Detailed Design Review Summary – Hardware (11/3/08) (3:00pm – 4:00pm)

The Detailed Design Review began with a summary of the action items from the previous Design Review. Of all the previous action items, only the Thevenin equivalent circuits for the input devices had not been completed due to the engine being offline for the majority of Fall Quarter. The spark operation had no direct connection to the ECU and did not require a more detailed investigation, sending only high/low signals to the ECU. The IAR had been confirmed to run small test programs, although more investigation was needed to confirm the exact configuration settings. The Texas Instruments test bench was also confirmed by Prof. Slack to have a 50% discount, reducing the price from $400 to $200.

Moving into the hardware components, the voltage regulator system was the first topic under discussion for the review. The existing voltage regulators from the previous generation design could not operate the microprocessor correctly and required a piggyback system to the Texas Instruments test board to operate properly. This problem had not been fixed due to time constraints; the exact cause of error had only been pinpointed in the final week of P08221's testing. The new design implementing the TPS70302 was revealed along with a variation from the TPS703xx family, either of which can be implemented on the new ECU PCB. It was brought to attention that the resistor values, confirmed in hardware testing, could provide some error due to their tolerances. Examination of the datasheets for the various ECU load circuits in the past had shown all logic circuits fell within the tolerance created by the resistive loads; although changing over to the fixed voltage regulator would completely eliminate those problems.

The second topic of discussion was the occasional failure of the injector control circuits. Testing had revealed that Prof. Slack's suggestion to look for an EMF voltage spike was correct and a voltage build-up of over +30Vdc was observed during testing (both hardware and simulation). This had been countered in hardware and simulation testing with the addition of an injector feedback diode. An error in the pre-read documents was pointed out by Prof. Slack, that the injector driver's ON/OFF descriptions had been reversed. Dr. Phillips also noticed that the +3.3Vdc to +5.0Vdc conversion presently executed by an op-amp could just as easily be completed using a level converter (this also applies to the relay control circuitry). The injector circuitry had been analyzed using Dr. Hoople's RLC meter to create a Thevenin equivalent circuit for use in simulations. Prof. Slack brought up the question of the timing of the injector control circuits from simulation and how it had been selected; simulation was confirmed post-design review to be operating at the engine's max run speed. The question of feedback resistors/diodes was brought up and the reasoning for multiple diodes; no sufficient reasoning could be developed in part due to the lack of information on the existing diodes. Investigation into the populated PCB boards was planned to gain the zener diode part numbers; although it was recommended that they be removed entirely.

Next, the relay control circuit was examined. Simulation had shown that the relay current of 150mA was likely damaging the op-amps. A PMOS transistor was put into use to control the relay with the op-amp aiding in switching the transistor. Dr. Philips recommended that this too should be replaced with a level shifter. The transistor and the various feedback components were agreed upon by the majority to be overkill for the ECU, but the final decision made was to leave unpopulated spaces for the components on the PCB for testing. An error with the PMOS circuits, reversing the source and drain pins, provided in the pre-read documents was pointed out, although the error had already been fixed on the PCB. NPN bipolar transistors were recommended as a replacement for the PMOS devices and would need investigation to be confirmed.

The PCB layout was then presented before the Design Review. The PCB revisions were found to be missing from the web and needed to be uploaded along with all previous revisions. Prof. Slack again reminded the team that the input impedances (a.k.a. Thevenin equivalent circuits) needed to be added to the design circuit and that the black boxes of the logic circuits needed to be replaced. This process had already been started, but due to its low priority nature, it had been delayed to finish work on the PCB. The engine was confirmed by the Formula Team to be operational later in the week so that Thevenin Equivalent circuits could be developed, esp. the CDI box with its potentially large impedance. The wiring diagram for the pinouts could not be confirmed as matching with the Motec ECU and was promised to be verified at some point in the future. The cam and crank sensors were also planned for testing to discover their current voltage characteristics with the aid of Prof. Slack.

At this point the design review concluded due to time constraints on several major participants.

The second ECU design review for software was planned to commence at 3:00 pm the following day.