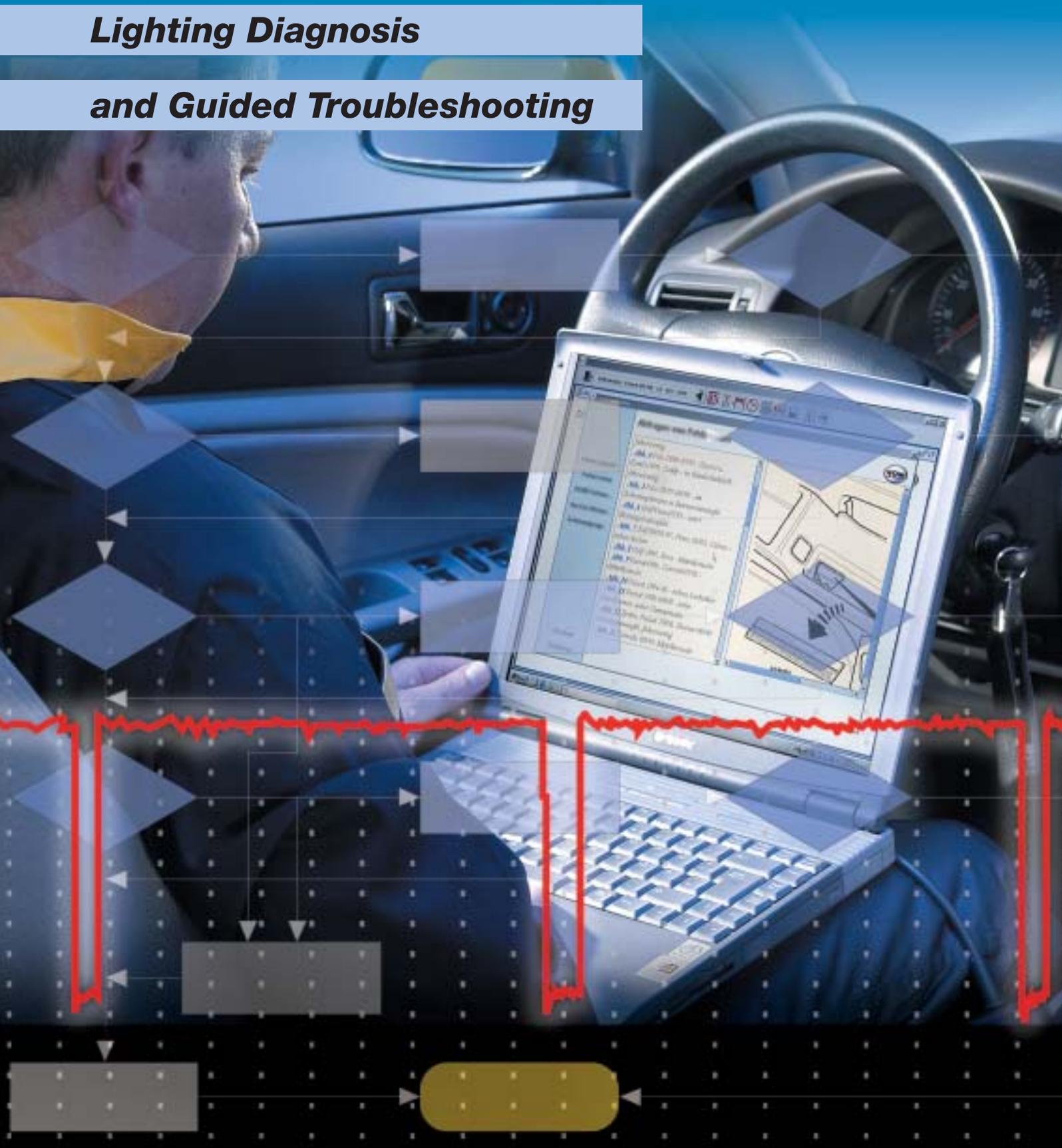


Lighting Diagnosis

and Guided Troubleshooting



*Ideas today for
the cars of tomorrow*

Lighting technology and diagnosis

Vision is the most important sense for people who wish to drive safely. However, this sense may be severely impaired in twilight and bad weather or if the window panes are dirty. This impairment means an increased risk of accidents but the increasing traffic density also increases the risk potential on the road. New lighting technology is continually being developed and existing technology improved to bring drivers home safely despite all hazards and to face the challenges of traffic.

However, these developments make vehicle lighting systems even more complex. For example, it was long ago that the alternator only provided power for the lighting: more and more units are added that communicate via a vehicle electric system. The light is becoming ever more electronic and complex. And this development means higher demands on the garage.

The learning of new technologies and facts and the technical equipment of the garage are decisive factors. The times will soon end when a test light and an analogue voltmeter were sufficient as the standard equipment of a toolbox. More sophisticated equipment is required to diagnose and service the lighting systems of modern vehicles. In addition to the beamsetter, the digital multimeter, the oscilloscope and the diagnostic tester are the motor vehicle expert's most important "aide-de-camp".

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This booklet explains the most basic error diagnosis steps. The contents range from the first error analysis steps to correct beam adjustment. Additionally, the possibility that a diagnostic tester offers in this context are looked at in detail.

Please note that this booklet cannot deal comprehensively with the matter due to the complexity of the different systems on the market.

Firstly, here are some notes on the measuring procedure.

Avoid piercing the cables whenever possible! Water may enter the cable through the holes made (depending on the place of installation) and cause corrosion in the cable sheathing. This kind of fault is hard to find.

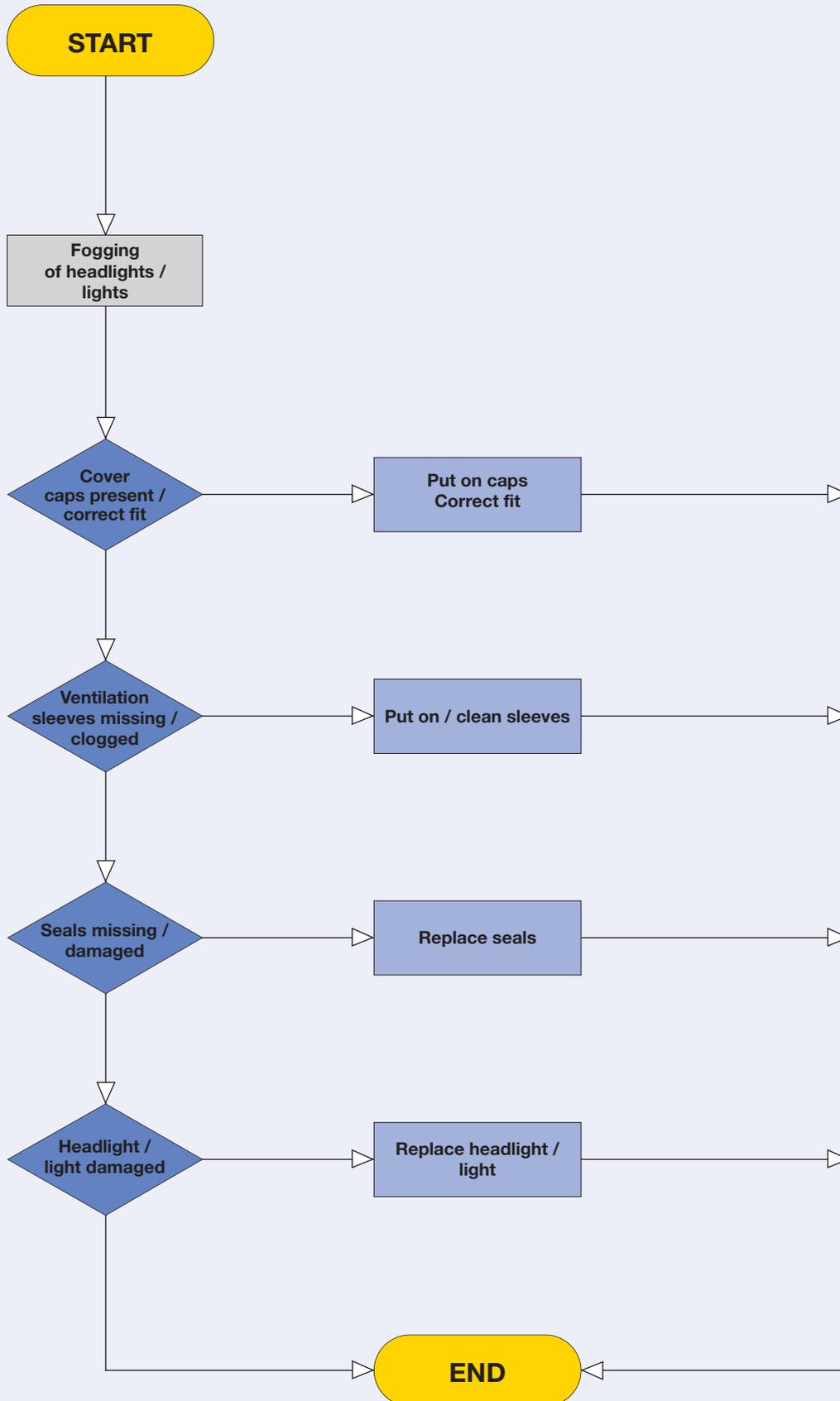


Some vehicle manufacturers offer a selection of so-called Y-adapters. However, the large variety of connection plugs makes it almost impossible for the garage to have all Y-adapters in stock. Therefore, a rather simple and also practical approach is access from the rear of the plug connections. Measurements can be taken without damage by using probe tips (flexible if possible).



