|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| User Requirement Number: 1 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall be powered by an automotive electrical system. | |
| Rationale: The project needs to run an automotive engine, and therefore needs to be run on an automotive electrical system. | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 1.1 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall operate continuously with an input of 10-30V | |
| Rationale: An automotive electrical system will sustain a voltage of 10 – 14V in normal operation, but in some circumstances such as vehicle jumpstarting or other conditions, the voltage could be as high as 30V for short periods of time where the ECU needs to operate through. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 1.2 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall survive up to 100V transients for up to 100 milliseconds | |
| Rationale: An automotive electrical environment can be very noisy with large voltage spikes that can damage electrical components. The project should be able to survive even very noisy electrical inputs. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 1.3 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall remain operational down to 5V for up to 40 milliseconds | |
| Rationale: When an engine is starting, the starter motor draws a large amount of current. Under cold cranking conditions the system voltage can drop as low as 5V for up to 40 milliseconds. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 1.4 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have reverse voltage protection up to -24V DC | |
| Rationale: Accidents happen! Batteries can be hooked up backwards, frayed wires can short out connectors, and faulty installers can flub the power connections. All inputs should have robust reverse polarity input protection. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 1.5 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall consume less than 1A of current | |
| Rationale: 1 amp is a lot for an embedded computer. The project should not draw more than this very generous current budget. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| User Requirement Number: 2 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall be able to determine engine rotation vector with various sensors | |
| Rationale: In order to run an engine, the ECU needs to know how quickly and what location the engine is at all times. This is done using different sensor types in different engine setups, and this project should support those. | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 2.1 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall be able to determine engine rotation vector with an accuracy of no more than 0.2 degrees | |
| Rationale: The ECU needs to know very accurately how far the engine has rotated and should know how far the engine has rotated at all times within an accuracy of no more than 0.2 degrees. If the ECU does not know where the engine is in its cycle then the ignition may happen at the incorrect time causing engine damage. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 2.2 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall support for two variable reluctance (VR) sensors for cam angle sensing | |
| Rationale: Variable Reluctance sensors are one of the most accurate rotation sensing devices on the market. They are used in many engine setups to determine engine angle. Some engines have more than one sensor for other features such as variable valve timing. While this feature will not be implemented in this project, the hardware will be there for future expansion. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 2.3 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall support two digital hall effect or optical sensors for cam angle sensing | |
| Rationale: Some engines use a toothed wheel and optical or hall effect sensors to determine engine rotation. Some engines have two. These will be supported along with VR sensors. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| User Requirement Number: 3 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall be able to drive engine spark plugs | |
| Rationale: If there is no spark, there is no bang! If there is not bang, there is no go. | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 3.1 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have two spark output channels supporting four spark plugs in a wasted spark configuration | |
| Rationale: Two spark outputs are enough to run a 4 cylinder engine in a wasted spark configuration. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 3.2 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have a user configurable 3D (RPM vs. Airflow vs. Timing) spark map | |
| Rationale: In order to do engine tuning, the user needs to be able to program a wide variety of engine operating conditions. This is done through a spark map. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 3.3 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have user configurable dwell time | |
| Rationale: Different spark plug configurations need to have the coil packs charged up for a different length of time depending of the setup. The user needs control over this. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| User Requirement Number: 4 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall be able to drive engine fuel injectors | |
| Rationale: In order to run an engine, the ECU needs to be able to control the injectors to flow fuel into the engine | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 4.1 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have two high impedance injector outputs, supporting four injectors in batch fire mode | |
| Rationale: Two injector outputs running four injectors is enough to run a four-cylinder engine. The injectors will be running in batch fire mode. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 4.2 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have a user configurable 3D (RPM vs. Airflow vs. Fuel) injection map | |
| Rationale: In order to run an engine, the ECU needs to know how much fuel to inject for every given engine status. The user needs the ability to change this table to do engine tuning. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| User Requirement Number: 5 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have support for various air flow measurement devices | |
