2008, 2009 AND 2010 FIA FORMULA ONE WORLD CHAMPIONSHIP

INVITATION TO TENDER FOR ECU SUPPLY CONTRACT

PREAMBLE

The FIA's objective is to hold an open tender process for the purposes of selecting an official supplier whose task it will be to ensure the production and delivery of all of the engine control units (ECUs) for all of the participants in the 2008, 2009 and 2010 rounds of the FIA Formula One World Championship.

This document sets out the terms and conditions under which tenders should be submitted and explains the minimum requirements that the selected supplier will be expected to meet.

The following indicates the timetable that the FIA intends to follow in making its selection.

26 May 2006: Issuing of the invitation to tender

23 June 2006: Deadline for submitting tenders

25 June 2006: Opening of the tenders

5 July 2006: Decision as to the selection

Thereafter, the selected supplier will be required to produce ECUs according to the following timetable

29 September 2006: Two units available for selective bench testing

9 March 2007: One prototype unit to each team for testing

1 May 2007: Submission of hardware and software design for final FIA approval

1 June 2007: Hardware and software designs frozen

1 October 2007: Delivery of three units per team

16 November 2007: Delivery of three further units per team

1 February 2008: Delivery of all pre-ordered units for use prior to commencement of the 2008 season (further units to be supplied on demand)

PART I - GENERAL

1. DEFINITIONS

In this invitation to tender the following terms should be understood as follows:

1.1 The **CHAMPIONSHIP** means the FIA Formula One World Championship.

1.2 The **COMPETITORS** shall mean the racing teams that have been accepted by the FIA to take part in the CHAMPIONSHIP.

1.3 The **CONTRACT** shall mean the agreement appointing the MANUFACTURER to supply the ECUs to COMPETITORS to be signed between the MANUFACTURER and the FIA upon completion of this tendering procedure.

1.4 **ECUs** shall mean the engine control units required to operate a Formula One engine and drivetrain control system, as further detailed in section 8.2 below and in the SPECIFICATIONS.

1.5 **EVENT** means any event forming part of the CHAMPIONSHIP entered onto the International Sporting Calendar of the FIA for any year, commencing at the scheduled time for scrutineering and sporting checks and including all practice, qualifying at the race itself and ending at the latest time for the lodging of a protest under the terms of the FIA's International Sporting Code.

1.6 The **FIA** shall mean the Fédération Internationale de l'Automobile which is the sole organiser of the CHAMPIONSHIP.

1.7 The **FIA ENGINEER** shall mean the technician appointed by the FIA:

- to carry out all technical checks and controls,
- to grant the necessary approval prior to the starting up of production.

1.8 The **MANUFACTURER** shall mean the ECU manufacturer which tenders and, after selection by the FIA, enters into the CONTRACT.

1.9 **SPECIFICATIONS** shall mean the ECU Hardware Requirement Specification and the ECU Outline Software Requirement Specification, as attached at Annex A.

1.10 The **SPORTING AND TECHNICAL REGULATIONS** mean the Formula One Sporting Regulations and the Formula One Technical Regulations as from time to time published and amended by the FIA in accordance with its statutes and regulations. The 2008 SPORTING AND TECHNICAL REGULATIONS are available on the FIA's website www.fia.com.

1.11 **SUPPLY CONDITIONS** means the conditions under which the MANUFACTURER shall supply the ECUs to the COMPETITORS, as more fully described in Article 4 herein.

1.12 The **TENDERER** means any person or entity making a tender offer subsequent to this invitation to tender.

1.13 **TESTING** means tests as defined in and authorised by Article 63 of the Formula One Sporting Regulations.

2. <u>INVITATION TO TENDER</u>

2.1 TENDERERS are hereby invited to submit a tender for the CONTRACT to become the sole MANUFACTURER of ECUs for use by the COMPETITORS in the CHAMPIONSHIP for the racing seasons 2008, 2009 and 2010.

2.2 Only tenders which demonstrate that the TENDERER is capable of meeting the conditions set out in Part II (SUPPLY TERMS & CONDITIONS) and which meet the requirements of Part III (PROCEDURE AND ADDITIONAL REQUIREMENTS) will be considered for the award of the CONTRACT.

PART II - SUPPLY TERMS & CONDITIONS

3. CONTRACT

3.1 The TENDERER that is selected to become the MANUFACTURER will be invited to enter into the CONTRACT with the FIA which will contain, inter alia, the following minimum terms and conditions relating to the supply of ECUs.

4. SUPPLY CONDITIONS TO COMPETITORS

4.1 The MANUFACTURER shall agree in its contract with the FIA to supply an unlimited number of ECUs to the COMPETITORS on standard terms and conditions (including a set price per unit) which shall apply to every sale to every COMPETITOR during the CONTRACT. These shall be known as the SUPPLY CONDITIONS.

4.2 Each TENDERER must attach a copy of its proposed SUPPLY CONDITIONS to its tender. At a minimum the SUPPLY CONDITIONS shall specify the price per unit, the ordering procedure, the maximum delay between the receipt of the order and delivery and the payment terms offered by the MANUFACTURER to the COMPETITORS.

4.3 These SUPPLY CONDITIONS may not be altered in any way during the CONTRACT without the express consent of the FIA.

4.4 The SUPPLY CONDITIONS shall apply to each individual supply arrangement entered into between the MANFACTURER and each COMPETITOR during the CONTRACT.

4.5 The SUPPLY CONDITIONS may provide that each COMPETITOR shall be responsible for the care and maintenance of the ECUs and for transportation of them to each EVENT.

5. COMMERCIAL ASSOCIATION RIGHTS

5.1 Together with the CONTRACT, the FIA will grant to the MANUFACTURER the right to describe itself (including in its advertising and other publicity) as the “official ECU supplier to the FIA Formula One World Championship” or its direct equivalent in other languages (hereinafter referred to as the “**ASSOCIATION RIGHT**”).

5.2 The ASSOCIATION RIGHT granted will be coterminous with the CONTRACT.

5.3 No other description of the supply relationship or the CONTRACT other than the description set out above will be permitted.

5.4 The FIA will maintain a right to require the immediate withdrawal of any advertisement that it judges to be contrary to the CONTRACT or the reputation, standing or interests of the CHAMPIONSHIP, the FIA or motorsport generally.

5.5 Any publicity, advertising or promotional activity engaged in by the MANUFACTURER pursuant to the ASSOCIATION RIGHT shall be entirely at the MANUFACTURER’s own expense.

5.6 The grant of the ASSOCIATION RIGHT will not include the right to use the FIA Formula One World Championship logos or any of the FIA's intellectual property (save that the approved description set out in the ASSOCIATION RIGHT itself may be used);

5.7 Although the CONTRACT will not prevent the MANUFACTURER from entering into such arrangements at its own expense, for the avoidance of doubt the grant of the ASSOCIATION RIGHT will not include any advertising or promotional rights at EVENTS.

5.8 The ASSOCIATION RIGHT will not create any rights for the MANUFACTURER to associate any product with any COMPETITOR. However, the MANUFACTURER will not be prevented by the CONTRACT from entering into private publicity arrangements with COMPETITORS that would otherwise be permitted.

6. <u>PROJECT MANAGEMENT & SUPERVISION</u>

6.1 The FIA shall appoint a project manager to liaise between the MANUFACTURER, the COMPETITORS and the FIA, all reasonable costs of which shall be borne by the MANUFACTURER.

6.2 The MANUFACTURER shall bear all reasonable costs of development of the ECUs incurred by the FIA ENGINEER and his support staff, including software tools, looms and test equipment.

7. <u>PRODUCTION AND DELIVERY DATES</u>

7.1 The MANUFACTURER shall make available to the FIA, at the MANUFACTURER's own cost, no later than 29 September 2006, two prototype ECUs for selective bench testing.

7.2 No later than 9 March 2007, the MANUFACTURER shall make available to each of the COMPETITORS one pre-production ECU, at the MANUFACTURER's own cost. The MANUFACTURER shall carefully consider any comments or suggestions on the ECUs received from the COMPETITORS and from the FIA.

7.3 The hardware and software design specifications of the ECUs shall be submitted to the FIA for approval on or before 1 May 2007 and approved by the FIA on or before 1 June 2007, after which date no further modifications or alternations to the ECUs' specifications shall be permitted without the express consent of the FIA.

7.4 The MANUFACTURER shall make available for purchase three ECUs to each of COMPETITORS for delivery on 1 October 2007 at the latest.

7.5 The MANUFACTURER shall make available for purchase a further three ECUs to each of COMPETITORS for delivery on 16 November 2007 at the latest.

7.6 The MANUFACTURER shall make available for purchase to each of COMPETITORS any other ECUs ordered for the start of the 2008 season for delivery on 1 February 2008 at the latest. Thereafter, further supplies of ECUs shall be arranged between the MANFACTURER and COMPETITORS in accordance with the SUPPLY CONDITIONS.

7.7 The MANUFACTURER shall make available to each COMPETITOR all necessary technical support personnel and equipment to assist with installation of the ECUs during the first three deliveries of the ECUs to the COMPETITORS (on or before 9 March 2007, 1 October 2007 and 16 November 2007. The MANUFACTURER should identify the basis on which it might charge for additional "after sales" technical support over and above that needed to install the ECUs and the track support detailed in paragraphs 7.8 and 9.1. Thereafter, the MANUFACTURER shall make available a minimum of one technical support person per COMPETITOR for such time until the FIA Engineer considers that the installation of the ECUs is satisfactory.

7.8 The MANUFACTURER shall provide all necessary technical support personnel and equipment on-site throughout the duration of each EVENT for all COMPETITORS.

8. TECHNICAL CONDITIONS

8.1 The MANUFACTURER shall supply ECUs that are in conformity with the SPECIFICATIONS and the SPORTING AND TECHNICAL REGULATIONS (in particular Article 8 of the Formula One Technical Regulations). In addition, the MANUFACTURER shall supply ECUs that are capable of being used to ensure that COMPETITORS’ cars comply with TESTING requirements.

8.2 The MANUFACTURER shall supply ECUs that, as a minimum, comprise:

(a) a controller for:

- an 8 cylinder engine, including single injector and spark plug per cylinder, throttle actuator, pneumatic valve air pressure, lambda sensors and fuel pumps;
- a 7 speed semi-automatic sequential gearbox and hydraulic multi-plate carbon clutch;
- a hydraulic differential;
- an energy recovery system;
- a number of digital output drivers including: fuel hatch cover, reverse gear, rain lamp.

(b) steering wheel electronics for switch inputs and driver displays

(c) optionally, a switch panel in the cockpit

(d) a voltage regulator for car electrical power management

8.3 Before starting production, the MANUFACTURER shall submit a detailed technical study to the FIA ENGINEER for written approval and possible modifications according to the observations of the FIA ENGINEER.

8.4 The MANUFACTURER may not make any change to the ECUs during the CONTRACT without the express agreement of the FIA.

8.5 The MANUFACTURER will, to the fullest extent possible and save as otherwise agreed with the FIA, ensure that all ECUs supplied to COMPETITORS during the CONTRACT are identical and that the performance of the ECUs remains consistent at all times.

8.6 The MANUFACTURER will supply the FIA and each COMPETITOR with technical information and updates on an equal basis in a timely fashion. Any additional technical information supplied to one COMPETITOR (even on the basis of a request from a COMPETITOR) must be made available to all COMPETITORS on the same basis and without delay.

9. TESTING

9.1 To facilitate TESTING by COMPETITORS, the MANUFACTURER will be present at its own expense at a maximum of twenty official TESTING days nominated by the FIA out of season, and a maximum of ten such test days in season, with all necessary spare parts personnel and equipment to fit and service the ECUs. TESTING will be at a maximum of two locations in any one week out of season and at one location in any given week in season. Locations will be specified by the FIA, but all will be within Europe.

PART III - PROCEDURE AND ADDITIONAL REQUIREMENTS

10. TENDERING CONDITIONS

10.1 Tenders must comply with the terms and conditions set out in this Part III. Any tender not so complying will not be considered for the award of the CONTRACT.

11. TENDERS

11.1 Tenders must be submitted in a closed and sealed envelope addressed to Maître JAQUIERY, Huissier de justice, 6, Place des Eaux-Vives – 1207 Geneva – Switzerland (telephone number: +41.22.849.59.49), no later than 5pm on 23 June 2006.

11.2 The TENDERER is requested to send **four copies of his tender.**

11.3 TENDERERS are advised to submit tenders by registered mail, recorded delivery or by hand. Whatever method of tender delivery is chosen shall be entirely at the TENDERERS' risk.

11.4 By submitting a tender, the TENDERER agrees to keep that tender open for acceptance for THIRTY days following the 23 June 2006 deadline for submission of tenders.

11.5 Any envelope received after the 23 June 2006 deadline shall not be considered.

11.6 A receipt will be issued to the TENDERER at his request and shall serve as an acknowledgement of receipt.

11.7 On 25 June 2006, Maître JAQUIERY shall present all the envelopes to the FIA and shall open them during a public meeting. Each TENDERER may attend the opening of the envelopes and may personally verify that the seals of each envelope are firmly secure prior to their official opening.

