Lucent Tag

Hardware Description

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2. Introduction

2.1. Prototype Design

Since prototypes are designed to quickly and imprecisely, some modules on this prototype were designed using “shortcut” modules. There are 3 instances of this on the board including the power supply, the microcontroller, and the Zigbee module. Each of these modules are system system-on-board examples of the element to simplify design. Since each of these modules is significantly more expensive (in money and board real estate) than the individual components, the end design can be assumed to be build using the required individual components. The aforementioned modules will detail the differences in components.

2.2. Board Descriptions

The two types of boards, the gun module and ref module, are two completely separate devices, but still communicate with each other via a Zigbee mesh network. These modules were designed for similarity in design. The hardware modules that are contained in each module is listed below.

2.2.1. Gun Module’s Hardware

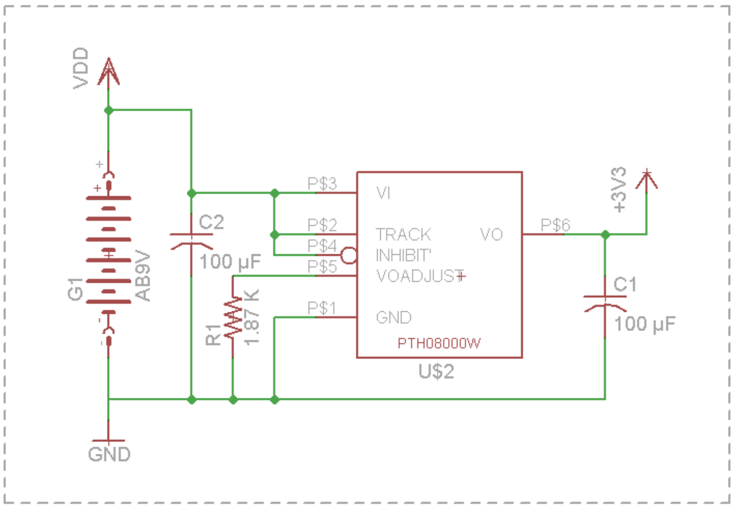
The gun module contains the power supply, KL02Z32M MCU, RTC clock circuit, IR and muzzle flash LEDs, IR Sensors, integrated sound chip, Zigbee module, and the GUI.

2.2.2. Ref Module’s Hardware

The ref module exists entirely as an interface between the gun modules and the computer, so it contains USB, UART over RS-232, Zigbee, and KL24Z32M.

