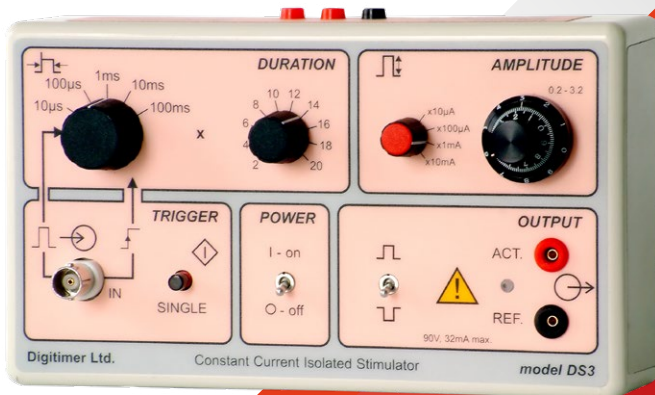


Digitimer

DS3

Isolated Stimulator with Constant Current Output

OPERATOR'S MANUAL

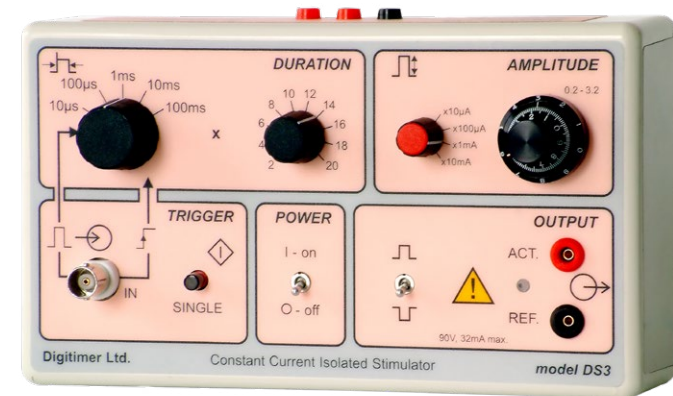


PRODUCT REGISTRATION

Please take time out to register your new product.

You can even do it online at:-

www.digitimer.com/register



The Digitimer
DS3 Isolated Stimulator
with Constant Current Output

PRODUCT REGISTRATION

For a speedy response to all your questions now and in the future, please take time out to register your new **DS3** stimulator at www.digitimer.com/register now!

Product registration permits us to quickly advise you of any safety matters or new product information.

This web address is your point of contact for all questions regarding the DS3. The contents of this site are now growing rapidly, so please bookmark it so that you can visit it regularly to check out the new items.

Why Register your purchase?

Digitimer periodically offers enhancements and firmware updates to our products. Without product registration, users of our products may miss out on announcements of important enhancements to the products that they are using. Digitimer Limited does not make our customer list available to anyone else. Any information that you provide to us is strictly confidential.

How to Register your purchase

Product registration can be accomplished in two ways. You may fill out and mail in the product registration/warranty card supplied with each Digitimer Limited product. You may also register on-line at our www.digitimer.com/register website.

Product announcement mailing list

Digitimer has E-mailing lists, which we use as our primary outlet for announcements of new products, product enhancements and product updates. We strongly recommend that all users of our products sign up for the list that is most appropriate to their area of interest. E-mail is kept to a minimum and list membership is kept in the strictest confidence. Only Digitimer Limited can send mail to members of our e-mailing lists.

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HISTORY OF THE DS3

The DS3 continues the line of isolated stimulators from Digitimer Ltd. and complements the DS2A with its Constant Voltage output. A line that spans back over 35 years

The line started with the Devices Ltd. model 2530, then through Mk II, Mk III and Mk IV to the 2533 - all of which needed a -12V trigger signal. Then DS2 evolved using self-contained, readily available, 9V batteries and worked with either a -12V or +12V trigger input. The DS2A followed and was characterised for use with positive trigger signals that also include most "TTL" outputs. The DS2A was also available with a Special Modification that provided a Constant Current output. This is what led to the birth of the **DS3**.

In 2021 the DS3 was internally updated with a new PCB that is fitted with surface mount (SMT) rather than thru-hole components.

