

HANDHELD
PRECISION DIGITAL VOLTAGE SOURCE
Model PDVS2mini

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

Handmade in Great Britain by Ian Johnston

**UK
CA**



INDEX

FUNCTIONS & FEATURES	2
SPECIFICATION SUMMARY	2
OPERATION OF INSTRUMENT	3
MAIN	5
COMMS	6
SETTINGS	7
CALIBRATION	8
FIRMWARE UPGRADE	9, 10
WINDOWS PC APPLICATION	11
HARDWARE	12
FREQUENTLY ASKED QUESTIONS	13
PRODUCT DISCLAIMER & WARRANTY	14
CE CERTIFICATE & DECLARATION	15
CALIBRATION RECORD (BLANK)	16

The screenshots & photos in this manual may not necessarily 100% reflect the actual hardware and/or firmware version and are as a guide only.

FUNCTIONS & FEATURES

- True 0 Vdc to 10 Vdc user adjustable output (5d.p's, approx. 10uV steps)
- Voltage setting via up/down pcb pushbuttons
- Soft power switch
- Based on the industry standard LM399AH (0.5 ppm/degC) voltage reference
- All digital calibration, no internal potentiometers
- 20bit DAC with an accuracy/stability down in the uV's (using a PLC filter of 1.0 or higher)
- Battery voltage monitor, including low voltage warning, auto-shutdown and charging status
- Output voltage monitor including short circuit protection
- 2.4" 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, and saved to flash rom
- Charging pcb/socket for Li-ion batteries using a battery management IC. Batteries and DC adaptor are not supplied
- Battery reverse polarity protection
- ABS Hammond enclosure
- Manual including factory calibration/settings test record. Unique serial number
- UKCA approved (Previous to 01/01/2021 it was CE approved)

SPECIFICATION SUMMARY

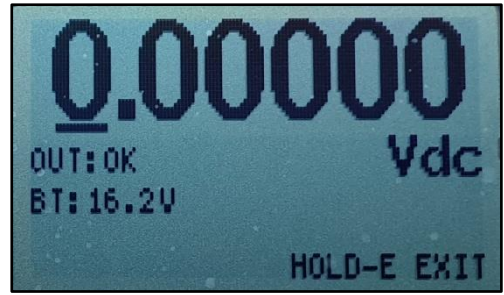
- Voltage reference = Uses an LM399AH (0.5 - 1 ppm/degC temperature coefficient)
- 0.00000 Vdc to 10.00000 Vdc in 10 uV (0.00001 Vdc) steps
- Load = 3kohm minimum. Example: At 10Vdc output with 3kohm load = 3.3mA (whilst maintaining output within approx. 10uV)
- Accuracy = Within 50uV. Typically 0.0005% at 10V output
- Stability = 0.00005Vdc variation worst case. Orientation of the unit may effect output (calibrated horizontally), as will powering from external DC
- Temperature coefficient (unit) = Typically < 3 ppm across a 10degC temperature change (see product webpage for tempco test)
- INL (Integral Non-Linearity) per DAC datasheet = Typical +/- 1bit, Max./Min. = +/- 64bit across 20bit range (however the 11 setpoint system used reduces this considerably)
- Drift (12 months typical) = tba - SPEC TO BE CONFIRMED
- Stabilization time = 10mins to 1hr depending on ambient temperature, coming off battery charge and last use
- Output short circuit = indefinite (20mA)
- Power (batteries) = Two Lithium-Ion re-chargeable 9V PP3 batteries (Not supplied, 600mAh batteries recommended)
- Power (external power) = 18 to 21Vdc input for battery charging. 400mA min recommended
- Battery consumption = 100mA approx. at power up, reducing to 50mA approx. when LM399AH heater has stabilized (a few minutes)
- Battery quiescent current (unit switched off) = 4uA approx.
- Battery = Approx. 12hrs (EBL 600mAh re-chargeable batteries) typical continuous operation
- Dimensions = 106mm x 66mm x 47mm
- Contains 3D printed & laser cut parts.

