E30 M3 Single Box Solution by PNPECU v1
Technical information

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Preface : If you are unsure about any of the information shown in this document please contact us via social media or email : info@pnpecu.com

This PNPECU solution is based on Baldurs Control Systems LPC4 ECU. The PnP has been designed around the 35pin OEM DME connector pinout to interface with the engine and vehicle with additional functionality thanks to the LPC4.

The Base map provided already has all inputs and outputs configured and so minimal setup should be required.

PNPECU provides lifelong free setup support to the original buyer. If you are not the original buyer of the ECU and require setup support, please contact us.

OEM Sensors usage for most common Alpha-N * MAP setup

Sensor	Used	Usable	Information
Crank speed	Yes		Crankshaft Signal
Crank reference	Yes		Camshaft Signal
AFM Vane Position		Yes	Analog 1
AFM Air temp		Yes	Analog 3
TPS Closed		Yes	Replaced with varible
TPS Open		Yes	Throttle position sensor
Coolant temp	Yes		Analog 2
Narrow band Lambda		Yes	Analog 5

Baro sensor		Yes	Analog 4
A/C Compressor Signal	Yes		Digital 1

OEM Actuator usage

Actuator	Used	Usable	Information
Idle control valve	Yes		Output 3 & 5
Tacho output	Yes		Output 1
Fuel usage output	Yes		Output 6
Evap solenoid	Yes		Output 4
Fuel pump relay	Yes		Output 2

Additionally, the PNP offers the use of a fast-acting air temp sensor through the original AFM connector and extension.

Additional Spare I/O

Inputs	Signal type	Signal information	Notes
Digital 2	Active Low	5.7k Ohm 5V pullup	12V safe
Digital 5	Active Low	5.7k Ohm 5V pullup	12V safe
CANBUS			

Outputs	Current capacity	Drive side	Pin
Ignition driver 1	15A	Low	40-37
Ignition driver 2	15A	Low	40-38
Ignition driver 3	15A	Low	40-39
Ignition driver 4	15A	Low	40-40
Ignition signal 1	50mA	5v High	40-33
Ignition signal 2	50mA	5v High	40-34
Ignition signal 3	50ma	5v High	40-35
Ignition signal 4	50mA	5v High	40-36
Injection 1	5A	Low	40-27
Injection 2	5A	Low	40-28
Injection 3	5A	Low	40-29
Injection 4	5A	Low	40-30
Output 7	5A	Low	40-31
Output 8	5A	Low	40-32
CANBUS			40-7 & 40-8

The ECU has been equipped with 4 internal ignition drivers and therefore can provide control for four inductive ignition coils (dumb coils). These can be for example BMW M50/M54/S54/N54/B58 etc options. At the same time the ignition signals are also available for use with logic level coils (smart coils) such as VAG R8 coils or similar. The two types of ignition signal outputs allow the user to choose any coils of their choosing. Special considerations need to be made in case of wanting to use CDI systems.

The ECU has total 4 Injector outputs and in the standard configuration two are being used. However all 4 are available in the 40pin connector and so if a camsync sensor is fitted sequential fuelling is possible with additional wiring. The two spare outputs can also be used for secondary injection, like additional fuel injectors, N2O or Water Methanol Injection Solenoids. Otherwise Injector 3 and Injector 4 outputs are available for any PWM output required such as Boost control, Electric Fan control etc.

CANBUS / OBDII

The ECU comes with one of the most flexible CANBUS system available in any standalone aftermarket ECU. The ECU has native OBDII signal output and so can send data for display or logging to all OBDII compatible systems such as mobile phone or tablet apps (eg Torque, RealDash etc) via the appropriate CAN module as one would purchase for their modern vehicle.

Through the flexible CANBUS architecture the ECU is able to send and receive data between almost any CANBUS device, these are things like.

- Keypads
- Lambda controllers
- OEM / Aftermarket Transmission Controllers
- OEM Instrument clusters
- Vehicle CANBUS networks
- ABS / Stability control systems
- Motorsport displays
- Power Distribution Modules

Any incoming signal can then be made to interact with the ECU for further enhancement such as

- Individual Cylinder Closed Loop Lambda
- Individual Cylinder Exhaust Gas Temperature
- Traction control
- Transmission torque management control

The possibilities are only limited to the external CANBUS devices and the signals they can provide.

