Titolo

Analisi di spettro su segnali I&Q mediante scheda audio PC (fino 190 KHz)

C. Bortolotti, M. Roma

Rapporto interno IRA 475/13

Indice:

Schede tecniche allegate:

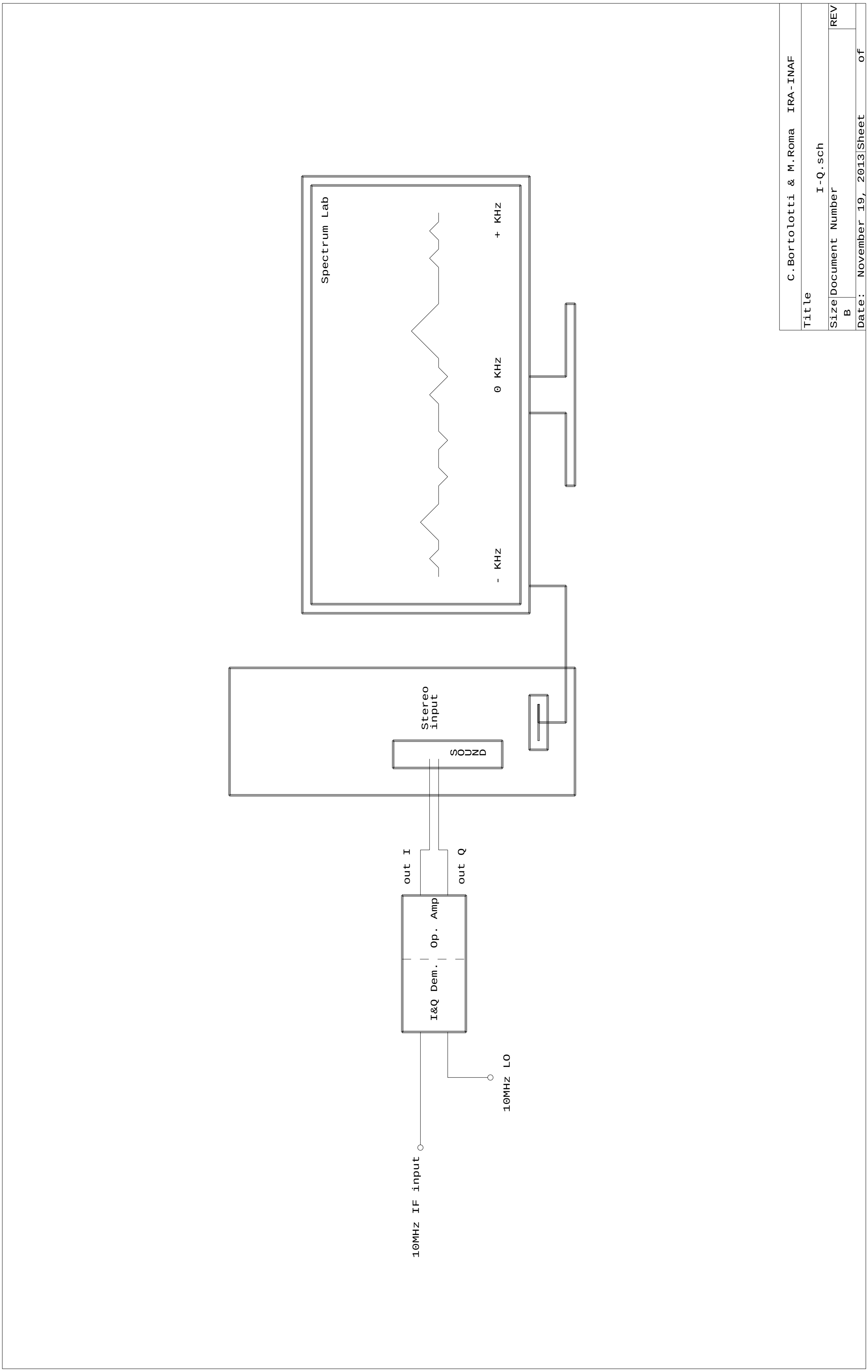
A. Demodulatore I&Q Mini-Circuits MIQA-10D
B. Amplificatore Operazionale LMH6702
C. Scheda audio PC ASUS XONAR D2/PM

Descrizione del sistema

In questo rapporto interno viene descritto un dispositivo “low cost” per analisi di spettro in bande relativamente strette (max 190 KHz) realizzato con pochi componenti ed utilizzando un normale PC, ma con prestazioni interessanti sia in risoluzione spettrale che velocità di elaborazione e visualizzazione.

Lo schema a blocchi, riportato nella pagina seguente, evidenzia la semplice architettura di tale sistema, che in pratica si riduce ai seguenti componenti:

- Dispositivo demodulatore I&Q con amplificazione del segnale “audio”
- PC dotato di scheda audio con ingresso stereo
- DL4YHF's Amateur radio software: Audio Spectrum Analyzer "**Spectrum Lab**" scaricabile in rete sul sito http://www.qsl.net/dl4yhf/spectra1.html



10MHz IF input
10MHz LO
I&Q Dem.
Op. Amp
out I
out Q
SOUND
Stereo input
Spectrum Lab
- KHz
0 KHz
+ KHz
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Demodulazione ed amplificazione segnale I&Q

Il progetto si basa sulla realizzazione di un ricevitore a conversione diretta.
La conversione diretta in banda base risulta circuitalmente molto semplice richiedendo un numero esiguo di componenti per la sua realizzazione, inoltre si ottengono migliori caratteristiche se confrontate con un ricevitore di tipo supereterodina.

Si è individuato come elemento cardine per la realizzazione di questo ricevitore il componente MIQA-10D della Mini-Circuits, frequenza RF/OL 9-11 MHz, che integra al suo interno i 4 elementi costituenti il vero demodulatore I&Q che sono:

- divisore per 2 a 0° di sfasamento
- divisore per 2 con le uscite sfasate tra loro di 90°
- mixer che ha come ingressi RF e LO non sfasato
- mixer che ha come ingressi RF e LO sfasato di 90°

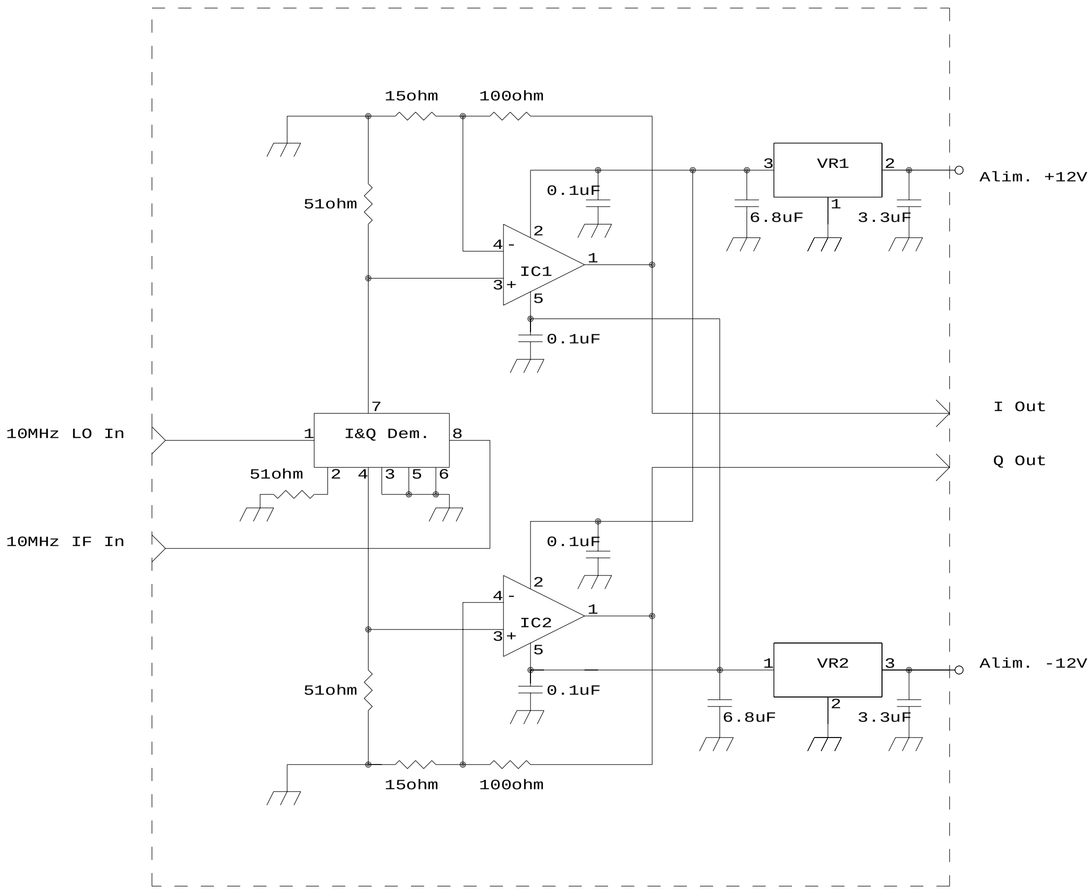
Al demodulatore vengono applicati rispettivamente sul pin 8 e sul pin 1 i segnali d'ingresso RF e OL.
Il segnale RF viene splittato dal divisore per 2 a 0° di sfasamento e le 2 uscite divengono gli ingressi RF dei successivi 2 mixer.
Il segnale dell'OL viene splittato dal secondo divisore a 90°, l'uscita a 0° di sfasamento arriva all'ingresso OL del mixer che così effettua la conversione della parte reale I in uscita sul pin 7, mentre l'altra uscita diviene l'ingresso OL del secondo mixer per la conversione della parte immaginaria Q in uscita sul pin 4.

Le due uscite I e Q vengono amplificate a livelli ottimali (gain = 8) dai due moduli operazionali LMH6702 che seguono, questi sono stati scelti con una banda passante molto larga al fine di non introdurre sfasamenti spuri che avrebbero deteriorato l'ortogonalità tra parte reale e parte immaginaria.

Il circuito sopra descritto è stato realizzato su una schedina in vetronite spessore 1,2 mm, lavorata in dual-layer mediante apposita fresina.
Il tutto è contenuto in una piccola scatola metallica connettorizzata SMA, comprensiva di n.2 regolatori di tensione +/- 5V per incrementarne l'isolamento.

I segnali I e Q sono quindi inviati mediante cavo schermato agli ingressi Left e Right della scheda audio descritta in seguito ed utilizzata come digitalizzatore.