11.8 The selected TENDERER shall be informed by fax no later than 7 July 2006.

11.9 The FIA has taken reasonable care to ensure that this invitation to tender is accurate in all material respects. This invitation to tender is provided solely by way of explanation of the ECU supplying conditions and neither the FIA, nor any of its representatives or employees make any representation or warranty, or accept any responsibilities for the accuracy or completeness of any of the information contained in this invitation to tender; nor shall they be liable for any loss or damage suffered by any TENDERER in reliance on this invitation to tender or any subsequent communication.

11.10 The FIA reserves the right to change any aspect of this invitation to tender at any time, to issue an amended invitation to tender or to provide the TENDERERS with clarification in relation to the content of the invitation to tender and the proposed process. Such change, amendment or clarification may be provided by the FIA in such form as the FIA considers appropriate. For the avoidance of doubt, in the event that potential TENDERERS find any aspect of this invitation to tender unclear, questions should be directed to the FIA. The FIA will not be responsible for any misunderstanding that could have been avoided or remedied by the potential TENDERER posing a suitable question to the FIA. Should the FIA agree that any aspect could usefully be clarified it will provide such clarification and where appropriate will publicise that clarification.

11.11 Nothing in this invitation to tender nor any communication made by the FIA or its representatives or employees shall constitute a contract between the FIA and any prospective TENDERER. The FIA shall be under no obligation to accept any tender offer submitted in response to this invitation to tender if, in the sole discretion of the FIA, the FIA considers that no tender offer meets with the FIA's criteria for the supplying of the ECUs.

11.12 Each TENDERER is responsible for all costs, expenses and liabilities incurred in the preparation of its tender, including any responses to requests for further information by the FIA and any travel or negotiations with the FIA (whether or not the TENDERER is ultimately selected).

12. <u>Mandatory contents of tenders</u>

12.1 Each tender must contain precise details of the name, address and contact person of the TENDERER as well as sufficient information to allow the FIA to identify the corporate group to which the TENDERER belongs.

12.2 Each TENDERER shall submit its proposed SUPPLY CONDITIONS which should include price per unit, details of technical support (see paragraphs 7.8 and 9.1), maintenance, annual refurbishment and any other associated charges for:

(a) ECUs with the requirements set out in Section 6.4 of the ECU Hardware Requirement Specification, and

(b) ECUs without the requirements set out in Section 6.4 of the ECU Hardware Requirement Specification.

12.3 Each tender must contain a statement indicating why, in the TENDERER’s submission, it should be selected by the FIA for the award of the CONTRACT. This statement should indicate the TENDERER’s experience in the manufacture of ECUs for sporting use, its experience in supplying national and/or international motorsport competitions and indicate any other facts which the TENDERER believes should be taken into account by the FIA.

12.4 Each TENDERER must present a document explaining in precise terms how, if selected, it would meet the requirements set out in Part II above.

12.5 The tender must contain detailed technical documentation on all the qualities and specifications of the ECUs to be supplied.

12.6 Each tender must contain the following declaration signed by a senior officer of the TENDERER on its behalf: “We certify the contents of this tender offer to be true and complete in all material respects. If, following submission of this tender, there is any change in circumstances which may adversely affect our ability to perform the tasks as we have proposed, we shall promptly notify the FIA in writing, setting out the relevant details in full”.

13. SELECTION

13.1 The FIA shall select the TENDERER which, in the FIA's sole opinion, most closely satisfies the scope of the task described and the requirements and interests of the CHAMPIONSHIP.

13.2 The FIA will not be required to give reasons for the acceptance or refusal of any particular tender.

13.3 The completion of the process of selection of a TENDERER shall be subject to the FIA and the TENDERER entering into the CONTRACT appointing the TENDERER as MANUFACTURER in accordance with the procedure set out herein.

13.4 A draft CONTRACT will be provided to the selected TENDERER which reflects the terms agreed and required in this invitation to tender and the terms set out in the tender offer that is accepted. The selected TENDERER will have 10 calendar days from the delivery of the draft CONTRACT in which to send any comments and to supply the documents necessary for the finalisation of the CONTRACT. No variation to the central terms or themes of this invitation to tender or the offer submitted will be permitted at that stage and the opportunity to comment will be provided only to allow technical amendments that are necessary to give the CONTRACT full force and effect. If this time limit is not respected, the FIA reserves the right to revise its position on the award of the CONTRACT resulting from the invitation to tender, and by submitting a tender the TENDERER agrees that it waives all right of legal action in the event of such a revision.

13.5 It will be a term of the CONTRACT that neither the CONTRACT nor any part of it may be assigned, subcontracted or transferred under any circumstances whatsoever without the express prior written agreement of the FIA.

14. GUARANTEE

14.1 It shall be a pre-condition to the completion of the CONTRACT that the MANUFACTURER shall produce an attestation certifying that it has a first demand guarantee in place which provides for at least the following terms, together with an executed copy of the said first demand guarantee.

14.2 The guarantee must be issued by a top-ranking international financial institution and must guarantee a payment in favour of the FIA of a minimum of **100,000,000 (one hundred million) euros.**

14.3 The guarantee may be called upon by the FIA in the event that a payment is demanded (whether in damages or otherwise) by any third party or the FIA for any breach of the MANUFACTURER’s legal or contractual obligations, including any payment or compensation that might arise from any flaws in the MANUFACTURER’s product or the MANUFACTURER’s negligence or any costs, damages or expenses arising from its failure to supply the requisite ECUs (including a failure to supply ECUs which are fit for purpose and a failure to supply sufficient quantities of ECUs).

14.4 The CONTRACT shall contain the following clause releasing the MANUFACTURER from liability if such failure to supply is due to a force majeure event:

"In the event that the MANUFACTURER is unable to supply the quantities of ECUs required in accordance with the provisions of this CONTRACT, the MANUFACTURER shall not be liable if such failure to supply is due to a force majeure event, such as war, insurrection, earthquake, riot, or depletion of stocks of raw materials, if such depletion affects all the companies which are rivals of the MANUFACTURER and blocks the entire industrial production of ECUs typically used for motor racing.

Depletion of stocks of raw materials which does not affect the entire ECU manufacturing industry shall not be considered a force majeure event. Strikes and other social strife or problems which prevent manufacture of the ECUs in the factories of the MANUFACTURER are also not considered to be force majeure events."

14.5 No occurrence other than the force majeure events referred to above shall release the MANUFACTURER from liability in case of failure to supply.

14.6 The first demand guarantee must be irrevocable and in a form that allows the FIA to enforce and call upon that guarantee with its first demand by sending a fax to the guarantor, indicating the contractual or other breach which has arisen and which justifies enforcement of the first demand guarantee without the need for any substantiation or further justification of such demand and without any further judicial or administrative formalities.

14.7 Upon receipt of the said fax and without the right to dispute or question the justification for the demand the guarantor shall be obligated to release the amount demanded to the FIA (subject always to the maximum of 100,000,000 (100 million) euros.).

14.8 The reliance and enforcement by the FIA on the first demand guarantee given by the MANUFACTURER's financial institution shall not itself lead to the presumption that the MANUFACTURER is ultimately responsible for the breach of obligations identified by the FIA, in whole or in part. The MANUFACTURER shall retain the right, if it deems this necessary to defend its interests, to lay any dispute before any courts having appropriate jurisdiction. However, this right shall only be exercised after the guarantee payment has been released to the FIA and shall not entitle the MANUFACTURER to seek to prevent the payment of the guarantee amount if that amount has been demanded in accordance with the terms hereof.

14.9 If a competent court makes a final determination which is not subject to appeal or has not been appealed by the FIA within six months, that the MANUFACTURER had not breached its obligations, then the FIA shall reimburse all or part of the amount paid under the performance guarantee as appropriate

14.10 The FIA may call upon and enforce the first demand guarantee referred to above once for full payment, or several times for partial payment, of the amount of the performance guarantee, i.e. up to a total maximum of 100,000,000 (100 million) euros.

14.11 The first demand guarantee must enter into force at the latest on the day of execution of the CONTRACT and shall remain in full force and effect for the entire term of the CONTRACT.

14.12 The first demand guarantee is a payment obligation and not a collection obligation, and it shall not be affected in any way by the absence of any action on the part of the FIA to obtain payment from the guarantor.

15. CHANGES TO SPORTING AND TECHNICAL REGULATIONS AND CHANGES TO THE SPECIFICATIONS

15.1 The SPORTING AND TECHNICAL REGULATIONS together with the International Sporting Code of the FIA constitute the legal, administrative and technical framework of the CHAMPIONSHIP and the conditions set forth therein shall have binding force and prevail among the parties to the CONTRACT.

15.2 The SPECIFICATIONS identify the technical characteristics of the ECUs to be supplied.

15.3 By submitting a bid, TENDERERs acknowledge that both the SPORTING AND TECHNICAL REGULATIONS and the SPECIFICATIONS are subject to amendments from time to time by the FIA. The FIA will consult with the MANUFACTURER that is selected as a result of this process before making any change to its SPORTING AND TECHNICAL REGULATIONS or the SPECIFICATIONS which may affect the MANUFACTURER's compliance with the obligations set out in the CONTRACT and will give the MANUFACTURER as much notice of any change as practicable. However, the MANUFACTURER will not hold (whether under the CONTRACT or otherwise) any right to impede such changes as the FIA deems necessary.

15.4 The MANUFACTURER shall be responsible (at its own cost) for all research and development associated with the manufacture of the ECUs, including the making of any changes to the ECUs that may be necessitated by any amendment to the SPORTING AND TECHNICAL REGULATIONS and/or the SPECIFICATIONS without any modification of the SUPPLY CONDITIONS or any of the terms provided for in the CONTRACT.

16. GOVERNING LAW AND LANGUAGE

16.1 The key documents in connection with this invitation to tender shall be drafted in English. The language which shall prevail for the interpretation of the provisions of this invitation to tender and the CONTRACT will be English.

16.2 The governing law shall be French law and it shall apply to this invitation to tender, as well as to the CONTRACT.

16.3 The Court having jurisdiction to settle any dispute which may arise between the FIA and the TENDERER or MANUFACTURER shall be the Tribunal de Grande Instance de Paris, France.

ANNEX A

SPECIFICATIONS

FIA ECU Hardware Requirement Specification

1. INTRODUCTION

For 2008 the FIA is introducing a standard Electronic Control Unit (ECU) for Formula 1 with the aims of reducing the cost of racing, removing driver aids such as traction control and allowing the FIA to check engine use and testing mileage. The standard ECU will control the Engine, Gear Box, Clutch and Differential on the car – no other electronic controls will be allowed.

This document is an example hardware specification for an ECU that will meet the requirements brought about by the 2008 Formula One regulations. It presents in detail the inputs and outputs required for the ECU, the unit's processor core and the unit's interfaces to the other electronics units on the car (driver's display and controls and the team data acquisition system). It also considers the mechanical, environmental, quality and manufacturing aspects for the unit.

This document needs to be read in conjunction with the FIA 2008 ECU Outline Software Requirement Specification that covers in outline the control strategies the ECU needs to provide, the requirements for logging and diagnostic software within the ECU and the PC software requirements for the system. It is these that will define the amount of processing power and storage required within the unit.

A key facet of the ECU is its ability to provide high-level diagnostics making it straightforward to use and easy to diagnose faults with the cars systems.

This document focuses on the technical functionality needed and it is beyond its scope to cover detailed commercial, contractual, design, manufacturing, support and supply aspects.

However a proposal should include annual maintenance and repair requirements and costs, software update support for the life of the tender in addition to initial development, individual team integration support and track support for 19 races and five tests per season.

The details of any components to be proposed by the supplier for use with the electronics units supplied should be provided.

It is intended that each team will be permitted to build their own control looms to a standard FIA connectivity specification. A facility to automatically check loom compliance at the track will be required as part of a proposal.

All parts of the system must be designed to ensure that the system will effectively prevent the use of driver aids including but not limited to traction control, launch control and automatic gear changing.

- There will be only one FIA approved software version that cannot be changed by the team.
- A foolproof means to ensure that all software contained within the units is identical to that validated and approved for use.
- Each unit will have a unique serial number marked externally and will be sealed and have its identity tracked throughout its entire life cycle.
- Each unit must have suitable provision to allow it to be sealed to prevent tampering.
- A maximum fixed rev limit adjustable only by the FIA.
- A secure ability to restrict the data logging capability and configurability and to prevent data erasure during race weekends.
- Engine and team specific setup data will have individual engine supplier and team identification. The PC software supplied to teams must recognise this and prevent unauthorised access.

1.1 Document Revision History

Revision	Date	Summary of Changes
1	19/05/2006	

1.2 Related Documents

Document Name	Notes
FIA 2008 ECU Outline Software Requirement Specification	Gives outline of the control, logging and PC software for the unit.

