Supplementary Files –

1. Supplementary Table 1: Experiment Statistics

	LED driver active (experimental condition)				LED driver diabled (control condition)	
	Animal # 658		Animal # 2483		Animal # 2483	
Trial #	Pre-stimulus*	Stimulus*	Pre-stimulus	Stimulus	Pre-stimulus*	Stimulus*
1	0.5	2.25	0.25	1.5	.25	.25
2	0.0	1.5	0	1.75	.5	.25
3	0.5	1.75	-0.5	1.5	0	0
4	0.5	1.5	0.25	1.5	.25	.5
5	0.25	1.5			.25	0
Mean	0.35	1.70	0	1.75	.25	.2
Std. Dev.	0.22	0.33	0.35	0.13	.088	.10
Student's T-test	P = 0.0004		P = 0.0036		P = .6213	
Student's T-test, combined data	P = 0.00000024					

*indicates animal rotations per 30 second interval (positive is counter-clockwise direction)

2. Circuit Schematics – High Resolution PDF schematics follow this document.

    Supplementary Figure 1: Motherboard Module

    Supplementary Figure 2: Optics Module – Single Bank Control Logic

    Supplementary Figure 3: Radio Module

3. Use of Software

Opening an experiment session. The experimenter can initialize the wireless network by plugging the USB interfaced wireless base station into a PC running Windows XP or Vista (For Mac users, functionality has been also verified using a Windows XP virtual machine session using VMware Fusion in OS X v10.4 and higher) and opening a Hyperterminal session with the tether. The base station appears as a COM port on the PC; the specific port address (e.g. COM3) will vary from machine to machine, but may be found by navigating to the Device Manager and expanding the "Ports (COM & LPT)" tab (in Windows XP, Control Panel -> System -> Hardware -> Device Manager). When recognized by the computer, the base station will appear as "MSP430 Application UART." With the COM port identified, the Hyperterminal session may be opened (using 9600 baud, 8-N-1, and no parity bit UART port control settings). These parameters can be saved as a pre-configured Hyperterminal session to ease future setup.

Running the Experiment. Once the Hyperterminal session is opened, the user is greeted with a splash screen outlining all of the software commands supported by the wireless system. This user interface is hosted on the base station to simplify the software needs. A simple experiment session with a remotely triggered 130 Hz, 5ms pulse train on LED1 is described below.

Typing, “Hello” will list all of the networked wireless devices in the range of the base station. All network pairing is handled behind the scenes to simplify operation. Each device is identified by a unique 4-digit hexadecimal ID tag (e.g., “CAFE”), which was assigned to the device when it was programmed and may be customized to suit the documentation protocol of the laboratory. To address a specific device, the command must be preceded by the device name (see example below).

We first select the desired output channel. “ST=1” will set the output channel to LED 1. We next set the pulse width and frequency of the selected channel. “PW=x” will set the pulse width of stimulation to x milliseconds. “FR=x” sets the pulse frequency to x Hz. With these parameters sent, the stimulation engine on the remote device is now set, and the device can be toggled on/off with user commands (“GO” and “STOP”). The device is now in active transmit/receive mode, so the latency between the user’s requesting a pulse train and the start of the train on the remote device is <1ms.

Sample Hyperterminal Session:

=> Hello

“Networked Devices Found: CAFE”

=> CAFE ST=1

“Device CAFE channel 1 initialized”

=> CAFE 1 PW=5

"Device CAFE channel 1 pulse width set to 5 ms"

=> CAFE 1 FR=130

"Device CAFE channel 1 frequency set to 130 Hz"

=> CAFE 1 GO

"Device CAFE channel 1 active"

=> CAFE 1 STOP

"Device CAFE channel 1 stopped"

Remote Device Control: User Commands

Hello – returns the IDs of all networked headborne devices.

