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Unleashing

Endless Possibilities for Cable Networks

by Jan Ariesen, Chief Technology Officer

There has always been a clear divide between upstream and downstream data splits, making it possible to upgrade signals in the existing network using by-pass filters and diplex filters in the active components. But this separation has become a limiting factor when upgrading the network; each upgrade requires new filters and additional labour. Technetix has now developed a bi-directional amplifier, without the need for diplex filters. This article will explain how to create more bandwidth and flexibility within the same infrastructure and how this technology will make 1.8GHz ESD installations feasible without amplifier respacing.

Jan Ariesen,
CTO, Technetix

Jan Ariesen's career in the cable industry started in 1983 when he joined the Research & Development team at Tratec in the Netherlands, where he developed numerous headend, access and In-home products. Tratec and Technetix joined forces in 2005 and Jan's role became more involved with the technology and commercial teams.

Jan became Chief Technical Officer (CTO) of Technetix in 2012 and, with his team, has created innovative technologies and products that improve network performance and make them ready for the future. He is now Chief Technology Officer at Technetix.

Imagine a world in which the telephone had been limited to push-to-talk functionality. The speed and pattern of global economic development might now look quite different, because limiting the rate at which data can be exchanged is a drag on progress.

Yet similar restrictions across cable networks are generally accepted. The necessary splitting of frequencies for upstream and downstream traffic has imposed a heavy cost, putting a significant chunk of the frequency range beyond use. Today, some of your network's theoretical resources are left constantly dark in a 'crossover area', effectively dead. It cannot be accessed...until now.

Technetix has developed and patented an amplifier solution which puts the entire frequency range into play. Not only does the amplifier allow all of the frequencies to be used all of the time, the frequency split becomes so flexible that it can adapt in real-time to the live balance of upstream and downstream traffic. Perhaps even more significantly, it opens cable to the world of full duplex networks.

> **Not only do you have the opportunity to generate additional demand, it is likely to come to you at a higher price point. At the very least, it will help you reduce subscriber churn and margin erosion.**

What motivated this innovation?

In the 1990s, bandwidth demand was still dominated by the downstream traffic of broadcast TV. This downstream hunger was further exaggerated from 2000 onwards with web page downloads, followed by video streaming. Some things do not change. Households and businesses still hunger for more bandwidth - but of a different shape. FaceTime, live Instagramming and TikTok all require a different up/down balance. This made us contemplate - what if we could release the frequencies currently being held captive?

In answering that question, cable operators are given an entirely new world of possibilities.

Firstly, the new amplifier solution has the potential to spark a renewed surge of product innovation. Escaping fixed frequency splits means re-opening the possibilities of what the customer can buy and how households can be billed.

If the customer is better served by an up:down ratio of 1:5, rather than the 1:10 commonly baked into networks today, then the technical restrictions on doing so have been lifted. Even a complete reversal to 5:1 is no longer problematic.

Many a broadband product manager has been bound by what felt like the basic physics. Changing these parameters makes market innovation inevitable. Some customers might pay handsomely for unrestricted upload speeds which constantly adapt to actual usage patterns. What could an operator do with these capabilities?

Secondly, this innovation can create improved market competitiveness for cable networks and the potential for a fresh source of growth in subscribers. An innovative cable product can shift the centre of gravity in the market, away from low-cost options towards the premium end. Market momentum, currently shared across a range of competitors, could be tilted in an operator's favour.

With a network constantly adapting to the flows of upstream and downstream traffic, we believe that operators will also be providing a premium product to their existing customer base.

Not only do they have the opportunity to generate additional consumer demand, it is likely to come at a higher price point. At the very least, it will help operators to reduce subscriber churn and margin erosion.

Thirdly, and just as significantly, we believe that we can help operators to reduce the long-term cost of network operations. Once upgraded, cable networks become far more efficient. As all frequencies are being used, capacity is immediately increased. The medium-term needs for further network upgrades are diminished, taking cost out of operations.

Meanwhile, the economics of flexibility are transformed. In fact, the financial risk inherent in the potential of the up/down traffic pattern changing over time is solved permanently. Instead of buying new rolling trucks and upgrading networks, simply update the proportion of bandwidth given to upstream data.

It might be worth running CFOs through the implied long-term savings.

All of this suggests that the amplifier innovation presented has the ability to significantly improve the margin profile of cable operators over the next two decades, securing and extending their market relevance for the long term as well as offering obvious immediate gains.

