M461 Technical Specification 29T-068148TK-03

Release 2.9.0 (r2020-1)

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Chapter 1. Technical specification

This document is the technical specification for OpenECU part *01T-068148-000 Issue 1*. Within this document, that part is referred to as the *M461-000 ECU*.

> **Note**
>
> For a list of issues and possible work arounds for this ECU, found after publication of this document, please refer to the hardware errata for this ECU (named *29T-068148ER-xE M461 Technical Spec Errata*).

Specific option control may exist for this part. In that case, parts of this document will be overridden by an option control specific technical specification. Please refer to the option control technical specification for more information.

1.1. Overview

This technical specification relates to the following ECU variant:

- M461D-000 — for development and testing, including full interactive calibration tool integration.

Table 1.1. Specification

Specification	Variant
	M461D-000
Status	Available [a]
Processor	MPC5534
Rate	80MHz
Code space	up to 768KiB [b]
RAM space	up to 832KiB [b]
Calibration space	up to 256KiB [b]
Calibratable	Y
Reprogrammable	Y
Power control relays	-
Actuator supplies	-
Sensor supplies	4
Inputs	33
Outputs	14
CAN buses	2
LIN buses	-
RS232 links	-
Connectors	2x40
Weight	1.5Kg

Specification	Variant
	M461D-000
Vibration	6g random RMS
Shock capability	TBC
Enclosure	IP68 [c]
EMC	SAE J1455 [d]
Partial operating voltage	7 to 36V
Full operating voltage	8 to 32V [e]
Standby current (typical)	0.15mA at 12V [f]
Operating current (typical)	175mA at 12V [g]
Operating temperature range	-40 to +105°C
Storage temperature range (installation)	-40 to +125°C
Storage temperature range (shipping)	-40 to +125°C

[a] Target ECU available for general use.
[b] See list of possible memory configurations in section 'Memory - configuration'.
[c] Designed for under bonnet(hood)/chassis mounting.
[d] Load dump protection to SAE J1455 specification.
[e] Designed for 12V or 24V vehicles.
[f] 0.3mA at 24V.
[g] 100mA at 24V. When running idle task with I/O disconnected.

1.2. Function reference

Various input and output functionality is supported where some pins may be capable of more than one function. Some functions require a combination of pins but not all pin combinations are possible.

Table 1.2. Function reference

I/O type	External	Internal	Pins
Power			
ECU supply	1	-	A10+A20+A30
ECU ground	1	-	C1+C2+C11+C12+C38
Sensor supply	4	-	A8, A18, C8, C18
Module control, status			
Ignition sense	1	-	A12
Module control FEPS	1	-	A2
Module status Flash code	1	-	A27
Communication			
CAN buses	2	-	A37+A36, C37+C36
Inputs — time based			
Analogue	23	36	A16, A22, A23, A24, A28, A32, A33, A34, C3, C4, C6, C13, C14, C16, C21, C22, C23, C24, C25, C31, C32, C33, C35

I/O type	External	Internal	Pins
Digital	10	26	A12, A26, C7, C27, C28, C29, C30, C34, C39, C40
Frequency	10	13	A12, A26, C7, C27, C28, C29, C30, C34, C39, C40
PWM	10	-	A12, A26, C7, C27, C28, C29, C30, C34, C39, C40
Quadrature	9	-	A26, C7, C27, C28, C29, C30, C34, C39, C40
Outputs — time based			
Digital	14	7	A1, A5, A7, A11, A15, A17, A21, A25, A31, A35, C5, C10, C15, C20
PWM	14	-	A1, A5, A7, A11, A15, A17, A21, A25, A31, A35, C5, C10, C15, C20
Inputs — angle based			
None	-	-	
Outputs — angle based			
None	-	-	

Chapter 2. Connector pinout

The M461-000 variants have two ECU connectors (pockets) named A and C, which have pinouts as given in the following tables. Currents listed are RMS unless otherwise stated.

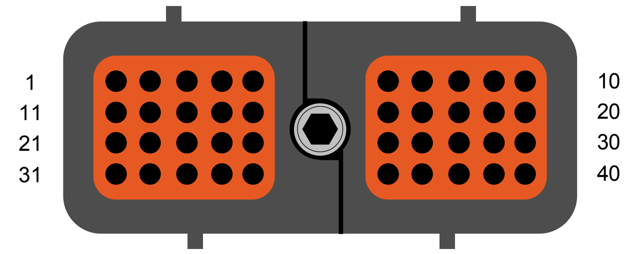
The following abbreviations are used in the pinout tables below:

C	Communication
I	Input
M	Monitor
O	Output
P	Power

CT	Current trip
GND	Ground
PSU	Power supply
PWR	Power
RTD	Resistance temperature detector

2.1. Pocket A

Connector packs can be ordered from Pi. Individual connector components can be ordered from Pi or from various manufacturers.



Note: the protrusions visible here, on the back of the connector shell, do not line up with those on the mating side, which fit into receiving channels on the ECU connector.

Table 2.1. Part numbers for the mating connector

Supplier	Part number	Part
Deutsch	DRC26-40SA	Connector with A keyway

Table 2.2. Part numbers for the turned pin

Supplier	Part number	Part
Deutsch	0462-201-20141	Pin
	0413-204-2005	Plug for unused position
	HDT-48-00	Crimper
Pins A1, A2, A5, A7, A8, A9, A10+A20+A30, A11, A12, A15, A16, A17, A18, A19, A21, A22, A23, A24, A25, A26, A27, A28, A31, A32, A33, A34, A35, A36, A37 and A38		

Table 2.3. Part numbers for the formed pin

Supplier	Part number	Part
Deutsch	1062-20-0122	Pin
	0413-204-2005	Plug for unused position
	DTT-20-00	Crimper

Supplier	Part number	Part
Pins A1, A2, A5, A7, A8, A9, A10+A20+A30, A11, A12, A15, A16, A17, A18, A19, A21, A22, A23, A24, A25, A26, A27, A28, A31, A32, A33, A34, A35, A36, A37 and A38		