Il circuito sopra descritto opera nella banda 9-11 MHz, tale banda può essere variata impiegando altri tipi di demodulatore.



LEGENDA :

I&Q Dem.: M.C. MDQA-10D

IC1-2: Op. Amp. National MLH6702 (G=8)

VR1: 78L05
VR2: 79L05

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Scheda audio PC

Spectrum Lab è il programma che viene utilizzato per l'analisi dei dati, questo software usa come digitalizzatore (ADC) la scheda audio del PC, a seguito dei primi test effettuati abbiamo riscontrato la necessità di dotarci di una scheda audio più performante dotata di banda passante più estesa di quella standard montata internamente nei comuni computer (24-48 KHz).

La scelta è caduta su una scheda connettorizzata PCI della ditta Asus modello Xonar D2/PM che oltre ad avere una banda passante di 96KHz per canale (massimo S.R. 192kHz) possiede anche un'ottima dinamica grazie all' ADC Cirrus Logic CS5381*1 di cui è dotata (24 bit / 120dB SNR), ulteriore caratteristica ricercata per il nostro utilizzo.

Le caratteristiche complete della scheda audio sono riportate nell'allegato C.

Programma “Spectrum Lab”

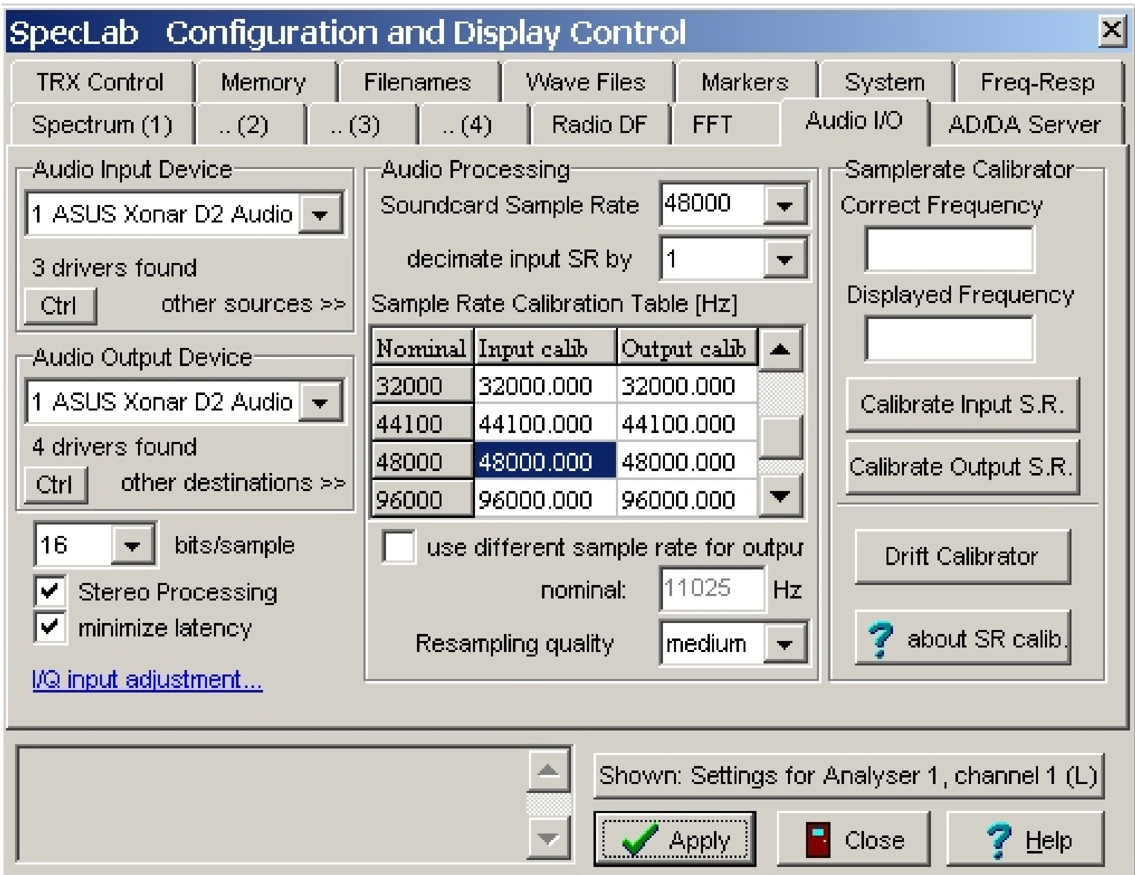
Il software utilizzato è prodotto da DL4YHF (Wolfgang "Wolf" Büscher) e come detto si tratta di un Audio Spectrum Analyzer chiamato "**Spectrum Lab**" che realizza l’FFT del segnale. Questo programma può essere utilizzato in diverse configurazioni e dispone di molti ausili, anche relativamente complessi.

Il segnale da analizzare opportunamente amplificato viene acquisito tramite la scheda audio del PC e, in funzione della configurazione di utilizzo, deve essere fornito mono (audio semplice) o stereo (segnale I&Q).

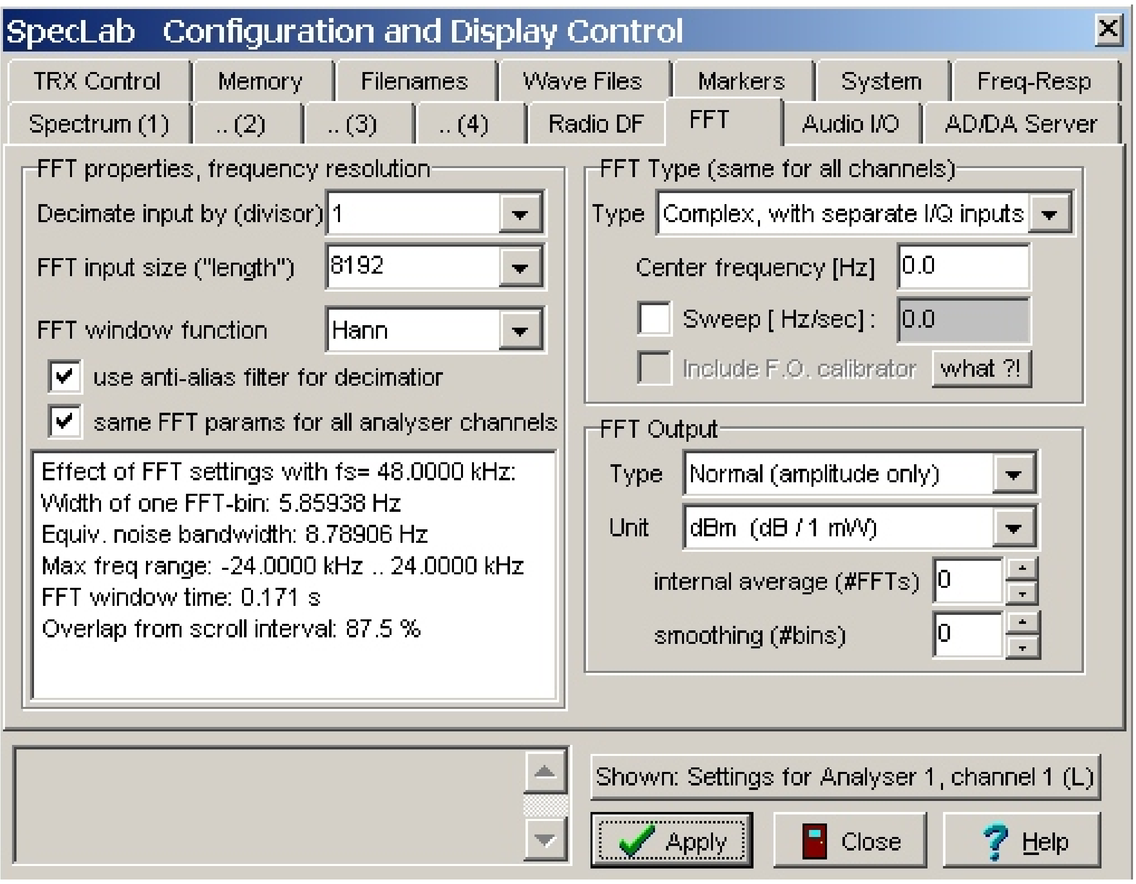
Nel nostro caso, come detto in precedenza, abbiamo adottato la configurazione I&Q in quanto questa tecnica rende più facile la conversione di segnali IF in banda base, mantenendo una buona reiezione di immagine tra USB ed LSB. Inoltre, a parità di frequenza di campionamento della scheda audio utilizzata, questa tecnica permette l’analisi di una banda con larghezza doppia.

Il software è scaricabile dal sito http://www.qsl.net/dl4yhf/spectra1.html ed una volta installato necessità di alcune impostazioni preliminari. Seguono n.4 immagini (relative al menù a tendina ***Option***) che riportano i principali settaggi da noi adottati per l’utilizzo di Spectrum Lab in configurazione I&Q:
in questo caso Sample Rate = 48000 e FFT size = 8192 per un Noise BW eq. di 8,7 Hz.

