MDSR TX Compliance and RX Performance Testing

Alex Schwarz
VE7DXW
alexschwarz@telus.net

Adam Farson
VA7OJ/AB4OJ
farson@shaw.ca

Website: http://users.skynet.be/myspace/mdsr

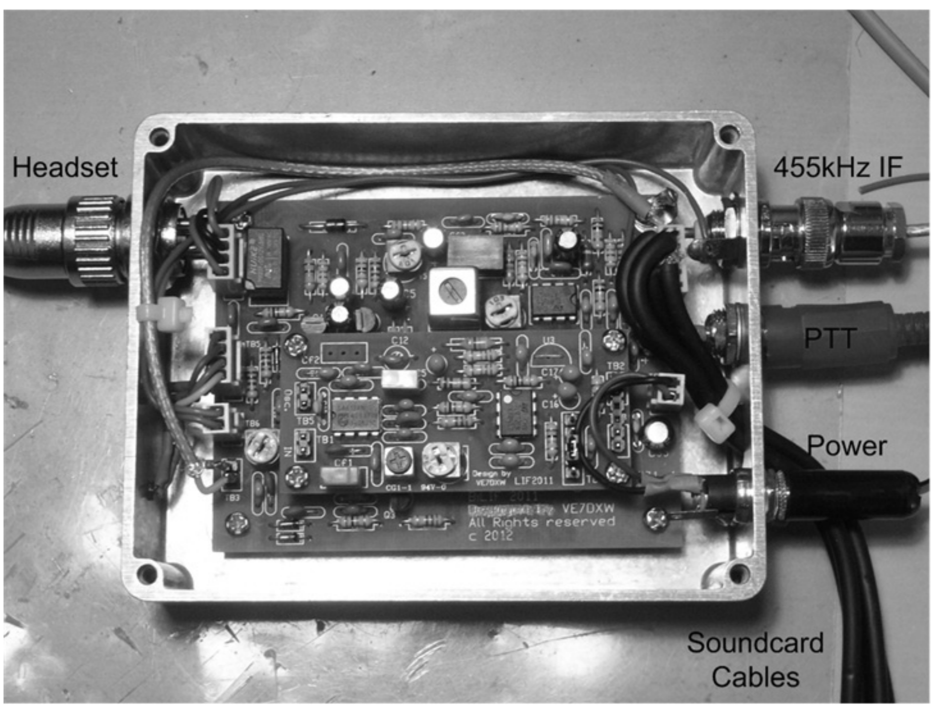
MDSR TX Up-converter

Introduction

The RX section has been published in the last 2 years of the TAPR show and most recently in the July 2012 issue of the QST magazine. This document describes the hardware and the software of the TX section of the MDSR development. The TX section has been tested with the help of Adam Farson (VA7OJ/AB4OJ) in his RF test lab. The RX section has also been tested and compared with amateur radio transceivers that Adam had previously tested.