For the results of the measurements to be as required, vehicle-specific information such as wiring diagrams or set values are indispensable. However, in vehicles with lighting systems that can be diagnosed it is possible in most cases to test the various lighting functions with a diagnostic tester.

Part 1 – Guided troubleshooting in case of excessive fogging



* In the case of complaints, all the fault sources listed should be checked.

Fogging in lighting systems

A frequent problem is fogged cover lenses of clear-glass headlights. The effect occurs after driving in rain or after a cold night and is a normal physical process. The headlight ventilation presses the expanding warm air out of the switched-on headlight. When the headlight is switched off, it cools down slowly and the outside air saturated with humidity is sucked into the headlight. If the air humidity is high and temperature differences are large, then this may cause water condensation on the inside of the cover lens. This process is called fogging.

If the cover lens is fogged, the light aperture should dry within a certain period of time when the headlight is operated. However, this time may vary depending on the ambient temperature and the relative humidity of air. This fogging effect also occurs in headlights with profiled cover lenses where due to the profiling the fog film is less visible than in clear-glass headlights.

However, if the fogging is so severe that water drops form on the cover lens (**see Fig. 1**) or water even accumulates in the bottom area of the headlight (**see Fig. 2**), then the work steps shown in the fault tree should be carried out. Likewise, possible clogging of the ventilation openings in the headlight (**see Fig. 3**) should be checked. To dry the headlight, it may be blown through with oil-free compressed air. The facts described also apply to lights.



Fig. 1



Fig. 2

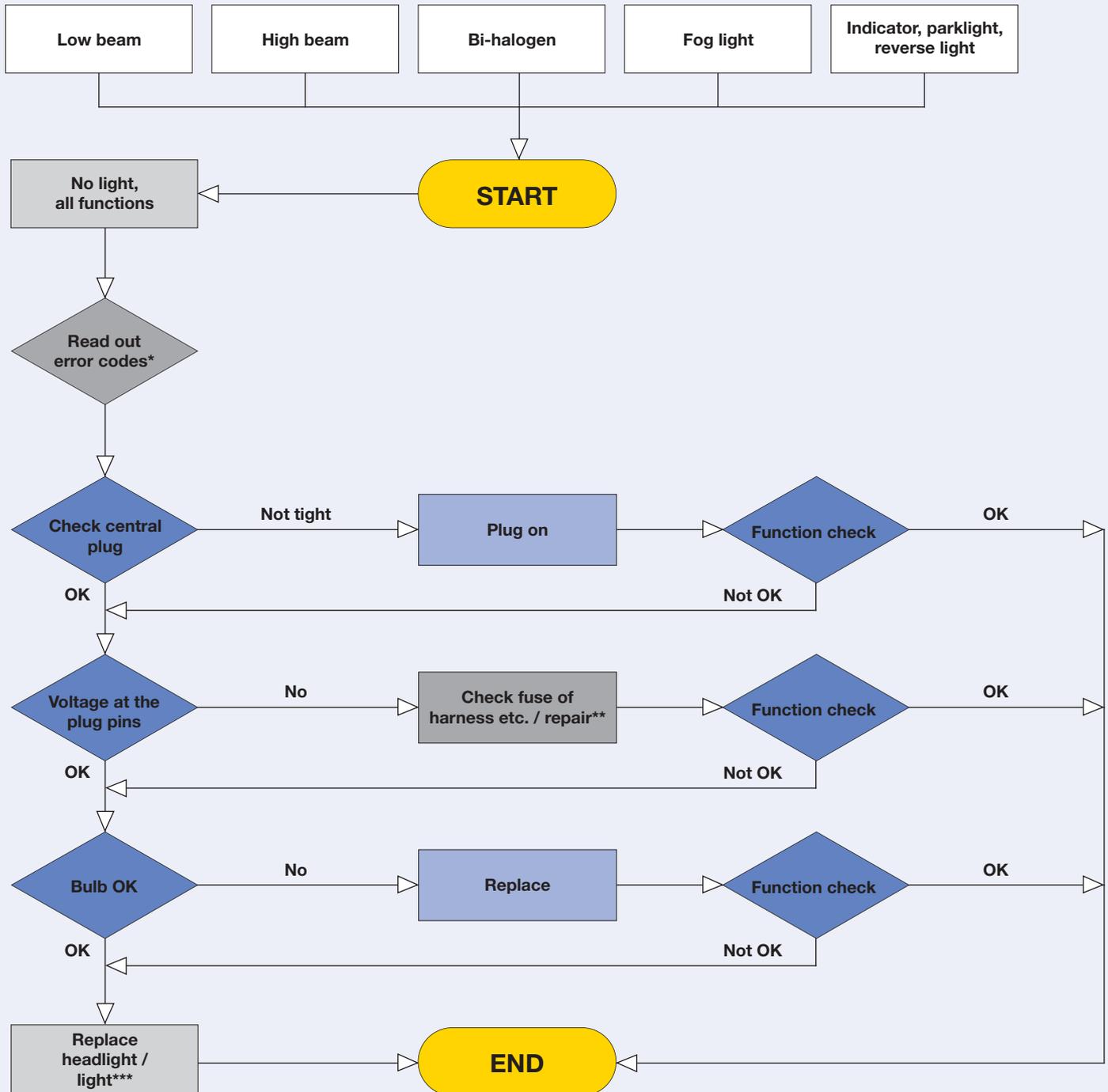


Fig. 3

Part 2 – Guided troubleshooting in exterior lighting systems

In the past, the designs of headlights and lights, as well as their electrical control, have been rather simple. The equipment of vehicles with electronic components has also affected the lighting systems. Meanwhile, several manufacturers use control units to control and monitor the lighting functions.

The fundamental diagnostic steps are as follows:



* In vehicles with lighting systems that can be diagnosed. The error memory is to be erased after successful repair.

** This also includes components such as light switches, vehicle electric system control units etc.

*** In some cases, the failure cause may be in the wiring/contacting inside the headlight / light. If so, then in most cases the respective component needs to be replaced completely.

Exterior lighting systems

We will explain the control of the exterior lighting functions by the vehicle electric system control unit in a VW Touran. The signals coming from the light switch are evaluated directly by the vehicle electric system control unit. The steering column electronics control unit sends other light signals such as indicator, high beam and headlight flasher to the vehicle electric system control unit via the "comfort" CAN data bus (**see Fig. 1**).

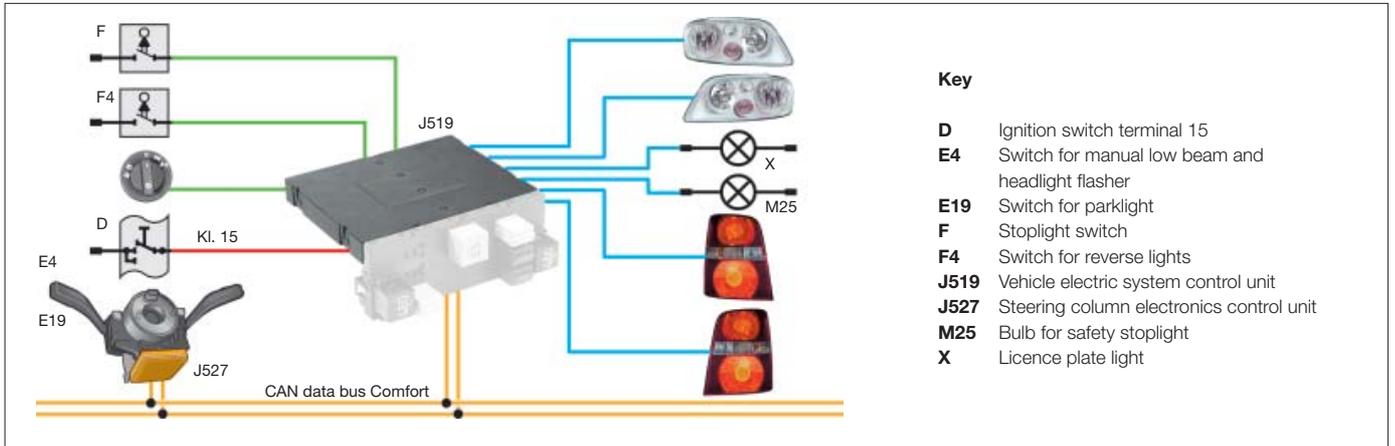


Fig. 1: Function diagram

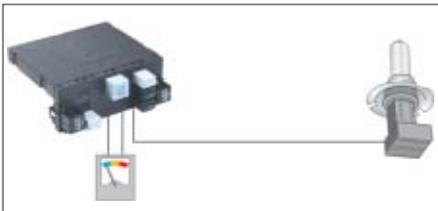


Fig. 2: Cold check

The vehicle electric system control unit is also responsible for bulb monitoring (failure check). This monitor is active in switched-off condition (**cold check**) and in switched-on condition (**hot check**).