2. MECHANICAL

2.1 Dimensions

To be defined by the vendor of the ECU. Maximising reliability by design has a higher priority than miniaturisation.

2.2 Weight

To be confirmed.

2.3 Case Material

Machined Aluminium with black anodised finish.

2.4 Connectors

Deutsch AS Series. Types and pin-out to be confirmed.

2.5 Installation

2.5.1 Heat sink

The unit's enclosure to include mounting points allowing fitment of a bespoke heat sink to suit different car designs.

2.5.2 Anti Vibration Mounts

The ECU is supplied with anti-vibration mounts and it is required that these be used to mount the unit in the car.

3. ENVIRONMENTAL

3.1 Storage Temperature

-25 to 85 °C ambient temperature.

3.2 Operating Temperature

0 to 70 °C case temperature.

3.3 Operating Thermal Shock

1°C/second over operating temperature range.

3.4 Fluid Ingress Protection

To be rated to IP66 (EN60529). Impervious to all normal motor racing fluids.

3.5 Vibration

3.5.1 Design Validation

The design to be validated by demonstrating that the unit survives when vibrated using the profile below for three hours in each axis hard mounted to the shaker table.

Frequency (Hz)	Acceleration (G^2/Hz)
10.0	0.0016
20.0	0.016
200.0	0.016
430.0	3.40
435.0	0.11
2000.0	0.11

3.5.2 Production Units

Each production unit to be tested hard mounted to a shaker table for 15 minutes in one axis using the vibration profile above.

3.6 Electromagnetic Compatibility

The ECU to comply with the requirements of electromagnetic compatibility directive 2004/108/EC that is applicable from 20th July 2007.

4. ELECTRICAL

4.1 Supply Voltage

Nominal operating voltage: 13.6 ±2.0 Volts. Outside this range the unit should have an option to cut the engine.

Minimum start-up voltage threshold: 10.5Volts.

Continuous DC operating range: 9.0 - 18.0Volts.[1]

A detailed system proposal should include a standard specification for a voltage regulator to support the supplied ECU system with additional capability for team data acquisition and telemetry systems, including facilities for managing and controlling loads only under the direct command of the ECU under specific circumstances to be defined. As an example switching off non-critical units at low engine rpm and reporting load capacity availability in real time to the team data acquisition units.

4.2 Supply Current

Quiescent and operating current to be confirmed.

4.3 Supply Protection

Indefinite voltage reverse protection.

Over voltage shutdown protection to 30 Volts.

DC under voltage shutdown protection.

[1] Sensor excitation regulation, injector and ignition drive circuitry specification guaranteed only at nominal operating voltage.

5. CONNECTIONS

5.1 General

Figure 1 shows the primary external connections to the ECU. It is beyond the scope of this document to attempt to show the complete car system architecture.

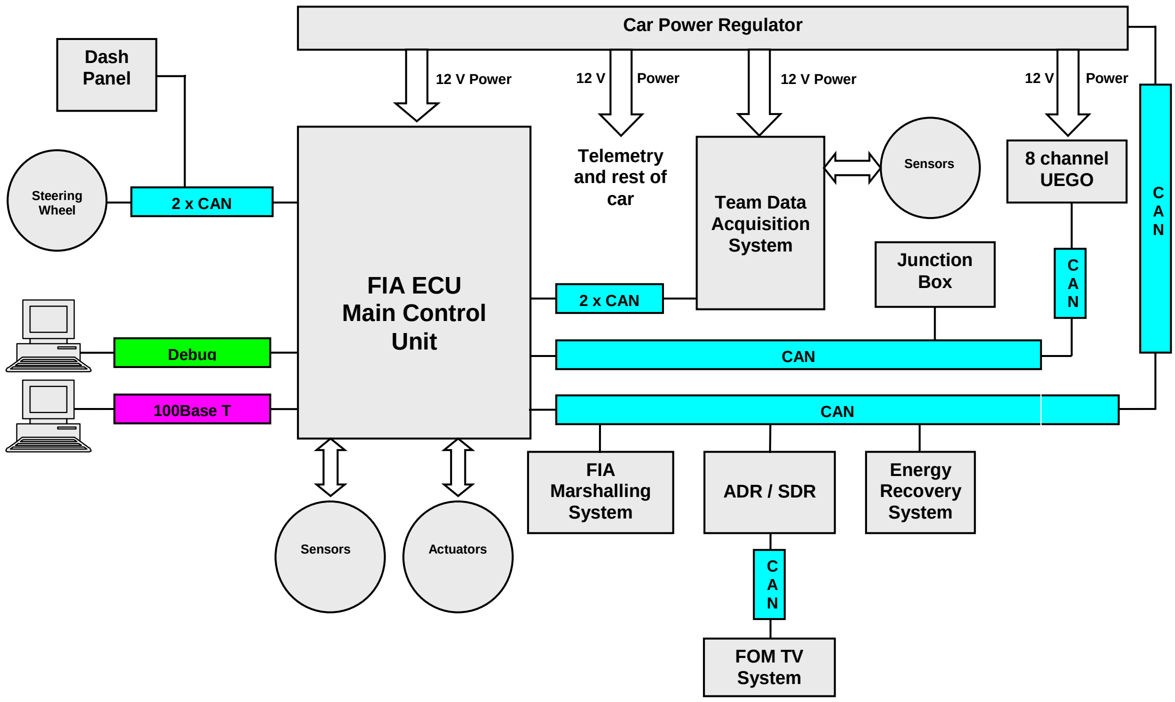

Figure 1

5.2 Pinouts

To be specified by the vendor.

6. SENSOR AND ACTUATOR INTERFACES

Only one hardware build will be manufactured; all input selection options will be configured via software.

6.1 Control System Input/Output Type Summary

- 6 off ±10mA servo-valve current drives with current and voltage monitoring.
- 31 off 0-5V single ended analogue inputs.
- 2 off UEGO/wideband LAMBDA sensor analogue inputs.
- 7 off PT1000 temperature sensor single ended analogue inputs.
- 5 off LVDT inputs.
- 2 off K-type thermocouple inputs.
- 6 off digital switch line inputs.
- 8 off digital speed inputs configurable to suit variable reluctance or Hall effect input types.
- 1 off digital lap trigger input.
- 12 off high side drive outputs.
- 8 off low side drive outputs.
- 8 off inductive ignition drives.
- 8 off injector drives.
- 10 off regulated 5V sensor excitations, max 25mA.
- 17 off unregulated 12V sensor excitations, max 50mA
- 2 off unregulated 12V sensor excitations, max 100mA.
- 4 off AC sensor excitations for LVDTs.
- 2 off UEGO sensor heater drives.
- 2 off variable reluctance crank sensor inputs
- 1 off variable reluctance/hall effect cam sensor input.
- 2 off oscilloscope diagnostic outputs.
- 25 sensor and comms grounds

6.2 Input/Output allocations

The FIA ECU is designed to interface to the sensors and actuators that are used within the control systems of Formula 1 cars. In addition, sensors needed in order to provide warnings, alarms or other indicators to the driver, via his cockpit/steering wheel display, need to be interfaced to the ECU. This is because it is the only device that may communicate with the display.

Table 1 lists all external control sensor and actuator signals that interface to the FIA ECU.

Description	ECU Input/ Output	Primary Control Category	Type
Engine air valve pressure 1	Input	Engine	0-5V analogue input
Engine air valve pressure 2	Input	Engine	0-5V analogue input
Engine air valve tank pressure	Input	Engine	0-5V analogue input
Airbox air pressure	Input	Engine	0-5V analogue input
Air valve pressure control	Output	Engine	High Side Drive
Ambient air temperature	Input	Engine	PT1000 analogue input
Cam sensor	Input	Engine	Digital variable reluctance or hall effect Cam input
Crank sensor 1	Input	Engine	Digital variable reluctance, Crank Input
Crank sensor 2	Input	Engine	Digital variable reluctance, Crank Input
Ignition drives	Output	Engine	Inductive Ignition Drive (8 off)
Injector drives	Output	Engine	Peak Sustain and Hold Injector Drive (8 off)
Injector supply voltage	Input	Engine	0-5V analogue input
Fuel Pump drive 1	Output	Engine	Low Side Drive
Fuel Pump drive 2	Output	Engine	Low Side Drive
Fuel Pump drive 3	Output	Engine	Low Side Drive
UEGO Sensor left bank	Input	Engine	UEGO analogue input
UEGO Sensor right bank	Input	Engine	UEGO analogue input
UEGO Sensor Heater Left	Output	Engine	UEGO Heater
UEGO Sensor Heater Right	Output	Engine	UEGO Heater
Gearshift servo-valve drive	Output	Gearbox	10mA current drive
Gearbox shift drum position 1	Input	Gearbox	0-5V analogue input
Gearbox shift drum position 2	Input	Gearbox	0-5V analogue input
Gearbox input shaft speed	Input	Gearbox	Digital variable reluctance or Hall effect speed input
Reverse solenoid	Output	Gearbox	High Side Drive
Clutch servo-valve drive	Output	Clutch	10mA current drive
Clutch position 1	Input	Clutch	0-5V analogue input
Clutch position 2	Input	Clutch	LVDT
Clutch actuator hydraulic pressure	Input	Clutch	0-5V analogue input
Differential servo-valve drive	Output	Differential	10mA current drive
Lateral Acceleration	Input	Differential	0-5V analogue input
Longitudinal Acceleration	Input	Differential	0-5V analogue input
Differential actuator hydraulic pressure	Input	Differential	0-5V analogue input
Throttle servo-valve drive	Output	Throttle	10mA current drive
Engine throttle position 1	Input	Throttle	0-5V analogue input
Engine throttle position 2	Input	Throttle	LVDT
Hand controller demand	Input	Throttle	0-5V analogue input
Throttle Pedal Input 1	Input	Throttle	0-5V analogue input or LVDT
Throttle Pedal Input 2	Input	Throttle	0-5V analogue input
Front Brake pressure	Input	Throttle	0-5V analogue input
Rear Brake pressure	Input	Throttle	0-5V analogue input
Hand controller enable	Input	Throttle	Digital switch line
Hydraulic System pressure	Input	System	0-5V analogue input
Lap Trigger	Input	System	Digital lap trigger

Garage Mode Select	Input	System	Digital switch line
Engine kill ignition switch	Input	System	Digital switch line
Front Left Wheel speed	Input	System	Digital variable reluctance or Hall effect speed input
Front Right Wheel speed	Input	System	Digital variable reluctance or Hall effect speed input
Rear Left Wheel speed	Input	System	Digital variable reluctance or Hall effect speed input
Rear Right Wheel speed	Input	System	Digital variable reluctance or Hall effect speed input
Power Management Control 1	Output	Power Manage	High Side Drive
Power Management Control 2	Output	Power Manage	High Side Drive
Power Management Control 3	Output	Power Manage	Low Side Drive
Fuel Flap Solenoid drive	Output	Ancillary	High Side Drive
Rear Light drive	Output	Ancillary	High Side Drive
Neutral Finder lock-out drive	Output	Ancillary	High Side Drive
Neutral Finder activation drive	Output	Ancillary	High Side Drive
Squirt Jet solenoid 1	Output	Ancillary	High Side Drive
Squirt Jet solenoid 2	Output	Ancillary	High Side Drive
Gearbox oil pressure	Input	Alarm	0-5V analogue input
Engine oil pressure	Input	Alarm	0-5V analogue input
Engine crankcase pressure	Input	Alarm	0-5V analogue input
Engine coolant pressure	Input	Alarm	0-5V analogue input
Fuel Pressure	Input	Alarm	0-5V analogue input
Fuel Collector Pressure	Input	Alarm	0-5V analogue input
Fuel Collector Level	Input	Alarm	0-5V analogue input
Gearbox oil temperature	Input	Alarm	PT1000 analogue input
Engine oil temperature	Input	Alarm	PT1000 analogue input
Engine coolant temperature	Input	Alarm	PT1000 analogue input
Fuel Temperature	Input	Alarm	PT1000 analogue input
Exhaust Temperature Left	Input	Alarm	Thermocouple
Exhaust Temperature Right	Input	Alarm	Thermocouple
Diagnostic Output 1	Output	Diagnostic	Oscilloscope Output
Diagnostic Output 2	Output	Diagnostic	Oscilloscope Output
Spare Servo Valve Output 1	Output	Spare	10mA current drive
Spare Servo Valve Output 2	Output	Spare	10mA current drive
Spare Analogue Input 1	Input	Spare	0-5V analogue input
Spare Analogue Input 2	Input	Spare	0-5V analogue input
Spare Analogue Input 3	Input	Spare	0-5V analogue input
Spare Analogue Input 4	Input	Spare	0-5V analogue input
Spare Analogue Input 5	Input	Spare	0-5V analogue input
Spare Analogue Input 6	Input	Spare	0-5V analogue input
Spare Switch Input 1	Input	Spare	Digital switch line
Spare Switch Input 2	Input	Spare	Digital switch line
Spare Switch Input 3	Input	Spare	Digital switch line
Spare Speed Input 1	Input	Spare	Digital variable reluctance or Hall effect speed input
Spare Speed Input 2	Input	Spare	Digital variable reluctance or Hall effect speed input
Spare Speed Input 3	Input	Spare	Digital variable reluctance or Hall effect speed input
Spare High Side Drive 1	Output	Spare	High Side Drive
Spare High Side Drive 2	Output	Spare	High Side Drive
Spare Low Side Drive 1	Output	Spare	Low Side Drive
Spare Low Side Drive 2	Output	Spare	Low Side Drive
Spare Low Side Drive 3	Output	Spare	Low Side Drive
Spare Low Side Drive 4	Output	Spare	Low Side Drive

Spare LVDT 1	Input	Spare	LVDT
Spare LVDT 2	Input	Spare	LVDT
Spare PT1000 1	Input	Spare	PT1000 analogue input
Spare PT1000 2	Input	Spare	PT1000 analogue input

Table 1 – Sensor and Actuator Signals

Note that where there are multiple inputs measuring the same physical thing, such as in the case of the throttle pedal, the inputs are split between different signal conditioning and processing modules within the electronics hardware to minimise the chances of an internal ECU fault having a critical effect on the control systems.