ST – selects the LED channel to be programmed (must be preceded by device ID)

PW – sets the pulse width in milliseconds of the stimulation waveform (preceded by ID and channel)

FR – sets the frequency of the stimulation waveform in Hz (preceded by ID and channel)

GO – toggles stimulation waveform on (must be preceded by device ID and channel number, e.g. "CAFE 1 GO")

STOP – toggles stimulation waveform off (must be preceded by device ID and channel number, e.g. "CAFE 1 STOP")

SLEEP – sends the target device into idle mode for a period of time, in seconds. Note that this command will result in shutdown of the radio chipset! Upon elapse of the sleep period, the device will wake up, initialize the radio and reconnect to the network. (must be preceded by device ID)

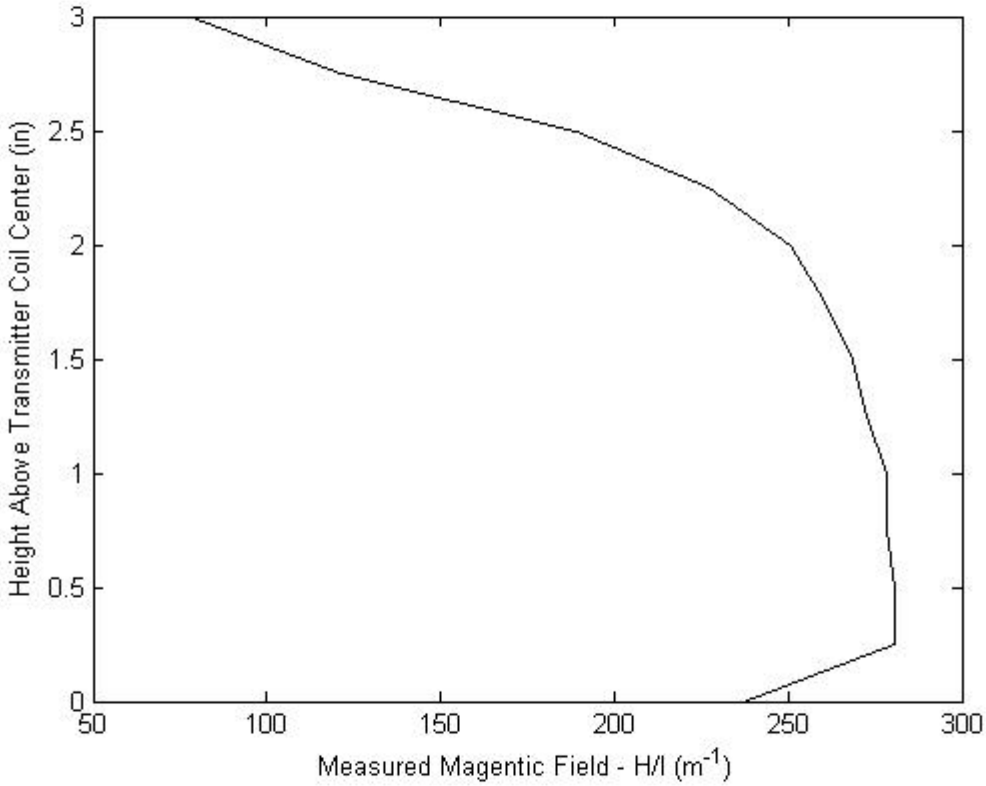
MATLAB scripting of experiment sessions: If precise temporal control of waveform toggle, generation of complex waveforms , or automated experiment sessions for high-throughput use is desired, a control script can be implemented in MATLAB (Mathworks) or any number of alternative open source languages featuring I/O port control, (e.g. Python). For detailed descriptions and modifications required to support Mac or Linux operation, see the Mathworks support page, here.

All commands described above are interpreted by the USB base station identically, whether through Hyperterminal or any other COM port interface. One simply initializes the COM port according to the command below, and then may proceed as described above using the wireless system's native command set. Pre-written m-files can then run autonomous experiment sessions of substantial complexity.

```
port = serial ('com1', 'BaudRate', 9600, 'Parity', 'none', 'DataBits', 8, 'StopBits', 1);
```

