MEMS Wireless Transceiver for Use of Non-Invasive System Diagnostics

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Critical Design Review - Summer 2019

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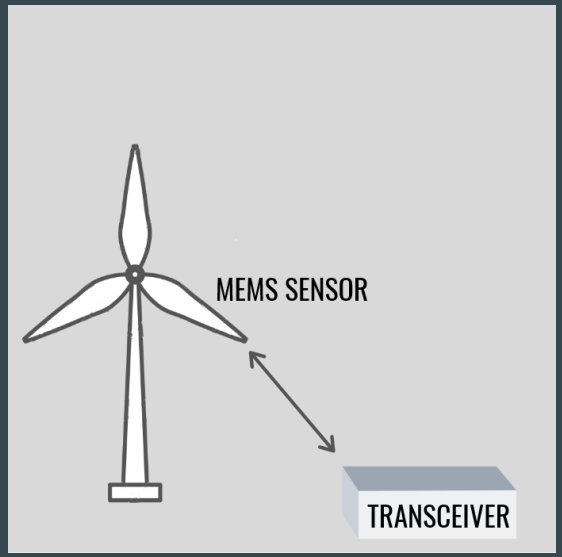
MOTIVATION

- Noninvasive testing helps avoid catastrophic failures by identifying issues early.
- Our sponsor requires a method of communicating with a MEMS sensor that is placed inside a rotating motor.
- Current technology does not support the frequency the sponsor wants to operate at.



REQUIREMENTS

- Design a transceiver that transmits and receives frequencies within the 27 MHZ ISM band
- Visualize received signal for analysis
- Transmit data to computer for potential further analysis

DESIGN SPECIFICATIONS

CATEGORY:	SPECIFICATION:
Power	Consume less than 10 watts
Production Cost	Cost less than $1,500.00
Tx/Rx Distance	A minimum distance of 1 m
Deliverables	Microcontroller code

STANDARDS

- IEEE Standard 1149.1-2001 IEEE Standards Test Access Port and Boundary-Scan Architecture
  - “This standard relates to the maintenance, testing, and support of assembled printed circuit boards (PCBs) and the testing of internal circuits.”
  - Provides an easier way to test and troubleshoot the PCB
- ❖ Standard Wireless Communication Protocols (Wifi, Bluetooth) cannot be used at the selected design frequency (~27 MHz), as such the transceiver module had to be custom designed from scratch.

DESIGN CONSTRAINTS - FREQUENCY

- Availability of components is limited at this frequency band
  - Self-resonant frequency of inductors limits components even more
  - Inductors must have a self-resonant frequency 10x the higher than the operational frequency

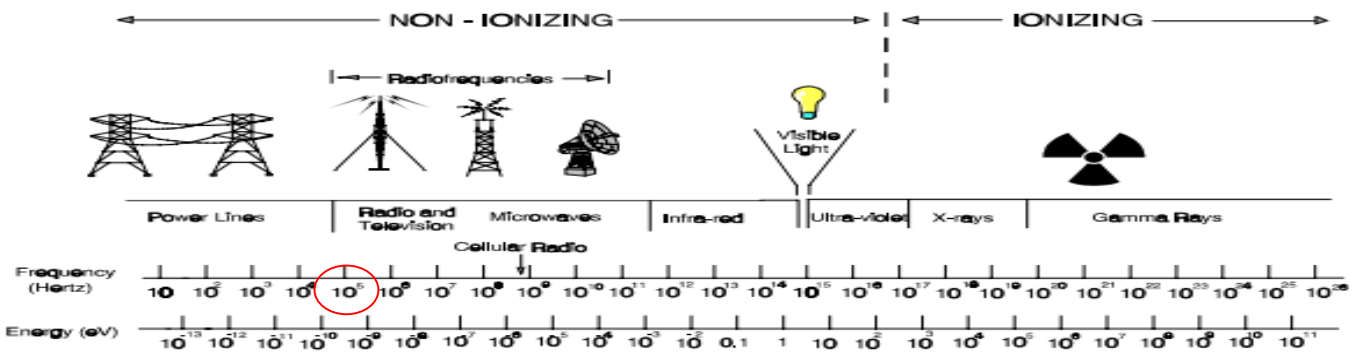
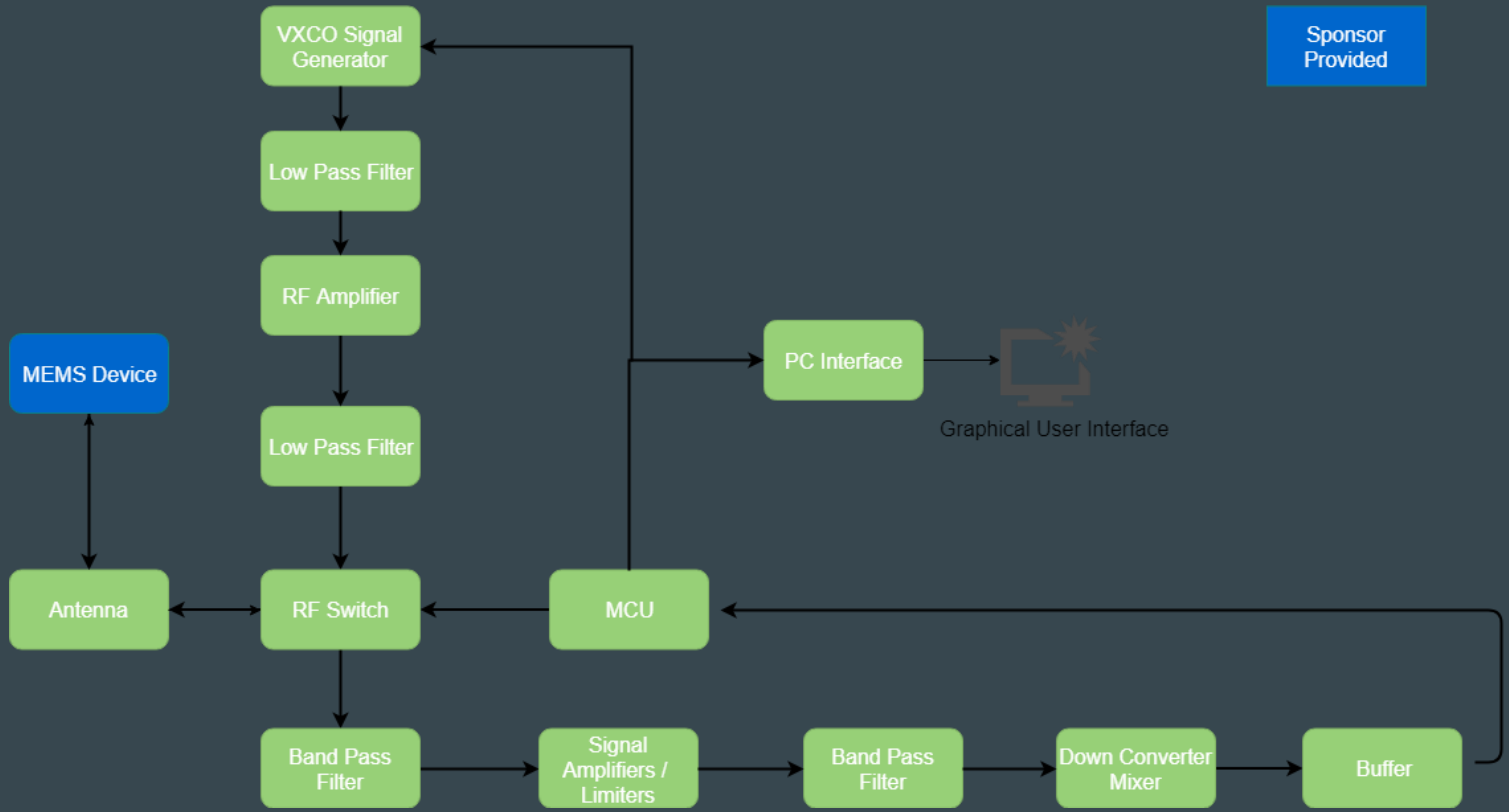
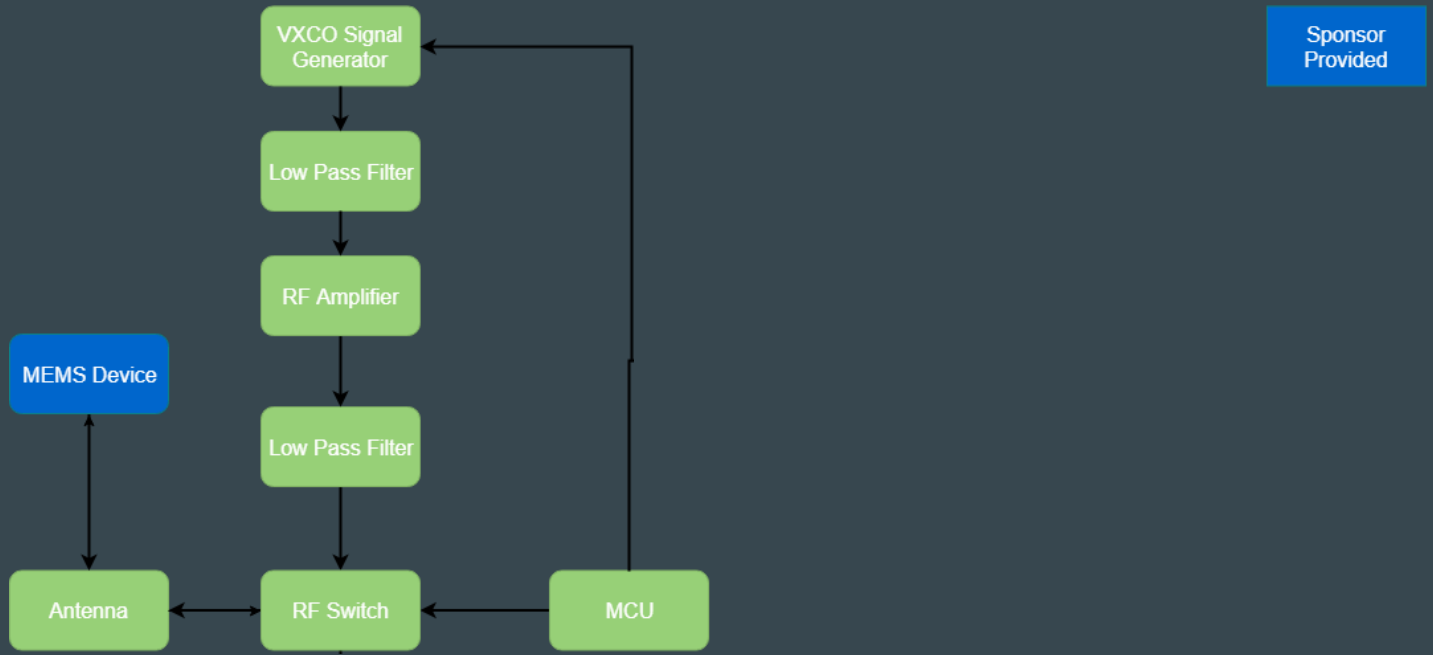