HARDWARE & CONTROLS OVERVIEW

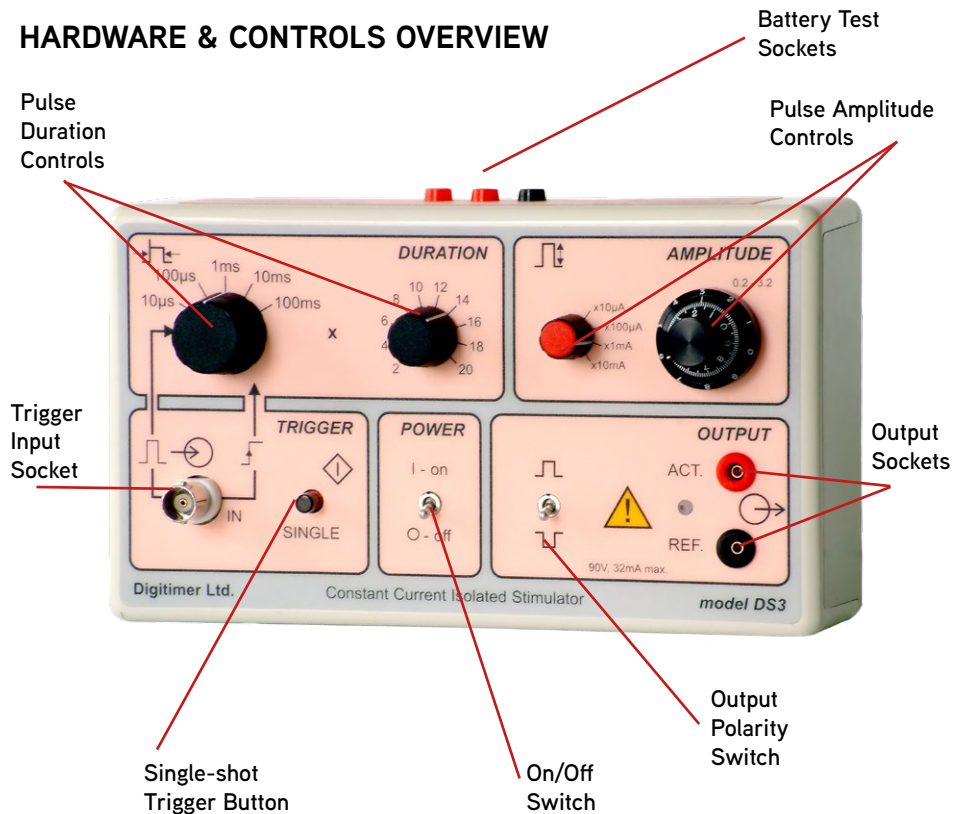


Figure 1 – DS3 Front panel connections and controls.

The **DS3** provides a precise Constant Current stimulus controllable in Pulse Duration and Amplitude from self-contained batteries.

The range of pulse duration's available may be varied using a six-position switch and multiplier within the range 20µs to 2 seconds, as well as being externally controlled.

A three-turn dial on the front panel of the instrument provides a continuous adjustment of the output amplitude, which is indicated on the vernier dial as 0.2 to 3.2. Do not attempt to turn the dial beyond the 3.2 position as damage will result.

With the four ranges (x10µA; x100µA; x1mA and x10mA) currents from 2µA to 32mA can be selected. A locking lever prevents inadvertent changes in amplitude.

In order to prevent damage, this locking lever must be released before adjustment of the dial.

The presence of an output pulse is indicated by an LED located next to the output sockets.

The Output is isolated from the trigger source by an optical device that ensures a very low capacitive coupling between trigger source and stimulator to reduce artefact.

The self-contained batteries, without a DC-DC converter, ensure that the stimulator is ultra-quiet and does not induce any high-frequency noise into the recording system.

It is also worth noting that battery current is only drawn when the stimulator is delivering an output pulse. This greatly extends the life of the batteries.

When constant current stimulators are used to stimulate very high-impedance, high-capacitance cells the electrode tip can charge up and stimulation be lost. This is because constant current stimulators have a very high output impedance which will not discharge the cells. The **DS3** provides an output discharge circuit which operates (if user enabled) after each stimulus pulse. An internal jumper selects this feature.

The stimulator is produced in a box made of an insulating material and may therefore be connected to a metal mounting frame without connecting the internal circuits of the instrument to ground.

MAJOR FEATURES

- Self-contained unit using standard internal batteries.
- Output is isolated from trigger source.
- Low current consumption. No current used when no output pulse.
- Triggers from most sources. From 3V, 5µs upwards.
- Single shot button.
- Wide Constant Current range (2µA to 32mA)
- Accurate and repeatable Current Amplitude
- High voltage compliance (90V)
- Indication of every output pulse delivered.
- Wide range of Pulse Durations (20µs to 2 seconds, Internal)
- External control of Pulse Duration (using External Control position).
- Accurate and repeatable Pulse Duration.
- Output polarity reversal switch.
- Output Clamp circuit for high capacitance cells/preparations.
- Touch-proof 2mm output sockets.

SYMBOLS USED













	Off (power) - Indicates OFF position of Battery Power switch.		On (power) - Indicates ON position of Battery Power switch.
	Input - signal input connector.		Output - stimulus output connector.
	Positive going pulse required.		Active "high" square wave pulse required.
	"Start Process" Manual Trigger Button (Single).		Warning, consult accompanying documents.
	Output Pulse Duration Controls.		Output Pulse Amplitude Controls.
	Normal Polarity Output Pulse. Red socket goes positive wrt Black socket.		Reverse Polarity Output Pulse. Red socket goes negative wrt Black socket.

