



WBo₂ 2E0 Test Procedure

Revision (Rev 0.3), July 13th 2005

We appreciate your feedback with suggestions on how to improve the structure of this document. This is best be done by sending a short email to

peter@techedge.com.au ... with subject = "2E0 (rev 0.3) test procedures updates"

Please ensure you have the latest version of this document before suggesting changes. The latest version is available from this page

<http://wbo2.com/2E0/kit.htm>

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Section 1.0 Introduction

This document outlines the troubleshooting sequence for the DIY WBo2 **2E0** unit. The test sequence is divided into five sections (sections 2 – 6).

- Section 2. Power supply and Derived Voltages
- Section 3. CPU and Host Communications
- Section 4. Analog Interface Circuitry
- Section 5. Sensor Interface
- Section 6. Functional Checks
- Section 7. Calibration and Setup
- Appendix A. Change History

We assume that the WBo2 2E0 unit has been assembled by the person reading this document and that they are familiar with the naming of all components. A basic understanding of electronics and personal computers is also assumed. The tests and actions described are to be performed in sequence, and, unless otherwise stated, all tests require the **sensor to be disconnected** from the WBo2 unit.

If a test procedure fails or doesn't produce the desired measurement or result (a negative result), then this is a pointer or clue to an underlying build problem or component fault that must be investigated and rectified before proceeding. In many cases, an indication of where to look for the fault will be given, but this does not mean the fault you have will be readily diagnosed. Note also that a negative result may also be an indication that the test has not been performed correctly, and all negative tests should be checked to confirm that the test procedure has been understood and followed correctly.

Remember too that the schematics page <http://wbo2.com/2E0/schem.htm> is an excellent source for debugging should you find your measurements do not match the results presented here.

1.0 Possible Problems You May Encounter

As much as we'd like everyone to be able to build and have a functioning Wbo2 unit in the shortest timeframe, our experience has shown that maybe 5% of constructors will not have well enough developed skills to fault find Wbo2. The **most common causes of faults** for WBo2 constructors are :

1. Poor soldering leading to shorts and open circuits, or worse, "cold solder" joints.
2. Incorrect, missing, and **swapped placement** of components.
3. Reversing polarised components (diodes, electrolytic capacitors, ICs, etc.)
4. Poor static electricity minimisation resulting in damaged ICs.
5. Badly or incorrectly constructed cable from Wbo2 to the sensor.
6. Using an **inadequate power supply** (must be able to supply **3 Amps at 14 Volts**)
7. Testing with a multimeter or DVM with poor or semi-**flat batteries**.

If there is any misunderstanding about the required steps to perform then we suggest you do **NOT** proceed, but rather, contact the **oz-diy-wb** Yahoo list (preferably) for assistance from other like minded constructors, or contact Tech Edge for clarification and help in proceeding (*Note : Tech Edge cannot guarantee it will always reply in a prompt fashion*). Please remember that there may be errors in the steps below and we rely on your feedback to correct these errors.

In the case of a unit that cannot be debugged, refer to the **Warranty** link on the home page to find out how to receive an **RMA** (Return To Manufacturer's authority) that can be used to send your unit back to us for fixing. We will charge according to how long it takes us to repair your unit. In extreme cases we may deem your unit uneconomic to repair.

1.1 Basic Tools Required

The most essential tool is your own understanding of electronics, and a willingness to troubleshoot. Also essential are the following basic test items you should already have.

- **DVM**: (Digital Voltmeter) 3.5 digit, 10 M ohm input impedance (test clips highly recommended).
- **Power Supply**: 12-15V (13.8 nominal) @ 2A (always check the voltage under full load). A good unit also has a selectable current limit, and shows voltage and current. Note that one of the tests calls for an adjustable power supply with variable output from below 10 Volts to above 20 Volts.
- Wire **jumpers** with test clips.

- PC with **terminal emulation** (serial comms) program and functional serial port (like *Hyperterminal*). See the note below about USB serial adaptors.

It is assumed you also have the following parts supplied with all kits (you are required to solder the DB9 connector for DIY kits).

- WBo2 serial cable (RJ45 to 9 pin "D" female)
- WBo2 power cable

1.2 Basic Assembly

PCB assembly is described elsewhere (see the Wbo2 web site), however it is recommended that the testing process begins with all discrete components and IC sockets installed, but with **NO** ICs installed except the **DAC7612** (which is pre-installed by Tech Edge) and the **5V voltage** regulator **U10**.

During the test procedure instructions will be given to install ICs; this **MUST** be done with the power removed from the WBo2 unit, and power subsequently re-applied as required by the instructions.

1.3 Voltage measurements

When an instruction is given to **measure** a voltage, this assumes a positive DC voltage with respect to ground, unless specifically stated. For example, "measure +5V" implies connecting the negative DVM input to ground, the positive DVM input to the +5V signal, and setting the DVM to a suitable DC voltage range, generally the lowest range setting that will encompass the expected voltage. We recommend you turn off the auto ranging DVM features if present on your meter. After the measurement instruction, the expected result will be given in parenthesis, for example (4.95, **5**, 5.05), the three values being the lowest acceptable result, the nominal voltage, and the highest expected result.

As well as confirming that the actual result is within the limits given, it is expected that the result will be recorded. Here's a complete example:

- measure +5V (4.95, **5**, 5.05)

When a measurement is to be taken with respect to a reference voltage other than ground, the instruction will read "measure CAL wrt VGnd", in which case the method above is modified to use the second signal as the DVM negative input connection. Signals may be described in two different formats:

- By name (eg. +5V)
- By location (eg. U7p3, Y1p8) – where U7p3 means IC U7 pin 3.

