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Design and implementation of advanced systems in a flexible-stretchable technology for biomedical applications

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ABSTRACT

This paper presents the design and implementation of an advanced system on flexible and stretchable technology. The technology platform consists of a matrix of flexible non-stretchable functional islands linked together by a net of elastic interconnections. Several technologies have been developed and tested in the design of simplified demonstrators before studying the design of an advanced system. The target system is a wireless battery charger which supplies power and supports bidirectional data transfer during recharge. The system is intended to serve as a general purpose platform for biomedical parameter monitoring and the design is focused on the embedding in clothes.

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1. Introduction

Portable electronic systems have become typical components in everyday life. The target applications in this paper are in the field of biomedical parameter monitoring [1–5] and smart clothing that improve the safety of workers in harsh environments [1,2] form the focus of the created system. The presence of these systems should be hardly noticeable to the user. One way to improve comfort and portability is to embed them in textile; another is the use of fully flexible integrated carriers. The combination of the two strategies implies the need for elastic substrates which provide a waterproof encapsulation and guarantee good adhesion to the textile fibers. The adoption of a flexible substrate does not necessarily guarantee the flexibility of the entire electronic circuit. The layout and the placement of the constituent components of the circuit, on such a substrate, are crucial to preserve the envisaged applications. Since components are intrinsically rigid, a too dense or not well-organized layout may drastically limit the flexibility of the overall structure. Design efforts should focus in a routing where rigid components form an ordinate grid and their proximity is limited in order not to affect the overall flexibility. However, system flexibility does not imply stretchability. In fact, even if the substrate is stretchable, the routing lines are intrinsically not, unless a dedicated design is adopted. Our proposed approach, aiming the realization of flexible-

stretchable electronic systems, consists of a network of flexible non-stretchable islands connected by stretchable joints [6–9]. In this way an overall flexible-stretchable electronic circuit can be achieved by composing a set of non-stretchable functional units. Common SMD components, platinum plated electrodes, antennas and flexible batteries can be incorporated [6]. Some systems have been presented that use wireless power supplies but often require external electronics in close proximity for control and power supply [1,2]. The system presented in this paper takes advantage of a combination of an inductive link and a rechargeable battery. The inductive link is meant to recharge the battery when the system is not in use (e.g. overnight). During battery recharge, bidirectional data transfer is supported in order to tune the system parameters and download stored data (e.g. biological parameters) from the textile-embedded acquisition system. Several simplified demonstrators have been developed to test the technological feasibility. An advanced system has been designed, and is currently in production on flexible-stretchable technology [6,10].

2. Design and implementation

A good understanding of the technology limitations is fundamental in order to succeed in the design. A standard PCB design can be transferred to a silicone substrate only when some essential adaptations are carried out.

Firstly, the ground plane is missing and the dielectric properties of silicone may change depending on temperature variations and moisture exposure [11,12]: silicone elastomers are in fact

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Fig. 1. Block level schematic of the wireless battery charging system (top) and its implementation on flexible-stretchable substrate (bottom), consisting of three flexible substrates, interconnected with stretchable paths.

easily penetrated by water and contaminated by ions [12]. This is especially an issue in case of remote powered systems relying on inductive links. To compensate the effect of varying substrate losses, thicker metal routing is used in the design of coil antennas.

Secondly, current stretchable circuit technologies at CMST allow for one metal layer only; for conductor crossovers one needs to use $0\ \Omega$ cross-over resistors in the stretchable circuit part. An alternative is to realize a multilayer structure on a standard rigid or flexible circuit interposer, which is then mounted as a component on the stretchable circuit. With this approach, even a single layer design can achieve complex interconnects. The drawbacks are an extended assembly time and a larger layout compared to a two layer design.

The concept underlying the design is illustrated in Fig. 1. On the top, a block level schematic of the developed system is depicted. The left and right parts are respectively the external base and the embedded battery charger which are connected by the inductive link. A microcontroller (MCU) monitors the battery status, manages the communication process and drives the load. For demonstration purposes, the load consists of a LED array. In a future stage, their place will be taken by sensors for biomedical parameter monitoring and a memory module for data storage. Research is

ongoing to integrate heart beat and respiration rate monitoring systems. The heart beat can be extracted from ECG measurements [13] or by applying pulse oximetry techniques [14]. The respiration rate can be monitored by detecting the resistive, capacitive or inductive variation of a conductive ribbon (e.g. conductive silicone) wound around the patient's chest. These changes are related to the ribbon extension/contraction cycle occurring during the respiration activity. A combination of a few parameters can be used to get better read-out when the variation of a single parameter is not large enough to allow a clear detection. A similar approach was developed and tested in textile [13] and the implementation on silicone based technologies is now under investigation.