| Rationale: In order to run an engine, the ECU needs to know how much air is flowing into the engine | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 5.1 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall support potentiometer type (barndoor type) air flow meter. | |
| Rationale: In order to run an engine, the ECU needs to know how much air is flowing into the engine This is one common device to do so. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 5.2 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall support a Manifold Absolute Pressure (MAP) sensor for air flow sensing | |
| Rationale: In order to run an engine, the ECU needs to know how much air is flowing into the engine This is one common device to do so. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 5.3 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have support for a Mass Air Flow (MAF) sensor for air flow sensing | |
| Rationale: In order to run an engine, the ECU needs to know how much air is flowing into the engine This is one common device to do so | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| User Requirement Number: 6 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have Exhaust Gas Oxygen (O2) sensor inputs | |
| Rationale: In order to tune and engine and run it in closed loop mode during stable driving conditions, the ECU needs to knowhow much unburned O2 there is in the exhaust gasses. | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 6.1 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall support narrowband O2 sensor input | |
| Rationale: This is a common OEM sensor for measuring free oxygen in exhaust gasses. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 6.2 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall support externally processed wideband O2 sensor data | |
| Rationale: This is a common aftermarket sensor for measuring free oxygen in the exhaust gasses. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| User Requirement Number: 7 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have an input for a throttle position sensor (TPS) | |
| Rationale: The ECU needs to know the position of the throttle in order to have a more accurate guess in how much fuel needs to be injected. | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 7.1 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall support switch type TPS | |
| Rationale: This is a common input device from many OEM throttles | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 7.2 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall support potentiometer based TPS | |
| Rationale: This is a common input device from the throttle | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| User Requirement Number: 8 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have Idle Air Control (IAC) support | |
| Rationale: At startup and at idle, some air needs to be let into the engine even when the throttle is all the way closed in order for the engine to run. In closed loop idle, this airflow needs to be adjusted, and at startup, extra air needs to be let into the engine to prevent stalling. | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 8.1 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have PWM output for IAC solenoid type valves | |
| Rationale: A PWM actuated solenoid is a common to control idle air flow | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 8.2 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have stepper motor control for stepper motor type IAC valves | |
| Rationale: A stepper motor actuated solenoid is a common to control idle air flow | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| User Requirement Number: 9 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall support general vehicle I/O | |
| Rationale: There are other peripherals that the ECU needs to control other than the basic spark and fuel. | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 9.1 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have fuel pump control | |
| Rationale: In some systems, the ECU needs to be able to turn on and off the fuel pump. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 9.2 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have an Idle Air Temperature (IAT) input | |
| Rationale: The ECU needs to know the temperature of the air entering the engine in order to have stable closed loop idle control. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 9.3 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall support clutch and neutral switch input | |
| Rationale: The ECU needs to know when the engine is idling vs. running with a load in order to determine when to go into closed loop idle mode. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 9.4 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall support tachometer output | |
| Rationale: Many systems rely on the ECU to pass a tachometer output to other vehicle systems such as the dash gauges. | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 9.5 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have several configurable logic level inputs and outputs | |
| Rationale: This is for future expansion | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 9.6 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have several configurable logic level inputs and outputs | |
| Rationale: This is for future expansion | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| User Requirement Number: 10 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall be sized appropriately to fit in OEM ECU locations | |
| Rationale: This allows the system to seamlessly integrate into an existing vehicle system | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 10.1 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall be no larger than 150x150mm | |
| Rationale: This is both to keep costs low as well as allowing the ECU to fit into many OEM ECU locations | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| System Requirement Number: 10.2 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall weigh less than 1 Kg | |
| Rationale: | |
| Model: | |
| Verification Plan: | |
| Verification Data: | |

|  |  |
| --- | --- |
| Project Name: Engine Control Unit | |
| User Requirement Number: 11 | Version: 0 |
| Originator: David Tolsma | Approval: |
| Requirement: Shall have a BOM cost of less than $200 | |
| Rationale: This ECU should not cost significantly more than other existing aftermarket options | |