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Conductive Fabric Study and Its Application for Wearable Devices

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Conductive fabric, wearable electronics, resistance behaviour, MedTex130, electrical behaviour, soldering effect, stretchable

Abstract

The integration of electronics into clothes has created demand for aesthetic, flexible and conductive materials that can serve as reliable circuit paths. Among these, conductive fabrics have emerged as a promising alternative to conventional wires in wearable devices due to their lightweight structure, comfort and ability to follow the movement. This study investigates the performance of a silver-plated nylon fabric, MedTex130 as a conductive fabric in a simple wearable LED circuit application. A series of experimental tests were conducted to evaluate the fabric's electrical behaviour under real-world conditions. Resistance was measured across various strip lengths 1 cm to 8 cm, widths 0.3 cm on shiny and non-shiny surfaces. Additional tests evaluated how stretching up to 100% affected resistance value, how the fabric responded to 0Hz frequency direct current (DC) voltage up to 12 V and how thermal stress from soldering impacted conductivity and material integrity. The results showed that resistance increased with length and decreased with width, consistent with Ohm's law. Interestingly, resistance dropped significantly when the fabric was stretched, particularly on the non-shiny side, with some samples showing up to 94% reduction. Although the fabric supported LED activation up to 12 V, significant heat build-up was observed above 5 V. Furthermore, soldering at typical temperatures ≥350°C caused permanent damage to the silver coating, leading to a drastic increase in resistance. The observed resistance variation and thermal degradation directly affect power efficiency, user safety and long-term reliability in wearable devices, indicating that conductive fabrics are suitable only for low-voltage, low-current applications with careful thermal management. Overall, the findings confirm the fabric's capability for low-voltage wearable circuits but also highlight limitations in heat tolerance and the need for alternative joining methods.

1. Introduction

The rapid development of wearable technology has led to a growing need for materials that combine both electrical functionality and physical flexibility. Traditional wiring solutions, such as copper conductors are reliable for signal and power transmission but pose significant drawbacks when integrated into wearable systems. They are rigid, heavy and limit fabric flexibility which can compromise comfort, safety and long-term wearability [1].

To overcome these limitations, researchers have explored various textile-based conductors that merge electrical conductivity with the softness and stretchability of fabrics. Among these, conductive fabrics which is textiles coated with or embedded with conductive elements such as silver, carbon, or graphene, have shown great promise for use in flexible electronics, e-textiles and smart garments [2], [3]. Cataldi et al. [2] reported graphene-based textile conductors with resistance values below 10 Ω under strain, while Kang et al. [3] demonstrated conductive cotton fabrics exhibiting stable conductivity and low sheet resistance suitable for wearable applications. These studies highlight the importance of low resistance and mechanical robustness in textile-based conductors. Their advantages include conformability to the human body, integration into standard garment construction and compatibility with motion. However, while many commercial conductive fabrics are available, systematic verification of their performance under real-world wearable conditions is still lacking.

Previous studies have also explored multifunctional conductive textiles. Zhang et al. [4] demonstrated MXene-decorated fabrics with combined strain sensing and Joule heating capabilities. Lim et al. [5] investigated stretchable silver nanowire composites with improved mechanical resilience, while Zulan et al. [6] reported reduced graphene oxide-coated silk fabrics with enhanced conductivity for e-textiles. However, these works focus primarily on material synthesis rather than practical integration challenges such as soldering and low-voltage circuit implementation, which are addressed in this study.

MedTex130 is a commercially available silver-plated nylon and spandex fabric, advertised with surface resistance below 5 Ω/sq [7]. It offers a combination of conductivity and elasticity, making it a strong candidate for wearable circuitry. However, there is not many journals or article published about its behaviour under stretching, soldering and low-voltage applications.

This study aims to fill this gap by experimentally evaluating the resistance behaviour of MedTex130 across different fabric dimensions and surface orientations. Additionally, the fabric's response to stretching, voltage loading and thermal exposure from soldering is examined. The findings are used to design and validate a simple wearable LED circuit layout, representing a glove-based interface. Like other studies on flexible interconnects [4], [5], [6], the goal is to assess feasibility, identify integration limits and provide design guidance for future textile-based electronics.

2. Methodology

Fig. 1 shows the project flowchart in order to complete this study. The study begins with find and understand the related thesis, journal or article based on conductive fabric. Once understand the behaviour of conductive fabric and its concept, a simple circuit of LED is designed using proteus for simulation testing. Hence, an emulation testing is conducted for real-world practice to test the functionality of the substitution conventional wire to conductive fabric. In this study, there are four (4) testing conducted to evaluate the behaviour of conductive fabric which is resistance test, stretch test, electrical test and solder test. Lastly, all the data are collected and analysed to show the result of the testing.