In either case, locate the signal on both the schematics and the PCB. Refer to the appropriate image referred to in the on-line parts list. Another measurement option is indicated using a single test within parenthesis, as in the following examples :

- measure MUXA (>4.5V) ensure voltage at MUXA is greater than 4.5V
- measure MUXB (<0.5V) ensure voltage at MUXB is less than 0.5V

As it is very easy to allow the DVM probes to slip, it is recommended that good quality test clips are used, especially for the ground reference, which is quite close to the fuse (left hand pin of D2).

1.4 Connections and jumpers

An instruction to **connect** two signals implies that a wire jumper needs to be connected between the signals, for example "connect DACV to Vs" requires:

- Identifying the source (first) signal on the schematics, and then on the PCB. The most convenient connection points are either testpoints, jumper pins and the wire lead of resistors which connect to the appropriate signal.
- Identifying the target (second) signal, as above.
- Using a wire jumper with test clips to firmly connect the two signals together. Care **MUST** be taken to ensure no short circuits occur.

Other instructions requires that a resistor be connected between two signals, for example

- *connect 100 ohm resistor between Ip and VGnd.*

After identifying the connection points, as above, two test leads are used (one for each signal), the other end of each lead then being connected to the leads of the resistor specified. Also noted will be a request to *jumper two pins on IC sockets*, for example:

- *jumper U1p2 to U1p3.*

This is best accomplished using a lead cut from one of the installed resistors, cut and bent to the required length and then very carefully inserted into the IC socket. When connections must be made between pins on different IC sockets, use a short length of resistor lead inserted into each IC socket, and connect these together using a wire jumper with test clips. Take great care not to deform the IC contact when inserting and removing these connections.

1.5 Serial Ports & User Interface

The test method relies heavily on using a PC terminal emulator program to communicate with the WBo2 unit's user interface. One such PC program is **Hyperterminal**. The required settings are listed below but first ensure the port is off-line with *{Call, Disconnect}* then select *{file properties, Configure...}* and set the following

- **speed** 19,200 bps
- **bits** 8
- **parity** none
- **stop** 1 bit
- **flow** ALL flow control options disabled (*note : very important*)

Lastly, set the following parameter to see your commands as they are entered

- **echo** local, use *{File Properties, setting, ASCII setup...}*.

Another contender for talking to WBo2 is the WBo2 **config** program (*downloadable from Tech Edge via WBo2.com/sw/conf.htm*). Use the **Comms** tab screen to set the COMM port and then enter commands and see their results.

It is possible to use a **USB to serial converter** to either add the first, or another serial port to your PC. We don't recommend any particular brand but certainly early model units seem to have some problems.

Serial Loop-back Test : The majority of PCs use a 9 pin male "D" connector (known as a DB9) for the serial port, and a quick check of both the terminal emulator software and the serial port hardware may be performed by shorting pins 2 and 3 of the DB9 connector together and following this serial loop-back test :

Typing any alphabetic character on the keyboard should result in that character being displayed twice on the screen (one from the local echo and the second from the loop-back receive data). Once the terminal emulator is connected to a WBo2 unit and is working, **commands** can be sent to WBo2, and it should provide responses. The commands to type are described here using angle brackets as delimiters; for example :

<i02>

... is an instruction to type the key sequence **i02** (ie. letter **i**, number zero, and number **2** followed by the **Enter** key. Note : do not type the angled brackets). Also note that the commands are case sensitive (ie. make sure the **Caps Lock** key is not depressed). The commands comprise a command character ("**i**" in the example above) plus parameters specific to each command; these will be described in a later section, but are all in hexadecimal format, and may take the following forms:

- nibble (single character) eg. **<m0>**
- byte (two characters) eg. **<i02>**
- w (four characters) eg. **<d2200>**

The majority of commands will respond with a hexadecimal response, for example the **<v>** command will return the response **"> 0042"**, which in this case is simply the software version number. Invalid commands (eg. **<vv>**) will return a **"Err vv"** string, indicating that the WB user interface software (UI) cannot process the command given, which is echoed back to the user. If the response is to be recorded, the command string will be followed with a pair of braces; for example

<i01> []

... implies that the response code should be noted, whereas :

<m0>

... indicates that the response is not of significance. Only the four hex digits need to be recorded.

When the WBo2 unit is first powered on, it will display a sign-on string such as:

tec2E0r0845

... which identifies the version of firmware installed in the unit. It is important that only firmware for the 2E0 product is used. Any 2E0 version is suitable for this test procedure, and it is recommended that the firmware is NOT upgraded to a later version until all steps have been completed.

Two seconds after the firmware version string is displayed, the WBo2 unit may start sending logging data, which may appear as random rubbish on the PC screen. The **<tf>** command will stop this data being sent,

allowing debug commands to be entered. To prevent logging transmission after subsequent power cycles, use the following sequence of commands:

<s0302> turn off auto-logging, and select CAL mode for the Tx frame type
<w> [] write config data to EEPROM, [ensure result is NOT 0x8000]

1.6 Test Modes

The User Interface can be used to set the WBo2 unit into different operating modes. The unit defaults to mode 1 (operational) which is indicated on a completed 2E0 unit with an AFR, eg. [14.7], or heater status indications on the end display, eg. [h0]. Prior to the majority of the tests to be taken, the WBo2 must be placed in mode 2 (config mode), using the following commands:

<m0> "off" mode, indicated on a completed 2E0 by displaying [OFF]
<m2> "config" mode, indicated on a completed 2E0 by displaying [CAL]

Result codes returned by WBo2 can be ignored for both of these steps.

1.7 Test Commands Available

Once in config mode, a number of UI commands will be used to generate test voltages and read the CPUs analog to digital converter channels, amongst others.