BiLIF Hardware

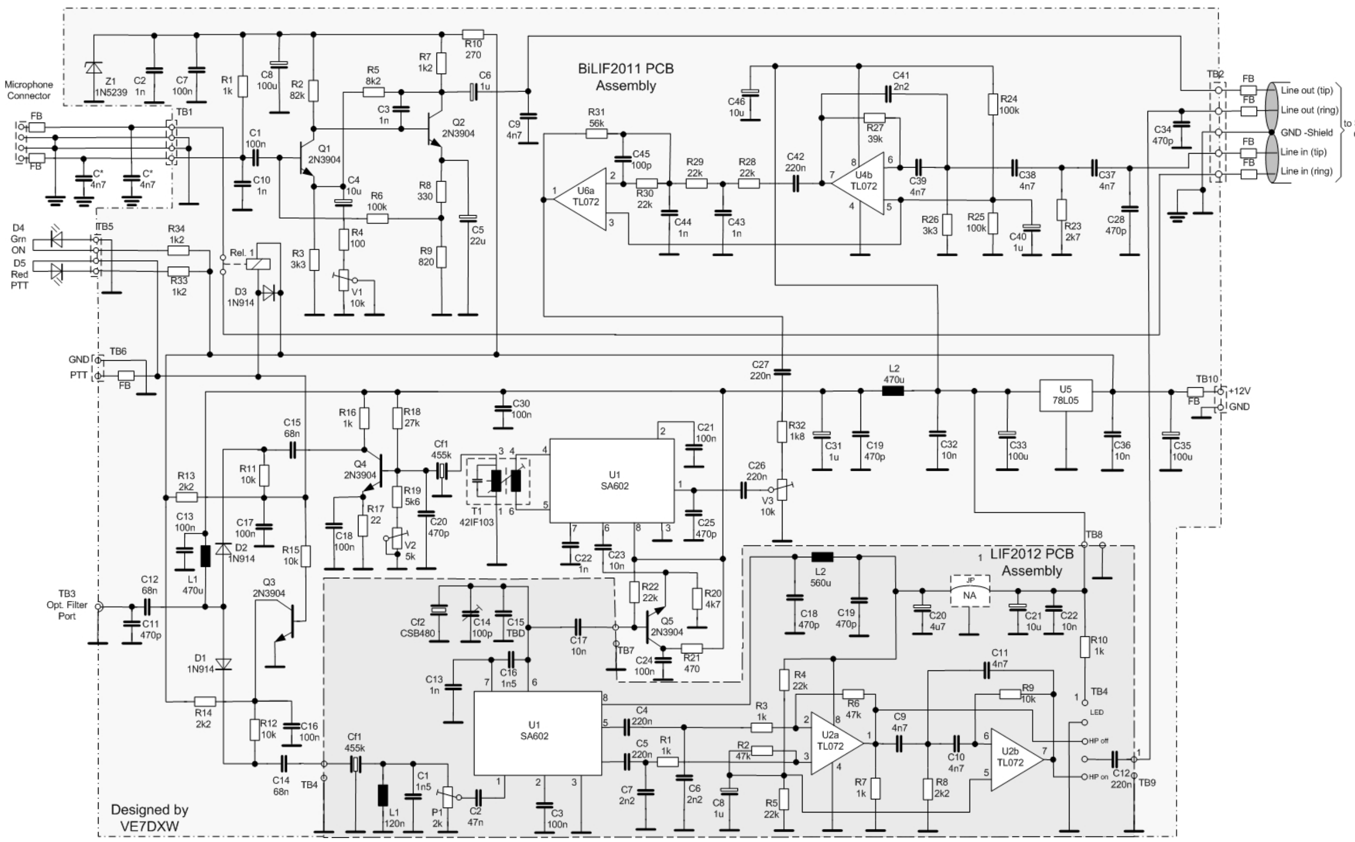
The assembled BiLIF converter box is shown below.



BiLIF (up-converter)

The TX up-converter utilizes the LIF2011 RX converter's LO for the conversion of the computer generated TX IF to 455 kHz. The TX bandwidth is ±5 kHz to allow analog modulation protocols such as USB, LSB, AM and FM to be converted to 455 kHz which is then sent to a transceiver that is set into transponder mode. The RX LIF PCB is mounted on top of the up-converter PCB and makes up the RX-TX BiLIF assembly.

Schematics:



Added Circuits and Modifications to Pass TX Compliance Test:

TX Input Pass-band filter: 10 – 14 kHz with 18 dB attenuation per octave:
This pass-band filter is realized with an op-amp high-pass and an op-amp low-pass filter working at unity gain. The high-pass filter eliminates all of the audio card sounds below 7 kHz that the computer may accidently generate and ensures a clean SSB signal after up-conversion to the 455 kHz +/-2kHz frequency range. The low-pass eliminates spurious sound-card (computer noise) output above 14 kHz.

Up-Converter Signal Combiner and Filtering:
T1 has been added to the circuit to allow the use of both outputs of the SA602, and to provide pre-filtering and impedance matching for the 455 kHz crystal filter. A simple 2-pole filter can be used because the unwanted sideband signal already has a +24 kHz offset.