Cold check

When the ignition is switched on, a small current is applied to the individual bulbs four times for periods of 500 ms. The vehicle electric system control unit can detect a defective bulb based on the current value (**see Fig. 2**).

Hot check

The individual bulbs are controlled by semiconductor components located in the vehicle electric system control unit that detect overload, short-circuit or interruption (**see Fig. 3**).

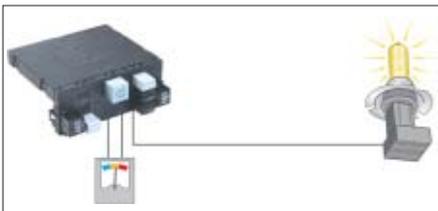


Fig. 3: Hot check

If an error is detected in both checks, then an error is entered into the error memory and the driver is informed by means of a control lamp in the cockpit. Once the bulb is replaced, the error is deleted and the control lamp goes out.

When taking measurements, the fact that some lighting functions are controlled by pulse width modulation must be taken into account. One of the advantages of this technology is that the bulbs can be operated with their optimal rated voltage despite high and fluctuating on-board voltage. This increases bulb service life.



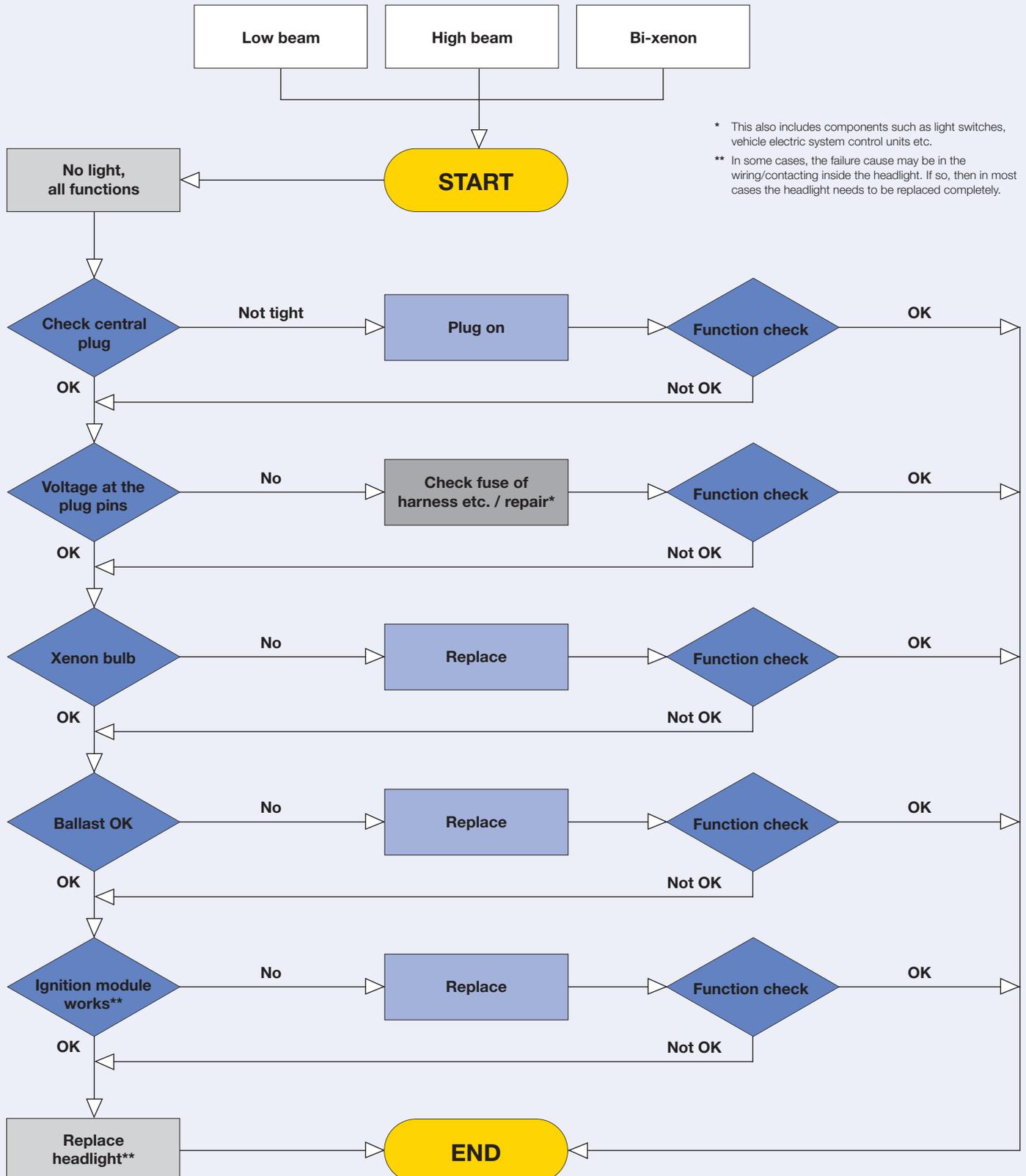
► For more information about this technology, see the Hella booklet "Pulse width modulation in vehicle lighting systems".

An increasing number of vehicles allows direct control of the individual lighting functions by means of a diagnostic tester via the "actuator test" menu. In this way, the mechanic can activate a lighting function and at the same time read the result of the measurement. This is helpful when measuring inrush currents or searching for voltage peaks.

Part 3 – Guided troubleshooting of xenon headlights

Xenon headlights have been on the market for more than 15 years now. At first, this type of headlight was reserved for luxury-class vehicles but nowadays xenon systems can be found in almost all vehicle classes. Due to ongoing developments, there are several generations of xenon systems installed in motor vehicles.

The fundamental diagnostic steps are the following:



Xenon lighting

3rd and 4th generation xenon systems are the most common Hella systems on the market and will therefore be looked at here.

In 3rd generation xenon systems (**see Fig. 1**), ballast and ignition modules are integrated in one housing. The high tension for igniting the xenon bulb is routed to the bulb plug through a special cable.



Fig. 1

In 4th generation xenon systems (**see Fig. 2**), ballast and ignition modules are separated. Additionally, there are differences with regard to the xenon bulbs of this generation. While in the D2 bulb the ignition module can be detached (**see Fig. 2, top right**), ignition module and bulb form an inseparable unit in the D1 bulb (**see Fig. 2, top left**) and cannot be separated from each other.

► For more information on xenon lighting, see the Hella booklet "Lighting technology basic knowledge".



Fig. 2

The fault tree shown should be followed for error diagnosis. However, here are some helpful notes on diagnosis:

1. Both ballasts (for 12 V) work in a voltage range of between 9 and 16.5 V.
2. Diagnosis may, as a rule, be based on the "cross-exchange principle". The fault cause is determined by exchanging the individual components between the headlights. An example for the xenon bulb: if the fault travels with the bulb, then the bulb needs to be replaced. If the fault remains in the headlight, then the fault may be caused by the ballast, the ignition module or the vehicle.

However, dismantling and reinstallation of components is often rather laborious and time-consuming. D2 bulbs can also be tested using a simple "test setup" (**see Fig. 3**). The setup includes a 3rd generation ballast (e.g. from a car involved in an accident), a battery or transformer and plugs for the ballast (**see Fig. 4**). This allows you to quickly check the function of the xenon bulb.

