HappyGem (v1.0)

Notes

Microcontroller / Transceiver

The ATmega128RF microcontroller with integrated IEEE 802.15.4 transceiver was used because we were familiar with the AVR microntrollers, and because it's their only µC with an integrated transceiver.

An integrated module with chip antenna, crystals and shielding was used: the deRFmega128 by Dresden Elektronik. The reason is that when making more than a few devices, an FCC or CE license is required if the device has intentional radiators. Getting an FCC/CE license for a device can be quite expensive, so for small runs a licensed module can be a better option.

Unfortunately, the range achieved by this design was a lot shorter than what was achieved with the PCB antenna in the prototype. I don't know if this is because the chip antenna has worse performance, or because I have too many PCB traces close to the

JTAG

A custom JTAG connector was used. Since only 7 of the pins on the standard 10-pin JTAG connector is required for programming/ debugging, I figured we could save some space. A single-row 8-pin connector was used. The extra pin is used for the USART for printing debug information.

An adaptor was made to connect the HappyGem to a standard JTAG debugger.

LED drivers

A 16 channel PWM LED driver was used. This allows the brightness of each LED to be controlled precisely. The LED driver is capable of controlling each channel with 4096 or 65536 steps (12 or 16 bit).

To save on cost and reduce the number of PCB traces, each channel on the LED driver is connected to the cathode of the red, green and blue LED on each LED package. Three transistors gates power to every red, green and blue LED. By shining all red LEDs for a few milliseconds, followed by all blue LEDs and all green LEDs, we can display all colors of the rainbow through persistence of vision. In other words, we can control 48 LEDs with one 16 channel LED driver.

Microphone

The microphone circuit is a simple common emitter amplifier. The inductor (or ferrite bead) L2 is intended to reduce noise on the power supply (which gets very noise when the LEDs are used).

The design does not appear to work very well. It is possible to get a usable signal from the microphone through the ADC, but it's very noisy. It's possible that it could be improved through some tweaking, but it's also possible that it will never get very good considering the amplifier gets its power from VDD, while the ADC's reference voltage is AVDD (generated by the µC).

Power supply

A variable boost regulator was used for the power supply. The output voltage is set by the voltage divider formed by the two resistors R3 and R4.

