



Data Sheet

WBH-Diag Pro

Firmware version 1.1

Data sheet version 1.4

March 2010

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<http://www.obd2-shop.eu>

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1 Introduction

1.1 Important Details

No function warranty for the software is taken over. No liability for incorrect functions and their consequences (for example at hard and software or at the vehicle) is taken over.

Manipulations at controllers in the vehicle can cause irreversible damage and impair the road safety. Use only functions with which you are knowing the effect.

Consult the original repair manual of the manufacturer to the interpretation of error messages and around always get to know permitted change to parameters.

The information in the available manual is published without consideration for a possible patent protection. All data without guarantee. The author can neither take a legal responsibility nor any liability for incorrect data and their consequences.

1.2 Description

With the new protocol interpreter chip WBH-Diag Pro is the vehicle manufacturer-specific diagnostic (OBD) for vehicles from the VAG Group (VW, Audi, Seat, etc.) cheap, reliable and much easier, because regardless of the hardware diagnostic tools.

The heart of it is a microcontroller, which is complete control the protocol (KWP1281) to the vehicle inspected. The software on the diagnostic tool must be neither the time-critical initialization, nor the protocol level, or worry about the timing. The μC ensures likewise for the fact that a once developed connection to the vehicle remains maintaining. Past are the times, in which problems led with timing by the interface (e.g. with USB) to the break or let only no connection to the vehicle come.

Already with a simple terminal program the diagnostic chip can to be addressed and vehicle specifications left to query itself. Owing to the simple command logic therefore individual diagnostic programs can be written without high expenditure and without study of the KW1281 protocol, which are optimized for the respective targeted application. Like that it is possible, to provide software for each operating system (e.g. Windows, Windows Mobile, Unix, Apple) and each hardware (PDA, Laptop, CarPC etc.). As software developers you can concentrate then completely on the functions of your diagnostic tools.

WBH-Diag Pro supports only the KW 1281 Protocol on the K- and L-lines.

1.3 Features

WBH-Diag Pro acts as interpreter between vehicle protocol and diagnostics tool.

Vehicle-laterally it is attached to the diagnostic line(s). These are the K and L-line. For VAG cars these lines can be tap either over the connection called VAG 2x2-Plug, that often are in the engine compartment or over the standardized OBD II socket in the passenger compartment.

The diagnostic tool communicates over a serial interface (19,200 Baud, 8N1) with the WBH-Diag Pro chip. Like that it is possible to attach the chip to many different hardware concepts: e. g. to the serial COM port of a PC, the serial interface of an own micro controller application or via Bluetooth to a PDA etc.

The functions of the WBH-Diag Pro are

controlled via regular AT commands, which are sent as plain language characters by the diagnostic tool to the chip. With these instructions the chip can be configured or the connection to a controller in the vehicle will be built etc.

If WBH-Diag Pro made a connection to a controller, the following functions of the vehicle diagnosis can be used:

- Read measured values
- Read single measured values
- Read diagnostic trouble codes (DTCs)
- Clear DTCs
- Read the Readinesscode
- Software configuration
- Channel adaptation
- Login
- Basic settings
- Output test

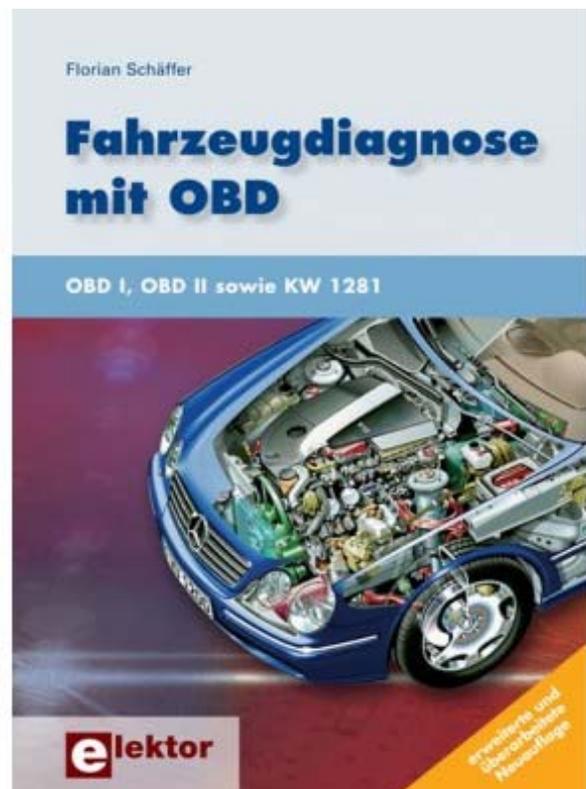


1.4 Resuming Information Offers/Assistance

A discussion forum can be found on the website <http://www.blafusel.de/phpbb/>. Being worth value can be also a visit of the web page http://www.blafusel.de/misc/obd2_start.html.

