Automated Connector Processing Tackles Exploding FTTP Connector Market

By

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Abstract

With Verizon, SBC, and BellSouth's initiative to use Fiber to the Premises (FTTP) as a means to leapfrog the limited consumer bandwidth provided by DSL and Cable Modems and Verizon's recent awarding of FTTP contracts to its key suppliers, fiber optic connector usage is predicted to soar.

Automation of the key "pinch points" of connector termination process, where most of the yield fallout occurs in a manual production, is imperative in order to reach the aggressive FTTP cost and quality targets. Integration of the polishing, cleaning, and inspection processes is shown to be an effective solution for high volume batch processing of the APC connectors as required by the burgeoning FTTP build outs.

Intro

Verizon has committed to deploying FTTP services (i.e. The Triple Play) to 1 million homes in the US this year, 2 million in '05, and over 4 million in '06, at which point SBC has indicated it will also begin its initial FTTP rollout. The Passive Optical Network (PON) architecture selected by these local carriers is based upon preconnectorized fiber optic splitters and drop cables which are to be deployed in the Outside Plant (OSP).

Preconnectorized cables and modules have been selected such that service can be incrementally deployed to subscribing customers in a simple “plug and play” fashion by lower skilled craft personnel.

The initial part of the project now underway is to build out the feeder and distribution portion of the network so that a majority of the homes in a target area are “passed by” and then can be easily connected when an individual subscriber opts to take the high bandwidth services offered by the local carrier.

The architecture of the network is based upon fiber optic feeder cables (typically 12, 24 or 48 fiber count) that are fusion spliced to preconnectorized splitter modules within the Service Area Interconnect (SAI) or Fiber Distribution Hub (See Figure 1). Also, within the SAI are preconnectorized distribution cables (often as high as 432 fiber count!) that are fusion spliced to the distribution side of the network. Higher skilled construction crews do all of this initial fusion splicing, but are not need to subsequently connect individual subscribers.

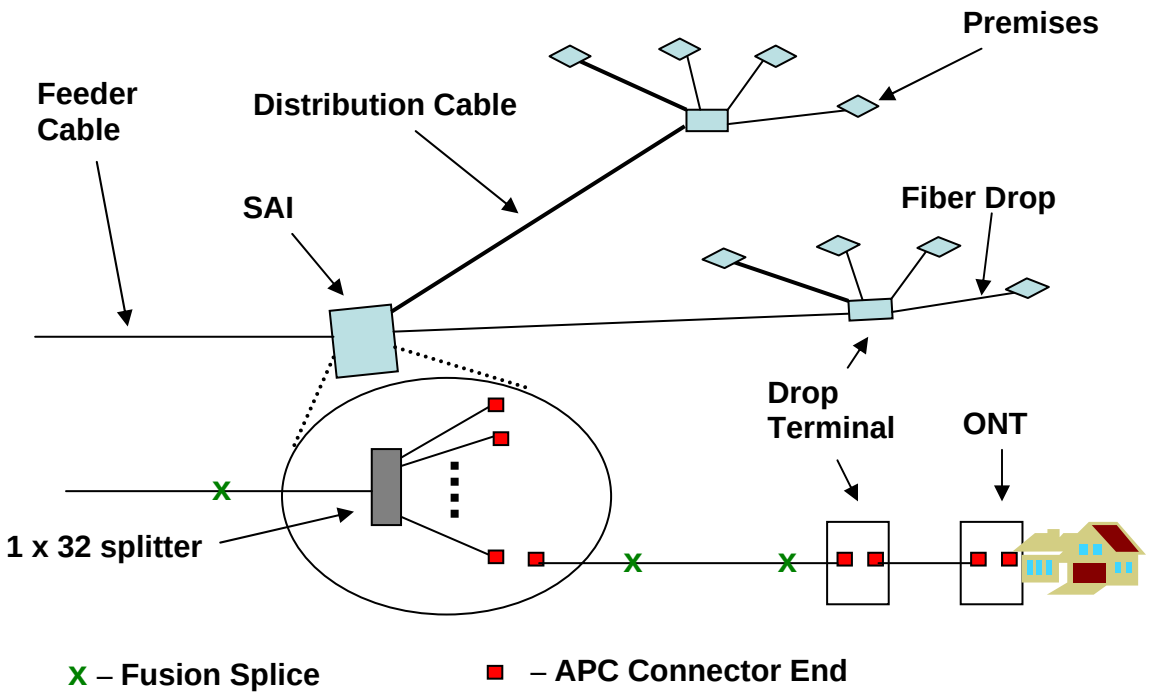

Figure 1 - APC Connectors in FTTP OSP

Once a customer subscribes to the service, a craftsperson connects one of the preconnectorized splitter output ports to the corresponding preconnectorized distribution cable port in the SAI and installs an ONT at the customer premises. The craftsperson then utilizes a laser range finder to determine the distance from the drop terminal to the ONT in order to select the correct length of preconnectorized drop cable (typically ranging

from 50 to 250 ft) in order to complete the final connection from the drop terminal to the subscriber's ONT.

