

FPGA-BASED FLIGHT CONTROLLER

Project Guide

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Group 8

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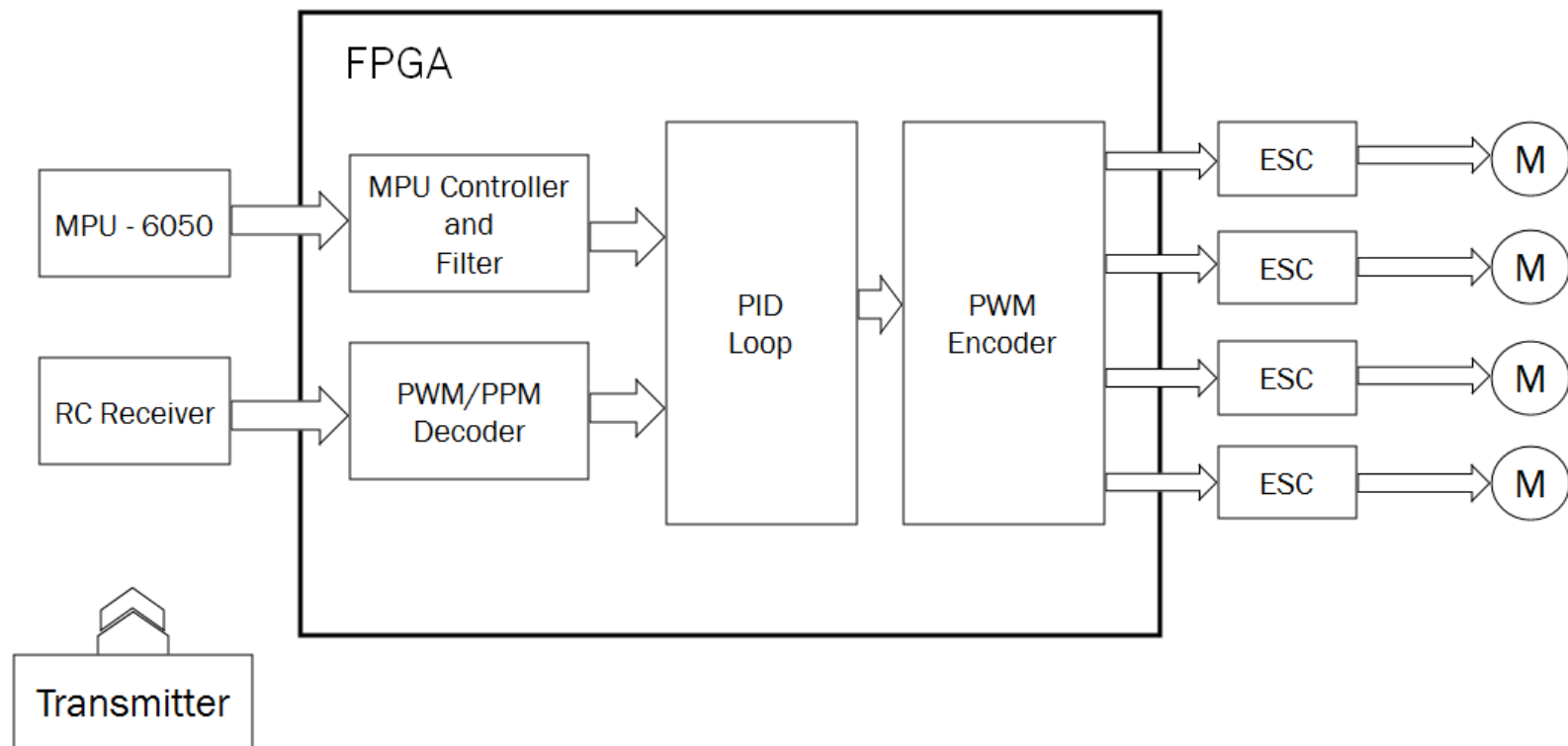
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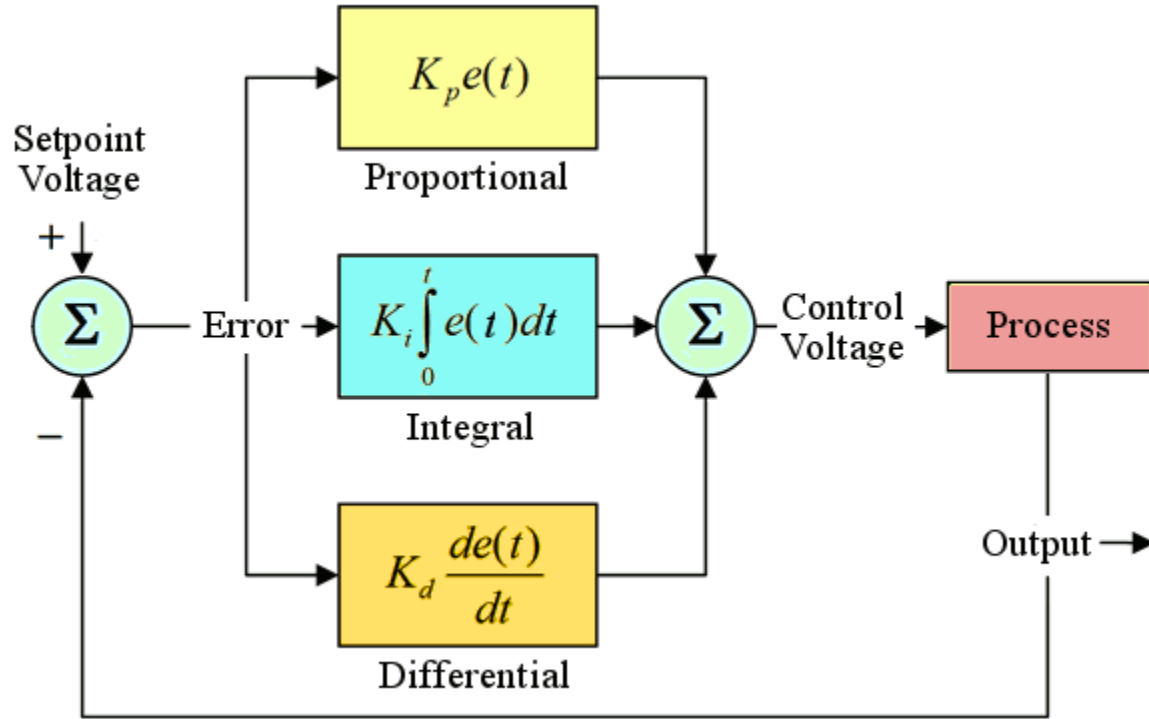
IDEA OF THE PROJECT