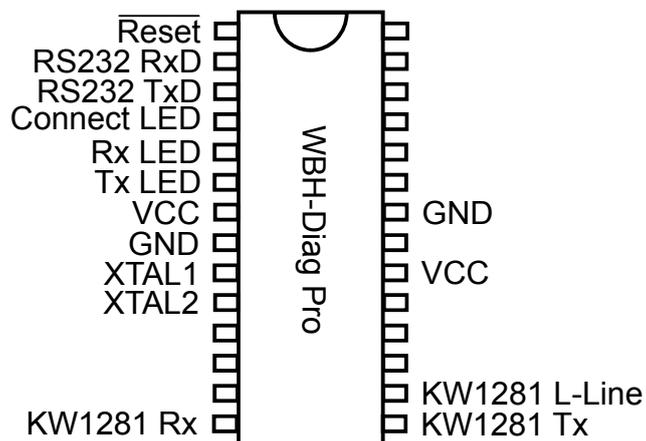
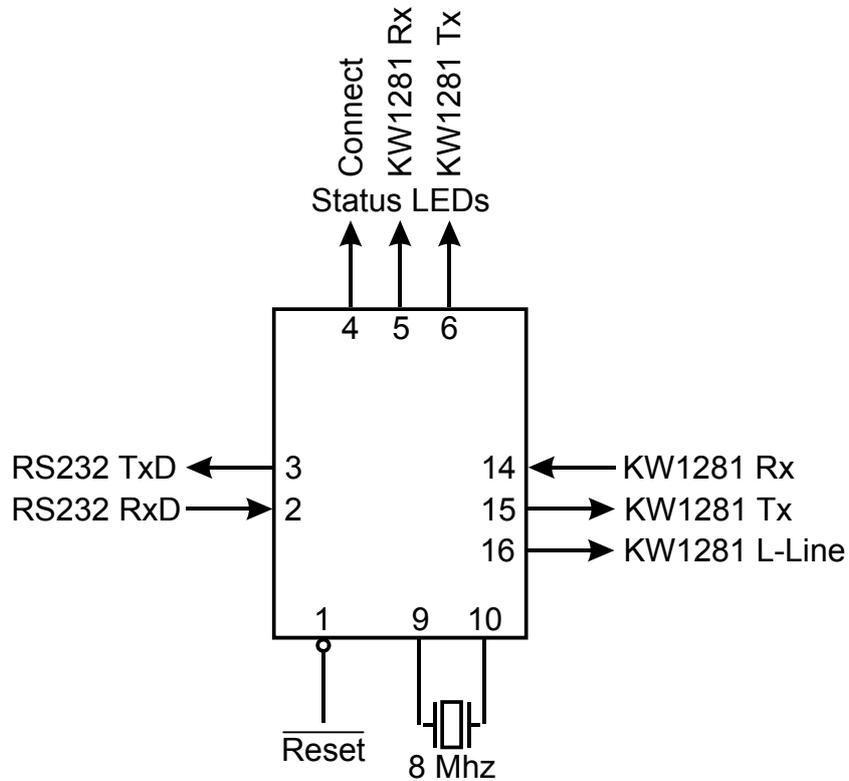
For a detailed introduction into the topic is referred to technical literature. For example (available in German and Dutch):

Fahrzeugdiagnose mit OBD; OBD I, OBD II sowie KW 1281; Florian Schäffer; Elektor-Verlag; ISBN 978-3-89576-223-9.



2 Technical data

2.1 Block Diagram and Pin out



2.2 Pin Descriptions

/Reset (1)

Logical Low at this Pin will reset the MC. If unused, this pin should be connected to logical High level (VCC).

RS232 RxD (2)

RS232 data input. The signal level follows the supply voltage VCC (=High).

RS232 TxD (3)

RS232 data output. The signal level follows the supply voltage VCC (=High).

Connect LED (4)

Like the other LED pins this pin can drive directly a LED. Unused pins High on this pin indicates that WBH-Diag Pro is connected to the vehicle and maintained that connection.

KW1281 Rx LED (5)

High indicates that data is received from the car.

KW1281Tx LED (6)

High indicates that data are send to the car.

VCC (7, 20)

Connections for the positive supply voltage. Both pins must be connected.

GND (8, 22)

Connection for the signal ground. Both pins must be connected.

XTAL1 (9), XTAL2 (10)

A 8.000 MHz crystal must be connected between this both pins. In addition matching capacitors for the crystal (typically ever 22 pF) between each pin and signal ground (GND) must be installed.

KW1281 Rx (14)

This is the signal input for the data connection from the car (separated data on the K-Line from the car). The signal level follows the supply voltage (High=VCC).

KW1281 Tx (15)

Data output (K-Line) to the car. Datenausgang (K-Leitung) zum Fahrzeug. As with all connections to the vehicle is a signal adjustment necessary to the approximately 12 V or 24 V of the vehicle.

KW1281 L-Line (16)

On this pin the L-Line will be connected. This line is needed only for the wake-up by some cars and can be unconnected if unused.

2.3 Electrical Characteristics

The WBH-Diag Pro based on a microcontroller AVR ATmega168 by Atmel (see <http://www.atmel.com>). For more technical

information, please study the data sheet of the manufacturer.

Ambient Temperature with Power Applied:.....	-55 °C to +125 °C
Voltage on each Pin without /Reset	-0,5 V to VCC+0,5 V
Maximum Voltage	6,0 V
DC Current of each I/O Pin.....	40,0 mA
DC Current VCC and Ground.....	200,0 mA
VCC	2,8 V to 5,5 V

3 Functions

The following considerations show how the WBH-Diag Pro chip communicates. There are two groups of commands:

- AT commands to control the WBH-Diag Pro. These commands are to configure the chip and control the connection to the controller in the vehicle. These commands are found

at the Hayes-based instruction for modems and always begin with "AT".

- Diagnostic commands with which you look (after the connection) to the vehicle diagnostic data etc. These commands always start with a double-digit code number for the diagnostic function.

