

HANDHELD
PRECISION DIGITAL VOLTAGE SOURCE
Model PDVS2

A multitude of uses as a calibrator, reference and fully adjustable precision voltage source.

Handmade in Great Britain by Ian Johnston



Manual Version 1.2b (10/06/17)

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FUNCTIONS & FEATURES

- True 0 Vdc to 10 Vdc user adjustable output in 10 V mode (4d.p's effective, 38.146uV).
- A 2nd mode offering 0.01 Vdc to 2.0 Vdc user adjustable output (5d.p's effective, 10 uV).
- Voltage setting or ramp up/down controls via the 12 button numeric keypad.
- Digital Rotary Encoder (potentiometer) allowing quick, on the fly adjustments of the output voltage.
- LED backlighting (auto-limiting).
- Soft power switch.
- Based on the industry standard LM399AH voltage reference.
- All digital calibration, no internal potentiometers.
- 18bit DAC with an accuracy/stability down in the uV's.
- Battery voltage monitor, including low voltage warning, charging status and auto-shutdown.
- Output voltage monitor including overload / short circuit protection.
- 3" Graphics Monochrome LCD (128x64 pixels).
- Atmel Atmega1284 micro-controller (uses Arduino bootloader).
- Precision chopper op-amp on final output with extra stability achieved using low tempco resistors.
- Re-calibration by the user possible via keypad/LCD and saved to flash rom.
- On-board charging for Li-ion batteries (batteries and DC adaptor not supplied).
- Battery & DC input reverse polarity protection.
- Quality Hammond 1599 case.
- Quality aluminium anodized & engraved front panel.
- Quality 4mm banana sockets.
- Calibration/Settings test record supplied, unique serial number.
- Software function- PLAYBACK mode.
- Software function- RAMP mode.
- Software function- Remote Operation via Windows app (via USB port).
- CE Approved.

SPECIFICATION SUMMARY

- Voltage reference = LM399AH (0.5 - 1 ppm/degC temperature coefficient).
10V mode = 0.0000Vdc (true zero) to 10.0000Vdc in 38.146uV steps (minimum).
2V mode = 0.01000Vdc to 2.00000Vdc in 10uV steps (minimum).
- Load = 3kohm minimum. Example: At 10Vdc output with 3kohm load = 3.3mA (whilst maintaining output within approx. 10uV).
- Accuracy = 0.001% (within 100uV).
- Stability = 0.0001Vdc variation max. 10V mode, 0.00004Vdc typical variation in 2V mode.
- Drift (long term) = This has not been characterized.
- Temperature coefficient (output voltage) = Less than 1 ppm/degC (11.5degC tested variation).
- Stabilization time = typically 10mins when stored at approx. 23degC.
- Output short circuit = indefinite.
- Power Source (batteries) = Two Lithium-Ion/Lipo re-chargeable 9V PP3 batteries (600mAh min. batteries recommended). Batteries must be match charged prior to use and capable of 250mA charge current.
- Power Source (external power) = 18 to 24Vdc input (also charges the batteries) @ 400mA recommended.
- Battery life = Approx. 12hrs (using EBL 600mAh batteries) typical continuous operation with backlighting off.
- Current drain = ~45mA after the LM399AH reference stabilizes & backlighting turned off.
- Dimensions = 158mm x 83mm x 35mm (case size).

OPERATION OF INSTRUMENT

Power on: Press and hold the power button.

Power off: Press and immediately release the power button.
The LCD will clear and the LED will turn off.

The unit will provide a low battery warning at 13.0Vdc and will auto shutdown at 12.5Vdc. Both settings are adjustable via settings.



Initialize: The splash screen will be displayed on power up displaying the software version before displaying the MAIN MENU. It is recommended to wait 10mins from cold to allow the LM399AH reference to stabilize.

- 1 – MAIN The main output control screen
- 2 – PLAYBACK MODE Playback 5 fixed voltages over time
- 3 – RAMP MODE Ramp up/down between 5 voltages over time
- 4 – COMMS ON/OFF Enable/disable the USB comms
- 5 – 2V/10V MODE Switch between the 2Vdc and 10Vdc FSD modes
- 6 – SETTINGS User adjustable settings
- 7 – CALIBRATION User adjustable calibration
- 8 – B.LIGHT ON/OFF Turn on/off the LED backlighting (this session)

NOTE: When on the MAIN screen hold the '0' button down to return to the menu.

