University of Glasgow

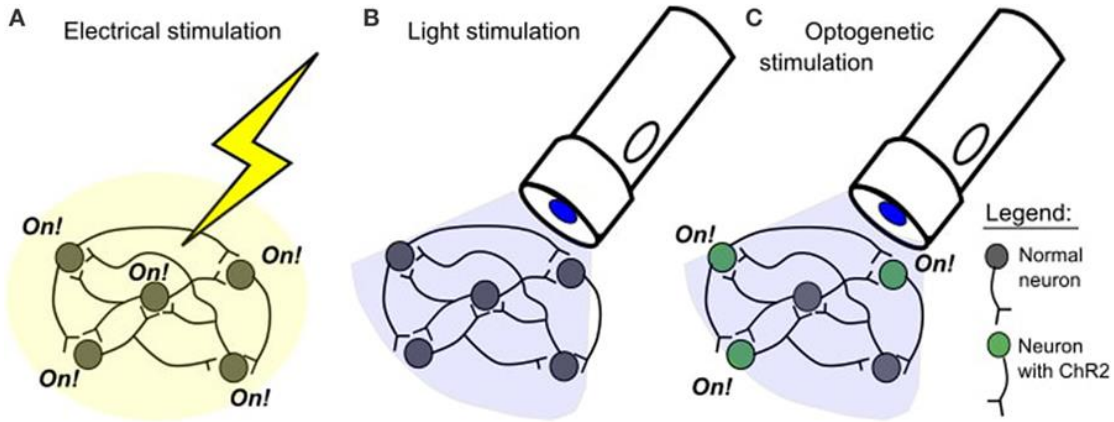
IMPLANTABLE MICROELECTRONIC DEVICE:

DESIGN AND TEST OF MICROELECTRONIC DEVICE FOR OPTOGENETIC APPLICATIONS

1. OVERVIEW OF THE PROJECT

Purpose of the project

- Wireless Power Supply
- Microelectronic Device
- Optogenetics Technique



Lim, D. H., & LeDue, J. (2017) *What Is Optogenetics and How Can We Use It to Discover More About the Brain?*. Frontiers for young minds.

Restrictions

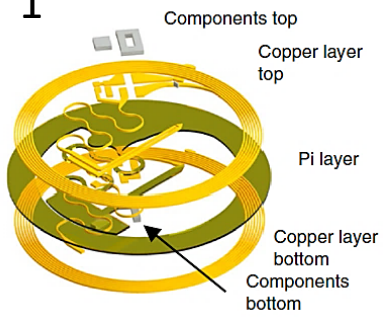
Low power device (Just to supply a LED)	**Wireless Power** (Magnetic coupling power harvesting)	**Flexible substrate** (must be adaptable to the Surface)	**Biocompatibility** (encapsulation is crutial)

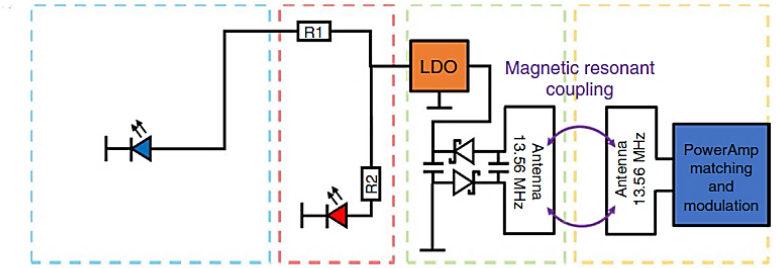
2. PREVIOUS SIMILAR WORKS

John Rogers' Research Group → Different designs from the most simple to "higher" complexity.

In their work *Fully implantable optoelectronic systems for battery-free, multimodal operation in neuroscience research* (2018) in *Nature Electronics:*

1





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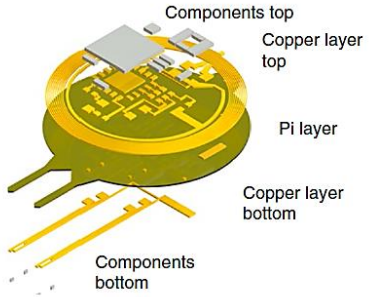

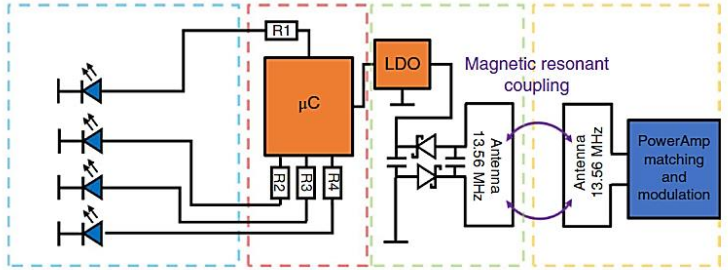

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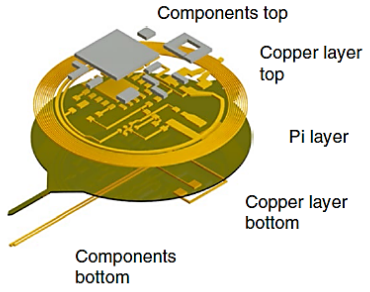

