LPC4 ECU
-
REFERENCE MANUAL

Baldur Gíslason

July 12, 2017

Contents

1 Introduction 2

2 Wiring 3
- 2.1 Pin-outs and description . . . 3
  - 2.1.1 Pin numbering . . . 3
  - 2.1.2 Connector A pin-out . . . 5
  - 2.1.3 Connector B pin-out . . . 6
- 2.2 Wiring diagram . . . 7
- 2.3 Wiring guidelines . . . 8
  - 2.3.1 Grounding . . . 8
  - 2.3.2 Engine speed sensors . . . 8
  - 2.3.3 Ignition outputs . . . 8

2.3.4 Idle control 8
2.3.5 Programmable outputs 9

3 Software configuration 10
3.1 Crank/cam trigger configuration 10
3.1.1 Basic trigger 11
3.1.2 Versatile multi tooth decoder 12
3.1.3 Dual edge trigger 15
3.1.4 Duty cycle coded trigger 15
3.2 Internal data logging 15
3.3 Performing firmware upgrades 16

A Real time data fields 18

B LPCX expansion board 29
B.1 Wiring 29
B.1.1 Connector C pin-out 31
B.1.2 Connector D pin-out 32

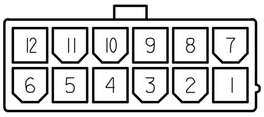
1 Introduction

LPC4 is an engine management system for spark ignition engines, capable of sequential fuel injection and ignition on 4 cylinder engines, bank fire and waste spark or distributor spark on engines with up to 8 cylinders. In addition to the more common four stroke engines, two strokes and Wankel type engines are supported as well.
It must be noted that many aspects of the configuration and strategies are also documented inside the configuration file. If you push F1 while editing a variable in the Calibrator application, you will get context sensitive help related to the category you are editing.

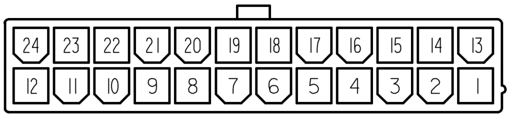
2 Wiring

2.1 Pin-outs and description

2.1.1 Pin numbering



(a) Connector B



(b) Connector A

Figure 2.1: Connectors on the back of the controller and their pin numbering.

2.1.2 Connector A pin-out

Pin	I/O	Function	Note
1	OUT	5V sensor supply	200mA max
2	IN	Analog 0 - TPS (APP A in ETC mode)	100kΩ pull-down
3	IN	Analog 1 - Lambda (APP B in ETC mode)	51kΩ pull-up
4	OUT	Ground return for analog sensors	
5	IN	Analog 4 0-5V	51kΩ pull-up
6	IN	Analog 5 0-5V	51kΩ pull-up
7	IO	CAN H	120Ω termination
8	IO	CAN L	120Ω termination
9	OUT	Output 1 (Tach out)	Low-side switch, 5A max, 1kΩ pull-up to 12V
10	OUT	Output 2 (Fuel pump relay)	Low-side switch, 5A max
11	IN	Power ground	
12	IN	Power ground	
13	IN	Digital input 1	Active low, 5.7kΩ 5V pull-up, 12V safe
14	IN	Analog 2 - Coolant temperature sensor	3kΩ pull-up
15	IN	Analog 3 - Charge air temperature sensor	3kΩ pull-up
16	OUT	Ground return for crank/cam sensors	
17	IN	Cam sync input	2.2kΩ pull-up
18	IN	Crank trigger input	2.2kΩ pull-up
19	IN	Wheel speed input	Active low, 5.7kΩ 5V pull-up, 12V safe
20	OUT	Ground for signal shields	(or extra power ground)
21	OUT	Output 4	Low-side switch, 5A max
22	OUT	Output 3 (PWM idle)	Low-side switch, 5A max. Clamping diode to supply pin.
23	IN	Digital input 2	Active low, 5.7kΩ 5V pull-up, 12V safe
24	IN	Switched +12V supply	Internally fused

2.1.3 Connector B pin-out

Pin	I/O	Function	Note
1	OUT	Output 5 (PWM idle anti-phase)	Low-side switch, 5A max
2	OUT	Output 6	Low-side switch, 5A max
3	OUT	Injector 1	Low-side switch, 5A max
4	OUT	Injector 2	Low-side switch, 5A max
5	OUT	Injector 3	Low-side switch, 5A max
6	OUT	Injector 4	Low-side switch, 5A max
7	OUT	Output 7	Low-side switch, 5A max
8	OUT	Output 8	Low-side switch, 5A max
9	OUT	Ignition 1	5V logic or low-side switch 10A max[1]
10	OUT	Ignition 2	5V logic or low-side switch 10A max[1]
11	OUT	Ignition 3	5V logic or low-side switch 10A max[1]
12	OUT	Ignition 4	5V logic or low-side switch 10A max[1]

