Title: APPARATUS AND METHODS OF DETECTING AND CONTROLLING TWISTS IN MULTICORE CABLES

Abstract: The apparatus includes a transducer (12) coupled to a wheel driven by the cable (4) to indicate the speed of travel of the cable. A calibration unit (18) converts this speed in collaboration with a nominal twist rate set into the unit, into an output signal having a frequency equal to the nominal twist frequency of the cable. A detection assembly (10) downstream of the wheel (6) detects the variations in thickness of the twisted cable as it passes and thus produces a signal having a frequency component directly related to the actual twist rate. An analyser (18) conducts a fourier analysis on the output of the detector and, with the aid of the nominal twist frequency, is able to select the frequency component representative of the actual twist frequency. The actual twist frequency is compared with the nominal twist frequency by a comparator (20) and the resulting difference signal is fed back to the twisting assembly.
APPARATUS AND METHODS OF DETECTING AND CONTROLLING TWISTS IN MULTICORE CABLES

The present invention relates to methods and apparatus for detecting and controlling twists in multicore cables.

Cables used for telecommunication and other high technology applications are required to be manufactured to high specifications since the way in which two or more conductors are twisted together can effect attenuation and crosstalk.

Generally, cables which have two or more conductors twisted together rely on the apparatus generating the twist to ensure that the twisting takes place in a regular and uniform manner. However, in practice, the twist produced will vary and this in turn will vary the attenuation within the conductors and the crosstalk between them.

It is an object of the present invention to provide apparatus and method of measuring the twist in a twisted cable as it is being manufactured so that with the aid of feedback, the twisting action can be modified to reduce non-uniformity towards zero.

According to the present invention, there is provided apparatus for detecting the twist in a multistrand or multicore cable into which a nominal twist per unit length is introduced, the apparatus comprising means for measuring the speed at which the cable
travels and producing a reference signal having a frequency equal to the nominal twist rate of the cable, means for measuring the variation of a transverse dimension of the cable when viewed from a fixed point near which the cable passes, to produce an output signal including a frequency component equal to the twist frequency, an analyser for conducting an analysis on the output and conditioned by the reference signal to output only a measurement signal having said twist frequency.

The analysis may be a Fourier analysis, or a timing analysis, or other type of analysis.

According to the present invention, there is further provided a method of detecting twist in a multistrand or multicore cable comprising the steps of monitoring the variation in profile of the cable as it passes a predetermined location to produce a measurement signal having a frequency component equal to the actual frequency of twist, determining the nominal twist frequency of the cable, conducting an analysis of the measurement signal and with the aid of the nominal twist frequency separating out from the measurement signal the component having the actual frequency of twist.

According to the present invention there is still further provided apparatus for detecting the speed and twist rate in a cable having at least two twisted elongate elements and travelling along a predetermined path, the apparatus comprising first and second sensors spaced apart along said path by a predetermined distance, each sensor comprising a light source and detection means positioned about said path so that the cable interrupts the
light path from the source to the detector means to cast a varying shadow on the detector as the cable travels along the predetermined path, and means for processing the outputs of the two detector means to determine the actual speed and twist rate or the deviation, if any, from the actual speed and twist rate.

The outputs of the detector means may be used in conjunction with a nominal speed and twist rate for the cable, to determine the actual speed and twist rate or deviation.

Apparatus and methods for detecting and controlling the twists in multicore cables, will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which:

Figure 1 is a plan view of the apparatus;

Figure 2 is a front elevation of the apparatus of Figure 1;

Figure 3 is a view from one side of the optical detection system of the apparatus of Figures 1 and 2; and

Figure 4 is a front elevation of another apparatus embodying the invention.

Figure 1 shows part of the twisted cable production line. Individual strands or conductors are taken from separate supply reels (not shown) and fed through a twisting assembly 2 in which orbital rotary components (not shown) produce a twist in the cable. The twisted cable 4 emerging from the assembly 2 passes over a pair of spaced supporting wheels 6 and 8. A detection arrangement 10 straddles the cable as it passes between the wheels 6 and 8.
The shaft of the wheel 6 is coupled to a transducer 12 which provides an output proportional to the speed of the wheel which in turn is dependent upon the speed of travel of the cable 4.