Table 2.4. Connector pinout — Pocket A

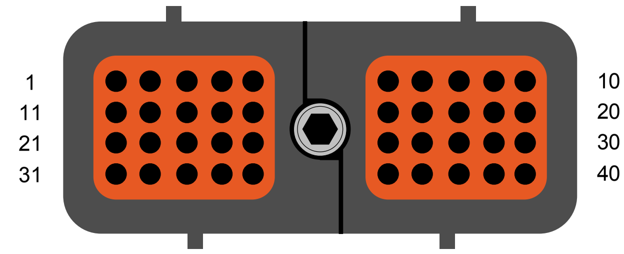
Main connector — Pocket A								
Pin	**P**	**Function**	**I/O**	**M**	**Loading**	**Filter**	**Range**	**Notes**
A1		Digital	O	Y	Low side		5A	Related to internal channels Monitor (ct), Monitor (d) and Monitor (v).
A2		FEPS	I		82k series with bias of 11k to V_{GND} and 10k to 5V	323Hz	-16V to +17V	Module flash programming control.
A3	No function.							
A4	No function.							
A5		Digital	O	Y	Low side		8A	Related to internal channels Monitor (ct), Monitor (d) and Monitor (v).
A6	No function.							
A7		Digital	O	Y	Low side		100mA	Related to internal channels Monitor (d) and Monitor (v).
A8		Sensor supply	P	Y			5V, 250mA	Sensor supply 1. Can be turned on and off by the application for diagnostics purposes, see also: A9. Related to internal channels DOT disable-EXT-PSU1 and Monitor (v).
A9		Sensor ground	P					Sensor ground 1, see also: A8. Related to internal channel AIN extern-gnd.
A10		V_{PWR}	P				7A	Maximum of 21A in total when all V_{PWR} pins connected in parallel. Related to internal channel AIN VPWR.
A11		Digital	O	Y	Low side		5A	Related to internal channels Monitor (ct), Monitor (d) and Monitor (v).
A12		Digital	I		4k7 to V_{GND}	6.9kHz	0V to V_{PWR}	Key position (ignition sense) input. Related to internal channel DOT hold-PSU.

Main connector — Pocket A								
Pin	**P**	**Function**	**I/O**	**M**	**Loading**	**Filter**	**Range**	**Notes**
A13	No function.							
A14	No function.							
A15		Digital	O	Y	Low side		8A	Related to internal channels Monitor (ct), Monitor (d) and Monitor (v).
A16		Analogue	I		51k to V_{GND}	22Hz	0V to 5V	12-bit unsigned conversion.
A17		Digital	O	Y	Low side		100mA	Related to internal channels Monitor (d) and Monitor (v).
A18		Sensor supply	P	Y			5V, 250mA	Sensor supply 2. Can be turned on and off by the application for diagnostics purposes, see also: A19. Related to internal channels DOT disable-EXT-PSU2 and Monitor (v).
A19		Sensor ground	P					Sensor ground 2, see also: A18. Related to internal channel AIN extern-gnd.
A20		V_{PWR}	P				7A	Maximum of 21A in total when all V_{PWR} pins connected in parallel. Related to internal channel AIN VPWR.
A21		Digital	O	Y	Low side		5A	Related to internal channels Monitor (ct), Monitor (d) and Monitor (v).
A22		Analogue	I		51k to V_{GND}	220Hz	0V to 5V	12-bit unsigned conversion.
A23		Analogue	I		51k to V_{GND}	220Hz	0V to 5V	12-bit unsigned conversion.
A24		Analogue	I		51k to V_{GND}	220Hz	0V to 5V	12-bit unsigned conversion.
A25		Digital	O	Y	Low side		8A	Related to internal channels Monitor (ct), Monitor (d) and Monitor (v).
A26		Digital	I		4k7 to V_{PWR} through diode	6.9kHz	0V to V_{PWR}	
A27		Flash code	O		Low side		100mA	ECU status information.
A28		Analogue	I		51k to V_{GND}	42Hz	0V to 5V	12-bit unsigned conversion.
A29	No function.							

Main connector — Pocket A								
Pin	**P**	**Function**	**I/O**	**M**	**Loading**	**Filter**	**Range**	**Notes**
A30		V_{PWR}	P				7A	Maximum of 21A in total when all V_{PWR} pins connected in parallel. Related to internal channel AIN VPWR.
A31		Digital	O	Y	Low side		5A	Related to internal channels Monitor (ct), Monitor (d) and Monitor (v).
A32		Analogue	I		51k to V_{GND}	220Hz	0V to 5V	12-bit unsigned conversion.
A33		Analogue	I		51k to V_{GND}	220Hz	0V to 5V	12-bit unsigned conversion.
A34		Analogue	I		51k to V_{GND}	220Hz	0V to 5V	12-bit unsigned conversion.
A35		Digital	O	Y	Low side		2A	Related to internal channels Monitor (ct), Monitor (d) and Monitor (v).
A36		CAN+ (high)	C		124R			CAN bus 0 high (+ve).
A37		CAN- (low)	C		124R			CAN bus 0 low (-ve).
A38		CAN shield	C					CAN bus 0 shield.
A39	No function.							
A40	No function.							

2.2. Pocket C

Connector packs can be ordered from Pi. Individual connector components can be ordered from Pi or from various manufacturers.



Note: the protrusions visible here, on the back of the connector shell, do not line up with those on the mating side, which fit into receiving channels on the ECU connector.

Table 2.5. Part numbers for the mating connector

Supplier	Part number	Part
Deutsch	DRC26-40SC	Connector with C keyway

Table 2.6. Part numbers for the turned pin

Supplier	Part number	Part
Deutsch	0462-201-20141	Pin
	0413-204-2005	Plug for unused position
	HDT-48-00	Crimper
Pins C1+C2+C11+C12+C38, C3, C4, C5, C6, C7, C8, C9, C10, C13, C14, C15, C16, C18, C19, C20, C21, C22, C23, C24, C25, C26, C27, C28, C29, C30, C31, C32, C33, C34, C35, C36, C37, C39 and C40		

Table 2.7. Part numbers for the formed pin

Supplier	Part number	Part
Deutsch	1062-20-0122	Pin
	0413-204-2005	Plug for unused position
	DTT-20-00	Crimper

Supplier	Part number	Part
Pins C1+C2+C11+C12+C38, C3, C4, C5, C6, C7, C8, C9, C10, C13, C14, C15, C16, C18, C19, C20, C21, C22, C23, C24, C25, C26, C27, C28, C29, C30, C31, C32, C33, C34, C35, C36, C37, C39 and C40		