Power source: The primary source of power is the batteries. The best performance of the unit is when the batteries are being used to supply power without any external power.

External DC input supplied cable: Red +, Blk -.
The battery terminals and the external DC input are reverse polarity protected.
Use only matched charged state batteries, i.e. don't fit two batteries that are not charged to the same capacity.

The batteries must be capable of charging at a rate of up to 250mA. Most are, but please check.

The batteries can be charged in-place using the DC socket on the side.
The unit can be used whilst being powered from the ext. DC socket but with the following important restrictions/notes:

- Minimum DC supply (absolute min.): = 14Vdc
- Maximum DC supply (absolute max.): = 24Vdc
- Minimum DC supply (to charge the batteries): = 18Vdc
- Maximum DC supply (to charge the batteries): = 24Vdc

When the batteries are fully charged charging is auto-disabled. To reset this unplug the external DC input and reconnect it, or re-enable "Batt. Chg. Enable" under Settings. This is to avoid trickle charging the Lithium-Ion batteries.

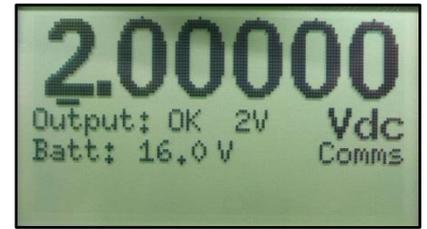
On disconnecting the ext. DC socket after fully charging the batteries the battery voltage should display approx. 16.8Vdc.

Most Lithium-Ion PP3 batteries have a built in protection circuit and can shut themselves down if over-discharged. Brands can differ so you may have to adjust the low battery warning and auto-shutdown voltages accordingly.

Notes:
To run the unit off external DC power but without charging the batteries you can turn off charging via the SETTINGS menu.

MAIN

Setting an output: Simply type the voltage required using the keypad.
Use the '*' key as the dp., and use the '#' as ENTER.
Note: The voltage being set will be displayed on the LCD as you type.



E.G. 1.23456 ↵
10.00000 ↵

You can also shortcut data entry when zero's are required:

E.G. 1.25 ↵
10 ↵
5.678 ↵

The unit will recognize when numbers are entered wrongly, or outwith the parameters of the unit, e.g. multiple dp.'s, over 10Vdc, or under 0.04Vdc etc.

If you make a mistake and want to abort the voltage you are trying to set then there is no 'BACK' button, however simply keep pressing any number key and the display will roll round and clear allowing you to start again.

To ramp the currently set voltage up or down, simply press the '*' (down) or '#' (up) keys. 1 press at a time raises or lowers the voltage by 1 least significant digit. Press and hold the '*' or '#' to ramp up/down the output 1mV at a time.

Rotary Encoder: An alternative to using the keypad is to use the rotary knob on the front of the unit to increase/decrease the output voltage.
Press the rotary encoder to select the digit to be modified which is noted by the underscore below the digit.

Output Protection: The voltage monitor detects when the output has been overloaded or subject to a short circuit. The unit will immediately reduce the output to 0Vc (approx.) and display an "ERR" message on the LCD. When the problem is resolved the unit will recover back to normal.

Best Stability: For the most accurate and stable output it is highly recommended to run the unit from the batteries with no external DC power input. This helps avoids any ground loop noise entering the system.
Also, turn the backlighting OFF.

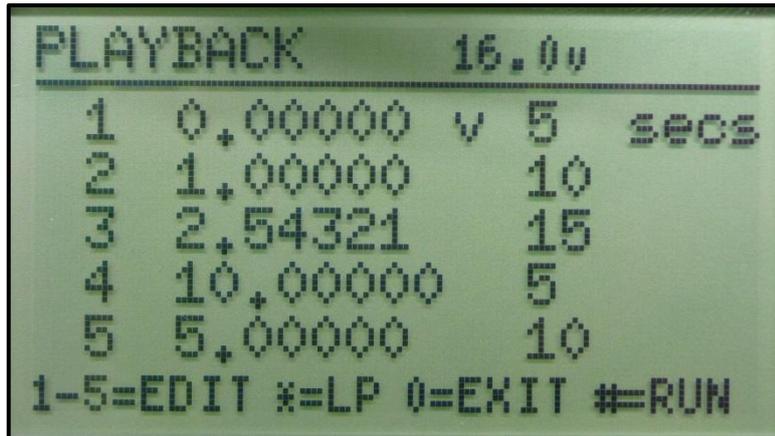
Screen Messages:

"CHG"	-	Batteries are charging.
"FULL"	-	Batteries are now fully charged.
"OVER"	-	The Battery charge current exceeded the maximum allowable.
"OK"	-	The main voltage output is functioning and is accurate.
"ERR"	-	An irregularity has been detected on the main voltage output, e.g. an external short circuit or over-current may have pulled the output low.
"10V"	-	The unit is in 10V mode.
"2V"	-	The unit is in 2V mode.
"Comms"	-	USB comms is active.
"Minimum = 0V"	-	The minimum allowable output voltage is reached.
"Maximum = xxV"	-	The maximum allowable output voltage is reached.

Back to Main Menu: Hold '0' on the keypad to return to the main menu.

PLAYBACK MODE

Playback mode: The user can set up 5 voltages that can be played back over time. Each one of the 5 has a time in seconds associated with it.



	Voltage (V)	Time (secs)
1	0.00000	5
2	1.00000	10
3	2.54321	15
4	10.00000	5
5	5.00000	10

1-5=EDIT * =LP 0=EXIT # =RUN

At the bottom of the screen is the menu.

1-5=EDIT EDIT VOLTAGE / TIME:

Press 1, 2, 3, 4 or 5 to edit the voltage and time for that line. The edit feature is enabled when the playback mode is inactive (not running).

To set line 1 to 1.23456 Vdc and for a specified time of 8 seconds:-

E.G. 1
1.23456 (no need to press ENTER)
08 (no need to press ENTER)

Changes made are saved to EEprom when existing playback mode.

*=LP ENABLE/DISABLE LOOP MODE:

If loop mode is enable then when playback is running and line 5 finishes it will loop around to the start again automatically.

With loop mode turned off, playback terminates when line 5 finishes.

LP will appear at the top of the screen when loop mode is enabled.

0=EXIT EXIT:

Exit back to the main menu.

#=STOP START/STOP PLAYBACK:

Start and stop playback.

When running, the current time in seconds is displayed at the top right corner of the screen.

Notes:

1. The battery voltage is displayed at the top of the screen for convenience.
2. Setting a time of 0 seconds will effectively mean that line is skipped.
3. A '*' appears against the line currently in operation.

RAMP MODE

Ramp mode:

The user can set up 5 voltages that can be played back over time with the output ramping up or down between the adjacent voltages. Each one of the 5 has a time in seconds associated with it which determines how long the ramp should take between the adjacent voltages.

```
RAMP 7.50000v 15.9v LP 0
 1 10.00000v 10 secs
 2  5.00000    5
 3  0.00000   10
* 4 10.00000    3
* 5  2.50000    8
1-5=EDIT *=LP 0=EXIT #=$STOP
```

At the bottom of the screen is the menu.

1-5=EDIT EDIT VOLTAGE / TIME:

Press 1, 2, 3, 4 or 5 to edit the voltage and time for that line. The edit feature is enabled when the ramp mode is inactive (not running).

To set line 1 to 1.23456 Vdc and for a specified time of 8 seconds:-

E.G. 1
1.23456 (no need to press ENTER)
08 (no need to press ENTER)

Changes made are saved to EEprom when existing playback mode.

*=LP ENABLE/DISABLE LOOP MODE:

If loop mode is enable then when ramp is running and line 5 finishes it will loop around to the start again automatically.

With loop mode turned off, ramp terminates when line 5 finishes.

LP will appear at the top of the screen when loop mode is enabled.

0=EXIT EXIT:

Exit back to the main menu.

#=\$STOP START/STOP RAMP:

Start and stop ramp.

When running, the current time in seconds is displayed at the top right corner of the screen.

Notes:

1. The battery voltage is displayed at the top of the screen for convenience.
2. Setting a time of 0 seconds will effectively mean that line is skipped.
3. A '*' appears against the 2 lines currently being ramped between.

