M250 Technical Specification 29T-068276TK-05

Release 2.6.0 (r2016-1)

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Chapter 1. Technical specification

This document is the technical specification for OpenECU part *01T-068276-03M05-000* or greater. Within this document, that part is referred to as *M250-000*.

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-068276ER-xE M250 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:

- M250D-000 — for development and testing, including full interactive calibration tool integration.

Table 1.1. Specification

Specification	Variant
	M250D-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	1
Sensor supplies	2
Inputs	19
Outputs	13
CAN buses	2
LIN buses	-
RS232 links	-
Connectors	1x46

Specification	Variant
	M250D-000
Weight	1.1Kg
Vibration	Ford class IIIB
Shock capability	Ford class II
Enclosure	IP67 [c]
EMC	Ford EMC CS 2009, category AX
Partial operating voltage	6 to 36V [d]
Full operating voltage	6.5 to 36V [e]
Standby current (typical)	<0.01mA at 12V [f]
Operating current (typical)	200mA at 12V [g]
Operating temperature range	-40 to +105°C
Storage temperature range (installation)	-40 to +120°C
Storage temperature range (shipping)	-40 to +85°C

[a] Target ECU available for general use.
[b] See list of possible memory configurations in section 'Memory - configuration'.
[c] Designed for chassis mounted applications.
[d] At room temperature
[e] Designed for 12V or 24V vehicles.
[f] <0.01mA at 24V.
[g] 125mA 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	-	A2
ECU ground	1	-	A31
Actuator supply	1	-	A16
Sensor supply	2	-	A25, A39
Module control, status			
Ignition sense	1	-	A26
Module control FEPS	1	-	A27
Module status Flash code	1	-	A27
Communication			
CAN buses	2	-	A28+A43, A29+A44
Inputs — time based			

I/O type	External	Internal	Pins
Analogue	19	44	A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A19, A20, A21, A22, A23, A24
Digital	7	26	A10, A11, A12, A13, A14, A15, A26
Frequency	6	12	A10, A11, A12, A13, A14, A15
PWM	6	-	A10, A11, A12, A13, A14, A15
Quadrature	6	-	A10, A11, A12, A13, A14, A15
Outputs — time based			
Digital	11	13	A1, A17, A18, A30, A32, A33, A34, A35, A36, A45, A46
H-bridge	2	-	A17+A46, A30+A1
PWM	11	6	A1, A17, A18, A30, A32, A33, A34, A35, A36, A45, A46
PWM synchronised	3	-	A32, A33, A34
Inputs — angle based			
Crank-shaft primary	1	-	A10
Cam-shaft	1	-	A11
Analogue	19	64	A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A19, A20, A21, A22, A23, A24
Analogue injector duration	14	-	A3, A4, A5, A6, A7, A8, A9, A14, A15, A19, A21, A22, A23, A24
Outputs — angle based			
Injector saturating	6	-	A32, A33, A34, A35, A36, A45
Ignition	7	-	A18, A32, A33, A34, A35, A36, A45

Chapter 2. Connector pinout

The M250-000 variants have one ECU connector (pocket) named A, which has a pinout as given in the following table. 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.

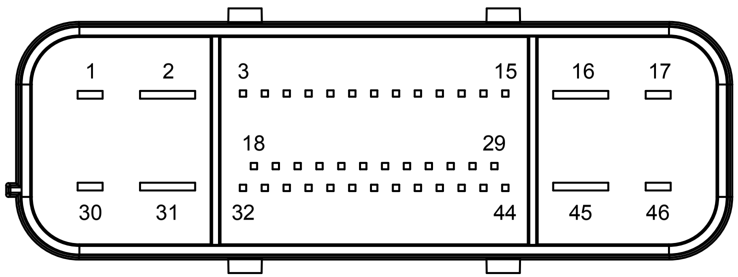


Table 2.1. Part numbers of the mating connector

Supplier	Part number	Part
TE	1326110-1	Cable mount connector (right handed)
	1326341-1	Cable mount connector (left handed)
	1326113-1	Cover

Table 2.2. Part numbers for the 6.3 mm pin

Supplier	Part number	Colour	Part
Yazaki	7116-4142-02	Tin	Female crimp contact
	7158-3081-50	Red	Seal (for wire 1.40 mm - 2.10 mm)
	7158-3082-90	Blue	Seal (for wire 2.18 mm - 3.00 mm)
	7158-3083	Black	
	7158-3080-60	Green	Plug for unused position
Pins A2, A16, A31 and A45			

Table 2.3. Part numbers for the 2.8 mm pin

Supplier	Part number	Colour	Part
TE	1326032-4	Tin	Female crimp contact
Yazaki	7158-3111-60	Green	Seal (for wire 1.19 mm - 1.90 mm)
	7158-3112-70	Yellow	Seal (for wire 1.88 mm - 2.10 mm)
	7158-3113-40	White	Seal (for wire 2.18 mm - 3.00 mm)
	7158-3114-90	Blue	Plug for unused position
Pins A1, A17, A30 and A46			

Table 2.4. Part numbers for the 0.64 mm pin

Supplier	Part number	Colour	Part
TE	0638551-1	Tin	Female crimp contact

Supplier	Part number	Colour	Part
Deutsch	0413-204-2005	Red	Plug for unused position
Pins A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A18, A19, A20, A21, A22, A23, A24, A25, A26, A27, A28, A29, A32, A33, A34, A35, A36, A39, A40+A41, A43 and A44			

Table 2.5. Connector pinout — Pocket A

Main connector — Pocket A								
Pin	P	Function	I/O	M	Loading	Filter	Range	Notes
A1		Digital	O	Y	Low-high side		8A	Related to internal channels DOT select-high-side, Monitor (c), Monitor (ct), Monitor (d) and Monitor (v).
								Associated with A30 if configured as an H-bridge output; otherwise, it can be selected to be a low-side or high-side output. Range given is for a resistive load. For inductive loads this rating may need to be reduced depending on inductance, duty cycle and operating temperature. Related to internal channels DOT select-high-side, Monitor (c), Monitor (ct), Monitor (d) and Monitor (v).
A2		V_{PWR}	P	Y			40A	Related to internal channel AIN VPWR.
A3		Analogue (RTD)	I		10k to 5V	1.72KHz	0mV to 416.7mV	12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, V_a=V_m*0.08334.
A4		Analogue (RTD)	I		10k to 5V	1.72KHz	0mV to 416.7mV	12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, V_a=V_m*0.08334.
A5		Analogue (RTD)	I		10k to 5V	1.72KHz	0mV to 416.7mV	12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, V_a=V_m*0.08334.
A6		Analogue (RTD)	I		10k to 5V	1.72KHz	0mV to 416.7mV	12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, V_a=V_m*0.08334.
A7		Analogue (RTD)	I		10k to 5V	1.72KHz	0mV to 416.7mV	12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, V_a=V_m*0.08334.
A8		Analogue (RTD)	I		10k to 5V	1.72KHz	0mV to 416.7mV	12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, V_a=V_m*0.08334.

Main connector — Pocket A								
Pin	**P**	**Function**	**I/O**	**M**	**Loading**	**Filter**	**Range**	**Notes**
A9		Analogue (RTD)	I		10k to 5V	1.72KHz	0mV to 416.7mV	12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, $V_a=V_m*0.08334$.
A10		Digital	I		4k7 to V_{PWR} through diode	7.8kHz	0V to V_{PWR}	Crank-shaft position sensor. V_{LH} >= 3.5V V_{HL} <= 1.5V.
		Analogue				100Hz	0V to 5V	12-bit unsigned conversion.
A11		Digital	I		4k7 to V_{PWR} through diode	7.8kHz	0V to V_{PWR}	Cam-shaft position sensor. V_{LH} >= 3.5V V_{HL} <= 1.5V.
		Analogue				100Hz	0V to 5V	12-bit unsigned conversion.
A12		Digital	I		4k7 to V_{PWR} through diode	7.8kHz	0V to V_{PWR}	V_{LH} >= 3.5V V_{HL} <= 1.5V.
		Analogue				100Hz	0V to 5V	12-bit unsigned conversion.
A13		Digital	I		4k7 to V_{PWR} through diode	7.8kHz	0V to V_{PWR}	V_{LH} >= 3.5V V_{HL} <= 1.5V.
		Analogue				100Hz	0V to 5V	12-bit unsigned conversion.
A14		Digital	I		4k7 to V_{PWR} through diode	7.8kHz	0V to V_{PWR}	V_{LH} >= 3.5V V_{HL} <= 1.5V.
		Analogue				100Hz	0V to 5V	12-bit unsigned conversion.
A15		Digital	I		4k7 to V_{PWR} through diode	7.8kHz	0V to V_{PWR}	V_{LH} >= 3.5V V_{HL} <= 1.5V.
		Analogue				100Hz	0V to 5V	12-bit unsigned conversion.
A16		Actuator supply	P	Y	High side		20A	High side actuator power. Related to internal channels Monitor (ct), Monitor (d) and Monitor (v).
A17		Digital	O	Y	Low-high side		8A	Related to internal channels DOT select-high-side, Monitor (c), Monitor (ct), Monitor (d) and Monitor (v).
								Associated with A46 if configured as an H-bridge output; otherwise, it can be selected to be a low-side or high-side output. Range given is for a resistive load. For inductive loads this rating may need to be reduced depending on inductance, duty cycle and operating temperature. . Related to internal channels DOT select-high-side, Monitor (c), Monitor (ct), Monitor (d) and Monitor (v).
A18		Digital	O	Y	Low side		500mA	Related to internal channels Monitor (d) and Monitor (v).

