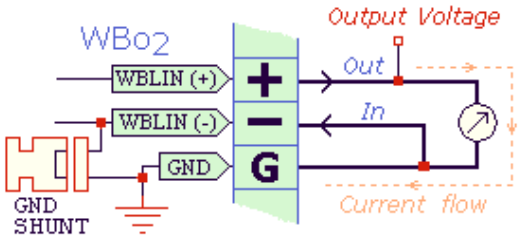
WB_{lin}+/- Explanation & Issues

Apart from our first **WBo2** (**2A0**) unit, all **Tech Edge** **wideband** products have "differential" **WB_{lin}+** and **WB_{lin}-** output pins. This feature can be used to good advantage to reduce the effects of *noise* and *voltage offsets* that can be present in an automotive measuring situation. Most units are shipped with this feature **disabled** because we have found many people don't understand how it works.

This *technical note* explains how the feature works and how you can use it. If it looks too complicated then scroll down to the hookup example section, but we suggest you read through this to understand how **WB_{lin}+** and **WB_{lin}-** can enhance your WBo2 usage. Remember that there is software to Configure WBlin outputs.

WB_{lin} Quick Overview ... WBlin- is an Input!



The wideband linear output voltage appears at the **WB_{lin}+** output pin (**+** in diagram). The **GND** pin (**G** in diagram) is also important when using WBlin+ because any current drawn from the WBlin+ pin must return via the GND pin. The **WB_{lin}-** pin (**-** in diagram) is **not** an output but a *reference input* for the WBlin+ output driver. Within reason, small voltages, either positive and negative, fed into the WBlin- pin will be added to the WBlin+ output, and this allows small *offset voltages* between WBo2 and the measuring device (ECU, logger, etc.) to be automatically factored out. Because WBo2 uses up to 3 Amps of current, when it is operating normally, the GND point WBo2 sees may be higher than the GND point seen by the measuring device. On the other hand, if a high current device uses WBo2, then the ground voltage difference may be reversed. As described below, this difference between WBo2 and the device can be factored out by correctly inter-connecting WBo2 and the other device.

The WBlin+ output can drive just a few milli Amps of current and the *current is limited* by a **100 Ohm** resistor so the maximum shorted current is **10 mA** per volt of output, but the output op-amp will itself limit the current before this point is reached. Plan on using no more than **5 mA** of current which means the input impedance of your device, as seen by the WBlin+ output, should be higher than **1 kOhm**. This means that many moving coil voltmeters, can be directly driven.
Tip : Always remember that :

- WBlin is the most accurate of the voltage outputs (usually a 12 bit DAC).
- WBlin- is a high impedance input that is used to offset the WBlin+ output.
- Any current drawn from the WBlin+ output returns via the GND point.
- Check the internal WBlin-GND shunt - it is usually in place when you buy WBo2.

WB_{lin} +/- "Differential " Outputs

First, an explanation about the **"differential"** *output* name. We called it that because many better quality data loggers have *differential inputs* and to indicate what we're trying to do, we hijacked the name . Technically speaking our differential output can better be described as output (**WB_{lin}+**) with a *ground reference input* (**WB_{lin}-**). What! our output is really an input? Well, yes. To find out what's happening, first we'll look at the *problem we're trying to solve*.

The image *(fig 1. at right)* shows the **OUT**PUT buffer in your **WBo2** unit (left of the dotted line). It is connected to a **Logger** (or recording device) with an **IN**PUT buffer stage. The central green dots represent the **WBLIN** or **wideband** output pin, and the **GND** is the ground level common to both WBo2 and the logger.

The left circle with a **wave** symbol represents the voltage at **A** *generated* by WBo2 (this will be some value between 0 and 5 Volts). The right circle with an **arrow** represents the voltage *measured* at the **B** point (with a voltmeter or by the device itself).