A list of control sensors and actuators approved for use with the ECU will be compiled in conjunction with the supplier.

6.3 Control System Input / Output Summary

Sensor Type	ECU Function											
	Engine	Gearbox	Clutch	Differential	Throttle	System	Power Manage	Ancillary	Alarm	Diagnostic	Spare	Total
0-5V analogue input	4	2	2	3	6	1			7		6	31
LVDT			1		2						2	5
PT1000 analogue input	1								4		2	7
Thermocouple									2			2
UEGO analogue input	2											2
Digital variable reluctance or Hall effect speed input		1				4					3	8
Digital variable reluctance or hall effect Cam input	1											1
Digital variable reluctance, Crank Input	2											2
Digital lap trigger						1						1
Digital switch line					1	2					3	6
±10mA current drive		1	1	1	1						2	6
Peak Sustain and Hold Injector Drive(8 off)	8											8
Inductive Ignition Drive (8 off)	8											8
High Side Drive	1	1					2	6			2	12
Low Side Drive	3						1				4	8
UEGO Heater	2											2
Oscilloscope Output										2		2

It will be possible to configure:

- one spare LVDT as a clutch position backup signal.

- one spare low side driver output as a lap trigger output pulse.

- one spare low side driver output as a crank synchronisation output pulse.

- one spare high side driver output as an auxiliary oil valve output.

A detailed design proposal could make use of standard external interface units to reduce main unit pin count. As an example an LVDT might be proposed as an approved gearbox position sensor not specifically detailed in this specification.

6.4 Integral Non-Control Data Acquisition Signals

The ECU must include internally integrated or external interfaces to the following signals including sufficient suitable protected sensor excitation supplies and data acquisition capacity for logging them all over a normal race distance. Within the constraints of the hardware these logging only sensors will be free for individual teams to select.

Table 2 lists the external non-control sensors supported

Description	Number	Type
Suspension damper displacement	4	0-5V analogue input
Suspension load cells	6	Strain gauge input
Ride Height sensor	4	0-5V analogue input
Gyro (roll, pitch, yaw)	3	0-5V analogue input
Brake wear	4	LVDT
Brake temperature	4	0-5V analogue input
Brake balance bar position	1	0-5V analogue input
Brake master cylinder position	2	0-5V analogue input
Hub accelerometer	4	0-5V analogue input
Drive Shaft Torque	2	0-5V analogue input
Gearbox shaft speeds	2	Digital variable reluctance or Hall effect input
Gearbox oil temperature	1	0-5V analogue input /PT1000 analogue input
Tyre pressure	4	0-5V analogue input or CAN interface
Tyre temperature	4	0-5V analogue input or CAN interface
Vertical acceleration	1	0-5V analogue input (see control sensors also)
Skid temperature	2	0-5V analogue input /PT1000 analogue input
Floor load cell	2	Strain gauge input
Diffuser pressure	2	0-5V analogue input
Power steering pressure	2	0-5V analogue input
Steering angle	1	0-5V analogue input
Steering torque	1	0-5V analogue input
Oil level / quality	1	0-5V analogue input or serial interface
Clutch temperature	1	0-5V analogue input /PT1000 analogue input
Barometric pressure	1	0-5V analogue input
Pitot pressure	1	0-5V analogue input
Pitot static pressure	1	0-5V analogue input
Yaw pitot pressure	1	0-5V analogue input
Engine oil radiator temperature	2	0-5V analogue input /PT1000 analogue input
Engine cylinder pressure	2	0-5V analogue input
Engine coolant radiator temperature	2	0-5V analogue input /PT1000 analogue input
Hydraulic fluid temperature	1	0-5V analogue input /PT1000 analogue input
Hydraulic return pressure	1	0-5V analogue input
LPA position	1	0-5V analogue input
Oil swirl pot pressure	1	0-5V analogue input
Marshall Neutral accumulator pressure	1	0-5V analogue input
Speed over ground sensor	1	CAN or serial interface
Spare	4	0-5V analogue input
Spare	2	LVDT
Spare	2	0-5V analogue input /PT1000 analogue input

6.5 Input/Output Specification

6.5.1 Analogue Inputs

6.5.1.1 Type 1: 0-5 Volt

Type	Single ended, unipolar, absolute measurement.
Input Range	0-5 Volts.
Resolution	12 bit
Input impedance	> 1MΩ
Accuracy	0.1% FS
Zero error	0.1% FS
Input filtering	low pass at 850 Hz cut off frequency for 4kHz inputs, 100Hz cut off for 1kHz inputs.
Maximum sample rate	1 kHz standard, 4 kHz for inputs used for feedback in closed loop servo valve controllers
Protection	Short to Vbatt, Ground
Note	Inputs read 0Volts when input open circuit

6.5.1.2 Type 2: PT1000 Temperature Input

Type	Single ended, unipolar, absolute measurement.
Input Range	0-5 Volts.
Resolution	12 bit
Input impedance	5 kohm pull up to 5V
Accuracy	0.5% FS
Zero error	0.5% FS
Input filtering	3 pole low pass at 100 Hz
Maximum sample rate	10 Hz
Protection	To be defined.
Note	Designed for use with PT1000 sensors.

6.5.1.3 Type 3: LVDT

Type	5 wire, ratiometric measurement.
Input Range	3.5 Volts rms. Max
Resolution	12 bit
Input impedance	> 1MΩ.
Accuracy	0.6% FS
Zero error	0.6% FS
Input filtering	low pass of rectified secondary value at 850 Hz cut off frequency for 4kHz inputs, 100Hz cut off for 1kHz inputs.
Maximum sample rate	1 kHz standard, 4 kHz for inputs used for feedback in closed loop servo valve controllers
Protection	Short to Vbatt or Ground
Note	1. For use with ac excitations. See 6.5.3.5. 2. Channels derived from each rectified secondary input available for diagnostic purposes. 3. Measurement value rescaled from calculation: (secondary 1 – secondary 2) / (secondary 1 + secondary 2)

6.5.1.4 Type 4: UEGO

Type	NTK / Bosch
Input Range	0-5 Volts.
Resolution	12 bit
Input impedance	100 kohms / 4.7 nF
Accuracy	2%
Current Control	Analogue or Digital PID
Input filtering	To be defined
Maximum sample rate	100Hz
Protection	Short to Vbatt or Ground
Note	

6.5.2 Digital Inputs

6.5.2.1 Type 1: Speed Inputs

Type	Selectable variable reluctance or hall effect
Input Voltage Range	± 100 V (VRS)
Maximum Input Frequency	10 kHz
Resolution	24 bit counter using min 8 MHz clock
Switching Threshold	Programmable, 8 bit resolution
Switching Hysterisis	Programmable, 8 bit resolution
Input circuitry	1KΩ pull-up to 5Volts in Hall effect mode
Maximum sample rate	200Hz
Protection	Short to Vbatt, Ground
Note	Diagnostic channels available giving 16 bit input pulse counter and current input level. Maximum sample rate of 100Hz.

6.5.2.2 Type 2: Crank Sensor

Type	Variable reluctance
Input Voltage Range	± 100 V
Maximum Input Frequency	50 kHz
Resolution	0.1 degree
Arm Threshold	Engine speed dependent threshold
Trigger Threshold	Programmable, 8 bit resolution
Protection	Short to Vbatt, Ground
Note	- Designed for maximum engine speed of 22000 RPM with 24-2 tooth or other crankshaft trigger disk. Only one tooth configuration should be supported for reliability and reduced cost.

6.5.2.3 Type 3: Cam Sensor

Type	Selectable variable reluctance or hall effect
Input Voltage Range	±30 V
Maximum Input Frequency	10 kHz
Resolution	0.1 Degree
Arm Threshold	Programmable, 8 bit resolution
Trigger threshold	Programmable, 8 bit resolution
Protection	Short to Vbatt, Ground
Note	Designed for maximum engine speed of 22000 RPM with single tooth camshaft trigger disk.

6.5.2.4 Type 4: Switch Line

Type	Single ended, unipolar
Input Voltage Range	0-5 Volts, TTL level switching

Maximum Input Frequency	10 Hz
Resolution	On / Off
Input impedance	1 kohm pull up to 5V
Maximum sample rate	100Hz
Protection	To be defined
Note	

6.5.2.5 Type 5: Lap Trigger

Type	To match vendor's lap trigger

6.5.3 Analogue Outputs

6.5.3.1 Type 1: Servo-valve Drive

Type	Bipolar current drive
Output Range	±10 mA
Resolution	±11 bit
Servo valve impedance	1 kohms maximum, inductance 2H maximum, Suitable to drive a Moog E024 and E050 valves
Accuracy	0.5% of FS
Zero error	0.5% of FS
Maximum control rate	4kHz
Voltage Drive	±20 V maximum across servo valve
Protection	Short circuit to Vbatt or Ground
Note	Diagnostic channels available giving output voltage and current measurements. Maximum sample rate of 1kHz with 12-bit resolution. True 0 current reporting. Moog output current disable or configurable DC bias current is required during unit power up, in addition to the ability to hold existing DAC values through a warm start caused by a system processor reset.

6.5.3.2 Type 2: Regulated 5V Sensor Excitation

Type	Single ended voltage drive
Output Voltage	Fixed 5 Volts
Accuracy	0.1%
Maximum Current	50mA minimum
Protection	- Short circuit to Vbatt or ground - A short-circuit on one excitation does not affect other excitations
Note	- Diagnostic channels available giving output voltage and current measurements. Maximum sample rate of 100Hz with 8 bit resolution. True 0 current reporting.

6.5.3.3 Type 3: Unregulated Sensor Excitation (50mA)

Type	Single ended voltage drive
Output Voltage	Tracks supply voltage
Accuracy	Not applicable
Maximum Current	50mA minimum
Protection	- Short circuit to Vbatt or ground - A short-circuit on one excitation does not affect other excitations
Note	- Supporting diagnostic channels giving output voltage and current measurements. Maximum sample rate of 100Hz with 8 bit resolution. True 0 current reporting.

6.5.3.4 Type 4: Unregulated Sensor Excitation (100mA)

Type	Single ended voltage drive
Output Voltage	Tracks supply voltage
Accuracy	Not applicable
Maximum Current	100mA minimum
Protection	- Short to Vbatt or ground - A short-circuit on one excitation does not affect other excitations
Note	- Supporting diagnostic channels giving output voltage and current measurements. Maximum sample rate of 100Hz with 8 bit resolution. True 0 current reporting.

6.5.3.5 Type 5: AC Excitation for LVDTs

Type	Bipolar sinusoidal ac voltage drive
Output Amplitude	0.5 to 3 Vrms selectable in 0.5V steps
Output Frequency	2 to 10 kHz in 500 Hz steps
Maximum Current	20 mA RMS
Accuracy	Amplitude ± 20%, Frequency ± 10%
Offset	5% FS
Protection	- Short circuit protection. - Short to Vbatt or Ground - A short-circuit on one AC excitation does not affect other AC excitations
Note	Supporting diagnostic channels giving average excitation output voltage. Maximum sample rate of 100Hz with 8 bit resolution. Open circuit detection.

6.5.4 Digital Outputs

Detailed specification of digital outputs including type, output impedance, voltage range, current limit, protection and monitoring provision is to be specified.

6.5.5 Ignition Drives

Type	Inductive drive stage.
Dwell duration resolution	1 μs
Dwell duration range	0 – 1 mS
Spark angle control	0.1° degree
Maximum peak current	20 A
Protection	Fixed fly-back voltage clamp, short circuit protected
Diagnostics	- Open and short circuit condition detection and indication on a per drive basis. - Charge current and spark duration measurement on a per drive basis.
Other Features	- Adaptive dwell to achieve target peak current based on charge current monitoring. - Can operate in wasted spark mode over full operating range - Designed for latch-up free operation - buffered outputs for connection to external team Ionisation logging system.