[1] Depending on build time options

2.2 Wiring diagram

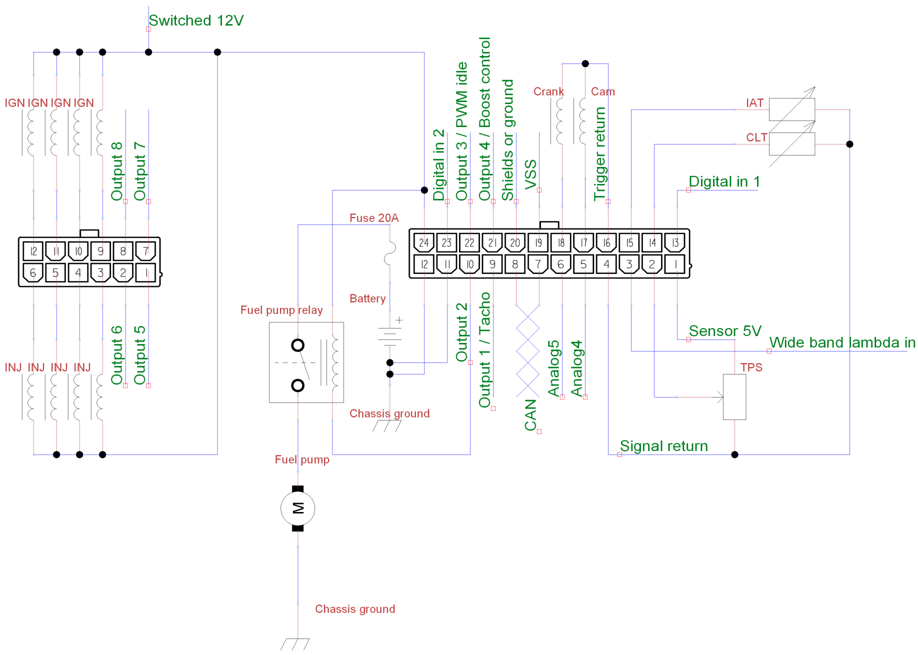


Figure 2.2: Typical basic wiring

2.3 Wiring guidelines

2.3.1 Grounding

The controller should be connected to the battery negative terminal or another reliable grounding point by a pair of $1.5mm^2$ wires or a single $6mm^2$ wire joined to smaller wires near the connector. An improper ground connection will cause electrical noise and possibly faults with controller operation. If utilising factory wiring, joining all of the supply ground wires for the original ECU should suffice.

2.3.2 Engine speed sensors

The inputs on the controller for crank/cam sensors are of schmitt trigger logic type, with 2.2kΩ pull-ups and with over-/undervoltage protection diodes. Thus they may be connected directly to open-collector or logic sensors (Hall effect, optical) or variable reluctance sensors. Some poorly designed VR sensors have an output voltage too small at cranking speeds for reliable starting, for those an amplifier module must be installed in the controller.

2.3.3 Ignition outputs

The default is to have four 5V logic-level outputs current limited to 18mA. Internal coil drivers for passive coils can be specified at order time, from 1 up to 4 coils.

2.3.4 Idle control

The LPC4 supports three types of idle control valves. 2 wire PWM, 3 wire PWM and 6 wire stepper. 4 wire stepper can be handled by fitting pull-up resistors to each wire. A value of 15Ω and 2W has been shown to work well on the common GM/Chrysler valves. A 2 wire PWM valve must be connected to output number 3. A 3 wire PWM valve uses outputs 3 and 5 to drive each coil. Stepper valves can be connected to any of the outputs but usually outputs 5 through 8 are used, arrangement of the wiring does not matter as it can be configured in software.

2.3.5 Programmable outputs

The ECU has eight programmable outputs and while all low speed functions are applicable to every output, some PWM functions have dedicated outputs. This means that if those functions are used, they can only be assigned to the specified output. Outputs 1, 3 and 4 provide high accuracy PWM capability, with events timed to the nearest microsecond and a maximum PWM frequency of 2000Hz. Since firmware version 1.8, outputs 5 through 8 provide lower accuracy PWM capability with microsecond timing but possible timing error of individual pulses up to 100 microseconds. Maximum frequency on those outputs is 200Hz and although average error is on the order of zero, due to the nature of these software driven outputs occasional pulses may be out by as much as 100 microseconds. The exception is output 5 when in PWM idle anti phase mode, where it is driven at full 1 microsecond precision.