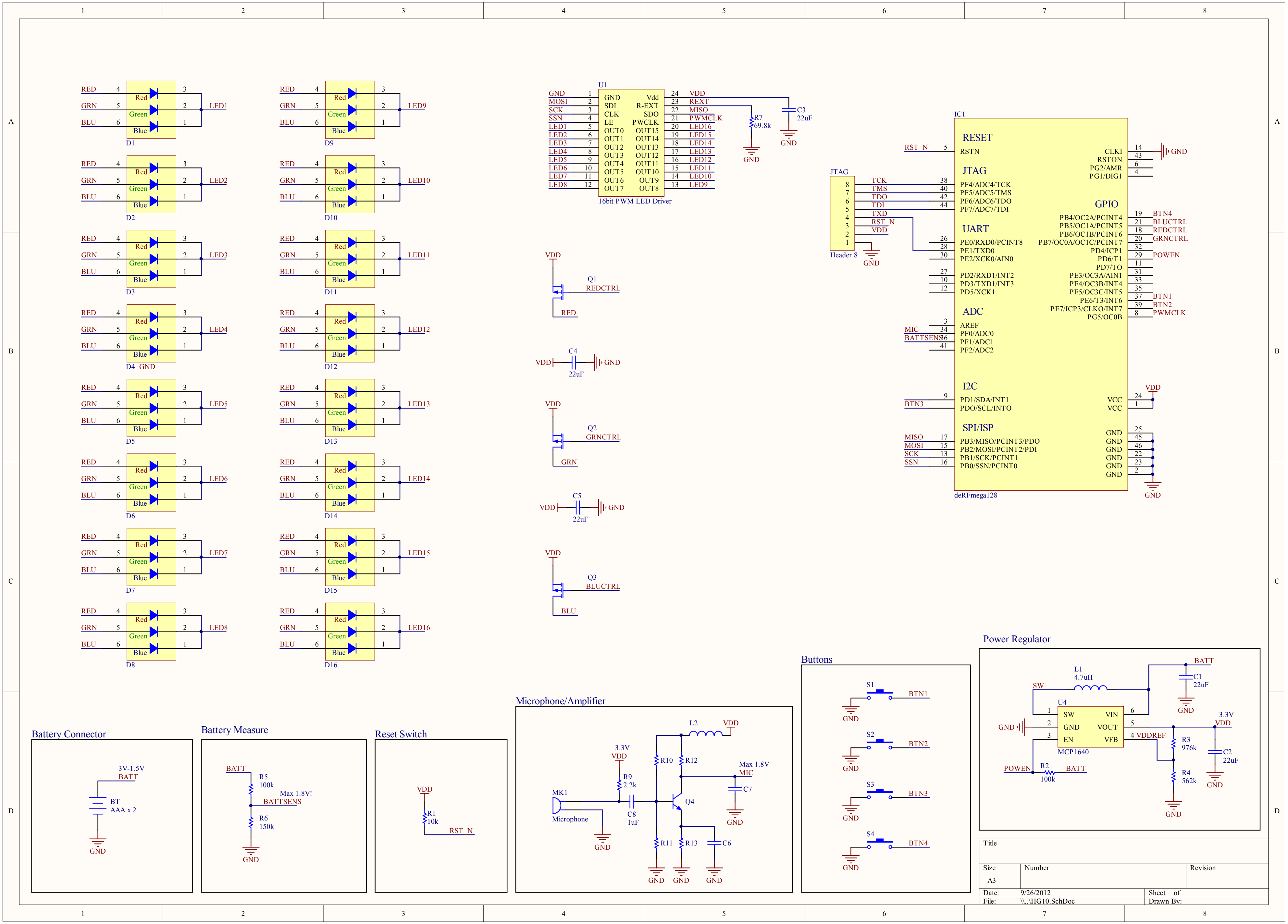
We've had some problems related to the pull-up resistor R2. For some reason the µC has under some (unknown) condition pulled down the POWEN signal during start-up, which disables the power supply. Replacing the 100k resistor indicated with a 0R has fixed this, but that makes it impossible to disable the power supply. I don't know wether this would have been useful to us. It's possible that we could save some power by shutting down the power supply when the µC goes to sleep. But we would have had to wake up quite often and enable the power supply for a while in order to avoid brown-out.

Battery measurement
To let us read the battery voltage, a voltage divider formed by the resistors R5 and R6 reduces the voltage. The maximum voltage of the two batteries should be 3V, while the maximum voltage of the ADC is 1.8V.

