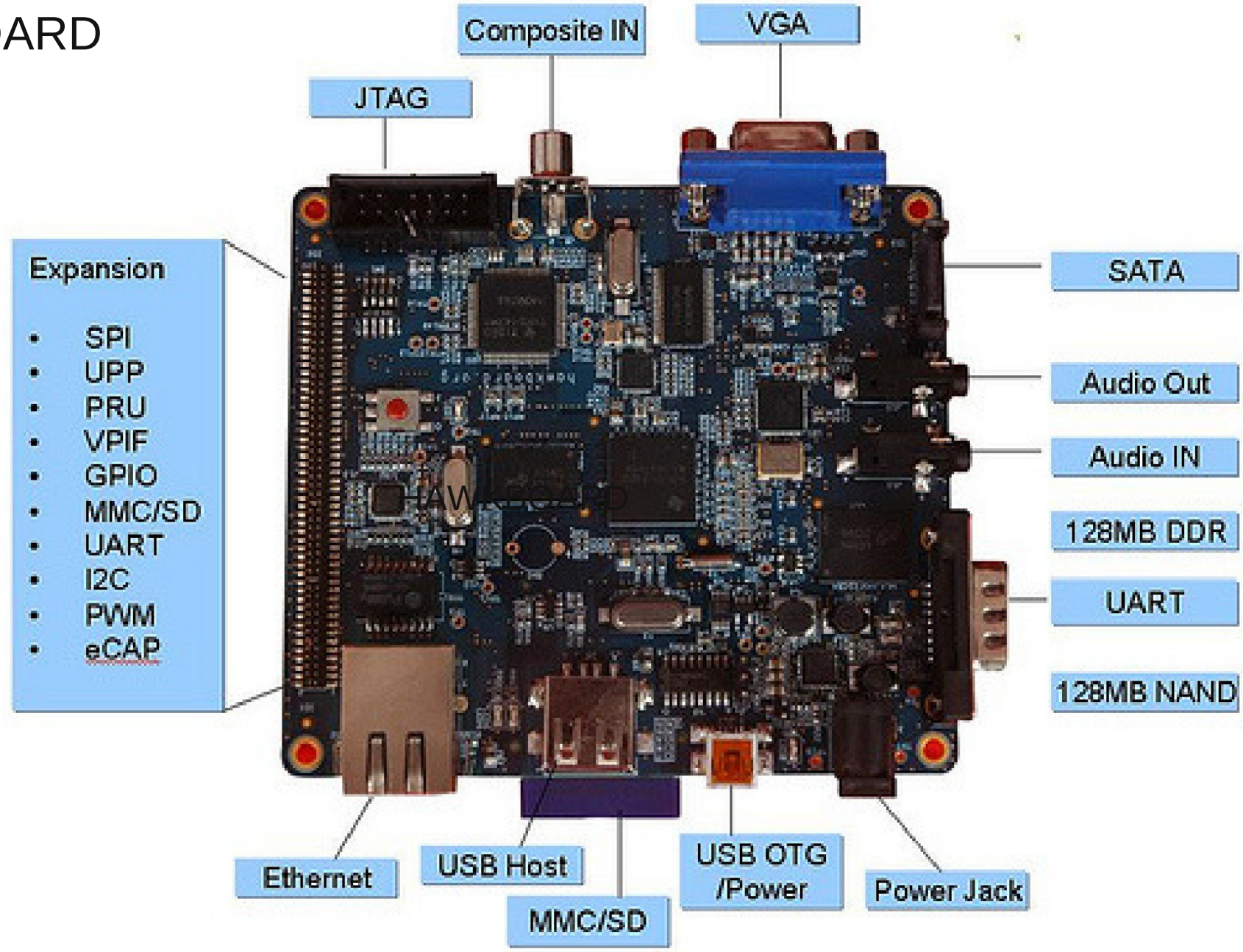
TI OMAP L138


JTAG Interface
ARM Subsystem
DSP Subsystem
System Control
Input Clock(s)
PLL/Clock Generator w/OSC
General-Purpose Timer (x3)
RTC/ 32-kHz OSC
Power/Sleep Controller
Pin Multiplexing
ARM926EJ-S CPU With MMU
4KB ETB
16KB I-Cache
16KB D-Cache
8KB RAM (Vector Table)
64KB ROM
C674x™ DSP CPU
AET
32KB L1 Pgm
32KB L1 RAM
256KB L2 RAM
BOOT ROM
Switched Central Resource (SCR)
Peripherals
DMA
Audio Ports
Serial Interfaces
Display
Video
Parallel Port
Internal Memory
Customizable Interface
EDMA3 (x2)
McASP w/FIFO
McBSP (x2)
I2C (x2)
SPI (x2)
UART (x3)
LCD Ctlr
VPIF
uPP
128KB RAM
PRU Subsystem
Control Timers
Connectivity
External Memory Interfaces
ePWM (x2)
eCAP (x3)
USB2.0 OTG Ctlr PHY
USB1.1 OHCI Ctlr PHY
EMAC 10/100 (MII/RMII)
MDIO
HPI
MMC/SD (8b) (x2)
SATA
EMIFA(8b/16B) NAND/Flash 16b SDRAM
DDR2/MDDR Controller

TI OMAP demo ploscice

	CPU	MEM	MASS STOR	COM	DISP	EXP
HAWK cca 9x10cm 90 EUR OMAP L138	300MHz 1x ARM926EJ-S 1x TMS320C674x (float)	RAM 128M FLASH 128M	SATA I & II SD/MMC	RS232 Ethernet 100 1x USB 2 slave 1x USB 1.1 host	VGA (LCD)	UPP, VPIF, PRU, 2x UART, 2xSPI, I2C,HRPWM, GPIO, Audio I/O, video IN
BEAGLE cca 8x8cm 128 EUR OMAP 3530	700MHz 1x ARM Coretex A8 1x TMS320C64x	RAM 256M FLASH 256M	SD/MMC	(RS232) 1xUSB 2 slave 1x USB 2 host	DVI-D S-video (LCD)	UART, McSPI, GPIO, PWM, Audio I/O
PANDA cca 10x12cm 175 USD OMAP 4430	1GHz 2x ARM9+SIMD 1x DSP??	RAM 1G	SD/MMC	RS232 Ethernet 100 1x USB 2 slave 2x USB 2 host Bluetooth WLAN	DVI-D HDMI (Video out) (LCD)	Camera, UART, SPI, I2C, GPMC, VBUS, USB host, Handsfree

HAWKBOARD


Composite IN
VGA
JTAG
Expansion
SPI
UPP
PRU
VPIF
GPIO
MMC/SD
UART
I2C
PWM
eCAP
SATA
Audio Out
Audio IN
128MB DDR
UART
128MB NAND
Ethernet
USB Host
MMC/SD
USB OTG /Power
Power Jack