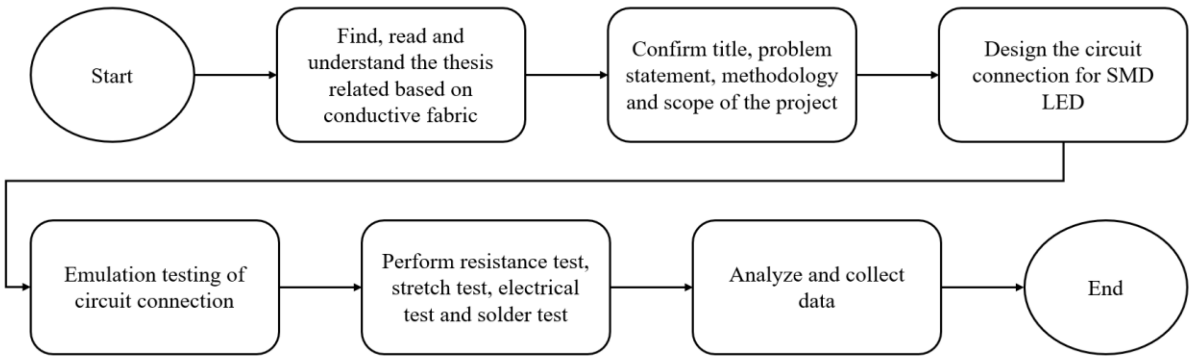

Fig. 1 *Flowchart of the project*

2.1 Hardware materials

Fig. 2 and Fig. 3 show the sources of power supply used in this project which is coin battery CR2032 with 3V and DC power supply. The battery is selected for this project because of its capability to provide sufficient voltage to light up the LED beside the low-profile shape. Other than that, DC power supply delivers a stable and adjustable direct current voltage which is very useful in experiments to test the performance of conductive fabric under different voltage levels.

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Fig. 2 *CR2032 3V battery*

Fig. 3 *DC power supply*

The project uses SMD LED as an output indicator for the complete circuit. The LED consumes 10mA at full drive current which is compatible with the power source 3V CR2032 battery or DC power supply. Despite its compact design and low-profile, SMD LED provides a necessary light [8]. Fig. 4 shows the SMD LED used in this project. Moreover, to have a complete circuit, conductive fabric is the main material in this project. Fig. 5 shows the conductive fabric which is MedTex130. This fabric is a substitute for conventional wire such as copper which provides a stretchable and seamless to user while it can integrate with SMD LED. The MedTex130 fabric exhibits a shiny surface corresponding to the silver-plated conductive layer, while the non-shiny side consists of the textile substrate with indirect contact to the conductive coating. Both surfaces were tested to evaluate surface-dependent conductivity and contact behaviour.

Fig. 4 *SMD LED*

Fig. 5 *MedTex130*

There are two (2) important tools in this project. Fig. 6 shows the first measurement tool which is a digital multimeter and Fig. 7 shows the adjustable soldering iron. The multimeter is to measure the voltage, current and resistance value of the conductive fabric. The accuracy of the reading determined the performance of the conductive fabric.

Fig. 6 *Digital multimeter*

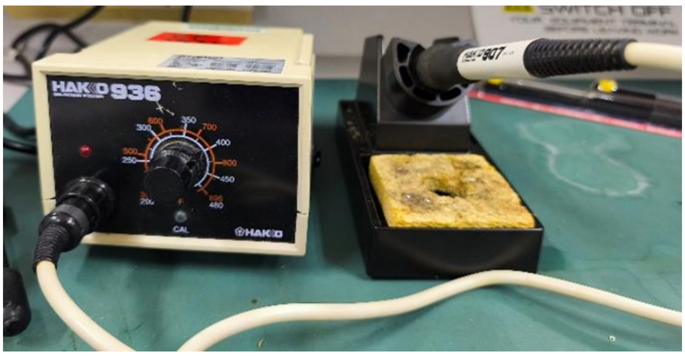

Fig. 7 *Adjustable soldering iron*

The adjustable soldering iron is used to connect the SMD LED to conductive fabric surfaces. The adjustable temperature control feature is important in this study especially when doing research to find out the best temperature for conductive fabric and the effect of soldering towards conductive fabric.