The circuitry is meant to be implemented on a hermetically sealed network of flexible islands connected by elastic interconnections [6,10]. The number of islands is application-dependent and can theoretically be expanded to a large web. In the presented work, a configuration based on three islands is used. The first island only contains a planar coil that can eventually be replaced by an embroidered one [13]. Power regulation and data communication sub-modules are located on the second island. DC power is distributed to electronics on other islands. A third island contains an ultra thin rechargeable battery, a MCU, a battery charger and the load.

2.1. System design

Fig. 2 depicts a simplified schematic of the developed system. The circuit can be divided in three functional blocks: the power unit, the telemetry unit and the control block. The power module includes an inductive link with its magnetic field source at the primary side, a power receiving/converting circuit at the secondary side, a battery charger and a rechargeable lithium cell. The inductive link provides power for the battery charge and electronics during the charging operation. The link is driven by a dedicated class E driver and the induced alternating field is partially picked up by a parallel resonant LC tank at the secondary side. A doubling configuration rectifier was chosen to improve the link robustness to misalignments and decoupling. A two-stage voltage regulation provides 5 V to the battery charger and 3.3 V for the controller and the rest of the electronics. Two low drop-out (LDO) regulators in a SOT23 package are used. They only require stabilizing capacitors as external components. The battery charging is handled by a dedicated IC (LTC4054I) by Linear Technology which also comes

Fig. 2. Simplified schematic of the developed system. A power amplifier drives an AC current through the primary coil, hence generating a magnetic field. Part of the field is picked up by the secondary coil, which converts it to a voltage. The received power is then rectified, regulated and distributed to the load, the rest of the electronics and to the battery charger. The system also supports bidirectional data communication using OOK modulation in the downlink and absorption modulation in the uplink.

Fig. 3. Principle of stretchable electronics (top) and characterization of horse shoe shaped stretchable interconnections (bottom) [18].

in a SOT23 package and only requires a few external components. Its large dynamic range in charging current, from 10 to 150 mA, makes this product suitable for wireless battery charge applications. The charging current can be set easily by changing the resistor R_{prog} . The selected battery is an ultra thin Li-ion rechargeable cell (PGE0053559) which has 3.7 V nominal voltage and 65 mAh capacity. The battery thickness, a mere 500 μm , makes this component the perfect candidate for this application. A charging current of 30 mA was set in order to achieve a full charge in a few hours, lower rates or larger cells can be implemented as well. The backbone of the above described control block is a MCU (PIC16F687). The monitoring of the charge is performed in combination with a shunt monitor (INA138) which provides the battery's charging current to the MCU. Information about the battery voltage is directly available to the MCU through a voltage divider. These signals are then digitized and stored in temporary registers awaiting transmission. A second LDO is required to provide a constant voltage to the MCU in both wireless and battery supplies. The charger and the shunt require 5 V to work properly. Since this level cannot be achieved with a 3.7 V battery and these components do not need any bias in battery mode, the MCU supply was set to 3.3 V. In this way full operation is guaranteed also when the battery starts its discharging cycle. Diodes D_3 and D_4 are required to prevent the charger and the shunt to be biased while the system is battery powered, and also, to avoid any current draw from the battery during recharge. The telemetry module supports bidirectional data transfers at 4.8 kbps. Power and data share the same channel, through the inductive link. Although several kinds of modulation are possible, On–Off–Keying (OOK) modulation for the downlink (primary to secondary side) and absorption modulation [1] for the uplink are selected. The OOK modulation is performed by directly acting on the gate of M_1 ; data are recovered at the secondary side with the cascade of an envelope detector, a filter stage and a comparator before being processed by the MCU. Absorption modulation is achieved by changing the equivalent impedance at the primary side, through actuation of the switch M_2 . This variation can be detected at the primary side in several ways: detecting the voltage drop across the coil L_1 with a high resistance (or capacitive divider) or detecting the current drop with a small transformer in series with L_1 [1,15]. In both cases the data detection should not affect the driver behavior. Data demodulation is performed again with an envelope detector and a comparator. In order to maximize the bandwidth in both directions, a master-slave communication strategy was defined with the master located at the primary side.

The telemetry module is controlled by a PC through a serial port in the external base.

