

# UBA External Devices Manual

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# Introduction

This manual describes the use of external devices with your UBA.

The UBA is a very versatile battery analyzer: it can test almost all types of batteries. But there are some battery tests the UBA can't perform. That's why we've included three accessory ports on the UBA that can be used to connect to external instruments. This manual shows you how to use the first accessory port (the other two aren't yet supported).

This manual describes how the UBA can use external loads, chargers, voltage amplifiers, current and temperature sensors. With these devices, you can greatly expand the functionality of the UBA.

Appendix A includes a description of the format for describing the external devices in the calibration file, and a hardware description of the accessory port.

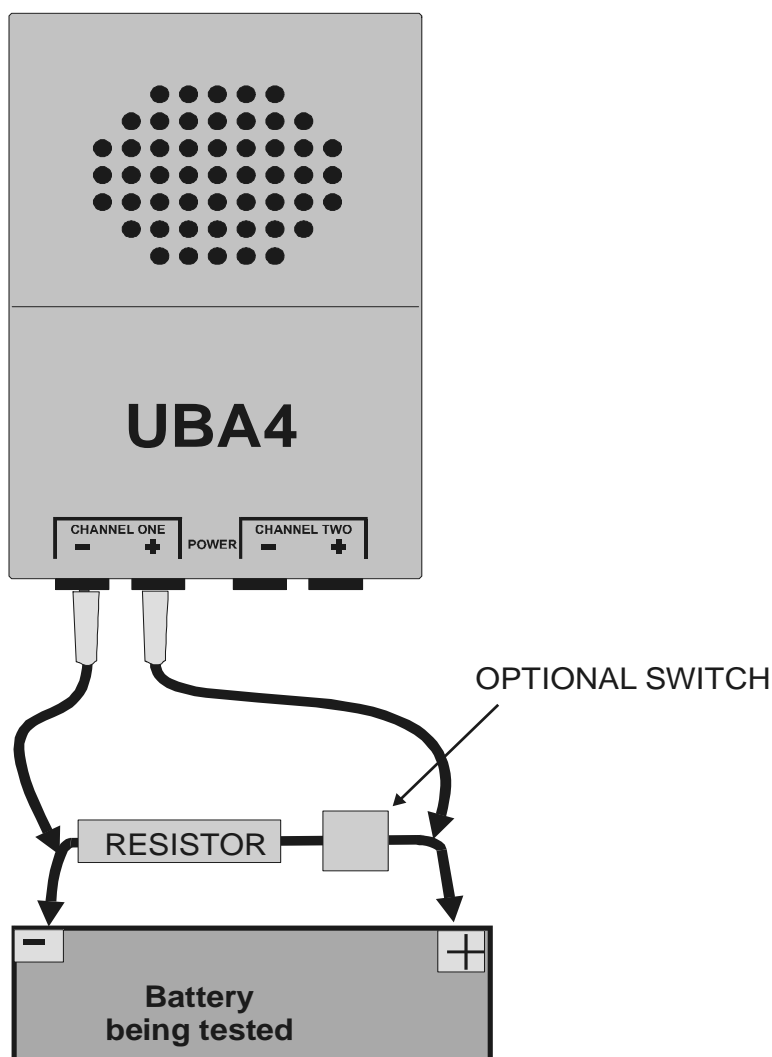
## Using a Resistor as an External Load

You may want to use a resistor instead of the UBA's internal load as a load for battery testing. Here are reasons why:

1. You require a load current greater than that which the UBA can supply. For example, you want to discharge a battery at 10A. You could buy two or three UBAs and combine their channels, but a power resistor is generally less expensive.
2. You require a load current less than that which the UBA can supply. For example, you want to discharge a small "button" size battery. You can buy a UBA modified with its load current controllable down to less than a milliamp, but a resistor is less expensive.
3. You want to discharge a primary battery with a resistor to test to the ANSI specification.
4. You want to discharge the battery down to 0V, match the intended load, or monitor the charge or discharge current of a battery in situ.

### *Method 1 - Manually Connect the Resistor*

The simplest way to use a resistor as a load is to connect it to the battery and then start a battery analysis. The UBA then acts as a data logger.



Adding a switch makes it easier to connect the load to the battery and start the battery analysis simultaneously. For the battery analysis, use a battery analysis routine (BAR) with a load current of zero and a cut off voltage of zero (a data logger BAR). UBA Console will record the voltage while the battery is being discharged. You can calculate the load current by dividing the battery voltage by the load resistance and you can calculate the battery capacity by integrating the current. You can integrate the current by importing the test results into a spread sheet and creating a column with the load current (in milliamps) where each cell is calculated by dividing the voltage by the load resistance. Create a delta capacity column beside the current column where each cell is the current multiplied by the time between rows (in hours). The sum, shown in the delta capacity column, is the capacity (in mAh).

### Example for manually calculating capacity

Time (hours)	Voltage	Current (mA)	delta capacity
T <sub>0</sub> (start time)			
T <sub>1</sub>	V <sub>1</sub>	$I_1 = V_1/R * 1000\text{mA}$	$\square C_1 = I_1 * (T_1 - T_0)$
T <sub>2</sub>	V <sub>2</sub>	$I_2 = V_2/R * 1000\text{mA}$	$\square C_2 = I_2 * (T_2 - T_1)$
....			
T <sub>N</sub>	V <sub>N</sub>	$I_N = V_N/R * 1000\text{mA}$	$\square C_N = I_N * (T_N - T_{N-1})$
			Total: $\square C_1 + \square C_2 + \dots + \square C_N$

The problem with using this method for rechargeable batteries, is that the battery isn't automatically disconnected when it reaches its cut-off voltage, this may overdischarge and damage it, and UBA Console doesn't give a current during the test nor a capacity afterwards – you have to do this manually. An improvement on this test is to specify the resistance of the resistor load you're using, which brings us to the next method.

### Method 2 - Manually Connect the Resistor and Specify Its Resistance

If UBA Console knows the value of the load resistor, it cannot only calculate the load current and display it during the battery analysis, it can also display the capacity discharged in real time and record the final capacity. UBA Console uses the resistor value to calculate the load current and capacity.

### Calibration File Modifications

The UBA Console receives the value of the load resistor from the UBA calibration file. The load resistor is specified as an external load device as follows:

**ExtLoadDevice: name 3 resistance limit**

*name* is a name you give the resistor; '3' is the model number for a resistor; *resistance* is its resistance in ohms; and *limit* is the maximum power in Watts that the resistor can dissipate (use '0' for no limit).

Example, a 5 Ohm 2W resistor.

```
*ExtLoadDevice: name model resistance limit (this line is an
optional comment)
ExtLoadDevice: Resistor-5R 3 5 2
```

For further details, consult the *UBA External Device Reference* in Appendix A.

For this method you have to manually connect and disconnect the load resistor, below we show you how to have the UBA do this for you.

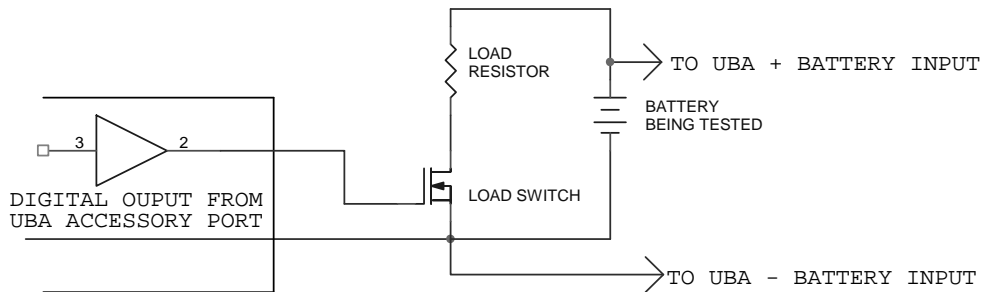
For maximum accuracy we suggest that you have the UBA's battery leads connect across the resistor load and switch if used and then run wires from the resistor to the battery. This way UBA Console will use the voltage across the resistor to calculate the load current and, if you specify the wire resistance from the battery to the load, will display the battery voltage with the voltage drop removed.

### Method 3 - The UBA Controls the Load Resistor

With this method, UBA Console connects the resistor load at the beginning of the discharge cycle and disconnects it afterwards. It requires something to control the load, such as the Vencon HCLM (high current load module) the Vencon Relay Module or you can build your own load controller using the output from the accessory port as described below.

#### Controlling the Load with Direct Digital Drive

This circuit requires only one FET. But you can use this circuit only if you have direct access to the accessory port, either on the UBA PCB (available if no other accessory port 1 accessories are used) or via a connector mounted on the back of your UBA (if ordered with your UBA).

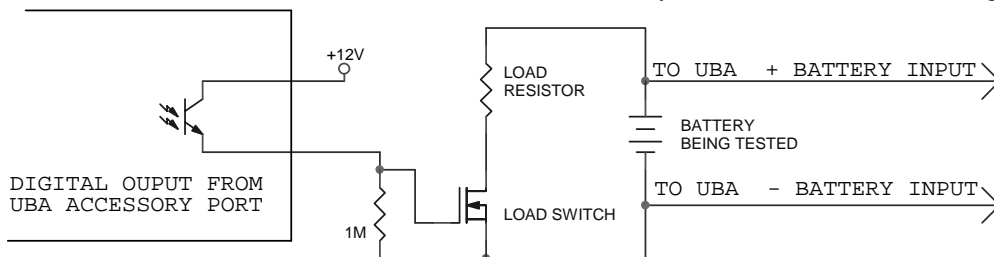


CONTROLLING THE LOAD WITH DIRECT DIGITAL DRIVE

The digital output directly drives a FET. A logic level FET is recommended because the maximum output of the UBA is 5V (no load). A logic 1 on the accessory port output connects the load resistor. Try to use a digital output that has a default (reset) low value (DO1) so that, after reset, the load is switched off. Keep the wire from the battery negative to the FET as big and as short as possible to minimize any voltage drop.

#### Controlling The Load With Optically Coupled Drive

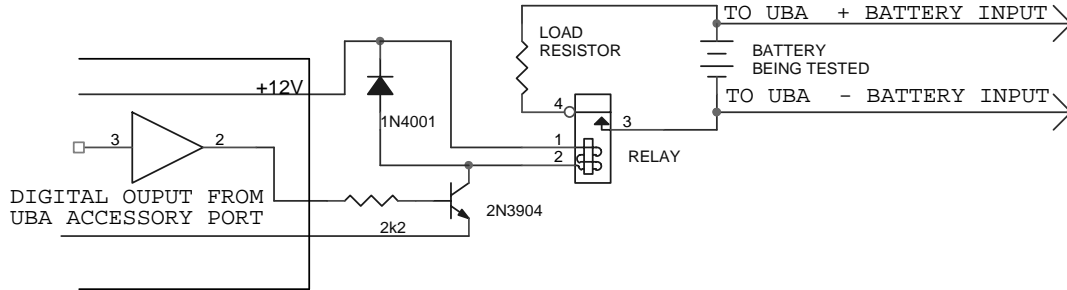
If you have an opto-coupled accessory output use this circuit. It requires 8 to 15 Volts to supply the voltage to the FET (or less if you use a logic level FET). You can use an external power supply, the battery being tested (if its voltage is high enough), or a small 9V battery. Although this circuit is a bit more complicated than the direct-drive circuit, it isolates the switch from the UBA and is best when using high current loads, which is an advantage. Try to use a digital output that has a default (reset) low value (DO1) so that, after reset, the load is switched off. Note: because this circuit is isolated, you can use it to control a charger.