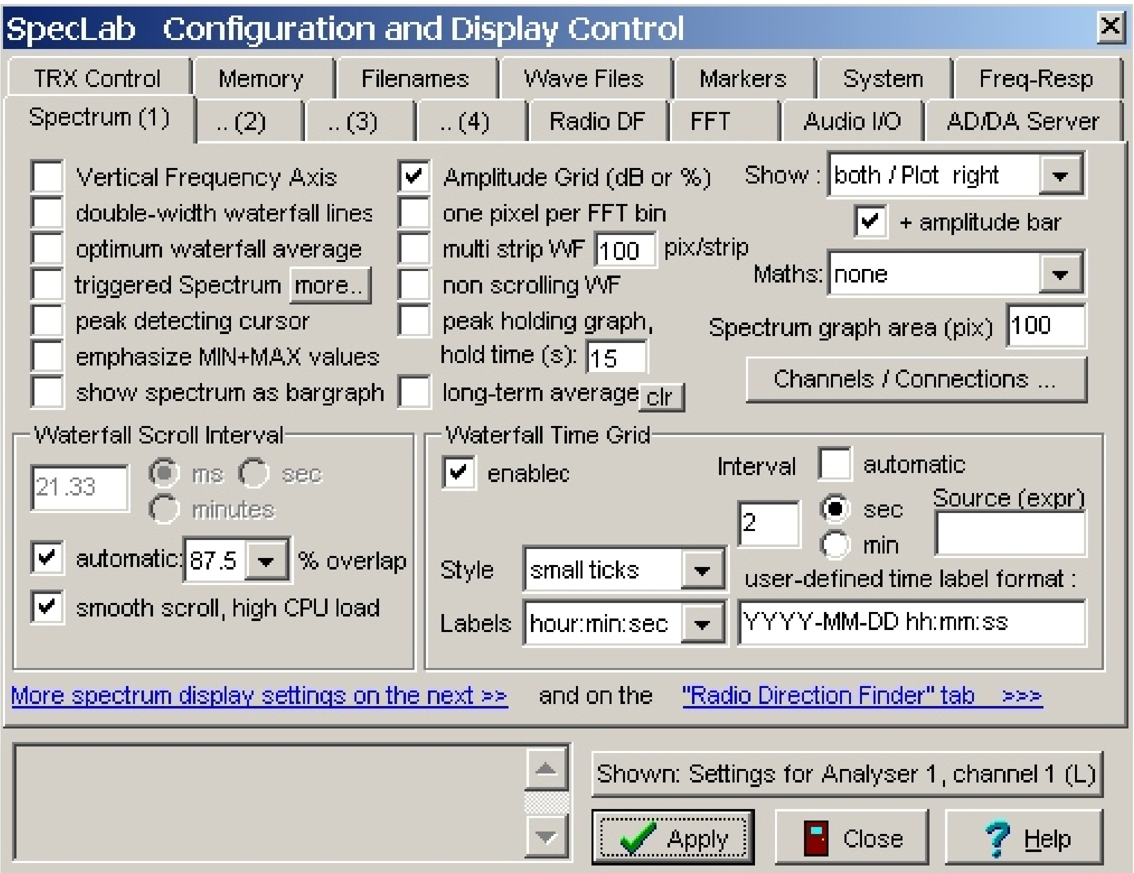
sottomenù Audio I/O



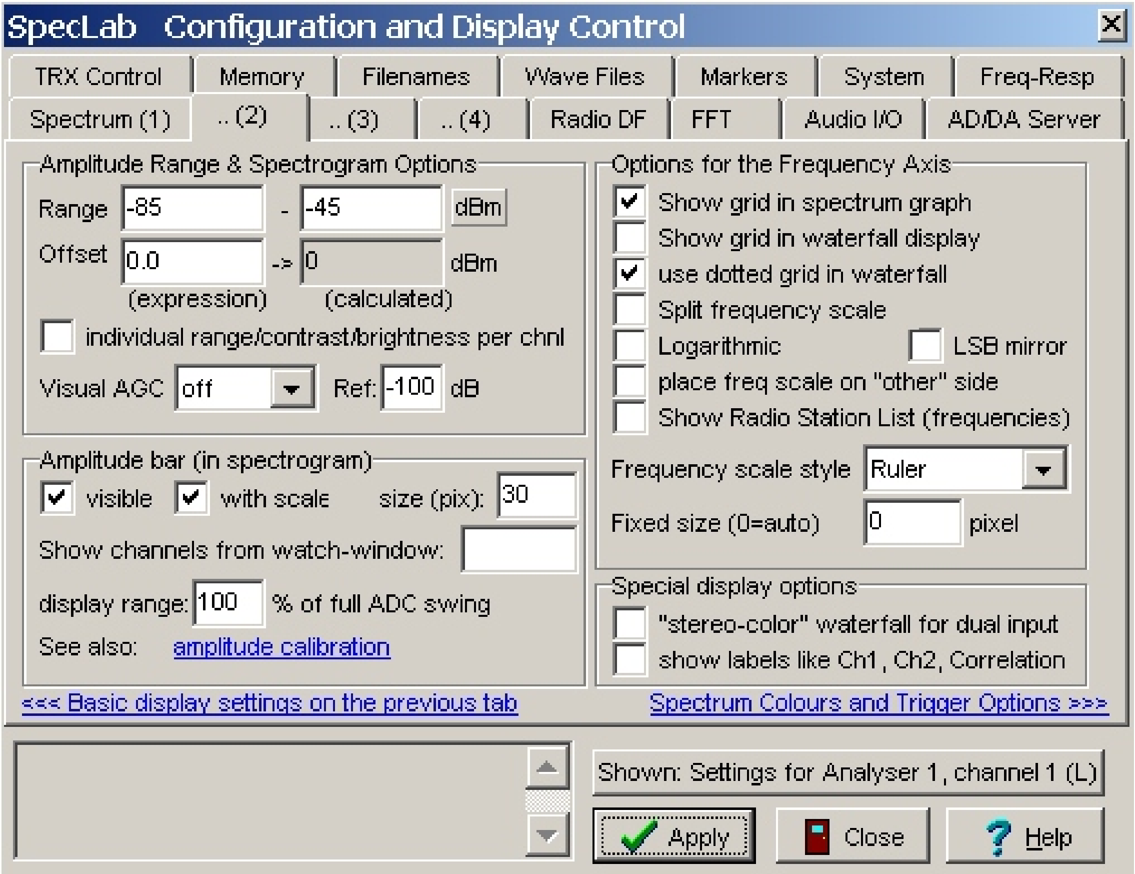
sottomenù FFT



Sottomenù Spectrum (1)



Sottomenù Spectrum (2)



Nella pagina che segue viene riportata l'immagine di una "schermata" tipica del programma "SpecLab" che oltre a visualizzare lo spettro istantaneo del segnale acquisito ne memorizza l'andamento (colore in funzione dell'ampiezza) con un grafico tipo cascata (waterfall). La velocità di scorrimento di questo grafico è funzione del numero di FFT, della S.R. (e dal grado di overlap) impostati:

- Sample Rate da 5512 a 192000
- FFT da 32 a 524288
- velocità massima della "cascata" fino a 200 linee al Sec.

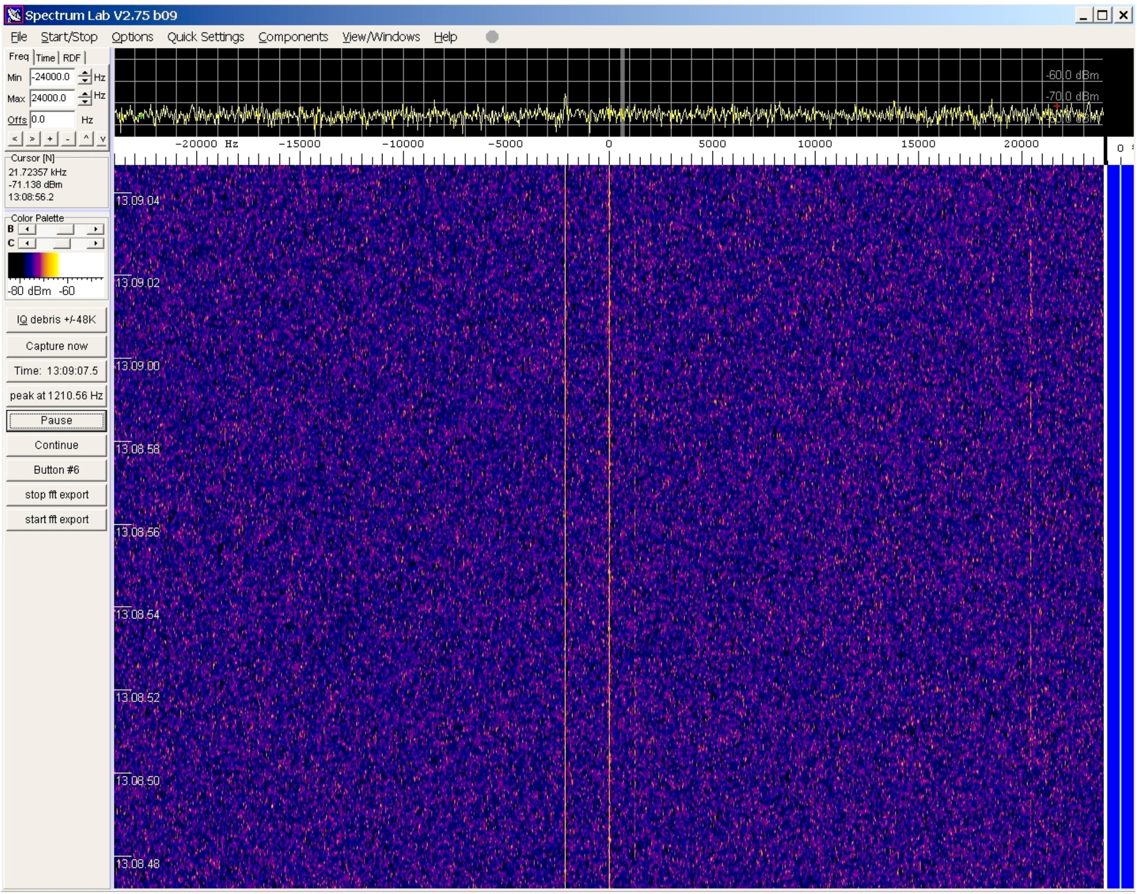
Nell'immagine, oltre allo 0Hz, sono visibili alcuni segnali attorno a –2 e +22 KHz.

Il software permette anche di visualizzare lo spettro relativo alla media di un certo numero di FFT (average), di abilitare una seconda traccia che memorizza temporaneamente i picchi della traccia (peak-hold) ed altre numerose funzioni, tra cui l'esecuzione in automatico di alcune operazioni "schedulate", oltre al salvataggio di file tipo immagine, audio o dati.

