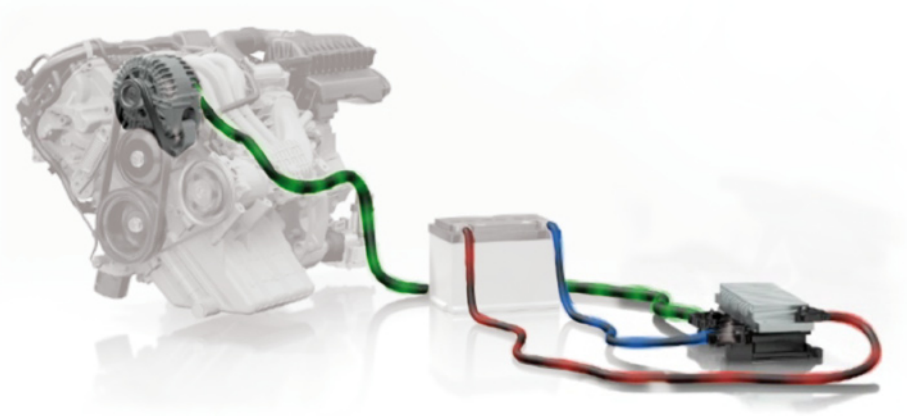
StARS by Valeo,
the technical handbook

GB Note



«When I stop... I stop polluting!
Thanks to the Valeo microhybrid system»

valeo added

Enabling a better automotive world

Valeo

CONTENTS

GLOSSARY

BMS: Battery Management System

BSI: Built-In System Interface

COMBI: Instrumentation box management

ECU: Electronic Control Unit

CAN: Communication protocol: the controllers, sensors and actuators communicate with each other on two cables

ESP® : Programme électronique de stabilité

IBS: Intelligent Battery Sensor

LED: Light Emitting Diode

LIN: Local Interconnection Network

MOSfet: Electronic power switch where a voltage controls the opening or closing of the gate

PCU: Converter

SAM: Modulate for setting in motion

SRS: Secondary restraint system

TCU: Transmission Control Unit

ESP® : Bosch registered trademark

INTRODUCTION

StARS stands for Starter Alternator Reversible System. The StARS combines the alternator and starter functions in a single machine.
Its main feature is that it stops the engine when the vehicle is stopped, and instantaneously and quietly restarts it when a gear is engaged or the brake pedal released.
Its advantages are many: when stopped, there is no noise, no vibration, and no polluting gases are emitted. This system also saves fuel (up to 15% in town/city driving conditions according to the vehicle model) and reduces CO_2 emissions (also up to 15% depending on the model of the vehicle).
Today, StARS is fitted to the smart fortwo mhd and to the Citroën C2, C3 and C3 facelift.
This manual describes the StARS components and includes a diagnosis methodology.

Today, on the independent spares part market, two starter alternators are available: references 439900 and 439901 and three cables: 595420, 595421 and 595423 (cf. passenger vehicle catalogue 2009-2010).

CITROËN C2 **CITROËN C3** **CITROËN C3 facelift**	1.4i 16V 1.4i 16V 1.4i 16V	M/A M M	ET3J4 / L5 ET3J4 / L5 ET3J4 / L5	11/05> 10/04>10/05 08/07	**439900**	**595420**
smart fortwo mhd	1.0i	M/A	132.910	01/07>	**439901**	**595421** **595423**

1. PRESENTATION OF StARS

1.1. Advantages of StARS

1.1.1. Advantages for the user

- **Fuel savings, no consumption when stopped:**
  Gains in consumption are 10% for urban use, 6% in standard mixed cycle and can reach 15% when the traffic is heavy (*). The CO_2 emissions are reduced accordingly. This gain contributes to reducing greenhouse gas emissions. The successive engine startups do not increase fuel consumption but on the contrary lead to gains in consumption and make driving more pleasant.

(*) According to Valeo tests conducted in dense urban traffic

- **No vibrations, no noise when stopped:**
  In urban driving conditions, the vehicle is stopped 35% of the time. This is why, with its ultra silent system, Stop and Start helps increase the quality of life in towns and cities substantially. It also improves comfort when the engine is in standby mode: no vibrations, no external noise emissions, gain in acoustic comfort inside (noise level divided by 4).

- **Immediate and silent restart:**
  Stop and start of the engine are automatic; engine restart is instantaneous (in less than 350 milliseconds) and completely silent.

