

Staying Connected to Your Broadband - An Improved ADSL Filter

By Stephen Wilson, G3VMW

Many of us in the UK have our houses connected to the telephone network by long, overhead lines. This is especially true in rural areas and in older properties where these overhead telephone lines can be up to about 150 feet (46m) in length. I live in a rural Yorkshire village in a house that was built in 1969 and consequently, the overhead telephone line that connects me to the telephone network is about 130ft (40m) long; an ideal length for an HF antenna in some respects. For years, I have been plagued with constant ADSL router disconnects when trying to use the Internet and my radio equipment at the same time. Power levels as low as 10W on 160m and 80m were enough to totally kill my Netgear DG834GT router and cause the ADSL to renegotiate down to the lowest connect speed of 125kbps. It would then take two to three days of no interruptions before the ADSL synchronisation speed came back to the normal 4Mbps or so. My crude solution was simply to cut the power to my ADSL router before I used the radio.



However, more recently, things got a lot more complicated when some of my near neighbours all got broadband ADSL. They, like me, are all connected to the telephone network by long overhead BT lines. Even if I powered down my own router, every time I went on the bands with QRP, I disconnected all the neighbouring broadband routers around me. If you think TVI makes you unpopular, this adds a whole new dimension.

British Telecom (BT), is our UK private telecommunications monopoly and the only provider of the *last mile*¹ copper connection to the house (excluding cable networks). They were most definitely not interested in the QRM. Not their problem you see:

"Radio interference from a Radio HAM?"

"He thinks OUR overhead lines are the problem?"

"Ho Ho Ho! You are having a laugh, we're the professionals."

"Go and tell him it must be his radio equipment that is faulty."

OK, so we know where BT thinks the problem lies. Sadly, none of us here can rent a telephone line from anyone else but BT and we don't have cable network providers out here in the backwoods. The only practical solution then was to find a way of keeping my RF out of all the local ADSL routers.

A Short ADSL Primer

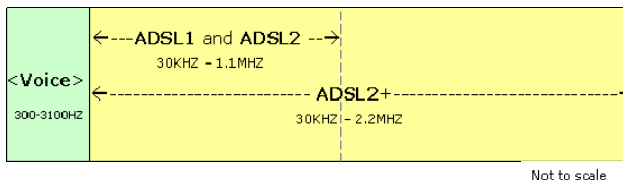
So that we understand the nature of the beast and because it is important to identify what sort of broadband you have to select the correct filter, I've included here a very short description of UK ADSL systems and the baseband frequencies that are used.

ADSL (*Asymmetric Digital Subscriber Line*) works by transmitting signals through traditional PSTN phone lines at higher frequencies than normal analogue voice signals. Voice signals fall within the 300 to 3400 Hz frequency range, whilst ADSL1 and ADSL2 both work in the 30 kHz to 1.1 MHz

frequency range. However, ADSL2+ works in the 30 kHz to 2.2 MHz range. By doubling the available downstream frequencies, you roughly double the amount of bandwidth available.

¹ The "last mile" conundrum of how to deliver broadband connectivity from a communications provider to a customer's home is famously known in UK telecommunications circles.

Although there are two basic flavours of ADSL: ADSL1 and ADSL2, there are a number of additional variations, the most significant of which are ADSL Max, an enhanced 8Mbps ADSL1 and ADSL2+, an enhanced ADSL2 that can provide download speeds of up to 24Mbps.



Above: a frequency chart showing different ADSL signals

Although voice calls do not use frequencies above 3400 Hz, the telephone equipment itself can generate spurious noise at higher frequencies, which can lead to data corruption within the ADSL frequency band. To prevent this, telephone equipment must be filtered to suppress this spurious noise and this can be achieved by fitting a micro-filter to each phone or by fitting a filtered faceplate on the incoming NTE5 master socket.

Improved ADSL Filters

After some investigation on the web with Google and after reading older messages archived on some of the amateur radio mail reflectors, I became aware of two possible methods of improving RF immunity for ADSL broadband routers. These were:

- a) The RF-1 KY Filter made by the KY Filter Company, Davis, California:

<http://www.ky-filters.com/>

- b) A design for a home-made ADSL filter by OZ7C:

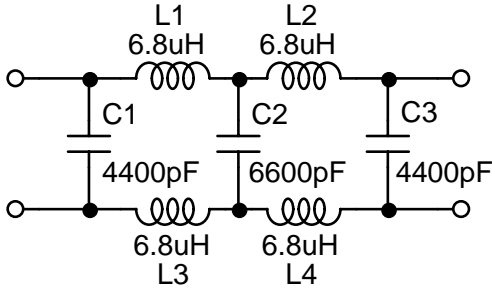
http://www.ddxg.dk/oz7c/adsl/adsl_160m_filter.pdf

I decided to try the KY Filter and ordered one from the company. The current cost is \$27.95 USD plus postage. However, when the filter arrived, I was disappointed with the performance and although it did provide a slight improvement, it didn't stop the constant disconnects. However, the OZ7C ADSL filter looked promising and several people had reported success with this filter.