FIGURE 2. *The Electromagnetic Spectrum*

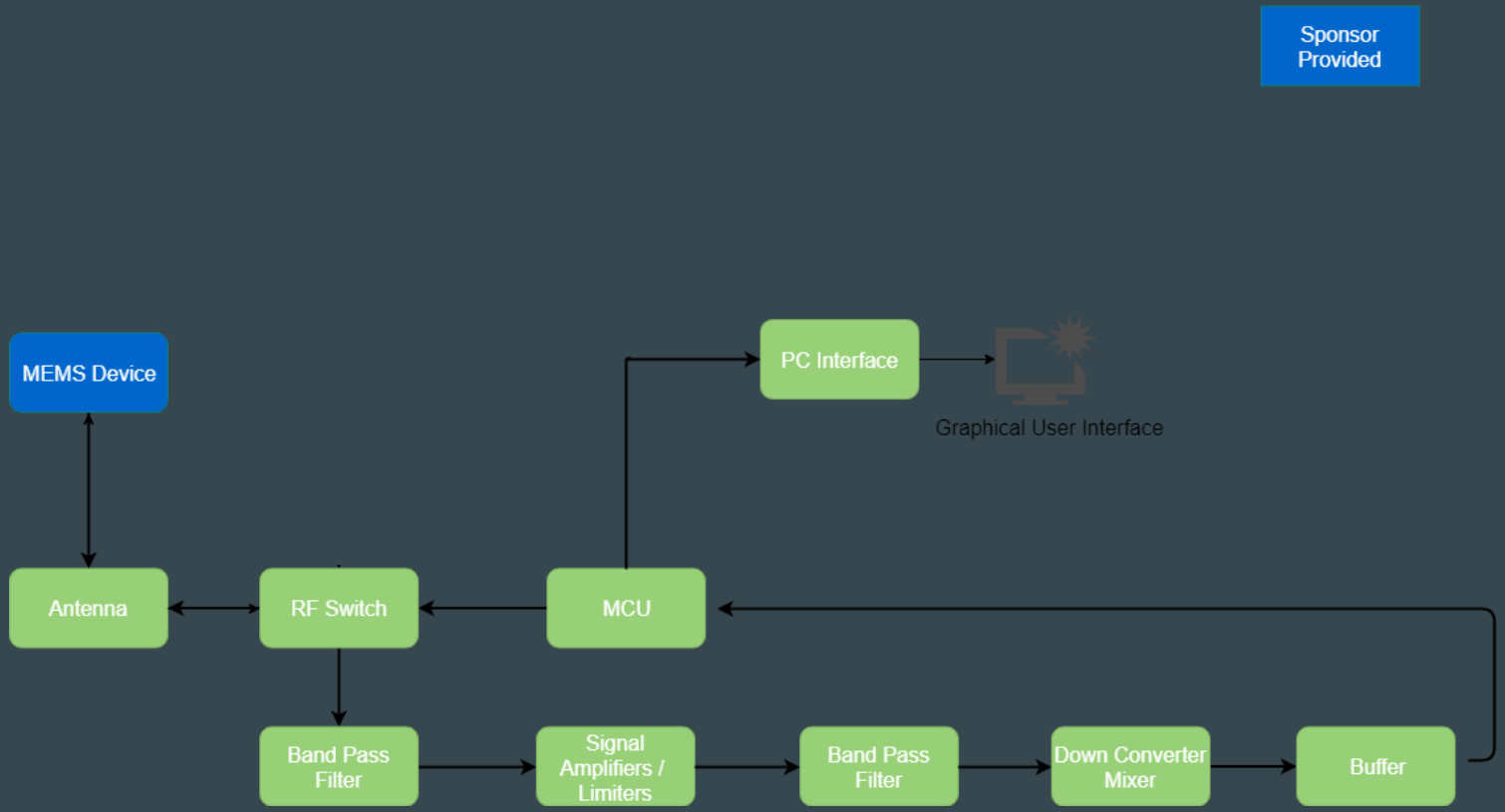
DESIGN IMPLEMENTATION



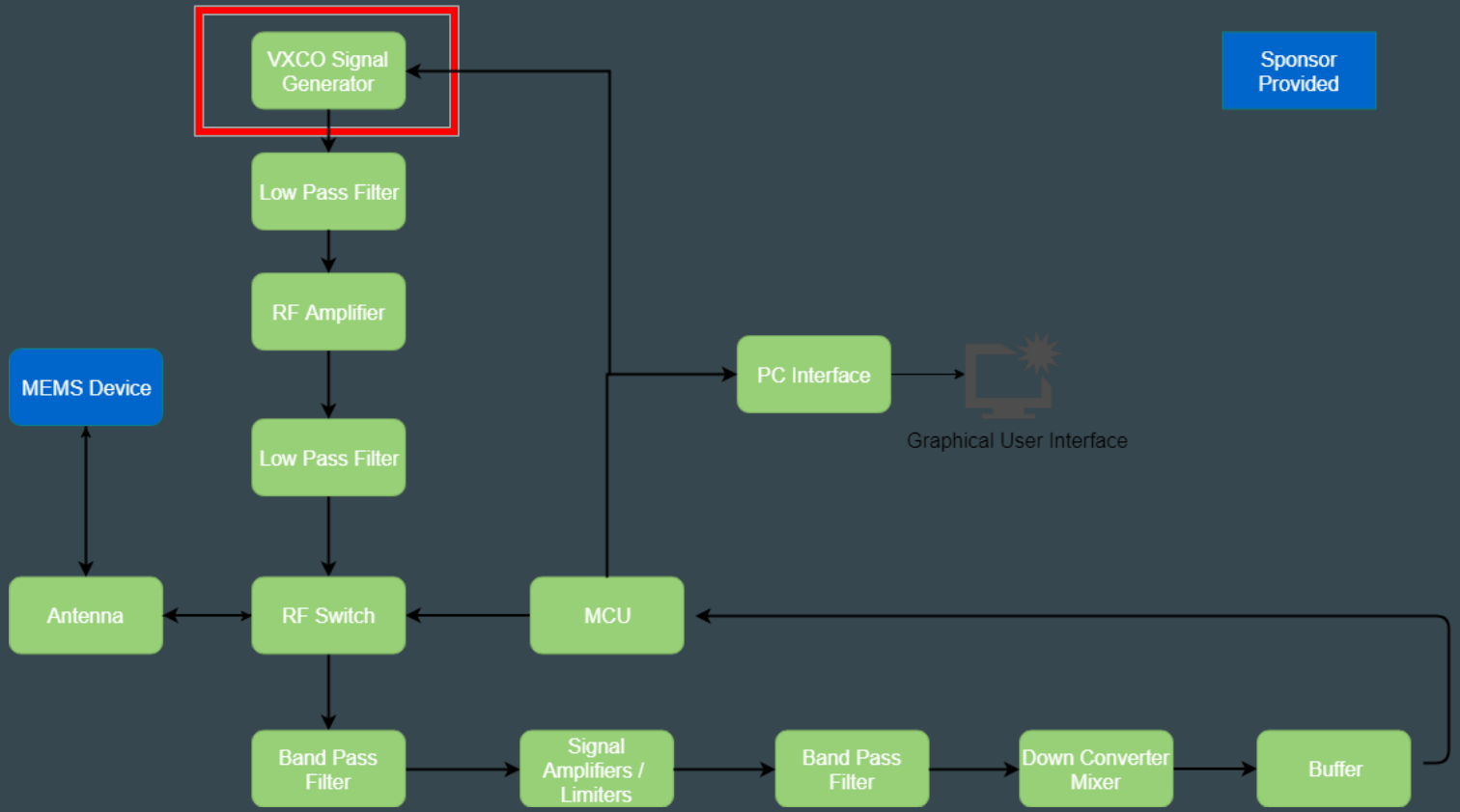
DESIGN IMPLEMENTATION: Transmission



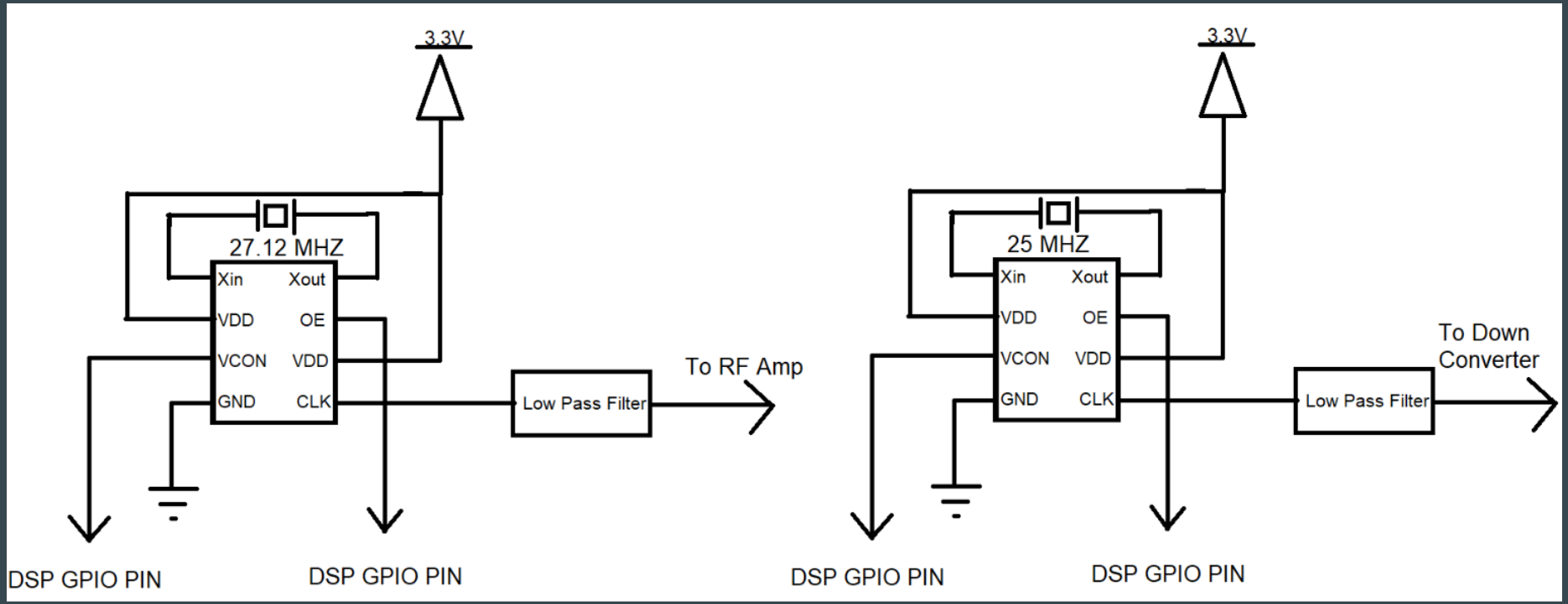
DESIGN IMPLEMENTATION: Signal Reception



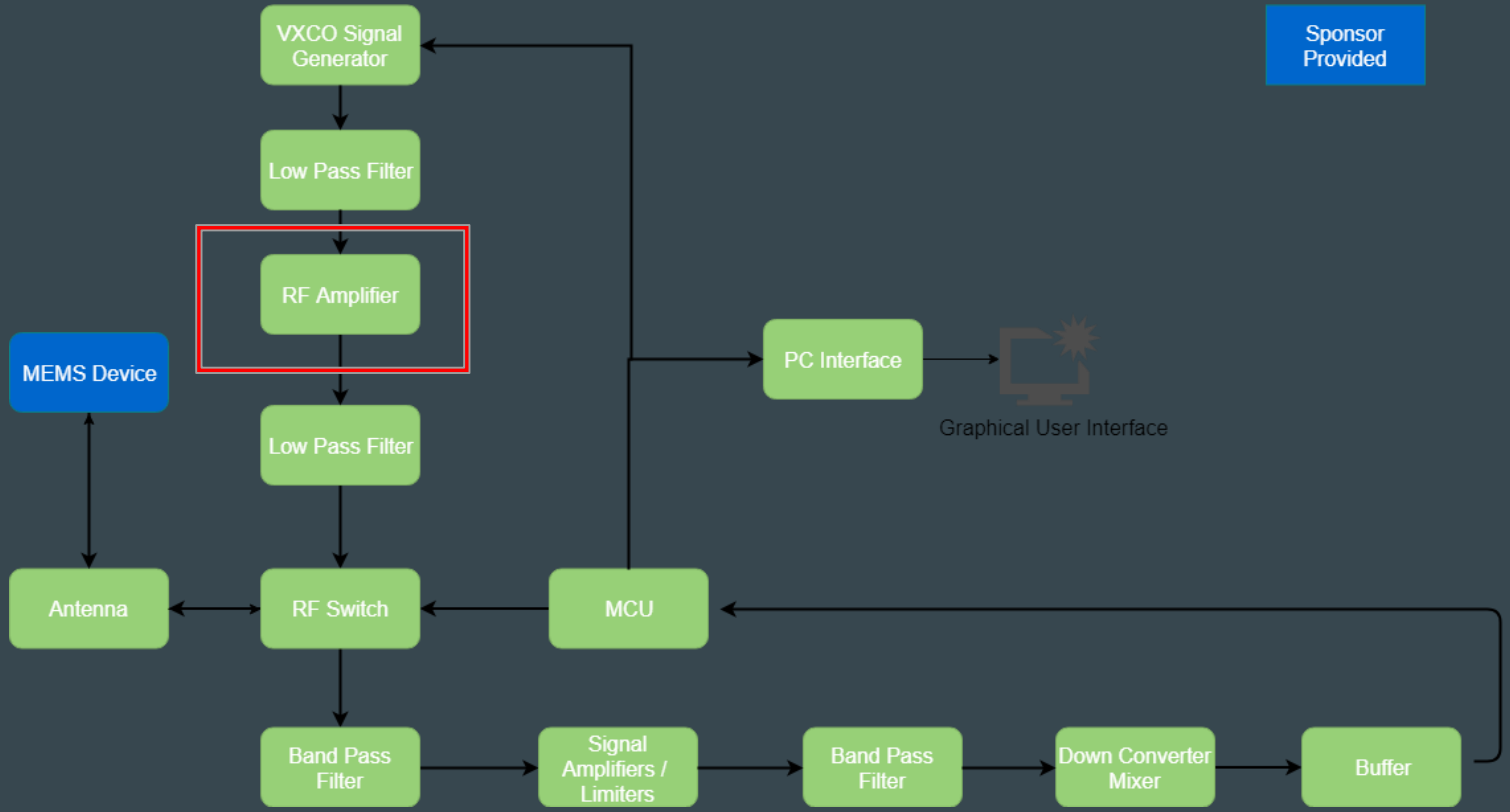
SIGNAL GENERATION



SIGNAL GENERATION

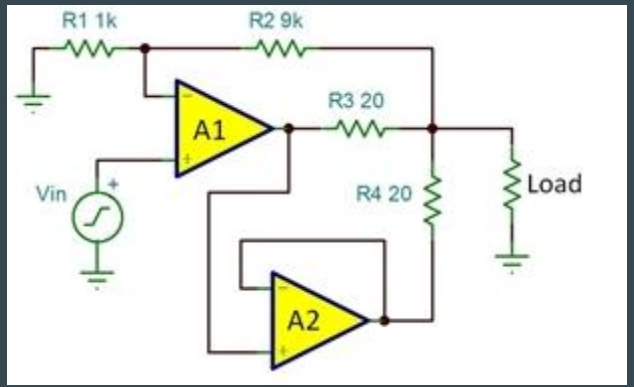


TRANSMITTED SIGNAL AMPLIFICATION