Table 1 - Symbols used on the DS3.

TRIGGER SOURCES & INPUT REQUIREMENTS

Digitimer Ltd offer a growing range of trigger sources. These range from simple pulse generators and other timing modules of the **NeuroLogtm** system through to crystal-controlled programmers.

Input Requirements

The **DS3** stimulator will only trigger from a positive pulse. Should it be necessary to use a negative trigger pulse, this can be achieved as the BNC socket is isolated from the rest of the circuitry. By connecting the centre of the input BNC socket to ground (or common) and driving the body of the BNC to the negative signal, the unit triggers as normal.

The amplitude of the trigger pulse applied to the BNC socket on the front panel should be between 3V and 20V when loaded by the input circuit of the stimulator.

The trigger input characteristics graph shows the minimum usable pulse duration ($\mu\text{s}/\text{V}$) and the minimum input current (mA/V) to ensure satisfactory operation.

The stimulator will trigger from the leading edge of the trigger pulse with a delay of approx. $6.5\mu\text{s}$ at 2.5V, reducing to $4\mu\text{s}$ at 3V, and $2.5\mu\text{s}$ at 5V. As the graph shows, if a higher amplitude trigger pulse is available, it should be used. This lowers the pulse duration required as well as the delay generated by the unit.

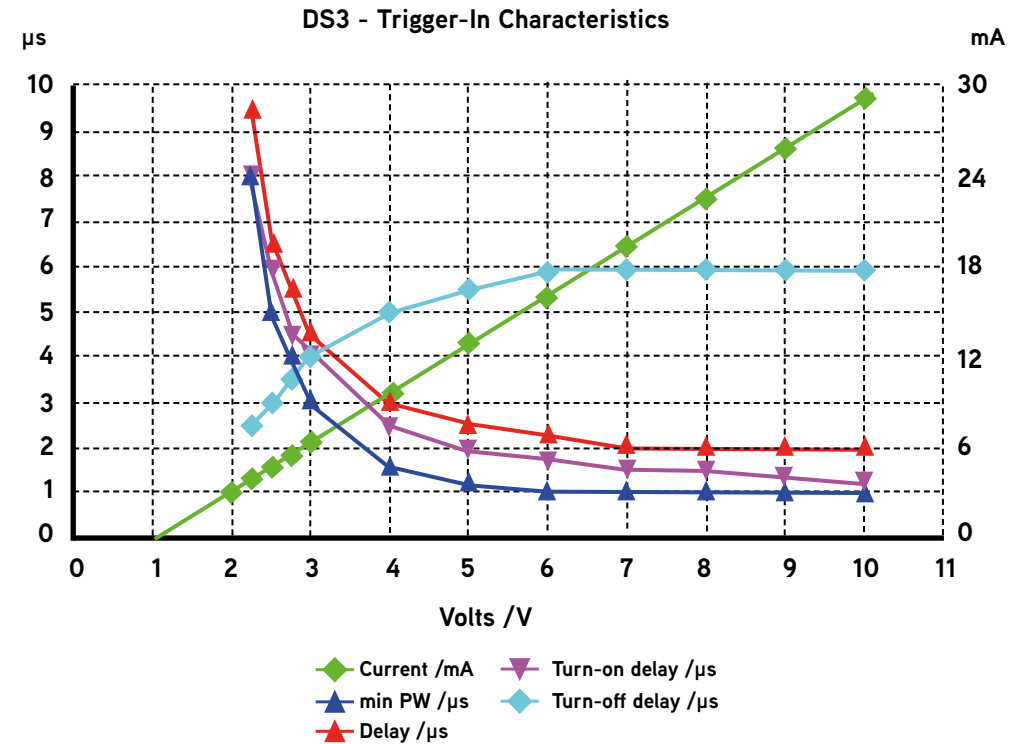


Figure 2 - DS3 Trigger-In Characteristics.

EXTERNAL PULSE DURATION CONTROL

External control of pulse duration is activated by rotating the 6 position rotary switch to the most anti-clockwise (counter-clockwise) position, so the white line on the knob lines up with the arrow below the 10 μ s label on the front panel.

When external control of pulse duration is selected the output stimulus timing will be controlled by the duration of the Trigger-In stimulus pulse.

It should be noted that (with a 5V input pulse) there is only a very short delay of <2 μ s for the turn-on and <6 μ s for the turn-off. When a typical TTL pulse is used, which will only be about 3V, these are matched at 4 μ s each.

