



# Digital Control Electronics For Optical Gyroscopes

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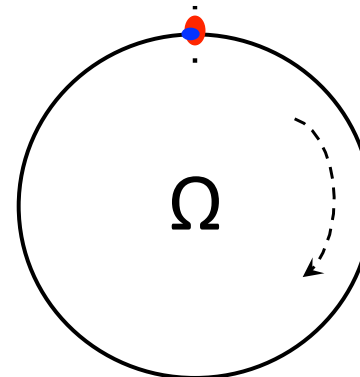
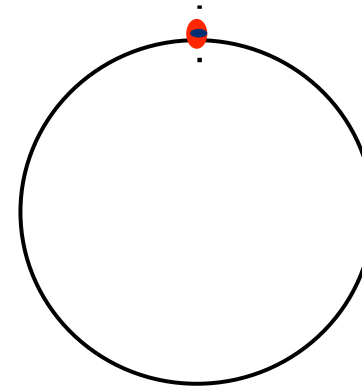
Dept. of Electrical & Computer Engineering

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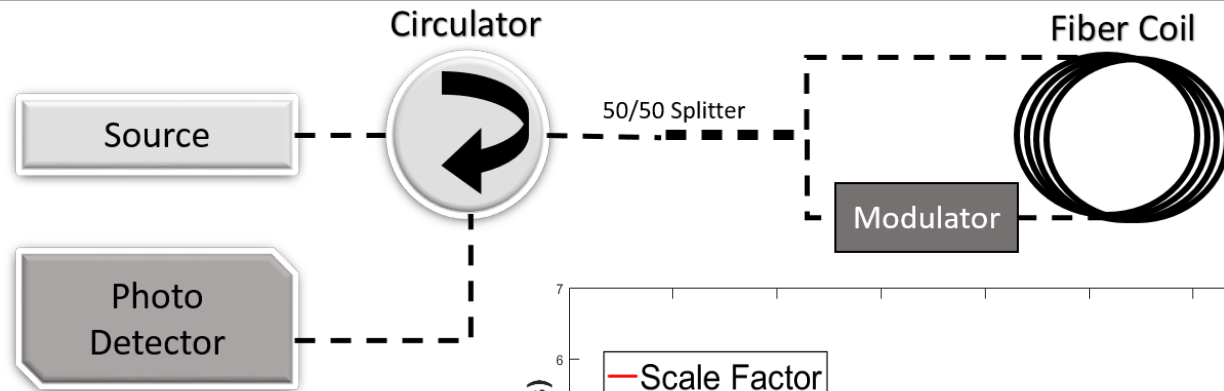
# What Is An Optical Gyroscope?

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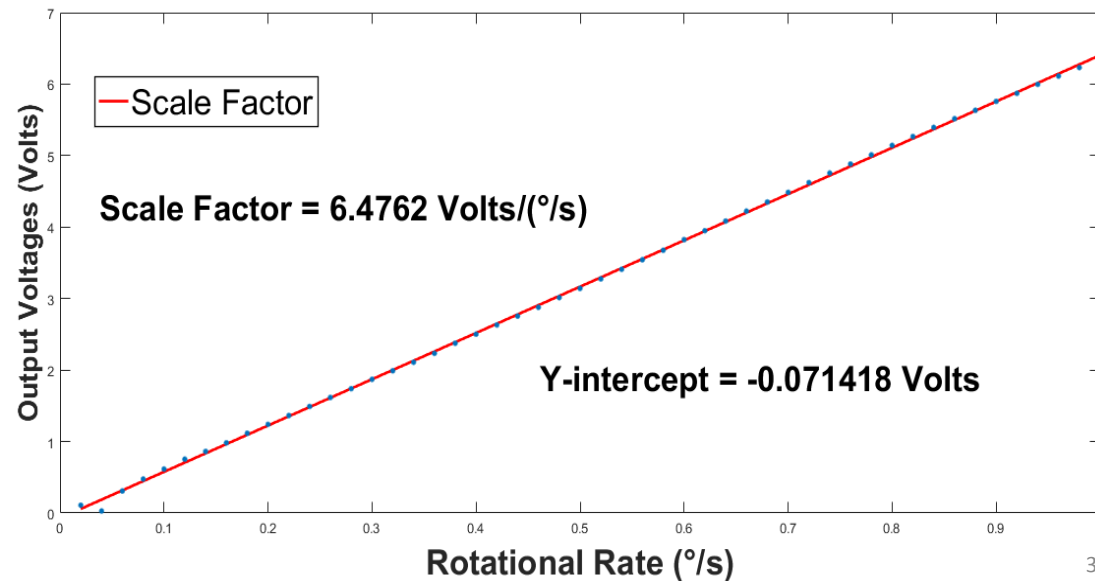
- Highly Sensitive Rotational Sensors
- Employed in Aircraft Navigation
- Potential Use in Other Industries