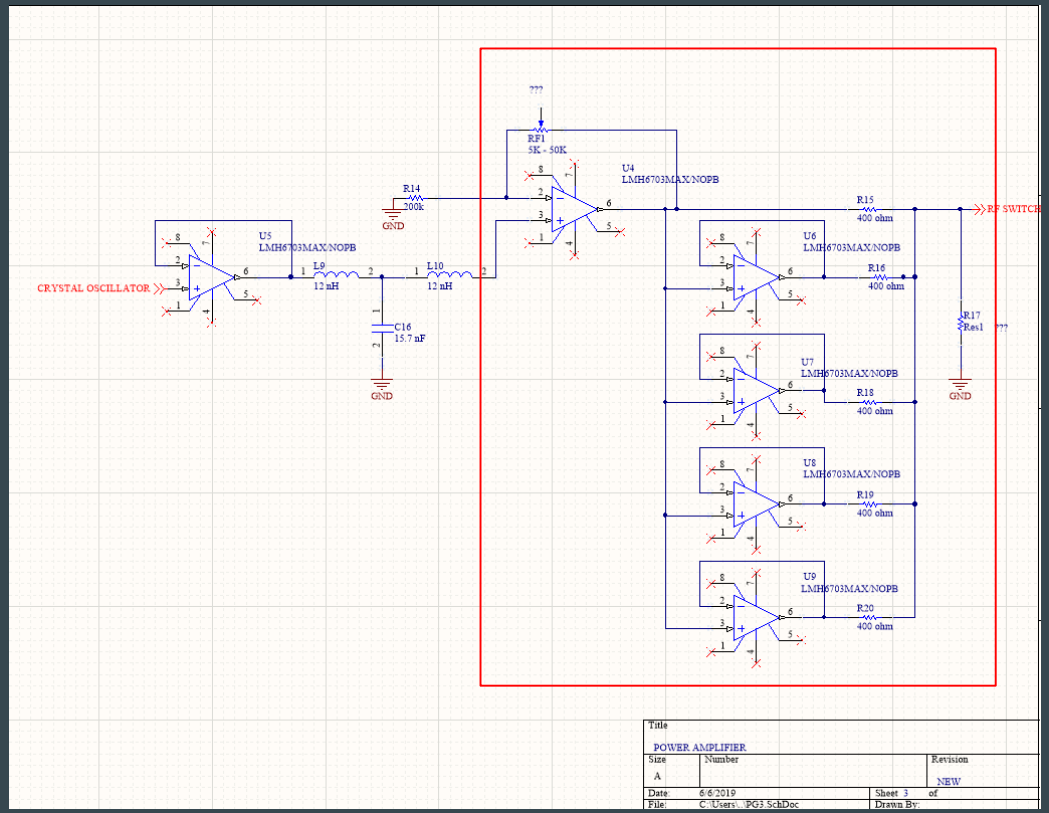


Power Amplifier Design

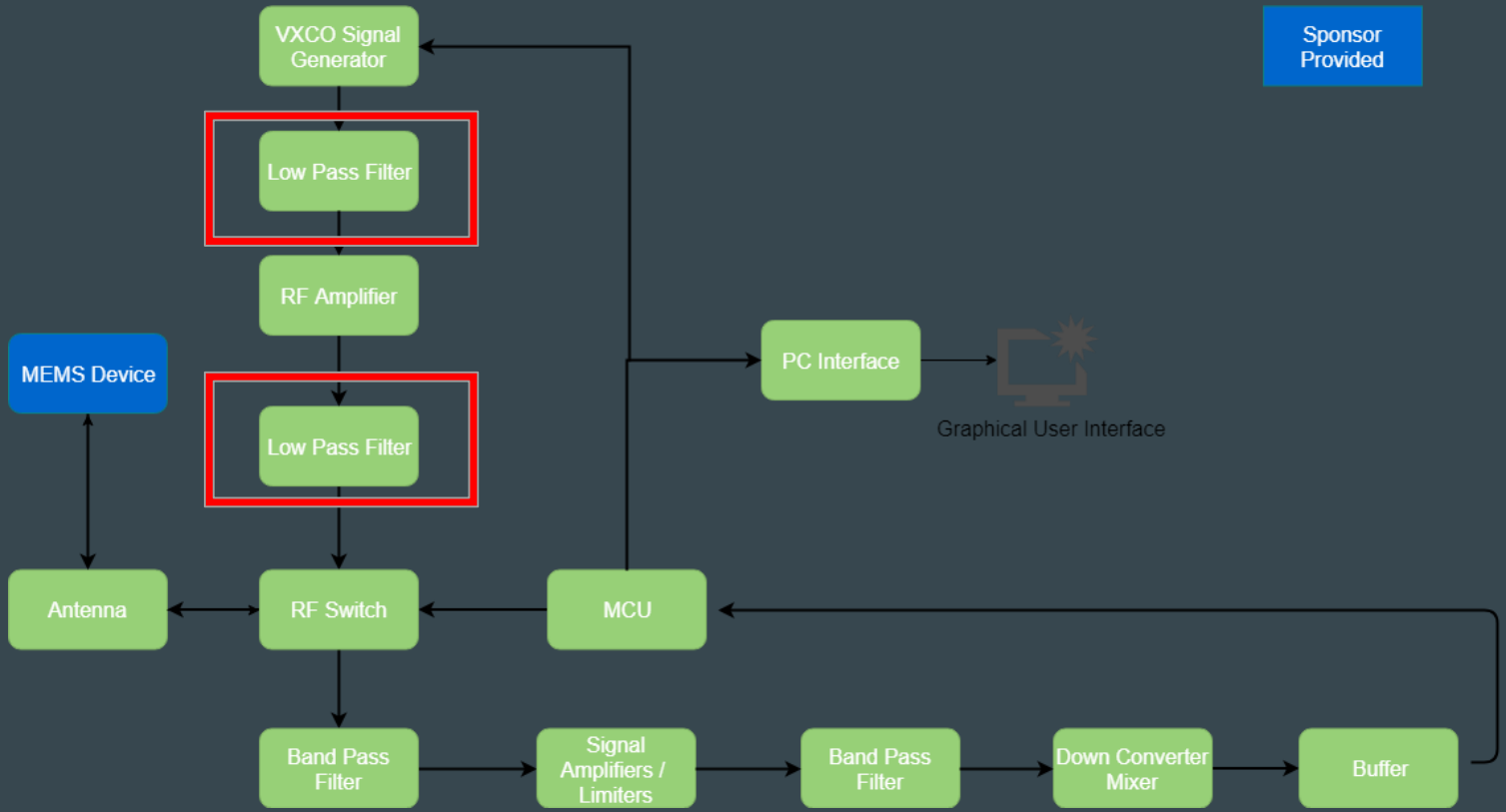
- Operational amplifiers were placed in master slave configuration to increase current output.
- Slew rate was made to be sufficiently large to allow for minimum signal distortion.
- Operational amplifier power driver provides a cheaper and more powerful alternative to costly wide band amplifiers.