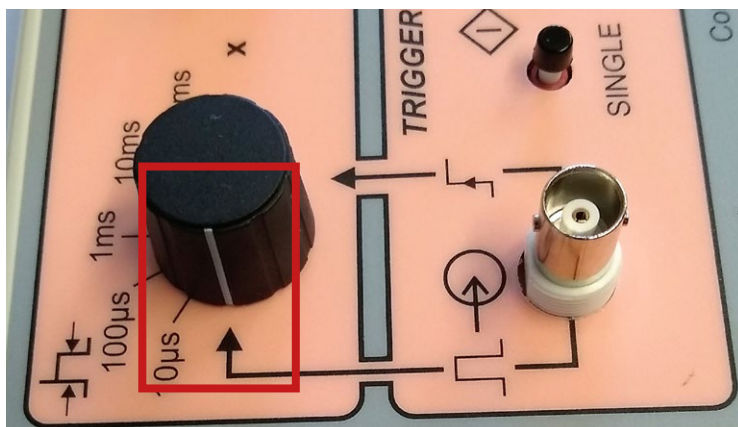


Figure 3 - Pulse duration control - Rotated anti-clockwise to the "external control" position.

SINGLE-SHOT TRIGGER BUTTON

A single-shot facility is provided by means of a push button to the left of the on/off switch. This operates at all times irrespective of other trigger inputs.

It should be noted that in external control of pulse duration, the single shot button produces a single very short (~10 μ s) pulse or an output for the duration of holding the button, dependant on an internal jumper. This jumper is factory preset to give a short pulse. See later section if you need to change this.

OUTPUT CHARACTERISTICS

The stimulus output is isolated from the trigger source by an optical circuit providing less than 3pF capacitive coupling. Power is provided by a battery source that is loaded only during the generation of an output pulse. Continuous control of pulse duration from 20 microseconds to 2 seconds is available by means of a five-position range switch and multiplier potentiometer. A sixth position gives total external control over this duration.

A three-turn potentiometer varies the amplitude of the output pulse from 2 μ A to 32mA from a battery voltage of 90V.

The **DS3** stimulator has an output pulse that has a square shape, having rise time of 1 μ s and fall time of 3 μ s into a resistive load and its presence is indicated by a front panel LED.

As constant current stimulators have a very high output impedance, if they are used to stimulate very high-impedance, high-capacitance cells the electrode tip charges up and stimulation is lost.

The **DS3** provides an output discharge circuit which operates (if user enabled) after each stimulus pulse. An internal jumper selects this feature.

The polarity of the output pulse may be reversed by means of the Normal/Reverse switch. Normal means that the red output terminal goes positive with respect to the black terminal.

DEVICE MOUNTING

The **DS3** can be mounted and positioned in any plane and 19" rack mounting is possible by using two of the box fixing screws through the model D121-11.

ACCESSORIES

The DS3 is supplied with the following parts -

- Full set of batteries (fitted)
- A pair of unwired output connector plugs (NL985P)
- Operator's Manual (this manual)

The following accessories are available for purchase from Digitimer Ltd.

- **D121-11** - Mounting frame that allows two units to be mounted together in a 19" rack
- **DG2A** - Train Delay Generator, provides stimulus frequency inc. a delayed pulse
- **NL985P** - Additional pairs of output plugs (one red/one black)

BATTERIES

The **DS3** stimulator employs a total of 11 x 9V (PP3, IEC - 6R61) batteries using one of them to power only the **control circuits** and ten just for the **output circuit**.

As the control circuitry takes about 15mA during the pulse and nothing at other times and the output stimulus can be anything from 2µA to 32mA, the rate of usage of the two sets will normally be greatly different.

This feature allows the user to easily check (on the external sockets) and change either one, ten or eleven batteries as required.

Control Circuit Battery

The **DS3** will operate fully even when the control circuit battery has discharged down as far as 6.5V. This is 72% of its nominal voltage of 9V. Below this level the output amplitude will start to reduce until the battery reaches about 5V when the control circuit will stop. There is no loss of timing accuracy before the unit stops.

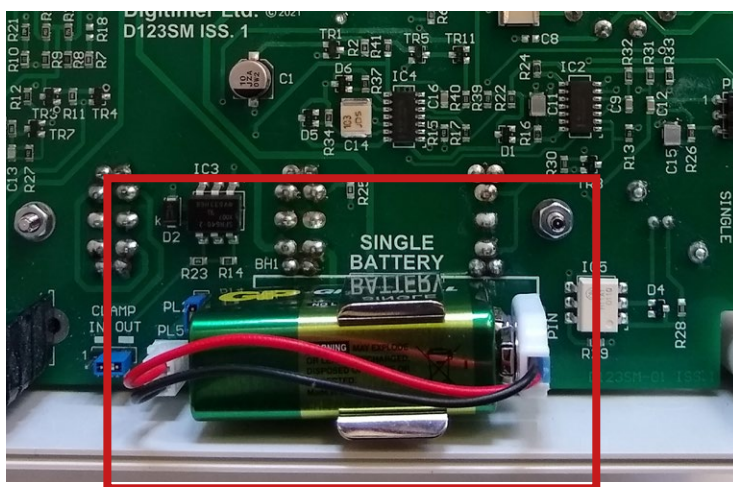


Figure 4 - The single control circuit battery is mounted on the main PCB.

