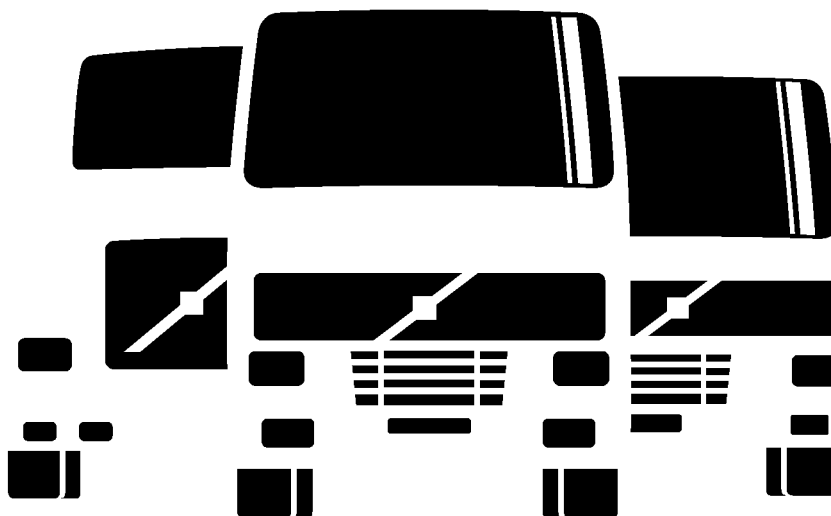


MID 128 Engine control unit, fault codes

MID 128 Engine control unit, fault codes



T0009739

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MID 128 Engine control unit, fault codes

Note: More information about fault codes is available in
Guided Diagnostics

Fault code	Function	FMI	Fault
PID26	Fan speed	3	Signal not available Short-circuit+, signal cable Short-circuit-, signal cable Open-circuit, signal cable Open-circuit, earth cable
		8	Interference in the signal cable.
PID45	Pre-heater relay	3	Short-circuit+
		4	Short-circuit-
		5	Open-circuit
PID84	Vehicle speed	9	Signal absent from VECU (MID144)
PID85	Cruise control status	9	Signal absent from CC
PID91	Pedal message	9	Signal absent from VECU (MID144)
PID94	Fuel pressure	1	Pressure critically low
		3	Short-circuit+ Signal cable Open-circuit Earth cable
		5	Open-circuit, 5V supply cable Short-circuit-, signal cable Open-circuit, signal cable
		7	Low pressure
PID97	Water in the fuel sensor	3	Short-circuit+, signal cable
		4	Short-circuit-, signal cable
PID98	Oil level	1	Below the range
		4	Short-circuit-, positive side
		5	Short-circuit+, positive side Open-circuit, positive side Open-circuit, negative side
PID100	Oil pressure	1	Below the range
		3	Short-circuit+, signal cable Open-circuit, earth cable
		5	Open-circuit, 5V supply cable Short-circuit-, signal cable Open-circuit, signal cable
PID 102	Charge pressure	0	Below the range
		2	Incorrect
		3	Short-circuit+, signal cable Open-circuit, earth cable
		5	Open-circuit, 5V supply cable Short-circuit-, signal cable Open-circuit, signal cable
PID105	Charge air temperature	2	Incorrect
		4	Short-circuit-, signal cable

Fault code	Function	FMI	Fault
		5	Short-circuit+, signal cable Open-circuit
		10	Stuck
PID107	Air filter indicator	0	Critically above the range
		3	Short-circuit+, signal cable
		4	Short-circuit-, signal cable
		5	Open-circuit
PID108	Ambient pressure	2	Within range
		3	Short-circuit+, signal cable
		4	Short-circuit-, signal cable
PID110	Coolant temperature	0	Critically above the range
		4	Short-circuit-, signal cable
		5	Short-circuit+, signal cable Open-circuit
PID111	Coolant level	1	Below the range
		3	Short-circuit-, signal cable
		5	Short-circuit+, signal cable Open-circuit
PID153	Crankcase pressure	0	Above range
		2	Within range
		3	Short-circuit+, signal cable Open-circuit, earth cable
		5	Open-circuit, 5V supply cable Short-circuit-, signal cable Open-circuit, signal cable
PID158	Battery voltage	4	TOO LOW
		3	TOO HIGH
PID171	Ambient air temperature	9	Signal absent from IC (MID140)
PID173	Exhaust temperature	4	Short-circuit-
		5	Short-circuit+ Open-circuit
PID175	Oil temperature	0	Above range
		4	Short-circuit-, signal cable
		5	Short-circuit+, signal cable Open-circuit
PID190	Engine rpm	0	Above range
PID224	Immobilizer	2	Incorrect data from IMMO (MID163)
		12	No response from IMMO (MID163)
PID228	Calibration factor (K)	11	Signal absent from VECU (MID144)
PID245	Total mileage	9	Signal absent from IC (MID140)
PID251	Time data failed	9	Exceeded time limit
PID252	Date data failed	9	Exceeded time limit
SID 1/2/3/4/5/6	Injector 1/2/3/4/5/6	3	Short-circuit+, low side