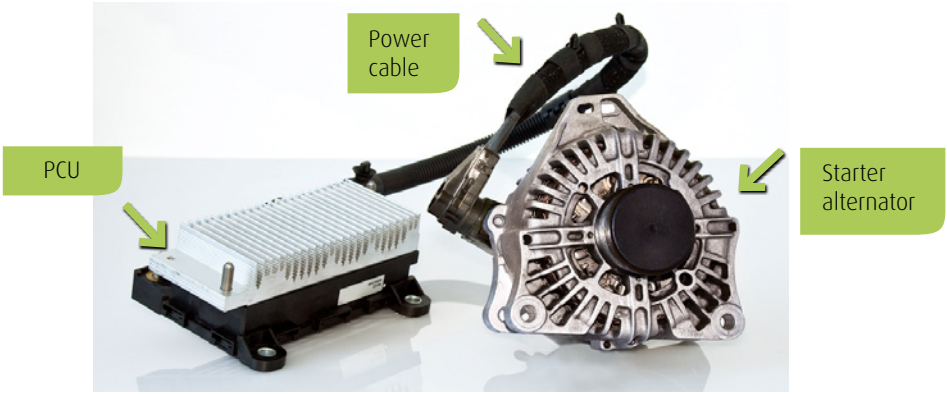
1.1.2. Advantages for the manufacturer

- The StARS starter alternator offers a substantial reduction in consumption and CO_2 emissions for a reasonable investment.
- The installation on the engine and the electrical integration are simple.
- The length of the powertrain is not increased unlike the case when a starter alternator is incorporated into the transmission line.
- The restart power is high: 2.5 kW under 14 volts.
- The electrical efficiency is higher than with a conventional alternator.

Thanks to its advanced operating mode, the StARS starter alternator adapts to all stop and start strategies required by the manufacturers. The system can take into account a large number of parameters related to the engine, the clutch, the gearbox, the braking system and other comfort and safety equipment in its current configuration. StARS can be associated with all petrol engines up to 2.0 litres and all diesel engines up to 1.6 litres and all types of gearboxes. From now, it can be fitted to all petrol and diesel vehicles whatever the engine capacities.

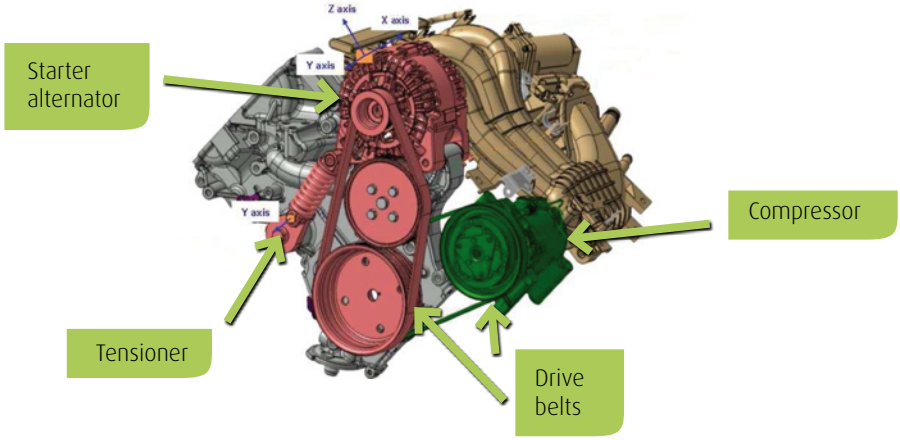
1.2. The main components of the system

Unlike a traditional vehicle, there is no alternator or starter; StARS includes three components: the starter alternator, the converter (or PCU) and the power cable.