Output Circuit Batteries

These are purely used to deliver the stimulus. Any reduced voltage will reflect in a reduced compliance for the output.

Battery Testing

When using the battery test terminals, it is desirable that the battery voltage is measured when operating with a repetitive trigger signal providing a duty cycle greater than 20% or by using the single-shot facility with the maximum (2 second) pulse duration. The usual stimulating electrode(s) should be placed in a saline-filled bath, so as to mimic the typical impedance of the preparation. This method will show up any high-resistance battery condition.

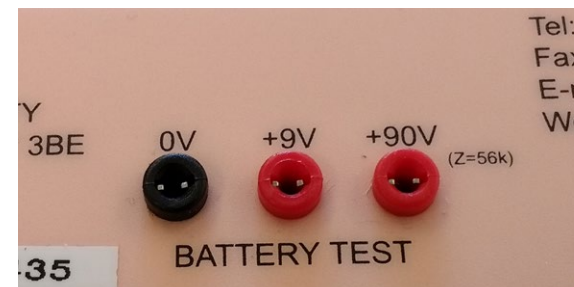


Figure 5 - Battery test sockets are provided to test the output and control batteries without disassembling the DS3.

Battery Life

This will depend on the frequency of operation and will therefore vary widely with the application, but the following example may be considered typical.

Output current - 20mA, duty cycle - 1:10, period of operation - 2 hours/day. Estimated life to end point voltage of 6V per 9V battery - 2 months.

Replacement batteries should be of premium grade sealed type, Alkaline preferred, and batteries should not be left in an unused stimulator.

Battery Replacement

This must only be performed by a competent person.

CAUTION must be used when replacing the batteries as they present voltages up to 99V between different points.



Figure 6 - Underside of the DS3 showing the case screw locations.

The **DS3** stimulator is manufactured in a two-part plastic box that is held together by four screws through the base of the box.



Figure 7 - With screws removed, the case halves can be slid apart.

The two halves may be separated by removing these screws, sliding the two halves apart and disconnecting the battery leads by removing the connectors.

Ten of the batteries are firmly held within the black compartment that is screwed to the base and one within the clip fixed to the main PCB.

All batteries in the 90V pack must be replaced at the same time.

Only use new batteries that are from the same manufacturer and are the same type. It may NOT be necessary to change all 11 batteries at the same time. See "Batteries" section in this manual.

Reassembly is the reverse process of the above ensuring that the base is fitted to the lid with the single battery on the side indicated by the label on the battery pack label. Do NOT tighten the screws more than necessary and ensure that there are no trapped wires between the case top and bottom when they are assembled.

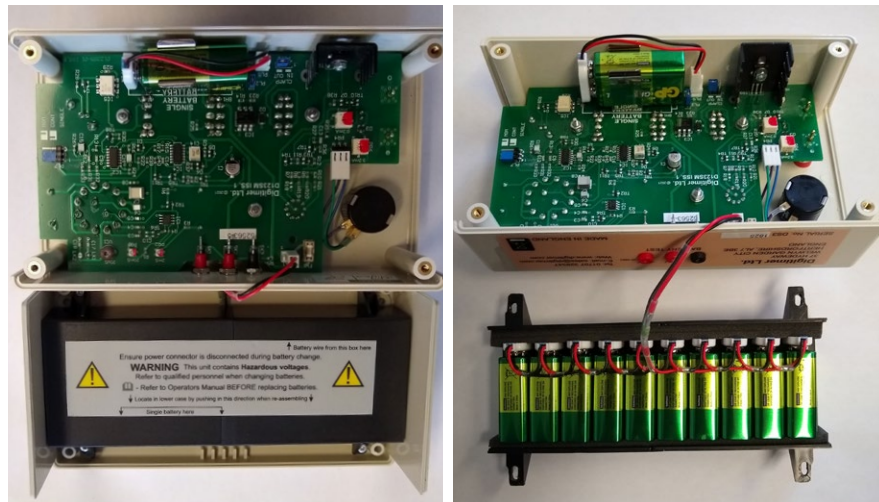


Figure 8 - Images of the opened unit (left) and the exposed battery pack (right).