Function	Output
Tachometer output	1
PWM idle control	3
PWM idle anti-phase	5

Figure 2.3: Functions with dedicated outputs

3 Software configuration

Refer to BG calibrator manual for introduction to the software. The default configuration file has the following defined keyboard shortcuts:

Key	Function
F5	Edit main fuel map
F6	Edit main ignition timing map

3.1 Crank/cam trigger configuration

The LPC4 ECU has a unique way of dealing with crank/cam trigger signals. This enables it to decode a large variety of different trigger arrangements without needing the firmware to specifically support each arrangement. As a consequence the configuration of the trigger inputs may seem confusing to first time users. To combat this, presets are provided for common configurations, see the presets dialog in the calibrator software and check if your engine is listed.

In this chapter, the primary (or only) trigger is always referred to as the crank trigger, despite the possibility of the reluctor or shutter wheel being driven from the camshaft. The primary/cam filter periods let the ECU ignore any event occurring within a certain amount of time since the previous event. Useful against certain types of noise in certain trigger arrangements. Must be set to a lower number than the shortest anticipated event interval at maximum engine operating speed.

The modes of trigger input operation are as follows:

Basic Single impulse on crank trigger input for each cylinder's firing event. Works for configurations that only require a single ignition output, either single cylinder, multi cylinder with distributor or multi cylinder running all cylinders in waste spark configuration. Also useful if no ignition control is required.

Versatile multi tooth The highly versatile crank/cam decoder for variable reluctance type crank sensors or hall effect setups where all the information required is available by decoding only one type of signal edge (rising or falling, not both).

Dual edge A variation of the versatile multi tooth decoder where alternating teeth defined are alternating polarity (rising or falling, starting with whichever is defined as the crank trigger active edge).

Duty cycle coded A variation of the versatile multi tooth decoder that triggers on one edge type (rising or falling) but measures the duty cycle, the ratio between high and low state. A pattern can then be entered denoting the duty cycle of past previous pulses and when that pattern is matched, the decoder generates a sync event. This arrangement is used on the earlier generation GM LS type engine (24X trigger) but this mode can also be configured to decode some Chrysler crank triggers.

Log only A mode that does not enable running an engine but does let one capture an event log of the crank/cam inputs without fuel being injected or ignited.

3.1.1 Basic trigger

This mode has only three configurable options. The trigger angle offset whose useful range would be from zero up to the angle between firing events. (90 degrees on a 4 stroke V8 f.ex). The crank trigger active edge and the pulses skipped when starting options are also used. Cam sync, trigger teeth and other options not used. Primary trigger filter period does apply.

3.1.2 Versatile multi tooth decoder

The basic operating principle of the versatile multi tooth decoder is that each tooth sensed by the crank angle sensor is defined by the crank angle that separates it from the previous tooth before it. The crank angle of the first tooth in the cycle (aka trigger angle offset) in degrees before top dead centre cyl 1 is also defined, cyl 1 being assumed to have an angle offset of zero in the cylinder angle table. The trigger angle offset can have a value of anywhere from zero to 719 degrees. Used in conjunction with the tooth gap table is also a tooth repeat table. The tooth repeat table saves the user from having to configure multiple tooth entries where a number of adjacent teeth all have the same spacing. As an example a 36-1 crank trigger wheel only needs two tooth entries. 20 degrees and 10 degrees, and in that case the repeat values are 0 and 33 as the first tooth of the 35 that are present only occurs once, zero repetitions are performed. The second tooth and the 33 teeth that follow it have the same tooth spacing so a value of 33 is used for the second repeat value. From knowing the angle of the first tooth and the spacing of every tooth from the previous one, the decoder can calculate engine speed as well as crank angle every time an event occurs on the crank trigger input, but this information is not enough to let the decoder find its reference point in the cycle. To find the reference point and start decoding from tooth one, there are a number of strategies available. At the time of writing they are as follows:

None In this mode, cam sync is relied upon entirely for crank angle reference. In this mode, there must be enough teeth defined to cover the entire cycle so if there are 12 teeth on the crank, the tooth config must account for 24 teeth or sync is deemed lost before the next cam sync opportunity.

Missing tooth In this mode, the decoder compares the spacing of adjacent events and if the interval between events exceeds the interval of the previous event by a configurable threshold (typically at least 1.5), the current event is deemed to be tooth one and crank decoding can start. In this mode, the first defined tooth must have its defined angle greater than the other teeth.

