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S900/S900TT
Stimulator

Operating Manual
Version 2.0

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I. Introduction

The Dagan S900 Stimulator was designed for precise timing control of electronic events in the research laboratory. This single channel stimulator is capable of controlling the interval and duration of a single event or of train sequences. The S900 can be used to drive the Dagan S900 isolators as well as isolators of other manufacturers for direct stimulation of physiological preparations.

This instrument features analog dial input controls for convenient and precise control of timing parameters. Unlike a conventional analog stimulator the accuracy and repeatability of functions has been maintained through the use of TTL digital timing oscillators and counters. As a result, the S900 does not suffer from temperature instability and drift problems associated with multiple analog timers.

The S900 can be used to create pulses at up to 1000-second intervals, it can create trains of pulses, and it can be used in conjunction with other timing devices for an unlimited number of timing routines.

To further expand the capabilities of the S900 the Quick Step command generator can be used to generate the analog pulse voltage output level while the S900 provides a D.C. bias. The Quick Step also adds the capability of automatic increment routines in which the stimulus level increases by a predetermined amount at each successive occurrence.

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II. Specifications

All internally generated time functions are continuously variable in six switchable ranges. Ten turn calibrated dials (optionally one turn) set the value within each range with .2% resolution.

Interval Control

CONTINUOUS - Free running internal clock for continuous pulses at internally defined interval. Pulse interval from 100 microseconds to 1000 seconds.

SINGLE - Single event triggered by initiate switch on front panel or optional Quick Step command generator.

External - Interval time controlled by external function generator, controller, or computer. TTL and CMOS compatible, positive edge triggered input.

GATE - External logic signal can be used to turn on and off the internal interval clock. Switch allows active high or active low input.

Pulse Delay- Sets time of delay from interval trigger to pulse. 10 microseconds to 100 seconds.

Pulse Width - 10 microseconds to 100 seconds in single pulse or in train modes.

Train Duration- 100 microseconds to 1000 seconds.

Train Pulse Interval - 10 microseconds to 100 seconds.

Timing outputs . Monitor output is a TTL and CMOS compatible output active during pulse. SYNC output of 50 microseconds synchronous with leading edge of pulse interval signal, TTL and CMOS compatible.

Analog output

RISE TIME-3.5 microseconds

NOISE-less than 100 microvolts RMS in 30 KHZ bandwidth (8 pole Bessel filter) at 10 volt output range.

RESOLUTION-.2 % of full-scale value

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Positive and negative adjustable voltage outputs are switchable between 0-1 volt range and 0-10 volt range. Outputs can be pulsed by stimulator timing function or switched on continuously. Output impedance is less than one ohm. When the optional Quick Step command generator is used the Quick Step sets the pulse amplitude while the internal signal can be used as a D.C. bias.

Error Lights - LED indicators illuminate to indicate when the S900 is unable to produce the functions as they have been set with the timing controls. For instance, if the pulse width is set for a longer time than the interval between pulses, the pulse width error LED will light indicating this function cannot be accomplished. The S900 will continue to operate but the outputs will not accurately reflect the control inputs under these circumstances.

Power- 120 or 240 VAC operation can be selected with an internal switch (shipped set for 120 volt operation unless specified at time of order). Fuse is located on main circuit board. Maximum power consumption is 9 watts. A semi-toroidal split bobbin transformer and steel cabinet covers are used to eliminate electro-magnetic fields and prevent interference from other lab equipment.

Packaging - The S900 is housed in a standard 19-inch rack mountable cabinet 3.5 inches high by 10 inches deep. BNC connectors supplied on all input and output connections.

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III. Circuit Description.

All timing in the S900 is controlled by a single 4.000 MHZ crystal controlled oscillator, which is divided by a binary counter to produce the master clock frequency of 500 KHZ. This clock frequency is divided by a chain of 6-decade counters to produce the seven clock frequencies, six of which are selectable on each of the five timing stages.

Five identical timers are used to control the pulse interval clock, pulse delay, pulse width, train duration and train pulse interval. These timers are controlled by a clock frequency, which is selected by the 6-position range switch associated with each timer. The timers are voltage controlled counters that count 1 to 500 depending on the voltage set by the front panel 10 turn dial. With the dial at it's 100% setting (maximum clockwise) the timer will reset after 500 counts. As an example, with a clock frequency of 50 KHZ and the dial at 100% it will take 500 counts for the counter to reset. The period of a 50 KHZ clock is 20 microseconds so 500 counts would equal 10 milliseconds. With the pulse interval range switch at .010 seconds and the dial at 100%, the pulse interval would be .010 seconds or 10 milliseconds.