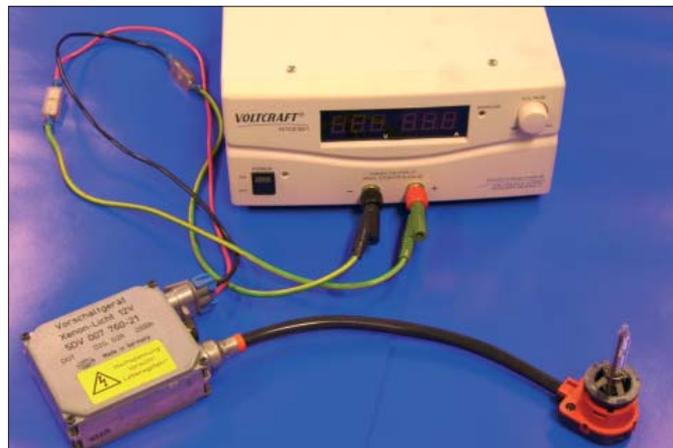


Fig. 3



Fig. 4

3. If the xenon bulb is all right and the supply voltage is applied to the headlight, then you should check the wiring from the central plug to the ballast. Since in most cases the ballast is installed underneath the headlight (sometimes in the headlight), dismantling is necessary.

Diagnosis will be explained exemplarily for the Vectra C (with Hella Xenon AFS headlight):

Dismantle the ballast or unplug the contact plug. Check continuity from the headlight central plug to the plug connection of the ballast (see Fig. 5).



Fig. 5

Fig. 6 shows the pin assignment of the headlight male connector. Only the pins shown are relevant to the check.

Fig. 7 shows the pin assignment of the female connector of the ballast.

If no fault is found there, continuity may be checked from the female connector of the ballast to the plug of the ignition module. **Fig. 8** shows the pin assignment of the female connector at the ignition module.

Due to the high voltage, no measurements must be taken inside the headlight when the headlight is switched on.

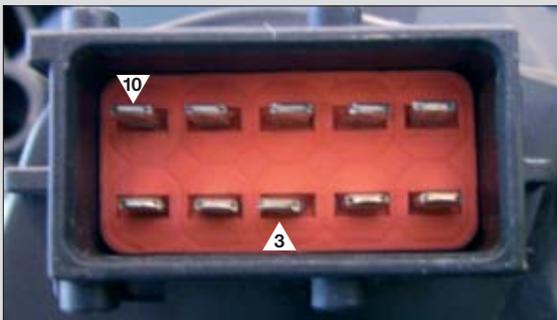


Fig. 6

3 = Supply voltage, low beam
10 = Earth

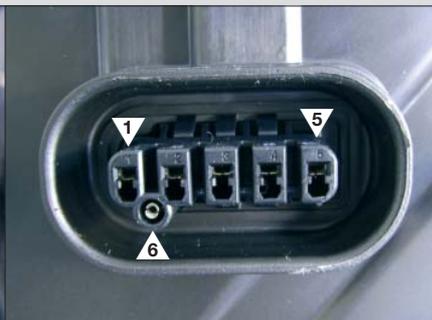


Fig. 7

1 = Supply voltage, low beam
2 = Earth
3 = Supply voltage, igniter
4 = Earth from igniter
5 = Igniter, high-voltage pulse
6 = Shielding (xenon bulb)

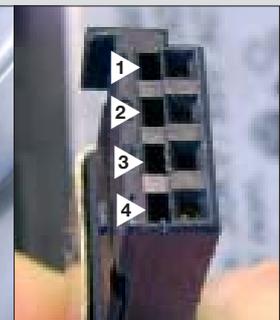
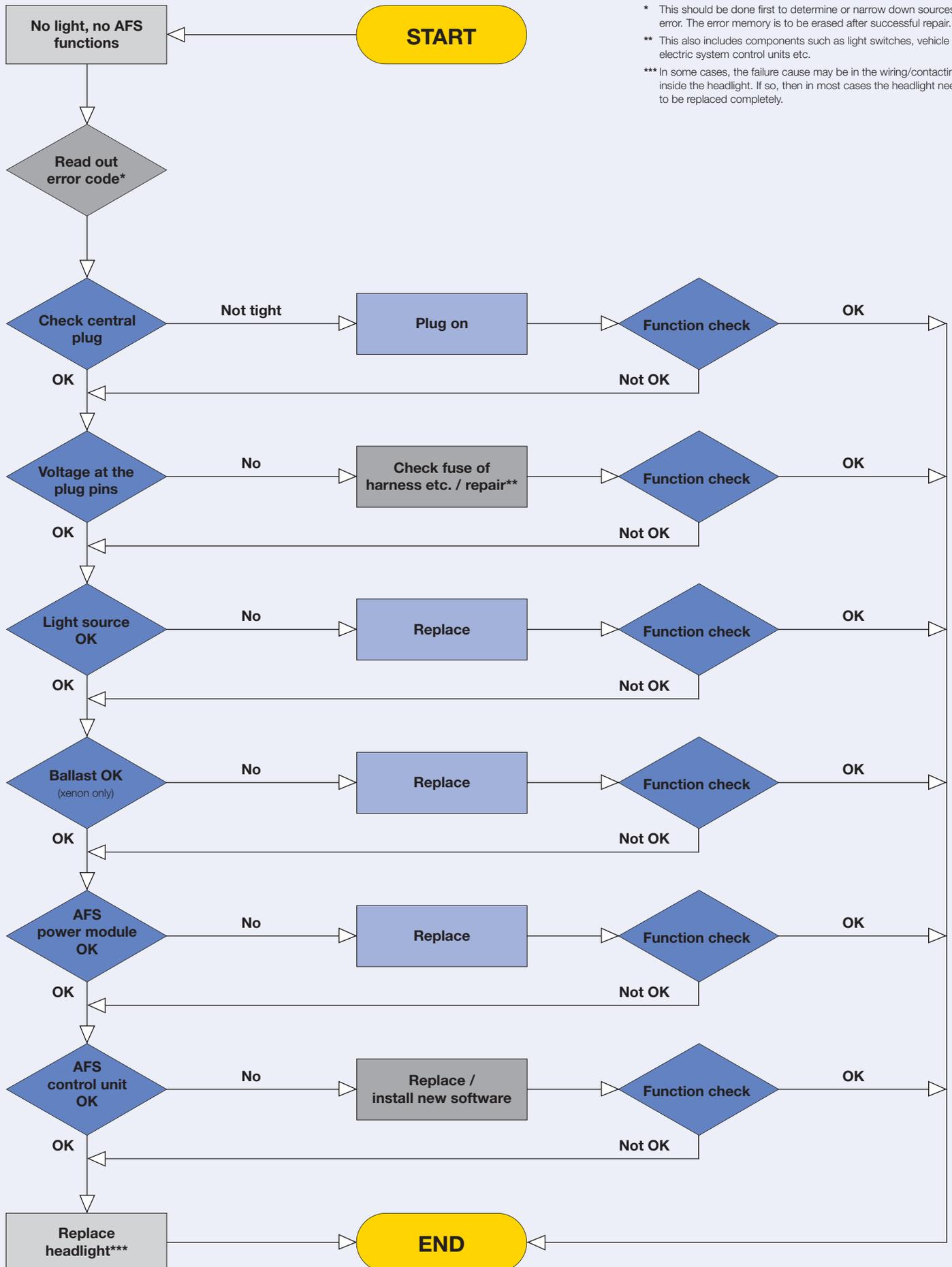


Fig. 8

1 = Igniter, high-voltage pulse
2 = Earth of igniter
3 = Not used
4 = Supply voltage, igniter

Part 4 – Guided troubleshooting in AFS systems



* This should be done first to determine or narrow down sources of error. The error memory is to be erased after successful repair.

** This also includes components such as light switches, vehicle electric system control units etc.

*** In some cases, the failure cause may be in the wiring/contacting inside the headlight. If so, then in most cases the headlight needs to be replaced completely.

Adaptive Frontlighting System (AFS)

AFS systems adapt the headlight beam to the driving situation specifically for the vehicle, e.g. in bends or on the motorway. This means a considerable improvement of safety and driving comfort. On the other hand, the number of components and thus the number of possible sources of errors are increased in such systems.

Today, these AFS systems are fully diagnosable because they include several input variables such as speed, steering angle and spring deflection of the axles that are received by the control unit via the CAN bus and evaluated. In this way, many data relevant to error detection can be indicated on the diagnostic tester.

Diagnostic examples

The AFS lighting system of the Opel Vectra C is to be used to provide some diagnostic examples. When a customer has a complaint (e.g. "bends are not illuminated"), then the error code should be read out first. The system shuts down when an error occurs. Then the headlight modules are moved to a centre position and an error code is stored. In the case shown (see Fig. 1), the right power module is detected as the source of the error.