OPERATION OF INSTRUMENT

Power on: Press and hold the power button until the LCD shows the PDVS2mini splash screen.

Power off: Press and immediately release the power button. The LCD will clear, power is now 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 is displayed on power up with the software version before displaying the MAIN screen. It is recommended to wait 10mins from cold to allow the LM399AH reference to stabilize.

Menu: To access the MENU, press and hold the ENTER button.

The Main Menu functions are as follows,

- UP – MAIN The main output control screen
- LEFT – SETTINGS Where user config settings can be changed.
- RIGHT – CALIBRATION Where calibration of the unit can be done.

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 cable wiring: 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/level.

The batteries must be capable of charging at a rate of 220mA. Most are, but please check.

The batteries are charged in-place using the DC socket on the top. The PDVS2mini must be powered up for charging to take place. This is so the PDVS2mini can actively monitor the charging process. The batteries won't charge with the PDVS2mini turned off.

The unit can be used whilst being powered from the ext. DC socket but with the following important restrictions/notes:

Minimum DC supply (to charge the batteries): = 18Vdc
 Minimum DC supply (no batteries fitted): = 18Vdc
 Maximum DC supply: = 21Vdc

Absolute Minimum DC supply: = 14Vdc (unit won't charge but will run)
 Absolute Maximum DC supply: = 21Vdc

.....cont.

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

MANUALLY DISABLE CHARGING:

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

RUNNING WITHOUT BATTERIES FITTED:

To run the unit without any batteries fitted then turn off charging via the SETTINGS menu. Without this you may get "OVER" on the display.
Please observe the minimum external DC supply voltage.

NOTES:

When running with batteries and also an external DC input the higher voltage of the two is used to power the unit. Highest voltage wins.

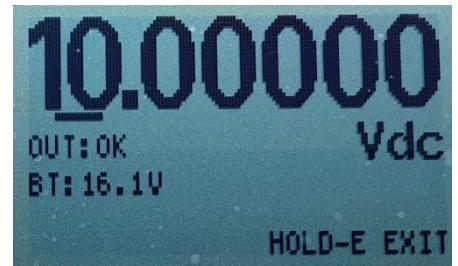
Most Lithium-Ion PP3 batteries have a built in protection circuit and can shut themselves down if over-discharged. Brands can differ so you may have to adjust the low battery warning and auto-shutdown voltages accordingly.

On disconnecting the ext. DC socket after fully charging the batteries the battery voltage should display approx. 16.8Vdc. This is two 8.4V PP3 Li-ion batteries in series.

MAIN

Setting an output: Use the LEFT & RIGHT buttons to select the digit you want to change then press the UP or DOWN to change the digit.

The digit selected is indicated with an underscore underneath.



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 avoid any ground loop noise entering the system.

Screen Messages:	"CHG"	-	Batteries are charging (also displays the charge current).
	"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.
	"BT"	-	Running on Batteries
	"DC"	-	Running on external DC supply
	"COMMS"	-	Serial comms is active

COMMS

On power up serial comms defaults to OFF.

The serial comms functionality is an added extra, as such the top acrylic panel must be removed to access the serial header at the top of the unit. The serial voltage levels are TTL.

To enable comms press and hold the LEFT & RIGHT buttons together. Enabled comms is indicated on the LCD as well as flashing the small red LED near the comms header..

If the serial comms is not being used then it is advised to leave it switched OFF as it will help the responsiveness of the unit.

The header on the top of the unit enables direct connection to a Windows PC via a suitable serial to USB converter, such as 3.3Vdc "Adafruit FTDI Friend". Not supplied.

Most adaptors will not plug in directly and will need an adaptor cable made up.