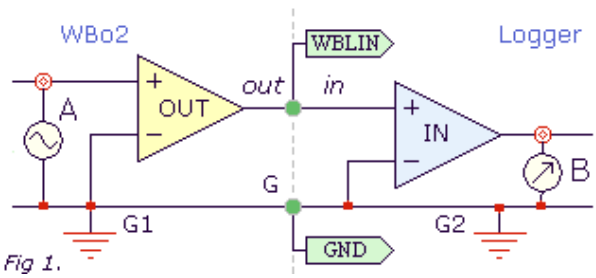


Fig 1.

Ideally the *measured* voltage (**B**) is the same as the *generated* voltage (**A**). The problem is that in any real world installation there will be small voltage differences between the two GND points **G1** and **G2**. Why, and what effect will this have? ...

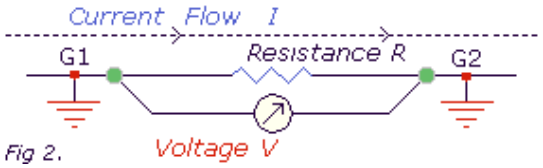


Fig 2.

In any real vehicle *current* flows through the vehicle's body *(refer fig 2. at left)*. Any conductor, including the vehicle body, has a certain ***resistance R*** that can be measured between two points (say **G1** & **G2**). The **R** will produce a *voltage* difference **V** when current **I** flows. Note: *V* = *I*/*R* according to Ohm's law.

It's important to note that the current between **G1** & **G2** doesn't need to be passing into **G1** or out of **G2**, but currents from other parts of the vehicle can cause a voltage difference between **G1** & **G2**. How does this affect us? ...

To see what can happen, first we divide the green dots *(from fig 1. above)*, representing the Input/Output & GND, into distinct input and output points. We also split the **G** point into **GND1** and **GND2** points representing the GND at the WBo2 *out* (G1) and at the logger *in* (G2). Lastly, we add a voltage source between G1 and G2 points *(see fig 3. at right)*. This source generates a **NOISE** voltage. So, what's the problem? ...

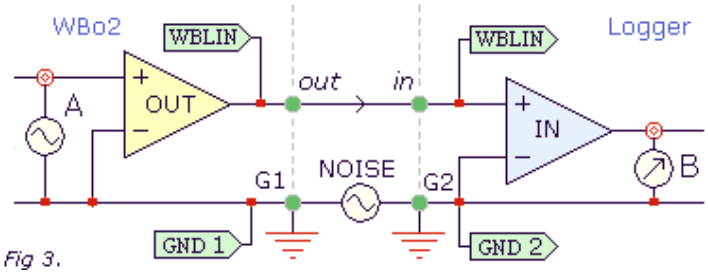


Fig 3.

Although the *out* & *in* points are at the same voltage, the NOISE voltage means the voltage between ***out*** and **G1** is *not the same* as between ***in*** and **G2**. In fact the voltage *measured* at **B** = voltage *generated* at **A** + **NOISE**. What can we do to get more accurate measurements? ...

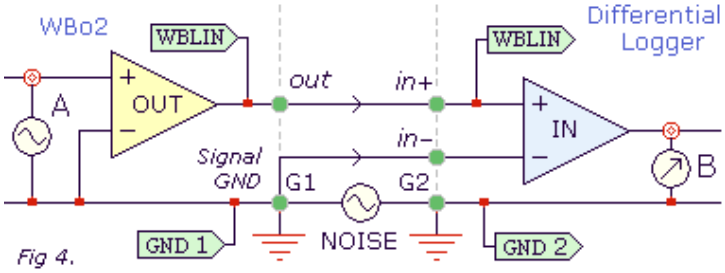


Fig 4.

Better quality loggers have differential inputs designed to avoid **noise** and ground loops. They will have **In+** and **In-** input pins to indicate that they log the *difference* between the + and - voltages. The image *(fig 4. at left)* shows how the new **In-** input of the logger is connected to the existing **G1** point.

