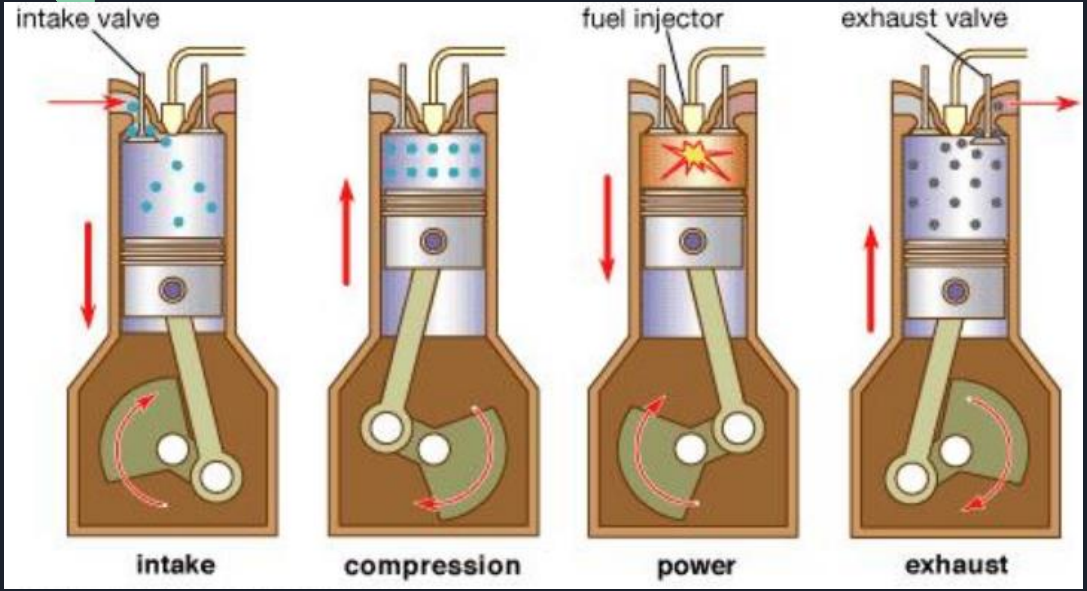
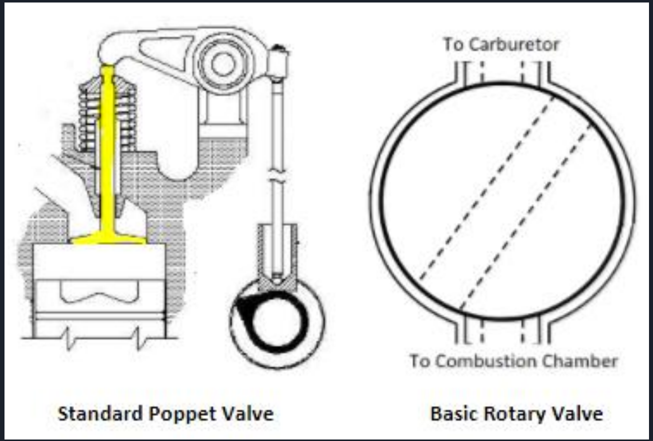
Engine Control Unit