CONTROLLING THE LOAD WITH OPTICALLY COUPLED DRIVE

## Controlling The Load With A Relay

This circuit uses the digital output to control a relay. Choose a relay to control a high current or because its contacts are isolated from the UBA, to control an external charger.



CONTROLLING THE LOAD WITH A RELAY

## Calibration File Modifications For a Controlled Resistive Load

As for an uncontrolled resistor load, the load's resistance is specified in the UBA's calibration file as shown below. It uses a similar format to an uncontrolled resistive load, with the additional ExtLoadControl field.

```
ExtLoadDevice: name 3 resistance limit ExtLoadControl
```

*name* is a name you give the resistor; '3' is the model number for a resistor; *resistance* is its resistance in ohms; *limit* is the maximum power in Watts that can be dissipated in the resistor (use '0' for no limit); and *ExtLoadControl* is the name of the device that connects (controls) the resistor.

The external load control is specified in a line right after the "ExtLoadDevice" line as follows:

```
ExtLoadControl: name 2 dochan_on dochan_off maxamps
```

*name* is a name that you give this control; '2' is the model number for an electronic switch; *dochan\_on* and *dochan\_off* are the digital output channels that turn the load on and off; and *maxamps* is the maximum current that this control can support.

The *dochan\_on* or *dochan\_off* entry is expressed in the form: "...cba" where each letter represents a output line, i.e.: "a" represents accessory digital output 0 and "b" represents digital output 1 (in the future "c" will be digital output 2 located on the 2<sup>nd</sup> accessory port). Setting the digit to "x" means no change; to "1" means set the line high; and to "0" means set the line low. *dochan\_off* can also have a value of "!" which means the opposite of *dochan\_on* (that is almost always what you want).

Example 1:

A 1 Ohm 100W resistor controlled by a FET driven directly by the accessory digital output line '1' where a high on this line turns the FET on would be specified as follows:

```
*ExtLoadDevice: name model resistance limit ExtLoadControl
ExtLoadDevice: My100W1RLoad 3 1 100 DirectSwitch
```

```
*ExtLoadControl name model dochan maxamps
ExtLoadControl: DirectSwitch 2 1x ! 10
```

Notes:

- specifying the ExtLoadControl controlling the ExtLoadDevice (“DirectSwitch” on the ExtLoadDevice line) tells UBA Console that this resistor is controlled and there’s no load current if the ExtLoadControl is off;
- the dochan of “x1 !” means that setting digital output ‘1’ high turns on the load and setting it low turns off the load;
- an exclamation mark (explained later) is not used after ExtLoadControl because digital output ‘1’ is set low after reset (but adding the exclamation mark won’t hurt and is probably a good idea).

Example 2:

A 2 Ohm 10W resistor controlled by a FET driven directly by the optical isolated accessory digital output line ‘0’ (a high on this line turns the FET on).

```
*ExtLoadDevice:  name  model  resistance  limit  ExtLoadControl
ExtLoadDevice:  My2OhmLoad  3      2          10      OptoSwitch

*ExtLoadControl  name  model  dochan  maxamps
ExtLoadControl!: OptoSwitch 2      x1 !    3
```

Notes:

- the dochan of x1 means that setting digital output ‘0’ high turns on the load;
- we’ve added an exclamation mark (!) after ExtLoadControl, to instruct UBA Console to set this control OFF (i.e. digital output ‘0’ low) after initializing the UBA. This is necessary because digital output ‘0’ is set high after reset and will remain that way until the ExtLoadControl! line is read in the calibration file.

For further details, consult Appendix A.

## **Testing With The Battery Connected to The Accessory Port**

You can use a resistor load when using an external amplifier (see *Running UBA Console to Monitor Charger Voltage and Current*) for the battery voltage. The external amplifier might be a high impedance amplifier for electrochemical research or a high voltage attenuator (amplifier with negative gain) for testing high voltage batteries. In that case, the external resistor load is assumed to be connected to the battery, and not the voltage going into the UBA.

For example:

```
*ExtVAmp:  name  model  aichan  Vin0  Vout0  ...  Vin_n  Vout_n
ExtVAmp:  10xAmp  2      0      0.0   0.0    ...  0.1   1.0

*ExtLoadDevice:  name  model  resistance  limit
ExtLoadDevice:  1R-Load  3      1          100
```

The example is using an amplifier with a gain of ten and a 1 Ohm resistor. If the battery voltage is 100mV the voltage going into the external analog input will be 1V. UBA Console will calculate 100mA as the current through the 1 Ohm resistor.

## **Combined Channels**

You can use an external resistor with combined channels. You may want to combine channels to increase the charge current, but still use a resistor for the load. In that case, UBA Console uses the voltage that is displayed when calculating the resistor load current. It works if you are using the average of all the combined channels (default) or you are selecting one of the battery inputs as the battery voltage.

If you prefer to use a different voltage for calculating the resistor current, you can use an external load device model 2 to describe the resistor. That model allows you to specify the source from which to sample the voltage used to calculate the load current.

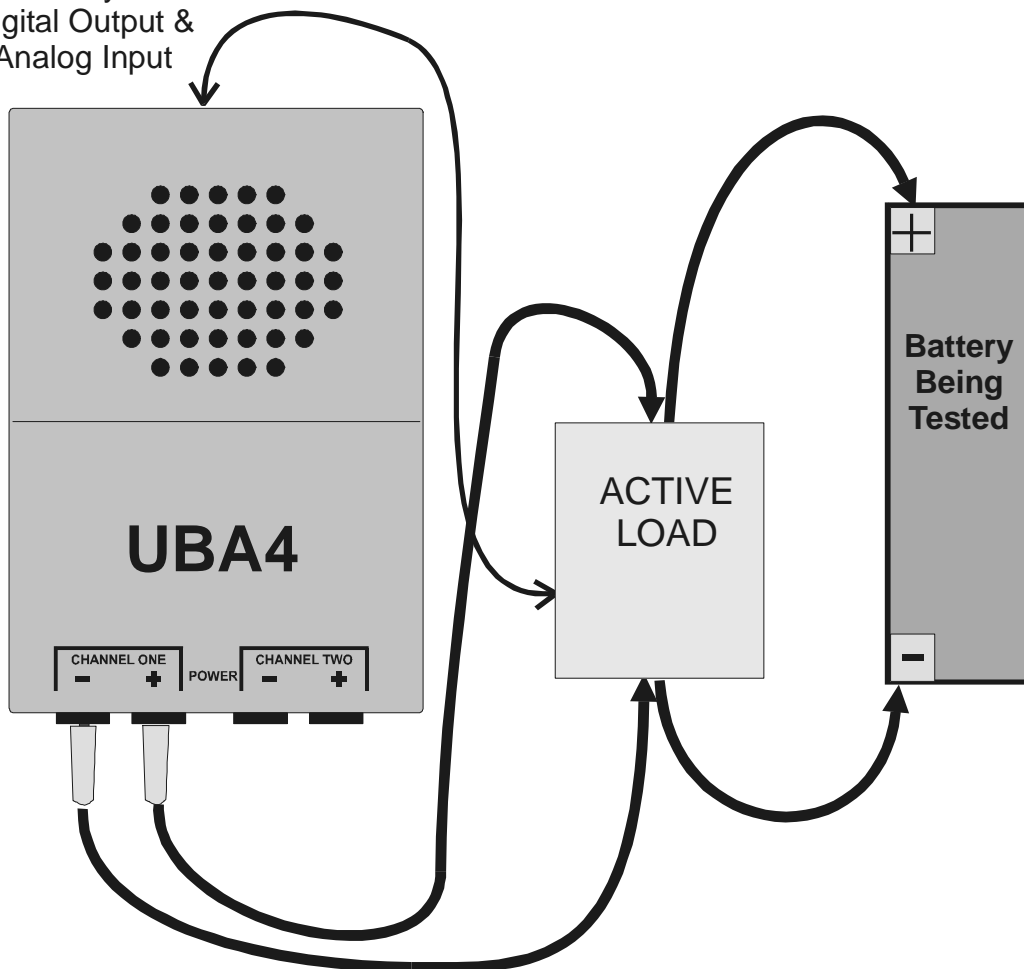
# Using an Active Load as an External Load

You can program your UBA to control an active load instead of the UBA's internal loads. Your UBA can turn on the active load at the beginning of the discharge cycle, measure the load current (if the active load has an analog output signal), and turn it off at the end of the cycle. You can program this to repeat.

## ***Controlling the Active Load***

The UBA controls the active load via a digital output on the accessory port. If the active load has a voltage output that represents the current, the UBA can monitor it with the analog input on the accessory port. The following is the way the active load should be set up:

Accessory Port:  
Digital Output &  
Analog Input



Note, the UBA is connected to the Active Load and not to the battery. This is done for two reasons. First this reduces the ground potential difference between the UBA and the active load which would interfere with the control and measurement of the active load. And second UBA Console assumes that it's measuring the voltage across the load and, if requested by setting the external resistance, can compensate for the voltage drop from the load to the battery.

## Calibration File Modifications For an Active Load

The ExtLoadDevice line, in the calibration file, describes if the UBA controls the ExtLoadControl line.

The ExtLoadDevice line specifies the type of load (constant current or constant resistance), the load current or resistance, and whether it's controlled. The ExtLoadControl line specifies how the load is controlled (only on or off are currently supported).

These lines are specified as follows:

```
ExtLoadDevice:  name 2 aichan limit control Iin0 Vout0 ... Iin_n Vout_n
ExtLoadControl!: name 2 dochan_on dochan_off limit
```

Where for the external load device *name* is a name you call the device; '2' is the model number for a general load; *aichan* is the analog input channel; *limit* is the maximum current; *control* is the name of the external load control that controls this device; and "*Iin0 Vout0...*" describe the I-V characteristics of the device. For the external load control, *name* is a name you call the control, '2' is the model number for an electronic switch, *dochan\_on* and *dochan\_off* are the digital output channel on and off settings and *limit* is the maximum current. For further information see Appendix A.

Depending on the type of load you have, there are a number of possible ways to program it, as shown below.

### Uncontrolled Constant Current Load with no Current Measurement

If your active load isn't controlled (i.e., is always on) and does not have a measured current output, you need only to specify the ExtLoadDevice with no analog input.

Example – 10A load.

```
*ExtLoadDevice: name model aichan limit control Iin0 Vout0
ExtLoadDevice: CCLoad1 2 -1 0 <none> 10 0
```

This specifies an ExtLoadDevice called CCLoad1 that doesn't measure a current output signal (the "-1"), isn't controlled by an ExtLoadControl (the "<none>"), has no current limit, and is always 10A.

### Uncontrolled Load with Current Measurement

If your load isn't controlled, but does have an output voltage representing the load current you need only an ExtLoadDevice line in the calibration file.

