COSMOneer Proto

Simulating a Satellite in Space

Summary

Generally speaking, “space” begins at 100km, otherwise known as the Kármán line, and Low Earth Orbit (LEO) is considered to lie between 160km and 2,000km. Orbiting spacecraft reside in Low Earth Orbit (or LEO) in order to benefit from the lack of atmosphere that causes drag, which would rapidly bring them back to Earth, burning them up along the way. Using low cost materials, wireless power and 3D printed parts, we simulate the low friction and zero gravity environment of LEO.

Cube satellites, the inspiration for the Cosmoneer Proto, rarely have an independent guidance system to control its attitude. Some tumble, others use Earth’s magnetic field, fewer use simple reaction wheels and rarely do they use control moment gyros. Using simple hobby electronics, we have recreated the more advance control moment gyro. A high speed flywheel (or gyro) is coupled with a servo to provide rotational torque in the Yaw Axis, similar to turning your head left and right.

In order to remain operating indefinitely in space, nearly all spacecraft rely on solar energy, a form of wireless power. Using a matched pair of wire coils, we transmit power from the Zero-G stand to the Cosmoneer Proto, providing a very close resemblance to solar power. Satellites are power limited in that they can only harness so much power via its fixed solar array. The Proto is therefore also limited in how much power it can consume via the wireless link.

Architecture

Most spacecraft designs tend to incorporate at the very least these basic systems: Command & Control, Power, Attitude Control and Communications. Using low cost components, the Cosmoneer Proto incorporates all of these systems at a very simple level.

Building on the Arduino architecture, serial infrared communications and the I2C bus, the Proto is able to further simulate the simplicity built into nearly all spacecraft. In fact, most cell phones have more computing power than most spacecraft in orbit.

Veering away from the cubesat standard, the Proto is housed in a spherical volume instead of a cube shape. While this increases complexity, it makes possible the ability to simulate a full three degrees of freedom (3DOF) in future versions.

Since the system is completely wireless and any communications require a line of sight link, audio and visual feedback are used to provide system status messages. Similar to “tones” used by some interplanetary spacecraft to denote the progression of descent stages during periods of near radio silence, our tones provide quick informational feedback as to what is happening right then.

Satellites tend to use light sensors to locate the sun and the earth to insure they are pointing in the right direction. Interplanetary spacecraft use asteroids and some stars to determine their location in space. The Cosmoneer Proto depends on the Earth’s magnetic field to calculate its heading.

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Proto Subsystems

Command & Control

Microcontroller

Used to sensing and controlling every aspect of the Cosmoneer Proto.

Communications

System Status LED

Used for simple user feedback from the MCU itself.

Perimeter LEDs

Controlled by 8 of the 16 individual PWM channels, 8 LEDs provide “at a glance” visual feedback.

Piezo Speaker

A single piezo element provides audio feedback.

Serial IrDA

An infrared transceiver and a serial IrDA protocol chip provide a solid communications protocol that can be initiated between Cosmoneer Protos, or a Proto and a ground-based station.

Attitude Control

Three Axis Compass/Magnetometer

Using the Yaw axis, directional heading values can be obtained.

Control Moment Gyro

A Servo, Gyro motor and brushless motor speed controller used to provide inertial guidance.

Power

Wireless Power Transmitter and Receiver

Used to simulate solar energy, Wireless power not only provides energy to function, but also provides a method to stay energized while remaining near friction-less.

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Product Features & Specifications

Overall

All detailed Mfg spec sheets can be found here.