Chris Taylor, Robert McInerney

(4 stroke) Internal Combustion Engine Basics



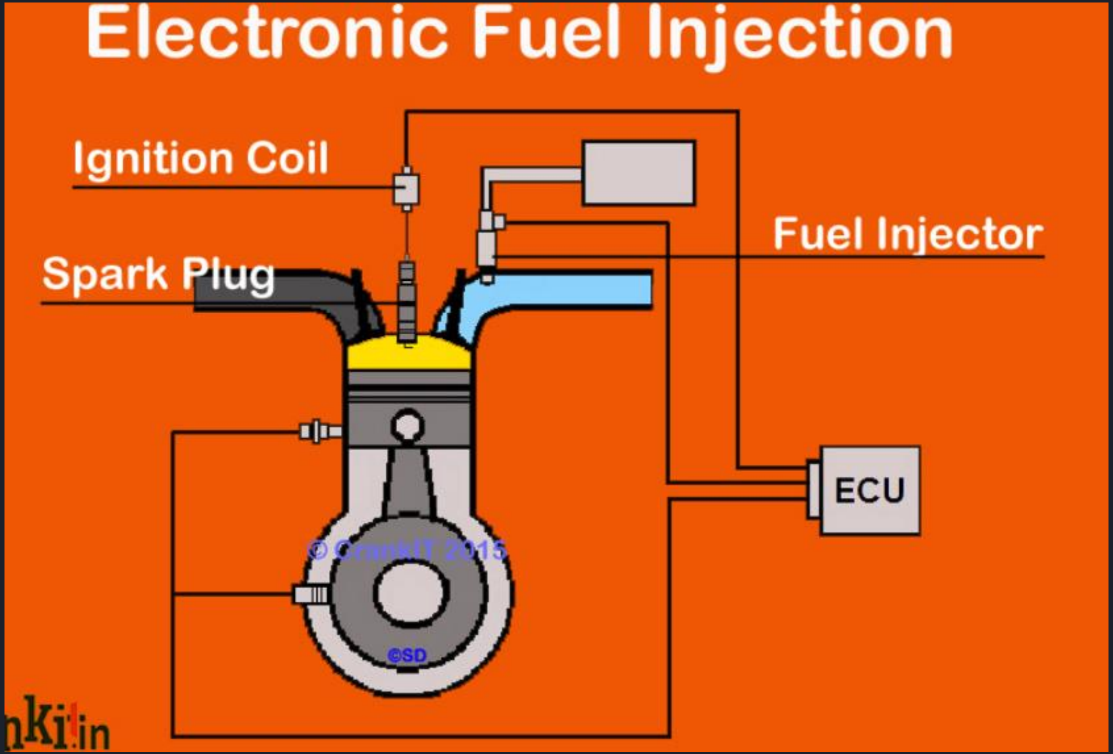


Poppet Valve vs. Rotary Valve

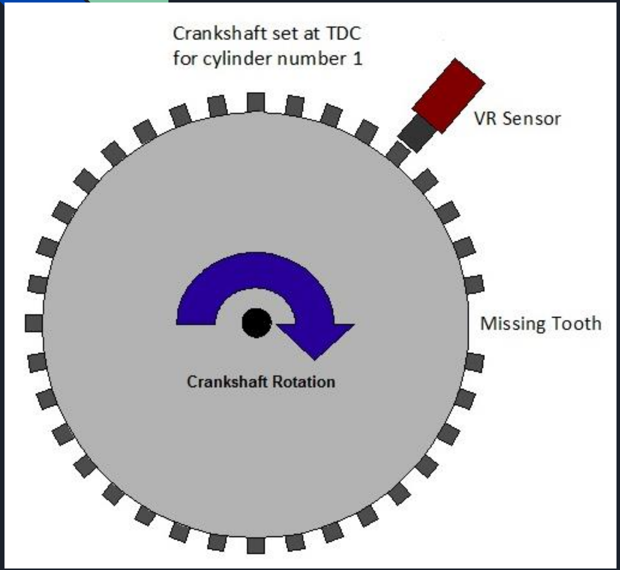
Combustion process requires precise timing

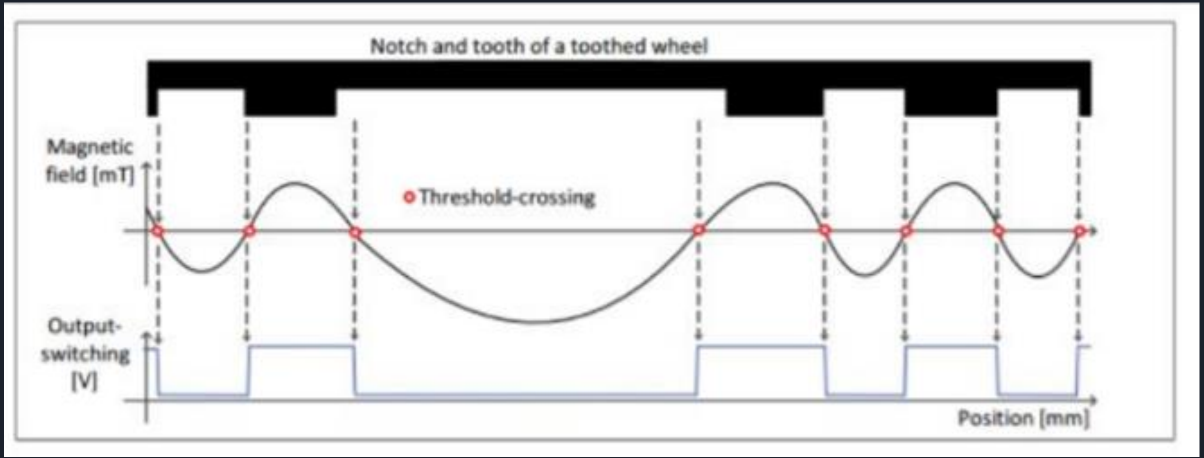
All events happen in relation to specific crank-shaft angular position

