Soundcard Based Noise Figure Alignment Aid

G4JNT & G3PLX   November 2011

Back in 1974, John Compton, G4COM, published an Automatic Noise Figure Alignment aid that automatically controlled a noise source connected to a receiver input, then measured the ratio between the receiver output with the source on and with it off. The ratio was displayed directly on a meter, with a linear dB reading directly related to the noise figure.   The design was reprinted in various RSGB publications and manuals over the years, and a kit was sold by Hands.   More information on the original design can be found at [1]

The noise output from the receiver was first rectified in a precision rectifier, then applied to a logarithmic amplifier.   The log output was then applied to a mixer stage or synchronous detector where it was multiplied by +1 or -1 in synchronism with the noise source's switching voltage. The output was passed though a low pass smoothing filter for display on an analogue meter.   Four op-amps in total were employed.

It worked as follows : The Rx audio output for noise source-on and source-off, when applied to the precision rectifier stage, gives two DC levels **Von**, and **Voff**. We want the *ratio* between these two voltages.. After the log amp stage, these become **LOG(Von)** and **LOG (Voff)** respectively.   As we know **LOG(V1 / V2)** = **LOG(V1) – LOG(V2)** then the two LOG terms can be subtracted to give a ratio By multiplying the *off* term by -1 and the *on* term by +1 in the synchronous detector, the resulting output applied to the meter after averaging is related to **LOG(Von / Voff)**.   Since noise figure expressed in dB is exactly of this form, the meter can be used to optimise the noise figure of a receiver, independently of the stage gain. Many thousands of these modules must have been built over the 37 or so intervening years, with the design modified and upgraded many times by various people.

But the whole thing is just asking to be digitised. While the audio side is straightforward in software, driving the noise source in synchronism with trying to identify the audio input samples as 'on' or 'off' noise certainly is not   Windows, and PCs generally, are notoriously incapable of accurate time synchronisation, and attempting to switch the noise source via a COM port or USB interface, while hoping to keep track of this with soundcard timing is, well – I won't say "impossible", but....

A straightforward solution is to switch the noise source independently with an externally generated square wave at a frequency of a few tens of Hz, then use the other channel of a stereo audio input to detect this on/off signal.   Now, as we know there is virtually no time skew between left and right audio channels, the noise source on/off control can be correlated exactly with the received audio. Figure 1 shows the concept.   Provided the switching signal is attenuated to no more than 2V peak-to-peak it can be applied directly to the soundcard input port. As the frequency response of most soundcards extends down to around 10 – 20Hz it should appear uncorrupted in the resulting data steam in parallel with the on/off audio samples, ready for software to measure, calculate and display.

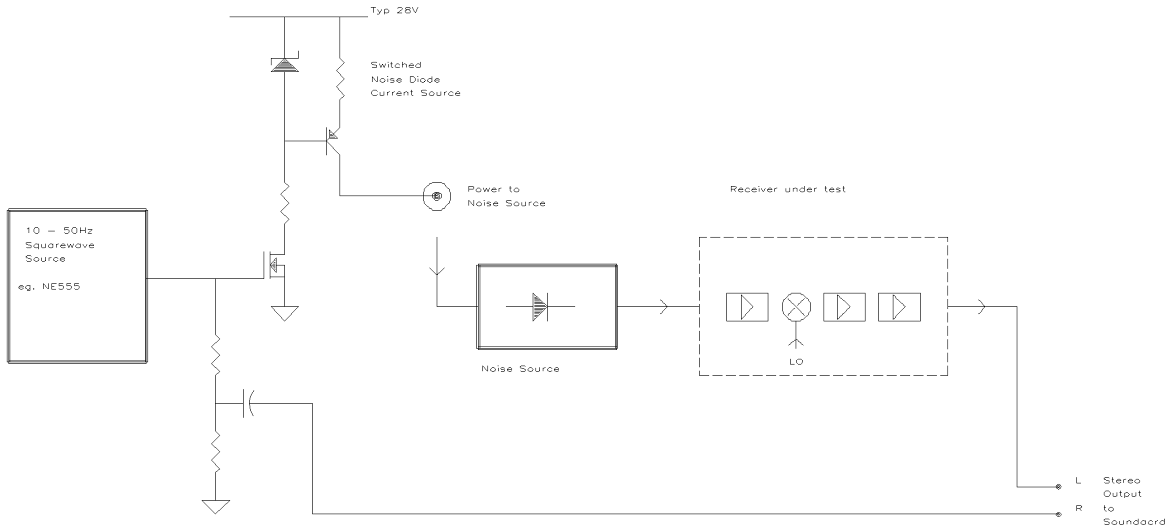

Figure 1 Automatic Noise Figure Test Set using a Soundcard

The Real Thing

The above words appeared in my *Design Notes* column in December 2011 RadCom , and even before I had seen my copy of the magazine, Peter G3PLX emailed with the first version of some software he had written to do just that. The latest version of ***NoiseMeter.exe*** is included within this archive file

