THE WEST RAND AMATEUR RADIO CLUB

January 2010
Volume 10, Issue 7

ANODE

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Special points of interest:

- Contact details on back page (corrected & updated Jan 2010)
- Ham-Comp Latest on web site.

Editor's Comments

Volume 10, Issue 7
January 2010

A New Decade?

Its a bit wet outside right now. Apparently we have had no more rain this year than usual. Living as I do high up on the ridge, I am not yet building an Ark. As I write this, the temperature is moderate and comfortable for working. My "tower" has not been struck more than once this year so far. Unlike previous years when the tower was struck by lightning on a regular basis. This could be as a result of my installing a fibre cable network between the garage and the ADSL router. [Murphy's Law!] The minute I use a normal wired network, the tower will be struck wiping out the usual list of network cards and switches.

At the committee meeting last Thursday night, we decided that the club really needs a club calendar. This would have the club's events (meetings etc.), bulletin readers and

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A Cost Effective Current-Mode 1:4 Balun

Ralph Holland constructs a Guanella balun.

Introduction

A cost effective current-mode 1:4 balun can be constructed from two lengths of coax, two ferrite rods, some electrical tape, cable ties, a length of PVC water-pipe and some connectors. This form of 1:4 current-mode balun is named after G. Guanella.

Principle

The operating principle is based on the cross-connection of two current-mode baluns. On the low impedance (current) end the transmission lines from each balun are connected in parallel while on the high impedance (voltage) end the transmission lines are connected in series. Since the current is divided equally between the two separate baluns the high impedance end sees half the current of the low impedance end, and since the voltages are also added in phase on the high impedance ends the device obtains a 1:4 impedance ratio. Only differential balanced currents are supported on the inside of the coaxes while currents on the outside of the braid are suppressed. The symmetry of the balanced load can be forced by grounding the centre terminal on the high impedance end (see the optional link in Figure 1).

Ideally the transmission lines should have a characteristic impedance of half the balanced load.

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A Cost Effective Current-Mode 1:4 Balun

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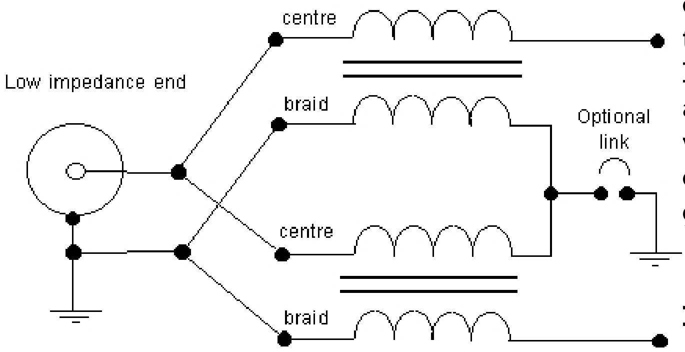

Figure 1 - Schematic

I have found that this balun is superior to the normally documented voltage-mode transformer or Ruthroff balun. The Guanella balun has perfect winding or transmission line symmetry with respect to the balanced load.

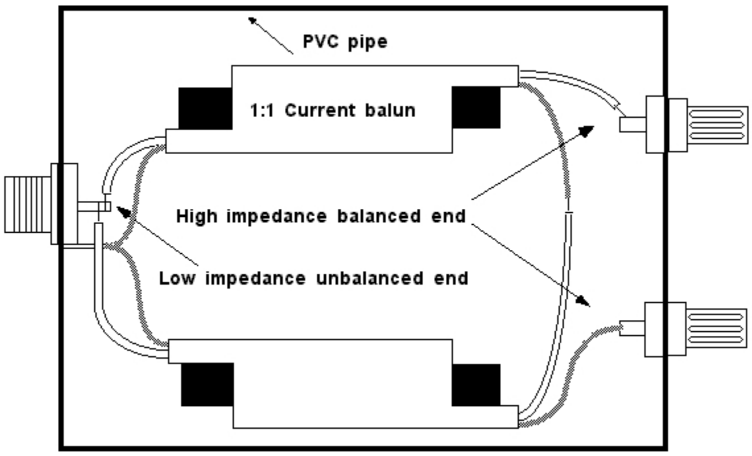

Figure 2 - Construction details for 1:4 balun

Construction

It is easy to wind the coax onto the ferrite rods. Experimental data supports 5 turns for coverage between 3 to 30 MHz, however if you want to operate at 1.8 MHz I have found that about 10 to 15 turns are required. The turns can be held by insulation tape and by applying two cable ties on the ends of the last layer on each rod. The low impedance end is terminated at a coaxial connector by taking the two centre-conductors in parallel to the centre pin and the two braids in parallel to the ground pin. On the high impedance end the top centre-conductor and the bottom braid are connected to the load, while the top braid is connected to the bottom centre-conductor - this junction can be grounded to force symmetry in the load.