6.5.6 Injector Drives

Type	Peak, Sustain and Hold with configurable peak and hold currents, sustain and hold times.
Maximum peak current	8 A per injector
Current resolution	Peak and hold levels programmable, 8 bit resolution
Injection angle control	0.1 degree
Injection duration control	1 μS
Injection duration range	0 – 100 mS
Protection	Flyback voltage clamp, over temperature and short circuit protected
Diagnostics	Short and open-circuit fault detection on a per drive basis. Injector current monitor on a per drive basis
Other Features	Independent configuration for each of two groups of four drives (1-4 and 5-8)

6.5.7 UEGO Sensor Heater Drives

Type	Current Drive
Maximum peak current	5 A
Driver type	PWM low side drive
Maximum switching frequency	25 kHz
Protection	Fly-back voltage clamp, over temperature and short circuit protected
Diagnostics	Short and open-circuit fault detection on a per drive basis

6.5.8 High Side Digital Outputs

Type	High Side Drive
Maximum Current	3A continuous
Output Voltage	Unregulated Vbatt
Maximum switching frequency	100 Hz
Protection	Short to Ground, Vbatt, over-temperature protection
Notes	PWM output drive capability required

6.5.9 Low Side Digital Outputs

Type	Low side (ground) switch
Maximum Current	5 A continuous
Maximum switching frequency	25 kHz
Output protection	Short to Ground, Vbatt, fly-back voltage clamp
Notes	PWM output drive capability required

6.6 Diagnostic Outputs

6.6.1 Diagnostic Output 1: DAC Driven

Type	Oscilloscope output
Voltage Range	0 – 5 V
Output Impedance	100 ohms
Output Protection	Short to Ground, Vbatt
Update Rate	4 kHz
Notes	This output to be driven by a DAC from the ECU microprocessor and should be capable of showing a reconstruction of any channel available in the system.

6.6.2 Diagnostic Output 2: Analogue MUX Driven

Type	Oscilloscope output
Voltage Range	0 – 5 V
Output Impedance	100 ohms
Output Protection	Short to Ground, Vbatt
Notes	This output should be driven by an analogue MUX inside the ECU and should be capable of outputting the following signals: Crank voltage, Cam voltage, current in each LSD, current in each Injector output, current in each Ignition output, current in each Uego heater.

6.7 Internal Sensors

The ECU should include the following internal sensors:

6.7.1 Temperatures

The ECU should measure its case temperature and the temperature of its core electronics. These sensors should be accurate to ±3°C over the range -20°C to 120°C.

6.7.2 Vibration

The ECU should include a three axis high bandwidth accelerometer to measure the vibration level inside the unit.

6.7.3 Supply Voltage

The ECU should measure the battery supply voltages to an accuracy of 0.05 V at a rate of up to 100 Hz.

6.8 Sensor and Actuator Types

The FIA ECU has been designed to operate with the following specific ranges of sensors and actuators:

To be defined.

6.9 Internal Data Acquisition

The ECU should include internal data logging capability sufficient for development of all ECU functions and detailed signal diagnostics over a race distance, in addition to supporting some future expansion and use of an 8 channel UEGO unit, team junction boxes and an energy recovery system control unit via CAN. PC data viewing and analysis tools will be required with ability to export data to common standard formats for use by other PC tools commonly in use.

6.10 Internal Real Time Clock Hardware

The ECU should include an internal timekeeping device which continues to accurately maintain time of day and date even when the unit is unpowered for 1 month minimum. Timekeeping must be accurate to 2 seconds a day worst case over the normal operating temperature and input voltage ranges.

7. COMMUNICATIONS INTERFACES

7.1 Pit System

Connection to the off-car pits system via the car server PC is provided by a 100BaseT link running a TCP/IP based protocol. This link is primarily used for the following purposes:

- Transfer of set-up and calibration parameters to the ECU.
- Offload of logged data.
- Operating diagnostic, calibration and configuration modes of the control systems.
- Loading application software.

Standard PC tools will be required as part of the supplied system to perform these functions.

7.2 Driver Controls and Display

Two CAN 2.0B buses are provided for connection to a driver display/switch input system. The protocol is to be defined and will be published in order that this port can also be used to interface to other displays and controllers in off-car bench and rig installations.

It is envisaged that a sealed module with some or all of this functionality would be intended to be housed by the team in the steering wheel, the necessity to provide an additional chassis mounted dash module for some of these functions and car power control should be determined by the supplier in specifying the detailed system layout.

The following information can be received by the ECU:

- Upshift request.
- Downshift request.
- Neutral request.
- Reverse request.
- Two clutch lever positions measured, single value passed to ECU.
- Speed limiter enable/disable request.
- Rear light switch on/off status
- Differential map selection.
- Fuelling map selection.
- Throttle map selection.
- Gearbox map selection.
- Engine mode selection.
- Display change/alarm acknowledge.
- ‘Push-to-Pass’ request.
- Various strategy failure mode overrides.

The ECU contains the intelligence for controlling the ‘dumb’ display and may transmit the following information to it: The LED and display module should be sealed module without external access to individual output drives.

- Number of shift lights to illuminate.
- Display messages for any text/numeric display fields that may be supported by the driver display.
- Required shift light and display fields brightness level.

7.3 Team Data Acquisition System

Two dedicated CAN 2.0B buses are provided. This allows the ECU to transfer channel information to the team's data acquisition system. The channels to be transferred and the rates are configured from the PC software by the team. The software limits the configuration to ensure that the bandwidth of the links will not be exceeded.

All channels are transferred in engineering quantities based on a defined set of units.

There is no transfer of data from the team system to the ECU.

7.4 FIA Communications

A CAN 2.0B bus is provided to allow the ECU to exchange information with other units that are fitted to the car due to regulatory requirements. This includes the Accident Data Recorder/Secondary Data Recorder, FIA Marshal System and the FOM TV unit.

The FIA Marshal system is currently under development and will allow various conditions, under the control of the marshals and race director, to be flagged to the driver via his cockpit/steering wheel display such as yellow, red and blue flag conditions. In the future, it could be used to impose restrictions on the cars control systems such as by setting a particular speed limit for safety reasons.

7.5 8 Channel UEGO/LAMBDA System

A CAN 2.0B bus is provided to allow the ECU to interface to an 8 channel UEGO sensor controller. This can be used during track testing or whilst engine running on the dynamometer in order to monitor and calibrate the engine fuelling system. This bus can be used to log data from additional team CAN junction boxes at other times.

7.6 Monitor Port

The ECU to include a communications port for low level monitoring and command operations including programming of application code, operating system, low level drivers and gate array logic device images.

This port is for not for access by the team and includes security measures to ensure that this is the case.

7.7 Energy Recovery System.

Support for CAN interfacing to an energy recovery system.

7.8 Communications Interface Summary

In summary the ECU to have the following Comms interfaces:

- 1 off 100 Base T Ethernet ports – for PC comms..
- Minimum 6 off CAN 2.0B ports with software switchable termination resistors – to support Steering Wheel and Dash, Team Data Acquisition, FIA units, voltage regulator, 8 Channel Uego, Energy Recovery System and spare capacity.
- 1 off monitor/debug port.

8. MICROCONTROLLER

8.1 General

- All microprocessors to be less than 40% loaded when running the software strategies defined as specified by the FIA, with CAN buses typically loaded and Ethernet and logging active. Control must be able to run whilst data upload is being performed.
- Main software code storage, map storage and workspace RAM to be less than 50% used when running the software strategies as specified by the FIA.
- Maximum start-up time (initially un-powered): 0.5 seconds.[2]
- Maximum restart time (whilst powered): 0.2 seconds.
- Minimum number of programming cycles for application control code: 1,000.
- Minimum number of programming cycles for maps: 10,000.
- All code images including control applications, operating system, low level drivers and logic gate array devices are programmable by external connection to the ECU with a means of verifying all of the code images programmed. This link to be provided with security to prevent unwanted reprogramming.
- The microcontroller architecture should allow for separate isolated chassis and engine application control microprocessors connected only via dual-port RAM and timing synchronisation signal lines to input/output driver microcontrollers. Thus the application controllers can only access necessary inputs and outputs indirectly via this dual-port RAM. Battery backed RAM devices should be available to each control processor to enable fast reliable system reset recovery.

[2] This is the maximum time taken until the ECU is fully active and is performing all operating system, input/output and control system functions normally.

9. MANUFACTURE, TESTING AND SERVICING

9.1 Service Interval

12 months.

9.2 Design Life Period

5 racing seasons, subject to servicing at specified interval and use within operating limits.

9.3 Quality Systems

The ECU is designed, manufactured and tested by an organisation operating a quality management system that is accredited with ISO9001 or equivalent.

FIA ECU

Outline Software Requirement Specification

1. INTRODUCTION

For 2008 the FIA is introducing a standard Electronic Control Unit (ECU) for Formula 1 with the aims of reducing the cost of racing, removing driver aids such as traction control and allowing the FIA to check engine use and testing mileage. The standard ECU will control the Engine, Gear Box, Clutch and Differential on the car – no other electronic controls will be allowed.

This document gives an outline requirement specification for the software that needs to run in the ECU and in its associated pit system. This document is sufficiently detailed to allow the scope of the strategies to be assessed and their processing requirements reasonably assessed. It does not attempt to provide the full details of the strategies – this task will be carried out separately.

This document needs to be read in conjunction with the FIA 2008 ECU Hardware Requirement Specification that gives firm requirements for the ECU hardware, including its I/O, its processing core and its environmental and production requirements.

A key facet of the ECU is its ability to provide high-level diagnostics making it straightforward to use and easy to diagnose faults with the cars systems.

This document focuses on the technical functionality needed and it is beyond its scope to cover commercial, contractual, design, manufacturing, support and supply aspects.

However a proposal should include annual maintenance requirements and costs, software update support for the life of the tender in addition to initial development, individual team integration support and track support for 19 races and five tests per season.

All parts of the system must be designed to ensure that the system will effectively prevent the use of driver aids including but not limited to traction control, launch control and automatic gear changing.

- There will be only one FIA approved software version that cannot be changed by the team.
- A foolproof means to ensure that all software contained within the units is identical to that validated and approved for use.
- A maximum fixed rev limit adjustable only by the FIA.
- A secure ability to restrict the data logging capability and configurability and to prevent data erasure during race weekends.
- Engine and team specific setup data will have individual engine supplier and team identification. The PC software supplied to teams must recognise this and prevent unauthorised access.

1.1 Document Revision History

Revision	Date	Summary of Changes
1	19/05/2006	

1.2 Related Documents

Document Name	Notes
FIA 2008 ECU Hardware Requirement Specification	Hardware requirement proposal

2. CONTROL FUNCTIONALITY

2.1 Summary

The ECU will provide real time control algorithms that interface via electrical input/outputs to control the hydro-mechanical systems of a Formula One car power train. The algorithms are designed to provide the necessary control with the minimum of complexity.

When running the control algorithms described in this section, none of the ECU's processors to be loaded at more than 40% capacity. This provides scope for future development.

It is intended that the application code for these strategies will be written using graphical code generation tools such as Simulink and Stateflow.

The source code for the control applications is available for review by the teams as it is 'open-source'. This ensures maximum transparency and allows them to gain a detailed understanding of the exact functionality of the software and how it will act as part of the control systems.

Parameters allowing the user to calibrate and configure the strategies are provided. These are split between types that can be configured by the team and those only by the FIA.

Sensor input health checking routines are provided that can trigger fallback modes in the strategies on the case of fault detection.

Each control strategy algorithm is summarised in the following sections that outline the key functionality, show the primary execution rate, inputs, outputs and configuration. This is intended as a top-level guide to the algorithms and not the in-depth explanation that can be afforded by detailed control specifications.

Note that whilst the execution rates for the algorithms are shown; in practice some channels or execution threads may be at slower rates. This is to reduce processor loading where a slower rate input such as temperature is in use.

2.2 Control Strategies Not Supported

The FIA ECU must not include strategies that would provide the following specific functionality:

- Traction Control
- Launch Start
- Engine Braking
- Auto clutch
- Automatic gear changing, gear pre-select, multiple gear shift sequences

2.3 Fuelling

2.3.1 Purpose

To generate injector phasing and fuelling time to control fuel injector drivers.

2.3.2 Strategy Summary

- Throttle position and engine speed inputs mapped to produce base injector fuel mass.
- Independent base fuel map for each of eight injectors.
- Base fuel maps with 15 site throttle axis and 45 site engine speed axis.
- A number of fuel mass modifiers are applied to the base value to produce the final fuel mass as shown in Table 1.