Fault code	Function	FMI	Fault
		5	Short-circuit+
			Short-circuit-
			Open-circuit, high side
			Short-circuit-, low side
		7	Clock calibration
		12	Low holding current, injector
		14	Special instructions
SID18	Water in the fuel sensor	3	Short-circuit+
		4	Short-circuit-
		5	Open-circuit
SID21	CAM speed sensor	2	Phase error
		3	Signal absent from camshaft sensor (Short-circuit+, short-circuit-, open-circuit)
		8	Interference in the signal cable.
SID22	Crankcase speed sensor	2	Intermittent or weak signal
		3	Signal absent from crankcase sensor (Short-circuit+, short-circuit-, open-circuit)
		8	Interference in the signal cable.
SID32	Waste gate	3	Short-circuit+
		4	Short-circuit-
		5	Open-circuit
		7	Stuck closed
SID33	Engine cooling fan control	3	Short-circuit+
		4	Short-circuit-
		5	Open-circuit
SID39	Starter motor output	0	Starter motor overheat
		3	Short-circuit+
		5	Open-circuit
		7	Gearbox not in neutral
		10	Gear synchronisation
		14	Power take-off engaged
SID70	Pre-heating sensor 1	3	Short-circuit+
		4	Short-circuit-
		5	Open-circuit
SID78	Fuel evacuation pump	3	Short-circuit+
		4	Short-circuit-
		5	Open-circuit
SID211	5V supply 2	3	Above range
		4	Below the range
SID230	Buffered IVS	3	Short-circuit+
		5	Short-circuit- Open-circuit

Fault code	Function	FMI	Fault
SID231	CAN1 J1939 communications link	2	Short-circuit+ Short-circuit- or open-circuit on one or other of the cables
SID232	5V supply 1	3	Above range
		4	Below the range
SID240	Program memory	2	Checksum fault
		7	Development SW
		11	Cell test position
SID253	Data memory	2	Checksum fault
		12	Checksum fault supplier
		14	Checksum fault on E2
SID254	RAM/Watchdog	3	RAM addressing failed.
		8	WD reset of CPU does not work.
		12	Write to RAM does not work
PPID55	Electronic control unit, temperature	4	Short-circuit-, signal cable
		5	Short-circuit+, signal cable Open-circuit
PPID109	Throttle disc EPG	3	Short-circuit+
		4	Short-circuit-
		5	Open-circuit
PPID122	VCB	1	Below the range
		3	Short-circuit+
		4	Short-circuit-
		5	Open-circuit
PPID123	ON/OFF EPG	3	Short-circuit+
		4	Short-circuit-
		5	Open-circuit
PPID124	EPG/ Wastegate PWM	3	Short-circuit+
		4	Short-circuit-
		5	Open-circuit
PPID270	NOx sensor Set by MID233 SCRT	2	Within range
		3	Short-circuit NOx signal
		5	Open-circuit, NOx signal
		9	Abnormal update
		12	Incorrect value
		13	Range control
		14	Signal absent from sensor due to Vbatt.
PPID273	AdBlue pressure Set by MID233 SCRT	1	Leakage
		2	Within range
		4	Short-circuit to earth

Fault code	Function	FMI	Fault
		5	Open-circuit
		7	Build up failed
		13	Electrical fault
		14	Heating failed
PPID274	AdBlue tank temperature Set by MID233 SCRT	1	Temperature too low
		4	Short-circuit to earth
		5	Open-circuit
PPID275	AdBlue filter temperature Set by MID233 SCRT	0	Temperature too high
		1	Temperature too low, electrical heating not possible
		2	Outside operating range
		4	Short-circuit to earth
		5	Open-circuit
PPID278	AdBlue level Set by MID233 SCRT	1	Level low, coolant capacity limited
		3	Short-circuit high
		5	Open-circuit Short-circuit low
		13	Sensor voltage supply outside range
		14	Level low, stop dosing
PPID385	AdBlue ECU voltage Set by MID233 SCRT	3	TOO HIGH
		4	TOO LOW
		12	Internal supply fault
		14	Internal supply critical fault
PPID386	Exhaust temperature sensor upstream of SCR cat. Set by MID233 SCRT	2	Incorrect Stuck
		4	Short-circuit to earth
		5	Open-circuit
PPID387	Exhaust temperature sensor Set by MID233 SCRT	2	Incorrect Stuck
		4	Short-circuit to earth
		5	Open-circuit
PPID435	Effective torque	0	Above range
		1	Below the range
PSID40	Inadequate reagent quality	1	Critically too low
		14	TOO LOW
PSID41	Reagent consumption	1	Critically too low
		14	TOO LOW

