Using redundant duplexers

In this second and final part, reclaimed filters are used to block pager interference.

PHOTO 1: A typical duplexer filter: Thales MPX2/6H-6/16 six cavity device.

RECAP. Recently, a number of redundant VHF duplexers had come the author's way. It was initially thought that these devices were probably of little use on the amateur bands, but last month I showed how one had been repurposed as a 2m/70cm diplexer.

So, what of these other uses elsewhere? The units at my disposal included the Procom DPF2/6H discussed last month, a Jaybeam DPF2/4S and a Thales MPX2/6H-6/16. All were originally operating around the 2m band. Read on, because they can have new life as notch filters, removing paging transmitter interference.

WHAT IS A DUPLEXER? A duplexer is a passive three port RF device that is generally connected between a separate receiver and a transmitter at their antenna sockets. The transmitter and receiver share a common antenna port and antenna, and the unit works with the transmitter and receiver operating at the same time, ie duplex operation. At the operating frequencies, the loss through the Tx and Rx ports to the antenna is negligible, certainly less than 1dB. At the same time, the loss between the Tx and Rx ports is considerable – usually greater than 50dB, typically 70dB and even more when tuning is optimised. Duplexer can range in size from a small PCB mounted circuit through cavity filters of hand-size proportions to the size of a fair-sized dustbin. Some cavity devices have been fabricated out of aluminium beer barrels – the barrel having, of course, been emptied of beer first.

DESCRIPTION. The three units examined were either four or six cavity devices. In the four port duplexer, two cavities were connected to the low port and the remaining two were tuned for the high port. In the case of the six cavity filter, three cavities were each used for the high and low port. There is some interaction between the low cavities and the high cavities when the filters are being tuned and this has been taken into account when tuning the filter.

BENCH TESTING. Looking at the units presented they were all found them to be tuned at the printed frequencies on their labels. I am fortunate in that I have access to some shiny test equipment, which makes setting up filters a doddle. I recognise that not everyone is so fortunate, although those who do have such equipment can sometimes be persuaded to let you use it occasionally. And it's amazing how many of the early network analysers or spectrum analysers with tracking generators have found their way down the food chain and are now in the hands of amateurs. The gear may not be sufficiently in calibration for professional purposes but most is more than good enough for amateur applications.

Using the Anritsu spectrum analyser with its tracking generator made the exercise of checking out the duplexers very easy. In the tests the analyser was connected in a way such that the tracking generator was connected to the antenna port and the port under test was connected to the analyser input. The remaining port was terminated. Failing to terminate this third port will result in an out of band dip in the response of about 6 to 10dB, but was shown not to affect the pass band at two metres.

Each duplexer underwent the same tests and plots were obtained for around the 2m band and further afield to encompass 70cm. The objective was to see what response could be obtained from the duplexers and see if they could have a use at 2m and/or 70cm band. The results found were very interesting. It was found on all three duplexers tested that the high and low passband frequencies yielded the lowest losses at 168MHz and 155MHz respectively, less than 1dB in all cases.

The particularly interesting thing to come out of the measurements was that there were deep notches in the response at frequencies other than the 'official' Tx and Rx figures. Depending on the port, these could be as deep as 50dB or more at 137 or 153MHz. The high frequency port passes the high frequency band and rejects the low frequency band, thus producing a notch filter on the low band region, ie 137MHz. Conversely the low frequency port produces a low loss at the low frequency band and rejects the high frequency band, producing a notch at 153MHz. At the same time, the attenuation at 2m was a very respectable 0.8dB in the case of the Thales device.

WHAT'S SO SPECIAL ABOUT 137 AND 153MHz? High power paging systems are used to cover large areas of the UK. The high ERP of these well-sited transmitters can cause problems to 2m receivers even several miles from the paging system. When the paging transmitter operates, it can completely 'flatten' the front end of the 2m receiver, causing massive de-sensing. There can also be breakthrough of the paging tones, which have a characteristic sound. Some radios are better than others in this regard, but any amateur receiver with a wide receive frequency range is likely to be susceptible. Older radios, with narrow band front ends, tend to be somewhat better in this regard. Professional VHF PMR equipment also seems to be better designed and, while not immune, can often reject a much higher level of out of band signal. But I digress.