Example:

```
*ExtLoadDevice: name model aichan limit control Iin0 Vout0
ExtLoadDevice: CCLoad2 2 1 0 <none> 10 1
```

This specifies an ExtLoadDevice called CCLoad2 with an output voltage signal representing load current. This signal is connected to accessory input 1 and a 10A load current gives an 1V signal (UBA Console assumes 0A gives 0V, thus an effective resistance of 0.1R).

### Controlled Constant Current Load with no Current Measurement

If your active load is controlled (i.e., can be turned on and off) but has no voltage output representing current, you need an ExtLoadDevice and ExtLoadControl line in your calibration file.

Example:

```

*ExtLoadDevice: name model aichan limit control Iin0 Vout0
ExtLoadDevice: CCLoad3 2 -1 0 CCSwitch3 10 0

*ExtLoadControl name model dochan maxamps
ExtLoadControl: CCSwitch3 2 x0 ! 20

```

This specifies an ExtLoadDevice called CCLoad3 with no current signal output, and no current limit. It draws 10A when turned on. An external load control called CCSwitch3, which turns on the load by putting a digital low on digital accessory output 0 and can control up to 20A, is also specified.

## Controlled Load with Current Measurement

You will need an ExtLoadDevice and ExtLoadControl line in your calibration file.

Example

```

*ExtLoadDevice: name model aichan limit control Iin0 Vout0
ExtLoadDevice: CCLoad4 2 1 0 CCSwitch4 100 1

*ExtLoadControl name model dochan maxamps
ExtLoadControl!: CCSwitch4 2 0x ! 20

```

This specifies an ExtLoadDevice called CCLoad4 with analog current signal on accessory input 1 that's controlled by CCSwitch4, has no current limit, and has 1V for 100A of current (effective resistance of 10mR).

An ExtLoadControl called CCSwitch4 which turns on the load by putting a digital low on digital accessory output 1 and has a 20A current limit, is also specified.

## Resistive Load Described As an Active Load

For a resistive load it's possible to specify a model of 2 (general load instead of 3 for resistor) and specify the I-V characteristic of a resistor. As an example:

```

*ExtLoadDevice: name model aichan limit control Iin0 Vout0
ExtLoadDevice: RLoad 2 -3 0 RSwitch 1 2

*ExtLoadControl name model dochan maxamps
ExtLoadControl!: RSwitch 2 x1 ! 20

```

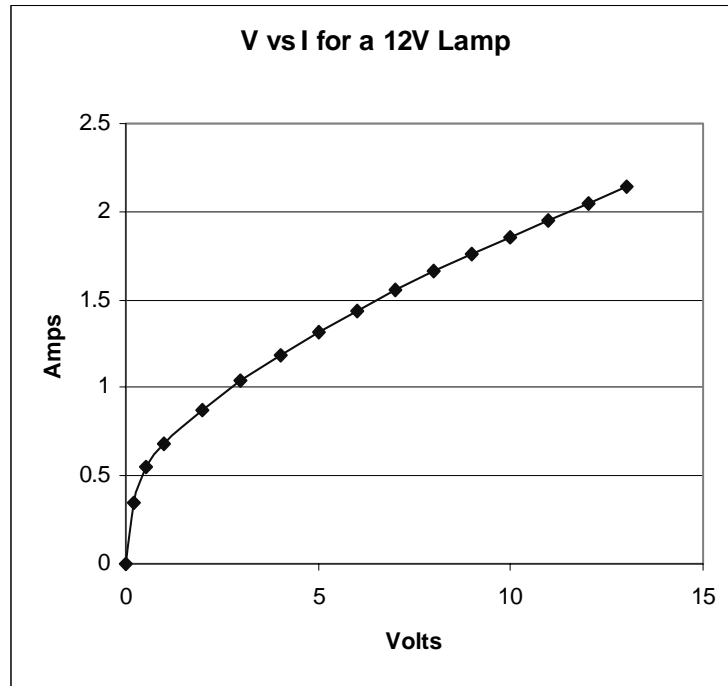
This specifies an ExtLoadDevice called RLoad with analog current signal on the battery input (which is what happens when a resistor is used) that's controlled by RSwitch, has no current limit, and has an output of 2V at a current of 1A (resistance of 2R).

An external load control, RSwitch, turns on the load by putting a digital high on digital accessory output 0 and has a current limit of 20A.

## Using a Non-Linear Load as an External Load

What about if you have a non-linear load, for example a light bulb or an electronic device. You can't describe it as a resistor which is linear. You probably thought that you can't describe it as an active load, because it isn't. But you can. Here's how. Say for example you have a light bulb as a load. We measured one at various voltages and got the following table and graph.

V (V)	I (A)
0	0
0.2	0.35
0.5	0.55
1	0.68
2	0.87
3	1.04
4	1.18
5	1.32
6	1.44
7	1.56
8	1.66
9	1.76
10	1.86
11	1.95
12	2.04
13	2.14



From the graph you can see that the V-I curve not straight. But you can describe the light bulb fairly accurate by a series of linear line segments. We do that by copying the data directly from the V-I table above (first reversing the V and I numbers) into the I-V description of the external load device. We get the following line:

```
*ExtLoadDevice: name model aichan limit control Iin0 Vout0
ExtLoadDevice: Lamp 2 -2 0 <none> 0 0 0.35 0.2 0.55 0.5
0.68 1 0.87 2 1.04 3 1.18 4 1.32 5 1.44 6 1.56 7 1.66 8 1.76 9 1.86 10
1.95 11 2.04 12 2.14 13
```

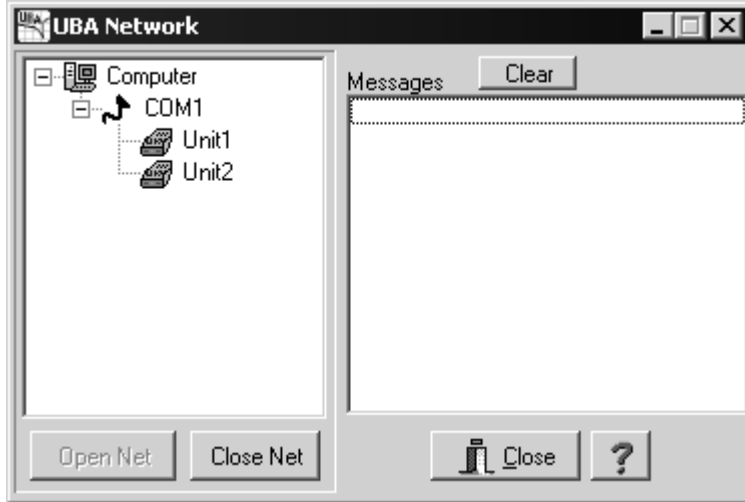
Another way to handle a non-linear load is to simply measure the load current. See the section "Using a Resistor as a Load Current Sensor" for an explanation.

## Running UBA Console with an External Load

When you start a battery test you have to specify that you are using an external load device and it has to be specified in the BAR. Begin by making sure you've added the correct lines to your calibration file and that everything is set up correctly.

### ***Step 1 - Verify that UBA Console has read any external devices in the calibration file.***

In UBA Network, double click on your UBA (Unit1 is this example).



You will get the UBA window. Click on Accessories and the following window will appear:



UBA Console has read the external load device “**MyBigLoad-1R**” and the external load control “**DirectSwitch.**” The “OK” means that the lines have passed a simple format test.

### ***Step 2 - Verify that the calibration lines and set-up are correct.***

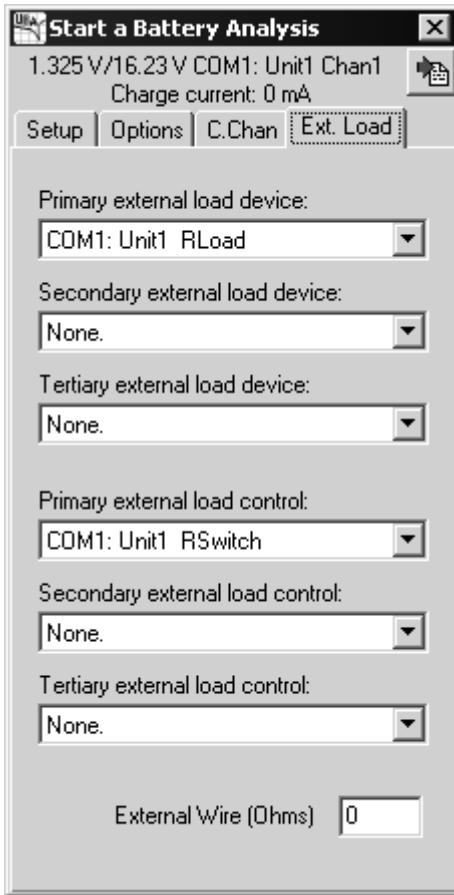
Close these windows and open a Multitester: choose the External Load tab then choose an external load device. If you have a external load control select it and turn it on by clicking on the “On” button. If the battery and load are connected, you should see the measured current displayed (you may have to wait a few seconds).

### **Step 3 - Run a Battery Analysis**

Before you can run a battery analysis, you must make a battery analysis routine (BAR) that uses the external device and control. Open an existing or a new BAR and choose or create the load action that’s to use the external load. Choose Primary for the external load device (and for the external load control if you have one) as shown below.



Save the BAR and start a battery analysis. Click on the External Load tab and choose the external load device to use as the primary load device and similarly for the external load control.



Now start the battery analysis. When the discharge action with an external load specified starts, the load will be connected (if an external load control is used) and the load current calculated and displayed.

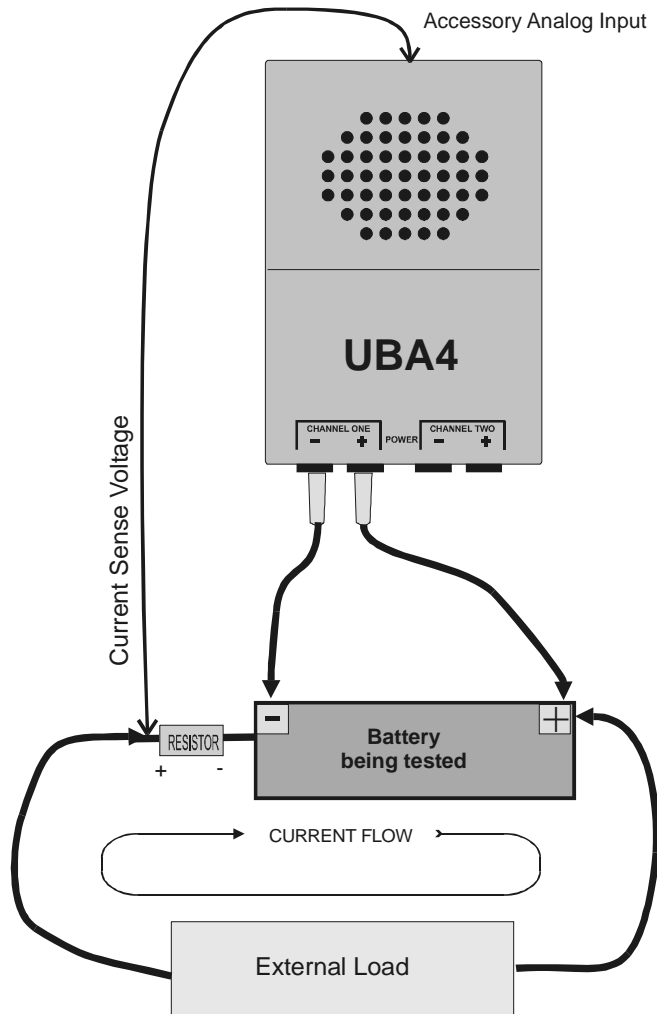
If you have more than one external load device or external load control, call one the primary and the other the secondary. You can control up to three devices and three controls in one battery test.