POWER AMPLIFIER (Texas Instruments LMH6703MAX/NOPB)



LOW PASS FILTER FOR ISM COMPLIANCE



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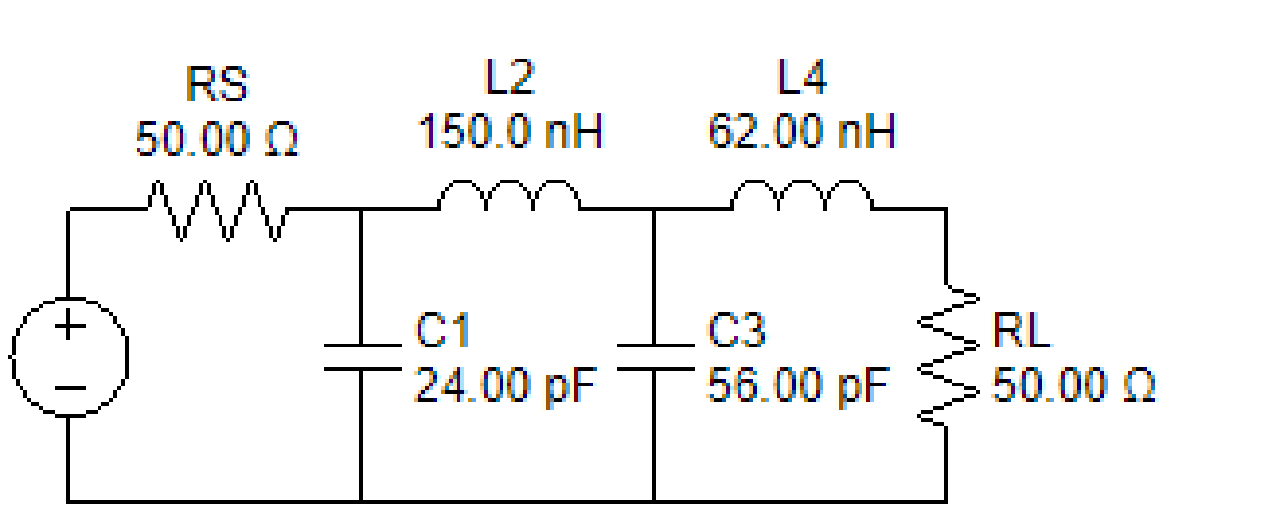
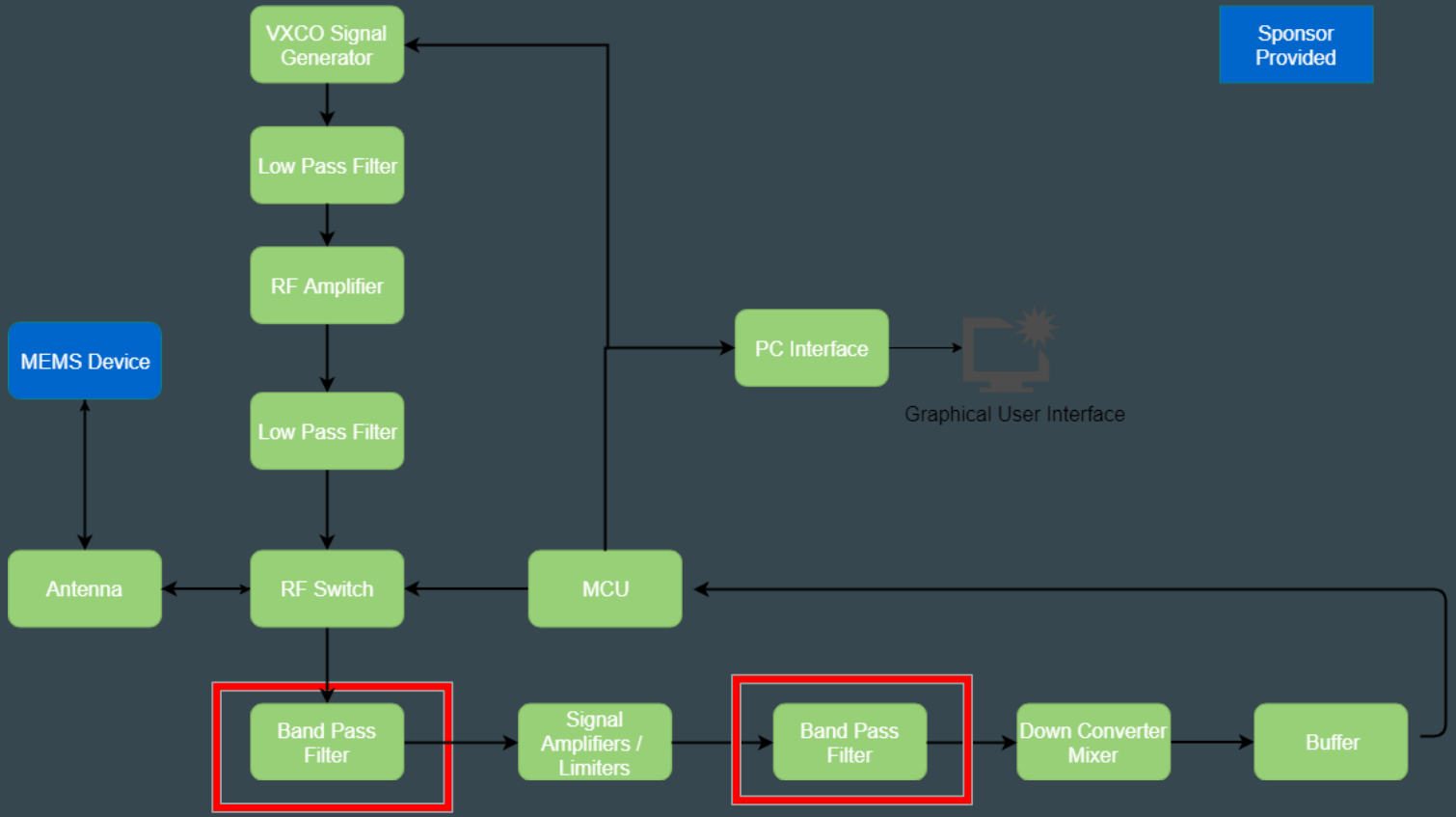
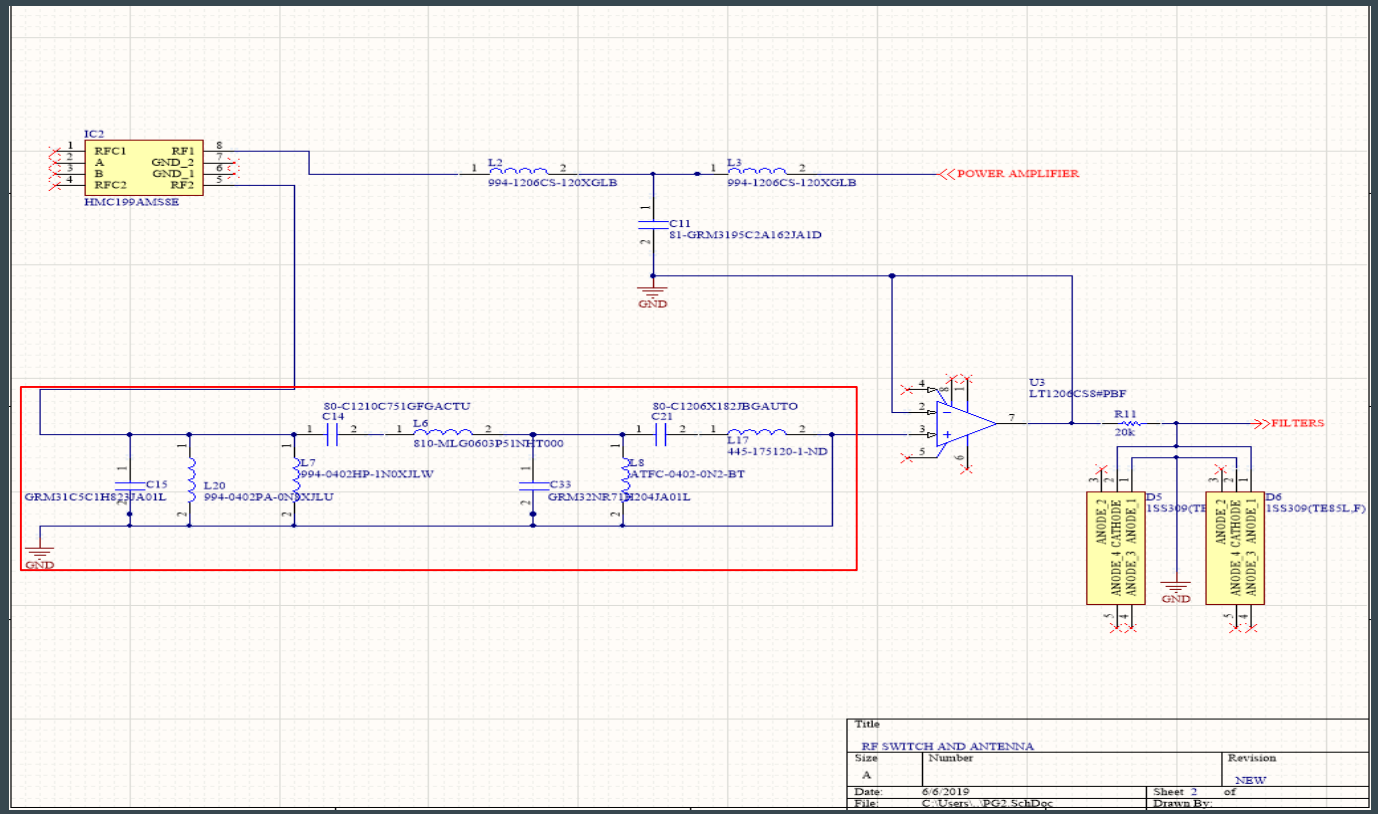