These are some of the commands, and required parameters, which are:

- **n** nibble (single hex character)
- **b** byte (two hex characters)
- **w** w (four hex characters)

cmd	param	resp	Action
a	w	data	Read EEPROM or RAM - depends on MSB of w MSB of w =0 read byte from EEPROM MSB of w =1 read word from RAM
e	w b	code	write b to EE, ram or registers
m	n	code	controls WBo2 main state machine
d	w	code	sets DAC (address embedded) 0xxx: both DACs 2xxx: DAC A (DACV) 3xxx: DAC B (WBVO)
p	w	code	sets PWM (address embedded) 0xxx: PWM A (SVout) 1xxx: PWM B (NBsim)
i	n1 n2	data	reads ADC channel n1 with mux set to n2
t	n n = 0 n = f n = ?	data	serial logging control, n=0, 1 .. e, f Send a single Tx Frame (only if Tx auto gen is disabled) Stop Tx Frames being sent (sets Tx auto gen OFF) Start Tx Frames sending (sets Tx auto gen ON if 0<n<f)
s	b1 b2	code	set config byte b1 to value b2
g	b	data	get config byte b
l	-	code	(ie. Letter <i>ell</i>) reload conf-RAM based data from EEPROM
w	-	code	write conf-RAM based config data to EEPROM
r	-	code	reload conf-RAM from ROM (<i>note</i> : command may change)
u	-	code	update system params from conf-RAM

v	-	code	display firmware version
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1.8 Analog Tests

Analog stimulation voltages generated by the DAC7612 **DAC** and taken from **U7p12** but a buffered version of this signal is also available at **Test Pin 2**. A commonly used test is referred to as a "DAC test", where a test voltage is generated, connected to a specified signal and a voltage measurement is performed. These all require the unit to be in config mode (**mode 2**, see section 1.6). An example of using the DACV signal would be:

```
<d27d0>          measure DACV (1.99, 2.0, 2.01)
```

Another set of tests uses the CPU's analog to digital converter (ADC) to sample a signal. In a similar fashion to the voltage measurements (section 1.3), a decision is made on the basis of a range of expected values; in the following, the ADC is used to measure a signal **<i02>**, the results are recorded ([]) and the result compared with the range given in parentheses.

```
<i02> [ ] (0x0189, 0x019A, 0x01AA)
```

It can be useful to use a pocket calculator to convert the hex numbers to decimal, if the reader is not experienced working with hexadecimal numbers.

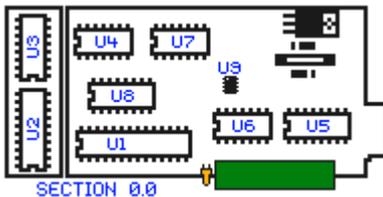
1.9 PCB Orientation, Test Points & Rev number

The descriptions below assume you are looking at the PCB so that the majority of the white silkscreen's writing reads normally (ie. left to right). The display PCB and red acrylic window are on the left and the black RJ45 connector is on the lower right. The green connector and the Amber heater LED are at the bottom.

Test points **TP1** to **TP5** are available on the board. **TP1** and the **DACV** testpoint are located just to the left of the FUSE, **TP2** is found directly below the fuse, between two electrolytic capacitors, **TP3** and **TP4** are directly above the centre of the green connector, and **TP5** is to the left of the DAC.

The PCB version or **Rev-** (ie. revision) number is printed on the component side at the top left of the PCB. Earlier boards were Rev-1, and Rev-2 is current from July 2005. The tests will refer to these Rev- numbers only if they are relevant to that test.

Section 2. Power Supply and Derived Voltage Tests



At this point, the WBo2 unit should be fully assembled with all discrete components and IC sockets, but **no ICs** should be loaded at this stage, except the **DAC7612** (it comes pre-soldered to the PCB) and the pair of 3 terminal **7805** voltage regulators (**U10**, located under the FUSE, and **U12**, located under the microprocessor's crystal). The power supply cable should be connected to a power supply (switched off), the sensor cable **NOT** connected, no Jumper Shunts installed, and the display board **NOT** connected.

2.1 Power Supply.

Connect the DVM's -ve (Black) lead to GND (a suitable point is the left end of D2, just below the fuse, marked **GND**). Connect the DVM's +ve lead (red) to the Anode side of D3 (ie. The leg opposite the ring marking on the PCB). This connection is to measure the +5V power supply voltage.

Briefly turn on the power supply and confirm the +5V supply. If other than 5V is present, turn off the supply immediately and investigate. Typically the Amber LED will be lit, but it will be tested further on.

2.2 +5V rail

Measure +5V (4.90, **5**, 5.10) { _ _ _ }

If no voltage is present then

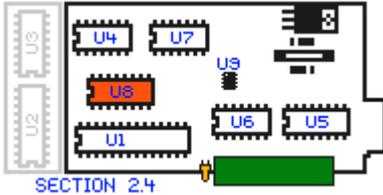
1. confirm there is power to the unit – measure the voltage at the top pin of Y4 (Call it VBatt)
2. Confirm that D1 has the band to the left and has power supply voltage on the right pin and on the left pin is at VBatt less a few 10ths of a Volt.
3. Confirm the fuse is not blown – if so, check for shorts in the area of the fuse, rectify, and then replace the fuse. If it blows again then you still have a short or D2 has been reversed (its band to the right).

2.3 Current Draw

If your power supply has a current meter,
the unit should be drawing no more than 100mA. { _ _ _ }

If more than 100mA is being drawn, remove power and check the polarized components, such as the Electrolytic capacitors have been installed correctly, and that no shorts exist on the +5v rail.

2.4 Reference divider for 2.0 Volts (VGND)



Install the **LMC6484** in position **U8** – note, it may be convenient to remove it later.

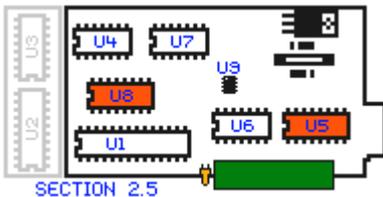
Measure **U8p12** (1.92, **2.0**, 2.08) { _ _ _ }

If not within these limits then check that **R5** and **R6** are correctly installed, and there are no shorts.