Extra tooth In this mode, the decoder compares the spacing of adjacent events and if the most recent interval is shorter than the previous interval by a configurable threshold (typically no more than 0.7, preferrably less) then that tooth is ignored and the next event following it is deemed tooth one and decoding can start. There is a very good reason why the extra tooth is ignored in the code. For one, having extra crank angle resolution at one part of the cycle is of little benefit, but if the exact angle of the extra tooth is not known then it would be very detrimental to engine control to include it in the decoder output. Therefore, in this mode, the extra tooth must not exist in the tooth definitions, the first tooth is the tooth following the extra tooth.

If a cam position sensor is present, there are a number of different strategies available to decode that. The behaviour of the cam sync differs if a crank sync strategy is configured or not. When a crank sync strategy is configured, the cam sync will not apply unless crank sync has been found, and when that happens the crank angle will be set to the correct phase according to the angle offset of crank tooth #1. If no crank sync strategy is selected, then the cam sync will apply immediately.
The cam sync strategies are the following:

Cam state on crank sync This mode is useful for hall effect or similar logic output cam position sensors with a single wide tooth (half moon type). In this mode, the cam signal is not logged and no interrupts are generated on edge events but instead the state of the cam signal is polled when a crank sync event happens (missing tooth, extra tooth). If the cam input is in a logic low state (less than 1 volt input) then the configured angle offset is applied and full sync mode is entered. If the cam input is in a logic high state, then the configured angle offset is applied, shifted by 360 degrees and full sync mode is entered.

Count cam impulses This mode is useful for all types of sensors and applies to cam wheels with as little as a single tooth but also applies to more complex arrangements. In this mode, every event on the cam input increments a counter but every event on the crank input reads the counter and resets it to zero. If the counter value matches the configured cam sync count, then cam sync is applied at that crank event and full sync mode is entered.
An example where this mode is used is the Subaru 6/7 pattern, where a series of two or three cam impulses can be used to determine the crank angle and cam phase.

Count crank impulses This mode applies to certain crank/cam patterns where there are two or more cam teeth unevenly spaced or a greater number of evenly spaced cam teeth with some oddly spaced crank teeth. A counter is incremented on every crank event but read and reset on every cam event. If the counter matches the configured cam sync count then the following crank event will apply the cam sync. An example where this mode applies is Cosworth YB where the cam sync has two teeth spaced at 180 degrees of crank rotation.

Primary trigger is cam This mode allows the use of a missing tooth or extra tooth trigger wheel rotating at cam speed so the reference tooth angle is correct and no extra cam position information is required for full sync operation.

Crank state on cam impulse This mode only applies to dual-edge trigger decoder mode, used to decode DSM/Miata/Neon trigger. Has a configurable option for what the crank state must be for the cam event to register. The crank event following the cam event is deemed tooth number one.

Cam count pattern Principally the same as count cam impulses mode, except instead of comparing only the current value of the counter every crank event, a configurable number of previous values are also considered. This is useful if the cam wheel has an insane amount of oddly spaced teeth, such as seen on early Chrysler/Jeep 4.7 V8.

3.1.3 Dual edge trigger

A mode for logic type sensors only (hall effect or optical). This mode is operationally identical to the versatile multi tooth trigger except that alternating teeth are expected to occur on alternating edges, with the first tooth occurring on the configured active edge for the crank trigger. Examples that use this include the Mitsubishi 4g63 and Mazda Miata, where it is used with cam sync.

3.1.4 Duty cycle coded trigger

A mode for logic type sensors only (hall effect or optical). This mode is operationally identical to the versatile multi tooth trigger except that the crank sync mode selector is not used. Instead it is hard coded to use a duty cycle pattern to sync. Normal trigger operation only happens on either a rising edge or a falling edge and the period since the last opposite edge divided by the period since the last active edge is the duty cycle. In the pattern, a value of 1 matches a duty cycle greater than 50% and a value of zero matches a duty cycle less than 50%. The pattern can have up to 8 positions. The typical use of this trigger mode is the GM LS1 engine, where it allows reliable operation with or without cam sync.

