Project Title: **Hybrid Synth**

Team Name: **Synthesize Me**

Team Members:
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**Project Abstract:**
Our Senior Design project will be an Analog Synthesizer. The synthesizer will consist of a digital part and an analog part. The digital part is the control system for the analog part. The digital control will accept MIDI input, and output a control voltage for the oscillators, as well as a low frequency oscillator (LFO) to modulate the analog signal. The analog segment is the synthesizer system. It consists of two voltage controlled oscillators (VCO), a signal mixer, a voltage controlled filter (VCF) with an envelope generator, and a voltage controlled amplifier (VCA) with an envelope generator. Each of these modules can be modulated by the LFO.
Introduction:

This synthesizer will be a useful tool for all musicians. It can be used in a recording studio, on the stage, or in the living room. It will be able to create a wide variety of sounds but still be compact and affordable. The use of MIDI for control allows a wide variety of products to control it. This further increases its usefulness.

The system will be different because it uses a microcontroller to provide the control voltages and LFO. Others such as The PIC Synth (http://www.synthdiy.com/show/?id=4142) uses digital oscillators and analog filters and amplifiers. There are a few other microcontroller synthesizers around but there are none for sale commercially. This is still a very new way to implement an analog synthesizer.

Technical Objectives:

The synthesizer will be controlled digitally. This will involve 2 Atmel processors, which will read MIDI inputs. The processors will output Control Voltages for the notes, LFO waveforms for the LFO selectors, and a Gate Voltage for the envelope.

The synthesizer has 3 main modules, all from analog design. These are the VCO, VCF, and VCA. The are two other types of circuits needed, a glide circuit and envelope generators.

The VCO, VCF, and VCA will be implemented using LM13700 transconductance amplifiers. These amplifiers allow for easy control voltage; this is well documented in datasheet.

The VCO will be able to output both triangle and square waves. These two waves provide a large amount of harmonics which can be later subtracted by filtering. The VCO works by a voltage, called a control voltage (CV), being applied to a node on the circuit. This causes it to oscillate at a certain frequency. This CV can be modulated by the LFO from the processor causes the frequency to modulate. This an effect known as vibrato.

The VCF will be able to select between a low pass, high pass, band pass, and band stop. The resonance will be selectable and filter should be able to get close to or enter self-oscillation. The center frequency can be controlled with a voltage. This also allows the LFO to control the frequency.

The VCA is the final stage of the synth. This will need to provide the gain to make the signal line level. The gain of the amplifier can be controlled by a voltage. This allows for the LFO to control the volume. This effect is called tremolo. The stage should have the standard output resistance to be able to provide proper transmission to a power amplifier.

The glide circuit is in the signal chain between the CV out from the microprocessor and the VCO. This circuit allows the CV into the VCO to slowly change when the note played changes. This creates a portamento effect, that is a slide in notes.

The envelope generator is used with the VCF and the VCA. It controls how the signal enters the VCF or VCA. The generator has four main components, attack, decay, sustain, release (ADSR). This is shown in Figure 1 below. When used with the VCA it creates the timbre of the sound. Controlling these parameters can make the synth sound like any instrument from a horn, to a guitar, to a violin.
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Figure 1: ADSR Envelope from http://ems.music.uiuc.edu/beaucham/software/m4c/m4c_intro_html/M4C_intro.ADSR.png

Cost Objectives:
Analog synthesizers are becoming less pertinent in today’s music world, as they are bulkier than digital synthesizers. Today’s analog synthesizers can cost anywhere from $300 - $3,000.

Our analog synthesizer will cost towards the lower end. Expenses that we will pay will cost around $200, split evenly between us.

References or Bibliograph:

Materials and Resources:
2 ATMEL Processors (Type TBD)
2 to 3 D-A Converters
LM13700 Transconductance Amplifier
MIDI Keyboard
Resistors / Caps / Op-Amps, etc.