PDVS2mini Serial Protocol:

A simple bi-directional Ascii based serial data protocol, BAUD: 250k,N,8,1
Rate = Data from PDVS2mini to PC is sent every 100mS

Format to PC VR0,0,12345
Format from PC <KeyVoltage, 0, 1.23456>

The following details all the data being sent from the PDVS2mini, and only a partial listing of the data from the PC.

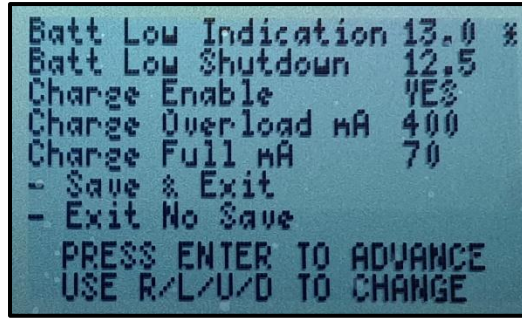
PDVS2mini OUTPUTS TO PC:

KV,0,	Output Voltage of PDVS2mini
BV,0,	Battery Voltage or DC Input Voltage
BVFM,0,	Battery Voltage Feed Mult
OVF,0,	Output Voltage Feedback
OVFM,0,	Output Voltage Feedback
BC,0,	Message = DC Input - Charging, DC Input, DC Input - Full, Running on Batteries, Battery Charge high mA!
BLI,0,	Message = Status - Low, Status - Ok
Mode,0,	Message = Main Menu, Normal, Calibration, Settings
BMIM,0,	Battery Monitor IC Mult
BI,0,	Battery current
CMS,0,	Cal Mode Sub
dacZ0,0,	DAC Zero Cal 0
dacS0,0,	DAC Span Cal 0
dacS1,0,	DAC Span Cal 1
dacS2,0,	DAC Span Cal 2
dacS3,0,	DAC Span Cal 3
dacS4,0,	DAC Span Cal 4
dacS5,0,	DAC Span Cal 5
dacS6,0,	DAC Span Cal 6
dacS7,0,	DAC Span Cal 7
dacS8,0,	DAC Span Cal 8
dacS9,0,	DAC Span Cal 9

OUTPUT FROM PC TO PDVS2mini:

<KeyVoltage,0,1.23456> Voltage requested to output from PDVS2mini

SETTINGS



```
Batt Low Indication 13.0 %
Batt Low Shutdown 12.5
Charge Enable YES
Charge Overload mA 400
Charge Full mA 70
- Save & Exit
- Exit No Save
PRESS ENTER TO ADVANCE
USE R/L/U/D TO CHANGE
```

User adjustable settings:

- | | |
|----------------------|---|
| Batt Low Indication. | Battery voltage at which the unit displays BATTERY LOW. |
| Batt Low Shutdown | Battery voltage at which the unit will auto-shutdown. |
| Charge 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. |
| Charge Overload 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. |
| Charge 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. |

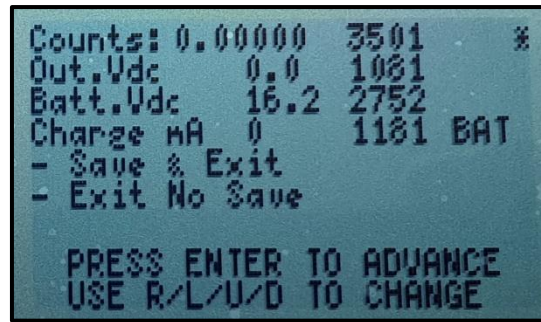
Use the ENTER button to advance through the various entries, and the other buttons to make changes.

See the Calibration record as supplied with your PDVS2mini for the original factory settings.