Pulse interval can be controlled either by the internal Pulse interval timer or by external controls as explained in the Specifications section of this manual. A rotary switch selects the source of interval control. When the continuous position is selected the pulse interval is controlled by the internal pulse interval clock. This clock is free running but can be reset to the beginning of its count with the RESET button. The pulse interval is set with the range switch and 10-turn dial as described above. When the pulse interval timer resets it triggers the pulse delay timer.

The pulse delay timer allows the user to control the amount of time after an interval trigger that the actual pulse or event occurs. This feature can be used with external trigger sources to allow recording equipment to begin recording before the event. The pulse delay timer is a monostable timer, which is triggered by the interval control. When the Pulse delay timer resets it triggers either the pulse width timer or the train duration timer.

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Single pulse operation

At the end of the pulse delay timing cycle a signal is produced that triggers the pulse width timer. The output becomes active as soon as the pulse width timer is triggered and remains active for the duration of the pulse width timing cycle. One pulse width timer controls pulse width in all modes of operation, single pulse, double pulse, and train.

Double Pulse operation

In the double pulse mode of operation the pulse width timer is activated twice during each interval cycle causing two output pulses. The pulse width timer is first triggered at the same time as the pulse delay timer. The second trigger occurs at the end of the pulse delay timer's cycle just as in single pulse operation. This feature allows the time between double pulses to be controlled by the pulse delay control. The double pulse feature can be used with trains also. In that case two trains are produced for each pulse interval time, separated by the pulse delay time.

Trains

In the train mode of operation the signal produced at the end of the pulse delay timer cycle triggers the train duration timer. When the train duration timer is active the train pulse interval timer is enabled. The train pulse interval timer is a free running timer, which triggers the pulse width timer once each cycle. The train pulse interval timer is disabled when the train duration timer resets. Additional circuitry is in place, which prevents the pulse at the end of the train from being cut short which would cause pulses in train of unequal duration. This does mean that a pulse which begins within the time determined to be the train duration may continue after that time. For purposes of selling up train parameters the train duration can be viewed as the time during which a pulse in train may begin.

Outputs

TTL and CMOS compatible outputs are available for monitoring and triggering external equipment. The monitor output is driven by the Pulse width timer and is high for the duration of a pulse. The output labeled SYNC is a one shot driven by the trigger signal that activates the pulse delay timer. This output is normally 50 microseconds duration but can be easily changed by the user if longer sync pulses are needed. This output makes a low to high transition synchronous with the leading edge of each pulse interval trigger.

The analog output section consists of a variable voltage reference which is set by a calibrated front panel ten turn dial and gated on and off by the pulse width timer. The voltage reference can also be switched on continuously with a front panel switch. This signal is amplified by a gain switchable amplifier to produce 1

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volt or 10 volt full-scale outputs. An inverted signal is also available which produces .1 volt or .10 volt outputs. The voltage outputs of the S900 have an extremely low output impedance to prevent errors caused by loading. A result of such low output impedance is a reduction in the ability to drive large capacitive loads. A capacitive load of greater than 10,000 picofarads may cause ringing at the output pulse waveform (typical coaxial cable has a capacitance of 30 picofarads per foot).

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IV. Using the S900

In this section step-by-step instructions are presented for setting up and using the S900 in single pulse, double pulse, and train modes of operation. To follow along you will need your S900 and an oscilloscope.

Flip on the power switch and you will see the power light come on as well as some of the error lights. The error lights will remain on only for a few seconds and then should remain off. Before attempting to set up any timing patterns it is a good idea to set all the timing dials to zero and to set all the range switches at their shortest time range (fully counterclockwise).

Single pulse operation

In this section the procedure for creating a 20-millisecond pulse at 500 millisecond intervals will be described. Beginning at the left side of the control panel set the interval source selector switch to continuous. This enables the free running internal interval clock. Set the Pulse Interval range switch to the 1.00 second range. Turn the pulse interval-timing dial up to the 50% position. With the range switch at 1.00 second full scale and the dial at 50% the pulse interval time will be 50% of 1.00 second or 500 milliseconds.

Moving to the right verify that the Pulse delay range switch and the dial are both at their minimum setting. It is not possible to achieve a zero setting on the S900 timing controls. The minimum setting is less than 1% of the full-scale setting. If pulse delay is not desired it is necessary to set the controls for the minimum delay. Verify that the train switch is in the off position and that the train timing controls are also at their minimum settings.