3.2 Internal data logging

As an option, the controllers can be fitted with internal data logging. The option involves fitting the hardware required for recording data inside the controller so the option must be fitted at purchase time or the unit returned to the vendor for reconfiguration. Controllers fitted with internal logging memory will generally have 8GB or more logging memory as well as a real time clock to time stamp the log files with time and date of when logging started. Data recorded at the highest available logging rate (100Hz) will take up around 2 megabytes per minute. At the time of writing the download rate is around 3 megabytes per minute so a 30 minute data log recorded at the highest rate would take around 20 minutes to download from the controller. Data can only be downloaded when a log isn't being captured and the engine isn't running. For that reason it is recommended that the controller is configured to not start recording until engine speed reaches some non-zero number, except for testing of the logging function itself. Once logging is started, it will continue until the controller is powered off. It is important to note that the binary format of the log files changes when the firmware is updated, so old logs can be downloaded but will not convert correctly to csv format when the configuration file open in the Calibrator application does not match the firmware that recorded the log.

3.3 Performing firmware upgrades

Whenever new features are introduced, new firmware becomes available for download at `https://controls.is/firmware/`. See the release notes if you are unsure of whether you should update or not. To perform a firmware upgrade:

1. Download firmware package from web site
2. Unzip firmware package into a directory on your hard drive
3. Connect USB cable between ECU and PC.
4. Power on ECU, do not start engine.
5. If you do not have the configuration backed up, run BG Calibrator, read configuration from ECU and save to file. This step may be skipped if you are performing the upgrade on an ECU you haven't made any previous configuration changes to.
6. Run `upgrade.cmd` in directory where firmware files are located.

7. Wait until the upgrade application finishes, should be on the order of 10 seconds.
8. Power ECU off.
9. Do not power ECU back on until you are ready to upload configuration to it.

The ECU has been upgraded but now contains invalid configuration. If you are proceeding with default configuration, simply open the default configuration file for the new firmware in BG calibrator and go on-line, then send local settings when prompted about what to do with the ECU side configuration. Otherwise, if you wish to retain your previous configuration, which is generally recommended, perform the following steps:

1. Run the BG Calibrator software
2. Open your old configuration file
3. Select `File -> Convert configuration` from the menu bar.
4. Select the configuration included with the new firmware in the file dialog.
5. The configuration has now been converted to the new format, save it and exit the Calibrator software.
6. Run the Calibrator software again and open the configuration file you saved previously, choose to work off-line.
7. Review the settings and verify that they make sense, see release notes for information about what settings may need revisiting.
8. Go on-line and power on the ECU. Do not start engine.
9. When prompted, select to use local settings, which will then be uploaded to the ECU.

After the configuration has been sent to the ECU and Calibrator application becomes responsive again, power the ECU off and then back on. Now you can start the engine.

A Real time data fields

This chapter contains a description of the data fields available for display or logging when the controller is connected.

time Time since ECU power-on, expressed in seconds.

analog0..7 Raw values of analog inputs, expressed in volts using the 5V sensor supply as reference.

injpw1..4 Injector opening pulse width as commanded by fuelling strategy, expressed in milliseconds.

injangle1..4 Start of injection angle expressed in degrees of crankshaft rotation before top dead centre. If injector outputs used equal the number of cylinders this is relative to TDC on each cylinder. If injectors are banked (more cylinders than injector outputs) these numbers are relative to TDC cyl 1.

supplyvoltage The voltage present on the 12V input pin on the ECU.

map Manifold Absolute Pressure, expressed in millibars/hectopascals. Source can be the internal MAP sensor or an external sensor connected to analog5 (Connector A, pin 6).

coolanttemp Engine coolant temperature expressed in degrees celsius.

airtemp Charge air temperature expressed in degrees celsius.

error0 Fatal errors that prevent fuel injection.

Bit mask with a number of different error sources. A value of 0 indicates no errors present. A value of 4096 indicates that the configuration is invalid, most likely a lookup table has configured dimensions exceeding its allotted storage. Any other value indicates a hardware or software fault and requires vendor attention.

error1 Errors that have to do with throttle position or control. Bit mask with two sources.

Bit	Description
0	TPS voltage below lower limit
1	TPS voltage above upper limit

error2 Errors that may be configured to not turn on the Check Engine Light, but if present the sensors they apply to are ignored and a default value is used. Bit mask with a number of different error sources.