Looking at the design of the OZ7C low pass filter, it is clear from the frequency plots that it was designed to start attenuating signals from just below 1 MHz. Since we know that in the UK ADSL1

and ADSL2 (but not ADSL2+) work up to 1.1 MHz, I decided to alter the filter characteristics slightly so that my filter began to attenuate unwanted signals from 1.1 MHz, to allow the entire wanted ADSL signal to pass through to my router. Whether this has made any significant improvement in practice, I'm not absolutely sure.

The original OZ7C article (shown below) used simple 6.8μH axial chokes, but for my filter, I decided to use Amidon T50-2 toroids to give some degree of accuracy in inductance values and to take advantage of the somewhat better Q of the toroidal inductors.

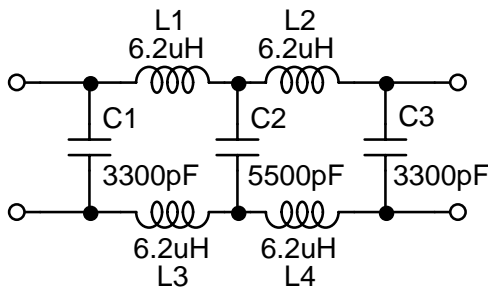


Above: Circuit of the original OZ7C Filter using axial chokes

Coming back to the design of the improved ADSL filter, I decided to use the circuit modelling facilities in the highly-rated LTSpice computer simulation program, which you may be interested to know is a free download from here:

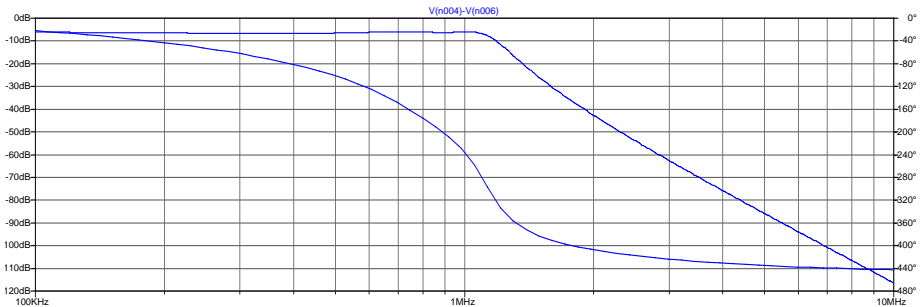
<http://www.linear.com/designtools/software/ltspice.jsp>

After trying a few different component options, the circuit below produced the best filter response and insertion loss. The filter is designed to be flat up to 1.1MHz and then to start attenuating rapidly after that. There is over 30dB of attenuation on 160m and over 55dB on 80m with very little insertion loss to the wanted ADSL signals.



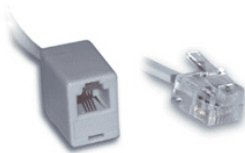
Above: Circuit of G3VMW's improved ADSL1 and ADSL2 Filter

The filter shown above is suitable for ADSL, ADSL Max and ADSL2 but *not* for ADSL2+ systems, which use a baseband up to 2.2 MHz. The 6.2 μ H inductors are made by winding 35 turns of 32swg wire on T50-2 toroids. It is a bit tedious, but not difficult. The capacitors can be paralleled up to achieve the capacitance. For C2, I used two capacitors marked 4700pF and 1000pF, which when paralleled up and measured on an AADE LC Meter, actually came out at 5500pF. Because there is a nominal 50v on a BT telephone line, the capacitors should be at least 63v or better still 100v working. I've used 63v capacitors because they were at hand, but 100v (or higher) working is probably a better choice.

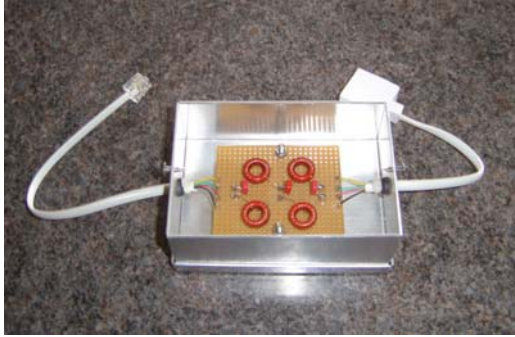


Above: LTSpice plot (top) of the response of the improved ADSL filter. Please note that 6dB of the insertion loss shown is because the plot is taken across a 75 ohm terminating resistor and the actual insertion loss is less than 0.3 dB.