Today's networks make for ever-increasing losses

As everyone in the broadband industry knows, cable networks need amplifiers to increase the 'gain' of downstream signals from the headend to homes and businesses. Equally, they 'boost' the upstream signal from customer premises to the headend.

This, however, poses a problem. How does the amplifier know which signals are going down and which are going up? Without physical separation, the signals lose all integrity.

Industry convention has solved the issue by using lower frequencies for upstream traffic and higher frequencies for

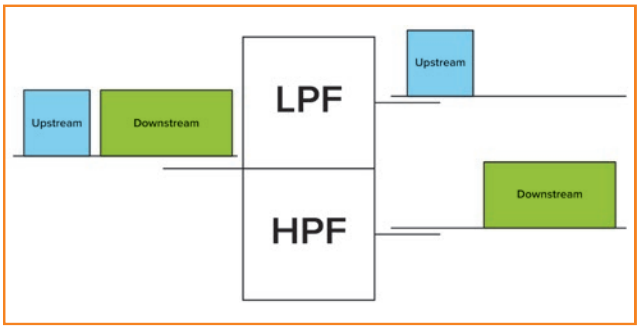

Figure 1: The diplex filter

the downstream. This is why your network uses diplex filters (DPFs) — they separate the upstream from the downstream by detecting the frequency of the signals. We can easily isolate the upstream via a low pass filter (LPF) and the downstream via a high pass filter (HPF).

It is the combination of the LPF and HPF that creates the diplex filter, shown in Figure 1 above.

Once the split has been made, the signals that have been isolated can be amplified. An amplifier with DPFs is represented in Figure 2 below.

The downstream signal receives gain from the left and is pushed out to the right. The upstream signal gets its gain from right to left.

So far, so good! Let's complicate things slightly now with a look at the practical implications of frequency separation.

Logic dictates that if different frequencies are allocated, a decision must be made on where the split between them occurs. This also decides the proportion of the signal given to the upstream and downstream.

However, all technology is limited - one of the limitations of this technique is the need to leave a gap between the two separation frequencies. Today's cable network amplifiers require some frequencies to be left unused. There has to be space between the end of the lower frequencies for the upstream signal and the start of the higher frequencies for the downstream.

A common frequency combination is 42/54MHz for instance. In this example, the upstream uses frequencies up to 42MHz and the downstream starts at 54MHz. The gap between the two frequencies is known as the 'crossover area', shown in Figure 3.

The extent of the crossover area is dictated by the steepness of its edges. Normally, the steepness is about 22%. This means that, as a percentage of where the high frequency starts, a crossover area of 22% is needed. In this particular case that means that 12MHz of the spectrum cannot be used, which is disappointing when trying to optimise network efficiency and capacity.

