Singlemode optical tree couplers for TTC distribution networks

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While the exact number of TTCoc required by all the LHC experiments has not yet been established, it appears that the total will be of the order of 50 1:16 couplers and 300 1:32 couplers, representing an investment of over 450 KCHF. Since singlemode couplers have in the past typically cost 2-3 times more than multimode couplers, price has dictated that multimode distribution be used at the experiments where the TTC signals are fanned out to many destinations. This scenario is now changing.

Fused couplers remain substantially cheaper than planar waveguide designs. Up to the present, the lowest cost fused couplers have been multimode fused biconic taper (FBT) components made by the Canstar division of FCI, since this Canadian facility can make 1:32 multimode couplers in a single fusion. Since singlemode fused couplers can only be made with fanouts of 1:2 or 1:4, several small couplers must be concatenated to make singlemode 1:16 and 1:32 modules. Hence labour cost is an important element in the fabrication of these devices. For both multimode and singlemode couplers, connectorisation also requires dexterity and time.

However, labour costs are substantially lower in South East Asia. As a result it is now becoming possible to procure singlemode 1:16 and 1:32 couplers, fabricated by the manual concatenation of smaller components, for substantially less than the cost of single-fusion multimode FBT couplers made in North America. Singlemode distribution results in improved optical signal amplitude and phase stability, particularly if any fibre movement occurs. Since singlemode optical fibre systems have superior performance to multimode ones, I recommend that they should now be considered for TTC distribution at the experiments. The laser transmitter modules (TTCex, TTCtx, TTCmx) can drive either singlemode or multimode systems and the recommended optoelectronic receivers are compatible with both. However, the TTCvx LED transmitter can only drive multimode fibre.

The concatenated singlemode coupler modules are physically somewhat larger than the multimode FBT devices but can still be housed easily in 1U 19" rack enclosures. The input and output fibres of the modules can be 900 µm loose tubes, which are much less fragile than the 250 µm coated fibres required by the high-fanout multimode FBT devices. This greatly facilitates the mounting of the modules in the rack enclosures. Because of the internal concatenation, the total fibre length is increased by about 1 metre (4.9 ns).

The cost of an optical coupler varies with the excess loss and uniformity specification which it is required to meet. The optical power level available from the laser transmitter modules is sufficient for a 1:32 coupler excess loss of up to 4 dB (insertion loss of 19.1 dB) to be quite acceptable. Furthermore, owing to the large dynamic range of the 1B43 photodiode/preamplifier with AGC, coupler uniformity is no longer a serious concern when this receiver component is employed. Hence it is not necessary to pay for Premium-Grade couplers - ordinary A-Grade products are acceptable for TTCoc production.

Singlemode A-Grade superfusion optical tree coupler modules can be supplied by Comcore Optical Technologies, for example, at the following indicative prices (fob Shanghai):

- 1:16 (TSM-7-A6-0-M6-A-1-M-0-6) - USD 230 (qty 10-99)
- 1:32 (TSM-7-E2-0-M6-A-1-M-0-6) - USD 460 (qty 100-499)

The coupler modules can also be supplied ready-mounted in 1U 19" rack enclosures with front-panel ST adaptors at the following prices:

- 1:16 (TSM-7-A6-0-M8-A-1-M-0-6) - USD 340 (qty 10-99)
- 1:32 (TSM-7-E2-0-M8-A-1-M-0-6) - USD 630 (qty 100-499)

A data sheet is available.
Notes for the data sheet: M8 package (1U 19" rack enclosure) is now available for 1:32 as well as 1:16 couplers.
Add 0.4 dB to the specified insertion loss for the connectors. i.e., max insertion loss:

- 1:16 - 15.5 dB
- 1:32 - 18.9 dB

Singlemode optical fibre connectors are somewhat more expensive than multimode ones but the additional cost of Corning singlemode ST connectors (and front-panel adaptors for the rack-mounting version) is included in the above prices. As there are no alignment problems between the connector ferrule and the large area photodiode, cheap multimode connectors can still be used for the optical receivers if desired.

Singlemode fibre is less expensive and more radiation resistant than graded-index multimode fibre. Ready-connectorised singlemode optical patchcords of 5 different lengths for use in TTC test setups will be introduced in CERN stores shortly. For the fibre installations at the experiments, ST Division have made a major market study of singlemode fibre for CERN and they have offered to make their expertise available to the experiment collaborations.

The following images are available:

- Interior of optical coupler module (1:10 example)
- Exterior of module (2:32 example)
- Rack enclosure (CERN version will have the optical connectors on the front panel)

The Comcore optical tree couplers are fabricated using a Thermal Diffusion Technology (TDT) which differs from the traditional FBT process in that the mode field diameter expansion in the coupling region is achieved by diffusion, without any fibre pulling and tapering. As a result the fibre diameter in the coupling region is undiminished and no surface micro-cracks are created, resulting in a more stable component with higher reliability.

An OFC conference paper outlining the TDT process is available.

In addition to the performance advantages of singlemode distribution and the higher reliability inherent in the TDT process, the use of these new optical tree couplers instead of multimode FBT devices should result in an overall cost saving of well over 100 KCHF.

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