Open Source Remote Drivetrain Data Acquisition System

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Abstract

The Mars Rover Design Team Drivetrain Motor Data Tracking and Acquisition System remotely aggregates and acquires current and voltage readings in order to feed a model based observer that tracks the quadrature axis flux linkage for each of six individual motors. Data is transmitted over a 6.5 watt radio intended for Point-to-multipoint WiFi HaLow (802.11ah) Backhaul links in the 33 centimeter band (900Mhz). The drivetrain consists of six synchronous permanent magnet motors and six custom printed circuit boards utilizing a variable frequency three-phase inverter topology. The synchronous control algorithm must utilize electromagnetic operating parameters highly dependent upon variations in specific motor construction and load conditions to derive motor model transformations. Analysis of acquired data provides more accurate motor models and allows for parameter identification in the fine tuning of motor specific operating points.

Introduction

Vehicle developed for urc, urc weight and cost restrictions (low cost solution increase applicability), task requirements, derived requirements (out of line of site communication, battery life, motor capability (hp, torque, etc))

This paper is intended as a design-project product application-note for a six-wheel all-terrain rechargeable electric vehicle, referred to by the Mars Rover Design Team (MRDT) as Gryphon, that is comprised of individual IoT endpoint sub-systems. Gryphon utilizes a WiFi HaLow (802.11ah) 6.5 watt radio in the 33 centimeter band (900Mhz) at network speeds of 150 Mbps to operate over a wide-area wireless backhaul access link and is capable of traversing vertical drops in excess of a half meter, inclines of 50 degrees, and non-line-of-sight (NLOS) coverage in Rocky terrain beyond 1 km.

Embedded modular device sub-systems are individually IP addressable on a standard RJ-485 wired 16 port Ethernet switch. Regulated DC power is available at 30V and 12V distributed via Anderson Powerpole Connectors from an Networked Power Management System comprising an 80 cell 8S10P lithium-manganese-nickel battery pack.

Figure 1:

First principles and design consideration are covered in: digital communication, radio frequency propagation, wireless access, electrodynamic propulsion, digital motor control, and data acquisition and digital filtering of magnetic field linkage signals in electric motors. Advantages of the synchronous motor and challenges in acquiring motor data of synchronous magnetic field linkages are shown. The benefits and detriments of various possible sensor and encoder installations are discussed. Finally, a feed-forward model-driven observer solution was chosen to derive flux field angle by direct-quadrature-zero transformation of three-phase shunt currents using a 400 MIPS single cycle 32x32 bit MAC DSP. A variable frequency drive modulating power inverter was developed adhering to a Booster Pack pin standard for the 32 bit MCU development shield by header pin access to 12-bit ADC's,

Enhanced Capture Modules, and High-Resolution dual-edge controlled PWM. Optimized software routines with built-in hardware acceleration as available in ROM were utilized for most data transformations, sliding mode filters, and parameter identification routines.

The vehicle was qualified over a 4 month test cycle both in the lab, and on the hills of the Missouri basin. The vehicle was named Gryphon and was selected to compete against other design-project electric vehicles in the desert of southern Utah at the Mars Desert Research Station in the annual University Challenge. Gryphon was the only Rover that operated a model based observer tracking the quadrature axis flux linkage of each individual motor. Gryphon showed a Dynamic torque response on the Mars-like terrain and recieved a perfect score in the terrain traversal and extreme delivery task.