- Main idea is to design a flight controller (FC) module in an FPGA board using **Verilog** to fly a quadcopter with the support of machine learning for the same.
- We plan to deploy our code in **Xilinx Virtex - 6** FPGA development board.
- Install the board on the quadcopter, along with other necessary hardware.
- To tune the flight parameters to achieve stable flight using a radio transmitter/similar manual input.
- We are planning to convert this project into a product.

BLOCK DIAGRAM



PID CONTROLLER LOOP



OBJECTIVES

- Basics of Verilog and understanding Vivado IDE.
- Testing and interfacing MPU-6050 with FPGA board.
- Implementing PID loop and PWM encoder in the FPGA.
- Determine how to manipulate the direction of motors according to the inputs obtained.
- Direct the input of ESC to control RPM of each motor in response to input from MPU and RC transmitter
- Assembling the rover with other components and final testing.

Literature Review I

A few main constraints that are required for small UAVs are small size, low weight and low power. FPGA provides:

- **Parallel processing** (all the bit at a time) and having large numbers of gates on a single chip (essential for less volume).
 - And also provides a cost saving platform.
- **Sensors** measure the air vehicle's attitude, angular rate, airspeed, heading, altitude and other functions and compare it to the desired states and the error signal is eliminated by the control surface.
- **Controller** is also an important block in the Flight Controller System(FCS). The modification and combining of signals from the different axes is accomplished in the controller.

Literature Review II

- **Kalman Filter and PID Controller** offers short transition, good stability, anti-disturbance, good control and fulfills the requirement of real-time and accurate control.

Using combination of Kalman filter and PID controller, UAV can avoid collision accident and accurate control.

- **FCS**

The goal of the FCS is to help the user with automatic compensation in all the maneuvers of the aircraft in case of any disturbance. The inputs of the system are the signals delivered by the RF receiver which delivers the commands coming from the user and the sensor's signals which give the direction and position of the aircraft in real time.