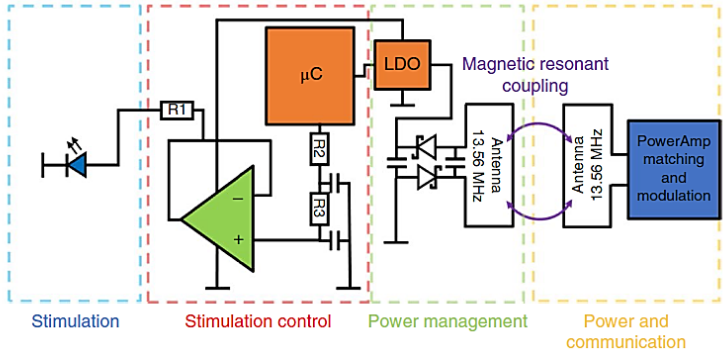

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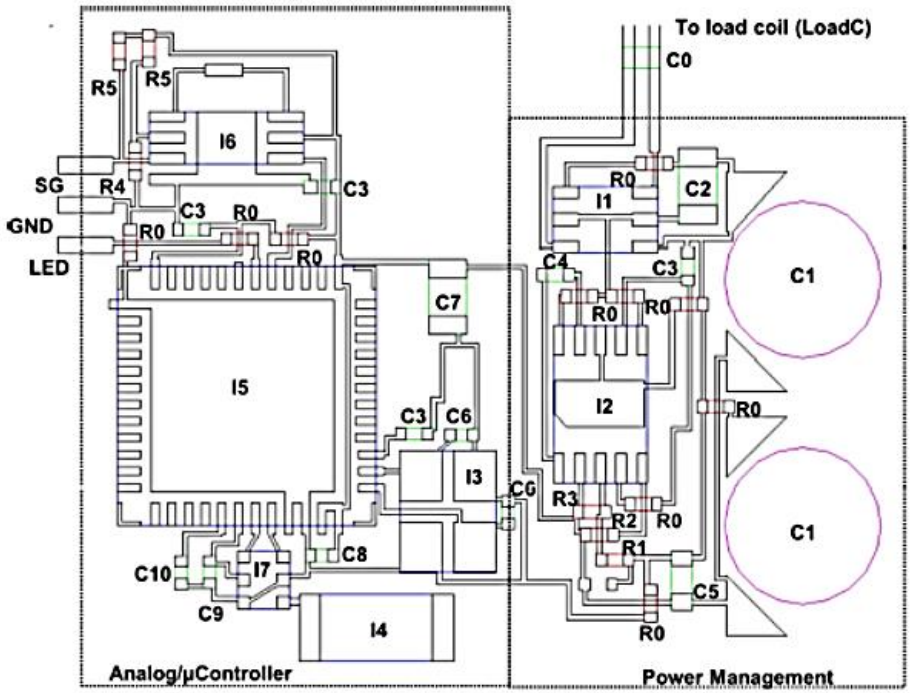

	Component	Product number
C0	86.5 pF	WCAP-CSGP 0402
C1	80 mF	XH414HG-IV01E
C2	1 µF	GRM033R71E102KA01J
C3	0.1 µF	CL03A104K03NNNC
C4	1 µF	CL03A105MP3ZSNH
C5	10 µF	CL05A106MP5NUNC
C6	12 pF	GRM0335C1E120GA01D
C7	47 µF	GRM188R60J476ME150
C8	10 pF	GRM033R71E102KA01J
C9	2.2 nF	GRM033R71A222KA01D
C10	47 nF	GRM033C80J473KE19D
R0	0 Ω	RC0603J000CS
R1	40.2 kΩ	RC0201FR-0740K2L
R2	220 kΩ	ERJ-1GEF2203C
R3	68 kΩ	ERJ-1GEF6802C
R4	22 kΩ	RC0201FR-0722KL
R5	1 MΩ	RC0201FR-071ML
I1	Schottky Diode	BAS40XY, 115
I2	DC Converter	LTC3255
I3	Crystal	CX2520DB16000D0WZRC1
I4	Antenna	2450AT18A100E
I5	Microcontroller	NRF51822
I6	Amplifier	INA333AIDGKR
I7	Balun	2450BM14E0003T

Mickle, A. D., Won, S. M., … Rogers, J.(2019*). A wireless closed-loop system for optogenetic peripheral neuromodulation*. Nature, 565(7739), 361.