The CANBUS has been made available in 5 different places on the auxiliary connectors.

Connector	CAN High pin number	CAN Low pin number	CANBUS no.
40pin	7	8	1
16pin	5,6,13,14	7,8,15,16	1

For further ease of adding CANBUS modules the 16pin connector has 12V and GND terminals.

PINOUTS

40 pin auxiliary connector.

Terminals are part number TE 5-963715-1

Pin no.	Function	Note	OEM Function
1	5V Analog supply	200mA max	
2	Analog 0	100k Ohm pull down	PNP Variable TPS
3	Analog 1	51k Ohm pull up	AFM
4	Analog GND		
5	Analog 4	51k Ohm pull up	Baro sensor
6	Analog 5	51k Ohm pull up	NB Lambda
7	CAN H		
8	CAN L		
9	Out 1		Tacho
10	Out 2		Fuel Pump Relay
11	Power GND		
12	Power GND		
13	Digital 1		A/C Compressor signal
14	Analog 2		Coolant Temp
15	Analog 3		AFM Air temp
16	Analog GND		
17	Camshaft signal		Crank reference
18	Crankshaft signal		Crank speed
19	Digital 5		
20	Analog GND		
21	Out 4		Evap Solenoid Relay
22	Out 3		Idle open
23	Digital 2		

24	Main relay out 12V+		
25	Out 5		Idle close
26	Out 6		Fuel Usage
27	Inj 1		Injectors 1,2
28	Inj 2		Injectors 3,4
29	Inj 3		
30	Inj 4		
31	Out 7		
32	Out 8		
33	Ignition signal 1		
34	Ignition signal 2		
35	Ignition signal 3		
36	Ignition signal 4		
37	Ignition driver 1		OEM Ignition coil
38	Ignition driver 2		
39	Ignition driver 3		
40	Ignition driver 4		

16 Pin connector

Terminals are part number TE 5-963715-1

Pin no.	Function	Note	OEM Function
1	Main relay out 12V+		
2	Main relay out 12V+		
3	Power GND		
4	Power GND		
5	CAN H		
6	CAN H		
7	CAN L		
8	CAN L		
9	Main relay out 12V+		
10	Main relay out 12V+		
11	Power GND		
12	Power GND		
13	CAN H		
14	CAN H		
15	CAN L		
16	CAN L		

Operational methodology

Fuel Load calculation.

Load calculation is where the engine uses sensor inputs to determine how much air is coming into each cylinder, it then compares this to the fuel system information and the desired air fuel ratio (Lambda) to determine how long each injector needs to be opened for.

The ECU can utilize almost any possible configuration found in any vehicle new or old.

- AFM for volume airflow and AFM Temp for density to provide mass airflow
- MAF for direct mass airflow (analog or frequency inputs)
- Alpha-N (Throttle angle and Engine speed)
- Alpha-N with MAP (Throttle Angle, Engine speed and manifold pressure)
- MAP (Speed density)
- Alpha-N with dual MAP (Throttle Mass Flow), one map sensor either side of the throttle/s.

The recommend method for fuel calculations is Alpha-N with MAP due to the S14 having individual throttle bodies. By fitting the supplied variable TPS the throttle angle (Alpha) becomes available. By connecting the internal map sensor to the fuel pressure regulator vacuum line via a T section the manifold pressure becomes available to the ECU. The model will take into an account the air intake charge temperature to derive the correct air density and massflow.

The main fuel map is represented with throttle position as the Y axis and the X axis is engine speed the output is volumetric efficiency in percentage.

The secondary fuel multiplier map handles the forced induction manifold pressure compensation with MAP as the Y axis and RPM as the X axis. Values in this table are multipliers, for all cases they should be 1.0 below 1000mbar/ 100kpa in the bottom row. For forced inducted engines this is the table that needs modifying for varying fueling above minimum boost. The Main fuel table should represent fueling for minimum boost.

The fuel model automatically considers the manifold pressure (positive and negative) already using the “General Purpose Modifier”. This should not be modified. The 1000 in the below examples is a constant used in the General Purpose Modifier.