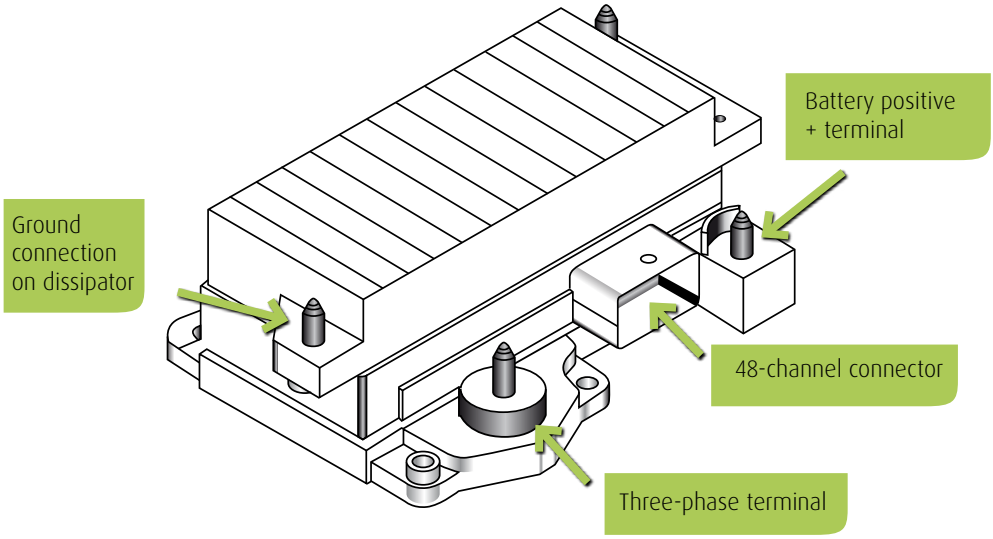
1.2.1. Starter alternator

The StARS starter alternator combines the functions of the alternator and the starter. In starter mode, start is instantaneous and silent thanks to the belt which permanently connects it to the crankshaft. The alternator mode benefits from a new technology improving the electrical efficiency. **The connection with the engine is by a belt and a dynamic tensioner.**

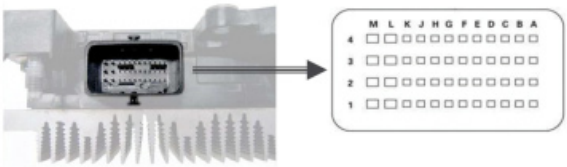


The first belt transmits the torque between the conditioned air compressor and the crankshaft, the second belt transmits the torque between the starter alternator, the water pump and the crankshaft. The starter alternator is installed on a pivot on one side and on the tensioner on the other side ; the tensioner pushes the machine so that the belt will be permanently tensioned.

1.2.2. PCU or converter



Focus on 48-channel connector:



		Fonction	Citroen	Smart		Fonction	Citroen	Smart		Fonction	Citroen	Smart
A1	A2	CAN Low 1	☒	☒	A3	Start Stop switch by push button	☒	☒	A4	CAN High 1	☒	☒
B1	B2	CAN Low 2	☒	☒	B3	Info + start contact key CAN250	☒		B4	CAN High 2	☒	☒
C1	C2	Measure tension + battery	☒		C3	Info sensor temperature battery 1915	☒		C4	Start Stop switch by push button	☒	☒
D1	D2	Ground sensor alternator	☒		D3				D4	Info sensor rotor positioning Ph U	☒	☒
E1	E2	Lighting LED inhibition switch	☒		E3	Mano contact brake pressure	☒ 7091	☒	E4	Info sensor rotor positioning Ph V	☒	☒
F1	F2				F3				F4	Info sensor rotor positioning Ph W	☒	☒
G1	G2				G3	Ground sensor	☒ 7091 & 1915		G4	Communication network	☒ CAN 50 line K, CAN LIN	☒ LIN
H1	H2				H3				H4			
J1	J2	Switch + 12V key "on"	☒ +APC	☒ KL15	J3	Security authorisation start	☒ Filaire	☒	J4	Measure tension "-" battery	☒	
K1	K2				K3	Supplying rotor positioning sensor (5V)	☒	☒	K4			
L1	L2	Info leading brake			L3	"+ "excitation rotor	☒	☒	L4	"-" excitation rotor	☒	☒
M1	M2	+ 12V constant	☒	☒ KL30	M3	"+ "excitation rotor	☒	☒	M4	"-" excitation rotor	☒	☒

1.2.3. Power cable

The power cable transmits electrical currents allowing the machine to operate in the two directions in start or battery charge mode.
Each end of the cable is equipped with a connector. The installation direction is given by the bundle anchoring points in the vehicle.

1.3. StARS operating principle

Pressing the ECO button activates the Stop and Start function: the vehicle has then exceeded 10 km/h for the first time, the battery charge available is sufficient.
Various computers: BSI, engine control, gearbox control, reversible alternator computer, etc. check that the stop conditions are met (foot on brake pedal, speed lower than 6 km/h, battery sufficiently charged, etc.). Once these conditions are met, the starter alternator computer gives the order to the engine control to stop injection, the engine then goes into standby mode.

The Stop and Start system is automatically deactivated under certain circumstances to guarantee safety (de-icing, demisting of windscreen activated, braking assistance insufficient) and passenger comfort (passenger compartment thermal comfort not reached). The driver can also voluntarily deactivate the device by pressing OFF.

2. TROUBLESHOOTING VEHICLES EQUIPPED WITH StARS

Reminder: StARS can be fitted to the following vehicles on the independent aftermarket:

CITROËN C2 **CITROËN C3** **CITROËN C3 facelift**	1.4i 16V 1.4i 16V 1.4i 16V	M/A M M	ET3J4 / L5 ET3J4 / L5 ET3J4 / L5	11/05> 10/04>10/05 08/07	**439900**	**595420**
smart fortwo mhd	1.0i	M/A	132.910	01/07>	**439901**	**595421** **595423**

Citroën C3 1st generation 10/04 > 10/05 is equipped with a converter communicating to standard CAN 250 whereas Citroën C2 and C3 facelift communicate to standard CAN500.