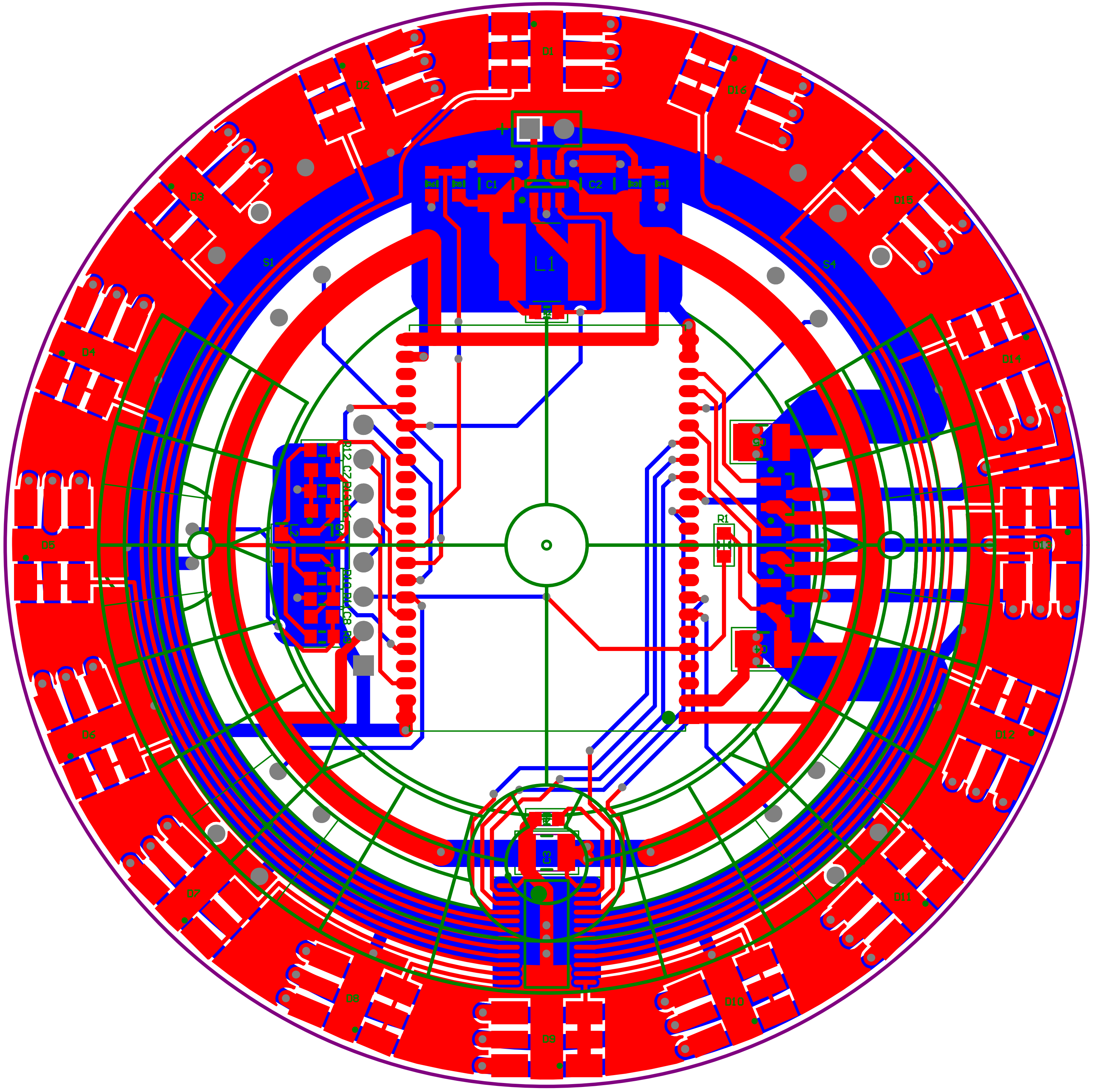
The bad thing about this design is that it's always drawing a small current from the batteries. With the values indicated in the schematic, it should be less than 12μA, but with a couple extra components we could have made it possible to shut down the voltage divider when we're not using it.

Reset
There is no reset button, but the adapted designed for the JTAG port has a reset button on it.

PCB
The PCB is two layer, to save on cost. I've avoided having a ground plane behind and near the deRFmega128 module, as specified in the user manual. But I've tried to have a small ground plane behind or near all the other components, and some of the traces.