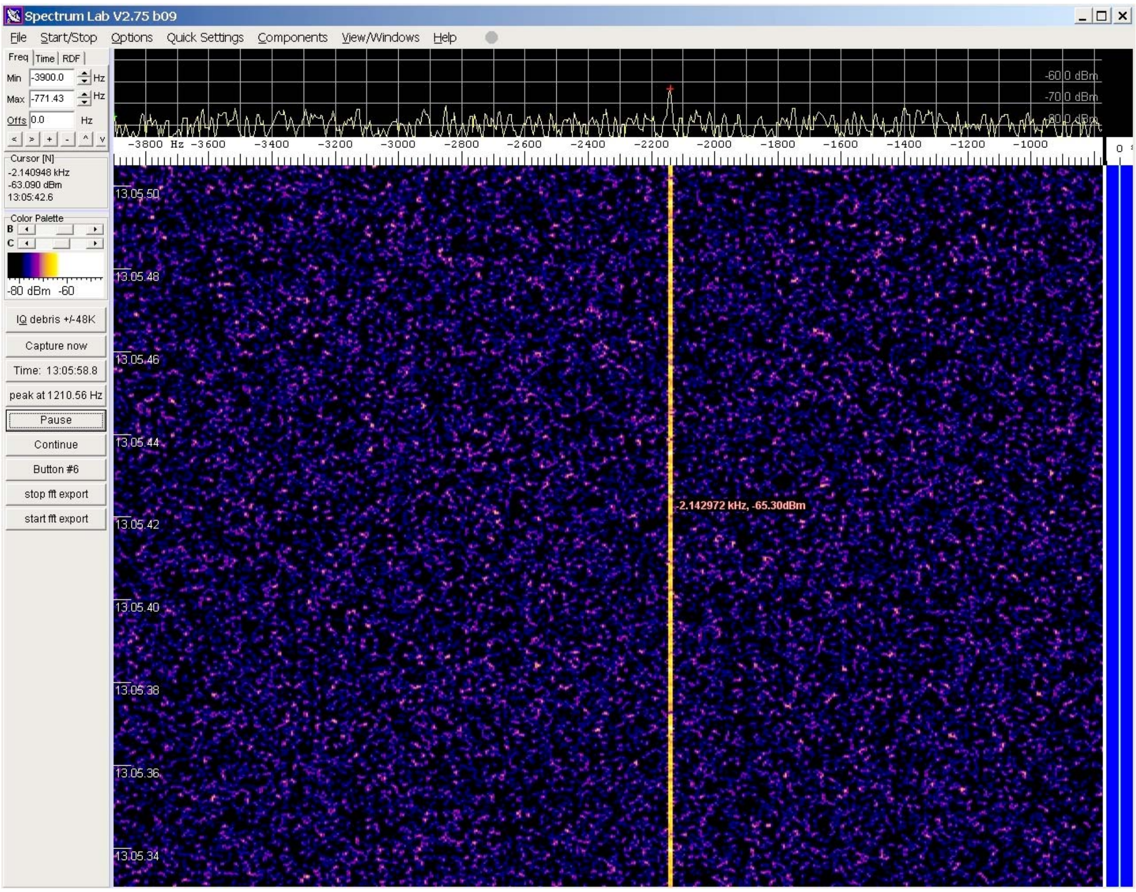
La seconda immagine riportata mostra come sia possibile effettuare lo zoom dei segnali acquisiti e misurarne alcuni parametri mediante marker.

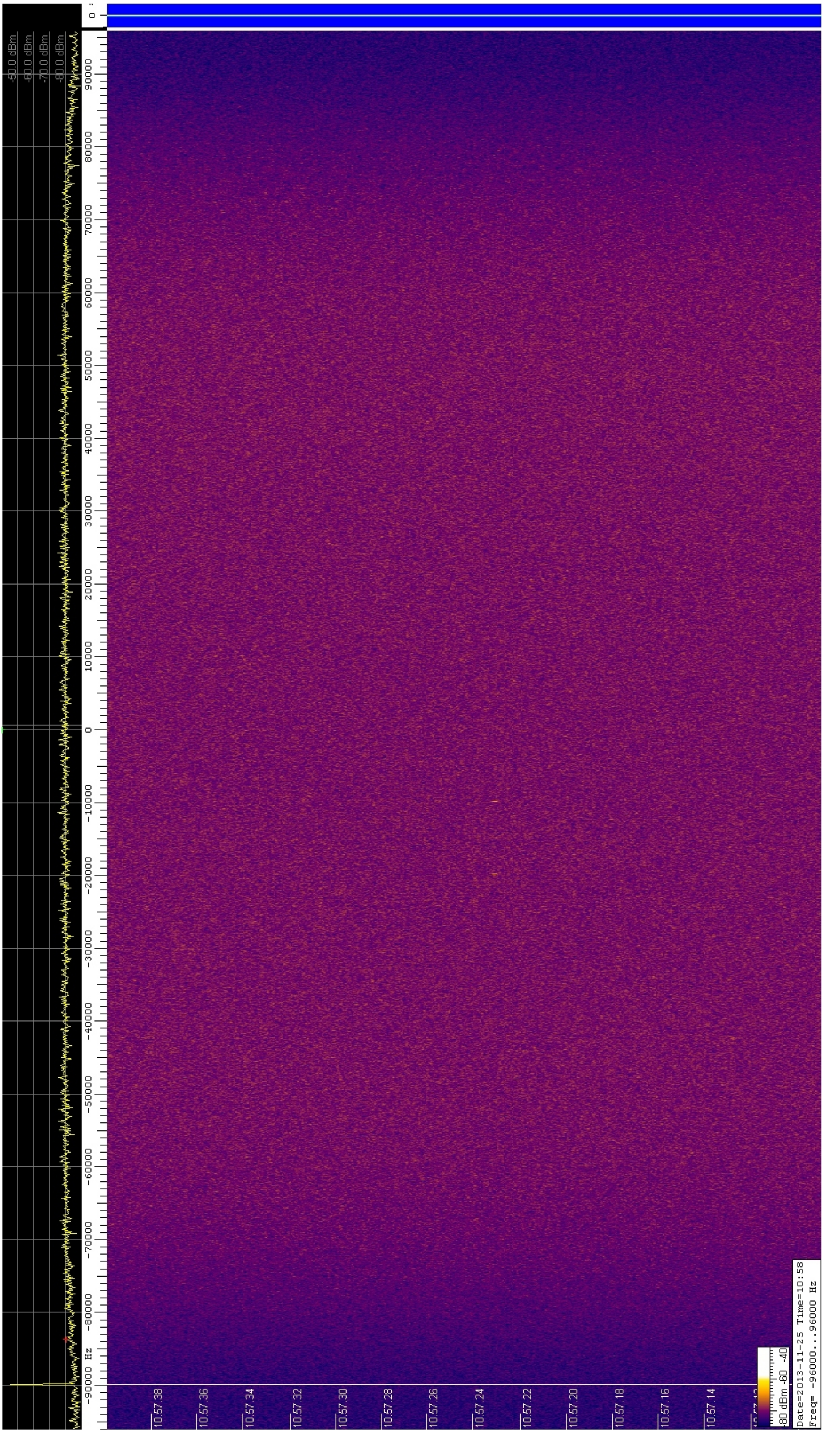
Nella pagina ancora successiva si riporta l'immagine di uno spettro ottenuto con impostazione SR=192000 (massima) ed FFT=32768, per una risoluzione di circa 6 Hz: si può notare il segnale presente a –90000 Hz ed il calo di 6dB ai bordi della banda.

“schermata” standard



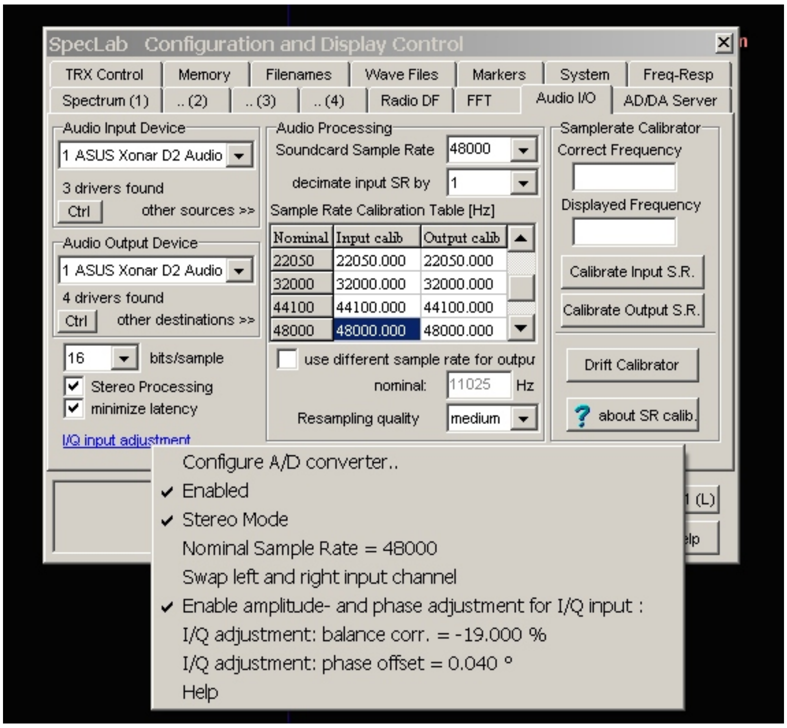
“schermata” zoom con indicazione del marker



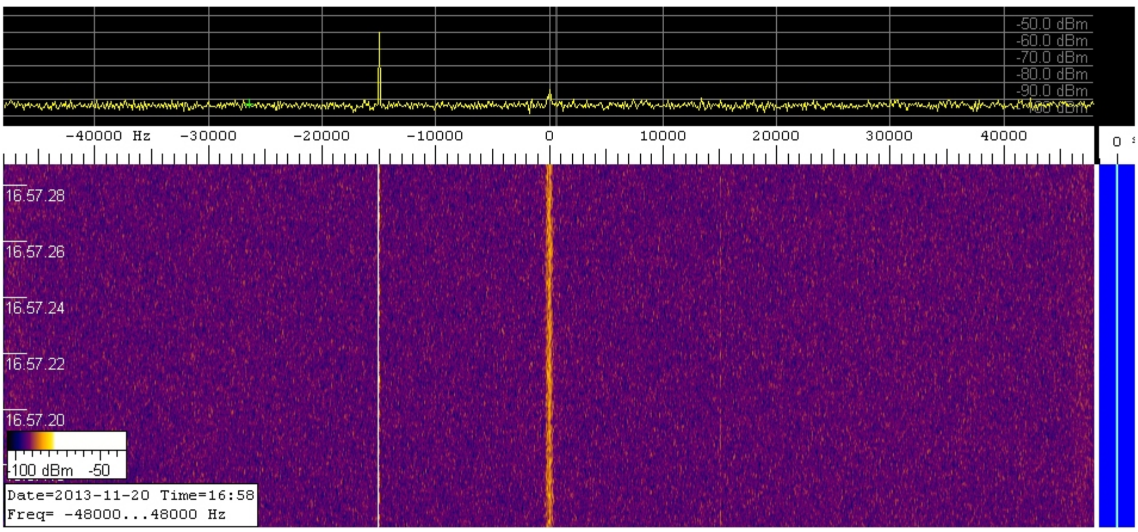

Date=2013-11-25 Time=10:58
Freq= -96000...96000 Hz

Alcune applicazioni

Il sistema è stato testato applicando segnali IF generati in laboratorio e le principali "tarature" hanno interessato il livello dei segnali OL ed IF. Si è inoltre intervenuti sulle regolazioni di bilanciamento e fase dei segnali I&Q mediante il menù a tendina di Spectrum Lab: ***Option / Audio I/O / I&Q input adj*** (come da immagine sottostante) attivando ***enable amplitude and phase adj*** ed applicando le idonee regolazioni di ***I&Q adjust balance*** e ***I&Q adjust phase offset***