The output of the transducer 12 is fed to a calibration unit 14. The calibration unit has an adjustable input which can be set to the nominal number of $360^\circ$ twists that the twisting assembly induces per unit length of the cable. The frequency $f_{\text{ref}}$ of the output signal of the calibration unit is thus arranged to equal nominal rate or frequency at which the conductors turn about each other (the twist frequency) as they pass over the wheel 6.

A detection assembly 10 downstream of the wheel 6 measures the variation in the lateral dimension of the cable as the conductors twist about each other and the resultant signal produced will include a number of frequency components including the actual twist frequency of the cable. The output of the detection assembly 10 is fed to an analyser 18 which conducts a Fourier analysis on the input signal. The analyser 18 also receives the reference frequency $f_{\text{ref}}$ which it uses to establish a bandwidth to select only the actual twist frequency component $f_t$ from the multitude of different frequency components established by the Fourier analysis.

Other types of analysis may be used, eg timing analysis.

This twist frequency component $f_t$ is fed together with the reference frequency $f_{\text{ref}}$ to comparator 20 which produces a difference signal $f_d$. The difference signal of frequency $f_d$
is fed back to the twisting assembly which responds by adjusting the twisting action in a sense to reduce the difference to zero.

Figure 3 shows the detection assembly 10 in more detail. As shown, a light emitter 22, on one side of the cable 4, is directed at a light receiver 24 in the opposite side of the cable. A first lens 26 located between the emitter 22 and the cable produces parallel rays of light, some of which are interrupted by the cable 4. Another lens 28 between the cable 4 and the receiver 24 receives the non-intercepted light and focuses the rays on the receiver 24.

As can be seen as the twist progresses, the amount of light intercepted by the cable will vary and so will the shadow cast by the light on the receiver 24. Hence, the output signal from the receiver will have a frequency component equal to the twist frequency.

The apparatus shown in Figure 4 is arranged to provide a first output indicative of the twist rate of a cable consisting of twin twisted strands or conductors and a second output indicative of the speed of the cable. Both of these parameters can be used in feedback systems to control the production of the cable.

As shown, the twisted cable 36, emerging from a twisting assembly 30, is supported by a downstream roller 32. A light shield 34 extending above the cable 36 is provided with two slots 34A and 34B spaced apart in the longitudinal direction of the cable 36 and extending tangential to the cable.
A light shield 38 extending below the cable 36 is also provided with two slots 38A and 38B spaced apart in the longitudinal direction of the cable and extending tangential to the cable. The slots 34A and 34B are in direct alignment with respective slots 38A and 38B.

A light source 40 projects a beam of light through slots 34A and 38A and a photodetector 42 receives the light emerging from the slot 38A. Similarly, a light source 46 projects a beam of light through the slots 34B and 38B and a photodetector 48 receives the light emerging from the slot 38B.

A filter 50 is connected to receive the output from the detector 44 and passes a signal having a frequency over a specific range.

A filter 52, similar to the filter 50, is connected to receive the output of the photodetector 48. A phase comparator 54 is connected to the outputs of the two filters 44 and 48 and provides a phase difference or error signal at an output terminal 56.

A processor 58 receives the output of the filter 50 to provide a speed or speed error signal at output terminal 60.

In operation, as the twisted cable passes between respective pairs of slots 34A, 38A and 34B and 38B, it will present a varying profile and so the shadow it casts on respective photodetectors 44 and 48, will vary in a generally sinusoidal manner. The output signal
from the detectors will thus include a selected frequency component related to the speed of
the cable, assuming the twist rate remains constant. Any variation in the twist rate will
manifest itself in a phase change in selected frequency components in the outputs of the two
detectors 44 and 48.

The two filters 50 and 52 are arranged to have a relatively narrow passband having a
centre frequency corresponding to the nominal twist frequency of the cable when run at
nominal speed. The processor 58, upon receiving the output signal from the filter 50,
converts it into a speed signal which is then fed to the output 60. Instead, the processor 58
may compare the output signal from the filter 50 with a nominal value and then feed an
error signal to the output 60.