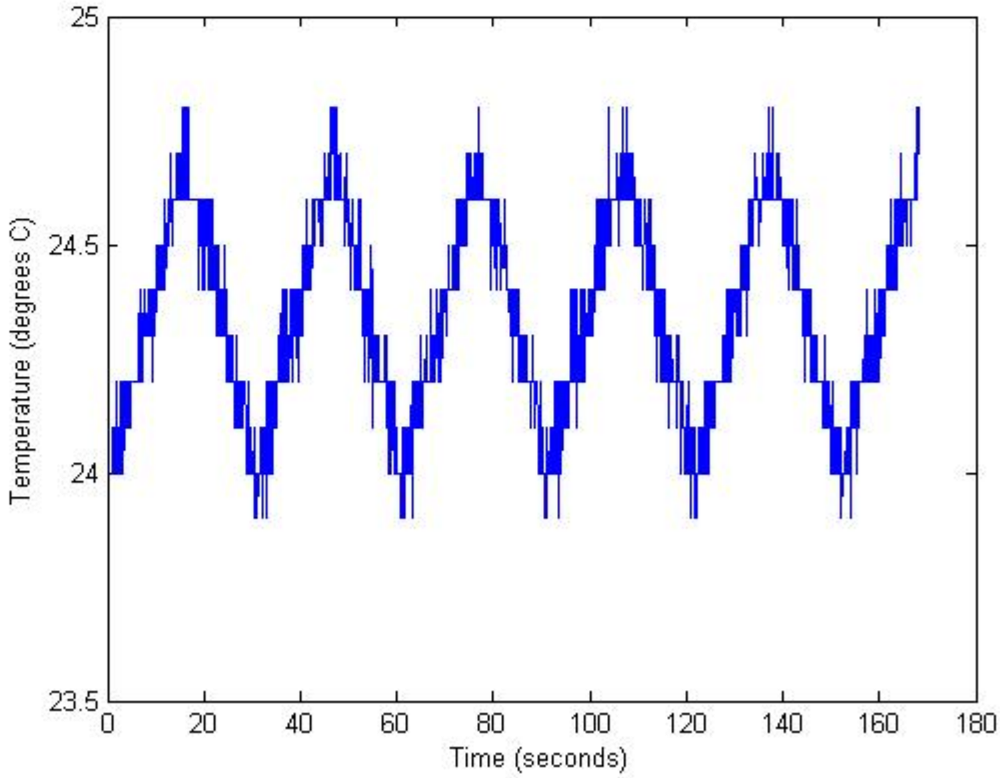
Note: Be sure to set 'com1' to the appropriate port name.