3.1 Communication with the WBH-Diag Pro

All commands between the diagnostic tool and the WBH-Diag Pro are exchanged as ASCII characters. All figures are in hexadecimal number system. All commands must be equipped with a newline (CR or \r or 0D_H) to be completed. An additional line feed (LF or \n or 0A_H) is not allowed. WBH-Diag Pro produces no echo of the received data. The incoming characters are not returned to a terminal program etc. to be displayed. The terminal program must generate a local echo of the input, if you want to see the entries.

Communicate with the WBH-Diag Pro on a regular RS232 serial interface. The data rate is fixed to 19.200 Baud with 8 data bits, no parity and one stop bit (8N1).

Once the chip is connected to the correct voltage, the three LEDs together are quickly switched on and off ten times in a lamp test. Subsequently, the chip announces itself with the following expenditure ready for use:

```
WBH-Diag Pro v1.0
>
```

The first output is a CR, followed by the software ID (with CR) and the

The reading of this information provides a good way for the diagnostic tool to verify that it is a matching chip, and the serial connection is configured correctly. At this

time was no connection to the vehicle diagnostic system.

With the angle bracket (greater-than symbol) WBH-Diag Pro signaled willingness to accept new commands. Was a command correctly, the WBH-Diag Pro sends no positive response back, but only a ">". Only when communication errors between the vehicle and WBH-Diag Pro (an incorrect value or command) is an appropriate response delivered. Misspelled commands (syntax error) or (currently) are not allowed statements answered with a question mark:

```
?
>
```

If it comes to connecting problems between WBH Diag Pro and the vehicle (e.g. because the controller is switched off by turning the ignition off), the error message appears at the latest after 2 seconds

```
DATA ERROR
>
```

The diagnostic connection is separate according to it and must be developed again (ATD) and the configuration of the WBH-Diag Pro was put back to the default values.

- ? **[Help]**
After entering a single Question mark you will get a list of all commands including a function overview in English.

3.2 AT-Commands

Basically, capitalization for these commands are not distinguished. Between the individual indications however no blanks and so on are permitted. It is possible at any time to send AT commands to WBH-Diag Pro.

ATBDT*nn* [BlockDelayTime]

The BDT (BlockDelayTime) specifies the break between two communication blocks in milliseconds, which is waited for by the program. This corresponds to the time P3 in the standard ISO 14230. A value of approximately 20...80 by *nn* is meaningful (00...FF_H is permitted). The default value amounts to 25.

With ATBDT? you can query the present attitude.

ATD*nn* [Dial]

Established a connection via diagnostic protocol to the vehicle.

For *nn* the controller number must be indicated. For example ATD01 for the engine control unit or ATD17 for the instrument cluster. An overview of the possible controllers and their number can be found in Appendix A: Control Units (only in German language).

The ignition must be switched on, equally some controllers such as radio, air conditioning system and extra heater. An engine run is not necessary necessarily.

The execution of the command may take a few seconds. WBH-Diag Pro sampled one after another from different baud rates to connect up to the vehicle (unless you have a fixed set ATN). Unable to connect, is "ERROR" reported:

```
>ATD0A
ERROR
>
```

Then there is no diagnostic data connection.

If successful, the code for the transmitting speed spent, with the connection (see ATN): "CONNECT: n"

Likewise, the control parameters issued by how they are delivered each controller.

The data are interpreted only slight by WBH-Diag Pro: Indications are sent not filtered to the RS232 interface. Here it can be that a controller divides the data into several blocks, which are separate by line-makeup (CR). How many data are sent, is dependent on the controller. WBH-Diag Pro interprets only the information for the workshop code (WSC) and software coding (SWC). These are marked by the respective abbreviations in the beginning and indicated exceptionally in the decimal system. As soon as all data were conveyed, one ">" spent. This always indicates like the readiness to receive further instructions.

```
>atd17
CONNECT: 5
1J0920801E
KOMBI+WEGFAH
RS. BOO V25
SWC: 05141
WSC: 00426
Ident.-Nr. W
EGFAHRS.:VWZ
6Z0X1334096
>
```

Only if with ATD a connection to the vehicle were made, diagnostic data can be queried. WBH-Diag Pro keeps the connection afterwards upright (Keep Alive) to the connection is separated electrical or by instruction (ATH). It is at any time possible to connect WBH-Diag Pro with another controller in which you use ATD*nn* again. If a diagnostic connection already exists, this is separated automatically before.

The maintenance of the connection expresses itself in regular flickering of the LED KW1281 Rx and KW1281 Tx. They do not have to worry about this cyclic communication.

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ATH [Hang Up]

Terminates an existing diagnostic connection to the vehicle. Subsequently, no more diagnostic functions can be accomplished until a new connection were developed. With this instruction also the automatic Keep Alive of the WBH-Diag Pro is terminated.

ATI [Information]

The software identification and the version of WBH-Diag Pro. These data correspond to those after applying the operating voltage. It can be meaningful to query these data if the RS232 connection were only manufactured after creation of the operating voltage. In this case the initial software identification on side of the diagnostic tools could not be evaluated.

ATIBT nn [InterByteTime]

The IBT (InterByteTime) specifies the break, which is kept between receiving and sending a byte by the program in milliseconds. This corresponds to the time P4 according to ISO 14230. A value of 10 worked satisfactorily and is the standard attitude. For problems in the connection establishment and during the program sequence you can vary the value nn between approximately 0...20 (00...FF_H is permitted). With ATIBT? you can query the present attitude.