Housing

The two balun sections can be housed in PVC water pipe. Cut a section large enough to make two end pieces which can be flattened with the aid of the heat from a hair-drier or heat-gun.

The circular end-sections can be cut with tin-snips. I drilled a hole for a panel-mount connector in one end and used banana connectors for the balanced feed on the other end. The end sections should be inserted inside each end of the pipe and held in place with the PVC pipe glue, but I have also found hot-melt glue adequate and easily removable.

Extra protection is obtained for the ends if you leave an overhang by inserting the ends further into the pipe.

References

HF Antennas for All Locations, Les Moxon, G6XN, RSGB.
Transmission Line Transformers, Jerry Sevick, W2FMI, 2nd Edition, ARRL.
A Cost Effective Current-Mode 1:1 Balun, Ralph Holland.

Email: Ralph Holland
Url: http://www.arising.com.au
Last modified Monday, 26 July 2004 23:41
[taken from his web page]

Mary Christmas

I tried very hard to include a radio, morse key, antenna etc… Page 3 girl. Hope you enjoy!

Direct Conversion for 2 metres

SM 5 BSZ - Linux pc radio. Optimised direct conversion receiver for 144 MHz using standard schottky diode mixers. (Jan 7 2007)

Fundamentals The block diagram of a direct conversion radio is given in figure 1. The local oscillator is at the centre of the desired passband and frequencies close to it will show up as audio frequency signals in the mixer outputs. An ideal mixer produces the sum and the difference frequency only while a real mixer also responds to overtones of the local oscillator. The first box, the filter, is inserted to suppress receiver response at the overtones of the local oscillator, 288 and 432 MHz for the 144 MHz receiver described in detail on this page. The relative phase between LO and RF must differ by about 90 degrees between the I and Q channels. Modest errors in the phase can be compensated by the computer but the relative phases and amplitudes must be very stable. The 90 degree phase shifter can be just a 1/4 wavelength section of coaxial cable. The mixers shift the frequency from around 144 MHz to audio frequencies. If standard devices with schottky diodes are used, as in the design presented here, the signal is also attenuated by about 8 dB. The audio amplifiers amplify the very low voltage present at the mixer output to a level that fits the soundcard of the computer.

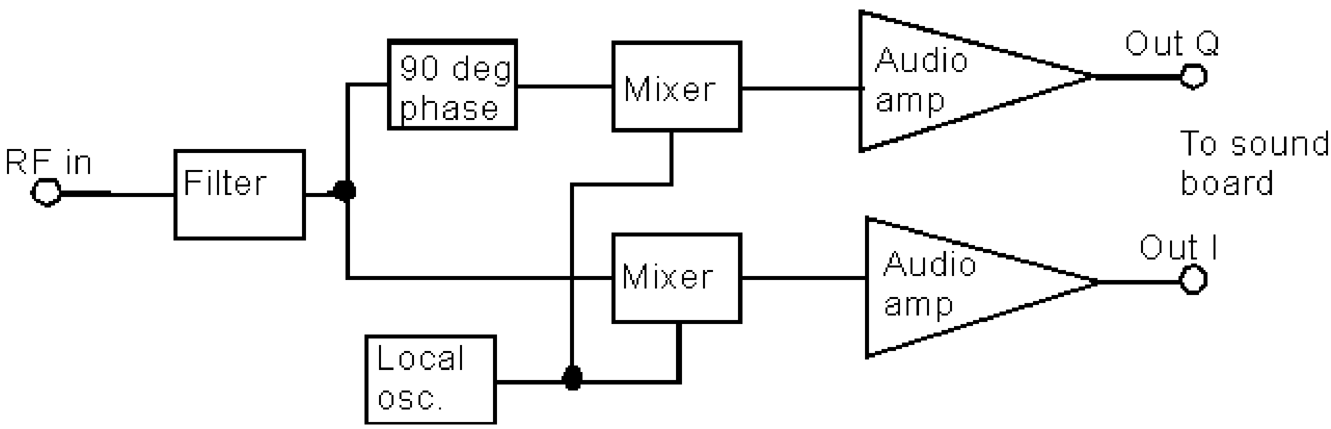

Fig 1. Block diagram for direct conversion radio.