Cosmoneer Proto Motherboard

Micro Controller – Atmega328p-au, 5V, 16Mhz

Compass – Honeywell HMC5883L, 3.3V

Serial IrDA – MCP2120-SL & TFBS4711, 5V

16ch PWM Controller – PCA9685, 5V

Control Moment Gyro Assembly

5g Micro Servo – 0.6kg torque (8 oz/in), 0.1 sec/60deg(4.8v), 4.2-6v input

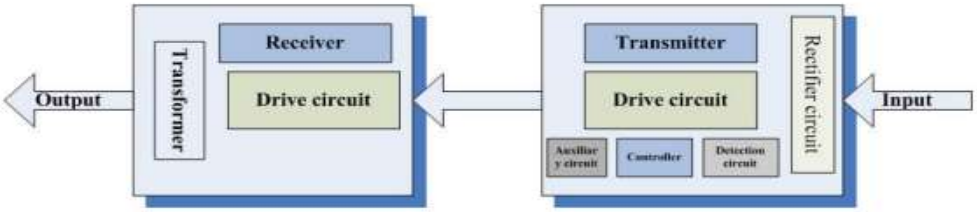
Brushless Motor – 5.5v 3 phase

Motor Controller – MX-3A ESC

Storage Sphere

Acrylic Sphere – 100mm OD, 97mm ID

Wireless Power Module



Specifications

Input Voltag	12.0 V
Input Voltage(limits)	13.5 V
Output Voltage	5V
Output Current(maximum)	600mA
Transmitter Coil Inductance	30uH
Coil Diameter	:38mm
Coil Height	2mm

Distance	Voltage	Current
1mm	5V	600mA
2mm	5V	450mA
3mm	5V	360mA
4mm	5V	310mA
5mm	5V	240mA
6mm	5V	210mA
7mm	5V	162mA
8mm	5V	150mA
9mm	5V	132mA
10mm	5V	120mA
11mm	5V	110mA
12mm	5V	70mA
13mm	5V	54mA
14mm	5V	41mA
15mm	5V	28mA
16mm	5V	19mA
17mm	5V	17mA
18mm	5V	10mA

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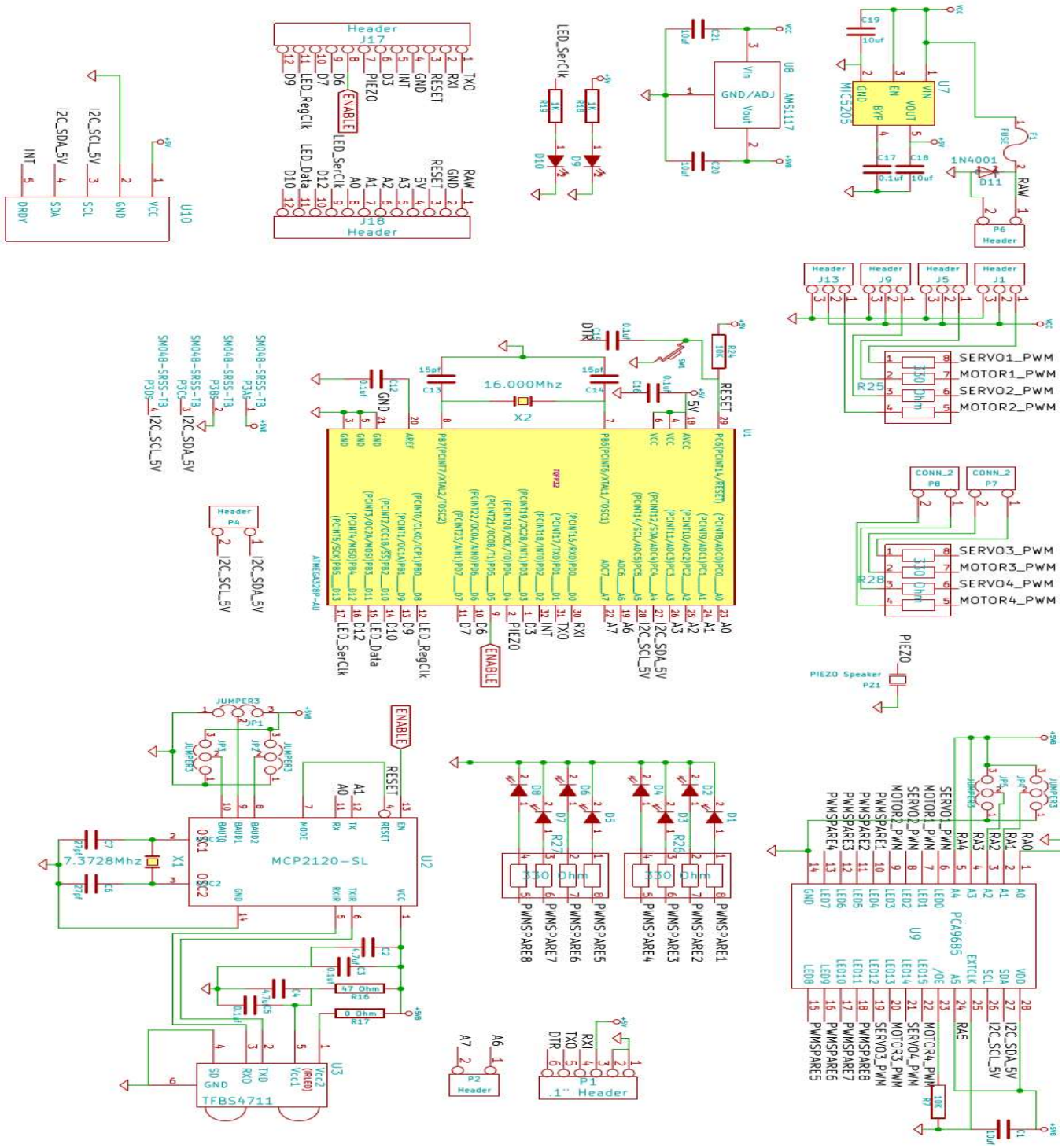
Schematic