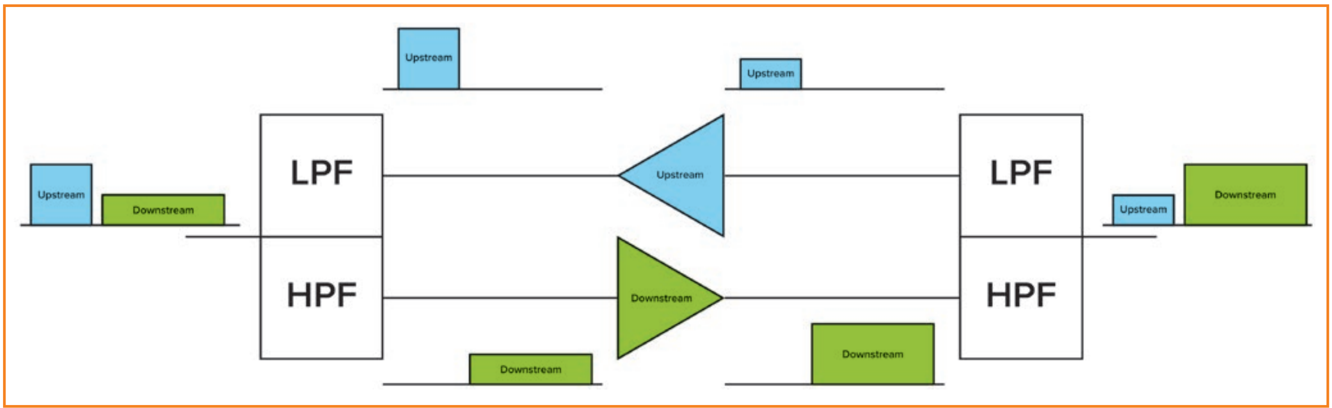

Figure 2: An amplifier with diplex filters

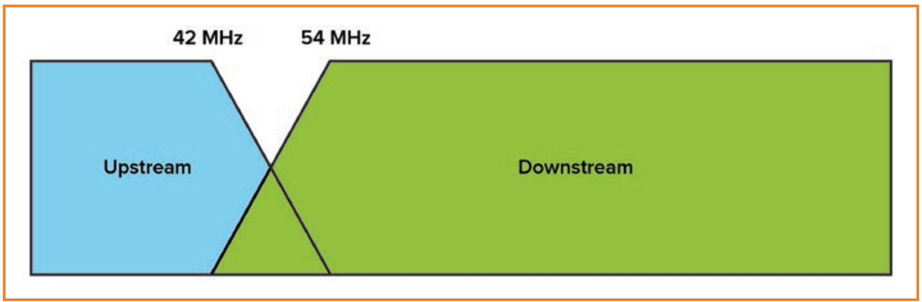

Figure 3: The frequency split with crossover area

Split	LPF (MHz)	HPF (MHz)	Crossover area (MHz)
42/54	42	54	12
65/85	65	85	20
85/105	85	105	20
204/258	204	258	54
684/804	684	804	120

Table 1: Common channels and their crossover areas

It gets worse - the problem escalates as the split frequency shifts to higher frequencies. As the percentage loss remains constant, the absolute frequency darkness within the crossover area gets larger. For instance, if the downstream frequencies start at 85MHz, the crossover area is 20MHz.

Accounting for other network objectives, common channels have emerged and it is easy to see how the crossover area eats into a large proportion of the capacity.

So, the higher the split frequency, the larger the crossover area and the greater frequency loss. This is a real limitation that has added cost to network operations through the inherent inefficiencies. Until now, the losses and the costs were unavoidable (see Table 1 above).

The diplex-free amplifier

While frequency splits enabled by diplex filters were fabulous in making cable networks functional, they have never been a perfect solution. The crossover area delineates the area for improvement. An entirely different approach was required to achieve full frequency use.

Instead of relying on the frequency of the traffic to imply its direction, the Technetix diplex-free DNA 1800 amplifier uses a patented isolator to detect it directly.

Whilst conceptually this is a less complex process than splitting frequencies, in practice it was not technically feasible. Figure 4 (right) shows how, now that this has been achieved, it greatly simplifies the amplification process. The downstream signal from left to right receives gain from the top amplifier. The upstream is boosted from the amplifier below.

***Note** - there is no need for a crossover area, because there is no frequency split and no gap between the lower and higher frequencies. Figure 5 clearly shows the difference between a diplex filter spectrum and a flexi-split/diplex filter-free spectrum.*

