# INTEGRATION OF ELECTRONIC COMPONENTS IN THE DESIGN OF FUNCTIONAL CLOTHING

*ELEKTRONISKO KOMPONENTU INTEGRĒŠANA FUNKCIONĀLĀ APĢĒRBA DIZAINĀ*

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***Abstract.*** *As technologies develop rapidly and continuously, they are also successfully incorporated into fashion, integrated into clothing, along with opportunities to improve the properties of textile fabrics. Impressive innovations are being created that can not only improve the quality of people's lives, but also show the creativity of designers in diverse clothing solutions, so it is necessary to study and analyse these possibilities and experiment with the implementation of achievements in a real environment. The perception of textiles has changed significantly to include electronic components, as a result today, smart textiles have been developed, that provide the user with increased functionality.*

*The purpose of the study is to identify the possibilities of integrating electronic components in the context of modern fashion design. The use of electronic components and examples from designer clothing collections are analysed, showing contemporary LED options and integrating them in the design project of the clothing collection.*

*In the course of the research, an experimental activity has been carried out in the research centre of Metalworking and Mechatronics (MM) of Rezekne Academy of Technologies. The purpose of the article is to evaluate the results of collaborative research of design and engineering students and their application in practice of design technology. Used research methods: theoretical – research, analysis of literature and Internet resources, empirical - experiment and its data processing. Participants of the research - students of engineering and design study programs, two lecturers, researchers. Study period 2022/2023. Project development is an extensive and complicated process, in order to fully develop a clothing model, it is necessary to make several prototypes until the best result is achieved. The research is of practical importance, as it substantiates cooperation in an interdisciplinary experimental process, its results and joint research activity.*

***Keywords****: electronic components, design, interdisciplinary project, textile.*

## Introduction

Actualization of technological (STEM and creative industries) knowledge and research which corresponds to the smart specialization strategy of Latvia. EU and Latvian strategic planning documents: An Agenda for the Modernisation of Europe's Higher Education Systems, Latvia's Strategy for Sustainable Development "Latvia 2030", provide bigger investment into new technologies, innovations; improvements in the education system and support for science. Support for generation and commercialization of new ideas, transfer of knowledge and user-oriented research, innovations, advancement of technologies are only some of the most prospective directions for development of economy. These documents, as a priority, include research development and practical application. The national innovation concept and programme provide for creating an innovative environment to promote practical use of scientific developments [1,2,3.].

The concept of wearing cloth started with cultural evolution for the purpose of covering body parts. However, with time, textiles are now not only used for wearing purposes but have multiple value-added options [4,5]. At the moment, user-defined textile wearables are widely involved in numerous fields, including medical, sports, military, and different defense-related projects [6,7].

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The study of the historical development of technology allows us to conclude that technologies are first introduced in other industries, until they start to be studied, implemented and used in fashion design, where they allow the development of completely new, innovative design solutions. M. Koontz predicted in 2000, with the change of centuries, that technology will play a major role in future clothing, there will be radical innovations in the field of "smart clothing", new fabrics, revolutionary decorative and functional progress of materials, computerized ready-made clothing design [8]. 10 years have passed and predictions in fashion design are coming true.

S. Burke and R. Sinclair [9] recognize the great influence of technology in fashion and the textile industry, process integration and globalization, sustainability, the development of digital textile printing, as the basis for new materials and processes. Authors C., H. Lin and C.M. Lin [10] in a study on the use of nanotechnology digital printing in clothing design, recognizes that nanotechnology is the 21st century's biggest driver of technological and industrial development. It is a new technology that is being widely researched. Integrating nanomaterials into textiles has great potential in creating functional, "smart clothing" and "smart textiles" [11].

Progress in the field of nanotechnology has contributed to the development of smart clothing, which combines electronics with textiles. The fashion of the future is made up of high-tech clothing: smart clothes and nanotechnology fabric [12]. International conferences and exhibitions are held, which confirm the popularity and importance of nanotechnology in the future. There are companies in Latvia that offer nanotechnology products, materials, and provide nanocoating services. Anyone interested can buy nano-coatings from various companies and distributors and do the coating themselves. There are success stories about start-ups with innovative solutions using nanotechnology, such as Bolt Threads, Spiber, Nano Textile, GoGoNano, etc.