- Timing and Control of FPGA input signals from sensors
- Synchronization of signals
- Generation of output PWM signals for controlling the motors

Literature Review III

- FPGA Block Diagram
- PWM encoder, PWM signal generator
- PWM decoder, Mapping unit(Effective motor output)

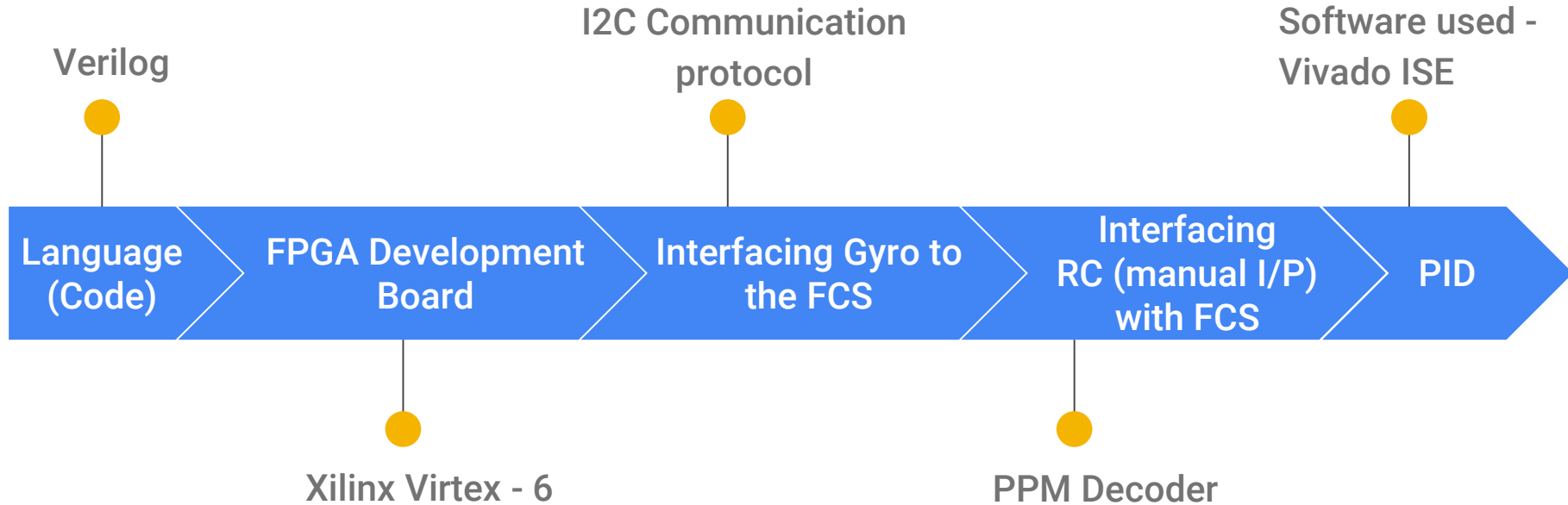
Motor1 output= Throttle - Roll_required + Pitch_required - Yaw_required.

Motor2 output= Throttle + Roll_required - Pitch_required - Yaw_required.

