# Proprioception Based Automotive Control

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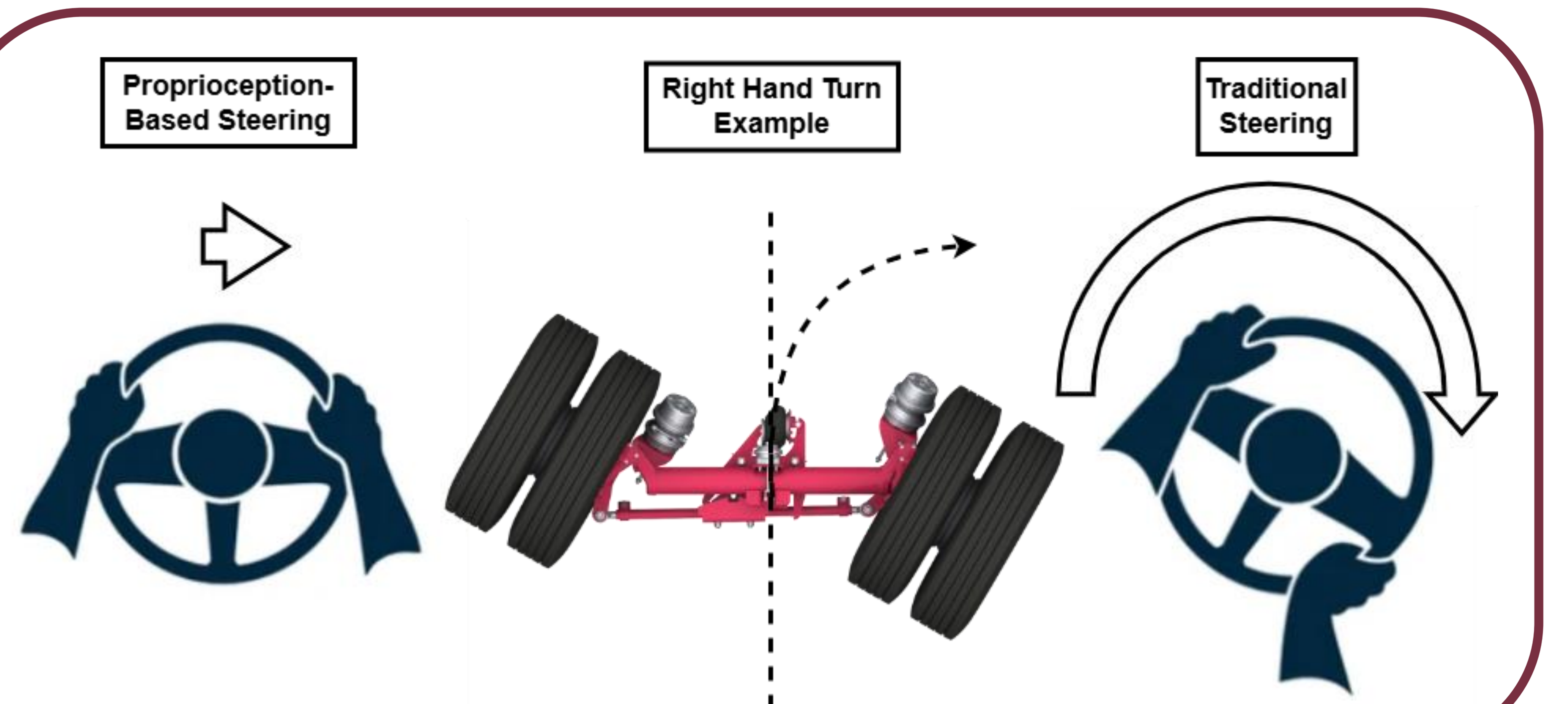
## Abstract