# Fiber Optic Gyroscope



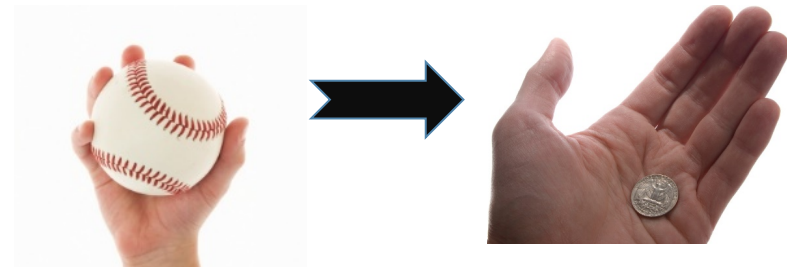
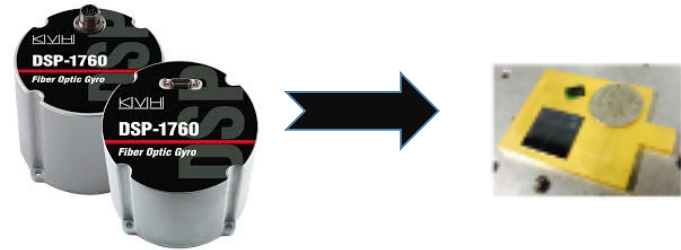
- Scale Factor
- Proper Frequency
- Allan Deviator



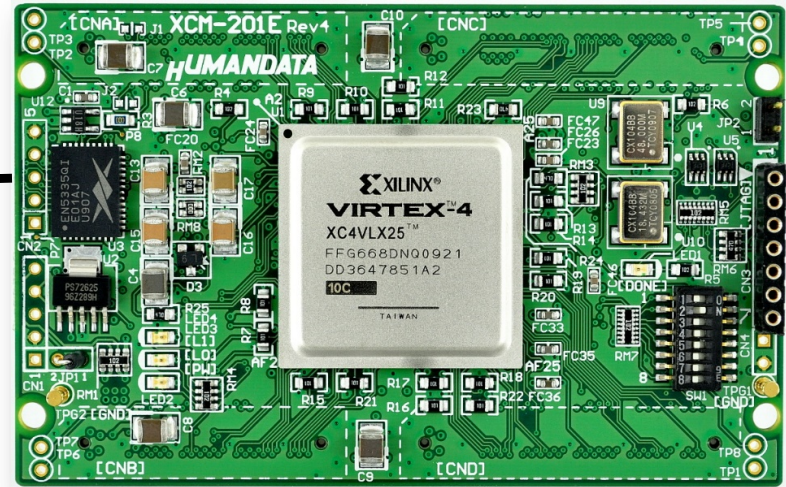
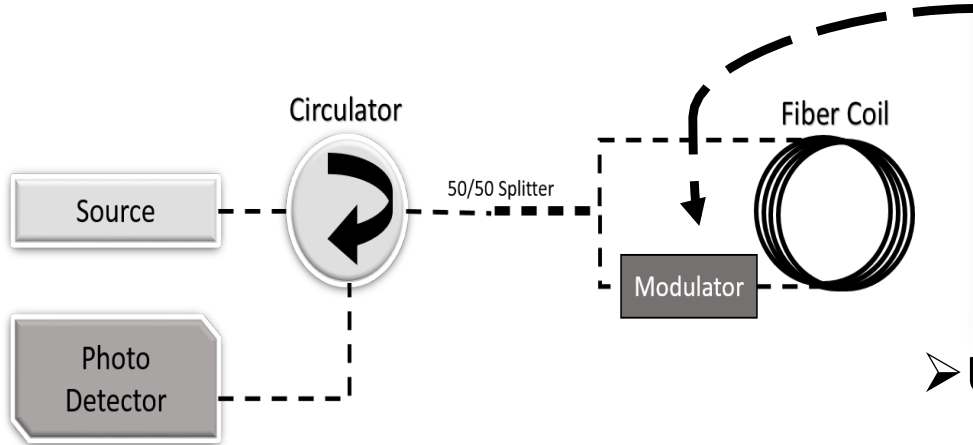
# Project Milestones