The filters were constructed on blank "Perfboard" with 1mm "Veropins", which were used as anchors to connect all the parts together. The flying leads for connection to the BT line was made from a 2m RJ11 modem extension lead obtained from eBay. These look like the picture at the left and come in all sorts of differing lengths. The filter connecting wires to the RJ11 plug and socket are just cut down in length to about 6" (15cms) per end and soldered to the "Veropins" on the "Perfboard" filter assemblies. The two centre conductors, usually red and green, carry the ADSL signal.



The picture below shows the simple construction technique used to build the filters with the circuit boards housed in small aluminium boxes 4" x 2 $\frac{3}{4}$ " x 1 $\frac{1}{2}$ " (10cms x 7cms x 3.5cms) and the RJ11 flying leads brought into the boxes via small rubber grommets with cable ties to stop the wires being pulled off the filter circuit board. The circuit board was fixed inside the box with two 15mm M3 nuts and bolts with a suitable spacer. This has proved very effective in practice and the filters are physically robust. It might be safer to hot glue the T50-2 toroids down to the circuit board, but I've not found this to be strictly necessary in practice.



Above: A completed ADSL filter

In terms of performance, the difference has been remarkable. I can now operate at 400W RF out on any band 160m through to 10m without disconnecting my ADSL1 broadband. The performance throughput of my broadband connection has also improved with higher router synchronisation speeds, which I think is due to the filter preventing Short Wave broadcast stations and other electrical noise being fed back to the router and reducing signal-to-noise ratio.

I have now provided several similar ADSL filters to my neighbours and they now enjoy their Internet without interruption from my transmitter. The goodwill has been worth the small outlay in parts and the time taken to build the filters.

G4RCG's troublesome ADSL2 installation

Fellow CW enthusiast, John Muzyka, G4RCG contacted me for some help with his particular ADSL installation and the fact that he couldn't operate on any band without disconnecting his and also, more worryingly, his next door neighbour's broadband connection.

G4RCG lives in a rural location with a significant run of overhead cable approximately 2 miles long, but he is served by the newer ADSL2 service, which supposedly provides better performance on long lines. ADSL2 can increase the data rate by as much as 50 kbps and extend the reach by about 600 feet. The line attenuation on John's ADSL service is 65dB compared to the 50dB line loss I have here. The best synchronisation speed he can manage on his Netgear router is just 2Mbps with a signal-to-noise ratio of 4.5dB. This looked like a bit of a challenge and would certainly give the G3VMW ADSL filter a tough test.

ADSL2 extends to up 1.1 MHz, just like normal ADSL and, in this case, BT had been very helpful by providing John with the ADSL2 since it was originally thought that his line loss would be just too great for any broadband service at all. BT Openreach engineers literally hand-picked their lowest loss copper cables for the long route, avoiding aluminium cored cables where they could.

There are a couple of tricks that BT used and might be worth mentioning here to maximise your ADSL connection and broadband speed. BT went the extra mile at John's QTH by fitting the NTE-2000 filtered faceplate. The NTE-2000 faceplates isolate the now largely defunct (third) bell wire from your broadband telephone line and help to give the best connection speed possible by

reducing noise and optimising line balance. Better balance means lower noise pick-up, which is something open-wire feeder enthusiasts have enjoyed for years.



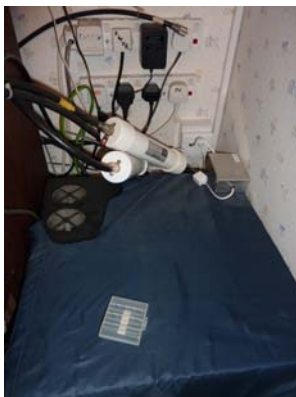
The NTE-2000 faceplate (shown above) is the type of ADSL faceplate that BT Openreach engineers fit on a full ADSL installation. The NTE-2000 replaces the plug-in front on a BT NTE5 master socket. The faceplate provides an ADSL modem/router outlet and also a standard BT filtered telephone outlet. IDC connectors on the rear provide filtered extensions, therefore you only need this faceplate and not a micro-filter at each extension. A "Krone" style IDC tool is required only if fitting extension wiring. The NTE-2000 can be obtained from various eBay suppliers or from here:

<http://www.run-it-direct.co.uk/BTNTE5ADSLfaceplate.html>

An improved ADSL faceplate called the XTE-2005, which I use here at G3VMW, can be obtained here:

<http://www.adslnation.com/products/xte2005.php>

It was now time for G4RCG to test the improved ADSL filter in practice and I was delighted to find that the filter worked very well. John operated heavily in this year's FOC Marathon CW Contest, which covers all bands 160m through 10m over a 48 hour period. Amazingly, his broadband stayed connected all weekend, even when he was on 160m. A second, identical ADSL filter did the trick for



John's next door neighbour, who incidentally has an impressive 67.5 dB of line loss on his ADSL line, fed from the local Wakefield exchange.