ATN n [Connection Speed]

This allows you to specify the baud rate, with the WBH-Diag Pro connect

with a control unit if the command ATD is used. The setting is valid until the next revision, a reset or the loss of voltage. A default can be useful if the diagnosis rate of connection is known and sequential search with the default should be bypassed to save time or because it is having trouble connecting. Possible parameters are:

n	Function
0	To try out all baud rates (default)
1	1.200 Bd.
2	2.400 Bd.
3	4.800 Bd.
4	9.600 Bd.
5	10.400 Bd.
?	Report of the current setting

The command does not provide the code for the transmitting speed with a possibly existing diagnostic connection was produced.

For example, the query of the current value:

```
>atn?  
0  
>
```

Example for a change:

```
>atn3  
>
```

ATZ [Reset]

Sets the WBH-Diag Pro on the default values. Any existing diagnostic connection is terminated. Then follows the software code as after applying a voltage output.

3.3 Commands for Vehicle Diagnostics

With the commands to the vehicle diagnosis you can read values from the controller and possibly modify (write). Not every controller always supports all functions. Each command consists of a two-digit code number which if necessary further data follow. All the answers are in hexadecimal (case no matter). The command numbers are adapted to the designators, who are

used also in the documents by VAG and with their diagnose units.

All of these commands are permissible only if a connection to the controller were developed before (ATD).

00 [Unit ID]

Return the device characteristics, such as those in the construction of the diagnostic connection (ATD) has been sent.

```
>00
074906018BK 2,51 R5 EDC
0200
SG 5115
SWC: 00002
WSC: 30004
>
```

02 [Read Trouble Codes]

This will give us all the error codes (Diagnostic Trouble Code: DTC) from the ECU query. For each line is spent the error code and the appropriate status code on the error cause (separately by a blank). Since with larger number of errors the data are sent by the controller in stages, it can come occasionally to short delays with the expenditure.

```
>02
465A A3
461E 23
4620 23
44AB 23
406A 23
>
```

There are five DTCs stored. The first indication is that it was the decimal error code 18010 with the status code 163 stored. There is no possibility of query individual error codes or the timing of the generation.

For the interpretation of error codes, please try the repair manual or the numerous websites on the theme:

- Numerous error codes in various files and also as a database. Free registration required:
<http://tech.groups.yahoo.com/group/obd-2/>
- English error codes OBD II corresponding ISO/SAE and special VAG:
<http://www.bentleypublishers.com/tech/audi/audi.dtc.table.htm>
- German error codes VAG-specific and status codes:
<http://audi100.selbst-doku.de/Main/VAG-COM-Fehlernummern>

03 [Output Test]

By calling this function, the control unit (if supported) tries a functional test of connected components. This may be, for example, a lamp test or the movement of a needle on the dashboard.

Never run the output test in a moving vehicle, because this can affect the ride (e. g. individual braking of the wheels).

The controller confirmed the output test with a double-digit code. This code then tells you which component has been activated and is equal the error code (see command 02). Supports the ECU (currently) no output test, WBH-Diag Pro reports "NA".

A full output test consists of the repeated calls of the output test until the controller examined sequentially all possible components.

WBH-Diag Pro then announces "END". You can not use a particular component directly. You can examine the test only gradually through. In between, you can theoretically other functions, but they could be reported possibly wrong or deviating values from the normal state. For some devices you can call the output test one after another. Other devices require ignition interruption before a new pass. Some ECUs can use the command 00 to cancel the output test (and then start again from the beginning).

Example for a complete output test:

```
>03
0296
>03
0297
>03
0512
>03
END
>
```

The controller could talk to three components, where the third test according to a DTC list is a lamp test of the instrument cluster.

04nn [Basic Settings]

Functions

Lets you control unit query of measurements for individual groups. The measurements supplied and the query of the groups correspond to the command 08 (further explanations see below). When basic setting you receive possibly different values, because the controller can try to move a connected component in the basic attitude.

05 [Clear Error Codes]

Herewith erase all memory errors. This affects not only the error codes, but also the Readinesscode, the resultant is reset so that it must be regenerate from the control unit only. Is the cause of each error had not been resolved, it may be that the same mistakes be registered new again in the memory of the control unit. There is no security warning instead, this is the task of the scan tool.

07nnnnxxxx [Software Configuration]

Each controller can be reprogrammed through a coding value. This enables several additional features enabled or disabled. What features are and how the associated code is built, is in the repair manual of the vehicle.

Besides the value for the software configuration is also the VAG workshop code (WSC) saved. Each VAG dealer uses its own unique code.

The software code is known as hexadecimal digit figure directly after the given command 07 (nnnn). Followed by the equally long workshop code (xxxx).

Accepted the ECU the modification, it announces itself with the same characteristics as well after the connection with ATD. For the encoding software code and the workshop will be the newly-set values shown.

Example of configuring the software code 05141_D (1415_H) and the workshop code 00426_D (01AE_H):

```
>07141501ae
1J0920801E
KOMBI+WEGFAH
RS. BOO V25
SWC: 05141
WSC: 00426
Ident.-Nr. W
EGFAHRS.:VWZ
6Z0X1334096
>
```

If the controller does not accept the parameters, no expenditure takes place and it follows the prompt.

08nn [Group Values and Raw Data]

This allows you to query a control unit and their connected sensors. What values and how many are delivered is different. The data are delivered in blocks at three values. Most controllers deliver four measurements per group, but also fewer measurements are possible.

Which measured values are supplied in which group and at which position, is different depending upon controller. All groups are never supported by a controller. Information for this must be inferred from the repair manual of the vehicle.