Additional Peripherals



Toothed Wheel and Sensor Design

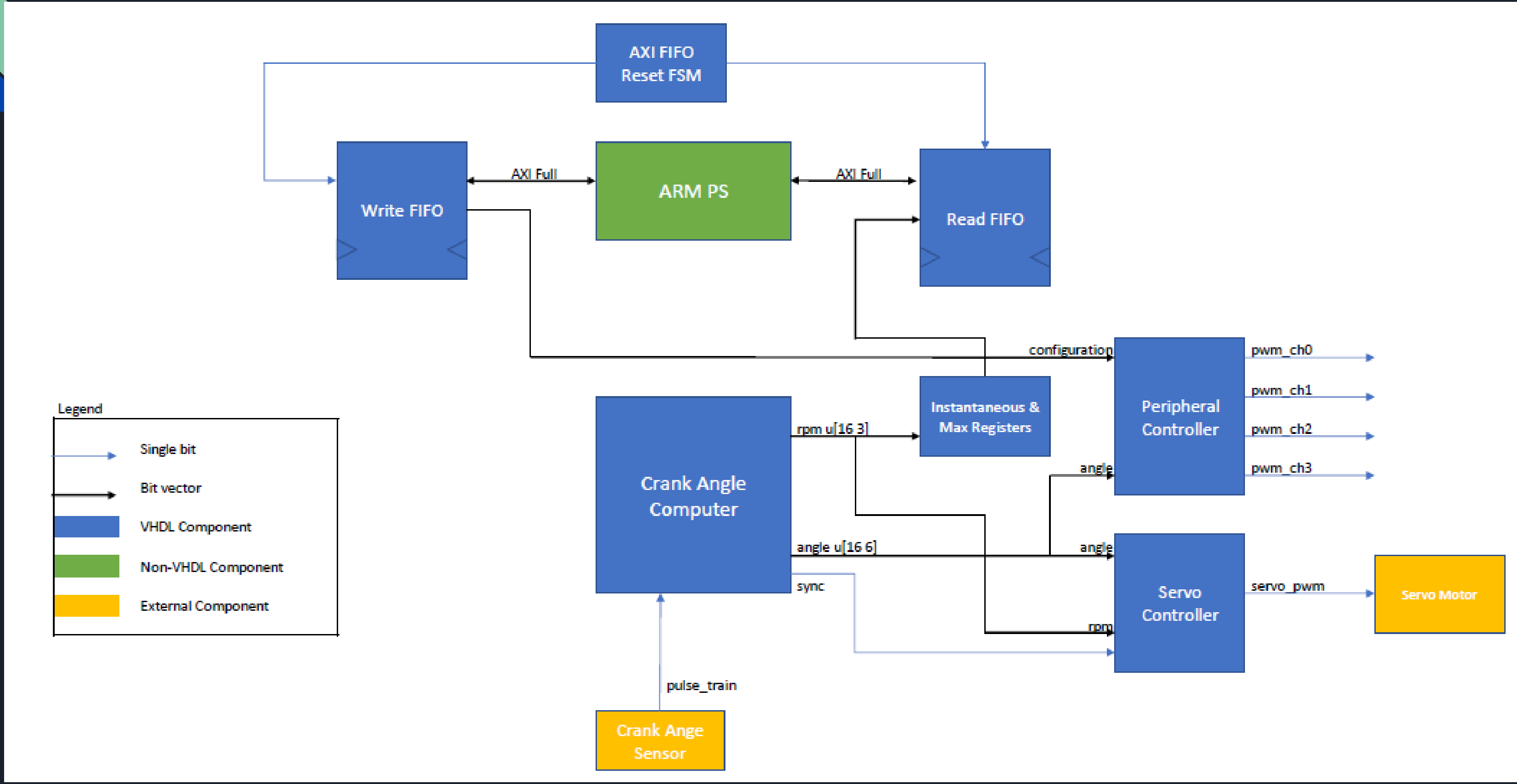




Sensor output to be sampled by ECU

60 tooth wheel, spinning at 5000 rpm = 100μs tooth width!