2.2 Software Part

This project used Proteus software to simulate the circuit design and test the possibility of the output project. Fig. 8 shows the simple design of circuit diagram of the project. It is a complete circuit consisting of battery as power supply, a push button, variable resistor and a LED using a series connection. As the LED is light up, there is no error in this circuit.

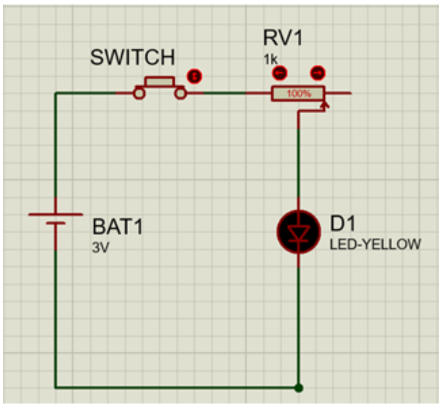

Fig. 8 *Circuit diagram*

2.3 Resistance Testing

The resistance testing focused on the electrical resistance of the conductive fabric across different dimensions lengths and widths and surfaces. To perform this testing, the MedTex130 conductive fabric will be cut into a few strips of various lengths which is 1cm to 8cm and widths of 0.3 cm were investigated. The results of 0.3 cm are presented here for clarity, as similar trends were observed for wider samples. The resistance value was measured using the multimeter by placing the probe at the end of the strip. This step was repeated for each of the strip and both sides of the surface, shiny side and non-shiny side. Fig. 9 shows how resistance testing using multimeter was conducted.

Fig. 9 *Resistance testing using multimeter*

2.4 Stretch Testing

The main objective of stretch testing is to analyse how stretching affects the conductive fabric properties. This testing was conducted by preparing 1cm to 8cm strips. The initial resistance values were record before performing the stretch test. The percentage of stretch was determined by the length of the strips. Five (5) categories of stretch 0%, 25%, 50%, 75% and 100% were used in this testing to study the effect before and after stretching. All test samples were prepared with a constant width of 0.3 cm to isolate the effect of elongation on resistance. Table 1 shows the applied sample's length with regards to the given elongation percentage.

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Table 1 *Applied sample's length*

Original Length (cm)	0% (×1.00)	25% (×1.25)	50% (×1.50)	75% (×1.75)	100% (×2.00)
1 cm	1.00	1.25	1.50	1.75	2.00
2 cm	2.00	2.50	3.00	3.50	4.00
3 cm	3.00	3.75	4.50	5.25	6.00
4 cm	4.00	5.00	6.00	7.00	8.00
5 cm	5.00	6.25	7.50	8.75	10.00
6 cm	6.00	7.50	9.00	10.50	12.00
7 cm	7.00	8.75	10.50	12.25	14.00
8 cm	8.00	10.00	12.00	14.00	16.00

2.5 Electrical Testing

The purpose of electrical testing is to evaluate the behaviour of the conductive fabric under 3V of DC voltage, the voltage drops of each conductive fabric and the current flow through the circuit. Two pieces of conductive fabric with the width of 0.3cm and 5cm length were connected to DC power supply. A short jumper wire was used between the conductive fabric and the SMD LED to ensure reliable mechanical contact. The additional resistance introduced by the jumper was assumed negligible compared to the fabric resistance. However, it may contribute to minor voltage drop variations observed in the measurements. The SMD LED is the indicator of the visual output which connected to the other end of the fabric strips, forming a close loop circuit. The voltage drops and current were measured using a digital multimeter. Fig. 10 shows the tested circuits.