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:

Use the ENTER button to advance through the 11 point output calibration as well as the other analogue related calibration, as follows:

Counts: 0.00000	XXXXXXX	Counts for 0.00000Vdc output
Counts: 1.00000	XXXXXXX	Counts for 1.00000Vdc output
Counts: 2.00000	XXXXXXX	Counts for 2.00000Vdc output
Counts: 3.00000	XXXXXXX	Counts for 3.00000Vdc output
Counts: 4.00000	XXXXXXX	Counts for 4.00000Vdc output
Counts: 5.00000	XXXXXXX	Counts for 5.00000Vdc output
Counts: 6.00000	XXXXXXX	Counts for 6.00000Vdc output
Counts: 7.00000	XXXXXXX	Counts for 7.00000Vdc output
Counts: 8.00000	XXXXXXX	Counts for 8.00000Vdc output
Counts: 9.00000	XXXXXXX	Counts for 9.00000Vdc output
Counts: 10.00000	XXXXXXX	Counts for 10.00000Vdc output
Out.Vdc XX.X	XXXX	Output monitor counts Calibration of the output DC voltage monitor.
Batt/DC.Vdc XX.X	XXXX	Battery / Ext. power supply Vdc Span counts Calibration of the Battery & external DC supply for the main screen.
Charge mA XXX	XXXX	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, and the other buttons to make changes.

UP/DOWN	-	1 count modify
RIGHT/LEFT	-	100 count modify for DAC, 10 count for all else
HOLD RIGHT/LEFT	-	1000 count modify for DAC, 100 count for all else

See the Calibration record as supplied with your PDVS2mini for the original factory 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.

PDVS2mini FIRMWARE UPGRADE (ATMEL AVRISP MKII)

Occasionally updated software for both the PDVS2mini and the free 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 upgrade process I have tested with Win7 & Win10 only, however I cannot guarantee it will work for you. If the process fails your PDVS2mini may become inoperable until you are able complete the upgrade process successfully. Important: You do this at your own risk.

Required before you start:

An Atmel AVRISP mkII programmer (USB with 6-pin type header) is req'd. The data line logic must be set to 3.3Vdc. If you are using a genuine Atmel AVRISPMkII then set J1 so that the programmer can deliver the correct 3.3Vdc logic levels. Other programmers may vary so please check.



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

A .HEX file will be supplied for the upgrade.

The 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.

Procedure:

Remove the 4 screws on the top of the unit, then locate JP1 Power Bypass header and link it out. The PDVS2mini will switch on. Important: Use batteries only, do not use external DC power.

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

Run AVRDUDESS and make the selections/options as follows

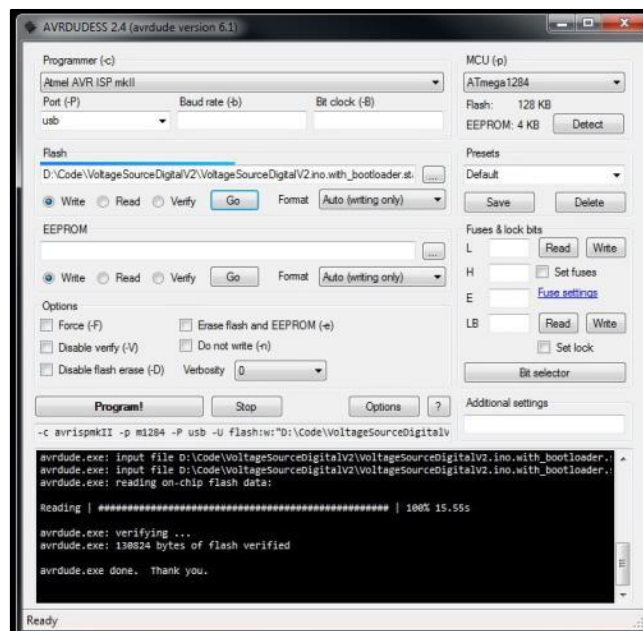
- Programmer = Atmel AVR ISP mkII
- MCU = ATmega1284
- Port = USB
- Under FLASH locate the new .HEX file



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

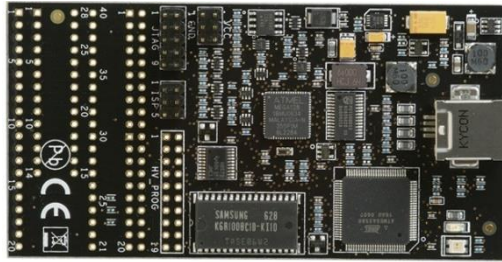
Press PROGRAM! on AVRDUDESS and the window at the bottom will show you the upload progress and should complete as shown (<30secs).