3. Hardware

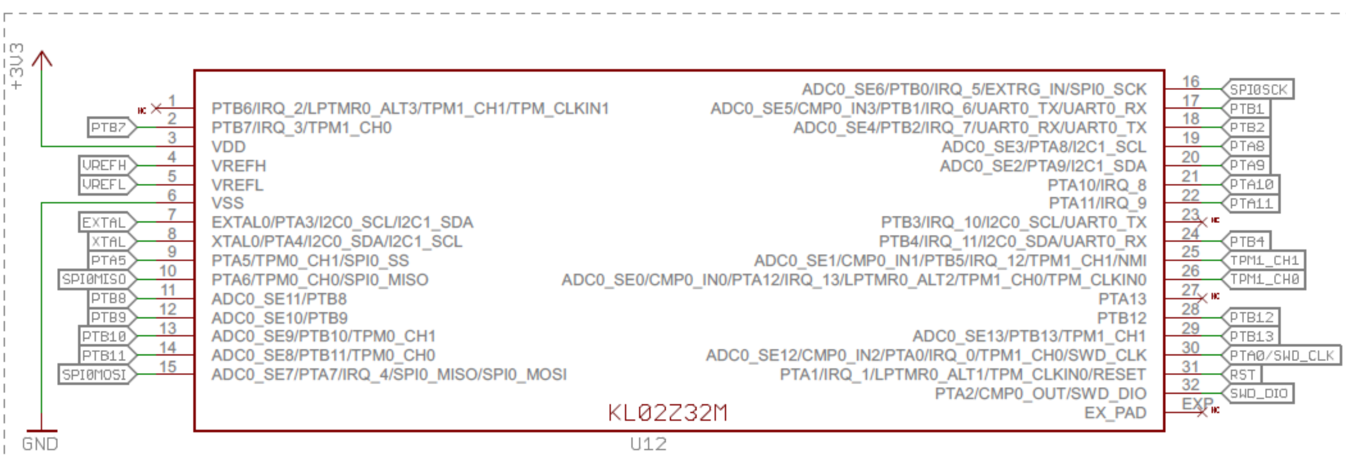
3.1. Power Supply



The power supply converts the batteries (7.2V nominal) to a 3.3V rail used by the entire system. *G1* represents the batteries used as the voltage source. This battery pack can range from 4.5V – 14V due to the PTH08000W's variable voltage input. *C2* is required by the datasheet to reduce the input ripple and must be ≥100µF. *C1* is optional, but is used to reduce the output ripple that can form from sudden current spikes (such as the IR LED switching) and should be placed close to the load. *R1* controls the output voltage, and 1.87kΩ adjusts it to 3.315V according to the datasheet.

3.2. Microcontroller

3.2.1. KL02Z32M



The microcontroller used is the KL02P32M48, which is an ARM M0+ by Freescale with 32 pins and runs at 48MHz. This controller was chosen due to its powerful architecture coupled with being very lower current, with additional low power options. The 32 pin package was necessary for all the GPIO pins required by the peripheral modules.

3.2.2. KL24Z32M

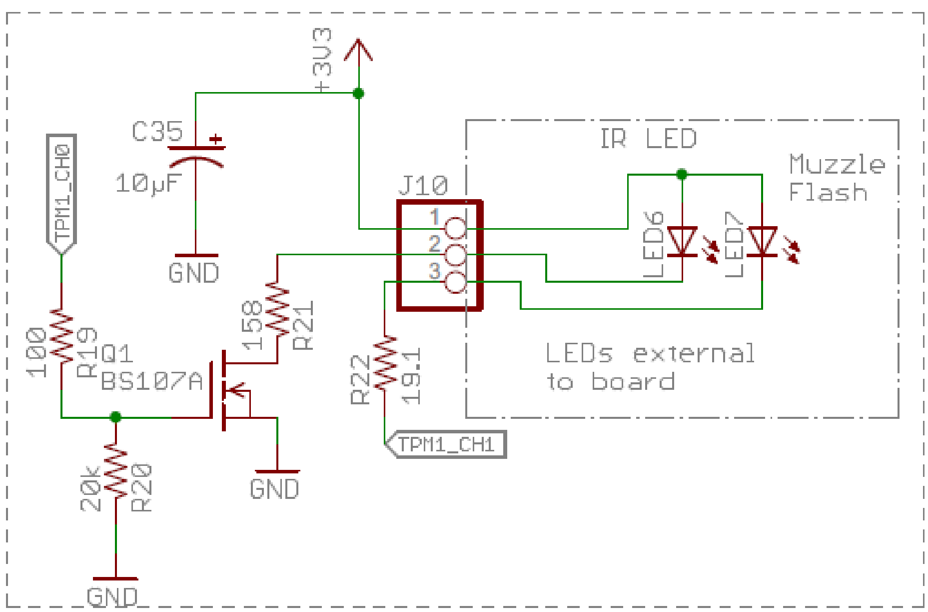
The KL24Z is nearly identical to the KL02Z except it also contains a USB that is required to communicate with a computer. An integrated voltage regulator on-chip from USB rails provide power for the whole board.