Fault code	Function	FMI	Fault
PSID42	Interrupted dosage activity	14	No dosing
PSID45	High NoX level	0	Above limit value, critical fault
		14	Above limit value
PSID75	AdBlue tank heating valve Set by MID233 SCRT	3	Short-circuit to battery
		4	Short-circuit to earth
		5	Open-circuit
PSID77	AdBlue ECU EEPROM Set by MID233 SCRT	3	ECU internal supply high
		4	ECU internal supply low
		12	Checksum, communication or write
PSID82	AdBlue internal filter heater Set by MID233 SCRT	3	Short-circuit to battery
		4	Short-circuit to earth
		5	Open-circuit
PSID84	AdBlue hose heater (BACKFLOW OUTLET) Set by MID233 SCRT	3	Short-circuit to battery
		4	Short-circuit to earth
		5	Open-circuit
PSID85	AdBlue ECU main relay Set by MID233 SCRT	3	Short-circuit to battery
		4	Short-circuit to earth
		5	Open-circuit
		6	Shut-off too late
PSID87	AdBlue pump motor speed Set by MID233 SCRT	0	Above speed
		1	Below speed
		10	No signal from pump
PSID89	AdBlue dosage valve Set by MID233 SCRT	3	Short-circuit to battery
		4	Short-circuit to earth
		5	Open-circuit
		7	Valve or hose blocked
		10	Valve stuck
		14	Frozen too many times
PSID90	SCR system capacity Set by MID233 SCRT	1	Dosage fault
		11	Underlying cause not known
		14	Major functional fault
PSID91	AdBlue consumption Set by MID233 SCRT	0	Level change in tank too great
		1	Level change in tank too small
PSID98	Charge pressure system	0	TOO HIGH

Fault code	Function	FMI	Fault
		1	TOO LOW
PSID101	Control valve for AdBlue cooling Set by MID233 SCRT	3	Short-circuit to battery
		4	Short-circuit to earth
		5	Open-circuit
		7	Mechanical problem
PSID102	AdBlue hose heater (INLET) Set by MID233 SCRT	3	Short-circuit to battery
		4	Short-circuit to earth
		5	Open-circuit
PSID103	AdBlue hose heater (BACKFLOW INLET) Set by MID233 SCRT	3	Short-circuit to battery
		4	Short-circuit to earth
		5	Open-circuit
PSID104	AdBlue hose heater (OUTLET) Set by MID233 SCRT	3	Short-circuit to battery
		4	Short-circuit to earth
		5	Open-circuit
PSID105	AdBlue directional valve Set by MID233 SCRT	3	Short-circuit to battery
		4	Short-circuit to earth
		5	Open-circuit
		7	Mechanical problem
PSID106	AdBlue system Set by MID233 SCRT	7	Mechanical problem
		12	Faulty component
PSID107	AdBlue external filter heater Set by MID233 SCRT	3	Short-circuit to battery
		4	Short-circuit to earth
		5	Open-circuit
PSID115	Empty reagent tank	1	TOO LOW
PSID161	VIN check 1	12	Defective device
PSID162	VIN check 2	2	Unreliable data
PSID201	CAN1 J1939 communication pause	9	No contact with VECU (MID144)
PSID202	CAN1 J1939 communication pause	9	No contact with ECU (MID140)
PSID205	CAN1 J1939 communication pause	9	No contact with TECU (MID130)
PSID229	CAN parameters from UDS Set by MID233 SCRT	9	Pause
		11	Underlying cause not known
PSID232	CAN2 J1939 communications link	2	Short circuit Short-circuit- or open-circuit on one or other of the cables.

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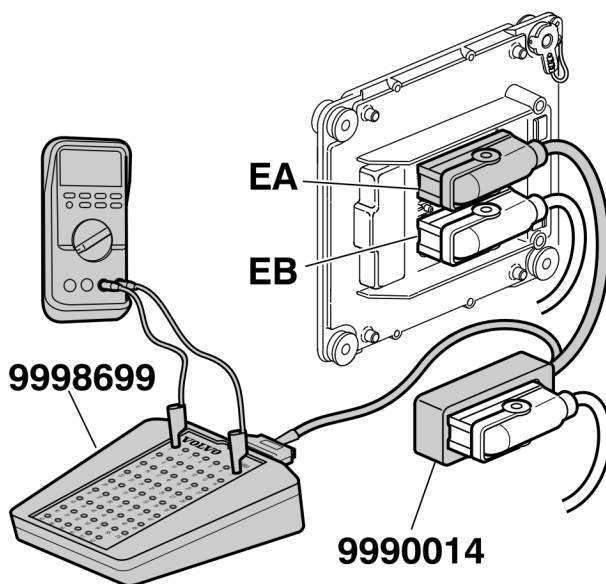
Engine control unit, check

Step 1: Checking the system.