That's it!.....disconnect and don't forget to remove JP1 PWR BYPASS jumper, and re-boot the PDVS2mini.



PDVS2mini FIRMWARE UPGRADE (ATEMEL AVR DRAGON)

An alternative method of updating the firmware is by using an Atmel AVR Dragon.



Launch Atmel Studio 7 and select TOOLS, DEVICE PROGRAMMING.

Connect the AVR Dragon to a USB port of your PC.

On the PDVS2mini bridge J1 (this selects 3.3V for ICSP). It is bridged by default.

On PDVS2mini (fresh batteries only, do NOT use DC power) fit a jumper to JP1 power bypass, the PDVS2mini will power up.

Connect an ISP cable (6-way both ends type) from the PDVS2mini ICSP header to the AVR Dragon ISP header (note orientation and pin1).

On Atmel Studio Select AVR DRAGON, ATmega1284, ISP.....then hit APPLY.

The PDVS2mini will be interrogated, you should see the programming voltage report 3.3Vdc and if you select FUSES you should see the settings populate, hit LOCK BITS you should see the same.....don't touch anything, this is just proving the PDVS2mini is being interrogated live.

Go to MEMORIES and under FLASH select the HEX file, press PROGRAM. You should see the Erase, Program and then Verify cycles. This should take about 40secs total.

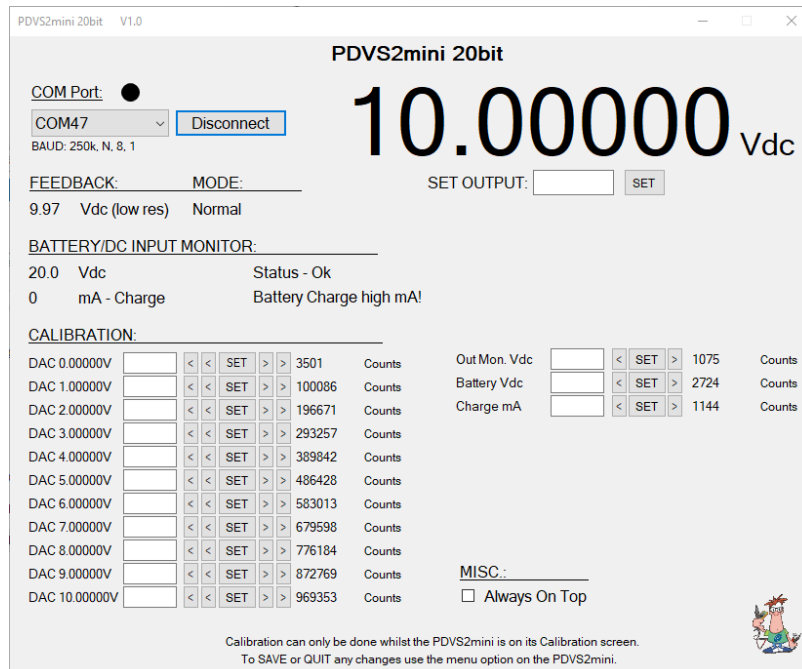
When finished unplug the PDVS2mini and remove JP1 power bypass.

PDVS2mini WINDOWS APPLICATION

The Serial comms interface is a free additional extra. The Windows app will be available to download at www.ianjohnston.com.

A suitable method of connecting to a Windows PC is required, the following example suggests using a serial TTL-USB comms adaptor. See page 6 (COMMS).

