VHF Radio Beacon For CubeSAT

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Contents

1 Introduction

This project, VHF Radio Beacon for CubeSAT, entails designing a backup communication system for a CubeSAT style satellite. The beacon, consisting of an FM transmitter circuit, will allow a terrestrial antenna to locate the satellite as it orbits around the earth. In addition to location to its location in space, the beacon will transmit status data encoded in DTMF tones (like dial tones).

In general, size, power, and environmental factors (vibrational tolerance and thermal management) will play a crucial role in this project. If designed correctly, our project has the potential to be flown into space and operate for an indefinite period of time. The chance of our project actually flying on a rocket and operating in orbit for an extended period of time is reason enough to warrant our interest.

1.1 Objectives

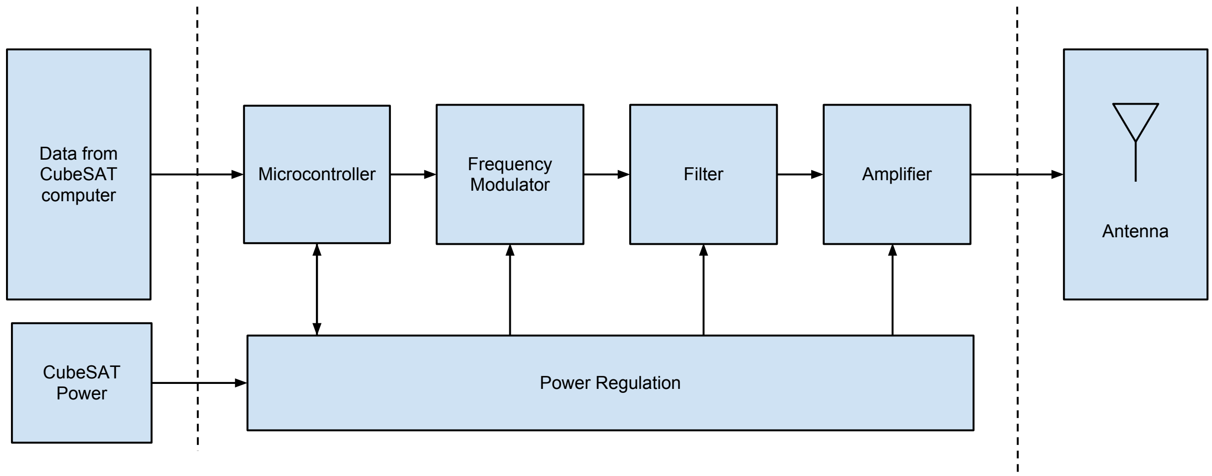
- 250mW total power consumption
- 100mW transmit power
- PCB Dimensions less than 3.5 by 1
- Survive vibrations from a rocket launch
- Withstand space environment
- Design for future development
- DTMF tone conversion and transmission

1.2 Benefits

- Tunable from 144-148MHz in 6.25kHz steps before launch
- Ability to locate satellite in orbit via terrestrial antenna
- Provides backup communications and status
- PIC-based to support legacy hardware
- Small size
- Power management capability

2 Design

2.1 Block Diagram



2.2 Block Descriptions

- Microcontroller:
  1. Interprets data from the CubeSAT onboard computer and passes it to the DTMF Transceiver. When not in use, the microcontroller goes into a low-power or off state. This module will serve to provide the main control and power management for the rest of the
  2. A DTMF signal needs to be generated for use in later stages of the beacon. As it is strongly recommended that a PIC microcontroller is used, the DTMF signal can be generated from an onboard D/A converter pin. Code on the microcontroller will translate data from the satellite into a DTMF signal. Additional filtering may be needed before the signal is sent to the next stage depending on the operating resolution of the D/A converter.

- Frequency Modulator: The DTMF data needs to be transmitted using FM as per the needs of the satellite. The Frequency Modulator unit will take the DTMF signal and push it out to 144-148MHz via frequency modulation. This unit will also incorporate a tuning ability so that before launch, a more specific frequency can be chosen from the operating range, preferably in 6.25 kHz increments.

- Filter: Removes unwanted signal characteristics from the modulated waveform. This filter will be a bandpass type filter, windowed somewhere around the 144-148MHz range.

- Amplifier: Boosts signal power to a minimum of 100mW. From here, a coaxial, impedance-matched connection to the onboard antenna is made.