Bit	Description
0	MAP voltage below lower limit
1	MAP voltage above upper limit
2	Coolant temperature sensor voltage below lower limit
3	Coolant temperature sensor voltage above upper limit
4	Charge air temperature sensor voltage below lower limit
5	Charge air temperature sensor voltage above upper limit
6	Lambda sensor voltage outside valid range
7	Lambda sensor lack of activity
8	Cam position sensor fault
9	Real time clock battery faulty or not fitted
10	Barometric pressure sensor low value
11	Barometric pressure sensor high value
12	EMAP sensor low value
13	EMAP sensor high value
14	MAP sensor value implausible for engine operating conditions
15	Engine overheating
16	Supply voltage too low
17	Supply voltage too high
18	Charge air overheating
19	MAP too high
20	Fuel pressure sensor low value
21	Fuel pressure sensor high value
22	One or more CAN receive sources has exceeded its timeout
23	Fuel pressure too low
24	Fuel pressure too high

throttle Throttle positon expressed as a range of 0 to 100 percent.

enginespeed Engine speed in revolutions per minute averaged across two firing events (180 crankshaft degrees on a 4 cylinder 4 stroke engine f.ex).

rawenginespeed Engine speed in revolutions per minute as calculated from two adjacent crank trigger events.

idleP, idleI, idleD Idle PID control coefficients, for analysis of PID behaviour to aid PID tuning.

roadspeed Driven wheel speed in kilometres per hour.

roadspeed2 Undriven wheel speed in kilometres per hour.

roaddistance Distance covered by driven wheels since ECU power on.

flags0 Bit field indicating status of various ECU features, subject to change with firmware revision but at the time of writing the current firmware uses the following bits:

Bit	Description
0	Engine is running above cranking speed
3	Overboost fuel cut active
4	Overrun fuel cut active
5	Overrun fuel cut delayed
6	Traction control active
7	Nitrous oxide active
8	Nitrous oxide present in cylinder (activates fuel and ignition trims)
9	Lambda sensor considered ready for feedback use by fault detection logic
10	Nitrous stage 2 active
11	Nitrous stage 2 present in cylinder

flags1 Bit field indicating status of various ECU features, subject to change with firmware revision but at the time of writing the current firmware uses the following bits:

Bit	Description
0	Fuel cut rev limit active
1	Spark cut rev limit active

mainfrequency The number of iterations of the entire background loop program completed in one second. An indicator of ECU "CPU load". Normally in the thousands.

boostpw Boost control solenoid output duty cycle.

boosttarget Boost control target pressure.

boostP, boostI, boostD Boost control PID coefficients, for analysis of PID behaviour to aid PID tuning.

fuelmass Fuel quantity commanded by fuelling strategy, in milligrams of fuel injected per cylinder per cycle.

logging Indicator that the internal data logger, if present, is recording data.

logseq The sequence number of the data log being recorded by the internal logger.

logstatus Error indicator for the internal data logging. Has a value of zero during normal operation, if the logging fails for some reason this variable will get a non-zero value.

runtime Time since engine speed was below cranking threshold.

date Time and date, in calendar units, if ECU is fitted with the internal logging option.

ecutemp Internal ECU temperature in degrees celsius.

sparkangle1..8 Ignition angle commanded by the ignition timing strategy, in degrees of crankshaft rotation before top dead centre on each cylinder.

dwell Ignition coil dwell time decided by voltage to dwell function as well as time available from duty cycle restrictions.

synclosscount Number of times the crank sync strategy has deemed the signal erroneous and performed a resync.

synclossreason An extra parameter logged by the crank sync strategy in case of a resync. No documentation available at this time, contact vendor for assistance.

syncstate Bit field indicating state of crank sync strategy. Possible values:

Value	Description
0	Engine stopped, no signal from crank position sensor
1	Engine rotating, signal from crank position sensor but crank angle or speed yet u
3	Engine rotating, speed and angle known but no cam sync
7	Engine rotating, speed, angle and phase known

crankevent, camevent The time of the last event at crank position or cam position inputs, in microseconds since ECU power on.

idlevalvepos Stepper idle valve actual position, in number of steps.

idletgtpos Stepper idle valve commanded position, leading actual position.

idlevalvepwm PWM idle valve pulse width in microseconds.

warmupmult Cold engine fuel modifier. A value of 1 means no changes done to commanded fuel by warm up strategy.

airtempmult Charge air temperature fuel modifier in use.

fuelsecmult Fuel secondary table modifier in use.

injdc1..4 Fuel injector duty cycle.

deltathrottle Throttle position rate of change, in percent per second.

deltamap MAP rate of change in millibar/second.

deltarpm Engine speed rate of change in RPM/second.

synctooth Field in crank tooth table in use at sync time, used by multi tooth trigger strategy.

syncrepeat Crank tooth repeat downcounter value at sync time. Used by multi tooth trigger strategy.

camtooth Field in crank tooth table in use at last cam shaft position sensor impulse. Used by multi tooth trigger strategy.

camrepeat Crank tooth repeat downcounter value at last cam shaft position sensor impulse. Used by multi tooth trigger strategy.

transientfuel Fuel added or removed from injected fuel mass due to throttle transients, in milligrams per cylinder per cycle.

outputs Bit field showing states of general purpose outputs.

