Digital Control Electronics For Optical Gyroscopes

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What Is An Optical Gyroscope?

- Highly Sensitive Rotational Sensors
- Employed in Aircraft Navigation
- Potential Use in Other Industries
Fiber Optic Gyroscope

- Scale Factor
- Proper Frequency
- Allan Deviation

Graph:
- Scale Factor = 6.4762 Volts/(°/s)
- Y-intercept = -0.071418 Volts

Diagram:
- Source
- Photo Detector
- Modulator
- Fiber Coil
- Circulator
- 50/50 Splitter
Project Milestones

Goal: Miniaturize Bulky Optic Gyros into On-Chip Versions.

- Size Reduction
- Low Power Draw
- Very Precise Measurements
- Digital Control Electronics
Field Programmable Gate Array (FPGA)
- Can Be Used For Many Purposes

Used As Function Generator
- Applies Frequency To Phase Modulator
- If Applying Correct Frequency, Sensitivity Of Gyro Is Maximized
FPGA Tools And Software

- Very High Speed Integrated Circuit Hardware Descriptive Language (VHDL)
  - Hardware Descriptive Programming Language Exclusive to FPGAs

- Xilinx ISE Design Suite 14.7
  - Native FPGA Programming & Assignment Software

- ISIM VHDL Simulation Software
  - Models VHDL Behavior
FPGA Signal Traces

- Programmed FPGAs to synthesize different frequencies
- Also changed duty cycle of signal

Ex: Generate 5MHz, Simulation to Oscilloscope Trace

Ex: Variable Duty Cycle, 75% to 25%
Traces To IP Core Comparisons

- IP Cores: Code In VHDL Libraries (Pre-Coded)
- Checked Oscilloscope Traces From Custom Code to IP Cores

VHDL Custom

10 MHz

IP Core

25 MHz
Why Do This?

- **Goal:** Create Program To Dynamically Change Signal Frequency
  - Would Allow Us To Approach Proper Frequency By Testing More Frequencies
  - Example Modeling Of Proper Frequency
    - Pre-Recorded Data To Show How to Find Proper Frequency
  - Proper Frequency Found At Lowest Voltage
    - Want To Use FPGA Dynamic Signal To Find Proper Frequency
Current Roadblock(s)

- Current Signal Frequency Can be Changed Statically
  - After Re-Programming Or Restarting Oscilloscope

- Problem: Can’t Make Signal Change Dynamically
  - No Oscilloscope Restart Or Re-Programming
Future Research & Testing

- Control Electronics:
  - More Testing Of FPGAs
  - Integrate FPGA Signals With Gyroscope

- Error Analysis:
  - Analysis Techniques Such As Allan Deviation (Frequency Stability)
  - Apply To Discover Noise Error Types And Possible Solutions

- General:
  - Attempt Closed Loop Circuit of Optical Gyroscope
  - Custom Beginning-To-End Gyroscope Testing Process
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Questions?