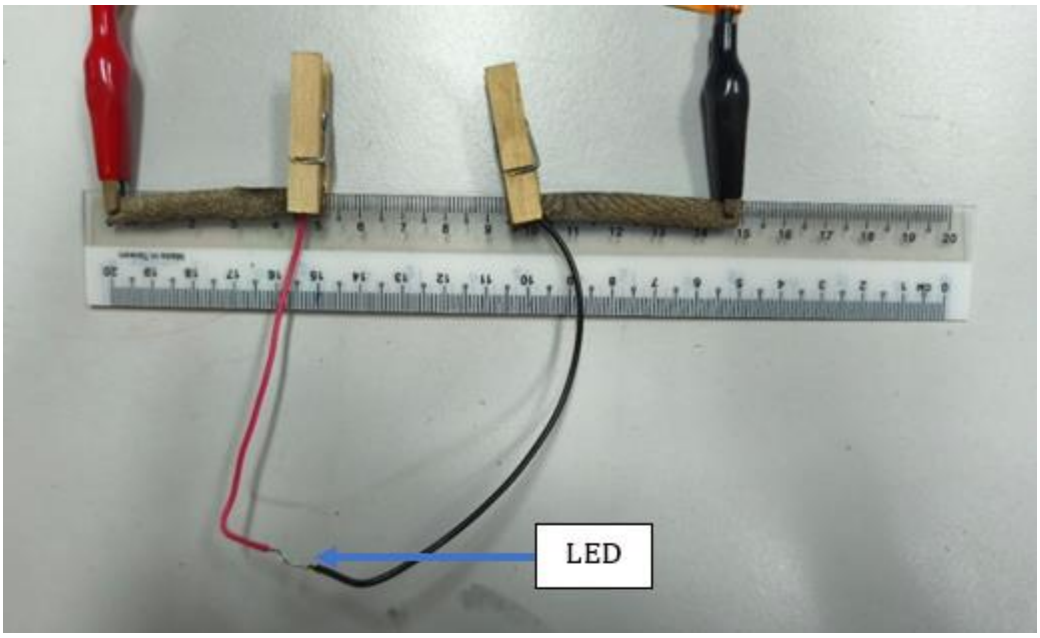

Fig. 10 *The tested circuit using conductive fabric connected to SMD LED*

3. Results

3.1 Resistance Measurement

The test was conducted on MedTex130 fabric strips ranging from 1 cm to 8cm in length with the same width (0.3 cm). Although the datasheet specifies a surface resistance below 5 Ω/sq, the measured resistance values in this study are higher due to the narrow strip geometry, contact resistance and probe spacing used in two-point measurements. The results are therefore consistent with the datasheet when considering practical measurement conditions rather than ideal sheet resistance. Fig. 11 shows a clear increasing trend of resistance with fabric length for both surfaces, confirming that longer conductive paths introduce higher resistance. The non-shiny surface exhibits lower resistance at shorter lengths, likely due to improved probe contact and pressure distribution. The result is shown in Table 2 and Fig. 11.

Table 2 *Resistance value on shiny and non-shiny surface*

Fabric Length (cm)	Shiny surface (Ω)	Non-shiny Surface (Ω)
1	399.00	115.30
2	1140.00	680.00
3	1336.00	895.00
4	1620.00	1275.00
5	1830.00	1688.00
6	2080.00	2415.00
7	3140.00	2781.00
8	3250.00	2825.00

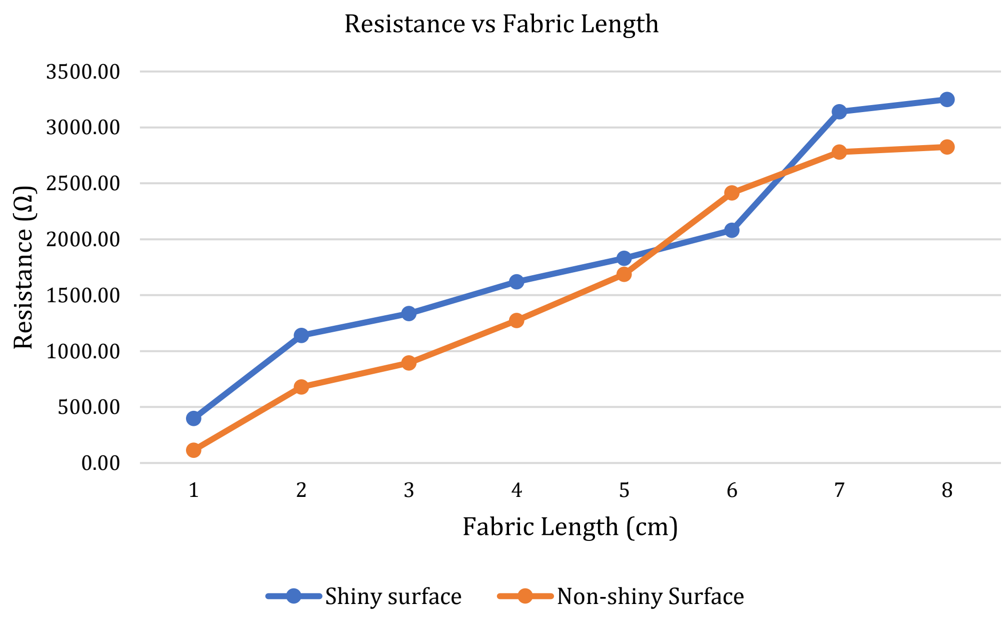

Fig. 1 *Measured resistance (Ohm) value with referred to fabric length (cm)*

3.2 Effect of Stretching Fabric on Resistance

The study shows effect of fabric stretching to the resistance value. The fabric width is fixed at 0.3cm but varied in length (from 1cm to 8cm). Table 3 shows the stretching effect on shiny side. The relations were plotted in Fig. 12. Each series represents a different stretch percentage (0%–100%), illustrating the progressive reduction in resistance with increasing elongation.