Soundcard

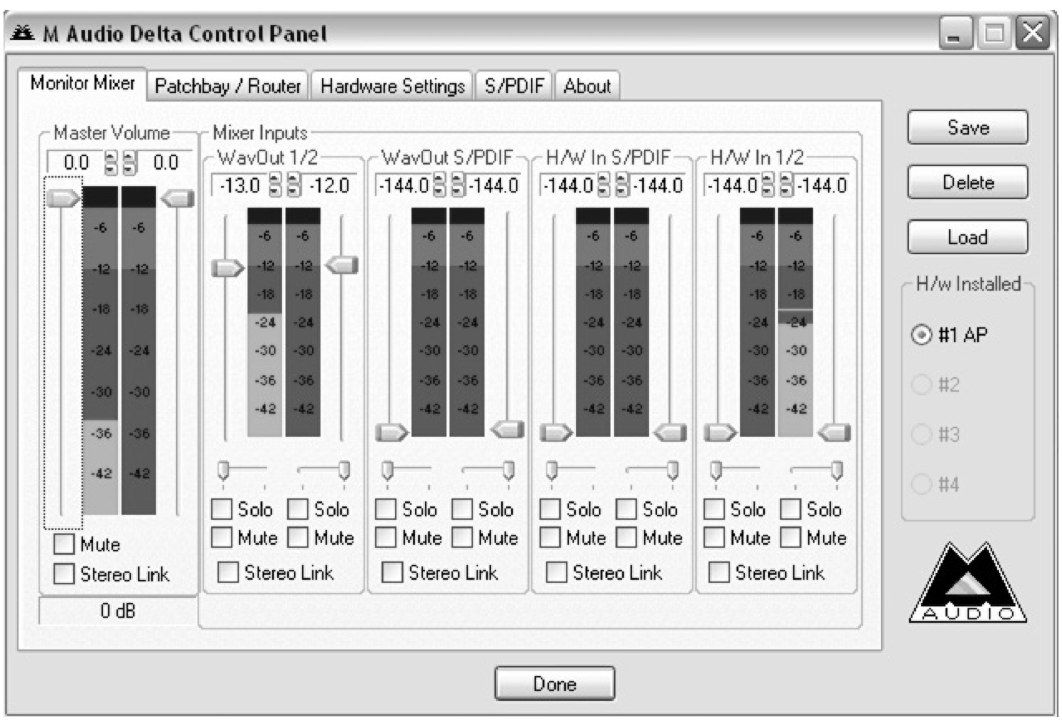
Early TX tests showed quite clearly that an on-board soundcard or even a standard plug-in (PCI) soundcard would not provide a signal clean enough to get acceptable measurements. As a solution, a professional grade Audiophile M2496 PCI card from M-Audio was used. The changeover brought about several major improvements.

- Low noise and high spectral purity (Phase noise @ 10 kHz offset: -117 dBc/Hz).
- Excellent IMD performance of the up-converter.
- Fast response and low conversion lag (64mS).
- RCA connectors providing better shielding and ground connections.
- The M Delta audio control panel software has audio level meters for easy calibration.

Soundcard Calibration

There are two different properties or signal busses that have to be set: the recording and the play control. The M Audio Delta Control Panel simplifies the setup by providing input and output channel setup in one window. The level indicator makes calibrating the BiLIF simple.

M Audio Delta Control Panel:



The driver default values are used and no additional setup is required.

s From the BiLIF to the Soundcard and Required Levels

Signal	Connected to:	0 dB Level
Microphone line level	Input left	0.7Vss for full output
LIF RX signal	Input right	0.7Vss for S9 input
Demodulated Audio Out	Output left	to headset or speaker
LIF TX signal	Output right	0.7Vss for TX max PO

It is important that the level indicators never reach the red area and that all signal levels are adjusted accordingly. The table with the signal levels shown here can be used to connect the BiLIF to the soundcard. Further details will be available in the BiLIF building manual.

Computer

The computer that was used for testing and development was a Pentium Dual Core with a clock speed of 2.2 GHz and 1 GB of RAM. The operating system on this computer is Windows XP. The MDSR software V2.5 was used for all testing.
Note: The MDSR software will run on Win2000, WinXP, Win Vista and Win7.