Name	Description	Type
Engine cranking	Applied during engine cranking period (and for a configurable period after engine start) mapped from throttle position and engine speed.	Adder
Oil temperature compensation	Mapped from engine oil temperature	Multiplier
Transient throttle position compensation	Applied if the throttle demand is from the pedal. Derived from throttle position and filtered rate-of-change of throttle position.	Multiplier
Fuel Switch Air temperature/pressure compensation	At high throttle position and if temperature/pressure feature enabled, modifier taken from air pressure/temperature compensation calculation. At high throttle position and if temperature/pressure feature disabled, modifier taken from configurable constant. At low throttle position, alternate configurable constant applied. Air pressure value derived from either measured air pressure, filtered air pressure or that from a simple model based on car speed.	Multiplier
Gearshift throttle blip enrichment	Multiplier controlled from gearshift status in order that fuelling can be adjusted prior to and during gearshift throttle blips.	Multiplier
Overrun Fuel Shut-off	If engine speed is above a threshold and throttle position is below a threshold, sets the multiplier to 0	Multiplier
Dynamometer Tune	Value from dynamometer 'Slew Box'	Multiplier
Driver Fuel Map Selection	Mapped from driver fuel map selection with different value for high and low throttle positions.	Multiplier
Closed Loop Fuelling	Value generated by Closed Loop Fuelling control	Multiplier
Engine Speed Controller	Value generated by Engine Speed Controller	Multiplier

Table 1 – Fuel Mass Modifiers

- Final fuel mass converted to an injector fuel time with compensation for injector supply voltage, fuel pressure and temperature.
- Fuel phase mapped from throttle position and engine speed.
- Injector fuelling time and phase fed to low level injector driving and scheduling module that interfaces to hardware.
- Fuelling for individual injectors cut using cut pattern and scheduling information from Power Level controller.
- No fuelling when engine kill active.
- Fuel metering algorithm based on injection time updated every injection with corrections for injector type and drive voltage: Details to be defined.

2.3.3 Processing Rate

2 milliseconds outer loop, once per engine firing for scheduling.

2.3.4 Primary Inputs

Throttle position, engine speed, cranking status, throttle control status, air pressure, air temperature, car speed, driver fuel map selection, engine kill status, Power Level Control fuelling cut pattern and scheduling, Engine Speed Controller and Closed Loop Fuelling fuel multipliers, injector supply voltage,

2.3.5 Primary Outputs

Intermediate and final injector fuel mass/time values, multipliers, adders per cylinder, fuel phase, fuel metering.

2.3.6 Team Configuration

Cranking period guard time, base fuel maps with configurable 15 site throttle axis and 45 site engine speed axis, individual cylinder fuel mass maps, cranking fuel mass maps, car speed fuel mass multiplier map, driver fuel map, fuel mass to time constant, fuel phase map, air pressure filtering and calculation parameters, fuel metering calculation parameters.

2.3.7 FIA Configuration and Limitations

To be determined.

2.4 Ignition Control

2.4.1 Purpose

To generate required ignition spark angle and dwell time to drive low level spark driver.

2.4.2 Strategy Summary

- Common spark advance produced for all eight cylinders.
- Throttle and engine speed inputs axis for base map lookup.
- Spark advance 'adders' applied from Engine Speed Controller when engine idling speed control or Pit Lane Speed Limiter control is active.
- Dynamometer 'Slew Box' spark advance adder applied in dyno mode only.
- Gear dependent 'adder' applied to base map value during up shifts.
- Configurable minimum/maximum clipping applied to final spark advance.
- Dwell time mapped from supply voltage.
- Scheduling of spark cut based on cut pattern from Power Level Control module.
- Interface to low level spark hardware driver.

2.4.3 Processing Rate

Once per cylinder firing.

2.4.4 Primary Inputs

Throttle position, engine speed, current gear, engine idling control status, gearshift status, spark cut pattern from Power Level Controller, spark adder and status from Engine Speed Controller.

2.4.5 Primary Outputs

Interfacing to low level spark driver, final spark advance, and ignition control status.

2.4.6 Team Configuration

Base spark maps, dwell time voltage/time map, minimum/maximum spark advance value clipping.

2.4.7 FIA Configuration and Limitations

Two base spark maps, selectable by driver when car stationary for 3 seconds.

Minimum/maximum spark advance value clipping.

Track session type.

Maximum dwell time update rate.

Crank sensor "fallback" switching latching in race mode until car stationary 3 seconds.

2.5 Power Level Control

2.5.1 Purpose

To determine the appropriate engine power ‘level’ to be used, and if this is less than full power, apply the appropriate cut patterns to the fuelling and ignition algorithms.

2.5.2 Strategy Summary

- Arbitrates all sources of power level demand and applies the lowest one.
- Power level sources are: ‘hard’ engine rev limit, ‘firm’ engine rev limit, gearshift rev limit, FIA rev limit, stall prevention rev limit, engine speed controller.
- Maps the power ‘level’ to a spark and/or fuelling cut pattern to be applied.
- Algorithm applies rotating cut patterns for use in fuelling and spark modules.
- To avoid risk of engine stall, requested power levels ignored and full power applied, if engine speed is below a limit.

2.5.3 Processing Rate

Once per cylinder firing.

2.5.4 Primary Inputs

Engine speed, power level demands from other algorithms.

2.5.5 Primary Outputs

Fuelling and ignition cut patterns, status.

2.5.6 Team Configuration

Selection of fuelling and sparking cut types used for each power level source. Configuration of rotating cut patterns for use with fuelling and sparks. Full power level engine speed. Mapping for power level to fuelling/spark cut patterns

2.5.7 FIA Configuration and Limitations

FIA rev limit.

2.6 Engine Rev Limiting

2.6.1 Purpose

To evaluate a number of engine rev limiting conditions and assign the appropriate power level to each in order that engine speed is limited.

2.6.2 Strategy Summary

- Independently evaluates each of the following rev limit sources: 'hard' rev limit, 'firm' rev limit, FIA, stall prevention.
- 'Soft' rev limiting by use of throttle control provided by Engine Speed Controller – see Section 2.7.
- For 'hard' limiter, applies configured power level if engine speed above limit, otherwise full power.
- For 'firm' rev limit, applies a power level mapped from the difference between engine speed and the rev limit if engine speed exceeds the limit.
- 'Firm' rev limit threshold calculated as the lowest of a gear dependent limit, that to be applied in the case of air valve low pressure alarm or that set if the Garage Mode Select input is active.
- For FIA limiter, applies 0 power level if engine speed above gear dependent limit, otherwise full power.
- If stall prevention status shows that it has been triggered, applies configured power level, otherwise full power.

2.6.3 Processing Rate

Once per cylinder firing.

2.6.4 Inputs

Engine speed, current gear, stall prevention status, air valve low pressure alarm status.

2.6.5 Primary Outputs

Rev limit and power level for each rev limit source.

2.6.6 Team Configuration

Air valve low pressure alarm rev limit, map for engine speed to power level for use with 'firm' limiter, power level and rev limit thresholds for use by 'hard' and stall prevention limiters.

2.6.7 FIA Configuration and Limitations

FIA rev limit.

Air valve or engine oil low pressure alarm rev limits latching in race mode.

Minimum values for all gear dependent rev limits.

2.7 Engine Speed Controller

2.7.1 Purpose

To control engine speed to a target value.

2.7.2 Strategy Summary

- Uses a combination of ignition, fuel and throttle demands to control engine speed.
- Takes engine speed demands and status from Idling Speed Control and Pit Lane Speed Limiter modules and arbitrates overall demand.
- Closed loop controller operating on engine speed target/actual difference generating ignition/fuel modifiers and 'power level' demand outputs.
- Provides 'soft' rev limiting function where throttle control is used to limit engine speed rather than hard fuel/ignition cut.
- Includes a closed loop throttle demand controller with an input mapped from target engine speed.

- When demand is from Pit Lane Speed Limiter control, throttle controller driver pedal demand can be overridden to help control. If so, this demand never exceeds that from the pedal.
- When the demand is from Idling Speed control, independent engine speed thresholds used for throttle and spark advance demands.
- When the demand is from Idling Speed control, spark advance demand produced mapped from current engine speed.
- When the demand is from Idling Speed Control, one of two fixed throttle demands produced dependent on whether car is moving or not.

2.7.3 Processing Rate

1 millisecond.

2.7.4 Primary Inputs

Pit Lane Speed Limiter status and engine speed demand, Idling Speed Control status and engine speed demand, throttle demand from driver pedal.

2.7.5 Primary Outputs

Fuel modifier, ignition modifier, power level demand, throttle demand, status.

2.7.6 Team Configuration

Separate closed loop controller gains and parameters for use when demands are from idling speed and pit lane speed limit control. Mapping of idling speed spark advance from engine speed. Idling speed control throttle demands.

2.7.7 FIA Configuration and Limitations

None.

2.8 Pit Lane Speed Limiter

2.8.1 Purpose

To produce a target engine speed demand derived from the maximum permitted pit lane speed in order that the car speed can be held under the limit.

2.8.2 Strategy Summary

- Limits car speed to a configured maximum when active.
- Generates a target engine speed from target car speed and knowledge of power train step-down ratio.
- Demand fed to Engine Speed Controller.
- Target speed limit set based on track session type.
- Activated by momentary driver switch press if current gear is within allowable range and not already active.
- Deactivated by momentary driver switch press if already active.

2.8.3 Processing Rate

10 milliseconds.

2.8.4 Primary Inputs

Driver switches, current gear, track session type, power train step-down ratio.

2.8.5 Primary Outputs

Activation status, target engine speed and car speed.

2.8.6 Team Configuration

Speed Limit for each session type.

2.8.7 FIA Configuration and Limitations

Not legal outside pit lane.

2.9 Idling Speed Control

2.9.1 Purpose

To control engine idling speed.

2.9.2 Strategy Summary

- Idle speed function activated when engine speed is below a threshold and either in neutral gear or clutch is deemed disengaged.
- Generates an engine speed demand that is fed to the Engine Speed Controller.
- Different engine speed demand produced depending on whether the car is moving or stationary.

2.9.3 Processing Rate

10 milliseconds.

2.9.4 Primary Inputs

Engine speed, clutch position, current gear, car speed.

2.9.5 Primary Outputs

Engine speed demand and status.

2.9.6 Team Configuration

Engine speed enabling thresholds, clutch position threshold, Target engine idling speeds.

2.9.7 FIA Configuration and Limitations

Maximum allocable engine idle speed.

Maximum engine speed enable threshold.

Minimum clutch position threshold.

2.10 Fuel Pump Control

2.10.1 Purpose

To provide the electrical drive to the car’s fuel lift pumps.

2.10.2 Strategy Summary

- Independent control of two lift pump drives.
- Pumps switched on for a priming period at system power up or removal of engine kill.

- Pumps driven using out-of-phase pulse width modulated control in either open or closed loop modes when engine is running.
- In open loop, control drive mapped from engine speed.
- In closed loop, control drive based on fuel pressure target/actual error and mapped from engine speed.
- Pumps switched off when engine kill applied.
- Option to monitor each fuel pump current and turn off the drive if over-current for longer than a limit.

2.10.3 Processing Rate

100 milliseconds.

2.10.4 Primary Inputs

Engine kill status, Engine Speed, Measured fuel pump current.

2.10.5 Primary Outputs

Two Fuel Pump Drives, over current fault indicators

2.10.6 Team Configuration

Duration of pump priming period, open or closed loop mode, closed loop controller, PWM period, Pump-on duty cycle, maximum fuel pump current and shutdown time.

2.10.7 FIA Configuration and Limitations

None.

2.11 Engine Starting

Cranking phase and synchronisation management to be defined.

2.12 Closed Loop Fuelling

2.12.1 Purpose

To achieve a target exhaust air/fuel ratio by adapting the fuelling demand.

2.12.2 Strategy Summary

- Target lambda mapped from filtered engine speed and throttle position.
- Fuelling strategy adapted by providing a fuel multiplier mapped from target lambda.
- Closed loop controller used to achieve target lambda.
- Controller uses PI controller with proportional and integral gains both mapped from engine speed and throttle position.
- Operates only above a configurable throttle position. throttle or full range throttle operation.
- Low pass filtering of UEGO sensor inputs.
- Strategy disabled if engine speed is outside of operating band.
- Independent control for each cylinder bank.
- Enable/disable status controlled from driver map selection.
- Lambda sensor heater control.

2.12.3 Processing Rate

10 milliseconds.

2.12.4 Primary Inputs

Left and right hand cylinder bank UEGO sensor inputs, engine speed, throttle position, drive map selection.

2.12.5 Primary Outputs

Fuel multiplier values for left and right cylinder banks, lambda error and closed loop controller values, status information, filtered UEGO sensor values.

2.12.6 Team Configuration

Map of target lambda from engine speed, mapping of lambda target to fuel multiplier, closed loop controller gains and configuration, UEGO filtering parameters, throttle position above which closed loop fuelling operates, minimum and maximum operating engine speeds.

2.12.7 FIA Configuration and Limitations

None.

2.13 Alarms

2.13.1 Purpose

To monitor various control system related parameters and strategies and if outside of normal operating limits; can flag warnings via the driver display, telemetry or logged data, assert a low engine rev limit, request neutral (gearshifting or neutral clutch disengage system) and/or stop engine.