3.3. Clock Circuit

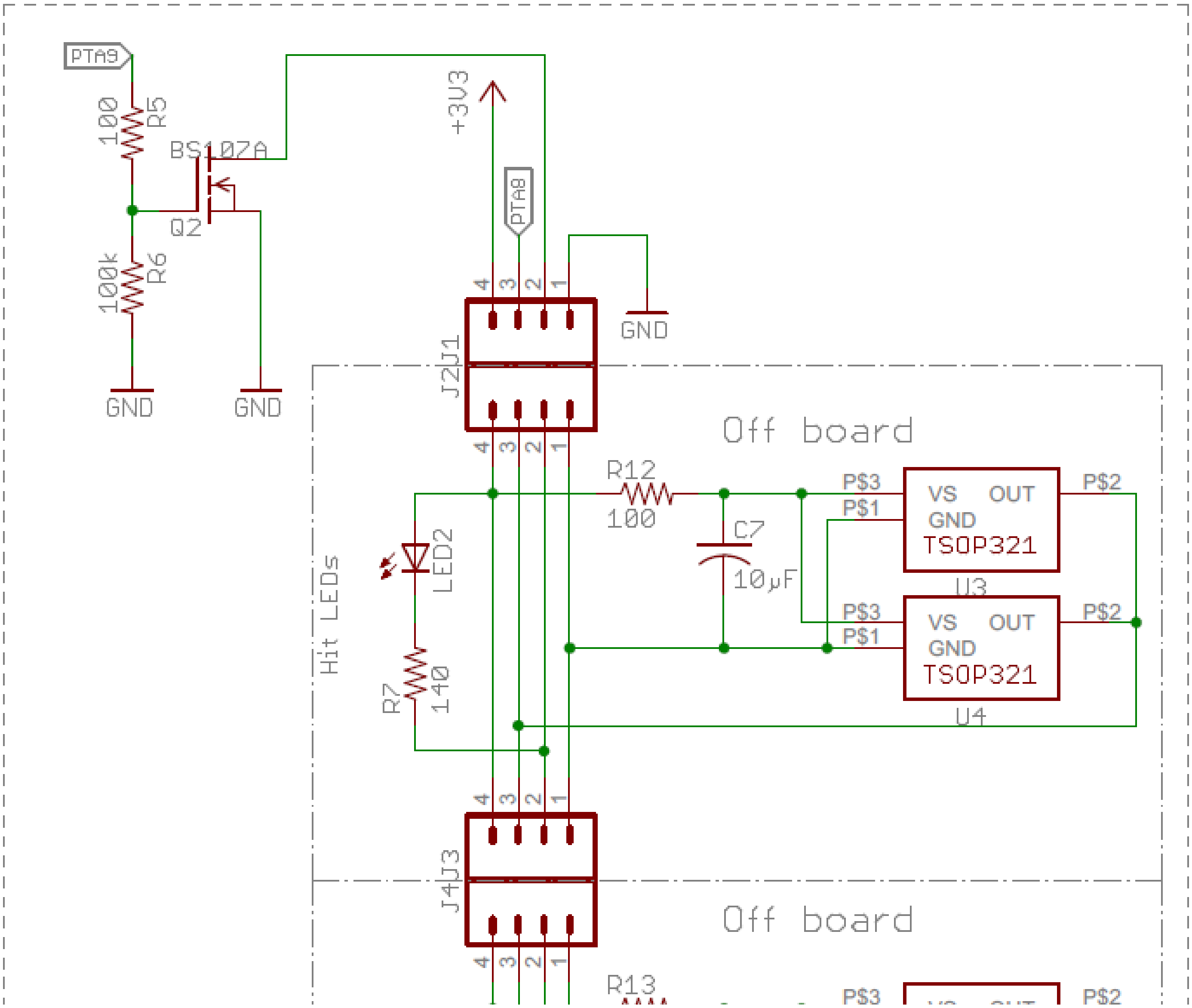
The external clock used is for the real time clock (RTC). The RTC will be useful for timing in the software.

3.4. IR and Muzzle Flash LEDs

The IR LED (TSAL6100) can pulse 200mA of current at 50% duty cycle, which is precisely how the LED will be operated. Assuming the voltage drop over the LED is 1.35V (according to datasheet) then with the 19.1Ω will allow 102mA of current to flow. This is unfortunately too much current to pass through the KL02, so the GPIO pin will switch an n-channel MOSFET to sink the current. The muzzle flash LED only uses about 15mA, assuming 1.2V voltage drop over LED. This current can be sourced by the KL02, so no transistor is required. The IR LED can use up to 200mA when pulsed at this duty cycle, and the muzzle flash LED can use a max of about 28mA at 50% duty cycle, assuming 20mA max at 100% duty cycle. Since the 2 LEDs are controlled by separate GPIO pins, the muzzle flash's brightness can be altered.