Bit	Description
0	Always off
1	Fuel pump
2	Fan control
3	Check Engine Light
4	N2O solenoid
5	N2O stage 2 solenoid
10..13	General purpose outputs
20..23	Stepper motor outputs

sclimit Rev limit imposed by gear shift cut if ignition/fuel cuts enabled, also used to deactivate gear shift cut when so configured.

scretard Ignition retard value imposed by gear shift cut.

tcretard Ignition timing removed by traction control system, in degrees of crankshaft rotation.

lcretard Ignition timing removed by launch control, in degrees of crankshaft rotation, unless launch control is configured to absolute timing, then this value is the ignition angle in degrees before TDC.

sparkcutlimit The active rev limit for ignition control.

fuelcutlimit The active rev limit for fuel injection.

din1interval Interval between the 2 most recent impulses on digital input 1, when digital input 1 is configured for frequency input. Expressed in microseconds.

vssinterval Interval between the 2 most recent impulses on the driven wheel speed input, if not configured as a general purpose polled input. Expressed in microseconds.

gear The current transmission gear, as determined from the ratio of driven wheel speed to engine speed.

slipspeed The speed difference between driven and undriven wheel speeds in kilometres per hour. A positive number means driven travels faster than undriven, negative number vice versa.

canrx1 A counter that increments whenever a packet is received by the CAN bus controller. Rolls over at 255 and starts counting again from zero.

cansrc0..15 General purpose variables that can be assigned values from packets received on the CAN bus interface, as configured in the CAN bus options.

pwm0duty Output duty cycle of general purpose pwm function.

pwm1duty Output duty cycle of general purpose PID function.

pwm1P, pwm1I, pwm1D General purpose PID function coefficients.

pwm2duty Output duty cycle of general purpose PID function 2.

pwm2P, pwm2I, pwm2D General purpose PID function 2 coefficients.

ign_idleadvance Ignition timing added or removed by closed loop idle speed control, in degrees of crankshaft rotation. Positive number means added timing.

idletargetspeed The idle speed target used by the closed loop idle control.

lambda Combustion lambda ratio as read from the lambda sensor input.

lambdatarget Target lambda ratio for closed loop fuelling.

ign_airtempretard Ignition timing removed due to abnormal charge air temperature, in degrees of crankshaft rotation. Not used while engine below cranking speed threshold.

ign_gpmod1 Ignition timing added or removed by general purpose ignition modifier, in degrees of crankshaft rotation. Not used while engine below cranking speed threshold.

fuel_gpmod1 General purpose fuel modifier. Not used while engine below cranking speed threshold.

calpot Calibration switch selected position, if present.

ltft Fuel added or removed by closed loop fuel control, in percent. A positive number means fuel is added.

fuel_n2oadder Fuel added or removed by nitrous oxide strategy, in milligrams per cylinder per cycle. A positive number means fuel is added.

ign_n2oretard Ignition timing removed by nitrous oxide strategy.

camangle When cam sync is present and configured as edge sensitive, this variable shows the angle of the last registered cam sync edge, in degrees before TDC cyl 1, adjusted for range according to the cam angle detection configuration.

camangle2 Same as camangle, but for the second camshaft if fitted.

rawcamangle Cam angle of the last cam sync edge without adjusting for range.

rawcamangle Same as camangle, for the second camshaft if fitted.

cylcontrib1..8 The contribution of each cylinder in accelerating the crankshaft, measured in microseconds across adjacent events. A positive number means acceleration, a negative number is deceleration. This is computed by taking the time the engine takes to rotate the inter-cylinder angle (180 degrees on a typical 4 cylinder) and noting the difference across two consecutive firing events. Only available when using multi tooth trigger modes. If no cam sync is present then cylinders that are 360 degrees out of phase (cylinders sharing the same waste spark coil) can not be told apart but the code will still do the numbers for two separate cylinders.

nvvalid Binary indicator that shows if the non-volatile memory in the ECU contained valid data on start-up. This will normally be true if the ECU is fitted with the internal data logging and RTC option.

lclimit The active rev-limit imposed by the launch control. Zero if launch control inactive.

emap Exhaust manifold absolute pressure, if sensor is fitted and configured.

ratio_map_emap The ratio between inlet manifold absolute pressure and exhaust manifold absolute pressure. A value greater than one means inlet manifold pressure is higher than exhaust manifold.

barometer Atmospheric pressure, if sensor fitted and configured.

ratio_map_baro The ratio between inlet manifold pressure and barometer. A value greater than one means inlet manifold pressure is greater than barometric pressure.