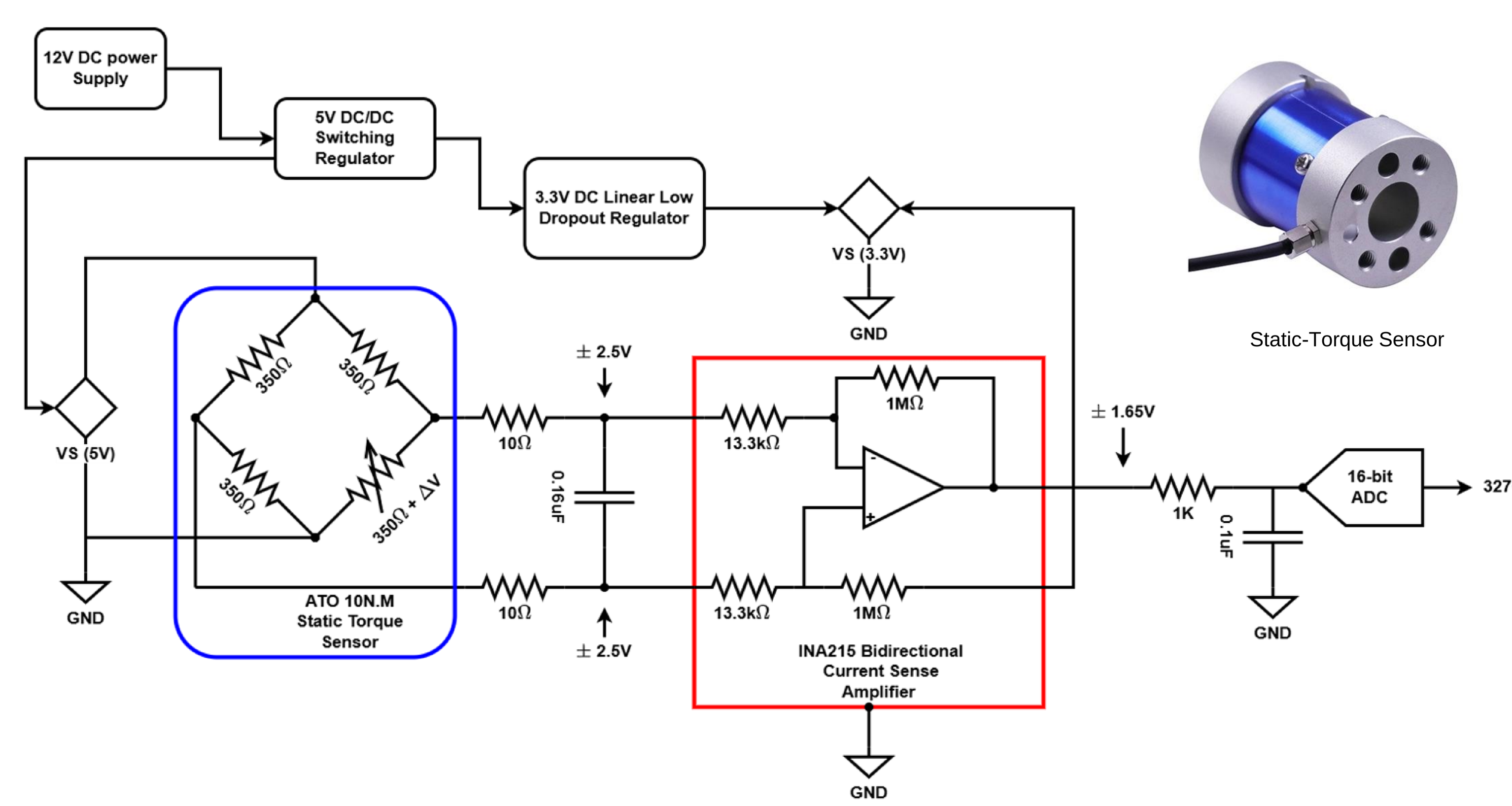
*The increasing performance of modern racing vehicles subjects drivers to extreme forces, making precise control increasingly challenging. Inspired by aerospace innovations, this research explores integrating proprioception — the body's ability to sense movement and position — into a high-performance steering system. By leveraging proprioception in a closed-loop control system, this approach aims to enhance driver response and vehicle stability. The proposed system will be developed and tested in a simulated racing environment, offering a novel human-machine interface to optimize control under extreme conditions.*

