vegetable objects (e.g. small pieces of pod), and non-vegetable objects (e.g. small stones). In our experiments, we used two different RBF neural networks to associate each sample with one of the above classes: one was trained using the *k*-means clustering algorithm for the whole training set (i.e. without considering the class-memberships of the training samples); the other was trained using the proposed technique. The training phase was carried out on 505 samples; the test was performed on another 504 samples, independently chosen. Several trials were carried out by increasing the number of hidden neurons (and hence the number of kernel functions) from 10 to 100 (in steps of five). These trials allowed us to compare the behaviours of the classification errors made by the two training techniques for different numbers of kernel functions. For each trial carried out with the proposed technique, an equal number of kernel functions was chosen for each class.

Fig. 2 shows the classification errors made on the test set with the classical and the proposed techniques. The results confirm that the proposed technique significantly reduces the classification error made by the RBF neural classifier. In particular, the smallest classification error obtained using the classical technique was 14.70% (for 80 hidden units), whereas the minimum classification error obtained with the proposed technique was 13.06% (for 70 hidden units).

In addition, Fig. 2 confirms that the classification error incurred by the classical technique shows an oscillatory behaviour with regard to the number of hidden neurons considered (this makes it critical to fix the number of hidden units for an RBF neural classifier). On the contrary, the proposed technique results in a more stable trend of the classification error and consequently provides a better framework for choosing the architecture of an RBF neural classifier.

Conclusions: We have proposed a simple supervised technique for RBF neural network classifiers. In our experiments, this technique significantly reduced the classification error made by the classifier. In addition, a more stable behaviour of the classification error, with regard to the number of hidden units, was obtained. This renders the selection of the number of hidden units in an RBF network a less critical choice.

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10Gbit/s alternate polarisation soliton transmission over 300km step-index fibre link with no in-line control

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A straight-line in-field transmission was performed over a 300km step-index fibre link installed between Roma and Pomezia using a 10Gbit/s stream of 1550nm alternate-polarisation solitons. Standard SDH 10Gbit/s line terminals were used at the transmitter and receiver sides. Error-free transmission was obtained with optical amplifiers placed every 50km and with no in-line soliton control. It is important to underline that in this case the large chromatic dispersion was compensated for by fibre non-linearity without resorting to chromatic dispersion compensators.

The growing demand for large capacity communication links raises the problem of the already installed worldwide fibre infrastructure which is mostly constituted by step-index (SI) fibres with zero dispersion at 1.3μm. So far, dispersion management and/or wavelength division multiplexing (WDM) have been demonstrated to be suitable solutions for upgrading the existing fibre infrastructure. Those solutions require system adjustment, such as the introduction of dispersion compensating fibres or, in the case of WDM, an upgrade in terms of the number of channels, instead of simply increasing the capacity of the single channel, which would save in overall transmission bandwidth. In this Letter, we report an optimised transmission scheme which makes it possible to improve the maximum distance achievable on SI fibre with only a single channel, without resorting to the insertion of in-line components (such as chirped gratings, dispersion-compensating fibres, mid-span phase-conjugators, or even synchronous amplitude or phase modulators). The method simply exploits the reduced interaction efficiency experienced by orthogonal solitons to increase the duty cycle in the data stream [1], and it is implemented with a polarisation encoder which alternates orthogonal states of polarisation in the data stream. The effectiveness of alternate polarisation encoding has been theoretically predicted [2] and experimentally verified at 40Gbit/s over 800km in a dispersion-shifted fibre setup [3]. The maximum transmission distance achieved with our SI fibre system, based on alternate polarisation encoding, was 300km, thus extending the limit of 253km found with the dispersion supported transmission (DST) technique [4], another method of transmission with no in-line control.

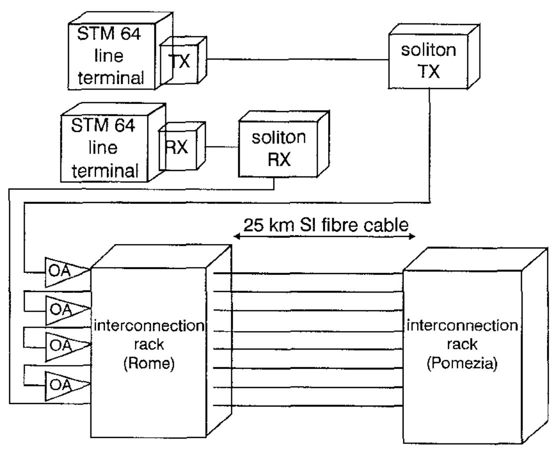

Fig. 1 *Line configuration*

The line configuration is shown in Fig. 1, with the experimental setup shown in Fig. 2*a*. The 5GHz soliton pulses emitted by the soliton generator have adjustable duration between 45 and 65ps and ~ –3dBm average power. The pulses are amplified by means of a polarisation maintaining optical amplifier up to 11dBm and sent to the polarisation encoder.

The 10Gbit/s electrical data are provided by the STM-64 line terminal whose clock also drives the entire setup. The electrical signal is divided into two 5Gbit/s electrical bit streams by means of the bit divider. The two 5Gbit/s electrical bit streams are used to modulate the 5GHz optical pulse streams by means of Mach-Zehnder modulators. Finally, the two 5Gbit/s optical pulse streams are time-interleaved by introducing a 100ps differential delay, and combined by means of the polarisation encoder. The output of the whole source is a 10Gbit/s pulse train with adjacent time slots having orthogonal polarisation (alternate polarisation encoding). A typical eye diagram is shown in Fig. 3*a*.

