Leveraging fiber optical tap technology

Taps application guide

COMMSCOPE®

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FTTX solutions with optical taps

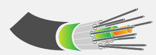
FTTH deployments in areas with a low to medium subscriber density can cost significantly more per home passed than compared to a dense urban or MDU (multi-dwelling unit) environment. Fiber optic taps are optimized for rural FTTH: they reduce costs, improve the business case, and can help secure project funding.

Urban and suburban FTTH networks typically use a PON (Passive Optical Network) with splitters to distribute optical signals. PON networks can be classified as two architectures, centralized and cascaded. Centralized split architectures are typically the most flexible, and usually are the most expensive, distributed split architectures involve two stages of splitters, typically one closer to the central office or head end and then one closer to the subscriber, balancing flexibility with cost.

A distributed tap architecture is different. It uses fiber optic taps instead of splitters and a linear daisy-chain topology. Imagine taking a fiber in a fiber cable, cutting it in the middle, and splicing a fiber optic tap into the fiber. Now the signal can pass through the tap and continue down the fiber while the tap siphons or drops off a portion of the signal for locally connected subscribers. Multiple taps can be placed where needed down the line until the optical link budget is exhausted or the maximum number of subscribers per OLT (Optical Line Terminal) port (typically 32 to 64 or more subscribers).

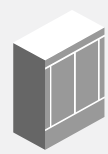
This same concept may be applied in urban and suburban networks, and even MDU environments, using integrated balanced splitters (typically 1:4 or 1:8 depending on density and services to cover). In these cases, it is highly important to simulate total link losses, taking into account the particular optical parameters of the case, and determine the tap value sequence as well as the connectorized configuration (spliced/connectorized hub and/or terminal thru ports).

HOW ARE OPTICAL TAPS OPTIMIZED FOR FTTX?



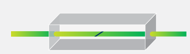
CABLES

Less fiber cable is required, which results in significant cost savings in long distances of rural deployments. In urban, suburban and MDU applications, a connectorized approach allows for the use of single-fiber drop cables, resulting in a "plug and play" deployment. Also, the same low fiber count cable can be used to pass all homes.



CABINET

Tap architecture often avoids the need for an equipment cabinet and mounting pad, as well as cabinet installation labor. Low count fiber cables are run directly into the serving area, without the need of a cabinet to house centralized splitters and connections.



SPLICING

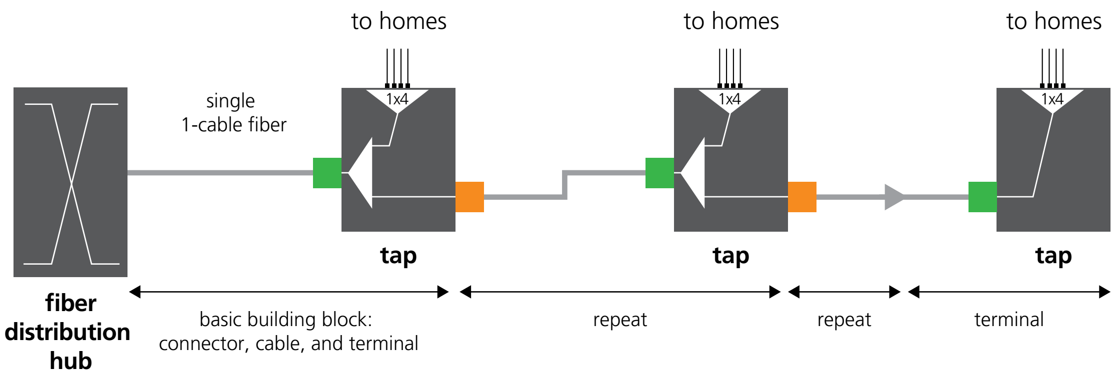
In spliced thru variants, installers do not need to maintain complicated splice maps, as the same fiber strand is spliced the same way at every tap in a cascade.