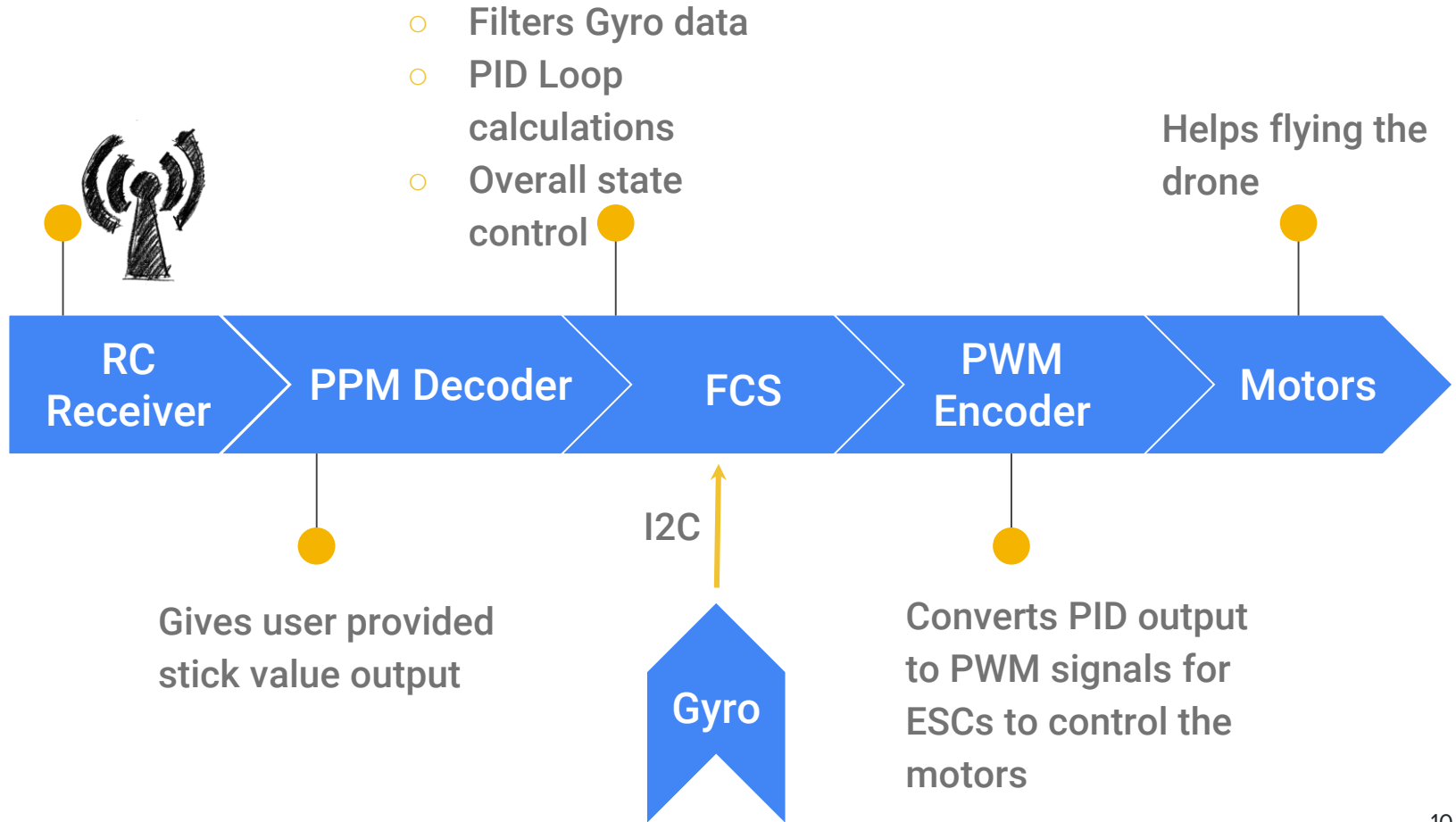
Motor3 output= Throttle + Roll_required + Pitch_required + Yaw_required.

Motor4 output= Throttle - Roll_required - Pitch_required + Yaw_required.

Feasibility Study



CONTROL DIAGRAM



WORK DONE

- Athul - Installed whole of Vivado package
- Medha - Installed whole of Vivado package
- Omar - Installed whole of Vivado package
- Sebastian - learned the basics of FPGA by referring online sources like sites, coursera, youtube which covered concepts such as Look up tables(LUTs), FPGA dev process design flow, ASIC, SoC, LEs, CPLDs.

REFERENCES

- [1] N. Monterrosa, J. Montoya, F. Jarquín and C. Bran, "[Design, development and implementation of a UAV flight controller based on a state machine approach using a FPGA embedded system](#)" 2016 IEEE/AIAA 35th Digital Avionics Systems Conference (DASC), Sacramento, CA, 2016, pp. 1-8, doi: 10.1109/DASC.2016.7778069.
- [2] B. L. Sharma, N. Khatri and A. Sharma, "[An analytical review on FPGA based autonomous flight control system for small UAVs](#)," 2016 International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT), Chennai, 2016, pp. 1369-1372, doi: 10.1109/ICEEOT.2016.7754907.
- [3] Gadde, Premkumar & Rajmohan, Jayalakshmi. (2018). "[Design and Implementation of FPGA Based Quadcopter](#)", International Journal of Engineering Technology Science and Research, ISSN 2394 – 3386., 2018, Volume 5, Issue 3.

Thank you :)