Conditions:

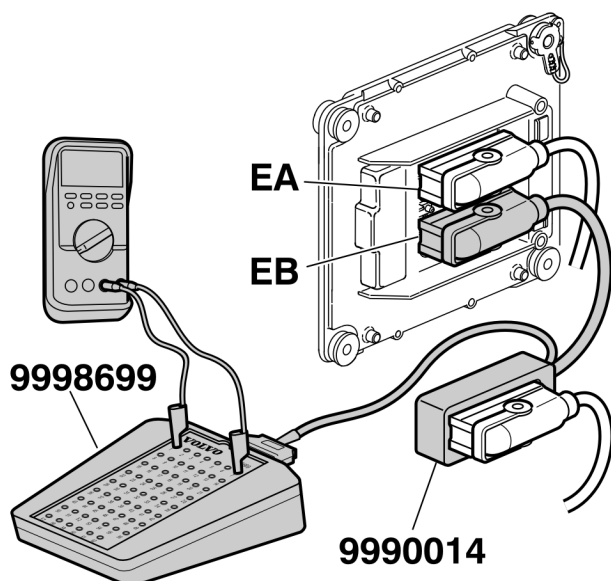
- Adapter 9990014 and breakout box 9998699 connected **between** the control unit and the cable harness.
- Control unit connected
- Ignition key in **drive position**
- Engine switched off
- Measurement position **voltage DC** with multimeter 9812519.
- U_{bat} = Battery voltage
- > = More than
- < = Less than
- $\approx$ = Approximately equal to

Note: If the values in general do not agree, check the common earth terminals EA11, EB18, EB58, EB59, EB61 and EA57.



Conne- ction	Signal type	Measurement points	Expected value	Note.
EA3 (D13, D9B)	Drain valve, primary filter	EA3 - EA57	$\approx 0.8 * U_{bat}$ (inactive) ≈ 0 V (active)	
EA3 (D16)	Fuel pump	EA3 - EA57	$\approx 0.8 * U_{bat}$ (inactive) ≈ 0 V (active)	
EA7	Supply to sensor (5 V)	EA7 - EA57	4.80 - 5.15 V	
EA21	EGR pressure	EA21 - EA11	0.5 V	
EA22	Charge pressure sensor, signal	EA22 - EA11	1.1±0.7 V	(at sea level)
EA30	EGR temperature sensor, signal	EA30 - EA11	≈ 4.9 V (+20°C)	

Con- nec- tion	Signal type	Measurement points	Expected value	Note.
EA31	Oil temperature sensor, signal	EA31 - EA11	$\approx 3.0\text{ V (+20}^{\circ}\text{C)}$ $\approx 0.4\text{ V (+100}^{\circ}\text{C)}$	
EA35	Fan speed sensor	EA35 - EA39	0 – 5 V	Spin the fan by hand. The value should oscillate between 0 - 5 V.



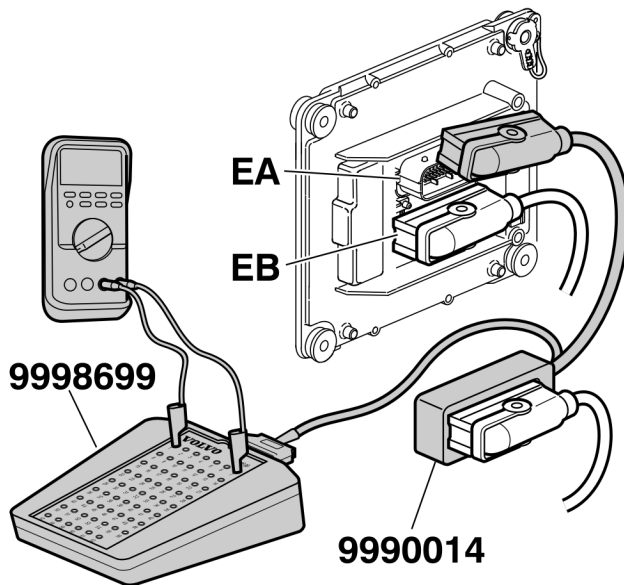
Con- nection	Signal type	Measurement points	Expected value	Note.
EB11	Oil pressure sensor, signal	EB11 - EB18	≈ 0.5 V (with engine shut-off)	
EB15	Buffered idle switch	EB15 - EB59	< 4 V (inactive) > 8 V (active, i.e. with depressed accelerator)	
EB16	Fuel pressure sensor, signal	EB16 - EB18	≈ 0.5 V (with engine shut-off)	
EB17	Supply to sensor (5 V)	EB17 - EB18	≈ 5 V	
EB23	Coolant level sensor, signal	EB23 - EB10	≈ 0.9 * U _{bat} (open) ≈ 0 V (closed)	Normally "open" with the starter key in drive position.
EB24	EGR position 1	EB24 - EB18	≈ 0.2 - 0.8 V (valve closed)	
EB25	Pre-heater relay	EB25 - EB59	U _{bat} (open) 0 V (closed)	
EB27	Coolant temperature sensor, signal	EB27 - EB18	≈ 3.0 V (+20°C) ≈ 0.6 V (+85°C)	
EB28	Crankcase pressure sensor	EB28 - EB18	2.9±0.6 V (at sea level)	Engine stationary
EB30	VCB	EB30 - EB61	U _{bat} (inactive) 0 V (active)	Normally "inactive" with the ignition key in drive position.
EB33 Note: Only (D16E)	Drain valve, primary filter	EB33 - EB61	U _{bat} (inactive) 0 V (active)	
EB38	EPG	EB38 - EB59	≈ U _{bat} (inactive) ≈ 0 V (active)	Normally "inactive" with the ignition key in drive position.
EB49	Fan control	EB49 - EB59	≈ U _{bat} (inactive) ≈ 0 V (active)	The fan is engaged when the fan coupling relay is inactive. The fan is off when the fan coupling relay is active.