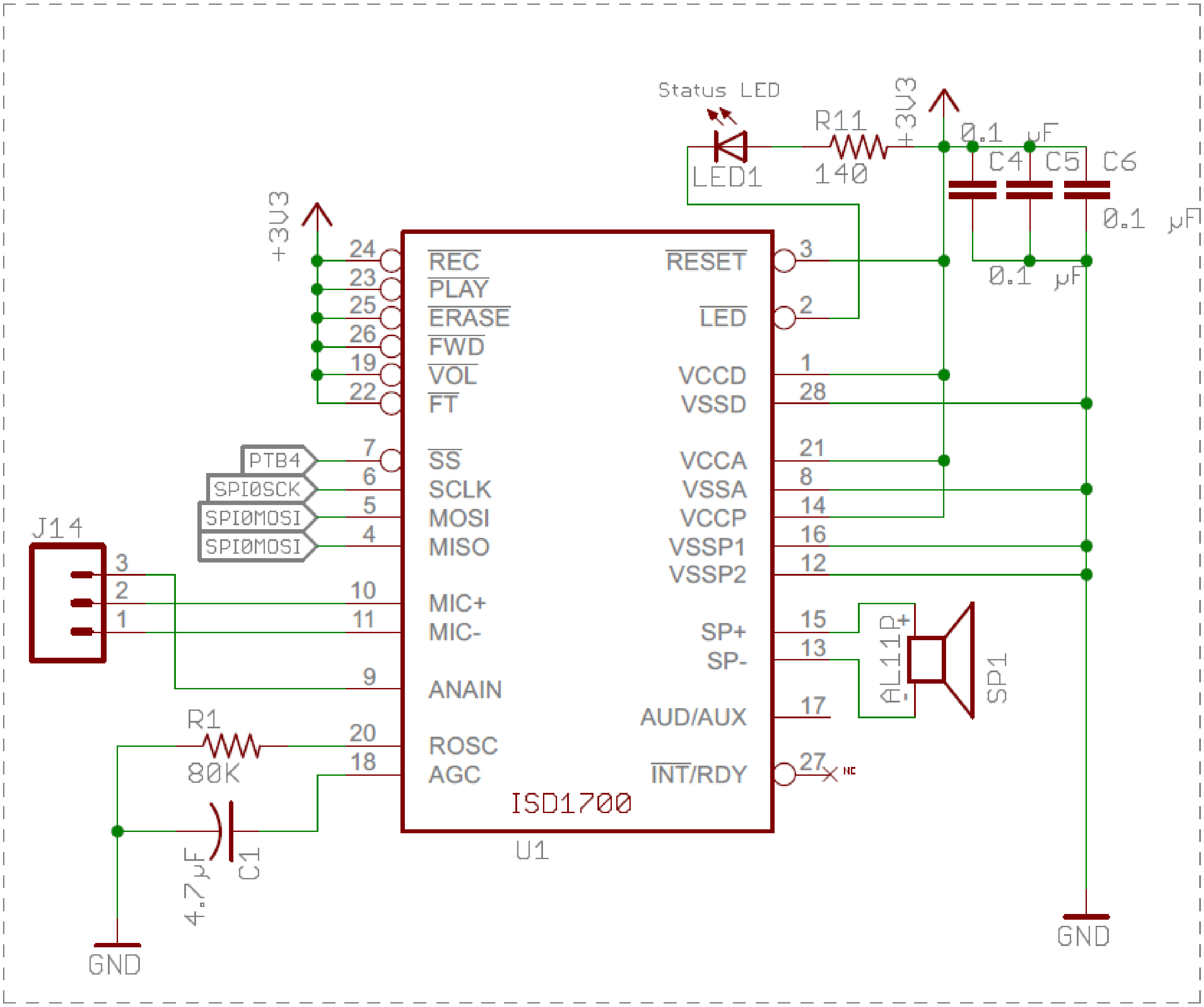


3.5. IR Sensors



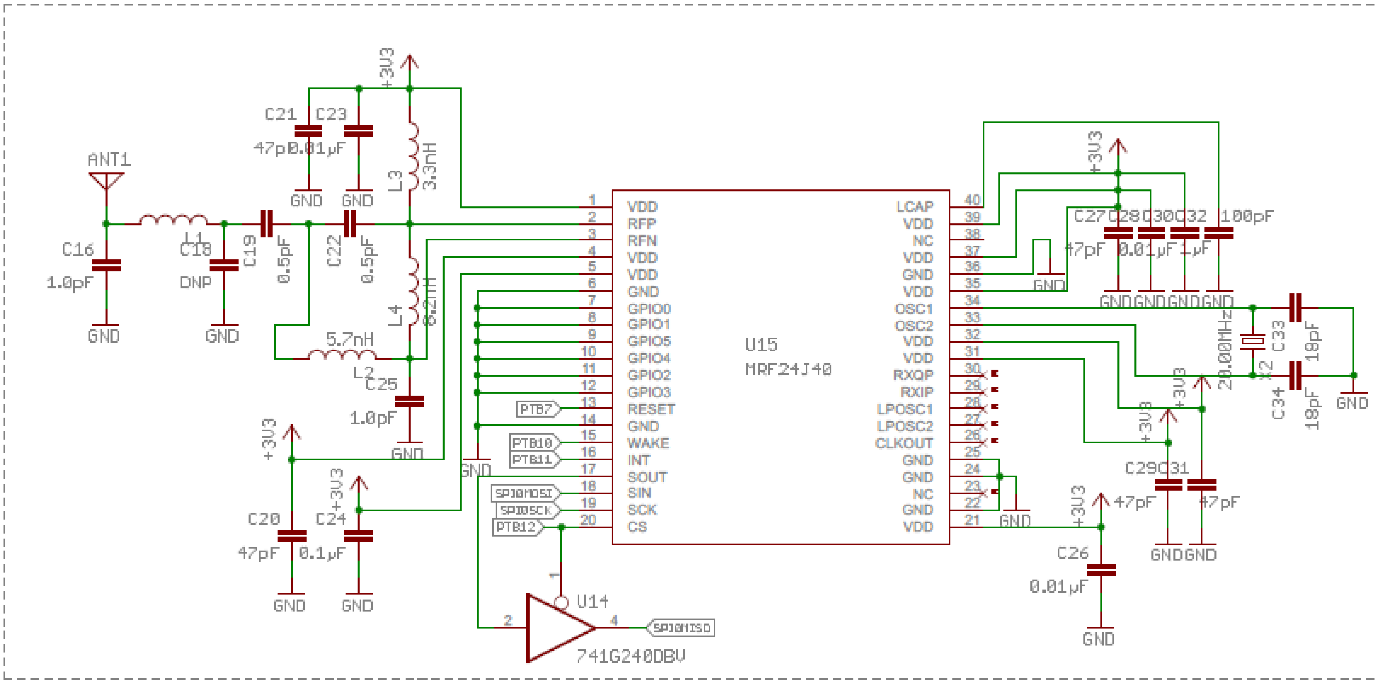
Infrared messages are sent between competing players, and these messages are received by TSOP321 IR receiver chips. A total of 8 of these IR receiver ICs will be used, separated in 4 packages of 2 receivers each. These receivers sense light at 56kHz (same as the IR LEDs) while filtering out noise. Additionally, each of these packages will contain an LED and current limiting resistor to flash when a hit is detected. The low pass filter leading to the input of the TSOP321 is recommended by the data sheet for protection against EOS. All the output data lines of the TSOP321s are tied together to form a wired OR, so when any single receiver pulls low then the whole node asserts low. When a successful hit is detected in software, PTA9 asserts pulls Q2 high to turn on the hit LEDs and sources about 15mA per LED.