3. Technologies for flexible-stretchable interconnections

In a flexible-stretchable electronic circuit, the interconnection network should be elastic. For the realization of elastic interconnections, innovative work was recently performed by researchers from Princeton University [8,16], where elastic joints are achieved by electron-beam evaporation of a 100 nm thick gold film on an elastic polydimethylsiloxane (PDMS) substrate. Drawbacks of this technique are the restriction to extremely thin gold films, the need for high cost equipment and for non-standard assembly technologies on those substrates. The resulting skin-like electronic circuits are useful for electronic skin applications. Another implementation contains a microelectrode array for monitoring the neuron-electrical activity in the brain [16]. Our work in the field of elastic electronics is based on the realization of electrical interconnections by 2D spring shaped metallic tracks, which are embedded in an elastic polymer membrane. Conventional PCB manufacturing process flows are used to achieve these interconnections.

In Section 3.1, the basic shapes for flexible and stretchable technologies are discussed. Sections 3.2 and 3.3 describe two possible technologies to obtain these patterns completely embedded in silicone. The process flow of the production of the demonstrators, explained in Sections 4.1 and 4.2, refers to these two technologies.

3.1. Geometry of the interconnections

Fig. 3 depicts the idea underlying the realization of stretchable interconnections. The function of the elastic joints is of paramount importance in order to give stretchability to a structure composed by non-stretchable elements.

The goal is to create elastic interconnections which can support at least 50% and up to 100% elongation. Although the required elongation in the target application will probably stay below 30%, the 100% target guarantees a better reliability. Moreover, aiming at washable electronics embedded in textile implies that the systems should be able to survive harsh environments (crumpling, twisting, etc.), so that elongations close to 100% might be needed.

Finite element analysis (FEA) has been used to characterize the shape of the conductors in order to allow high deformations without permanent damage [17]. Based on these results, the interconnections between two islands will form a two-dimensional horseshoe-shaped metal track [6]. In this design, stresses are distributed in a wider region instead of being concentrated in a small zone. The horseshoe pattern is created by joining a series of circular arcs. Fig. 3 (bottom) resumes the main characteristics of a horseshoe shape meanders. They are defined by an angle H between the

Table 1
Characterization results of different patterns for stretchable interconnections [19].

Shape	Resistance increase at mid-elongation (%)	Mean resistivity (Ω/cm)	Mean E_{max} elongation (%)
H0	1.76	0.94	57.53
H30	1.19	1.86	74.82
H45	1.28	2.23	77.68

extremities of the shape and the horizontal line, a width W and a diameter D . Shapes with a positive or negative angle of “x” degrees are defined as Hx and $H-x$ respectively [18]. H45 has a high maximum elongation, but a higher electrical resistance. H0 has a lower maximum elongation, but a lower resistance. H-20 is a stackable structure to reduce the pitch drastically [17,18]. As shown in Table 1; H0, H30 and H45 have a very low increase of resistivity (<2%) during mid elongation. Mean E_{max} increases from 58% for H0 up to 78% for H45 [19]. Depending on the target application, a compromise between a high maximal elongation (hence, reliability) and a low track resistance should be found. In order to increase the reliability of stretchable electronic interconnections, the meanders can be shunted by the deposition of a stretchable conductive polymer layer on top of the metal tracks, which has lower conductivity but higher elongation and reliability. If the metallic meander is broken, the conductive polymer acts like a bridge or a shunt and insures global connectivity [19,20].

The polymer can be silver-filled or an organic conductive polymer (polypyrrole, pedot, polyaniline, etc.), but should be stretchable. Amongst the products available on the market XCS80091-1 from Emerson & Cumming and DA 6524 from Dow Corning have been tested [19,20]. A layer of XCS80091-1 with 300 μm width and height was tested by Axisa et al. [19] in association with a 425 μm H45 meander. The resistivity of the compound increases from 0.7 Ω/cm up to 1.4 Ω/cm , from no deformation up to 100% extension. It was shown that the compound intervention starts at about 60% elongation with a slight increment of the joint resistance [19].

The DA 6524 has excellent adhesion to most common substrates, is moisture resistant, support extensions up to 80% and is characterized by excellent electrical conductivity (volumetric resistivity 0.3 m Ω/cm). Although the performances are extremely promising, a drawback is certainly its cost: about 400 USD per 36 g of product, which limits the use of this material to very special cases.