The phase comparator 54 compares the phases of the two output signals from the
filters 50 and 52 and provides a difference signal at output 56. Instead, the comparator may
compare the phase difference with a nominal phase difference and feed an error signal to
the terminal 56.

The signals at the outputs 60 and 56 can be fed back to the assembly 30 to maintain
the speed and twist rate of the cable substantially constant.

It will be appreciated that while the detection assembly is described as an optical
sensor, other sensors which can detect a change in the twist of the cable can equally be
used, for example, a capacitive or ultrasonic detection system.
In some embodiments, it may not be necessary to determine the nominal twist frequency and twist rate for a cable.
CLAIMS

1. Apparatus for detecting the twist in a multistrand or multicore cable into which a nominal twist per unit length is introduced, the apparatus comprising means for measuring the speed at which the cable travels and producing a reference signal having a frequency equal to the nominal twist rate of the cable, means for measuring the variation of a transverse dimension of the cable when viewed from a fixed point near which the cable passes to produce an output signal including a frequency component equal to the twist frequency, an analyser for conducting an analysis on the output and conditioned by the reference signal to output only a measurement signal having said twist frequency.

2. Apparatus according to Claim 1, including a comparator for comparing the reference frequency signal and the measurement signal and producing a control signal representative of the frequency difference.

3. Apparatus according to Claim 1 or to Claim 2, wherein said measuring means comprises capacitive means.

4. Apparatus according to Claim 1 or to Claim 2, wherein said measuring means comprises ultrasonic means.

5. Apparatus according to Claim 1 or to Claim 2, wherein said measuring means comprises optical means.
6. Apparatus according to Claim 5, wherein said optical means comprises a light emitter directed at a light detector positioned on the opposite side of the cable path to the emitter, a first lens for directing the light from the emitter in parallel rays across the cable and a second lens for receiving the parallel light rays from the first lens and not interrupted by the cable and focusing them on the detector.

7. Apparatus as claimed in any preceding claim, wherein the analyser conducts a Fourier analysis.

8. Apparatus as claimed in any of Claims 1 to 6, wherein the analyser conducts a timing analysis.

9. A method of detecting twist in a multistrand or multicore cable comprising the steps of monitoring the variation in profile of the cable as it passes a predetermined location to produce a measurement signal having a frequency component equal to the actual frequency of twist, determining the nominal twist frequency of the cable, conducting an analysis of the measurement signal and with the aid of the nominal twist frequency separating out from the measurement signal the component having the actual frequency of twist.

10. A method according to Claim 9, including the step of comparing the actual frequency of the twist with the nominal frequency and producing a difference signal representation of the difference.
11. A method according to Claim 10, including the step of using the difference frequency to adjust the twisting apparatus producing the twist in the cable in a sense to reduce the difference in frequency to zero.

12. A method as claimed in any of Claims 9 to 11, wherein a Fourier analysis is conducted on the measurement signal.

13. A method as claimed in any of Claims 9 to 11, wherein a timing analysis is conducted.

14. Apparatus for detecting the speed and twist rate in a cable having at least two twisted elongate elements and travelling along a predetermined path, the apparatus comprising first and second sensors spaced apart along said path by a predetermined distance, each sensor comprising a light source and detection means positioned about said path so that the cable interrupts the light path from the source to the detector means to cast a varying shadow on the detector as the cable travels along the predetermined path, and means for processing the outputs of the two detector means to determine, in conjunction with a nominal speed and twist rate for the cable, the actual speed and twist rate or the deviation, if any, from the actual speed and twist rate.

15. Apparatus according to Claim 11, including for each sensor, a filter having a passband based around a frequency corresponding to the speed of the cable along said predetermined path.
16. Apparatus for detecting the twist in a multistrand or multicore cable substantially as hereinbefore described, with reference to the accompanying drawings.

17. A method of detecting the twist in a multistrand or multicore cable, substantially as hereinbefore described.
FIG. 4