COMMS ON/OFF

Enable or disable the USB serial comms traffic. On power up the unit defaults to OFF.

This option does not inhibit the USB port detection in Windows only the serial data traffic, so when you connect via USB to a PC (Windows) the port will auto-detect but no data will transfer until comms is enabled.

FTDI virtual serial port: Baud = 250k,n,8,1

The simple bi-directional ascii based serial data protocol is available on request.

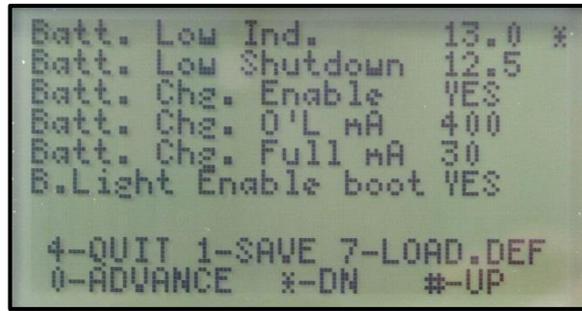
If the USB serial comms is not being used then it is advised to leave it switched OFF as it will help the responsiveness of the keyboard and rotary encoder etc.

2V/10V MODE

This switches the unit between the 10Vdc FSD mode and the higher resolution 2Vdc FSD mode.

- | | |
|----------|--|
| 10V mode | True 0Vdc to 10Vdc user adjustable output,
4 dp's effective,
38.146uV steps.
Note: In this mode the 5 th dp is presented and can be controlled but will not necessarily render a change to the voltage output as the resolution is 38.146uV's. |
| 2V mode | 0.01Vdc (10mV) to 2.0Vdc user adjustable output,
5 dp's effective,
10uV steps.
Note: This mode renders full control over the 5 th dp. |

SETTINGS



User adjustable settings.

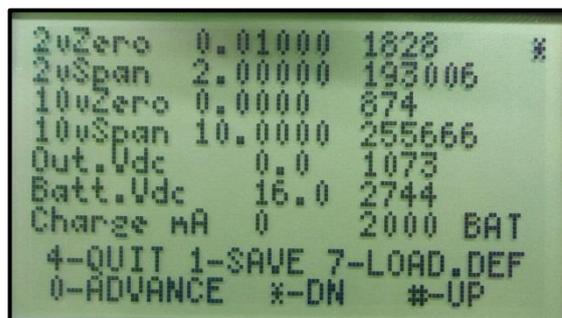
Batt. Low Ind.	Battery voltage at which the unit displays BATTERY LOW.
Batt. Low Shutdown	Battery voltage at which the unit will auto-shutdown.
Batt. Chg. Enable	Enable / disable battery charging. This setting is useful when an external DC source is used but the user doesn't want the batteries to charge.
Batt. Chg. O'L mA	Charge overload current setting. The charging circuit is self-contained, but as a safety setting to protect the batteries & electronics if the charge current goes too high (a faulty battery perhaps). The charging will be shutdown. The maximum current should be approx. 250mA, so the default setting here of 400mA gives some margin.
Batt. Chg. Full mA	Current (mA) at which the battery is determined to be near full. The charging circuit is self-contained, but as an added extra the software can shutdown charging if the battery is approaching near full capacity. This is done by monitoring the charge current and if it drops below a specific level then the charger is shutdown.
B.Light Enable boot	Selects whether the backlighting is enable by default at start up. The backlighting on/off control on the main menu still allows for the backlighting to be controlled for that session.

Use the menu options as detailed at the bottom of the screen to navigate the various entries, Quit, Save etc. Please note that LOAD.DEF will load pre-set factory settings and NOT your as-shipped custom settings.

See the Calibration record at the back of this manual for all the custom settings for your unit. Any changes to settings are saved to EEPROM.

Note: If you decide to make any adjustments to the above settings then please record the original settings before you start.

CALIBRATION



User adjustable / factory calibration.