The controller marks each measured value by a characteristic number, which permits then conclusions on it, as from the supplied numbers the measured value is computed and in which unit. An overview of the suitable formulas etc. you find in the appendix B. A measured value inscription of the respective data are only possible conditionally due to the unit.

With nn you designate the desired group of measured values.

```
>0802
07 64 31
01 C8 00
25 00 1E
2C 00 21
>
```

The first number of each line is the characteristic number for measured value computation. The two following numerical values are called in the ap-

Functions

pendix B byte A and byte B and to place the actual measured value.

In the example the group 2 is queried. Four measured values (per one per line) for this group were supplied. The first block supplies then a computed measured value of

$$0.01 * A * B =$$

$$0.01 * 64_{\text{H}} * 31_{\text{H}} =$$

$$0.01 * 100_{\text{D}} * 49_{\text{D}} = 49 \text{ km/h}$$

With this command also those ten raw data measured values, which often know as "Group 00" are designated, to be selected. In addition the value must be indicated 00 for *nn*. Each data value of the answer is then ends with a CR. The meaning of the numerical values is to be inferred from the repair manual of the vehicle.

```
>0800
B3
85
00
B9
FF
80
80
80
80
80
>
```

There are also a few control units, which has a very exotic answer. This sends first a lookup table, with the measured values, and text characters. In further queries can be the index pointer be queried to this table and calculated values. The WBH-Diag Pro combines these two queries automatically and delivers the received first lookup table and then after a line break the (four) follow-bytes. How many bytes the lookup table contains varies. Query and output looks like this example:

```
>0804
88 F6 00
8D 01 4A
20 20 20
20 30 03
20 20 20
20 52 03
20 20 20
20 30 03
20 20 20
20 31 48
03 20 20
20 20 32
48 03 20
20 20 20
33 48 03
20 20 20
20 34 48
03 20 20
20 20 31
4D 03 20
20 20 20
32 4D 03
20 20 20
20 33 4D
03 20 20
20 20 34
4D 03 8E
01 00 86
01 00
0B 05 44
00
>
```

The first 3 bytes are calculated values for the first measurement value.

The byte sequence 8D 01_H (bytes 4 and 5) points out that an ASCII lookup table follows (for the second measurement value). This consists of 74_D bytes (6. bytes 4A_H). This lookup table provides 11 data blocks, each finish with a value of 03_H. The first block of data (byte 7...12) with the index value of 0 consists of the ASCII values for " 0" (<blank> <blank> <blank> <blank> 0). The end-byte 03_H is not included in the text conversion.

Followed by 6 bytes for the third and fourth measurement value.

With the help of four additional bytes after the line break now the measured values can be calculated and the displayed text from the lookup table can be determined. Since the lookup

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table was sent as the second value, is the second extra byte for the table crucial (05_H). So it refers on the block with the index 5. This is the sixth data block, as with 0 starts to count. This data block is represented in the example the text " 3H" (<blank> <blank> <blank> 3H).

09nn [Single Reading]

Sometimes a single reading of a specific channel is performed in the repair manuals. WBH-Diag Pro delivers either the result (16-bit hex value) or "NA" if the channel for the specified single reading is not supported.

```
>0903
0286
>
```

10nnxxxx [Channel Adaptation]

The channel adjustment is similar to the software configuration to cover the behavior of the control unit to influence. What features there are and how the associated code is built, is in the repair manual of the vehicle.

When the channel will adapt distinction between two modes: Enter only the channel number *nn* to offer only the value adjustment (channel value) and possibly the four measurements supplied by some controllers in some channels. The measurements will be interpreted exactly how to read a group (see command 08). The channel number may be in the range of 0...99_D, where it is not being examined of WBH-Diag Pro.

If the selected channel is not supported by the controller, it informs you with the text "NA" about it.

Reading channel 11_D (supported by this controller, delivers only the value adjustment (128_D), no measurement values):

```
>100b
0080
>
```

Reading of channel 50_H (not supported by example):

```
>1050
NA
>
```

Retrieving the exemplary existing channel 1, also provides further data in addition to the value adjustment:

```
>1001
0080
01 32 00
01 32 7F
25 00 0E
25 00 10
>
```

To modify the channel value of a channel, enter the channel number *nn* and the new channel value *xxxx*. Will the control unit accepted the new value command prompt appears. Successful store of value 0180_H in channel 2:

```
>10020180
>
```

If the specified channel or the value is invalid "ERROR" spent:

```
>100200AA
ERROR
>
```

11nnnnxxxx [Login]

Some features are available only to or by using an authentication login to the control unit. The necessary login code is device-dependent and is available in the service documents to the vehicle below.

With a false login code most ECUs react with a blockade of further communication, why then the connection between WBH-Diag Pro and the ECU is disconnected. You must be turn the vehicle ignition off and after about 10 to 60 seconds turn on an then again connect with the controller (ATD).

The login will be specified the login code *nnnn* and the workshop *xxxx* code. The workshop code (WSC) can be assisted by the previous setting and will then depart in the ECU as the new stored value.

Successful login with login code 93_D an the (new) WSC 430_D.

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>11005D01AE

>

When a false login code "ERROR" appears and the diagnosis is disconnected to the control unit. You can now usually no more new connect with this controller, until it is was turned off and back. The connection to other devices is possible.

15

[Readiness Code]

The Readiness code gives information over it whether the controller had sufficient time to accomplish different equipment tests. It does not mean whether the test was successful then or not and also not, whether there is an error code entry. For everyone component which can be tested stands a bit. If the component is missing or the test final, the appropriate bit is set by the controller to 0. If the bit stands on 1, you must be put back still more trip distance with the car.