EB50	Waste gate	EB50–EB59	$\approx U_{\text{bat}}$ (inactive) $\approx 0 \text{ V}$ (active)	Normally “inactive” with the ignition key in drive position.
EB51	SAE J1939 (CAN high)	EB51 - EB61	2.5 - 4.0 V	
EB55	SAE J1939 (CAN low)	EB55 - EB61	0 - 2.5 V	
EB57	Power supply, control unit	EB57 - EB59	U_{bat}	
EB60	Power supply, control unit	EB60 - EB61	U_{bat}	

Step 2: Function check (Cable harness and circuit)

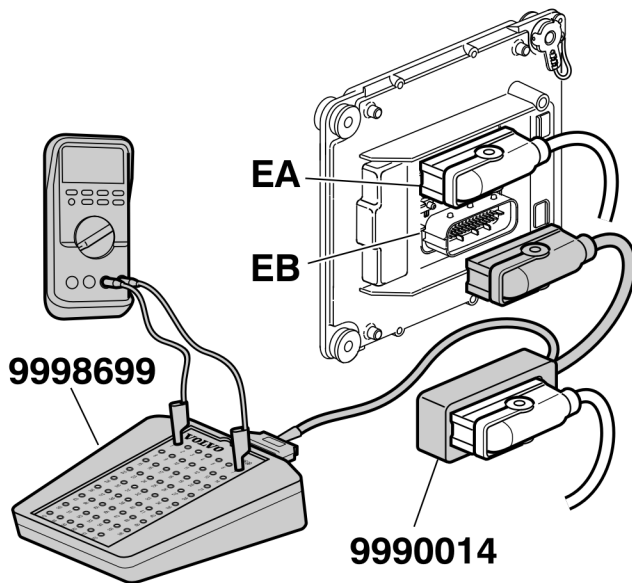
Conditions:

- Adapter 9990014 and breakout box 9998699 connected to the cable harness.
- Control unit disconnected
- Ignition key in **stop position**
- Measurement position **resistance** with multimeter 9812519.



Conne- ction	Signal type	Measurement points	Expected value	Note.
EA3	Fuel pump	EA3 - EA57	$> 10\Omega$	
EA12	Unit injector cylinder 2 (injector)	EA12 - EA62	$0.9 - 5.2 \Omega (20^{\circ}\text{C})$ $1.5 - 5.8 \Omega (100^{\circ}\text{C})$	
EA16	Unit injector cylinder 2 (return valve)	EA16 - EA59	$1.1 - 5.8 \Omega (20^{\circ}\text{C})$ $1.9 - 6.2\Omega (100^{\circ}\text{C})$	
EA20	Unit injector cylinder 1 (needle control valve)	EA20 - EA62	$0.9 - 5.2 \Omega (20^{\circ}\text{C})$ $1.5 - 5.8 \Omega (100^{\circ}\text{C})$	
EA24	Unit injector cylinder 1 (spill valve)	EA24 - EA59	$1.1 - 5.8 \Omega (20^{\circ}\text{C})$ $1.9 - 6.2\Omega (100^{\circ}\text{C})$	
EA28	Unit injector cylinder 3 (injector)	EA28 - EA62	$0.9 - 5.2 \Omega (20^{\circ}\text{C})$ $1.5 - 5.8 \Omega (100^{\circ}\text{C})$	
EA30	EGR temperature sensor	EA30 - EA11	$30 - 45\text{k}\Omega$	
EA31	Oil temperature sensor, signal	EA31 - EA11	$\approx 1.9 \text{ k}\Omega (+20^{\circ}\text{C})$ $\approx 100 \Omega (+100^{\circ}\text{C})$	
EA32	Unit injector cylinder 3 (return valve)	EA32 - EA59	$1.1 - 5.8 \Omega (20^{\circ}\text{C})$ $1.9 - 6.2\Omega (100^{\circ}\text{C})$	
EA36	Unit injector cylinder 6 (injector)	EA36 - EA61	$0.9 - 5.2 \Omega (20^{\circ}\text{C})$ $1.5 - 5.8 \Omega (100^{\circ}\text{C})$	
EA37	Tachometer sensor, flywheel, +	EA37 - EA38	$775 - 945 \Omega$	
EA40	Unit injector cylinder 6 (return valve)	EA40 - EA60	$1.1 - 5.8 \Omega (20^{\circ}\text{C})$ $1.9 - 6.2\Omega (100^{\circ}\text{C})$	
EA41	Tachometer turbo	EA41 - EA42	$0.8 - 1 \text{ k}\Omega$	