Block Diagram

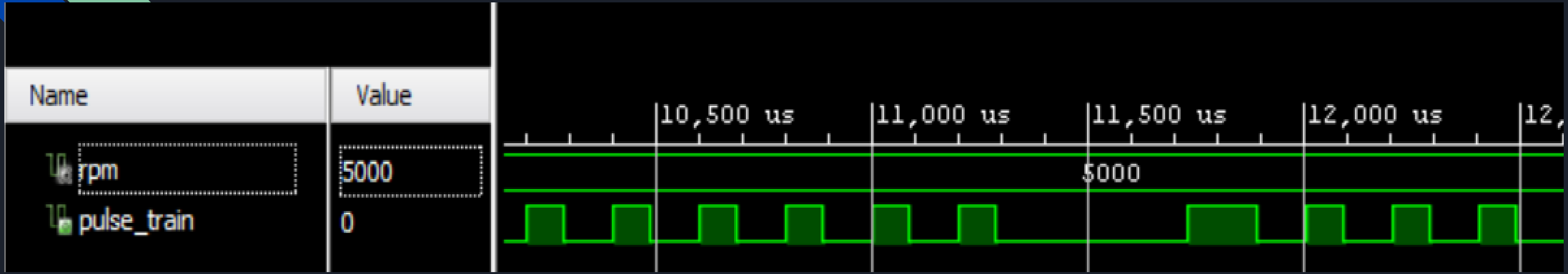


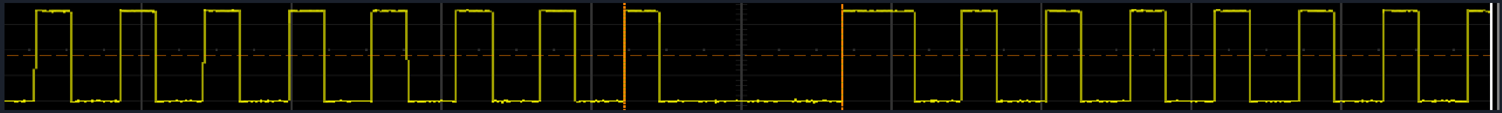
AXI Interface

- Writing:
  - I/O channels are used to add new peripherals to the system quickly without diving into vhdl code
  - Parameters given to the system:
    - Duty Cycle
    - Start Angle (NOT WORKING)
    - Stop Angle (NOT WORKING)
    - PWM Channel (0,1,2,3)
- Reading:
  - Current RPM
  - Max RPM reached

Simulation - Crank Angle Computer (Sensor mimicry and synchronization)

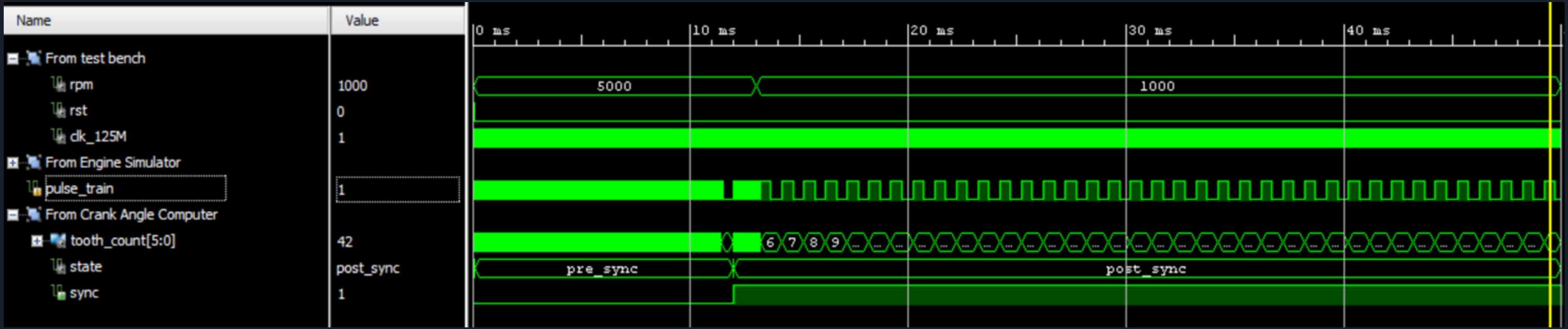
Mimicry of physical crank position sensor