With the deletion of the DTCs (see above) all bits of the controller are set to 1 (up to the bits, whose equivalent components are missing). Usually only OBD-II engine devices makes available a Readiness code.

The inquiry of the Readiness code supplies a byte value for the code or the expenditure "NA", if the Readiness code cannot be supplied, because it is not supported by the controller.

The byte value must be interpreted binary. The individual bits stand for the following devices:

Bit	Function
xxxx xxx1	Catalyst
xxxx xx1x	Heated catalyst
xxxx x1xx	Evaporative system
xxxx 1xxx	Secondary air system
xxx1 xxxx	A/C system refrigerant
xx1x xxxx	Oxygen sensor
x1xx xxxx	Oxygen sensor heater
1xxx xxxx	EGR system

Example.:

>15

65

$65_H = 0110\ 0101_B$

Diagnosis finished or component not build in for the devices EGR system, air condition system refrigerant, secondary air system and heated catalyst.

4 Example Application

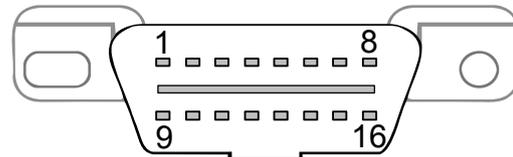
The following circuit shows, how simply the interpreter chip WBH-Diag Pro is integrated into a circuit, which then can be attached to the serial interface of a PC (RS232 signal level approx. +/-12 V).

If you integrate WBH-Diag Pro in to an application which works on 3...5 V signal levels at the U(S)ART you can do it naturally without a level shifting on the RS232 side.

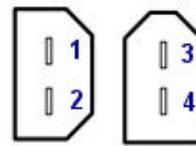
The signal level of the vehicle diagnostics must but in any case to be adjusted. It should be noted that the proposed circuit is designed for vehicles with 12 V board voltage. These are usually cars and light trucks. For heavy trucks with 24 V battery voltage the circuit must be modified: Both resistors R2 and R3 with 510 Ω must be replaced by 1 kΩ and it's possible necessary to cool the voltage regulator IC4.

The circuit board is connected with the diagnosis K and L lines and the power of

the vehicle. These signals can be either will be picked off the standard OBD II connector in the passenger compartment or at the VAG 2x2 jack (mostly in the engine).