For a centralized PON based architecture utilizing preconnectorized splitters in the SAI and preconnectorized drops to the ONT, we see 6 APC connector ends are located in 3 different OSP cabinets as follows:

SAI – Fiber Distribution Hub where Splitter is located:

- Connector on Splitter scales with homes subscribing
- Connector on preconnectorized Distribution Cable scales with homes passed

Drop Terminal – Fiber Terminal where preconnectorized Fiber Drop Cable is "dropped" to the ONT on the side of the house:

- Connector on preconnectorized Distribution Cable scales with homes passed
- Connector on preconnectorized Drop Cable scales with homes subscribing

ONT:

- Connector on preconnectorized Drop Cable scales with homes subscribing
- Connector end that is inside the ONT is typically a fiber stub within a receptacle based TROSA scales with homes subscribing

Thus, we see 2 connector ends are required for each home passed and another 4 connector ends are required when a home subscribes for service.

APC Connectors

Fiber optic connectors are typically deployed within inside plant (ISP) environments, i.e., within Central Offices (COs) or within Controlled Environment Vaults (CEVs). The only fiber optic connector type that has been field proven in an OSP environment is the angled physical contact (APC) connector. CATV companies have been successfully using APC connectors in the OSP for over fifteen years. However, for CATV companies, APC connector usage is typically limited because:

- CATV fiber spans are typically thin (i.e., use low fiber count cables)
- CATV only uses connectors for the node service cables interfacing with active electronics in the OSP

CATV applications typically prefer to fusion splice their plant to minimize the back reflection that can degrade their analog signaling Carrier to Noise Ratio (CNR). However, there is an advantage to having the active amplifiers that are deployed in their Hybrid Fiber Coax (HFC) networks to be connectorized because maintenance can be eased. The only connector that meets their Return Loss requirements for their analog signaling (i.e., 65dB) is APC connectors.

Since Verizon desires to have their FTTP build outs capable of handling multiple transmission protocols, they too have chosen to utilize APC connectors. The additional

benefit of utilizing APC connectors in PON architecture is that you can avoid the use of terminators on the unused splitter ports. Unused splitter ports with standard “flat polished” UPC connectors must be “terminated” to avoid the large air/glass reflectance (~14.5dB) that can disrupt the upstream lasers in the OLTs. Fiber optic terminators are a simple device that act as an “optical sink” minimizing back reflection; but, are yet another optical component that the carrier must inventory. Standardizing on APC connectors eliminates the need to terminate the used ports as unterminated APC connectors have ~65dB Return Loss from their “angle polished” air/glass interfaces.

Verizon’s decision to utilize APC connectors is the first true mass deployment of this connector type. While connector suppliers had ramped up capacity for other fiber optic connector types during the “Telecom Bubble”, the APC connector business remained somewhat of a lower volume niche market. Based on the projection of homes passed and subscribed by Verizon and the number of APC end per subscriber seen in Figure 1, combined with the additional connectors that will be required within the Fiber Distribution frames (FDFs) and OLTs to terminate the feeder cables in the CO we find explosive APC growth is anticipated (see Figure 2).