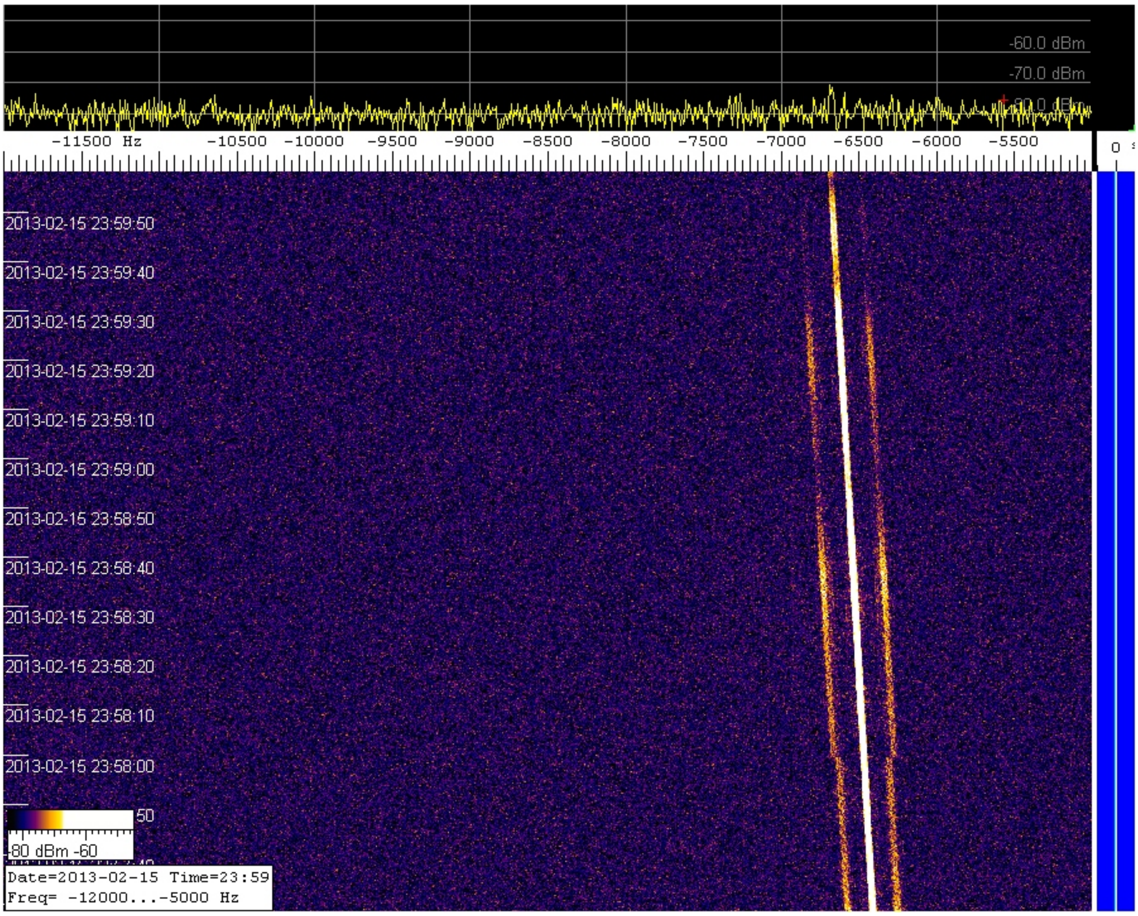


Con la migliore configurazione è stata ottenuta una reiezione immagine USB-LSB di 40-50 dB, come visibile nella figura sottostante.

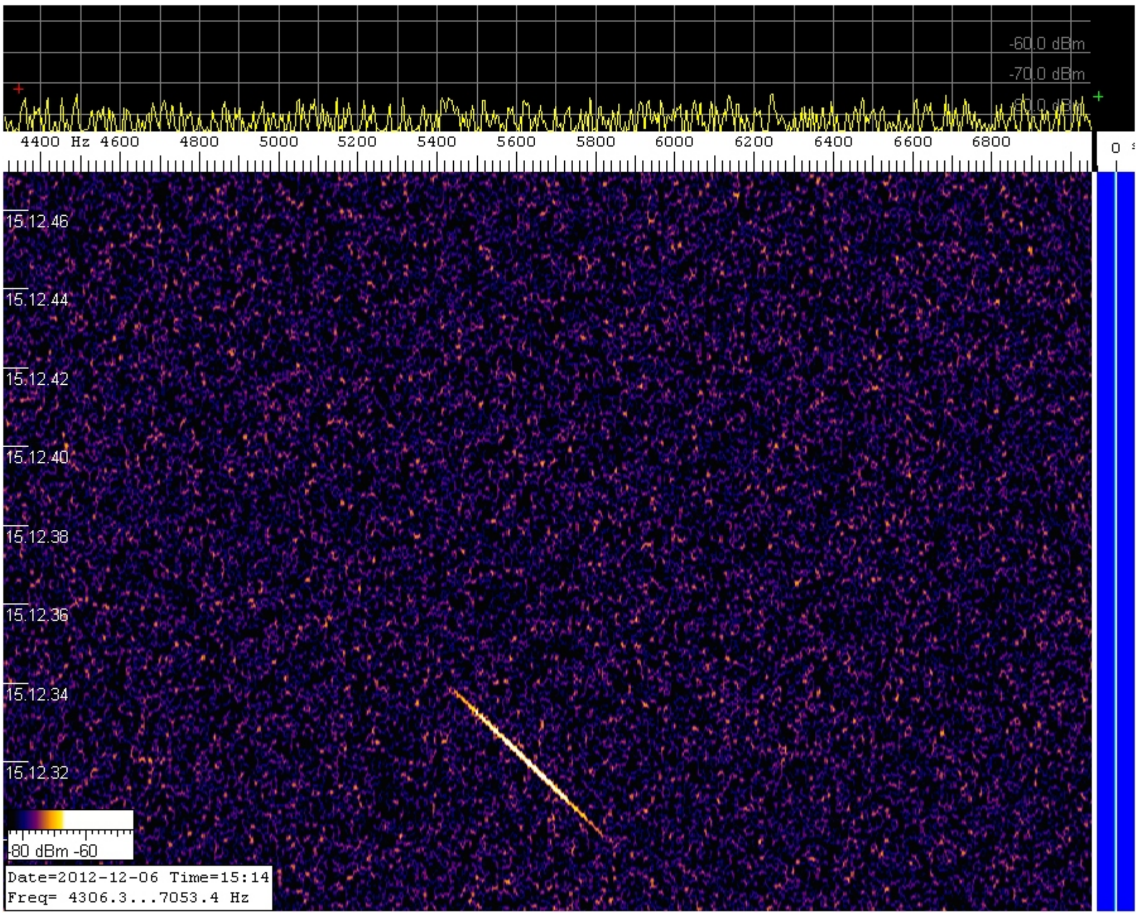


Il dispositivo è poi stato impiegato con successo nella visualizzazione real-time di segnali-eco acquisiti in occasione di test ed esperimenti di tipo radar bistatico, di cui di seguito si riportano alcuni spettri. Quando necessario, è stato inserito a monte un idoneo sistema di conversione per riportare il segnale IF a 10 MHz (es. IF Croce 30 MHz).

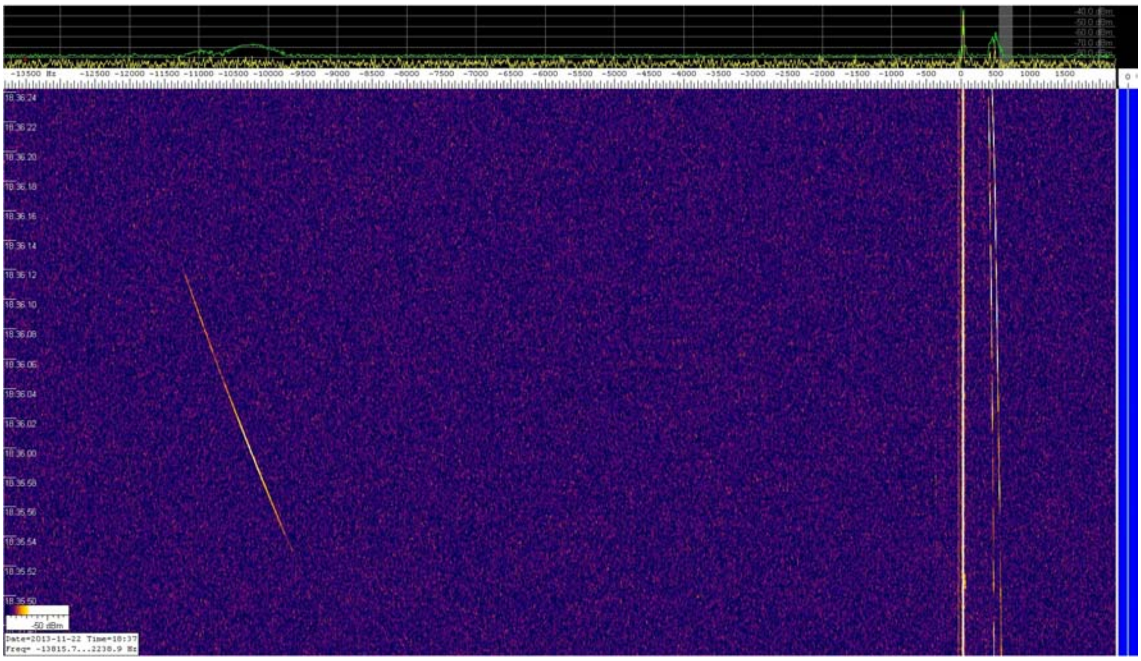
Radar bistatico in banda C: eco dell'asteroide 2012DA14 ricevuto con Parabola VLBI



