



Swansea University
Prifysgol Abertawe



Flexipower: A Printed RF Energy Harvesting System

ActInPak

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Welsh Centre for Printing and Coating
WCPC
Canolfan Argraffu a Chaeu Cymru

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FLEXIPOWER Aims



Flexipower aims to produce an entirely printed radio frequency (RF) energy harvesting system.

- This will enable the creation of fully printed electronic systems without the need for batteries or external wiring.
- Can create hybrid devices with conventional electronic components such as low power microcontrollers and LEDs to turn printed sensors and circuits into full products with visual feedback.



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Potential Applications



- Smart Packaging
- Counterfeit Detection
- Healthcare
- Building Monitoring
- Wearable Sensors
- Data Logging



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Example: Short range smart bandage



A printed bio-sensor could be incorporated into a bandage to identify the early stages of infection

- Sensor can be monitored wirelessly through the bandage
- Reduced number of unnecessary dressing changes
- Ability to assess wound status at home without removing the dressing



Hybrid Example: LED Display



A printed antenna can be used as the power source for one or more conventional LEDs

- The LEDs will light when an RFID reader/Smartphone is brought within 5cm of the antenna
- The substrate remains thin and flexible and does not require a conventional Printed Circuit Board (PCB)
- The use of transparent conductive inks and dielectrics is being investigated (Transparency 92-100%). The printed system could be made essentially invisible



Video 1

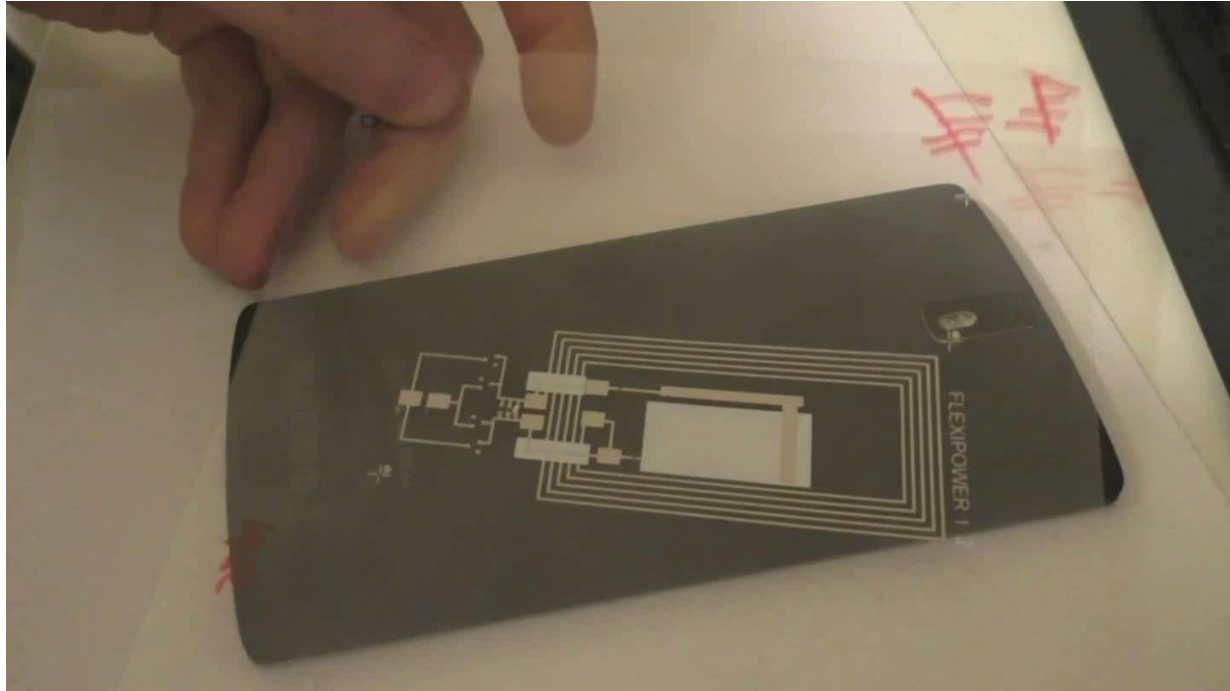


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Video 2



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Example: Wireless thermometer



Monitoring temperature at multiple points can allow smarter temperature control.