INTERNAL VIEW & JUMPERS

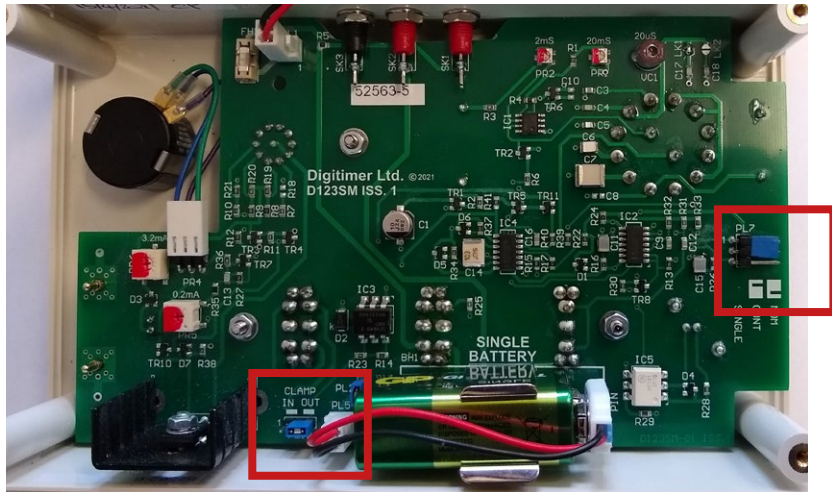


Figure 9 - Internal view of DS3, showing jumper locations.

“Single” Jumper

The “Single” jumper determines the Output delivered if the “SINGLE” button is pressed when the external duration control is selected.

- “MOM” (factory setting) Produces a very short pulse ~10µs when pressed.
- “CONT” Produces an active output for the duration of the press. This could be useful in dye marking etc.

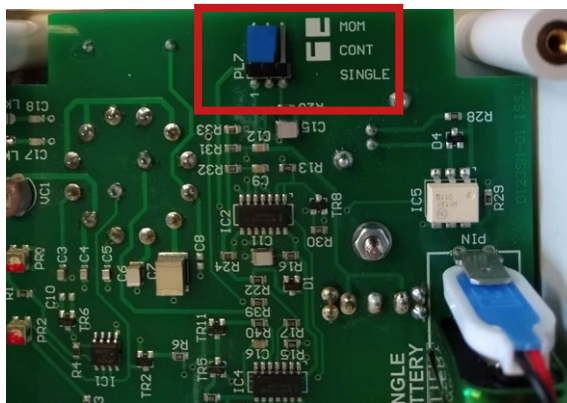


Figure 10 - Location of the “Single” jumper, showing it set to the “MOM” position.

“Clamp” Jumper

- “CLAMP OUT” (factory setting)
- “CLAMP IN”

The Output is open circuit between pulses.
 The Output is short-circuited for 20µs after each Stimulus. This will discharge the cells and stop them charging up. See later section.

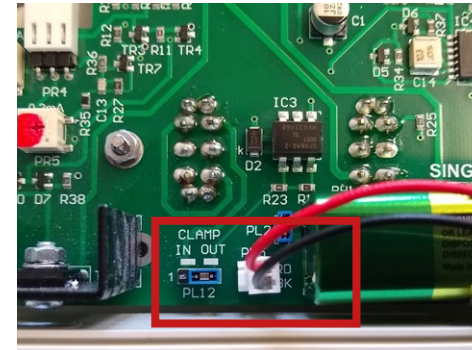


Figure 11 - Location of the “Clamp” jumper, showing it set to the “OUT” (default) position.

OUTPUT CLAMP OPERATION

Whenever a high output impedance stimulator (a Constant Current unit) is used to deliver a stimulus to a cell, the cell will retain some of that energy between stimuli and “charge-up”. The DS3 has a User enabled CLAMP circuit that operates for 20µs after each stimulus pulse. This will discharge cells with capacitances as high as 1000pF. This is indicated in the following plot.

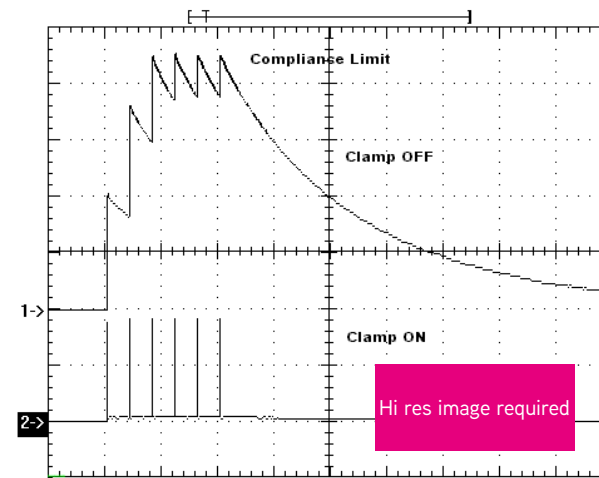


Figure 12 - Illustration of the effect the “Clamp” circuit has during repetitive stimulation.