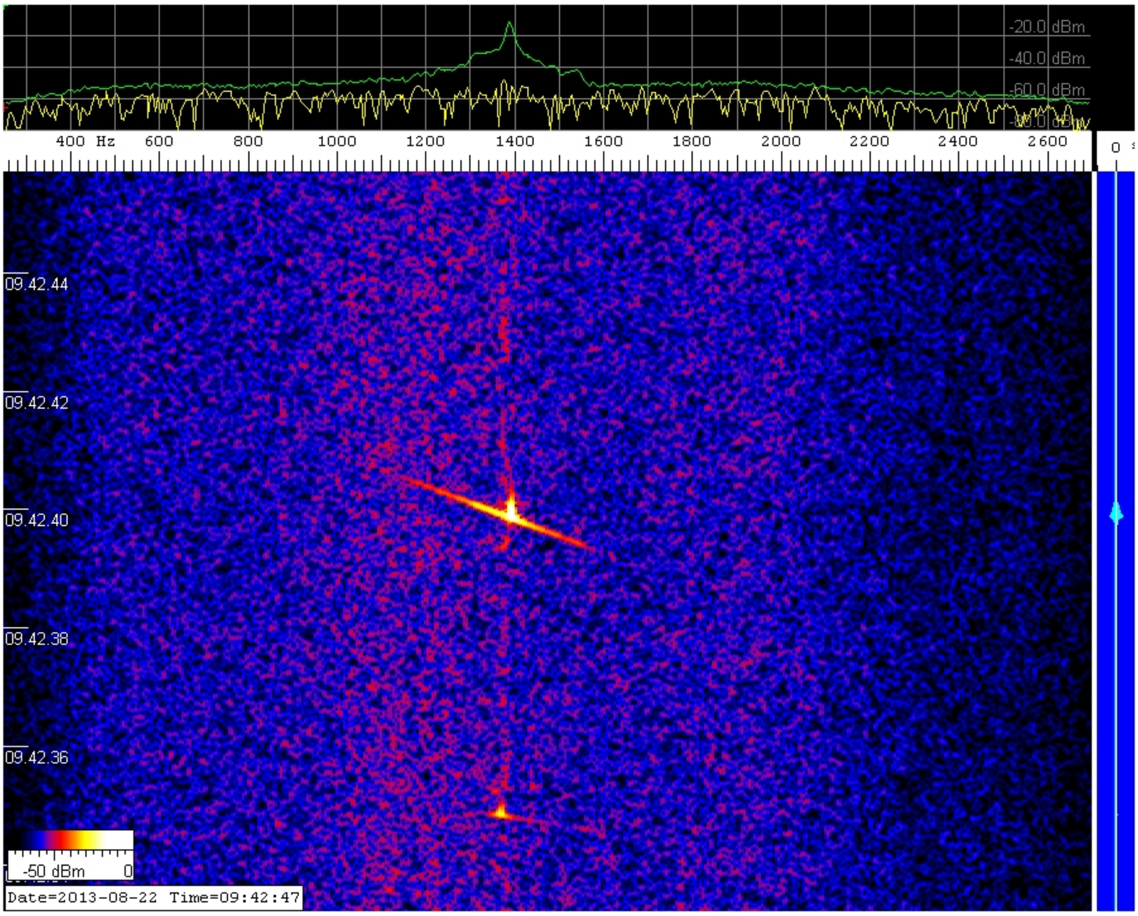
Radar bistatico in banda P: eco ricevuto col canale 4 Est (ramo E/W)



Radar bistatico in banda P: eco ricevuto con ¼ di cilindro BEST2 (ramo N/S)



Eco Radar Graves a 143,050 MHz ricevuto col sistema rfi Torre



Riferimenti

- Wolfgang Büscher
  Spectrum Lab - Manual and Help Index
  http://dl4yhf.ssl7.com/speclab/index.htm

Ringraziamenti

Si ringrazia **Stelio Montebugnoli** per aver svolto il ruolo di Referee interno.

Special thanks to **Wolfgang Büscher** for its powerful free software "Spectrum Lab"

Schede tecniche allegate:

A. Demodulatore I&Q Mini-Circuits MIQA-10D
B. Amplificatore Operazionale LMH6702
C. Scheda audio PC ASUS XONAR D2

Plug-In

I&Q Demodulator

MIQA-10D

50Ω 9 to 11 MHz

CASE STYLE: A06
PRICE: $52.20 ea. QTY (1-9)

Maximum Ratings

Operating Temperature	-55°C to 100°C
Storage Temperature	-55°C to 100°C
LO/RF Power	50mW
I&Q Current	40mA

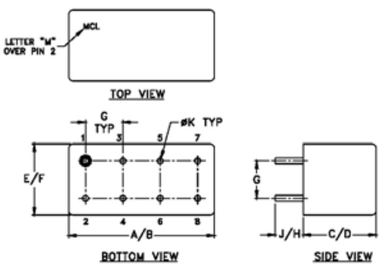
Permanent damage may occur if any of these limits are exceeded.

Pin Connections

LO (carrier)	1
RF (signal)	8
I (0°)(ref.)	7
Q (90°)*	4
50Ω TERM EXT.	2
GROUND	3,5,6
CASE GROUND	3,5,6

*Q= I+90° for LO<RF
Q= I-90° for LO>RF

Outline Drawing



Outline Dimensions (inch / mm)

A	B	C	D	E	F
.770	.800	.285	.310	.370	.400
19.56	20.32	7.24	7.87	9.40	10.16

G	H	J	K	wt
.200	.20	.14	.031	grams
5.08	5.08	3.56	0.79	5.2

Features

- hermetically sealed metal case
- excellent 3rd and 5th order harmonic suppression
- good amplitude and phase unbalance

Applications

- radar and communication systems
- military, hi-rel applications

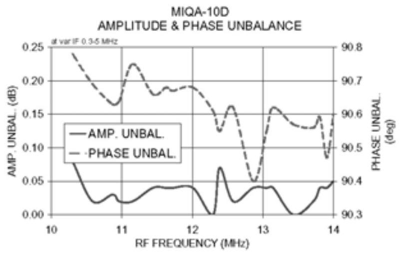
Demodulator Electrical Specifications

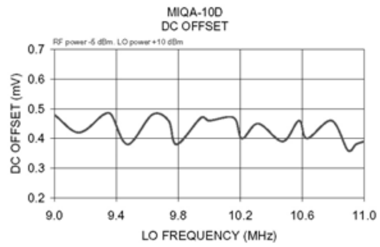
FREQUENCY (MHz) RF (SIGNAL) LO (CARRIER)		I&Q		CONVERSION LOSS (dB)			AMPLITUDE UNBALANCE (dB)		PHASE UNBALANCE (Deg.) with reference to 90°		HARMONIC SUPPRESSION (dBc) 3XI/Q		5XI/Q	
f_L	f_U	Min.	Max.	$\bar{x}$	σ	Max.	Typ.	Max.	Typ.	Max.	Typ.	Min.	Typ.	Min.
9	11	DC	2	6.0	0.10	7.0	0.15	0.3	1.0	3.0	50	35	65	55

Note:
1. Operating LO Power: 10±0.5 dBm
2. 1 dB Compression at +4 dBm RF input
3. DC offset 1mV typ.
4. Conversion Loss=RF power, dBm - (I+Q) power, dBm

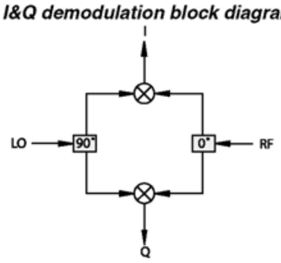
Typical Performance Data

Frequency (MHz) LO=10MHz RF	I&Q	Conversion Loss (dB)	Amplitude Unbalance (dB)	Phase (I&Q) (deg.)	Frequency (MHz) LO	RF	DC Offset (mV)
10.30	0.30	5.85	0.08	90.78	9.00	9.10	0.48
10.59	0.59	5.82	0.02	90.69	9.16	9.26	0.42
10.87	0.87	5.80	0.03	90.63	9.32	9.42	0.48
10.96	0.97	5.80	0.02	90.64	9.37	9.47	0.48
11.15	1.15	5.83	0.02	90.75	9.47	9.57	0.38
11.44	1.44	5.78	0.04	90.66	9.63	9.73	0.48
11.63	1.63	5.77	0.04	90.68	9.74	9.84	0.46
11.72	1.72	5.77	0.04	90.67	9.79	9.89	0.38
12.01	2.01	5.75	0.04	90.68	9.95	10.05	0.47
12.29	2.29	5.73	0.00	90.61	10.00	10.10	0.46
12.39	2.39	5.73	0.07	90.55	10.16	10.26	0.47
12.58	2.58	5.72	0.02	90.62	10.21	10.31	0.40
12.86	2.86	5.71	0.04	90.40	10.32	10.42	0.45
13.05	3.05	5.70	0.04	90.55	10.47	10.57	0.39
13.15	3.15	5.69	0.04	90.62	10.58	10.68	0.46
13.43	3.43	5.67	0.00	90.57	10.63	10.73	0.40
13.72	3.71	5.63	0.02	90.56	10.79	10.89	0.46
13.81	3.81	5.62	0.04	90.59	10.90	11.00	0.36
13.91	3.91	5.61	0.04	90.47	10.95	11.05	0.38
14.00	4.00	5.61	0.05	90.60	11.00	11.10	0.39





I&Q demodulation block diagram



Allegato A – Demodulatore I&Q Mini-Circuits MIQA-10D

LMH6702 1.7 GHz, Ultra Low Distortion, Wideband Op Amp

Check for Samples: LMH6702

FEATURES

V_S = ±5V, T_A = 25°C, A_V = +2V/V, R_L = 100Ω, V_{OUT} = 2V_{PP}, Typical Unless Noted:

- **$2^{nd}/3^{rd}$ Harmonics (5MHz, SOT-23) −100/−96dBc**
- **−3dB Bandwidth (V_{OUT} = 0.5 V_{PP}) 1.7 GHz**
- **Low Noise 1.83nV/√Hz**
- **Fast Settling to 0.1% 13.4ns**
- **Fast Slew Rate 3100V/µs**
- **Supply Current 12.5mA**
- **Output Current 80mA**
- **Low Intermodulation Distortion (75MHz) −67dBc**
- **Improved Replacement for CLC409 and CLC449**

APPLICATIONS

- **Flash A/D Driver**
- **D/A Transimpedance Buffer**
- **Wide Dynamic Range IF amp**
- **Radar/Communication Receivers**
- **Line Driver**
- **High Resolution Video**

DESCRIPTION

The LMH6702 is a very wideband, DC coupled monolithic operational amplifier designed specifically for wide dynamic range systems requiring exceptional signal fidelity. Benefiting from current feedback architecture, the LMH6702 offers unity gain stability at exceptional speed without need for external compensation.