# UBA Load Monitoring

This describes the ways to use an external resistor to sense load current. This is an advanced application and is meant only for esoteric battery testing applications.

## ***Using a Resistor as a Load Current Sensor***

When using an external load resistor with your UBA you normally connect the resistor to the load (with or without a control mechanism). But you can also use a resistor to measure load current. Use the following set up:



Notice that the resistor is in series with the battery and an external load. The UBA can measure the voltage across this resistor to calculate the load current.

Connect the current sense voltage to the analog input on the accessory connector and the UBA will use it as the load current. This works only when using an external load, not the UBA's internal load.

Since the UBA is measuring the voltage across the battery (and not the external load) use a value of 0 for the external wire resistance.

## Warning

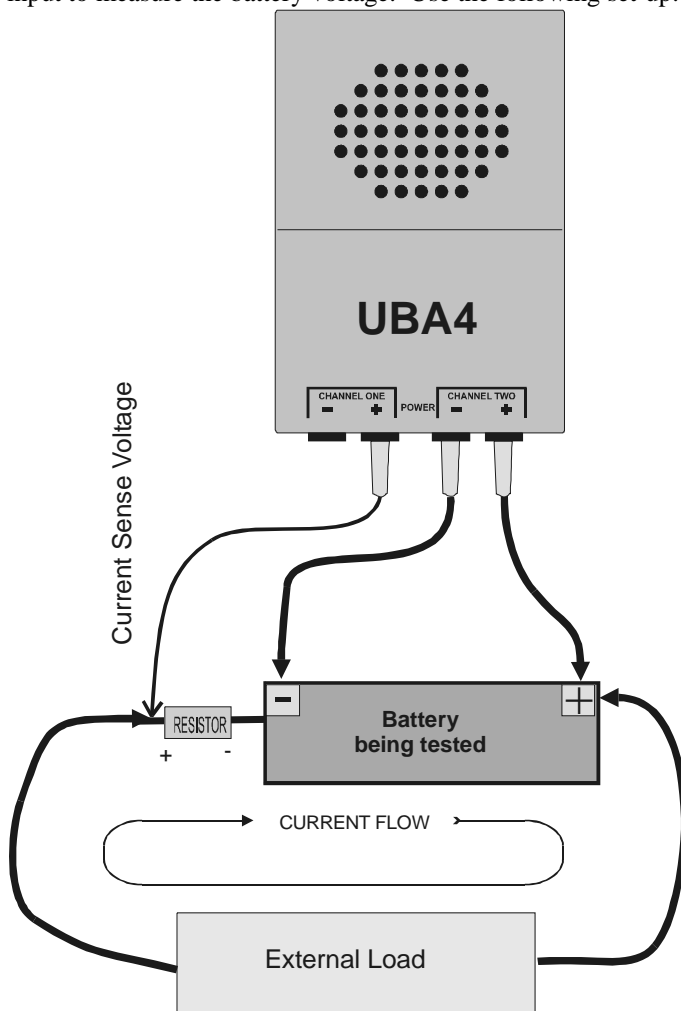
The accessory port is not protected against ESD (electrostatic discharge) nor voltages outside the range from 0 to +5V. The UBA warranty does not cover damage to the accessory port.

If you're using this set-up with a 0.5 Ohm sense resistor, you would add this to your calibration file:

```
*ExtLoadDevice:      name      model aichan limit control Iin0 Vout0
ExtLoadDevice:  CurrentSense  2      1      10  <none> 1 0.5
```

Because the resistor is being used to sense the current and not as the load, we have to use a general load (model 2). Doing so enables us to specify that the accessory port monitors the current sense voltage. In this example we've specified an "aichan" of 1, which is accessory port 1 analog input '1'.

If you want to use an current sense resistor, but don't have any accessory connector installed specify a combined channel UBA and use the channel 1 input to measure the current sense voltage and channel 2 input to measure the battery voltage. Use the following set-up:



This set up isn't as accurate as connecting the current sense voltage to the accessory input because the low voltage range of the battery input is 0 to 7V, or almost one third less sensitive than the accessory input. But the battery voltage input is more accessible and better protected against over-voltage.

For this set up add to the calibration file:

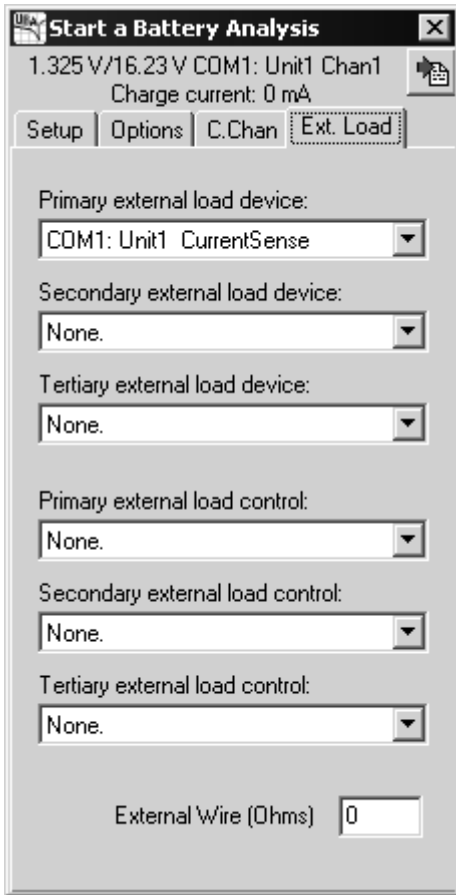
```
*ExtLoadDevice:      name      model aichan limit control Iin0 Vout0
ExtLoadDevice:  CurrentSense 2      -2      10 <none> 1 0.5
```

Here we specify '-2' as the aichan, which means that the resistor voltage is applied to the actual physical battery input (which in a combined channel set-up is the first battery input). Set up the UBA to use combined channels 1 and 2 and specify that channel 2 is to be used for the battery input (so it doesn't average channel 1 and 2). Now the virtual UBA will be using channel 2 for the battery voltage and channel 1 for the current.

With either of these set ups, the load current will be monitored and recorded with the battery voltage. To use this in a battery test you need to select the current sense resistor for the load current. First make a battery analysis routine (BAR) and specify "Primary" for the external load device, as shown below:



Then when starting a battery analysis, specify this BAR and choose "CurrentSense" for the primary load device as shown below. The battery analysis will interpret the sense resistor current as the load current.



# Using a UBA to Test a Battery Charger

One of the reasons customers purchase a battery analyzer is that their batteries aren't giving the performance they expect. Buying new batteries doesn't solve the problem because users don't know if the problem is caused by defective batteries, incomplete charging, or because batteries are being damaged by either equipment or chargers.

The UBA can be used to monitor battery voltage and current while a battery is being charged and discharged by the customer's equipment. By examining the voltage and current profile one can see if the battery is being properly charged and discharged, i.e., not overcharged and not overdischarged.

## **Important Note**

The circuitry inside the UBA is grounded via the serial line (if using a grounded PC, which is the case for desktop systems) and by the power supply (if using a grounded power supply, which is what we supply with the UBA). The negative battery inputs on the UBA are connected to this ground. Therefore if your equipment is not electrically floating, you have to isolate the UBA or your equipment from ground. You can isolate the UBA with a serial port optoisolator and a linear power supply (both available from us).

## **Warning:**

The accessory port is not protected against ESD (electrostatic discharge) nor voltages outside the range from 0 to +5V. The UBA warranty does not cover damage to the accessory port.

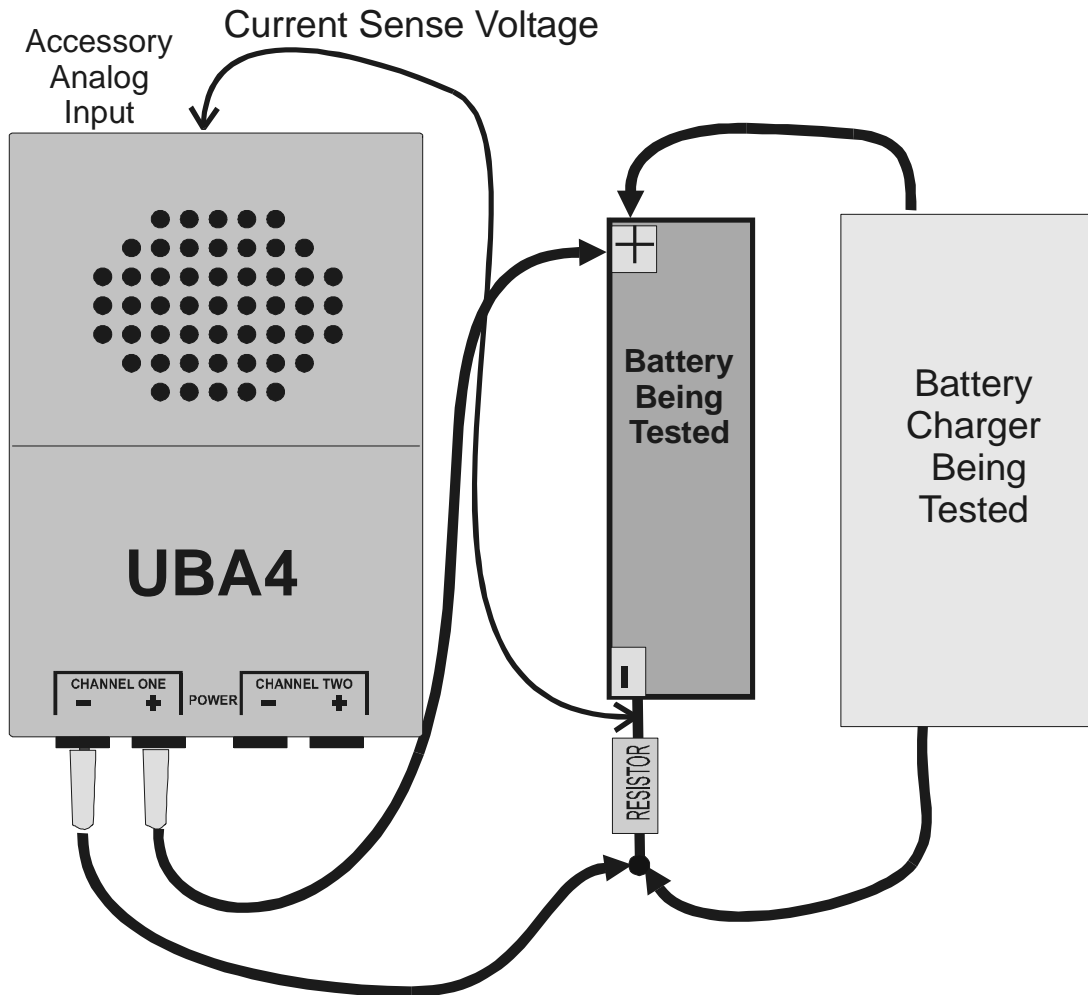
## ***Monitoring Charger Voltage and Current***

The UBA can monitor both the battery voltage and charging current (and, optionally, the battery temperature) while a battery is being charged with your equipment. After the charger has finished, you can plot the battery voltage and current, and examine the total charge delivered to the battery. Based on these observations, you can monitor how the charger is working.

