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TOUGHNESS OF AUGMENTED CABLES FOR ETHERNET TECHNOLOGY ASSESSMENT

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Abstract

This paper provides a method of assessing the toughness of augmented cables required for Ethernet technology. The use of augmented category 6 (Cat 6A) in Ethernet-enabled Internet of Things (IoT) infrastructure continues to grow due to the high demand for services requiring such configuration. The increasing demand for Cat 6A over Ethernet is due to its ability to transmit both data and power to devices used in IoT which is cost-saving. However, the availability of counterfeit and substandard cables in the market disguised as category-rated cables is of great concern to cable installers and engineers. There is also the basic problem of handling stress anticipated during installation as cables could be manipulated in the form of repeated coiling and uncoiling. Therefore, there is a need to have a method of assessing the toughness of the cables before deployment. In this paper, two Cat 6A cables from different manufacturers were selected from the market to be used as samples for the experiment. The Cat 6A cables were exposed to two rounds of coiling to imitate the handling stress anticipated during installation. The return loss and near-end crosstalk (NEXT) of the cables which are the major performance indicators were collected using the DSX-5000 cable analyzer for each of the test processes. This is to evaluate their resilience or otherwise to handling stress. Feature Selective Validation (FSV) which is a standardized method of measuring the degree of agreement between two data sets was used in this research. The results showed the cable with the lowest variations between the first and third test measurements for each of the pairs examined. The method presented showed that it can be used to assess cable measurements which can lead to objective decisions on the cables selected for deployment.

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1.0 INTRODUCTION

Augmented Cat 6A cables are the Telecommunications Industries Association/Electronic Industries Association (TIA/EIA) cabling required for 10GBASE-T Ethernet technology [1]. The Cat 6A cables are designed for a maximum frequency of 500MHz when required to support 10 Gigabit Ethernet [2]. Cat 6A is now the cabling of choice for new installations requiring Ethernet-compliant communication for high data speed [3]. The Cat 6A choice is due to its robustness, backward compatibility and future upgrade capabilities [4]. Another factor driving the demand for Cat 6A is the ability to simultaneously transmit data and power which is a basic requirement for the Internet of Things (IoT) [5], [6]. Power over Ethernet cabling enables the use of twisted pairs in smart building applications for data transmission and low-voltage supply to security cameras, sensors, light-emitting diodes (LED) lighting, etc. [7]. It also enables connections to wireless fidelity (WIFI) access points [8]. A table showing the differences between Cat 6A and Cat 6 is shown in Table 1 [2 - 4].

However, the aforementioned applications cannot be achieved without a reliable cabling infrastructure. The problem of counterfeit and substandard cables in the market disguised as Ethernet-compliant is a worrying trend for cable installers and contractors [9], [10]. The installation of any of these substandard cables could lead to liabilities for the installers and contractors due to potential network problems that may affect the quality of service [11]. The other fundamental issue is the degradation that could be inflicted on the twisted pairs due to handling and bending radius problems from coiling during installation [12], [13]. The toughness of a cable is therefore crucial, as stress from coiling and uncoiling during installation can make the pairs open up resulting in return loss and crosstalk problems [14]. Therefore, there is a need to provide a method of assessing the toughness of Cat 6A cables for frequencies up to 500MHz. In this paper, two Cat 6A cables from different manufacturers were selected from the market. They were subjected to two rounds of coiling and uncoiling to imitate stress from handling during installation. Return loss and near-end crosstalk (NEXT) will be collected during each process to examine the cable's resilience to handling stress. The Feature Selective Validation (FSV) method will be used to assess the degree of agreement between the data sets. The FSV is a standardized tool used to objectively compare two data sets [15], [16]. The technique presented in this paper can be used to undertake an objective assessment of cable measurements to minimize liabilities that may arise after installation.