Software Modifications to Pass TX Compliance Test:

MDSR Software:

The MDSR software TX section was reworked and tested on the spectrum analyzer for compliance with the Audiophile 2496 soundcard.

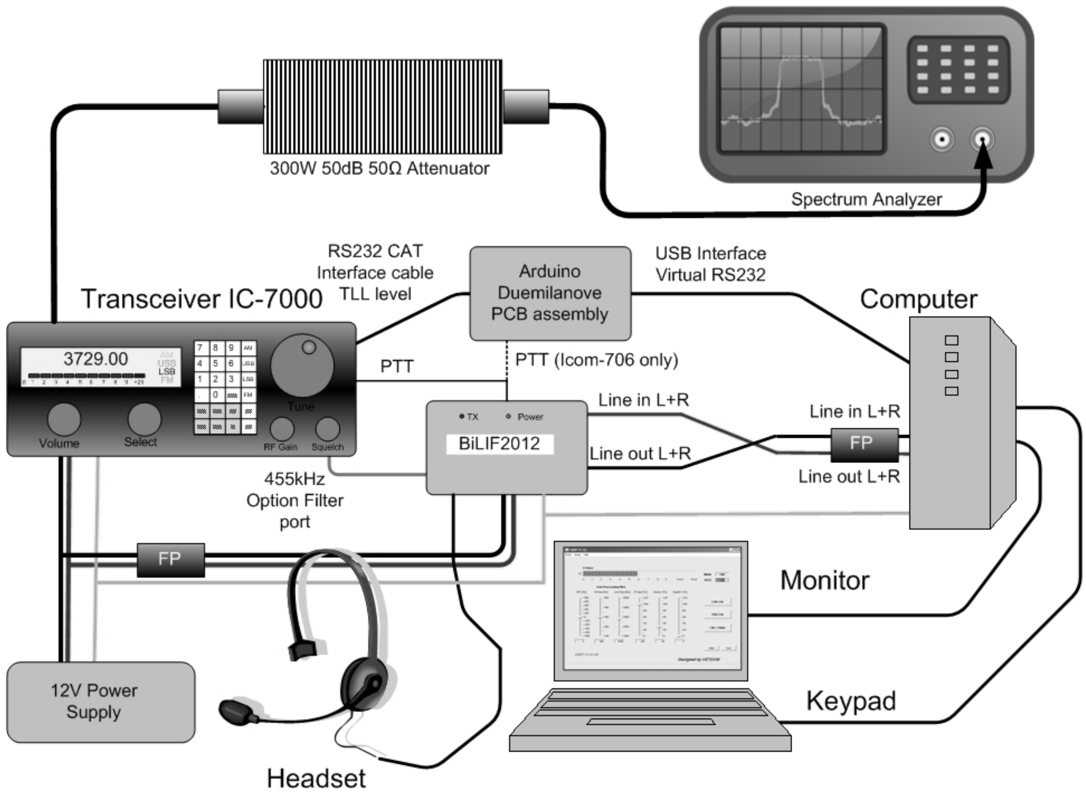
Graphic User Interface:

The graphic user interface of the MDSR software was updated to implement the changes to the TX calibration window and also to extend the TX functionality to the RX window for normal operations.

Audio Engine – modulator:

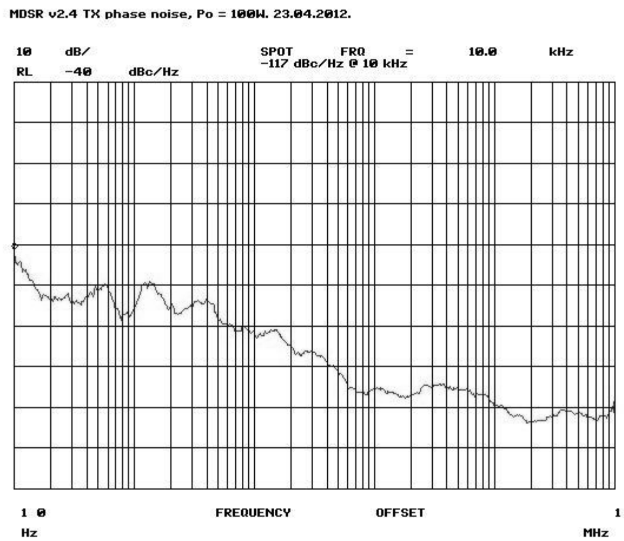
The TX audio synthesizer was modified to provide more filtering and an individual USB – LSB Q factor adjustment was added to the TX setup. This allows the modulated SSB to be adjusted for best audio quality on USB and LSB separately.