The realized RTA Grant project "Experimental studies in the integration of electronic components to improve the functional properties of textile fabrics" gives the opportunity to the academic staff of various branches in cooperation with students and businessmen to conduct experimental research, test the possibilities of new materials, and develop new, innovative design solutions and product designs using the new technologies. Cooperation between education, science and business promotes interdisciplinary research in RTA, innovative technological solutions in the development of design products.

## Materials and methods

The purpose of the study is to identify the possibilities of integrating electronic components in the context of modern fashion design. The use of electronic components and examples from designer clothing collections are analysed, showing contemporary LED options and integrating them in the design project of the clothing collection.

**Methods of research used**: theoretical – research and analysis of literature and Internet resources, empirical - experiment and its data processing.

**Participants** - students of design study programs of RTA, two lecturers, researchers. Research period – year 2022/2023.

## Theoretical statement

Reasoning for the topicality: As technologies develop, they are integrated into clothing, along with opportunities to improve the properties of textile fabrics, help people's health, promote safety and protection, and also work as decoration.

Development is taking place in many areas, including textile products. In order to make the outfit more original and modern, new materials are used. Fashion is cyclical, the latest

fashion is often borrowed from the clothing designs of the past. Thanks to technology, Space Age design, popularized in the 1960s, is making a comeback.

Smart textiles use fabrics that are designed and manufactured to incorporate technologies that provide increased functionality to the wearer. These textiles have many potential applications, such as the ability to communicate with other devices, conduct energy, transform into other materials, and protect the wearer from environmental hazards. In recent years, research and development on wearable, textile-based, personal systems that provide health monitoring, protection, and security, as well as healthy lifestyles, have attracted great interest [13].

Electronic components, well, are not unheard of in the digital world. With the development of medicine, science, as well as technology, electronics are most often integrated into clothing or accessories, such as glasses, to help people's daily lives. There are different ways to achieve this by monitoring the state of health or regulating movements. Textile substrates (fibers, yarn, cloth and clothing) combined with nanostructured electroactive materials provide the researcher with a universal route to create advanced wearable electronics compatible with the human body and other conditions [14]. Many of the products on display at recent tech shows were new, but they illustrate the wide range of possibilities these technologies offer. For example, Netherlands-based Philips Design's “Bubelle” dress changes color and brightness level depending on the mood of the wearer (See Fig.1).

*1. Fig*. **“Bubelle” dress** https://inderpreetd.wordpress.com/2018/08/30/the-bubelle-dress/

As technology develops, so do materials, including textiles. Engineers, by researching and experimenting, find solutions to improve people's daily life and make it better. The most widely known new materials that people can think of are fabrics that have electronics embedded in them. However, that's not all, there are other types of fabrics, such as fire retardant fabrics and thermochromic fabrics that determine body temperature, conductive fabrics. Conductive fabrics, also called metallized fabric or smart fabric, use conductive metals such as nickel, gold, carbon, stainless steel or titanium. Typical base materials are cotton, wool, polyester or nylon. There are two categories of conductive fabrics. The first is intrinsically conductive fibers and conductive polymers. The second is a non-conductive or less conductive substrate. They are either coated or embedded with an electrically conductive element. Other features include corrosion resistance and the need for smaller seams. Conductive fabrics are becoming increasingly popular, especially in the telecommunications, medical and wearable electronics industries. Many have an NFPA Class A flame rating [15].

Smart fabrics and wearable electronics are set for the success of portable electronics as the next step in today's information technology era. To be considered "smart", a textile(See Fig.2.) structure must integrate the ability to sense and respond to environmental stimuli. In a broad sense, the stimuli and response of smart textiles can have a variety of origins, including

chemical, thermal, magnetic, and electrical. The latter is related to the category of smart textiles that combine electronics with textile structures, referred to as electronic textiles or e-textiles, although other terminology such as "texttronics" is used. One of the main challenges for the success of wearable e-textile technology is the development of lightweight and flexible components and fiber structures with high electrical conductivity that can withstand the stresses associated with textile wear and care. Indeed, the lack of flexibility and weight associated with metallic conductors are the main obstacles to overcome in the burgeoning field of electronic textiles or e-textiles [16].