2.13.2 Strategy Summary

- Sources monitored include: air valve pressure, oil pressure, stall prevention, throttle control, throttle pedal, engine synchronisation, water temperature, crankcase pressure and ECU temperature.
- Warnings, rev limits, neutral request and engine stop configuration set individually for each source.
- Independent enable control based on configured track session type.
- Oil pressure alarm threshold mapped from engine speed with a qualifying time.
- Independent monitoring of each air valve pressure input.
- For safety reasons, engine kill asserted if stall prevention is triggered and not cleared within ten seconds.

2.13.3 Processing Rate

10 milliseconds.

2.13.4 Primary Inputs

Engine air valve pressures, oil pressure, stall prevention status, throttle status, throttle pedal system status, engine synchronisation status, water temperature, crankcase pressure, ECU temperature, track session type.

2.13.5 Primary Outputs

Rev limits, status, drive to neutral clutch disengage solenoid.

2.13.6 Team Configuration

Warnings, rev limits, neutral request and engine stop configuration enablers, and thresholds for each trigger source. Independent air valve pressure alarm configuration for each of the two sensor inputs. Driver alarm messages and indicators.

2.13.7 FIA Configuration and Limitations

ECU temperature shutdown threshold and action.

Rev limits latching in race mode.

2.14 Throttle Pedal Processing

2.14.1 Purpose

To process the analogue inputs from the throttle pedal assembly, check for error conditions and generate the appropriate engine throttle demand.

2.14.2 Strategy Summary

- Engine throttle demand generated by mapping from pedal demand.
- Minimum and maximum pedal travel positions fixed to correspond to minimum and maximum engine throttle positions.
- Driver throttle pedal map selection.
- Processing of two throttle pedal inputs allowing continued operation in the case of one faulty input.
- ‘Stuck pedal’ fault checking by monitoring for both brake pressure and throttle pedal demand conditions. Zero throttle pedal demand output in this case.
- Normally uses front brake pressure for stuck throttle but can switch to rear brake pressure in the case of front sensor fault.
- Fixed ‘limp home’ throttle demand may be used in the case of detected pedal fault.
- Fault detection and handling.

2.14.3 Processing Rate

2 milliseconds.

2.14.4 Primary Inputs

Three throttle pedal demand inputs, drive map selection, front and rear brake pressure.

2.14.5 Primary Outputs

Engine throttle demand derived from pedal, status and error conditions.

2.14.6 Team Configuration

Pedal to engine throttle demand maps, fault detection and handling.

2.14.7 FIA Configuration and Limitations

Pedal map selection change with car stationary 3 seconds only.

Prevent "Stuck pedal" use at starts and systematic track use.

"limp home" demand value latching in race mode.

2.15 Throttle System

2.15.1 Purpose

To provide positional control of the engine throttles based on demand.

2.15.2 Strategy Summary

- Closed loop PID controller for positional control of throttle operating on difference between demanded and actual position.
- Closed loop controller interfaces to a servo-valve current drive.
- Arbitration of a number of demand sources including throttle pedal, gearshift throttle blip, hand controller, Engine Speed Controller, stall prevention.
- Use of two engine throttle position sensors.
- Fault detection of both engine throttle position sensors for out-of-range and position mismatch faults.
- Monitoring of difference between demanded and actual throttle position for fault detection.
- Fallback switching of engine throttle position sensor in case of fault.
- Hydraulic system status used to enable control, fixed current applied to servo-valve if not active.
- Translation of throttle demand percentage to actual throttle position using 0% as idling angle.
- Ability to use hand controller as demand input.

2.15.3 Processing Rate

2 milliseconds, 250uS closed loop controller.

2.15.4 Primary Inputs

Two independent engine throttle position inputs, engine throttle demand derived from throttle pedal, throttle demand from gearshift, hand control throttle demand, Engine Speed Controller demand and status, hydraulic system status, stall prevention system status.

2.15.5 Outputs

Servo-valve current drive, status and error indication.

2.15.6 Team Configuration

Calibration mapping of throttle demand to throttle position including idling angle, PID controller gains and configuration, fault detection criteria and error handling actions, stall prevention throttle demand.

2.15.7 FIA Configuration and Limitations

Sensor "fallback" switching latches till car stationary for 3 seconds in race mode.

Hand controller input active with car stationary only.

2.16 Clutch

2.16.1 Purpose

To provide positional control of the clutch and to arbitrate a number of demand sources.

2.16.2 Strategy Summary

- Closed loop PID controller for positional control of clutch operating on the difference between demanded and actual positions.
- Configuration allowing use with two clutch position inputs where one is used for primary control with fallback to the second in case of failure. Alternatively, clutch control can be configured to use only one positional input.
- Controller interfaces to a servo-valve current drive.
- Switches to open loop mode with fixed current output when there is no active demand source.
- Arbitration of driver clutch lever, gearshift and stall prevention demand sources.
- Processing of driver lever input with mapping to position demand.
- Configurable clutch lever map but with fixed fully-engaged and disengaged points corresponding to minimum and maximum lever positions.
- Stall prevention demand causes a configurable clutch disengaged position to be applied.
- Closed loop position demand arbitration is achieved by taking the maximum position demand from all sources.
- Hydraulic system status used to enable control, fixed current applied to servo-valve if not active.
- Line pressure monitoring and over-pressure protection provided by applying open loop current.
- Clutch lever pulled and clutch disengaged status indicators generated to flag other control modules of these conditions.
- Ability to use hand controller as demand input.
- Fault detection algorithm applied to clutch position and line pressure sensor inputs.

2.16.3 Processing Rate

2 milliseconds, 250uS closed loop controller.

2.16.4 Primary Inputs

Two independent lever demand inputs from driver, gearshift demand, stall prevention status, clutch position, clutch actuator hydraulic system status.

2.16.5 Primary Outputs

Servo-valve current drive, status and error information. Clutch lever ‘pulled’ and clutch position ‘disengaged’ status indicators.

2.16.6 Team Configuration

PID controller gains and configuration, over pressure thresholds, stall prevention clutch demand, open loop servo-valve current demands, clutch lever mapping, fault detection criteria and error handling actions, use with one or two clutch position inputs.

2.16.7 FIA Configuration and Limitations

Minimum stall prevention clutch demand.

Hand controller input not active in race mode.

2.17 Differential

2.17.1 Purpose

To control the locking characteristic of the differential by the use of pressure control.

2.17.2 Strategy Summary

- Closed loop PID controller for control of pressure applied to differential clutch pack. Operates on the difference between demanded and actual pressure.
- Controller interfaces to a servo-valve current drive.
- Mapping algorithm using inputs of rear wheel speed difference, throttle position, lateral and longitudinal acceleration to generate demanded pressure.
- Configurable differential maps selected from driver map selection.
- Hydraulic system status used to enable control; fixed current applied to servo-valve if control not active.
- Pressure monitoring and over-pressure protection provided by applying open loop current.
- Fault detection algorithm applied to clutch pack pressure sensor and other inputs used in mapping algorithm.
- Monitoring of demanded and actual pressure difference for fault detection.
- Ability to use hand controller as demand input.

2.17.3 Processing Rate

2 milliseconds, 250uS closed loop controller.

2.17.4 Primary Inputs

Differential pressure, rear wheelspeeds, lateral and longitudinal acceleration, throttle position, driver map switch, hydraulic system status.

2.17.5 Primary Outputs

Servo-valve drive, status and error information.

2.17.6 Team Configuration

PID controller gains and configuration, over pressure thresholds, open loop servo-valve current demands, differential locking characteristic mapping, fault detection criteria and error handling actions.

2.17.7 FIA Configuration and Limitations

None.

2.18 Gearshift

2.18.1 Purpose

To provide a means of controlling the gearshift mechanism and process shift requests.

2.18.2 Strategy Summary

- Can be configured to suit 'proportional' or 'ratchet' type gearboxes by use of closed loop PID control or open loop current control to control the position of the shift drum.
- Engine downshift over-rev protection by refusal of downshift requests that would lead to engine speed exceeding a configured limit for each gear.

- Processes gearshift requests from the driver and validates them against a number of preconditions before deciding whether to action the request. These are shown in Table 2.

Shift Request Type	Precondition
Upshift	Reverse gear not currently selected
Upshift	Current gear is not the highest gear
Upshift	If current gear is neutral, gearbox input shaft speed is slow enough to allow a safe shift
Downshift	Neutral, 1st or reverse gear not currently selected
Downshift	Engine throttle is below a threshold
Downshift	Engine would not over-rev
Neutral	Not already in neutral
Neutral	Engine throttle is below a threshold
Neutral	Engine would not over-rev due to downshifting through intermediate gears
Reverse	Current gear is neutral
Reverse	Car speed is below a threshold

Table 2 – Gearshift Precondition Checks

- State machine controllers executed during gearshifts providing demands for throttle, clutch, engine power control and shift drum position/current during shifting.
- Timing, threshold and demand parameters used by the state machines are configured in 'shift tables' indexed by driver map switch selection.
- Determination of currently selected gear from shift drum position or as a fall-back from calculated gear.
- No multiple or 'stacked' downshift requests except for neutral selection - driver must call each gearshift.
- Status indicator flagged when throttle blip is to be used during a gear shift in order that Fuelling strategy can react.
- Generates a calculated gear number from the ratio of car speed and engine speed using knowledge of the drive train step down ratio for each gear.
- Hydraulic system status used to enable control, fixed current applied to servo-valve if not active.
- Reverse gear selected by use of a solenoid drive that is independent of forward gears.
- Provision for 'primary' and 'backup' shift drum position sensors with the controller switching source in case of detected sensor failure.
- Mismatch checking of the two shift drum position sensors and use of the calculated gear to determine which is at fault.
- Ability to use hand controller as demand input.
- A first gear shift request is applied when status indicates the anti-stall system has triggered.
- Fault detection algorithms applied to primary and back-up shift drum position sensor inputs.

2.18.3 Processing Rate

2 milliseconds, 250uS closed loop controller.

2.18.4 Primary Inputs

Driver shift requests for upshift, downshift, neutral and reverse. Primary and backup shift drum position, engine speed, driver throttle pedal, hydraulic system status.

2.18.5 Primary Outputs

Servo-valve current drive, reverse solenoid control, clutch demand, throttle demand and blip status, engine rev limit/power level demand, status and error information.

2.18.6 Team Configuration

6 or 7 gears, downshift over-rev protection for each gear, PID controller gains and configuration, throttle, clutch, and power limiting demands and timing used during gearshifts, fault detection criteria and error handling actions, gear ratios for power train step down ratio, rear wheel diameter.

2.18.7 FIA Configuration and Limitations

Minimum gear dependent over-rev protection values.

Maximum state times and total shift times and number of retries.

Maximum delay from request to shift start or reject.

2.19 Hydraulics System Condition

2.19.1 Purpose

To indicate to other car control systems whether the hydraulic system is active and provide fault condition monitoring.

2.19.2 Strategy Summary

- Indicates that the hydraulics system is active when system pressure or engine speed is above a threshold.
- System marked inactive when both engine speed and hydraulic pressure below a threshold.
- Fault detection monitoring of sensors.

2.19.3 Processing Rate

10 milliseconds.

2.19.4 Primary Inputs

System pressure, Return pressure, Hydraulic tank level, Engine Speed.

2.19.5 Primary Outputs

Status and fault indication.

2.19.6 Team Configuration

Expected operating levels, fault thresholds and timings.

2.19.7 FIA Configuration and Limitations

None.

2.20 Stall Prevention

2.20.1 Purpose

To detect potential engine stall conditions and generate clutch and throttle demands to attempt to avoid this.

2.20.2 Strategy Summary

- Uses engine speed, rate of deceleration and predicted engine speed 'look ahead' schemes to predict potential stall conditions.
- Signals clutch controller to disengage clutch on triggering.
- Throttle demand generated on triggering.
- Rev limiter applied when triggered.
- Automatic downshift to first gear when triggered.
- Trigger condition cleared by driver pulling clutch lever.
- Engine kill asserted ten seconds after activation if not cleared by driver.
- Various configurable arming conditions including car moving qualifier, selected gear number, front and rear speed.
- Configurable strategy enabling conditions.
- For safety reasons, engine kill asserted by Engine Alarms module if stall prevention triggered and then not cleared by the driver within ten seconds.

2.20.3 Processing Rate

2 milliseconds.

2.20.4 Primary Inputs

Engine speed, car speed, current gear, clutch lever position.

2.20.5 Primary Outputs

Stall prevention status.

2.20.6 Team Configuration

Enabling of stall prevention strategy. Configuration of arming conditions based on car speed, gear number, engine speed, qualifying times, engine speed 'look ahead'. Trigger conditions based on engine speed, rate of engine speed, front and rear speeds, qualifying times.

2.20.7 FIA Configuration and Limitations

Minimum clutch disengagement demand.

2.21 Fuel Flap

2.21.1 Purpose

To control the drive releasing and closing the car's fuel flap.