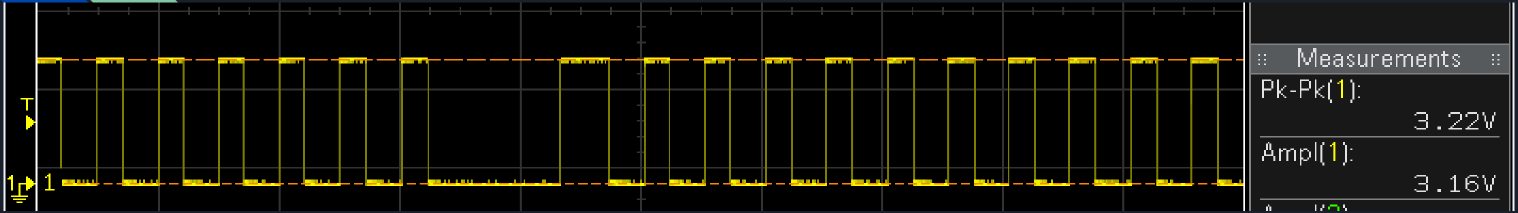
Oscilloscope capture of sensor output

Synchronization after 1 revolution

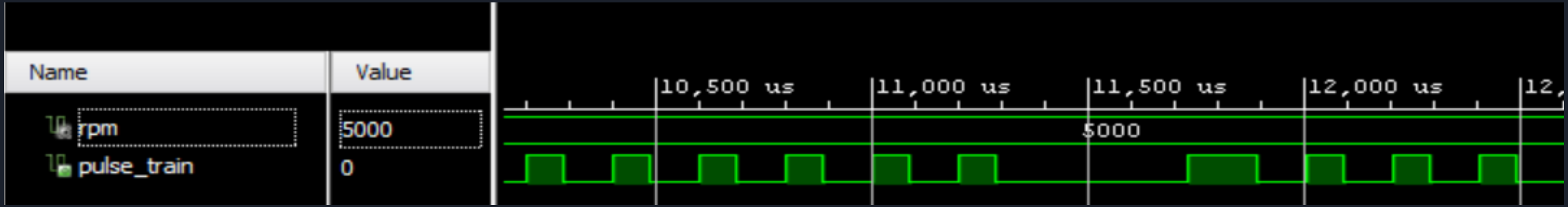


Shortcomings - Implemented Hardware vs Simulation

Mimicry of physical crank position sensor



