Team LuGER
Laser Guided Energy Receiver

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Basic Project Description:

• Use a laser to sense vibrations on a window
• Demodulate the reflected signal to get audio data
• Process and filter the audio data
  – Analog filtering
  – Digital filtering
• Store both analog and digital sound files of the recorded data
• Interface with a Pocket PC
• Wirelessly transmit the digital data to alternate locations such as surveillance vehicles or cell phones via radio or laser
Tasks:

- Laser Send/Receive
- Analog Preamplification
- Analog Filtering and Storage
- Analog Playback (real-time)

- Digital Filtering and Storage
- Digital Playback

- VGA output of waveforms
- Distance Finder
- RF transmission of stored data
A known signal is sent to the receiver and preamp. Sound waves travel to the reflecting surface and cause vibrations on the surface. The signal bounces back modulated by the vibrations on the surface.

Collected data is sent to the processing unit. Analog filtering and amplification are performed. The processed data is sent to the PC, speakers, and PDA. The PC performs data storage, FPGA controls, and data analysis. The RF transmitter sends data to the radio, cell phone, etc.

Spartan-III Processing Unit:
- A/D conversions
- Time stamping
- RS-232 communications
- Data buffering
- Audio playback
- Digital storage
Laser

• What the device needs to do:
  - Send a known signal
  - High powered enough to get a good signal back

• What we need to do:
  - Mount laser on a tripod for an ideal situation
  - Determine the range of angles that can be used
  - Determine what the difference will be between the sent signal and the received signal
  - Ensure safe conditions for indoor and outdoor laser operation
  - Shield the power transformer
Laser Test Results

• Signal Tests
  - The average power output of the 5mW laser was 1.2mW
  - The voltage detected from the laser is 800mV
  - The laser test with the receiver unit displayed noise caused by the AC - power transformer. This was solved by shielding the laser and supply.

• Beam Scatter Tests
  - The laser scatters very little

• Shielding of the Laser
  - Eliminated high frequency noisy from the beam and isolated a problem with the noise coming from the lights at 120Hz
Receiver

• Functional Description
  - Receive modulated signal
  - Converts the signal into voltages
  - Amplify the signal into the 0-5V range
  - Send analog data to the back plane

• Parts and Interfaces
  - LM387 Preamp, LM741 & LM348 amplifiers, L14R3 phototransistor
  - Interface with the back plane will be via a 2 X 20 female edge connector installed on a PCB

M. Weimer
Receiver

• Reflected Signal Tests
  - The laser reflected approximately 60% of its power
  - Sinusoid waves detected clearly with minimal noise on the lower voltage peaks if the amplifier is saturated
  - Scattering of the laser beam doesn’t affect the phototransistor’s ability to correctly sense signal amplitudes

• Noise Tests
  - Background noise caused by fluorescent lights and power transformer
  - Vibrations from surrounding area affect the signal
Receiver
Receiver
Receiver Module
Analog Filtering

• Functional Description
  - Filters the analog signal from the receiver unit for audible human voices
  - Divide the signal into regions to correct frequency response problems
  - Obtain signals in the 0-20KHz range
  - Bandstop filters
  - Signal Pumping Cards

• Parts and Interfaces
  - OP-amps for 2nd order Chebychev bandpass filters
  - Interfaces with the back plane through a 2X20 female edge connector
Faux Equo

• Functional Description
  - Analog filters will use a high-pass filter on signals greater than 12KHz
  - Low-pass signals below 100Hz
  - Divide the remaining signal into 4 divisions: 100, 1K, 2K, 4K and 12K.

• Parts Lists and Interfaces
  - Op Amps, resistors, capacitors and circuit card construction
  - 2X20 female edge connectors
Analog Filter Circuit Design
Faux MoBo
(pseudo Motherboard)

• Functional Description
  - The back plane for all interface modules to connect to
  - Allows for modular bandpass filters through replacement of slot cards
  - Provide power to the bandpass filters
  - Supply voltage of 0-9V for the connecting cards

• Parts and Interfaces
  - 2X20 male edge connectors
  - PCB layout and population
Faux MoBo
(pseudo Motherboard)
The diagram displays three different operation modes:

1. Digital Filtering
2. Digital Storage (through RS-232 output)
3. Digital output to analog signal (Real time digital playback)
FPGA

• Functional Description
  - Receive the filtered data
  - Buffer the data
  - Control the communications between each modular unit
  - Control of audio playback

• Parts and interfaces
  - Connects to the back plane through female ribbon cables
FPGA
FPGA Test Results

• I/O verification
  - List of I/O verified
  - Confirmation of I/O voltage settings

• Memory Tests
  - FPGA and memory were programmed successfully
  - Use of the memory established
DSP

- Functional Description
  - Will smooth digital signal
  - Will provide squelch
  - Possibly perform Fourier analysis

- Parts and Interfaces
  - Verilog and schematics in Xilinx on FPGA
DSP

• Smoothing
  - May use a low order non-recursive smoothing function such as
  
  \[ y_n = \frac{x_n + x_{n-1}}{2} \]

• Squelch
  - Will use a simple time delay coupled with a event failure enable for a given sample length

• Fourier Analysis
  - May provide details on amplitudes of different frequencies graphically
Sampling

• Functional Description
  - 8-bit A/D and 8-bit D/A converts
  - 18.9K sampling rate, the same rate as a CD-ROM
  - Send the sampled data to storage

• Parts and Interfaces
  - MAX108, MAX533 and RAM
Communications

• RS-232 Functional Description
  - 56.6kbps rate will be use in conjunction with a data storage.
  - 9 bit even parity
  - Signal levels on the FauxMobo will utilize 0-9V and converter to RS-232 binary

• Tests Results
  - Verified control of outputs
Communications

• What will be sent?
  - Start string of 111111110 will start a “Chunk”
  - Next 9 bits will be timestamp from last transmission in secs.
    (deals with squelch)
  - 9 bit even parity digital voltage value will be sent

• When will it be sent?
  - We will store the values to RAM, and send a string at 56.6k across RS-232 serial cable to receiving computer/PDA after storage, and after a given signal.
  - Eventually, if time allows, this will also be able to be sent via RF using same bit patterns.
PDA

• **Functional Description**
  - Data storage unit
  - Analog playback from digital storage
  - Our PDA uses windows CE, so programming will be in C type environment for proprietary digital signal input.