Main connector — Pocket A								
Pin	**P**	**Function**	**I/O**	**M**	**Loading**	**Filter**	**Range**	**Notes**
								Coil/spark (smart) driver. Related to internal channels Monitor (d) and Monitor (v).
A19		Analogue	I		51k to V_{GND}	99Hz	0V to 5V	12-bit unsigned conversion.
A20		Analogue	I		51k to V_{GND}	99Hz	0V to 5V	12-bit unsigned conversion.
A21		Analogue	I		51k to V_{GND}	99Hz	0V to 5V	12-bit unsigned conversion.
A22		Analogue	I		51k to V_{GND}	99Hz	0V to 5V	12-bit unsigned conversion.
A23		Analogue	I		51k to V_{GND}	99Hz	0V to 5V	12-bit unsigned conversion.
A24		Analogue	I		51k to V_{GND}	99Hz	0V to 5V	12-bit unsigned conversion.
A25		Sensor supply	P	Y			5V, 250mA	Sensor supply 1. Can be turned on and off by the application for diagnostics purposes. Related to internal channels DOT disable-EXT-PSU1 and Monitor (v).
A26		Digital	I		4k7 to V_{GND}	258Hz	0V to V_{PWR}	Key position (ignition sense) input. V_{LH} >= 4.55V V_{HL} <= 3.95V. Related to internal channel DOT disable-PSU-hold.
A27		FEPS	I		82K series followed by bias of 10K to 5V and 11K to V_{GND}	323Hz	±18V	Module flash programming control. Mutually exclusive use with Flash code output function. You can not connect both at the same time.
		Flash code	O		Low side		10mA	ECU status information. Mutually exclusive use with FEPS input function. You can not connect both at the same time.
A28		CAN+ (high)	C		No termination resistor			CAN bus 0 high (+ve), see also: A43. Related to internal channel DOT disable-CAN.
A29		CAN+ (high)	C		124R			CAN bus 1 high (+ve), see also: A44. Related to internal channel DOT disable-CAN.
A30		Digital	O	Y	Low-high side		8A	Related to internal channels DOT select-high-side, Monitor (c), Monitor (ct), Monitor (d) and Monitor (v).
								Associated with A1 if configured as an H-bridge output; otherwise, it can be selected to be a low-side or high-side

Main connector — Pocket A								
Pin	**P**	**Function**	**I/O**	**M**	**Loading**	**Filter**	**Range**	**Notes**
								output. Range given is for a resistive load. For inductive loads this rating may need to be reduced depending on inductance, duty cycle and operating temperature. Related to internal channels DOT select-high-side, Monitor (c), Monitor (ct), Monitor (d) and Monitor (v).
A31		V_{GND}	P				40A	
A32		Digital (injector)	O	Y	Low side		5A/2A	The pin function (injector or digital) is software selectable. Related to internal channels DOT injector-clock, Monitor (c), Monitor (ct), Monitor (d) and Monitor (v).
		Digital						Coil/spark (smart) driver. Related to internal channels DOT injector-clock, Monitor (c), Monitor (ct), Monitor (d) and Monitor (v).
A33		Digital (injector)	O	Y	Low side		5A/2A	The pin function (injector or digital) is software selectable. Related to internal channels DOT injector-clock, Monitor (c), Monitor (ct), Monitor (d) and Monitor (v).
		Digital						Coil/spark (smart) driver. Related to internal channels DOT injector-clock, Monitor (c), Monitor (ct), Monitor (d) and Monitor (v).
A34		Digital (injector)	O	Y	Low side		5A/2A	The pin function (injector or digital) is software selectable. Related to internal channels DOT injector-clock, Monitor (c), Monitor (ct), Monitor (d) and Monitor (v).
		Digital						Coil/spark (smart) driver. Related to internal channels DOT injector-clock, Monitor (c), Monitor (ct), Monitor (d) and Monitor (v).
A35		Digital (injector)	O	Y	Low side		2A	Related to internal channels Monitor (c), Monitor (ct), Monitor (d) and Monitor (v).
		Digital						
A36		Digital (injector)	O	Y	Low side		8A	Related to internal channels Monitor (ct), Monitor (d) and Monitor (v).
		Digital						

Main connector — Pocket A								
Pin	**P**	**Function**	**I/O**	**M**	**Loading**	**Filter**	**Range**	**Notes**
								Although this output can be used for PWM drive, no recirculation diode is fitted in the standard hardware. Related to internal channels Monitor (ct), Monitor (d) and Monitor (v).
A37	No function.							
A38	No function.							
A39		Sensor supply	P	Y			5V, 250mA	Sensor supply 2. Can be turned on and off by the application for diagnostics purposes. Related to internal channels DOT disable-EXT-PSU2 and Monitor (v).
A40		Sensor ground	P	Y				A40 and A41 connected together internally. Related to internal channel AIN extern-ground.
A41		Sensor ground	P	Y				A40 and A41 connected together internally. Related to internal channel AIN extern-ground.
A42	No function.							
A43		CAN- (low)	C		No termination resistor			CAN bus 0 low (-ve), see also: A28. Related to internal channel DOT disable-CAN.
A44		CAN- (low)	C		124R			CAN bus 1 low (-ve), see also: A29. Related to internal channel DOT disable-CAN.
A45		Digital (injector)	O	Y	Low side		10A	Related to internal channels Monitor (c), Monitor (ct), Monitor (d) and Monitor (v).
		Digital						
A46		Digital	O	Y	Low-high side		8A	Related to internal channels DOT select-high-side, Monitor (c), Monitor (ct), Monitor (d) and Monitor (v).
								Associated with A17 if configured as an H-bridge output; otherwise, it can be selected to be a low-side or high-side output. Range given is for a resistive load. For inductive loads this rating may need to be reduced depending on inductance, duty cycle and operating temperature. Related to internal channels DOT select-high-side, Monitor (c), Monitor (ct), Monitor (d) and Monitor (v).

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 signed conversion. Not available on the default optioned hardware.
AIN accelerometer-y	I	Analogue	0V to 5V	Internal Y-axis accelerometer signal. 12-bit signed conversion. Not available on the default optioned hardware.
AIN accelerometer-z	I	Analogue	0V to 5V	Internal Z-axis accelerometer signal. 12-bit signed conversion. Not available on the default optioned hardware.
AIN gyro-angle-x	I	Analogue	0V to 5V	Internal X-axis gyroscope angle. 14-bit unsigned conversion. Not available on the default optioned hardware.
AIN gyro-angle-y	I	Analogue	0V to 5V	Internal Y-axis gyroscope angle. 14-bit unsigned conversion. Not available on the default optioned hardware.
AIN gyro-angle-z	I	Analogue	0V to 5V	Internal Z-axis gyroscope angle. 14-bit unsigned conversion. Not available on the default optioned hardware.
AIN gyro-temp-x	I	Analogue	0V to 5V	Internal X-axis gyroscope temperature. 12-bit signed conversion. Not available on the default optioned hardware.
AIN gyro-temp-y	I	Analogue	0V to 5V	Internal Y-axis gyroscope temperature. 12-bit signed conversion. Not available on the default optioned hardware.
AIN gyro-temp-z	I	Analogue	0V to 5V	Internal Z-axis gyroscope temperature. 12-bit signed conversion. Not available on the default optioned hardware.
AIN gyro-x	I	Analogue	0V to 5V	Internal X-axis gyroscope signal. 14-bit signed conversion. Not available on the default optioned hardware.
AIN gyro-y	I	Analogue	0V to 5V	Internal Y-axis gyroscope signal. 14-bit signed conversion. Not available on the default optioned hardware.
AIN gyro-z	I	Analogue	0V to 5V	Internal Z-axis gyroscope signal. 14-bit signed conversion. Not available on the default optioned hardware.