TX-Test setup with BiLIF and MDSR



hase Noise Testing:

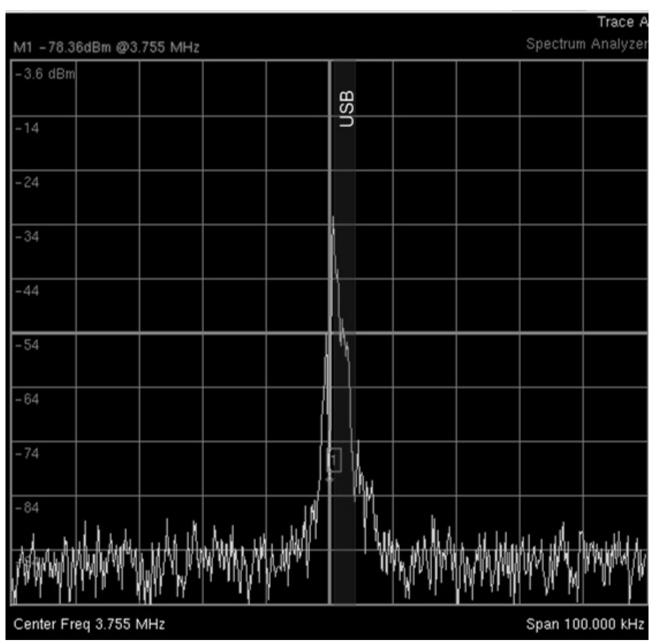
All audio and modulation engines were muted and only a 12 kHz carrier was generated by the sound-card using the MDSR software for this test. The transceiver frequency was set to 14.2 MHz and the output power to 100W.



Findings:
The phase noise of the BiLIF - IC-7000 configuration is excellent. At -117 Bc/Hz @ 10 kHz offset, it outperforms standard test equipment and provides a very good clean oscillator for RF modulation.

Spectral Purity and Spurious Emissions:

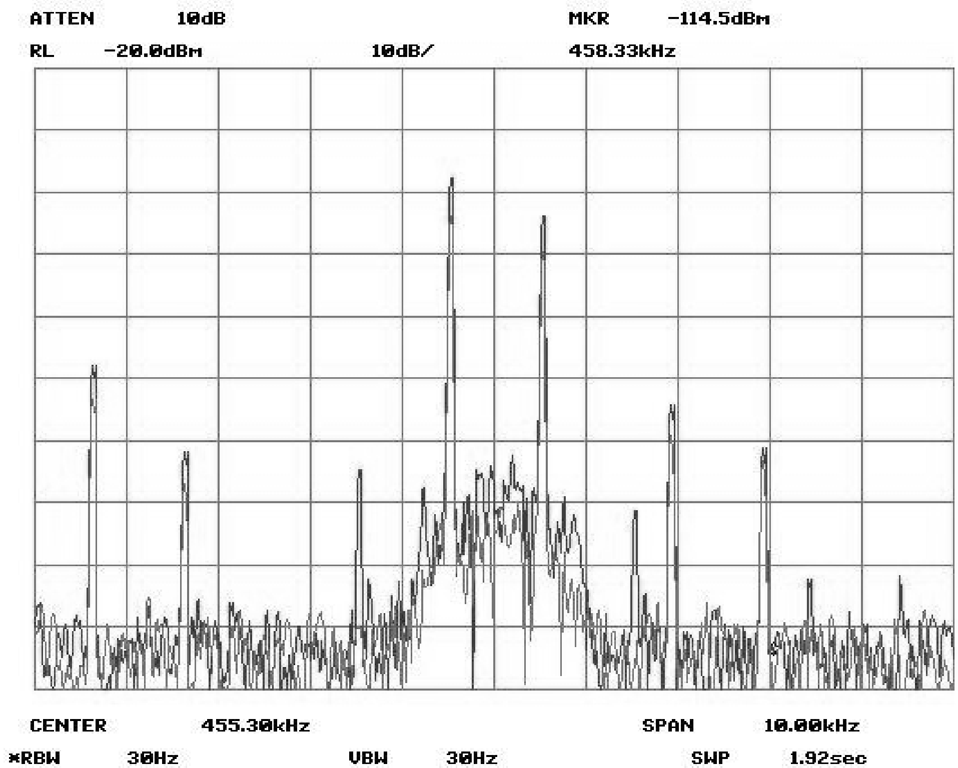
For this test the transceiver was set to 3.755 MHz and the MDSR was used to create a USB signal with 300 – 2400 Hz bandwidth. The microphone was used as the modulation source.