In order to measure the charger current, you need to put a small value resistor in series with the battery. The UBA can monitor the voltage on this resistor and convert it into a charge current. In addition, it will integrate the charge current to give you a capacity reading.

You want to choose a current sense resistor with a small enough value that doesn't effect the charging, but not so small that its voltage is difficult to sample accurately. We recommend a resistor less than 1 Ohm, preferably from 0.1 Ohm to 0.5 Ohm. In the Vencon High Current Load Module, we use a 2 milliohm resistor with an amplifier; it has a small voltage drop, dissipates little power, yet uses the full range of the UBA's ADC. The resistor should have a 1% tolerance and should be rated at least twice the expected power it will dissipate (use  $P = I \times I \times R$ , where  $P$  = power in Watts,  $I$  = current in Amps and  $R$  is resistance in Ohms).

To use the UBA accessory analog input set up your UBA as shown below:

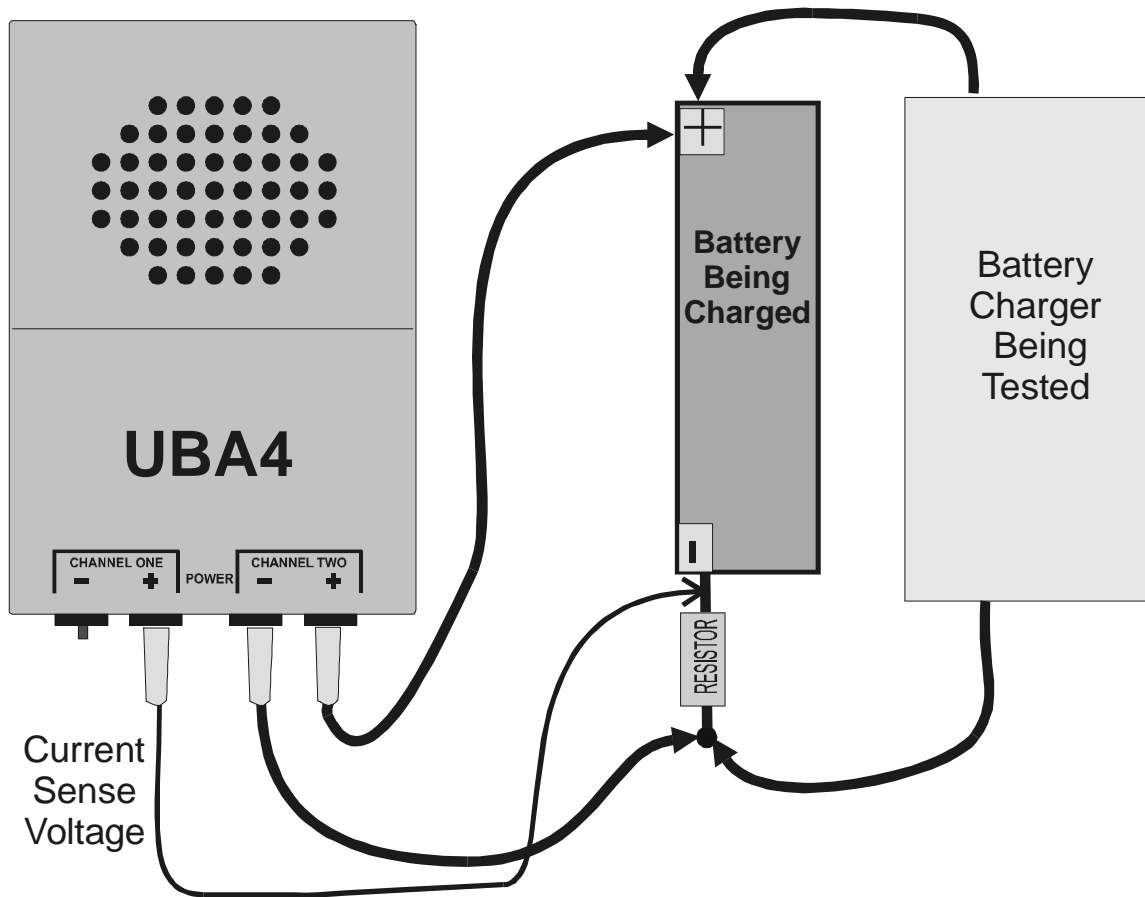


Add these lines to your calibration file:

```
*ExtLoadDevice:      name      model aichan limit control Iin0 Vout0
ExtLoadDevice:  CurrentSense 2      0      10  <none>  1 0.5
```

The ExtLoadDevice line describes a resistor with a 10W power rating and a 0.5 Ohm resistance, with the voltage on the resistor connected to Analog Input '0' on the accessory port.

Alternatively if you don't have an accessory connector installed, you can use the channel 1 input to measure the current sense voltage and the channel 2 input to measure the battery voltage as follows:



And add these lines to your calibration file:

```
*ExtLoadDevice:      name      model aichan limit control Iin0 Vout0
ExtLoadDevice:  CurrentSense 2      -2      10 <none> 1 0.5
```

Here we specify '-2' as the aichan, which means that the resistor voltage is applied to the actual (physical) battery input. UBA Console has to be set-up to use combined channels, specify that channel 2 is to be used for the battery input (so it doesn't average channel 1 and 2). As a result, the virtual UBA will be using channel 2 to get the battery voltage and channel 1 for the current.

## ***Considerations for Monitoring Charger Performance***

### **Pulsing Charge Current**

Many chargers (including the UBA) will sometimes pulse the charge current. In that case, you will have to add some filtering to the output of the current sense resistor. A simple RC filter might be enough. If the charge current is pulsed, the battery voltage will have some ripple on it. You can electrically filter this noise or just ignore it because UBA Console does some digital filtering.

### **Battery Voltage Error Due to Sense Resistor**

The current sense resistor will increase the battery voltage that both the UBA and the charger measure. That's the reason it's better to use a sense resistor with as small resistance as possible (but not too small, because it will increase the error in the current measuring circuitry).

A future UBA Console update can account for this extra voltage by subtracting it from the measured voltage reading.

## ***Running UBA Console to Monitor Charger Voltage and Current***

Ensure that you've added the appropriate lines to the UBA calibration file; then initialize the UBA. You can check that the ExternalLoadDevice and ExternalLoadControl lines in the calibration file were read by clicking the Accessories button on the UBA window (get this from the tree window in UBA Network by expanding on the COM port and double clicking on the UBA you are using). You should see the ExternalLoadDevice listed, and the ExternalLoadControl, if you specified one.

If you are using channel 1 to measure the charge current, start a virtual UBA (click on the Icon or Instrument|Virtual UBA) and add channel 2.

Test the set-up by starting a Multitester. If you are using channel 1 to measure current, select the "Setup" tab and change the "Get battery voltage from" list to COM1: Unit1 Chan2 (substitute your COM port and Unit number).

Note: the UBA Console does not support an external resistor during charge, but does in discharge mode. As long as you don't specify a load current, there's no problem in treating your set-up as if you're using an external load.

Click on the "External Load" tab. Drop down the "External load control" list and choose which external load control you are using (if you have one). If you are using an external load control, click on the "On" button. The charge current should be displayed in the "External load measured current" line.

Once that you have verified that everything is working in Multitester, you are ready to start a battery test. First, make a BAR (Battery Analysis Routine) that will act as a data logger. Start with a new BAR and add a Discharge Cycle (we have to use a load action because UBA Console doesn't support external devices for charging). Set the cycle up as follows:

1. Discharge Current: 0
2. Write to results file every: 5 (set this to your preference)
3. Click on the External tab.
4. Choose "Primary" for the ExternalLoadDevice.
5. Choose "Primary" for the ExternalLoadControl (if you are using one).

Now save the BAR.

Start a battery analysis and enter:

1. The number of cells
2. The battery capacity
3. The Battery Analysis Routine Filename; enter the BAR we just created
4. A Battery Analysis Filename; enter a filename to store the results.
5. If you are using channel 1 to monitor charge current, select the "Options" page and under "Get battery voltage from" choose ....Chan2.
6. Choose "External Load" tab. Choose the external load device under "Primary external load device" and if you are using an external load control, choose it under "Primary external load control" and then.
7. Now you can start the battery analysis (and if you haven't already, connect or start the battery charger).
8. Once the analysis has started, right click on the window and choose Grow and check the battery voltage and current.
9. When the charger finishes, stop the battery analysis and then use a spread sheet to examine the voltage and current graphs.

## Using an External Charger In a Charge/Discharge Cycle

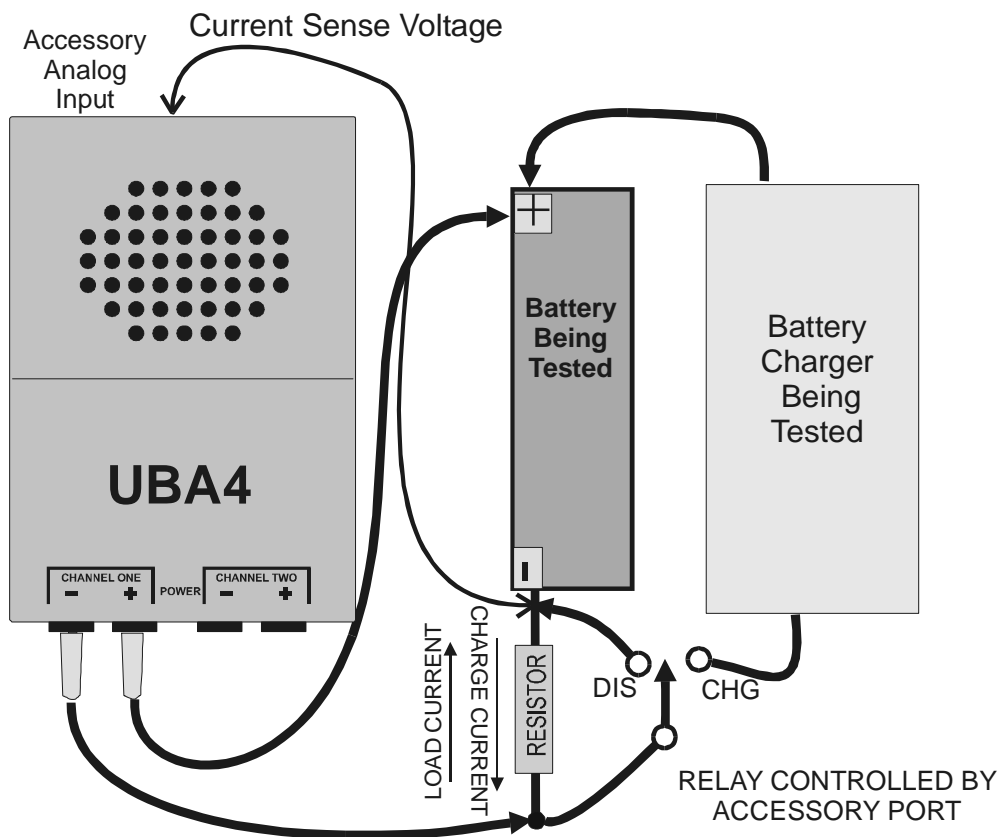
Using the digital output of the UBA accessory port, you can program the UBA to connect and disconnect your charger. The UBA accessory port has two digital outputs. If you have the optoisolated connector installed, the outputs will be optoisolated. Use the ExtLoadControl line in the calibration file to specify which digital lines to control and how to control them. For example, to set digital output 0 high during the discharge action, put these lines in your calibration file:

```
*ExtLoadControl      name          model  dochan  maxamps
ExtLoadControl: TurnChargerOn      2      x1 !    0
```