3.6. Integrated Sound Chip



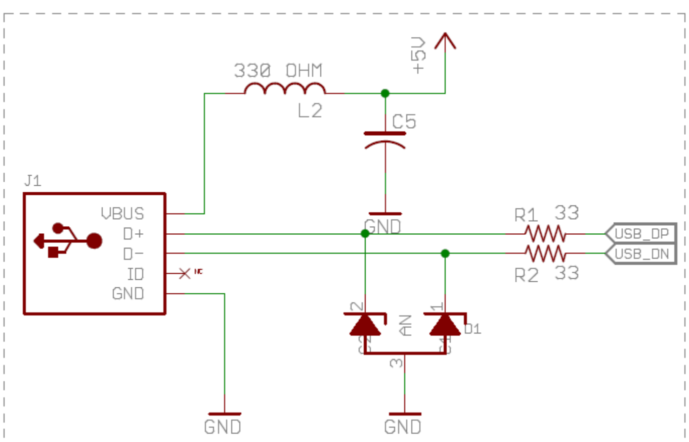
Sounds are played as part of the user interface, and all the sound will be controlled via an ISD1740. This IC records and plays back audio bites. There are 2 ways to control this device, either purely by GPIO/push buttons or SPI, which is the implemented method. Since the former method is not used, related pins (19, 22-26) are pulled HIGH. SPI is controlled by SPI0 with the slave select controlled simply by a GPIO pin, since SPI0 is used by multiple devices. Header pins were placed on the pins MIC+, MIC-, and ANAIN in case any additional recording is required. The 80k resistor sets the sampling frequency to 8kHz, meaning only a usable audio range of 4kHz. This sampling frequency was chosen because audio quality does not need to be high and that the audio takes less space, meaning a cheaper chip can be purchased. The capacitors used are suggested values of the datasheet. The LED can be placed on the schematic for testing, or can be simply omitted in final manufacture. The speaker outputs the audio.

3.7. Zigbee Module



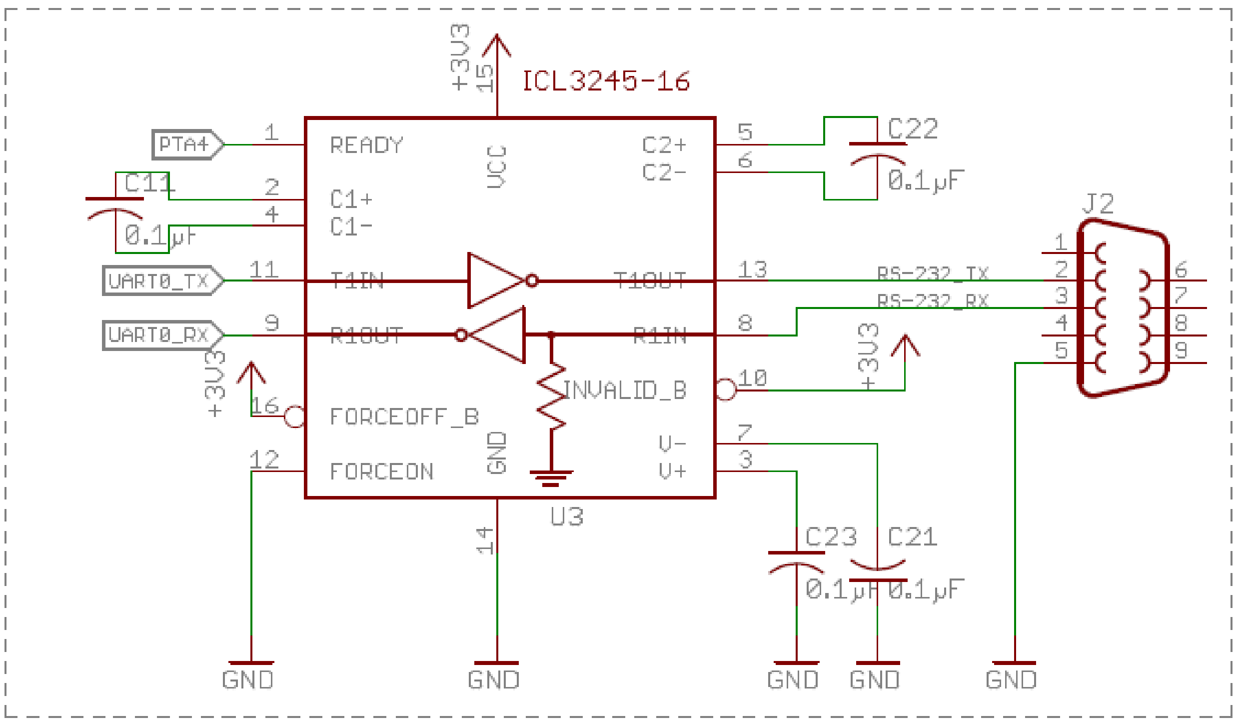
A Zigbee mesh network (IEEE 802.15.4) is used for communication. The ref module acts as the mesh hub and is a fully-functioning-device, while each gun module is a node and is a reduced-functioning-device. Things to note on the schematic is first the input impedance matching performed by the several capacitors and inductors leading up to the antenna. The carrier frequency is 2.4GHz. The 20.00MHz external clock is the main oscillator for the chip. The capacitor off of pin 40 is required for the PLL, and placement on the board must be carefully placed. All other capacitors not mentioned already are used as bypass capacitors, and should all be placed as close to the pins as possible. Communication to MRF24J40 on board is primarily through SPI. The tri-state buffer blocks the SPI from outputting when the chip is not selected.