In the pulse width section of the instrument verify that the double pulse switch is off. Set the pulse width range switch to .100 seconds and the dial to 20%. At 20% of the full-scale value of .100 seconds a pulse width of 20 milliseconds will be produced. With an oscilloscope connected to the monitor output you will be able to see a 5 volt 20 millisecond pulse at 500 millisecond intervals.

Double Pulse

The double pulse mode allows the generation of two pulses within each pulse interval. With the pulse interval and pulse width controls set as they were above for single pulse operation set the pulse delay range switch to .100 seconds and set the pulse delay timing dial to 75%. Flip the double pulse switch on and the oscilloscope should display a 20-millisecond pulse, another 20-millisecond pulse starting 75 milliseconds after the start of the first pulse, with the sequence repeating every 500 milliseconds. As you can see the pulse delay controls the interval between the two pulses in the double pulse mode while the pulse width

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and pulse interval controls retain their normal function.

To illustrate the function of the error lights try selling the pulse delay dial to 15%. What you are asking the S900 to do is to create a 20-millisecond pulse followed by another 20-millisecond pulse starting 15 milliseconds after the start of the first pulse. The Pulse width error light will illuminate indicating that this function is not possible with a 20-millisecond pulse width. If you reduce the pulse width to 10 milliseconds there will be no error light will and the S900 will function properly.

Trains

In the train mode of operation the pulse interval control and pulse delay control determine the occurrence of the train itself while the train duration and train pulse interval controls determine the contents of the train. The first decision to make when setting up the S900 in the train mode is the interval of the trains themselves. This is set with the pulse interval controls as described above for setting up single pulse operation. For this example set the pulse interval control for 500 milliseconds. Set the pulse delay range switch and dial to their minimum settings. Set the pulse width control for 20 milliseconds and verify that the double pulse switch is off. At this point the scope will display a 20-millisecond pulse at 500 millisecond intervals. To set up the parameters of the train itself select the 1.00 second range on the train duration range switch and set the dial for 30% to produce a train of 300-millisecond duration. Set the train pulse interval range switch for .100 seconds full scale and set the dial at 50% to produce pulses within the train at 50 millisecond intervals. Flip the train switch to the on position and the oscilloscope will display a train of 20 millisecond pulses at 50 millisecond intervals. With the train duration set for 300 milliseconds the train will consist of six pulses and the train will occur every 500 milliseconds.

In the train mode the double pulse switch allows the generation of two trains within each interval cycle. Double pulse does not change the number of pulses within each train.

If you gradually reduce the dial setting of the train duration control while observing the output on the oscilloscope you will notice that nothing happens for a moment. A point will be reached at which the last pulse in the train disappears. This is due to the fact that the S900 has been designed to prevent pulses in train of unequal duration. If a pulse starts during the time defined as train duration, the full duration of the pulse as set by the pulse width control is produced.

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Interval Control and Pulse Delay

In the examples thus far the event interval has been controlled by the internal interval timer. To illustrate other sources of interval control set the interval source switch to the single position. With the controls set as they were for the train demonstration press the initiate switch on the front panel. The oscilloscope will display a single train of pulses. There will be no output from the S900 until the initiate switch is depressed. If the pulse delay time is at the minimum setting you will see the train on the scope immediately after the switch is activated. Now set the pulse delay range switch to 10.0 seconds and the dial to 25% and press the initiate switch. It will take 2.5 seconds before the train appears on the scope display. The real value of this delay time will be apparent when using an external trigger to control the interval time. A timer can be used to trigger the S900 as well recording equipment. Using the delay time of the S900 the recording equipment can record information occurring immediately before the stimulation pulse occurs.

Error Lights

As indicated when describing Double Pulse operation, error lights illuminate to indicate when impossible timing functions have been set on the S900 controls. A more complete explanation on how to interpret these error lights is in order.

An illuminated error light indicates that the setting of the associated parameter is not consistent with the setting of other parameters. For example if the pulse interval time (either internal or externally generated) is set for 2 seconds and the Pulse delay is set for 3 seconds the Pulse Delay error light will indicate that the delay time is not consistent with the interval time. The S900 will continue to operate under such conditions, usually producing a pulse less frequently than the selected interval time.

The train error light will indicate if the train duration has been set for a time greater than the interval between trains. If the interval time has been set for 3 seconds and the train duration is set for 3.5 seconds the train error indicator light will alert you to this fact. The pulse width error light indicates a pulse width of greater duration than interval between pulses in single pulse, double pulse, or train modes.