Findings:
The spectral display reveals an absolutely clean signal without spurious emissions in the displayed spectrum at +/-50 kHz offset from the USB carrier.

IMD Test:

The intermodulation test was performed by using the MDSR software to generate two individual test tones at 700 Hz and 1700 Hz. These tones were then used as the modulation source for the MDSR 12 kHz output. The BiLIF up-converter was used to translate the modulated signal to a 455 kHz IF and the transceiver was used in transponder mode.



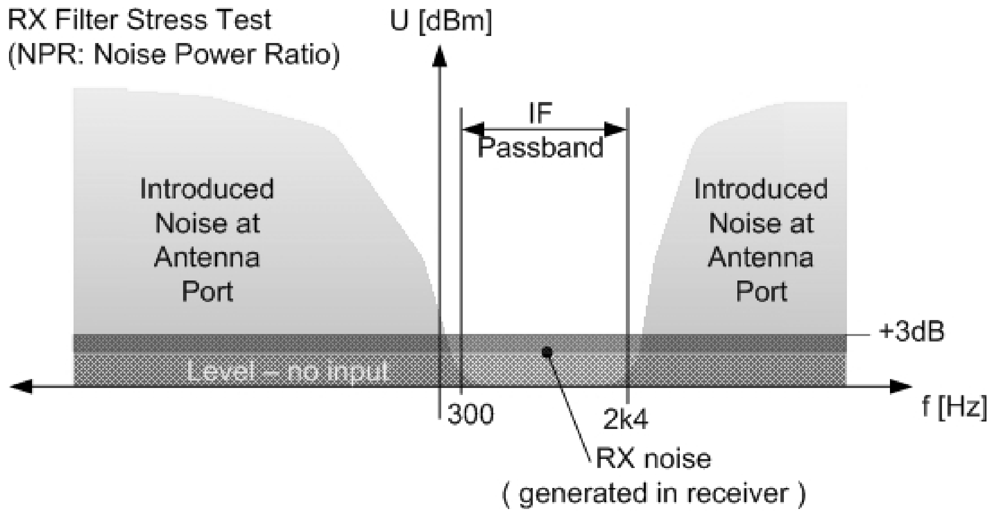
Findings:
The up-conversion process in the BiLIF creates a negative and positive image of the two tones and some spurious emissions. All unwanted spectral peaks are below -30 dB relative to the 2 peaks in the center.

Noise Power Ratio (NPR) – RX Filter Stress Test

Noise-power ratio (NPR) testing is a performance test technique in which a notched noise-band from a band-limited noise generator is applied at a fairly high power level to the input of the receiver under test. The receiver's IF bandwidth is less than that of the notch in the noise spectrum. NPR is the ratio of the idle-channel noise (ICN) with the applied noise-band (1) not notched and (2) notched.