2.1. Starting/stopping the Stop and Start system

Start: press **ECO**
Stop: press **OFF / ECO OFF**

When the green ECO light is on on the dashboard the Stop and Start function is active.

Citroën C2, C3, C3 facelift

smart fortwo mhd

2.2. Fault indicating

- **Citroën C3 1st generation 10/04 > 10/05:**
  The ECO button flashes + a beep is emitted for several seconds. The ECO LED remains on the dashboard
- **Citroën C2 and C3 facelift:**
  The onboard computer displays «Stop System Defective»
- **smart mhd:**
  The orange ECO light flashes for 10 seconds then goes off:

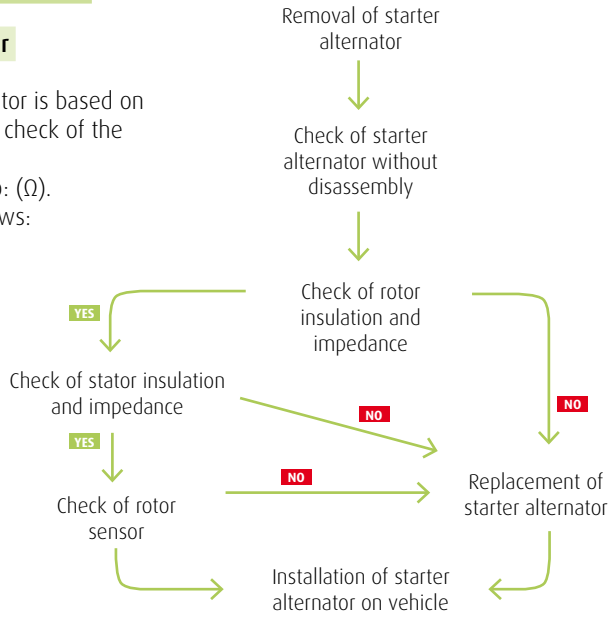
When the Stop and Start function is activated and the system is not yet capable of stopping the vehicle, the green light is off and the orange light is on.
When the Stop and Start function is activated and no ECO light comes on or flashes, this means that a rear door is open.

3. STOP AND START SYSTEM CHECKING METHODOLOGY

3.1. Checking Valeo components

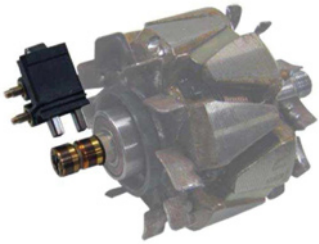
3.1.1. Checking starter alternator

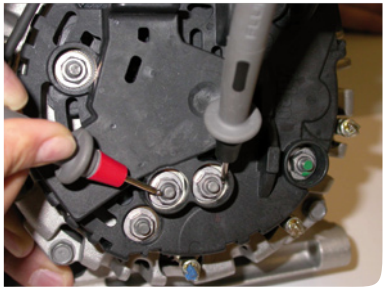
The electrical test of the starter alternator is based on a measurement of the impedance and check of the insulation using the multimeter.
The multimeter selector must be set to: (Ω).
The troubleshooting method is as follows:



Checking rotor:

- **Check the insulation of the rotor from the ground:** the rotor must be electrically insulated from the front and rear bearings of the starter alternator





- **Checking rotor impedance:** measure the impedance of the rotor, the coil and the impedance of the carbon brush contacts.
  The measured impedance must be between 0.5 ohms and 100 ohms.

To obtain correct measurement, Valeo recommends that you turn the rotor during the measurement

Checking stator:

- **Check the insulation of the stator from the ground:** electrically insulate the stator from the front and rear bearings of the starter alternator