Table 3 *Stretching effect on shiny side (Resistance in Ω)*

Fabric Length (cm)	Stretch Percentage				
	0%	25%	50%	75%	100%
1	399.00	310.70	223.40	139.20	50.80
2	1140.00	909.00	680.00	451.30	220.60
3	1336.00	1072.60	813.70	550.00	288.00
4	1620.00	1310.50	1005.00	697.50	390.20
5	1830.00	1583.70	1335.00	1090.20	661.00
6	2080.00	1860.50	1642.80	1423.00	804.00
7	3140.00	2623.70	2110.00	1601.50	1087.00
8	3250.00	2677.00	2106.50	1533.50	1360.00

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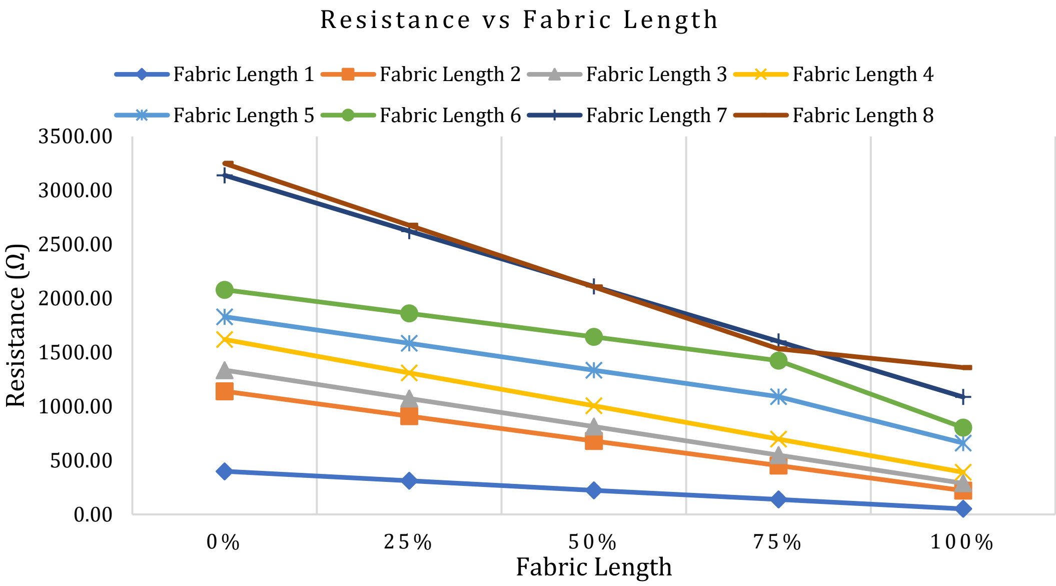


Fig. 2 *The relation between resistance and percentage of fabric length*

Table 4 and Fig 13 shows the stretching effect on non-shiny side. The test shows the similar trend in term of resistivity effect to fabric length. However, the resistance values were significantly higher when measured at the shiny side. These results provide valuable information to understand surface resistivity behaviour of MedTex130 before applied to any circuit development.

Table 4 *Stretching effect on non-shiny side (Resistance in Ω)*

Fabric Length	Stretch Percentage				
	0%	25%	50%	75%	100%
1	115.30	92.60	70.50	50.00	27.70
2	680.00	520.20	363.00	205.40	64.40
3	895.00	694.22	495.40	298.20	97.10
4	1275.00	958.20	641.20	322.80	103.30
5	1688.00	1266.00	845.80	430.50	116.80
6	2415.00	1833.70	1250.90	669.00	157.00
7	2781.00	2078.10	1376.60	673.70	174.10
8	2825.00	2115.30	1415.50	706.30	290.00