turbospeed Turbocharger angular speed in revolutions per minute, if sensor fitted and configured.

gpin Bit mask showing values of the different general purpose polled switch inputs. Bits assigned as follows:

Bit	Description
0	Digital in 1 (if not configured as high speed input)
1	Digital in 2
2	Analog 4
3	Analog 5
4	Wheelspeed input, if configured as general purpose switch input

fuelflow Computed fuel flow rate combined between all cylinders.

fp_rel_baro Fuel pressure relative to barometer (aka gauge pressure). If a fuel pressure sensor is fitted, one of the three fuel pressure values will be based on the sensor reading and the other two values will be computed from barometer and MAP values.

fp_rel_map Fuel pressure relative to inlet manifold pressure

fp_abs Fuel pressure absolute.

canrxerr Bit mask showing which CAN receive sources have exceeded their timeouts, if timeouts are set.

boosterror Difference between configured pressure reference (normally MAP) and boost pressure target. A negative number means pressure is below target, positive number means pressure is greater than target.

boostgptrim1..3 Boost target general purpose trim values.

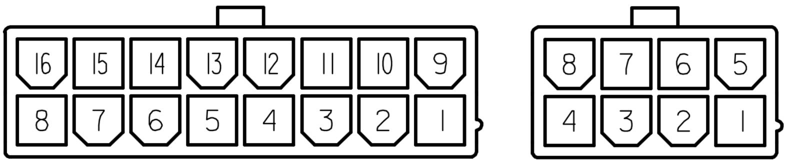
rollingtime Time since wheels started rolling, 0 if vehicle is stopped. A value of 0.001 seconds or greater means vehicle is moving. Stops counting at 65.535 seconds. Perfect for adjusting power after launch.

n2otime, n2os2time Time since nitrous stages 1 and 2 respectively were activated, a value of zero means the stage is inactive. Starts counting as soon as solenoid is switched on, stops counting at 65.535 seconds. Perfect for applying additional spark retard to soften the initial "hit" by using ignition timing trims.

B LPCX expansion board

An expansion board is available that fits inside the ECU case, part number LPCX. This expansion board adds 7 analog inputs, internal barometer, 2 extra digital inputs, 4 extra low side switch outputs and an H bridge drive output for electronic throttle control. If H bridge is used, only 3 of the low side drivers are available. The expansion board is incompatible with internal ignitors so if upgrading an ECU fitted with internal ignitors, external ignitors must be used instead.

B.1 Wiring



(a) Connector C (b) Connector D

Figure B.1: Connectors on the back of the expansion board.

B.1.1 Connector C pin-out

Pin	I/O	Function	Note
1	IN	+12V supply for H bridge	Not protected, use external 15A fuse. Only connect if using electronic throttle.
2	IN	PWM input for H bridge	Connect to pin 22 of connector A if using electronic throttle control.
3	IN	Analog 10 0-5V	3kΩ 5V pull-up
4	IN	Analog 8 0-5V	100kΩ pull-down. Throttle position A when using ETC.
5	IN	Analog 12 0-5V	51kΩ 5V pull-up
6	IN	Analog 14 0-5V	51kΩ 5V pull-up
7	OUT	Ground return for analog sensors	
8	OUT	5V sensor supply	200mA max, shared with other 5V outputs
9	IN	Digital input 3	Active low, 5.7kΩ 5V pull-up, 12V safe
10	IN	Digital input 4	Active low, 5.7kΩ 5V pull-up, 12V safe
11	IN	Analog 11 0-5V	3kΩ 5V pull-up
12	IN	Analog 9 0-5V	51kΩ 5V pull-up. Throttle position B when using ETC.
13	IN	Analog 13 0-5V	51kΩ 5V pull-up
14	NC	NC	Analog 15 if without internal barometric pressure sensor
15	OUT	Ground return for analog sensors	
16	OUT	5V sensor supply	200mA max, shared with other 5V outputs

B.1.2 Connector D pin-out

Pin	I/O	Function	Note
1	OUT	H bridge output 1	Positive in forward (opening) direction. 15A max current
2	OUT	H bridge output 2	Positive in reverse (closing) direction. 15A max current
3	IN	Power ground	Join to pins 11 and 12 on connector A
4	IN	Power ground	Join to pins 11 and 12 on connector A
5	OUT	Output 9	Low-side switch, 5A max
6	OUT	Output 10	Low-side switch, 5A max
7	OUT	Output 11	Low-side switch, 5A max. Not available when H bridge is used.
8	OUT	Output 12	Low-side switch, 5A max