With its 720MHz bandwidth (A_V = 2V/V, V_O = 2V_{PP}), 10-bit distortion levels through 60MHz (R_L = 100Ω), 1.83nV/√Hz input referred noise and 12.5mA supply current, the LMH6702 is the ideal driver or buffer for high-speed flash A/D and D/A converters.

Wide dynamic range systems such as radar and communication receivers, requiring a wideband amplifier offering exceptional signal purity, will find the LMH6702's low input referred noise and low harmonic and intermodulation distortion make it an attractive high speed solution.

The LMH6702 is constructed using VIP10™ complimentary bipolar process and proven current feedback architecture. The LMH6702 is available in SOIC and SOT-23 packages.

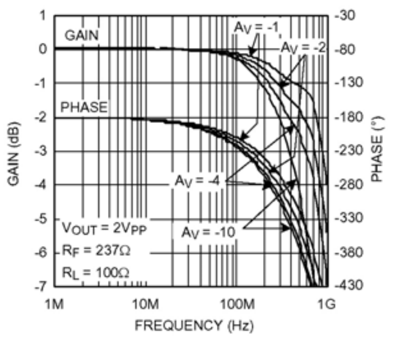


Figure 1. Inverting Frequency Response

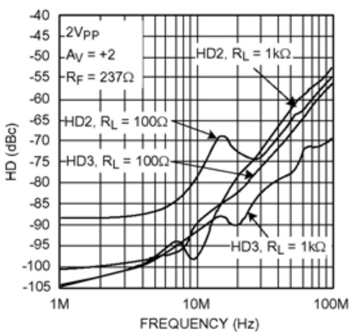


Figure 2. Harmonic Distortion vs. Load and Frequency

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings(1)(2)

V_S		±6.75V
I_{OUT}		See(3)
Common Mode Input Voltage		V^- to V^+
Maximum Junction Temperature		+150°C
Storage Temperature Range		−65°C to +150°C
Soldering Information	Infrared or Convection (20 sec.)	235°C
	Wave Soldering (10 sec.)	260°C
ESD Tolerance(4)	Human Body Model	2000V
	Machine Model	200V
Storage Temperature Range		−65°C to +150°C

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications, see the Electrical Characteristics tables.
(2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/ Distributors for availability and specifications.
(3) The maximum output current (I_{OUT}) is determined by device power dissipation limitations.
(4) Human body model: 1.5kΩ in series with 100pF. Machine model: 0Ω in series with 200pF.

Operating Ratings(1)

Thermal Resistance	**Package**	**(θ_{JC})**	**(θ_{JA})**
	8-Pin SOIC	75°C/W	160°C/W
	5-Pin SOT-23	120°C/W	187°C/W
Operating Temperature			−40°C to +85°C
Nominal Supply Voltage			±5V to ±6V

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications, see the Electrical Characteristics tables.

Electrical Characteristics(1)

A_V = +2, V_S = ±5V, R_L = 100Ω, R_F = 237Ω; unless specified

Symbol	Parameter	Conditions	Min(2)	Typ(2)	Max(2)	Units
Frequency Domain Performance						
$SSBW_{SM}$	-3dB Bandwidth	V_{OUT} = 0.5V_{PP}		1700		MHz
$SSBW_{LG}$		V_{OUT} = 2V_{PP}		720		
$LSBW_{LG}$		V_{OUT} = 4V_{PP}		480		
$SSBW_{HG}$		V_{OUT} = 2V_{PP}, A_V = +10		140		
$GF_{0.1dB}$	0.1dB Gain Flatness	V_{OUT} = 2V_{PP}		120		MHz
LPD	Linear Phase Deviation	DC to 100MHz		0.09		deg
DG	Differential Gain	R_L =150Ω, 3.58MHz/4.43MHz		0.024/0.021		%
DP	Differential Phase	R_L = 150Ω, 3.58MHz/4.43MHz		0.004/0.007		deg
Time Domain Response						
TRS/TRL	Rise and Fall Time	2V Step		0.87/0.77		ns
		6V Step		1.70/1.70		ns
OS	Overshoot	2V Step		0		%
SR	Slew Rate	6V_{PP}, 40% to 60%(3)		3100		V/µs
T_s	Settling Time to 0.1%	2V Step		13.4		ns

(1) Electrical Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that $T_J = T_A$. No guarantee of parametric performance is indicated in the electrical tables under conditions of internal self-heating where $T_J > T_A$. Min/Max ratings are based on production testing unless otherwise specified.
(2) Typical numbers are the most likely parametric norm. Bold numbers refer to over temperature limits.
(3) Slew Rate is the average of the rising and falling edges.

Electrical Characteristics[1] (continued)

$A_V = +2$, $V_S = \pm5V$, $R_L = 100\Omega$, $R_F = 237\Omega$; unless specified

Symbol	Parameter	Conditions	Min[2]	Typ[2]	Max[2]	Units
Distortion And Noise Response						
HD2L	2nd Harmonic Distortion	$2V_{PP}$, 5MHz[4] (SOT-23/SOIC)		−100/ −87		dBc
HD2		$2V_{PP}$, 20MHz[4] (SOT-23/SOIC)		−79/ −72		dBc
HD2H		$2V_{PP}$, 60MHz[4] (SOT-23/SOIC)		−63/ −64		dBc
HD3L	3rd Harmonic Distortion	$2V_{PP}$, 5MHz[4] (SOT-23/SOIC)		−96/ −98		dBc
HD3		$2V_{PP}$, 20MHz[4] (SOT-23/SOIC)		−88/ −82		dBc
HD3H		$2V_{PP}$, 60MHz[4] (SOT-23/SOIC)		−70/ −65		dBc
OIM3	IMD	75MHz, P_O = 10dBm/ tone		−67		dBc
V_N	Input Referred Voltage Noise	>1MHz		1.83		$nV/\sqrt{Hz}$
I_N	Input Referred Inverting Noise Current	>1MHz		18.5		$pA/\sqrt{Hz}$
I_{NN}	Input Referred Non-Inverting Noise Current	>1MHz		3.0		$pA/\sqrt{Hz}$
SNF	Total Input Noise Floor	>1MHz		−158		dBm_{1Hz}
INV	Total Integrated Input Noise	1MHz to 150MHz		35		μV
Static, DC Performance						
V_{IO}	Input Offset Voltage			±1.0	±4.5 **±6.0**	mV
DV_{IO}	Input Offset Voltage Average Drift	See[5]		−13		μV/°C
I_{BN}	Input Bias Current	Non-Inverting[6]		−6	±15 **±21**	μA
DI_{BN}	Input Bias Current Average Drift	Non-Inverting[5]		+40		nA/°C
I_{BI}	Input Bias Current	Inverting[6]		−8	±30 **±34**	μA
DI_{BI}	Input Bias Current Average Drift	Inverting[5]		−10		nA/°C
PSRR	Power Supply Rejection Ratio	DC	47 **45**	52		dB
CMRR	Common Mode Rejection Ration	DC	45 **44**	48		dB
I_{CC}	Supply Current	$R_L = \infty$	11.0 **10.0**	12.5	16.1 **17.5**	mA
Miscellaneous Performance						
R_{IN}	Input Resistance	Non-Inverting		1.4		MΩ
C_{IN}	Input Capacitance	Non-Inverting		1.6		pF
R_{OUT}	Output Resistance	Closed Loop		30		mΩ
V_{OL}	Output Voltage Range	$R_L = 100\Omega$	±3.3 **±3.2**	±3.5		V
CMIR	Input Voltage Range	Common Mode	±1.9	±2.2		V
I_O	Output Current		50	80		mA

(4) Harmonic distortion is strongly influenced by package type (SOT-23 or SOIC). See Application Note section under "Harmonic Distortion" for more information.
(5) Drift determined by dividing the change in parameter at temperature extremes by the total temperature change.
(6) Negative input current implies current flowing out of the device.

Allegato B3 – Amplificatore Operazionale LMH6702

Connection Diagrams

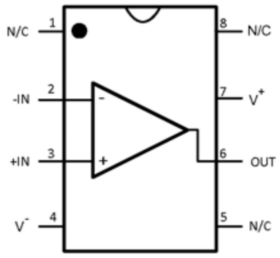


Figure 3. 8-Pin SOIC Top View

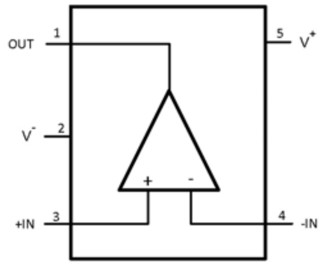


Figure 4. 5-Pin SOT-23 Top View

Allegato B4 – Amplificatore Operazionale LMH6702

APPLICATION SECTION

FEEDBACK RESISTOR

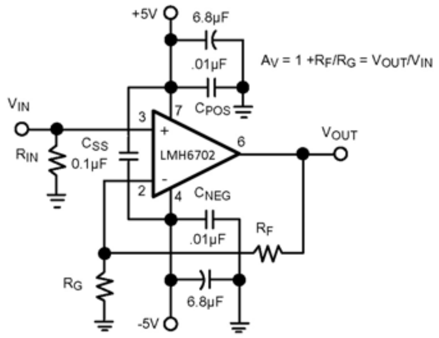


Figure 26. Recommended Non-Inverting Gain Circuit

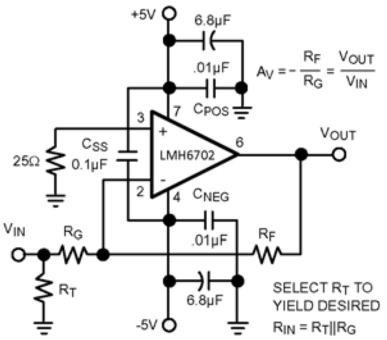


Figure 27. Recommended Inverting Gain Circuit

The LMH6702 achieves its excellent pulse and distortion performance by using the current feedback topology. The loop gain for a current feedback op amp, and hence the frequency response, is predominantly set by the feedback resistor value. The LMH6702 is optimized for use with a 237Ω feedback resistor. Using lower values can lead to excessive ringing in the pulse response while a higher value will limit the bandwidth. Application Note OA-13 discusses this in detail along with the occasions where a different R_F might be advantageous.