Table 1: Differences between Cat 6A and Cat 6 cables [2 - 4]

Augmented Category 6 Cable	Category 6 Cable
Tighter twists of cable pairs with thick conductors and jackets	Lesser twists with lighter conductors and jackets
Used for Power over Ethernet applications as the conductors can withstand heat	Cannot be effectively used due to heat problems as a result of lighter conductors
Maximum operating frequency (bandwidth) is 500MHz	Maximum operating frequency (bandwidth) is 250MHz
Maximum data speed of 10 Gigabit Per Second (10 Gbps)	Maximum data speed of 1Gbps

2.0 MATERIALS AND METHODS

2.1 Augmented Cable Materials

The two augmented cables considered for the experiment are foiled-unshielded Cat 6A cables from different manufacturers. The conductor materials are copper, while that of the insulator is polyethylene.

2.2 Measurement Methodology

The cable analyzer used for the experiment is the DSX-5000 which can handle the testing and certification of category 6A cables [17]. The analyzer can be used for Cat 6A measurements up to a frequency of 500 MHz as specified by the international standard ISO/IEC 11801 class E_A [17]. The analyzer has two components which are the “main” and the “remote”. The “main” component of the tester stores the results which can be extracted to a personal computer or laptop by connecting a universal serial bus (USB) to it [17], [18]. The two components have permanent link adapters connected to each end of the patch cords. The two other ends of the patch cords are then connected to two standard connectors called the registered jacks (RJ45) [18]. The RJ45 has pin holes which are used to connect the two ends of the cable under examination. The cables to be tested have four pairs of twisted wires each namely: orange, green, blue and brown. A pair of each cable has two twisted wires making a total of eight wires to be connected to the RJ45 interface using the T568B wiring standard that defines the pin-out order [19]. The tester uses the T568B pin-out configuration for the results as: Pair1,2 (orange pair), Pair 3,6 (green pair), Pair 4,5 (blue pair), Pair 7,8 (brown pair). The A software called the “Link Ware” is installed on the laptop to enable the conversion of the cable measurements to a readable form. In this paper, return loss and NEXT which are the two major signal degradation parameters are collected.

The measurements were collected as follows:
Measurement 1 (M1): A new 30m length of Cat 6A cable unwound and then stretched out for test.
Measurement 2 (M2): The 30m cable in M1 is coiled using about 30cm diameter and stretched out for a test.
Measurement 3 (M3): The test process in M2 is repeated.

The cable analyzer measurement setup is illustrated with a diagram in Figure 1.

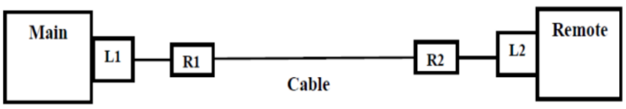

Figure 1: The diagram of the measurement setup using the cable analyzer (Note: “L1” and “L2” are the permanent link adapters, “R1” and “R2” are the RJ45 connectors and the “Cable” is the augmented Cat 6A cable under test)

2.3 The Feature Selective Validation Method

The FSV is a robust tool that was standardized to objectively quantify the similarity between two data

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sets [16], [20]. It enables objective decisions by removing the subjectivity of human beings in the comparison of data [21]. The FSV has been used in different areas of human endeavors to quantify data due to its versatility [16], [22], [23]. The FSV has two major parts: the amplitude difference measure (ADM) and the feature difference measure (FDM) [15]. The ADM measures the differences in amplitude, while the FDM measures the changes in the characteristics of the data sets [16], [22]. The data sets comparison is done on a point-by-point basis. The Global Difference Measure (GDM) is a combination of the ADM and FDM that gives the overall quality of the differences in the two data sets [21], [22]. The six quality agreement descriptors used by the FSV are: excellent, very good, good, fair, poor, and very poor [15], [20]. The FSV interpretation for GDM results are presented in Table 2 [15].

Table 2: FSV interpretation scale for GDM evaluated results [15]

FSV GDM Value	FSV Interpretation
GDM < 0.1	Excellent
0.1 ≤ GDM < 0.2	Very good
0.2 ≤ GDM < 0.4	Good
0.4 ≤ GDM < 0.8	Fair
0.8 ≤ GDM < 1.6	Poor
1.6 ≤ GDM	Very Poor

3.0 MEASUREMENTS RESULTS

3.1 Return Loss Measurements

The return loss measurements for pairs 1,2, 3,6, 4,5 and 7,8 of cable 1 are shown in Figures 2, 3,4 and 5 respectively. Similarly, the return loss measurements for pairs 1,2, 3,6, 4,5 and 7.8 of cable 2 are shown in Figures 6,7, 8 and 9 respectively. Figures 2 to 9 show that none of the return loss measurements crosses the specified limit. The plots in Figures 2 to 9 also show that the third test (M3) presented some distinct variations from M1 and M2 at some points, especially for cable 1. However, it will be difficult to quantify the variations between the first test (M1) which is the baseline and the second (M2) and third (M3) tests with the human eye. The FSV will, therefore, be used to objectively compare the return loss measurements (M1) with M2 and M3. This is to assess the toughness or resilience of the cables to the handling stress test.