Signal	I/O	Signal type	Range	Notes
AIN internal-ecu-temp	I	Analogue	241mV to 4981mV	Internal ECU temperature measurement. Conversion from voltage to temperature is non-linear and specified by a look-up table. 12-bit unsigned conversion.
AIN PSU+2.5VD	I	Analogue	0V to 5V	Internal 2.5V precision reference. 12-bit unsigned conversion.
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 monitor				
Monitor (c) (pin A1)	I	Analogue	±12.5A	Digital output current monitor. 12-bit unsigned conversion. To convert voltage (V) to current (I) use the equation, I=(V-2.5)*5.
Monitor (c) (pin A17)	I	Analogue	±12.5A	Digital output current monitor. 12-bit unsigned conversion. To convert voltage (V) to current (I) use the equation, I=(V-2.5)*5.
Monitor (c) (pin A30)	I	Analogue	±12.5A	Digital output current monitor. 12-bit unsigned conversion. To convert voltage (V) to current (I) use the equation, I=(V-2.5)*5.
Monitor (c) (pin A32)	I	Analogue	0A to 6.25A	Digital output current monitor. 12-bit unsigned conversion. To convert voltage (V) to current (I) use the equation, I=V*1.25.

Signal	I/O	Signal type	Range	Notes
Monitor (c) (pin A33)	I	Analogue	0A to 6.25A	Digital output current monitor. 12-bit unsigned conversion. To convert voltage (V) to current (I) use the equation, I=V*1.25.
Monitor (c) (pin A34)	I	Analogue	0A to 6.25A	Digital output current monitor. 12-bit unsigned conversion. To convert voltage (V) to current (I) use the equation, I=V*1.25.
Monitor (c) (pin A35)	I	Analogue	0A to 2.5A	Digital output current monitor. 12-bit unsigned conversion. To convert voltage (V) to current (I) use the equation, I=V*0.5.
Monitor (c) (pin A45)	I	Analogue	0A to 12.5A	Digital output current monitor with 884Hz filter. 12-bit unsigned conversion. To convert voltage (V) to current (I) use the equation, I=V*2.5.
Monitor (c) (pin A46)	I	Analogue	±12.5A	Digital output current monitor. 12-bit unsigned conversion. To convert voltage (V) to current (I) use the equation, I=(V-2.5)*5.
Current trip monitor				
Monitor (ct) (pin A1)	I	Digital	0 or 1	Digital input indicating current trip. The input is guaranteed to trip when I < -9.95A or I > 10.85A, and will not trip when -8.0A <= I <= 8.0A. Serial input.
Monitor (ct) (pin A16)	I	Digital	0 or 1	Digital input indicating current trip. The input is guaranteed to trip when I > 26.5A, and will not trip when I <= 20A. Serial input.
Monitor (ct) (pin A17)	I	Digital	0 or 1	Digital input indicating current trip. The input is guaranteed to trip when I < -9.95A or I > 10.85A, and will not trip when -8.0A <= I <= 8.0A. Serial input.
Monitor (ct) (pin A30)	I	Digital	0 or 1	Digital input indicating current trip. The input is guaranteed to trip when I < -9.95A or I > 10.85A, and will not trip when -8.0A <= I <= 8.0A. Serial input.
Monitor (ct) (pin A32)	I	Digital	0 or 1	Digital input indicating current trip. Hold: Guaranteed to trip when I > 2.35A, and will not trip when I <= 1.75A. Peak:

Signal	I/O	Signal type	Range	Notes
				Guaranteed to trip when I > 5.8A, and will not trip when I <= 5.0A. Serial input.
Monitor (ct) (pin A33)	I	Digital	0 or 1	Digital input indicating current trip. Hold: Guaranteed to trip when I > 2.35A, and will not trip when I <= 1.75A. Peak: Guaranteed to trip when I > 5.8A, and will not trip when I <= 5.0A. Serial input.
Monitor (ct) (pin A34)	I	Digital	0 or 1	Digital input indicating current trip. Hold: Guaranteed to trip when I > 2.35A, and will not trip when I <= 1.75A. Peak: Guaranteed to trip when I > 5.8A, and will not trip when I <= 5.0A. Serial input.
Monitor (ct) (pin A35)	I	Digital	0 or 1	Digital input indicating current trip. The input is guaranteed to trip when I > 11.6A, and will not trip when I <= 10.0A. Serial input.
Monitor (ct) (pin A36)	I	Digital	0 or 1	Digital input indicating current trip. The input is guaranteed to trip when I >= 11.0A, and will not trip when I <= 8.2A. Serial input.
Monitor (ct) (pin A45)	I	Digital	0 or 1	Digital input indicating current trip. The input is guaranteed to trip when I > 11.6A, and will not trip when I <= 10.0A. Serial input.
Monitor (ct) (pin A46)	I	Digital	0 or 1	Digital input indicating current trip. The input is guaranteed to trip when I < -9.95A or I > 10.85A, and will not trip when -8.0A <= I <= 8.0A. Serial input.
Digital				
DIN gyro-x-self-test-result	I	Digital	0 or 1	Read the self-test digital signal result on the Gyro-x device. Not available on the default optioned hardware.
DIN gyro-y-self-test-result	I	Digital	0 or 1	Read the self-test digital signal result on the Gyro-y device. Not available on the default optioned hardware.
DIN gyro-z-self-test-result	I	Digital	0 or 1	Read the self-test digital signal result on the Gyro-z device. Not available on the default optioned hardware.
DOT accel-self-test	O	Digital	0 or 1	Control self-test digital signal to the accelerometer device. Not available on the default optioned hardware.

Signal	I/O	Signal type	Range	Notes
DOT disable-CAN (pin A28 and A43)	O	Digital	0 or 1	Set to zero to enable CAN transmission, set to one to disable.
DOT disable-CAN (pin A29 and A44)	O	Digital	0 or 1	Set to zero to enable CAN transmission, set to one to disable.
DOT disable-EXT-PSU1 (pin A25)	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-PSU2 (pin A39)	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-PSU-hold (pin A26)	O	Digital	0 or 1	Control power supply to ECU in conjunction with the key position (ignition sense) input. Set the output to zero to enable power hold and one to disable it.
DOT gyro-x-self-test	O	Digital	0 or 1	Control self-test digital signal to the Gyro-X device. Not available on the default optioned hardware.
DOT gyro-y-self-test	O	Digital	0 or 1	Control self-test digital signal to the Gyro-Y device. Not available on the default optioned hardware.
DOT gyro-z-self-test	O	Digital	0 or 1	Control self-test digital signal to the Gyro-Z device. Not available on the default optioned hardware.
DOT injector-clock (pin A32)	O	Digital	0 or 1	PWM clock signal for injector (no effect if A32 is configured for PWM mode).
DOT injector-clock (pin A33)	O	Digital	0 or 1	PWM clock signal for injector (no effect if A33 is configured for PWM mode).
DOT injector-clock (pin A34)	O	Digital	0 or 1	PWM clock signal for injector (no effect if A34 is configured for PWM mode).
DOT select-high-side (pin A1)	O	Digital	0 or 1	Set to zero to select low-side, set to one to select high-side.
DOT select-high-side (pin A17)	O	Digital	0 or 1	Set to zero to select low-side, set to one to select high-side.
DOT select-high-side (pin A30)	O	Digital	0 or 1	Set to zero to select low-side, set to one to select high-side.
DOT select-high-side (pin A46)	O	Digital	0 or 1	Set to zero to select low-side, set to one to select high-side.
Digital monitor				

Signal	I/O	Signal type	Range	Notes
Monitor (d) (pin A1)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 6.95V V_{HL} <= 3.25V.
Monitor (d) (pin A16)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 6.95V V_{HL} <= 3.25V.
Monitor (d) (pin A17)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 6.95V V_{HL} <= 3.25V.
Monitor (d) (pin A18)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 6.95V V_{HL} <= 3.25V.
Monitor (d) (pin A30)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 6.95V V_{HL} <= 3.25V.
Monitor (d) (pin A32)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 6.95V V_{HL} <= 3.25V.
Monitor (d) (pin A33)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 6.95V V_{HL} <= 3.25V.
Monitor (d) (pin A34)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 6.95V V_{HL} <= 3.25V.
Monitor (d) (pin A35)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 6.95V V_{HL} <= 3.25V.
Monitor (d) (pin A36)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 6.95V V_{HL} <= 3.25V.
Monitor (d) (pin A45)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 6.95V V_{HL} <= 3.25V.
Monitor (d) (pin A46)	I	Digital	0 or 1	Digital output state monitor. V_{LH} >= 6.95V V_{HL} <= 3.25V.
Memory check				
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				
AIN extern-ground (pin A40 and A41)	I	Analogue	0V to 5V	Sensor ground voltage monitor. 12-bit unsigned conversion.
AIN VPWR (pin A2)	I	Analogue	0V to 40V	Switched power supply voltage monitor. 12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, V_a=V_m*8.
Monitor (v) (pin A1)	I	Analogue	0V to 33V	Digital output voltage monitor. 12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, V_a=V_m*33/5.