INCOMING SIGNAL FILTER



BANDPASS FILTER



INCOMING SIGNAL CONDITIONING

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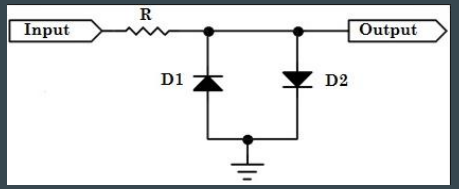
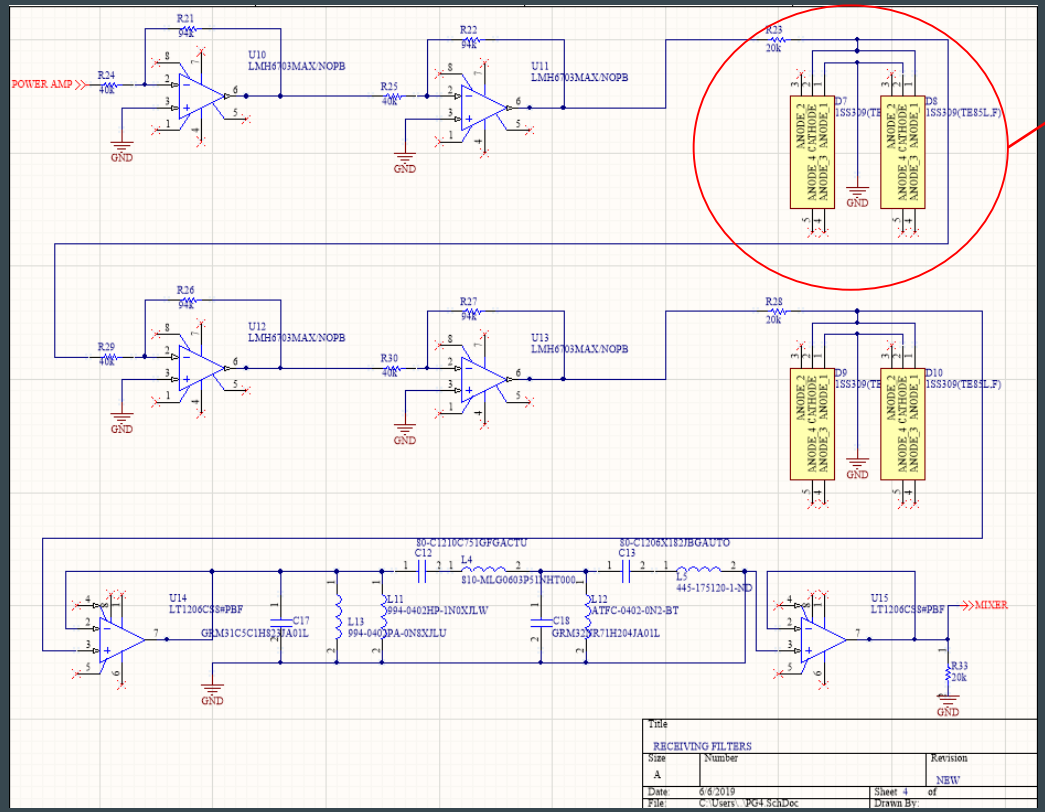
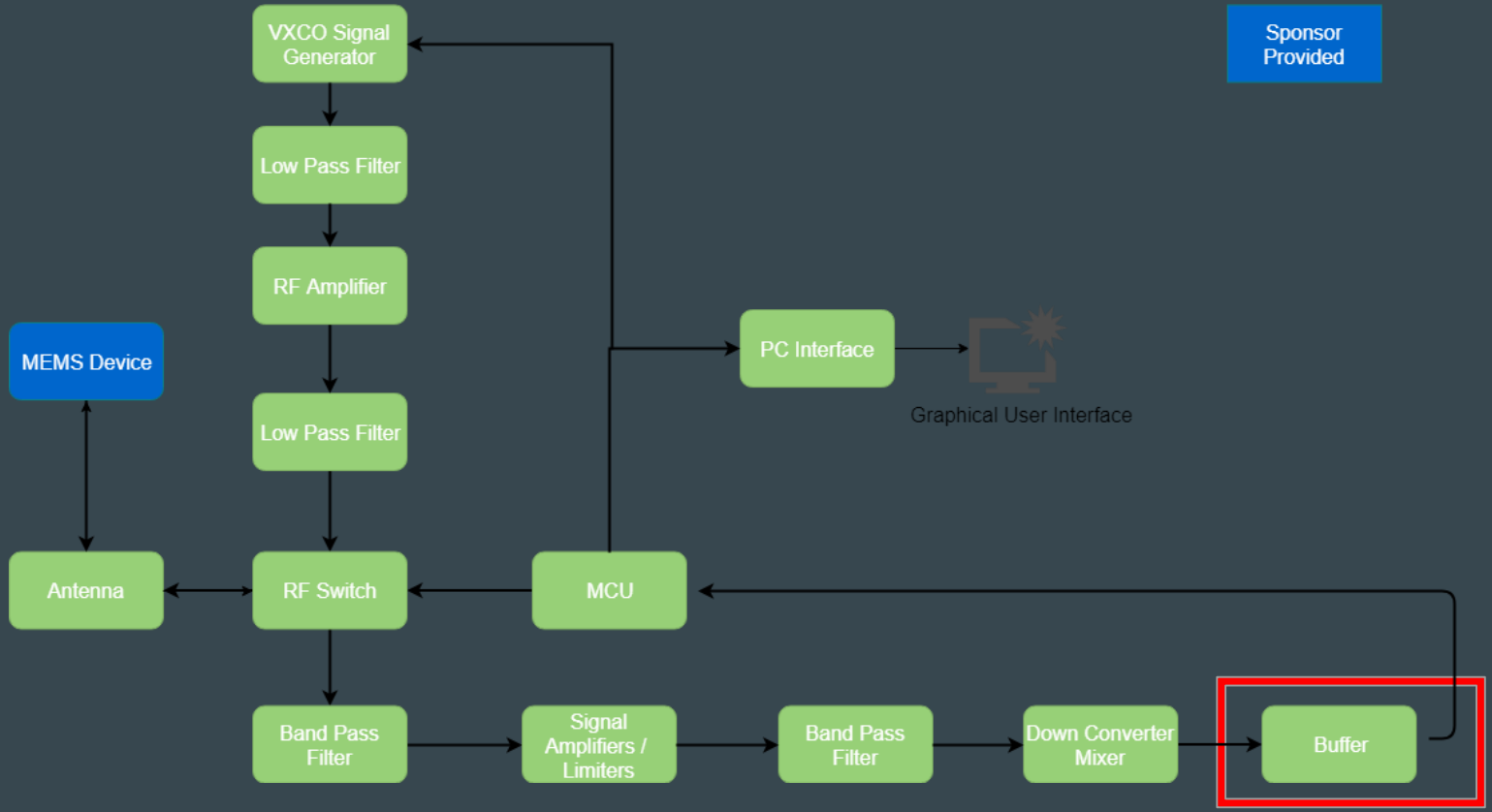




ADC SIGNAL BUFFER



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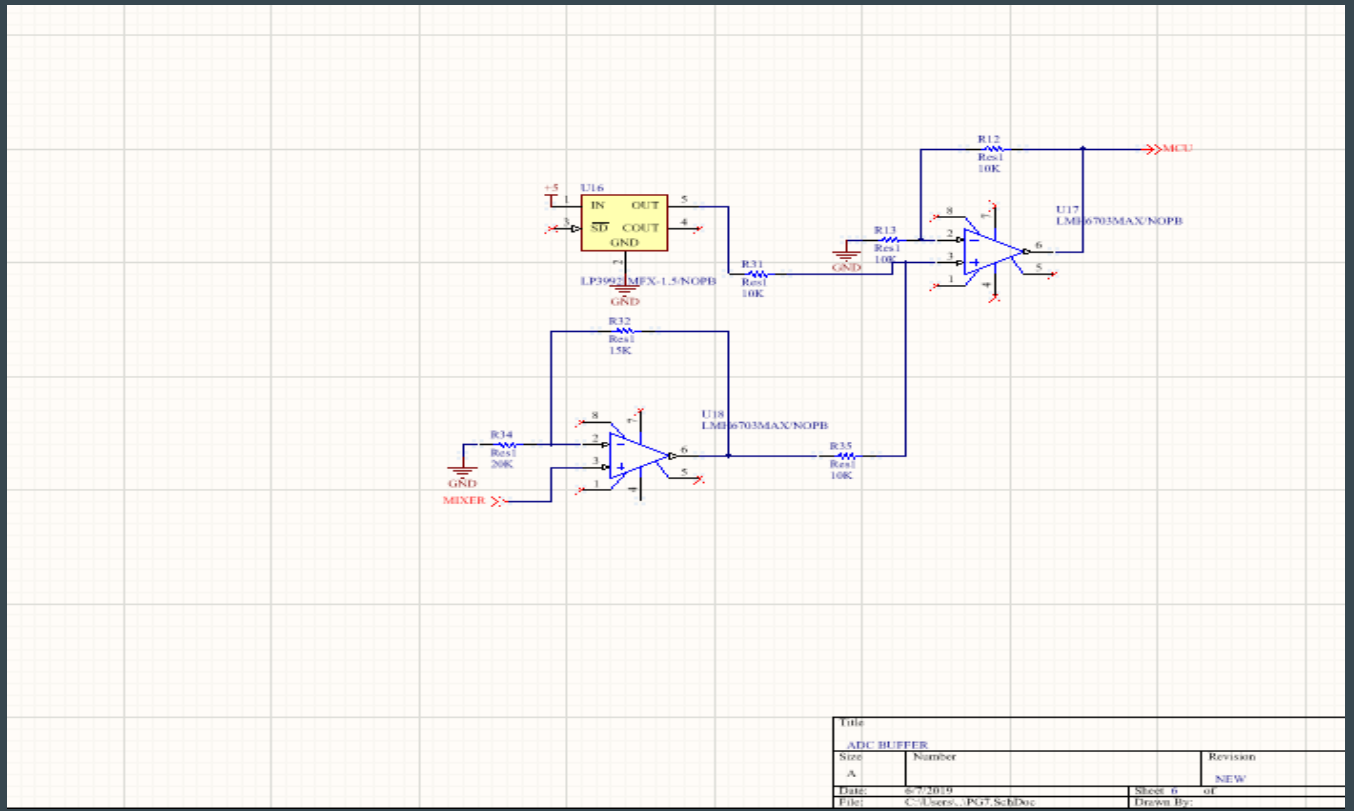
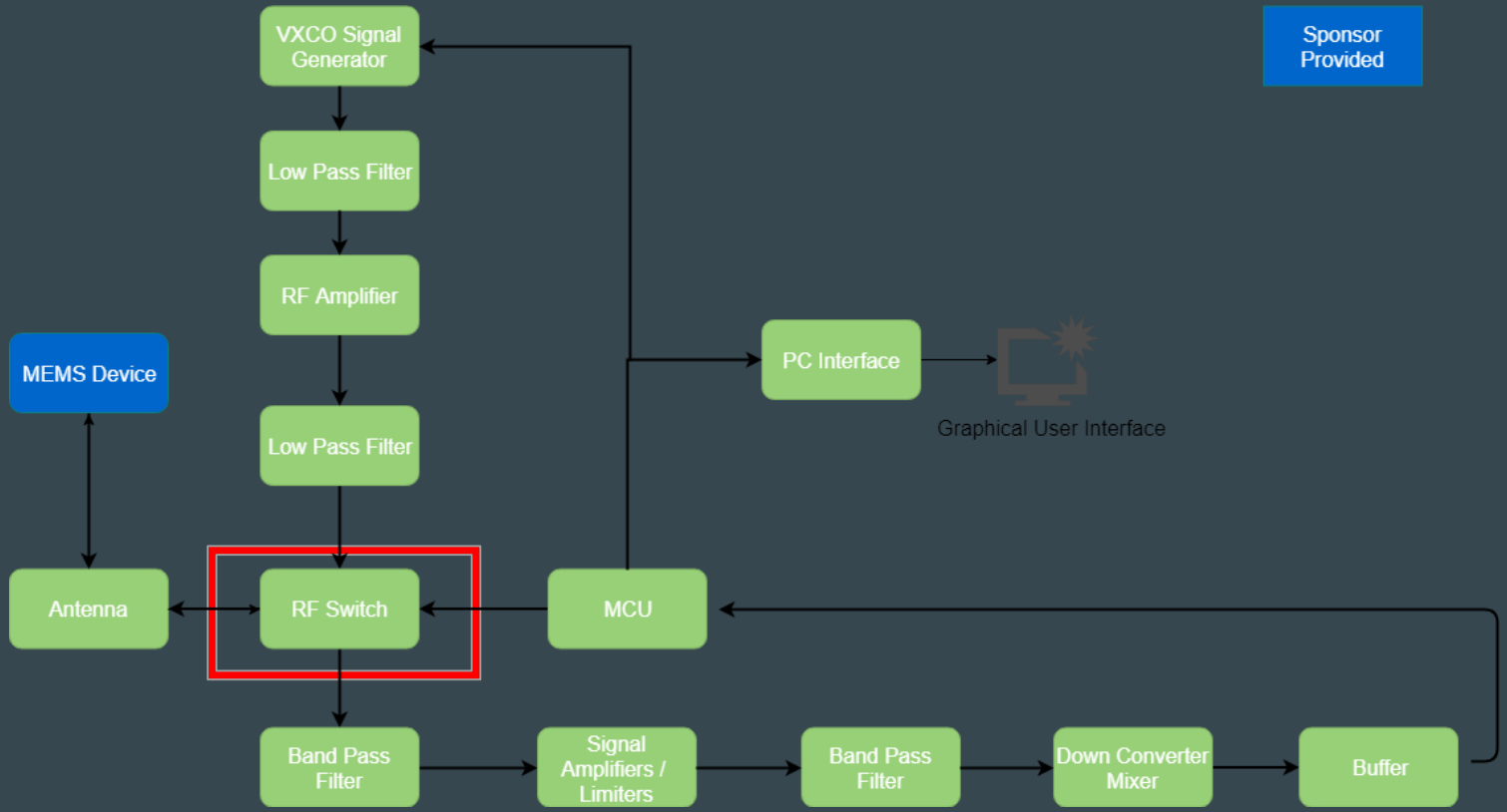
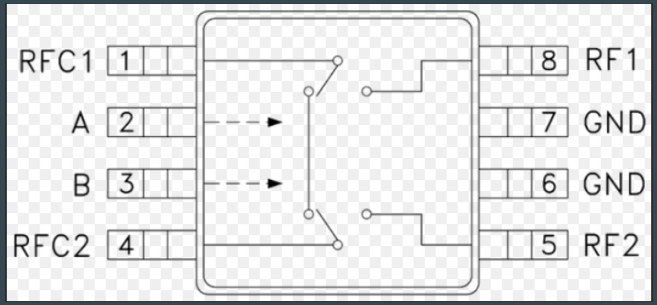