Measure **U8p13** (1.92, **2.0**, 2.08) { _ _ _ }

If not within these limits then check that **R7** is 100R and there are no shorts either side of R7.

2.5 RS232 positive supply



Install the **ST202** into **U5**. Measure U5p2 (9.0, 9.5,10.0) { _ _ _ }

If not within these limits then check for shorts around U5, and that the capacitors **C301** to **C305** are installed and there are no shorts across them.

2.6 RS232 negative supply

Measure **U5p6** (-9.0, **-9.5**, -10) { _ _ _ }

2.7 Serial loopback test

Jumper **U1p2** to **U1p3**

Perform the loopback test described in section 1.5. { _ _ _ }

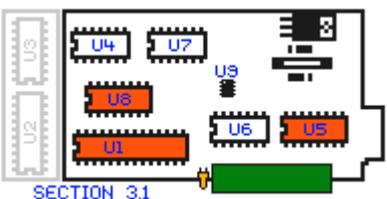
Remove the **U1p2** to **U1p3** jumper at completion of the test.

If no loopback is present then verify that loopback is possible by checking the DB9 directly by jumpering pins 2 and 3 of the RS232 cable's DB9 connector.

2.8 Auxiliary display supply (power on the RJ45 connector)

Measure voltage at **Y1p8** (top pin closest to **Y3**) This should be approximately at the supply voltage less 0.4V. { _ _ _ }

Section 3. CPU and Host Communications Tests



3.1 CPU startup

Install the **CPU (ATMega8)** at **U1**. Power on the unit. Connect the PC terminal emulator and verify the CPU

can communicate with the PC. { _ _ _ }

If not then either

- the CPU (**U1**) has not programmed properly (unlikely), or has no power,
- CPU has been zapped by static,

- there's a short on another of the CPU pins forcing it into a "strange" mode,
- the crystal (**X1**) is defective, or shorted, or open circuit, or,
- there's a short across **C307** or **C308** (the 15 pF capacitors), or capacitors are the wrong value.

3.2 Heater (Amber) LED operation

The amber heater LED should have a dim but fast flash of about 10 times/second however at this stage there are many causes for the LED to be inactive. { _ _ _ }

If no activity, check the LED's connection and wait until we do further checks below.

3.3 Firmware version, RS232 operation

Ensure that power to Wbo2 is turned off. Connect the RS232 cable and start the terminal emulator (see section 1.5). When WBo2 is powered up and running properly it continually (and blindly) pumps out RS232 logging data frames.

Now turn ON the power to Wbo2 and observe the default binary logging data stream. This will appear mostly as strange symbols. If you do not see any data from WBo2 then first check that Hyperterminal has been set up properly (see section 1.5), and then check the complete data path through RS232 chip U5 to the CPU U1.

We don't want this to intrude on our debugging so we'll turn off:

- <tf> turn off logging frames [we expect response "> 400F"]
- <s0302> turn off auto-logging, and select CAL mode for the Tx frame type
- <w> [] write config data to EEPROM, [ensure result is NOT 0x8000]

Now turn Wbo2 off, wait two seconds, and turn it back on. Ensure that there is a response such as "tec2E0r0845" which is made up of "tec", "2E0" & "r0nxx". { _ _ _ }

Further confirm communication from the PC to WBo2 is working by typing **V** to return the WBo2 unit's current firmware version number { _ _ _ }

Check there is a response then, depending on the firmware WBo2 has been flashed to :

for **Isu** <v> [] Ensure first two digits of response code are 08 { _ _ _ }

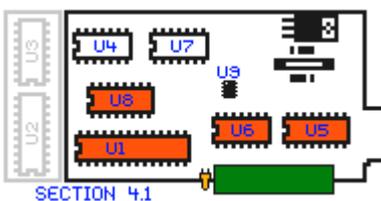
3.4 Emergency boot (Force re-flash function)

Power down unit. Insert a jumper shunt in **J2** at the bottom left of the PCB (marked **RESCUE**)

Power on the WBo2unit. Ensure terminal window shows string "**AlaR**" { _ _ _ }

Note, some random characters may appear prior to the required string, due to noise on serial line during power on. After testing, remove shunt **J2**.

Section 4. Analog Interface Circuitry Tests



4.1 SVout

Power down the unit. Install **LM324** at **U6** (the right of the CPU). Power on unit. Note: **SVout** is available at **TP2** as well as **Y1p1**, which is the RJ45 connector at the right of the PCB. **p1** is at the bottom of **Y1** (PCB view) or left (connector view). Ensure the **TP2** signal is routed to the **Y1p1** output too.

- <m0> <m2>
- <p0000> Measure **SVout** (0.0, **0.0**, 0.020) { _ _ _ }
- <p0200> Measure **SVout** (2.47, **2.5**, 2.53) { _ _ _ }
- <p03ec> Measure **SVout** (4.85, **4.9**, 4.95) { _ _ _ }

4.2 NBSim

Note **NBSim** is available at **TP3** as well as **Y5p6** and at **Y1p6** which is the RJ45 connector at the right of the PCB. **p6** is third from the top (PCB view) or right (connector view). Ensure the **TP3** signal is routed to the **Y1p6** output too.

The Jumper Shunt **J7** controls the 0-5v or 0-1v gain selection for Nbsim, and is intended for compatibility with ECUs requiring 0-1v inputs.

Install a Jumper Shunt at **J7 1-2** (marked with **5v**)

```

<m0> <m2>
<p1000>   Measure NBSim (0.0, 0.0, 0.020)           { _ _ _ _ }
<p1200>   Measure NBSim (2.47, 2.5, 2.53)           { _ _ _ _ }
<p13ec>   Measure NBSim (4.85, 4.9, 4.95)           { _ _ _ _ }
    
```

Remove the Jumper Shunt.