Whether the power module is actually defective can be found out with a "cross-exchange" check as already described in part 3 "Xenon lighting". Should the error persist, a continuity check may be made based on the headlight pin assignment. In this way, a fault in the headlight wiring can be detected.

The communication of the bend lighting control unit with other sensors and control units via the CAN bus may also be disturbed (error code U2108). In this case, the total resistance of the CAN bus system may be checked via the plug connection of the bend lighting control unit (see Fig. 2). The value must be between 50 and 70 Ω (see Fig. 3).

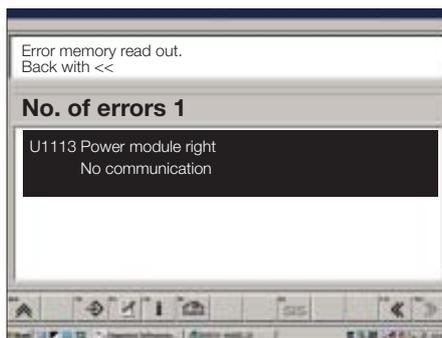


Fig. 1

PIN assignment	
PIN 1	CAN-High
PIN 2	CAN-Low

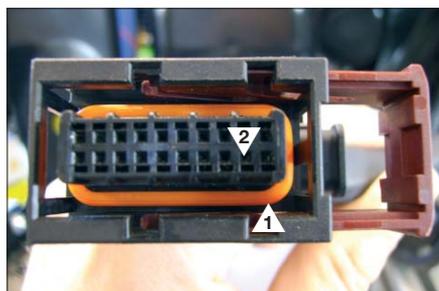


Fig 2: Resistance measurement between PINs 1 and 2.

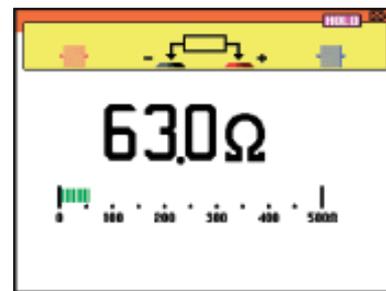


Fig. 3

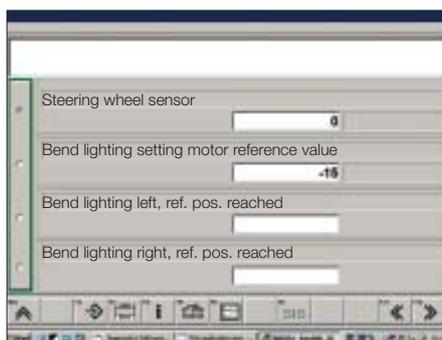


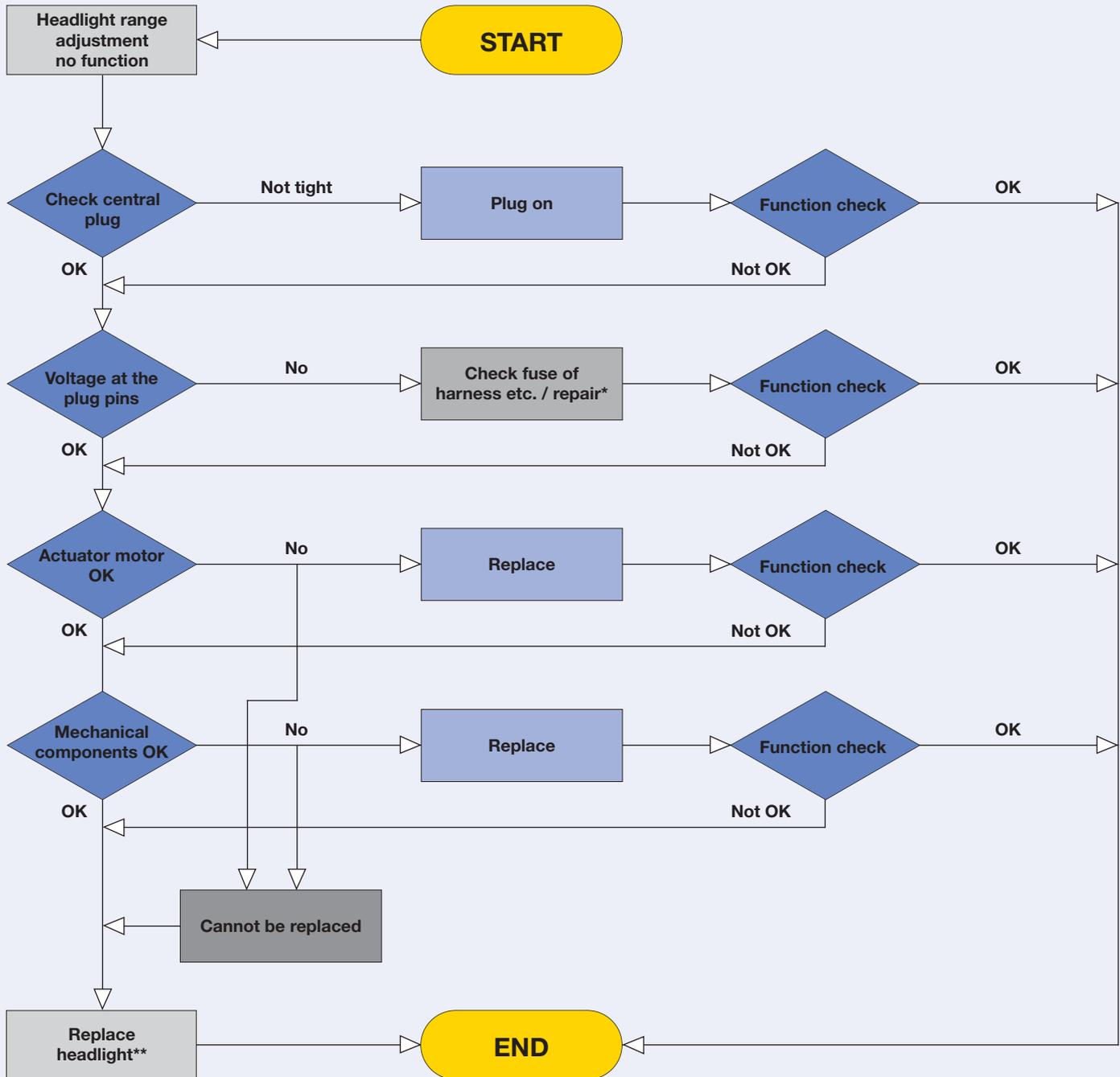
Fig. 4

Another diagnostic method is the actual/set value comparison. Depending on the diagnostic tester, this function is located in menu item "Measured values/parameter" or "Actual values". This diagnostic function indicates the current values of various components. They can then be compared to the set values (not stored in all diagnostic testers). Additionally, the current actuator state can be indicated (see Fig. 4).

Part 5 – Guided troubleshooting of manual headlight range adjustment

The major part of today's vehicles use the so-called headlight range adjustment mentioned above. Usually, geared electric motors that are controlled by an actuator in the passenger compartment are used in the system. .

The fundamental diagnostic steps are as follows:



* This also includes components such as levelling switches, vehicle electric system control units etc.

** In some cases, the failure cause may be in the wiring/contacting inside the headlight. If so, then in most cases the headlight needs to be replaced completely.

Manual headlight range adjustment

Error diagnosis will be explained for the manual headlight range adjustment system of the VW Passat (3B2).

Voltage measurements at the light switch

The headlight range adjustment actuator in the passenger compartment is supplied with power and signals via the light switch. If the actuator does not function when the light is switched on, then check the fuses and the light switch.

If the fuses are all right, then the light switch needs to be dismantled. After that, the vehicle electric system voltage can be measured between pin 2 (supply voltage) and pin 10 (earth) at the light switch plug (see Fig. 1). Now the light switch is turned to send the control voltage (56b) to the headlight range adjustment actuator via pin 4. If that is not the case, then the light switch might be defective.



Fig. 1

Position 0	9.42 V
Position 1	8.20 V
Position 2	6.54 V
Position 3	4.47 V

Voltage measurements at the headlight

At the central plug of the left headlight, the supply voltage is measured between pin 2 (yellow) and pin 10 (brown). It should be between 11.5 V and 14.2 V. The signal voltage is measured between pin 6 (brown/white) and pin 10 (brown). Depending on the position of the actuator (usually 0 – 3), the values shown in the table on the left are indicated.