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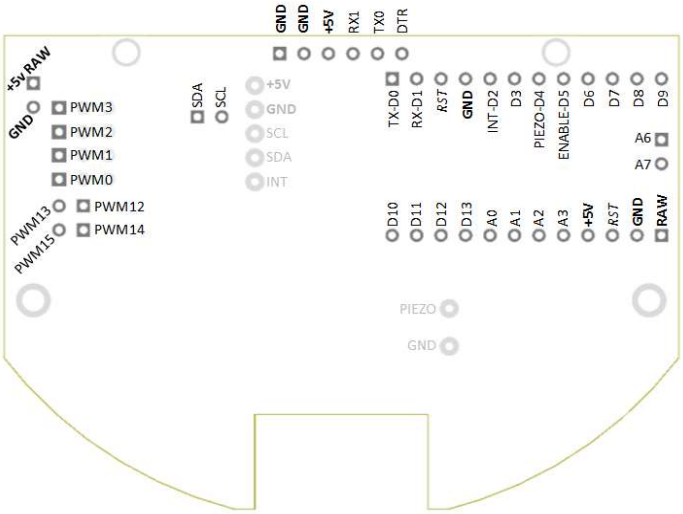
PCB Pin Map & Jumper Settings



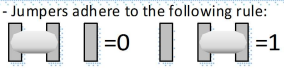
User Configurable Jumper Settings

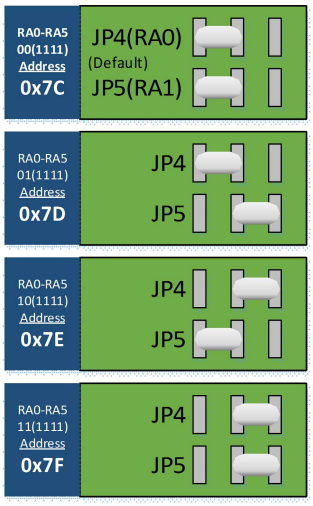
- Users may adjust jumper profiles to configure specific Cosmoneer settings.

WARNING! Please insure the center jumper does not bridge the two outer jumpers, else a power to ground short will result!

PCA9685 I2C Address Jumper Settings

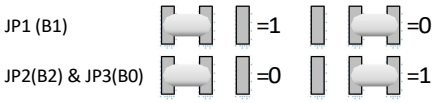
- Jumpers adhere to the following rule:

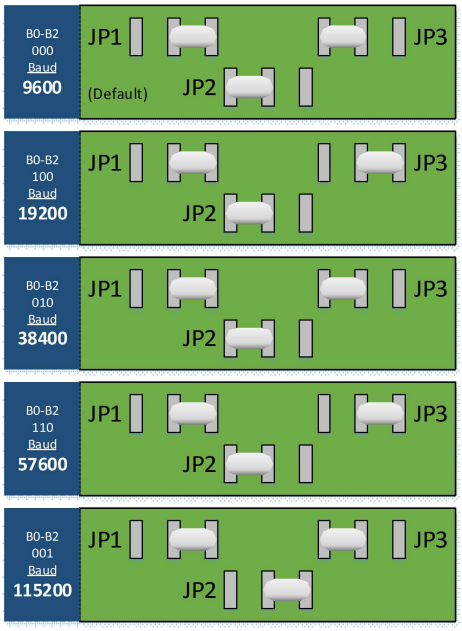




MCP2120 Baud Rate Jumper Settings

- Jumpers adhere to the following rules:





NOTE: These baud rates coincide with the use of an external 7.2728Mhz crystal (clock source).