3.8. USB



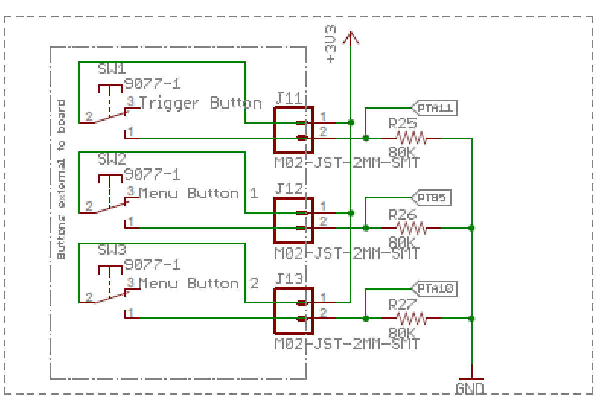
USB connects the board to a computer and provides both communication and power. The clamping diodes and resistors protect the board from voltage spikes on the data lines. The inductor and capacitor create a choke to insulate AC noise. Since the board is used as a USB device, the ID pin is left open.

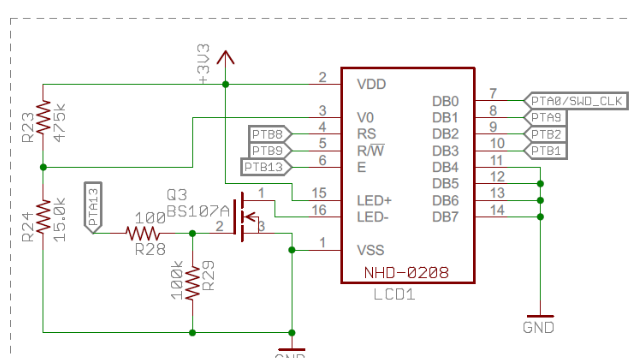
3.9. UART over RS-232



An RS-232 is also added to the board in case the user wants to communicate via UART. Since RS-232 has specific voltages for its HIGH and LOW, it must be converted through the ICL3245. For RS-232 only the 3 lines used are required.

3.10. Graphical User Interface (GUI)





The user interface is composed of 3 momentary push-buttons and a 2x8 LCD screen. The push-buttons are placed around the chassis of the gun: 1 on the trigger and 2 placed next to the LCD screen. The LCD screen is placed on the left side of the gun chassis, assuming right handed users. The contrast is voltage controlled, and is set by the voltage divider. The value used is the suggested level (~0.1V) was suggested by the datasheet. The MOSFET controls the backlight and can turn it off to save power.