2vZero	0.01000	Zero counts in 2Vdc mode Calibration of the 18bit DAC output.
2vSpan	2.00000	Span counts in 2Vdc mode Calibration of the 18bit DAC output.
10vZero	0.0000	Zero counts in 10Vdc mode Calibration of the 18bit DAC output.
10vSpan	10.0000	Span counts in 10Vdc mode Calibration of the 18bit DAC output.
Out.Vdc		Output monitor Span counts Calibration of the output DC voltage monitor.
Batt.Vdc / DC Inp.Vdc		Battery / Ext. power supply Vdc Span counts Calibration of the Battery & external DC supply for the main screen.
Charge mA		Charge current Span counts Calibration of the battery charging current monitor.

Use the menu options as detailed at the bottom of the screen to navigate the various entries, Quit, Save etc. Please note that LOAD.DEF will load pre-set factory settings and NOT your as-shipped custom settings. See the Calibration record at the back of this manual for YOUR settings.

Any changes to settings are saved to EEprom.

Note: If you decide to make any adjustments to the above settings/calibration then please record the original settings before you start.

BACKLIGHT ON/OFF

Enable or disable backlighting.

When enabled the backlighting only comes on when keypresses are made or when the rotary encoder is used, at which point the backlighting will illuminate for 5 secs.

Press the rotary encoder switch at any time to illuminate the backlighting.

On power up the unit defaults to backlighting ON.

The backlighting intensity dynamically reduces when the DC Input >18Vdc. This is to help preserve circuit stability & system integrity.

24.5Vdc and over DC Input (this is over spec!) the backlighting is automatically disabled.

FIRMWARE UPGRADES

Occasionally updated software for both the PDVS2 and the Windows app may be available. The current version numbers/dates will also be published at www.ianjohnston.com, contact us to request the upgrade files. The process to upgrade is as follows:

Required before you start:

An Atmel AVRISP mkII programmer (USB with 6-pin type header)
The data line logic must be set to 3.3Vdc.



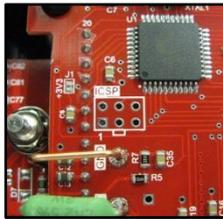
A copy of AVRDUDESS, freely available here:
<http://blog.zakkemble.co.uk/avrduess-a-gui-for-avrdude/>

PDVS2: A .HEX file will be supplied for the upgrade.

In general, your current calibration/settings will not be overwritten, but it is advisable to have them written down. Please refer to the ReadMe.txt file that accompanies the .HEX file for information and any additional instructions.

Remove the 4 screws on the back of the unit, then locate the “PWR BYPASS” header and link it out (with fresh batteries fitted). The PDVS2 will switch on.

Connect the AVRISPMkII to the ICSP header on the Pcb. You will need a 6-pin (2x3) male-to-male header. Note the orientation of the header.



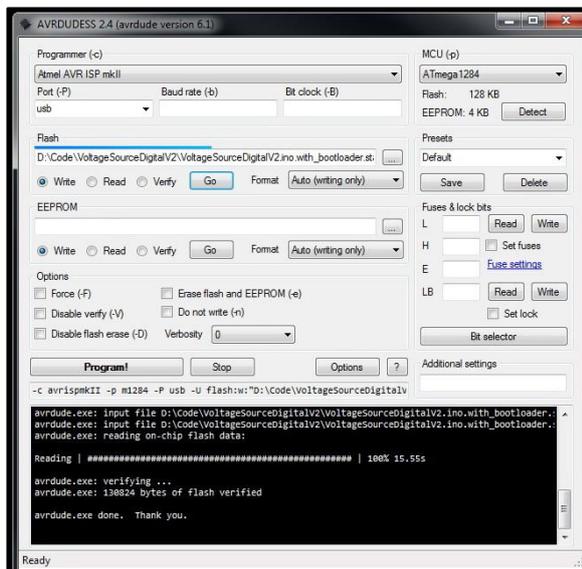
Run AVRDUDESS and make the selections/options as follows:

- Programmer = Atmel AVR ISP mkII
- MCU = ATmega1284
- Port = USB
- Now under FLASH locate the new .HEX file

Important!, if the ICSP header is loose in the Pcb then hold it to one side so that all 6 contacts are made.

Press PROGRAM! on AVRDUDESS and the window at the bottom will show you the upload progress and should complete as shown (<30secs).