Note: UBA Console doesn't support external charge controls, but you can use a discharge action with 0 load current. This would be useful if you wanted to test a charger. You could design a BAR with the following actions:

1. Regular discharge cycle with load current specified that will discharge the battery
2. Optional discharge action with 0 current and a time limit that allows the battery to recover from the previous discharge
3. Discharge action that turns on your charger. Give this action a time limit that will allow the charger being tested to complete the charge, i.e., 1 or 2 hours
4. Optional rest discharge
5. Go to step 1 and repeat as many times as you want.

Connect your UBA as shown:



In this set-up, we use a relay to connect the charger to the battery. During charge the relay is in the “CHG” position and, while resting or during discharge, the switch is in the “DIS” position. In addition, when the

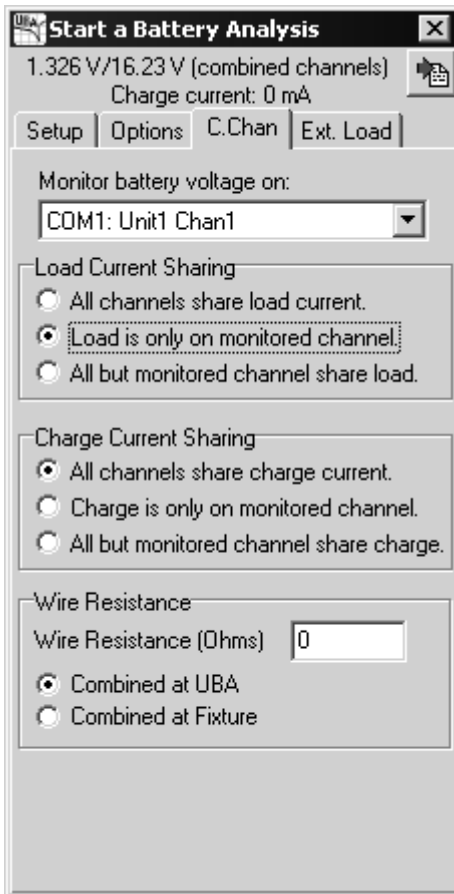
charger is disconnected the current sense resistor is shorted so that the load current doesn't create a negative voltage; it can damage your UBA and reduce the measured battery voltage.

This is the calibration file entry for a 0.5R current sense resistor, a relay on digital output 0 (high is on) and the current sense resistor connected to accessory analog input 0.

```
*ExtLoadDevice:      name      model aichan limit control Iin0 Vout0
ExtLoadDevice:      CurrentSense 2      0      10      MyRelay 1 0.5
```

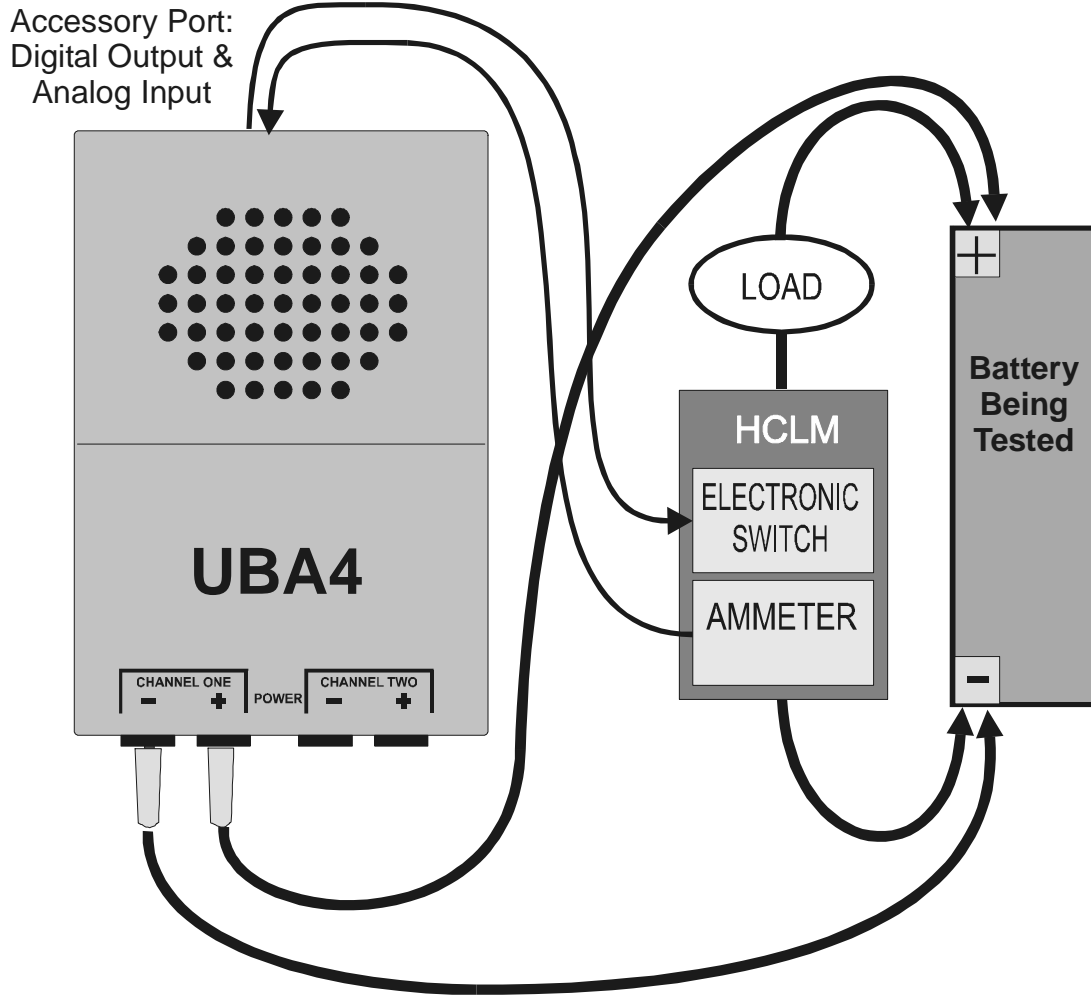
```
*ExtLoadControl      name      model dochan maxamps
ExtLoadControl!:     MyRelay      2      x1 !      0
```

If you use channel 1 to monitor charger current, the load current will be split between the combined channels. Because channel 1 is connected to the sense resistor (shorted by the relay), no actual current will be drawn from this channel. Therefore the actual load current will be one-half what you requested. When starting a battery analysis, you can specify that "Load is only on monitored channel" so that channel 1 has no load current. This is shown below:



# Vencon High Current Load Module

The Vencon High Current Load Module (HCLM, which also refers to the VHCLM in this discussion) consists of two sections: an electronic switch and an electronic ammeter, which are packaged in the same enclosure; both are capable of handling up to 15A (HCLM) or 50A (VHCLM) of current. The HCLM, which you can order directly from us, does not come with a load.



UBA Console controls the UBA, which connects the external load to the battery with the HCLM electronic switch and monitors the load current with the HCLM ammeter. The external load can be non-linear because the HCLM ammeter monitors the actual load current. Here is an example of the lines in the calibration file describing the HCLM.

```
*HCLM SWITCH:
*ExtLoadControl  name          model dochan aichan mode  amps
ExtLoadControl:  SwitchSN      1     x0     0     1    20

*HCLM AMMETER
*ExtLoadDevice:  name model aichan dochan Rout limit control Rgnd Iin0 Vout0 Iin1 Vout1
ExtLoadDevice:  Shunt25A 1  1  1x  1 50 SwitchSN 0.001 0 0 1 .09 10 .9
ExtLoadDevice:  Shunt50A 1  1  0x  1 50 SwitchSN 0.001 0 0 1 .03 10 .3
```

Note that there are two ExtLoadDevice lines; this is because the ammeter has two ranges, 0 to 25A and 0 to 50A. When starting a battery analysis, you choose which range to use.

# Appendix A - UBA External Device Reference

External devices are specified by adding lines to the UBA calibration file, one line per device. The line is added before the last line (the “\*end of calibration file” line). Use a text editor (Microsoft notepad is fine) or contact us for help. You can have as many external device lines in your calibration file as you want. When you start a battery analysis, specify which one you are using. UBA Console normally won’t allow you to choose two external devices that use the same lines on the same accessory port.

Comment lines in your calibration file start with an asterisk (“\*”) and are ignored.

The external devices that connect to the UBA’s accessory port 1 are:

## External Loads

External load devices and external load controls go together to describe an external load. An external load device loads the battery and an external load control controls the external load device. You can have an external load device that’s always connected, i.e., a resistor, which doesn’t require an external load control. Some loads, such as a constant current switch, require both an external load device line and an external control device line to be properly described.

## External Load Devices

An external load device is a load that has either a defined load current relationship (i.e. a resistor or a fixed constant current load) or a voltage output that represents load current. External load devices are described in the UBA’s calibration file by the **ExtLoadDevice** line.

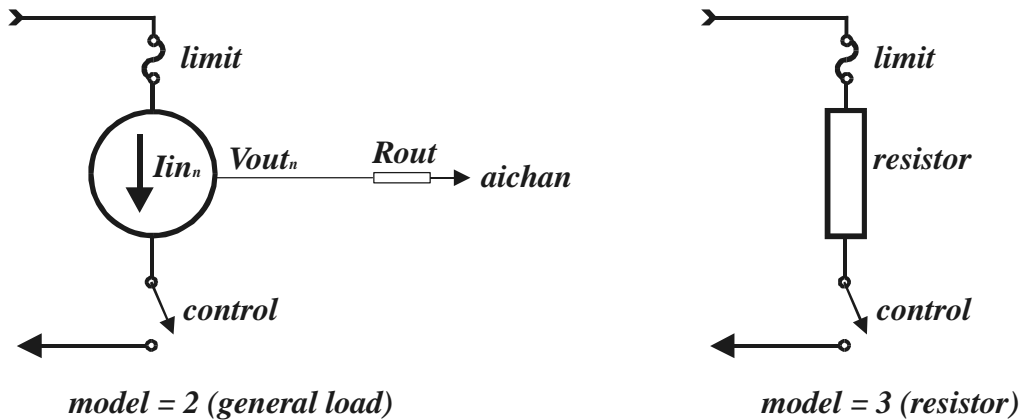


Diagram Representation of External Load Device

## ExtLoadDevice Syntax:

*ExtLoadDevice: name model aichan dochan Rout limit control Rgnd Iin<sub>0</sub> Vout<sub>0</sub> Iin<sub>1</sub> Vout<sub>1</sub> ... (model 1)*  
*ExtLoadDevice: name model aichan limit control Iin<sub>0</sub> Vout<sub>0</sub> Iin<sub>1</sub> Vout<sub>1</sub>... (model 2)*  
*ExtLoadDevice: name model resistor limit control (model 3)*

where

- o *name* is any name you give this control. The name can contain any characters except spaces.