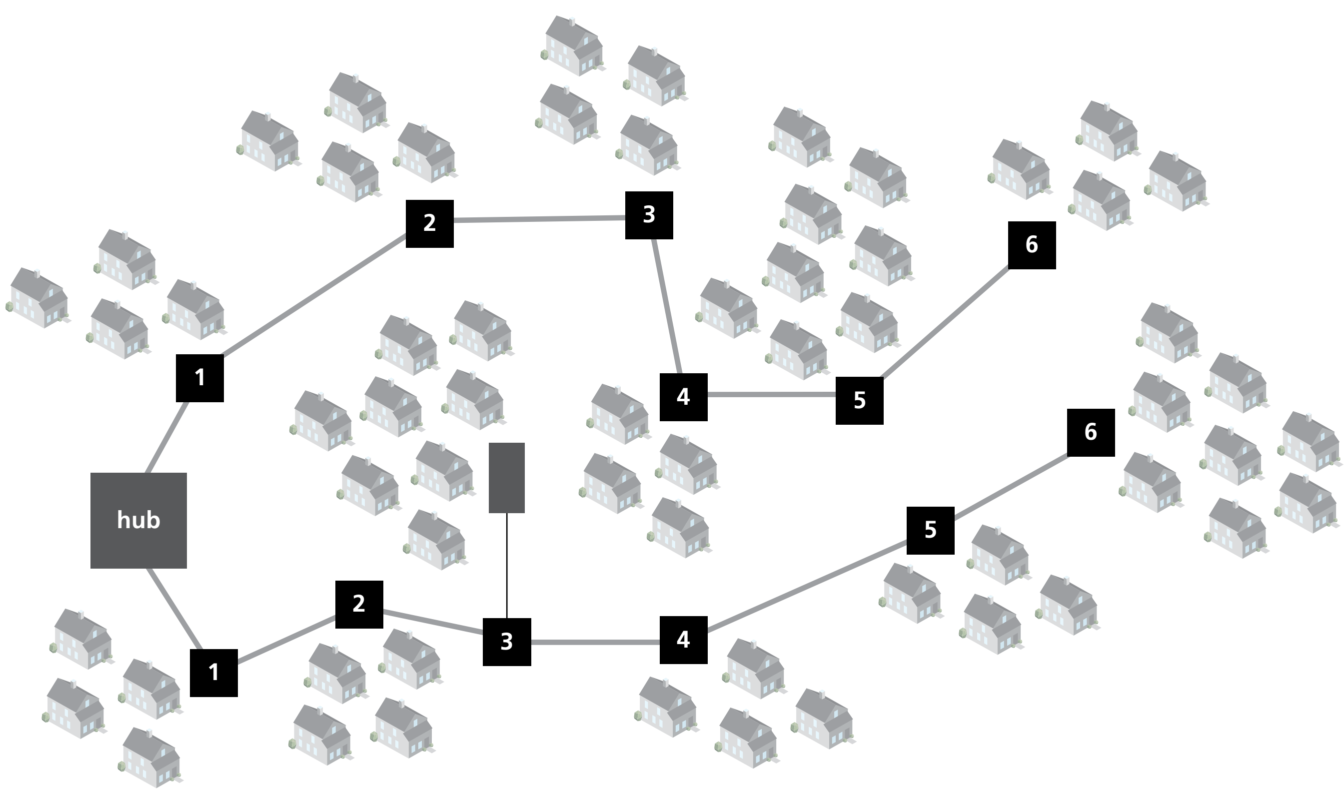
COST

A simplified design with less cable and less equipment means faster installations, at a lower cost. It also allows for the maximization of existing fiber, wherever the deployment of additional cables is costly.

Optical taps: deployment concept

The repeatable concept of the tap technology allows for simple and fast deployment. The first step on creating an effective design is the definition of the services to provide and basic parameters that determine the terminal configurations to be used. Once these parameters are set, the repetition of the defined building blocks will be the foundation for a plug and play network, a repeatable network design concept. A typical example of a medium to low density area is as follows:





Configurations

To build the network, each housing type is available in three configurations, described here.

1. Tap drop off with unbalanced splitter

2. Tap with integrated balanced splitter (2, 4 or 8 port)

3. Terminating tap with integrated balanced splitter (2, 4 or 8 port)

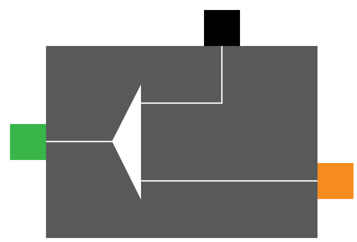
COLOR CODE (PORTS)	
BLACK	Single-fiber drop connector (drops)
ORANGE	Single-fiber drop connector (thru)
GREEN	Single-fiber drop connector (input, feed from previous terminal)

1 Tap drop off

The tap drop off is a closure with an integrated tap which is available with different split ratios as shown in the table. The image here shows the schematics inside the terminal and the color code of the adapters of this terminal.

