Data

Phase shift networks help interface your computer to the æther.

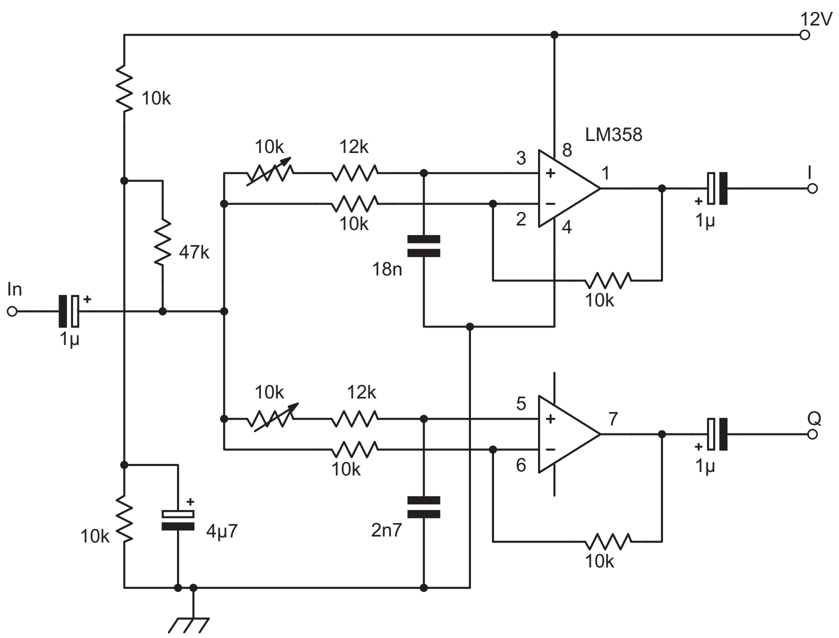

FIGURE 1: Circuit diagram of the all-pass network for generating two quadrature audio drive signals from a single audio tone.

AUDIO PHASE SHIFTER. Most datamode software generates audio tones that are designed to feed into the audio circuitry of a conventional SSB transceiver for upconversion to the final RF output. On the LF bands, 137kHz and more recently 503kHz, this is not always convenient as transceivers do not cover the bands and the signal has to be further transverted. This difficulty is one of the reasons for the limited use of modern digital modulation techniques on these bands. But, what if it were possible to directly convert from audio to RF? With audio tones of typically 1 – 2kHz and a conventional mixer, the image band will lie just 2 – 4kHz away – a difficult filtering problem even at 137kHz. The image cancelling, or dual channel, I/Q mixer technique will help here as the opposite sideband can typically be reduced by 40 to 50dB compared with the wanted output. Suitable image reject upconverter designs can be found at [1] and [2].

But what if the dual I/Q outputs are not available from the computer, as is the case with most current datamode software? Now the 90° I/Q audio drives have to be generated in hardware from a single audio tone. Many audio phase shift designs have appeared over the years, some with quite complex configurations giving acceptable full speech-band performance and a web search of "Phasing SSB Transmitters" will reveal several designs. *[Also, see this month's Homebrew – Ed]* However, these either use a zero-IF configuration where the unwanted speech product lies on top of the wanted signal so a sideband rejection of 20dB is often adequate, or are used for QRP operation on HF where sideband leakage can go unnoticed. At LF, where the image is probably out-of-band, decent opposite sideband rejection is obligatory.

For LF use, we are only really interested in a narrow audio range for low bandwidth modulation types (such as PSK31, WSPR or Olivia) and provided we restrict the audio to no more than a few hundred Hz in width, a remarkably accurate phase shift can be formed from a simple all-pass circuit configuration like that in **Figure 1**. This all-pass network uses a pair of operational amplifiers and a few Rs and Cs to give unity gain in each channel over the full audio spectrum, while over the frequency range of interest there is a reasonably accurate 90° phase *difference* between the two outputs. Two preset resistors allow fine tuning of the relative phase shift and allow the frequency range and suppression in the image reject mixer to be traded-off. The Excel spreadsheet in [3] simulates the all-pass design and can be used to investigate graphically how rejection across the audio band is affected as the all-pass component values are altered.

ALIGNMENT. It helps greatly if a spectrum display that can show both output sidebands simultaneously is available. An SDR with spectral display is ideal for this task, but a simple direct RF conversion to baseband followed by a wide band audio analysis program running at 44 or 48kHz sampling is sufficient. If a wideband receiver is not available, a normal SSB receiver can even be used to align the network, either by tuning over the two sidebands, or by switching between LSB/USB reception. (If you physically connect the converter output to a receiver then do so though an appropriate attenuator or you risk damaging the receiver front end). Apply an audio tone at the desired frequency and observe both sidebands and carrier leakage on the spectrum display. The allpass network has no influence on carrier leakage (mixer balance) and if this is significantly worse than 40dB, it suggests a fault in the mixer. Ensure the correct sideband is selected – for the opposite one swap over the I and Q channels.