Soundcard noise levels. The audio boards have high input impedance. The Delta44 input impedance is 10 kilo ohms for example. The noise level produced by a 10 kilohm resistor is about 12.6 nV in 1 Hz bandwidth. The noise level of the Delta44 is about 200 nV in 1 Hz bandwidth in the least sensitive position, (ossmix +4 DB) corresponding to a noise figure of about 24 dB. In the most sensitive position (ossmix -10 DB) the noise figure is about 5 dB. These noise figures are the noise figures for a 10 kilo ohm source impedance for which soundcards are designed. The disadvantage of setting the soundcard in high sensitivity mode is that the noise floor becomes higher in relation to the limit where the A/D converter saturates. The signal level corresponding to the noise floor is lowered by about 10 dB but the signal level corresponding to A/D saturation is lowered by 14 dB!! The low noise amplifier one can select to use does not only have a low noise figure, it also contributes some noise.

Adding a preamplifier to get better noise figure will normally result in reduced dynamic range. Now, for use as the amplifier following a schottky diode mixer, the soundcard preamplifier is a bad choice. A good amplifier to use in a 50 ohm system should have a noise level in the order of 1 nV in 1 Hz bandwidth. In a 50 ohm system the high sensitivity mode of the Delta44 corresponds to a noise figure of 20 dB while the high level mode noise figure is about 40 dB with a 50 ohm source impedance. Even though it is possible to connect the A/D board directly to schottky mixers Very low cost radio, it is obvious that a low noise amplifier designed for about 50 ohm input impedance will allow lower signal levels

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Direct Conversion for 2 metres

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out from the mixer with better performance for strong signals as a result.

Low noise, low impedance audio amplifiers The easiest way to get a low noise amplifier suitable for use between the schottky mixers and the computer audio boards is to use the AD797 from ANALOG DEVICES. This amplifier is designed for use as low noise amplifier The noise figure is close to zero at 200 ohms input impedance and well below 2 dB at 50 ohms. This amplifier is specified to have total harmonic distortion below -120 dB so it will not degrade performance for large signals. The A/D boards have their harmonic distortion in the -90 to -100 dB range. Linearity of A/D boards The problem with the AD797 is cost and availability. The two channel direct conversion radio described here would need four of these amplifiers at a total cost of USD 45 (April 2001).

It is possible to get equally good performance using low cost standard components as shown in fig. 2.

The amplifier in fig.2 is not difficult or critical in any way. The basic idea is to add a low level preamplifier with a bipolar transistor having high current in front of a low cost low noise op-amp. The second stage gives a voltage gain of 3.51 which is about as much gain one can use from a RC4136 without any noise at the output detectable with a Delta44 board in high level mode (ossmix +4 DB) The second stage is just an ordinary inverting amplifier but the input resistor is split in two halves to get a point where a LC notch filter can be added. This notch filter gives very high attenuation at 52 kHz while it does not affect frequencies below 48 kHz at all. The optional notch filter extends the useful frequency range from about 89 to 92 kHz and is by no means necessary. The B+ voltage, half the supply voltage, is common to all 4 channels, I and Q for two antennas. The first stage, consisting of a bipolar transistor and a RC4136 section has a voltage gain of 1036/36 = 28.8 times. The A+ voltage is common to all 4 amplifiers. The component values in the schematic diagram are for a supply voltage in the range 12 to 20 volts to give a voltage at the col-