- **Check stator impedance:** its value is around 20 mohms

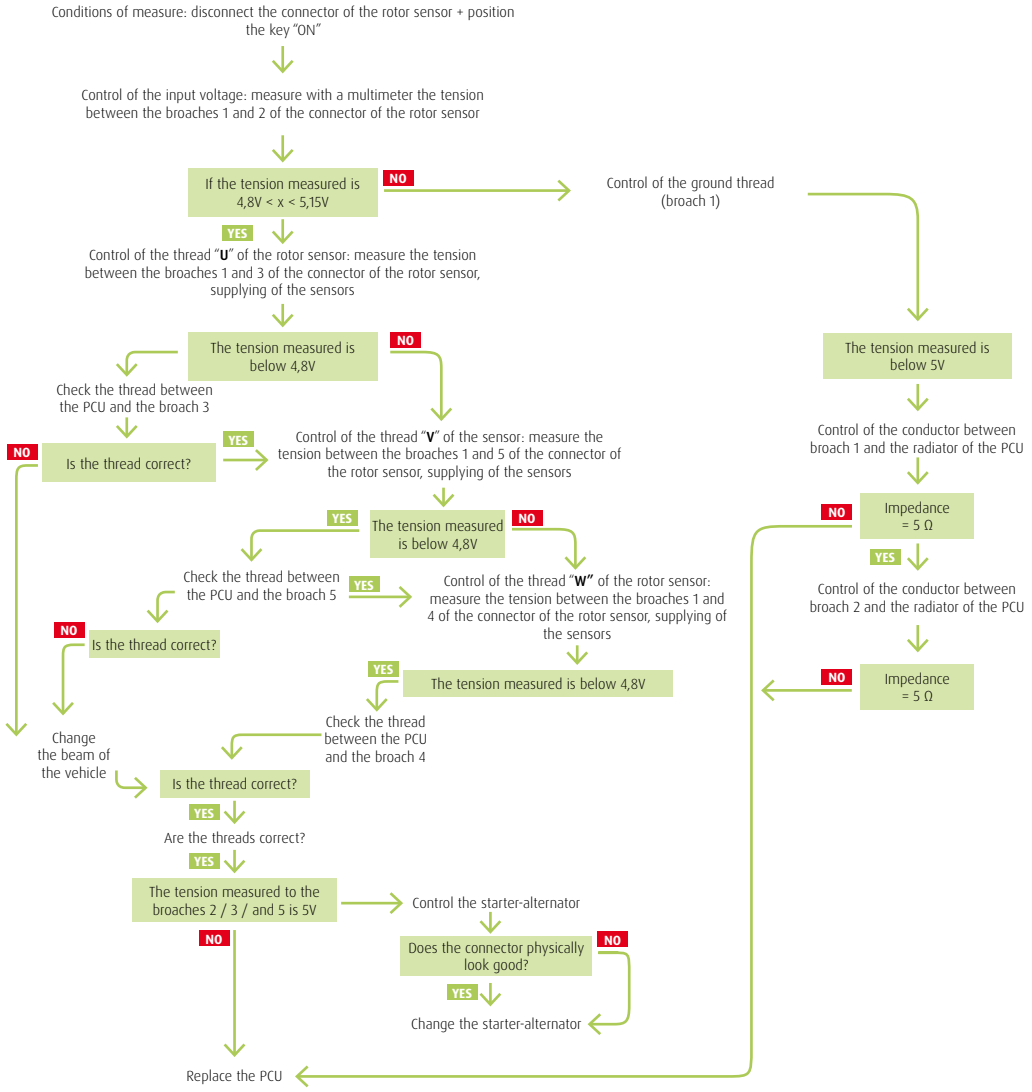
Valeo recommends using a milliohmmeter for the measurement

Checking rotor sensor:

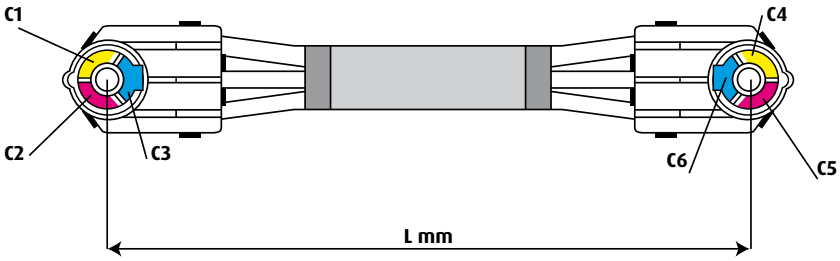
- **Control of the insulation of the rotor in relation to the ground:**

This sensor measures the rotation of the rotor. The position of this electrical sensor determines to which MOSfet the information is sent. A sensor defect can be caused by a connection, installation, PCU or starter alternator problem.

To locate a rotor sensor defect, Valeo recommends the following method:



3.1.2. Checking power cable



Remove the power cable and, using a multimeter, do the checks below.
To comply, the power cable must meet the following technical specifications:

a. Check electrical continuity between points **C1-C4** **C2-C5** **C3-C6**

b. The resistance of each cable must correspond to the values below:

VS P/N s	CTR	L = mm	R = mΩ
595421	Smart lhd	2260	2,9825
595423	Smart rhd	2670	3,5235
595420	Citroën	844	1,1138

lhd: left hand drive, rhd: right hand drive

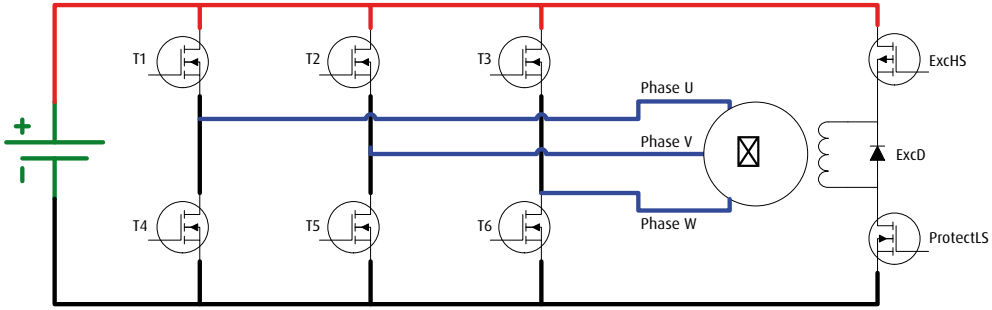
Then reattach the cable to the starter alternator and to the PCU with 2 nuts; recommended torque: **17 Nm ± 15 % (2,5 Nm).**

3.1.3. Checking converter

a. Test

The ideal method to test a MOSfet is to make this transistor conduct by applying a voltage between the gate and the source and by measuring the impedance of the channel. This operation is however not easy to do and we will therefore use a multimeter to test the PCU.
Set the multimeter selector to diode function:

Converter diagram:



If there is an open circuit, the multimeter will display symbol OL. When a diode is tested, the value displayed depends on the temperature.

The table below gives an indication of the minimum and maximum values.
If the measured value is outside tolerances, this means that there is probably a defect on the tested component.
Caution: correctly position multimeter polarity to measure the voltage of the diode.

Component	Average measurement	Minimum measurement	Maximum measurement
Freewheeling diode	0,40V	0,25V	0,52V
MOSfet diode bridge	0,49V	0,3V	0,65V
MOSfet upper stage excitation	0,54V	0,35V	0,70V
MOSfet protection	0,54V	0,35V	0,70V

Test the upper and lower stages, one after each other.

• **Testing MOSfet upper stage**

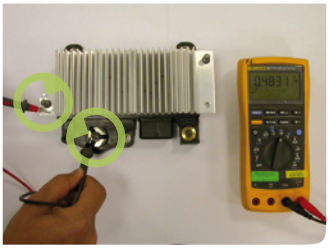
Test of T1: The image shows how to test T1. The PCU must not be supplied by a current source during the test. The voltage read on the multimeter must be between the values given in the table. The values measured must not differ by more than 0.1 volt.
The power measurements of all the MOSfet diodes must not differ by more than 0.1 volt.

Testing T2 and T3: Transistors T2 and T3 are tested according to the same method as T1, by correctly positioning the multimeter probes.

• **Testing MOSfet lower stage**

Testing T4, T5 and T6: Transistors T4, T5 and T6 are tested with the same method as the others by correctly positioning the multimeter probes.

T4



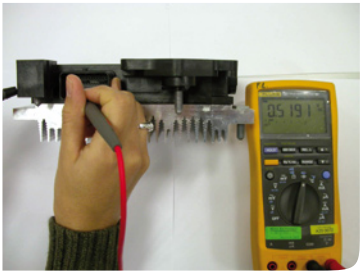
T5

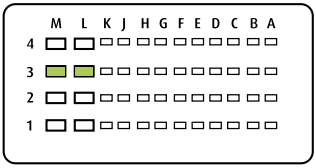
T6

b. Checking excitation:

• Testing MOSfet upper stage

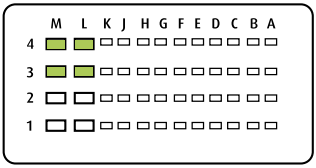
The «MOSfet upper» stage is tested between output B+ and connector pins L3, M3 which are excitation «+» broaches.





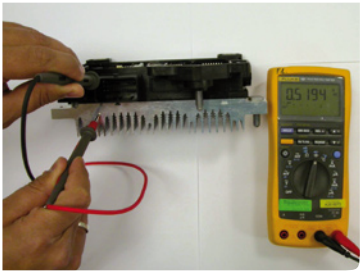
• Testing freewheeling diode

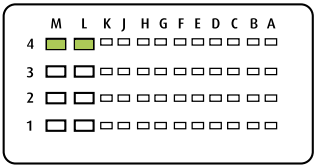
The freewheeling diode is tested between connector pins L3, M3 which are respectively the excitation «+» terminals and L4, M4 which are the excitation «-» broaches.



• Testing MOSfet protection

MOSfet protection is tested between the ground and connector pins L4, M4 which are the excitation «-» broaches.





c. Replacing converter:

The converter can only be replaced by a product with same or higher software version. Some products are today only available in the manufacturer's network. Indeed, certain converters incorporate data related to the general environment of the vehicle (type of engine, antipollution, etc.) the availability of which is related to a manufacturer's agreement.

