LPC8 ECU
-
REFERENCE MANUAL

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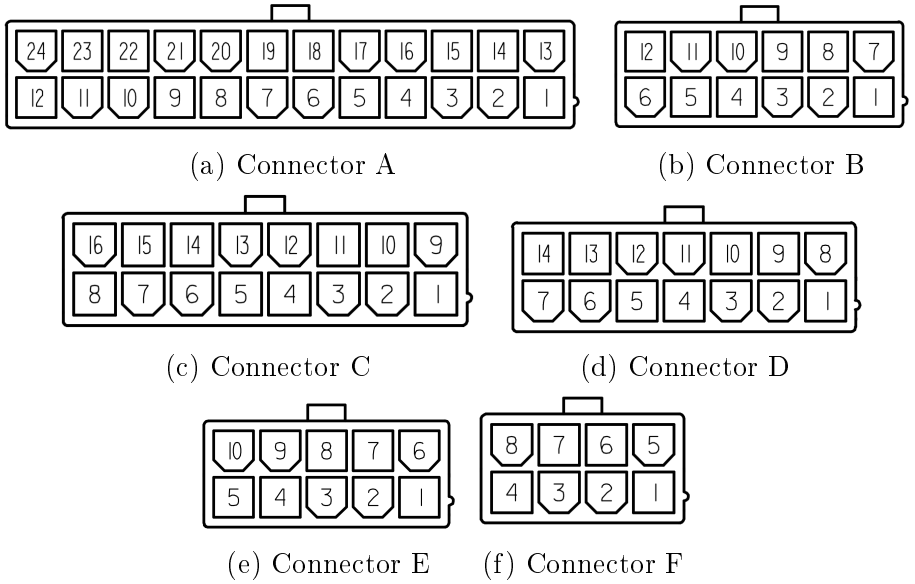
1 Introduction

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.
LPC8 is an evolution of the LPC4 that adds sequential fuelling and ignition for up to 8 cylinders as well as more sensor inputs, including but not limited to an integrated wide band lambda sensor controller for Bosch LSU sensors and inputs for two knock sensors. On the LPC8, internal data logging and real time clock is standard fitment, but an option on the LPC4. The LPC8 also has electronic throttle control support standard while the LPC4 requires an add-on board for that.
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.
An update to the LPC8 hardware made available in January 2021 introduced a redesigned lambda sensor interface with more comprehensive sensor diagnostic capability and more configurable operation for compatibility with a greater variety of sensors. The update also added an optional connector for a second lambda sensor as well as 6 additional analog inputs (1 added analog input without the second lambda option)

2 Wiring

2.1 Pin-outs and description

2.1.1 Pin numbering



(a) Connector A (b) Connector B

(c) Connector C (d) Connector D

(e) Connector E (f) Connector F

Figure 2.1: Pin numbering of the different connectors on the back of the controller. Note that the connectors are not oriented as shown but the locking tabs face inwards. Connector E only present on units with second lambda sensor option, located on front panel above USB port. Connector F also located on the front, present on units with serial number 2200 and above.

2.1.2 Connector A pin-out

Pin	I/O	Function	Note
1	OUT	5V sensor supply	200mA max
2	IN	Analog 0 0-5V - TPS (APP A in ETC mode)	100kΩ pull-down
3	IN	Analog 1 0-5V (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 default
18	IN	Crank trigger input	2.2kΩ pull-up default
19	IN	Digital input 5	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	Ignition 5	5V logic, 50mA max. Also capable of being a 5A low side switch output[1]
4	OUT	Ignition 6	5V logic, 50mA max. Also capable of being a 5A low side switch output.
5	OUT	Ignition 7	5V logic, 50mA max. Also capable of being a 5A low side switch output.
6	OUT	Ignition 8	5V logic, 50mA max. Also capable of being a 5A low side switch output.
7	OUT	Output 7	Low-side switch, 5A max
8	OUT	Output 8	Low-side switch, 5A max
9	OUT	Ignition 1	5V logic, 50mA maximum current sourced[2]
10	OUT	Ignition 2	5V logic, 50mA maximum current sourced
11	OUT	Ignition 3	5V logic, 50mA maximum current sourced
12	OUT	Ignition 4	5V logic, 50mA maximum current sourced

[1] Prior to serial number 2200 the function of ignition outputs 5-8 could be altered at build time, from 2200 and up the function can be switched between logic level or low side switch in software, but note that they are ganged together so either all four are logic level or all four are low side switches.

[2] Current limit of all ignition outputs was 15mA in older controllers prior to serial number 2200

2.1.4 Connector C pin-out

Pin	I/O	Function	Note
1	IN	Knock sensor 1	
2	IN	Knock sensor 2	
3	IN	Lambda sensor nernst voltage	Connect to pin 6 of LSU4.9 sensor (black wire)
4	OUT	Lambda sensor virtual ground	Connect to pin 2 of LSU4.9 sensor (yellow wire)
5	IN	Analog 10 0-5V	51kΩ 5V pull-up default, software selectable 2975 Ω
6	IN	Analog 8 0-5V	100kΩ 5V pull-down. Throttle position A when using ETC.
7	IN	Analog 12 0-5V	51kΩ 5V pull-up.
8	OUT	Ground return for analog sensors	
9	IN	Digital input 4 (vehicle speed typical)	Active low, 11kΩ 5V pull-up, 12V safe. Software configurable pull down on units sold or updated after January 2021.
10	OUT	Lambda sensor pump current	Connect to pin 1 of LSU4.9 sensor (red wire)
11	IN	Lambda sensor trim resistor	Connect to pin 5 of LSU4.9 sensor (no wire)
12	IN	Digital input 3	Active low, 11kΩ 5V pull-up, 12V safe. Software configurable pull down on units sold or updated after January 2021.
13	IN	Analog 11 0-5V	51kΩ 5V pull-up default, software selectable 2975 Ω
14	IN	Analog 9	51kΩ 5V pull-up. Throttle position B when using ETC.
15 15	NC IN	NC Analog 18	Older units 51kΩ 5V pull-up. Only units sold or updated after January 2021.
16	OUT	5V sensor supply	200mA max, shared with other 5V outputs

2.1.5 Connector D pin-out

Pin	I/O	Function	Note
1	OUT	Throttle H bridge output 1	Positive in forward (opening) direction. 15A max current
2	OUT	Injector 1	Low-side switch, 5A max
3	OUT	Injector 2	Low-side switch, 5A max
4	OUT	Injector 3	Low-side switch, 5A max
5	OUT	Injector 4	Low-side switch, 5A max
6	OUT	Lambda heater	Low-side switch, 5A max, connect to pin 3 of LSU4.9 sensor (white wire)
7	IN	Power ground	Join with wires from pins 11 and 12 of connector A no more than 150mm away from controller.
8	OUT	Throttle H bridge output 2	Positive in reverse (closing) direction. 15A max current
9	OUT	Injector 5	Low-side switch, 5A max
10	OUT	Injector 6	Low-side switch, 5A max
11	OUT	Injector 7	Low-side switch, 5A max
12	OUT	Injector 8	Low-side switch, 5A max
13	IN	+12V supply for H bridge	Not protected, use external 15A fuse. Only connect if using electronic throttle.
14	IN	Power ground	Join with wires from pins 11 and 12 of connector A no more than 150mm away from controller.

2.1.6 Connector E pin-out

This connector is only present on units sold or updated after January 2021 with the second lambda controller option.

Pin	I/O	Function	Note
1	OUT	Lambda sensor 2 virtual ground	Connect to pin 2 of LSU4.9 sensor (yellow wire)
2	IN	Lambda sensor 2 nernst voltage	Connect to pin 6 of LSU4.9 sensor (black wire)
3	OUT	Lambda sensor 2 pump current	Connect to pin 1 of LSU4.9 sensor (red wire)
4	IN	Lambda sensor 2 trim resistor	Connect to pin 5 of LSU4.9 sensor (no wire). Optional.
5	OUT	Lambda 2 heater	Low-side switch, 5A max, connect to pin 3 of LSU4.9 sensor (white wire)
6	IN	Analog 19 0-5V	51kΩ 5V pull-up.
7	IN	Analog 20 0-5V	51kΩ 5V pull-up.
8	IN	Analog 21 0-5V	51kΩ 5V pull-up.
9	IN	Analog 22 0-5V	51kΩ 5V pull-up.
10	IN	Analog 23 0-5V	51kΩ 5V pull-up.

2.1.7 Connector F pin-out

This connector is only present on units with serial number 2200 and up.

Pin	I/O	Function	Note
1	OUT	Output 9	Low-side switch, 1A max
2	OUT	Output 10	Low-side switch, 1A max
3	IN	Ignition switch input	12V in to activate main relay, does not power ECU by itself
4	OUT	Main relay control	Low-side switch, 1A max
5	OUT	Output 11	Low-side switch, 1A max
6	OUT	Output 12	Low-side switch, 1A max
7	IO	CAN bus 2 H	Without 120Ω termination
8	IO	CAN bus 2 L	Without 120Ω termination

2.2 Wiring diagrams

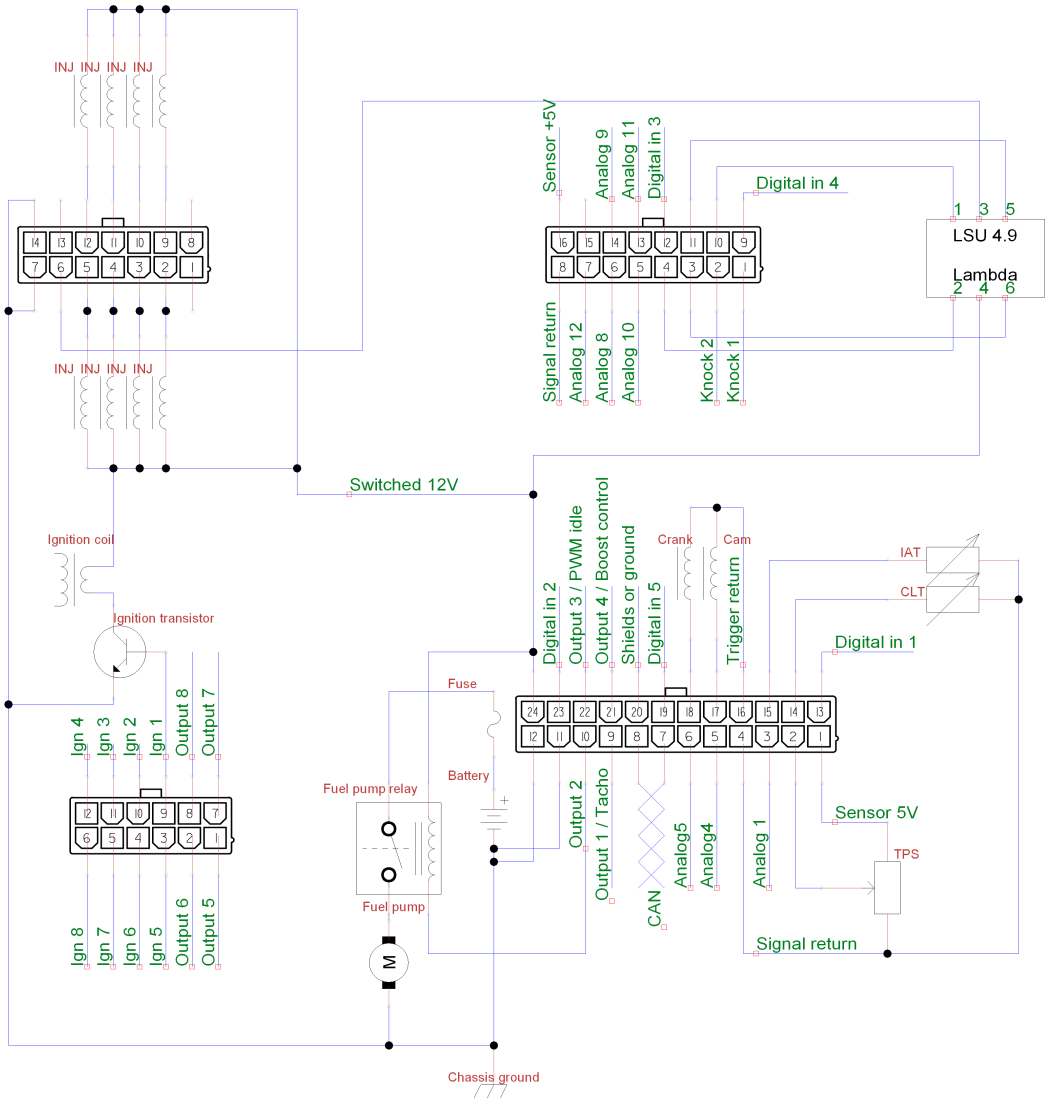


Figure 2.2: Typical basic wiring

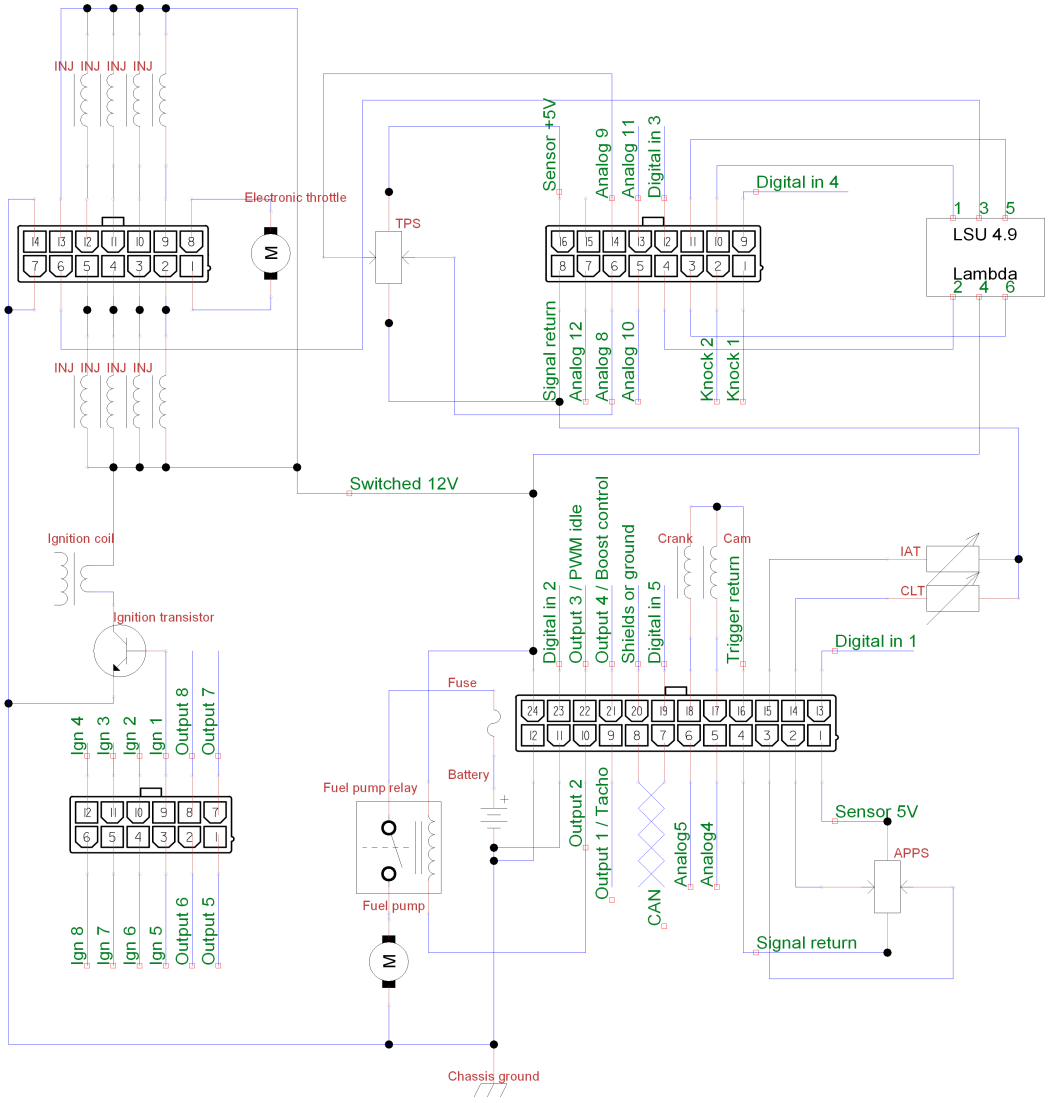


Figure 2.3: Typical wiring with electronic throttle.

2.3 Wiring guidelines

2.3.1 Grounding

The controller should be connected to the battery negative terminal or another reliable grounding point by at least a pair of $1.5mm^2$ wires or a single $6mm^2$ wire joined to smaller wires near the connector. The controller requires 4 ground wires, connected to pins 11 and 12 of connector A and pins 7 and 14 of connector D. These 4 ground wires must be joined together no more than 150mm away from the controller. From this joint you may connect the ground wire(s) that go to the battery or cylinder head. 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 LPC8 has eight 5V logic-level outputs current limited to 15mA. To utilise those outputs requires either ignition coils with internal igniters or an external ignition transistor module. If your engine has neither, a good cost effective transistor module for up to 8 coils may be purchased from `https://controls.is/itm8.html`

2.3.4 Idle control

The LPC8 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. When using electronic throttle control, a dedicated idle control valve is typically not necessary or desireable, but is supported by the controller firmware nonetheless. If not using the electronic throttle for idle control, simply set the idle control authority in the electronic throttle section of the configuration to zero.

2.3.5 Electronic throttle control

In electronic throttle control mode, the accelerator pedal connects to pins 1 through 4 on connector A and throttle position sensors on the throttle body connect to pins 6 and 14 on connector C as well as shared sensor ground and sensor 5V supply. It is not recommended to share the ground path or 5V feed for the accelerator pedal with any other sensor.
The electronic throttle motor connects to pins 1 and 8 of connector D, in current direction that opens the throttle, positive voltage will be supplied from pin 1 and negative from pin 8.
The throttle driver bridge needs a +12V supply feed to pin 13 of connector D. An in-line fuse rated 10-15A is recommended to protect the circuit.

2.3.6 Lambda sensor

The LPC8 includes a controller for one wide band lambda sensor. Calibration is provided to run Bosch LSU 4.9 sensors but if you are able to create your own calibration data, other LSU sensors as well as certain NTK sensors may be used.
For LSU4.9 sensors, no calibration is typically necessary as the sensor's trim resistor is used for reference.

LSU 4.9 pin	Function
1	Pump current, pin C10 on ECU, red wire
2	Virtual ground, pin C4 on ECU, yellow wire
3	Heater negative, pin D6 on ECU, white wire
4	Heater positive, 12V power when ECU is powered, grey wire
5	Reference resistor, pin C11 on ECU, terminated inside connector, no wire
6	Nernst voltage, pin C3 on ECU, black wire

Figure 2.4: Bosch LSU4.9 sensor wiring

2.3.7 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. 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 2.5: Functions with dedicated outputs

2.4 Mercedes G320 M104 engine wiring

Power supply

In the case of LPC8 the power ground wires should join together into a junction with 4 wires going to pins A11, A12, D7, D14

Wire colour	Function	OEM pin	LPC4/8 pin
red/black	ECU +12V	1/27	A24
red/yellow	ECU +12V	1/39	LPC8 D13
brown	Power ground	1/32	A11
brown	Power ground	1/33	A12

Injector 1 (Y62y1)

Device pin	Wire colour	Function	OEM pin	LPC4 pin	LPC8 pin
1	grey/black	+12V	+12 junction		
2	grey/black	Negative	2/23	B3	D2

Injector 2 (Y62y2)

Device pin	Wire colour	Function	OEM pin	LPC4 pin	LPC8 pin
1	grey/blue	+12V	+12 junction		
2	grey/blue	Negative	2/15	B4	D3

Injector 3 (Y62y3)

Device pin	Wire colour	Function	OEM pin	LPC4 pin	LPC8 pin
1	grey/green	+12V	+12 junction		
2	grey/green	Negative	2/2	B5	D4

Injector 4 (Y62y4)

Device pin	Wire colour	Function	OEM pin	LPC4 pin	LPC8 pin
1	white/blue	+12V	+12 junction		
2	white/blue	Negative	2/3	B6	D5

Injector 5 (Y62y5)

Device pin	Wire colour	Function	OEM pin	LPC4 pin	LPC8 pin
1	grey/yellow	+12V	+12 junction		
2	grey/yellow	Negative	2/12	B7	D9

Injector 6 (Y62y6)

Device pin	Wire colour	Function	OEM pin	LPC4 pin	LPC8 pin
1	grey/violet	+12V	+12 junction		
2	grey/violet	Negative	2/24	B8	D10

Ignition coil 1/6 (T1/1)

This requires an ITM8 ignition amplifier module, or alternatively an LPC4 with internal coil drivers option.