## Introduction

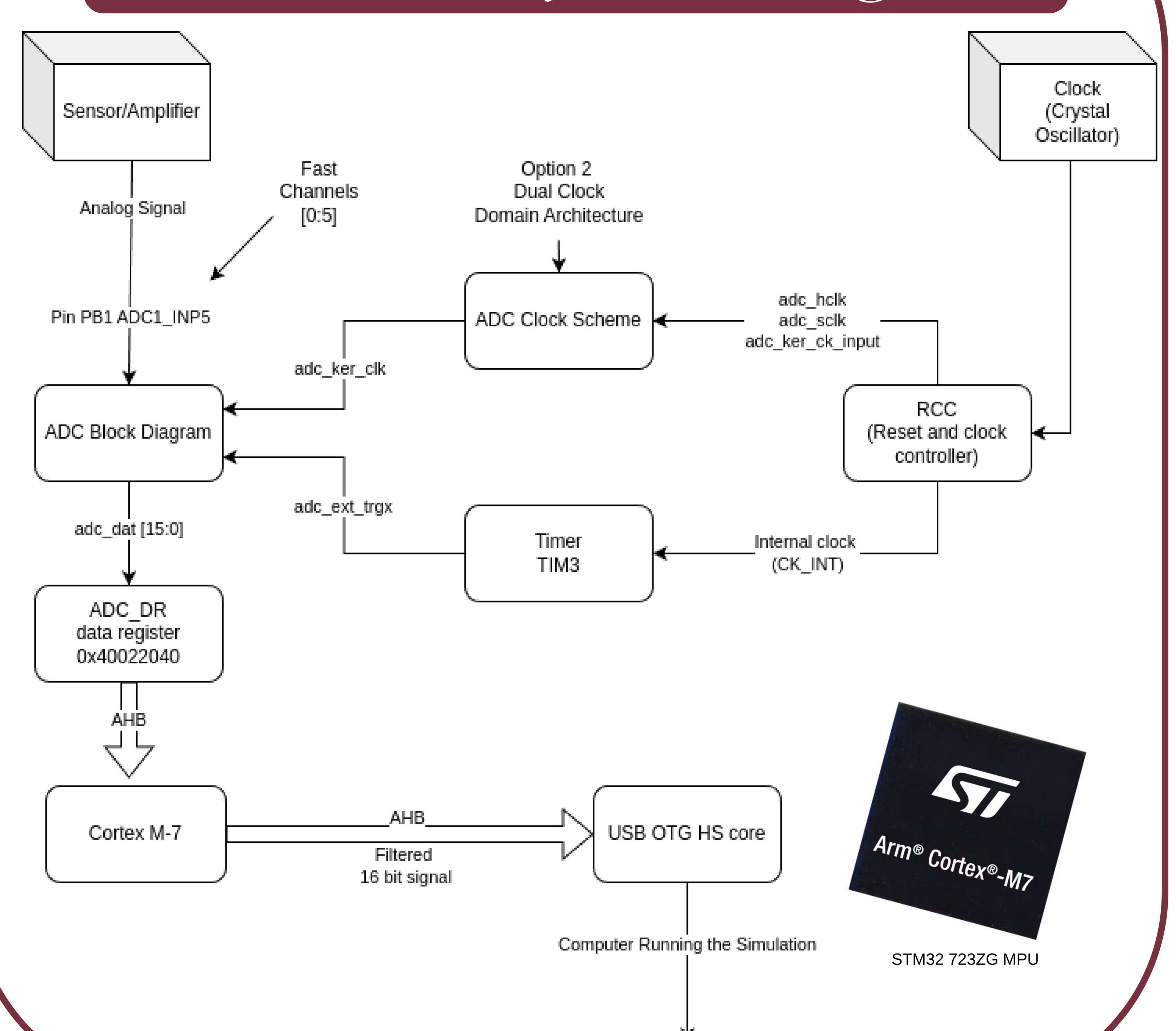
High-performance racing vehicles demand precise and immediate driver inputs, yet traditional steering systems often introduce limitations in feedback fidelity and response time. As speeds increase, mechanical power-assisted steering can often reduce a driver's ability to make real-time, high-precision adjustments. In an environment where milliseconds matter, optimizing the human-machine interface (HMI) is essential for both control and stability [1]. Aerospace engineering has tackled similar challenges through fly-by-wire (FBW) technology, replacing mechanical linkages with electronic control systems to enhance pilot precision and adaptability. FBW has revolutionized aviation by improving response time, stability, and control while integrating artificial haptic feedback to compensate for lost mechanical sensation [2]. Beyond aviation, recent research in autonomous driving and human steering models highlights the growing role of proprioception in vehicle control. Studies show that proprioceptive sensors can enhance vehicle state estimation, even in high-slip scenarios where external inputs like GPS and vision struggle [3]. Additionally, driver behavior models suggest that visual and kinesthetic cues play a crucial role in steering control, though current steering systems do not fully utilize these sensory mechanisms [4]. This research proposes a proprioception-based steering system for high-performance racing vehicles, leveraging sensory feedback through electronic steering controls to enhance driver responsiveness and stability. Unlike conventional systems that reduce haptic feedback, this approach will provide real-time proprioceptive input, improving situational awareness and control precision. Additionally, unlike traditional steering wheels that require large rotational inputs, this system will minimize excessive turning, instead relying on small force-based adjustments for more intuitive and efficient control. The system will be tested in a simulated racing environment to evaluate its effectiveness and potential for real-world application.




## Circuit Schematic Diagram




## Embedded System Diagram




## Discussion

In the Circuit Schematic Diagram, a 10 Nm static torque sensor utilizes a strain gauge in a Wheatstone bridge configuration to measure torque under tensile and compressive forces. The sensor is powered by a 5V rail, derived from a 12V DC power supply via a DC/DC switching regulator. A 3.3V linear LDO regulator further steps down the voltage to supply the amplifier and ADC, ensuring stable operation. The differential voltage output from the sensor is filtered and amplified by a zero-drift, bidirectional current-sense amplifier, referenced to a 16-bit ADC integrated into the microcontroller/development board. The analogue signal is sampled at 100 Hz and deposited as a 16-bit value in the ADC_DR register, from which the Cortex M-7 MicroProcessing Unit(MPU) retrieves the data over the Advanced High-performance Bus(AHB) for signal processing. The bit-stream is then sent to the USB core to be packetized according to the Human Interface Device(HID) protocol and is then sent to the computer where the vehicle simulation is being run.

## Results


## References

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