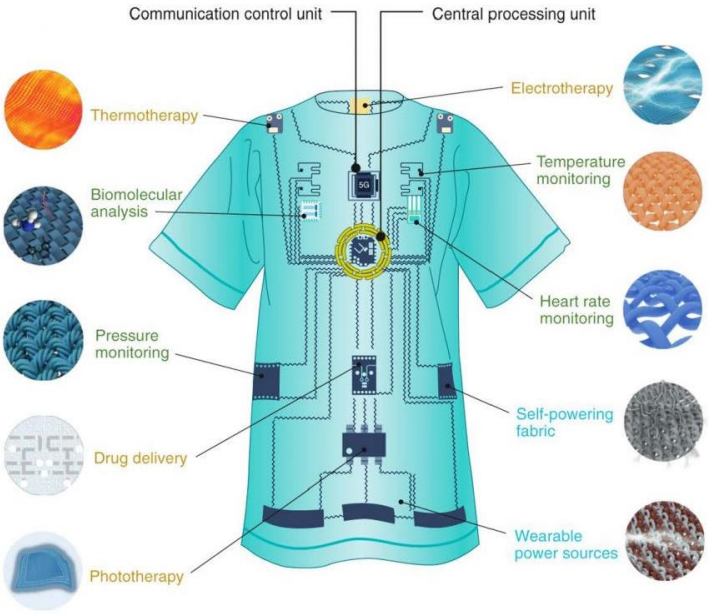


*Fig.2*. **Smart textile** https://www.bioeng.ucla.edu/smart-textiles-for-wearable-healthcare-and-sustainability/

There are already examples in the scientific literature of clothing, mostly for babies, changing color in case of fever, giving parents a visual cue. Today, fiber color change temperature discrimination allows color change under precisely defined conditions. Because of circulatory problems, it became possible to detect local infections [17].

- As technology advances, smart clothing is becoming popular. They provide more possibilities than the clothes we wear every day.
- Countless types of technologies are being integrated, each contributing to its own function. Starting with protective functions, up to a purely decorative approach (See Fig.3).


*Fig 3.* **Healthcare e-textile system prototype design** ("Astroskin" shirt by Carre Technologies Inc. (Hexoskin)) [17]. https://www.mdpi.com/2079-9292/11/1/99

Different levels of smart textiles:

- First-generation of smart textiles are those that sense environmental changes but cannot adjust their properties.
- Second-generation smart textiles include fabrics that first sense changes or environmental stimuli and then respond accordingly.
- Third-generation active textiles are integrated with soft and smart electronics that include sensors, optical gadgets, nanogenerators, and energy storage devices (See Fig.4).

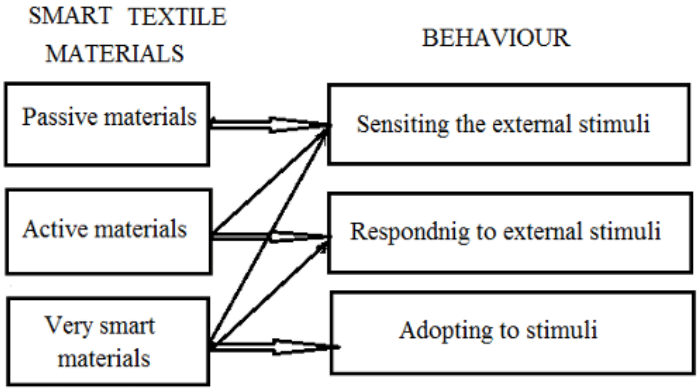


*Fig.4.***Diferent generation of smart textile**.
https://www.researchgate.net/figure/Classification-of-smart-materials-considering-their-behavior_fig1_318110866

Some examples of smart textiles:

Adidas's introduced commercially the first smart shoes to the market in 2004. The smart shoes consist of a sensor, microprocessor, electric motor, and the actual smart electronic textile material. It can adjust its cushioning system. That depends on what surface the wearers are running over or walking (See Fig.5.).


*Fig.5*. **Smart shoes** https://textiledetails.com/application-of-smart-textiles/

The smart baby vest is equipped with microchips and sensors. It can continuously monitor vital issues. Such as heart, lungs, as well as body temperature. As a result, doctors can easily detect heart circulatory illnesses. Besides, it is also used for other adult patients' life-threatening situations to save a life See (Fig.6.).