- Operation:
- Download the zip file containing the install files for the PDVS2mini app. Extract the files to a folder on your PC then double click on SETUP.EXE. Follow the on-screen prompts to install the app. If the app install fails then see below.
 - Turn on COMMS on the PDVS2mini by holding down the LEFT & RIGHT buttons.
 - Start the PDVS2mini Windows app.
 - Select the COM port.
 - Press CONNECT and the data will appear.



Windows app install fail?

Norton Antivirus and some other anti-virus apps recognize the SETUP.EXE file as containing a virus. This is a *false positive* and I have reported this to Norton etc. You will need to fix the issue before downloading or unzipping the files. Depending on your Antivirus software you should be able to whitelist the file.

HARDWARE

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

- FUSE 1 - 1A time delay fuse (Schurter UMZ 250 series).
- J1 - 3.3Vdc supply to ICSP header. Default = shorted.
- ICSP - In Circuit Serial Programming header, used for uploading new firmware.
- JP1 - Linking this bypasses the (soft) power switch.

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 220mA 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 "Charge Full mA" preset (see SETTINGS) the charging will cease and "OFF" will be displayed. At this point the MAIN screen will display "FULL". The charger disconnects from the batteries completely (DC pass-through), no trickle charging.
- Q. Why does the charge current suddenly drop to 0mA from 200mA+ when I am charging the batteries in the PDVS2mini?
- 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 PDVS2mini that it suddenly stops charging and the charge current drops to 0mA. To fix this, remove the batteries from the PDVS2mini and charge them separately in a standalone charger. This will match them again and you can return them to the PDVS2mini. If this problem persists then you may have a faulty/weak battery.*
- Q. Can I run the PDVS2mini 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 at least 250mA. 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 PDVS2mini 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.*
- Q. There's a blob of sealant on my Pcb covering some components?
- A. *This isn't a quality issue, but is infact protecting the DAC filter components from possible humidity issues. The sealant used is non-corrosive and designed for electronics.*
- Q. When I change the output by a least significant digit (10uV) the output sometimes does not change by much?
- A. *It is changing, it's just the INL affected step change between two bits may be so small it may not appear on your DMM, and due to rounding.*

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.

Important Updates:

Specification change 08/11/21: Max. external power for battery charging reduced to 21Vdc from 24Vdc.

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.

Ian Johnston Engineering Ltd.

CERTIFICATION & DECLARATION OF CONFORMITY
FOR UKCA MARKING

COMPANY CONTACT DETAILS

66 Martin Drive, Stonehaven
Grampian Area, Scotland
AB392LU
Tel. 01569 765433 - Mob. 07835 391781
Email: ian@ianj.net

Ian Johnston Engineering Ltd. Declares under their sole responsibility that their:
Handheld Precision Digital Voltage Source
Model: PDVS2mini

complies with the Essential Requirements of the following UKCA (equivalent EU) Directives:
EMC Directive 2014/30/EU
RoHS 2 Directive 2011/65/EU

and further conforms with the following UKCA (equivalent EU) Harmonized Standard:
EN 61326-1:2013 Electrical equipment for measurement, control and laboratory use. EMC
Requirements. General requirements. Electromagnetic compatibility, Electromagnetic radiation.

Dated: 01/01/2021

Position of signatory: Director

Name of Signatory: Ian Johnston

Signed below:

On behalf of Ian Johnston Engineering Ltd.



PDVS2mini – TEST / CALIBRATION RECORD

FUNCTION	COUNTS	VOLTAGE OUTPUT
0.00000		
1.00000		
2.00000		
3.00000		
4.00000		
5.00000		
6.00000		
7.00000		
8.00000		
9.00000		
10.00000		

FUNCTION	COUNTS
Out.Vdc	
Batt.Vdc	
Charge mA	
Batt.Low Shutdown	
Charge Enable	
Charge Overload mA	
Charge Full mA	

TEST	
Serial Comms	
Soak Test Duration	hrs
External DC Input	
Battery Charge/Discharge Test	

Serial Number =

Ambient Temperature =

Date =