3.2. Technology 1: “biocompatible technology”

The process to embed golden meander interconnections in a stretchable material was described in Ref. [18] and is shown in Fig. 4. In step 1, a photoresist layer is spin coated on a copper foil. In step 2, the photoresist is patterned with the desired conductor shape. Because gold cannot be electroplated directly on the copper and cannot be soldered, the third step involves the electroplating of three layers, instead of one. First a nickel or platinum seed layer, second, a 4 μm thick gold layer and third, a Ni–Au finish to allow soldering components on pad areas. Steps 4–7 are then straightforward: remove the photoresist, mould in a stretchable material and cure for 4 h at 60 °C, remove the copper foil, mould and cure the inverted sample. Silastic MDX4-4210 from Dow Corning has been chosen as the stretchable substrate material for moulding. It is a medical grade silicone elastomer with a low Young’s modulus of 0.726 MPa [21], high elongation up to 470%, a viscosity of 60,000 cP and hydrophobic surface. Thicker layers of the silicone can be applied to the areas where components are soldered to give a better protection to excessive strain.

The above-described process was developed in the frame of the Bioflex project (Flemish Government IWT SBO programme

(contract 04101)). Although the technology certainly has some beneficial properties for biomedical applications, so far no complete devices have been implanted for a long time period. In vitro testing has been performed in order to prove how surface treatment of both top and bottom layer of the processed PDMS results in a waterproof sealing [22]. In order to achieve a highly biocompatible system, leaking of metals from the encapsulated device should be avoided [22]. Rather than using adhesive bonding materials, non-thermal plasma treatment of the two layers was used to enhance their adhesion [22]. Plasma treatment of the external surfaces was also shown to be beneficial in order to increase the hydrophilic behavior of the overall structure, therefore promoting the biocompatibility [22,23]. An exhaustive study about the aging effect of the hydrophilic effect is also discussed in Ref. [22].

Although the technology has not been used yet in human body implants, there are examples in literature where flexible silicone based systems have been tested *in vivo* in cochlear implants [24], neural interfaces [25] and monitoring systems [26,27]. The implant of a PDMS encapsulated bladder monitor in a rabbit, lasting for a few hours, has been described by Coosemans et al. [27].

3.3. Technology 2: “Fast prototyping technology”

Fig. 5 contains the process steps of the “Fast prototyping technology”. This technology has been described in Ref. [28] and consists of laser cutting meander interconnects directly on a flex-print circuit. First, a flexible board is fixated to a support, using an adhesive (i.e. wax), either locally or on its entire surface. This prevents its movement during processing and ensures the flatness of the flex (Fig. 5(2)). Then the meander shaped interconnections and the functional islands are cut using a YAG laser (Fig. 5(3)) set with the following parameters: Nd at 355 nm wavelength, 375 mW of power, a frequency of 10 kHz, an ablation speed of 5 mm/s, a Gaussian beam spot of $\sim 20 \mu\text{m}$ diameter, and a perpendicular angle. In the third step, the excess of material not forming the meanders

Fig. 4. Process sequence for metallic stretchable interconnections embedded in PDMS [18].

Fig. 5. Process flow to obtain a stretchable electronics board using Nd-YAG laser cutting technology and moulded interconnect device (MID) for encapsulation [28].

is cut off (Fig. 5(4)). Then the top layer of the flexible circuit is embedded in polymer using a moulding, casting or laminating step (Fig. 5(5)). At this stage, the support can be removed by dissolving the adhesive or melting the wax (Fig. 5(6)), the circuit is embedded completely using moulding or casting. Moulded interconnect device (MID) is chosen as it is a reliable way to embed components in a polymer [6,29]. The system is encapsulated inside a mould; the polymer is injected and cured at a temperature of 150 °C for a period of 30 min. The moulding plates are made out of polyetherimide ULTEM® 1000, based on its broad chemical resistance, its high heat resistance and its high mechanical strength and rigidity. The result is a system composed of flexible islands interconnected by conductive and stretchable meanders all embedded in a polymer (Fig. 5(7)). This technology allows the production of a stretchable system out of any flexible board. Complex multilayer stretchable electronic boards can also be produced using this technology.

4. Experimental results

To explore the limits and potentials of the technology, two simplified demonstrators were designed and produced before approaching the realization of the wireless battery charger. This section describes the realization process of these prototypes, the work towards the realization of the final device and concludes with a discussion on the measurements and testing.