Stimulus A burst of 6 x 220µA, 200µs pulses with an ISI of 10ms.

Oscilloscope Scales 25ms/div., 20V/div.

Dummy Cell 1100pF in parallel with ~50Mohm.

Trace 1 **CLAMP OUT** - Shows the effect of no clamp on the output.
 NOTE that the 3rd stimulus is NOT the same amplitude as the previous two as the cell is charged and the stimulator has reached its 90 V limit.

Trace 2 **CLAMP IN** - Here the Output Clamp is automatically activated after each stimulus.
 NOTE that all six stimuli are presented to the preparation at equal amplitude.

SPECIFICATIONS

Pulse Duration

Range: 20µs to 2s plus External control.

Control: A single turn control provides continuous adjustment over range 2 to 20.

Ranges:

10µs	giving 20µs to 200µs;
100µs	giving 200µs to 2ms;
1ms	giving 2ms to 20ms;
10ms	giving 20ms to 200ms;
100ms	giving 200ms to 2s.

External giving the same as the input

The pulse duration is the product of the two dial settings but in "External" the variable control has no function. Internal pulse widths have ±10% accuracy.

Output

Current range: 2µA to 32mA in four overlapping ranges.

Amplitude Control: A three-turn dial provides continuous adjustment. The dial indicates the output current range from 0.2 - 3.2.

Current Ranges:

x10µA	giving 2µA to 32µA
x100µA	giving 20µA to 320µA
x1mA	giving 200µA to 3.2mA
x10mA	giving 2mA to 32mA

Compliance: 90V from 10 x 9V batteries. This reduces to 87V at the top of each output range.
 It should be remembered that 'new' batteries are ~9.5V and will slowly fade to ~6V, with use, before quickly dying.

Indicator: An LED operates for the duration of each output pulse.

Polarity Switch: Normal: Red output terminal positive w.r.t. Black. Reverse: Red output terminal negative w.r.t. Black.

Impedance: Approximately 100Mohm, in the off condition.

CLAMP Duration: 20µs, sufficient to discharge 1000pF.

Terminals: Two 2mm Touch-proof sockets on the front panel, spaced at 0.75".

Trigger

Voltage: A positive pulse of minimum 3V, maximum 20V amplitude is required to trigger the stimulator.

Current:	The trigger input current varies from 6mA to 62mA over the above voltage range.
Pulse duration:	The trigger pulse duration should not normally be less than 4µs.
Isolation:	Optical coupling is employed between the trigger source and the stimulator circuitry. The capacity coupling is less than 3pF.
Single Shot:	A single-shot push button is provided. This operates at all times irrespective of other trigger inputs. NB: See "Single Shot" section earlier.

Batteries

Type:	PP3, IEC - 6R61 style batteries. Alkaline preferred.
Number:	1 for the Control Circuit 10 for the Output Stimulation circuit.
Current Consumption:	Control Circuit battery is ~15mA; Output Circuit - the load current, only.
End point:	Control: 6.5V without any lack of performance; 5V with lack of output amplitude accuracy. Output: Only reflects on Output compliance. Note that current is drawn only when delivering an output pulse.
Test Sockets:	Sockets are provided on the side of the instrument case to allow the batteries to be checked without removing them from the case. Ensure measuring device has a high impedance.

Unit:

Dimensions:	Panel Size: 190mm x 110mm.
Depth:	80mm over knobs.
Mounting:	One or two stimulators may be mounted in a 19" rack using a specially fabricated mounting frame (model D121-11) available from Digitimer Ltd.
Weight:	800g complete with batteries.

WARRANTY INFORMATION

Limited Warranty

Digitimer Limited warrants to the first purchaser, for a period of one year from the date of purchase, that this Digitimer instrument (hereafter referred to as the "Product") will be free from defective workmanship and materials, and agrees that it will, at its option, either repair the defect or replace the defective Product or part thereof at no charge to the purchaser for parts and labour. The Product must be returned to Digitimer Limited, carriage paid and insured. Digitimer Limited will return the Product, carriage paid and insured, in the most appropriate method as determined by Digitimer Limited. If a faster shipping service is desired by the customer, any additional special delivery expenses must be paid by the customer.

This warranty does not apply to shipping damage. Digitimer Limited fully insures all shipments. Any claims of damage upon receipt must be filed with the carrier and Digitimer Limited immediately.

This warranty does not apply to any exterior appearance item of the Product which has been damaged or defaced, which has been subjected to misuse and abuse, abnormal service or handling, or which has been altered or modified in design or construction.

This warranty does not apply to any interconnection cables supplied with the Product.

This warranty does not apply if any unauthorised repairs, modifications or alterations have been made to the Product.