*Fig.6*. **Smart baby vest, smart fire Fighter Jacket**
https://textiledetails.com/application-of-smart-textiles/

Electrically conductive textiles. The implementation of sensors and actuators in the textile industry is mainly focused on the conductive properties of the textile material. Electroconductive polymers in this sense are widely used in the textile industry (See Fig.7).

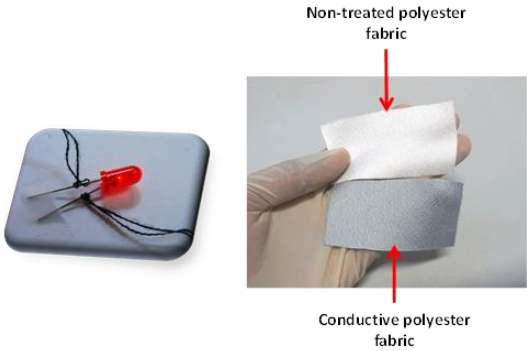


*Fig.7* **Conductive polyester fabric** https://sites.unica.it/dealab/conductive-textiles/

Sensors on textiles. Different types of sensors can be integrated on textiles for different applications; such as thermal sensors, touch sensors, pressure sensors, optical sensors, chemical sensors, olfactory sensors, etc (Fig.8.).

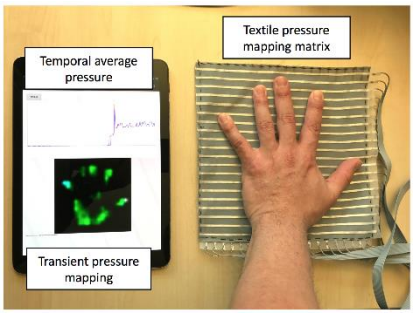


*Fig.8*. **Sensors on textiles**. https://www.mdpi.com/1424-8220/17/11/2585

Various are offered types of LED lights: A two-electrode diode; Addressable diodes; Diode strip; Sew in diodes; Diode flexible panels. Types of LED lights: El wire; El panels; El paint; Optical fibers; El tape.

Several are also known types of connections (Fig.9, 10.).

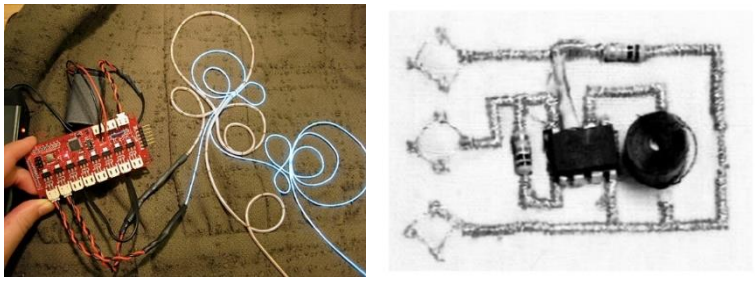

*Fig.9*. **Wire and Thread** [18] **connection**.
https://makezine.com/article/technology/wearables/programming-el-wire-fashion
https://www.mdpi.com/1996-1944/14/17/5113

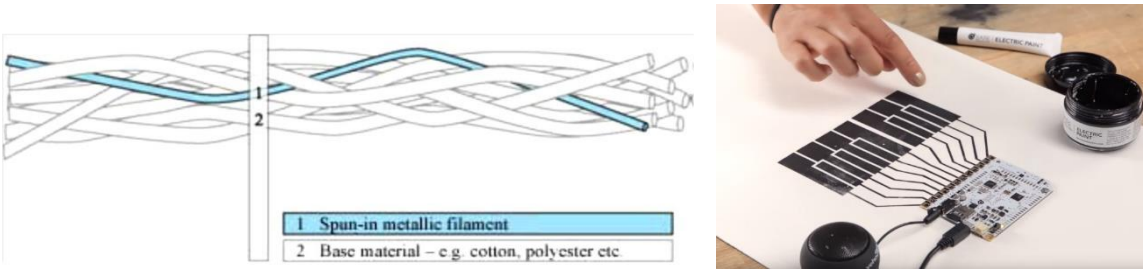


*Fig.10*.**Connection with fibers and paint**.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4168435
https://www.electronicproducts.com/conductive-paint-is-not-just-a-toy

