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Impulse Response of a 36-Core Few-Mode Photonic Lantern Hybrid Spatial-Multiplexer

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Abstract:

Space division multiplexing (SDM) using fibers with multiple cores and/or supporting multiple modes has become an essential technology to support Pbit/s transmissions in a single fiber [1,2]. Despite significant mode-mixing in few-mode fibers (FMF), the original signals can be recovered through multiple-input multiple-output (MIMO) equalization, provided mode-dependent loss (MDL) is small [3]. Furthermore, mode scrambling at the transmitter improves tolerance to MDL and maximizes system capacity if all supported modes are used to transmit information [3]. Thus, the MDL and mode mixing properties of spatial multiplexers (SMUXs) are important.

In this work, we characterize the impulse response of a 36-core three-mode photonic lantern SMUX, similar to [4], with no mode selectivity, coupled to 2.9m 36-core three-mode fiber including a splice, using a spatially diverse optical vector network analyzer (SDM-OVNA). Each mode group was identified and significant mode-mixing was found at the splice.

The SDM-OVNA setup is a swept-wavelength interferometer as shown in Fig. 1(a), using time multiplexing with fiber delays for separation of device responses from different paths and thus allowing full characterization of one photonic lantern in a single sweep [5].

The measurement of the 36 photonic lanterns yields a 6×6 time domain response for each core, as shown in Fig. 1(b). Reduced 3×3 matrices as shown in Fig. 1(c) and (d) are obtained when summing over the four possible polarization paths between an input-output pair. Comparing these across the 36 cores of the fiber, two groups with different behavior are identified: i) three peaks are visible within the time response matrix entries as in Fig. 1(c), ii) two additional peaks located between the extreme and central peaks are visible as in Fig. 1(d). The groups of cores are found to be in opposite halves of the fiber, as highlighted in Fig. 1(e), showing a camera image of the cleaved fiber facet.

Analysis of their relative delays and comparison with the known fiber differential mode delay [2] allows identification of mode groups and mode-mixing paths, showing significant mode mixing to take place at the multicore few-mode fiber splice. Furthermore, insertion loss and MDL of the system are further analyzed.

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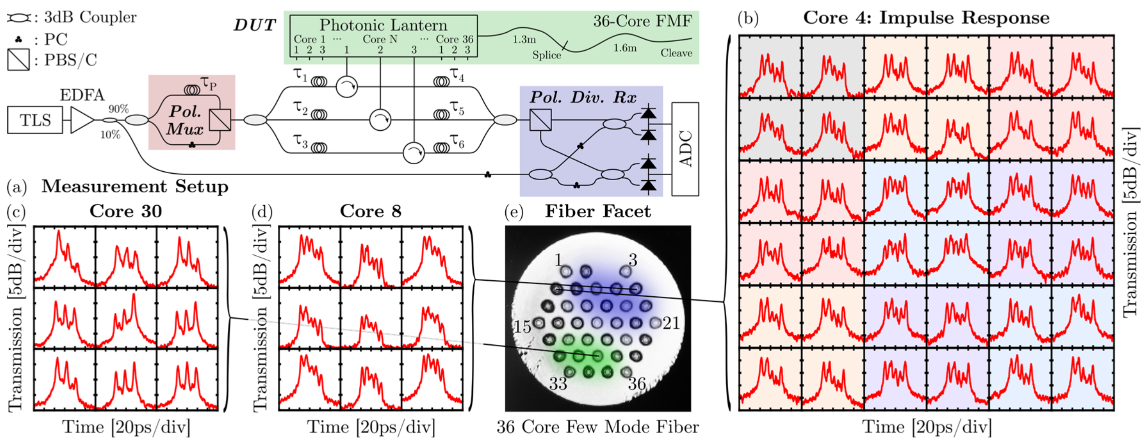

Figure 1. (a) Spatially-Diverse Optical Vector Network Analyzer Setup; (b)-(d) measured impulse responses: full 6×6 response of core 4, polarization combined 3×3 responses of cores 8 and 30; (e) camera image of cleaved fiber facet with core identifications and regions of different behavior highlighted.