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# Remote Nodes for Wavelength Shared Hybrid PON Supporting Video Overlay

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**Abstract:** A novel architecture has been proposed to enhance performance of power-splitting PON systems cost-effectively, with re-use of existing equipment. Here we demonstrate the feasibility of a modular and cost-effective WS-HPON remote node supporting analog video overlay.

## 1. Introduction

Passive Optical Networks (PONs) are being deployed widely. The wide adoption of these passive, power-splitting PON architectures, typically serving 32 users by means of Time Division Multiple Access, and operating at serial rates of up to 2.5Gbps rates, indicates that this set of technologies is the most cost-effective and mature for providing broadband access today.

Applications such as video conferencing, and immersive on-line shopping will continue increasing the demand for bandwidth. Operators are considering next generation access architectures to provide higher capacities at lower cost per user than existing systems [1].

## 2. Wavelength-Shared Hybrid PON

WDM with a relatively small number of wavelengths can provide a very flexible, low-risk, cost-effective upgrade path for power-splitting PON systems. The proposed Wavelength-Shared Hybrid GPON (WS-HGPON) is an architecture that can be cost-effectively reconfigured to behave like a standard GPON system, a stack of GPON systems, or hybrids of these, depending on particular needs in the future [2].

Figure 1 shows an example of a symmetrical WS-HGPON with four downstream channels and four upstream channels. The downstream WDM signals from the Optical Line Termination (OLT) are distributed by the Remote Node (RN) to groups of Optical Network Units (ONUs). All ONUs in the PON have identical optical receivers to be able to receive any one of the downstream wavelengths.

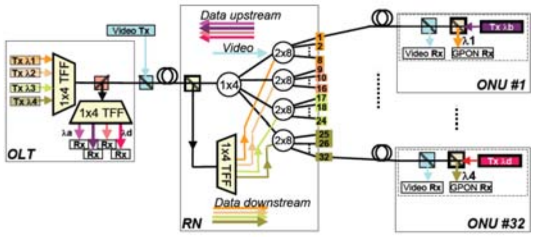


**Fig. 1 Symmetrical (4λ+4λ) WS-HGPON.**

In the upstream, four different wavelengths are used. However, ONUs with fixed wavelength transmitters can be deployed anywhere in the PON, because optical signals outside the downstream wavelength band containing the downstream sub-bands are passed through power splitters just like in the case of a standard GPON. The upstream wavelengths are demultiplexed at the central office with low-loss thin-film filters. The problem associated with WDM-PON systems of having to use more complex technologies to realize colorless ONUs is avoided this way.

This architecture is very cost-effective because of the very small number of additional off-the-shelf components used to quadruple the capacity in both directions over a conventional power-splitting PON.

Enhancement band services such as video overlay or other future access systems operating outside the GPON downstream wavelength band can easily be supported in this approach.

## 3. WS-HGPON Remote Nodes

A WS-HGPON Remote Node can be realized cost-effectively with only five thin-film filters. We have built a modular version of a WS-HGPON RN consisting of six cards as shown in Fig. 2. There are four conventional 2x8 power splitter modules, one conventional 2x4 power splitter module, and one HGPON upgrade band-drop/MUX module. The first five modules can be used to build a standard 1x32 RN (a cascade of 1x4 and 1x8).

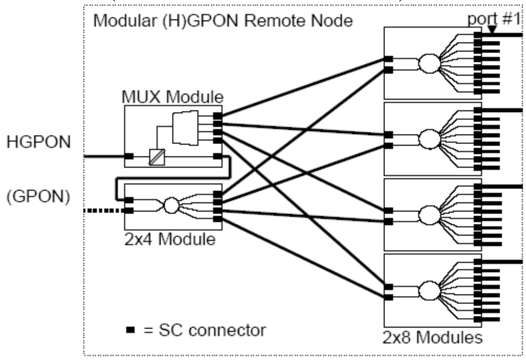


**Fig. 2 A modular WS-HGPON RN.**

The WS-HGPON upgrade module can be inserted between OLT and an input of the 2x4 module to drop and demultiplex the four downstream wavelengths. Each individual wavelength output is then connected to one unused 2x8 splitter module input to distribute single downstream wavelengths to groups of 8 ONUs. All other wavelengths outside the drop band containing the four downstream wavelengths are passed by the WS-HGPON upgrade module to the input of the 2x4 module. Video overlay signals are broadcast to all ONUs in this way, and all upstream signals are collected as if the RN were a standard power splitting RN.