Signal	I/O	Signal type	Range	Notes
Monitor (v) (pin A16)	I	Analogue	0V to 33V	Digital output voltage monitor. 12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, $V_a=V_m*33/5$.
Monitor (v) (pin A17)	I	Analogue	0V to 33V	Digital output voltage monitor. 12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, $V_a=V_m*33/5$.
Monitor (v) (pin A18)	I	Analogue	0V to 33V	Digital output voltage monitor. 12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, $V_a=V_m*33/5$.
Monitor (v) (pin A25)	I	Analogue	0V to 5V	Sensor supply voltage monitor. 12-bit unsigned conversion.
Monitor (v) (pin A30)	I	Analogue	0V to 33V	Digital output voltage monitor. 12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, $V_a=V_m*33/5$.
Monitor (v) (pin A32)	I	Analogue	0V to 33V	Digital output voltage monitor with 884Hz filter. 12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, $V_a=V_m*33/5$.
Monitor (v) (pin A33)	I	Analogue	0V to 33V	Digital output voltage monitor with 884Hz filter. 12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, $V_a=V_m*33/5$.
Monitor (v) (pin A34)	I	Analogue	0V to 33V	Digital output voltage monitor with 884Hz filter. 12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, $V_a=V_m*33/5$.
Monitor (v) (pin A35)	I	Analogue	0V to 33V	Digital output voltage monitor with 884Hz filter. 12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, $V_a=V_m*33/5$.
Monitor (v) (pin A36)	I	Analogue	0V to 33V	Digital output voltage monitor. 12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, $V_a=V_m*33/5$.
Monitor (v) (pin A39)	I	Analogue	0V to 5V	Sensor supply voltage monitor. 12-bit unsigned conversion.

Signal	I/O	Signal type	Range	Notes
Monitor (v) (pin A45)	I	Analogue	0V to 33V	Digital output voltage monitor. 12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, $V_a=V_m*33/5$.
Monitor (v) (pin A46)	I	Analogue	0V to 33V	Digital output voltage monitor. 12-bit unsigned conversion. To convert measured voltage (V_m) to actual voltage (V_a) use the equation, $V_a=V_m*33/5$.

Chapter 4. Operational details

4.1. ECU power

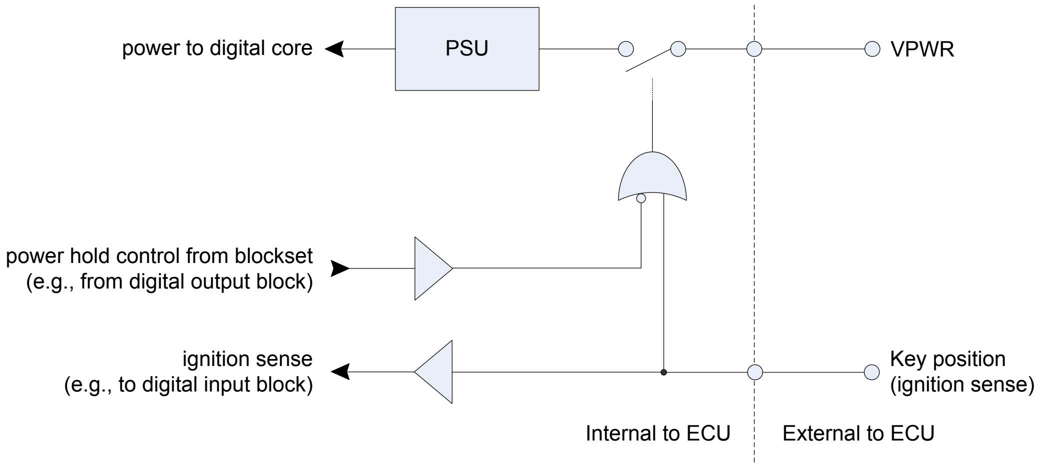
The power supply pin (V_{PWR} A2) and the ground pin (V_{GND} A31) are both rated to 40A.

The ECU is designed for 12V or 24V vehicles and will operate over the range 6.5V to 36V. The ECU is protected against reverse supply connection (for at least 60 seconds). All inputs and outputs are protected against short-to-V_{PWR} or short-to-V_{GND} over normal operating range.

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} A2) and key position (ignition sense) input (pin A26) are asserted. The key position input (pin A26) 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 disable-PSU-hold 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 disable-PSU-hold channel low *as soon as* the external key position input (pin A26) is closed and only set high once all required shutdown tasks have completed.

4.3. ECU power — actuator supplies

The ECU can provide power to actuators through a high-side power pin (A16) and control if this pin is asserted or not. See Section 4.16, "Digital output — high-side actuator output control" for further details.

4.4. ECU power — sensor supplies

The ECU provides two external sensor power supplies (pins A25 and A39). Each sensor supply can be switched off by setting the appropriate internal channel (DOT disable-EXT-PSU1 or DOT disable-EXT-PSU2) to one, 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 ratiometric 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. PSU 1 and 2 monitor voltages

Voltage [a]	Meaning
4.975V - 5.00V	Output shorted to battery

Voltage [a]	Meaning
4.925V - 4.975V	Normal operation
0V - 4.925V	Output over current or short to ground

[a] These voltages are based on absolute A/D counts (referenced to the ECU's internal 5V supply) and should not be adjusted ratiometrically against the ECU's 2.5V reference (internal channel AIN PSU+2.5VD). This is only from the perspective of diagnostic. For the purpose of end measurement accuracy and voltage reporting all adjustments should be applied.

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 - 220mV	Normal Operation
> 220mV	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 ratiometric measurements.

4.5. Analogue inputs

The analogue inputs (pins A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, A13, A14, A15, A19, A20, A21, A22, A23 and A24) 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, A17, A18, A30, A32, A33, A34, A35, A45 and A46 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 33V, a loading of 41.5K to ground and a filter of 93Hz. 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.

4.6. Analogue inputs — ratiometric measurement

Ratiometric sensors are read in as a ratio between the sensor and reference voltages (V_{sens}/V_{ref}). Correction is only required on channels for which an absolute voltage measurement is required. Correction is not required for sensors supplied from the 5V sensor supply and which produce an output that is ratiometric to the supply.

To read a variable sensor which is an absolute referenced sensor (V_{sens},V_{abs}) the V_{ref} for the ADC requires correction:

$$V_{ABSOLUTE} = \frac{V_{MEASURED} \times V_{REF}}{V_{2.5} \times 2}$$

Where $V_{MEASURED}$ is the A/D conversion for an external pin, V_{REF} is the A/D conversion for internal channel AIN VRH, $V_{2.5}$ is the A/D conversion for internal channel AIN PSU+2.5VD, and *2* is a constant.

4.7. Analogue inputs — accelerometer inputs

The internal accelerometers are not available on the standard optioned hardware. If present, then the internal accelerometer channels (AIN accelerometer-x, AIN accelerometer-y and AIN accelerometer-z) have a full scale of ±2g, with a 12-bit signed range of representation. The sensitivity of the device is 1024 counts/g with a minimum of 952 counts/g and 1096 counts/g. There is no zero-offset for these count values. The range for these count values is [-2048 2047] and the relationship between the the acceleration counts and V_{ADC} is:

$$V_{ADC} = \frac{ACCELERATION * 5}{4096}$$

The full scale range of the accelerometer is ±2g so acceleration counts will never reach [-2048 2047] full range.

The accelerometer is also has a self-test signal (DOT accel-self-test), that when asserted, will cause the value on the accelerometer channels (AIN accelerometer-x, AIN accelerometer-y and AIN accelerometer-z) to change. The output change has a range of [200 750] counts but on average will fluctuate at about 460 counts. Note however, that this signal will remain asserted until the application specifically de-asserts it.

> **Note**
>
> The use of these channels are only valid on an M250-00Z which is an M250 with an IMU populated. Attempting to access these channels without the IMU populated will have no effect.

4.8. Analogue inputs — gyroscope inputs

The internal gyroscopes are not available on the standard optioned hardware. If present, then the internal gyroscope channels (AIN gyro-x, AIN gyro-y and AIN gyro-z) output a 14-bit signed value with a range of [-4368 4368] counts. This range represents a scale of ±320°/s. The relationship between rotation and the ADC voltage (V_{ADC}) is:

$$V_{ADC} = \frac{ROTATIONRATE * 5}{4096}$$

> **Note**
>
> While the gyroscope values are 14-bits signed, the full range of 14-bits [-8192 8192] is not used.