4. Measurement of power transmitter's magnetic field strength

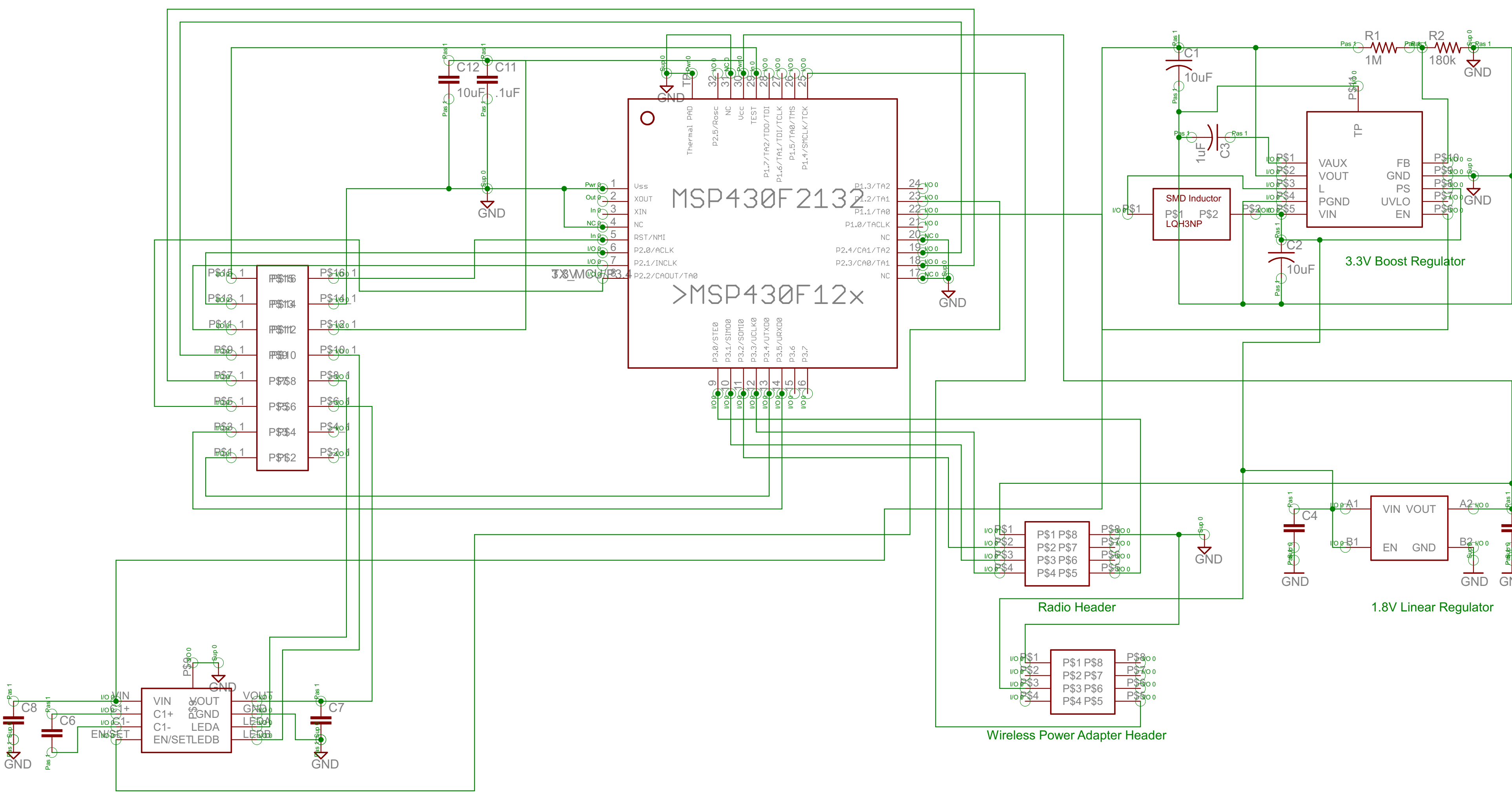


Supplementary Figure 4: Power Transmitter Magnetic Field Strength. Magnetic Field M produced by power transmitter coil per Ampere's law is measured about the vertical axis (coming out of the power transmitter coil, perpendicular to the cage floor), as described in Methods and field strength is plotted as a function of distance above the power transmitter coil. Note the convention of unit H/I, where I=5A is the DC current inside the transmit coil.