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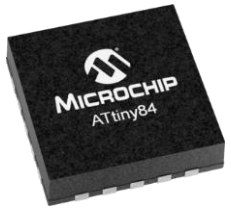
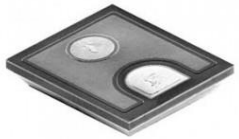
Technical Features

- **Substrate**: Pyralux AP8535R, a flexible substrate for bioimplantable devices.
- Microcontroler (μC): **ATtiny84(Atmel)** → many documentation available.
- LDO: **NCP161 ON semiconductor** → Good specs. for low power device.
- Cree® TR2227™ LEDs→ 3.15 V and 20mA.
- Other passive components: 0201 and 0402 package size.





Possible Problems

- Accesibility to the μC: just once before the surgery.
- Temperature of the implant due to the μC performance.
- Biocompatibility problema when adding a μC in an implant (soldering components, resins, etc)

2. PREVIOUS SIMILAR WORKS

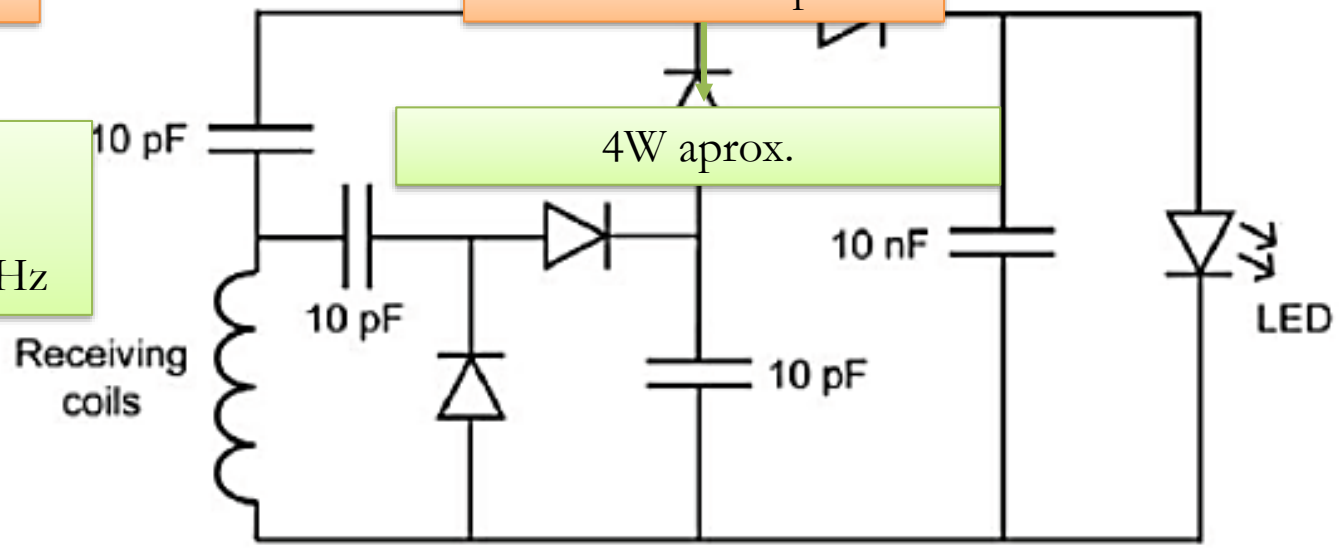
Ada Poon' Research Group → Simple design with a magnetic coupling.

Magnetic Coupling

Three turn coil
SMD capacitor (4 pF)
Resonant frequency1.5GHz

Power consumption

4W aprox.



Ho, J. S., Tanabe, Y., Iyer, S. M., Christensen, A. J., Grosenick, L., Deisseroth, K., ... & Poon, A. S. (2015). *Self-tracking energy transfer for neural stimulation in untethered mice. Physical Review Applied*, *4*(2), 024001.

2. PREVIOUS SIMILAR WORKS

Ada Poon' Research Group → Simple design with a magnetic coupling.

Technical Features

- Magnetic Coupling: Three turn coil with SMD capacitor (4pF) and resonant frequency of 1.5GHz.
- Power consumption: approximately 4W.

Possible Problems

- Designed for only 1 or more leds working at the same pulse.
- No control structure implemented.
- Usage of non biocompatible-flexible substrate.

3. IDEAS FOR IMPROVEMENT

Problems found

- Using a **microcontroller inside the brain** increases the size of the implant so far.
- For more that one μILED they used a μC → What about using different frequencies for powering different μILEDS?
- Fixed antenna with helmet or subdermal implant on the patient.
- Poon's device → improve substrate, technical characteristics (Using CREE LED) and improving the power management on the circuit (Light intensity of the LE, temperature, power consumption, etc).