The analogue inputs also provide the following gyroscope channels (AIN gyro-angle-x, AIN gyro-angle-y and AIN gyro-angle-z) which is a 14-bit unsigned value representing the angle, in degrees, of the gyroscopes. The 14-bit unsigned value has a range of [0 9827] counts and represents a range of angles [0 359.9630]°.

The gyroscopes each also have temperature outputs on the following gyroscope channels (AIN gyro-temp-x, AIN gyro-temp-y and AIN gyro-temp-z) which are represented by a 12-bit signed value with a range of [-40 105]°C or a range of [-447 551] counts.

The relationship between the angle and temperature outputs and the ADC voltage follow the same equation as the gyroscope output values.

> **Note**
>
> Although the temperature output values are represented by 12-bits signed, the full range of 12-bits is not used.

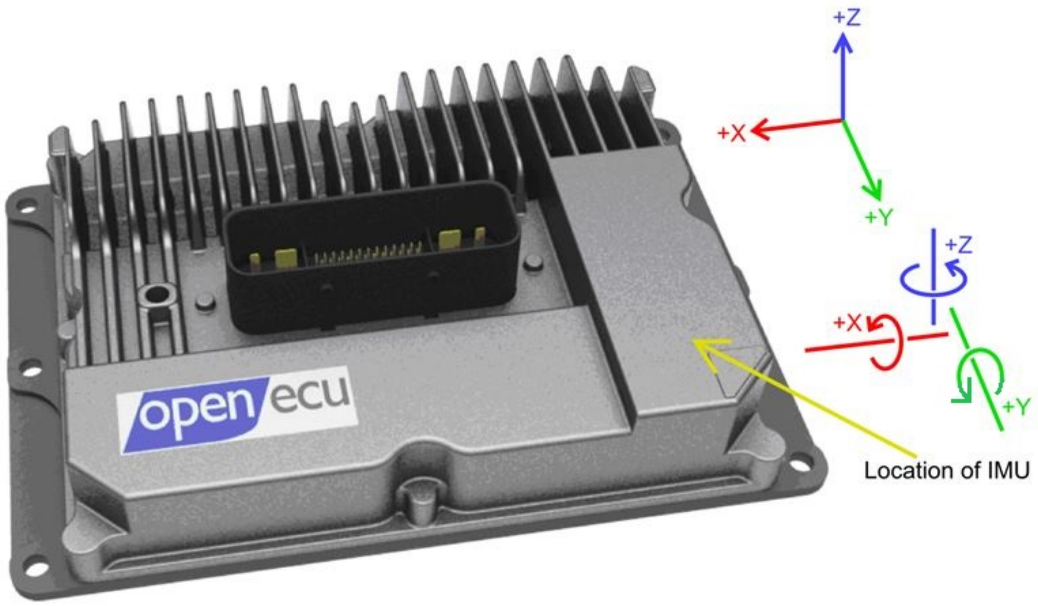
In addition to the gyroscope outputs, the gyroscopes each have their own self-test channels (DOT gyro-x-self-test, DOT gyro-y-self-test and DOT gyro-z-self-test), which when asserted will assert a pass/fail bit which can be read with the following channels (DIN gyro-x-self-test-result, DIN gyro-y-self-test-result and DIN gyro-z-self-test-result). Note that once the self-test has completed for the gyroscopes, the self-test bit will de-assert itself. There is no need to manually de-assert this bit.

> **Note**
>
> The use of these channels are only valid on an M250-00Z which is an M250 with an IMU populated. Attempting to access these channels without the IMU populated will have no effect.

4.9. Analogue inputs — accelerometer and gyroscope orientation

The accelerometer and gyroscope orientation is pictured below:

Figure 4.2. Orientation of accelerometer and gyroscope axes



4.10. Analogue inputs — internal temperature input

The ECU has an internal temperature sensor. The relationship between temperature and the ADC voltage (V_{ADC}) for the internal temperature sensor is non-linear. The temperature over a range of -55°C to +150°C correlates to voltage by Table 4.3, "Internal temperature input".

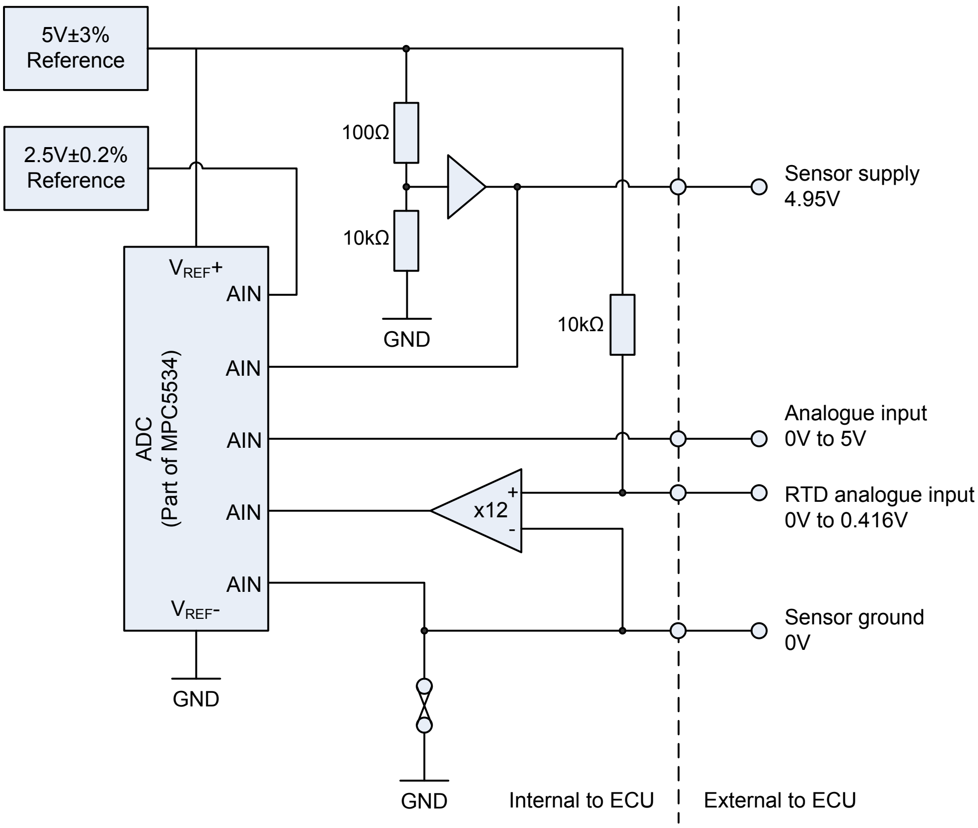
Table 4.3. Internal temperature input

Temperature (°C)	Voltage (V)	Temperature (°C)	Voltage (V)
-55	4.981	50	2.499
-50	4.973	55	2.265
-45	4.962	60	2.041
-40	4.947	65	1.830
-35	4.927	70	1.634
-30	4.900	75	1.454
-25	4.866	80	1.290
-20	4.821	85	1.143
-15	4.765	90	1.011
-10	4.694	95	0.893
-5	4.608	100	0.789
0	4.504	105	0.698
5	4.379	110	0.617
10	4.234	115	0.546
15	4.068	120	0.483
20	3.882	125	0.429
25	3.676	130	0.381
30	3.456	135	0.339
35	3.223	140	0.302
40	2.983	145	0.269
45	2.740	150	0.241

4.11. Relationship between V_{REF}, sensor supplies and inputs

The ECU power arrangement is shown in Figure 4.3, “VREF arrangement”. The figure shows the relationship between the internal 5V V_{REF} and ground, the external sensor supply and ground, and the analogue inputs.

Figure 4.3. V_{REF} arrangement



The internal low precision 5V reference supplies the reference pin on the ADC. A high precision 2.5V reference can be read on a direct (unscaled) ADC channel. This can be used to calculate the true value of the 5V reference and subsequently used to improve accuracy on all other channels. The 5V reference is divided down to 4.95V to provide the external sensor supply. The exact voltage being produced can be read on a direct (unscaled) ADC channel. The sensor ground is a nominal 0V, but may be slightly above this due to voltage drop across the protection device.

The exact voltage on the pin can be read on a direct (unscaled) ADC channel. Standard 0-5V inputs are passed directly to the ADC with no scaling. RTD analogue inputs have a 10K pullup to the internal reference voltage. The voltage difference between the input and sensor ground is amplified by a gain of 12 and then passed to an ADC input.

4.12. Digital inputs

The digital inputs (pins A10, A11, A12, A13, A14 and A15) sense the binary state based on the pin voltage and a threshold.

Not inverted
: For pins A10, A11, A12, A13, A14 and A15, the signal is not inverted: low if <= 1.5V and high if >= 3.5V, with a hysteresis >= 0.823V.