ADJUSTING THE NOTCH. It is worth mentioning at this stage that almost all filters of this ilk are tuned with studs, as can be seen in the photos. These studs have a locking arrangement, which varies from make to make and device to device. They may use a proprietary locking compound, a lock nut, a friction clip, a dab of paint or – as has occasionally been seen in the field – white correction fluid! If the threads of the tuning screws are clogged with any sort of locking compound, it is best to clean out the holes and screws to avoid damaging these threads. One of my duplexers has M4 threaded

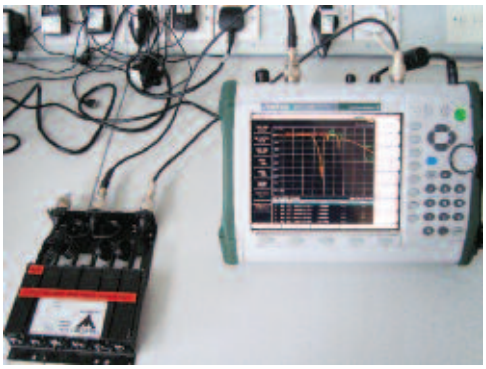

PHOTO 2: The Procom DPF2/6H six cavity duplexer under test using a modern spectrum analyser with tracking generator. Note the BNC terminator on the unused port.

screws and these were easily cleaned out by running an M4 die down the thread.

It's very easy to make adjustments to filters using professional test equipment, but there are other ways for those without ready access to these expensive toys. At a minimum, you'll need an RF signal generator and a receiver (or transceiver) able to cover the pager frequencies.

Connect the RF output of the generator to the antenna port of the duplexer. Connect the receiver's aerial socket to the Tx or Rx port on the filter, depending on which side you're tuning. Terminate the unused filter port. What do I mean by terminate? Plug in a suitable 50Ω load. This could simply be a pair of ¼ watt 100Ω resistors in parallel in the body of a BNC or N-type connector. Alternatively, an old BNC network terminator will do at a pinch. In this instance it's not essential that the termination is exactly 50Ω, so 75Ω will do if that's all you've got handy. Just make sure that you use exactly the same load when putting the filter into service. Don't worry about the power rating: there's going to be about 50dB of isolation between the transmitter and the terminator or, to put it another way, for every 10W you transmit, the terminator will see about 0.1mW. If you fail to terminate the unused port, this will almost certainly have little effect on the pass band but it will probably affect the out-of-band response by about 6 to 10dB.

Set the signal generator and receiver to the centre frequency you want to reject – either 137MHz or 153MHz. Adjust the generator to minimum output before you switch on the output. Slowly bring the output level up until you can clearly hear it on the receiver.

Adjust the cavities for minimum received signal as shown on the S-meter. You'll probably have to keep increasing the output level of the signal generator, because the attenuation will increase so the signal is below the receiver noise floor. You need to use good quality coax and connectors for this sort of operation because signal leakage from cables can really muck up your adjustments, making you think signals are going through the filter when in fact they're radiating across the bench.

You should find it possible to introduce a notch of about 50dB relative to the direct output of the signal generator. Don't fall into the trap of just connecting the high level output of the generator to your radio – that's the way to blast the front end to smithereens. Use the generator's level control to reduce the output BEFORE you do the comparative test! Although S-meters are notoriously inaccurate, they do give a good relative indication of level.

The final part of the test is to check the through attenuation at the transmit frequency. Remove the RF generator for the next part of this test and substitute a suitably rated dummy load. Using a *low power setting* on your transceiver and an inline VSWR meter between it and the duplexer, adjust the cavities for minimum VSWR. Go back to the previous procedure and check there is still adequate attenuation at the relevant pager frequency, ie some 50dB at 137MHz or 153MHz. This is an iterative process and it will probably take several sets of fiddling before you can make no further improvement.

Lastly, check the power with an in-line VSWR/power meter before and after the duplexer. There should only be about 1dB (10%) power loss through the duplexer anywhere in the 2m band.