If signal and supply voltage are present but the actuator motor nevertheless does not function, then the wiring between the headlight central plug and the plug of the actuator motor should be checked for continuity. If the wiring is all right, then the actuator motor of this headlight needs to be replaced. Twist the motor to unlatch it (see Fig. 2). Then detach the connection to the reflector and take the motor out of the headlight housing.

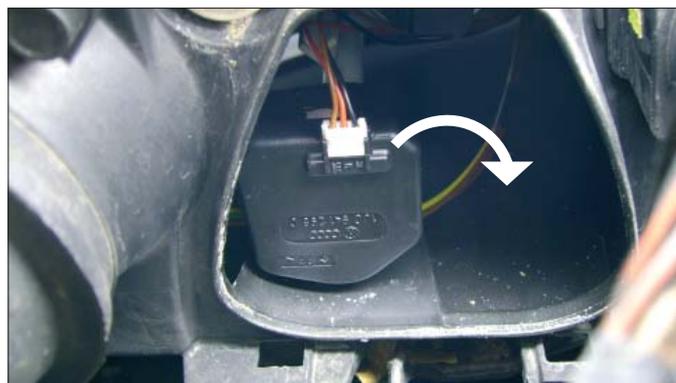
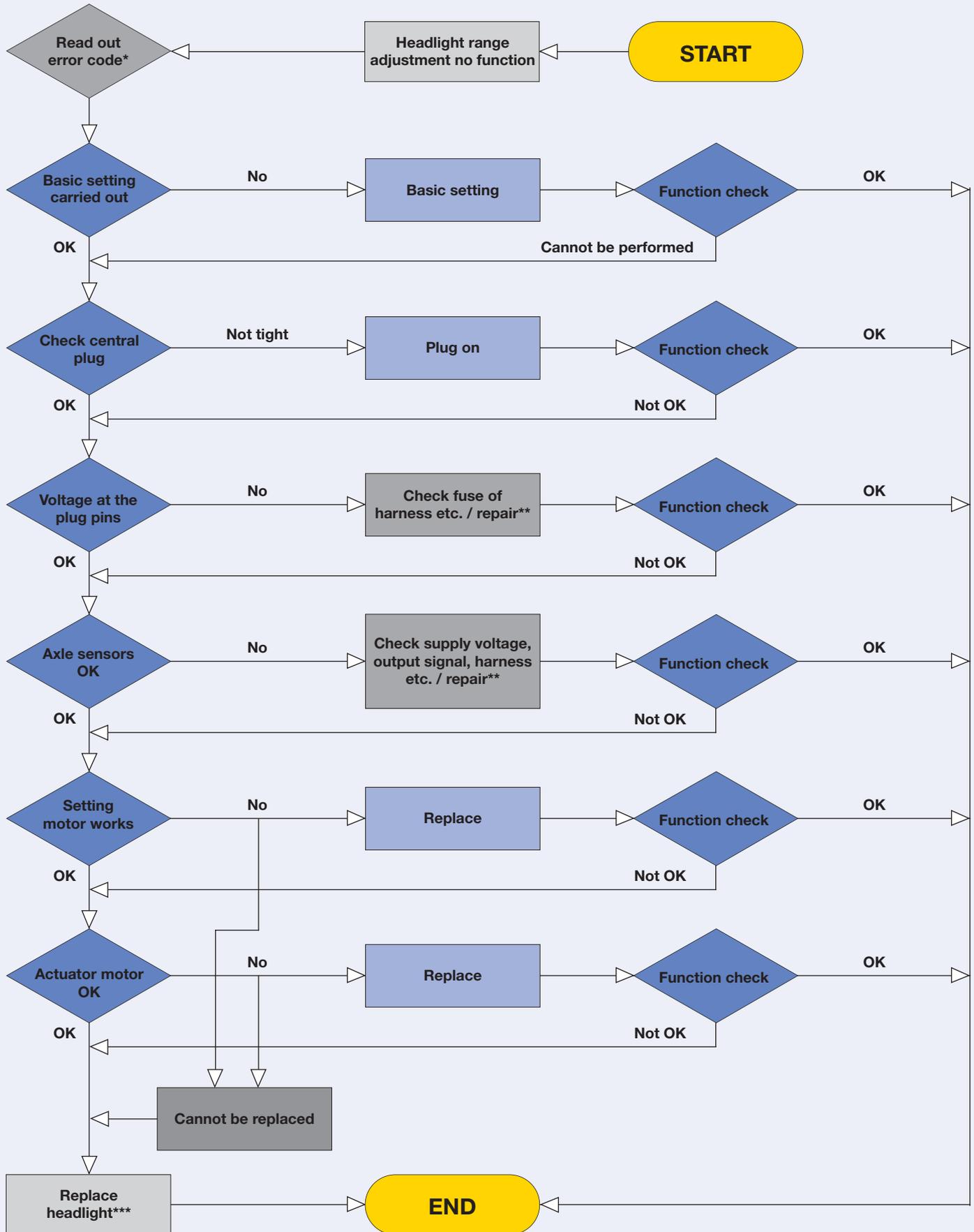


Fig. 2

Part 6 – Guided troubleshooting of automatic headlight range adjustment



* This should be done first to determine or narrow down sources of error. The error memory is to be erased after successful repair.

** This also includes components such as headlight range adjustment control units, vehicle electric system control units etc.

*** In some cases, the failure cause may be in the wiring/contacting inside the headlight. If so, then in most cases the headlight needs to be replaced completely.

Automatic headlight range adjustment

In many countries, legal regulations require an automatic headlight range adjustment to be installed when xenon lighting is installed. The automatic headlight range adjustment automatically adjusts the inclination angle of the headlight to the correct position independent of the vehicle load. Axle sensors (one or two sensors, system-specific) measure the spring deflection and send the spring deflection data to the headlight range adjustment control unit. The headlights are then set to the optimal position by a headlight range adjustment actuator motor for each headlight. However, as mentioned above, different systems exist. ► For more information on the systems, see the Hella booklet "Basic knowledge lighting technology".

Diagnostic examples

In the following, some examples are given of error diagnosis in the automatic headlight range adjustment systems of Opel Vectra C and Omega B. Many headlight range adjustment systems can be diagnosed but not all diagnostic testers can communicate with the headlight range adjustment control unit. In these cases, some diagnostic steps can be taken using a multimeter and an oscilloscope.



Fig. 1

In the Opel Omega B, the voltages can be measured at the plug connections of the axle sensors (see Fig. 1). The supply voltage is 5 V. To test the function of the sensor, the ball joint at the sensor arm needs to be loosened, so that the sensor arm can move freely. If the sensor arm is moved slowly, then the voltage values should be between 0.6 V and 3.7 V for a functioning sensor. If the voltage suddenly drops within this range, then the axle sensor is very likely defective.

Inductive axle sensors are installed in the Opel Vectra C that send pulse width modulated voltage signals to the headlight range adjustment control unit. The PWM signals can be measured with an oscilloscope at the plug connection (see Fig. 2) of the headlight range adjustment control unit (see Fig. 3). The supply voltage for the axle sensors can also be measured at the plug connection.

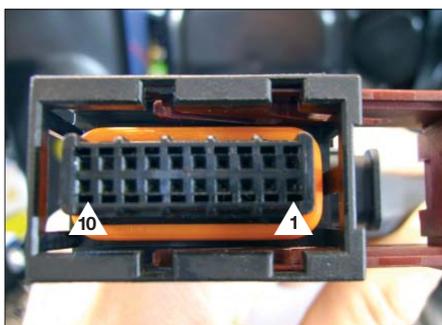


Fig. 2

PIN assignment	
PIN 5	PWM signal axle sensor front
PIN 6	PWM signal axle sensor rear
PIN 7	Earth axle sensor front
PIN 8	5 V supply voltage axle sensor front
PIN 9	5 V supply voltage axle sensor rear
PIN 10	Earth axle sensor rear