HARMONIC DISTORTION

The LMH6702 has been optimized for exceptionally low harmonic distortion while driving very demanding resistive or capacitive loads. Generally, when used as the input amplifier to very high speed flash ADCs, the distortions introduced by the converter will dominate over the low LMH6702 distortions shown in the Typical Performance Characteristics section. The capacitor C_{SS}, shown across the supplies in Figure 26 and Figure 27, is critical to achieving the lowest 2nd harmonic distortion. For absolute minimum distortion levels, it is also advisable to keep the supply decoupling currents (ground connections to C_{POS}, and C_{NEG} in Figure 26 and Figure 27) separate from the ground connections to sensitive input circuitry (such as R_G, R_T, and R_{IN} ground connections). Splitting the ground plane in this fashion and separately routing the high frequency current spikes on the decoupling caps back to the power supply (similar to "Star Connection" layout technique) ensures minimum coupling back to the input circuitry and results in best harmonic distortion response (especially 2nd order distortion).

If this lay out technique has not been observed on a particular application board, designer may actually find that supply decoupling caps could adversely affect HD2 performance by increasing the coupling phenomenon already mentioned. Figure 28 below shows actual HD2 data on a board where the ground plane is "shared" between the supply decoupling capacitors and the rest of the circuit. Once these capacitors are removed, the HD2 distortion levels reduce significantly, especially between 10MHz-20MHz, as shown in Figure 28 below:

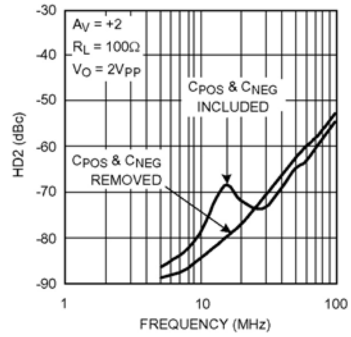


Figure 28. Decoupling Current Adverse Effect on a Board with Shared Ground Plane

At these extremely low distortion levels, the high frequency behavior of decoupling capacitors themselves could be significant. In general, lower value decoupling caps tend to have higher resonance frequencies making them more effective for higher frequency regions. A particular application board which has been laid out correctly with ground returns "split" to minimize coupling, would benefit the most by having low value and higher value capacitors paralleled to take advantage of the effective bandwidth of each and extend low distortion frequency range.

Another important variable in getting the highest fidelity signal from the LMH6702 is the package itself. As already noted, coupling between high frequency current transients on supply lines and the device input can lead to excess harmonic distortion. An important source of this coupling is in fact through the device bonding wires. A smaller package, in general, will have shorter bonding wires and therefore lower coupling. This is true in the case of the SOT-23 compared to the SOIC package where a marked improvement in HD can be measured in the SOT-23 package. Figure 29 below shows the HD comparing SOT-23 to SOIC package:

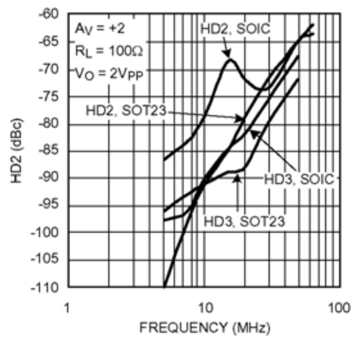


Figure 29. SOIC and SOT-23 Packages Distortion Terms Compared

The LMH6702 data sheet shows both SOT-23 and SOIC data in the Electrical Characteristic section to aid in selecting the right package. The Typical Performance Characteristics section shows SOIC package plots only.

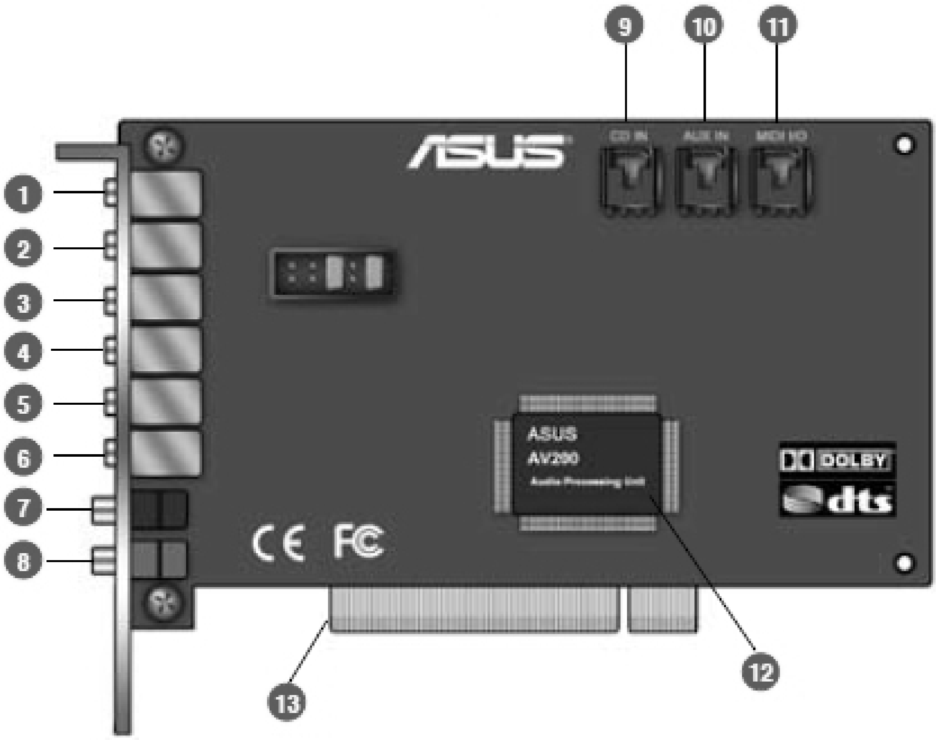
Xonar D2/PM

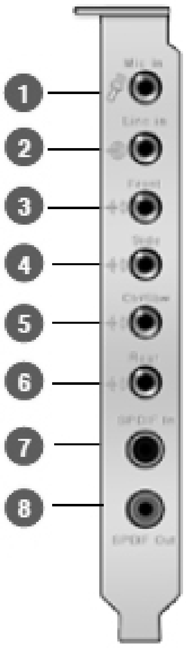
Bus Compatibility	PCI
Audio Performance	**Output Signal-to-Noise Ratio (A-Weighted) (Front-out) :** 118 dB **Output THD+N at 1kHz (Front-out) :** >0.0004 %(-108 dB) **Frequency Response (-3dB, 16bit/44.1KHz input) :** 10 Hz to 46 KHz **Output/Input Full-Scale Voltage :** Unbalanced Output : 2 Vrms (5.65 Vp-p)
Chipset	**Audio Processor :** ASUS AV200 High-Definition Sound Processor (Max. 192KHz/24bit)
Sample Rate and Resolution	**Analog Playback Sample Rate and Resolution :** 44.1K/48K/88.2K/96K/176.4K/192KHz @ 16bit/24bit **Analog Recording Sample Rate and Resolution :** 44.1K/48K/88.2K/96K/176.4K/192KHz @ 16bit **S/PDIF Digital Output :** 44.1K/48K/88.2K/96K/176.4K/192KHz @ 16bit/24bit **S/PDIF Digital Input :** 44.1K/48K/88.2K/96K/176.4K/192KHz @ 16bit/24bit **ASIO Driver Support :** 44.1K/48K/88.2K/96K/176.4K/192KHz @ 16bit/24bit
Connectivity	**Analog Output** 4 x 3.5 mm jack (1/8") (Front out/Side out/Center-Subwoofer out/Rear out) **Analog Input** 2 x 3.5 mm jack (1/8") (Line-in/Mic-in) **Digital** 1 x S/PDIF out (1 x Coaxial) 1 x S/PDIF in (1 x Coaxial) 1 x MIDI in/out 1 x Aux in (4-pin header)
Special Features	Dolby® Technologies : Dolby® Digital Live/Dolby® Headphone /Dolby® Virtual Speaker /Dolby® Pro-Logic II DTS® Technologies : DTS Interactive Encoder/DTS Neo:PC technologies
Accessories	H6 extension board cable x 1 DVI-to-HDMI cable x 1 HDMI-to-HDMI cable x 1 S/PDIF adaptor x 2 3.5mm-to-RCA adaptor cable (8-ch) x 4 Additional MIDI card, cable, and external standard MIDI adaptor Y cable x 1 Quick Start Guide x 1

Allegato C1 – Scheda audio PC ASUS XONAR D2

2. About Hardware

2.1 Xonar D2 Audio Processing Card





No	Item	Description
1	**Microphone Jack**	Connect your external PC microphone to this 3.5mm jack for voice input. Built-in high-quality Microphone pre-amplifier.
2	**Line Input Jack**	Connect analog devices like MP3 players, CD players, music synthesizers and other line-level sound sources to this 3.5mm jack for audio recording or processing. (Through Ultra-high fidelity 118dB SNR A-D converter)
3	**Headphone/Front Output Jack**	Connect your headphones or 2/2.1 channel speakers to this jack. For multi-channel speaker systems, connects to the front left/right input on the powered speakers.
4	**Side Surround Output Jack**	Connects to the surround channel input on 4/4.1/5.1/6.1/7.1 powered analog speakers.
5	**Center/Subwoofer Output Jack**	Connects to the front center/subwoofer input on 5.1/6.1/7.1 powered analog speakers.
6	**Rear/Back Surround Output Jack**	Connects to the Back Surround input on 6.1/7.1 powered analog speakers.
7	**S/PDIF Input**	Coaxial and optical TOSLINK combo digital input jack. Connects to external digital audio sources such as MD players, CD players, or DVD players, for audio recording or loopback.
8	**S/PDIF Output**	Coaxial and optical TOSLINK combo digital output jack. Connects to external digital decoder or digital speaker systems, Home Theater systems, AV receivers for outputting digital audio including PCM, Dolby Digital, DTS, WMA-Pro, etc.
9	**CD Input Header**	4-pin header. Connects to the Analog Audio output on the back panel of CD/DVD-ROM drive using an Analog CD audio cable, which is usually available with your CD/DVD-ROM drive. You can still play CD audio through the Xonar driver without connecting this. We recommend playing audio through the driver to take advantage of the Xonar's high quality D-A converter, but this header is provided in case you need it.
10	**Aux Input Header**	4-pin header. Usually connects to the Analog Audio output of TV tuner card or other sound source inside your PC system. (To monitor your TV tuner card's audio from this Aux-In, you must enable the "monitor" function for Aux-In in the Xonar Audio Center software's recording mixer.)
11	**MIDI I/O Header**	Connects to the additional MIDI board/bracket (available in the package)
12	**Main Audio Processor**	ASUS Xonar AV200 Audio Processing Unit (DuplexHD 192K/24bit)
13	**PCI Bus Golden Fingers**	Connects to the PCI slot on your motherboard