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



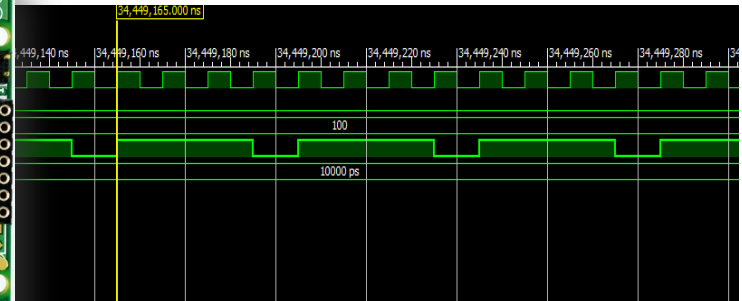
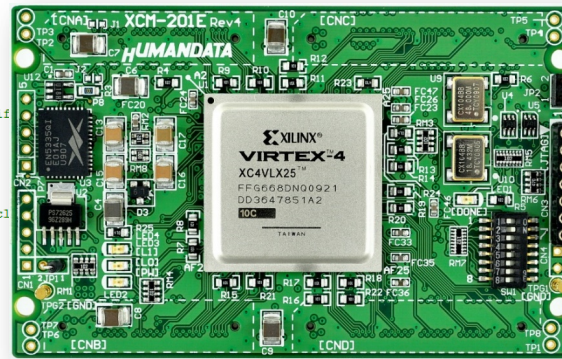
- Used As Function Generator
  - Applies Frequency To Phase Modulator
  - If Applying Correct Frequency, Sensitivity Of Gyro Is Maximized

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

```

1  library IEEE;
2  use IEEE.STD_LOGIC_1164.ALL;
3  use IEEE.NUMERIC_STD.ALL;
4
5
6  entity sqrInWave is
7  Port ( clk, restart : in STD_LOGIC := '0';
8        inputButton : in STD_LOGIC_VECTOR(0 to 3);
9        Vout         : out STD_LOGIC := '0');
10 end sqrInWave;
11
12 architecture sqrInWave_Arch of sqrInWave is
13 constant clk_divider : integer := 10; --Operating at 10MHz, change if
14 signal high_pulse : STD_LOGIC := '0';
15
16 begin
17
18   sqwave_proc : process(clk, restart)
19     variable clk_divider_counter : integer := 0; --range from 0 to cl
20   begin
21
22     if (rising_edge(clk)) then
23       if (restart = '1') then
24         clk_divider_counter := 0;
25         high_pulse <= '0';
26       end if;
27
28       if (clk_divider_counter = clk_divider - 6) then --for 50% duty cycle
29         clk_divider_counter := 0;
30         high_pulse <= not high_pulse;
31       else
32         clk_divider_counter := clk_divider_counter + 1;

