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# Miniature Wearable Microcontrollers for Smart Garments

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## ABSTRACT

*In the emerging field of e-textiles advances in smart materials, fibers structures, nanotechnology, miniaturization of processing units and other electronic components allow providers to develop smart clothing with capabilities like sensing, reacting, computing and interacting. To realize the convergence of textiles and computing recent miniaturized embedded system plays a vital role. The embedded systems integrated into textiles enable them to think and adjust the systems behavior and configuration according to the specific requirement. These boards could be easily integrated into the fabric to develop finished or prototyping e textiles products. This paper highlights the salient technical hardware specifications and comparison of core set of feature of recent embedded systems like Adafruit Gemma, Adafruit Flora, Arduino LilyPad and also highlights the latest applications and future scope of smart garments in different sphere of life.*

***Keywords-*** *adafruit, arduino, e-textiles, flora, gemma, lilypad, smart garments.*

## I. INTRODUCTION

E-textile is the seamless convergence of electronic components and textiles. E-textiles or Smart fabrics include the integration of conductive yarns and electronic components while maintaining the textile features. The key features to be followed while integrating electronic components into the garments are: flexibility, stretchable, breathability, wearable, weather proof, water resistant, comfort, light weight, less visible, high conductivity and low cost. E-textiles allow designers or developers to generate new thinkable products which could acquire, analyze, store, transmit/receive or display data in an organized manner. The major components that could be the part of any electronic textiles are: sensors, actuators, microcontrollers, interconnection and power source [1]. Each component has a defined function sensor sense the biometric or environmental phenomenon, actuator take action upon the sensed data independently or guided by microprocessor, microcontrollers compute, analyze, store data, interconnection lines provides transmission of data within or to external components and power source provides current to run the electronic components into the fabric[1].

E textiles can be categorized based on the integration of electronic components into the fabric as aesthetic or classical e-textiles or advanced or dynamic textiles [2]. Aesthetic textiles include very basic passive or active electronic components like capacitors, integrated circuits (ICs), LEDs etc. Dynamic garments are innovative designs which incorporate intelligence within textile. Microcontroller is used to control applications packaged

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with a microprocessor, RAM, program storage and interface (I/O) circuitry. The new use of graphine and 2D material inks to create printed circuits are flexible, stretchable, washable, and consumes less power to run are very much suitable for applications in smart garments. The use of small size microcontrollers due to nanotechnology and advancement in electronic textiles yarns & integrated sensors open up new set of smart clothing. At present most of the e-clothing uses rigid electronic components integrated in textiles that makes them not breathable, uncomfortable to wear, unbendable and non washable.

The commercialization of E-textiles (or Electronic textiles) opens up the gateway to support wide applications in the field of medical, military, entertainment, fashion, interior decoration, sports, personal or business communication, aerospace, security and safety. For example in business interactions workers may wear smart textiles attire for communication with co workers. The uniform of workers embedded with electronic communication facilities may support e-mail, video conferencing or voice chatting. In medical field using e-textiles doctors could collect medical parameters in real time of patient sitting at home. In recent decades the research, developments and applications of electronic components and modules has grown manifold. The use of miniaturized microcontroller's technology is dynamic, ubiquitous and play a vital role in the generation of Smart or intelligent clothing.

## II. COMPARATIVE STUDY OF TECHNICAL SPECIFICATIONS AND FEATURES OF MICROCONTROLLERS FOR SMART GARMENTS PROTOTYPING PROJECTS

The tiny microcontrollers with stitched circuits have a great acceptance within the community of designers and developers to create numerous innovative smart textiles projects. This new trend allows fashion designers to dream out of the box. This section provides the comparative study in terms of technical specifications as provided in Table no1 and salient features of adafruit flora, arduino lilypad, adafruit gemma for better understanding of miniaturized microcontrollers.

### ADAFRUIT FLORA

One of the fully featured, cost effective wearable and sewable microcontrollers based on Atmega32u4 chip is Flora from Adafruit. Atmega32u4 serves the processing power for the module. It is open-source environment offers easy hardware and software. It comes with accessories like stainless steel strands, location tracker module and NeoPixels light emitting diodes that can be used with the main board [3]. It works seamlessly with Flora accessories. The complete system architecture of Flora provides six digital pins, two communication pins, two serial pins, a reset button JST connector, mini USB and four LED indicators.