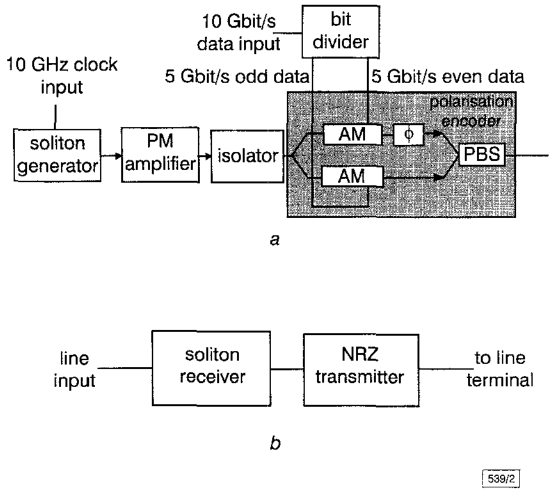

Fig. 2 *Polarisation encoding source scheme and RZ to NRZ converter*

a Polarisation encoding source scheme
b RZ to NRZ converter

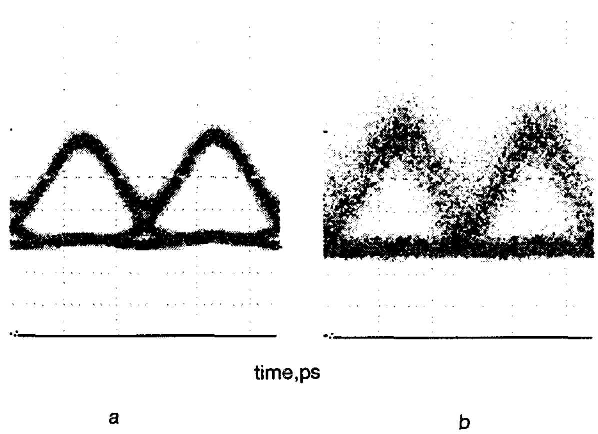

Fig. 3 *Eye diagram of 10Gbit/s orthogonal polarisation coded signal*

a At output of transmitter
b After 300km
Horizontal scale 20ps/div

The link is made with a 25km cable which also contains 20 SI fibres (ITU-T G652), looped back in pairs at a transit station in Pomezia (25km south of Rome) in order to obtain 10 spans of 50km each. All the terminations of the spans are located in Rome (see Fig. 1). The mean attenuation, chromatic dispersion and polarisation mode dispersion of these fibres are 0.24dB/km, D = 16.2ps/nm/km and PMD = 0.04ps/km$^{1/2}$, respectively. At each span end we introduced a commercially available optical amplifier with a saturated output power of +14dBm. The maximum polarisation dependent gain of the amplifiers was PDG = 0.3dB, whereas the maximum differential group delay was DGD = 1ps. This configuration, with all the terminations in the same laboratory, permitted us to check the quality of the transmission after each span of 50km by monitoring the signal just before each amplifier. The soliton pulses at the end of the line were detected by means of an RZ to NRZ converter placed just before the STM-64 line terminal receiver (Fig. 2*b*).

The eye diagram obtained after 300km is shown in Fig. 3*b*. As can be seen, with 50ps pulses (the optimal FWHM pulse duration obtained from numerical simulation of performance evaluation) the eye pattern is quite clean up to 300km, while for longer propagation distances a good transmission result cannot be obtained. Several parameters were adjusted to obtain the best result: line input power, amplifier gain, and pulse duration.

The bit error rate (BER) measured by the receiver terminal is shown in Fig. 4 against the power level at the preamplifier input.

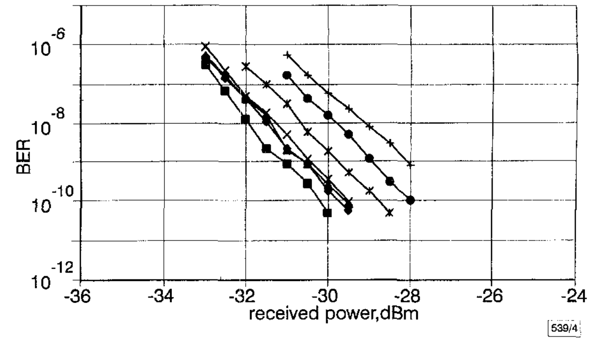

Fig. 4 *BER measurement results for source back-to-back and after each 50km*

◆ back-to-back
■ 50km
▲ 100km
× 150km
✳ 200km
● 250km
+ 300km

As shown by the BER results, after 200km the power penalty of the system was 1.5dB, and < 3dB after 300km. In this configuration, after 300km, a BER < 10^{-9} was achieved with a received optical power of –28dBm. For comparison we also evaluated the system performance with a 10Gbit/s BER test set. We noticed that at 300km propagation distance it is possible to reach excellent values of BER measurement down to 10^{-12} with a 2^7–1 word length. With the same word length, transmission up to 500km is also feasible. These results, obtained with the short word, suggest that the real limitation of the system arises from some pattern effect that is increasingly efficient with increased pattern length. In fact, by resorting to a deterministic data stream, we found that short patterns are more stable than longer ones.

Conclusions: We report the longest propagation distance of 300km obtained at 10Gbit/s using a conventional step-index fibre link without any dispersion compensating technique or in-line signal control, but only with optical amplification every 50km.

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