Fibre characterisation for quantum key distribution field trials

A. R. Dixon[1*], Y. Tanizawa[1], H. Sato[1], S. Kawamura[1], M. Fujiwara[2] and M. Sasaki[2]

[1]*Toshiba Corporate Research & Development Center, 1 Komukai-Toshiba-Cho, Saiwai-ku, Kawasaki 212-8582, Japan*
[2]*National Institute of Information and Communications Technology, 4-2-1 Koganei-city, Tokyo 184-8795, Japan*
alexander.dixon@toshiba.co.jp

Introduction

Quantum key distribution (QKD) is increasingly moving from laboratory experiments into real world optical communication networks. To understand differences in operation between controlled laboratory environments and these telecom networks it is important to characterise the parameters of the fibre which are important for quantum key distribution operation. Here we describe methods and results from characterising a deployed telecom fibre optic network which is being used for quantum key distribution field trials[1].

Parameters Characterisation Methods

The parameter characterisation methods described are:

1. **Total fibre attenuation loss –** Using a laser source and an optical power meter.
2. **Fibre attenuation loss as a function of distance –** Using an Optical Time Domain Reflectometer (OTDR).
3. **Polarization extinction ratio –** Using a laser source and a linear polarizer as input and a polarization controller followed by a polarizing beam splitter and optical power meter.
4. **Polarization rotation as a function of time –** Using a laser source and a linear polarizer as input and a polarizing beam splitter and optical power meter.
5. **Polarisation mode dispersion –** A polarised broadband light source is injected into the fibre and the polarised light intensity is measured as a function of (rapidly scanned) wavelength at the fibre exit.
6. **Chromatic dispersion –** Using an OTDR to input four different wavelengths (1.31/1.41/1.55/1.625 μm) into the fibre and measures the return time allows fitting a delay vs wavelength curve and calculating the dispersion.

Results

The installed fibres are 45km long with a total attenuation of 14.5 dB, with 50% aerial fibre. Splice and connection points can be seen increasing the fibre loss at specific distances.

Polarisation extinction ratios above 25dB are possible. As shown in Fig. 1 polarisation rotation by the fibre becomes significantly faster during day time (9:00 – 17:00). Polarisation mode dispersion (PMD) also varies with time, as shown in Fig. 2, over a range of 0.5 - 1.5 ps with a mean value of ≈ 1 ps. Significantly increased PMD is seen during daylight hours.

Chromatic dispersion is measured as 16-17 ps/(nm.km).

Polarisation rotation, polarisation mode dispersion and chromatic dispersion can all negatively impact the performance of QKD systems which use either polarisation or narrow (~ns) pulses, and should be compensated for optimal performance.

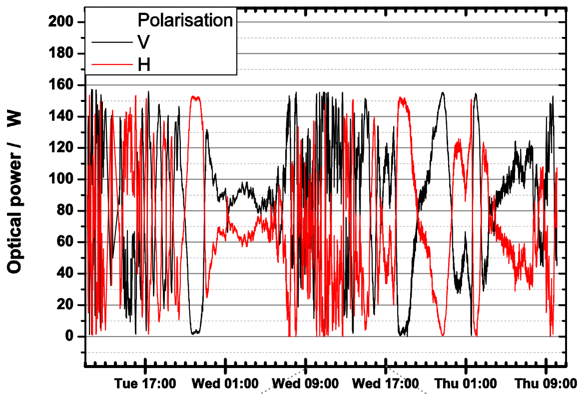

Figure 1: Measured polarisation rotation in installed fibre as a function of time over a 5 day period.

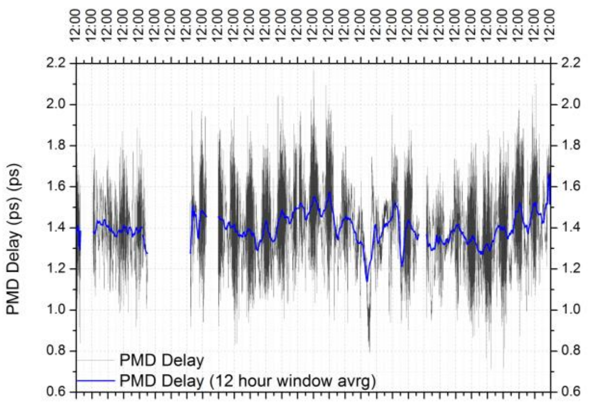

Figure 2: Measured PMD in the installed fibre over a 30 day period (time on top axis). Individual (12s separated) values are shown in black with a 12 hour moving average shown in blue.

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[1]JGNX Testbed (www.jgn.nict.go.jp) (2016).