The study of scientific articles allows us to conclude that the use of technology in clothing and fashion design is increasing it introduces changes in traditional processing processes that allow significant saving of resources. Researchers focus on fashion as one of the most wasteful industries in the world, but thanks to new technologies and consumer demand, this is starting to change. Fashion design is associated with responsibility towards people and the environment. With the help of technology, it is possible to increase the quality of clothing processing and the time of use and its characteristics. The experimental activity ensures the determination of the optimal parameters and their safe application for the development and post-processing of the textile clothing collection. A fashion designer should establish cooperation with specialists, engineers who are familiar with equipment specifications and relevant technologies that can be successfully integrated into fashion design.

## Results and discussion

The research problem is the situation understood as a theoretical or practical issue or problem which needs to be studied [20].

In the RTA scientific grant for research project "Experimental studies in the integration of electronic components to improve the functional properties of textile fabrics" research is carried out. The project has been implemented in cooperation with RTA Metalworking and Mechatronics (MM) research center, textiles with integrated electronics are being researched.

The grant project provides the development of scientifically based research for the integration of functional textile fabrics in smart clothes to improve their usage characteristics, promoting the use of advanced technologies, new solutions in the design of textile products, improving the design process of smart clothes: research of the current situation and achievements of the industry in the use of functional textile fabrics in smart clothes, analysis and use for the provision of research; determination of the optimal parameters and directions of the intelligent processing process of textile fabrics; - selection, development, analysis and compilation of methods and recommendations on the application of functional textile fabrics in smart clothing, the use of advanced technologies; selection of technically and economically justified solutions; the use of advanced technologies, functional textile fabrics, in the production of smart clothing designs; involvement of production companies to obtain feedback; evaluation of quality, usability and durability; the development of a new integrated, interdisciplinary study, which promotes scientific research for students and the latest knowledge in the theory and practice of the industry and related sciences for academic staff; expansion of cooperation with entrepreneurs for the use of research results and for ensuring the improvement of the content of study programs.

In the grant project, the following results were obtained for specific samples of textile fabrics:

1) Samples of different textile fabrics, preparation of materials for experimental research, based on theoretical reasoning;
2) Trials of possibilities/types of development of functional textile fabrics for improvement of usability properties, testing of samples of experimental textile fabrics for determination of optimal parameters.
3) Development of a model design project, foreseeing the possibilities of integrating electronics, making a prototype (See Fig.14.).
4) Research of existing studies on the integration of functional/intelligent processing methods, techniques and technologies;
5) Research into the use of functional/intelligent processing possibilities and methods, techniques and technologies in polyester textile fabric, using RTA's material and technical provision;
6) Analysis of experimental results and comparison with theory;
7) Use research results for improved solutions in the development of designs in RTA student’s qualification works. (Qualification thesis: Integration of electronic components in clothing design).

Fabrication of textiles with an integrated electroconductive system (See Fig.11.):

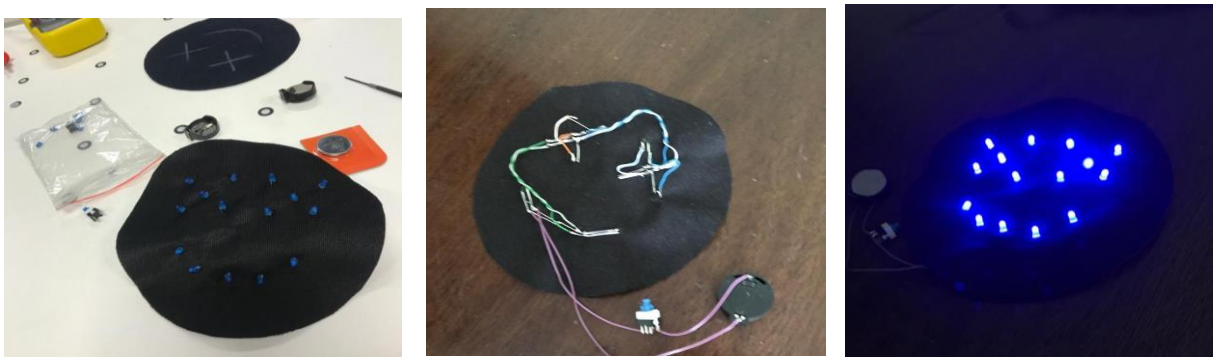

Fig.11. The results of the experiment were obtained in the RTA grant project. Integrating LEDs into textiles.