```



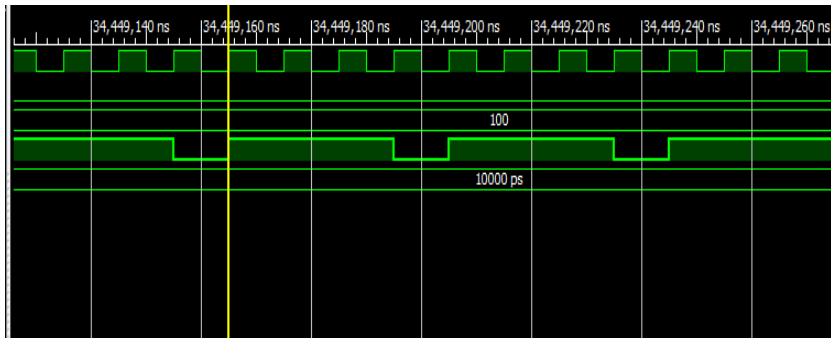
- Xilinx ISE Design Suite 14.7
  - Native FPGA Programming & Assignment Software
- ISIM VHDL Simulation Software
  - Models VHDL Behavior



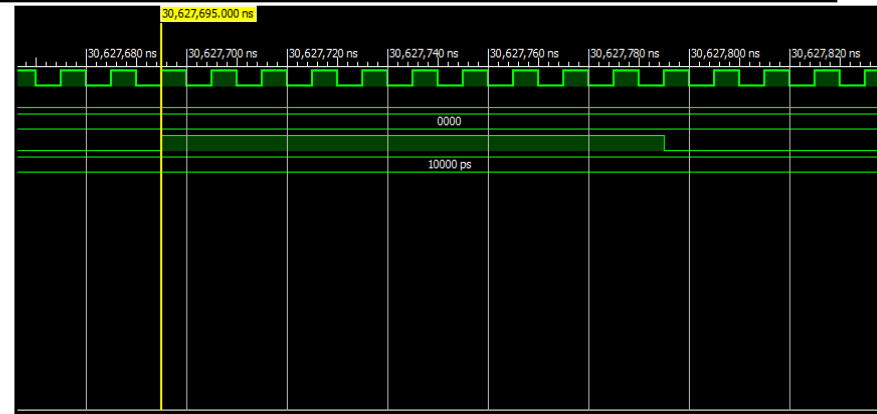
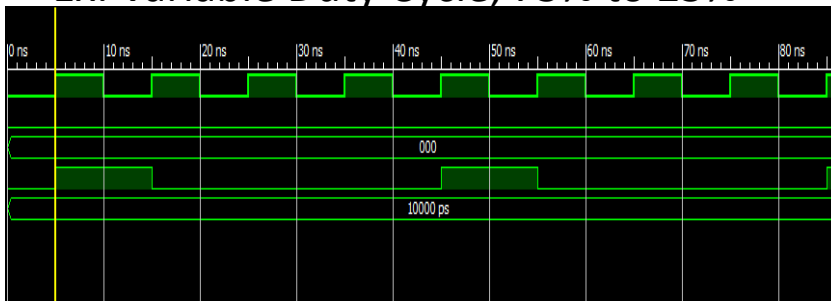
# FPGA Signal Traces



- Programmed FPGAs To Synthesize Different Frequencies
  - Also Changed Duty Cycle Of Signal