Device pin	Wire colour	Function	OEM pin	LPC4/8 pin
1	black/yellow	Negative	2/21	B9
15	pink/red	+12V	+12 junction	

Ignition coil 2/5 (T1/2)

This requires an ITM8 ignition amplifier module, or alternatively an LPC4 with internal coil drivers option.

Device pin	Wire colour	Function	OEM pin	LPC4/8 pin
1	black/white	Negative	2/9	B10
15	pink/red	+12V	+12 junction	

Ignition coil 3/4 (T1/3)

This requires an ITM8 ignition amplifier module, or alternatively an LPC4 with internal coil drivers option.

Device pin	Wire colour	Function	OEM pin	LPC4/8 pin
1	black	Negative	2/10	B11
15	pink/red	+12V	+12 junction	

Crankshaft position sensor (L5)

Device pin	Wire colour	Function	OEM pin	LPC4/8 pin
1	green	Signal	2/30	A18
S	shield	Return	2/29	A16

Camshaft position sensor (L5/1)

Device pin	Wire colour	Function	OEM pin	LPC4/8 pin
1	brown/green	Return	2/19	A4
2	yellow/grey	Signal	2/8	A17
3	red/blue	+12V	+12 junction	

Knock sensor 1 (A16/1)

Not applicable to LPC4

Device pin	Wire colour	Function	OEM pin	LPC8 pin
1	shield	Return	2/40	C8
2	yellow	Signal	2/41	C1

Knock sensor 1 (A16/2)

Not applicable to LPC4

Device pin	Wire colour	Function	OEM pin	LPC8 pin
1	shield	Return	2/42	C8
2	violet	Signal	2/43	C1

Camshaft position sensor (L5/1)

Device pin	Wire colour	Function	OEM pin	LPC4/8 pin
1	brown/green	Return	2/19	A4
2	yellow/grey	Signal	2/8	A17
3	red/blue	+12V	+12 junction	

Throttle body (M16/6)

This engine does not have a true electronic throttle system so the throttle body is only supported as a manual throttle body. With the LPC8 it is possible to convert to a true electronic throttle by

adding a separate pedal position sensor and fitting a true fully electronic throttle body.

Device pin	Wire colour	Function	OEM pin	LPC4/8 pin
2	black	Motor	2/4	no connect
3	blue	Motor	2/26	no connect
5	violet	Return	2/18	A4
6	white	Sensor 2	2/7	no connect
7	yellow	Sensor 1	2/39	A2
8	grey	+5V supply	2/6	A1

Intake air temperature sensor (B17)

Device pin	Wire colour	Function	OEM pin	LPC4/8 pin
1	brown/white	Return	2/28	A4
2	green/white	Signal	2/37	A15

Engine coolant temperature sensor (B11/4)

On this sensor, pins 2 and 3 connect to the instrument cluster and have nothing to do with the ECU.

Device pin	Wire colour	Function	OEM pin	LPC4/8 pin
1	green/red	Signal	2/36	A14
4	brown/white	Return	2/28	A4

Intake manifold switchover valve (Y22/5)

Device pin	Wire colour	Function	OEM pin	LPC4/8 pin
1	green/violet	Negative	2/14	B2
2	black/violet	+12V supply	+12 junction	

Camshaft timing solenoid (Y49)

Device pin	Wire colour	Function	OEM pin	LPC4/8 pin
1	brown/grey	Negative	2/1	B1
2	black/violet	+12V supply	+12 junction	

Malfunction indicator lamp (A1e10)

Device pin	Wire colour	Function	OEM pin	LPC4 pin	LPC8 pin
D2	brown/white	Control	1/17	C1	F1

Fuel pump relay (K40k1)

Device pin	Wire colour	Function	OEM pin	LPC4 pin	LPC8 pin
E3	blue/red	Control	1/29	C2	F2

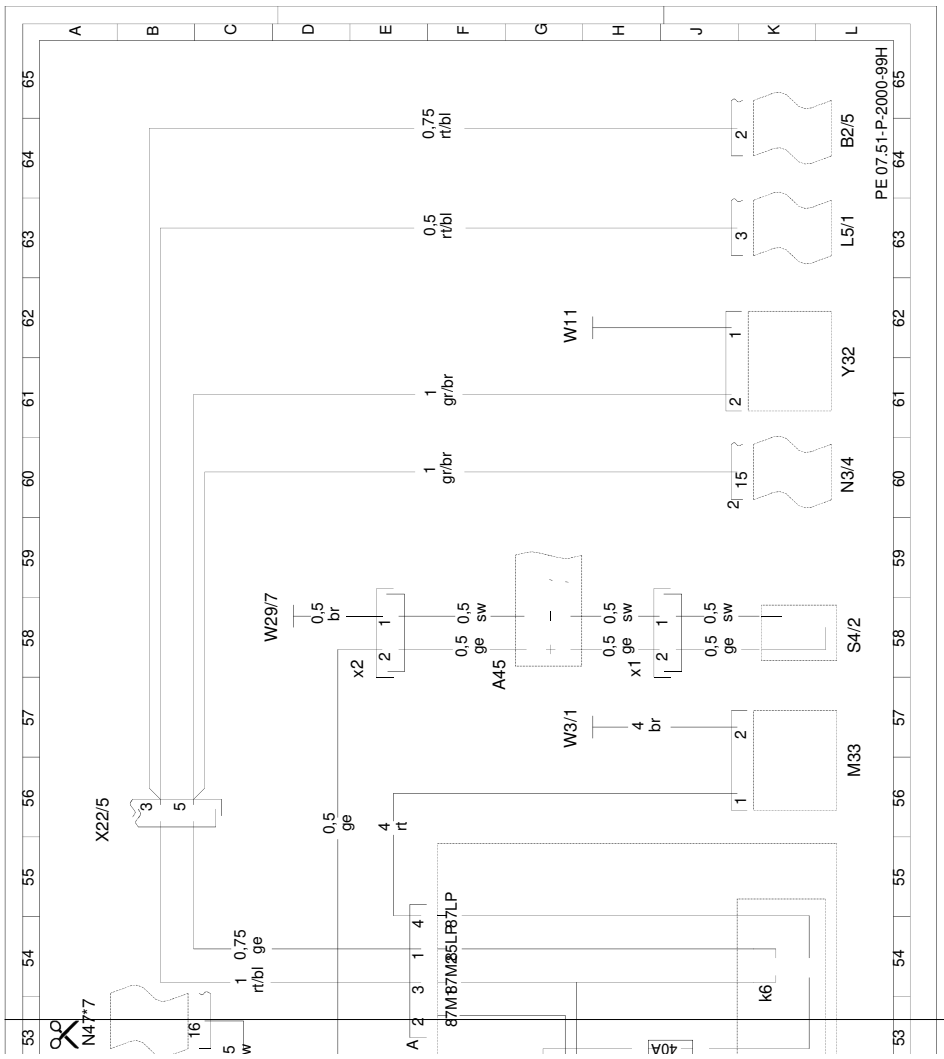
2.4.1 Factory wiring diagrams for G320

Document number: pe07.51-p-2000-99h
Document title: Wiring diagram HFM-SFI sequential multiport fuel injection/ ignition system

Code:	Designation:	Coordinates:
A1	Instrument cluster	27 L
A1e10	O2 sensor malfunction indicator lamp	26 L
A45	Horn/airbag clock spring contact	57 G
A45x2	FAN relay module clock spring contact connector	57 E
B19	TWC temperature sensor	30 L
B2/5	Hot film MAF sensor	64 L
F1	Fuse box	20 H
F1f25	Fuse 25 circuit 15	20 H
G3/1	O2 sensor downstream of TWC	28 L
H2	FAN horns	45 A
H2	FAN horns	47 A
K32	ABS shut-off relay module 1	52 A
K40	Relay module	39 L
K40	Relay module	51 L
K40f1	Differential locks/traction system fuse	49 J
K40f2	EDC/circuit 87 Motronic (2) fuse	39 J
K40f3	Circuti 87 Motronic (1) fuse	38 J
K40f4	AIR pump fuse	52 J
K40f5	Fuel pump fuse	37 J
K40f6	FAN horn fuse	41 J
K40k1	Fuel pump relay	37 K
K40k4	FAN horn relay	43 K
K40k5	Differential locks relay	50 K
K40k6	AIR pump relay	53 K
K40k9	Circuit 87 Motronic 1 and 2 relay	39 K
L5/1	Camshaft position sensor	63 L
M1	Starter	7 L
M3	Fuel pump	34 L
M33	AIR pump	56 L
N3/4	HFM-SFI [HFM] engine control module	5 A
N3/4	HFM-SFI [HFM] engine control module	15 A
N3/4	HFM-SFI [HFM] engine control module	25 A
N3/4	HFM-SFI [HFM] engine control module	32 A
N3/4	HFM-SFI [HFM] engine control module	41 A
N3/4	HFM-SFI [HFM] engine control module	60 L
N54/1	IR DAS [IR FBS] control module	4 L
S16/1	Starter lockout and reverse lamp switch	10 L
S2/1	Ignition/starter switch	5 L
S2/1	Ignition/starter switch	49 A

Document number: pe07.51-p-2000-99h
Document title: Wiring diagram HFM-SFI sequential multiport fuel injection/ ignition system

Code:	Designation:	Coordinates:
S4/2	FAN horn switch	58 L
S4/2x1	FAN horn switch connector	57 H
S40	Cruise control switch	15 L
S40x1	Cruise control switch connector	13 H
S65	Transmission overload protection switch	11 L
S76	Differential lock switch group	51 A
S9/1	Stop lamp switch	18 D
W11	Ground (engine _ connection point for ground wires)	62 H
W12	Ground (center console)	28 H
W12	Ground (center console)	32 L
W29/2	Ground (right A pillar)	36 D
W29/7	Ground (steering column)	11 E
W29/7	Ground (steering column)	58 D
W3/1	Ground (right front wheelhousing)	57 H
W3/2	Ground (left front wheelhousing)	45 A
W30	Ground (frame)	34 H
X11/4	Data link connector (DTC readout)	42 D
X12/3	Terminal block circuit 15, 30, 61 (3-pin)	21 F
X12/3	Terminal block circuit 15, 30, 61 (3-pin)	31 L
X12/3	Terminal block circuit 15, 30, 61 (3-pin)	38 C
X12/3	Terminal block circuit 15, 30, 61 (3-pin)	49 A
X14	Circuit 50 connector	6 G
X22/2	Automatic transmission connector	9 G
X22/5	Engine/main harness connector (6-pin)	55 B
X4/30	Terminal block engine circuit 30	8 G
X47/5	TD signal connector	25 L
X92/3	Frame connector (22-pin)	34 F
Y32	AIR pump switchover valve	61 L
Y58	Fuel tank vent valve	23 L
Z50/1	Connector sleeve 1	17 F
Z50/4	Connector sleeve 4	18 L
Z50/5	Connector sleeve 5	48 D
Z50/7	TN connector sleeve	24 F
Z61	Vehicle speed signal connector sleeve (ABS output)	2 F



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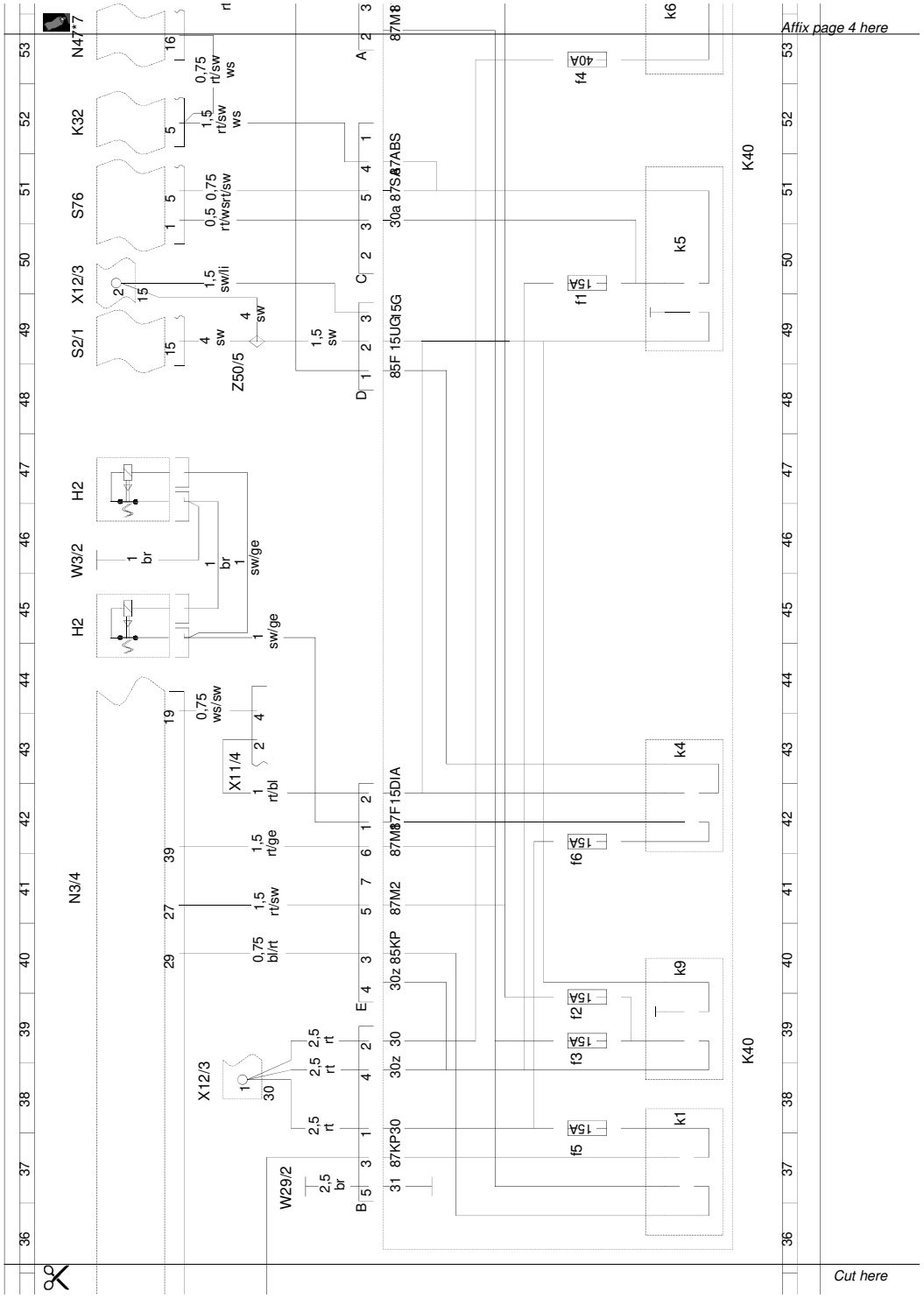
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Wiring diagram HFM-SFI sequential multiport fuel injection/ ignition system / pe07.51-p-2000-99h
ENGINE 104.996 in MODEL 463 as of 1.1.96 Engine compartment / frame floor system wiring harnesses / Printed on: 28.01.2022 / Page
N47*7
K32
S76
S2/1
X12/3
Z50/5
H2
W3/2
N3/4
X11/4
W29/2
K40
k1
k4
k5
k6
k9
f1
f2
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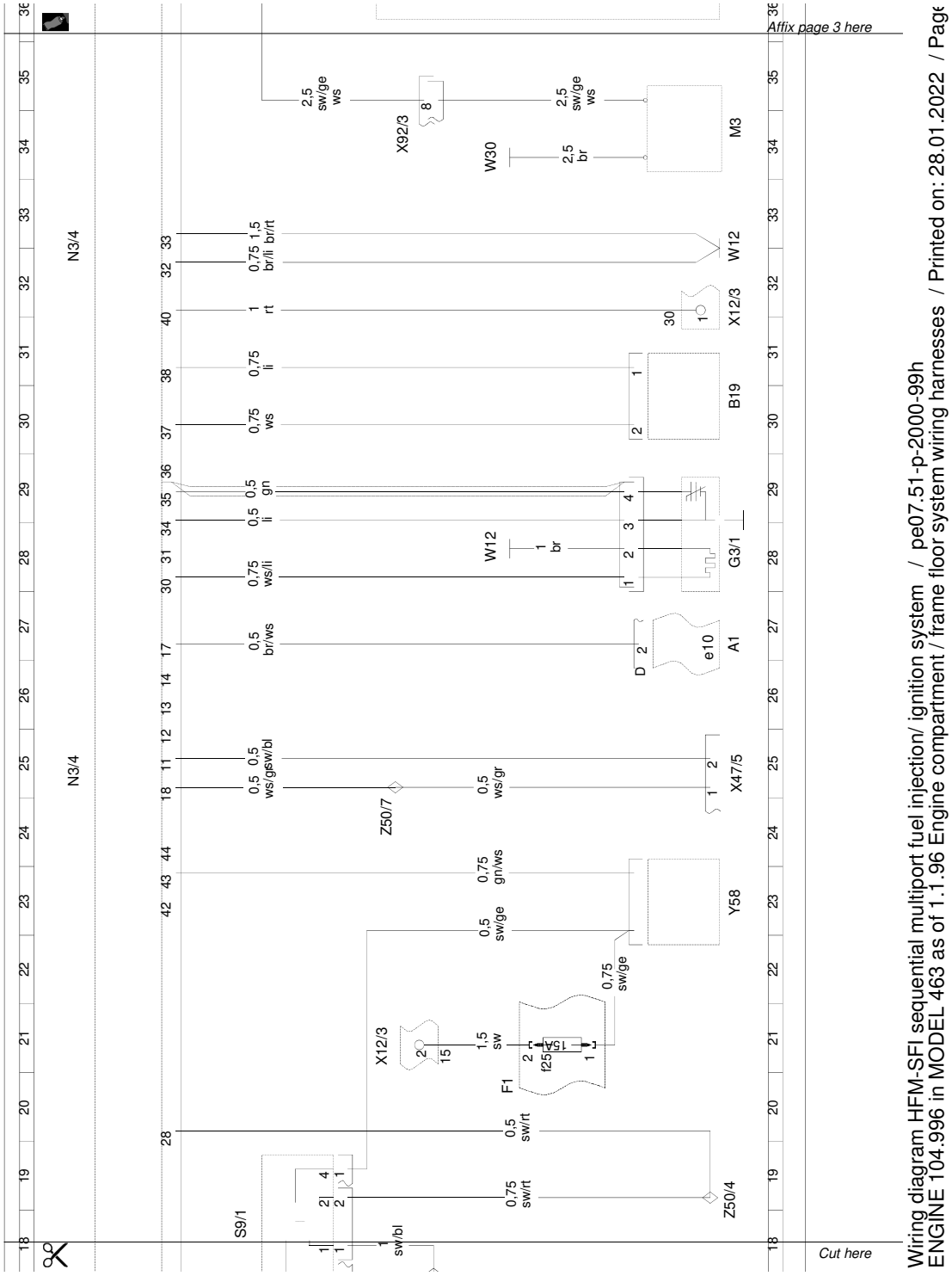
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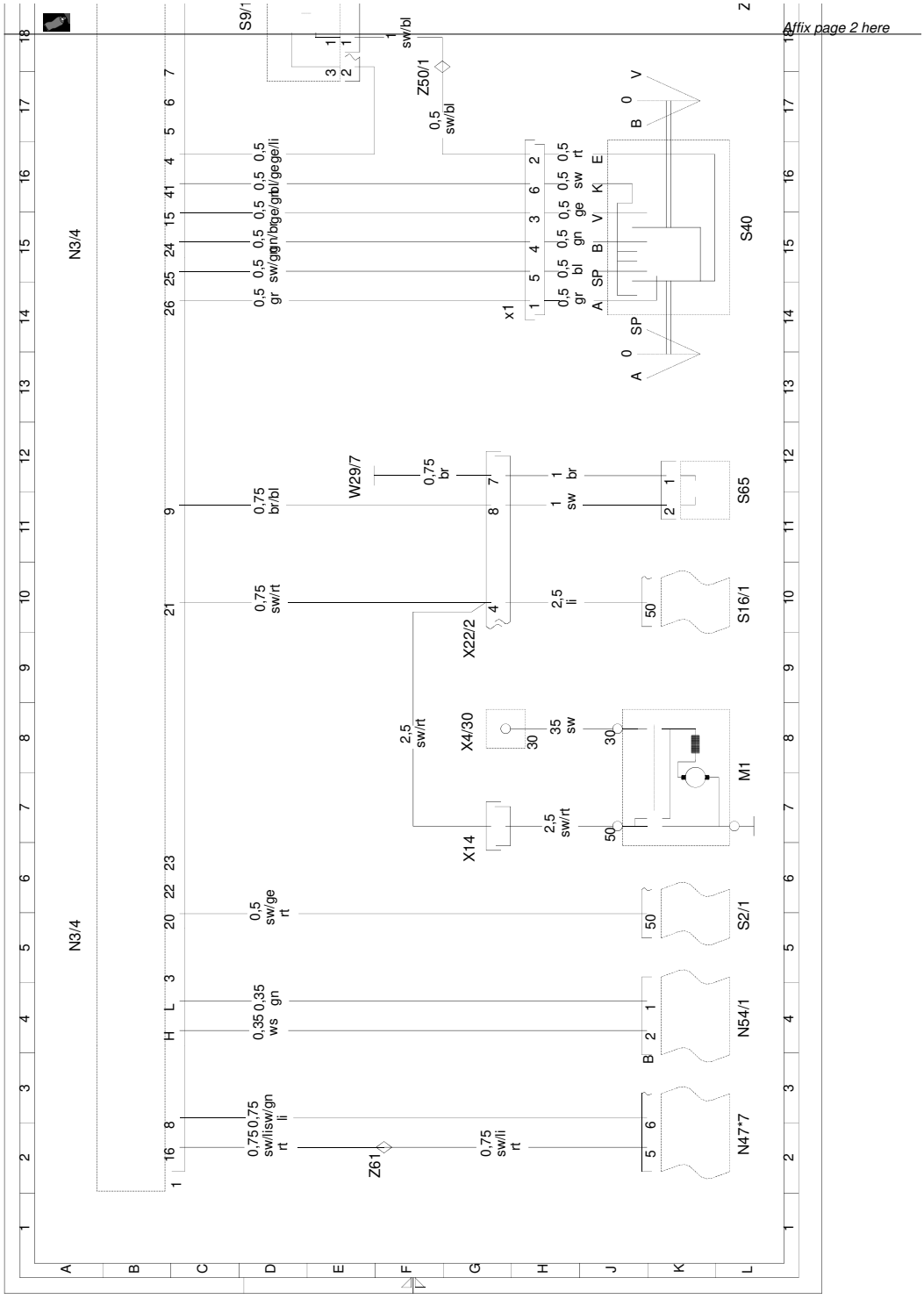
N3/4
N3/4
X92/3
W30
M3
W12
X12/3
B19
G3/1
W12
A1
e10
X47/5
Z50/7
Y58
X12/3
F1
f25
15A
S9/1
Z50/4
Wiring diagram HFM-SFI sequential multiport fuel injection/ ignition system / pe07.51-p-2000-99h
ENGINE 104.996 in MODEL 463 as of 1.1.96 Engine compartment / frame floor system wiring harnesses / Printed on: 28.01.2022 / Page