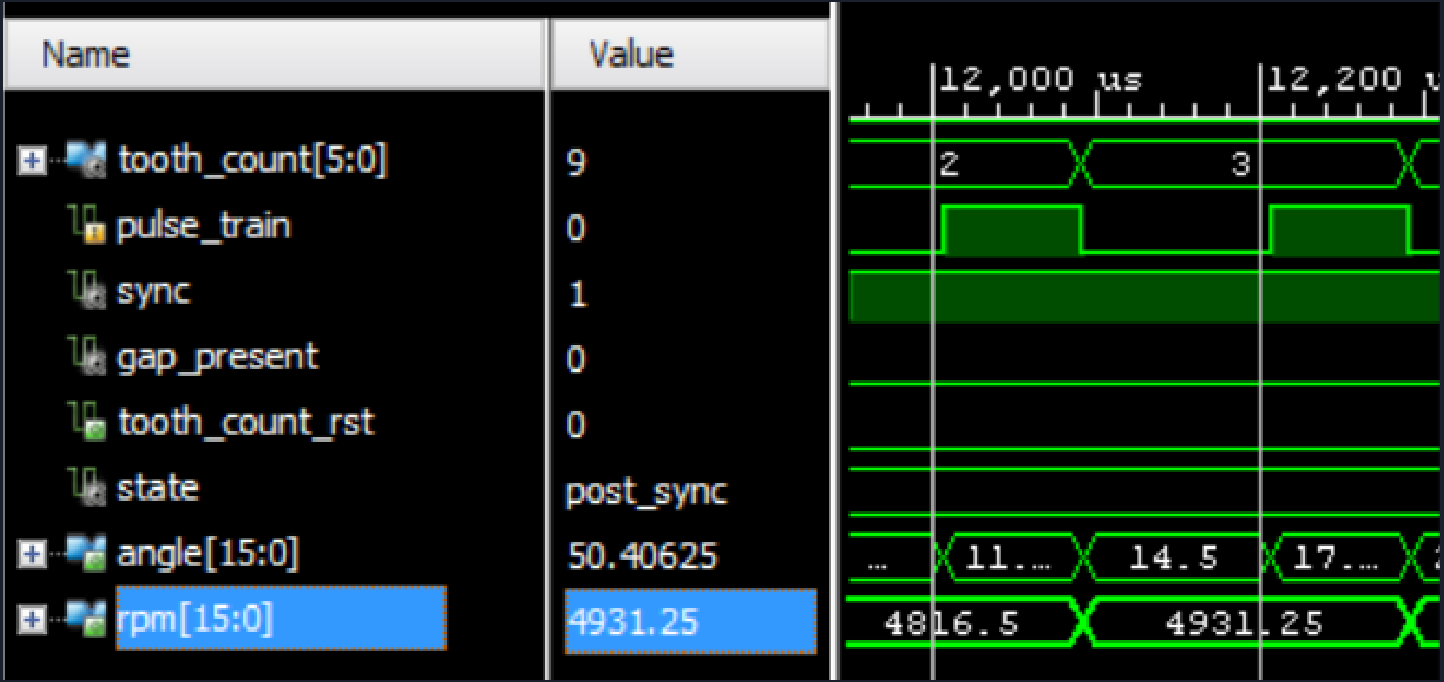
Arduino simulation of sensor



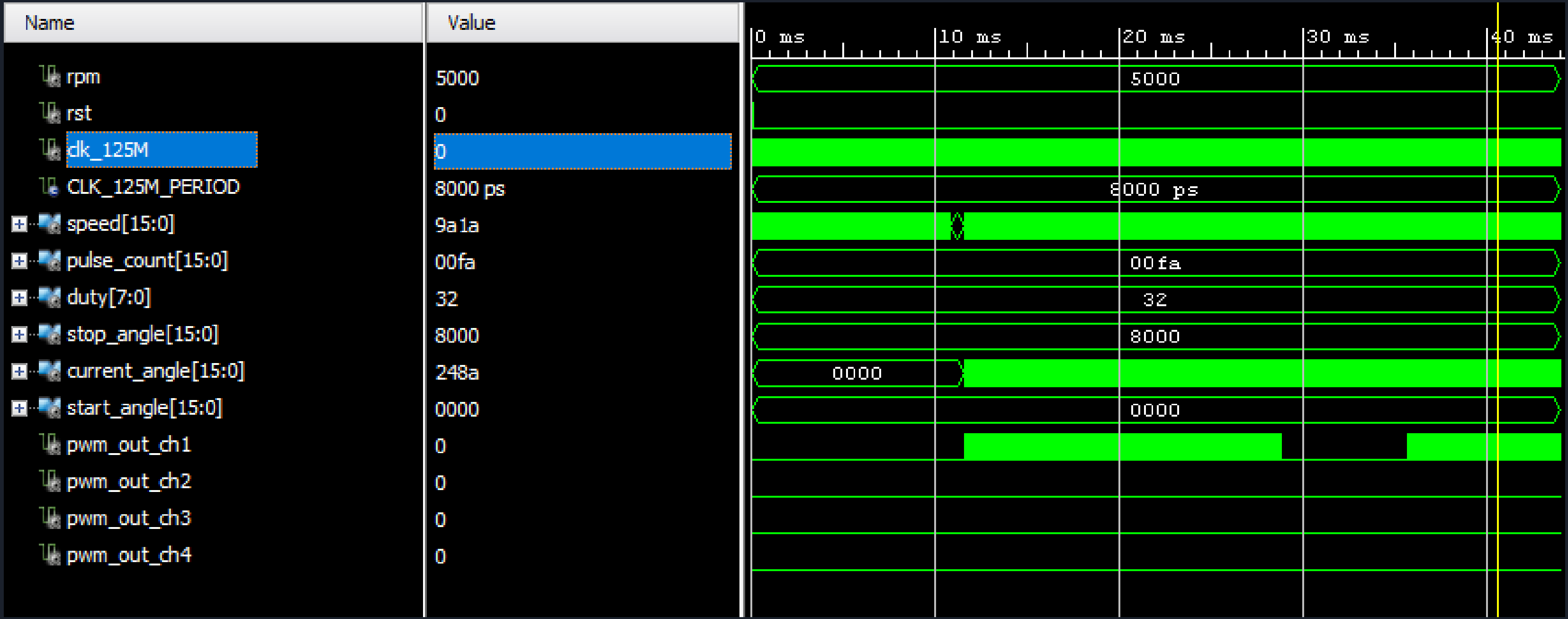
Simulated waveform for testing

System appears to be losing ‘sync’ resulting in pulse output of 0V.