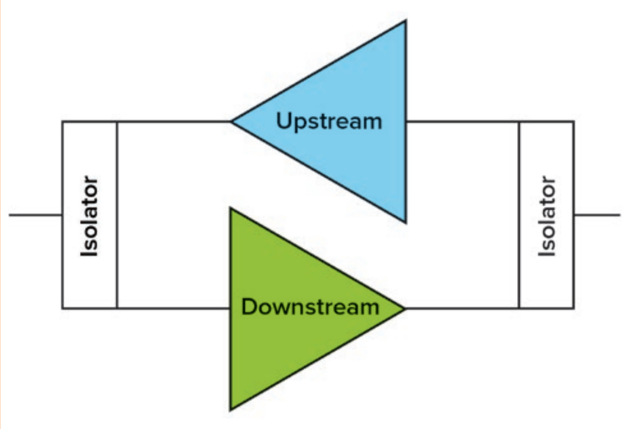

Figure 4: The diplex-free amplifier

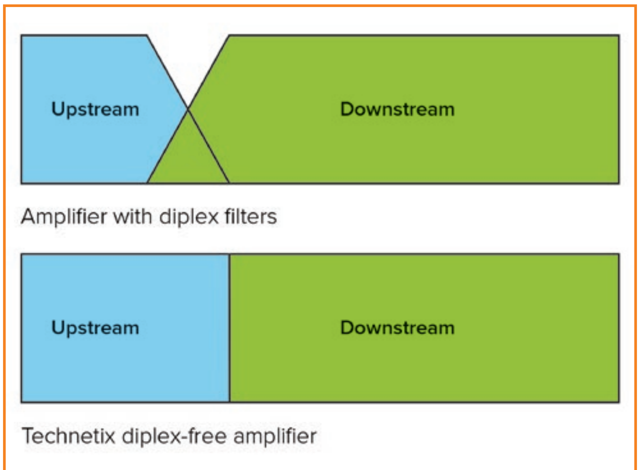

Figure 5: Comparing frequency use

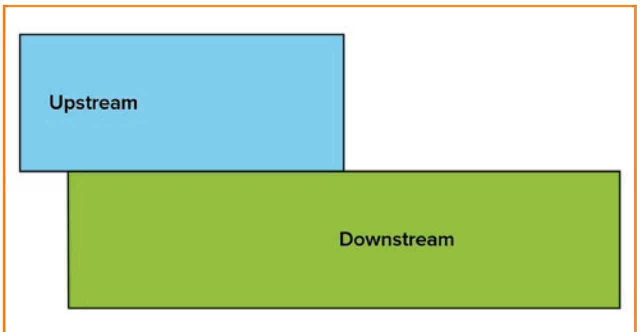

Figure 6: Full duplex frequency use

"The real potential is the impact on an operator's bottom line, with no frequency loss via crossover areas; the flexi-split or full duplex options have the power to change the economics of cable networks."

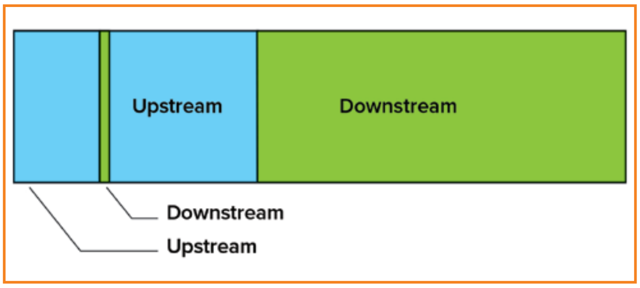

Figure 7: Signal plan with a downstream signal in the upstream band

As there are no filters, the cable network operator can choose where the upstream frequency stops and the downstream frequency starts. There is no frequency gap and it is entirely flexible. In fact, this 'flexi-split' frequency can be changed constantly, in real-time, to adapt to changing demand conditions if required.

There is another option as well; the network no longer requires a frequency split at all. The isolator in the diplex-free amplifier only detects direction of travel, meaning that cable networks can benefit from all the characteristics of being full duplex. Figure 6 (previous page) shows that the upstream can simply be placed right on top of the downstream.

The final notable benefit of a filter-less network is the ability to add a downstream signal in the middle of the upstream. This is very advantageous as some CPE devices need a downstream maintenance carrier at low frequencies. Figure 7 above shows an example of such a signal plan.

DNx 1.8GHz

As a result of the patented technology outlined in this article, Technetix has developed the innovative DNx 1.8GHz amplifier. This amplifier eliminates the need for diplex filters: the upstream is already 684MHz and the downstream increases to 1800MHz.

Features	
Low power	< 6 Watt
Size on an outdoor tap	6"x4"
Upstream	12 - 684 MHz gain @ 684 MHz = 7 dB
Downstream	85 - 1800 MHz gain @ 1800 MHz = 20 dB
Tilted (anti-coax) frequency performance	

Table 2: Technetix DNx 1.8GHz amplifier features

The DNx 1.8GHz is compatible with full duplex DOCSIS (FDx), extended spectrum DOCSIS (ESD) and flexi-split duplex DOCSIS (FDD). This low-power amplifier (<6 Watt) is a suitable building block for a distributed gain architecture (DGA). It is also suitable for every network operator looking to achieve the DOCSIS 4.0 standard.

Conclusion

The diplex-free amplifier solves a long-standing challenge and is an entirely different category of amplifier. We believe that it has the capacity to transform cable networks.

The real potential is the impact on an operator's bottom line, with no frequency loss via crossover areas; the flexi-split or full duplex options have the power to change the economics of cable networks.

This flexibility will reduce operating expenditure by reducing labour costs, making it practical to maintain existing CPE devices and increase the reliability of the network. It is a suitable addition to a High Efficiency Low Maintenance (HELM) network.

We expect a wave of product innovations and improvements to lead to more subscribers paying higher average subscription rates. These improvements can be projected against a lower cost of network provisioning and maintenance over the long-term.

Together, these factors have the power to change the industry's margin profile for decades.

Contact

Email: **premton.bogaj@technetix.com**

Website: **www.technetix.com**