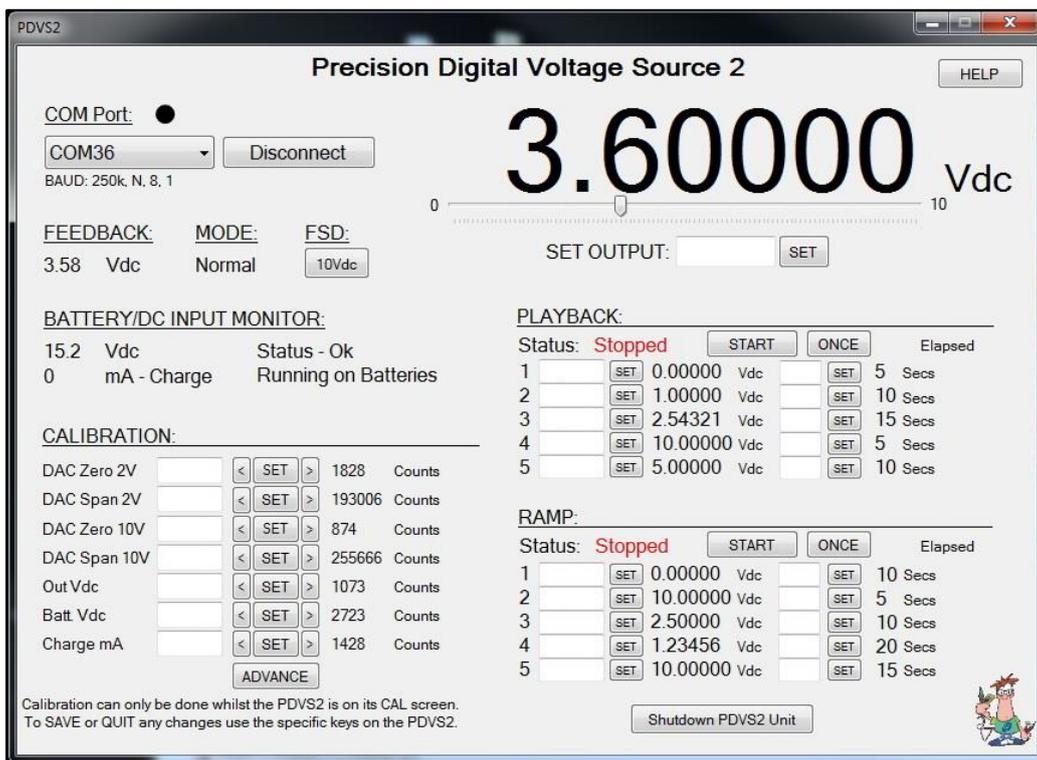
That's it!.....disconnect everything and don't forget to remove the PWR BYPASS jumper, and re-boot the PDVS2.



PDVS2 WINDOWS APPLICATION

The USB port on the side of the unit enables direct connection to a Windows PC.

- Operation:
- Connect a mini USB cable (not supplied), await automatic FTDI driver installation.
 - Install the Windows app.
 - Start the PDVS2 app.
 - Select the COM port. If the FTDI drivers have loaded correctly then usually a COM port other than COM1 will be listed. This is the virtual serial port.
 - Press CONNECT and the data will appear.



The Windows app basically mimics the LCD and operation of the PDVS2 itself, including setting and output voltage, changing modes, start/stop Playback & Ramp modes and also Calibration.

Note: By default at power up the PDVS2 comms is disabled, e.g. the USB port will be detected but no communications will occur. See option 4 on the PDVS2 main menu.

HARDWARE

The following relate to items on the Pcb (printed circuit board):

- FUSE 1 - 315mA time delay fuse (Schurter UMZ 250 series).
- FUSE 2 - 1A time delay fuse (Schurter UMZ 250 series).
- J1 - 3.3Vdc supply to ICSP header. Default = open.
- ICSP - In Circuit Serial Programming header, used for uploading new firmware.
- JP1 PWR BYPASS - Linking this bypasses the (soft) power switch.
- JP2 - DTR disable from Cpu RESET pin. Default = open.