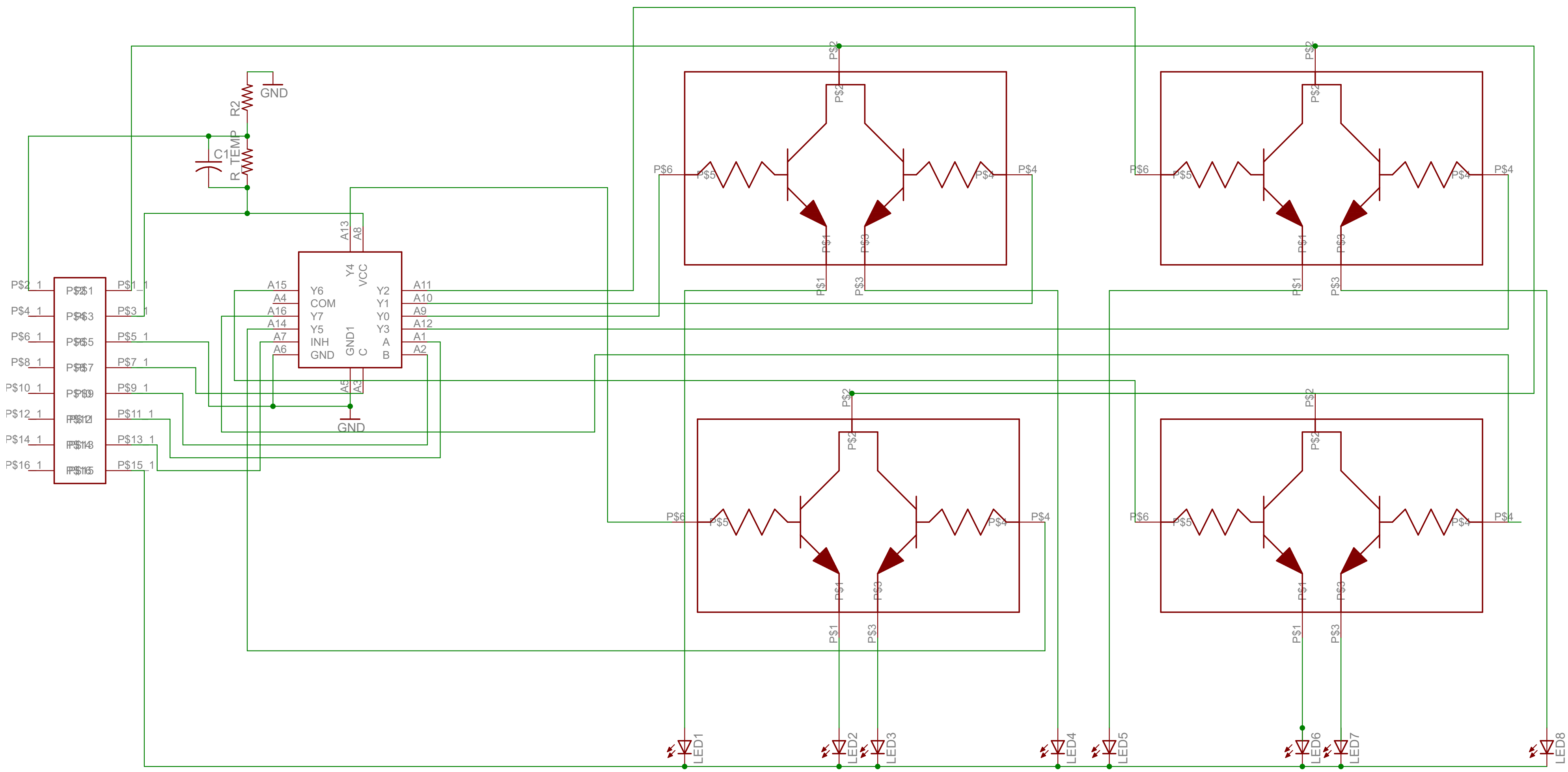
5. Measurement of Optics Module – Skull Interface Temperature Under LED Operation