Flora as shown in Fig. 1 is empowered with built in USB port to directly program it. To begin with Flora you require Micro-B USB cable to plug it and Arduino 1.6 or higher development environment to upload program. Flora provides USB support for human interface devices such as keyboards, mouse, game controllers, MIDI Device and to connect straight to computers or cell phones. Flora has a reset button to reboot the system. It has the capability to sense the environment based on the signals received from a variety of sensors and act upon

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according to its surroundings by controlling LEDs, motors or actuators. You can power it via USB connector or JST connector. When powered with battery pack or small size rechargeable lithium polymer (LiPo) battery the flora is offered with power switch for easy and efficient battery on/ off control. . LiPo battery is charged externally which reduces the chance of fire catch into the fabric. On board regulator maintains the steady voltage and allows it to run at 3.3V to power 3.3v modules and sensors. It can handle battery packs from 3.5 V to 9V DC input. It easily handles battery problem reverse polarity due to onboard polarized connector and protection diodes. Flora can glow 50 Neopixels from on board power supply or up to 500 Neopixels via external power source (e.g. LiPo battery).

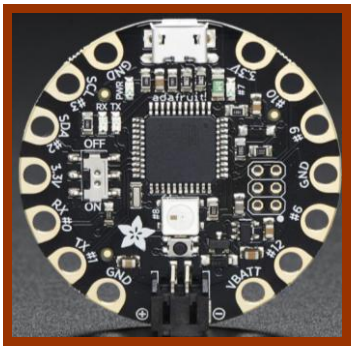


Figure. 1. Flora [ 3]

The design of FLORA enables easy integration into the fabric because all the components are embedded on board and won't create hindrance in exquisite fabric.

**ARDUINO LILYPAD**

Lily Pad Arduino as shown in Fig. 2 is particularly designed to work new trends projects like in smart clothing. It provides good introduction of e textiles to the designers. The best part of LilyPad microcontroller is that it is sewable to the clothing with conductive strands. It provides large connecting pads for easy sewing and connection. It is also easy to attach it with other electronic components such as sensors, actuators, power source using conductive threads. Modules which can be attached to Lilypad are GPS Module, Bluetooth Module, RFID Module Temperature &Humidity Sensor Gas Sensor, Flex Sensor, Photo resistor, infared, force- sensitive resistor, Piezo sensor, tilt sensors, motors, buzzers, vibration motors etc. It was launched by Leah Buechley and SparkFun Electronics and based on ATmega168V or ATmega328V chipset which operates at 8MHz clock speed. It can be powered with range of voltages 2.7 and 5.5 volts when external power source is used like an AC-to-DC adapter, battery pack or small size LiPo battery.

Never apply more than 5.5 volts or connect reverse polarity battery to the LilyPad it may lead to the destruction of the kit. Another way to power it is using USB connection.

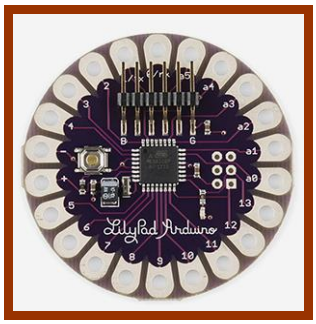


Figure. 2. LilyPad [ 4]

It works out of the box without external hardware programmer because it is pre loaded with boot sequence that enables programmer to upload new code on top of it. It is lighter in weight, round package structure and loaded with minimum external components to keep it small, simple and to minimize snagging into delicate garments. They are washable up to some extent via hand wash by mild detergent.

**ADAFRUIT GEMMA**

Adafruit Gemma microcontroller as shown in Fig. 3 is an ultra small, lightweight and cost effective board to integrate into fabric to realize your e textiles projects. It is based on Attiny85 chipset and runs at 8MHz clock speed [5]. It is powered by micro-B USB connector or via battery and easily programmable with an Arduino environment. It is also provided with USB bootloader for easy reprogramming. It is empowered with a reset button for accessing the bootloader or rebooting the system and an on-board power LED. It is also called a mini Flora. The design of Gemma leads to certain disappointments too such as no serial port connection, create problem in making out the presence of Gemma bootloader with USBv3 interface and does not work with Linux environment.