3.2 Near-end Crosstalk Measurements

The NEXT measurements for pairs 1,2-3,6, 3,6-4,5, 4,5-7,8 and 7,8-1,2 are presented in Figures 10 to 13 for cable 1. Similarly, the NEXT measurements for pairs 1,2-3,6, 3,6-4,5, 4,5-7,8 and 7,8-1,2 are presented in Figures 14 to 17 for cable 2. The graphs in Figures 10 to 17 shows that the measured NEXT does not cross the limits. However, there is the need to quantify the variations between the measured NEXT results to enable the assessment of the toughness or resilience to handling stress test as this cannot be done with the human eye. The FSV will therefore be used to objectively compare the NEXT measurements M1 (baseline) with M2 and M3.

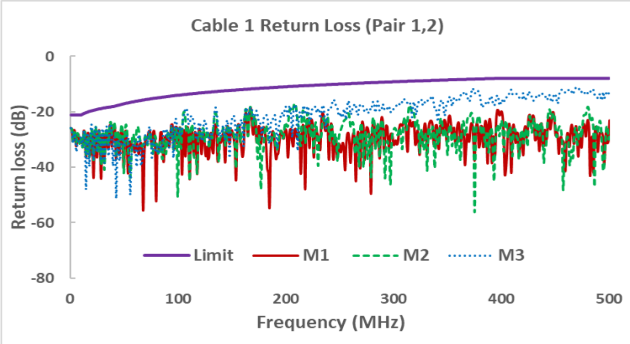