4.1. Realization of the first demonstrator

The first demonstrator consists of a flexible circuit cased in silicone as a carrier. This is a single functional island containing a receiving antenna for inductive power transfer, a half bridge

rectifier, a voltage regulation module and a LED that is made blinking by applying OOK modulation to the power carrier. The built-in device was realized using a variant of the biocompatible technology [30], using copper instead of gold for the routing and a thickness of 70 µm in order to keep the receiving coil's quality factor high. The purpose of this demonstrator is showing the feasibility of the process within a simple application and to test the moisture resistance of the package (Fig. 6).

4.2. Realization of the second demonstrator

The second simplified demonstrator is an evolved version of the first one. Besides proving the moisture resistance, it is intended to prove the feasibility of the stretchable interconnects between two functional flexible islands. In this case the first island contains the receiving coil and the conversion electronics whereas the second island contains a MCU which drives a LED array with a user defined pattern. This clustering was chosen as it needs only two interconnections (GND and VDD).

One of the main constraints for the realization of this demonstrator is its size. All fabrication machines of the laboratory (photolithography, lamination) are sized for square 4 in. (~10 cm) substrates, and the demonstrator is over 10 cm in size. The dimensions of the demonstrator can be seen in Fig. 7 together with a phase of the production process. Therefore the demonstrators have been processed in three steps:

Fig. 6. Simplified wireless power transfer demonstrator: detail (top) and moisture resistance test (bottom). The built-in device consists of a LC resonating tank, a rectifier/regulator stage and a LED which is made blinking by applying OOK modulation to the power carrier.

Fig. 7. A realization phase of the simplified prototypes (top) and the dimensions of the second demonstrator (bottom).

First, the two flexible islands are fabricated, following the standard procedure for flexible fabrication. To start, 20 μm of polyimide (Upilex 25S) was laminated on a 70 μm thick copper foil (TW-TW from CircuitFoil, Luxembourg). The thickness of the copper foil was chosen to have a better quality of the secondary coil. Following, photolithography is used before etching with a CuCl_2 solution. After this, the solder mask is screen-printed and the components are soldered using a lead free SAC solder paste in a reflow oven. The shunt wire closing the coil is soldered manually, as it is a one-layer flexible electronic board.

Secondly, the interconnections are fabricated in two versions according to the technologies described in Sections 3.2 and 3.3. Both versions will create interconnections which consist of two parallel tracks embedded in a 1 cm width, 250 μm thick and 7 cm long PDMS band. Each track consists of three parallel sub-tracks connected to the same solder pad at the end of the band. Each sub-track is a H45 meander with a width of 25 μm and an external radius of 82 μm .

The first version has been processed according to technology 1 “biocompatible technology” with a track thickness of 8 μm and is then covered by a screen-printed line of conductive silicone (DA 65-24 from Dow Corning). Each line of conductive silicone has a width of 1.7 mm and a thickness of 30 μm insuring the reliability of the interconnection.

The second version has been processed according to technology 2 “Fast prototyping technology” where the tracks are laser cut from a 18 μm thick TW-YE copper foil from CircuitFoil.

In the third step of the fabrication process, the stretchable interconnections are connected to the flexible islands with conductive silicone DA 65-24 from Dow Corning and embedded with 1 mm metal casting plates. Both top and bottom PDMS layers have a thickness of 1 mm. An adhesion promoter 1200OS from Dow Corning is used and a thicker top layer is cast over the areas containing soldered components to protect them against excessive strains.

4.3. Towards the realization of the final device

Once the technology was assessed, the realization of a flexible-stretchable advanced system could begin. The layout of the wireless battery charger, described in Section 2, was transferred from a rigid

PCB to a flex realization. The main constraint for the prototype realization is again its dimensions which will first force a multi-step process with the separate realization of flexible islands and interconnections, and their assembly and casting afterwards. The critical point will be the link between the second and third island since it requires four stretchable lines (VDD, GND, DATA.IN and DATA.OUT). The reliability of the elastic joints will be of utmost importance to guarantee the correct operation of the system. In this view, the biocompatible process to realize the interconnections is preferred.

4.4. Measurements and testing

The first demonstrator was shown to be fully operational for 30 days submerged in tap water. Fig. 6 depicts on the top a detail of the flexible demonstrator and on the bottom a phase of the testing in liquid environment. The magnetic field source is placed under the jar and the embedded LED is blinking.