Table 2.8. Connector pinout — Pocket C

Main connector — Pocket C								
Pin	**P**	**Function**	**I/O**	**M**	**Loading**	**Filter**	**Range**	**Notes**
C1		V_{GND}	P					C1, C2, C11, C12 and C38 connected together internally.
C2		V_{GND}	P					C1, C2, C11, C12 and C38 connected together internally.
C3		Analogue (RTD)	I		10k to 5V	124Hz	0V to 0.454545V	12-bit unsigned conversion.
C4		Analogue	I		51k to V_{GND}	42Hz	0V to 5V	12-bit unsigned conversion.
C5		Digital	O	Y	Low side		2A	Related to internal channels Monitor (ct), Monitor (d) and Monitor (v).
C6		Analogue	I		51k to V_{GND}	42Hz	0V to 5V	12-bit unsigned conversion.
C7		Digital	I		36k to V_{GND}	6.9kHz	0V to 5V	
C8		Sensor supply	P	Y			5V, 250mA	Sensor supply 3. Can be turned on and off by the application for diagnostics purposes, see also: C9. Related to internal channels DOT disable-EXT-PSU3 and Monitor (v).
C9		Sensor ground	P					Sensor ground 3, see also: C8. Related to internal channel AIN extern-gnd.
C10		Digital	O	Y	Low side		2A	Related to internal channels Monitor (ct), Monitor (d) and Monitor (v).
C11		V_{GND}	P					C1, C2, C11, C12 and C38 connected together internally.
C12		V_{GND}	P					C1, C2, C11, C12 and C38 connected together internally.
C13		Analogue (RTD)	I		10k to 5V	124Hz	0V to 0.454545V	12-bit unsigned conversion.
C14		Analogue	I		51k to V_{GND}	42Hz	0V to 5V	12-bit unsigned conversion.

Main connector — Pocket C								
Pin	**P**	**Function**	**I/O**	**M**	**Loading**	**Filter**	**Range**	**Notes**
C15		Digital	O	Y	Low side		8A	Related to internal channels Monitor (ct), Monitor (d) and Monitor (v).
C16		Analogue	I		51k to V_{GND}	22Hz	0V to 5V	12-bit unsigned conversion.
C17	No function.							
C18		Sensor supply	P	Y			5V, 250mA	Sensor supply 4. Can be turned on and off by the application for diagnostics purposes, see also: C19. Related to internal channels DOT disable-EXT-PSU4 and Monitor (v).
C19		Sensor ground	P					Sensor ground 4, see also: C18. Related to internal channel AIN extern-gnd.
C20		Digital	O	Y	Low side		2A	Related to internal channels Monitor (ct), Monitor (d) and Monitor (v).
C21		Analogue (RTD)	I		10k to 5V	124Hz	0V to 0.454545V	12-bit unsigned conversion.
C22		Analogue	I		51k to V_{GND}	220Hz	0V to 5V	12-bit unsigned conversion.
C23		Analogue	I		51k to V_{GND}	220Hz	0V to 5V	12-bit unsigned conversion.
C24		Analogue	I		51k to V_{GND}	63Hz	0V to 5V	Can be treated as an individual input, or as a differential input with C25. 12-bit unsigned conversion. Related to internal channel AIN diff..
C25		Analogue	I		51k to V_{GND}	42Hz	0V to 5V	Can be treated as an individual input, or as a differential input with C24. 12-bit unsigned conversion. Related to internal channel AIN diff..
C26		No function						This pin is directly tied internally to the analogue ground of the ECU. Care must be taken to protect from shorts to positive voltage in the wiring harness.
C27		Digital	I		4k7 to V_{PWR} through diode plus 51k to V_{GND}	6.9kHz	0V to V_{PWR}	

Main connector — Pocket C							
Pin	**P**	**Function**	**I/O**	**M**	**Loading**	**Filter**	**Range**	**Notes**
C28		Digital	I		4k7 to V_{PWR} through diode	6.9kHz	0V to V_{PWR}	
C29		Digital	I		4k7 to V_{PWR} through diode	6.9kHz	0V to V_{PWR}	
C30		Digital	I		4k7 to V_{PWR} through diode	6.9kHz	0V to V_{PWR}	
C31		Analogue	I		51k to V_{GND}	42Hz	0V to 5V	12-bit unsigned conversion.
C32		Analogue	I		51k to V_{GND}	63Hz	0V to 5V	12-bit unsigned conversion.
C33		Analogue	I		51k to V_{GND}	63Hz	0V to 5V	12-bit unsigned conversion.
C34		Digital	I		4k7 to V_{PWR} through diode	6.9kHz	0V to V_{PWR}	
C35		Analogue	I		51k to V_{GND}	42Hz	0V to 5V	12-bit unsigned conversion.
C36		CAN+ (high)	C		124R			CAN bus 1 high (+ve).
C37		CAN- (low)	C		124R			CAN bus 1 low (-ve).
C38		V_{GND}	P					C1, C2, C11, C12 and C38 connected together internally.
C39		Digital	I		36k to V_{GND}	6.9kHz	0V to V_{PWR}	
C40		Digital	I		36k to V_{GND}		0V to V_{PWR}	

Chapter 3. Internal signals

Table 3.1. Internal signals

Signal	I/O	Signal type	Range	Notes
Analogue				
AIN accelerometer-x	I	Analogue	0V to 5V	Internal X-axis accelerometer signal. 12-bit unsigned conversion.
AIN accelerometer-y	I	Analogue	0V to 5V	Internal Y-axis accelerometer signal. 12-bit unsigned conversion.
AIN accelerometer-z	I	Analogue	0V to 5V	Internal Z-axis accelerometer signal. 12-bit unsigned conversion.
AIN cold-junction-temp	I	Analogue	0V to 5V	Cold junction temperature: 0.251V @ -40°C; 1.31525V @ +125°C. 12-bit unsigned conversion.
AIN diff. (pin C24 and C25)	I	Analogue	0V to 5V	Differential input. 12-bit unsigned conversion.
AIN extern-gnd (pin A9, A19, C9 and C19)	I	Analogue	0V to 5V	Common sensor ground voltage monitor. 12-bit unsigned conversion.
AIN gyroscope-temperature	I	Analogue	0V to 5V	Internal gyroscope temperature. 12-bit unsigned conversion.
AIN gyroscope-x	I	Analogue	0V to 5V	Internal X-axis gyroscope signal. 12-bit unsigned conversion.
AIN gyroscope-y	I	Analogue	0V to 5V	Internal Y-axis gyroscope signal. 12-bit unsigned conversion.
AIN gyroscope-z	I	Analogue	0V to 5V	Internal Z-axis gyroscope signal. 12-bit unsigned conversion.
AIN PSU+3V3	I	Analogue	0V to 5V	Internal 3.3V power supply. 12-bit unsigned conversion.
AIN PSU+5VD	I	Analogue	0V to 6V	Internal 5V power supply. 12-bit unsigned conversion.
AIN VPWR (pin A10, A20 and A30)	I	Analogue	0V to 40V	Power supply voltage. 12-bit unsigned conversion.