Adjust the two presets for the best unwanted sideband rejection. A quick way to align the all-pass network optimally over a range of frequencies is to use broadband noise as the audio input rather than a single tone. The resulting spectrum will show the sideband cancellation over the whole frequency range simultaneously, although FFT averaging will be needed to show the response properly when using noise as input. Suitable flat spectrum (white) noise, in the 200 – 3000Hz region can be obtained from an SSB receiver at maximum gain with no signal present, or from a pseudo noise code generator such as the one in **[4]**. (Note that noise from FM and AM receivers is *not* white – that from an FM demodulator is particularly spiky).

Minor adjustments of amplitude balance between the I/Q drives to the mixer can further improve sideband rejection and can be made by altering very *slightly* the value of one or other of the feedback resistors around the op-amps. Optimising both phase and amplitude matching by a fraction of a percent can make dramatic improvements to sideband rejection. Spot-frequency rejection values in excess of 50dB have been seen, although these are only achieved typically over a span of a few tens of Hz.

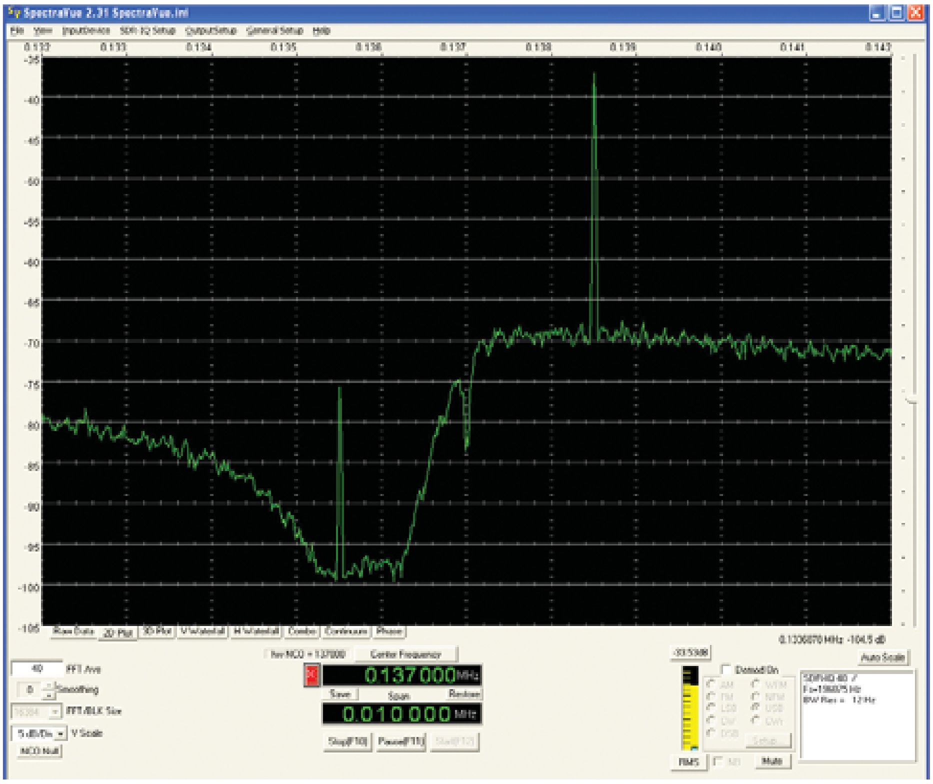

FIGURE 2: Output of the Allpass network, driving an FST3125 bus-switch mixer at 137kHz. The drive signal is 1.5kHz tone + white noise.

RESULTS. **Figure 2** shows the output spectrum of the all pass network when driving a simple bus-switch mixer at 137kHz with an SDR-IQ receiver as the analyser. Frequency span is 10kHz, and the audio drive is white noise mixed with a tone at 1500Hz. Sideband rejection has been optimised over the band 1000- 1500Hz and it can be seen that at 1500Hz a rejection of 37dB has been obtained. A few dB of improvement in sideband rejection can be made by fine adjustment of amplitude and, when re-adjusted for optimum rejection at 1500Hz, 45dB isolation was achieved. More details of the complete upconverter can be found in **[5]**.

The outputs from the opamps could be used directly to drive FS3125 type bus switch mixers. To take advantage of this simplification, remove the output DC blocking capacitors and change the bias circuitry at the input to deliver 2.5V so the mixer inputs are biased to the middle of their range with a 5V supply.