Install a Jumper Shunt at **J7 2-3** (marked with **1v**)

```

<m0> <m2>
<p1000>   Measure NBSim (0.0, 0.0, 0.020)           { _ _ _ _ }
<p1200>   Measure NBSim (0.47, 0.5, 0.53)           { _ _ _ _ }
<p13ec>   Measure NBSim (0.85, 0.9, 0.95)           { _ _ _ _ }
    
```

Remove the Jumper Shunt.

You may now place the Jumper Shunt on **J7** according to your intended usage.

4.3 Tacho Input

Connect **Y5p9** to **U4p9** (this uses an internally generated TTL signal **MUXB** to “tickle” the RPM circuitry).

```

<m0> <m1> (note M1, not M2 this time)
<s0301>
<t0>      Ensure second last field (RPM) contains an entry
           between 0x160 and 0x2A0                       { _ _ _ _ }
    
```

Remove the connection **Y5p9** to **U4p9**.

Note: Test results outside these limits are not a cause for concern, as long as they are non-zero, but may be of help in diagnosing a problem if the displayed RPM values are incorrect or ‘spiking’ when installed in a vehicle.

4.4 SPI (internal bus) and DAC (U9 = DAC7612)

The following tests that the CPU can communicate with the DAC via the internal SPI bus, and that the DAC’s output buffers are working.

```

<m0> <m2>
<d2000>   Measure DACV U4p15 (0.0, 0.0, 0.01)     { _ _ _ _ }
<d27d0>   Measure DACV (1.99, 2.0, 2.01)           { _ _ _ _ }
<d2fff>   Measure DACV (4.075, 4.095, 4.115)       { _ _ _ _ }
    
```

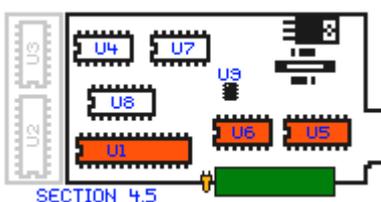
The next test is taken from the lower leg (The leg closest to the green connector) of **R216**, found directly below the **U6** silkscreen marking.

```

<d3000>   Measure WBVO R216 (0.0, 0.0, 0.01)     { _ _ _ _ }
<d37d0>   Measure WBVO (1.99, 2.0, 2.01)           { _ _ _ _ }
<d3fff>   Measure WBVO (4.075, 4.095, 4.115)       { _ _ _ _ }
    
```

If both tests fail then the DAC, or communications from the CPU to the DAC (via SPI) are not working properly. If one but not the other fails, then the relevant output circuitry must be checked.

4.5 ADC channels (User Input testing)



Note : the **74HC4052** mux **U4** and the **MC33204** op-amp **U8** must **not** be present for this series of tests.

4.5.1 ADC Channel 0

Jumper **U4p15** to **U4p13**. This is the DACV signal from the U9 DAC7612 to the CPU’s ADC0 input.

```

<m0> <m2>
<d2000> <i00>   [] (0x0000, 0x0000, 0x0000)           { _ _ _ _ }
<d27d0> <i00>   [] (0x0191, 0x019A, 0x01A2)           { _ _ _ _ }
<d2fff> <i00>   [] (0x0337, 0x0347, 0x0357)           { _ _ _ _ }
    
```

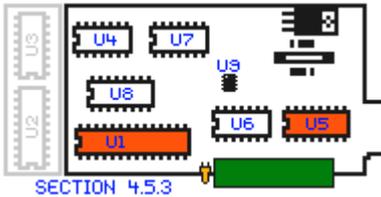
remove the **U4p13** end of the jumper ONLY for use in the next test ...

4.5.2 ADC Channel 1

jumper **U4p15** to **U4p3**

```
<m0> <m2>
<d2000> <i10>      [] (0x0000, 0x0000, 0x0000)      {____}
<d27d0> <i10>      [] (0x0191, 0x019A, 0x01A2)      {____}
<d2fff> <i10>      [] (0x0337, 0x0347, 0x0357)      {____}
```

remove the **U4p3** end of the jumper ONLY for use in the next test ...



4.5.3 ADC Channel 2

Remove **LM324** op-amp **U6** for the next test..

jumper **U4p15** to **U6p7** (we have moved from U4 to **U6** in this test).

```
<m0> <m2>
<d2000> <i20>      [] (0x0000, 0x0000, 0x0000)      {____}
<d27d0> <i20>      [] (0x0191, 0x019A, 0x01A2)      {____}
<d2fff> <i20>      [] (0x0337, 0x0347, 0x0357)      {____}
```

remove the **U4p15** jumper.

note for tests 4.5.1 to 4.5.3 : If any of the above 3 ADC channel tests fail then the path from the ADCn pin to the CPU should be checked for solder bridges or other shorts.

4.6 Multiplexer Control Logic

This confirms that the mux control signals from the CPU (that control routing of signals to the CPU's A/D inputs) are functioning correctly. MUXA & B are found on pins 10 (MUXA) and 9 of U4.

```
<m0> <m2>
<i01>              Measure MUXA (>4.8V)              {____}
                   Measure MUXB (<0.2V)              {____}
<i02>              Measure MUXA (<0.2V)              {____}
                   Measure MUXB (>4.8V)              {____}
```

4.7 Multiplexers, User inputs

The following tests verify the operation of the user inputs. First power down the unit, then

- install **74HC4052** at **U4**
- Install **LM324** at **U6**

Return power to the unit and perform the following tests 4.7.n test

4.7.1 User 1 Input

jumper **U4p15** to **Y5p1** – this routes the DACV voltage to the user input USR1

```
<m0> <m2>
<d2000> <i01>      [] (0x0000, 0x0000, 0x0002)      {____}
<d27d0> <i01>      [] (0x0191, 0x019A, 0x01A2)      {____}
<d2fff> <i01>      [] (0x0337, 0x0347, 0x0357)      {____}
```

remove the **Y5p1** end of the jumper ONLY for the next test ...