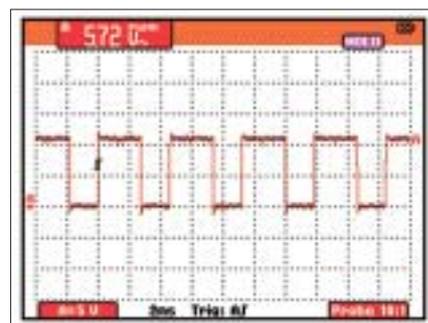


Fig. 3

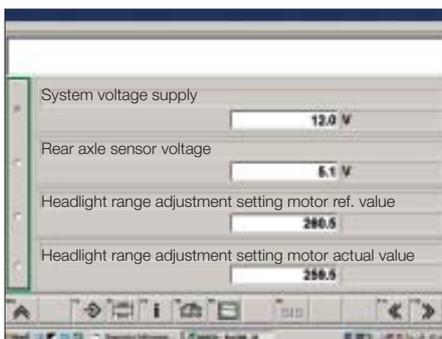


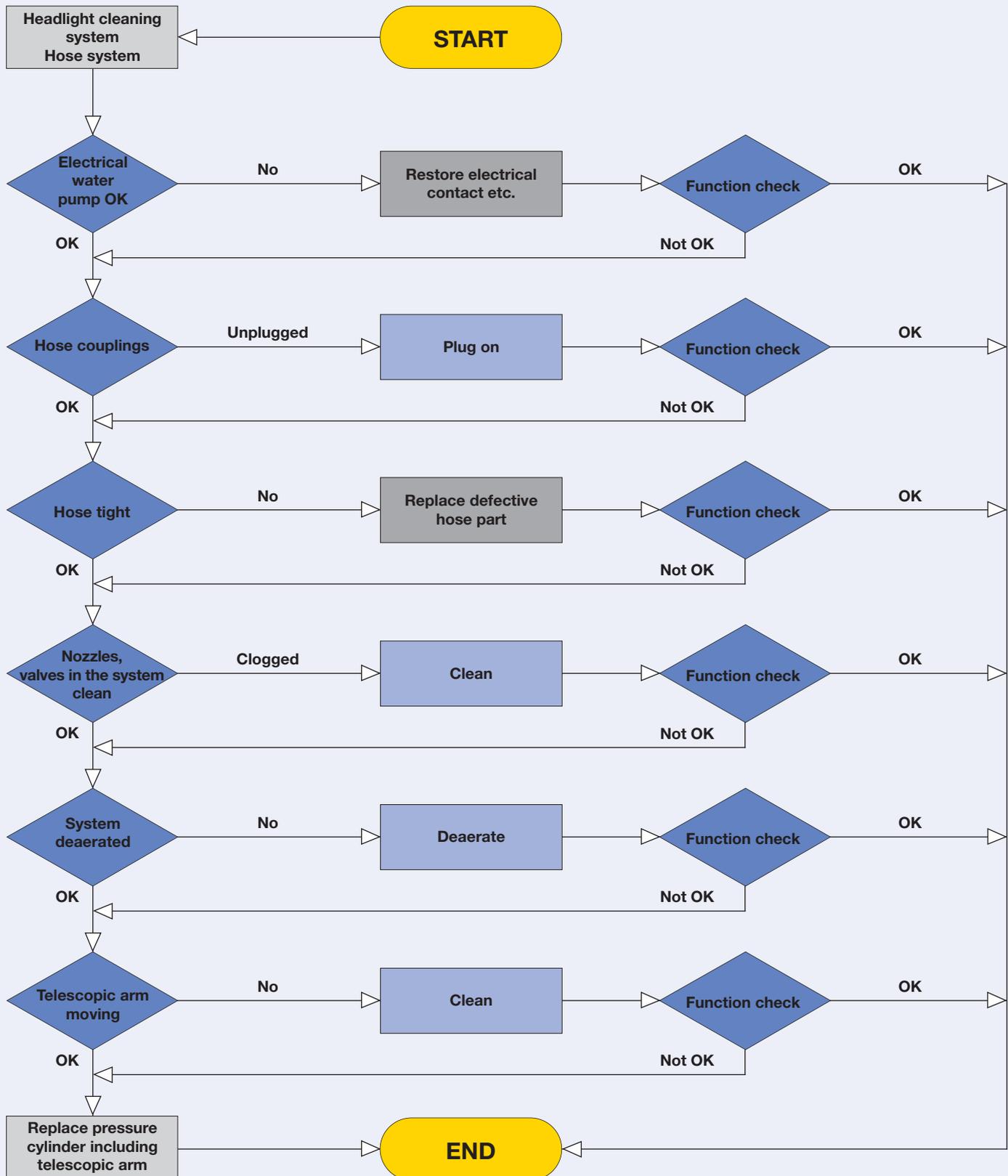
Fig. 4

The control unit should remain connected during the measurements. The measurements should be taken via the rear side of the plug.

The diagnostic tester gives the mechanic a multitude of diagnostic options, from the reading out and erasing of the error codes to the indication of the actual data (see Fig. 4). The normal position of the system may also be adjusted with a diagnostic tester. This is necessary if, for example, an axle sensor is replaced or if the setting position needs to be newly adjusted when the headlight is adjusted. This issue is dealt with in the next section.



Part 7 – Guided troubleshooting in headlight cleaning systems



* In some cases the reason for the failure can be within the pressure cylinder. In these cases the complete pressure cylinder has to be replaced.

Headlight cleaning systems

Light-intensive headlights are more likely to cause dazzling due to dirt. Therefore, the law demands headlight cleaning systems in addition to automatic headlight range adjustment for such powerful headlights. Headlight cleaning systems with telescopic cylinders are common on the market and will be looked at here.

Diagnostic examples

Should the rotary pump not run when the washing function is started (no clearly audible noise), then check the supply voltage and the fuse. If with the pump working the water jet sprays only on one side or is very weak, then check the polarity. This is because rotary pumps run in either direction but with different hydraulic capacities. Also important is correct hose installation because a kinked hose means a substantial reduction of the flow rate.

If a hose is leaky, then the defective portion may be cut out and replaced by a new connection piece (see Fig. 1).



Fig. 1

Sometimes, dirt may get into the system via the washer-fluid tank and clog valves or nozzles. If that has happened, the only remedy is to thoroughly flush out the entire system. The spray nozzles can be taken out of the pressure cylinders. To do this, pull out the telescopic arm against the pressure of the spring, unlock the catch with a small screwdriver (see Fig. 2) and pull the nozzle out of the cylinder towards the front. To obtain an optimal cleaning effect, check the nozzle adjustment and readjust if need be as specified by the manufacturer. There is a special adjusting lever for this that engages into the washer nozzle (see Fig. 3).