The fuel output from the model is then

Primary fuel table * Secondary fuel table * 1000/MAP(mbar) = Table output.

In the Alpha-N with MAP this looks like so

Alpha-N * MAP Compensation * (1000/MAP) = Output

Example:

Primary table lookup = 100% VE @ 100% TPS @ 6000rpm

Secondary table lookup = 1.00 @ 2000mbar @ 6000rpm

1000/2000mbar = 2

100 * 1.00 * 2 = 200% Total VE.

Ignition load calculation

The ignition load can also be all the same options as the fuel calculations with addition the load axis can be represented by the current fuel load calculation (mg/cycle). The recommended method is Speed Density or MAP * RPM for standard camshaft engines as the exact ignition at part throttle is much less crucial as the fueling and in standard form the manifold pressure is a strong representation of the exact incoming airflow, this uses one table for the ignition advance control.

However many will want to use Alpha-N ignition control only. This can be achieved by changing

- Ignition primary load source – TPS
- Ignition primary load breakpoints – Adjust threshold points.

Consult PNPECU for getting any alternative load based ignition advance setup properly.

Fuel system software calibration

The ECU is able to utilize the standard BMW narrowband for calibration purposes, but caution should be taken as the exact lambda values higher or lower than Lambda 1 have extremely bad resolution on a narrowband sensor and so it would be very difficult to measure accurately the exact Lambda for increased load or lean running conditions. The Narrowband sensor analog input can be replaced with a 0-5v output wideband controller for more accurate closed loop lambda control. For convenience the narrowband analog is also available on the 40 pin connector on pin 6.

NOTE : Be sure to disconnect the narrowband sensor from the OEM connector to not cause misreading when also having a wideband controller output wired to pin 40-6.

The ECU is also able to receive Lambda data from any CAN Bus based Lambda controller and multiple at that. If the CANBUS information is not available from the manufacture or you need help with setting up the CAN Receive please contact PNPECU.

Examples

- Single Lambda controller to monitor all four cylinders – **most common approach**
- Four Lambda controllers, where each is installed in each exhaust runner. The average per injector pair is used for closed loop fuelling on that bank since Injectors are paired in the standard engine harness
- Four Lambda controllers, where each is installed in each exhaust runner. Two additional injector signals have been added to gain sequential and individual cylinder fuel control. Each Cylinders Lambda controllers is used in that cylinders closed loop lambda control.
- Five Lambda controllers, where four are used for monitoring and then a single one for closed loop control for all exhaust gases after the exhaust collector.

In individual cylinder closed loop adjustments for turbo charged vehicles PNPECU recommends that the Bosch ADV sensors are used with the appropriate Lambda controller so that the exhaust pressure is compensated for automatically. If an Exhaust Back Pressure sensor was fitted the ECU can perform the compensation automatically after some testing and validation for accuracy.

For accurate fuel tables, enrichments and good closed loop control it´s imperative that the fuel settings are accurate. These are

- Engine size
- Number of cylinders
- Fuel specific gravity (kg/l)
- Fuel composition (Ethanol content)
- Fuel pressure
- Fuel temperature
- Injector flow rate
- Injector ultra-low opening time flow rate (important for big injectors)

- Injector dead time values

In the E30 M3 some assumptions must be made since many of the sensor inputs are not available but can be added for various scenarios like being able to use pump fuel or E85 without having to do any calibration changes before heading out for a drive.

The main important detail is the injector dead time / latency / offset values vs battery voltage as this allows correct fuel delivery during starting as well as when there is an alternator failure. For setups where there will be varying fuel pressure (delta pressure across the injectors) being used then a deadtime adjustment table is available to make sure that the fuel delivery is accurate at all times.

Ignition system software calibration.

In the OEM single coil setup the coil dwell times have all been setup already. For all other scenarios the new coils dwell times must be known and setup in the ECU.

NOTE : If a logic level ignition output is to be used with a smart coil then the same inductive IGBT output cannot be used for any other function as these outputs mimic eachother, please take that into consideration when planning auxiliary output functions.