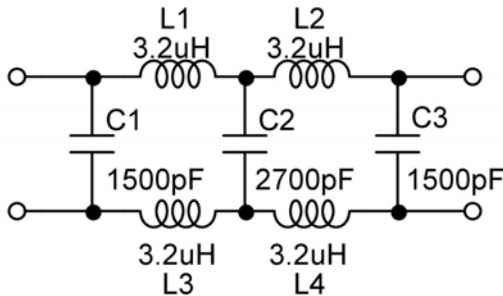
Above: John G4RCG's ADSL2 filter in place and located on top of his Acom 2000A amplifier

An ADSL2+ Filter

You may have noticed that many of the UK ISPs are now advertising ADSL2+, which allegedly more than doubles the capacity of ADSL1 and 2 so that speeds of between 20 and 24Mbps are available for downloading and up to 3.5Mbps for uploading. These speeds are dependent on the distance a user is from the exchange and ultimately whether the local BT telephone exchange has been upgraded to the new digital BT 21CN system.

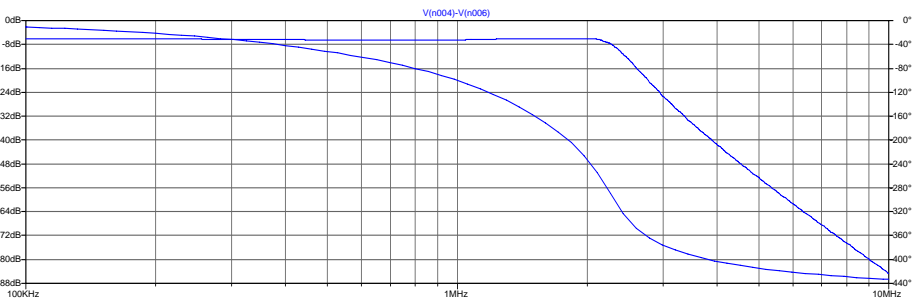
As previously observed, ADSL2+ specifies a downstream frequency band up to 2.2 MHz, resulting in a significant increase in data rates on shorter phone lines. On ADSL2+ the upstream direction uses from 30 kHz to 138 kHz and isn't an issue here. However, the downstream direction uses frequencies from 138 kHz to 2.2 MHz. Since ADSL2+ extends up to 2.2 MHz, 160m operation is always going to be problematic.

Using LTSpice, I designed and built an ADSL2+ filter in exactly the same fashion as the earlier ADSL1 filters and then did a frequency sweep (at a nominal 75 ohms impedance) using my N2PK Vector Network Analyser (VNA). Thankfully, the actual filter response was very close to the predicted response obtained from the LTSpice circuit simulation.



Above: Circuit details of the G3VMW ADSL2+ filter. L1 to L4 are 25 turns of 32swg on an Amidon T50-2 toroid

I have not been able to test the ADSL2+ filter shown above since I don't know anyone locally that has the service and is troubled by RFI issues. However, there is no reason why the filter should not work as well as the improved ADSL filter described earlier, but with the obvious exception of 160m.



Above: LTSpice plot of the response (top trace) of the experimental ADSL2+ filter above

These ADSL filters might be the answer to a problem if you find that you are disconnecting your broadband Internet connection every time you operate. Whilst I can't guarantee a cure, the ADSL filters described have worked well for me and equally well for John G4RCG. In addition, I do advise that you take every step possible to maximise your ADSL connection by using a filtered faceplate.

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Until he retired recently, Steve Wilson G3VMW was the engineering manager in charge of telecommunications for Yorkshire Electricity (now part of the NPower Group) and was based in Leeds. He is a member (MIET) of the Institute of Engineering and Technology (formerly the IEE). Steve enjoys CW contesting, LF band DX and home construction. He is a member of FOC and is on the DXCC Honor Roll with 337 countries confirmed on CW and only needs P5 (North Korea). If you wish, you can contact Steve by email at: g3vmw@yahoo.co.uk or by mail (QTHR).