70cm. As mentioned earlier, plots were obtained up to 500MHz. This part of the investigation was to see if the duplexers could have any use at 70cm. The answer was yes, some could. Having checked the duplexers I found that some exhibited a low loss at 70cm as well as 2m. Last month we saw how this feature was used as a diplexer, running two aerials from a single cable. Some of the filters were very low loss at 70cm, whereas others had as much as 5 or 6dB (75%) attenuation.

SUMMARY. Some units can be usable at VHF and UHF but their actual responses cannot be guaranteed, or predicted, at UHF. But the re-tuned duplexer is perfectly reliable at VHF as a notch filter. The only difference between the two Procom units I tested appears to be age. Although physically apparently the same – and the same model number – as the older one, its newer sibling exhibits much lower loss at 435MHz. VSWR measurements at 2m and 70cm with the newer Procom duplexer were both 1.1:1.

IN USE. The maximum power ratings of the duplexers tested were all in the region of 50W. In consideration of this and the fact that we have re-tuned them outside their original spec, it is sensible to ensure that the through power is always kept below this level. Using the duplexer in this way should be an effective way of cutting out received pager interference and causing minimal loss at 2m and possibly 70cm to boot. All this goes to show that it's sometimes worth picking up old filters at rallies – you never know when they will come in handy.

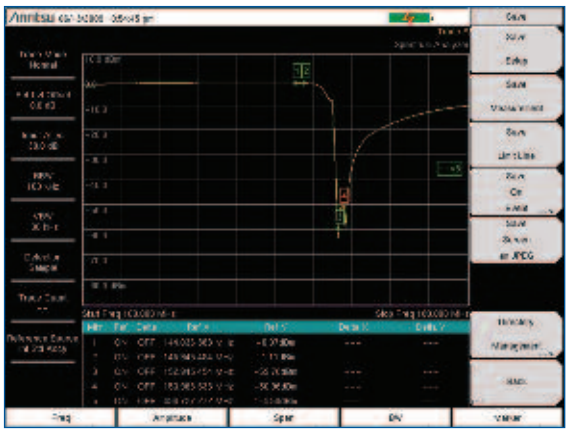

FIGURE 1: Measurements on a duplexer tuned to notch 153MHz, giving an attenuation of >50dB at that frequency and a loss of <1dB at 145MHz.

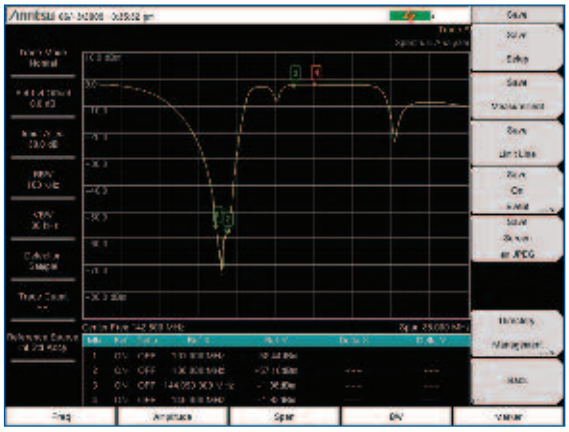

FIGURE 2: Notch filter showing a 60dB notch at 137MHz.

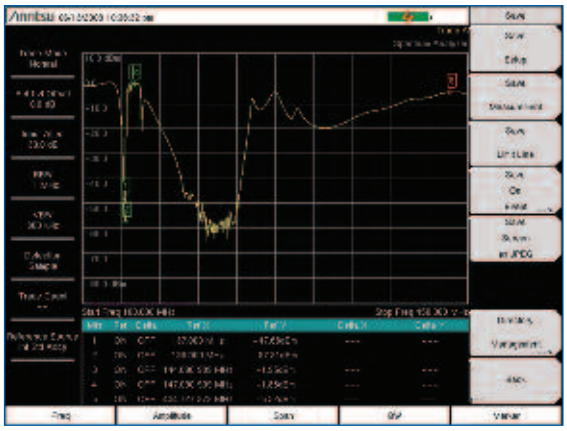

FIGURE 3: Loss at 2m and 70cm.