U1
GND
SDI
CLK
LE
OUT0
OUT1
OUT2
OUT3
OUT4
OUT5
OUT6
OUT7
Vdd
R-EXT
SDO
PWCLK
OUT15
OUT14
OUT13
OUT12
OUT11
OUT10
OUT9
OUT8
16bit PWM LED Driver
R7
69.8k
C3
22uF
IC1
RESET
RSTN
JTAG
PF4/ADC4/TCK
PF5/ADC5/TMS
PF6/ADC6/TDO
PF7/ADC7/TDI
UART
PE0/RXD0/PCINT8
PE1/TXD0
PE2/XCK0/AIN0
PD2/RXD1/INT2
PD3/TXD1/INT3
PD5/XCK1
ADC
AREF
PF0/ADC0
PF1/ADC1
PF2/ADC2
I2C
PD1/SDA/INT1
PDO/SCL/INTO
SPI/ISP
PB3/MISO/PCINT3/PDO
PB2/MOSI/PCINT2/PDI
PB1/SCK/PCINT1
PB0/SSN/PCINT0
CLKI
RSTON
PG2/AMR
PG1/DIG1
GPIO
PB4/OC2A/PCINT4
PB5/OC1A/PCINT5
PB6/OC1B/PCINT6
PB7/OC0A/OC1C/PCINT7
PD4/ICP1
PD6/T1
PD7/TO
PE3/OC3A/AIN1
PE4/OC3B/INT4
PE5/OC3C/INT5
PE6/T3/INT6
PE7/ICP3/CLKO/INT7
PG5/OC0B
VCC
GND
deRFmega128
JTAG
Header 8
Q1
REDCTRL
Q2
GRNCTRL
Q3
BLUCTRL
C4
22uF
C5
22uF
Battery Connector
3V-1.5V
BATT
BT
AAA x 2
Battery Measure
R5
100k
Max 1.8V!
BATTSENS
R6
150k
Reset Switch
R1
10k
RST_N
Microphone/Amplifier
MK1
Microphone
R9
2.2k
C8
1uF
L2
Max 1.8V
MIC
Buttons
S1
BTN1
S2
BTN2
S3
BTN3
S4
BTN4
Power Regulator
L1
4.7uH
U4
SW
GND
EN
VIN
VOUT
VFB
MCP1640
C1
22uF
R3
976k
R4
562k
C2
22uF
R2
100k
POWEN
VDDREF
Title
Size
A3
Number
Revision
Date:
9/26/2012
Sheet of
File:
\\..\HG10.SchDoc
Drawn By:



	Qty	Part	Des.	Description	URL	Price (1)	Total
	1	deRFmega128-22C00	IC1	uC/RF/Antenna Module	http://www.digikey.com/product	$26.41	$26.41
	1	MCP1640BT-I/CHYCT-ND	U4	Var. volt reg.	http://search.digikey.com/us/en/	$0.70	$0.7
	1	587-2081-1-ND	L1	10uH Ind	http://search.digikey.com/scripts	$0.40	$0.4
	5	587-1356-1-ND	C*	22uF 1206 Cap	http://search.digikey.com/us/en/	$0.35	$1.75
	16	CLV6A-FKB-CK1P1G1BB7R3R3CT-ND	LED*	RGB LED	http://search.digikey.com/scripts	$0.75	$12
	1	497-10620-1-ND	U1	16-bit PWMLED Driver	http://search.digikey.com/us/en/	$3.00	$3
	3	DMP3098LDICT-ND	Q*	P-Channel FET	http://search.digikey.com/us/en/	$0.44	$1.32
	4	450-1649-ND	S*	Push button	http://search.digikey.com/scripts	$0.12	$0.48
	1	BC2AAAW-ND	BT	AAA Battery holder	http://search.digikey.com/us/en/	$0.94	$0.94
	1	P100KGCT-ND	R5	100k 0603 Res	http://search.digikey.com/us/en/	$0.02	$0.02
	1	P150KGCT-ND	R6	150k 0603 Res	http://search.digikey.com/us/en/	$0.02	$0.02
	1	P976KHCT-ND	R3	976k 0603 Res	http://search.digikey.com/us/en/	$0.04	$0.04
	1	P562KHCT-ND	R4	562k 0603 Res	http://search.digikey.com/us/en/	$0.04	$0.04
	1	P69.8HCT-ND	R7	69.8k 0603 Res	http://search.digikey.com/us/en/	$0.04	$0.04
						Total(1)	$47.16