No sales organisations, other than Digitimer Limited itself, are authorised to make any warranties other than those described above, or to extend the duration of any warranties beyond the time period described above on the behalf of Digitimer Limited. If Digitimer Limited agrees to such a modification of this warranty, Digitimer will furnish a modified copy of this agreement, which must be presented if a claim is being made under these modified terms.

Obtaining Warranty Service

Warranty service of this Product can be obtained by returning the Product, carriage paid and insured, to Digitimer Limited, or the Distributor from whom the equipment was purchased. Prior authorisation before shipping the product is advised for the most expedient service.

Product change or discontinuation

Digitimer reserve the right to discontinue any instrument or to change its specification without notice, and without responsibility for incorporating changes in instruments already sold.

REFERENCES

The Digitimer DS3 Isolated Constant Current Stimulator has been referenced in over 500 research papers, which can be viewed on **Google Scholar**. A few of the most highly cited papers published since 2019 are provided below.

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FREQUENTLY ASKED QUESTIONS

1. What is the maximum trigger rate of the DS3?

The unit can be triggered fast enough to allow >99% "on" time, but the "off" time must >20 microseconds – so, very fast!

2. Can the DS3 be used to stimulate human subjects?

The DS3 does not have medical device directive (MDD) certification and has not been designed for safe human use. We offer a range of MDD compliant stimulators for human/patient connection.

3. Can I control the DS3 using a computer?

Yes and no. The DS3 features an external "gate" input allowing externally derived trigger pulses to define stimulus duration. However, the output amplitude is always determined by the front panel setting of the stimulator. We recommend our NeuroLog system to those interested in using a computer generated waveform to define stimulus timing/polarity and strength.

4. I want to stimulate with a longer pulse duration than 2 seconds, in order to lesion some tissue, is it possible to do this?

Yes, there are two simple methods:-

(i) The DS3 has the ability to be gated by an external pulse i.e. when external control of pulse duration is selected the output stimulus timing will be controlled by the trigger-in stimulus pulse. It should be noted that (with a 5V input pulse) there is only a very short delay of $2\mu\text{s}$ for the turn-on and $6\mu\text{s}$ for the turn-off. When a typical TTL pulse is used, which will only be about 3V, these are matched at $4\mu\text{s}$ each.

(ii) Alternatively, if a trigger pulse is not available or exact timing is not crucial (for instance when lesioning or injecting dye, there is a jumper which can be set to allow the unit to deliver a current for the duration the single shot button is held down. The internal "Single" jumper determines the output delivered when the "SINGLE" button is pressed (when "EXTERNAL" Duration is selected).

"MON" (factory setting) produces a very short pulse ~10 μs when pressed.

"CONT" produces an active output for the duration of the press. This could be useful in dye marking etc.

5. I can't decide between the constant current DS3 and constant voltage DS2A MkII- how should I choose?

The visible difference between the two units (apart from the colour!) is that the output control of the DS2A is defined in Volts while the output of the DS3 is defined in Amps. The actual stimulus passing through your preparation is measured in Amps in both cases and is dependent upon Ohms Law ($V = IR$). If your preparation has a variable impedance (R) and you

are using a constant voltage (V) source such as the DS2A, then the actual current (I) passing through the tissue may vary considerably between each stimulus, which may not be a good idea if you want to apply reproducible stimuli. With the DS3, the constant current circuitry prevents variations in tissue impedance from altering the size of current applied (within the 90V compliance limit of the unit), leading to the stimulator equivalent of WYSIWYG – "What You Set Is What You Get". Unfortunately there are no well defined rules governing the circumstances under which either stimulator should be used. If you are not sure and feel the need to evaluate either or both please contact us.

6. I have an old DS2 constant voltage stimulator and I recall that Digitimer offer a conversion to constant current. Is this still possible?

No, Digitimer no longer offers this service. Since the introduction of the new DS3 constant current stimulator, this unit is now offered to customers requiring a constant current version of the DS2A.

7. Is it possible to use two DS3 stimulators in parallel in order to stimulate through the same electrodes with different pulse types?

Yes, this is quite simple to setup and has been summarized in an application note.

8. How long do the batteries last for and can I use rechargeable replacements?

Battery life will depend on the frequency of operation and will therefore vary widely with the application, but the following example may be considered typical. Output current – 20mA, duty cycle – 1:10, period of operation – 2 hours/day. Estimated life to end point voltage of 6V per 9V battery – 2 months. In in vitro electrophysiology applications, the battery life will most likely be far longer as the currents being used will be lower. Replacement batteries should be of premium grade sealed type, alkaline preferred and batteries should not be left in an unused stimulator.

Rechargeable batteries are not recommended, as their voltages tend to decline very suddenly, which could lead to a failure in the middle of an experiment.

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