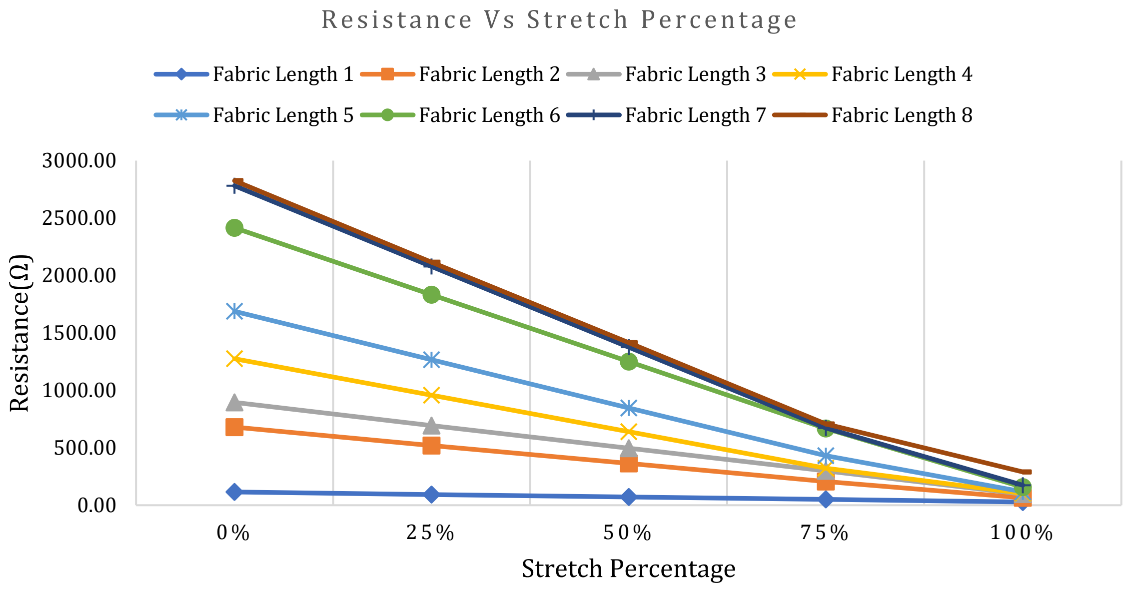


Fig. 3 *Graph resistance vs fabric length on non-shiny surface*

3.3 Electrical Measurement

This section showed the result of electrical testing of a complete circuit in Fig. 10. The results show how total resistance value influence the current flow through the circuit. This is a basic theory of Ohm's Law when the voltage constant and the resistance increases, hence the current will decrease. Table 5 shows the result of the testing where 3VDC is supplied where *Vt* represents the total measured voltage across the entire circuit, including the conductive fabric and LED.

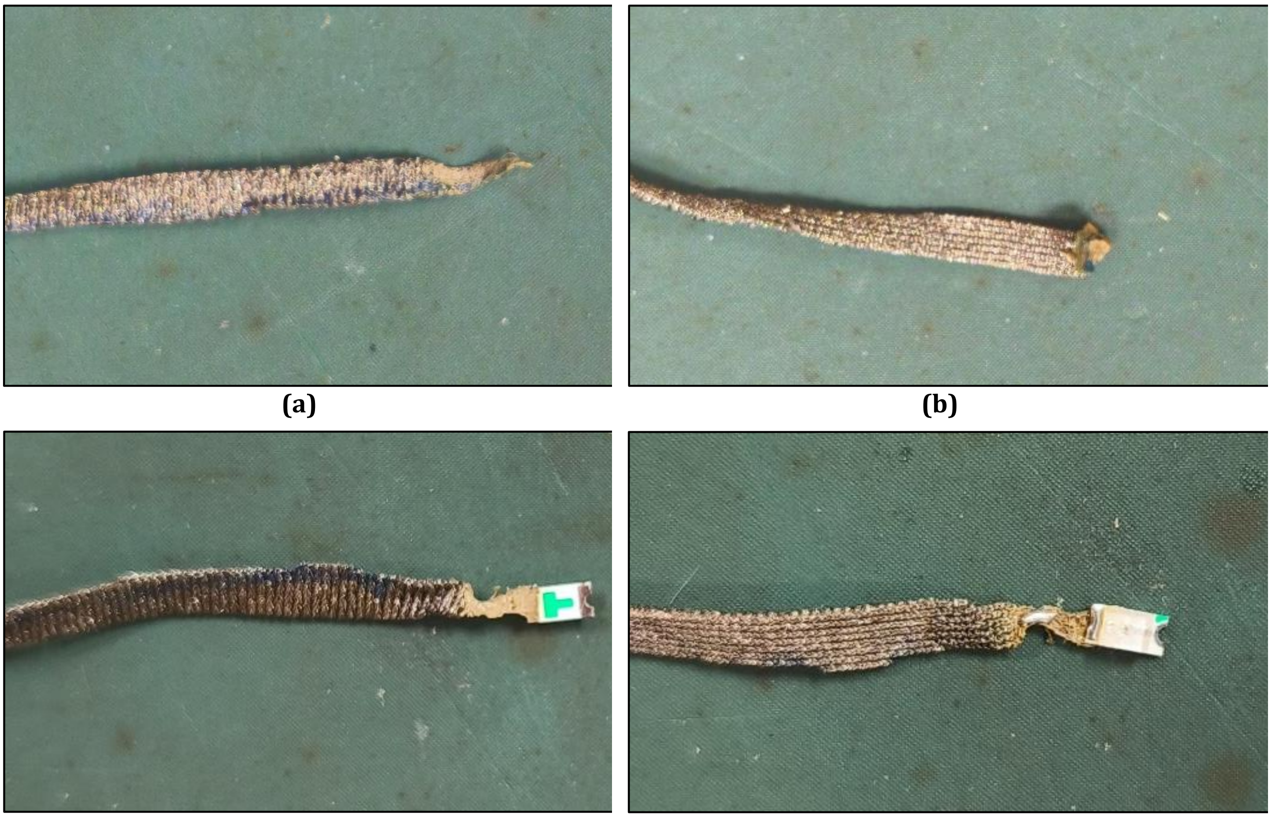
Table 5 *Voltage drop across conductive fabric*