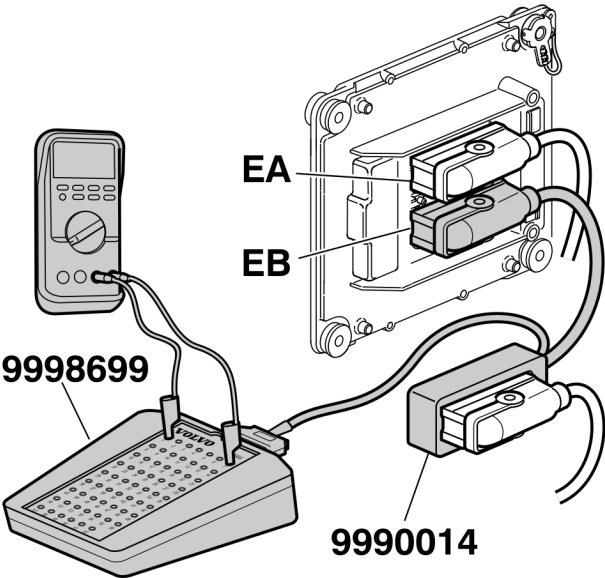
EA44	Unit injector cylinder 5 (injector)	EA44 - EA61	0.9 - 5.2 Ω (20 $^{\circ}$ C) 1.5 - 5.8 Ω (100 $^{\circ}$ C)	
EA45	Camshaft sensor, +	EA45 - EA46	775 - 945 Ω	
EA47	Charge air temperature sensor, signal	EA47 - EA11	$\approx$ 2.4k Ω (+20 $^{\circ}$ C) $\approx$ 1.1k Ω (+40 $^{\circ}$ C)	
EA48	Unit injector cylinder 5 (return valve)	EA48 - EA60	1.1 - 5.8 Ω (20 $^{\circ}$ C) 1.9- 6.2 Ω (100 $^{\circ}$ C)	
EA52	Unit injector cylinder 4 (injector)	EA52 - EA61	0.9 - 5.2 Ω (20 $^{\circ}$ C) 1.5 - 5.8 Ω (100 $^{\circ}$ C)	
EA56	Unit injector cylinder 4 (return valve)	EA56 - EA60	1.1 - 5.8 Ω (20 $^{\circ}$ C) 1.9- 6.2 Ω (100 $^{\circ}$ C)	



Conne- ction	Signal type	Measurement points	Expected value	Note.
EB3	Oil level sensor	EB3 - EB4	11.7 - 12.9 Ω ($\approx$ +22 $^{\circ}$ C)	
EB13	EGR valve 1, engine	EB13 - EB9	1 - 10 Ω	
EB23	Coolant level sensor, signal	EB23 - EB10	> 100 k Ω (open) normal level < 5.0 Ω (closed) low level	
EB27	Coolant temperature sensor, signal	EB27 - EB18	1.9 k Ω (20 $^{\circ}$ C) 160 Ω (185 $^{\circ}$ C)	
EB49	Fan control	EB49 - EB57	< 50 Ω	

Conditions:

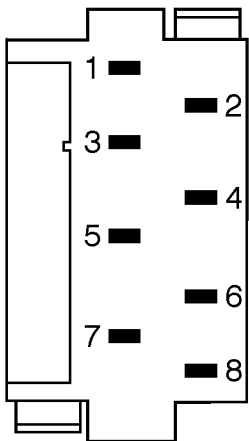
- Adapter 9990014 and breakout box 9998699 connected **between** the control unit and the cable harness.
- Control unit connected
- Ignition key in **stop position**
- Measurement position **resistance** with multimeter 9812519.