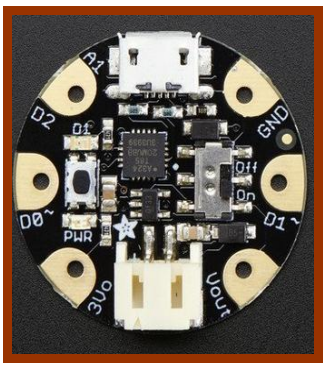


Figure. 3. Gemma [5]

It is not fully arduino compatible but the best part is that it could be used on any computer. It is provided with gold plated holes so that it does not corrode and easily sewable. To connect battery use JST battery input as it is not provided with battery input pin. It is recommended to work with 4-6 V because when we pass higher volts it gets wasted as heat. It works fine with LiPoly, coin-cells batteries. It is a drawback with Gemma that you have to remove or shut down the battery when you are done as it is not provided with switch off button. It also has a

secret reset button that allows the programmer to reprogram Gemma with the help AVR burner so use it when required. It is recommended for beginners to have hands on experience to develop e-textiles projects. The detail comparison of flora,lilypad and gemma miniature microcontrollers is provided in Table no.1.

**Table No 1: Comparative study of Technical Specifications of Compact Size Microcontrollers**

| Features | Flora | LilyPad | Gemma |
|---|---|---|---|
| **Chipset** | ATmega32u4 | ATmega168 or ATmega328 | ATtiny85 |
| **Clock Speed** | 8MHz | 8MHz | 8MHz |
| **Memory** | Flash : 16 KB (of which 2 KB used by bootloader)<br>SRAM : 2.5kB<br>EEPROM: 1KB | Flash : 16KB(out of which 2KB is used for boot loader)<br>SRAM : 1 KB<br>EEPROM: 512bytes | Flash : 8KB (out of which 2.75K taken for the bootloader)<br>SRAM : 512 bytes<br>EEPROM: 512bytes |
| **Power Source** | JST connector with battery backwards protection<br>3.5-9V , 2A connector and Recommended 6V DC to avoid overheating of 3.3 V on board regulator<br>USB input supports 4.5V-5.5V<br>3.3V output pad regulator delivers 150mA and main board uses 20mA so not recommended more than 100mA | Operating Voltage: 2.7-5.5 V<br>Input Voltage:<br>2.7-5.5 V | Mini-USB jack or JST for external output with automatic switch over, Power efficient require only 9 mA to run, 3.3V power regulator with 150mA output, can be powered up to 16V reverse-polarity protection<br>thermal and current-limit protection |
| **Pin Configurations:** | Four Indicator LEDs<br>power good<br>digital signal LED for bootloader feedback<br>data Rx (receive)/Tx(transmit) | 14 Digital I/O Pins<br>6 Analog Input Channels<br>6 PWM Channels | 2 I/O Pins<br>1 Analog Input Channels<br>2 PWM Channels<br>For interfacing sensors supports I2C channel |

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| Features | Flora | LilyPad | Gemma |
|---|---|---|---|
| | | | |
| **ICSP (In-Circuit Serial Programming) header** | easy reprogramming via bypassing bootloader for advanced users | easy reprogramming via bypassing bootloader for skilled used | Not Available |
| **sewing tap pads** | 14 sewing tap pads<br>For easy attachment and electrical connections such as modules or sensors | 22 sewing tap pads<br>For easy attachment and electrical connections such as modules or sensors | 6 sewing tap pads |
| **Software** | Arduino IDE works on Windows or Mac | Arduino IDE works on Windows or Mac | Arduino IDE works on Windows or Mac<br>USB uploading of programs |
| **Size** | 1.75" diameter | 0.3 x 0.3 x 0.3 cm | 28mm diameter |
| **Weight** | 4.4 grams | 5gm | 2 gm |
| **Price** | $13.45 | $19.95 | $9.95 |

## III. LATEST AND PROPOSED APPLICATIONS OF SMART GARMENTS

Rising number of research and innovation activities for small size microcontrollers such as adafruit Gemma, Flora, Arduino LilyPad and technological development is bound to provide new opportunities for endless applications in every sector of life.

For those who suffer from edema in the lower limbs, Edema ApS is working on to develop washable stockings to measure and supervise the changes in leg volume. Further it can also be used to monitor other medical problems such as congestive heart failure or pre-eclampsia that occurs during pregnancy [6].

A research is going on in University of Bristol to develop soft robotic clothing [6] that would support people in walking and also provides bionic strength to climb stairs, making move between sitting and standing positions. It involves nanotechnology and full body supervisory technology. Microcontrollers could allow e-clothing to be turned into biosensors as Maxim's ultra small size microcontroller analyses body fluids and vapors. The Maxim's ARM Cortex-M4F 32-Bit MCUs based MAX30102 Pulse Oximeter & Heart-Rate Sensor could be easily integrated in e-clothing [6].

Google's Project Jacquard launched Levi's Commuter Trucker Jacket for bicycle rider has garnered the attention of researchers towards gesture recognition in e-clothing that has the power to provide interaction with

services such as music, map application, call handling using touch or gesture sensitive locations on the jacket sleeve [7].