Inverted
: For pin A26, the signal is inverted: low if >= 4.5V and high if <= 4.0V, with a hysteresis of >= 0.1V.

Note

The external digital signals are all low pass filtered to prevent signals of excessive frequency from tying up the target processor (e.g. to prevent spurious interrupts occurring from high frequency noise coupling).

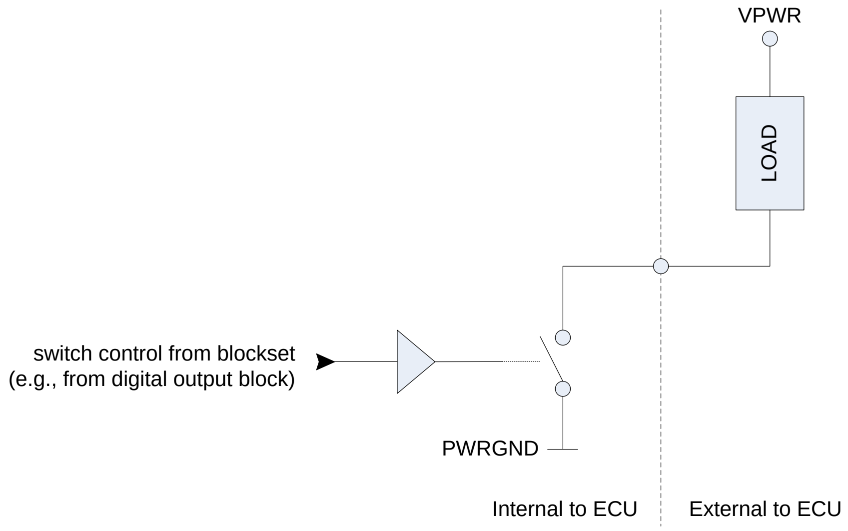
Note

If any of the pins A1, A17, A18, A30, A32, A33, A34, A35, A45 and A46 are not being used as digital outputs then it is possible for them to be used as digital inputs with a loading of 41.5K to ground 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 <= 3.3V and high if >= 6.9V, with a hysteresis >= 0.2V.

4.13. Digital outputs

The digital outputs (pins A1, A17, A18, A30, A32, A33, A34, A35, A36, A45 and A46) can be used as low-side drivers. That is, the ECU switches the output pin to ground, the actuator is connected to the output pin and the battery (or to the ECU's high-side power pin, A16, see Section 4.16, “Digital output — high-side actuator output control” for further details).

Figure 4.4. Low-side switching arrangement for digital outputs



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 4.4, “Low-side digital output leakage current” for typical leakage currents at specified operating voltages.

Table 4.4. Low-side digital output leakage current

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

Warning

The digital outputs are not guaranteed to work properly when the ECU supply (battery) is outside 7V - 32V. It is recommended to monitor the ECU supply voltage on A2 and set the digital outputs to a safe state in your application software. The safe state depends on your application. In most applications, the safe state is to disable the outputs to protect the circuitry and to prevent unwanted output activation.

Note

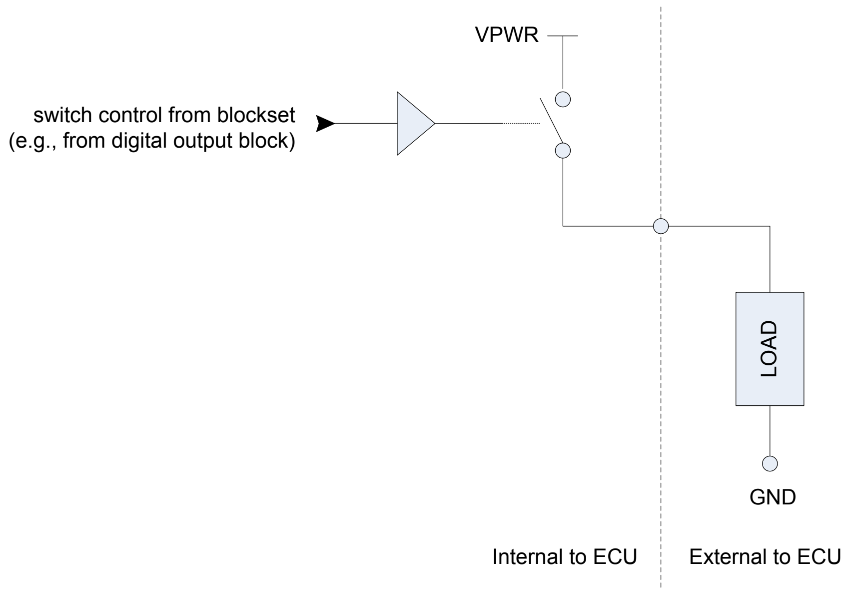
The H-Bridge pins (pins A17+A46 and A30+A1) can be used independently either as high-side or low-side pins. Drivers are configured as low-side or high-side by setting the corresponding internal channels (e.g., DOT select-high-side).

Note

Pin A36 uses an IGBT output transistor and can be used to drive a spark coil, the rest of the outputs use MOSFETs.

When a pin is configured as a high-side, the ECU switches the output pin to V_{PWR} and the actuator is connected to the output pin and ground.

Figure 4.5. High-side switching arrangement for digital outputs



4.14. Digital output — state monitoring

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

When the pin is used as a PWM, there are two possible uses for such a feedback:

- Before starting a PWM, by reading the monitors on the pin to check for open or short circuits.

- By reading the average voltage on a PWM outputs and comparing it with the demanded PWM width and the battery voltage reading you can perform a consistency check that the PWM output is performing as expected. This method can be applied if the PWM frequency is higher than the filter cut off frequency (100Hz).

> **Note**
>
> Pins A32, A33, A34, A35, and A45 have current monitors which are hardware filtered with a nominal cut off frequency of 884Hz. If the PWM frequency is greater than this cut off frequency, the average current through these pins can be measured.

> **Note**
>
> Pins A1, A17, A30, and A46 have current monitors which are not hardware filtered. Only the instantaneous current can be read.

When the pin is used as a plain digital output, feedback is used as follows:

- Read the monitors on the pin to check for open or short circuits.

> **Note**
>
> Pin A18 and A36 do not have current monitor channels.

> **Note**
>
> The underlying timer for the M250 I/O has a rate of 4MHz.

> **Note**
>
> Because the platform does not sample the current feedback signal synchronised to the 'on' stage of the PWM output, the application cannot easily derive an average current reading.

4.15. 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 one. 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 zero.

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.

Note

The over-current trip channel has no function when a channel is configured as an injector. In this state, reading the channel will give undefined results.

4.16. Digital output — high-side actuator output control

The high-side output arrangement provides for a single switch (pin A16) to turn on or off actuators controlled by the ECU. Thus a load supplied by the high-side drive and controlled by a low-side drive has two independent means of being switched off, which is desirable for critical loads that must be turned off even if the low-side drive should fail in a conducting state.

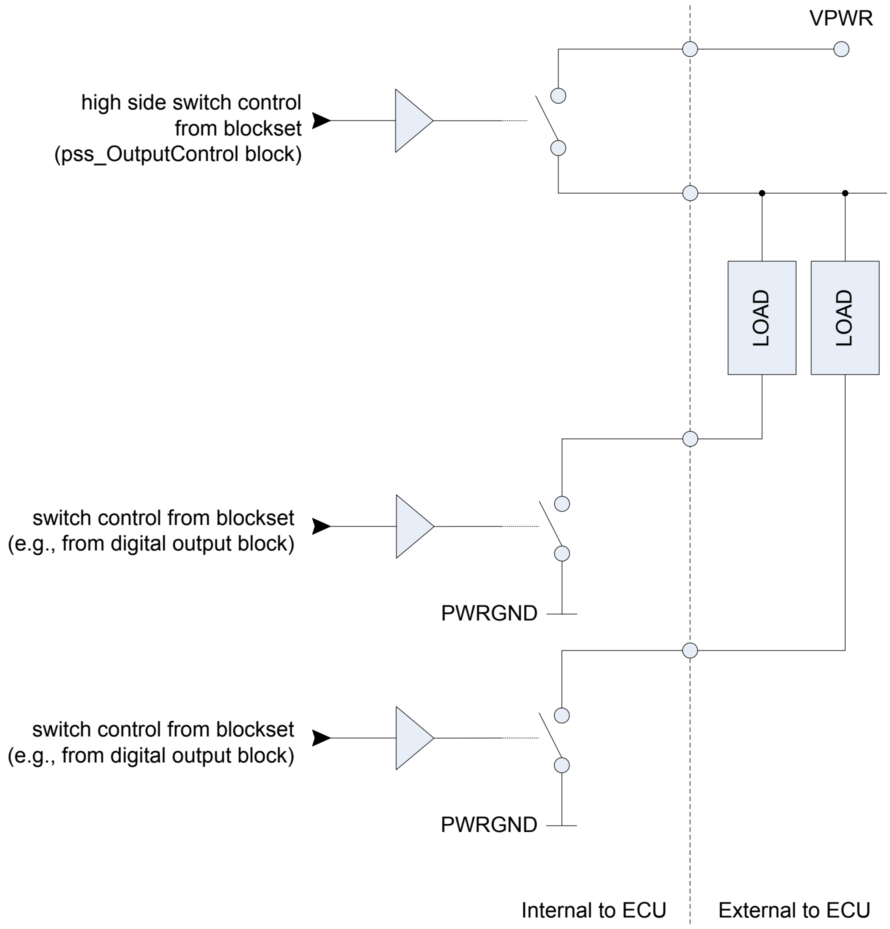
Note

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.