RF SWITCH: TX/RX SELECT

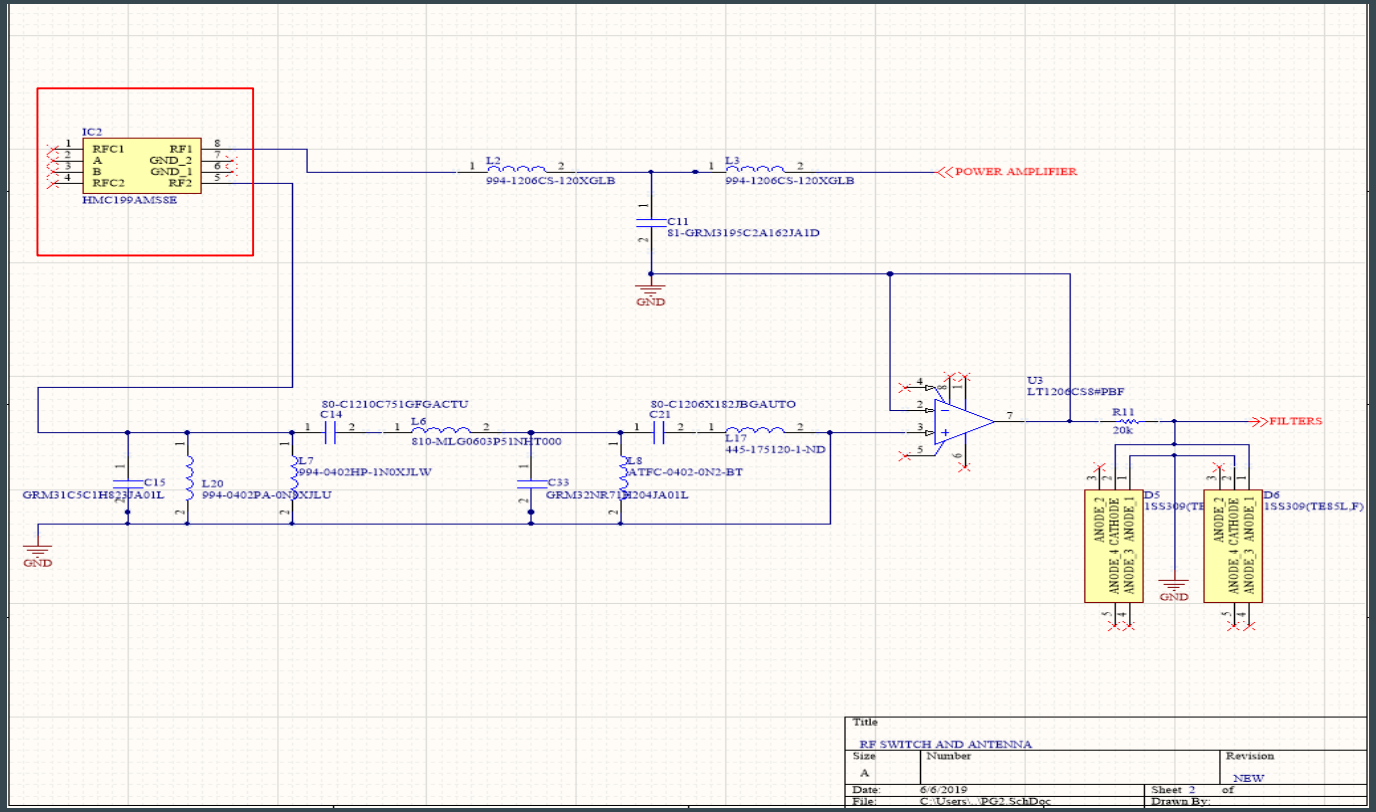


ANALOG DEVICES HMC199AMS8

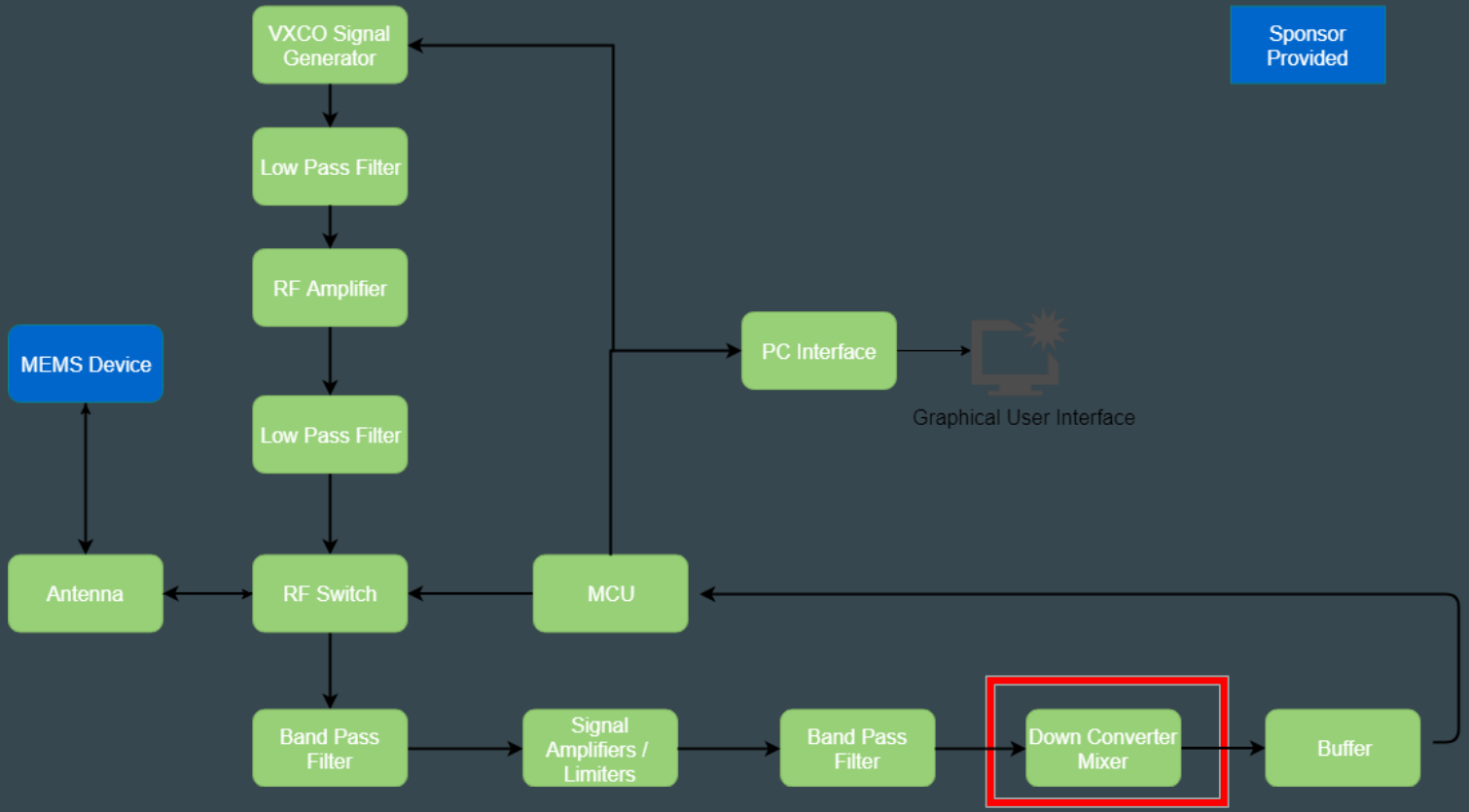
Part	Analog Devices HMC284AMS 8GE	IDT F2912	*Analog Devices HMC199AMS 8 / 199AMS8E*
Switching Time	5 ns	1.1 us	20 ns
Operating Frequency Range	DC - 3.5 GHz	300 kHz - 8 GHz	DC - 2.5 GHz
Cost	$3.46	$4.75	$2.54