All the vehicle's systems, such as BSI, COMBI, SRS, ESP, etc. communicate with each other thanks to the LIN and/or CAN network and this is why:

ANY REPLACEMENT OF THE CONVERTER WILL REQUIRE A COMPLETE RESYNCHRONISATION using an appropriate diagnosis station.

4. ENVIRONMENT OUTSIDE StARS VALEO COMPONENTS

The components below do not belong to the Stop and Start system but can send a fault code to the system.

4 .1. Battery

Battery characteristics recommended by manufacturer:

Vehicle	Capacity	Starting power	Remarks
Citroen C2 & C3	55 Ah	650 A	Main battery
Citroen C2 & C3	5 Ah		Additional battery (motorbike type)
Smart Fortwo MKII	60 Ah	680 A	Main battery

C3 Stop and Start specific features:
An additional battery is placed under the driver's seat. In the Stop phase, the two batteries supply the onboard network. During start and restart phases, the additional battery alone supplies the following components: car radio, multifunction screen, air conditioning panel and combined front panel. This configuration avoids voltage fluctuations and car radio reset.
The smart fortwo mhd does not have an additional battery.

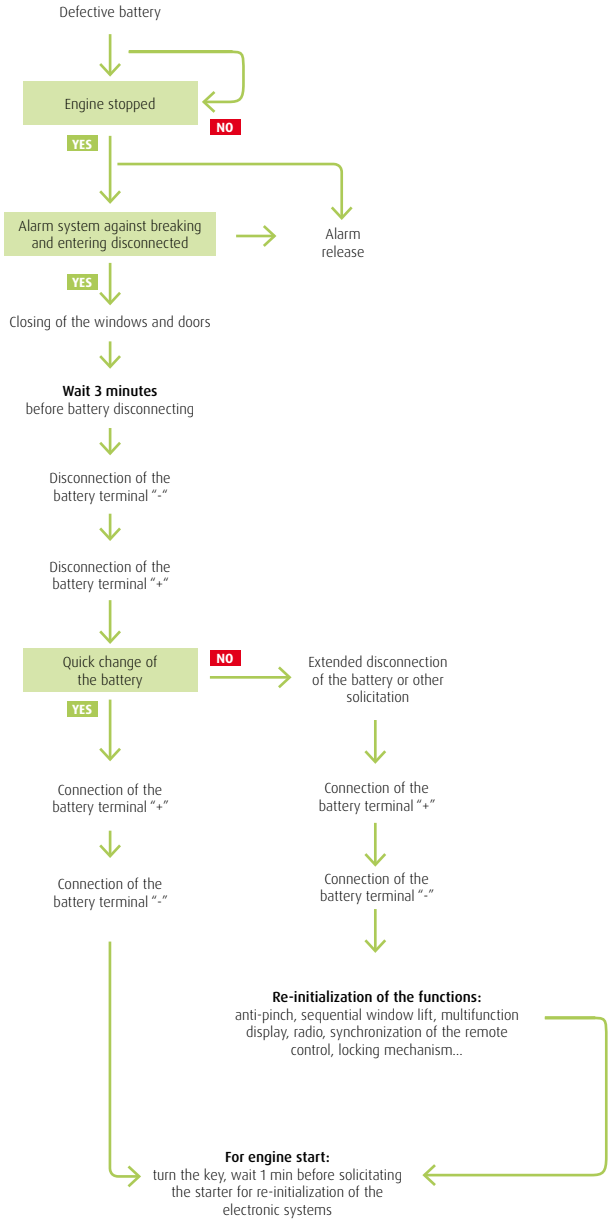
Battery probe:
This probe communicates with the converter via the LIN network for the Smart Fortwo MKII (1/2007>) and the Citroen C3 Facelift (11/2005>) or the CAN network for a hardwire link for Citroen C2 (9/2003>) & C3 (4/2002>10/2005).
This probe gives information on the battery: voltage, current and internal temperature of the battery.

The converter includes a Battery Management System (BMS); the BMS uses this data to calculate the charge of the battery and give the stop enable command.

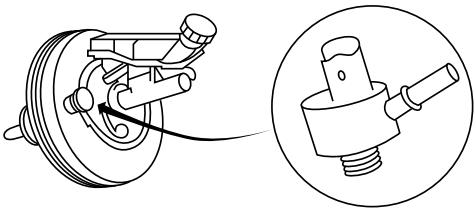
Battery replacement method:
To check that the battery is in good operating condition, perform the following tests:

- battery voltage check using a voltmeter
- acidity test if the elements of the battery are accessible (according to normal method)
- measurement of battery internal resistance

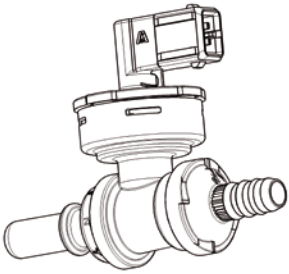
The method for replacing a common battery and an additional battery is the same.