The PNP ECU is setup to accommodate 1 (distributor),2 (wasted spark) or 4 coils (coil on plug, coil near plug). Depending on what type they are the wiring must be done correctly. The ECU can then setup properly.

- Primary dwell time
- Primary coil duty cycle limit
- Primary ignition coil assignment by cylinder
- Number of primary ignition outputs

It´s suggested that for wasted spark setups that Ignition output 1 is wired to coil that runs cylinder 1 and 4 and Ignition output 2 is wired to the coil that runs cylinder 3 and 2.

For 4 individual coils it´s suggested that each cylinder coil is wired to the corresponding ignition output numbers. E.g. Coil 1 – Ignition 1, Coil 2 – Ignition 2 etc.

OEM Functions , Outputs and Inputs

The PNP ECU manages all the OEM functions and each function can be made to function differently if desired.

Outputs

EVAP :

The EVAP relay control is controlled by General Purpose Logic 1 inside the ECU.

There the engine speed and throttle amount can be calibrated to manage when the EVAP relay is turned on.

IDLE Control :

The dual solenoid idle control is managed by the ECU´s internal closed loop idle control logic. Target idle speeds can be adjusted as required.

Tachometer :

The tachometer output is setup to mimic the standard 4 cylinder output, but in the event that the engine and loom are fitted to a car that has a tacho designed for 6 or 8 cylinder engines then that can be adjusted and no external changes are needed.

Fuel pump relay :

The fuel pump relay is primed during ECU power up and is then on when the engine is running.

If more elaborate fuel pump management is required like PWM or CANBUS contact PNPECU.

Fuel usage output :

The Fuel usage output is managed by the Generic PWM output. Since the table is based on total fuel mass being injected this should only require minor adjustment.

Inputs

Air temperature sensor :

The ECU receives temperature sensor voltage through the original AFM wiring , but the PNP is supplied with a adapter to allow a 2 wire temp sensor to be used when the AFM is removed. If the AFM is to be retained no action is required.

Air flow sensor :

The ECU receives airflow volume information from the AFM vane position. This is then calculated to provide airflow on a per cycle and cylinder basis. By combining the air temp sensor and airflow sensor air mass flow is achieved.

NOTE : If the AFM has been removed then Analog 1 is available on 40-3 for any analog sensor input. Analog 1 is also available in the AFM connector pin 2 which is free when fitted with the

air temp sensor adapter loom. If the AFM plug is to be used for additional analog 5V is also available there, but the analog ground must be spliced into as it´s already being used by the air temp sensor.

Coolant temperature sensor :

The ECU receives temperature sensor voltage and converts that to coolant temperature. This is then used for warmup and idle target set points.

A/C Compressor activation input signal :

The vehicle will send a signal to the ECU which tells it that the A/C compressor is running, the PNP ECU sees this signal and increases the idle control valve duty cycle a suitable amount so that there is no drop in engine speed while the A/C is active.

Throttle position :

The ECU has been designed to either work off of the standard two position sensor and when it´s being used that way the AFM must also be retained or a MAF fitted in it´s place or it can use a variable throttle position sensor. The common setup is variable TPS, internal jumpers must be moved to achieve OEM 2 position sensor functionality as well as software adjustments.

To calibrate the variable sensor it´s important that there is no issues with the throttle blade movements before setting the voltage range. Two calibration values need to be adjusted for accurate throttle angle measurements.

- Throttle position voltage sensing range
- Throttle position error limits – should be 0.5v above and below the working range.

Narrow band Lambda sensor :

The ECU is able to read the sensor output voltage and translate that to Lambda / AFR but this information is not highly accurate outside 0.95-1.05 Lambda range and so a wideband controller and sensor should be fitted. This can be either a 0-5v analog or canbus based controller.

To calibrate the wideband controller voltage range, consult the output of the wideband controller manufacturer. Be sure to wire the Lambda controller analog ground back to the ECU so that accurate ground offset exists between the two devices.

For canbus controllers please consult PNPECU.

Barometric pressure sensor :

The ECU receives voltage from the sensor and is able to show and make use of the barometric pressure for both fuel and ignition adjustments.

NOTE : If this sensor is removed then Analog 4 is available on 40-5 for any analog sensor input.