	R1	LED	R2	I	Vt
Test 1	0.552V	1.860V	0.553V	5mA	2.965V
Test 2	1.032V	1.891V	-	3mA	2.923V

The electrical testing compared voltage drops in two circuit configurations using MedTex130 conductive fabric with 0.3cm width and 5cm length each strip. Test 1 used two fabrics (R1 and R2) while Test 2 used a single strip (R1). According to Ohm's Law, an increase in resistance corresponds to a decrease in current. While the general trend was observed, Test 2 showed a lower current (3 mA) compared to Test 1 (5 mA). The voltage drops did not align perfectly with the theoretical expectation. This deviation may be due to several factors which is slight fluxes in the power supply output, inconsistency in fabric surface contact and the non-linear resistive behaviour of the conductive textile. Additionally, tolerance in LED forward voltage and measurement error could also affect the results. These observations highlight that while Ohm's Law provides a good theoretical basis, real-world textile-based circuits may introduce inconsistencies due to material and interface variability.

3.4 Soldering Effect

This section is the crucial part of the project which is the connection point between the SMD LED and the MedTex130 conductive fabric. A few strips of 0.3cm conductive fabric were prepared for this testing. The soldering results indicate that conventional soldering temperatures exceed the thermal tolerance of silver-plated textiles. At temperatures ≥350 °C, the conductive coating degrades, increasing resistance and compromising electrical continuity. This finding has critical implications for wearable fabrication. It is suggested that low-temperature bonding methods such as conductive adhesives or crimping are more suitable. Fig. 14 shows the effect at different soldering temperatures to the fabric. It is clearly seen that the fabric surface degraded due to the high temperature. This degradation causes the resistance at that point to increase and affected overall measurements.



(a) **(b)** **(c)** **(d)**

Fig. 14 *Soldering effect (a) Soldering at 450°C; (b) Soldering at 350°C; (c) Back view of soldering at 300°C; (d) Front view of soldering at 300°C*

4. Conclusion

This study successfully evaluated the suitability of MedTex130 silver-plated conductive fabric for use in low-voltage wearable electronic circuits. Through systematic experimentation, it was found that the fabric shows predictable electrical behaviour under various physical conditions relevant to wearable integration, including dimensional variation, mechanical strain, electrical loading and thermal exposure.

The resistance of the fabric increased proportionally with length and decreased with width, conforming to Ohm's law. However, an unexpected outcome was observed with surface dependence: the non-shiny side, though initially assumed to be less conductive, demonstrated lower resistance in some cases likely due to contact variability or uneven coating. Stretch testing revealed that the fabric's resistance consistently dropped with stretch, particularly on the non-shiny surface, with some samples showing up to 94% reduction at 100% strain. This behaviour indicates potential applications not only in circuit interconnects but also in strain-sensing components.

Electrical tests confirmed that the fabric can function effectively up to 12 V DC for powering an LED load. Nevertheless, current-induced heating became significant beyond 5 V, suggesting power limitations due to Joule heating. Additionally, the soldering trials revealed that conventional soldering techniques at typical electronics temperatures (≥ 350 °C) severely degrade the conductive surface, increasing resistance by more than tenfold and visibly damaging the fabric. This highlights a critical integration limitation and suggests that alternative bonding methods such as conductive adhesives or mechanical fasteners are more suitable.