Ex: Variable Duty Cycle, 75% to 25%



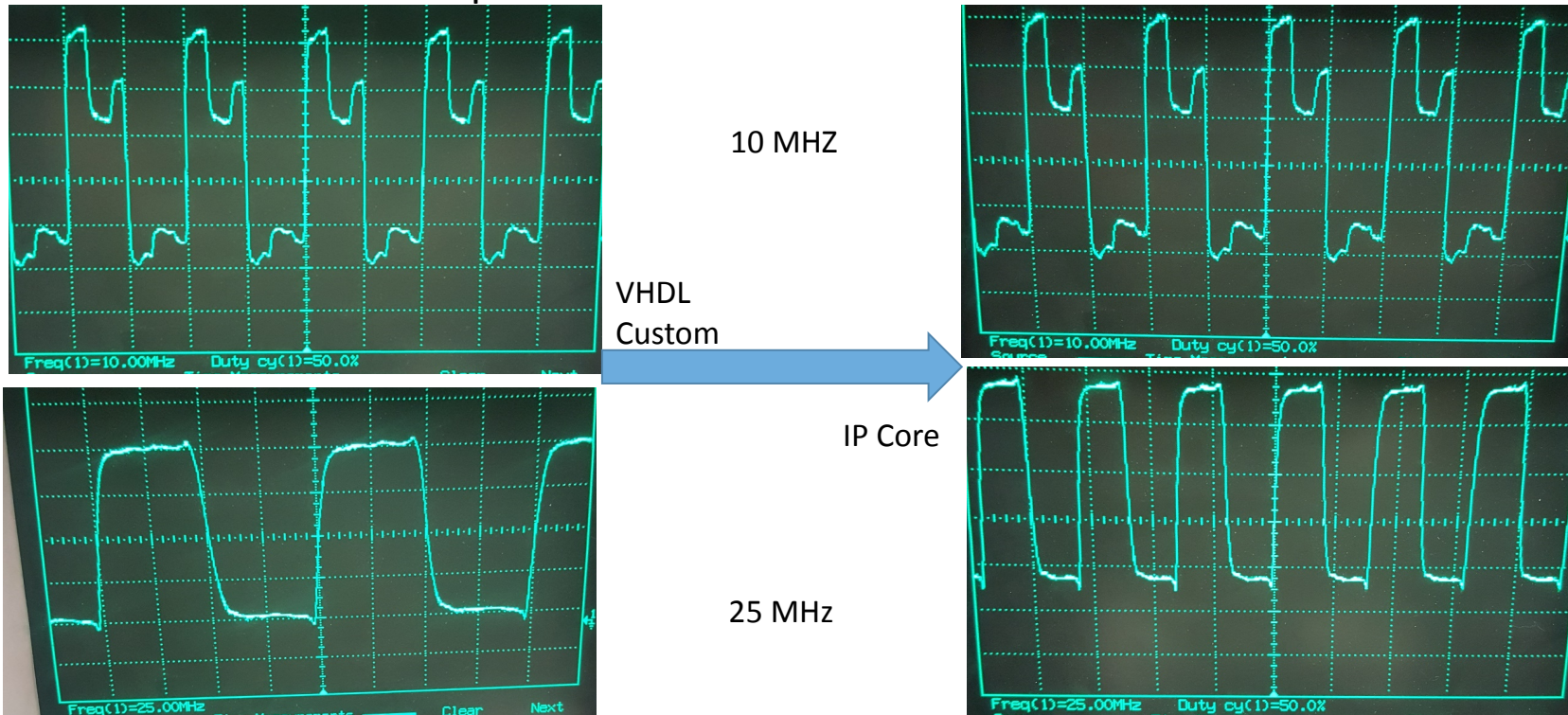
Ex: Generate 5MHz, Simulation To Oscilloscope Trace