Signal	I/O	Signal type	Range	Notes
AIN VRH	I	Analogue	0V to 5V	5V reference for analogue input conversions. 12-bit unsigned conversion.
AIN VRH-VRL 25%	I	Analogue	0V to 5V	1.25V reference for analogue input conversions. 12-bit unsigned conversion.
AIN VRH-VRL 50%	I	Analogue	0V to 5V	2.5V reference for analogue input conversions. Will read as 2.48V due to 20mV offset in processor implementation. 12-bit unsigned conversion.
AIN VRH-VRL 75%	I	Analogue	0V to 5V	3.75V reference for analogue input conversions. 12-bit unsigned conversion.
AIN VRL	I	Analogue	0V to 5V	0V reference for analogue input conversions. 12-bit unsigned conversion.
Current trip monitor				
Monitor (ct) (pin A1)	I	Digital	0 or 1	Digital input indicating current trip. Serial input.
Monitor (ct) (pin A11)	I	Digital	0 or 1	Digital input indicating current trip. Serial input.
Monitor (ct) (pin A15)	I	Digital	0 or 1	Digital input indicating current trip. Serial input.
Monitor (ct) (pin A21)	I	Digital	0 or 1	Digital input indicating current trip. Serial input.
Monitor (ct) (pin A25)	I	Digital	0 or 1	Digital input indicating current trip. Serial input.
Monitor (ct) (pin A31)	I	Digital	0 or 1	Digital input indicating current trip. Serial input.
Monitor (ct) (pin A35)	I	Digital	0 or 1	Digital input indicating current trip. Serial input.
Monitor (ct) (pin A5)	I	Digital	0 or 1	Digital input indicating current trip. Serial input.
Monitor (ct) (pin C10)	I	Digital	0 or 1	Digital input indicating current trip. Serial input.
Monitor (ct) (pin C15)	I	Digital	0 or 1	Digital input indicating current trip. Serial input.
Monitor (ct) (pin C20)	I	Digital	0 or 1	Digital input indicating current trip. Serial input.
Monitor (ct) (pin C5)	I	Digital	0 or 1	Digital input indicating current trip. Serial input.
Digital				
DOT disable-EXT-PSU1 (pin A8)	O	Digital	0 or 1	Sensor supply switch. Set to zero to turn on the power supply and to one to turn it off.

Signal	I/O	Signal type	Range	Notes
DOT disable-EXT-PSU2 (pin A18)	O	Digital	0 or 1	Sensor supply switch. Set to zero to turn on the power supply and to one to turn it off.
DOT disable-EXT-PSU3 (pin C8)	O	Digital	0 or 1	Sensor supply switch. Set to zero to turn on the power supply and to one to turn it off.
DOT disable-EXT-PSU4 (pin C18)	O	Digital	0 or 1	Sensor supply switch. Set to zero to turn on the power supply and to one to turn it off.
DOT gyro-self-test-1	O	Digital	0 or 1	Control self-test digital signal to the gyroscope device.
DOT gyro-self-test-2	O	Digital	0 or 1	Control self-test digital signal to the gyroscope device.
DOT hold-PSU (pin A12)	O	Digital	0 or 1	Control power supply to ECU in conjunction with the key position (ignition sense) input.
Digital monitor				
Monitor (d) (pin A1)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 3.4V V_{HL} <= 2.4V.
Monitor (d) (pin A11)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 3.4V V_{HL} <= 2.4V.
Monitor (d) (pin A15)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 3.4V V_{HL} <= 2.4V.
Monitor (d) (pin A17)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 3.4V V_{HL} <= 2.4V.
Monitor (d) (pin A21)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 3.4V V_{HL} <= 2.4V.
Monitor (d) (pin A25)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 3.4V V_{HL} <= 2.4V.
Monitor (d) (pin A31)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 3.4V V_{HL} <= 2.4V.
Monitor (d) (pin A35)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 3.4V V_{HL} <= 2.4V.
Monitor (d) (pin A5)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 3.4V V_{HL} <= 2.4V.
Monitor (d) (pin A7)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 3.4V V_{HL} <= 2.4V.
Monitor (d) (pin C10)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 3.4V V_{HL} <= 2.4V.
Monitor (d) (pin C15)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 3.4V V_{HL} <= 2.4V.
Monitor (d) (pin C20)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 3.4V V_{HL} <= 2.4V.
Monitor (d) (pin C5)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 3.4V V_{HL} <= 2.4V.
Memory check				

Signal	I/O	Signal type	Range	Notes
Monitor (counter eTPU background task)	I	Digital data	0 to 65535	Cyclic counter providing number of times the eTPU background task runs. Its rate of increase can be used to determine the rate of the background task.
Monitor (fc SDM-checksum)	I	Digital data	0 to 65535	Saturating counter providing number of times the eTPU module's data memory failed a checksum test.
Voltage monitor				
Monitor (v) (pin A1)	I	Analogue	0V to 39V	Digital output voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin A11)	I	Analogue	0V to 39V	Digital output voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin A15)	I	Analogue	0V to 39V	Digital output voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin A17)	I	Analogue	0V to 39V	Digital output voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin A18)	I	Analogue	0V to 5V	Sensor supply voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin A21)	I	Analogue	0V to 39V	Digital output voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin A25)	I	Analogue	0V to 39V	Digital output voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin A31)	I	Analogue	0V to 39V	Digital output voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin A35)	I	Analogue	0V to 39V	Digital output voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin A5)	I	Analogue	0V to 39V	Digital output voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin A7)	I	Analogue	0V to 39V	Digital output voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin A8)	I	Analogue	0V to 5V	Sensor supply voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin C10)	I	Analogue	0V to 39V	Digital output voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin C15)	I	Analogue	0V to 39V	Digital output voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin C18)	I	Analogue	0V to 5V	Sensor supply voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin C20)	I	Analogue	0V to 39V	Digital output voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin C5)	I	Analogue	0V to 39V	Digital output voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin C8)	I	Analogue	0V to 5V	Sensor supply voltage monitor. 12-bit unsigned conversion.

Chapter 4. Operational details

4.1. ECU power

The power supply pins (V_{PWR} A10+A20+A30) are connected internally in parallel. Similarly for the ground pins (V_{GND} C1+C2+C11+C12+C38).