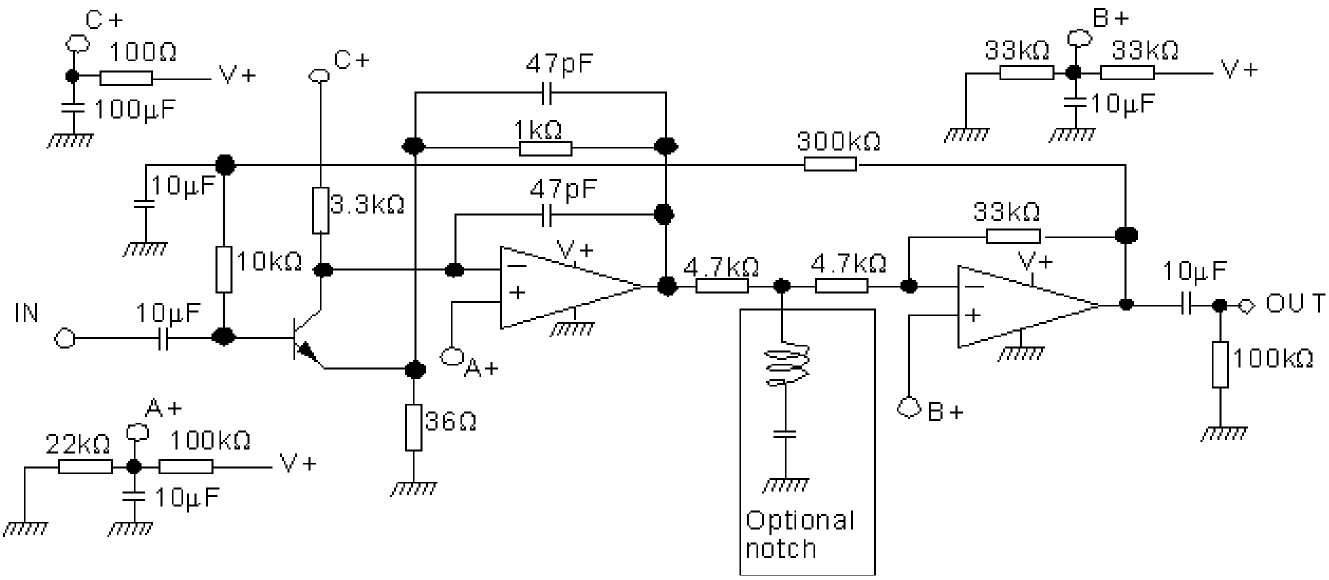

Fig 2. Low noise amplifier with a voltage gain of 100 times (40 dB) The input transistor should be rated 0.5 to 2A with a transition frequency Ft of at least 120 MHz. The op amp is RC4136 or similar. See text for further details.

lector of 2 to 3 volts. The A+ voltage and the collector resistor, 3.3k ohms in the schematic diagram set voltage and current of the input transistor and can be optimised for lowest noise figure. The 300 kilo ohm resistor that

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Direct Conversion for 2 metres

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feeds the output DC voltage back to the base of the transistor has to be selected to make the output DC voltage exactly half the supply voltage. (Change if A+ or collector resistor is changed) More clever ways of making the DC feed back are possible to avoid the need for adjustment, but this one is simple. Resistor values range from 270 to 330 kilo ohms in my 4 amplifiers. By feed back on the emitter the input impedance of this amplifier is high. If the input is left open it produces an increased noise level. This amplifier is designed to have a schottky diode mixer connected to IN so the base will see a low impedance and then the transistor will produce very little noise. The transistor can be anyone of BC489A, BFX34 or BUY49S. Typical low noise audio transistors like BC109 or BCY59 give much more noise. They are designed for smaller currents and give good noise performance at higher impedances. Probably any transistor rated about 1A with a transition frequency above 120 MHz will work well. The compensation capacitors, 47pF, should not be made larger than required to get stable operation. With the component values of fig.1 the amplifier matches the Delta44 A/D board and does not degrade the harmonic distortion of the system. The second harmonic is below -100 dB at full output level and higher orders are well below. The audio amplifier presented here increases the noise floor of the Delta44 audio board by 1 dB. Trading 1 dB of headroom between noise floor and saturation for a 40 dB lower signal level out from the mixers is a reasonable compromise. Selecting mixer type for highest spur free dynamic range A low level mixer such as SBL-1 or TUF-1 saturates at an input level of 1 dBm or 0.71 volts P-P. In a 50 ohm load the output level is 9 dB lower, 8 dB attenuation and 1 dB compression, or 0.25 volts P-P. A high level mixer such as RAY-1 saturates 14 dB higher and needs 14 dB more LO power. It is obvious that the low level mixers will produce harmonic distortion and intermodulation when they deliver the 100 milliVolts P-P required to saturate the Delta44 board since this level is only 8 dB below the 1 dB compression point. For this reason it would be natural to select a high level mixer. Using a RAY-1 gives good intermodulation and harmonic properties for the mixer, compatible with the performance of the Delta44 itself. The mixer does not only mix the LO with the RF signal. It also mixes the LO carrier with the noise sidebands that surround the carrier. Using a RAY-1 without severely degrading the noise floor, particularly at low frequencies is not compatible with normal local oscillators.