I built up the circuit of Figure 2 to drive a noise diode and the system was tested. A 555 oscillator delivers the square wave at a rate that can be adjusted over approximately 5 to 50Hz. This is attenuated to 1 – 2V pk-pk, and AC coupled to the soundcard Right Hand Channel input. The 555 output also switches on or off a PNP transistor configured as a current source. Most noise diodes need 10mA when on, and usually this comes from a source of at least 24V.

I had a MaCom diode to which I'd already added a precision current source delivering 10mA, but the driver was built with the simpler PNP based current source as well, (but set at 15mA) to act as a current limit if the output were shorted.

The noise diode feeds the input of the receiver under test and the output at audio is taken to the soundcard Left Hand Channel input. Peter's software detects the edges of the switching waveform and identifies which sections correspond to noise source on, and which to noise source off. A running average of mean-square voltage levels (corresponding to power) is maintained for each. The ratio of the levels for noise source on / noise source off is related to the noise figure of the system under test, and is shown in dB on the display. Additionally, the mean level which corresponds to relative gain is also shown. Both readings are updated at intervals of one second. Figure 3 shows the user screen with the software in use.

Select your soundcard of choice from the drop-down menu. A checkbox allows for soundcards with inverted inputs, if the ***Difference*** shows a negative value, the switching signal is being interpreted the wrong way round so tick this box. A bargraph shows the peak input amplitude. To avoid clipping noise peaks and reducing accuracy, ensure the bar does not hit the right hand side.

The soundcard is run at the maximum rate of 48kHz, so audio bandwidth can extend to 22kHz. On older soundcards, or if this is a problem, edit the '*samplerate=*' line in the ***noisemeter.ini*** file to your favourite samplerate. This file is automatically generated when the software is run. If the program doesn't like your samplerate, a warning pops up.

If the software does not detect any switching signal, or any audio input, one or other of the dB displays is replaced by a warning. However, in practice the leakage and noise present on many mid to low end cards may prevent this warning showing.

Test Results

Connecting the noise diode via a switchable attenuator to my IC746 set to 144MHz, SSB (with AGC off) gave the results shown. Switching the preamp in and out, altered the ***Difference*** figure by about 2.5dB. varying the RF gain (which is actually IF gain) changed the ***Mean Level*** value while the ***Difference*** remained substantially constant. Adjusting the attenuator shifted the readings as expected. Adjusting the switching rate over the range roughly 10 – 40Hz showed no obvious changes in reading

In an SSB bandwidth, the values do jump about by a couple of tenths of a dB, as would be expected with the relatively narrowband noise. The system was next tried with my direct conversion 144 MHz IQ converter. Using only one output channel of this means both sidebands of the downconverted signal are folded on top of each other, so the effective input noise bandwidth is twice what the soundcard can accept, around 44kHz. This lead to a substantially less jittery display and is the preferred solution for actual noise figure alignment and setting up

If the Excess Noise Ratio, ENR, of the noise diode is known then the noise figure of the equipment under test can be inferred by subtracting the measured ***Difference*** from the ENR.