The power supply pins are each individually rated to 7A and can be connected in parallel to provide a higher rating (e.g., using two pins gives 14A, three pins gives 21A, etc.). The maximum supply is 21A. All power supply pins are connected internally in parallel (similarly for the ground pins).

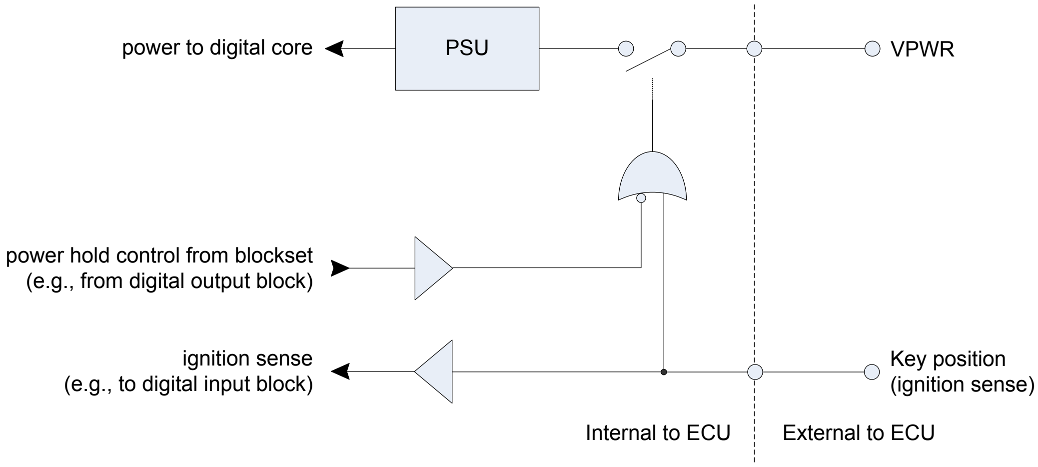
The ECU is designed for 12V or 24V vehicles. Some ECU functionality (e.g., output drivers) work only between 7.5V and 32V. The ECU is protected against reverse supply connection. All inputs and outputs are protected against short-to-V_{PWR} or short-to-$_{GND}$ over normal operating range.

> **Note**
>
> For correct operation of the M461 the power input (V_{PWR} A10+A20+A30) should be connected to a permanent supply and module power controlled using the ignition input (pin A12). Repeated switching of the power input while the module is operating may cause damage to the internal power supply. If the application requires that the power inputs are switched directly then additional suppression must be provided on the power inputs to eliminate negative transients.

4.2. ECU power — control

The ECU power arrangement is shown in Figure 4.1, “Switching arrangement for main power supply”.

Figure 4.1. Switching arrangement for main power supply



The ECU is powered up when the power supply pins (V_{PWR} A10+A20+A30) and key position (ignition sense) input (pin A12) are asserted. The key position input (pin A12) can be read as a digital input.

This arrangement allows for the ECU application software to hold the ECU on after the external key position input is opened, allowing, for example, non-volatile memory processing to occur. For the ECU to hold power the internal DOT hold-PSU channel needs to be asserted. Setting this internal channel low will hold power when the key position input is opened, setting it high will allow the ECU to power off when the key position input is opened.

> **Note**
>
> When using the 'power hold' functionality, it is best to set the internal DOT hold-PSU channel low *as soon as* the external key position input (pin A12) is closed and only set high once all required shutdown tasks have completed.

4.3. ECU power — actuator supplies

Unlike some other ECUs, the M461-000 does provide an actuator supply.

> **Note**
>
> When using the high-side actuator output control, all loads controlled by a low-side drive output must be supplied by the high-side actuator output. If the system includes loads controlled by low-side drive outputs supplied by the high-side actuator output and others supplied directly from battery positive, there is a potential for a sneak path to provide power to some actuators even if the module is powered off. If it is desirable to connect loads controlled by low-side outputs directly to battery positive, then do not use the high-side actuator output to control power to other loads controlled by low-side outputs.

4.4. ECU power — sensor supplies

The ECU provides four external sensor power supplies (pins A8, A18, C8 and C18) and common sensor ground (pins A9, A19, C9 and C19).

The sensors supplies can be individually switched off to allow the application software to perform intrusive diagnostics on sensors. Each output is monitored by an internal analogue input channel which can be used to check for short circuits and measure the exact output voltage for use with ratio-metric sensors.

The output voltage is guaranteed to never reach full scale in normal operation, hence a full scale indication should be taken to indicate a suspected short to battery. The value read from the voltage monitor when the corresponding PSU is enabled should be interpreted as follows:

Table 4.1. Sensor supply monitor voltages

Voltage	Meaning
> 4.97V	Output shorted to battery
4.85V - 4.95V	Normal operation
< 4.85V	Output over-current or short to ground

The value read from the common sensor ground voltage monitor should be interpreted as follows:

Table 4.2. Sensor ground monitor voltage

Voltage	Meaning
0mV - 20mV	Normal Operation
> 20mV	Output over current or short to battery

The sensor ground feedback can also be used in normal operation by the application software to provide a precision ground reference for ratio-metric measurements.

4.5. Analogue inputs

The analogue inputs (pins A16, A22, A23, A24, A28, A32, A33, A34, C3, C4, C6, C13, C14, C16, C21, C22, C23, C24, C25, C31, C32, C33 and C35) sample voltage with varying resolution and range. See the pin information for more details. Some of the analogue inputs have additional characteristics, as detailed in the following sections.

> **Note**
>
> If any of the pins A1, A5, A7, A11, A15, A17, A21, A25, A31, A35, C5, C10, C15 and C20 are not being used as digital outputs then it is possible for them to be used as analogue inputs with a range of 0V to 39V, a loading of 41k to V_{GND} and a filter of 104Hz. Providing the output transistor is switched off, the pin can be driven by an external source and pin's voltage monitor will reflect the actual voltage on the pin.

> **Note**
>
> Serial numbers 0544, 0591, 0594 through 0601, and 0606 do not have a bandwidth limiting filter installed on analogue inputs C3, C13, and C21. As a result, these inputs will not filter out high frequency noise and such noise may affect the input value.

4.6. Analogue inputs — internal temperature input

Although the ECU does not include thermocouple inputs, like some other ECUs, the M461-000 does retain the cold-junction temperature input which can be utilised as the internal temperature of the ECU.

