System Architecture

Quadruped Robotic Platform

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1.0 Introduction

1.1. Purpose/Scope

This document describes the Quadruped Robotic Platform's system architecture with particular focus on the software features and relevant interactions with hardware.

1.2. Acronyms, Abbreviations, and Definitions

Term	Definitions
DAC	Digital-to-Analog Converter – Converts a digital signal to an analog signal.
PWM	Pulse Width Modulation – Digitally generated variable-width square pulses representing the amplitude of an analog signal. Used in Quadruped actuator joint angle control.
MCU	Microcontroller Unit - Used to provide Quadruped with real-time peripheral device function control and processing such as providing PWM output to the actuators.
RPi 4B	Raspberry Pi 4B – Microcomputer with an ARM Cortex SoC that serves as the main processor for the Quadruped. Also features Wifi and Bluetooth modules allowing for .
SoC	System on Chip – Embedded computer system that is responsible for high frequency computations and high level event planning.
IK	Inverse Kinematics - Mathematical process of calculating the joint angle parameters needed to place the end of a kinematic chain in a defined position and orientation relative to the start of the chain, i.e., provides the joint angles required to produce a desired foot position for the Quadruped.
COTS	Commercial Off-the-Shelf - Hardware products that are commercially ready-made and available for sale.

2.0 Software Architecture

2.1. Physical Organization

The Quadruped Robotic Platform has two separate processors, the Raspberry Pi 4B and the Teensy 4.0 MCU, which communicate with each other via a USB cable (Serial) for event and command information. The SoC on the RPi 4B is responsible for high frequency computations and high level event planning, including the IK calculations for all 12 actuators. The RPi 4B is also responsible for interfacing with a PlayStation 4 joystick via a wireless Bluetooth connection, which provides user control to the

Quadruped in its kinematic pose mode. The Teensy 4.0 MCU is responsible for providing real-time interaction between the software and the electronic hardware on the

Quadruped. Currently, this only consists of providing PWM output to the actuator servos based on the joint angles calculated via the IK solver. Future implementation may provide the MCU with additional responsibilities including system voltage or current monitoring, or signal input from additional sensor modules.

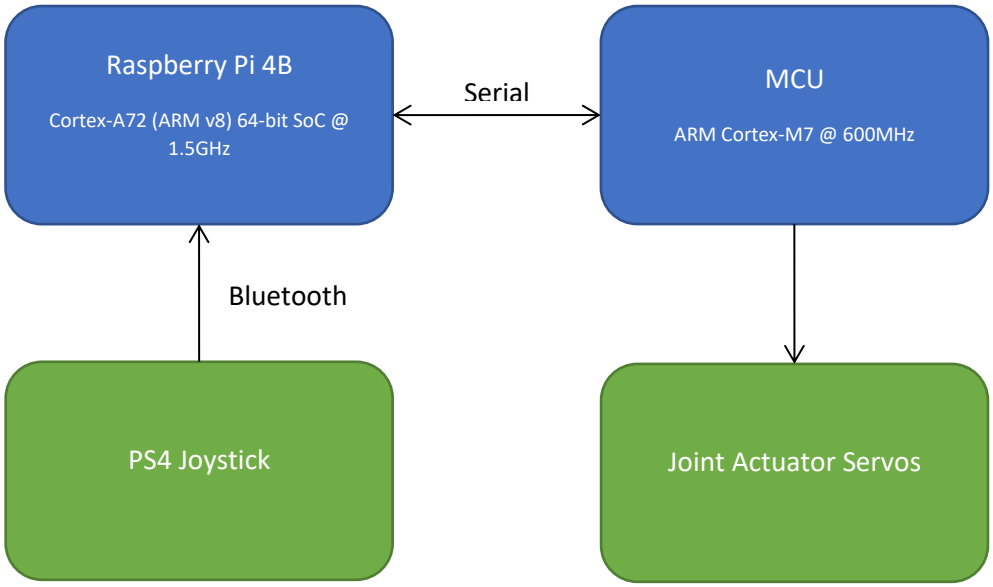

Figure 1: Quadruped's Microprocessors

2.1.1. Raspberry Pi 4B

The Raspberry Pi 4B is a single board computer based on a Broadcom BCM2711, quad-core Cortex-A72 (ARM v8) 64-bit SoC. The SoC runs the Raspberry Pi operating system (formerly Raspbian), which is a Linux-based OS. On the Quadruped, the RPi 4B is responsible for interfacing with the PS4 Joystick, running IK calculations, executing high level event plans, and sending event commands to the MCU for hardware function execution.

2.1.2. Teensy 4.0 Microcontroller

The Teensy 4.0 MCU is an ARM Cortex-M7 CPU. This CPU has onboard Analog/Digital converters for peripheral device I/O control. The Teensy 4.0 comes with 35 PWM pins and 18 analog input pins. The MCU currently provides servo PWM output on 12 digital pins. In future implementations, MCU will have the additional responsibility of relaying sensor information to the RPi.