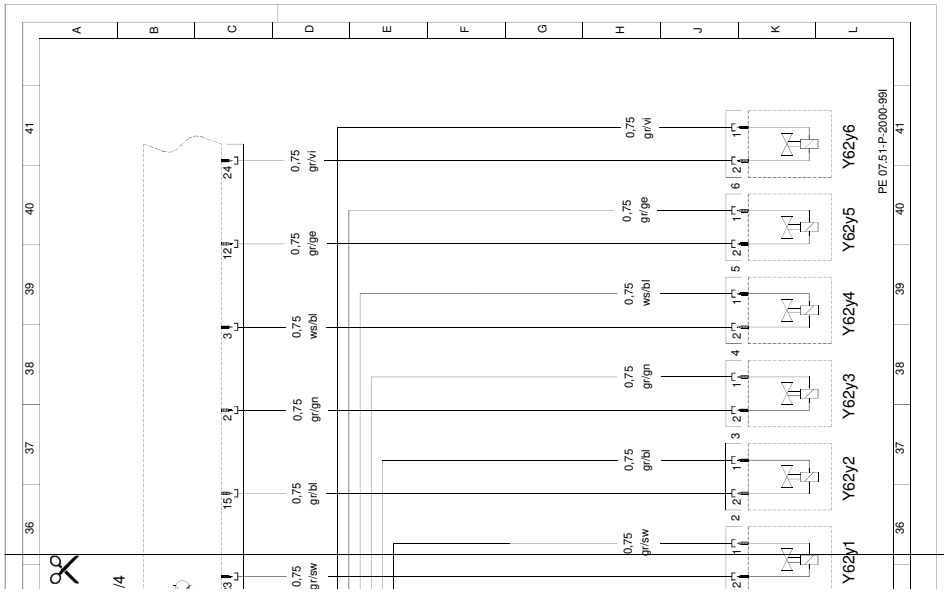
Wiring diagram HFM-SFI sequential multiport fuel injection/ ignition system / pe07.51-p-2000-99h
ENGINE 104.996 in MODEL 463 as of 1.1.96 Engine compartment / frame floor system wiring harnesses / Printed on: 28.01.2022 / Page

Document number: pe07.51-p-2000-99i
Document title: Wiring diagram HFM-SFI sequential multiport fuel injection/ ignition system

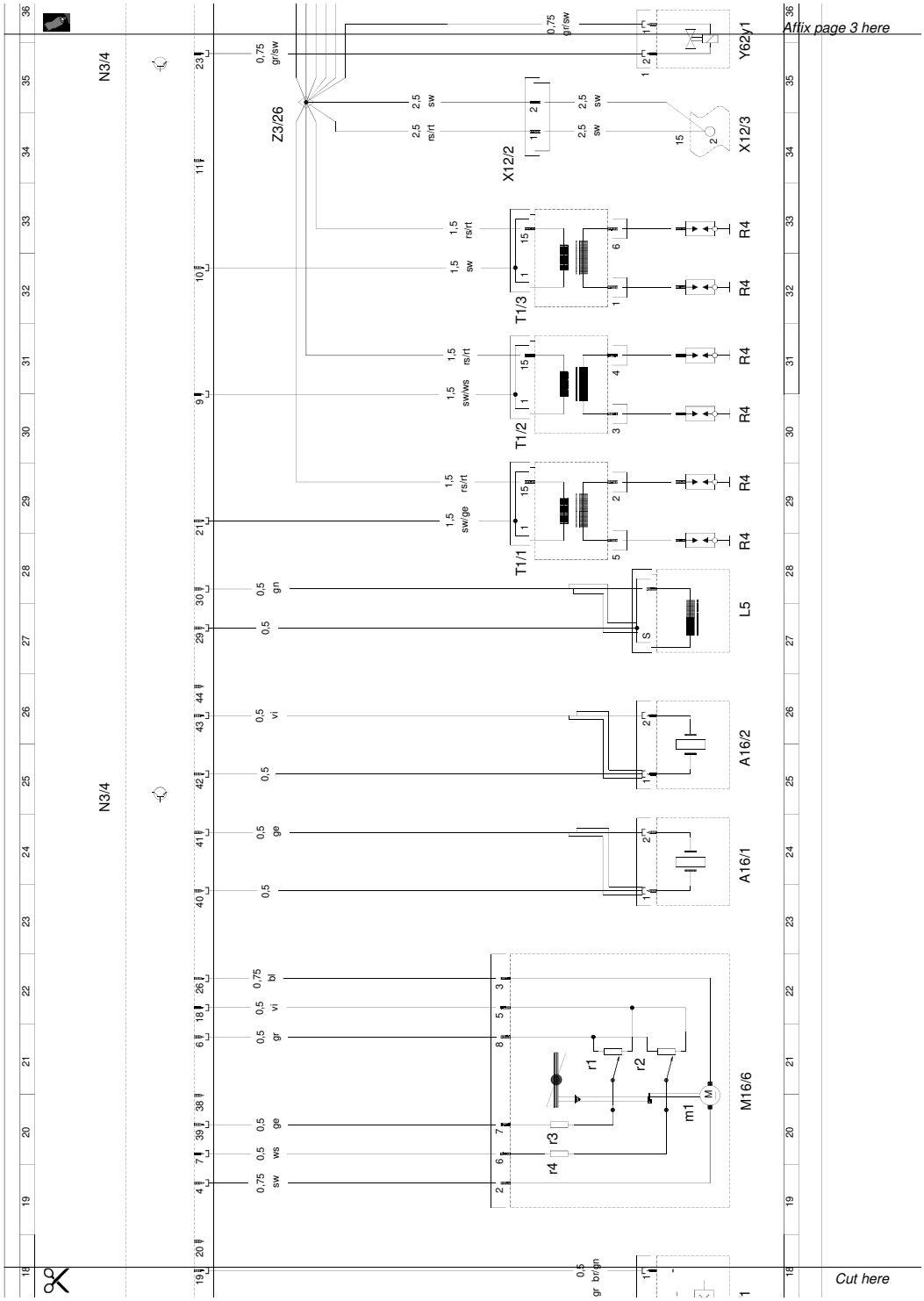
Code:	Designation:	Coordinates:
A1	Instrument cluster	11 L
A16/1	Left knock sensor 1	24 L
A16/2	Right knock sensor 2	25 L
A1p1	Coolant temperature gage	11 L
B11/3	ECT sensor (HFM-SFI/PEC [HFM/PMS])	10 E
B17	Intake air temperature sensor	14 F
B2/5	Hot film MAF sensor	16 L
F1	Fuse box	3 J
F1f25	Fuse 25, circuit 15	3 K
K40	Relay module	7 L
K40f2	EDC/circuit 87 Motronic (2) fuse	7 L
K40k6	AIR pump relay	7 L
L5	Crankshaft position sensor	27 L
L5/1	Camshaft position sensor	17 L
M16/6	Throttle valve actuator	20 L
M16/6m1	Actuator motor	19 K
M16/6r1	Throttle valve actual value potentiometer	20 J
M16/6r2	Drive actual value potentiometer	20 K
M16/6r3	Actual value potentiometer (sliding contact 1)	20 H
M16/6r4	Actual value potentiometer (sliding contact 2)	19 H
N3/4	HFM-SFI [HFM] engine control module	5 B
N3/4	HFM-SFI [HFM] engine control module	15 B
N3/4	HFM-SFI [HFM] engine control module	25 B
N3/4	HFM-SFI [HFM] engine control module	35 B
R4	Spark plugs	28 L
R4	Spark plugs	29 L
R4	Spark plugs	30 L
R4	Spark plugs	31 L
R4	Spark plugs	32 L
R4	Spark plugs	33 L
T1/1	Ignition coil 1	28 H
T1/2	Ignition coil 2	30 H
T1/3	Ignition coil 3	32 H
W11	Ground (engine _ connection point for ground wires)	8 D
W29/2	Ground (right A pillar)	9 L
X12/2	Circuit 15 connector (unfused)	34 H
X12/3	Terminal block circuit 30, 15, 61 (3-pin)	3 H
X12/3	Terminal block circuit 30, 15, 61 (3-pin)	34 L
X22/5	Engine/main harness connector (6-pin)	4 H

Document number: pe07.51-p-2000-99i
Document title: Wiring diagram HFM-SFI sequential multiport fuel injection/ ignition system

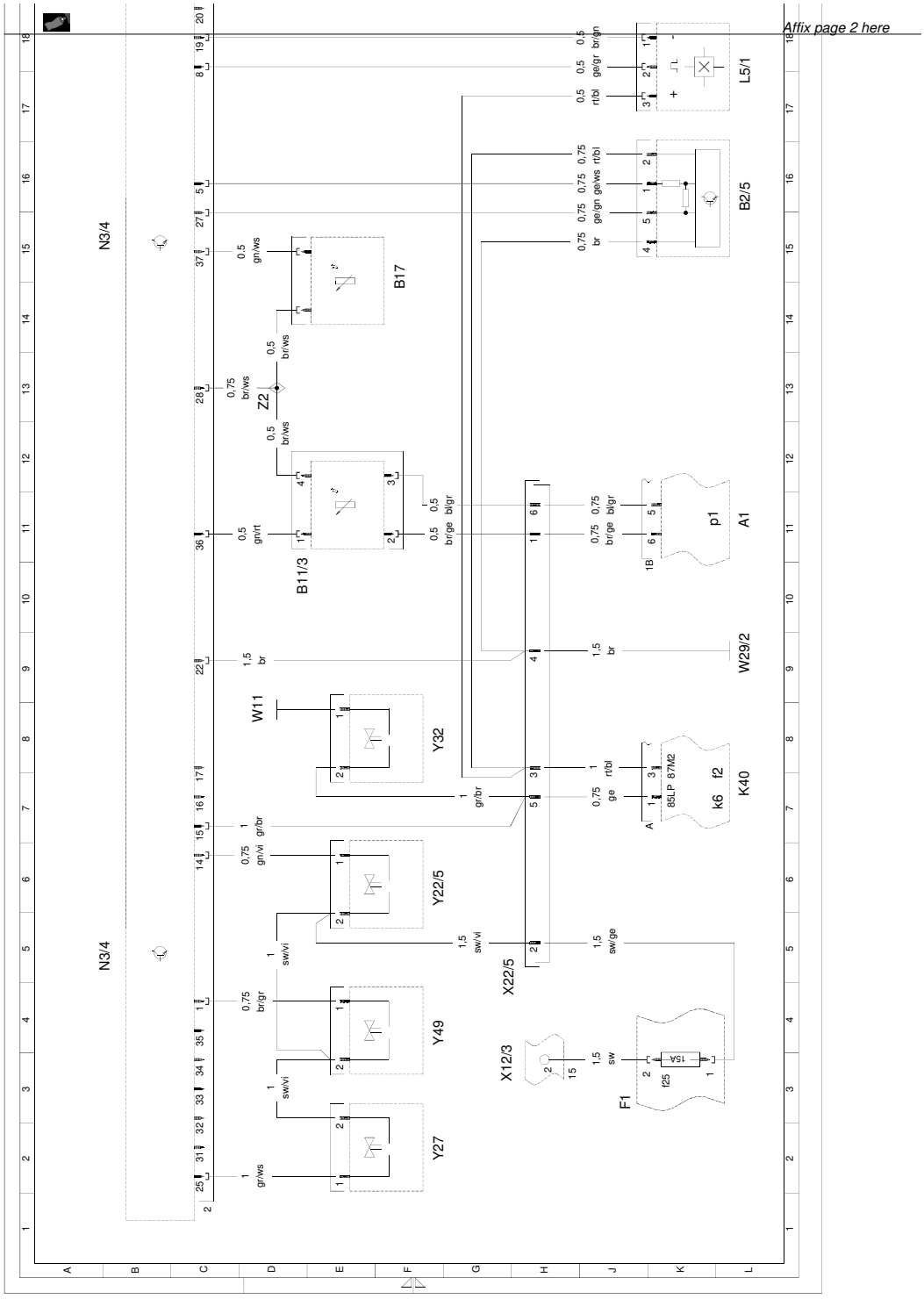
Code:	Designation:	Coordinates:
Y22/5	Intake manifold switchover valve	6 G
Y27	EGR switchover valve	2 G
Y32	AIR pump switchover valve	8 G
Y49	Adjustabel camshaft timing solenoid	4 G
Y62y1	Valve cylinder 1	35 L
Y62y2	Valve cylinder 2	36 L
Y62y3	Valve cylinder 3	37 L
Y62y4	Valve cylinder 4	38 L
Y62y5	Valve cylinder 5	39 L
Y62y6	Valve cylinder 6	41 L
Z2	TD connector sleeve	13 D
Z3/26	Circuit 15 connector sleeve (unfused)	34 D



Wiring diagram HFM-SFI sequential multiport fuel injection/ ignition system / pe07.51-p-2000-99i
ENGINE 104.996 in MODEL 463 as of 1.1.96 Engine block wiring harnesses / Printed on: 28.01.2022 / Page 3/3



Wiring diagram HFM-SFI sequential multiport fuel injection/ ignition system / pe07.51-p-2000-99i
ENGINE 104.996 in MODEL 463 as of 1.1.96 Engine block wiring harnesses / Printed on: 28.01.2022 / Page 2/3



Wiring diagram HFM-SFI sequential multiport fuel injection/ ignition system / pe07.51-p-2000-99i
ENGINE 104.996 in MODEL 463 as of 1.1.96 Engine block wiring harnesses / Printed on: 28.01.2022 / Page 1/3

2.5 Mercedes M113 engine wiring

The wire colours for the 5 plug ECU are based on the W211 E500. The wire colours for the 6 plug ECU are based on the W163 ML55 AMG.

Crankshaft position sensor (L5)

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	Signal	green	3/26	E38	A18
2	Return	green/white	3/13	E37	A16

MAP sensor (B28)

Not found on all M113 engines, although the wiring for it is always in place.
Earlier engines use a sensor with a 3 pin mini-timer type connector, later engines use a sensor with a 3 pin Micro Quad Lok (MQS) connector.
Early type:

Device pin	Function	6P colour	6P pin	LPC8 pin
1	Signal	red/blue	E23	A6 analog in 5
2	Return	brown/grey	E24	A4
3	+5V	pink/black	E22	A1

Late type:

Device pin	Function	5P colour	5P pin	LPC8 pin
1	Return	brown/grey	3/9	A4
2	Signal	red/grey	3/10	A6 analog in 5
3	+5V	pink/black	3/39	A1

Oil level sensor (B40)

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	Signal	grey/blue	3/15	E17	A13 digital in 1
2	Return	brown/black	3/9	E16	A4
3	+5V	red/yellow	3/39	E15	A1

Camshaft position sensor (B6/1)

Device pin	Function	5P colour	5P pin	6P colour	6P pin	LPC8 pin
1	Return	brown/green	3/9	brown/green	E39	A4
2	Signal	pink	3/2	pink	E40	A16
3	+12V	red/blue		red/green		

Mass air flow sensor (B2/5)

Normally you would connect only pins 1 and 3 of the MAF sensor for an air temperature signal, unless you plan to use the MAF sensor flow signal, then connect all 5 wires.

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	Air temperature signal	yellow/green	3/8	E45	A15 analog in 3
2	+12V	red/blue			
3	Return	brown	3/12	E48	A4
4	+5V	brown/yellow	3/25	E46	A1
5	Air flow signal	yellow/white	3/11	E47	A5 analog in 4

Knock sensor 1 (A16/1)

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	Return	shield	3/16	E41	C8
2	Signal	violet	3/4	E42	C1

Knock sensor 2 (A16/2)

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	Return	shield	3/3	E43	C8
2	Signal	yellow	3/17	E44	C2

Coolant temperature sensor (B11/4)

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	Signal	green/red	3/5	E29	A14 analog in 2
2	Return	brown/white	3/9	E28	A4

Left bank upstream O2 sensor (G3/3)

Not used. Use LSU 4 wide band lambda sensor instead.

Right bank upstream O2 sensor (G3/4)

Not used. Use LSU 4 wide band lambda sensor instead.

Generator (G2)

No connection to ECU required.

Variable intake manifold switchover valve (Y22/6)

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	Negative	green/violet	2/14	E12	B1 output 5
2	+12V	red/green			

EGR vacuum solenoid valve (Y31/1)

Normally not used, but if used, then the mass air flow sensor should also be retained.

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	Negative	green/white	2/7	E5	B2 output 6
2	+12V	red/green			

Secondary air vacuum solenoid valve (Y32)

Normally not used, but if used, you will have to come up with your own control strategy for it.