The relationship between temperature and the ADC voltage (V_{ADC}) and ADC counts (C_{ADC}) for the internal temperature sensor is:

$$V_{ADC} = T_{CJ} \times 0.00645 + 0.509$$

$$C_{ADC} = T_{CJ} \times 5.28255 + 416.871$$

over a range of -40°C to +125°C.

4.7. Analogue inputs — internal accelerometer inputs

The internal accelerometer channels (AIN accelerometer-x, AIN accelerometer-y and AIN accelerometer-z) have a zero point of 1.65V and give an output swing of 600mV/g. The relationship between acceleration and the ADC voltage (V_{ADC}) is:

$$V_{ADC} = 1.65 + 0.6 \times ACCELERATION$$

The full scale range of the accelerometer is ±2g so V_{ADC} will never reach 0V or 5V in normal operation.

4.8. Analogue inputs — internal gyroscope inputs

The internal gyroscope channels (AIN gyroscope-x, AIN gyroscope-y and AIN gyroscope-z) have a zero point of 2.5V and give an output swing of ±2.25V for rotation rates in the range ±50°/s. The relationship between rotation and the ADC voltage (V_{ADC}) is:

$$V_{ADC} = 2.5 + \frac{2.25}{50} \times ROTATIONRATE$$

In addition to their analogue outputs, the gyroscopes have two self test signals (internal channels DOT gyro-self-test-1 and DOT gyro-self-test-2). Asserting these signals high introduces an offset to V_{ADC} for diagnostic purposes.

Asserting internal channel DOT gyro-self-test-1 high causes V_{ADC} to change -1.9V. Asserting internal channel DOT gyro-self-test-2 high causes an opposite change of +1.9V. The self-test response follows the viscosity temperature dependence of the package atmosphere, approximately 0.25%/°C.

> **Note**
>
> Asserting both self-test channels simultaneously is not damaging. Both are fairly closely matched (±5%), but asserting both high simultaneously may result in a small apparent null bias shift proportional to the degree of self-test mismatch.

The gyroscope devices provide a single temperature signal (internal channel AIN gyroscope-temperature. This signal may be used by the application software to compensate for drift of the gyroscopes. The relationship between temperature and the ADC voltage (V_{ADC}) for the gyroscope temperature sensor is:

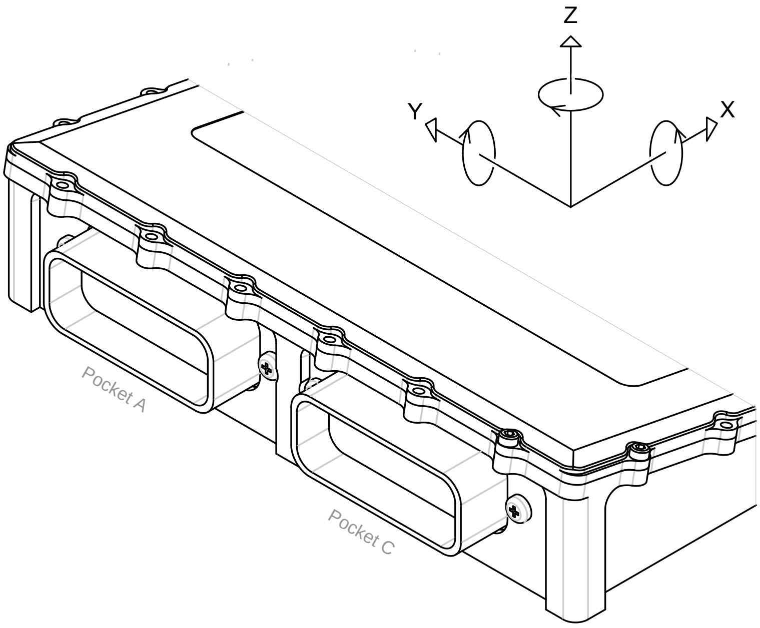
$$V_{ADC} = 2.275 + 0.009 \times TEMPERATURE$$

over a range of -40°C to +125°C. Refer to the ADXRS614 data-sheet from Analog Devices for further information on temperature calibration.

4.9. Analogue inputs — internal accelerometer and gyroscope orientation

The accelerometer and gyroscope orientation is pictured below:

Figure 4.2. Orientation of accelerometer and gyroscope axes



4.10. Digital inputs

The inputs work on a voltage threshold. If the external pin is above the threshold voltage the input will be 0, if the external pin is below the threshold the input will be 1 (i.e. signal is inverted between the external pin and the software).

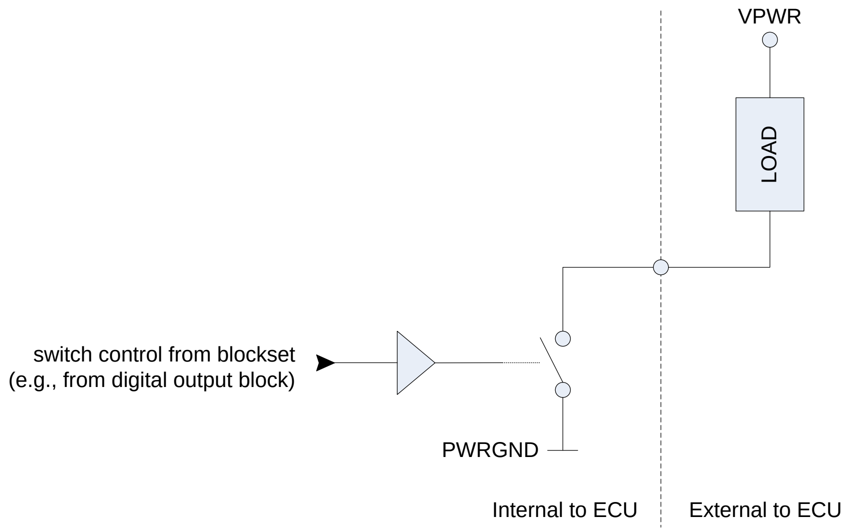
> **Note**
>
> The external signals are all low pass filtered to prevent signals of excessive frequency from tying up the target processor.

> **Note**
>
> If any of the pins A1, A5, A7, A11, A15, A17, A21, A25, A31, A35, C5, C10, C15 and C20 are not being used as digital outputs then it is possible for them to be used as digital inputs with a loading of 41k to V_{GND} and no input filter. Providing the output transistor is switched off, the pin can be driven by an external source and the pin's digital monitor will reflect the actual state of the pin. The digital monitor signal is not inverted: low if <= 3.5V and high if >= 6.9V.