4.7.2 User 2 Input

Install Jumper Shunt **J5** to tie the **Ground Reference** of USR2 to Ground.

jumper **U4p15** to **Y5p2** – this routes the DACV voltage to the differential user input USR2

```
<m0> <m2>
<d2000> <i20>      [] (0x0000, 0x0000, 0x0002)      {____}
<d27d0> <i20>      [] (0x0191, 0x019A, 0x01A2)      {____}
<d2fff> <i20>      [] (0x0337, 0x0347, 0x0357)      {____}
```

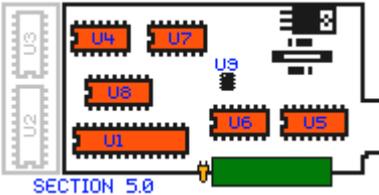
remove the jumper...

4.8 WBlin Output

The WBlin output is available at the **TP4** test point, but the output to the outside world is at **Y5p4** (**Y5p5** is the ground reference signal for WBLIN, and should be grounded by installing jumper **J4** during these tests.)

```
<m0> <m2>
<d3000> Measure WBlin (0.0, 0.0, 0.01) { _ _ _ }
<d37d0> Measure WBlin (2.39, 2.44, 2.49) { _ _ _ }
<d3fff> Measure WBlin (4.90, 5.00, 5.10) { _ _ _ }
```

Section 5. Sensor interface



Power down the unit and install **LMC6484** at **U7**, install **MC33204** at **U8**, All **IC**'s, on the main PCB, should now be installed.

Power the unit back ON.

5.1 Vref (VGND, 2.0 Volt Virtual Ground Reference)

```
Measure Vref at J1p2, ie. right above the U7 designator (1.92, 2.0, 2.08) { _ _ _ }
```

5.2 Vref Monitor

Ensure **J1** is installed

```
<m0> <m2>
<i03> [] (0x0191, 0x019A, 0x01A2) { _ _ _ }
```

5.3 Vs amp (Sense Cell Voltage, VsX1 & VsX5 inputs)

Connect DACV at **U4p15**, to Vs at **Y3p1**. **Y3** is the circular 8 pin connector at the right of the PCB and **p1** is at the top of **Y3** on the PCB.. There are two outputs to be tested, a **VsX1** and a **VsX5** signal.

```
<m0> <m2>
<d27d0> <i13> [] (0x0191, 0x019A, 0x01A2) { _ _ _ }
<i10> [] (0x0000, 0x0000, 0x0006) { _ _ _ }
<d29c4> <i13> [] (0x01F6, 0x0200, 0x020A) { _ _ _ }
<i10> [] (0x01E0, 0x0200, 0x020A) { _ _ _ }
```

Remove connection DACV to Vs

5.4 Ip Drive Circuit & Ip Sense Circuit

This test checks that the **Ip Sense** circuitry **U7C** correctly records the sense current that is made to flow through a temporarily attached 100 ohm resistor (this resistor is supplied with recent kits).

Connect the spare 100 ohm ¼ resistor from Ip to VGnd. The Ip signal is on **Y3p3** and **VGnd** is on **Y3p2**. It may be easiest to connect the 100 ohm resistor directly to pins 2 and 3 of the circular 8 pin connector at the right end of the PCB (in the 1 and 3 o'clock positions for a correctly assembled unit).

A DVM may optionally (test marked as * below) be used to directly measure the current through the 100 ohm resistor.

Note: The **<i00>** command reads the current as determined by the differential amplifier circuitry around U7C. The actual Ip drive circuitry is from U7D and the DAC we have already tested.

```
<m0> <m2>
<d27d0> * Measure Ip wrt VGnd (-0.02, 0, 0.02) { _ _ _ }
<i00> [] (0x0189, 0x019A, 0x01AA) { _ _ _ }
<d23e8> * Measure Ip wrt VGnd (-0.263, -0.272, -0.280) { _ _ _ }
<i00> [] (0x005D, 0x0060, 0x006D) { _ _ _ }
<d2bb8> * Measure Ip wrt VGnd (0.263, 0.272, 0.280) { _ _ _ }
<i00> [] (0x02BE, 0x02D4, 0x02E9) { _ _ _ }
```

Remove resistor from **Ip** to **VGnd**

5.5 H+ (vBatt) monitor

H+ is the voltage at the "High", or positive (+ve) side of the sensor's heater drive circuitry – this is also the full battery voltage vBatt. Circuitry monitors ¼ of this battery voltage. This test compares the value vBatt, measured directly using a multimeter, with the value sensed by the CPU.

```
<m0> <m2>
Measure vBatt          []                               { _ _ _ _ } *1*
<i30>                  [] call this value ADC – (it is in hex) { _ _ _ _ }
convert ADC value to decimal (ADCd) with a calculator          { _ _ _ _ }
convert ADCd to voltage (Voltage V = ADCd / 51.2)             { _ _ _ _ } *2*
compare V (*1* above) with the calculated value (*2*)          { _ _ _ _ }
```

A typical measurement is vBatt = 13.55v (measured at **Y3p7**), **<i30>** returns 02A8, which is a reading of 13.28v. An error of ±0.5v is acceptable.

5.6 H- monitor

H- is like H+ but measures the voltage on the other side of the heater. This side of the heater is switched to GND via the FET under control of the CPU. This test compares the value vBatt measured with a multimeter with the value sensed by the CPU. The 100 ohm test resistor should be connected to pins 6 and 7 of the circular 8 pin sensor connector Y3.