FREQUENTLY ASKED QUESTIONS

- Q. When charging batteries what should I observe?
- A. *If you want to see what's going on then go to the CALIBRATION screen and you will be able to observe the "Charge mA".*
With a relatively flat set of batteries when you first start charging you should observe a constant current of around 230mA and "CHG" will be displayed (and a similar message on the MAIN screen). It will stay this way for some time until the charging system switches to constant voltage. When this happens you should observe the Charge mA slowly dropping. Eventually, when the mA drops below the "Batt. Chg. Full mA" preset (see SETTINGS) the charging will cease and "OFF" will be displayed. At this point the MAIN screen will display "FULL".
- Q. Why does the charge current suddenly drop to 0mA from 200mA+ when I am charging the batteries in the PDVS2?
- A. *The Lithium-Ion PP3 batteries are charged in series, as are the two cells within each battery. It is important for successful charging that the batteries are the same capacity & type and have the same capacity of charge in them before trying to charge them. Failure to do this can mean the internal protection circuit of one of the batteries can detect a possible over charge and shutdown. The symptom of this is that when you are charging batteries within the PDVS2 that it suddenly stops charging and the charge current drops to 0mA. To fix this, remove the batteries from the PDVS2 and charge them separately in a standalone charger. This will match them again and you can return them to the PDVS2. If this problem persists then you may have a faulty/weak battery.*
- Q. Can I run the PDVS2 without any batteries fitted?
- A. *You can, but depending on the accuracy and stability you are looking for on the output it's not recommended. External DC supplies can sometimes generate noise and ground loops into a system. Running on batteries negates this. This is also true when running with batteries and with the external DC Input connected.*
- Q. What power source can I use to charge the batteries?
- A. *Using the DC connector (tail) supplied you can use any electronic linear bench power supply that's capable of 400mA (thus giving some margin). Just set it to 20Vdc. At this voltage you can also run the unit permanently off the bench power supply. You can safely run it like this with the batteries installed because once the batteries fully charge the charging circuit becomes disabled. It is strongly advised to be very careful when using wall plug type power supplies since especially the linear type can output a much higher voltage than is printed. Also, it is advised not to use wall type switch mode type power supplies as these can be notoriously noisy.*
- Q. Is there an Apple or Linux version of the PDVS2 Windows app?
- A. *Unfortunately not, I am only able to write code for the Windows desktop. However, the ascii based serial protocol is available on request if you want to write your own.*

PRODUCT DISCLAIMER & WARRANTY

Disclaimer:

Information has been carefully checked and is believed to be accurate; however, no responsibility is assumed for inaccuracies. This software/firmware of the actual unit shipped may be subject to change and may differ from the contents of this manual.

Ian Johnston Engineering Ltd reserves the right to make changes without further notice to any products to improve reliability, function, or design. Ian Johnston Engineering Ltd does not assume any liability arising out of the application or use of any product or circuit; neither does it convey any license under its patent rights of others.

The general policy of Ian Johnston Engineering Ltd does not recommend the use of its products in life support, aircraft applications or other such critical activities wherein a failure or malfunction of the product may directly threaten life or injury. The user of Ian Johnston Engineering Ltd products in life support, aircraft applications or other such critical activities assumes all risks of such use and indemnifies Ian Johnston Engineering Ltd against all damages.

Limited warranty:

Ian Johnston Engineering Ltd warrants only to the purchaser of the Product from Ian Johnston Engineering Ltd (the "Customer") that the product purchased from Ian Johnston Engineering Ltd (the "Product") will be free from defects in materials and workmanship under the normal use and service for which the Product was designed for a period of:

12 months from the date of purchase of the Product by the Customer.

Customer's exclusive remedy under this Limited Warranty shall be the repair or replacement, at Company's sole option, of the Product, or any part of the Product, determined by Ian Johnston Engineering Ltd to be defective. In order to exercise its warranty rights, Customer must notify Company.

PDVS2 - CALIBRATION RECORD

FUNCTION	COUNTS	VOLTAGE OUTPUT
2vMode Zero		
2vMode Span		
10vMode Zero		
10vMode Span		

FUNCTION	COUNTS
Out.Vdc	
Batt.Vdc	
Charge mA	

FUNCTION	SETTING
Batt. Low Ind.	
Batt.Low Shutdown	
Batt. Chg. Enable	
Batt. Chg. O'L mA	
Batt. Chg. Full mA	
B.Light Enable boot	

FUNCTION	
USB Comms	
Backlighting	
Rotary Enc. / Keypad	

Serial Number =

Ambient Temperature =

Date =