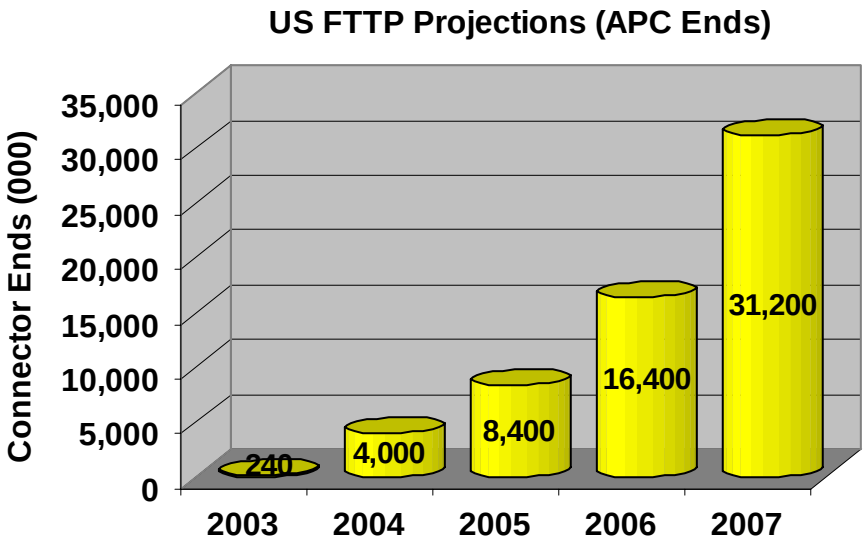

Figure 2: FTTP Connector Growth

Automation to the Rescue

Fiber optic connector manufactures had built up an inventory of fiber optic connector terminating and polishing equipment during the “Telecom Bubble”. The ability to attain new or slightly used equipment on the “grey market” combined with the movement of production to low labor cost countries overseas gave little incentive to connectivity manufactures to invest in new capital equipment. However the bulk of that equipment was for polishing and terminating 2.5mm (SC) or 1.25mm (LC) ferrule based connectors

with “flat” UPC polished ends. APC connectors never had such huge volumes, even during the Telecom Bubble, for manufactures to explore high volume production capabilities for these connectors.

APC connectors are inherently more difficult to produce than UPC connectors. Angle tolerances (typically 8+/-0.2 º) must be accurately controlled in addition to the standard geometrical parameters of: apex offset, radius of curvature, and fiber height. To make APC connectors today, manufactures typically must use standard bench top polishers and are limited to 12 port polishing jigs in order to produce quality product.

The most practical way to increase connector production capacity is to increase the number of parts you polish at one time. However, maintaining the strict geometric tolerance required for APC connectors while increasing your batch size is challenging. Consequently, even moving to an 18 port jig for APC connectors on a manual polisher is precarious.

By employing novel adaptive process controls on our polishing head, Sagitta has created standard processes for both the extended chamfer (aka “cone” or “pencil tipped”) as well as step based APC ferrules [1] for batch polishing 48 APC connectors at a time enabling throughputs in excess of 200 APC ends per hour. Highly efficient use of the films coupled with optimal process recipes ensure low cost of consumables. Furthermore, automated inspection algorithms eliminate the operator subjectivity involved in the manual visual inspection of polished connector end faces.

Typical geometrical results attained with Sagitta’s Gemini-Cx vs. industry standards for APC connector are shown below:

	Angle (°)	**Apex Offset (µm)**	**ROC (mm)**
Industry Standards	7.8 – 8.2	< 50	5 - 12
Typical Gemini Results	8 +/- 0.07	22 +/- 10	7 +/- 0.8

Table 1: Typical Results vs. Industry Standards

Guaranteed yield improvements and consumable cost savings combined with labor savings make this type of automation a compelling value proposition even in low labor cost countries. But more importantly, it may enable a US manufacturer to maintain domestic production, close to their FTTP customer. Unit cost comparisons between a “typical” US manufacturer employing manual processes and Gemini automation is summarized below:

Cost Component	US Qty	US Scrap	US U/C	US Cost	Gemini (in US) Qty	Gemini (in US) Scrap	Gemini (in US) U/C	Gemini (in US) Cost
BOM								
SC/APC Housing Parts	1	3%	$1.10	$1.10	1	2%	$1.10	$1.10
Ferrule	1	3%	$0.80	$0.80	1	2%	$0.80	$0.80
Boot	1	2%	$0.25	$0.25	1	1%	$0.25	$0.25
SM Fiber (2m)	2	2%	$0.04	$0.08	2	2%	$0.04	$0.08
Consumables	1	3%	$0.32	$0.32	1	2%	$0.15	$0.15
Packaging	1	1%	$0.09	$0.09	1	1%	$0.09	$0.09
Total Material Cost				**$2.64**				**$2.47**
DL & Overhead								
Direct Labor	0.17		$11.80	$1.97	0.02		$12.00	$0.18
Overhead fixed and variable	0.60			$1.18	0.60			$0.11
Depreciation (5 yr, SL)				$0.06				$0.13
Scrap Costs		2.8%		$0.16		1.9%		$0.05
Misc. (Freight, etc.)				$0.08				$0.08
Total DL & Overhead Cost				**$3.45**				**$0.55**
Total MFG COGS				**$6.09**				**$3.02**

Table 2: Unit Cost Comparisons

Automation of the polishing, cleaning, and inspection processes of fiber optic connector manufacturing is imperative in order to reach the aggressive FTTP cost and quality targets. Sagitta's Gemini-Cx is an effective solution for high volume batch processing of the APC connectors now being required by the burgeoning FTTP build outs.

References:

[1] Contreras et al, "Method of Achieving Excellent APC Connector End Face Parameters Using Chamfered Ferrules", *IEEE Electronic Components and Technology Conference*, p. 535, 1999.