- o **model** is:
  - 1 for the Vencon High Current Load Module (HCLM)
  - 2 for a general load
  - 3 for a resistor load
  
- o **aichan** (ExtLoadDevice models 1 and 2 only) is the analog input channel in which the device's output voltage is measured (in model 3 this assumes the battery voltage).
  - "0": accessory analog input 0
  - "1": accessory analog input 1
  - "-1": no analog input
  - "-2": the voltage on the battery input (for combined channels this is the first virtual channel) *after* any battery lead voltage compensation is performed (excluding external load wire resistance).
  - "-3": use the battery voltage that is being used (not necessarily the battery input). This is the value that is used for model 3 (a resistor). The battery voltage with voltage drop compensation is used (excluding external load wire resistance).
  
- o **dochan** (ExtLoadDevice model 1 only) is the digital output channel that can be used to select the device.
  
- o **Rout** (ExtLoadDevice model 1 only) output resistance of the device
  
- o **limit** (ExtLoadDevice models 1 and 2) is the maximum current that this device can support ('0' = no limit) in Amps
  - (ExtLoadDevice model 3) is the power rating of the resistor ('0' = no limit) in Watts.
  - (note, this parameter is required, but not supported in the current version of software)*
  
- o **control** is the name of the ExtLoadControl that controls this device. If there is no ExtLoadControl use <none> (or for model 3 just leave blank). If this entry is <none> (or blank for a resistor) the software will assume that the load device is always on.
  
- o **Rgnd** (ExtLoadDevice model 1 only) is the resistance of the ground cable
  - (note, this parameter is required, but not supported in the current version of software)*
  
- o **Iin<sub>0</sub> Vout<sub>0</sub> Iin<sub>1</sub> Vout<sub>1</sub> ...** (ExtLoadDevice model 1 and 2 only) is the I (current) vs V (voltage) characteristic of this device. For a given load current, the device's output voltage is specified. Iin<sub>0</sub> would normally be zero, and Vout<sub>0</sub> would be the output voltage of the load device when the current is 0. Iin<sub>1</sub> would be a larger current than Iin<sub>0</sub> and Vout<sub>1</sub> would be the output voltage of the load device at Iin<sub>1</sub>. You can have as many of these data points as you want, but they must be monotonic (i.e. Iin<sub>n+1</sub> ≥ Iin<sub>n</sub>). UBA Console uses these values to calculate the load current given the voltage at the specified analog input (**aichan**). If you specify a single point at 0, i.e. "10 0" then a constant current of 10A is assumed. If you specify a single point, not at zero, i.e. "1 10" then it assumes that there is a point at 0, i.e. same as "0 0 1 10".
  
- o **resistor** (ExtLoadDevice model 3 only) is the resistance of the resistor.

## ExtLoadDevice Examples

```
*ExtLoadDevice: name    model aichan limit control Iin0 Vout0
ExtLoadDevice:  X10IAmp 2      1      20 MySwitch 10 1
```

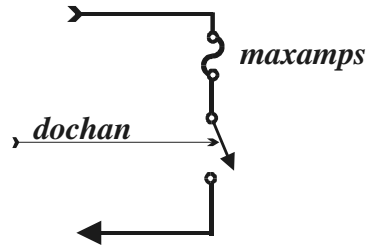
This is a model 2 external load that has its voltage output connected to accessory1 analog input 1, a limit of 20A, and is controlled by "MySwitch". It's a current amplifier that with an effective resistance of 0.1R: at 0A current it gives 0V, and at 10A it gives 1V.

```
*ExtLoadDevice: name model resistance limit  
ExtLoadDevice: 10hm 3 1 100
```

This is a 100W 10hm resistor. Because no ExtLoadControl is specified, the software assumes this resistor is always connected.

## External Load Control

External Load Control is a device that controls the load, i.e.: connects or disconnects it. It is controlled by the digital outputs on the accessory port.



*model = 2 (Electronic Switch)*

*Diagram Representation of External Load Control*

### ExtLoadControl Syntax:

**ExtLoadControl!:** *name model dochan\_on aichan maxamps* (model=1)

**ExtLoadControl!:** *name model dochan\_on dochan\_off maxamps* (model=2)

Where:

- o **!** is an optional exclamation mark which sets the external load control off after the UBA is initialized;
- o **name** is any name that you give this control. The name can contain any characters except spaces;
- o **model** is:
  - 1 for the Vencon High Current Module
  - 2 for an electronic on/off switch;
- o **dochan\_on** is the digital output channel that controls the load. It is expressed in the form: "...cba" where each letter represents a output line, i.e. "a" represents accessory digital output 0 and "b" represents digital output 1 (in the future "c" would be digital output 2 on the 2<sup>nd</sup> accessory port). Setting the digit to "x" means no change, to "1" means set the line high; and to "0" means set the line low. For model 1 the complement of **dochan\_on** is used to turn the load off.
- o **dochan\_off** (model 2 only)  
This is similar to **dochan\_on**, only it is used to turn the load off. A value of "!" means use the complement of **dochan\_on**.
- o **aichan** (external load control model 1 only) is the analog input channel. In model 1, it feeds back the voltage drop on the control device for monitoring purposes.
  - "0" means accessory analog input 0
  - "1" means accessory analog input 1
  - (note, this parameter is required, but not supported in the current version of software)

- o *maxamps* is the maximum current that this control can support. If the current exceeds this, the control is turned off. A value of 0 means no limit.  
(note, this parameter is required, but not supported in the current version of software)

## ExtLoadControl Examples

```
*ExtLoadControl name    model  dochan  maxamps  
ExtLoadControl: MySwitch 2      x0 !      20
```

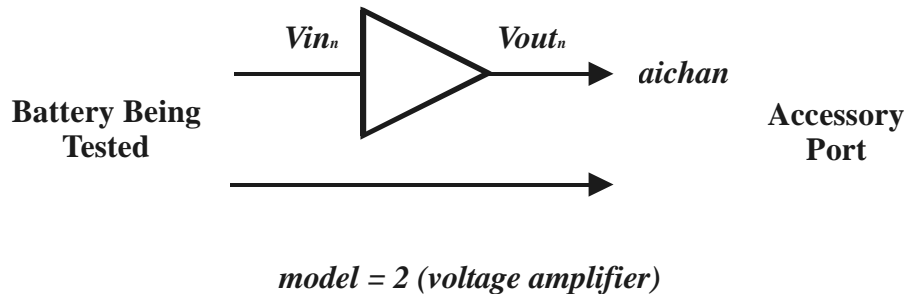
This external load control, which is called “MySwitch”, is turned on by a low to digital output 0 and can handle up to 20 Amperes. Note: because it’s turned on by a low from digital output 0, this load will be turned off if the UBA resets. The first line (with the asterisk as the first character) is an optional comment line that helps with the understanding of the actual data line.

```
*ExtLoadControl  name    model  dochan  maxamps  
ExtLoadControl!: 2ndSwitch 2      1x !      50
```

This external load control, which is called “2ndSwitch”, is turned on by a high to digital output 1 and can handle up to 50 Amperes. Because of the exclamation mark following the ExtLoadControl word, this control will be turned off after the UBA is initialized. Note: because it’s turned on by a high from digital output 1, this load will be turned off if the UBA resets.

## External Battery Voltage Amplifier/Attenuator

The accessory connector can also be used support a voltage amplifier (or attenuator) that connects to your battery. It would be useful to have a third electrode amplifier for measuring an electrochemical cell or for differentially measuring a battery voltage.



*Diagram Representation of External Battery Voltage Amplifier*

### Battery Voltage Amplifier/Attenuator Syntax:

**ExtVAmp** : *name model aichan dochan Rout lbias Vin<sub>0</sub> Vout<sub>0</sub> ... Vin<sub>n</sub> Vout<sub>n</sub>* (model 1)

**ExtVAmp** : *name model aichan Vin<sub>0</sub> Vout<sub>0</sub> ... Vin<sub>n</sub> Vout<sub>n</sub>* (model 2)

where:

- **name** is any name you give this amplifier. The name can contain any characters except spaces;
- **model** is:  
1 for the Vencon Extremely Low Current Module  
2 for a simple voltage amplifier;
- **aichan** is the analog input channel:  
“0” for accessory analog input 0  
“1” for accessory analog input 1;
- **dochan** (model 1 only) is the digital output channel that controls the load. It is expressed in the form: “10” where each digit represents a output line, i.e. “0” represents accessory digital output 0 and “1” represents digital output 1. Setting the digit to “x” means no change, to “1” means set the line high; and to “0” means set the line low. *(note, this parameter is required, but not supported in the current version of software)*
- **Rout** (model 1 only) is the output resistance of the amplifier
- **lbias** (model 1 only) is the bias current of the amplifier *(note, this parameter is required, but not supported in the current version of software)*
- **Vin<sub>0</sub> Vout<sub>0</sub> ... Vin<sub>n</sub> Vout<sub>n</sub>** is the DC response of the amplifier expressed as input output points.

### ExtVAmp Examples

\*ExtVAmp: *name model aichan Vin<sub>0</sub> Vout<sub>0</sub> ... Vin<sub>n</sub> Vout<sub>n</sub>*

ExtVAmp: 10xAmp 2 0 0.1 1.0

This describes an 10X amplifier that connects to analog input 0. A battery voltage of 1V is represented by 0.1V.

## External Temperature Sensor – Voltage Output

The UBA accessory port will accept a voltage representing a temperature.