Warning

The digital outputs are not guaranteed to work properly when the ECU supply (battery) is outside 7V - 32V. It is recommended to monitor the ECU supply voltage on A2 and set the digital outputs to a safe state in your application software. The safe state depends on your application. In most applications, the safe state is to disable the outputs to protect the circuitry and to prevent unwanted output activation.

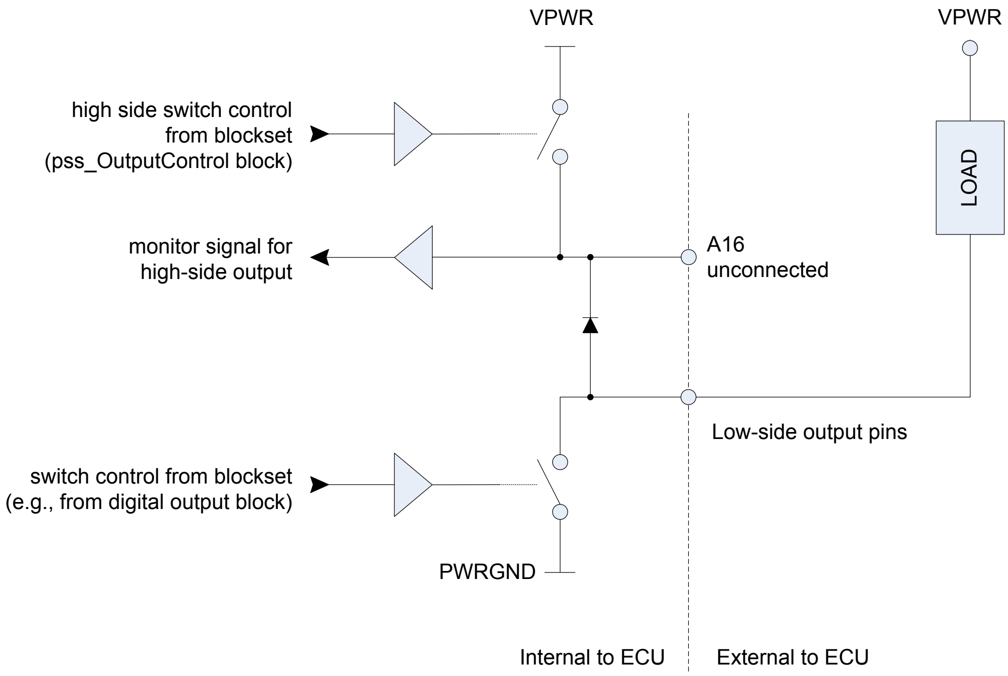
Figure 4.6. Switched output control for digital outputs



4.17. Digital output — high-side actuator output diagnostics

The high-side actuator output (pin A16) has a number of internal monitor signals (digital, voltage and current trip). However, there is a connection between the low-side output pins and the high-side actuator output monitor signals which can result in incorrect monitor signals when the high-side output is unconnected.

Figure 4.7. High-side actuator output diagnostic



The diagram shows the connection between the low-side and high-side actuator outputs. The diode provides a current recirculation path for inductive loads. However, if both the low and high-side control is turned off, then the monitor signal should be ignored (especially if the low-side load has low resistance).

Recirculation diodes are present on output pins A18, A32, A33, A34, A35 and A45, however the diodes on A32, A33 and A34 are switched out of circuit when injector mode is selected and the output is switched off.

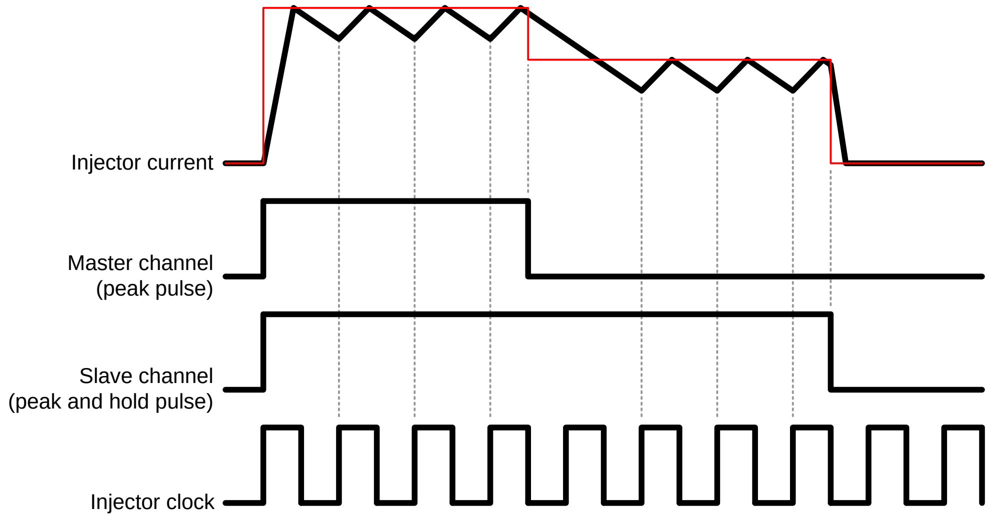
Warning

If there is a mixture of loads connected to the high-side actuator pin, and to V_{PWR} direct, then when both the low and high-side control is turned off, the loads connected to the high-side actuator pin may draw current. For this reason, it is recommended that loads are only connected between the high-side actuator pin and those low-side output pins.

4.18. Digital output — injector operation

The injector outputs (pins A32, A33 and A34) allow the injector current to be regulated at two different levels, called the peak and the hold currents. The application software must provide two digital signals, one for the duration of the peak current and one for the duration of the peak and hold current. The application software must provide a clock for the injector current modulation (see internal channels A32, A33 and A34).

Figure 4.8. Injector operation



The internal *injector clock* channel must be configured to output a continuous 50% duty cycle square wave at an application determined frequency. This will typically be in the range 100Hz to 10KHz.

The peak and hold digital signals can be generated through the use of the *pdx_PWMSynchronisedOutput* Simulink block or the *pdx_spwm_output()* C-API function. The master channel corresponds to the peak signal, and the slave channel corresponds to the peak and hold signal. The master and slave channels must have identical frequency and the slave delay must be set to zero. The injector clock signal can be generated through the use of the *pdx_PWMOutput* or *pdx_PWMVariableFrequencyOutput* Simulink blocks or the *pdx_pwm_output()* C-API function.

> **Note**
>
> The over-current trip channel has no function when a channel is an injector or configured as an injector. In this state, reading the channel will give undefined results.

> **Note**
>
> When operating in injector mode, the hardware switches the recirculation diode into circuit when the *peak and hold pulse* is high and out of circuit when low. This results in a slow decay of the current during the off periods of the hardware generated PWM and a rapid decay of the current flow at the end of the injection period (to ensure the fastest possible closing of the injector).

4.19. Digital output — configurable injector outputs

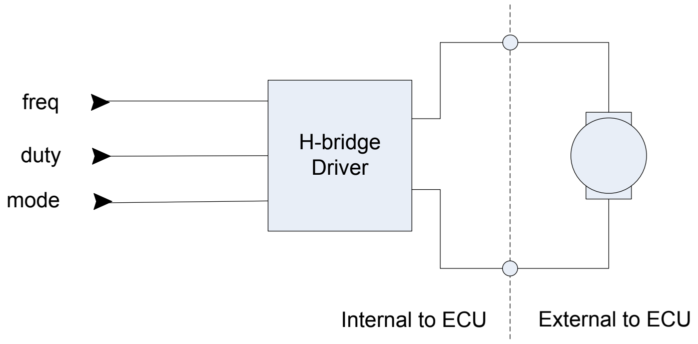
The injector outputs (pins A32, A33 and A34) can be configured as either an injector output or a PWM output. The pin output mode can be selected through the use of the *pcfg_Config_M250* Simulink block or the *pcfg_setup_m250()* C-API function.