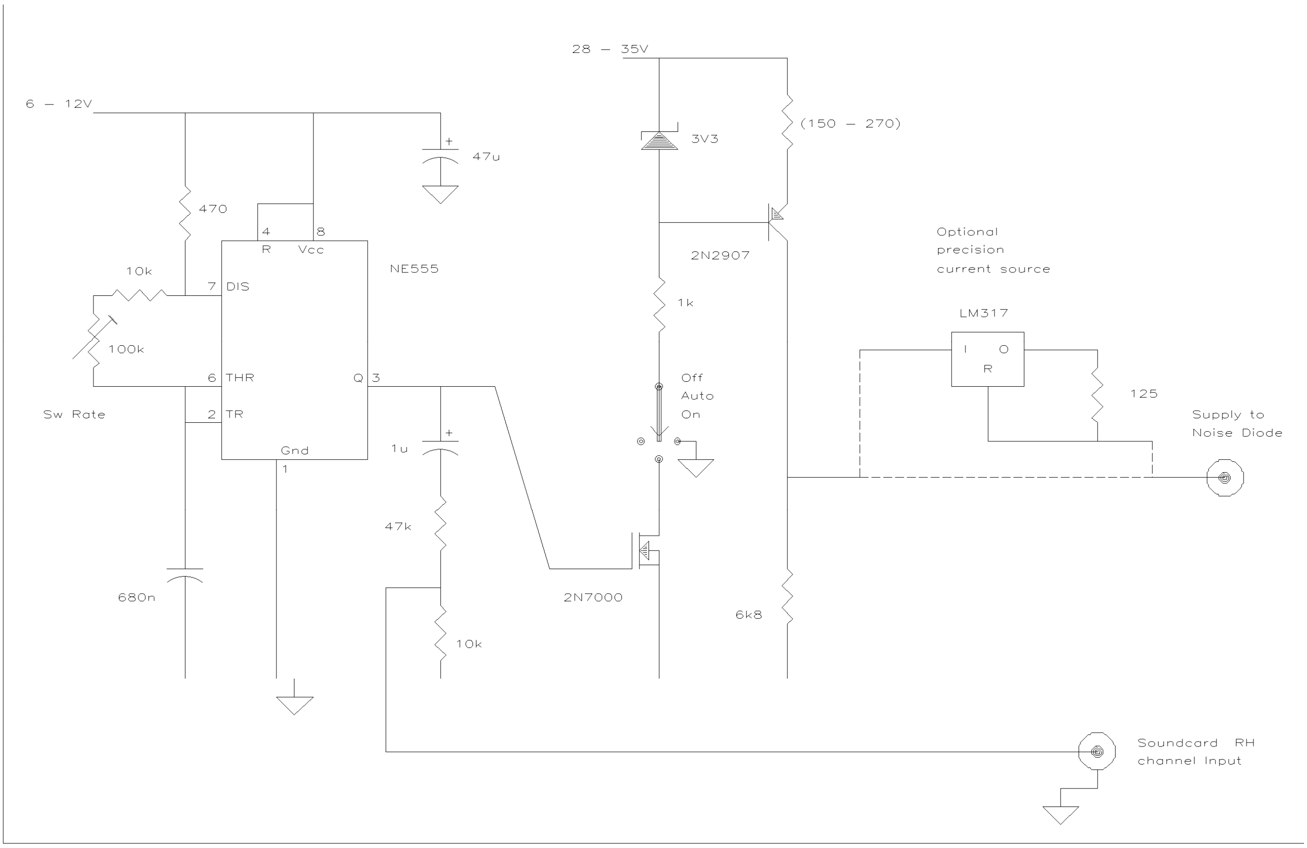

Figure 2 Switching Source and Noise Diode Interface.

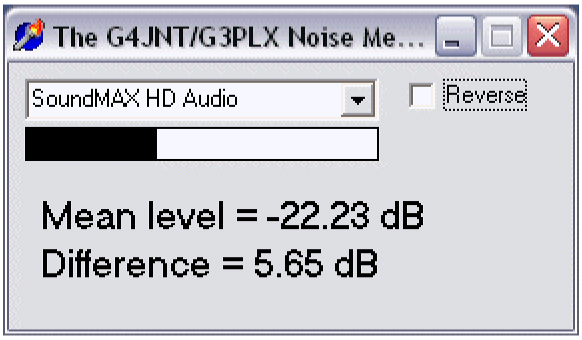

Figure 3 User Screen

A Few Caveats

Make sure there is good isolation between the two audio paths. Any leakage of the high amplitude switching signal into the audio path will get interpreted as a valid signal and will affect the reading accuracy. It may be worth adding some additional attenuation to the switching signal path over that shown in Figure 1. The software will accept significantly lower level.

Stray noise, hum loops and things can provide enough signal input to fool the software into thinking signals are present, so if you don't see the warning messages when either channel is disconnected, suspect stray pickup.

The switching signal applied to the soundcard needs to be preserved throughout the chain, it should not see significant droop in the applied waveform. So when using the lowest switch rate settings, do not use any lower value coupling capacitors than those shown in Figure 2. With a time constant of 57ms these values should be OK down to the lowest 10Hz switching rate.

This technique is capable of quite high accuracy noise figure determination when used with care.

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[1] Original G4COM Noise Figure Alignment Aid

http://www.g3pho.free-online.co.uk/microwaves/com.htm