Connec- tion	Signal type	Measurement points	Expected value	Note.
EB51	SAE J1939	EB51 - EB55	60 Ω	When there is no terminal resistor 120 Ω (or when the contact EA is disconnected)

Step 3: Function check (engine control unit)

- Conditions:
- Control unit connected
 - Measurement via the data link connector
- DC no. = Connection in data link connector

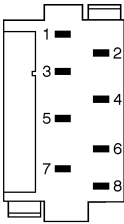
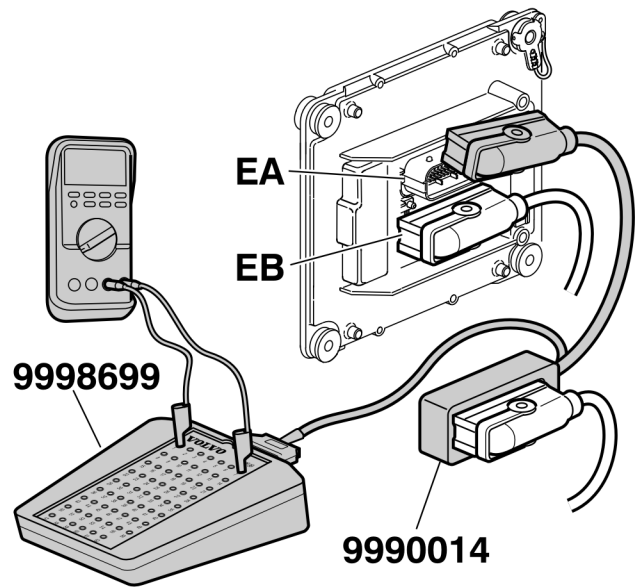


Connec- tion	Signal type	Measurement points	Expected value	Note.
DC3	SAE J1587/1708	DC3 - DC2	0 - 5 V	

Conditions:

- Adapter 9990014 and breakout box 9998699 connected to cable harness **EA**
- Control unit connector EA disconnected
- Ignition key in **stop position**
- Measurement position **resistance** with multimeter 9812519.

DC no. = Connection in data link connector

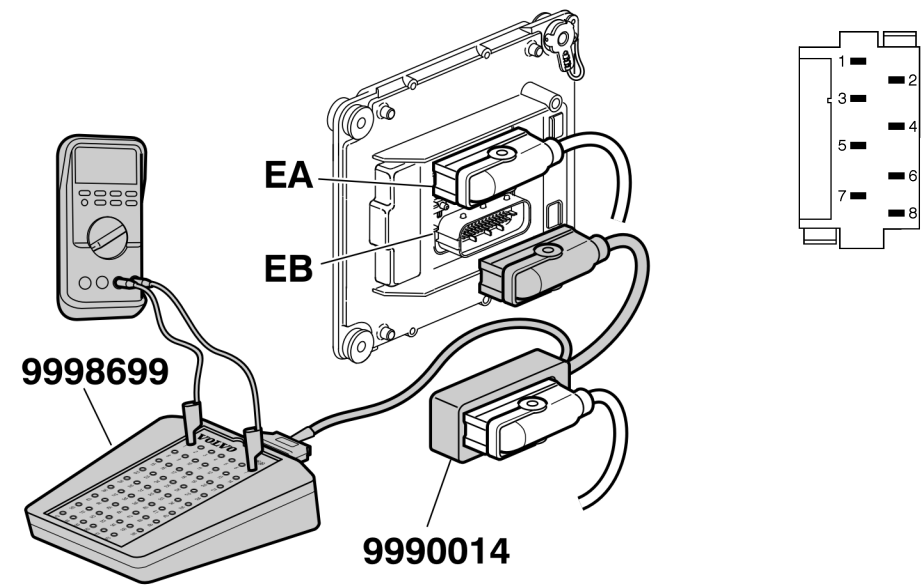


Conne- ction	Signal type	Measurement points	Expected value	Note.
EA33	SAE J1587-/1708 (CAN high)	EA33 - DC3	0 - 5 Ω	
EA34	SAE J1587-/1708 (CAN low)	EA33 - DC2	0 - 5 Ω	

Conditions:

- Adapter 9990014 and breakout box 9998699 connected to cable harness **EB**
- Control unit connector EB disconnected
- Ignition key in **stop position**
- Measurement position **resistance** with multimeter 9812519.

DC no. = Connection in data link connector



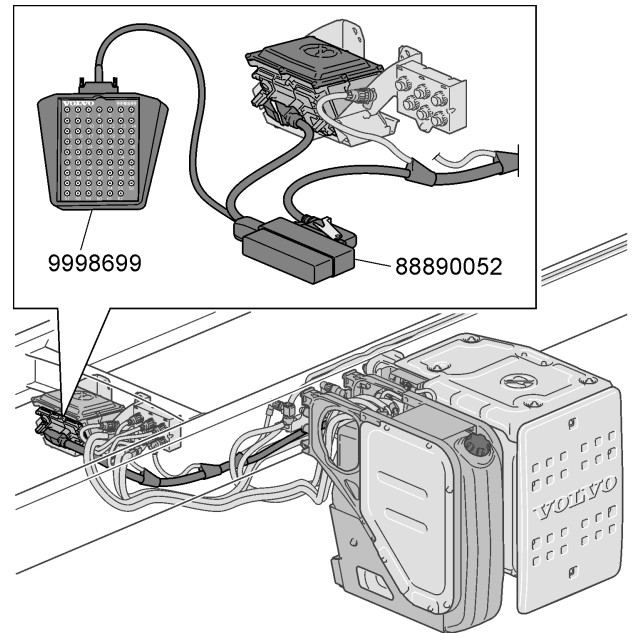
Conne- ction	Signal type	Measurement points	Expected value	Note.
EB51	SAE J1939 (CAN high)/1939 (CAN low)	EB51 - EB55	120 Ω	

SCRT, fault tracing

Step 1: Checking the system.

