1 Overview

The Vehicle Control Unit (VCU) is used to coordinate and process inputs from vehicle peripherals and smart devices, to instruct and augment vehicle operation. It acts as the brain, controlling system hardware (e.g. displays, lights, motor controllers) through infinitely adjustable software-defined control schemes that run on it. *NOTE: This is not a motor controller itself! Motor control requires additional hardware the VCU will command.*

This additional layer of control and technology enables several opportunities in electric vehicles. As a vendor independent unit it can be reconfigured to suit differing battery and motor systems - not locked into a specific ecosystem or subset of products. Acting as a supervisor of other hardware it can allow systems to influence one another that would previously operate in isolation. The VCU also has the ability to do data logging which when combined with its Internet of Things (IoT) capabilities makes it possible to enable fleet monitoring and management. All this, while still being able to replicate the functionality of simpler modules that handle just throttle or lights.

The VCU is flexible enough to be implemented during prototyping and proof-of-concept stages, as well as used in series production vehicles, while remaining small and light enough to fit in even the smallest of micro-mobility vehicles. It can be configured to operate an entire vehicle on its own, or be used in a network with other units to handle operating more complicated vehicles by distributing tasks across the individual units. For example one VCU can operate a tractor vehicle which connects to a trailer with a separate VCU to operate trailer systems.

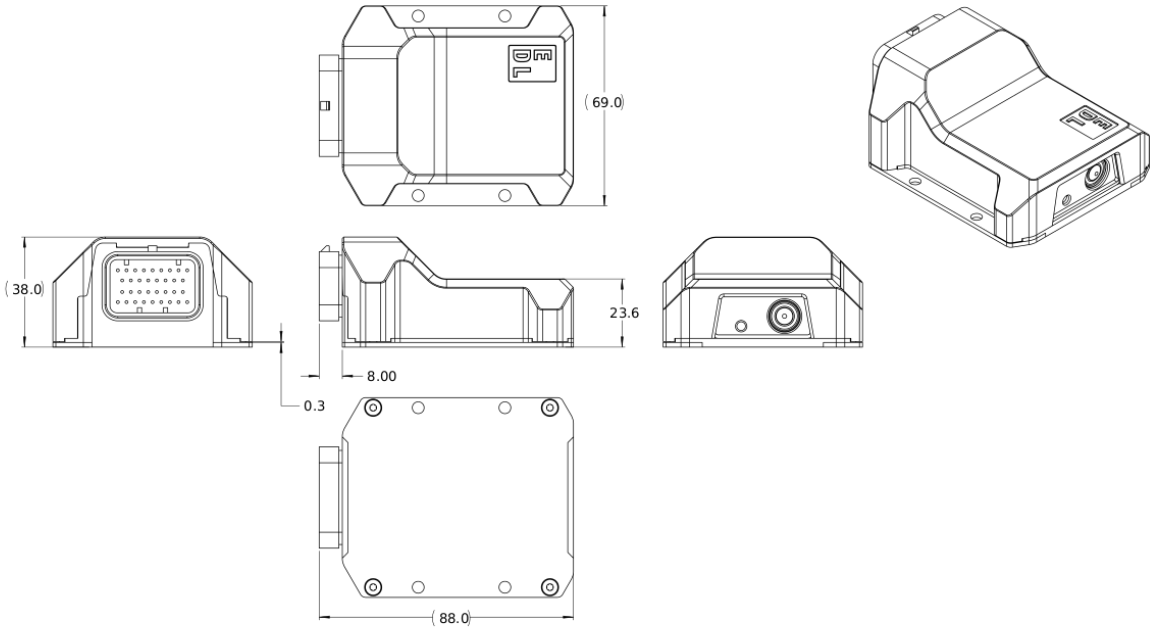
The system is initially configured/programmed by Engineering Design Lab (EDL) to suit client design requirements for their vehicles, although it may be reprogrammed after delivery by either party. Features made possible by adding such a controller to a vehicle:

- Over the air (OTA) firmware updating
- Field adjustable vehicle behaviour, either by the user or centrally for fleets
- Smartphone based access control
- Multiple VCUs can be networked together for more complicated vehicles or modular assemblies
- Rollover/crash detection
- Implementation of a gradual user training program, for example, unlock full power after 100 km ridden.
- "Limp home" mode to conserve battery
- Reactive power limits based on incline
- Region-specific configurations/features such as legal speed limits
- Adjusting regenerative braking based on battery level
- Traction control
- Electrically controlled "differential" for multi-motor systems, front-rear and/or left-right
- Tamper detection
- Stability control
- Torque vectoring

2 Mechanical Features

The mechanical design of the VCU has the following features:

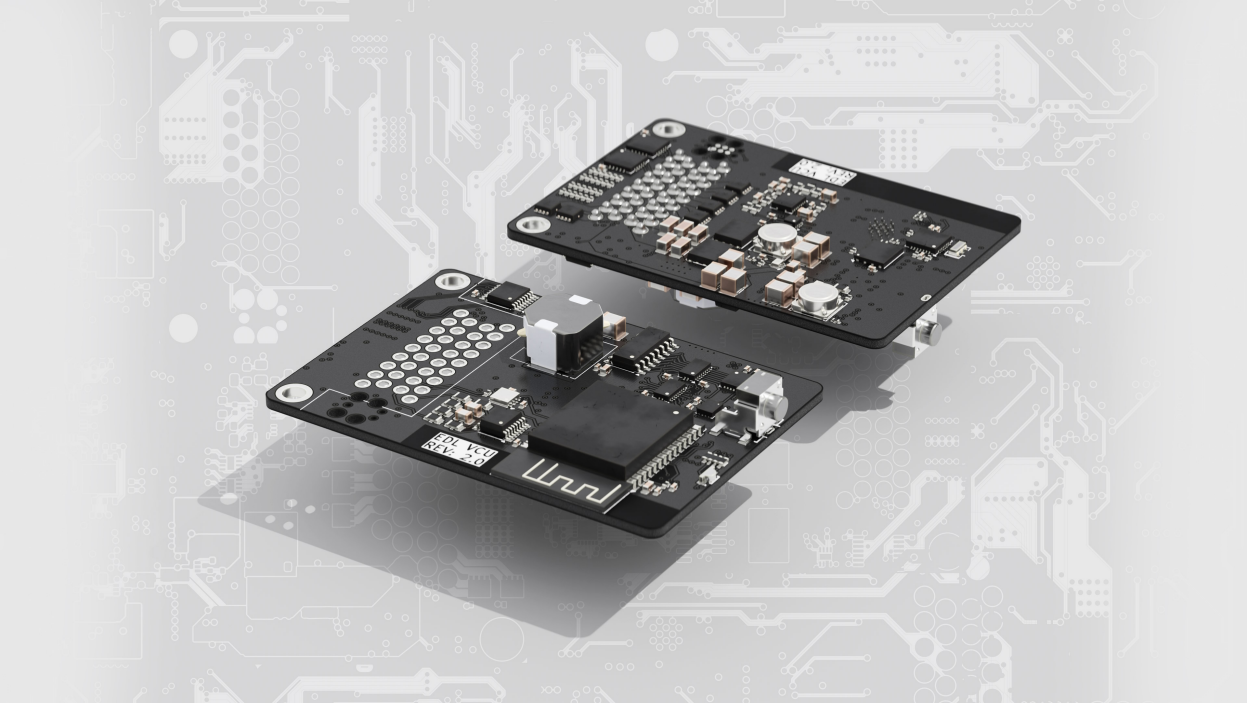
- Maximum dimensions: 89 x 69 x 39 mm (3.50 x 2.7 x 1.54 in)
- Approximate weight: 270 g (0.6 lbs / 9.5 oz.)
- IP67 enclosure and connector
- Rugged and vibration resistant
- Rated temperature range: -40 °C to 85 °C (-40 °F to 185 °F)
- Primarily plastic enclosure with metal lid used for mounting and heat dispersal
- Designed for ease of repair and/or replacement



3 Electrical Features

The core electronic features embedded in the VCU are:

- Working power input voltage range from 12 V to 95 V
- Wifi and Bluetooth Low Energy connectivity
- Two independent CAN communication buses
  - One bus supports CAN 2.0B
  - One bus supports CAN-FD (and CAN 2.0B)
  - CANopen compliant
- 100 V, 1.5 A tolerant output lines to control high power peripherals (e.g. alarm, lights)
- 100 V tolerant inputs for system monitoring (e.g. key) (threshold voltage high/low is 20 V)
- Analog inputs for user input devices (e.g. throttle or steering)
- Low-voltage general purpose input/output pins configured for either 5 V or 12 V operation
- RGB status LED
- Dedicated flash chip with 16 MiB of space for storing logs, configurations, etc.
- 32-bit Processor with 8 MiB flash, 512 KiB RAM
- Six-axis Inertial Measurement Unit (IMU) (acceleration, gyroscope) on board
- Physical reset button



4 Inputs and Outputs

The VCU uses a 34-pin TE Connectivity SUPERSEAL 1.0mm connector (TE 6437288-2) which mates with TE 4-1437290-1 and tolerates up to 7 A per pin. The connector offers 2 independent CAN buses, 22 general purpose input/output pins, and two regulated power rails at 5 V and 12 V. The detailed breakdowns across revisions are below *(all pins are digital only unless specified otherwise)*:

GPIO Summary of VCU Revision 3.0

Port	Pins	Notes
0	6	5 V GPIO or 12 V Output
1	6	5 V GPIO or 12 V Input, Analog Input at either range
2	6	100V tolerant low-side sinks to battery negative (1.5 A each)
3	2	100V tolerant digital input
4	2	Digital potentiometer (12 V max). *One pin is upper end of pot., the other is the wiper.*
X	2	Daughter board GPIO. *Function varies based on daughter board installed.*
CAN1	2	CAN H/L connections for CAN 2.0B bus
CAN2	2	CAN H/L connections for CAN FD bus
5V	1	5 V 1 A rail
12V	1	12 V 4 A rail
USB	2	USB primarily for programming