Figure 2: Return loss for cable 1 using pair 1,2

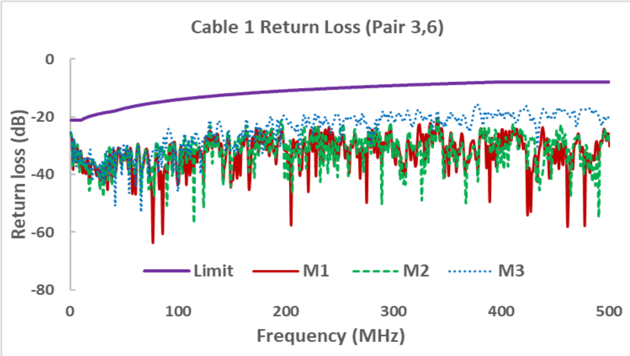

Figure 3: Return loss for cable1 using pair 3,6

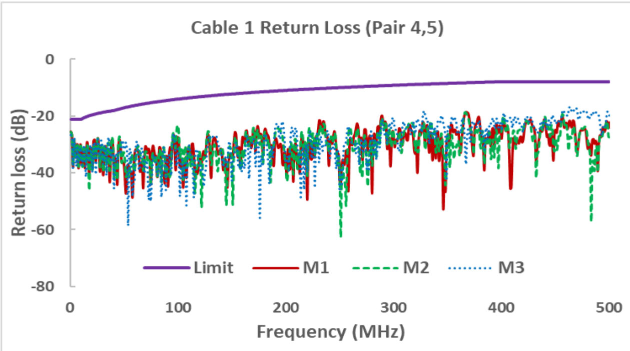

Figure 4: Return loss for cable 1 using pair 4,5

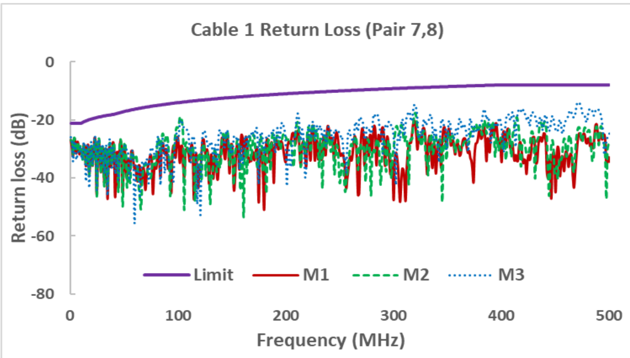

Figure 5: Return loss for cable 1 using pair 7,8

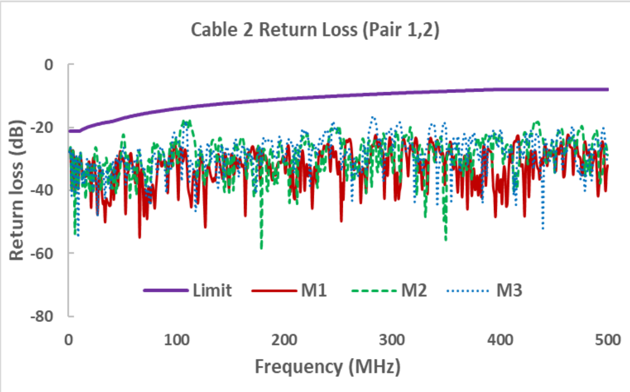

Figure 6: Return loss for cable 2 using pair 1,2

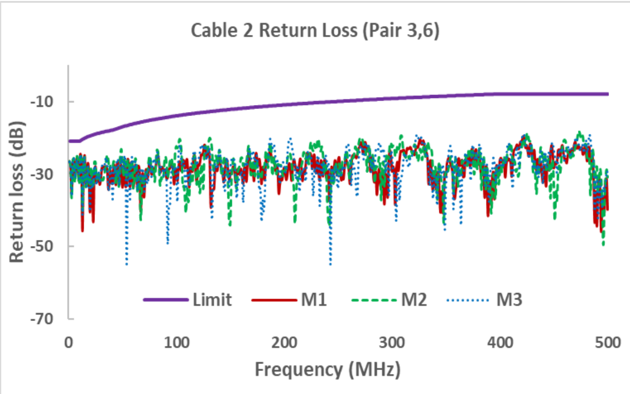

Figure 7: Return loss for cable 2 using pair 3,6

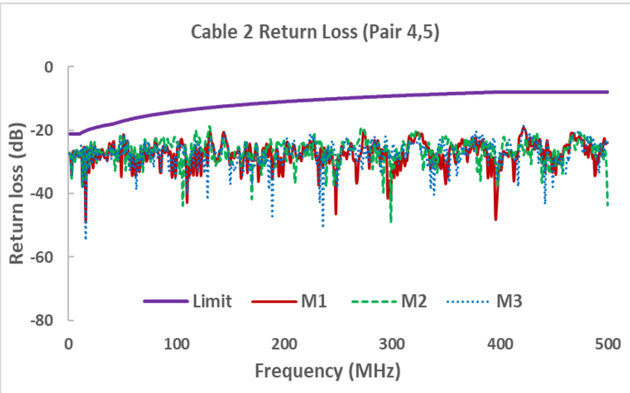

Figure 8: Return loss for cable 2 using pair 4,5

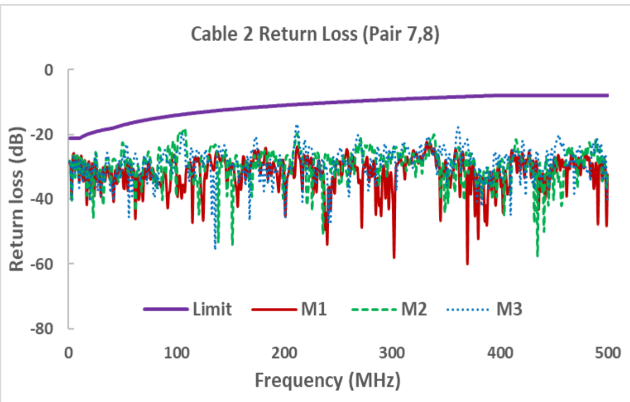

Figure 9: Return loss for cable 2 using pair 7,8

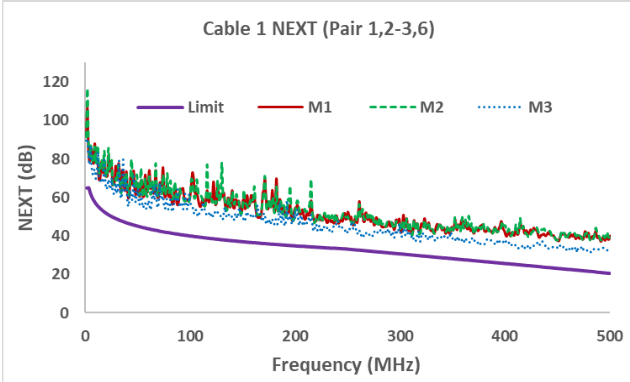