**ExtTempProbe : name aichan V@20C V/C Rin**

Where:

- o **name** is any name you give this temperature sensor; the name can contain any characters except spaces.
- o **aichan** is the analog input channel:  
“0” for accessory analog input 0  
“1” for accessory analog input 1
- o **V@20C** is the voltage at 20<sup>±</sup> Celsius.
- o **V/C** is the voltage change per degree Celsius
- o **Rin** is any series resistance from the output of the sensor to the input of the accessory port

Example:

```
*ExtTempProbe: name chan V@20C V/C Rin
ExtTempProbe: Temp1 0 0.68 0.018 1000
ExtTempProbe: Temp2 1 0.68 0.018 1000
```

## External Thermistor Sensor

The UBA accessory port will accept a voltage representing a temperature, in the following form:

**ExtThermistorRabcd : name aichan R@25C a b c d Rpu Vpu**

Where:

- o **name** is any name that you give this thermistor; the name can contain any characters except spaces
- o **aichan** is the analog input channel:  
“0” for accessory analog input 0  
“1” for accessory analog input 1
- o **R@25C** is the thermistor resistance at 25<sup>±</sup> Celsius
- o **a b c d** are the parameters of the thermistor
- o **Rpu, Vpu** is the value of the resistor connecting the thermistor to voltage Vpu  
(*Rpu and Vpu aren't supported in current version of software*)

Example

```
*ExtThermistorRabcd: name chan R@25C a b c d Rpu Vpu
ExtThermistorRabcd: WhiteTherm 0 10000 0.0033 2.5e-4 2.6e-6 6.7e-8 0 0
ExtThermistorRabcd: BlueTherm 1 10000 0.0033 2.5e-4 2.6e-6 6.7e-8 0 0
```

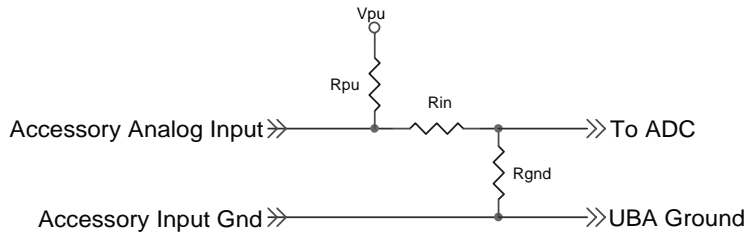
## Accessory Analog Input

This isn't an external device, but the input network inside your UBA. UBA Console uses it to calculate the transfer function from the external device to the ADC input.

The accessory port has two analog inputs. The AnalogInR lines in your calibration file, which describe how they are wired, are provided by Vencon and shouldn't have to be modified.



Accessory Analog Input Model 0



Accessory Analog Input Model 1

### AnalogInR : aichan Rin Rgnd model Rpu Vpu

Where:

- o **aichn** is analog input channel
- o **Rin** is the series resistor
- o **Rgnd** is the ground resistor
- o **model** is the model:
  - 0 straight attenuation
  - 1 thermistor pull up resistor installed
  - 2 thermistor pull up with Rin located between Rpu and thermistor
  - 3 for linear thermistor input (not yet supported)
- o **Rpu (model 1 only)** pull up resistor resistance
- o **Vpu (model 1 only)** pull up resistor voltage

Example:

Standard UBA4 without thermistor connector:

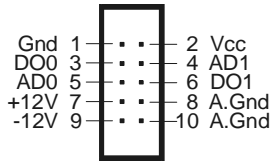
```
*      chan Rin  Rgnd  model
AnalogInR: 0   0 100000 0
AnalogInR: 1   0 100000 0
```

Standard UBA with thermistor connector:

```
*      chan Rin  Rgnd model  Rpu  Vpu
AnalogInR: 0 3010 100000 1   26100 5
AnalogInR: 1 3010 100000 1   26100 5
```

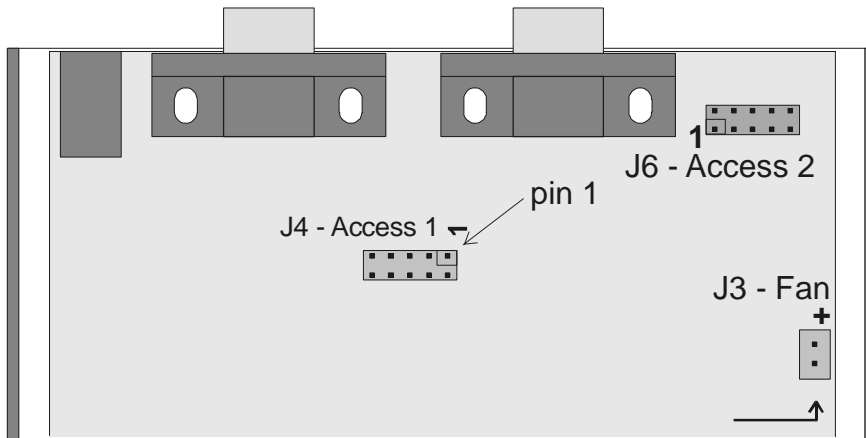
## Appendix B - UBA Accessory Port1

Accessory Port1 contains power, two digital outputs and two analog inputs. It is located inside the UBA on the PCB. You can connect to this port either by opening your UBA and connecting directly to the Access1 header or by ordering a Vencon accessory port extender that attaches to the back of your UBA. You should not attach directly to the Access 1 connector because it isn't polarized. You have to open the case to access the connector and the wire can interfere with the operation of the fan. In addition to the accessory port extender, we also offer an optoisolated extender that isolates the digital outputs.



### Access1 Connector

Note, pin 1 is denoted by an arrow on the back of the UBA4 or by a "1" on the PCB.



Top View UBA PCB

### Accessory Port 1 Pinout:

Pin	Name	Description
1	Gnd	Digital Ground
2	Vcc	+5V – connects directly to internal +5V supply.
3	DO0	Digital output "0" (default high)
4	AI1	Analog input "1"
5	AI0	Analog input "0"
6	DO1	Digital output "1" (default low)
7	+12V	+12V – connects directly to internal +12V supply.
8	A.Gnd	Analog ground.
9	-12V	-12V supply. This needs to be enabled inside the UBA.
10	A.Gnd	Analog ground.

## **Notes:**

### **Grounds:**

Both “Digital Ground” and “Analog ground” are connected internally inside the UBA. Use the “Analog ground” for referencing outputs that go to the analog inputs. Keep the current on the “Analog ground” to less than 20mA to limit ground potential errors inside the UBA.

### **Power Supplies +5 and +12V:**

These outputs are not current limited. The maximum current you can draw depends on the power supply being used. If you are using a 24V power supply, keep the total current below 50mA; for a 15V power supply, keep the total current below 100mA. If you draw too much current, the voltage regulators will overheat and shut down. If you require more current, you can add a heatsink to the voltage regulators (ask us for details).

### **Power Supply –12V:**

The –12V supply isn’t enabled by default. If you require –12V, you have to install a 1k resistor for R84. The current on this line is really small, less than 1mA.

### **Digital outputs:**

These are 5V logic family “HC” outputs. They can safely source or sink up to 2mA. Because there is no additional electrical protection beyond what’s provided on the IC on these lines, caution is strongly advised.

### **Digital Output Default State**

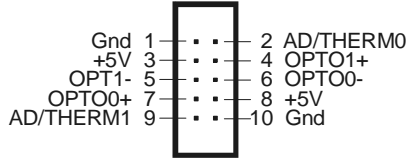
When the UBA is reset (after it’s powered on or when it times out) the digital output lines take the following state: DO0 high, DO1 low. Design your external device so that these states set it OFF, otherwise when the UBA resets your device will turn on. If you add an exclamation mark to the end of “ExtLoadControl”, when the UBA is initialized your device will be turned OFF.

### **Analog inputs:**

The analog inputs are from 0 to 2.5V and connect directly to the A/D converter with a 100k load resistor. There is no additional electrical protection beyond what’s provided on the IC on these lines, caution is strongly advised.

# Appendix C - UBA Accessory Port1 Optoisolated Output

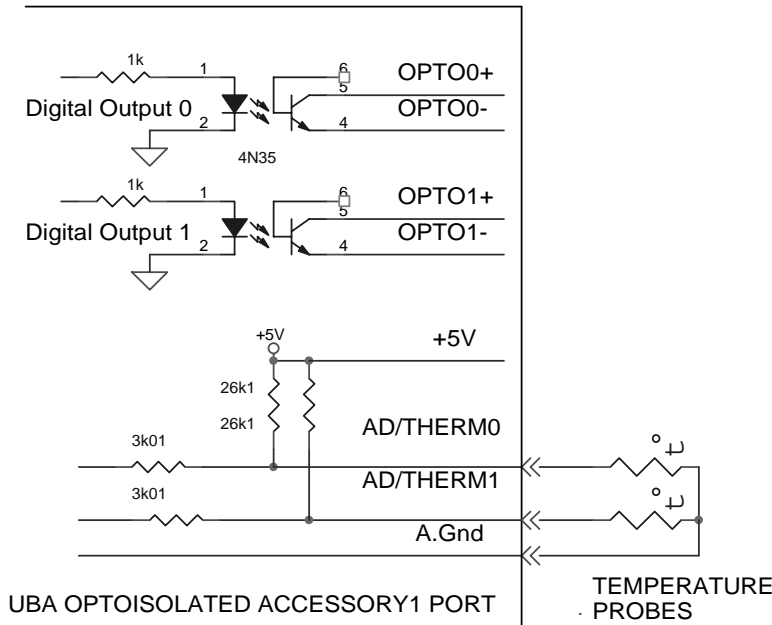
The Accessory Port1 is also accessible with an optoisolated output.



Access1 Optoisolated Connector

## Accessory Port 1 Optoisolated Pinout:

Pin	Name	Description
1	A.Gnd	Analog ground.
2	AD/THERM0	Analog input 0 or thermistor input
3	+5V	Connects directly to the +5V internal UBA supply.
4	OPT01+	+ve isolated output of digital 1
5	OPT01-	-ve isolated output of digital 1
6	OPT00-	-ve isolated output of digital 0
7	OPT00+	+ve isolated output of digital 0
8	+5V	Connects directly to the +5V internal UBA supply.
9	AD/THERM0	Analog input 1 or thermistor input
10	A.Gnd	Analog ground.



## Notes:

### Analog Grounds:

Analog grounds are connected internally inside the UBA. Keep the current on the “Analog ground” to less than 20mA to limit ground potential errors inside the UBA.

**Power Supply:**

These 5V outputs are not current limited. Keep the current low so that the current on the analog grounds is less than 20mA.

**Optoisolated Output:**

There are two optoisolated output: OPTO0 and OPTO1. They can control up to 2mA  
They have a maximum forward voltage of 30V and a maximum reverse voltage of 7V.

Note, the outputs of the optoisolator (2N35) connect directly to the output connector with no protection circuitry – don't exceed the forward or reverse voltage otherwise you will damage the isolator.

**Digital Output Default State**

When the UBA is reset (after it's powered on or when it times out) the digital output lines take the following state: OPTO0 On, OPTI1 Off. Design your external device so that these states set it to OFF; otherwise when the UBA resets your device will turn on. If you add an exclamation mark to the end of "ExtLoadControl", when the UBA is initialized your device will be turned OFF.

**Analog inputs:**

These inputs have a 26k1 pull up to +5V resistor and then connect to the A/D converter via a 3k01 resistor (see schematic). The voltage range is 0 to 2.5V. There is only a small zener diode for protection on these lines, caution is strongly advised.

## Footnotes:

**Accessory Port 2**

This is a high speed digital output. It isn't supported yet by UBA Console.

**Accessory Port 3**

This is a four channel analog output. It isn't supported yet by UBA Console.

**Future Upgrades**

1. External loads, not external chargers, are only supported in UBA Console.
2. When testing a battery charger, the voltage drop across the sense resistor is added to the battery voltage.
3. When selecting an external load device with an external load control, automatically select the external load control