4.11. Digital outputs

The digital outputs (pins A1, A5, A7, A11, A15, A17, A21, A25, A31, A35, C5, C10, C15 and C20) are low-side drivers. That is, the ECU switches the output pin to ground, the actuator is connected to the output pin and the battery.

Figure 4.3. Switching arrangement for digital outputs



> **Note**
>
> The underlying timer for the M461 I/O has a rate of 4MHz.

The low-side digital outputs contain internal monitoring circuitry that provides diagnostic information. However, as a consequence a small leakage current will flow through the actuator when the low-side output driver is turned off. Refer to Table 4.3, "Low-side digital output leakage current" for typical leakage currents at specified operating voltages.

Table 4.3. Low-side digital output leakage current

Supply Voltage (V)	Typical Leakage Current (mA)
12	0.400
24	0.800

4.12. Digital output — state monitoring

The actual state of an output pin can be monitored using a corresponding internal *digital monitor* and internal *analogue monitor* channel. The digital monitor channel simply reflects the on or off state of the actual output. The analogue monitor channel measures the actual voltage at the pin after scaling.

4.13. Digital output — driver protection

The over-current trip state of an output pin can be monitored using a corresponding internal *over-current monitor* channel. In normal operation the internal over-current trip channel will be 1. If the output channel experiences an over-current, the output channel will be forced off by the ECU and the over-current trip channel will be set to 0.

The over-current trip latch can be cleared and the tripped outputs enabled by the *pss_OvercurTripReset* Simulink block or by calling the *pss_overcur_trip_reset()* C-API function.

> **Note**
>
> To help component heat dissipation and to help prevent component stress, the platform software ensures there is at least 50ms between each request to clear the over-current trip latches.

4.14. Serial inputs and outputs

Some of the internal and external inputs and outputs are classed as serial. The connector pinout tables and internal channel tables above specify whether a pin or channel is serial or not.

When a serial input is read, the measurement reflects the value of the input taken last time the application task ended. I.e., the value of the input is delayed by one cycle of the task period. When a serial output is set, the driven state is updated at the end of the current application task. I.e., there is a delay between requesting a change in the output state, and the output state honoring that request.

4.15. Communication — CAN

The CAN buses (pins A37+A36 and C37+C36) are implemented using high-speed CAN transceivers. Each CAN bus has terminating resistors fitted. Fleet and developer ECUs support two CAN buses (see the pin details for more information).

4.16. Memory — configuration

The ECU supports different memory configurations for application, calibration and RAM sizes, some of which require external calibration RAM (see Section 4.18, “Memory — calibration capabilities”).

Table 4.4. Memory configurations supported

Configuration	App size (KiB)	Cal size (KiB)	RAM size (KiB)	External RAM required?	Run-time calibration supported?
A [a]	512	256	64	N	N
	512	256	64	Y	Y
B	512	256	832	Y	Y
C	640	128	192	Y	Y
D	768	64	768	Y	Y

[a] If an OpenECU target that supports memory configuration is loaded with an application in which no such configuration has been specified, then configuration A will be used as the default.

4.17. Memory — non-volatile storage and lifetime

The ECU supports non-volatile memory storage in Flash. Battery backed RAM is not supported.

The processor's Flash memory is split into small and large memory blocks. The application and calibration are stored in large blocks, whilst DTC information, freeze frames and so on are stored in small blocks.

The largest Flash block can take up to approximately 7.5 seconds to erase. This occurs in an environment where the Flash has been erased and programmed many times at its temperature extreme. The typical erase time is smaller, especially at ambient temperatures. Reprogramming an ECU (where many large blocks would be erased), or storing DTC information across power cycles, can therefore take some time. Users and applications should take this into consideration.

The minimum number of erase cycles is approximately 1,000 for large Flash blocks and 100,000 for small Flash blocks. This occurs in an environment where the Flash has been erased and programmed many times at its temperature extreme. The typical number of erase cycles is larger, especially at ambient temperatures.

The minimum data retention is approximately 5 years for blocks which have been erased less than 100,000 times, and approximately 20 years for blocks which have been erased less than 1,000 times.

The information about the Flash has been taken from Freescale's MPC5534 Microcontroller Data Sheet document, revision 4 (dated Mar 2008).

4.18. Memory — calibration capabilities

The ECU supports both offline calibration (where all of the ECU's calibration memory is reprogrammed whilst the application is stopped) and online calibration (where individual calibrations can be modified whilst the application runs). These calibration capabilities are supported through two ECU types:

- Developer ECUs — Supports offline and online calibration Uses an external RAM device to map calibrations, normally stored in non-volatile memory, to RAM to support modifications of calibration whilst the application runs. This provides all of the processor's RAM for the application and platform library, whilst adding additional RAM to support calibration.
- Fleet ECUs — Does not provide external RAM or the ability to calibrate whilst the application runs (offline calibration is still supported). These units are lower-cost and intended for fleet trials or production.

4.19. System modes

The ECU can run in one of two system modes: reprogramming mode and application mode. In *reprogramming* mode, the ECU can be reprogrammed with application software from a calibration tool. In *application* mode, the ECU runs the programmed application software. The ECU enters reprogramming mode either by measuring the external *FEPS* A2 pin at power up, or when attempting to reflash over CCP when the application is not inhibiting reflashing.

Table 4.5. System mode selection

Voltage	System mode
> +17V	Enter reprogramming mode. If valid application software has previously been programmed, then use the CCP settings from that application, otherwise use the default CCP settings.
< -16V	Enter reprogramming mode. Use the default CCP settings.
Otherwise	Enter application mode if valid application software has previously been programmed, otherwise enter reprogramming mode.

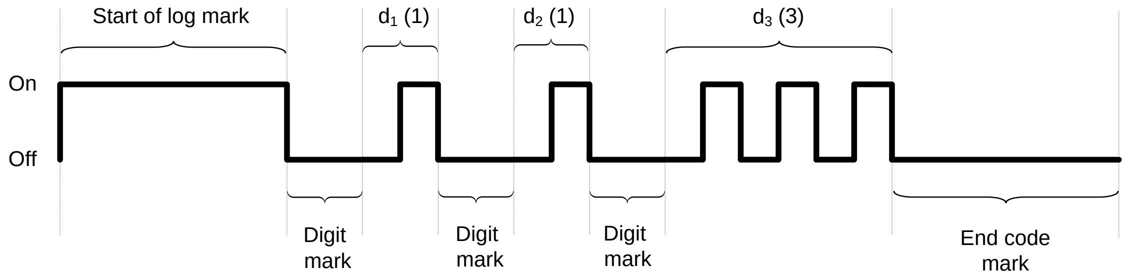
> **Note**
>
> The default CCP baud rate for the M461 is 250kbps.