As an example, results of authors experiment (See Fig.12.).

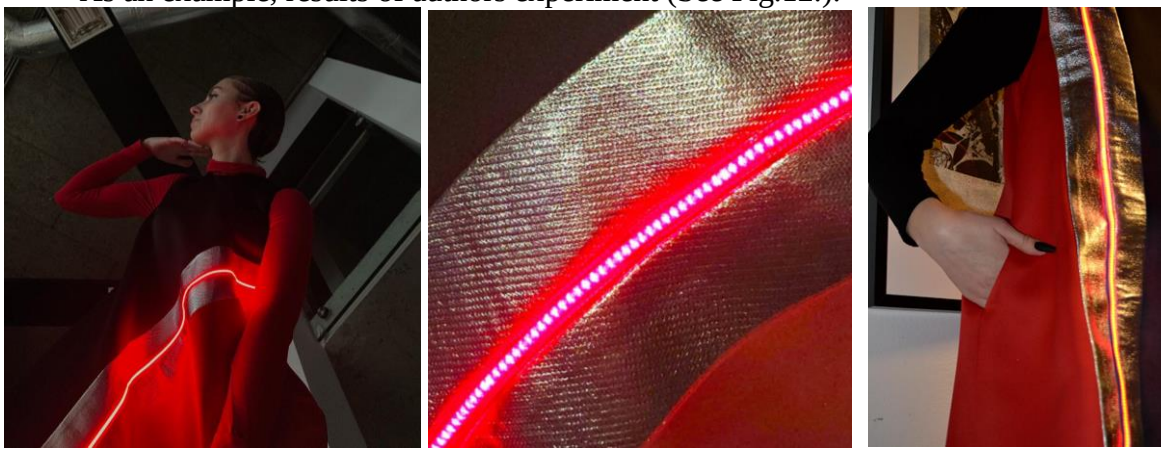

Fig.12. Development of a model design project, foreseeing the possibilities of integrating electronics, making a design sample.

## Conclusions

- Modern global development tendencies in manufacturing show continuous use of latest technologies in raw materials and the technological process of product manufacturing. One of these technologies is the various smart material processing possibilities.
- In global research, in the manufacturing of functional products, materials and processing technologies are constantly being improved, which ensures the design of new, improved products and the improvement of existing technological possibilities in product manufacturing.
- The projects designed by RTA students and user-oriented research, fulfilment of real requested works, design where research results are required promote the practical application of the research results, the expansion of cooperation with entrepreneurship sectors.
- The integration and use of technologies for creating unique, complex designs, improving the quality of textile materials, and developing smart clothing has become a current trend in fashion design;
- In recent years, the design concept features sustainable, environmentally friendly design, which calls for the evaluation of production technologies, processing methods, which affect the resources of the whole world, the environment, the climate and the health of the population. The researched smart textile technology is recognized as sustainable, streamlining and facilitating people's lives;

- Fashion design must be responsible, not only by introducing the latest technologies, but also by getting involved and following up on their research, by choosing processes and products that are proven and recognized as safe for the environment and people;
- With the rapid and continuous development of technology, more impressive e-textiles and clothes are created, which can not only improve the quality of people's lives, but also show the creativity and talent of designers in creating original clothing solutions.
- The range of types of LED diodes is wide, each designer can find the most suitable type to use in the design of their project according to their abilities and wishes.
- When comparing the selected materials, the incompatibility of the fabrics in terms of thickness was found, therefore, the required effect was not created. This was improved by using an adhesive cloth for the silver cloth so that the strip, which is meant to be an accent, retains that function.
- Involvement of academic staff, students, and entrepreneurs in innovative projects, advancing the scientific research capacity of the academic staff, ensuring technological excellence and transfer for the advancement of entrepreneurship is the foundation for the scientific and research development of Rezekne Academy of Technologies (RTA).

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