2.1.3. Software/Hardware System Architecture

This is the overall software/hardware architecture of the Quadruped Robot

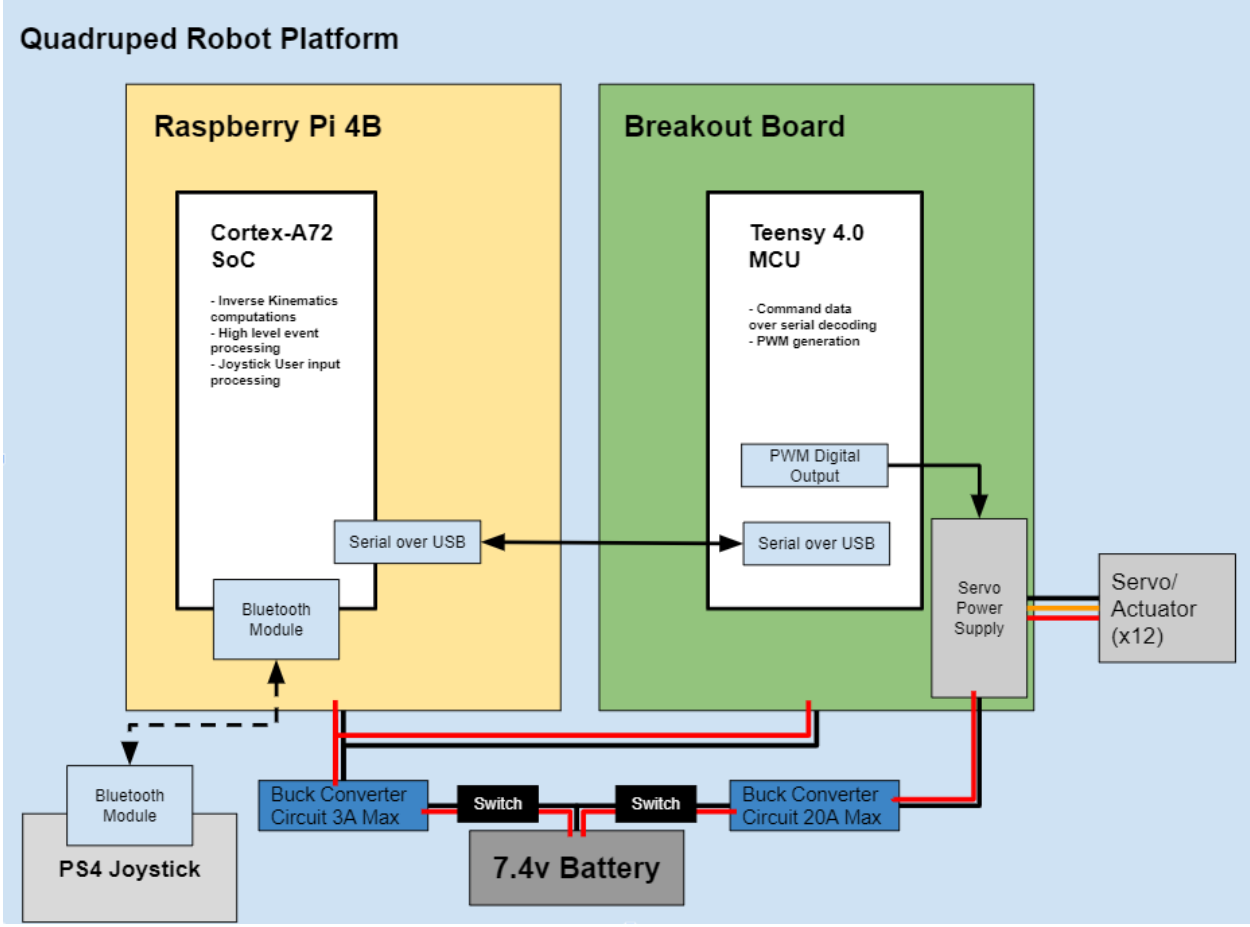

Figure 2: Quadruped System Architecture

2.1.3.1 Converter Circuits

The Quadruped MCU and RPi 4B are both powered by 5v DC. Power delivery from the 7.4v battery is provided by a COTS LM2596, a switching buck converter with an input range from 6-20v and with a potentiometer for adjusting input/output voltage ratio. The joint servos are powered by 6.8v DC. Power delivery is provided by a separate COTS YPG20A switching buck converter for load isolation. The converter has a 20A max current rating to accommodate the high-current draw operation of the servo actuators. In future implementations, converter circuit designs will be integrated into the custom carrier board.

2.1.3.2 PS4 Joystick

In the user control mode, the Quadruped receives user input via a PS4 Joystick Controller communicating wirelessly with the RPi's integrated Bluetooth module. The joystick features two thumb sticks each with X & Y axis input, a direction pad, triggers pads, and four press buttons. Event streams are decoded at the RPi, and event hooks are attached to button press or thumb stick manipulation events.

2.2. Functional Organization

2.2.1. Raspberry Pi 4B

WIP

2.2.2. Teensy 4.0 Microcontroller

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2.3. Data Structure Organization

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2.4. External Interfaces

2.4.1. RPi – MCU Communication

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