4.20. Flash codes

The ECU has a dedicated external pin (A27) for flashing a lamp. The flash sequence represents a set of codes. Each code is a three digit number, where each digit is flashed a number of times equal to its value.

An example would be the flash sequence for code *113*. The flash sequence is broken down into a series on marks, or on and off pulses as follows:

Figure 4.4. Flash code sequence



Each of the marks lasts for a specific duration:

Table 4.6. Flash code example

Mark	Duration and meaning
Start of log mark	3s — marks the start of the flash code list
Digit mark	1s — marks the start of a digit
d_n	*n*s — *n* digits, where the output is turned off for 0.5 second, then for 0.5 seconds, *n* times
End code mark	3s — marks the end of a code (i.e., end of 3 digits)

After the *end code mark*, the ECU will either flash the next code, or return to the start of the list and flash the first code. The ECU always has at least one code to flash.

Each code represents information about the ECU state. If there is no flash sequence, or a malformed flash sequence, then the ECU is malfunctioning. Otherwise, the flash sequence will represent one of the following codes:

Table 4.7. Flash codes

Code	Meaning
111	In application mode — no other condition has been detected.
112	In reprogramming mode with the FEPS pin negative.
113	In reprogramming mode with the FEPS pin high.
114	In reprogramming mode via a FEPS-less reprogramming request.
115	In reprogramming mode because no valid application software exists.
116	In reprogramming mode due to FEPS pin electrical failure.

Code	Meaning
117	In reprogramming mode due to repeated reset during application mode.
118	In reprogramming mode due to failed application checksum tests.
128	In reprogramming mode due to failed memory check tests.
119	In reprogramming mode due to a FEPS-less ISO reprogramming request.
121	In reprogramming mode due to an unknown failure.
123	In reprogramming mode due to a watchdog reset.
222	In reprogramming mode due to the application not having a valid license.

4.21. Calibration capabilities

Developer units have the capability to accept calibration changes while the application software is running. Fleet units do not have this capability.

4.22. Floating point capabilities

The ECU closely adheres to the IEEE-754 for floating point numbers.

When using Simulink, floating point Simulink models are supported — all calculations are performed using single-precision (even if the model uses double-precision, the ECU performs calculations using single-precision).

When using the C-API, floating point applications are supported — all calculations are performed using single or double precision, as determined by the application code (although double precision will incur some software overhead — see the compiler reference manual for further details).

The rounding mode is set to *round-to-nearest*. In some conditions, the ECU will not adhere to the IEEE-754 standard:

Table 4.8. Floating point conditions

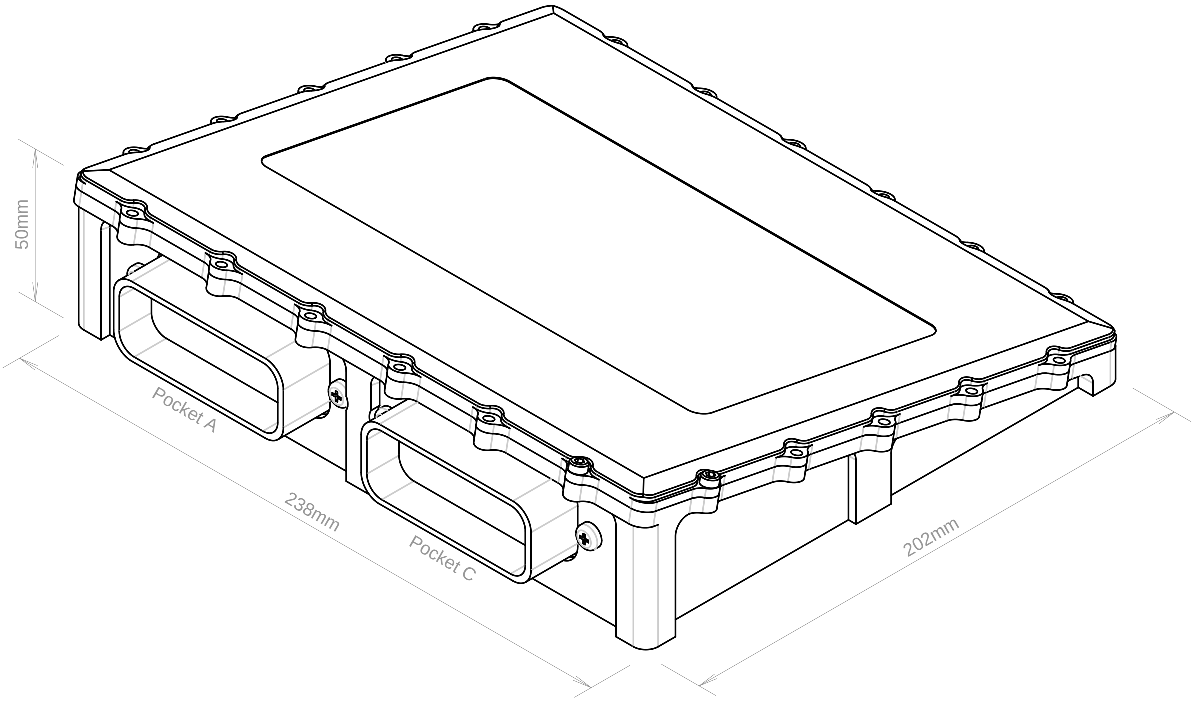
Condition	Result
Underflow	The result of a calculation underflow is ±*0*. The sign is based on the signs of the operands.
Overflow	The result of a calculation overflow is ±*max* where *max* is approximately 3.4×10^{38}. The sign is based on the signs of the operands.
Divide by zero	

The ECU does not generate ±*Inf*, *NaN* or a denormalised number as the result of a calculation.

Chapter 5. Dimensions

The ECU has the following dimensions:

Figure 5.1. Outline of physical dimensions



Appendix A. Contact information

If you have questions, or are experiencing issues with OpenECU please see the FAQ website:

website
: *Support.OpenECU.com* [http://Support.OpenECU.com]

If you still have questions after searching through the FAQ, or want to discuss sales or proposals, you can contact main office:

Tel
: +1 734 656 0140

Fax
: +1 734 656 0141

during normal working hours (Mon to Fri, 0930 to 1700 EST).