Conditions:

- Adapter 88890052 and breakout box 9998699 connected **between** the control unit and the cable harness.
- Control unit connected
- Ignition key in **drive position**
- Engine switched off
- Measurement position **voltage DC** with multimeter 9812519.
- U_{bat} = Battery voltage
- > = More than
- < = Less than
- $\approx$ = Approximately equal to

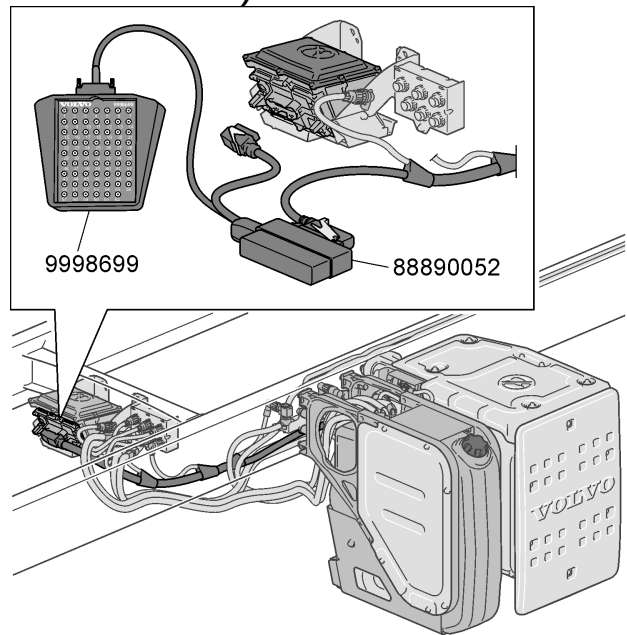


Connection	Signal type	Measurement points	Expected value
A6	Tank level sensor/temperature sensor supply	A6 - A17	4.75-5.25 V
A8	Catalytic converter temperature sensor, upstream, signal	A8 - A19	$\approx 0.9 \text{ V (25}^{\circ}\text{C)}$ $\approx 1.5 \text{ V (300}^{\circ}\text{C)}$
A10	Catalytic converter temperature sensor, downstream, signal	A10 - A11	$\approx 0.9 \text{ V (25}^{\circ}\text{C)}$ $\approx 1.5 \text{ V (300}^{\circ}\text{C)}$
A18	Tank level sensor, signal	A18 - A17	0.30-4.75 V
A12	Supply voltage from F10 (DR signal)	A:12 - A:22	U _{batt}
A33	Supply voltage from F94	A:33 - A:22	U _{batt}
A32	Supply voltage from F94	A:32 - A:22	U _{batt}
A31	SAE J1939-7 (CAN high)	A:31 - A:22	2.5-4.0 V
A30	SAE J1939-7 (CAN low)	A:30 - A:22	0-2.5 V

Step 2: Function check (Cable harness and circuit)

Conditions:

- Adapter 88890052 and breakout box 9998699 connected **to** the cable harness.
- Control unit disconnected
- Ignition key in **stop position**
- Measurement position **resistance** with multimeter 9812519.



Connection	Signal type	Measurement points	Expected value
A7	Tank temperature sensor, signal	A7 - A17	≈ 15.0 kΩ (0°C) ≈ 4.7 kΩ (25°C)
A8	Exhaust temperature sensor, upstream, signal	A8 - A19	≈ 220 Ω (25°C) ≈ 350 Ω (200°C)
A10	Exhaust temperature sensor, downstream, signal	A10 - A11	≈ 220 Ω (25°C) ≈ 350 Ω (200°C)
A21	Earth	A21 - Earth	≈ 0 Ω
A22	Earth	A22 - Earth	≈ 0 Ω
A31	SAE J1939-7 (CAN high)	A31 - A30	120 Ω
A13	Tank heating valve	A13 - A35	40 -55 Ω
A24	Dosing valve	A24 - A25	1.5 -5.0 Ω
	Filter heater		Not possible to measure
A14	Hose heater 1	A14 - A34	10 -15 Ω
A4	Hose heater 2	A4 - A34	8 -15 Ω
A2	Hose heater 3	A2 - A35	8 -13 Ω
A1	Hose heater 4	A1 - A35	11 -15 Ω
A3	External filter heater	A3 - A35	30 -70 Ω