The IC202 produces a relatively clean signal, but it is far from good enough to use as local oscillator together with a RAY-1 mixer. The degradation caused by the noise sidebands of the IC202 is as follows:

Frequency	Degradation
40kHz	6dB
10kHz	10dB
4kHz	20dB
1kHz	30dB

To use this configuration, a IC202 for LO and a RAY-1 mixer one has to add 30 dB of RF gain to overcome the noise 1 kHz away from the band centre. To not loose dynamic range in the Delta44 it is then necessary to reduce the audio amplifier gain by 30 dB Then the RAY-1 will be saturated before the Delta44. For use with high level mixers in a direct conversion receiver a much better LO than the IC202 is required. By using a low level mixer with 14 dB lower LO power one reduces the low frequency noise from the oscillator mixing with the LO sidebands by 28 dB which means that the IC202 is good enough to use as local oscillator. The harmonic distortion from the mixer is the dominating non-linearity, a signal that nearly saturates the Delta44 produces overtones that are about 60 dB below the fundamental if the mixer is NOT loaded by 50 ohms. The filter of fig. 2 followed by the amplifier of fig.1 does not load the mixer, which means that the output voltage is twice as high compared to a 50 ohm load. Leaving the mixer unloaded means that the input signal can be reduced by 6 dB for the same output volt-

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Direct Conversion for 2 metres

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age, but saturation of the output is at 330 milliVolts giving a better margin between saturation and the level giving full signal for the Delta44. In all texts I have seen about the use of schottky diode mixers it is stated that the mixer must be terminated in 50 ohms. When the IF frequency is low, 0 to 45 kHz this is not true.

The same is very probably the case for normal IF frequencies like 10.7 MHz if the combined performance of the mixer and the amplifier following it is considered. Allowing the IF amplifier to be loaded by the output impedance of the mixer only reduces the noise floor because the noise level of the amplifier will increase much less than 6 dB when the 50 ohm termination is removed. When comparing the intermodulation properties for signals at a certain level above the noise floor the unloaded mixer gives better performance than the loaded one.

In case the IF amplifier uses noise free feed back to present the mixer with a 50 ohm load the situation may be different. That is feasible at normal IF frequencies but not in a direct conversion radio. Filters must protect the audio amplifier from RF signals The peak to peak voltage at the output of the mixer is 100 milliVolts for the strongest permissible in band signal. The output amplitude is then about 10 volts peak to peak which is about the level required to saturate the Delta44 board. The mixer is wideband and will of course produce the same level independently of the frequency separation between the local oscillator and the RF signal. The audio amplifier can not deliver the 10 volts P-P output at high frequencies. Already at 75 kHz the second stage of the amplifier in fig.2 limits the amplitude because of inadequate slew rate of the RC4136. In this respect the AD797 is much better, it goes up to about 300 kHz. The first amplifier stage of the amplifier in figure 2 works all the way up to 150 kHz because it is not required to deliver as high output voltage. The compensation capacitors slow it down but the three times lower output amplitude eases the slew rate requirements.

The small signal bandwidth of the first amplifier stage of fig. 2 is 2 MHz. At this frequency the first stage can only deliver about 100 milliVolts P-P corresponding to only 3.5 milliVolts at the input. It is absolutely necessary to protect signals 1 to 2 MHz away from the centre frequency from reaching the audio amplifier to prevent strong intermodulation between signals that are only a few milliVolts at the mixer output. In the 144 MHz receiver described here the centre frequency is fixed near 144.100 MHz. If no filters are used severe problems would arise from strong FM signals in the 145 to 146 MHz range that would mix with each other in the first audio amplifier stage which is non-linear already 30 dB below the strongest permissible in band signal. A filter directly on 144 MHz can not provide the desired attenuation so a filter must be inserted between the mixer and the audio amplifier. The filter must attenuate by at least 30 dB at 1 MHz to give a similar dynamic range for signals in the 145 to 146 MHz region as for the desired 90 kHz passband around about 144.100 MHz. The mixer is capable of giving more output than 100 milliVolts, it is a good idea to suppress signals around 1 MHz by more than 40 dB for a low level mixer like SBL-1 or TUF-1 while 60 dB attenuation is useful if a high level mixer is used. The filter shown in fig. 3 has the following characteristics:

Freq	Attenuation
79kHz	20dB
115kHz	30dB
173kHz	40dB
263kHz	50dB
395kHz	60dB
567kHz	70dB
764kHz	80dB

The impedance level is chosen to not load the mixer. The filter degrades the noise figure slightly at frequencies above 30 kHz because the input transistor of the audio amplifier will see a much higher impedance than 50 ohms

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there.