Two versions of the second demonstrator have been realized (one sample in each of the two technologies). They were both functional right after production. The laser cut sample has failed in the meantime due to mechanical stress. A preliminary conclusion is that at least a better design of the flex-to-stretch transitions is necessary for achieving better resistance to mechanical stress. Ideas for improvement are under investigation and will be published in a separate paper. Fig. 8 depicts the two versions of the second demonstrator, with at the top the prototype realized with the “biocompatible process”. The details of the interconnection, consisting of multiple metal tracks with conductive silicone, are illustrated in the magnification (top and bottom views). At the bottom the same demonstrator realized with the “fast prototyping process” is shown. The magnifications again depict a detail of the meander and a joint between the interconnection and functional island.

Fig. 8. Demonstrators of the flexible-stretchable platform. At the top: the realization with the biocompatible process; at the bottom: the realization with the fast prototyping process. In both the realizations, the first island (left) contains an LC tank, a rectifier and a regulation stage, the second island (right) contains a μC and a LED array. In this case no data transfer is foreseen through the link but the LEDs blinking pattern is driven by the controller.

The three steps realization has to be considered as a preliminary solution due to the lack of equipment at CMST laboratories. This solution was adopted to verify whether the system's functionalities were preserved under *mild* stress conditions. Further realization will be based on a single step production. The mechanical failure of such a built-in device has been studied in [31] and comes to the conclusion that a decrease of stress concentration can be achieved by gradual flex to stress transitions, mainly by avoiding sharp connection angles in the meander-pad junction. This principle has been applied to the design of the developed systems (detail of Fig. 8 (bottom)).

The wireless battery charger was tested in its PCB and flexprint realization before processing the layout in the flexible-stretchable technology. Fig. 9 depicts a testing phase of the charger. The flexprint has been cut in three parts corresponding to the different functional islands to be connected by elastic joints. For testing purposes standard copper wire was used to link the islands at this stage.

The inductive link supports a power transfer up to 200 mW, it is robust to misalignment and coil distance variation up to 10 cm. Bidirectional data transfer, with a rate fixed at 4.8 kbps, is supported during recharge cycles.

When the inductive link is absent, the battery provides power to the MCU which supplies the load. The system works as a stand-alone station, the array of LEDs display a Ready status, i.e. a blinking pattern of the 8th LED. When the inductive link is present, power to the MCU, load and battery charger is received through the inductive link. The charger starts charging the battery and the LED array displays a thermometric scale of the battery status.

Sending the "Retrieve" command results in the MCU returning two bytes through the uplink channel. The two bytes are respectively the voltage over and the current to the battery. Fig. 10 depicts the transmitted and received signals respectively on the downlink and uplink. In the top figure, the upper graph is the signal at the primary side before modulation onto the carrier; the lower graph shows the same signal after demodulation at the secondary side. Noise can be seen before and after the signal because the comparator involved in the demodulation process could not compare the signal to a previous state and hence giving a toggling output. This problem will be solved by adding a hysteresis to the comparator input.

The uplink (bottom figure) was tested using a block wave (upper graph). Here, the received signal is shown before demodulation and it represents the voltage variation across the coil L_1 (lower graph).

Fig. 9. Testing of the flexible version of the wireless battery charger. The final system consists of three islands and its implementation is in progress using in the MID technology. The first island only contains the power receiving coil, the second one the power conversion electronics and the modulation/demodulation unit, the third contains the μ C, the battery charger and the LED array.

Fig. 10. Wireless battery charger: measurements of transmitted (upper graph) and received (lower graph) data for downlink (top figure) and uplink (bottom figure). The received signal is shown before demodulation for the uplink, after demodulation for the downlink.

5. Conclusion

A stretchable-flexible technology platform for the realization of electronics circuits has been proven to be sufficiently reliable to allow the implementation of advanced systems.

Two different technologies have been tested and compared on simple demonstrators in order to evaluate the potential for integration of more advanced systems. Moisture resistance and elastic interconnections of different functional islands were proven. The design of a wireless battery charger is presented and its layout oriented towards the implementation on the stretchable-flexible technology. The system was tested in its flexible realization and the prototype is now in its final production step using the target technology. Robustness of the inductive link, charging of the battery and bidirectional data communication on a flex-and-stretch print realization for integration in clothes, have been demonstrated. The link can provide power up to a maximal distance of ~ 10 cm and up to a maximum of 200 mW. A bidirectional data transfer at a fixed rate of 4.8 kbps is guaranteed during the battery recharge.

The system functionality was tested with an integrated micro-controller. Future implementations of this system will involve the integration of sensors, to monitor biomedical parameters such as heart beat, temperature, humidity and respiration rate.

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