In this case the signal of the secondary output of the unbalanced splitter is "dropped" to a single drop port (black port), while the primary output, with less insertion loss, is terminated in another single drop port (orange port) to continue the daisy chain. This single drop can be connected to a more peripheral terminal where splicing and or splitting is performed. This topology enables a greater spatial coverage though the possible number of drops remains the same for each chain. It allows for either the feed of very low customer density, or the deferral of CAPEX when market penetration is uncertain (adding integrated splitter terminals as services are required). Not all tap-thru/drop terminal combinations are recommended. Refer to the table here:

		Drop terminal		
		2	4	8
Tap attenuation max (dB)	2	X	X	X
	3.2	X	X	X
	4.7	X	X	X
	6	X	X	X
	7.8	X	X	X
	9.2	X	X	X
	11.2	X	X	X
	13.5	X	X	NA
	14.4	X	NA	NA
	17.9	X	NA	NA



These values do not include connectorization of input, thru and drop ports. Include maximum 0.4dB when applicable.

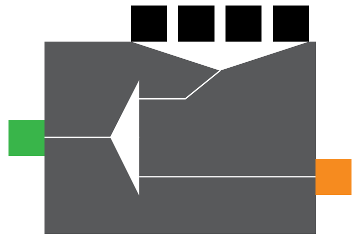
Tap/thru split ratio %	Thru loss max (dB)	Drop loss max (dB)
30/70	6.00	2.00
45/55	4.10	3.20
60/40	2.70	4.70
70/30	2.00	6.00
80/20	1.30	7.80
85/15	1.00	9.20
90/10	0.80	11.20
93/7	0.60	13.50
95/5	0.50	14.40
97/3	0.40	17.90

Configurations

2 Tap with integrated balanced splitter

The tap with an integrated balanced splitter is a closure with an integrated unbalanced 1:2 splitter as well as either a 1:2; 1:4 or 1:8 balanced splitter added to the secondary output of the first. The image here shows the schematics inside the terminal and the color code of the adapters of this terminal.

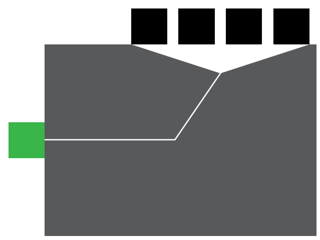
This terminal is available with the same different split ratios as shown in the table on the previous page, however the insertion losses of the secondary output of the splitter need added the insertion loss of the balanced splitter.



1:4 splitter variant

3 Terminating tap with integrated balanced splitter

The terminating tap is a closure with either 2, 4, or 8 drop ports evenly distributed, it has no thru port for daisy chaining, and it is used to terminate a run or expand one built with tap drop off closures. The image here shows the schematics inside the terminal and the color code of the adapters of this terminal.



1:4 splitter variant

These values do not include connectorization of input, thru and drop ports. Include maximum 0.4dB when applicable. In each variant the signal of the secondary output of the unbalanced splitter is split again with a balanced splitter and these are terminated as single drop ports (black), while the primary output, with less insertion loss, is again terminated in another single drop port (orange) to continue the daisy chain.

Tap/thru split ratio %	2 port taps		4 port taps		8 port taps	
	Thru loss max (dB)	Drop loss max (dB)	Thru loss max (dB)	Drop loss max (dB)	Thru loss max (dB)	Drop loss max (dB)
Terminating	NA	3.70	NA	7.10	NA	10.40
30/70	6.00	5.80	6.00	9.20	6.00	12.50
45/55	4.10	7.00	4.10	10.40	4.10	13.70
60/40	2.70	8.50	2.70	11.90	2.70	15.20
70/30	2.00	9.80	2.00	13.20	2.00	16.50
80/20	1.30	11.60	1.30	15.00	1.30	18.30
85/15	1.00	13.00	1.00	16.40	1.00	19.70
90/10	0.80	15.00	0.80	18.40	0.80	21.70
93/7	0.60	17.30	0.60	20.70	NA	NA
95/5	0.50	18.20	NA	NA	NA	NA
97/3	0.40	21.70	NA	NA	NA	NA