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	Negative	grey/brown	2/13	E10	B7 output 7
2	+12V	red/green			

Fuel injector 1 (Y62/y1)

Injector positive feeds splice to a red/blue wire in the harness.

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	+12V	grey/black			
2	Negative	grey/black	3/27	E25	D2

Fuel injector 2 (Y62/y2)

Injector positive feeds splice to a red/blue wire in the harness.

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	+12V	grey/red			
2	Negative	grey/red	2/18	E14	D3

Fuel injector 3 (Y62/y3)

Injector positive feeds splice to a red/blue wire in the harness.

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	+12V	grey/green			
2	Negative	grey/green	2/21	E2	D4

Fuel injector 4 (Y62/y4)

Injector positive feeds splice to a red/blue wire in the harness.

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	+12V	grey/green			
2	Negative	grey/green	2/19	E13	D5

Fuel injector 5 (Y62/y5)

Injector positive feeds splice to a red/blue wire in the harness.

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	+12V	grey/yellow			
2	Negative	grey/yellow	3/28	E26	D9

Fuel injector 6 (Y62/y6)

Injector positive feeds splice to a red/blue wire in the harness.

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	+12V	grey/violet			
2	Negative	grey/violet	2/22	E1	D10

Fuel injector 7 (Y62/y7)

Injector positive feeds splice to a red/blue wire in the harness.

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	+12V	grey/pink			
2	Negative	grey/pink	2/23	E3	D11

Fuel injector 8 (Y62/y8)

Injector positive feeds splice to a red/blue wire in the harness.

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	+12V	grey/brown			
2	Negative	grey/brown	2/20	E4	D12

Electronic throttle actuator (M16/6)

There appear to be two variants of this device.

Early engines:

Device pin	Function	Colour	6P pin	LPC8 pin
1	Motor +	black	F2	D1
3	Motor -	blue	F1	D8
5	+5V	red	E33	C16
6	Secondary signal	white	E34	C14
7	Primary signal	yellow	E31	C6
8	Return	brown/red	E32	C8

Late engines:

Device pin	Function	Colour	5P pin	LPC8 pin
1	Motor +	black	1/3	D1
2	+5V	violet	3/22	C16
3	Return	grey	3/19	C8
4	Motor -	blue	1/6	D8
5	Secondary signal	white	3/20	C14
6	Primary signal	yellow	3/21	C6

Ignition coil 1 (T1/1)

The ignition coils require two ignition amplifier channels each. So two ITM8 or similar devices are required.
Normally, both ignition coils on each cylinder would be controlled by the same ECU output, but if you wish to experiment with leading/trailing timing then you would have to pair together one half of each ignition coil with the coil from another cylinder on one output, and a the other half with the other half of the coil from that same cylinder on a different output.
In that configuration, you would pair together cylinders 1-6, 2-8, 3-5, 4-7.
Otherwise, control both coils of cylinder 1 with ignition output 1, both coils of cylinder 2 with ignition output 2 and so on.

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	Coil A	black	3/47	F21	B9 via ITM8
2	+12V	black/green			
3	Coil B	black/white	3/2	F20	B9 via ITM8

Ignition coil 2 (T1/2)

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	Coil A	yellow	3/44	F18	B10 via ITM8
2	+12V	black/green			
3	Coil B	yellow/white	1/4	F19	B10 via ITM8

Ignition coil 3 (T1/3)

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	Coil A	green	3/49	F4	B11 via ITM8
2	+12V	black/green			
3	Coil B	green/white	2/12	F5	B11 via ITM8

Ignition coil 4 (T1/4)

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	Coil A	blue	3/45	F7	B12 via ITM8
2	+12V	black/green			
3	Coil B	blue/white	1/7	F6	B12 via ITM8

Ignition coil 5 (T1/5)

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	Coil A	violet	3/46	F14	B3 via ITM8
2	+12V	black/green			
3	Coil B	violet/white	1/5	F13	B3 via ITM8

Ignition coil 6 (T1/6)

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	Coil A	grey	3/50	F16	B4 via ITM8
2	+12V	black/green			
3	Coil B	grey/white	1/9	F17	B4 via ITM8

Ignition coil 7 (T1/7)

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	Coil A	white	3/48	F11	B5 via ITM8
2	+12V	black/green			
3	Coil B	white/blue	2/6	F12	B5 via ITM8

Ignition coil 8 (T1/8)

Device pin	Function	Colour	5P pin	6P pin	LPC8 pin
1	Coil A	red	3/43	F9	B6 via ITM8
2	+12V	black/green			
3	Coil B	red/white	2/5	F10	B6 via ITM8

Recirculated air flap actuator (M16/7)

Supercharged engines only. Requires a HBD1 or equivalent H bridge driver.

Device pin	Function	Colour	5P pin	LPC8 pin
1	Motor -	blue/red	2/11	HBD1 pin 2
2	Return	blue/yellow	2/1	C8
3	+5V	blue/violet	2/4	C16
4	Motor +	brown	2/10	HBD1 pin 1
5	Secondary signal	blue/white	2/2	N/C
6	Primary signal	blue/black	2/3	C15 analog in 18

To complete this connection, connect HBD1 pin 6 to PWM output such as pin A22 (output 4) and HBD1 pin 5 to any other output such as pin A10 (output 2). HBD1 pins 3 and 4 should go to the same ground location as the ECU. Pin 7 and/or 8 should get a switched 12V input.

2.5.1 Factory wiring diagrams for ML55 AMG

Document number: pe07.61-p-2000-99ag
Document title: Wiring diagram - ME-SFI fuel injection and ignition system

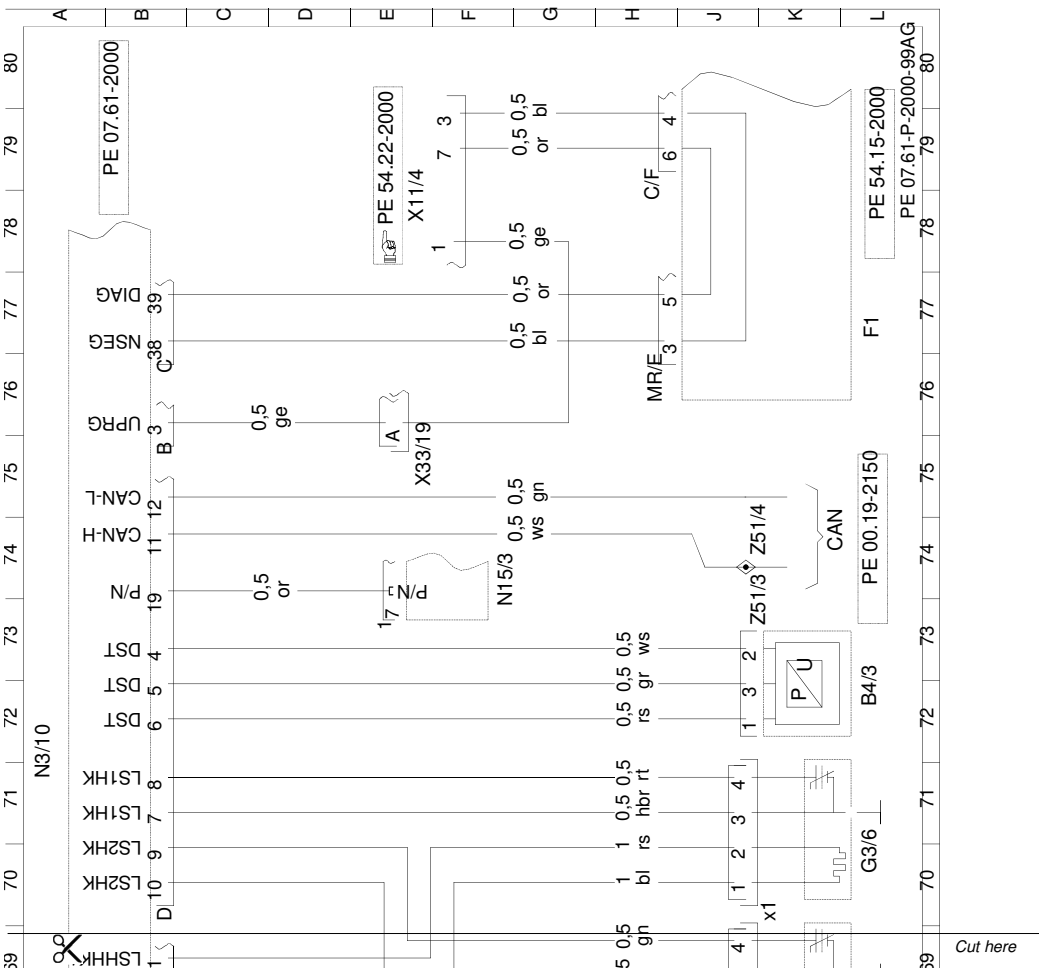
Code:	Designation:	Coordinates:
A16/1	Right knock sensor 1	25 L
A16/2	Left knock sensor 2	27 L
B11/4	Coolant temperature sensor	24 L
B2/5	Hot film MAF sensor	9 L
B28	Pressure sensor	30 L
B4/3	Fuel tank pressure sensor	72 L
B40	Oil sensor (oil level, temperature and quality)	32 L
B6/1	Camshaft Hall sensor	22 L
C4	Radio interference suppression capacitor	37 K
C4	Radio interference suppression capacitor	50 K
F1	Fuse and relay module	2 C
F1	Fuse and relay module	52 C
F1	Fuse and relay module	77 L
F1f11	Fuse 11	7 C
F1f19	Fuse 19	52 D
F1f26	Fuse 26	49 D
F1f45	Fuse 45	50 D
F1k12	Circuit 15 relay	5 C
F1k28	Secondary air injection pump relay	54 D
G1	Battery	5 K
G3/3	Left O2 sensor upstream TWC [KAT]	64 L
G3/3x1	Left O2 sensor upstream TWC [KAT] connector	64 K
G3/4	Right O2 sensor upstream TWC [KAT]	66 L
G3/4x1	Right O2 sensor upstream TWC [KAT] connector	66 K
G3/5	Left O2 sensor downstream TWC [KAT]	68 L
G3/5x1	Left O2 sensor downstream TWC [KAT] connector	68 K
G3/6	Right O2 sensor downstream TWC [KAT]	70 L
G3/6x1	Right O2 sensor downstream TWC [KAT] connector	70 K
L5	Crankshaft position sensor	28 L
M16/6	Throttle valve actuator	34 L
M16/6m1	Actuator motor	34 K
M16/6r1	Throttle valve actual value potentiometer	35 J
M16/6r2	Drive actual value potentiometer	35 K
M16/6r3	Actual value potentiometer (sliding contact 1)	34 H
M16/6r4	Actual value potentiometer (sliding contact 2)	33 H
M33	AIR pump	51 L
N10	All-activity module	4 A
N15/3	ETC control module	73 G
N3/10	ME-SFI [ME] control module	10 A

Document number: pe07.61-p-2000-99ag
Document title: Wiring diagram - ME-SFI fuel injection and ignition system

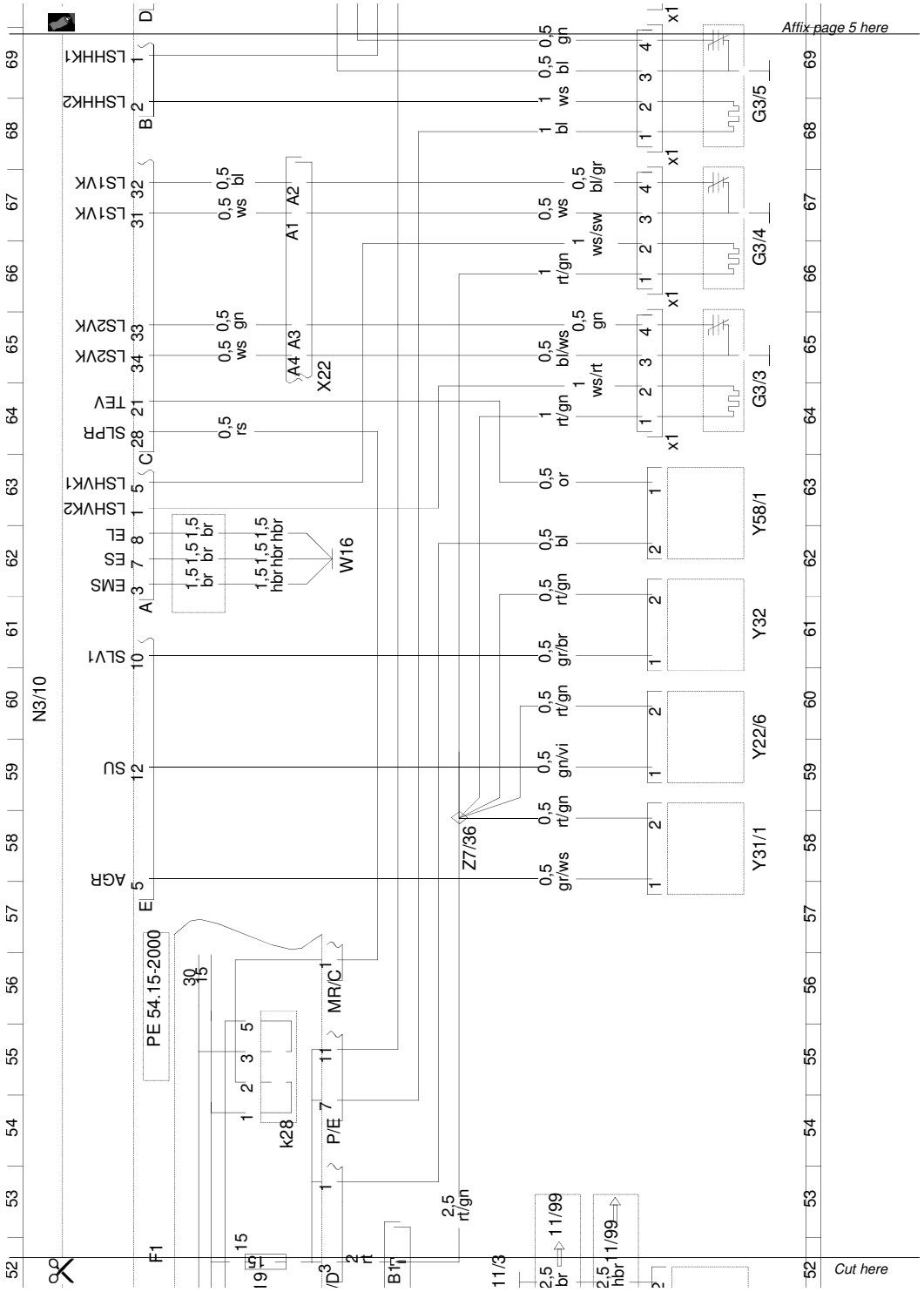
Code:	Designation:	Coordinates:
N3/10	ME-SFI [ME] control module	20 A
N3/10	ME-SFI [ME] control module	30 A
N3/10	ME-SFI [ME] control module	40 A
N3/10	ME-SFI [ME] control module	50 A
N3/10	ME-SFI [ME] control module	60 A
N3/10	ME-SFI [ME] control module	71 A
S2	Starter switch	3 L
T1/1	Cylinder 1 ignition coil	38 L
T1/2	Cylinder 2 ignition coil	40 L
T1/3	Cylinder 3 ignition coil	41 L
T1/4	Cylinder 4 ignition coil	42 L
T1/5	Cylinder 5 ignition coil	44 L
T1/6	Cylinder 6 ignition coil	45 L
T1/7	Cylinder 7 ignition coil	47 L
T1/8	Cylinder 8 i gnition coil	48 L
U1	Valid for USA	9 D
U43	Valid for ECE	4 E
W11/3	Ground (engine - left side)	37 G
W11/3	Ground (engine - left side)	50 G
W11/3	Ground (engine - left side)	52 G
W16	Ground (component compartment)	36 F
W16	Ground (component compartment)	62 E
W16/4	Ground (output ground - component compartment - right)	6 L
X11/4	Data link connector	78 F
X12/3	Terminal block (circuit 30, 15, 31, 3-pin)	5 D
X22	Engine compartment and engine connector	7 F
X22	Engine compartment and engine connector	49 F
X22	Engine compartment and engine connector	64 E
X33/19	Engine control module programming voltage connector	75 F
X4/37	Circuit 30 terminal block	4 G
Y22/6	Variable intake manifold switchover valve	59 L
Y31/1	EGR [ARF] vacuum transducer	58 L
Y32	Air pump switchover valve	61 L
Y58/1	Purge control valve	62 L
Y62	Injectors (LH-SFI, HFM-SFI, PEC [LH, HFM, PMS])	17 L
Y62y1	Fuel injector cylinder 1	13 L
Y62y2	Fuel injector cylinder 2	14 L
Y62y3	Fuel injector cylinder 3	15 L
Y62y4	Fuel injector cylinder 4	16 L

Document number: pe07.61-p-2000-99ag
Document title: Wiring diagram - ME-SFI fuel injection and ignition system

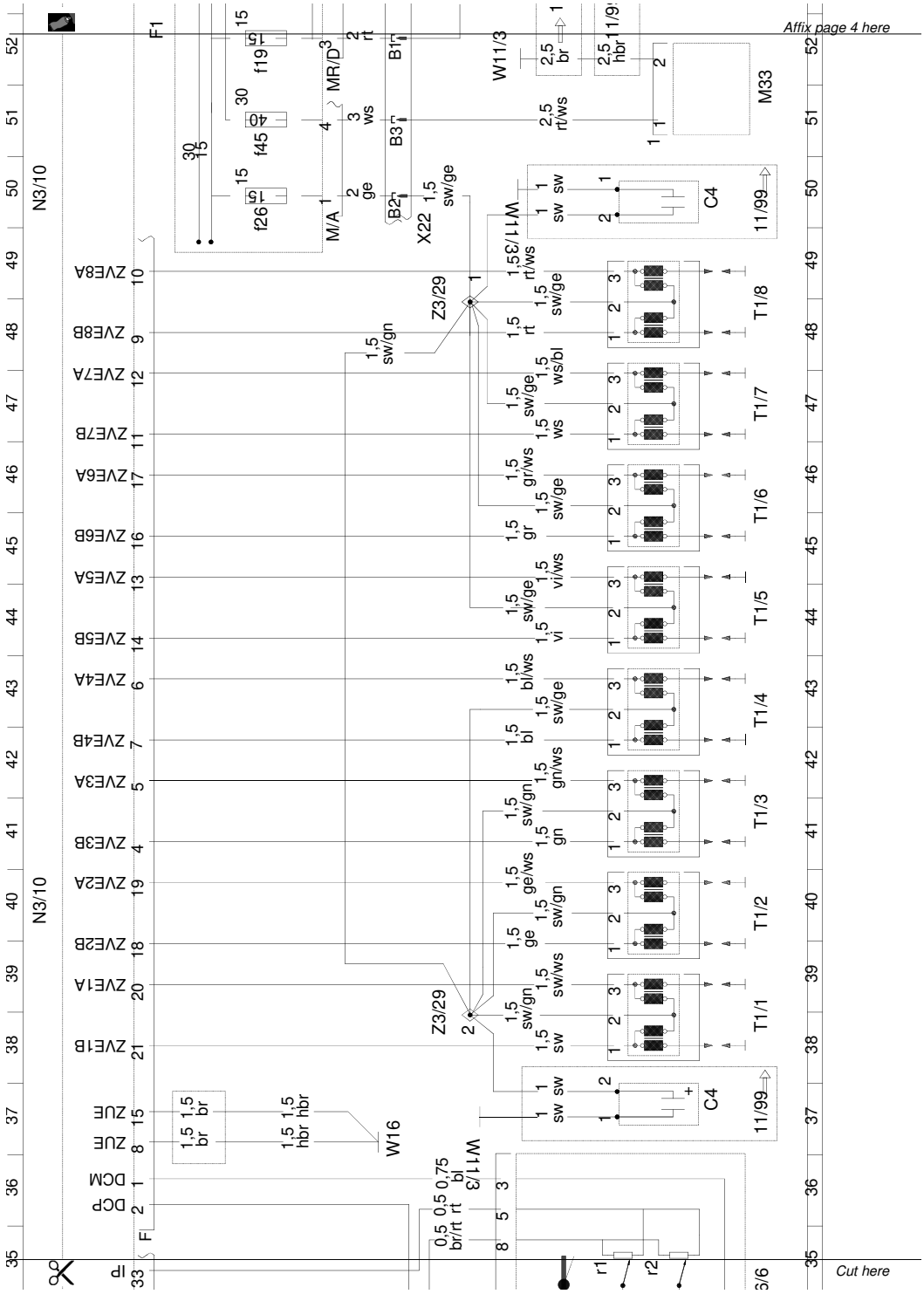
Code:	Designation:	Coordinates:
Y62y5	Fuel injector cylinder 5	17 L
Y62y6	Fuel injector cylinder 6	18 L
Y62y7	Fuel injector cylinder 7	19 L
Y62y8	Fuel injector cylinder 8	21 L
Z3/29	Circuit 15 connector sleeve (fused)	38 G
Z3/29	Circuit 15 connector sleeve (fused)	48 G
Z50/5	Cockpit connector sleeve (circuit 30)	3 H
Z50/9	Cockpit connector sleeve II (circuit 15)	1 H
Z51/10	Interior connector sleeve (circuit 30)	9 E
Z51/3	Interior connector sleeve (CAN-High 2)	73 K
Z51/4	Interior connector sleeve (CAN-Low 2)	74 K
Z7/35	Circuit 87M1e connector sleeve	12 H
Z7/35	Circuit 87M1e connector sleeve	12 F
Z7/36	Circuit 87M2e connector sleeve	58 G