In conclusion, MedTex130 is a promising conductive material for low-power, flexible wearable applications. Its electrical and mechanical properties are favourable for integration into smart garments, especially when low-voltage, non-soldered solutions are applied. Future work should address long-term durability, washability and encapsulation methods to extend performance in real-world environments.

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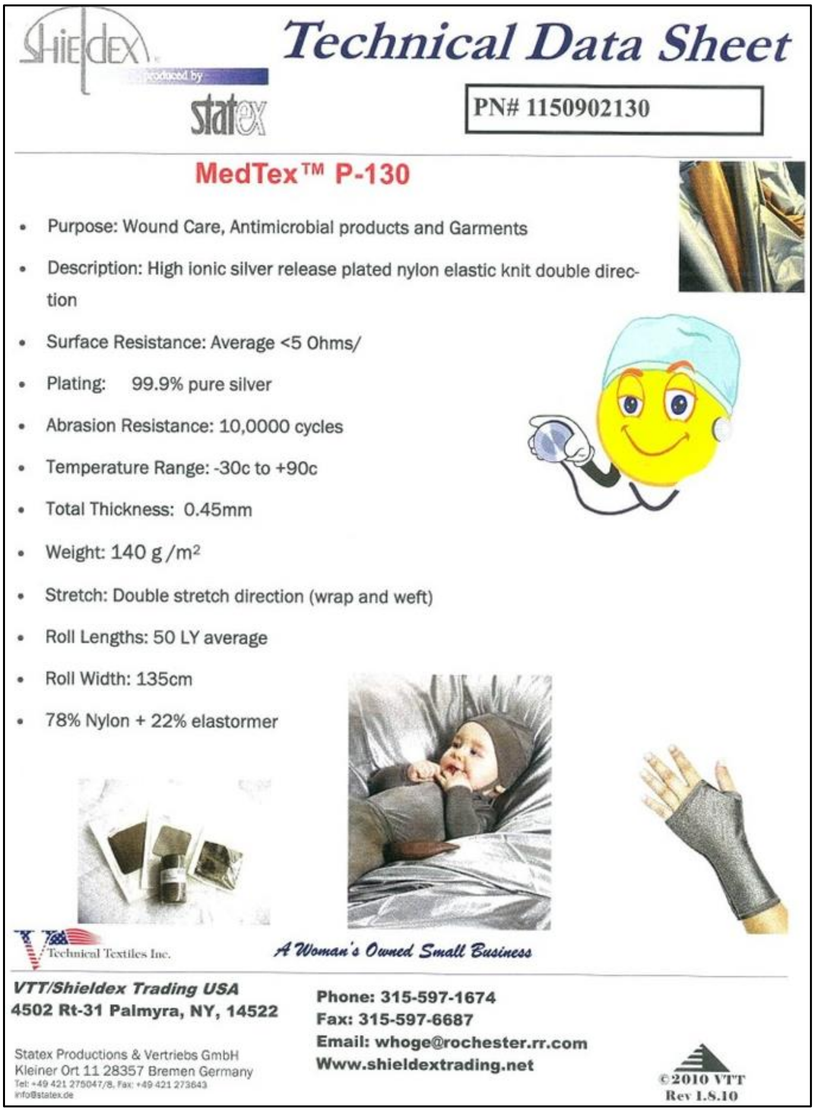
Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Luqman Bin Noor Azam, Samsul Haimi Bin Dahlan;* ***data collection:*** *Luqman Bin Noor Azam;* ***analysis and interpretation of results:*** *Luqman Bin Noor Azam, Samsul Haimi Bin Dahlan;* ***draft manuscript preparation:*** *Luqman Bin Noor Azam, Samsul Haimi Bin Dahlan. All authors reviewed the results and approved the final version of the manuscript.*

Appendix A: Datasheet of MedTex130



Shieldex produced by statex

Technical Data Sheet

PN# 1150902130

MedTex™ P-130

- Purpose: Wound Care, Antimicrobial products and Garments
- Description: High ionic silver release plated nylon elastic knit double direction
- Surface Resistance: Average <5 Ohms/
- Plating: 99.9% pure silver
- Abrasion Resistance: 10,0000 cycles
- Temperature Range: -30c to +90c
- Total Thickness: 0.45mm
- Weight: 140 g /m2
- Stretch: Double stretch direction (wrap and weft)
- Roll Lengths: 50 LY average
- Roll Width: 135cm
- 78% Nylon + 22% elastormer

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