The theory behind the NPR test is that the incident noise outside the notch will cause reciprocal mixing noise and multiple IMD products, which will appear in the idle channel (the receiver's IF pass-band) and raise the idle-channel noise (ICN). In effect, the applied noise simulates a band crowded with closely-spaced, extremely strong signals.

Spectrum of the NPR test signal

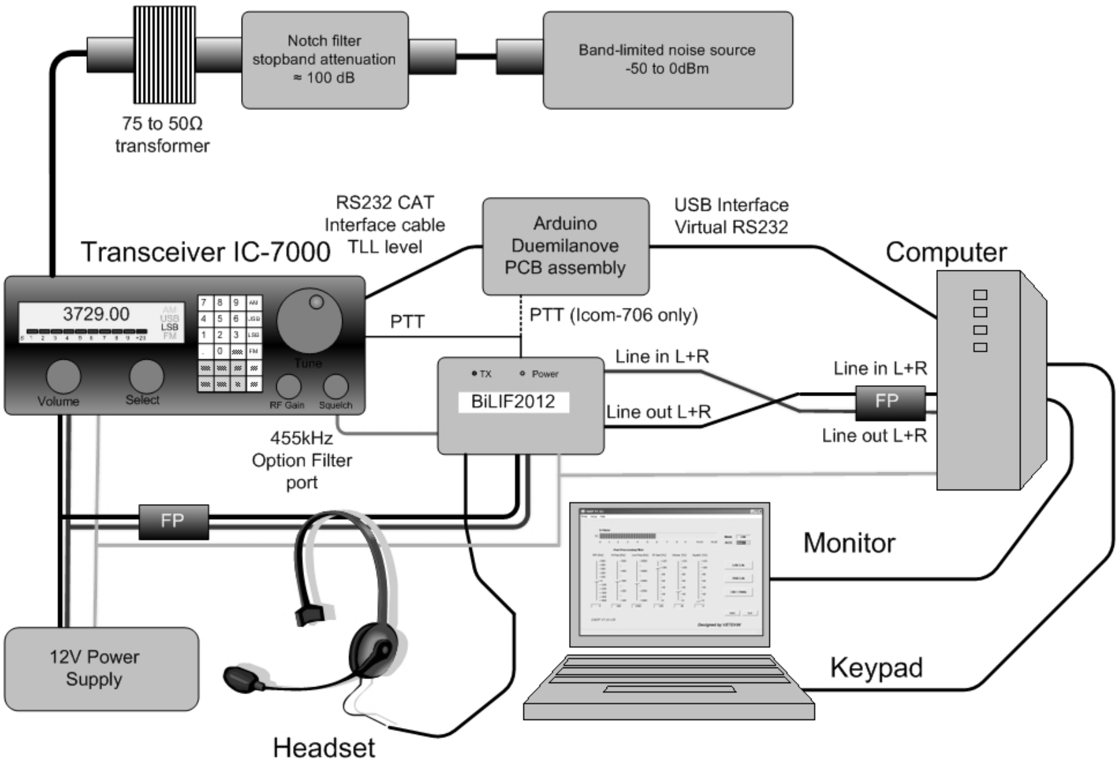


Testing Procedure:
The notch filter is 3 kHz wide at the bottom of the notch. It attenuates the applied broadband noise in the receiver's IF passband by ≈ 100 dB, and creates an IF channel in which the only noise will be that generated within the receiver. . During the test procedure, the generator output level is increased until a +3 dB increase of RX noise is seen at the receiver's audio output, as compared to no noise input. The test is run in SSB mode, at 2.4 kHz IF bandwidth.

The following reference describes the NPR test in detail:

http://www.ab4oj.com/test/docs/npr_test.pdf

NPR Test setup with BiLIF and MDSR



Test Results and Comparison:

The table below rates a list of transceivers that were tested by Adam (VA7OJ). Higher NPR values indicate better mixer performance. The test result of the IC-7000 with internal filtering and demodulation as compared to the IC-7000/MDSR combination is especially interesting. These results are identical.