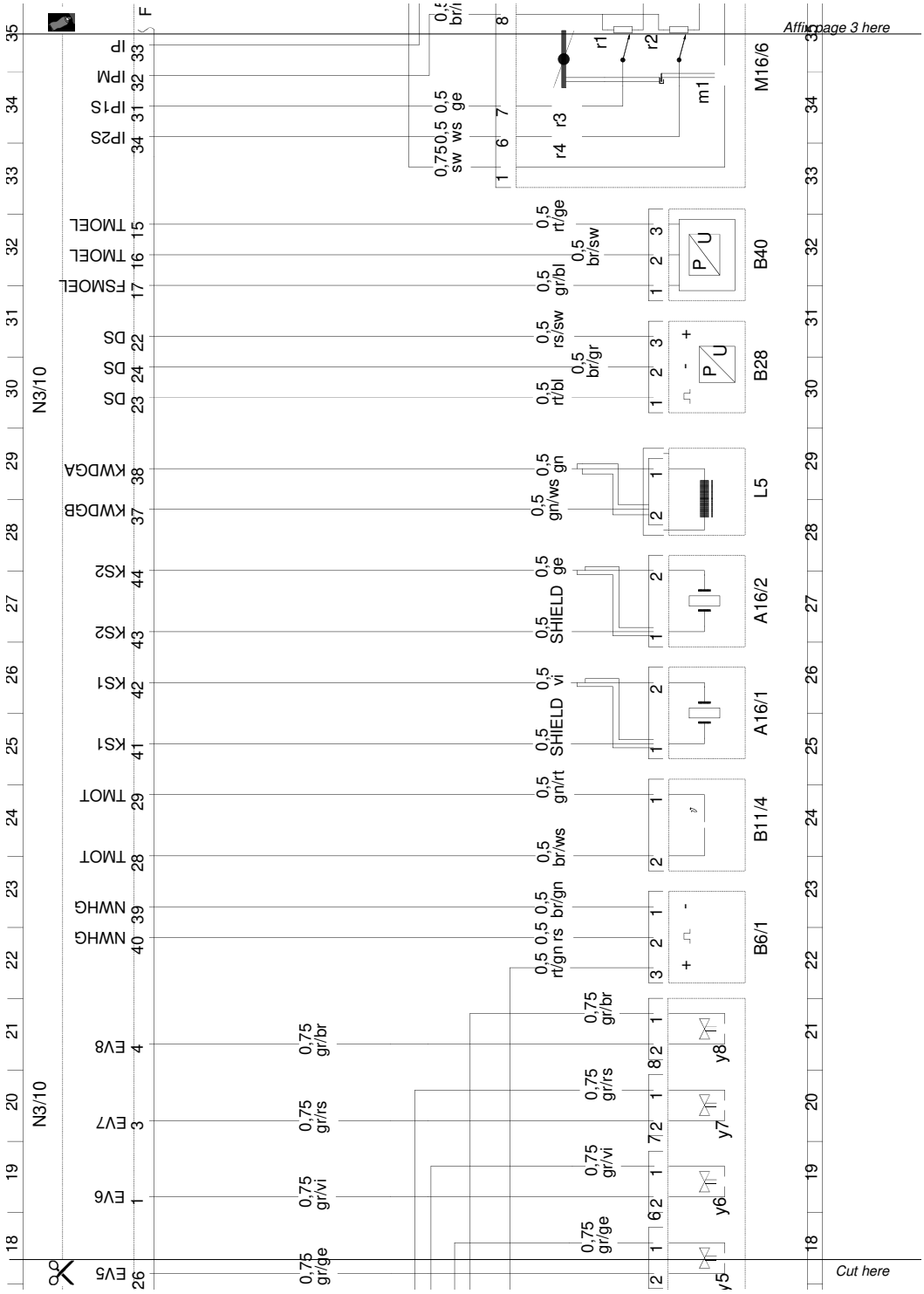
Wiring diagram - ME-SFI fuel injection and ignition system / pe07.61-p-2000-99ag
ENGINE 113 in MODEL 163 up to 31.8.00 Engine block wiring harnesses / Printed on: 18.10.2021 / Page 5/5



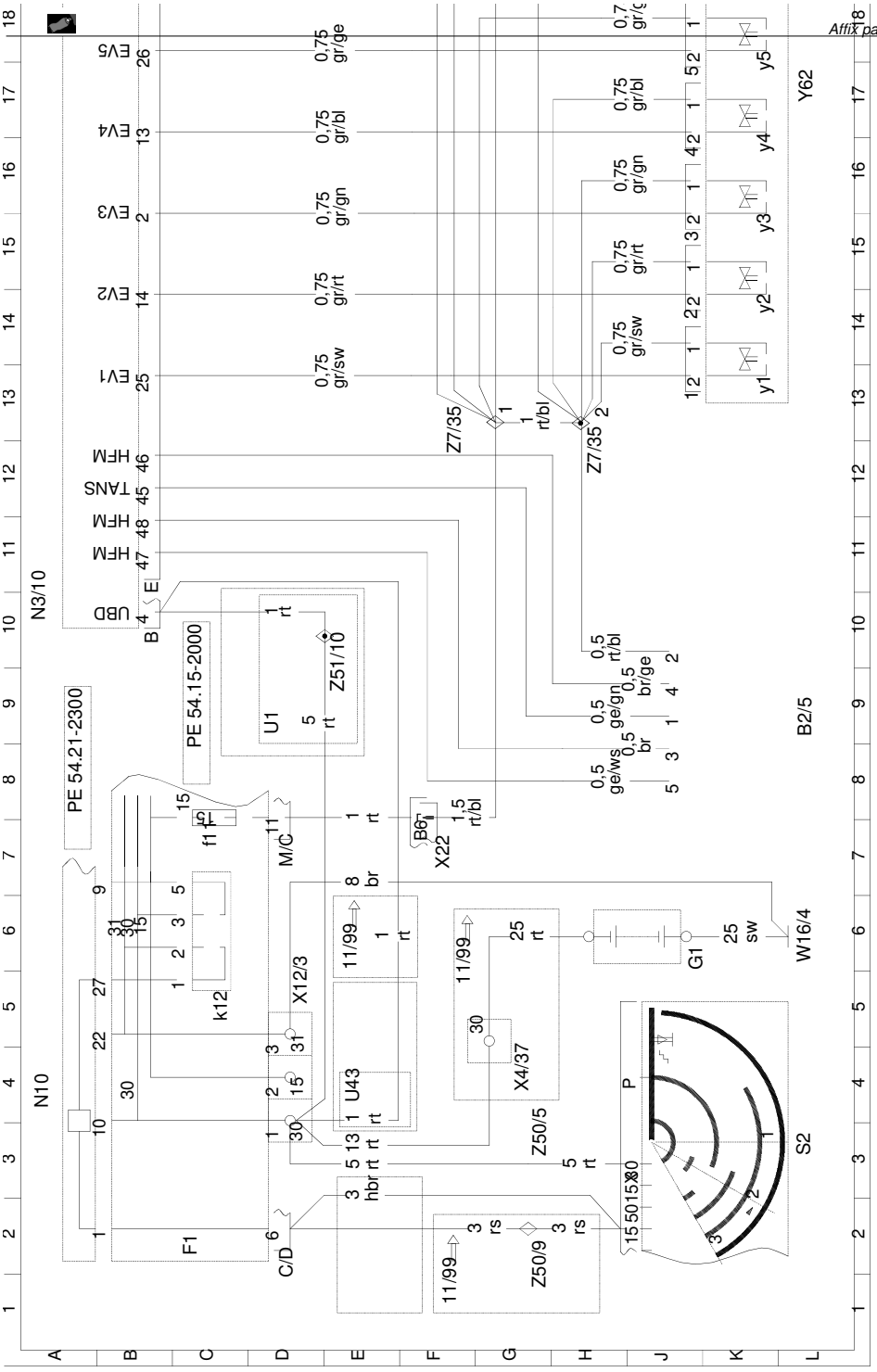
Wiring diagram - ME-SFI fuel injection and ignition system / pe07.61-p-2000-99ag
ENGINE 113 in MODEL 163 up to 31.8.00 Engine block wiring harnesses / Printed on: 18.10.2021 / Page 4/5



Wiring diagram - ME-SFI fuel injection and ignition system / pe07.61-p-2000-99ag
ENGINE 113 in MODEL 163 up to 31.8.00 Engine block wiring harnesses / Printed on: 18.10.2021 / Page 3/5



Wiring diagram - ME-SFI fuel injection and ignition system / pe07.61-p-2000-99ag
ENGINE 113 in MODEL 163 up to 31.8.00 Engine block wiring harnesses / Printed on: 18.10.2021 / Page 2/5



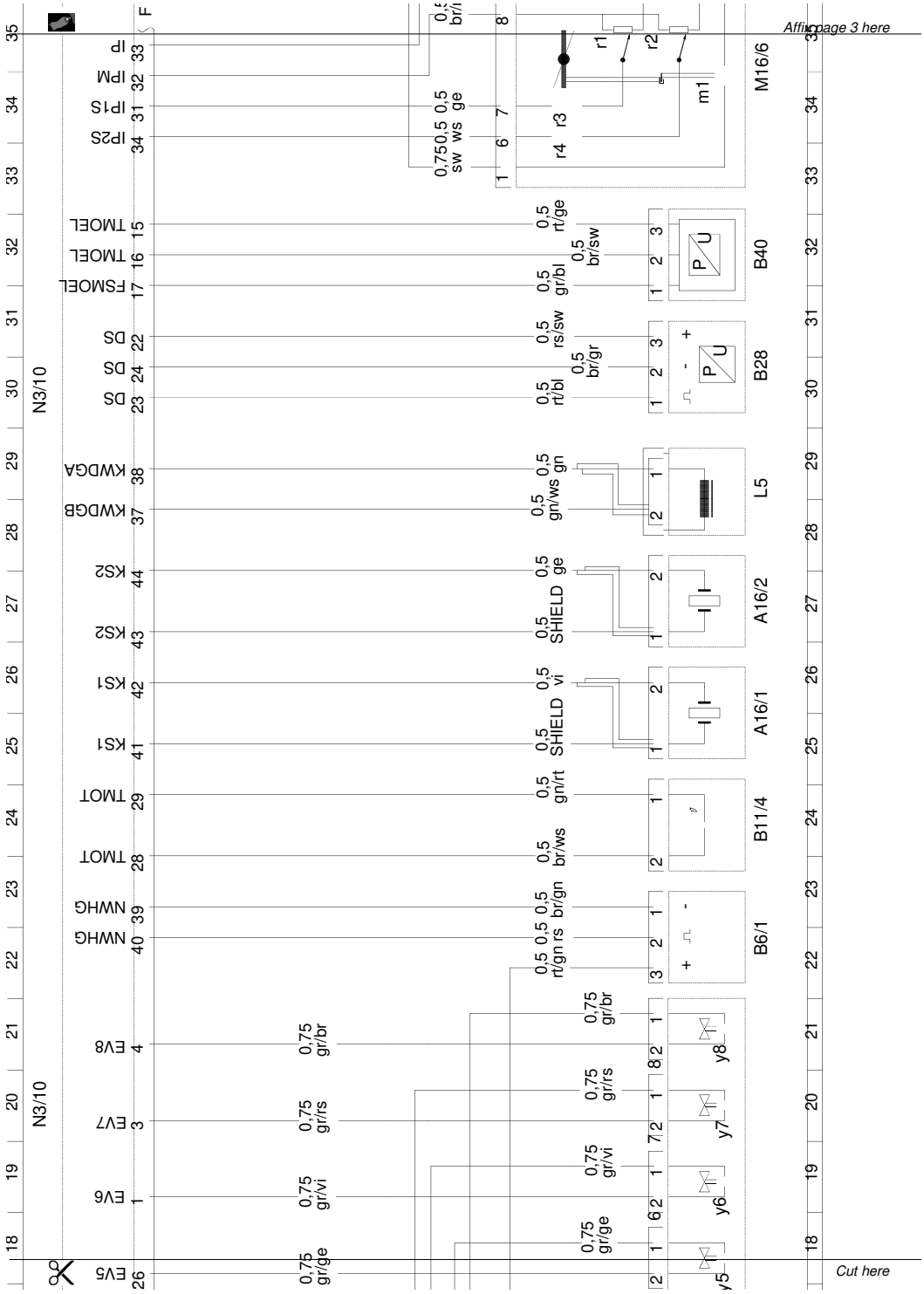
Wiring diagram - ME-SFI fuel injection and ignition system / pe07.61-p-2000-99ag
ENGINE 113 in MODEL 163 up to 31.8.00 Engine block wiring harnesses / Printed on: 18.10.2021 / Page 1/5

Document number: pe07.61-p-2000-99gm
Document title: Wiring diagram of ME-SFI fuel injection and ignition system

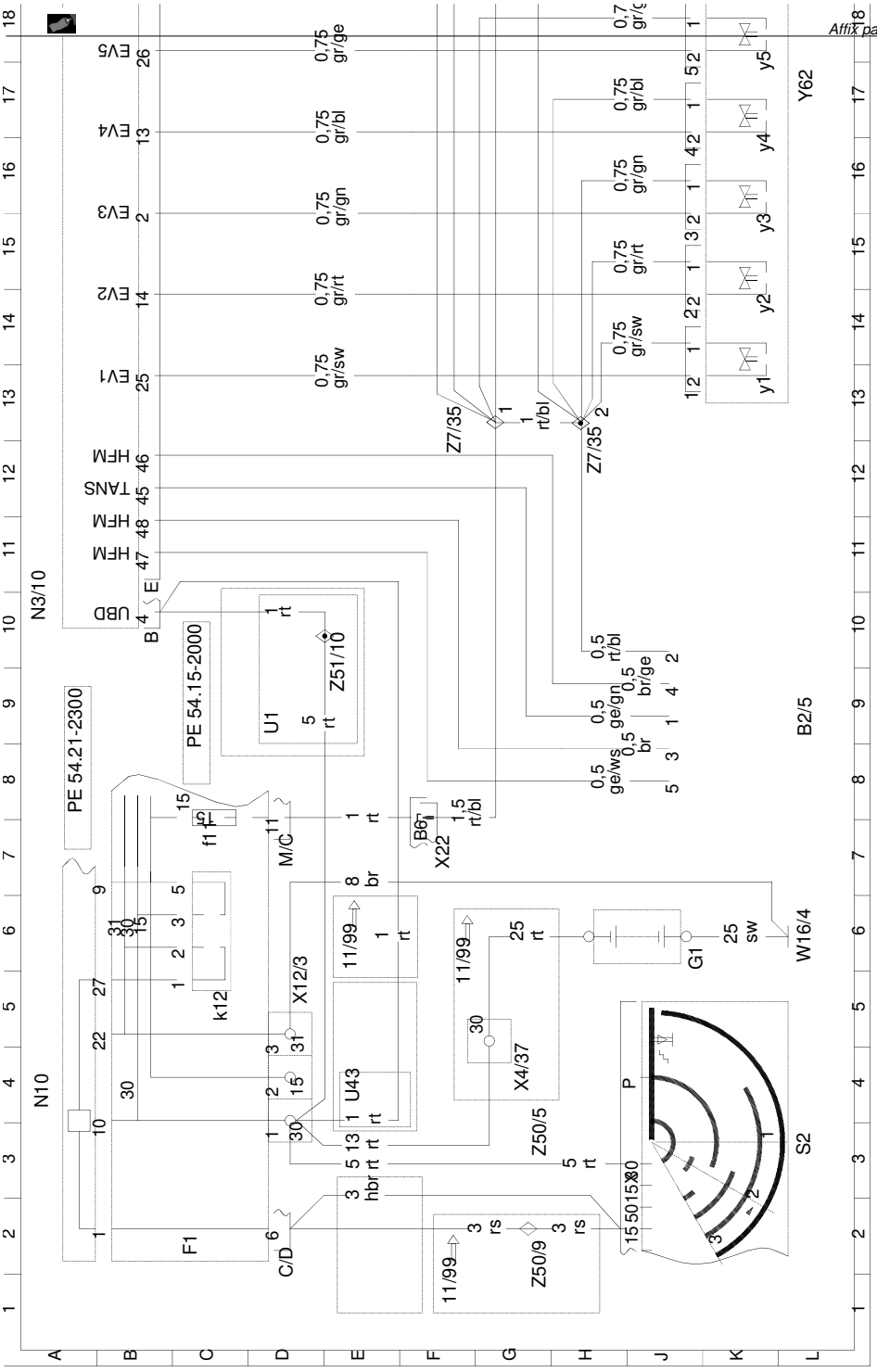
Code:	Designation:	Coordinates:
A6	STH and heater booster unit	33 L
B37	Pedal value sensor	17 L
F1	Fuse and relay module	2 B
F1	Fuse and relay module	32 C
F1f22	Fuse 22	38 D
F1f41	Fuse 41	39 D
F1k12	Circuit 15 relay	3 C
F1k19	Circulation pump relay	40 D
F2	Fuse and module box in right front footwell	24 K
F24/7	Circuit 30 auxiliary fuse, suction fan	10 F
F2f12	Fuse 12	27 H
F2f13	Fuse 13	28 H
G1	Battery	6 H
G1	Battery	11 D
M2/2	Control module box blower motor	42 L
M2/2x1	Control module box blower motor connector	41 J
M3	FP assembly	36 L
M3m1	FP 1	36 L
M4/7	Electric suction fan engine and AC with integrated control	12 L
N10	All-activity module	2 A
N10	All-activity module	33 B
N10	All-activity module	41 B
N3/10	ME-SFI [ME] control module	19 B
S2	Starter switch	4 L
U1	Valid for USA	38 L
W10	Ground (battery)	11 B
W16/4	Ground (output ground - component compartment - right)	7 L
W2	Ground (at right headlamp unit)	13 G
W2	Ground (at right headlamp unit)	43 E
W6	Ground (left wheelhousing in trunk)	30 L
X12/3	Terminal block (circuit 30, 15, 31, 3-pin)	6 E
X12/3	Terminal block (circuit 30, 15, 31, 3-pin)	32 E
X12/6	Circuit 31 terminal block at relay module 2	28 L
X12/7	Circuit 15R terminal block at relay module 2	27 L
X12/8	Circuit 15 terminal block at relay module 2	28 L
X12/9	Circuit 30 terminal block at relay module 2	27 L
X18	Interior and taillamp harness connector, cockpit	36 G
X18/20	Coolant level switch connector, heater booster "On"	21 E
X18/3	Interior/fuel tank connector	34 J

Document number: pe07.61-p-2000-99ag
Document title: Wiring diagram - ME-SFI fuel injection and ignition system