When A32, A33 and A34 is configured as an injector channel, the corresponding internal *current trip monitor* channel will give undefined results.

4.20. H-bridge outputs

The H-bridge outputs (pins) are controlled through the *pdx_HBridge_Output* Simulink block or the *pdx_hbridge_output()* C-API function.

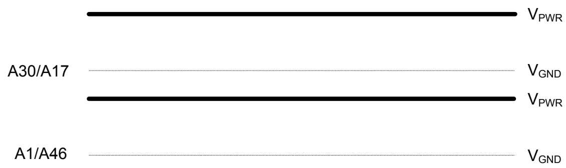
Figure 4.9. H-bridge arrangement



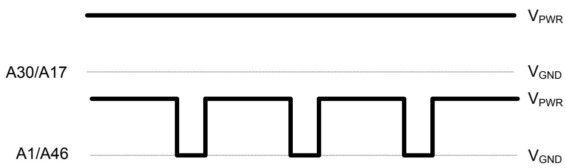
The H-Bridge can be driven in four modes:

No Drive
: In *no-drive* mode, the H-bridge is turned off leaving the pins to float.

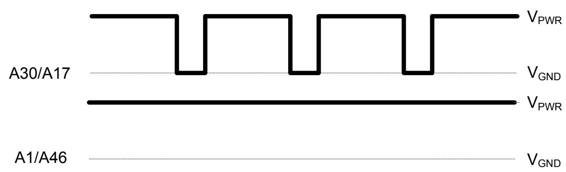
Brake
: In *brake* mode, both pins of the H-bridge are driven to V_{PWR}.



Forward
: In *forward* mode, pin A30 (or A17) is driven to V_{PWR} and pin A1 (or A46) pulsed, resulting in a current flow the opposite from the *reverse* mode.



Reverse
: In *reverse* mode, pin A1 (or A46) is driven to V_{PWR} and pin A30 (or A17) is pulsed, resulting in a current flow the opposite from the *forward* mode.



> **Warning**
>
> To avoid unexpected behavior, H-bridges should be set to NO DRIVE mode before flashing the ECU. This can be done by commanding the actuators to NO DRIVE any time the engine is not turning.

The frequency and the duty cycle of operation are controlled by the application. There are monitor inputs to check the output pin state.

> **Note**
>
> The H-Bridge pins can also be used separately as high-side or low-side drivers. It is not possible to use an H-bridge in both configurations in the same application.

> **Warning**
>
> The digital outputs are not guaranteed to work properly when the ECU supply (battery) is outside 7V - 32V. It is recommended to monitor the ECU supply voltage on A2 and set the digital outputs to a safe state in your application software. The safe state depends on your application. In most applications, the safe state is to disable the outputs to protect the circuitry and to prevent unwanted output activation.

4.21. 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.

4.22. Communication — CAN

The CAN buses (pins A28+A43 and A29+A44) are implemented using high-speed CAN transceivers. CAN bus 1 has terminating resistors fitted, CAN bus 0 doesn't.

4.23. Memory — configuration

The ECU supports different memory configurations for application, calibration and RAM sizes, some of which require external calibration RAM (see Section 4.25, “Memory — calibration capabilities”).

Table 4.5. 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

Configuration	App size (KiB)	Cal size (KiB)	RAM size (KiB)	External RAM required?	Run-time calibration supported?
	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.

4.24. 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).

4.25. 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.

4.26. 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 selects which mode to enter when it is powered up by measuring the external *FEPS* A27 pin.

Table 4.6. System mode selection

FEPS (A27) Voltage	System mode
>= +13V	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.
<= -18V	Enter reprogramming mode. Use the default CCP settings. [a]
Otherwise	Enter application mode if valid application software has previously been programmed, otherwise enter reprogramming mode.

[a] In early revisions of the hardware, using this negative voltage may damage the ECU, please consult the errata associated to your revision before using this functionality.

4.27. Flash codes

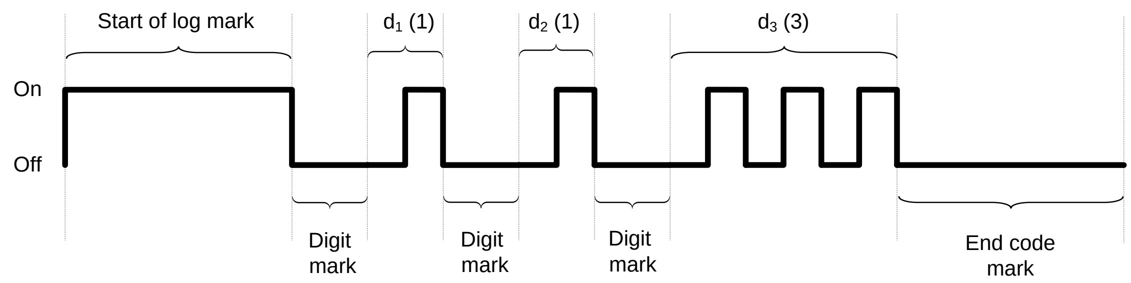
The ECU also uses the FEPS input (pin A27) as an output to flash an optional LED. The LED is connected between V_{PWR} (pin A2) and FEPS (pin A27). Note that the pin use as FEPS input or as lamp output is mutually exclusive.

> **Note**
>
> Pin A27 can supply up to 10mA, it is not capable of lighting a bulb.

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 4.10. Flash code sequence



Each of the marks lasts for a specific duration:

Table 4.7. Flash code example

Mark	Duration and meaning
Start of log mark	3s — marks the start of the flash code list

Mark	Duration and meaning
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 ON 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 4.8. 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.
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.

4.28. Calibration capabilities

Developer units have the capability to accept calibration changes while the application software is running.

4.29. 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 4.9. Floating point conditions

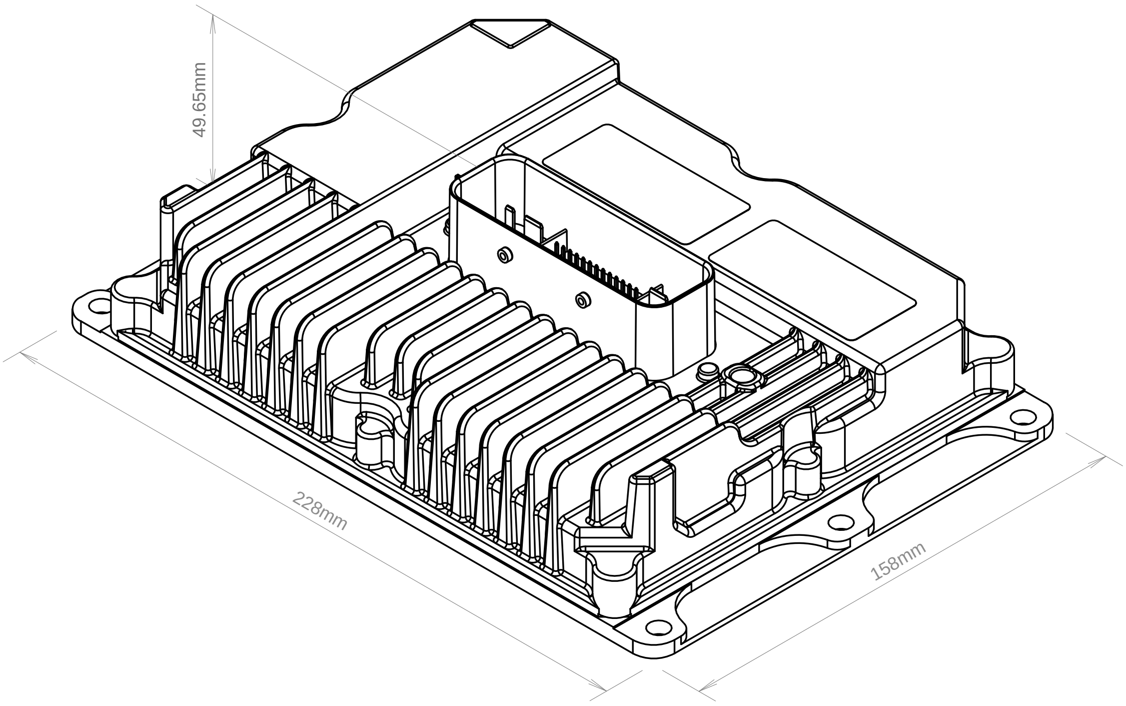
Condition	Result
Underflow	The result of a calculation underflow is ±*0*. The sign is based on the signs of the operands.
Overflow	The result of a calculation overflow is ±*max* where *max* is approximately 3.4×10^{38}. The sign is based on the signs of the operands.
Divide by zero	

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).