Simulation - Crank Angle Computer (Output)

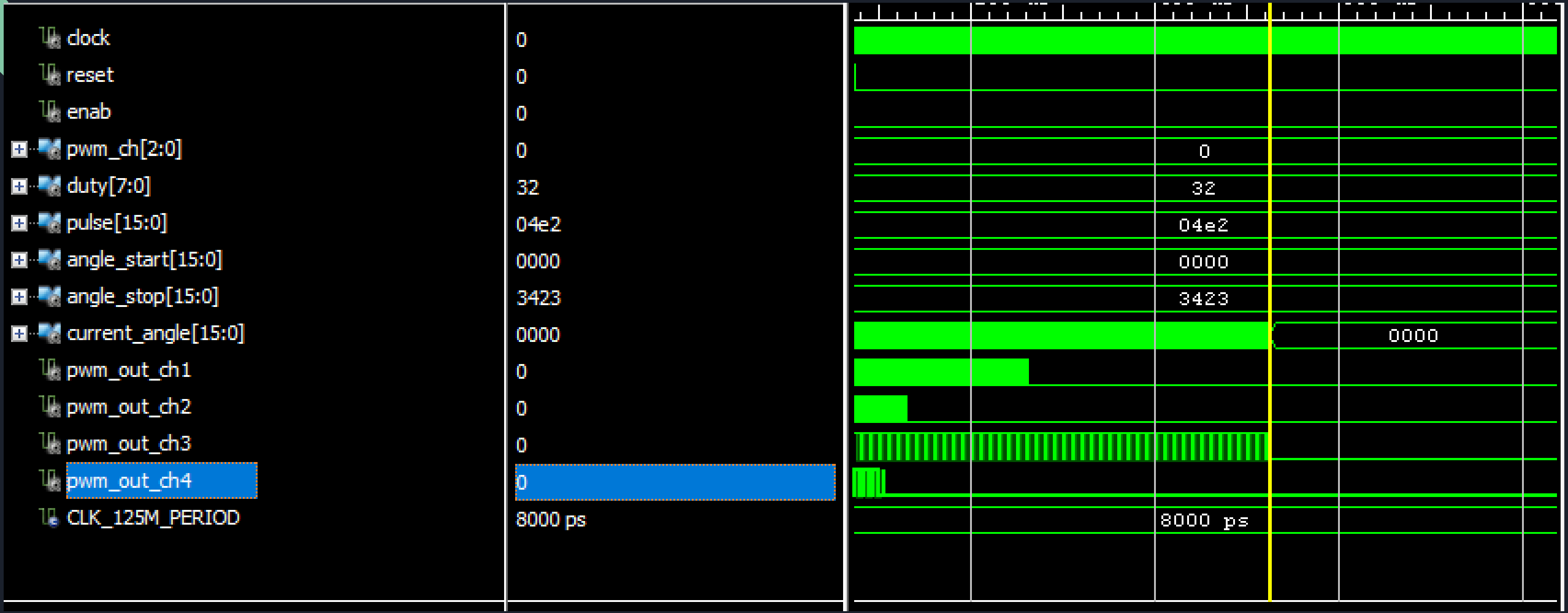


Simulation - Peripheral Interface



Pwm channels operate based off of start and stop angles of the system. The duty cycle can also be adjusted. This allows us to add new peripherals to the system at later date