Code:	Designation:	Coordinates:
N3/10	ME-SFI [ME] control module	20 A
N3/10	ME-SFI [ME] control module	30 A
N3/10	ME-SFI [ME] control module	40 A
N3/10	ME-SFI [ME] control module	50 A
N3/10	ME-SFI [ME] control module	60 A
N3/10	ME-SFI [ME] control module	71 A
S2	Starter switch	3 L
T1/1	Cylinder 1 ignition coil	38 L
T1/2	Cylinder 2 ignition coil	40 L
T1/3	Cylinder 3 ignition coil	41 L
T1/4	Cylinder 4 ignition coil	42 L
T1/5	Cylinder 5 ignition coil	44 L
T1/6	Cylinder 6 ignition coil	45 L
T1/7	Cylinder 7 ignition coil	47 L
T1/8	Cylinder 8 i gnition coil	48 L
U1	Valid for USA	9 D
U43	Valid for ECE	4 E
W11/3	Ground (engine - left side)	37 G
W11/3	Ground (engine - left side)	50 G
W11/3	Ground (engine - left side)	52 G
W16	Ground (component compartment)	36 F
W16	Ground (component compartment)	62 E
W16/4	Ground (output ground - component compartment - right)	6 L
X11/4	Data link connector	78 F
X12/3	Terminal block (circuit 30, 15, 31, 3-pin)	5 D
X22	Engine compartment and engine connector	7 F
X22	Engine compartment and engine connector	49 F
X22	Engine compartment and engine connector	64 E
X33/19	Engine control module programming voltage connector	75 F
X4/37	Circuit 30 terminal block	4 G
Y22/6	Variable intake manifold switchover valve	59 L
Y31/1	EGR [ARF] vacuum transducer	58 L
Y32	Air pump switchover valve	61 L
Y58/1	Purge control valve	62 L
Y62	Injectors (LH-SFI, HFM-SFI, PEC [LH, HFM, PMS])	17 L
Y62y1	Fuel injector cylinder 1	13 L
Y62y2	Fuel injector cylinder 2	14 L
Y62y3	Fuel injector cylinder 3	15 L
Y62y4	Fuel injector cylinder 4	16 L



Wiring diagram - ME-SFI fuel injection and ignition system / pe07.61-p-2000-99ag
ENGINE 113 in MODEL 163 up to 31.8.00 Engine block wiring harnesses / Printed on: 18.10.2021 / Page 2/5



Wiring diagram - ME-SFI fuel injection and ignition system / pe07.61-p-2000-99ag
ENGINE 113 in MODEL 163 up to 31.8.00 Engine block wiring harnesses / Printed on: 18.10.2021 / Page 1/5

Document number: pe07.61-p-2000-99ag
Document title: Wiring diagram - ME-SFI fuel injection and ignition system

Code:	Designation:	Coordinates:
Y62y5	Fuel injector cylinder 5	17 L
Y62y6	Fuel injector cylinder 6	18 L
Y62y7	Fuel injector cylinder 7	19 L
Y62y8	Fuel injector cylinder 8	21 L
Z3/29	Circuit 15 connector sleeve (fused)	38 G
Z3/29	Circuit 15 connector sleeve (fused)	48 G
Z50/5	Cockpit connector sleeve (circuit 30)	3 H
Z50/9	Cockpit connector sleeve II (circuit 15)	1 H
Z51/10	Interior connector sleeve (circuit 30)	9 E
Z51/3	Interior connector sleeve (CAN-High 2)	73 K
Z51/4	Interior connector sleeve (CAN-Low 2)	74 K
Z7/35	Circuit 87M1e connector sleeve	12 H
Z7/35	Circuit 87M1e connector sleeve	12 F
Z7/36	Circuit 87M2e connector sleeve	58 G

2.5.2 Factory wiring diagrams for W211 E500

Document number: pe07.61-p-2101-99db
Document title: Wiring diagram ME-SFI fuel injection and ignition system control unit

Code:	Designation:	Coordinates:
A0	Explanation of color codes	72 L
A16/1	Right knock sensor 1	10 L
A16/2	Left knock sensor 2	11 L
B11/4	Coolant temperature sensor	12 L
B2/5	Hot film MAF sensor	8 L
B28	Pressure sensor	2 L
B40	Oil sensor (oil level, temperature and quality)	4 L
B6/1	Camshaft Hall sensor	6 L
C4	Radio interference suppression capacitor	53 L
C4	Radio interference suppression capacitor	65 L
G2	Generator	20 L
G3/3	Left O2 sensor upstream TWC [KAT]	15 L
G3/3x1	Left O2 sensor upstream TWC [KAT] connector	13 K
G3/4	Right O2 sensor upstream TWC [KAT]	18 L
G3/4x1	Right O2 sensor upstream TWC [KAT] connector	17 K
L5	Crankshaft position sensor	1 L
M16/6	Throttle valve actuator	42 L
M16/6m1	Actuator motor	42 L
M16/6r1	Throttle valve actual value potentiometer	42 K
M16/6r2	Drive actual value potentiometer	42 K
M16/6r3	Actual value potentiometer (sliding contact 1)	41 K
M16/6r4	Actual value potentiometer (sliding contact 2)	41 K
M16/7	Recirculated air flap actuator	38 L
M16/7m1	Actuator motor	38 L
M16/7r1	Recirculated air flap actual value potentiometer	39 K
M16/7r2	Drive actual value potentiometer	38 K
M16/7r3	Actual value potentiometer (sliding contact 1)	37 K
M16/7r4	Actual value potentiometer (sliding contact 2)	37 K
N10/1	Driver-side SAM control module with fuse and relay module	51 L
N3/10	ME-SFI [ME] control module	4 A
N3/10	ME-SFI [ME] control module	12 A
N3/10	ME-SFI [ME] control module	20 A
N3/10	ME-SFI [ME] control module	28 A
N3/10	ME-SFI [ME] control module	36 A
N3/10	ME-SFI [ME] control module	45 A
N3/10	ME-SFI [ME] control module	53 A
N3/10	ME-SFI [ME] control module	60 A
N3/10	ME-SFI [ME] control module	68 A
R4	Spark plugs	46 L

Document number: pe07.61-p-2101-99db
Document title: Wiring diagram ME-SFI fuel injection and ignition system control unit

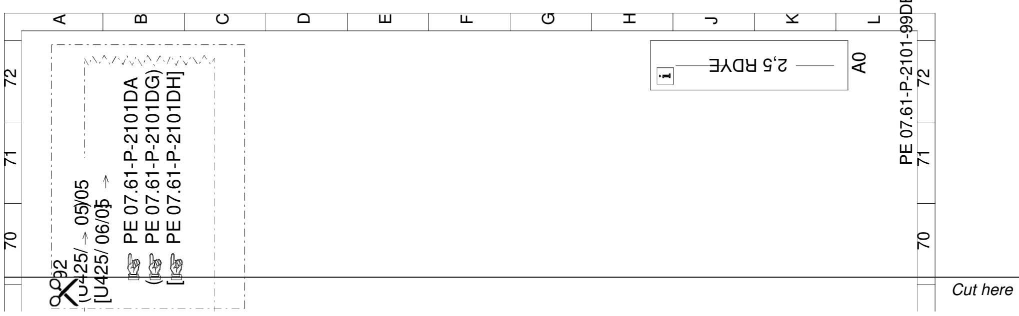
Code:	Designation:	Coordinates:
R4	Spark plugs	47 L
R4	Spark plugs	48 L
R4	Spark plugs	49 L
R4	Spark plugs	54 L
R4	Spark plugs	55 L
R4	Spark plugs	57 L
R4	Spark plugs	58 L
R4	Spark plugs	60 L
R4	Spark plugs	61 L
R4	Spark plugs	63 L
R4	Spark plugs	63 L
R4	Spark plugs	66 L
R4	Spark plugs	67 L
R4	Spark plugs	68 L
R4	Spark plugs	69 L
T1/1	Cylinder 1 ignition coil	46 K
T1/2	Cylinder 2 ignition coil	48 K
T1/3	Cylinder 3 ignition coil	55 K
T1/4	Cylinder 4 ignition coil	58 K
T1/5	Cylinder 5 ignition coil	60 K
T1/6	Cylinder 6 ignition coil	63 K
T1/7	Cylinder 7 ignition coil	66 K
T1/8	Cylinder 8 ignition coil	68 K
U150	Valid for engine 112	26 E
U150	Valid for engine 112	27 E
U150	Valid for engine 112	29 E
U150	Valid for engine 112	30 J
U150	Valid for engine 112	31 E
U150	Valid for engine 112	33 E
U150	Valid for engine 112	48 E
U150	Valid for engine 112	49 E
U150	Valid for engine 112	54 E
U150	Valid for engine 112	56 E
U150	Valid for engine 112	57 E
U150	Valid for engine 112	58 H
U150	Valid for engine 112	59 E
U150	Valid for engine 112	60 E
U150	Valid for engine 112	62 E
U150	Valid for engine 112	62 E

Document number: pe07.61-p-2101-99db
Document title: Wiring diagram ME-SFI fuel injection and ignition system control unit

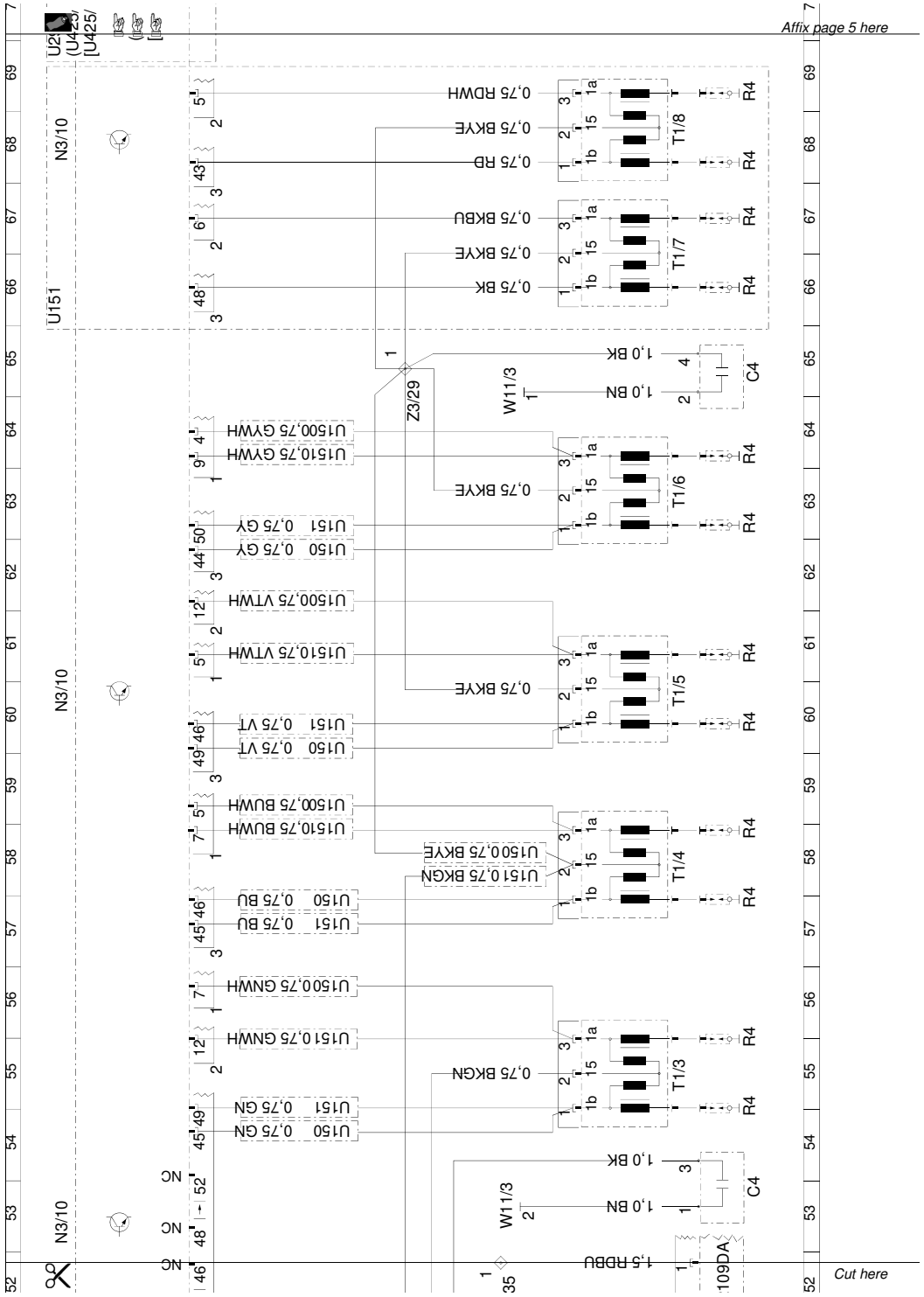
Code:	Designation:	Coordinates:
U150	Valid for engine 112	64 E
U151	Valid for engine 113	26 E
U151	Valid for engine 113	27 E
U151	Valid for engine 113	30 E
U151	Valid for engine 113	30 J
U151	Valid for engine 113	32 E
U151	Valid for engine 113	33 E
U151	Valid for engine 113	34 A
U151	Valid for engine 113	48 E
U151	Valid for engine 113	49 E
U151	Valid for engine 113	55 E
U151	Valid for engine 113	55 E
U151	Valid for engine 113	57 E
U151	Valid for engine 113	58 H
U151	Valid for engine 113	58 E
U151	Valid for engine 113	60 E
U151	Valid for engine 113	61 E
U151	Valid for engine 113	63 E
U151	Valid for engine 113	64 E
U151	Valid for engine 113	65 A
U292	Valid for all except E 55 AMG	69 A
U425	Valid for E 55 AMG	69 B
U425	Valid for E 55 AMG	69 A
W11/3	Ground (engine - left side)	53 H
W11/3	Ground (engine - left side)	64 H
Y22/6	Variable intake manifold switchover valve	21 L
Y31/1	EGR [ARF] vacuum transducer	22 L
Y32	Air pump switchover valve	24 L
Y62	Injectors (LH-SFI, HFM-SFI, PEC [LH, HFM, PMS])	26 L
Y62	Injectors (LH-SFI, HFM-SFI, PEC [LH, HFM, PMS])	33 L
Y62y1	Fuel injector cylinder 1	25 L
Y62y2	Fuel injector cylinder 2	26 L
Y62y3	Fuel injector cylinder 3	27 L
Y62y4	Fuel injector cylinder 4	29 L
Y62y5	Fuel injector cylinder 5	32 L
Y62y6	Fuel injector cylinder 6	33 L
Y62y7	Fuel injector cylinder 7	35 L
Y62y8	Fuel injector cylinder 8	36 L
Z3/29	Circuit 15 connector sleeve (fused)	50 H

Document number: pe07.61-p-2101-99db
Document title: Wiring diagram ME-SFI fuel injection and ignition system control unit

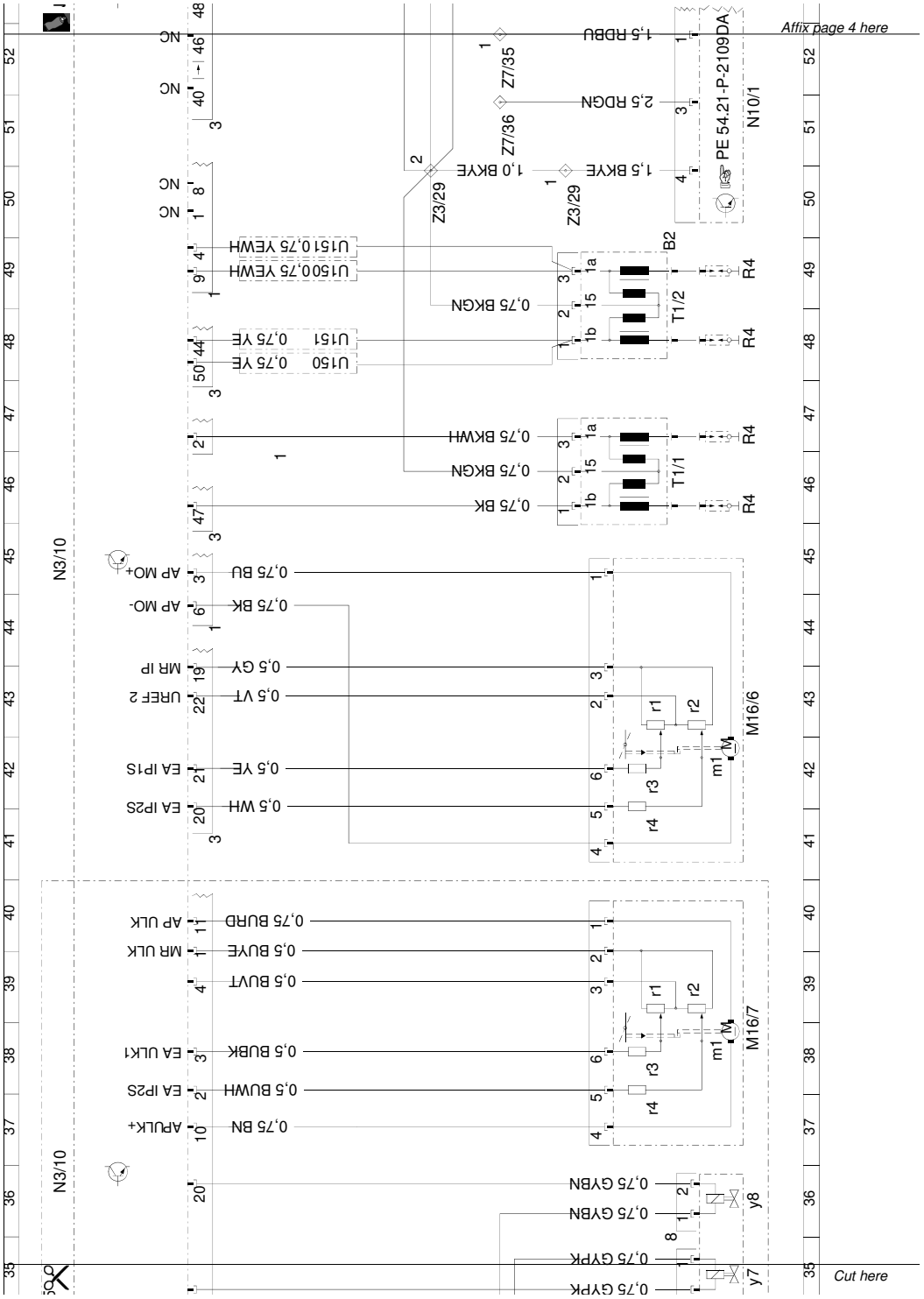
Code:	Designation:	Coordinates:
Z3/29	Circuit 15 connector sleeve (fused)	50 G
Z3/29	Circuit 15 connector sleeve (fused)	64 F
Z6/26	Sensor supply connector sleeve	3 G
Z6/27	Sensor ground connector sleeve	14 G
Z6/8	Sensor ground connector sleeve	5 G
Z6/8	Sensor ground connector sleeve	12 G
Z7/35	Circuit 87M1e connector sleeve	6 G
Z7/35	Circuit 87M1e connector sleeve	7 G
Z7/35	Circuit 87M1e connector sleeve	27 H
Z7/35	Circuit 87M1e connector sleeve	33 H
Z7/35	Circuit 87M1e connector sleeve	52 H
Z7/36	Circuit 87M2e connector sleeve	16 G
Z7/36	Circuit 87M2e connector sleeve	22 G
Z7/36	Circuit 87M2e connector sleeve	51 H