2.21.2 Strategy Summary

Monitors status of pit lane speed limiter and when active, turns on drive to release fuel flap.

Ability to use hand controller as demand input.

2.21.3 Processing Rate

100 milliseconds.

2.21.4 Primary Inputs

Pit lane speed limiter status.

2.21.5 Primary Outputs

Fuel flap solenoid drive, status.

2.21.6 Team Configuration

Enable control.

2.21.7 FIA Configuration and Limitations

None.

2.22 Car Speed Calculation

2.22.1 Purpose

To derive car speed from four wheel speed sensors.

2.22.2 Strategy Summary

- In the case that no faults have been detected with the wheel speed sensors, the algorithm calculates car speed as the faster of the two front speeds unless they are below a threshold. In this case, the average of the two rear speeds is used unless either rear sensor reads zero. In this case, the speed from the other rear sensor is used.
- A fault detection algorithm is used to monitor each wheel speed input. In the case of failure, speed will be reported as zero and an error indicator flagged.
- Distance channel calculation.
- Split time calculations for driver display.

2.22.3 Processing Rate

2 milliseconds.

2.22.4 Primary Inputs

Front left, front right, rear left, rear right wheel speeds.

2.22.5 Primary Outputs

Front speed, rear speed, car speed, status and fault indication.

2.22.6 Team Configuration

Split time distances.

2.22.7 FIA Configuration and Limitations

None.

2.23 Engine Speed Calculation

2.23.1 Purpose

To Calculate engine speed.

2.23.2 Strategy Summary

- Designed to use a single crank trigger disk pattern.
- Designed for maximum 22,000 rpm engine speed.
- Compensation provided for phase delay due to use of inductive sensor. This is mapped from engine speed
- Calculates engine speed based on the period for the last 90° of engine rotation.
- Calculates averaged engine speed from a rolling average of multiple 90° periods of engine rotation. Configurable for averaging over range 180° to 720°.
- Configurable zero engine speed timeout.
- Records engine speed rate-of-change excursions above a threshold.

2.23.3 Processing Rate

Event driven.

2.23.4 Primary Inputs

Crankshaft timing sensor timing signal.

2.23.5 Primary Outputs

Engine speed and averaged engine speed.

2.23.6 Team Configuration

Averaging period, zero speed timeout, maximum expected rate-of-change of engine speed, phase delay compensation.

2.23.7 FIA Configuration and Limitations

Maximum engine speed to be allowed.

Maximum rpm mapped phase delays.

2.24 Shift Lights

2.24.1 Purpose

To control the driver display shift light pattern based on engine speed.

2.24.2 Strategy Summary

- Shift lights lit based on engine speed exceeding gear dependent thresholds.
- Filtering applied to engine speed.
- Hysteresis levels applied to shift light switching points.

2.24.3 Processing Rate

10 milliseconds.

2.24.4 Primary Inputs

Engine speed.

2.24.5 Primary Outputs

Messages to driver display module.

2.24.6 Team Configuration

Engine speed triggering each shift light, engine speed filter, switching hysteresis.

2.24.7 FIA Configuration and Limitations

None.

2.25 Pneumatic Valve Pressure Control

Functionality to be defined.

2.26 Rear Light Control

2.26.1 Purpose

To switch power to the car’s rear light based on driver switch position.

2.26.2 Strategy Summary

Switch on, light powered. Switch off, light not powered.

2.26.3 Processing Rate

100 milliseconds

2.26.4 Primary Inputs

Rear light switch status change message from driver switch module.

2.26.5 Primary Outputs

Rear light power drive, status.

2.26.6 Team Configuration

None.

2.26.7 FIA Configuration

None.

2.27 Neutral Finder Lock-out Control

2.27.1 Purpose

To disable the neutral finder button when the engine is running to avoid accidental activation.

2.27.2 Strategy Summary

Output activated after engine has been running for a period and deactivated after it has stopped for a period.

2.27.3 Processing Rate

100 milliseconds

2.27.4 Primary Inputs

Engine speed.

2.27.5 Primary Outputs

Neutral finder lock-out drive, status.

2.27.6 Team Configuration

Activation and deactivation times and thresholds.

2.27.7 FIA Configuration

None.

2.28 Hand Controller

2.28.1 Purpose

To process the hand controller inputs and select the appropriate control application to apply the demand to.

2.28.2 Strategy Summary

- The hand controller provides an analogue demand input and a switch to enable it. The demand percentage can be applied as a controlling input to various control applications including throttle, gearshift, clutch and differential to allow these systems to be operated and tested. By default the hand controller feeds an input to the throttle system but the PC software can be used to override this and select an alternative target application.
- Fault checking of hand controller input.

2.28.3 Processing Rate

10 milliseconds

2.28.4 Primary Inputs

Hand controller raw input demand and switch status.

2.28.5 Primary Outputs

Calibrated hand throttle demand, enable status and target application indicator.

2.28.6 Team Configuration

Calibration of input to demand percentage.

2.28.7 FIA Configuration and Limitations

Not active on track.

2.29 Lubricating Oil Squirt Jet Solenoid Control

Functionality to be defined.

2.30 Closed Loop Fuel Map Adaption

2.30.1 Purpose

To adapt the fuelling maps to achieve the required air/fuel ratio for each cylinder based on individual cylinder lambda measurements.

2.30.2 Strategy Summary

- Can operate only during track tests or on the dynamometer.
- Uses individual cylinder lambda measurement from the external 8 channel UEGO system interfaced to the ECU via a CAN link.
- Proportional/Integral controller running on target/measured lambda value with gains mapped from engine speed and throttle position.
- Target lambda mapped from engine speed and throttle position on a per cylinder basis.
- Memory tables used for learned maps, populated as engine speed and throttle map sites are encountered.
- Adaption scheme using reverse interpolation to fit values to fuel map breakpoints.
- Limits on fuel amount that can be contributed as a result of CLFMA.
- Processing and error checking of UEGO sensor inputs.

2.30.3 Processing Rate

2 milliseconds.

2.30.4 Primary Inputs

8 channel UEGO sensors, engine speed, throttle position.

2.30.5 Primary Outputs

Gains, error term, learned maps, status and error information.

2.30.6 Team Configuration

Closed loop controller configuration, UEGO sensor fault limits and processing, Limits for fuelling amount from adaption.

2.30.7 FIA Configuration and Limitations

None.

2.31 Power Management

The car's power regulator is primarily responsible for management of the car system electrical power. It is critical that the current available from the alternator/battery is sufficient for the loads placed upon it. The current available varies depending on engine speed and this taken with the loads gives the cars 'current balance'. In order to minimise the size of the car battery, the current available at low engine speeds is usually limited and finely balanced.

The ECU has provision for a number of high and low side drives for connection to external devices such as telemetry radios, external sensor conditioning units etc. These can be controlled such that the external devices can be switched off or into low power standby modes at low engine speeds.

The detail of the Power Management strategy is yet to be specified.

2.32 Sensor Fault Detection

In addition to any specific fault detection provided at the control level by the individual strategies, control sensor signals are tested, and faults flagged for the following conditions:

- Signal level outside of expected operating range i.e. below minimum or above maximum level.
- Signal level intermittently outside of expected operating range.
- Excessive noise on signal.

For each control sensor, information will be available holding a count of the number of times that the sensor signal was outside operating range as well as the last recorded 16 values that were outside this range.

Sensor fault checking is enabled only when the control system is deemed to be active.

3. DATA LOGGING

3.1 Provision and capabilities

The ECU incorporates a data logger part of which is only configurable and accessible by the FIA. Logged data can only be cleared by the FIA.

Its capabilities are shown below:

Capacity:	Minimum 1 Gbyte Logging Storage, minimum 250 channels.
Data throughput:	Minimum 50,000 channel samples per second for control system logging, plus 50,000 channel samples per second for non-control sensor acquisition.
Modes:	- Continuous periodic logging - Burst logging based on events in the data. - No requirement for aperiodic or engine angle based logging. - Configurable 'keep newest' or 'keep oldest' modes in case of overflow.
Triggering:	Triggered by channel generated by on-board control software
Other features:	Non volatile storage of logged data Multiple logging table rates held on-board, selected by the track session type minimising configuration changes.

4. CONFIGURATION AND MONITORING

4.1 PC Configuration Software

4.1.1 Operating System Requirements

- Microsoft Windows XP and Windows Vista.

4.1.2 Features

- Editing, viewing, comparison and archiving of parameter datasets for the ECU control applications.
- Separate parameter dataset per control algorithm.
- Designed for management of multi-user sub-system parameter datasets but with single-user responsibility for overall set-up and car communications.
- Recording of set-up change history in human readable log files.
- Calibration of sensors and fuel injectors.
- Selections of channels and their transfer rate from the ECU control applications to the team system via the dedicated CAN 2.0b communication links.
- Low rate display viewing of channel values via cable link from ECU.
- Configuration of items to be shown on the driver display including alarm settings.
- Communications interface to dynamometer 'Slew Box'.

4.2 Internal Monitoring Channels

The ECU provides a number of channels that record internal parameters including:

- Microcontroller Temperature
- Case Temperature
- Injector drive stage temperature
- Ignition drive stage temperature
- Supply voltage
- Supply current
- Injector supply voltage
- Injector current
- Operating system timing, loading and status
- ECU serial number.
- ECU software version.
- ECU vibration – 3 axis

4.3 FIA Monitoring 'Telltales'

The ECU will generate, and store in non-volatile memory, the following information that may be viewed by the team but offloaded and reset only by the FIA:

- Total time that the unit has been powered.
- Total time that the hydraulic system has been active.
- Total distance recorded.
- Total time that the engine has been running.
- Total number of engine revolutions recorded.
- Total time that the engine has been running and box vibration was above a threshold.
- Total time that the engine has been running, box vibration was above a threshold and car speed was above a threshold.
- Total time that the box vibration has been above a threshold.
- Total number of system start-ups/resets.
- Maximum internal temperatures recorded.
- Minimum internal temperatures recorded.
- Maximum internal positive rate-of-change of temperatures.
- Maximum internal negative rate-of-change of temperatures.
- Maximum value recorded by internal accelerometer.
- Maximum supply voltage.
- Maximum injector supply voltage.
- Maximum supply current.
- Maximum injector current.
- Maximum loading and other CPU related diagnostics

4.4 Team Monitoring 'Telltales'

The ECU will generate, and store in non-volatile memory, minimum and maximum values recorded for the channels listed below. The team may reset this information by issuing a command from the PC software.

- Voltage levels for all analogue sensor inputs[1]
- Engine speed
- Throttle position
- Clutch position
- Clutch actuator hydraulic pressure
- Gearbox shift drum position
- Car speed
- Differential actuator hydraulic pressure
- Hydraulic system pressure
- Gearbox oil temperature

[1] For LVDT inputs, the levels for each of the two secondary inputs will be recorded.

- Gearbox oil pressure
- Engine oil temperature
- Engine oil pressure
- Engine coolant temperature
- Engine coolant pressure
- Fuel temperature
- Fuel pressure
- Engine air valve pressure 1
- Engine air valve pressure 2
- Gearbox input shaft speed
- Throttle pedal position
- Exhaust temperature left
- Exhaust temperature right
- Airbox air pressure
- Ambient air temperature

4.5 FIA Commands

The ECU supports commands, entered via the configuration and monitoring software, for the following functions that can only be issued by FIA personnel:

- Confirm box identity is that of an FIA ECU rather than a facsimile that appears to be one.
- Reset FIA telltales.
- Set race event mode to apply certain restrictions to test modes and strategies.

4.6 Team Commands

The ECU supports commands, entered via the configuration and monitoring software, for the following functions:

- Reset team telltales.
- Reset fault detection monitoring.
- Clear/set fuel metering.
- Control hydraulic flush/bleeding mechanism separately for throttle, clutch, differential and gearshift sub-systems.
- Control engine throttle sensor relationship learning procedure.
- Control automatic individual cylinder fuelling adjustment function.
- Control gearbox shift drum calibration learning function.
- Control clutch position calibration learning function.
- Control differential pressure learning function.
- Manual control switching of outputs for test and diagnostic purposes including high/low side drives, servo-valve drives and injectors.
- Set lap number.
- Select application for hand controller input.
- Set track session type, eg. test, race, qualifying, bench, dyno.

5. TEST RIG AND DYNAMOMETER SUPPORT

5.1 Summary

The FIA ECU is designed to interface to a wide range of test and development equipment when used away from the car by providing compatibility with ASAM (Association for Standardization of Automation and Measuring Systems) compliant applications. To do this the Calibration Tool for the ECU must provide a standard interface such as an ADAM MCD3 V2 interface (also knows as ASAP3). Precise details to be confirmed by teams.

In practical terms, this allows the ECU to be used in a range of dynamometer, test rig and simulation installations by giving access to live channel values, instigation of control commands and dynamic tuning of parameters and calibrations from PC applications or a 'Slew Box'/'Pot Box'.

These features should not be supported when the ECU is configured for a track session type that implies that the car will be running on a track.