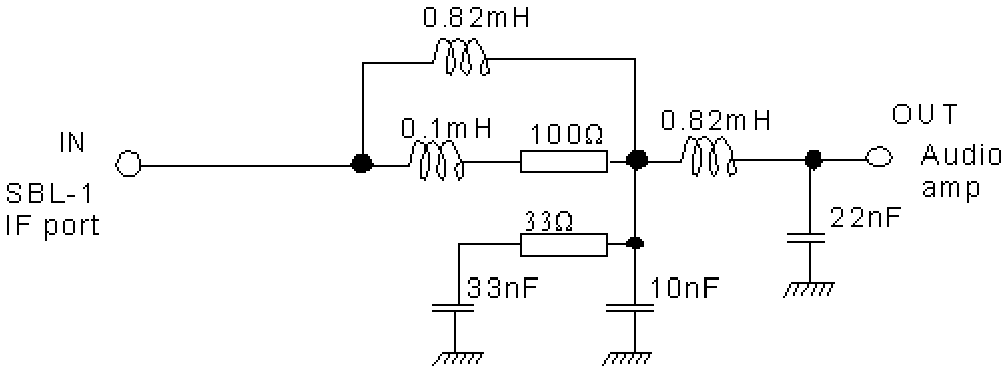

Fig 3. Filter to protect audio amplifier from high frequencies.

Local oscillator for direct conversion 144 MHz receiver To get a good idea about the absolute levels of sideband noise of different local oscillators at 144 MHz two X-tal oscillators as shown in fig. 4 were built. One is used as the local oscillator in the 144 MHz direct conversion radio while the other was used as a test signal. Fig. 5 shows the spectrum at 10 Hz resolution bandwidth when the 144 MHz X-tal oscillator is the signal source. Fig. 6 shows the noise floor, everything the same as fig.5 except that the test signal is switched off.

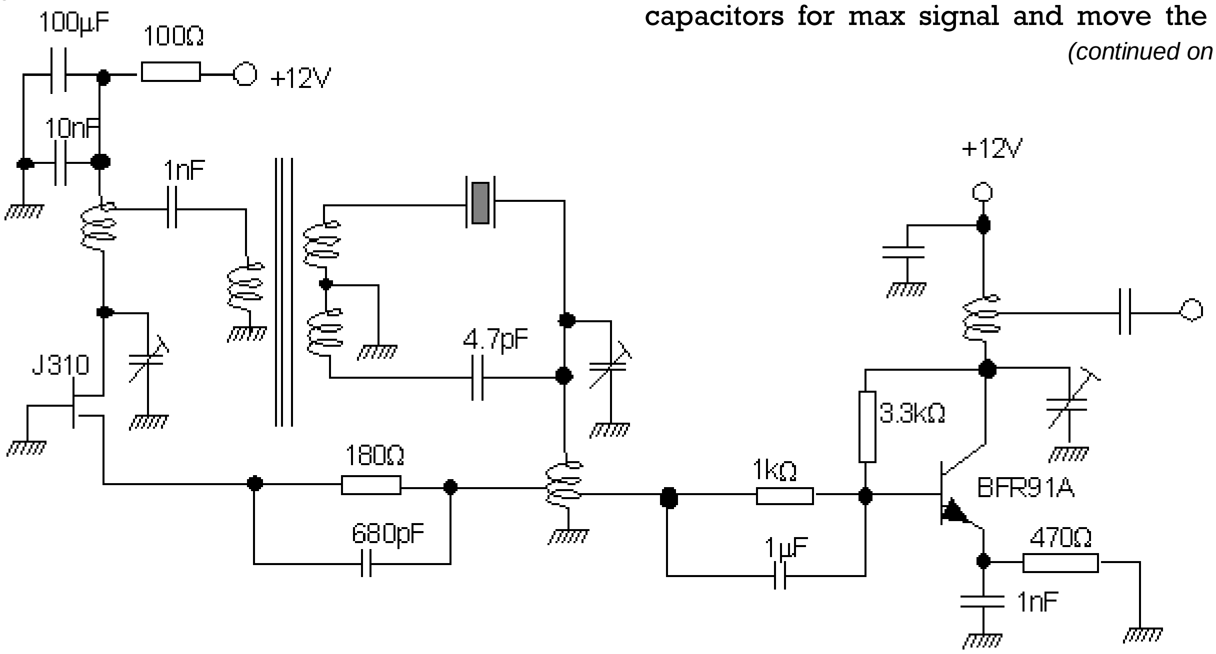

Fig 4. Xtal oscillator for 144 MHz. The X-tal is a computer grade 16 MHz X-tal. The 9th overtone is at 144.095 MHz with a Q of about 30000 (used as a filter the 3 dB bandwidth is 5 kHz) The transformer is the transformer of a SBL-1. The schottky diode mixers contain ferrite cores with trifilar windings. Unwind one turn from each end to get enough wire to solder on. Note that the 4.7 pF capacitor must balance the parallel capacitance of the crystal. It may be a good idea to make it a trimmer. For further details, see text.