Connect **H+** (**Y3p7**) to H- (**Y3p6**) using the 100 ohm test resistor

```
<m0> <m2>
Measure vBatt          []                               { _ _ _ _ } *1*
<i11>                  [] call this value ADC – (it is in hex) { _ _ _ _ }
convert ADC value to decimal (ADCd) with a calculator          { _ _ _ _ }
convert ADCd to voltage (Voltage = ADCd / 51.2)             { _ _ _ _ } *2*
compare V (*1* above) with the previous value (*2*)          { _ _ _ _ }
unless immediately going on with the next test, remove resistor from H+ to H-
```

A typical measurement is vBatt = 13.55v (measured at **Y3p7**), **<i11>** returns 02A8, which is a reading of 13.28v. An error of ±0.5v is acceptable.

5.7 Heater current monitor

Note that due to the small currents involved, this test is only a rough guide to the functionality of the circuits involved.

```
<m0> <m2>
If not already connected, connect H+ to H- using 100 ohm resistor. (reads the Ih signal ...)
<i12>                  [] (0x0000, 0x0000, 0x002)                { _ _ _ _ }
Connect junction of R113 and Q2 to ground, this turns on the FET
Confirm the heater LED (AMBER) turns ON                          { _ _ _ _ }
<i12>                  [] (0x0008, 0x001F, 0x0030)                { _ _ _ _ }
remove the resistor from H+ to H-
```

This may make the resistor quite warm if left connected.

5.8 Vs Sensing

This test confirms that the sensors Vs signal pickup circuitry is correctly wired (also see previous section 5.3 that checks that the Vs amplifier is working properly). There are different procedures for the LSU (ie. **6066** & **7057**) and the NTK (ie. **L1H1** & **L2H2**) sensor versions.

First, and most importantly, ensure that :

- The NTK/LSU jumper shunt **J3** is in the correct position (1-2 for **NTK**, 2-3 for **LSU**).

For the **LSU** test, note that **Vs** measurements are performed with a DVM between **GND** and **Vs**, but the additional 1k resistor (not supplied in the kit) is connected between **VGnd** and **Vs**. The 1k resistor is best connected to the circular 8 pin connector Y3 (connect between pins 1 and 2).

LSU version only test

<m0> <m2>

connect an additional 1k resistor from **Vs (Y3p1)** to **VGnd (Y3p2)**

<e8031fc>

<e803234> Measure Vs with DVM (3.3, **3.45**, 3.6) { _ _ _ }

<e803214> Measure Vs (0.85, **0.95**, 1.05) { _ _ _ }

<e8031dc> Measure Vs (1.95, **2.0**, 2.05) { _ _ _ }

remove the resistor from **Vs** to **VGnd**

NTK version only test

<m0> <m2>

<e8031fc>

<e803234> Measure Vs with DVM (3.3, **3.45**, 3.6) { _ _ _ }

<e803214> Measure Vs (0.0, **0.0**, 0.2) { _ _ _ }

Section 6. Functional checks

6.1 Sensor Status Tests

if already switched **ON**, power **down** the unit for at least 10 seconds.

Important - ensure your sensor is **NOT** connected in the following tests.

Power unit on

Confirm the **Amber** Heater LED is flashing at 10Hz rate (very dim flicker) { _ _ _ }

<s0381> Set frame generation to ASCII/HEX mode

<s0432> Set frame delay to 0x32 (40 decimal)

<w> Save frame parameters to EEPROM (sets them as the default)

<t1> Start auto Tx frame generation

Tx Frames generation should begin and this will show on the terminal emulator screen.

In the following steps, the **status word** referred to is the **final** hexadecimal word shown.

6.1.2 VBatt low status threshold

Adjust the supply voltage down to **10V**.

Confirm status word indicates : battery low (**xxx2**) { _ _ _ }

Note that at some point, as the supply voltage is increased, we expect that at about 10.5 Volts the status word should change to **NOT Low battery Voltage** status.

6.1.3 VBatt high status threshold

Adjust supply up to **19.5V**

Confirm status word: battery high status (**xxx1**) { _ _ _ }

Note that at some point, as the supply voltage is decreased, we expect that at about 18.8 Volts the status word should change to **NOT High battery Voltage** status.

6.1.4 Heater circuit open status test

Adjust supply to **13.8V**

Confirm status word: heater open status (**xxx4**) { _ _ _ }

6.1.5 Heater circuit shorted status test

Connect H+ to H- (**Y3p6** to **Y3p7** on the circular 8 pin connector)

Confirm status word: heater short status: (**xxx3**) { _ _ _ }

Remove connection H+ to H-

6.1.7 FET Open

Temporarily short the heater driver FET (Q3) Gate to Source pin. Do this by connecting the outer most two pins of the Q3 (top right TO220 package).

Confirm status word: FET Failure status: (**xxx5**) { _ _ _ }

Remove connection across FET

6.1.8 Preliminary Cable Test

As a preliminary test of the Wbo2 to Sensor cable, the two recent tests **6.1.4** & **6.1.5** and the earlier **5.7** test should be repeated, but with the sensor cable now connected (but **NO** sensor actually connected) and the **H+** and **H-** points at the sensor end of the cable. Note for the LSU sensor, the **BLUE** wire is the **H+** lead, and the **WHITE** wire is the **H-** lead. Remember, maybe 25% of faulty DIY-kit units we get back here have badly constructed cables. It is vitally important you have followed the cable construction guide (on the web site at <http://wbo2.com/cable/default.htm> and are confident your cable is 100%.)

6.2 Heater Warmup – First test with Sensor Connected

Power down the unit and connect the sensor via the sensor cable. Ensure the sensor is in free air (this means it is open to the air and not exposed to other than the atmosphere). Be extra careful to place the sensor on a non-flammable surface as the sensor body rapidly gets too hot to touch – we suggest a ceramic surface such as a saucer or a small floor tile. A thick low sided jar also works well (make sure the table doesn't burn UNDER the container). If everything is operating correctly, and if the power supply can maintain the 13.8 Volts it should be set to, then the heater will rapidly heat and internally it will glow a cherry red in close to 20 seconds. Remember, a large percentage of people who experience problems at this point have a power supply that cannot maintain the required sensor heater current (up to 3 Amps) and at least 12 Volts AT THE SAME TIME – possible symptoms of include a continually resetting processor (version string may be repeatedly sent).