• **Parts and Interfaces**
  - RS-232 connection
<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>Duration</th>
<th>Start</th>
<th>Finish</th>
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<tr>
<td>1</td>
<td>PDR presentation</td>
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<td>Tue 9/7/04</td>
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<td>Tue 9/7/04</td>
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<td>Laser mounting</td>
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<td>Thu 9/23/04</td>
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<td>8</td>
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<td>Tue 10/5/04</td>
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<td>Minimum functionality of FPGA state machine</td>
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<td>13</td>
<td>Modular interface complete</td>
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<td>Thu 9/23/04</td>
<td>Tue 10/19/04</td>
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<td>14</td>
<td>Integration of modular unit with receiver and FPGA</td>
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<td>Thu 10/21/04</td>
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<tr>
<td>15</td>
<td>Digital filtering and storage designed</td>
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<td>Tue 10/12/04</td>
<td>Mon 10/25/04</td>
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<td>Tue 11/2/04</td>
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<td>16 days</td>
<td>Wed 10/13/04</td>
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<td>Tue 11/2/04</td>
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<tr>
<td>23</td>
<td>Final technical manual</td>
<td>11 days</td>
<td>Tue 11/2/04</td>
<td>Tue 11/16/04</td>
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<td>24</td>
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<td>13 days</td>
<td>Tue 11/16/04</td>
<td>Thu 12/2/04</td>
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<tr>
<td>25</td>
<td>Design expo</td>
<td>0 days</td>
<td>Thu 12/9/04</td>
<td>Thu 12/9/04</td>
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</table>
Safety

• This project uses class II and class IIIa lasers
• Laser safety goggles will be worn if direct beam contact may occur
• Indirect laser radiation is not harmful
• Standard red laser pointers are rated class II-IIIa
Safety

Class II laser products
- Cannot harm the retina as blink reaction is sufficient protection
- Power output < 1 mW
- Generally in the wavelength range of 630-680 nm

Class IIIa laser products
- Safe for momentary viewing, are a recognized eye hazard if viewed through optics (telescopes, magnifiers)
- Power output between 1-5 mW
- Generally in the wavelength range of 630-680 nm
# Parts List

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiver</td>
<td>L14G3 Phototransistor, LM387, LM741 OP-Amp, 9V battery, tripod, and protoboard</td>
</tr>
<tr>
<td>Transmitter</td>
<td>Laser, acrylic, mounting braces, speakers and signal generator</td>
</tr>
<tr>
<td>Faux MoBo</td>
<td>Male 2X20 edge connectors, switches, LED’s, buttons, banana cable connectors, 5” x 12” PCB</td>
</tr>
<tr>
<td>FPGA</td>
<td>Xilinx Spartan 3</td>
</tr>
<tr>
<td>Playback</td>
<td>PC computer, Pocket PC PDA and speakers</td>
</tr>
<tr>
<td>Testing</td>
<td>D/A converters, A/D converters, OP amps, shielding, Casing materials and LED’s</td>
</tr>
<tr>
<td>Various Cards</td>
<td>PCB and edge connecting 2X20 females. Parts as needed (many op amps)</td>
</tr>
</tbody>
</table>
## Bill of Parts

<table>
<thead>
<tr>
<th>Part</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1mW and 5mW Lasers</td>
<td>$250</td>
</tr>
<tr>
<td>Xilinx Spartan-III FPGA</td>
<td>$150</td>
</tr>
<tr>
<td>Xilinx FPGA Accessories</td>
<td>$200</td>
</tr>
<tr>
<td>Dell Axim X3 Pocket PC (PDA) and Data Cable</td>
<td>$300</td>
</tr>
<tr>
<td>Safety Equipment</td>
<td>$200</td>
</tr>
<tr>
<td>Miscellaneous ICs and Components</td>
<td>$200</td>
</tr>
<tr>
<td>Miscellaneous Prototyping Materials</td>
<td>$300</td>
</tr>
<tr>
<td>Battery and Portable Equipment</td>
<td>$200</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$1800</strong></td>
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</table>
Division of Labor

• **Ryan Schnell**
  - FPGA Programming
  - Modular Unit Interface
  - Analog filter design
  - Faux MoBo design

• **Mike Wong**
  - FPGA Programming
  - Faux MoBo layout
  - Test plans
  - CDR presentation

• **Mike Weimer**
  - Receiver power supply
  - Analog filter testing
  - Parts procurement
  - Receiver testing
  - Silkscreening of CU logo and Scooby Doo on PCB

• **Jeremy Anderson**
  - RX and TX with PC
  - User manual
  - Accounting funds
  - Receiver testing
# Current Status

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiver Unit</td>
<td>70% complete</td>
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<tr>
<td>Analog Filter</td>
<td>60% complete</td>
</tr>
<tr>
<td>RS-232</td>
<td>40% complete</td>
</tr>
<tr>
<td>Analog Storage</td>
<td>30% complete</td>
</tr>
<tr>
<td>Digital Designs</td>
<td>20% complete</td>
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