To adjust the X-tal oscillator, break up the feed back loop by connecting the 180 ohm source resistor to ground and feed a signal source to the 680 pF source capacitor. This way the oscillator is converted to a X-tal filter for 144 MHz. Tune capacitors for max signal and move the tap at

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Direct Conversion for 2 metres

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the drain coil for maximum signal. place a 50 ohm load at the point where the feed back will be taken from and adjust the tap for maximum gain. The gain has to be a little more than one for the amplifier to oscillate through the filter when the feed back is in place. The 16 MHz X-tals have many resonances but the strongest one is usually about 10 dB stronger than the second strongest. Some X-tals have a very small difference between the two strongest resonances and should be avoided.

Fig 5. Sideband noise when listening to the 144 MHz X-tal oscillator with the direct conversion radio.

From fig.5 the sideband noise levels of a single X-tal oscillator can be estimated to the following values assuming the two oscillators are similar: Separation Noise level in 1 Hz bandwidth (kHz) below carrier (dB)

At 4 kHz offset the noise floor is lifted by about 2 dB which means that the combined noise from both the LO and the RF signal and from the flat noise floor itself is 1.6 times above the flat noise floor which means that the sideband noise from the LO is 0.3 times the flat noise floor or at about -3 dB, 130 dB below the carrier or 140 dB in 1 Hz bandwidth. This estimation is not very accurate. This result is discouraging compared to a state of the art 100 MHz X-tal oscillator which is 40 dB better according to fig.8 in the article Beyond Fractional-N, published in QEX Mar/Apr 2001 page 24. The X-tal oscillator

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described here is the best 144 MHz signal source I have ever seen. With one of them as the local oscillator the direct conversion radio is well suited to check the performance of conventional ham radio transmitters. Fig. 7 shows the spectrum of the IC202 with the same settings as those used to record figures 5 and 6.

The IC 202 measurement shows similar results close to the carrier but at a frequency separation of 4 kHz the IC 202 has reached its flat noise floor which is at -133 dB in 1 Hz or -100 dB in SSB bandwidth. The direct conversion receiver described here is more or less compatible with good quality 144 MHz transceivers. Dynamic range of 2 m Transceivers

Final discussion The radio described here has reasonable properties for large signals. The dominating non-linearity is the SBL-1 which is operated about 17 dB below its saturation level for the maximum signal permitted by the Delta44. The noise figure is about 20 dB and the Delta44 saturates at -14 dBm. Fig. 8 shows the full spectrum of the IC202 when the level is close to saturation and fig. 9 shows the corresponding noise floor. Undesired signals caused by the SBL-1 non-linearities are about 60 dB below the carrier corresponding to an intercept point IP3 somewhere around +10 dBm.

Fig 8. Full frequency range spectrum of a IC202 at near saturation of the Delta44. The peak at 48 kHz is 50 Hz hum, DC offset and very low frequency noise. The main signal is at 37 kHz corresponding to 11 kHz audio. The mirror image is at 59 kHz and it is suppressed by 60 dB because of the calibration built into the dsp program. Without calibration the mirror is around -20 dB with respect to the carrier. The second harmonic of the 11 kHz audio frequency is generated by the mixers and produces signals at 27 and 70 kHz while the third harmonic gives signals at 16 and 80 kHz.

To use the direct conversion receiver described here in a ultra low noise system one has to add about 35 dB RF gain. 20 dB to overcome the noise figure and another 15 dB to make the noise from the preamplifier dominate over the rest of the system noise by about 17 dB. The IP3 at the antenna will then be about -25 dBm.