Network design with optical taps

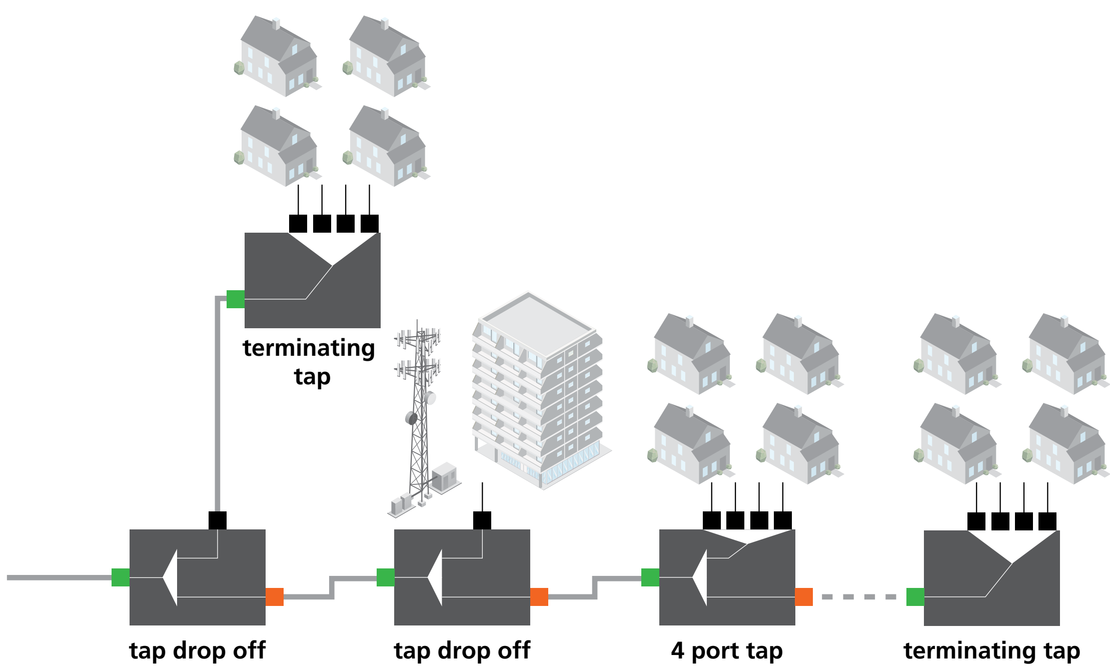
The different configurations of the tap terminals can be combined to provide maximum coverage of the distribution network while minimizing the CAPEX. According to the length of the link and number of terminals daisy chained, a first splitting level can occur in a fiber distribution hub, and a second splitting level within the tap terminals along with the unbalanced splitter.

The maximum number of terminals that can be daisy chained depends mainly on the total distance, and the balanced splitters included in the link. In order to build an optimized network utilizing optical taps, the following items should be considered prior to beginning the network design:

- Locate and identify all customers to have an overview of the total area to be covered/deployed
- Clear up all drawing nomenclature: hand holes, poles, ducts, terminals, etc.
- Identify feeder fiber cables availability. If available, define the fiber count & type of cables
- Locate nearest CO, Node or hub to determine the maximum distance allowed within the optical budget
- Take into consideration, drop cable distances/routes
- Identify any network deployment restriction: poles, aerial capacity, underground ducts
- Discuss the best location for tap terminals (aerial, pole, wall, manhole)
- Consider the maximum number of services per optical tap terminal
- Split ratio: specified by project

The selection of each variant will be determined by the services and market penetration defined for the specific area or project. The combination of different terminal designs makes for a more flexible network, allowing the convergence of different services such as SFUs, MDUs, businesses, cell towers and others.

The image here shows a combination of variants as an example of a design to match real needs.



Link loss calculations

To determine the overall link loss for a particular network design, it is necessary to take into consideration the following elements:

Physical

- Quality and quantity of splice points
- Connectors
- Split ratios
- Fiber make up (SMF 28 = 9 micron fiber)

Optics power

- Class of PON
- Receiver sensitivity

The physical elements will determine the added losses in the link, whilst the optics power will determine the total optical budget available for the link. Thus, the first step in calculating the link loss is to determine the typical losses for each element.

Once these elements are determined, identify the events in the link from the HE/CO downstream to the distribution hub, this value will be added to the optical tap's daisy chain insertion loss up to the terminal being calculated. For the tapped distribution network, follow the same addition process, take, for example, the scenario on the next page.

CALCULATING THE LINK BUDGET

+ Transceiver power budget

– Losses from multiplexing and demultiplexing

– Fiber losses

– Splice losses

– Patch panel and connector losses

= **Total link budget**

LOSS TABLES

Splitter loss table

Values do not include connectors.