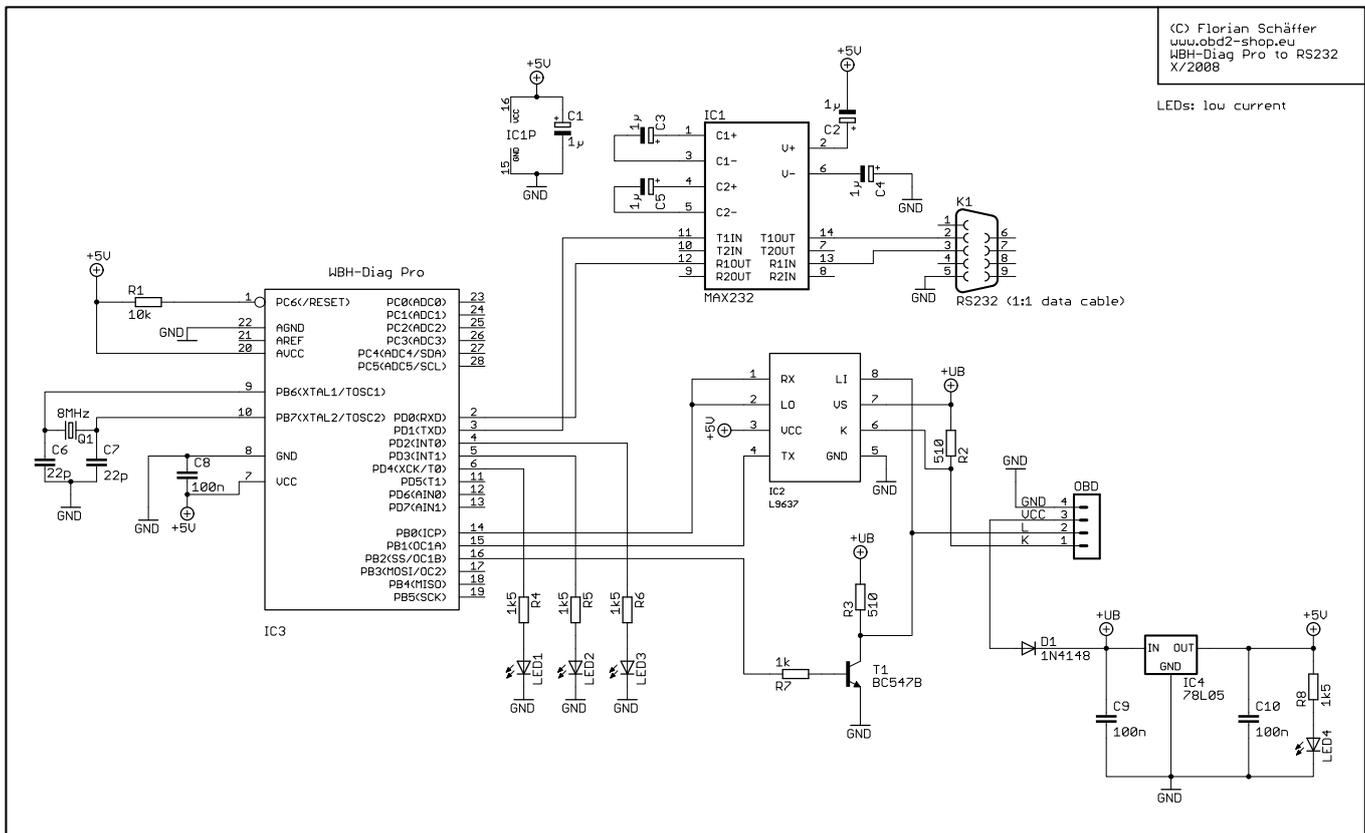


OBD II Jack



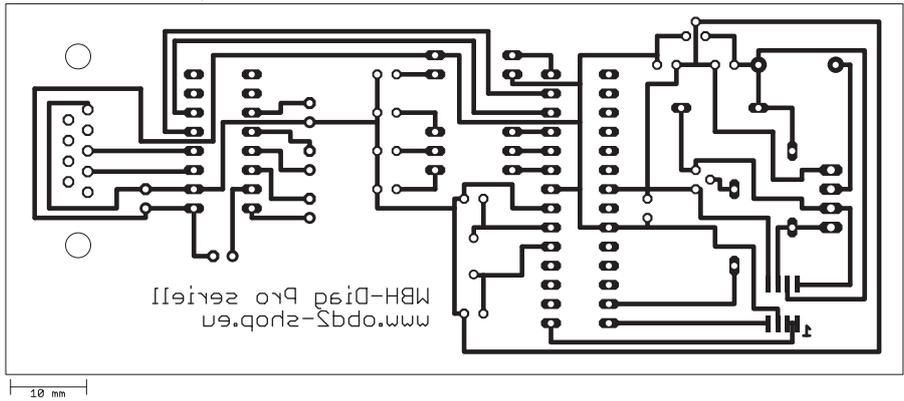
VAG 2x2

Signal	OBD II	VAG 2x2
GND	4+5	4
VCC	16	3
K	7	1
L	15	2

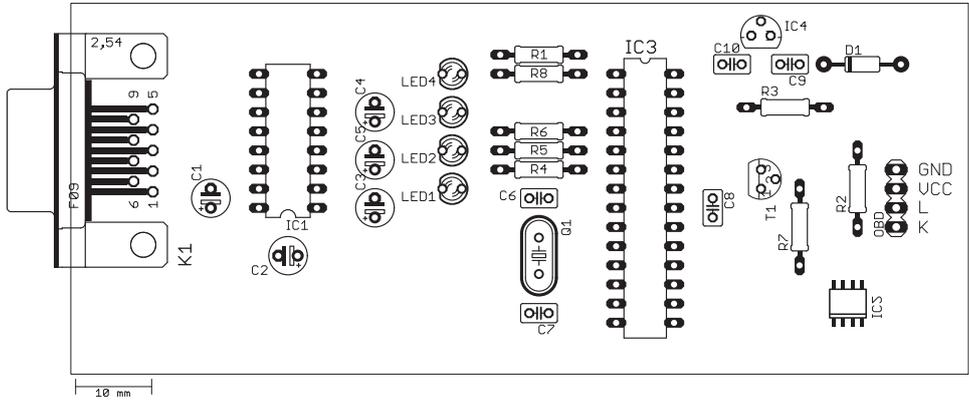


Example Application

WBH-Diag Pro seriell
www.obd2-shop.eu



WBH-Diag Pro seriell
www.obd2-shop.eu



Appendix A: Control Units

Address		Control Unit
Dez.	Hex.	
1	01	Motor (ECU)
2	02	Automatik Getriebe
3	03	ABS Bremsen
4	04	Lenkrad Winkel
5	05	Start Authentifikation
6	06	Beifahrer Sitzpositionsspeicher
7	07	Anzeige
8	08	Klima
9	09	Zentralelektrik
11	0B	Sekundäre Luftheizung
13	0D	Schiebetür links
14	0E	Mediaplayer 1
15	0F	Digital Radio
17	11	Motor 2
18	12	Kupplung
19	13	Automatische Abstandskontrolle
20	14	Federung
21	15	Airbag
22	16	Multifunktionslenkrad
23	17	Kombiinstrument
24	18	Zusatzheizung
25	19	CAN Gateway
29	1D	Fahrererkennung
30	1E	Mediaplayer 2
31	1F	Satelliteturner
33	21	Motor 3
34	22	Allrad
35	23	Bremskraftverstärker
36	24	ASR
37	25	Wegfahrsperre
38	26	Schiebedach
39	27	Anzeige hinten
40	28	Klima hinten
41	29	Licht links
45	2D	Intercom
46	2E	Mediaplayer 3
47	2F	Digital TV
49	31	Motor 4
50	32	Differentialsperre
52	34	Höhenverstellung
53	35	Zentralverriegelung
54	36	Fahrer Sitzpositionsspeicher
55	37	Navi
56	38	Dach
57	39	Licht rechts
60	3C	Assistent für Spurwechsel