Figure 10: Measured NEXT for cable 1 using the 1,2-3,6 pairs

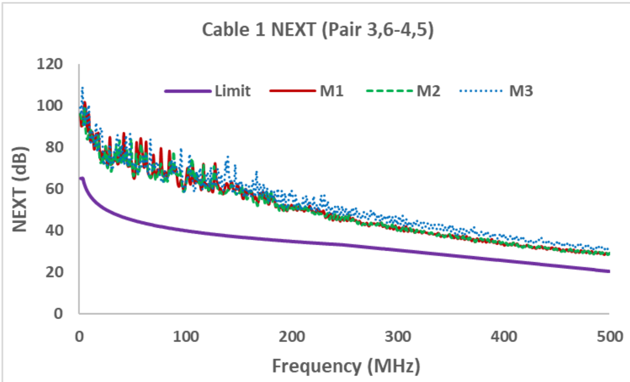

Figure 11: Measured NEXT for cable 1 using the 3,6-4,5 pairs

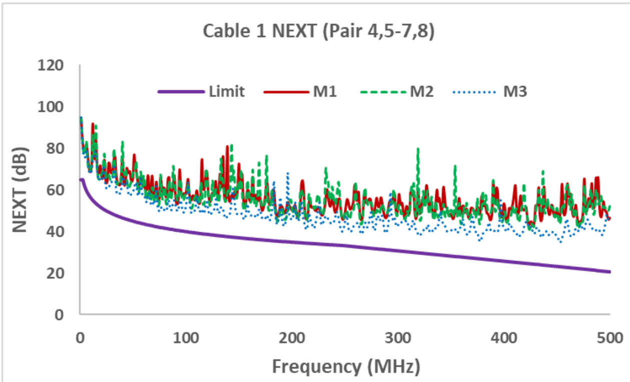

Figure 12: Measured NEXT for cable 1 using the 4,5-7,8 pairs

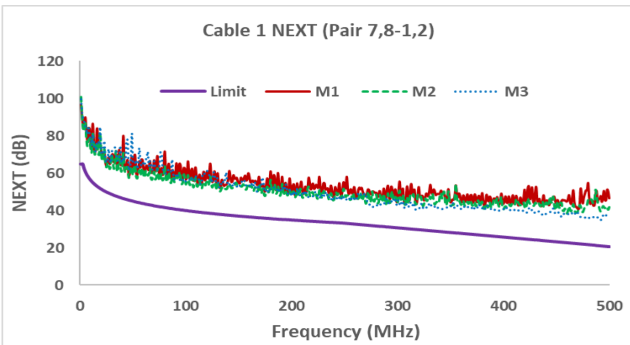

Figure 13: Measured NEXT for cable 1 using the 7,8-1,2 pairs

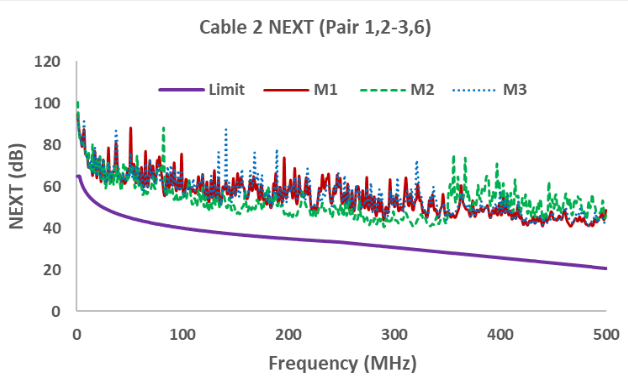

Figure 14: Measured NEXT for cable 2 using the 1,2-3,6 pairs

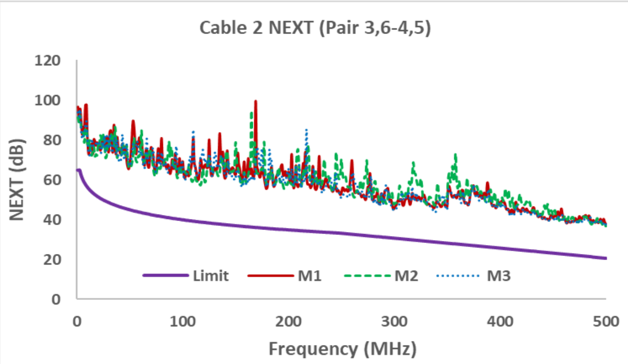

Figure 15: Measured NEXT for cable 2 using the 3,6-4,5 pairs

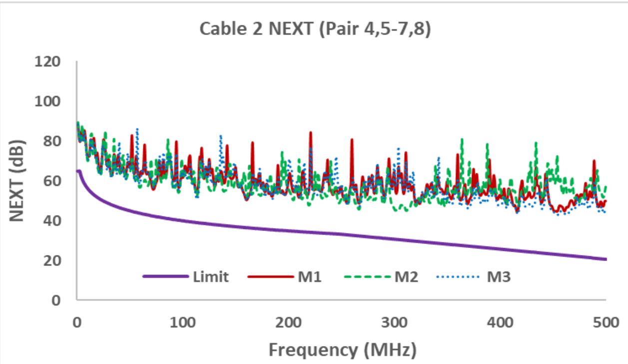

Figure 16: Measured NEXT for cable 2 using the 4,5-7,8 pairs

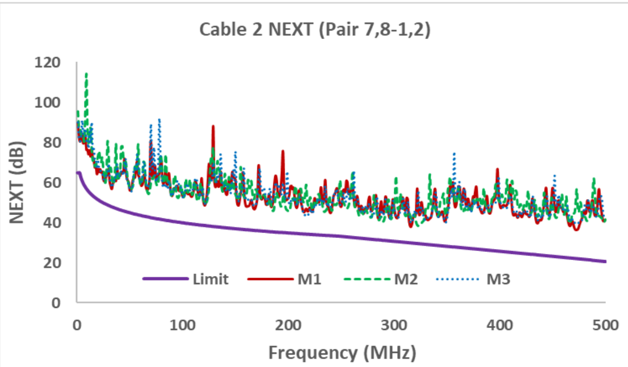

Figure 17: Measured NEXT for cable 2 using the 7,8-1,2 pairs

4.0 RESULTS AND DISCUSSIONS

4.1 FSV Comparison of Return Loss Measurement

The FSV comparison of return loss M1 and M2 measurements is presented in Figure 18. Figure 18 indicates that cable 1 gave the least changes between M1 and M2 in three out of the four pairs of the cable namely: 3,6, 4,5 and 7,8. Similarly, the FSV comparison of the return loss measurements M1 and M3 is presented in Figure 19. The result in Figure 19 indicates that cable 2 gave the least changes between M1 and M3 in all four pairs of the cable. In summary, cable 2 presented the best resilience to the handling stress test as it gave the lowest variations in return loss comparison between M1 and M3 in all the pairs of the cable.

