I.F.F. (Identification Friend or Foe) System

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Acronyms & Pre-Requisite Information

- MCU - Microcontroller Unit
- R.F. - Radio Frequency
- T.I. - Texas Instruments
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1 Introduction

This document is a "Mock Design Review" in preparation for the Design Review occuring during the week of February 29th, 2016. This will better prepare the team for documentation of the design and construction of the Infantry I.F.F. System.

2 Block Diagram

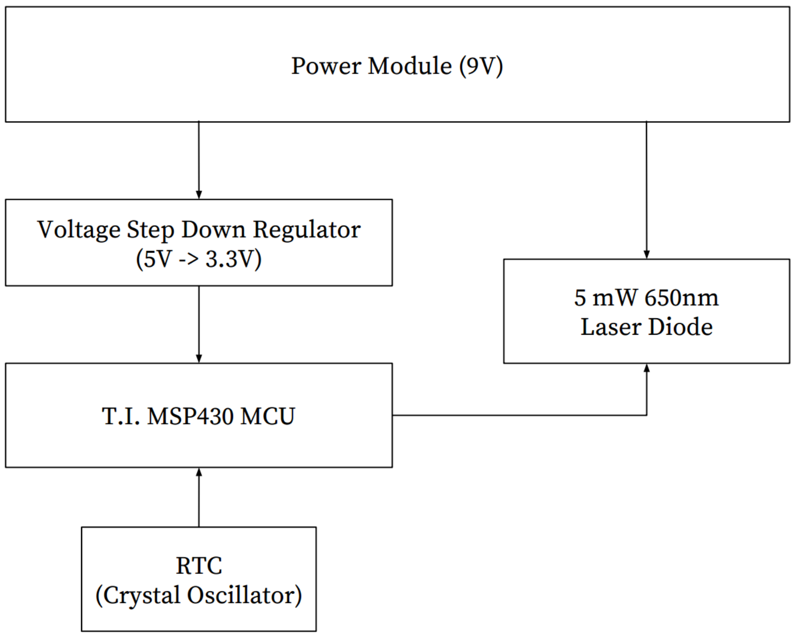

Figure 1: Block Diagram of Laser Transmitter

3 Block Description

The subsystem of the Laser Transmitter will be broken down into 5 primary modules:

1. Power Module
2. Voltage Step Down Regulator
3. Microcontroller
4. Real Time Clock
5. Laser Diode

Power Module

The Power Module will consist of a standard 9V battery. The type of 9-volt battery is at the discretion of the operator due to the availability on the market (i.e. either rechargable or disposable). However, a battery with least 250 mAh of use time must be selected to supply the circuit with 9V over a period of 8 hours. The team will chose to use a 9V 300 mAh NiMH Rechargable Battery for testing purposes.

The team decided to use a 9 V battery instead of four double-A batteries due to the need of maintaining a constant 3.3V over time as well as simplicity (having one battery with a regulator is much simpler than having 4 double A batteries).

Voltage Step Down Regulator

The LD1117V33 voltage step-down regulator will take the 9V supply input and step it down to 3.3V to supply the MSP430 MCU. The voltage regulator will supply a maximum of 900 mA of current which will be significantly less than this circuit draws.

Microcontroller

This design choice was by far the most difficult. The team chose to work with an T.I. MSP430F2274 Microcontroller Unit due to its simplicity, its availability in the ECE445 Senior Design Labs (inventory) and the number of GPIO Pins on board. The

Real Time Clock

The Real Time Clock is not entirely neccessary for the operation of the Laser Transmitter Subsystem, however it will be neccessary for the operation of the R.F. Receiver and thus must be included in the MCU circuit. It will operate using a 32.768 kHz Crystal Oscillator (as reccomended by T.I.)

Laser Diode

The 5mW laser diode will operate on 3.3V at 25mA so a 1.3lω resistor is neccessary to drop the current being supplied to the diode down to this threshold. This laser diode will prode a beam width of ___

Due to safety and ethical considerations, the requirements have changed for the divergence of the beam. The proposal stated a requirement of a 5-6 ft diameter beam at 50, 150, and 300 m (with optical adjustments allowed).

With some tolerance, the PIN photodiode can register an irradiance of 9 $\frac{W}{m^2}$. The laser required to achieve this irradiance is a function of the laser power and the radius of the beam. With relatively short distances of 0-300 m, atmospheric deflection of light is negligible.

Using trigonometry, the power as a function of radius is given by $P = \pi r^2 E_{req}$, where r is the radius (in meters) and E_{req} is the required irradiance of 9 $\frac{W}{m^2}$.

For a diameter equal to the one stated in the proposal ($\approx 1.6764m$), a $\pi(0.8382)^2(9) \approx 20mW$ laser is needed. A $20mW$ laser is a Class 3B laser, and is considered dangerous. For the scope of this senior design project, a $5mW$ laser will be used instead.

The radius achieved using a $5mW$ laser is given by $\sqrt{\frac{P}{E_{req}\pi}} = 0.420522m$. This is approximately a $2.75ft$ diameter beam, which is still the size of a person's chest.