Some other projects involves t-shirts that monitors blood pressure, heart rate, senses the respiratory rate and sweat of the wearer. Few researchers proposed Sensor Based Smart Wear and Weather WebBot that uses stretch materials and sensors to provide wearer comfortable fit across the curves of human body which ensures the wearable property according to the weather conditions using WebBot [8].

Now new trend has started due to researchers at MIT with the development of fibres that could be integrated with high speed optoelectronic semiconductor devices, light-emitting diodes (LEDs) and diode photodetectors. The Inman Mills, in South Carolina has woven fabrics with these components to create smart fabrics with flexible, washable and communicable properties [9].

Scough Company at New York has developed a scarf that enables the wearer to breathe fresh and pollution free air by cleansing the air. A French company Cityzen Sciences designed a Smart T-shirt for the health management of a sports person by measuring and monitoring parameter such as heart rate, running speed, GPS location etc. Adidas Adizero F50 Soccer Shoe is based on miCoach speed cell tracking device that reads various parameters required to measure the performance of the sports person such as speed, maximum speed, number of sprints, distance etc. and sends the captured measurements to the remote location for monitoring [10].

The projects may be concentrated and developed on connection between different assets, environment, user and products. In any organization the e-clothing could be used for asset maintenance, responsive manufacturing, supply chain management, operational intelligence, smart products and connected logistics, security and data management, smart procurement, security and safety of workers.

For security personnel prime research and development in the field of e-clothing would safeguard against injuries and hazards in the battlefield. Integrated sensors would allow developing wound detection mechanism, health/stress monitoring, energy harvesting and scavenging to maintain the communication, smart and safe uniform etc.

## IV. CONCLUSION

The impact of small size microcontrollers is tremendous to provide new dimensions to our society. Due to innovative development activities in e-textiles, it has become mandatory for researchers and manufactures to create super small microcontrollers. This will help to implement wearable projects that will make user's life easy, safe and better. A number of small size microcontroller chips are available in the market to start with the project development but this paper has highlighted comparative study of flora, lilypad & gemma microcontrollers and narrows down the choice for the hobbyist to accomplish task with minimum cost and programming skills. These microcontrollers have the capability to bring intelligence into the garments. In coming years the demand of smart garments would shoot up because of tremendous applications such as in health care, security, sports etc. but still it is long way to go to establish technologies for smart garments.

## REFERENCES

[1]. Paradiso R, De Rossi D. Advances in textile sensing and actuation for e-textile applications. Engineering in Medicine and Biology Society (EMBS), 2008 30th Annual International Conference of the IEEE; Vancouver (Canada): IEEE; 2008. p. 3629.

[2]. Sikander A. Manufacturing of E-textile. Available online: http://www.fibre2fashion.com/industry-article/7124/manufacturing-of-electronic-textile (accessed on 25.08.2018).

[3]. FLORA - Wearable electronic platform: Arduino-compatible - v3. Available online: https://www.adafruit.com/product/659 (accessed on 26.08.2018).

[4]. LILYPAD ARDUINO MAIN BOARD. Available online: https://store.arduino.cc/usa/lilypad-arduino-main-board (accessed on 27.08.2018)

[5]. Lady A. Introducing Gemma. Available online: https://learn.adafruit.com/introducing-gemma/introduction (accessed on 27.08.2018).

[6]. Peter B. The Future of Healthcare May Reside in Your Smart Clothes. Available online: https://www.mouser.in/applications/healthcare-may-reside-in-smart-clothing/ (accessed on 27.08.2018).

[7]. Michael S. The best smart clothing: From biometric shirts to contactless payment jackets. Available online: https://www.wareable.com/smart-clothing/best-smart-clothing (accessed on 28.08.2018).

[8]. Kyung-Yong C., Young-Joo N., Jung-Hyun L. Interactive Design Recommendation Using Sensor Based Smart Wear and Weather WebBot, Wireless Personal Communications November 2013, Volume 73, Issue 2, pp 243–256.

[9]. Introducing the latest in textiles: Soft hardware Available online: https://www.wearabletechnologyinsights.com/articles/15079/introducing-the-latest-in-textiles-soft-hardware (accessed on 29.08.2018).

[10]. Nanotechnology in textiles-wired and ready to wear textiles. Available online: https://www.slideshare.net/sargow27/nanotechnology-in-textileswired-and-ready-to-wear-textiles (accessed on 29.08.2018).