Detection of defects in aircraft wiring using Enhanced TDR

Introduction

A new measurement technique has been developed that allows detection of partial damage to the insulation and shielding of electrical wires and cables. The technique is best suited to testing electrical wiring in complex structures, such as aircraft, where several miles of wiring and cables are deeply buried within them. With no visual access to these wires, small defects in their braiding or insulation are impossible to find. Although TDR technique is well known and is frequently used in many fields, ranging from ecology to testing microelectronic circuits, systems developed so far are incapable of detecting minor faults resulting from insulation damage and partial degradation of electrical wires. These defects could go undetected for a very long time and may result in sparks and eventually fires. An Enhanced TDR technique has been developed within the AWARE project, at London South Bank University which allows detection of insulation damage in electrical wires, as well as defects in shield and braiding of coaxial and twisted pair cables.

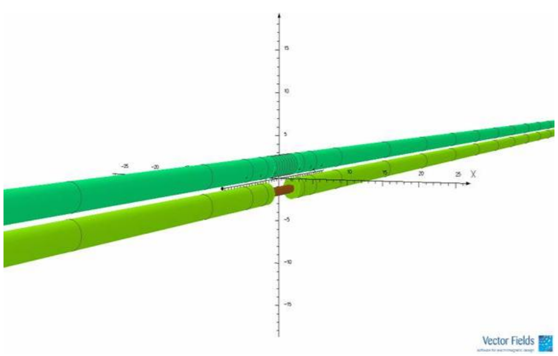

Figure 1 Model of the 10 metre twin cable in with an insulation fault of 10 mm on one of the wires.

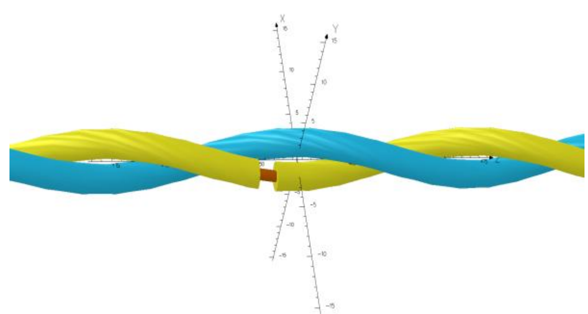

Figure 2 Simulation of a 2 mm flaw in one of the wires of a 500 mm unshielded twisted pair cable.

Project challenges

The TDR method is not new and has been in use for many years. It is however very attractive, since access to only one end of the wire system is required. The novelty of the new technique developed in AWARE is in the selective use of the method, and in the arrangement and injection of successive pulses into the wire under test, which puts the new testing into a completely new perspective. Computer models of the technique were initially simulated using Vector Field software from Cobham Technical Services, before test procedures were created. Figures 1 and 2 show initial 3D models of insulation fault created in an 8 Amp figure of eight power cable, and an unshielded twisted pair cable respectively. Figure 3 shows Agilent 81134A 3.35 GHz Pattern Generator and Agilent Infiniium MSO9404A, a 4 GHz, 20GS/s oscilloscope, which were used in the development of the technique. Figures 4 and 5 show an actual 10 mm damage created on the shield and insulation on one side of a coaxial cable (core conductor undamaged), and the corresponding fault detection using the ETDR technique respectively. This defect was created at around 4 meters from one end of a 6 metre long RG59 cable.

Figure 3 Agilent 3.35 GHz pattern generator and 4 GHz 20 GS/s Infiniium oscilloscope used for the development of the ETDR technique.

Figure 4. Coaxial cable with a 10 mm damage created on the shield and insulation on one side with the core conductor undamaged. The fault was created at around 2 meters from the end of a 6 meter long cable.

Detection of small defects normally requires high bandwidth. This means high frequency pulses with very high energies are needed for long time of flight through cables and wires, which could be longer than 20 metres, otherwise they dissipate after travelling a short distance. One of the biggest challenges in accomplishing this part of the AWARE project was using pulses with much lower frequency, in order to maintain low pulse energy for longer time of flight. Pulse frequency also needed to be high enough to allow testing live power cables without causing interference with the power frequencies, which could be as high as a few hundred hertz. Both these frequency constraints have been met and the initial measurements on 5 mm and 10 mm long shield only defects are promising.

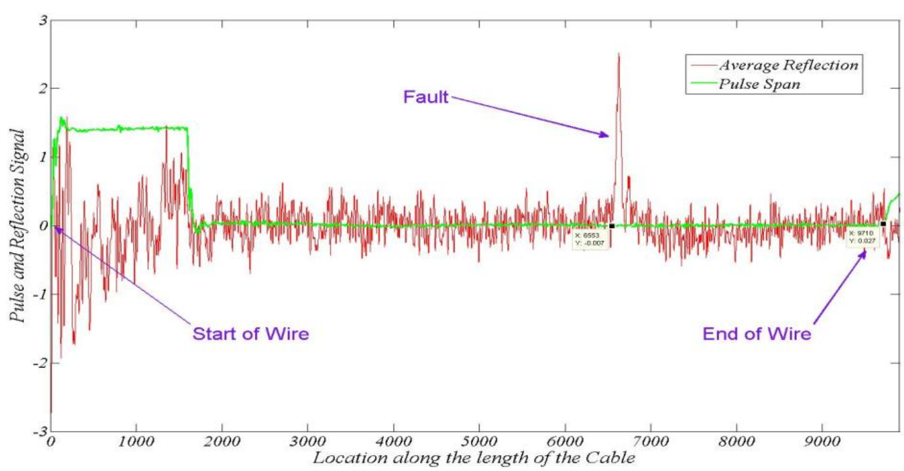

Figure 5. Result for a 10 mm fault created on shield and insulation on one side of a 6 meter length of RG59 coaxial cable, located about one third of the length from the end of the cable.

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