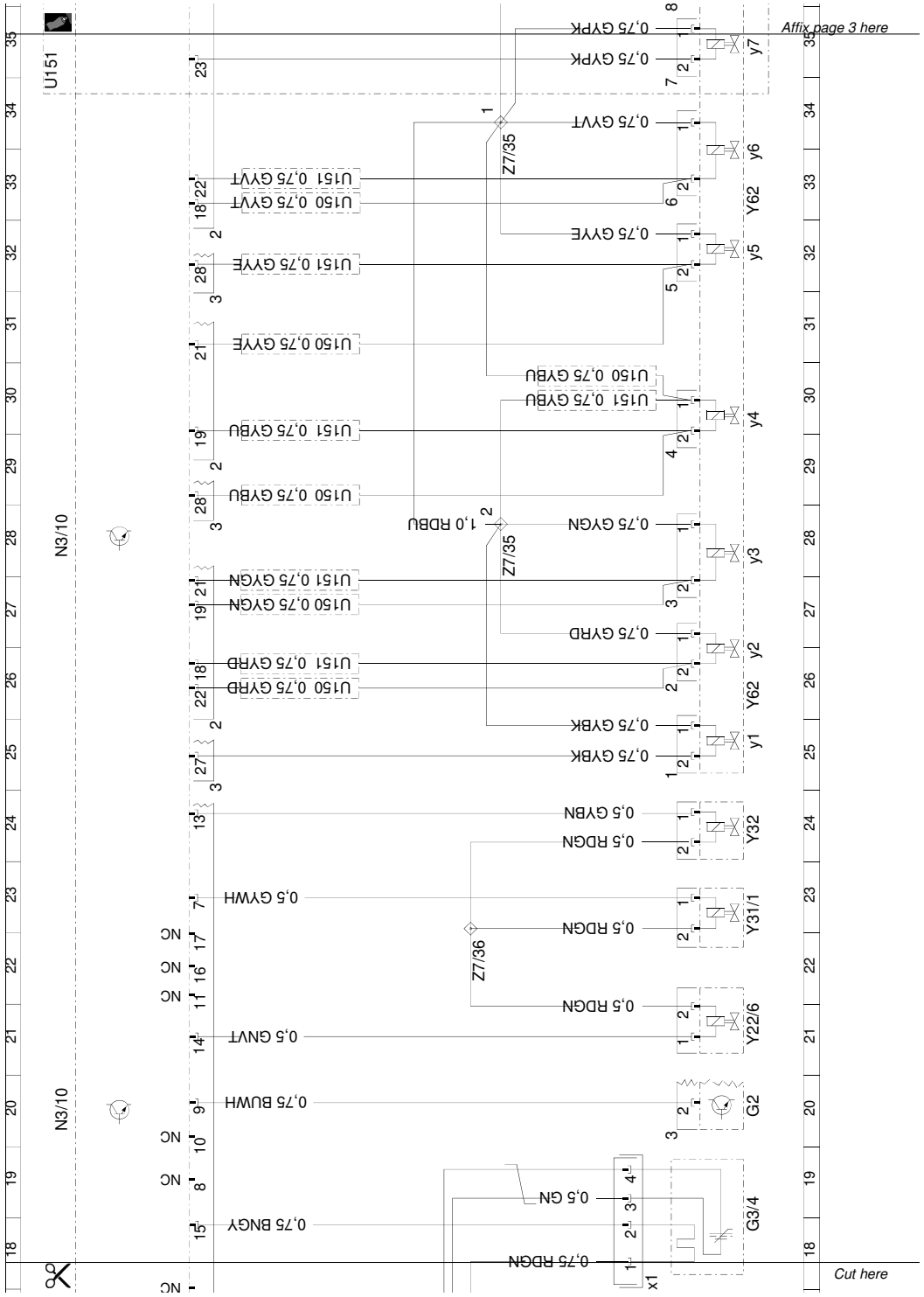
Wiring diagram ME-SFI fuel injection and ignition system control unit / pe07.61-p-2101-99db
ENGINE 112 up to 31.5.05, 113 up to 31.5.06 in MODEL 211 Steuergerät N3/10, Blatt 2' / Printed on: 29.06.2022 / Page 5/5



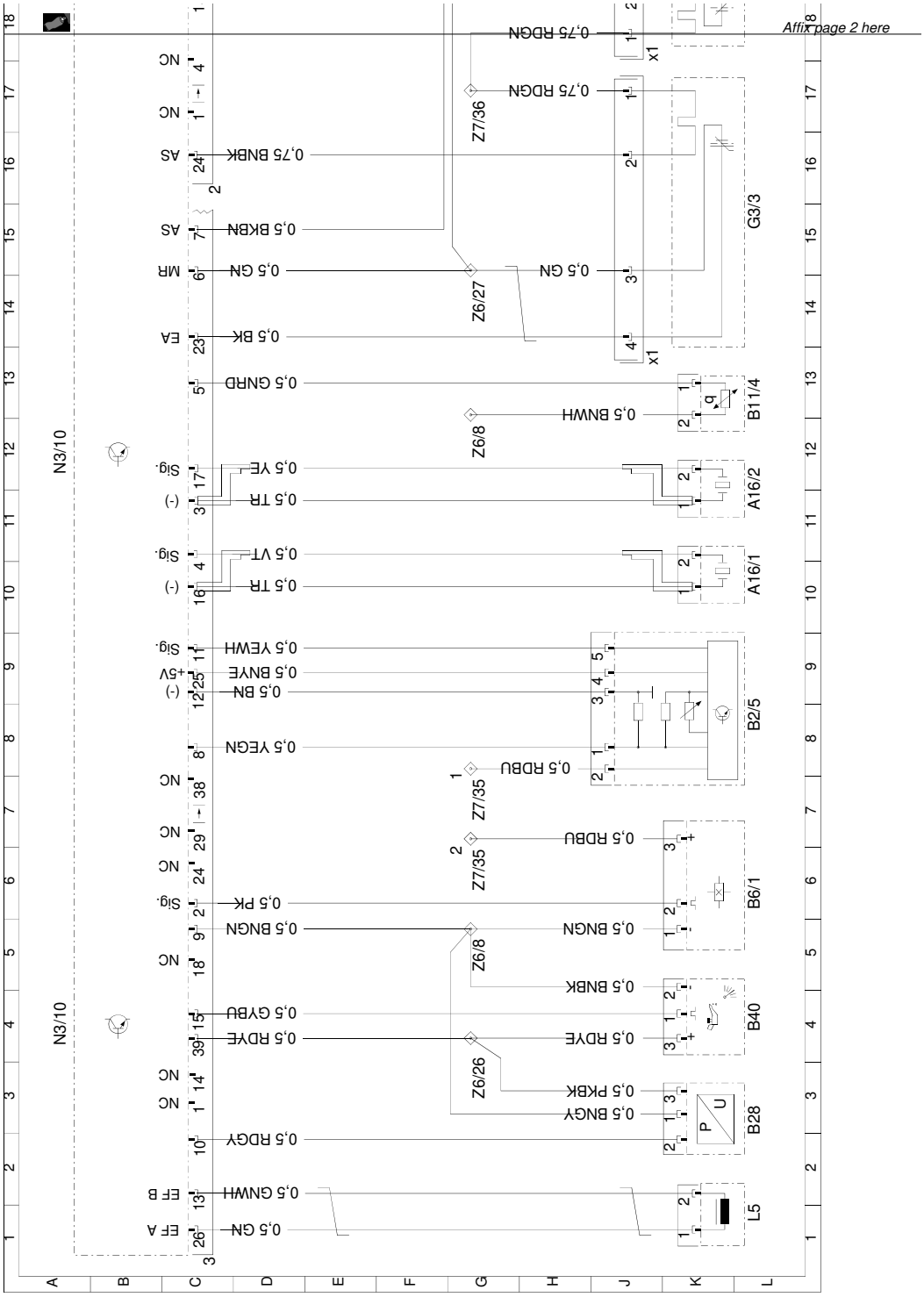
Wiring diagram ME-SFI fuel injection and ignition system control unit / pe07.61-p-2101-99db
ENGINE 112 up to 31.5.05, 113 up to 31.5.06 in MODEL 211 Steuergerät N3/10, Blatt 2' / Printed on: 29.06.2022 / Page 4/5



Wiring diagram ME-SFI fuel injection and ignition system control unit / pe07.61-p-2101-99db
ENGINE 112 up to 31.5.05, 113 up to 31.5.06 in MODEL 211 Steuergerät N3/10, Blatt 2' / Printed on: 29.06.2022 / Page 3/5



Wiring diagram ME-SFI fuel injection and ignition system control unit / pe07.61-p-2101-99db
ENGINE 112 up to 31.5.05, 113 up to 31.5.06 in MODEL 211 Steuergerät N3/10, Blatt 2' / Printed on: 29.06.2022 / Page 2/5



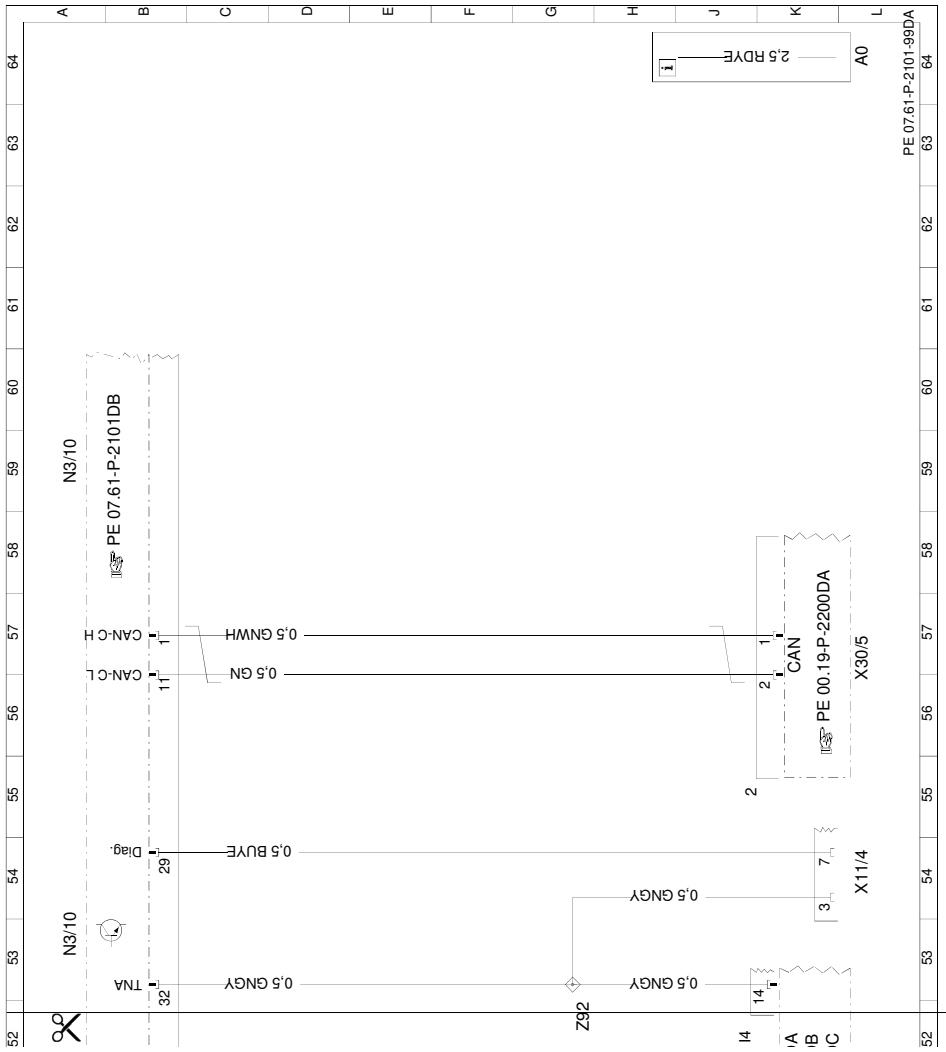
Wiring diagram ME-SFI fuel injection and ignition system control unit / pe07.61-p-2101-99db
ENGINE 112 up to 31.5.05, 113 up to 31.5.06 in MODEL 211 Steuergerät N3/10, Blatt 2' / Printed on: 29.06.2022 / Page 1/5

Document number: pe07.61-p-2101-99da
Document title: Wiring diagram for ME-SFI fuel injection and ignition system control unit

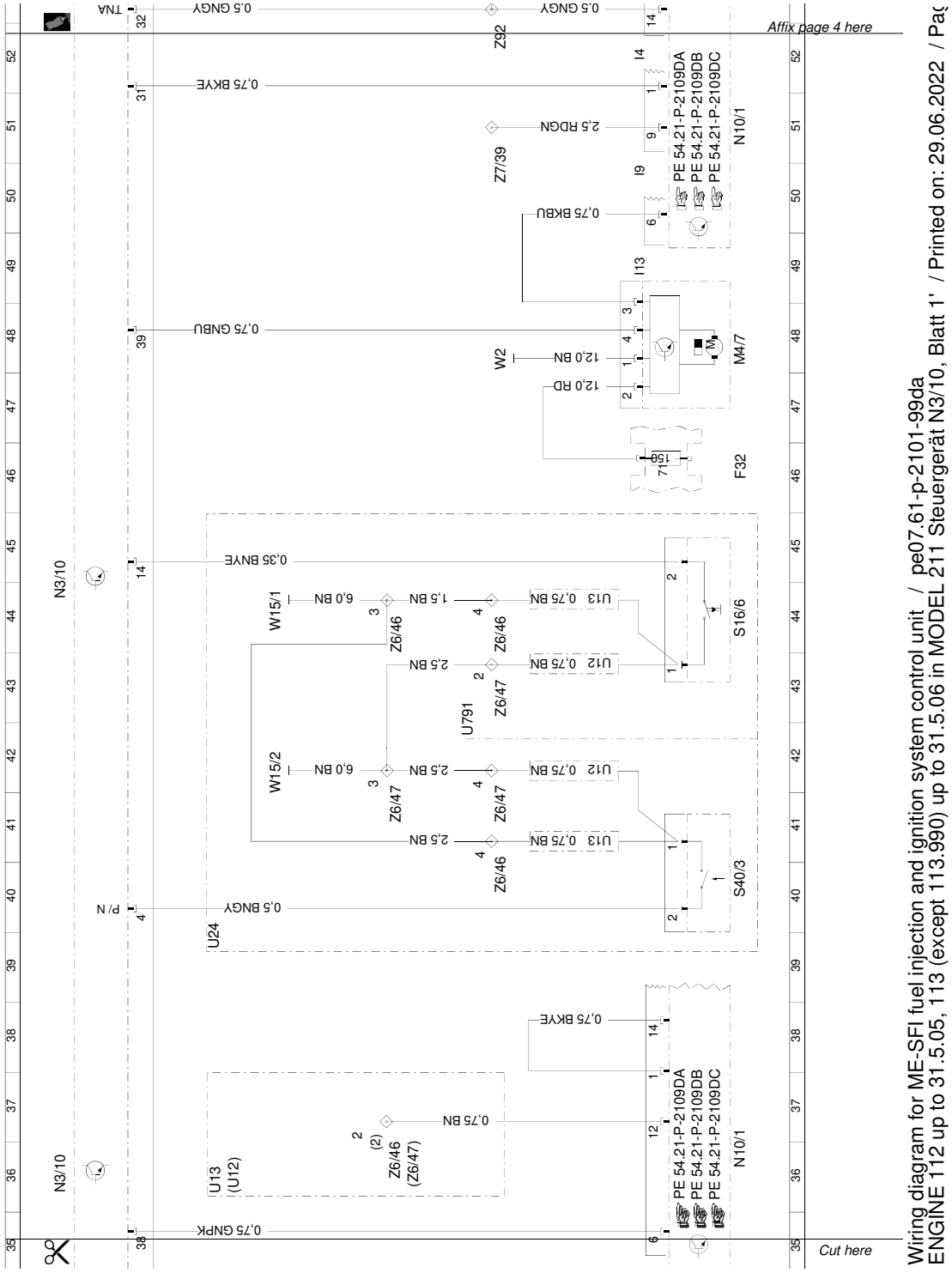
Code:	Designation:	Coordinates:
A0	Color code key	64 L
B37	Accelerator pedal sensor	19 L
B4/1	Left fuel level sensor	26 L
B4/2	Right fuel level sensor	25 L
B4/3	Fuel tank pressure sensor	12 L
F32	Front prefuse	46 L
F32f71	Fuse 71	46 K
F34	Interior fuse box	1 L
F34f42	Fuse 42	1 K
G3/5	Left O2 sensor downstream TWC [KAT]	17 L
G3/5x1	Left O2 sensor downstream TWC [KAT] connector	16 K
G3/6	Right O2 sensor downstream TWC [KAT]	15 L
G3/6x1	Right O2 sensor downstream TWC [KAT] connector	14 K
M3	Fuel pump (FP)	28 L
M33	AIR pump	33 L
M4/7	Electric suction fan engine and AC with integrated control	48 L
N10/1	Driver-side SAM control module with fuse and relay module	4 L
N10/1	Driver-side SAM control module with fuse and relay module	36 L
N10/1	Driver-side SAM control module with fuse and relay module	51 L
N10/1f43	Fuse 43	2 K
N10/2	Rear SAM control module with fuse and relay module	22 L
N10/2	Rear SAM control module with fuse and relay module	30 L
N3/10	ME-SFI [ME] control module	4 A
N3/10	ME-SFI [ME] control module	12 A
N3/10	ME-SFI [ME] control module	20 A
N3/10	ME-SFI [ME] control module	28 A
N3/10	ME-SFI [ME] control module	36 A
N3/10	ME-SFI [ME] control module	44 A
N3/10	ME-SFI [ME] control module	53 A
N3/10	ME-SFI [ME] control module	59 A
S16/6	Kickdown switch	44 L
S40/3	Clutch pedal switch	40 L
U12	Valid for left-hand steering	36 D
U12	Valid for left-hand steering	42 J
U12	Valid for left-hand steering	43 J
U13	Valid for right-hand steering	36 C
U13	Valid for right-hand steering	41 J
U13	Valid for right-hand steering	44 J
U24	Valid for MT [MG]	39 C

Document number: pe07.61-p-2101-99da
Document title: Wiring diagram for ME-SFI fuel injection and ignition system control unit