Note that it's very important that **In-** is connected as close as possible to WBo2's **signal GND** because WBo2 itself generates internal noise that can be seen between the signal and **power GND** points.

So, what if you don't have a differential logger? ...

One solution is to use the logger's **Signal GND** (**G2**) input point as a **Reference Input** (**out-**), and with the aid of a special op-amp circuit, raise or lower the **out+** signal to compensate as **out-** changes. The image *(fig 5. at right)* shows this.

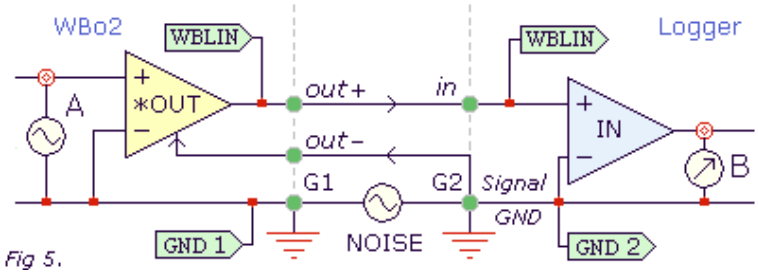


Fig 5.

In practice, this circuit works quite well when there's electrical noise and when the **out-** input is terminated correctly. But there are some restrictions. The **out-** input may go below the **GND1** voltage, so that the ***OUT** circuit must be able to also go below **GND1**. This implies the ***OUT** circuit's *-ve* supply must be powered from a negative voltage with-respect-to (WRT) GND. Similarly, as **out-** can have a positive value, the ***OUT** circuit's *+ve* supply must be powered from something more positive than WBlin's maximum positive voltage (ie. > 5 Volts).

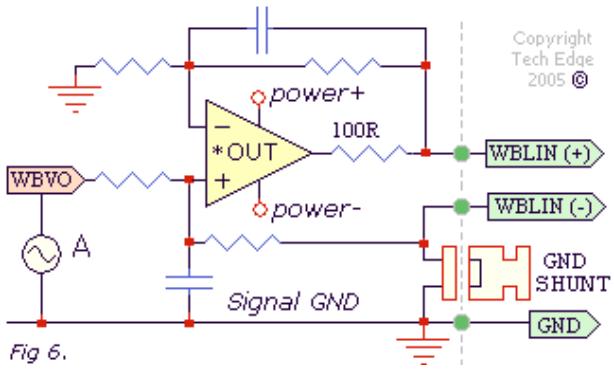


Fig 6.

The image *(fig 6. left)* shows a practical implementation of the above circuit that we have dubbed the "**differential output**" But we have added one important feature, the **GND SHUNT** (a **shunt** is also knows as a **jumper**).

The GND shunt is installed by default to ensure the ground reference input **WB$_{lin}$-** is not left floating. Remember that **WB$_{lin}$-** is the reference for the **WB$_{lin}$+** output. If left unterminated, **WB$_{lin}$-** could float above or below the **GND** point and cause the **WB$_{lin}$+** output point to also float up and down (as measured **w**ith-**r**espect-**t**o the **GND** reference). In the worst case, with the shunt unconnected and **WB$_{lin}$-** floating, the **WB$_{lin}$-** input could *add noise* to the output rather than remove noise as it was designed.

WB$_{lin}$ +/- Hookup Examples

These diagrams show WBo2's **WB$_{lin}$+/-** & **GND** connected to external devices such as loggers, ECUs, etc. The WBo2 connections *(left)* are shown in **green** (**+**, **-**, & **G**) and the logger *(right)* in **blue** (**I**, **+I**, **-I** & **G**). The input **I** is *single ended* and **+I** & **-I** are *differential inputs*. Although the default connection works, removing the jumper can result in better

performance.