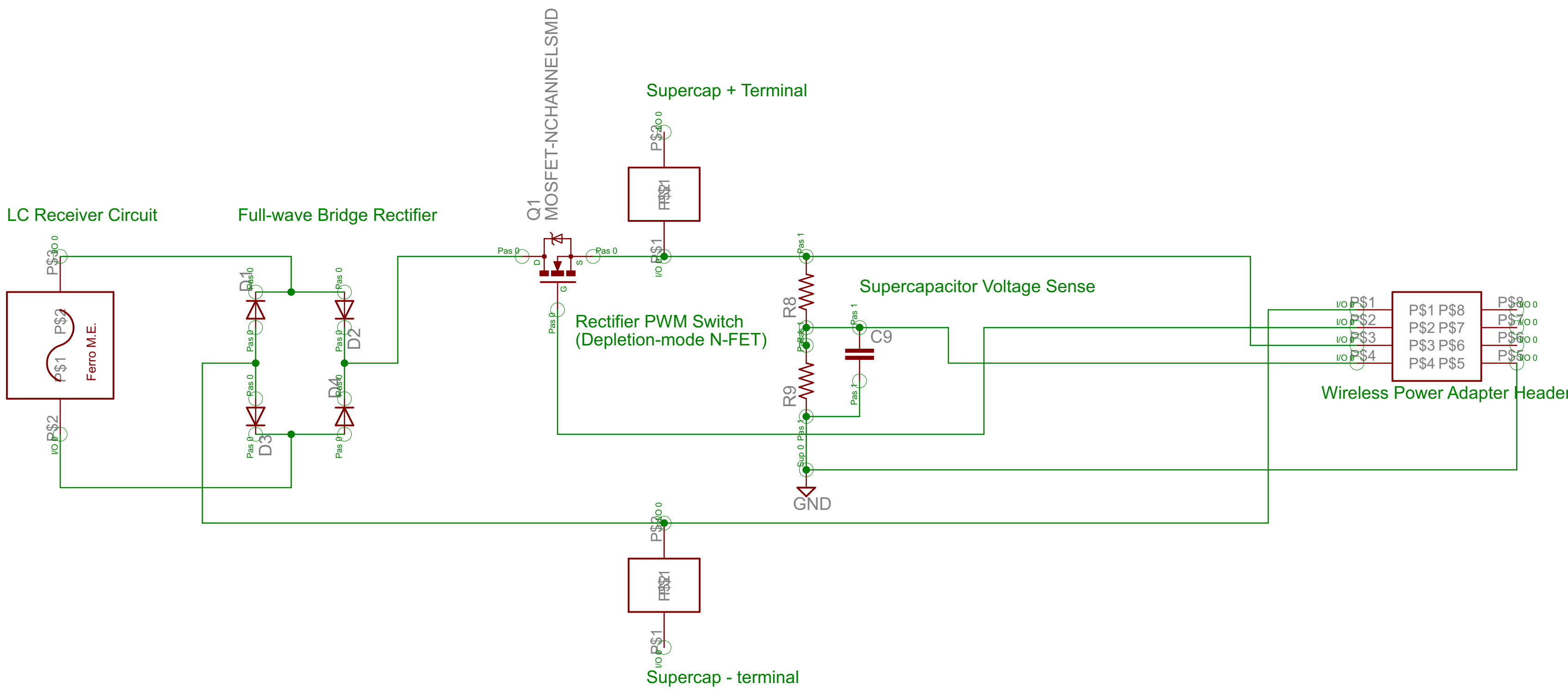


Supplementary Figure 5: Optics module steady-state operating temperature. Temperature of optics module thermal sink (LED-side) was measured as described in Methods. Supp. Fig. 5 shows steady state thermal profile of the optics modules used in actual behavioral experiments, under bench testing with a 15 second on / 15 second off pulse train of 30 Hz, 50% duty cycle operation using a lightweight 1 gram heat sink.



MSP430F2132
>MSP430F12x
TX_MCU_P3.4
Vss
XOUT
XIN
NC
RST/NMI
P2.0/ACLK
P2.1/INCLK
P2.2/CAOUT/TA0
Thermal PAD
P2.5/Rosc
Vcc
TEST
P1.7/TA2/TDO/TDI
P1.6/TA1/TDI/TCLK
P1.5/TA0/TMS
P1.4/SMCLK/TCK
P1.3/TA2
P1.2/TA1
P1.1/TA0
P1.0/TACLK
P2.4/CA1/TA2
P2.3/CA0/TA1
P3.0/STE0
P3.1/SIMO0
P3.2/SOMI0
P3.3/UCLK0
P3.4/UTXD0
P3.5/URXD0
P3.6
P3.7
C12
10uF
C11
.1uF
GND
C1
10uF
C3
1uF
C2
10uF
R1
1M
R2
180k
SMD Inductor
LQH3NP
VAUX
VOUT
L
PGND
VIN
FB
GND
PS
UVLO
EN
TP
3.3V Boost Regulator
C4
C5
VIN VOUT
EN GND
A1
B1
A2
B2
1.8V Linear Regulator
Radio Header
Wireless Power Adapter Header
C8
C6
C7
VIN
C1+
C1-
EN/SETLEDB
VOUT
GND
LEDA
LEDB


GND
R2
R_TEMP
C1
A13
A8
Y4
VCC
Y6
COM
Y7
Y5
INH
GND
Y2
Y1
Y0
Y3
A
B
GND1
C
A15
A4
A16
A14
A7
A6
A11
A10
A9
A12
A1
A2
A5
A3
GND
P$2_1
P$4_1
P$6_1
P$8_1
P$10_1
P$12_1
P$14_1
P$16_1
P$1_1
P$3_1
P$5_1
P$7_1
P$9_1
P$11_1
P$13_1
P$15_1
P$1
P$2
P$3
P$4
P$5
P$6
LED1
LED2
LED3
LED4
LED5
LED6
LED7
LED8



LC Receiver Circuit
Full-wave Bridge Rectifier
Q1
MOSFET-NCHANNELSMD
Supercap + Terminal
Rectifier PWM Switch
(Depletion-mode N-FET)
Supercapacitor Voltage Sense
Wireless Power Adapter Header
Ferro M.E.
D1
D2
D3
D4
R8
R9
C9
GND
P$1 P$8
P$2 P$7
P$3 P$6
P$4 P$5
Supercap - terminal