4.2. Braking pressure sensor



Citroën C2, C3, C3 facelift

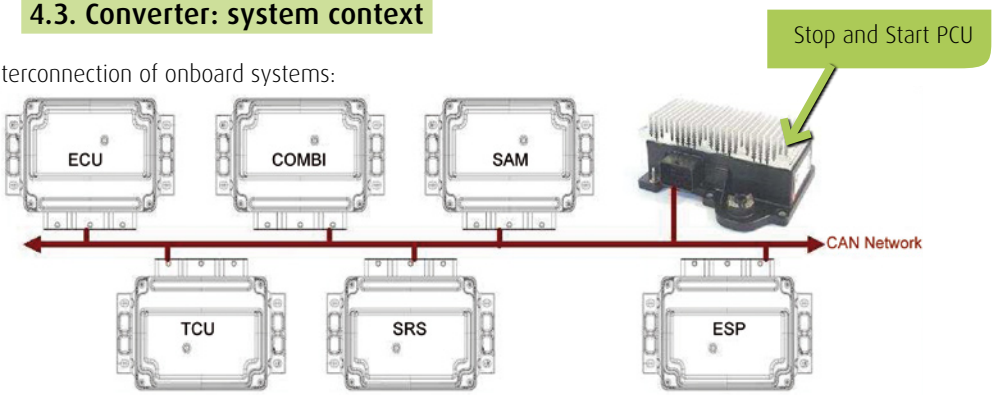


smart fortwo mhd

The sensor continually checks the pressure in the braking amplifier (Mastervac or Servofrein). If this pressure is not high enough to ensure braking assistance, the engine stop enable command is not sent. If the engine is already stopped, the converter automatically restarts the engine.

4.3. Converter: system context

Interconnection of onboard systems:



The ECU (BSI) is in charge of managing the engine
The ECU sends the following information to the PCU: engine status, engine requirement (stop enable), position of accelerator pedal, first start of order and engine temperature. The Stop and Start PCU sends the order to stop the engine to the ECU.

The TCU is in charge of managing the gearbox and the clutch
The TCU sends the following information to the Stop and Start PCU: start enable, gearshift status and clutch status.

The supplemental restraint system (SRS) is in charge of the airbag
The SRS indicates the occurrence of an accident to the Stop and Start PCU.

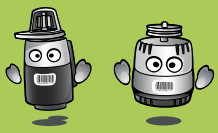
The ESP® is in charge of managing the braking system
The ESP® sends to the Stop and Start PCU the signal from the brake pedal and the speed of the vehicle.

- **Only for the smart fortwo mhd:**
  The electronic instrumentation management unit (COMBI) is in charge of the driving information

The COMBI sends the following information to the Stop and Start PCU: the speed of the vehicle and the voltage of the battery whereas the Stop and Start PCU sends the signals for the ECO indicator lights to the COMBI.

The SAM control module manages data acquisition
The SAM is in charge of managing signals and actuators.
The COMBI sends the following information to the PCU:
signal (KL15) = Key On
signal (KL50) = startup
rear door closed signal.

REMINDER:
All these systems communicate with each other via a LIN and/or CAN network; any change to the PCU will require complete RESYNCHRONISATION using an appropriate diagnosis station



CONCLUSION

When we know that under urban driving conditions, a vehicle is stopped almost 35% of the time and its engine is unnecessarily running at idle, the use of the Stop and Start function becomes obvious. It momentarily stops the engine, while waiting at a red light for example, and starts it again when power is requested. The StARS starter alternator performs this function in a fully automatic manner and substantially reduces consumption by up to 28% in heavy urban traffic.
The StARS startup alternator combines the functions of the alternator and the starter. In starter mode, start is instantaneous and silent thanks to the belt which permanently connects it to the crankshaft. The alternator mode benefits from a new technology improving the electrical efficiency. These two major advantages make the starter alternator the ideal product, providing real gains in terms of consumption and comfort by eliminating both the noise and the vibrations of the engine in stop and start phase.
Thanks to the ingenuity of the StARS starter alternator Valeo won the 2004 Engineer of the Year and the Pace Award in 2006, the EPOS/SIA Jury Grand Prix, distinctions which confirm the interest that the manufacturers show in this device as it contributes towards reducing polluting emissions: a reduction in CO_2 emissions of up to 28% in heavy urban traffic.
The StARS innovation falls perfectly into Valeo's environmental policy: investing in the design of products respecting the environment.

When I stop, I stop polluting!
Thanks to the Valeo microhybrid system

green by nature

A635458A

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