**Table 1 Measured Characteristics.**

| Module output loss (isolation) | 1550nm (dB) | 1491nm (dB) | 1496nm (dB) | 1501nm (dB) | 1505nm (dB) |
|---|---|---|---|---|---|
| MUX through | 0.4 | (-35) | (-31) | (-25) | (-23) |
| MUX demux ports #1…#4 | N.A. | 0.9 | 0.7 | 1.1 | 1.0 |
| | (-75) | (-51) | (-61) | (-59) | (-59) |
| 2x8 #1, port #1 | 16.5 | 9.5 | (-48) | (-41) | (-39) |
| 2x8 #2, port #1 | 15.8 | (-49) | 8.8 | (-40) | (-38) |
| 2x8 #3, port #1 | 16.2 | (-49) | (-49) | 10.8 | (-39) |
| 2x8 #4, port #1 | 16.1 | (-49) | (-48) | (-41) | 11.1 |

| Module output loss (reflection) | 1.312nm (dB) |
|---|---|
| HGPON input | 16.2 |
| GPON input | 16.0 |
| 2x8 #1 port #1 | (-57) |

All values including loss from SC connectors and patch cords between modules.

MUX port #1 corresponds to 1491nm, port #2 to 1496nm, port #3 to 1501nm and port #4 to 1505nm.

The performance characteristics of this WS-HGPON RN are shown in the Table 1. The video overlay wavelength was 1555nm, and the HGPON downstream wavelengths were selected to be 1491nm, 1496nm, 1501nm and 1505nm based on availability of optical transmitters in the lab. The upstream transmitter operated at 1312nm.

The requirements on the optical components are easy to meet. Standard Thin Film Filters have temperature coefficients below 3pm/$^o$C, equivalent to a shift of the filter edges by less than 0.38nm over a –40...+85$^o$C temperature range.

The isolation between the grid of downstream wavelengths, and other wavelengths such as video overlay and upstream is realized by the filters in the demultiplexer and the band drop filter together. Even with a drop filter with relatively low isolation, a very high isolation can be achieved between multiplexer ports and through port of –75dB, which is important for a high quality analog video signal distribution.

The band drop filter has to operate from 1260nm to over 1600nm and have low insertion loss outside the drop band, which was 100nm wide in this work. The losses due to the band drop filter were low, about 0.4dB at 1.55μm, and about 0.2dB at 1.3μm, which is within the measurement accuracy due to connectors.

The RN insertion losses vary between 9.5dB and 11.1dB. Compared to the insertion losses of 15.8dB…16.5dB at 1.55μm, and 16.2dB at 1.3μm we find that the distribution loss for WDM signals in the downstream is at least 4.7dB lower. One possible use of this is to reduce downstream power levels accordingly, to eliminate Raman cross-talk to analog video signals in the 1.55μm band [3].

## 4. Conclusion

We have demonstrated the feasibility of a remote node supporting our proposed WS-HGPON architecture, with analog video overlay. Only five additional thin-film filters are needed compared to a standard power splitting remote node and the loss of an WS-HGPON remote node will be only slightly higher than that of a GPON power splitting node.

## References


[1] R. Davey, et al, “Options for Future Optical Access Networks,” IEEE Comm. Mag., Oct. ‘06.

[2] M. Bouda, et al, “Cost-Effective Optical Access Upgrades using Wavelength Shared Hyrbid Passive Optical Network Architecture,” Paper NThD5, NFOEC, 2007.

[3] P. Palacharla, et al, “Video Overlay in Next Generation Passive Optical Networks,” OWS5, OFC’07.