- Power Management: Changes and regulates all voltage levels to their required values. Since power coming from the CubeSAT power distribution system will be at a specific voltage, regulation circuitry is needed. This may also trigger on and off stages to minimize power usage of the device.

3 Requirements and Verification

Module	Requirements	Verification
Microcontroller	1. Successfully interprets data from the main satellite computer. 2. Converts data packets into corresponding DTMF D/A output.	1. Wire a development board on a test bench or mount a PIC on a breadboard. 2. Write a test program that can mimic the sending of CubeSAT data. 3. Hook up an oscilloscope to the D/A pin of the PIC. 4. Send the microcontroller a packet of data. 5. View the oscilloscope output. If the scope waveform correctly matches the incoming data packets, the microcontroller works as expected.
Frequency Modulator	1. Frequency modulate any DTMF with a carrier frequency between 144-148MHz range. 2. The circuit has the capability to tune between frequencies.	1. Wire the frequency modulator circuit on a breadboard. 2. Connect input to a signal generator generating a signal in a 1200-1600 Hz range. 3. Connect input and output to an oscilloscope. 4. Verify that the circuit is able to output an FM signal at the desired frequency. 5. Change carrier frequency to a different, expected frequency in the 144-148MHz range. 6. Repeat steps 2-4 to verify the Frequency Modulator is working properly.

Filter	Eliminates any noise outside desired signal, which will be centered around 144-148 MHz.	1. Wire the filter to a breadboard. 2. Connect input to a signal generator generating a signal in the 144-148MHZ range. 3. Connect input and output to an oscilloscope. 4. Verify all noise outside filter BW is eliminated.
Amplifier	Increases signal power level to a minimum of 100 mW.	1. Measure power level of input signal using spectrum analyzer. 2. Verify the output power level is at or above 100mW.

4 Tolerance Analysis

Power use and transmission are the most critical requirements for this design. If the power used by the beacon is too high or transmit power too low then there will be no point in sending the beacon into space. The transmit power will be verified to show that a transmission link can be closed with powers of 100+/-5mW. Also, the power being delivered to the device may vary due to the power source being batteries, that will be constantly charging and discharging. The device must be able to operate for fluctuating input power levels.

5 Parts and Labor

Part	**Part Number**	**Cost**
PIC Microcontroller	PIC16C781	$4.89
144.132 MHz SAW Filter	SF2138B	$4.20
RF Modulator for VHF Band	NJM2519A	$1.13
RF amplifier-15dB gain	THS9001	$1.78
Miscellaneous Resistors, Capacitors, Inductors	N/A	$15.00
4 Layer PCB	N/A	$125.00
Total		$155.63

Laborer	**Rate ($/hour)**	**Hours**	**Total (Rate*2.5*hours)**
Russell	$40.00	145	$14500.00
Neal	$40.00	145	$14500.00
Jeff	$40.00	145	$14500.00
Total	$120.00	435	$43500.00

Grand Total	**$43655.63**

6 Calendar

Week	Neal	Jeff	Russell
Feb 4	Finish the Proposal Find power regulation ICs Register for Design contest	Start Designing FM modulator and filter Decide on filter-amplifier design approach	Polish Proposal Write code to drive 4-bit PIC outputs Get access to CubeSAT computer lab
Feb 11	Begin ordering parts Simulate FM modulator and filter	Design Amplifier Stage	Write PIC code for input, and test input output for PIC
Feb 18	Breadboard stuff Determine power management scheme	Order parts if needed Simulate FM modulator to Amplifier Stage Prepare design review	Draw schematics for Design
Feb 25	Breadboard entire circuit	Breadboard and verify the FM modulator to Amplifier Stages	Verify breadboarded circuit works
Mar 4	Begin PCB layout	Begin designing PCBs for the circuits	Write power management code for PIC
Mar 11	Order PCBs	Continue PCB design	Design Mock-up Demo
Mar 18	Spring Break	Spring Break	Spring Break
Apr 25	Solder PCB	Assemble Filter, amplifier, FM modulator	Make Mockup-up Presentation
Apr 1	Finish PCB layout	Finish building circuit	Verify functionality of subsystems
Apr 8	Thermal testing	Finalize Iteration of PCB design (if needed)	Make programs and devices needed for demo
Apr 15	Vibration testing	Maintain functionality for demo	Testing of Final Device Testing of Final Device
Apr 22	Begin compiling final paper	Demo preparation	Demo preparation
Apr 29	Polish Final Paper	Polish Final Paper	Polish Final Paper