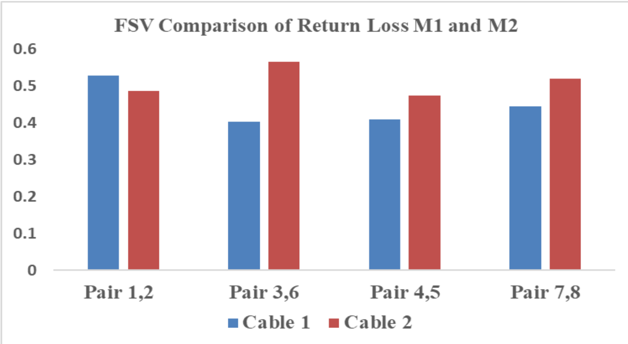

Figure 18: FSV comparison of return loss M1 and M2

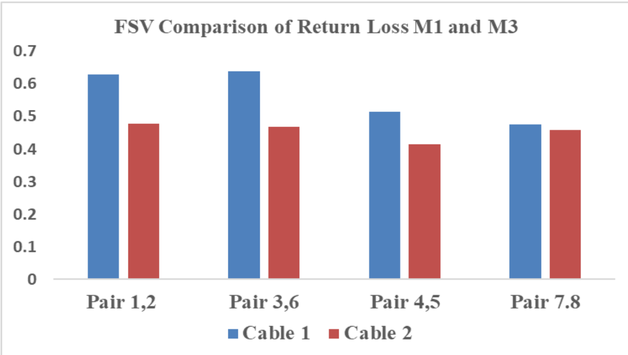

Figure 19: FSV comparison of return loss M1 and M3

4.2 FSV Comparison of Near-end Crosstalk Measurement

The FSV comparison of NEXT measurements M1 and M2 is shown in Figure 20. An observation of Figure 20 indicates that cable 1 gave the lowest changes between M1 and M2 in all the four pairs examined. Similarly, the FSV comparison of NEXT M1 and M3 measurements is presented in Figure 21. The result in Figure 21 indicates that cable 2 gave the lowest changes between M1 and M3 in three pairs of the cable (1,2-3,6, 4,5-7,8, 7,8-1,2). In summary, cable 2 presented the best resilience to the handling stress test as it gave the lowest differences in the comparison between return loss M1 and M3 in three out of the four pairs.

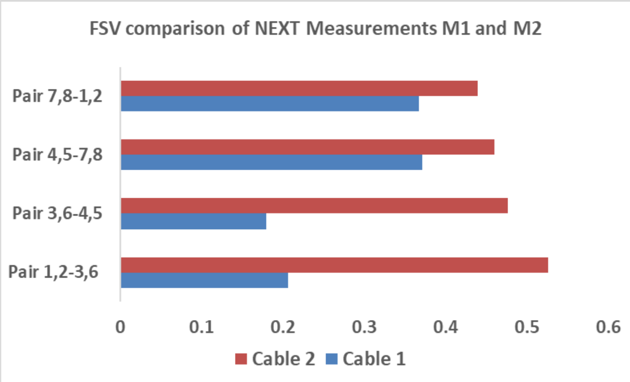

Figure 20: FSV comparison of measured NEXT M1 and M2

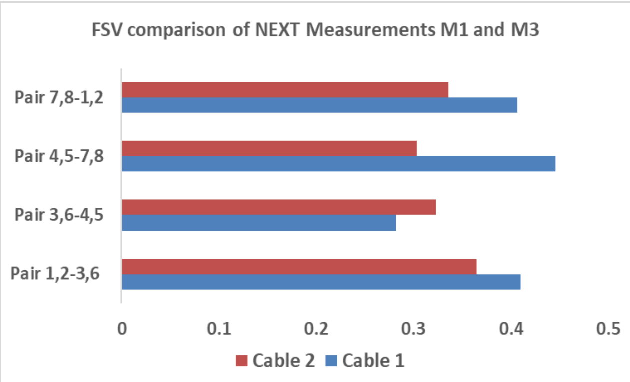

Figure 21: FSV comparison of measured NEXT M1 and M3

5.0 CONCLUSION

The paper has provided a technique that can be used to assess the toughness of augmented cables required for Ethernet technology. The research used two Cat 6A cables from different manufacturers for the experiment. The result of the assessment shows that cable 2 gave the lowest variations in the return loss comparison between (M1 and M3) in all pairs of the cable after the third test. Similarly, cable 2 also gave the lowest variations in the NEXT comparison after the third test, that is between (M1 and M3) in three pairs of the cable. In summary, cable 2 gave the best resilience to the handling stress test as it gave the lowest variations in all four pairs for return loss and three pairs for NEXT after the third test. The method presented can be used to undertake an objective assessment of the toughness of the cables selected for deployment in Ethernet technology which can help minimize liabilities.

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