4. Parts List

Item	Quantity	Part Description	Designators
1	1	Chip Capacitor 0402 X5R 1U	C16
3	2	Chip Capacitor 0402 COG 1.0P	C1, C10
5	2	Chip Capacitor 0402 X7R 10N	C8, C12
7	4	Chip Capacitor 0402 COG 47P	C17, C13, C7, C4
9	1	Chip Capacitor 0402 COG 100P	C18
11	5	Chip Capacitor 0402 X5R 100N	C21-C23, C11, C9
13	2	Chip Capacitor 0402 COG 0.5P	C7, C3
15	2	Chip Capacitor 0402 COG 18P	C19, C20
17	1	MRF24J40-I/ML	U2
19	1	741G240DBV SOT23-5	U1
21	1	KL24Z32M	U4
23	1	ICL3225E-16	U3
25	1	Chip Inductor 0402 8.2N	L5
27	1	Chip Inductor 0402 3.3N	L4
29	1	Chip Inductor 0402 5.6N	L3
31	1	Chip Inductor 0402 6.8N	L1
33	1	20 MHz Crystal	X1
35	1	GS0505C-GS08	D1
37	1	USBMOLEX-MINIB	J1
39	1	F09HP	J2
41	1	PINHD-2X5	J3
43	2	R-US_M0805 33OHM	R1, R2

Item	Quantity	Part Description	Designators
1	6	C-EU050-030X075, 10%, 12pF	C2, C3, C11, C12, C14, C15
3	4	C-EU050-030X075, 10%, 0.1µF	C4-C6, C24
5	1	C-EU050-030X075, 10%, 4.7µF	C1
7	6	C-EU050-030X075, 10%, 10µF	C7-C10, C17, C35
9	2	CPOL-USTT2D5, 10%, 100µF	C13, C32
11	2	C-EU050-030X075, 10%, 1.0pF	C16, C25
13	1	CPOL-USTT2D5, 10%, 10µF	C17
15	2	C-EUC0402, 10%, 0.5pF	C19, C22
17	5	C-EUC0402, 10%, 47pF	C20, C21, C27, C29, C31
19	3	C-EUC0402, 10%, 0.01µF	C23, C26, C28
21	1	C-EUC0402, 10%, 1µF	C30
23	1	C-EUC0402, 10%, 18Pf	C33, C34
25	8	PINHD 0.1" 1X4	J1-J8
27	1	PINHD-2X5	J9
29	1	PINHD-1X3	J10
31	3	M02-JST-2MM-SMT	J11-J13
33	1	M03PTH 1X03	J14
35	1	L-USL3216C 6.8nH	L1
37	1	L-USL3216C 5.7nH	L2
39	1	L-USL3216C 3.3nH	L3
41	1	L-USL3216C 8.2nH	L4
43	1	NHD-0208AZ-FSW-GBW-33V3-46651	LCD1
45	1	TSAL6100	LED1
47	6	LED 5mm, AMBER	LED2-LED7
49	3	BS107A	Q1-Q3
51	4	R-US_R0805, 80K	R1, R25-27
53	8	R-US_R0805, 100	R5, R12-R15, R19, R29, R28
55	2	R-US_R0805, 100K	R6, R29
57	5	R-US_R0805, 140	R7-R11
59	1	R-US_R0805, 1.87K	R16
61	1	R-US_R0805, 10M	R4
63	1	R-US_R0805, 19.1	R21
65	1	R-US_R0805, 158	R22
67	1	R-US_R0805, 475K	R23
69	1	R-US_R0805, 15.0K	R24
71	1	ALL11P SPEAKER, 8OHM	SP1
73	3	MOM NO SWITCH, 9077-1	SW1-SW3
75	1	EG1218S	SW4
77	1	ISD1740P	U1
79	8	TSOP32156	U3-U10

81	1	PTH08000W	U11
83	1	KL02Z32M	U12
85	1	741G240DBV SOT23-5	U14
87	1	MRF24J40 QFN40ML6X6mm	U15
89	1	32.768kHZ, CRYSTALHC33U-H	X1
91	1	20.00MHz, CRYSTALHC33U-H	X2