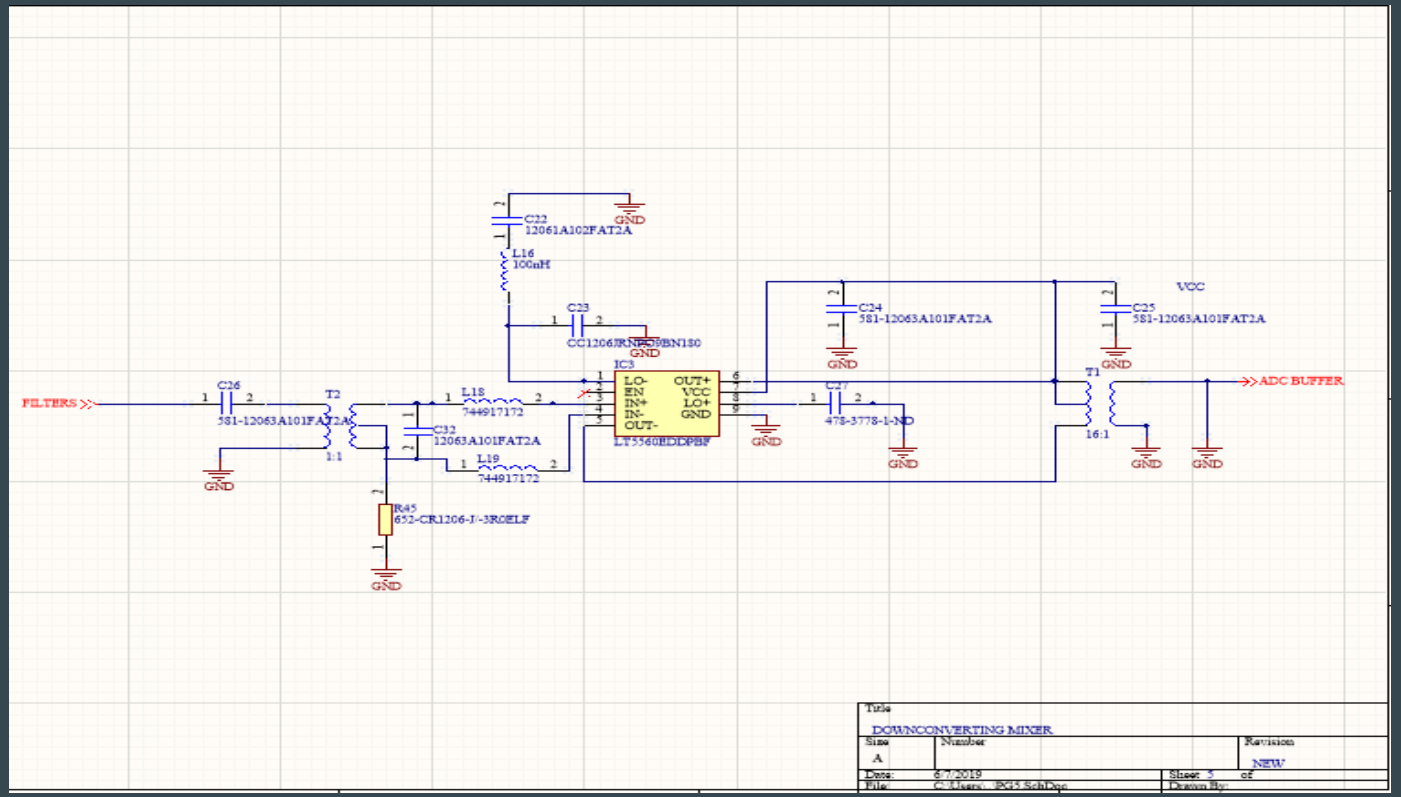
RF SWITCH (Analog Devices HMC199AMS8): RX/TX SELECT



DOWN-CONVERTER MIXER



DOWN-CONVERTER MIXER



Down-Converter Mixer

- Frequency is too high to be sampled by ADC
- Mixer shifts received signal frequency to a lower frequency (~27 MHz - ~1 MHz) for digital processing

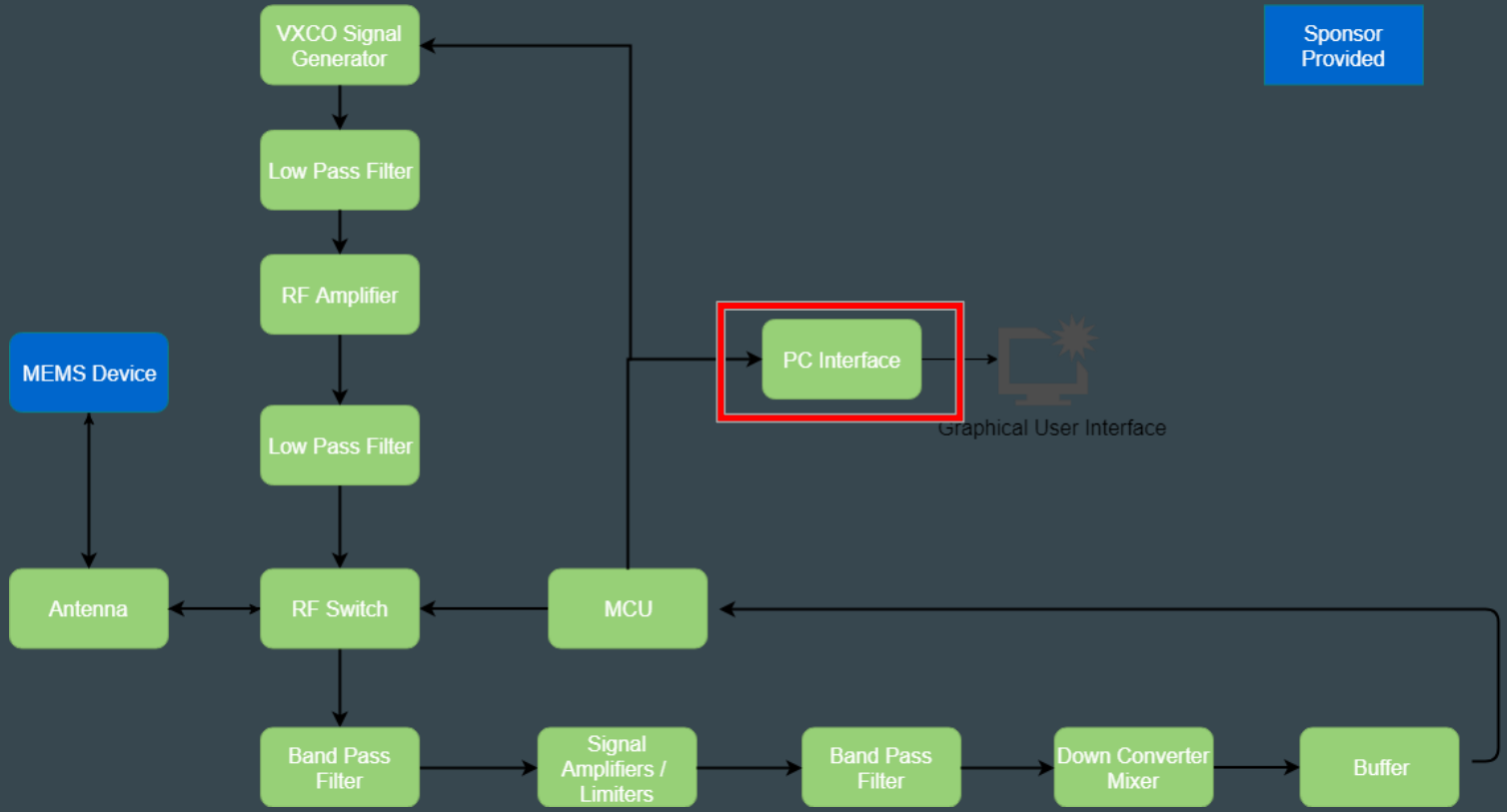
MCU


VXCO Signal Generator
Sponsor Provided
Low Pass Filter
RF Amplifier
MEMS Device
PC Interface
Graphical User Interface
Low Pass Filter
Antenna
RF Switch
MCU
Band Pass Filter
Signal Amplifiers / Limiters
Band Pass Filter
Down Converter Mixer
Buffer

MCU (TMS320F28335PGFA)

DEVICE	*TMS320F28335*	TMS320F28332
FREQUENCY (MHZ)	150	100
ON-CHIP FLASH MEMORY (kB)	512	128
# OF GPIO PINS	88	88
INSTRUCTION CYCLES (ns)	6.67	10
ADC CONVERSION TIME (ns)	80	80
COST	$25.98	$17.60