Split ratio	Typical loss (dB)	Connector type
1:2	3.4	SC/APC
1:4	6.7	SC/APC
1:8	9.9	SC/APC

Event loss table

Event	Typical loss (dB)
Fusion splice	0.05
SC/APC	0.2
Hardened single fiber	0.2
Multi-fiber connector	0.2
Hardened mult-fiber connector	0.2

Fiber loss table

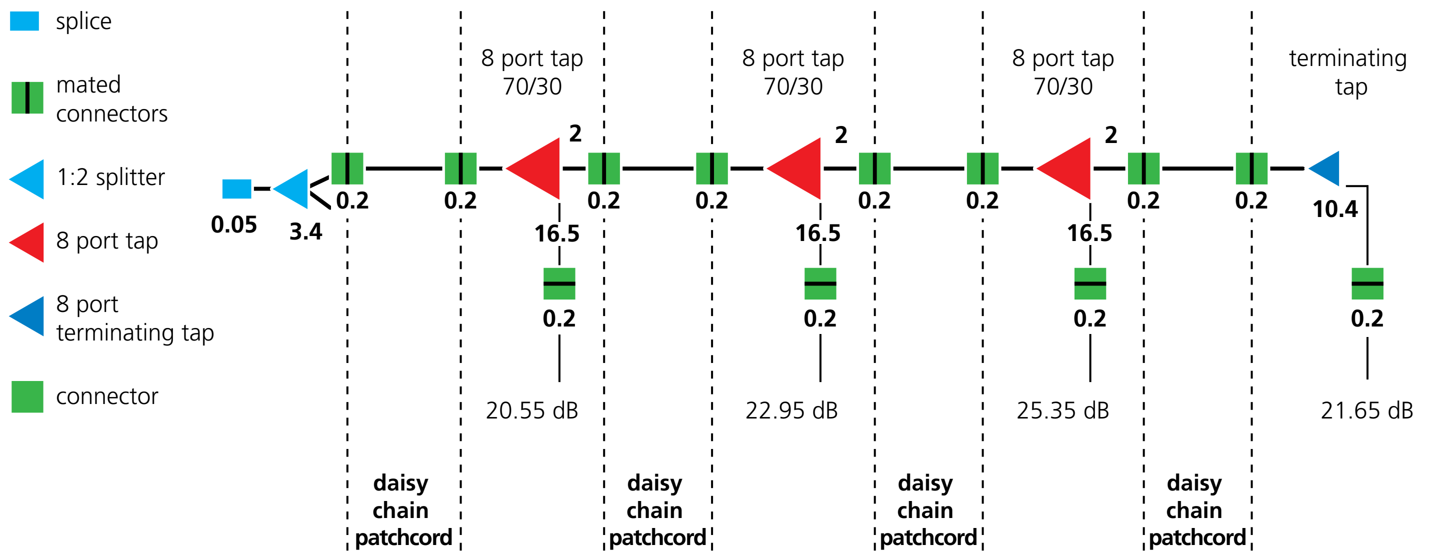
Wavelength (nm)	Loss/km (dB)	Loss/mi (dB)	Band
1550	0.25	0.4	C*
1490	0.28	0.48	S*
1310	0.4	0.64	O*

*Wavelengths used in BPON, EPON, GPON

Link loss calculations

Premise: Using a 1:2 split ratio at the hub and 8 port tapped hardened terminals (input, thru and drop ports). Individual events considered:

- 1:2 splitter = 3.4 dB (hub)
- 8 port 70/30 tap thru = 2 dB
- 8 port 70/30 tap drop = 16.5 dB
- 8 port terminating tap = 10.4 dB
- Hardened SC/APC connector = 0.2 dB



Hub: 0.05 dB (splice) + 3.4 dB (1:2 splitter) + 0.2 dB (hardened SC/APC) = 3.6 dB

First terminal drop

3.6 dB (hub) + 0.2 dB + 16.5 dB (tap drop port) + 0.2 dB = 20.55 dB

Second terminal drop

3.6 dB (hub) + 0.2 dB + 2 dB (tap thru port) + 0.2 dB + 0.2 dB + 16.5 dB (tap drop port) + 0.2 dB = 22.95 dB

Third terminal drop

3.6 dB (hub) + 0.2 dB + 2 dB (tap thru port) + 0.2 dB + 0.2 dB + 2 dB (tap thru port) + 0.2 dB + 0.2 dB + 16.5 dB (tap drop port) + 0.2 dB = 25.35 dB

Fourth terminal drop

3.6 dB (hub) + 0.2 dB + 2 dB (tap thru port) + 0.2 dB + 0.2 dB + 2 dB (tap thru port) + 0.2 dB + 0.2 dB + 2 dB (tap thru port) + 0.2 dB + 0.2 dB + 10.4 dB (terminating tap drop port) + 0.2 dB = 21.65 dB

To obtain the total link losses at each terminal, add upstream values from hub to CO/HE, this value will have to be added to the distribution losses previously calculated at each terminal. Make sure that addition at each terminal is within the optical budget determined by the optics used.

For support in evaluating application of an indexed solution in your network please contact your local CommScope representative.

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