FLDIGI. This new digital modem software brings together most of the amateur soundcard based datamodes into an easy to use versatile single package. Written by W1HKJ, it is available for free download from **[6]**. Different operating systems are catered for and versions for Windows XP, W2K, VISTA and OS X are currently available.

The operating modes included are:

CW – variable speed, weight, dot/dash ratio, rise/fall time
DominoEX 4, 5, 8, 11, 16, 22
Feld-Hell, FSK-Hell, FSK-Hell 105
MFSK-8, MFSK-16, MFSK-16pix
PSK-31, QSPK-31, PSK-63, QPSK-63, PSK-125, QPSK-125, PSK-250, QPSK-250
OLIVIA, various tones and bandwidths including user defined versions
RTTY various Baud rates, shifts, data bits, etc.
Throb-1, 2, 4, X-1, X-2, X-4
Thor-4, 5, 8, 11, 16, 22
WWV Receive - calibrate your sound card to WWV!

The latest version has many improvements to the user interface shown in **Figure 3**; new built-in logbook with contest-friendly data captures, macros and ADIF (Amateur Data Interface Standard) exports; new interface to QRZ / Hamlog online database systems; fully automated data capture for reporting to the *pskreporter* online database, menu accessible link to the *pskreporter* map; expanded macro language for helping with QSO exchanges; improved data capture from receive text to the QSO log; fully compatible with *pskmail*. Direct access to on-line help and descriptions is only a click away.

FLARQ. Fast Light Automatic Repeat reQuest is a file transfer application that is based on the ARQ specification developed by Paul Schmidt, K9PS. It is capable of transmitting and receiving frames of ARQ data via Fldigi. The interaction between Flarq and Fldigi requires no operator intervention with the two programmes exchanging data and command sets using a POSIX, System V Message Queue, totally transparent to the user. The programmes can be executed in either order and it is only necessary that both be running concurrently for the process to work.

One unusual use for Flarq has been for Olivia propagation tests on 503kHz. Graham, G0NBD set up Fldigi to transmit beacon messages at one minute intervals using the narrowband option of 8 tones with 250Hz bandwidth. Using Flarq and open receive, any other station hearing the beacon could connect to G0NDD and leave a message. This facility allowed Graham to run the beacon throughout the night when LF propagation is at its best, without having to be actually present and continuously monitoring his receiver to acknowledge calls.

MORE WSPRING. This narrow bandwidth beacon mode is gaining in popularity in a big way now, with dedicated spots on all the lower amateur bands. Most days several stations can be found sending low power probe signals with many more automatically reporting calls heard, particularly on 7 and 10MHz. The *WSPR.EXE* software described previously allows users to upload any decoded messages directly to a central website database **[7]**. No registration is needed for upload or viewing. Searches can be restricted to a callsign heard or callsign reporting it, by date, by unique reporter or any combinations of these. For example, only the occurrences of G4JNT heard by GM4ISM on 503kHz could be listed, or all calls on 7.04MHz.

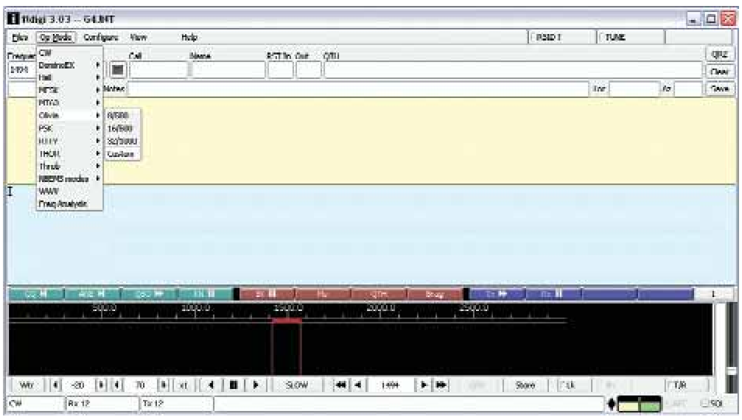

FIGURE 3: The Fldigi user screen.

REFERENCES

[1] www.w1tag.com/Phasing.htm
[2] www.g4jnt.com/IQConverters.htm
[3] www.g4jnt.com/OPA_AllPass.xls Spreadsheet for Allpass filter design. Alter the values of C1/ R1/ C2/ R2 to see how the rejection vs. frequency response changes
[4] Data, RadCom June 2006
[5] www.g4jnt.com/LFUpconv.pdf
[6] www.w1hkj.com/Fldigi.html
[7] http://wsprnet.org/meptspots.php