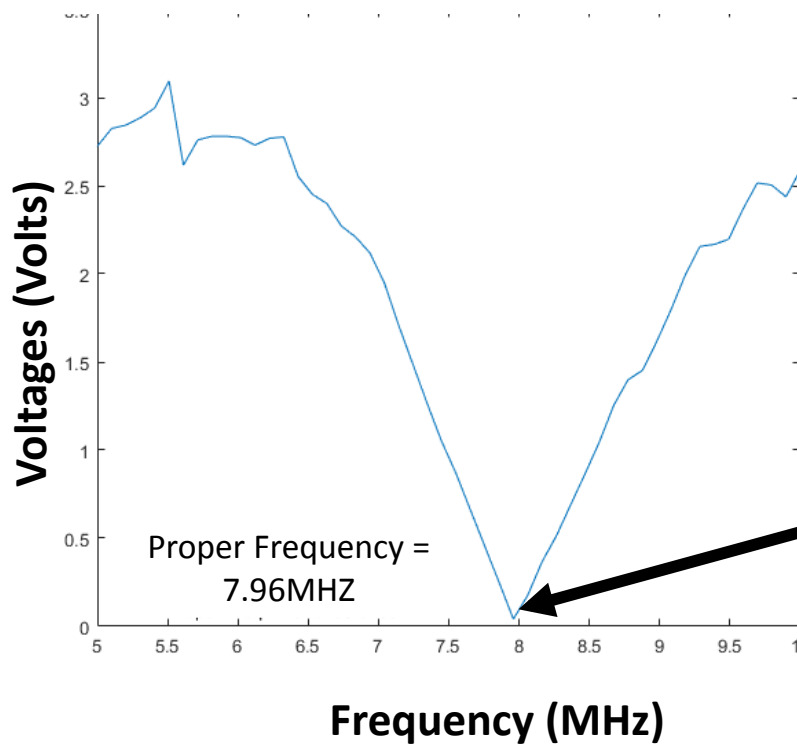
# Traces To IP Core Comparisons

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





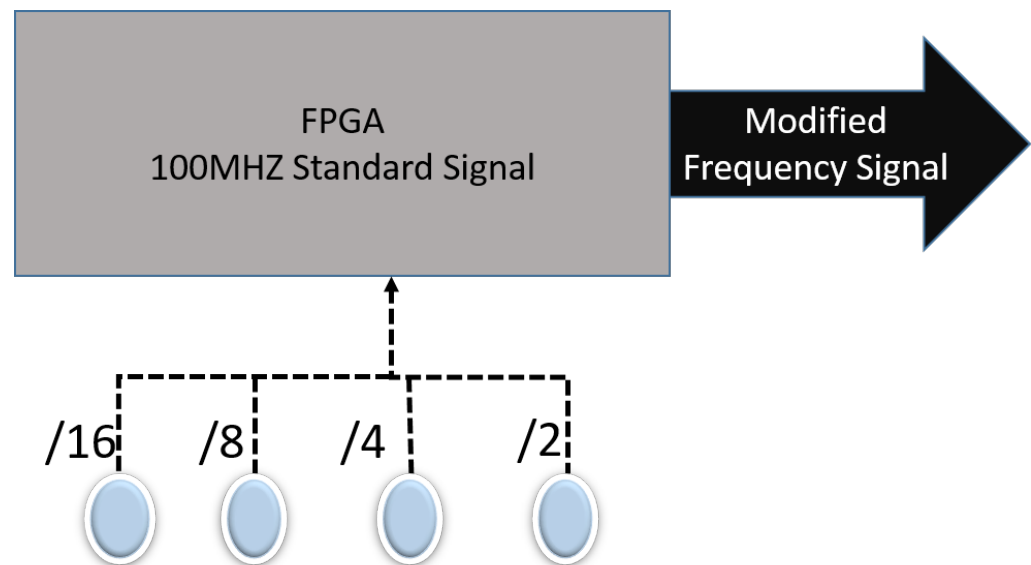
# Why Do This?



- 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 Staticly
  - After Re-Programming Or Restarting Oscilloscope
  
- Problem: Can't Make Signal Change Dynamically
  - No Oscilloscope Restart Or Re-Programming





# Future Research & Testing

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- 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



# Acknowledgements

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- I Extend My Gratitude To The Following:
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  - McNair Scholars Program
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Questions?