To test the direct conversion radio with respect to interference from signals at large frequency separations a AM modulated signal was used. When the level is adjusted to nearly saturate the Delta44 the SBL-1 produces audio of the modulation frequency at a level about 75 dB below the carrier. The SBL-1 works as a AM detector, sending signals into the RF port gives detected AM at the IF port. The AM detection is wideband, the level does not change even if the frequency is changed by 10 MHz in either direction. The non-linearity responsible for AM detection will of course mix all signals with each other and a good band pass filter in the RF amplifier chain will eliminate problems from strong out of band signals. This direct conversion receiver is low cost. The total component count for a complete two channel system and approximate component cost is as follows:

```
Item                 no     total SEK

LO:
trimmers              3        25
J310                  1         3
Bipolar               1         3
X-tal                 2        20 (every
second perhaps useless ??)
R and C              14        14

MIXER:
TUF-1                 4       140

FILTER:
inductors            12        30
R and C              20        20

AMPLIFIER
RC4136                2        12
bipolars              4         8
R and C              56        50
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Sum 325

The components add up somewhere around $30. The notch filters are excluded, I do not know what they would cost. The unit is uncritical and easy to build except for the X-tal oscillator that well can be replaced by something more conventional like a 12 MHz X-tal running at 36 MHz followed by two frequency doublers. It is interesting to have investigated the direct conversion radio built around standard schottky diode mixers. Comparing the experiences to the experiences with CMOS mixers makes it quite clear that the way to go is to make a two step conversion. The CMOS mixers can operate from a low noise X-tal oscillator at a fixed frequency in the 2.5 to 20 MHz range. Filters with a bandwidth of about 100 kHz can be used to protect these mixers from strong out of band signals. To mix from 144 to the fixed frequency a conventional design with high level schottky mixers can be used without the problems of LO sidebands mixing with the LO carrier since then the IF is far above the audio range.

Taken from his web site:

http://www.sm5bsz.com/

Visit his site for the left out pictures...

Editor's Comments

(Continued from page 1)

SARL events. Any other events could be added by the users or members. Also included should be the list of Holidays in South Africa. These will affect the decisions made by the club when to hold Flea Markets etc.

Also the generation of a printed and mounted "club calendar" would be useful to the club at meetings. So I will endeavour to set this up as a 'project' under the Ham-Comp meeting this month. I shall discuss the construction of a suitable calendar database and the accessing of the data via a web interface.

Having already done some research on this, I told the committee about Lightning and 'SunBird'. Sunbird is the open source version of the M$ Outlook calendar, which is 'free'. SunBird is being developed by Mozilla, the people who brought you FireFox and ThunderBird.

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I bought the December Elektor in the CNA the other day. A fairly thin magazine with a number of interesting circuits. As usual it was only just worth the R100…

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Firefox 3.x is now out and will automatically update itself. If you have a broadband connection that is... But the new online video is not worth trying here in SA. The bandwidth requirement makes the video jerky and breaks up the sound. Shame. The local Telkom network has been increasingly more erratic this last month. I don't think Telkom subscribers are going to watch the football this year online.

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West Rand Club History

Die Wesrand Radio Amateur klub is besig met die opstel van die klub se geskiedenis sedert sy ontstaan in 1938. Graag verneem ons van enig iemand wat oor inligting beskik in die verband.

Wees so vriendelik en laat ons u bydrae kry deur dit te stuur na willem@zs6wwj.co.za Ons sal u bydrae erken in die boek wat ons beoog om aan die einde van 2010 te laat verskyn.

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Established in 1948
KG33XU 26.14122 South - 27.91870 East

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1715

Phone: **082 342 3280** (Chairman)
Email: **zs6wr.club@gmail.com**
Web page: www.jbcs.co.za/ham_radio

Bulletins (Sundays at …)
11h15 Start of call in of stations
11h30 Main bulletin start

Frequencies
439.000MHz 7.6MHz split
Input: 431.4MHz (West Rand Repeater)
145,625 MHz (West Rand Repeater)
10,135 MHz (HF Relay)

Radio Amateurs do it with more frequency!

Chairman	Joop Hesp	ZS6C	082 342 3280	**zs6wr.club@gmail.com OR joophesp@telkomsa.net**
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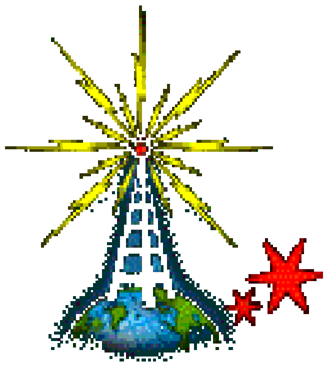
West Rand members - we need your input!

To make this the best ham radio magazine in South Africa we need your input. Please submit articles, comments, suggestions etc.

Please send plain text with no formatting to the email address below.

In July 2003, we re-published an Anode Compendium on CD. It has the issues from July 2000 until June 2005. This included the new Adobe reader. It has been updated, check with the chairman for details.



We need your input! Email us articles, comments and suggestions please.
zs6wr.club@gmail.com