- A single transmitter in a room can power multiple sensors
- Multiple temperature monitors results in more accurate model of the room temperature can be determined
- Avoids costly permanent wiring and can be easily moved to suit the user
- Various other sensor types could also be included: eg Humidity or Gas sensors



Required components



Transmission Side:

- Ambient RF Source
- RF generator

Receiver (Printed) Side:

- Antenna
- Rectifier
- Energy Storage
- Filter



Why Frequency Matters



Short range applications can use standard 13.56MHz frequency used by RFID. Limited range is unsuitable for some applications.

Long range applications can use high frequency bands such as 433MHz, 900MHz or 2.4GHz (or higher) depending on the region and amount of power required. Higher frequencies are more challenging to rectify and push the capabilities of printed diodes, and increased range reduces the amount of available power.



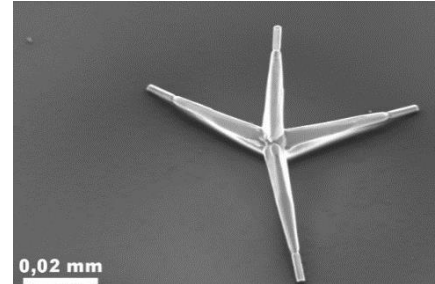
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Printed Diode Technologies



Even at 13.56MHz organic diodes are pushed beyond their comfort zone.



Zinc Oxide Diodes:

- 1-2 orders of magnitude higher electron mobility than organic diodes
- Does not decay when exposed to air.
- Difficult to print using traditional printing techniques due to pinholes and shorts
- Tetrapod structured crystals can be printed within an insulating binder

Doped Silicon Diodes:

- Very high mobility
- Does not decay when exposed to air.
- Tough to process material into an ink
- Demonstrated to work at 1.6GHz

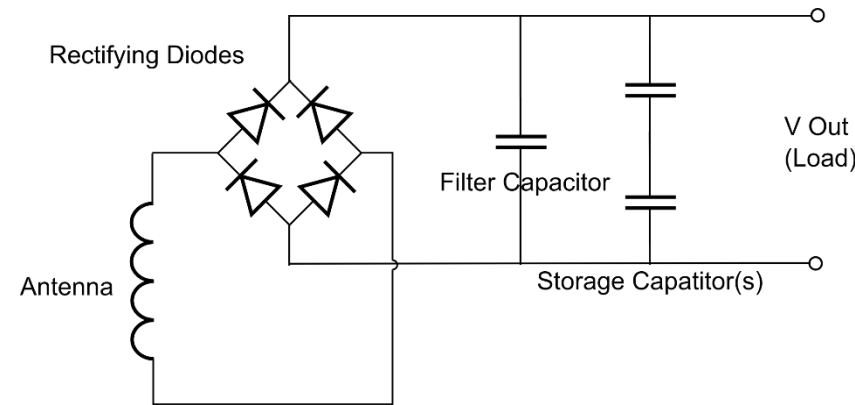


Rectifier Development



Diodes can be formed into either a half-wave or full-wave configuration. Determine best approach experimentally.

A filtered full-wave rectifier would be able to directly power printed electronic devices.

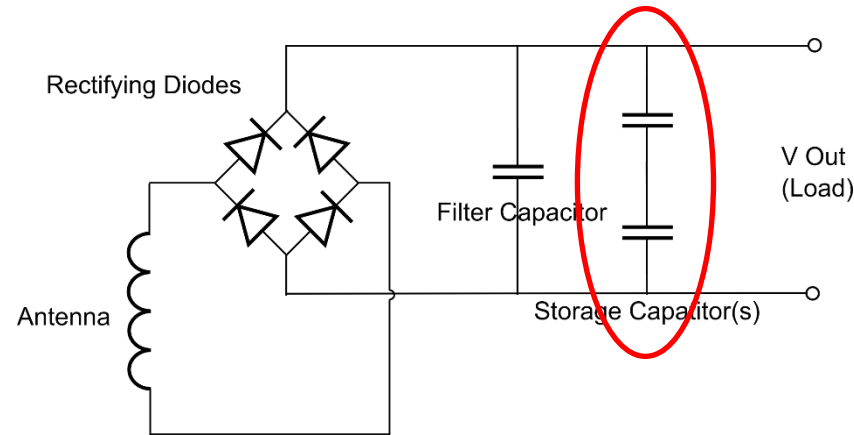


Energy Storage



The WCPC has created supercapacitors based on a water electrolyte.