Power unit **ON**. System current should start at near 1A (25°C sensor) { _ _ _ }

Supply current should ramp to 2A over a 10 second period { _ _ _ }

Confirm status word: **xxx0** { _ _ _ }

Current drops to under 1A (value depends on VBatt) after 20 to 25 seconds { _ _ _ }

6.3 HPID lock

Confirm status word: xx00 { _ _ _ }

6.4 Vslp PID lock

Confirm status word: 0300 { _ _ _ }

6.5 Ipx check

Ipx is the third field in the broadcast frames. Until calibration is performed, this can vary considerably between sensors, hence the wide range given here:

Ipx between 0x1E00 and 0x2400 { _ _ _ }

Ipx delta (difference) between samples should not exceed 0x0020 { _ _ _ }

6.6 Use WBCAL program and confirm cal within range

7057 sensor between **3580** and **3700** (default **3630**)

6066 sensor between **3380** and **3500** (default **3430**)

NTK sensor between **3700** and **3940** (default **3800**) { _ _ _ }

Values outside these ranges may indicate an old or unusual sensor, but are not necessarily indicative of a problem.

Section 7. Calibration and Setup

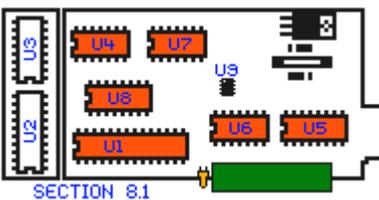
7.1 Free Air Calibration

The **CONF.exe** software, available from the **software** links at Wbo2.com should be use to calibrate the sensor. The sensor should be sitting in free air, and should be given a few minutes to heat up before running the calibration procedure.

Note that this calibration procedure relies on the sensor seeing the average “free air” oxygen concentration normally deemed to be 20.9%. If you blow on the sensor then the carbon dioxide in your breath will be seen by the sensor (ie. percent O2 will go down). If you leave the sensor sitting still for a long time then it will pump oxygen and the air around the sensor element will not have a 20.9% concentration. For best accuracy we suggest that you somehow organise a very low velocity supply of fresh air past the sensor while free-air calibrating. Perhaps slowly the waving the sensor element is an easy technique.

Section 8. Display Board

8.1 Display Board Checking

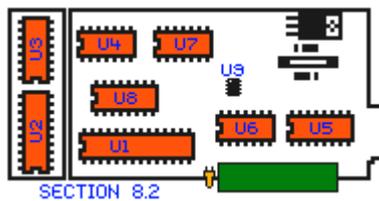


Power down the Wideband unit, and install the Display PCB, making sure that no **IC**'s are installed in the sockets of the Display PCB yet. Only the D2PAK (surface mount) **LM7805** voltage regulator, and the discrete components (resistors, capacitors, LEDs, wire links) should be installed.

NOTE: It is **Important** that the **TAB** of the **LM7805** is properly soldered to the PCB.

Power up the unit, and check the following with a multimeter.

Measure U2p20	(4.95, 5.00, 5.05)	{ _ _ _ }
Measure U3p1	(4.95, 5.00, 5.05)	{ _ _ _ }



Power down the unit, install the **TB62710 (U2)** and **TPIC6C595 (U3)**. Ensure they are installed the correct way.

8.2 Display Board Function

8.2.1 Initial Testing.

Power up the unit without a sensor installed.

The display should show **tE**,
then after a short delay, **h0**.

If nothing is displayed, or garbled characters, check that the LED module is installed in the correct orientation. Also ensure that the **TB62710 (U2)** and **TPIC6C595 (U3)** are not hot to the touch, and the unit (with no sensor connected) isn't drawing excessive current (>200mA).

Power down the unit.

8.2.2 Function testing.

Power up the unit with a sensor installed. Ensure the NTK/LSU jumper is set correctly.

Connect a sensor to the Wideband unit,

The display should show **tE**, after a short delay..
The display should show **H..** while the sensor is heating,
then a LEAN indication, eg. **L**.

Test the Unit by squirting butane (from a cigarette lighter) into the end of the sensor.

When RICH, expect to see **r**.
Then a rising AFR value, eg.. **14.7**.
Then a LEAN indication. **L**.

More information on the various status indicators will be available soon, but the LD02 user's guide available at <http://wbo2.com/ld02/guide.htm> is worthwhile reading, as the functions are almost identical.

8.2.3 Pushbutton testing.

Press PB1 repeatedly (The rightmost button as you face the display),

The LED brightness should cycle through 4 settings.

Press PB2 (The Leftmost button), while squirting butane into the sensor.

The Display should switch between Lambda and AFR (gasoline/ULP) indication.

9.0 Final Setup.

Refer to the Section on Shunts at <http://wbo2.com/2e0/kit.htm>, and decide which Jumper shunts to install as appropriate for your application.

Install the 2E0 into the grey case, ensure the screws are firmly installed (a drop of hot-melt glue securing the screws to the PCB may be appropriate to eliminate vibration), Apply the sticker, and install into your vehicle.

Problems or questions may be directed to the support group at

<http://autos.groups.yahoo.com/group/oz-diy-wb/>

or the Tech Edge contact page at

<http://www.techedge.com.au/contact.htm>

We appreciate any feedback you may provide on any obvious errors you found in the document.

Appendix A. Change History

0.1		Document generated from 2A0 test procedure 28 June 01 (draft)
0.2		Test done manually and Document checked by Adam, 08 July.
0.3		Add images showing IC's required at critical stages 13 July.