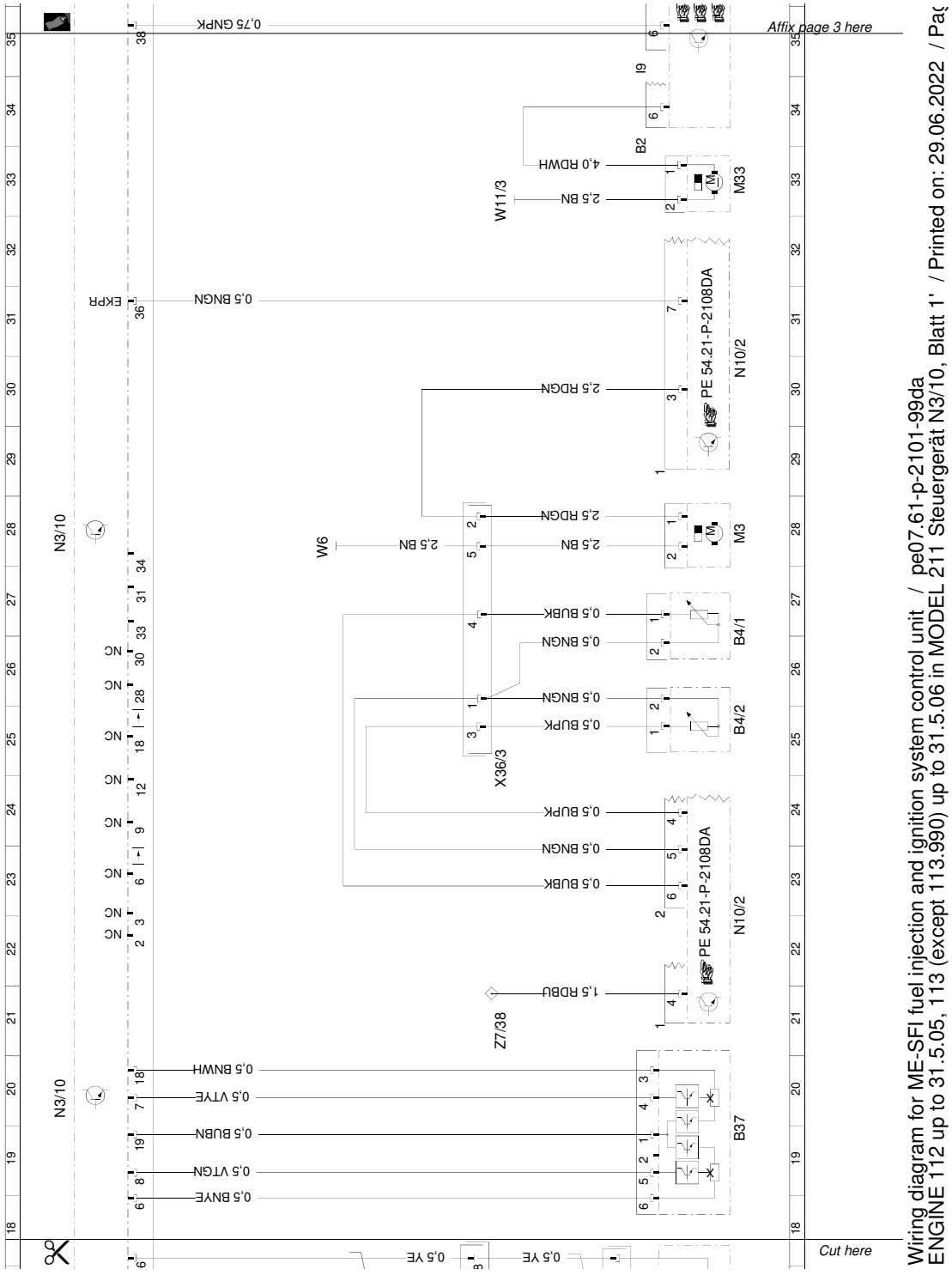
Code:	Designation:	Coordinates:
U630	Valid for {{USA}} and {{Kanada}}	8 F
U791	The electrical switching contact of the kickdown switch (S16/6) is being discontinued. Its function is being assumed by the accelerator pedal sensor (B37).	42 G
W11/3	Ground, engine, left	32 H
W15/1	Ground (right footwell)	44 D
W15/2	Ground (left footwell)	41 D
W15/3	Ground (electronics)	5 E
W2	Ground (at right headlamp unit)	48 H
W6	Ground (left wheelhousing in trunk)	28 E
X11/4	Data link connector	54 L
X26	Interior and engine wiring harness connector	14 H
X30/5	Left voltage distributor (CAN) connector	56 L
X36/3	Fuel pump wiring harness connector	24 H
Y58	Activated charcoal filter shutoff valve	9 L
Y58/1	Purge control valve	6 L
Z6/26	Sensor supply connector sleeve	14 D
Z6/46	Ground (W15/1) connector sleeve	36 F
Z6/46	Ground (W15/1) connector sleeve	40 H
Z6/46	Ground (W15/1) connector sleeve	43 H
Z6/46	Ground (W15/1) connector sleeve	43 F
Z6/47	Ground (W15/2) connector sleeve	36 F
Z6/47	Ground (W15/2) connector sleeve	41 H
Z6/47	Ground (W15/2) connector sleeve	41 F
Z6/47	Ground (W15/2) connector sleeve	43 H
Z7/35	Circuit 87 M1e connector sleeve	11 H
Z7/38	Circuit 87 M1i connector sleeve	2 G
Z7/38	Circuit 87 M1i connector sleeve	21 H
Z7/39	Circuit 87 M2i connector sleeve	14 E
Z7/39	Circuit 87 M2i connector sleeve	50 H
Z92	TNA-signal connector sleeve	52 H



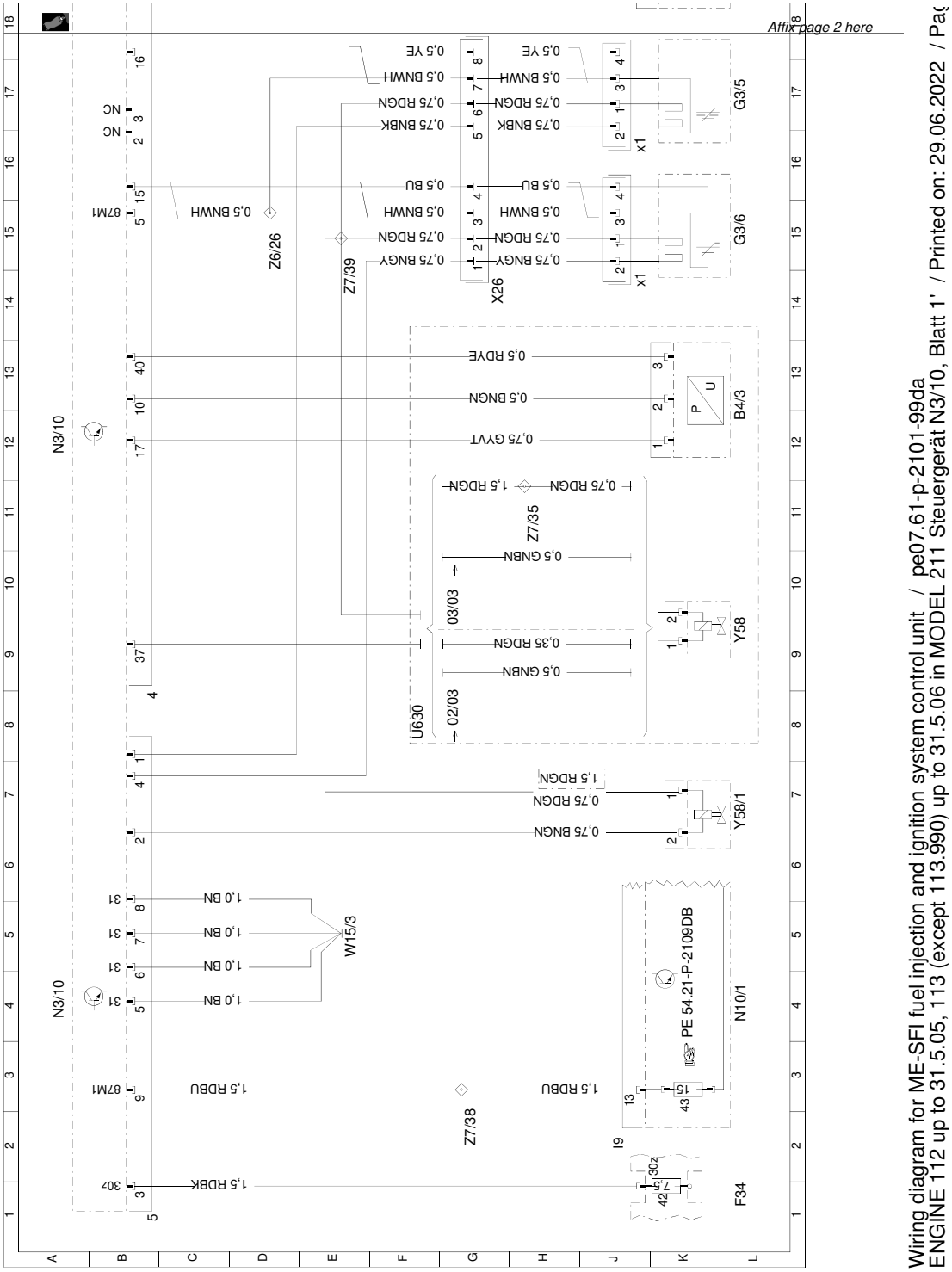
Wiring diagram for ME-SFI fuel injection and ignition system control unit / pe07.61-p-2101-99da
ENGINE 112 up to 31.5.05, 113 (except 113.990) up to 31.5.06 in MODEL 211 Steuergerät N3/10, Blatt 1' / Printed on: 29.06.2022 / Pa



Wiring diagram for ME-SFI fuel injection and ignition system control unit / pe07.61-p-2101-99da
ENGINE 112 up to 31.5.05, 113 (except 113.990) up to 31.5.06 in MODEL 211 Steuergerät N3/10, Blatt 1' / Printed on: 29.06.2022 / Pag



Wiring diagram for ME-SFI fuel injection and ignition system control unit / pe07.61-p-2101-99da
ENGINE 112 up to 31.5.05, 113 (except 113.990) up to 31.5.06 in MODEL 211 Steuergerät N3/10, Blatt 1' / Printed on: 29.06.2022 / Pa(



Wiring diagram for ME-SFI fuel injection and ignition system control unit / pe07.61-p-2101-99da
ENGINE 112 up to 31.5.05, 113 (except 113.990) up to 31.5.06 in MODEL 211 Steuergerät N3/10, Blatt 1' / Printed on: 29.06.2022 / Pag

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 and LPC8 ECUs have 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.

Two adjacent long gaps is used for 36-2-2-2 and similar configurations where the sync is found by detecting two adjacent gaps that are wider. (One tooth, two missing, one tooth, two missing again, for example.) In this strategy the sync threshold ratio is multiplied with the last tooth before the two big gaps, the previous two intervals must be bigger than the result and the interval before the referenced interval must also be smaller than the result to register sync.

Double check missing tooth takes the last interval (before the current tooth), multiplies by the threshold and both the current interval and the interval before the previous one must be shorter than the result. This is the recommended mode to use for most 36-1 and 60-2 and similar triggers. Note that in this mode the first tooth in the teeth table is the second tooth after the gap in the trigger wheel.

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.

3.1.5 Equal spacing missing tooth

This is a trigger mode that can be used interchangeably with versatile multi tooth on simple missing tooth setups (36-1 or 60-2 for example), with the possibility of ignoring the teeth on either side of the gap in the pattern if they prove to be imprecise in timing.

3.2 Internal data logging

The LPC8 controller includes 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 (500Hz) will take up around 10 megabytes per minute. At the time of writing the download rate is around 3 megabytes per minute so a 10 minute data log recorded at the highest rate would take around 30 minutes to download from the controller. To keep log sizes small without compromising on log resolution, burst mode is provided, where the logging rate can be kept low normally but accelerated during conditions that command it, such as when at full throttle.
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 or a stop condition is triggered. 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 bglog 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.

3.4 OBD2 communications

It is possible to perform OBD2 over CAN bus communications with the ECU. This enables the use of accessories that can display OBD2 data for instrumentation purposes (various OBD2 gauges, mobile phone applications and scan tools) as well as diagnostic trouble code readout. The protocol implemented is ISO15765-4 11 bit OBD over CAN.
To enable this functionality, the following configuration parameters must be set:

CAN bus data mode 500kbit

CAN receiving enable Enabled

OBD2 service enable Enabled

For diagnostic trouble codes, see Appendix B

3.4.1 Wiring

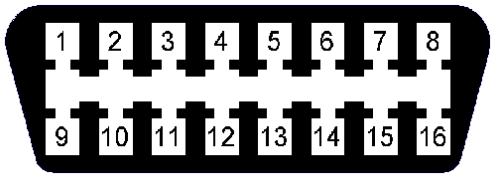


Figure 3.1: OBD2 female connector as seen from the end the scan tool plugs in to.

The OBD2 connector has four essential connections. Pin 6 (CAN-H) . Pin 14 (CAN-L) . Pins 4 and 5 connect to ground (any chassis ground will do) and pin 16 connects to +12V. The standard specifies that the +12V should be taken through a fuse directly from the battery but most OBD2 devices will also perform correctly if the 12V source is switched. For correct operation it may be necessary to have a 120 ohm termination resistor connected across the CAN wires if there is none connected to the CAN bus already.

3.4.2 Custom OBD2 PIDs

The ECU already implements nearly every standard OBD2 PID that is applicable to this application, but there are plenty of common sensors for which there is no documented standard OBD2 PID (for example, oil pressure) and also lots of examples of the ECU being used to monitor custom sensors. To facilitate this, custom OBD2 PIDs have been provided.

The custom PIDs can be used to add PIDs and they can also override existing PIDs if desired. For a list of defined standard PIDs see `https://en.wikipedia.org/wiki/OBD-II_PIDs`
It is safe to define custom PIDs in the range of 197 up to 223 (0xC5 to 0xDF in hex) without conflicting with any predefined PIDs.
In the Torque app, the OBD2 command to retrieve these values is 01 succeeded by the PID in hex, so to get PID 197 for example it would be `01 C5` OBD2 specifies the data is always in big-endian format meaning the most significant byte comes first, so the following data types are provided, but for most scenarios it is recommended to stick to either u8 or u16be:

bit Single bit to indicate a status, 1 or 0. Treat the same as a u8 byte but with only 2 possible values. Example formula in Torque app: `A`

u8 Single unsigned byte ranging from 0 to 255. Example formula in Torque app: `A`

s8 Single unsigned byte ranging from -128 to 127. Example formula in Torque app: `SIGNED(A)`

u16be 2 byte 16 bit unsigned integer ranging from 0 to 65535. Example formula in Torque app: `INT16(A:B)`

s16be 2 byte 16 bit signed integer ranging from -32768 to 32767. Not simple to use in Torque app, use unsigned value and offset it using input/output scaling on ECU instead.

u32be 4 byte 32 bit unsigned integer ranging from 0 to 4294967295. Example formula in Torque app: `INT32(A:B:C:D)`

s32be 4 byte 32 bit signed integer ranging from -2147483648 to 2147483647. Not simple to use in Torque app, use unsigned value and offset it using input/output scaling on ECU instead.

3.4.3 Transmitting data back

As of firmware version 2.3, the ECU provides a set of remotely manipulable bits that can be used to trigger things on or off, switching calibrations, etc. These bits can be manipulated by Calibrator scripts using the remote procedure call `remotebit` or using OBD2 commands. The results can be observed on the `remotebits` variables in the real time data.
To access the remote bits from OBD, use the `AA` command. The command takes 2 arguments. First argument is the bit number, from 00 to 07 and the second argument is the action to perform. The possible actions are:

00 Flip bit to 0 state.

01 Flip bit to 1 state.

02 Toggle bit between states.

03 Do nothing, just return current value.

04 Flip bit to 1 momentarily and then back to 0 about half a second later.

The `AA` command sends a reply on channel `EA` with two data bytes, the first data byte being the bit number that was accessed and the second data byte being the new state of that bit. To read the status of a bit using a custom PID in Torque, send the command `AA 00 03` where 00 is the bit you wish to read. The formula for the return data is simply `B`. To alter a bit from Torque create a push button widget that sends a raw OBD command, for example `AA 00 02` to toggle bit 0 between states each time you push the button.
Manipulating these bits from a Calibrator script can be done in a similar manner. Example:
`[ "rpc", "remotebit", [ 0, 2 ] ]` to toggle bit 0.

A Real time data fields

The descriptions of all the real time data fields have been moved into the configuration file as of firmware version 1.15. They can be read in the dialog for configuring the real time display or exported to a text document from Calibrator.

B Error codes

The error codes are stored on four bit masks, error0, error1, error2 and error3. They can be read using the Calibrator application (`Communication -> View controller errors` in on-line mode, `Tools -> Decode error variables` in log view mode). It is also possible to read the errors using an OBD2 scan tool if OBD2 connector is wired and OBD2 communications are enabled in the configuration. OBD2 DTC codes take the form of `P3XZZ` where X is the error variable, 0 for error0 and so on and ZZ is the bit offset in that variable, starting with 00. Note that these codes do not correspond with any auto manufacturer's codes.
As of firmware 2.0 it is also possible to configure the check engine lamp to flash when error codes are present. The lamp will alternate between slow and fast flash rate, with the number of slow pulses preceding the number of fast pulses. For example, four slow flashes succeeded by a single fast flash signifies low battery voltage. In the following error code tables, the second column shows the number of flashes associated with each error code.
Errors that prohibit engine starting (error0):

Value	Count	Description
P3000	1-1	Electronic throttle primary sensor low voltage
P3001	1-2	Electronic throttle primary sensor high voltage
P3002	1-3	Electronic throttle secondary sensor low voltage
P3003	1-4	Electronic throttle secondary sensor high voltage
P3004	1-5	Throttle position primary/secondary sensors disagree
P3005	1-6	Electronic throttle not following target
P3006	1-7	Engine enable input not active
P3007	1-8	Engine oil pressure low
P3008	1-9	Slave processor software fault
P3009	1-10	Slave processor hardware fault
P3010	1-11	Test mode active
P3011	1-12	Hardware fault
P3012	1-13	Configuration error
P3013	1-14	Firmware crashed
P3014	1-15	Firmware crashed in interrupt mode
P3015	1-16	Firmware crashed in priority interrupt
P3016	1-17	Second throttle primary sensor low voltage
P3017	1-18	Second throttle primary sensor high voltage
P3018	1-19	Second throttle secondary sensor low voltage
P3019	1-20	Second throttle secondary sensor high voltage
P3020	1-21	Second throttle position sensors disagree
P3021	1-22	Second throttle not following target

Errors that let the engine start and idle but disable the accelerator pedal in electronic throttle mode (error1):

Value	Count	Description
P3100	2-1	TPS voltage low
P3101	2-2	TPS voltage high
P3102	2-3	Accelerator pedal primary sensor low voltage
P3103	2-4	Accelerator pedal primary sensor high voltage
P3104	2-5	Accelerator pedal secondary sensor low voltage
P3105	2-6	Accelerator pedal secondary sensor high voltage
P3106	2-7	Accelerator pedal sensors disagree
P3116	2-17	Second TPS low voltage
P3117	2-18	Second TPS high voltage

Errors that will allow vehicle operation, but possibly at reduced performance (error2, error3 and error4):

Value	Count	Description
P3200	3-1	MAP sensor voltage low
P3201	3-2	MAP sensor voltage high
P3202	3-3	Coolant temp sensor open circuit
P3203	3-4	Coolant temp sensor short circuit
P3204	3-5	Air temp sensor open circuit
P3205	3-6	Air temp sensor short circuit
P3206	3-7	Lambda sensor voltage out of range
P3207	3-8	Lambda sensor lack of activity
P3208	3-9	Camshaft position sensor error
P3209	3-10	RTC battery fault or no RTC battery fitted
P3210	3-11	Barometric pressure sensor low voltage
P3211	3-12	Barometric pressure sensor high voltage
P3212	3-13	EMAP sensor low voltage
P3213	3-14	EMAP sensor high voltage
P3214	3-15	MAP signal implausible
P3215	3-16	Engine coolant temperature too high
P3216	4-1	Supply voltage too low
P3217	4-2	Supply voltage too high
P3218	4-3	Charge air temperature too high
P3219	4-4	Overboost protection triggered
P3220	4-5	Fuel pressure sensor low value
P3221	4-6	Fuel pressure sensor high value
P3222	4-7	Loss of CAN input data
P3223	4-8	Fuel pressure low
P3224	4-9	Fuel pressure high
P3225	4-10	Engine coolant temperature implausible
P3226	4-11	VVT primary cam off target
P3227	4-12	VVT secondary cam off target
P3228	4-13	Lambda reading too lean
P3229	4-14	Lambda reading too rich
P3230	4-15	MAF input low value
P3231	4-16	MAF input high value

Value	Count	Description
P3300	5-1	Lambda sensor 2 voltage out of range
P3301	5-2	Lambda sensor 2 lack of activity
P3302	5-3	Lambda 2 reading too lean
P3303	5-4	Lambda 2 reading too rich
P3304	5-5	N2O run aborted by low fuel pressure
P3305	5-6	Oil pressure sensor low value
P3306	5-7	Oil pressure sensor high value
P3307	5-8	Oil temperature sensor low value
P3308	5-9	Oil temperature sensor high value
P3309	5-10	VVT cam 3 off target
P3310	5-11	VVT cam 4 off target
P3311	5-12	Post compressor pressure sensor low value
P3312	5-13	Post compressor pressure sensor high value
P3313	5-14	Post restrictor pressure sensor low value
P3314	5-15	Post restrictor pressure sensor high value
P3315	5-16	Transmission temperature sensor low value
P3316	6-1	Transmission temperature sensor high value
P3317	6-2	User defined error 1
P3318	6-3	User defined error 2
P3319	6-4	User defined error 3
P3320	6-5	User defined error 4
P3321	6-6	Injector duty cycle exceeded maximum
P3322	6-7	Knock sensor 1 low input signal
P3323	6-8	Knock sensor 2 low input signal
P3324	6-9	Excessive knock detected
P3325	6-10	Fuel temperature sensor low input value
P3326	6-11	Fuel temperature sensor high input value
P3327	6-12	Fuel composition sensor low input value
P3328	6-13	Fuel composition sensor high input value
P3329	6-14	Mass air flow sensor signal implausible
P3330	6-15	DI fuel pressure sensor low input value
P3331	6-16	DI fuel pressure sensor high input value

Value	Count	Description
P3400	7-1	MAP sensor 2 low input value
P3401	7-2	MAP sensor 2 high input value
P3402	7-3	MAP sensor 2 implausible