UART: PC Interface



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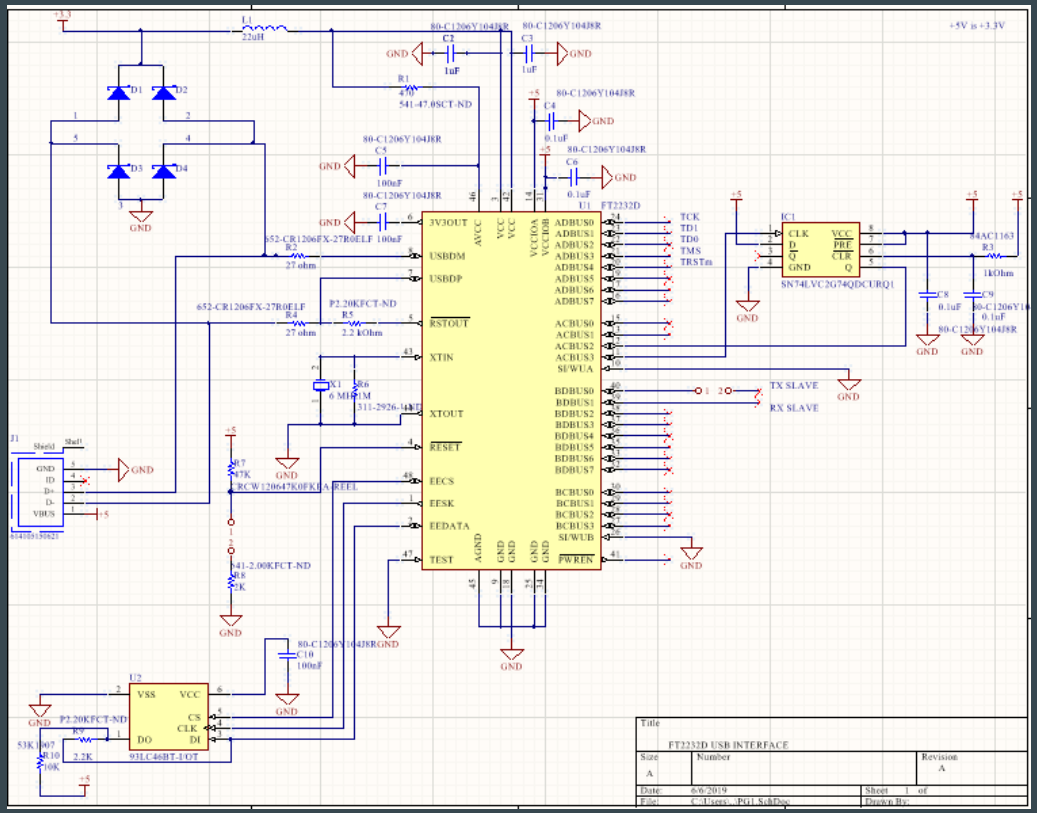
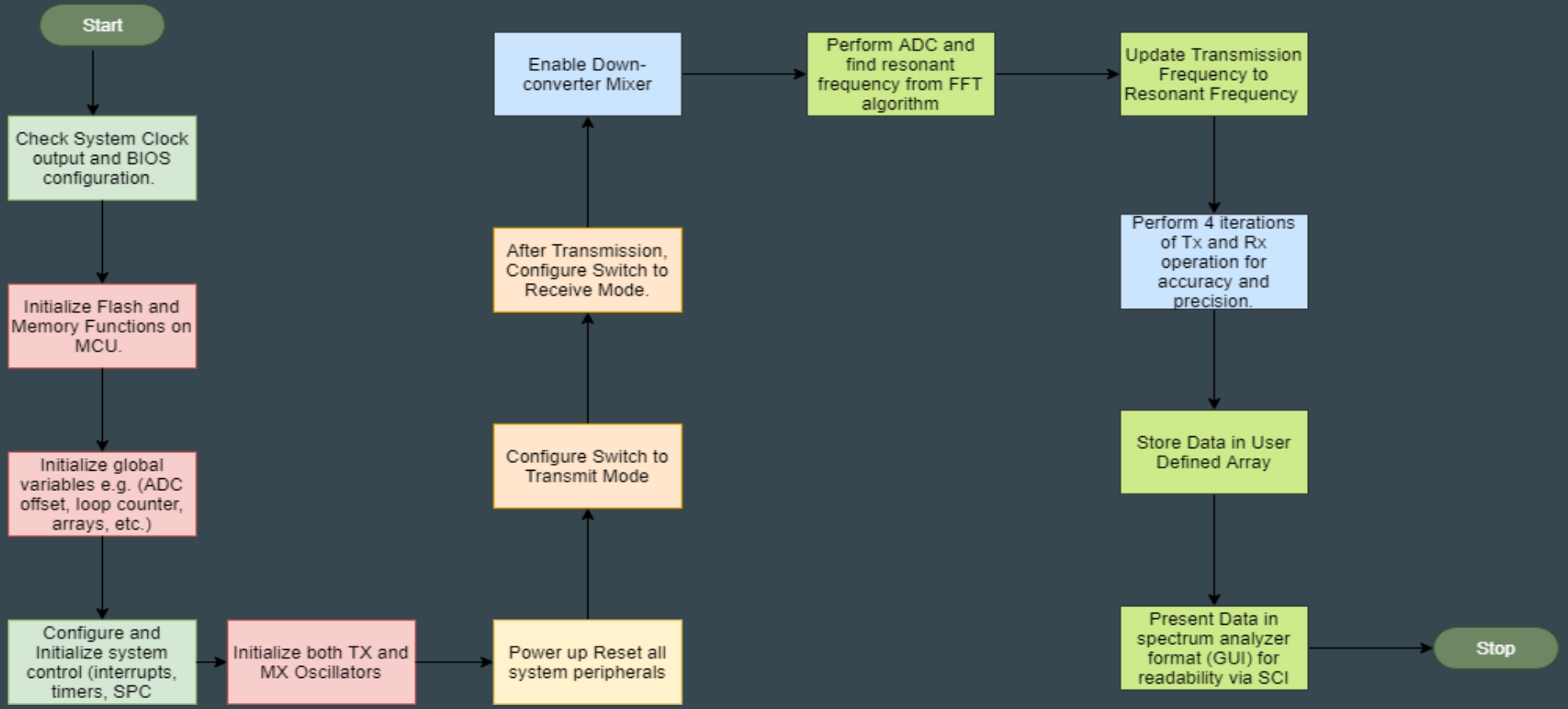


SOFTWARE CONCEPT DESIGN

The software design will make use of the following programs and interfaces:

Program Name	Function
TI Code Composer	For Editing, Debugging, Linking, mapping, and Compiling.
TI DSP software Overlay (C2000 Control Suite)	Provide Device specific code, header files, and example projects.
UART Software (Putty)	Output DSP data on PC via USB Port.

MCU SOFTWARE FUNCTIONALITY FLOWCHART



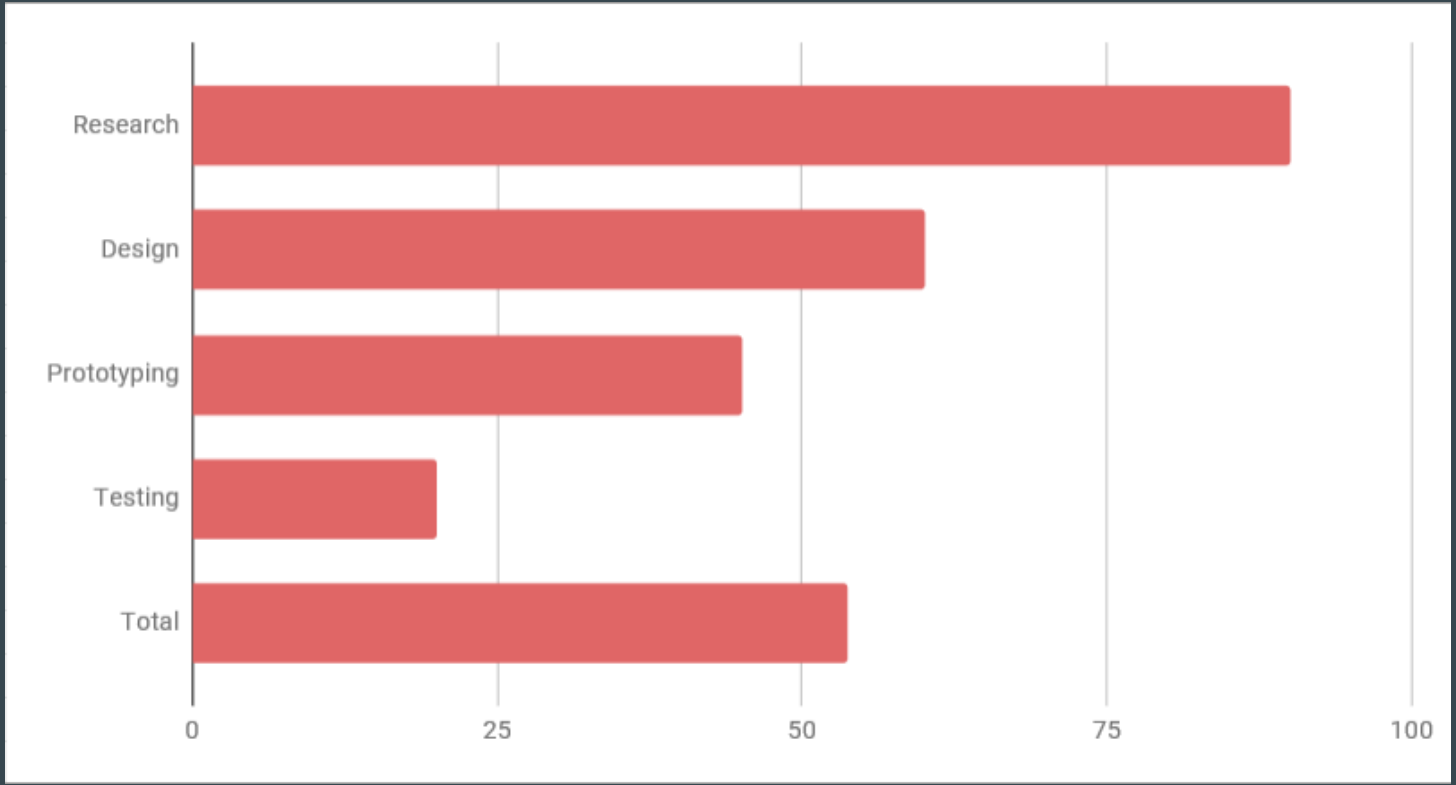
ADMINISTRATIVE

ASSIGNMENT	PRIMARY	SECONDARY
FILTER DESIGN	JUSTIN	TOLU
MIXER DESIGN	TOLU	JUSTIN
SCHEMATICS	JESSICA	JUSTIN
SOFTWARE	TOLU	JUSTIN, JESSICA
PCB DESIGN	JESSICA	JUSTIN, TOLU

PROJECT EXPENSES

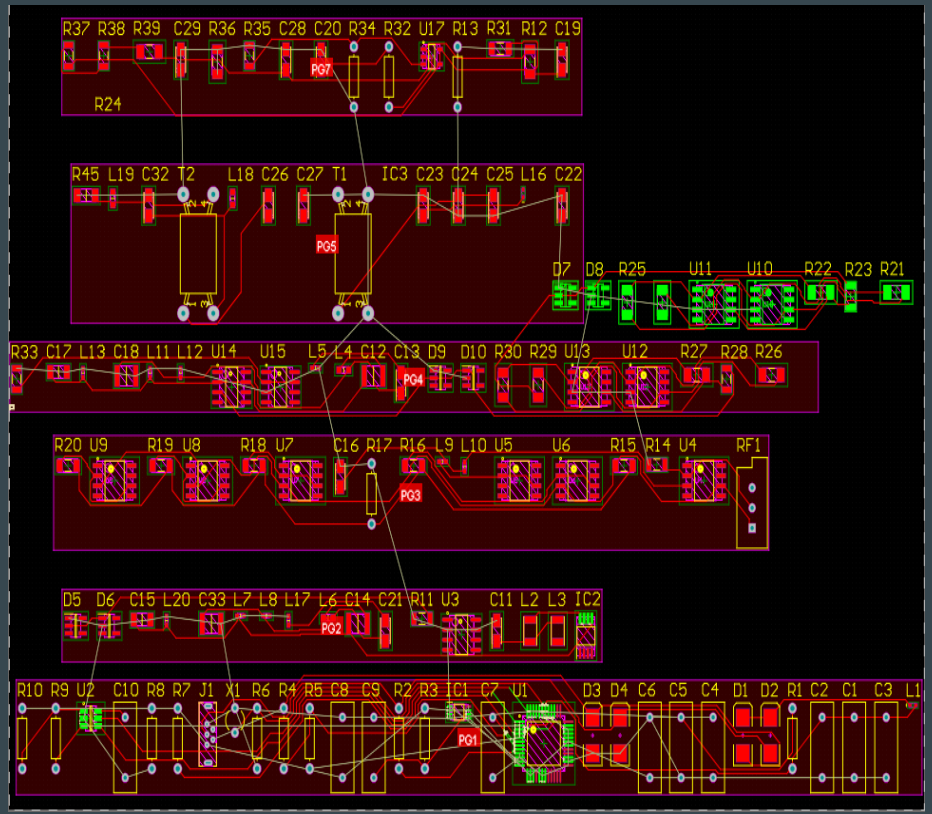
CATEGORY	ESTIMATED COST	PURCHASER
Total Parts	$736.39	Sponsor
Test Parts	$60.00	Sponsor
Altium Designer Software	$99.00	Group 9
PCB (5 boards)	$400.00	Sponsor
Final Document Binding	$20.00	Group 9
Total Project Cost	**$1,315.39**	-

PROGRESS REPORT



PROJECT CHALLENGES: PCB DESIGN

- Will require a multilayer device
  - 4 layer PCB:
    - Mounted components
    - Signal pathway
    - Power plane
    - Ground plane
- 100+ components to solder



INTENDED AGENDA

ASSIGNMENT	DUE DATE
PCB (rev. A)	6/10
Complete PCB	6/28
Complete Software	6/28
Complete Testing/Integration	7/19
Final Presentations	7/26

QUESTIONS?