Fig. 2

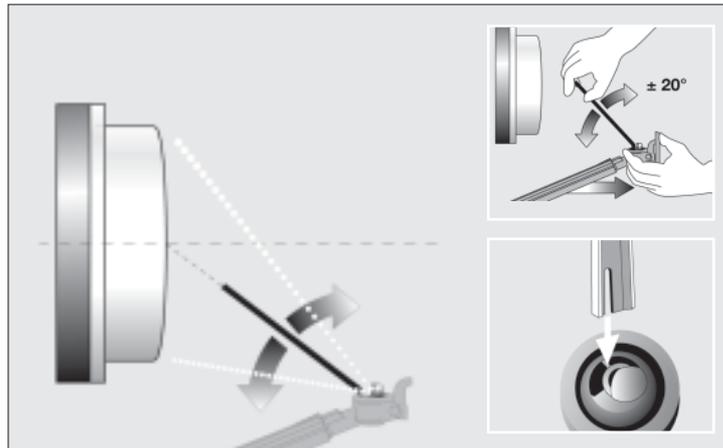


Fig. 3

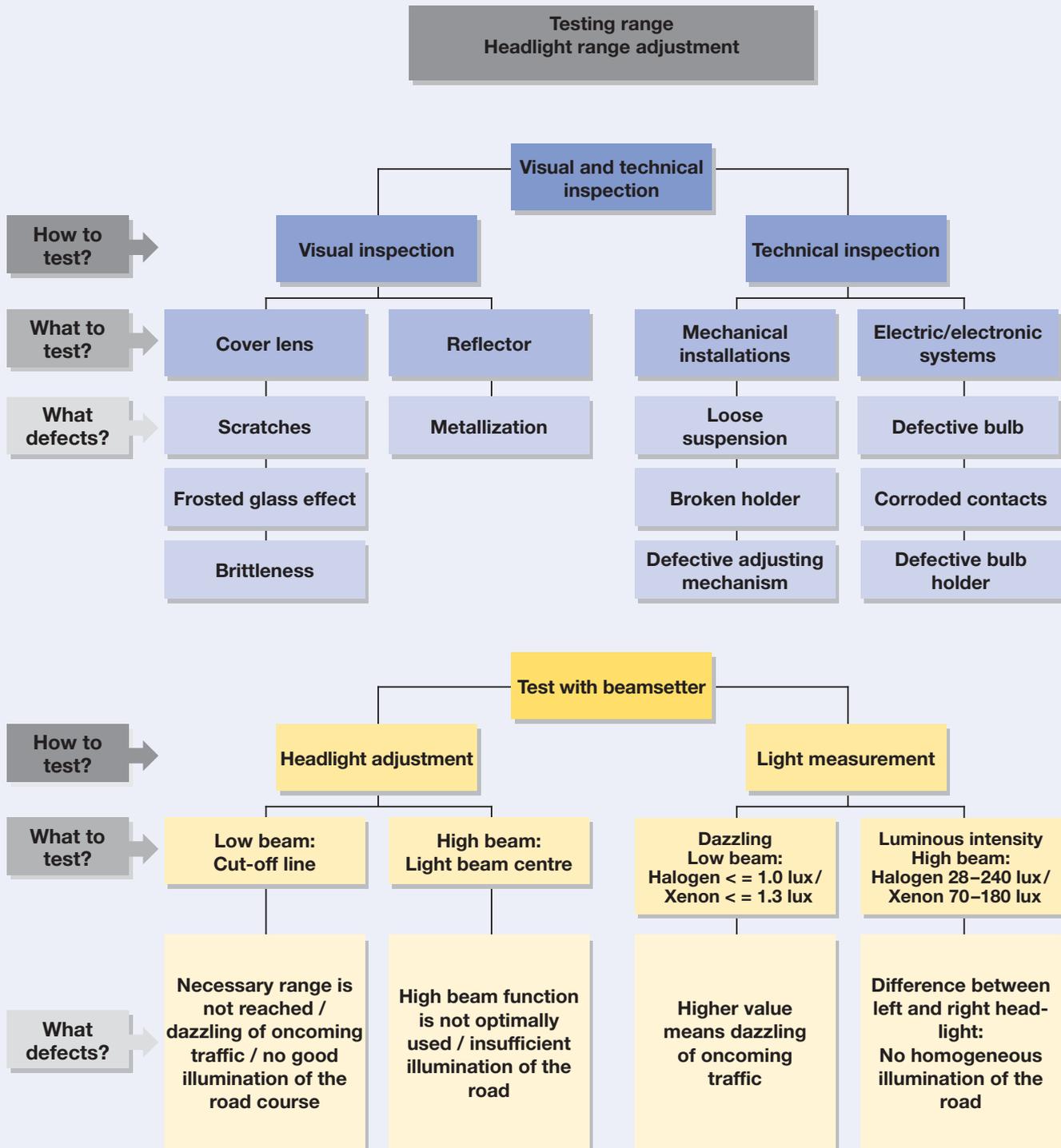
Notes on headlight cleaning systems:

- Some cleaning agents may foam if overdosed as this effect is increased by the whirl chamber nozzles.
- **The foam may stick on the headlight for a long time causing irregular light distribution.**
- The foam may stick on the headlight for a long time causing irregular light distribution.

Part 8 – Guided troubleshooting in the context of headlight adjustment

A correct headlight adjustment is the basic prerequisite to optimal road illumination and early detection of hazards. Therefore, the correct function and adjustment of the headlight should be checked once a year.

The fundamental diagnostic steps are as follows:



Error indications in headlights

Fault characteristics and their effects

As the complexity of the headlight systems increases, the number of possible sources of errors also increases. Some of the conventional errors at or in the headlight shown in the adjacent "Visual and technical inspection" are explained below.

Mechanical problems

If the headlight cannot be adjusted correctly or not at all, then this may be due to one or several of the following reasons:

- Play of the headlight axis and adjusting elements
- Unclipped parts
- Broken-off screwed connections (**see Fig. 1**)
- Adjusting elements jammed due to corrosion
- Bent or broken-off holders for bulb fastening



Fig. 1

These problems may even occur in headlights that have been in the vehicle for just one or two years. In most cases, these headlights are of inferior quality, with the design expenditure or the material used not coming up to the standard of original headlights.

Electrical problems

If there are differences between the brightness of the two headlights (low and high beam) or if a lighting function fails completely, then insufficient material properties may be the reason. If the crimping is insufficient (**see Fig. 2, top plug**), then contact resistance occurs and the light output is reduced. Loose plug connections may cause high transition resistance and, as a consequence, high temperatures. In the worst case, this may result in components being charred.



Fig. 2

Thermal problems

High temperatures occur when headlights are operated. These high temperatures may cause "degassing". Certain ingredients of the plastic are set free, e.g. softeners and other additives, and cause a "milky" precipitation on the inside of the cover lens (**see Fig. 3**).

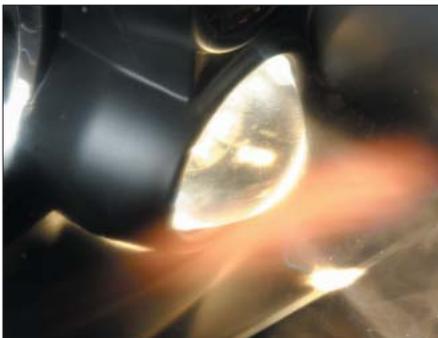


Fig. 3

Proceed as described below to adjust the headlight:

- Check headlight function.
- Check cover lenses for stone impact, scratches and dullness.
- Move vehicle onto an even surface (observe national regulations!) and prepare the vehicle as specified, e.g. tyres must have correct pressure etc.
- Observe manufacturer's instructions for vehicles with hydraulic or air suspension.
- **In many vehicles with automatic headlight range adjustment, a diagnostic tester is needed for headlight adjustment because the headlight range adjustment control unit needs to be in "basic setting mode" during the adjustment (depending on the manufacturer). If the cut-off line is correctly adjusted, this value is stored as the new default position (for more information, see below).**
- In manual headlight range adjustment systems, the switch must be set to the basic setting (0).
- The beamsetter must be aligned in front of the vehicle with the help of the broad-band sight vane (**see Fig. 4**).



Fig.4

- Use the scale wheel to adjust the test screen of the beamsetter to the correct percentage. This corresponds to the angle of inclination of the headlight's cut-off line. The specified values for the low and high beam are indicated near or directly on the headlight, e.g. 1.2% = 12 cm inclination over a 10 m distance.
- Check and, if necessary, adjust the cut-off line.
- Use the luxmeter to check whether the highest permissible glare value of the low beam is exceeded:
 - ≤ **1.0 lux for halogen light**
 - ≤ **1.3 lux for xenon light**

Headlight adjustment in automatic headlight range adjustment systems

If it is found during a headlight check that the cut-off line is not correct, then the diagnostic tester can be used to check whether there is a fault in the system or whether certain parameters are still within the desired range. For example, if an axle sensor is defective and is replaced, then the basic setting of the system needs to be carried out (calibration). Some work steps will be shown exemplarily for the Opel Vectra C with AFS headlights.

After selection of the vehicle, an overview of systems is displayed in which you select the system "Lighting control". After that, click on the system used in the vehicle **(see Fig. 5)**.

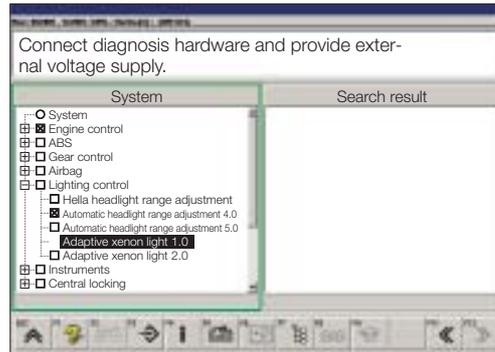


Fig. 5

Click on menu item "Basic setting". In the window that appears, you're asked to carry out the basic setting **(see Fig. 6)**.

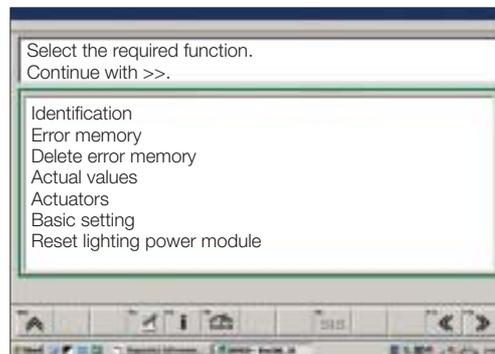


Fig. 6

Successful execution is confirmed and the diagnostic tester may be unplugged again **(see Fig. 7)**.

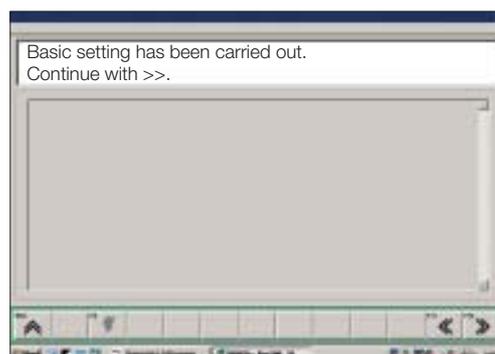


Fig.7

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