A. The **default WBo2 configuration** for **WB_{lin}+/-** is shown in the image *(fig 7a. at right)*. This configuration is a *single ended output with GND return*. The internal shunt (ie. jumper) is ON so that **WB_{lin}-** uses the WBo2 GND point as a reference. This configuration suffers from *poor noise rejection*, but avoids the possible situation of an unterminated **WB_{lin}-** picking up noise.

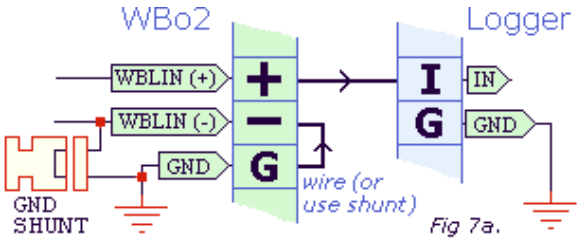


Fig 7a.

To minimise noise, keep the power cables short and connect WBo2's power ground at the same point as the logger's ground. Note that the external wire from **GND** to **WB_{lin}-** has the same function as the shunt **GND SHUNT**.

B. The image *(fig 7b. at right)* is the *configuration for using a differential logger*. The internal shunt (ie. jumper) is ON so that **WB_{lin}-** uses the WBo2 GND point as a reference. This configuration has *good noise rejection* by virtue of the logger's differential input. It can also be used for driving a high impedance moving coil meter (+ to +, - to -).

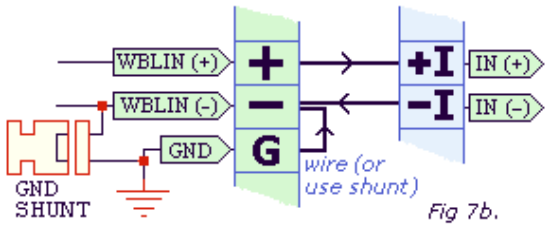


Fig 7b.

As many loggers (this includes ECUs) only have a single-ended input, this configuration may not be possible, but see the next example where the differential output feature is put to good use.

C. The image *(fig 7c. right)* shows the **best compromise** for connecting a *single ended logger* to WBo2's "differential" output. It compensates for ground noise by referencing **WB_{lin}+** to the logger's GND voltage. Note carefully that neither shunt nor wire connects WBo2's **GND** point to the **WB_{lin}-** input as doing so disrupts the remote GND sensing scheme.

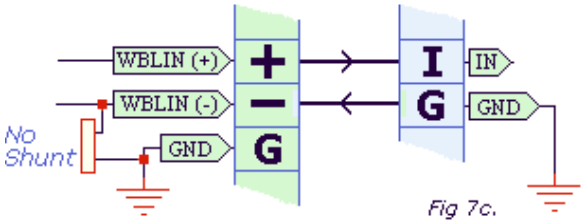


Fig 7c.

Note that it is **very important** that **WB_{lin}-** is connected to **GND** *at the logger end* as loss of that connection results in the following undesirable scenario ...

D. The image *(fig 7d. right)* shows how ***NOT* to connect *WB_{lin}-***. In this case **WB_{lin}-** is left unterminated and can pick up noise. The problem is also that **WB_{lin}-** can slowly rise above GND potential and it will bring the **WB_{lin}+** output up with it, making the WBo2 output useless.

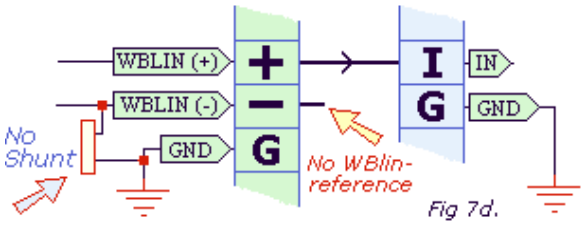


Fig 7d.

Locating WB_{lin}-GND Jumper Shunts

Refer to the product page for your controller to find where the WBlin-GND shunt is located.

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