These capacitors are safe to be consumed if printed on a rice paper substrate.

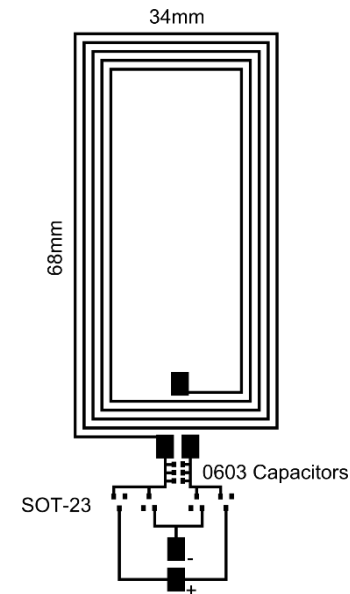
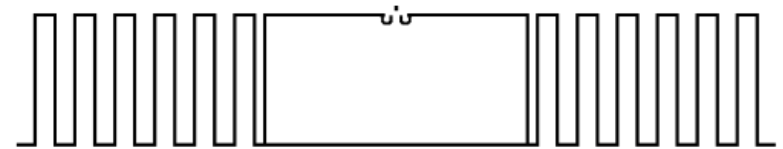


Supports Alternate Antenna Designs



Antenna design depends on the frequency, but will be tuneable to a small degree by having an adjustable capacitance.

Other designs will be required for each of the desired frequencies: 13.56MHz, 433MHz, 900MHz



Hybrid System



Hybrid systems can be formed with conventional silicon chips but printable antennas and energy storage.

- Printed components act as a low cost and flexible platform
- Chip provides complex functionality that is currently impossible in printed electronics

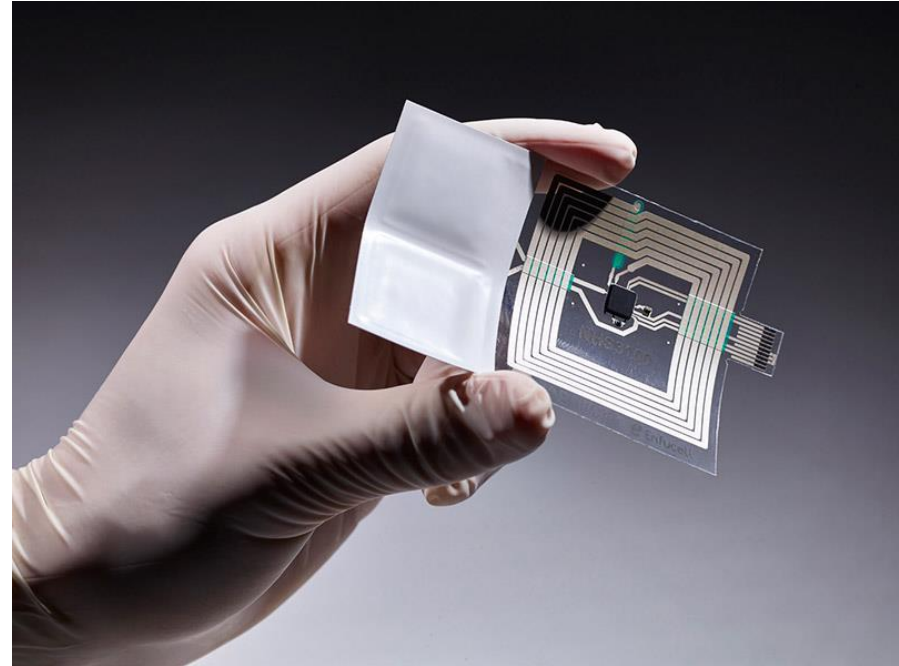


Image Credit: Quad Industries



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Summary



- Creation of a variety of diodes is underway and will form the basis of the harvesting system
- A high frequency rectifier would have applications in a wide range of devices including piezoelectric harvesters.
- A survey of the printed electronics community suggests there is significant demand for low power (1mW) low cost devices with a range of up to 1m.



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Acknowledgements and Questions



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Any questions?



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Thank You For Listening



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