Outputs

Up until now the monitor output has been the only output used on the S900. The monitor output is a logic level output that reflects the timing sequence produced by the instrument. The other logic level pulse available is labeled SYNC and is a short duration pulse that is in sync with the pulse interval trigger. If you connect the oscilloscope up to the SYNC output with the instrument producing the train sequence as described above you will see 50 microsecond pulses occurring at

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the interval rate. The Pulse Delay control allows you to vary the time between the sync pulse and the train of pulses.

To understand the function of the analog voltage outputs connect the oscilloscope to the POS output. Set the PULSE/CONT switch to the pulse position, the source select switch to Normal, the 1V/10Vrange switch to the 10V position and set the level dial to 50%. You should see an output that looks identical to the monitor output. By adjusting the level dial you will see that this output is adjustable in level. Now flip the range switch to the 1V position and you will see that the full-scale value of the output has been reduced to 1 volt. Connect the oscilloscope to the NEG output and you will see an identical signal except that it is a negative going pulse instead of positive.

For a description of the isolator output and the NORMAL/Q STEP + DC LEVEL switch refer to the manual sections pertaining to the isolator and Quick Step command generator.

Rear Panel Connectors

BNC Connector-- An analog (± 10 volts) signal may be added to all analog outputs (POS, NEG or S910 Isolator when used).

When used with the S910 Isolator this results in an "Analog In/Analog Out" Isolator. This is very useful for passing isolated complex waveforms, or when a computer is generating pulses or steps.

In all cases, the signal presented at the rear panel BNC connector is added to any DC level or pulse the S910 is generating.

25 Pin.- Mates with the Biphasic adapter - model S915.

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V. S910 Stimulus Isolation Unit

The Dagan S910 was designed as a full function, affordable, analog input analog output isolation unit for use with the S900 stimulator. The S910 is a photo isolated, battery-powered device capable of producing current and voltage stimulation. A single connection is needed between the S900 and S910 for easy set-up and operation.

Specifications

LINEARITY-3% over 90% of the output range.
COMPLIANCE (WORKING) VOLTAGE- 108 volts with fresh batteries
RISE TIME-10K ohm load, 10-volt pulse (l0mA) 6 microseconds
FALL TIME-10K ohm load, 10-volt pulse (l0mA) 8 microseconds
MAXIMUM CURRENT OUTPUT-10 milliamps
SOURCE RESISTANCE VOLTAGE MODE-10K ohms, 1% tolerance
POWER- Twelve 9 volt transistor radio batteries.

Using the S910

Before attempting to use the S910 verify that the batteries, which have been installed, are in good working order by pressing the test switch on the control panel of the unit. If the batteries are in satisfactory condition the red LED will light. If the indicator does not light replace the batteries with identical replacements. The S910 is powered by Twelve 9 volt transistor radio batteries.

A BNC connector on the back of the S910 connects to the ISOLATOR output of the S900. This is the only connection required for operation. The output of the S910 is available at the binding posts on the front of the instrument.

The rotary switch at the center of the front panel selects three ranges of current or voltage stimulus. Within each range the amplitude is controlled by the level dial on the S900. The values on the S910 indicate the value with the S900 level control at 100% (the voltage range switch does not affect the isolator output). The limiting compliance voltage of the S910 is 108 volts (with fresh batteries).

The toggle switch labeled NORMAL/OFF/REVERSE refers to the output of the isolator only. In the Normal switch position the outputs are active and the uppermost binding post is the positive voltage or current. The Reverse switch position reverses the polarity of the outputs making the uppermost binding post the negative output. The Off position disconnects the output binding posts only and does not remove power from the unit itself. The POWER/OFF switch should be turned off when the isolator is not in use to preserve battery life.

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VI. Cornerstone Warranty

Dagan Corporation warrants all Cornerstone Instruments to be free from defects in workmanship and material under normal use and service for a period of one year to the original purchaser. During this period Dagan Corporation will service your instrument at no charge. A phone call to us can usually provide enough data to confirm the problem. We will then immediately ship to you replacement parts, or if you prefer that we perform the service, return the instrument to us and we guarantee it will be repaired immediately and shipped back to you.

Please return the enclosed warranty card so that we may register you as the owner of your S-900 Stimulator and send you any updated information that we feel may enhance the operation and versatility of your instrument.

Warning . This instrument is not designed or intended for use in HUMAN APPLICATIONS or HUMAN EXPERIMENTATION.

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