Bandstop filter: f_0 = 5340 kHz. Band-limiting filter: 60 – 5600 kHz. 2.4 kHz, SSB.		
Radio type	Radio config.	NPR dB
Icom IC-7000 alone	Preamp off	64
	Preamp on	67
Icom IC-7000 + MDSR	Preamp off	64
	Preamp on	67
Icom IC-703	Preamp off	69
	Preamp on	70
Yaesu FT-897D	Preamp off	71
	Preamp on	65
Icom IC-7600	15 kHz roofing, Preamp off	79
	15 kHz roofing, Preamp 1	77
	15 kHz roofing, Preamp 2	76

Conclusion

These test results clearly show that the MDSR concept of reusing old analog transceivers and converting them into SDRs works extremely well. The BiLIF hardware and the MDSR software are flexible enough to be used with several different brands of transceivers (Icom, Yaesu and Kenwood, among others.). The overall results indicate a vast improvement over the conventional hardware modulation – demodulation inside each of the transceivers.

The cost of the conversion is about $200.- which includes the Audiophile sound card.

Acknowledgments

Special thanks to Guy Roels, ON6MU [guy.on6mu@skynet.be] for providing the inspiration for the LIF converter on his website (http://users.belgacom.net/hamradio/index.htm).

Thanks also to the North Shore Amateur Radio Club for the opportunity to present the MDSR project. Special thanks to Adam Farson VA7OJ/AB4OJ and David Shipman VA7AM for making available the specialized test equipment and facilities which were used to ensure that the MDSR development can meet the technical requirements

Thanks to Alex Shovkoplyas VE3NEA for the use of the OmniRig universal CAT control software.

Ham Radio operators contributing to the MDSR:

Contribution	Technology, Function	Name	email	Call Sign
CAT control	Visual Basic	Brian Kassel	bkassel@dakotablue.net	K7RE
DADP & MDSR Documentation	word processing, graphics	Alex Schwarz	alexschwarz@telus.net	VE7DXW
DADP and MDSR	PCB design, hardware and electronic design	Alex Schwarz	alexschwarz@telus.net	VE7DXW
DADP and MDSR audio engine	Java, NetBeans	Alex Schwarz	alexschwarz@telus.net	VE7DXW
LIF connected to IC-706	Hardware testing	Graham Le Good	g4gun@o2.co.uk	G4GUN
LIF connection of the IC-765	Hardware Testing	Sigfried Jackstien	siegfried.jackstien@freenet.de	DG9BFC
LIF kit building instructional video	video recording and editing -educational video	Richard Illman	ah6ez@comcast.net	AE6EZ

LIF kit connected to N-57 tube receiver	Hardware testing	Richard Illman	ah6ez@comcast.net	AE6EZ
LIF port installation into IC-735	Hardware Testing	Matthias Bopp	mailto:matthias.bopp@gmx.de	DD1US
MDSR - BiLIF2010 compliance testing	RF - Compliance tests	David Shipman	davidshipman@shaw.ca	VA7AM
MDSR - BiLIF2010 compliance testing	RF - compliance testing	Adam Farson	farson@shaw.ca	VA7OJ
MDSR Wiki setup	Java, web design	Bret McDanel	trixter@0xdecafbad.com	
MDSR website hosted at Belgacom compliments of Guy Roels	Web design	Guy Roels	guy.on6mu@skynet.be	ON6MU
MDSR with option to turn modulation off - multiple configuration file setup - variable IF	Beta tester and application consultant	Sigfried Jackstien	siegfried.jackstien@freenet.de	DG9BFC
OMNI Rig CAT software	Visual Basic	Alex Shovkoplyas	ve3nea@dxatlas.com	VE3NEA
OMNI-Rig software implementation into the SA-MDSR and MDSR software.	Visual Basic	Guy Roels	guy.on6mu@skynet.be	ON6MU
Proof reading and grammar corrections		Claire Spofforth		
Spectrum Analyzer, DADP control	Visual Basic	Guy Roels	guy.on6mu@skynet.be	ON6MU
setup of Vista and Win7	Software Testing	Kenneth S Stiles		KD0NQO
the use of a IC-703 for testing	short wave radio transmitter	Barry Bogart	barry_bogart@yahoo.com	VE7VIE