Address		Control Unit
Dez.	Hex.	
61	3D	Sonderfunktionen
62	3E	Mediaplayer 4
65	41	Dieselpumpe
66	42	Tür Fahrerseite
69	45	Innenraumüberwachung
70	46	Zentrale Komfortsteuerung
71	47	Soundsystem
72	48	Sitz hinten links
73	49	Lichtautomatik
76	4C	Reifenluftdruck
77	4D	Datenübertragung
78	4E	Anzeige hinten rechts
79	4F	Zentralelektrik 2
81	51	Elektrische Antriebe
82	52	Tür Beifahrerseite
83	53	Feststellbremse
84	54	Heckspoiler
85	55	Xenon Reichweitenkontrolle
86	56	Radio
87	57	TV Empfänger
88	58	Zusätzlicher Kraftstofftank
89	59	Abschleppschutz
92	5C	Spurassistent
94	5E	Anzeige hinten links
97	61	Batterie Regulator
98	62	Tür hinten links
99	63	Fahrerseite Einstieghilfe
100	64	Stabilisator
102	66	Sitz hinten rechts
103	67	Sprachkontrolle
104	68	Scheibenwischer
105	69	Anhänger
108	6C	Rückfahrkamera
109	6D	Heckklappe
110	6E	Anzeige Dach
111	6F	Zentrale Komfortsteuerung 2
113	71	Batterie Ladegerät
114	72	Tür hinten rechts
115	73	Beifahrer Einstieghilfe
116	74	Fahrwerkskontrolle
117	75	Telematik
118	76	Einparkhilfe
119	77	Telefon
120	78	Schiebetür rechts
125	7D	Zusatzheizung
126	7E	Anzeige Armaturenbrett

Appendix B: Calculating Measurement Values

ID	Calculation	Dimension
1	$0,2 \cdot A \cdot B$	rpm
2	$A \cdot 0,002 \cdot B$	%
3	$0,002 \cdot A \cdot B$	Deg
4	$\text{abs}(B-127) \cdot 0,01 \cdot A$	>127: "ATDC" sonst: "BTDC"
5	$A \cdot (B-100) \cdot 0,1$	°C
6	$0,001 \cdot A \cdot B$	V
7	$0,01 \cdot A \cdot B$	km/h
8	$0,1 \cdot A \cdot B$	
9	$(B-127) \cdot 0,02 \cdot A$	Deg
10	B=0: "kalt" sonst: "warm"	
11	$0,0001 \cdot A \cdot (B-128)+1$	
12	$0,001 \cdot A \cdot B$	Ohm
13	$(B-127) \cdot 0,001 \cdot A$	mm
14	$0,005 \cdot A \cdot B$	bar
15	$0,01 \cdot A \cdot B$	ms
16	Bit Wert	
17	chr(A) chr(B)	-
18	$0,04 \cdot A \cdot B$	mbar
19	$A \cdot B \cdot 0,01$	l
20	$A \cdot (B-128)/128$	%
21	$0,001 \cdot A \cdot B$	V
22	$0,001 \cdot A \cdot B$	ms
23	$B/256 \cdot A$	%
24	$0,001 \cdot A \cdot B$	A
25	$(B \cdot 1,421)+(A/182)$	g/s
26	B-A	C
27	$\text{abs}(B-128) \cdot 0,01 \cdot A$	<128: "ATDC" sonst: "BTDC"
28	B-A	
29	B<A : "1. Kennfeld" sonst: "2. Kennfeld"	
30	$B/12 \cdot A$	Deg k/w
31	$B/2560 \cdot A$	°C
32	B>128: B-256 sonst: B	
33	100 · B/A A=0: 100 · B	%
34	$(B-128) \cdot 0,01 \cdot A$	kW
35	$0,01 \cdot A \cdot B$	l/h

ID	Calculation	Dimension
36	$A \cdot 2560+B \cdot 10$	km
37		
38	$(B-128) \cdot 0,001 \cdot A$	Deg k/w
39	$B/256 \cdot A$	mg/h
40	$B \cdot 0,1+(25,5 \cdot A)-400$	A
41	$B+A \cdot 255$	Ah
42	$B \cdot 0,1+(25,5 \cdot A)-400$	Kw
43	$B \cdot 0,1+(25,5 \cdot A)$	V
44	A : B	h:m
45	$0,1 \cdot A \cdot B/100$	
46	$(A \cdot B-3200) \cdot 0,0027$	Deg k/w
47	$(B-128) \cdot A$	ms
48	$B+A \cdot 255$	-
49	$(B/4) \cdot 0,1 \cdot A$	mg/h
50	$(B-128)/(0,01 \cdot A)$ A=0: $(B-128)/0,01$	mbar
51	$((B-128)/255) \cdot A$	mg/h
52	$B \cdot 0,02 \cdot A-A$	Nm
53	$(B-128) \cdot 1,4222+0,006 \cdot A$	g/s
54	$A \cdot 256+B$	Zähler
55	$A \cdot B/200$	s
56	$A \cdot 256+B$	WSC
57	$A \cdot 256+B+65536$	WSC
58	1,0225 · B B>128: $1,0225 \cdot (256-B)$	\s
59	$(A \cdot 256+B)/32768$	-
60	$(A \cdot 256+B) \cdot 0,01$	sec
61	$(B-128)/A$ A=0: $(B-128)$	
62	$0,256 \cdot A \cdot B$	S
63	chr(A) + chr(B) + "?"	
64	A+B	Ohm
65	$0,01 \cdot A \cdot (B-127)$	mm
66	$(A \cdot B)/511,12$	V
67	$(640 \cdot A)+B \cdot 2,5$	Deg
68	$(256 \cdot A+B)/7,365$	deg/s
69	$(256 \cdot A +B) \cdot 0,3254$	Bar
70	$(256 \cdot A +B) \cdot 0,192$	m/s2

Appendix C: Software History

V 1.0 12.09.2008

V 1.01 20.10.2008

V 1.1 01.11.2008

- List of commands with "?"

V 1.2 27.11.2008

- Command 08 extended, so that lookup tables can be read