4 Circuit Schematic

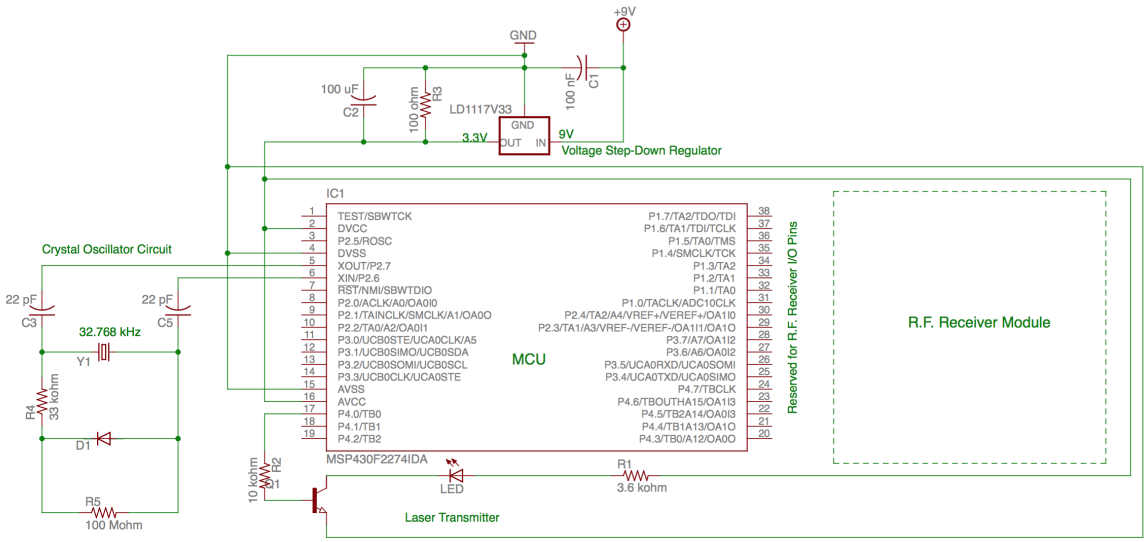

Figure 2: Circuit Schematic of Laser Transmitter

5 Plot

Figure 3 depicts the Nominal Ocular Hazard Distance (NOHD) vs the power of the laser diode on a 50% duty cycle. See ?? for more details on this calculation and what it means.

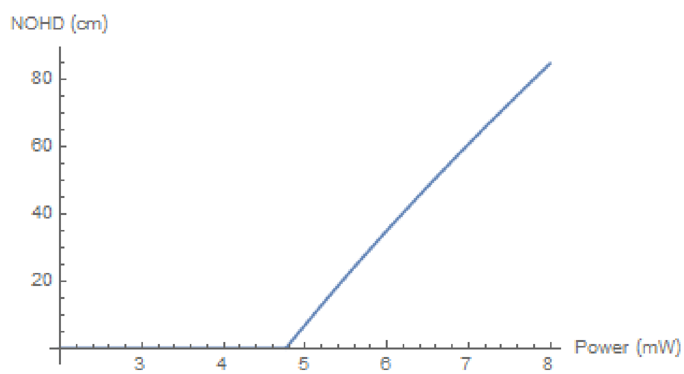

Figure 3: NOHD vs Power for Laser Diode

6 Requirements and Verification

FILL OUT TOGETHER

7 Safety & Ethical Considerations

The proposal requirements would have required a $20mW$ IR laser. Eric, can you put more information about registering the laser and shit at 20mW?.

The team will instead use a $5mW$ visible red laser. $5mW$ visible lasers have a low chance of injuring the eye, as the blinking reflex will save a victim from permanent damage; as opposed to IR lasers which can go unnoticed for several seconds.

The following is a calculation for the nominal ocular hazard distance (NOHD) of our laser, as defined by the ANSI Standard [?].

The maximum permissible exposure (MPE), as defined by the ANSI Standard [?] is the highest power or energy density of a light source that is considered safe, i.e. that has a negligible probability for creating damage. This MPE for a pulsing laser is calculated as the minimum of the following three rules:

1. Any single pulse in the train must not exceed the MPE for the pulse exposure time.
2. The exposure from any group of pulses delivered in time T must not exceed the MPE for time T, where T is 0.25 seconds (from the blinking reflex), for a visible laser.
3. For thermal injury, the exposure for any single pulse within a group of pulses must not exceed the single-pulse MPE multiplied by a multiple-pulse correction factor

The laser will pulse at a rate of 40 kHz. Assuming at most a 50% duty cycle, each pulse will be of max length $1.25 * 10^{-5}s$. The divergence of the beam is smallest for the longest range; a lower divergence is more restrictive in terms of safety, so this calculation uses $300m$. The divergence of the beam for 300m is 2.79 mrad and the beam waist is approximately $4mm$.

Following the ANSI Standard [?], the Rule 1 calculation is

$$5 * 10^{-3} * (\frac{2.79}{1.5}) = 0.0093\frac{J}{m^2}$$

The Rule 2 calculation is

$$\frac{18(.25^{0.75})(\frac{2.79}{1.5})}{.25*40000} = 0.0011837\frac{J}{m^2}$$

The Rule 3 calculation is

$$(.25 * 40000)^{0.25} * 5 * 10^{-3} * (\frac{2.79}{1.5}) = 0.093\frac{J}{m^2}$$

The most restrictive of all the rules is Rule 2, which gives us an MPE of $0.0011837\frac{J}{m^2}$.

At $5mW$ with a pulse width of $1.25 * 10^{-5}$, the power of the laser is $6.25 * 10^{-8}J$.

The NOHD is defined as

$$\frac{\sqrt{\frac{4*P}{\pi*MPE}}-2w}{\theta}$$

Where P is the power of the beam ($6.25*10^{-8}J$) and w is the waist of the beam ($1mm$). This gives an NOHD of

$$\frac{\sqrt{\frac{4*6.25*10^{-8}}{\pi*0.0011837}}-2(0.004)}{0.00279} = 0.0713m \approx 3in$$

The team will avoid eye damage by not working with their eyes inside of 3 inches from the laser. If it is necessary to get this close to the laser, the team will wear eye protection or simply power off the laser.