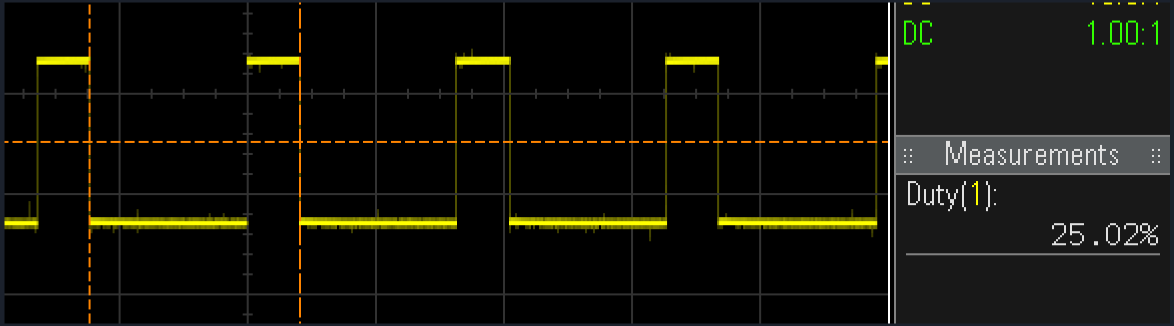
Simulation - Peripheral Interface

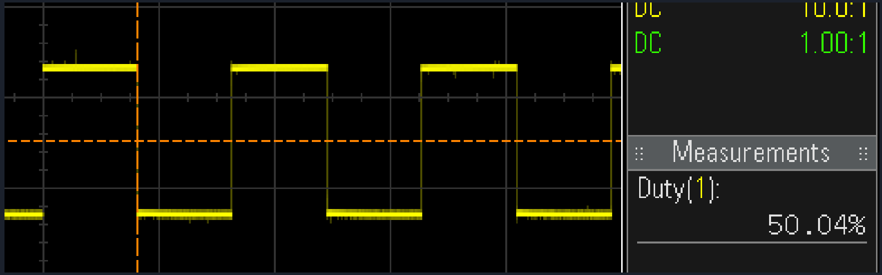


We can see how the duty cycle changes based on input data

Hardware Implementation

Hardware Implementation - Peripheral Interface






```
#define M1 0x327FFF20
#define M2 0x005A021C

#define M3 0x197FFF60
#define M4 0x005A021C
```

RPM Output via AXI

```
Instantaneous RPM:      5DCD

Max RPM reached:       5F2E
Instantaneous RPM:      5DCD

Max RPM reached:       5F2E
Instantaneous RPM:      5DCD

Max RPM reached:       5F2E
Instantaneous RPM:      5DCD

Max RPM reached:       5F2E
Instantaneous RPM:      5DCD
```

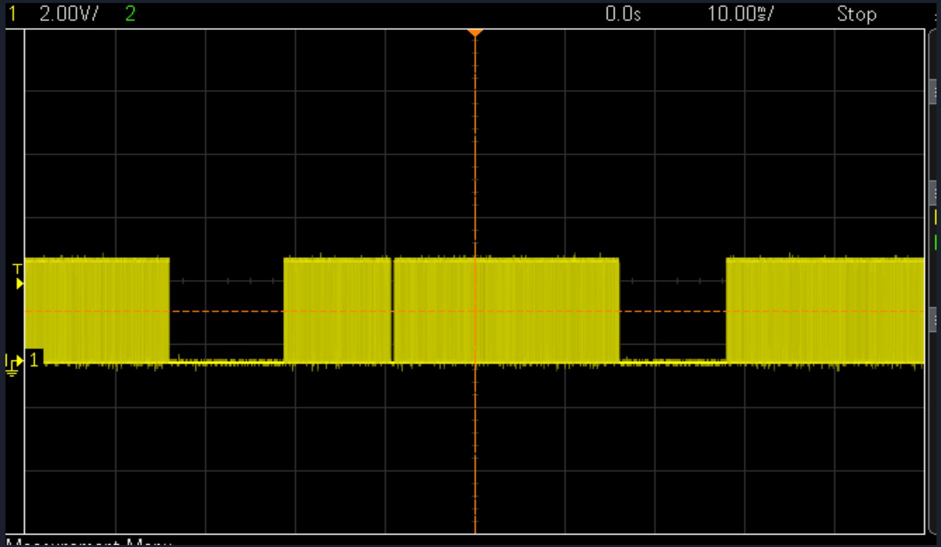
PS Console Output

```
>> qf = quantizer('ufixed', [16 3]);
>> hex2num(qf, '5f2e')

ans =

   3.0458e+03

>> hex2num(qf, '5dcd')

ans =

   3.0016e+03
```

Converted rpm via Matlab

Challenges

- Sync Signal in HW
- Start/Stop Angle
- Accuracy of RPM
- Timing issues



Sporadic start/stop of PWM output due to losing ‘sync’