

MODEL SIU8T
TRANSFORMER-COUPLED
STIMULUS ISOLATION UNIT

INTENDED USE

**An accessory stimulus isolation unit for nerve
and muscle stimulation procedures.**

**PLEASE
DO NOT LOSE
THIS MANUAL**

ONE MANUAL IS SHIPPED
with each instrument.

No "shortages" recognized.

Additional copies may be
purchased at cost by owners
of the instrument, but it is
necessary to give the exact
model and serial numbers.

The cost \$ _____

GRASS INSTRUMENT DIVISION
Astro-Med, Inc. Tel. 401-828-4000
600 East Greenwich Avenue • West Warwick, RI 02893



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WARNINGS

READ THIS BEFORE OPERATING SIU8T

The output voltage and available current of this Stimulus Isolation Unit when coupled to Grass Stimulator, is large enough to be lethal or cause burns particularly with long durations and high current settings.

The state of the art is such that the potential danger to human and animal subjects from sustained stimulation even at low levels is still not completely understood.

Grass Stimulator Models S9 and SD9 have built-in ground isolation circuits. All other Grass Stimulators should be used in conjunction with Grass Stimulus Isolation Units to reduce the effects of ground leakage currents.

Grass Instrument Division of Astro-Med, Inc. waives any responsibility whatsoever for any injuries incurred to the operator of this instrument or to any animal or human subject as a result of the improper use or abuse of this Stimulator.

MODEL SIU8T TRANSFORMER-COUPLED STIMULUS ISOLATION UNIT

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The Model SIU8T is a transformer isolated, constant voltage isolation unit designed to be used for clinical research nerve and muscle constant voltage stimulation.

The SIU8T can be used for clinical Evoked Potentials; nerve conduction, EMG; constant voltage procedures and has no DC capabilities.

SPECIFICATIONS

- Isolation** _____ Transformer Coupled;
Impedance to ground: Resistance $10^{12} \Omega$, Capacitance 33 pF
- Input** _____ Compatible with S10SCM, S10DSCM, S44, S48, S88, S11 and S8800 Stimulators
- Output**
(with 3k Ω load) _____ 200 V peak (HI output), 125 V peak (LO output);
1600 Ω source impedance maximum;
Up to 1 ms square wave;
Essentially constant voltage;
20 μ s rise/fall times;
25% decay at 1 ms pulse duration;
Continuously variable stimulus intensity
- Voltage Ranges** _____ 0 to 200V (HI range)
0 to 125V (LO range)
- Polarity** _____ Reversing switch included
- Power** _____ Powered by stimulus pulses, no additional power source required
- Physical Size** _____ 3.625" W x 2.25" H x 6.0625" Long
(9.2 cm x 5.8 cm x 15.5 cm)
Weight: 2 lbs. (0.9 kg)
Cable Length: 17 feet (5.1 m)



S242K96

GENERAL CONSIDERATIONS

Section 2.1

2 GENERAL CONSIDERATIONS

2.1 Design and Principle of Operation

2.1.1 The Grass SIU8T Stimulus Isolation Unit is a transformer-coupled circuit designed to be connected in series with the outputs of the S44, S48, S88, S10SCM, S10DSCM, S11 and S8800 Stimulators and the stimulating electrodes to isolate the stimulus from ground, thus reducing stimulus artifact. Precautions such as redundant isolation circuitry and short pulse durations are incorporated in the SIU8T. Additionally, an interlock is provided between the SIU8T and S10SCM, S10DSCM and S11, which prevents the accidental use of the Stimulators without the SIU8T Isolation Unit. The SIU8T does not reproduce DC currents nor will it reproduce pulse durations above 1 ms without decay of the plateau.

2.1.2 The danger of tissue damage, burns and shock due to improper stimulation parameters cannot be overstressed. High current, long pulse durations and high pulse repetition rate all contribute to the dangers mentioned.

It is important to realize that a safe stimulus current applied to gross surface electrodes, of fairly large surface area, may cause severe tissue damage when similar

currents are passed through small electrodes, such as needles. Current density (thus electrode area) and length of time the stimulus is applied are the real measure of possible damage, not just the current level.

Extreme caution should be exercised by operating personnel, however, since considerable power can be delivered from the stimulator directly. Only authorized personnel, knowledgeable in the use of stimulating devices who are cognizant of the problems associated with electrical stimulation should be permitted to use the stimulator. The choice of parameters, used for the application, are the responsibility of the investigator.

2.1.3 A low leakage transformer, driven directly from the output voltage of the Stimulator, isolates the stimulus from ground. The output voltage is controlled by the STIMULUS INCREASE potentiometer and the HI/LO switch (the HI/LO switch is included on the SIU8TB and later models). A POLARITY switch is also included. Refer to the circuit diagrams in Section 9. Since the SIU8T is transformer coupled it is never possible under any condition to get DC current flow through the preparation.

CONNECTION OF THE SIU8T TO STIMULATORS

Sections 3.1 - 3.2

3 CONNECTION OF THE SIU8T TO STIMULATORS

3.1 Connection to S44, S48, S88 and S8800 Stimulators

3.1.1 When ordered for use with the Grass S44, S48, S88 or S8800 Stimulators, the SIU8T is wired with the proper coaxial connector (PL259).

NOTE: Do not connect the SIU8T to the S1+S2 MONITOR OUTPUT connector on the S88 or S8800 Stimulator.

3.2 Connection to S10SCM, S10DSCM and S11 Stimulators

3.2.1 The SIU8T is provided with a four-terminal connector (CON-12PQ4-A) with two terminals wired as an interlock.

3.2.2 The following applies to the SIU8T Stimulator connector.

Terminal

- 1 Positive Stimulator Output
- 2
- Interlock
- 3
- 4 Ground

3.2.3 On all Grass Stimulators, with the exception of the S10DSCM, it is necessary to set the VOLTS multiplier switch to the X10(SIU) position.

OPERATION OF THE SIU8T

Sections 4.1 - 4.2

4 OPERATION OF THE SIU8T

4.1 Output Polarity

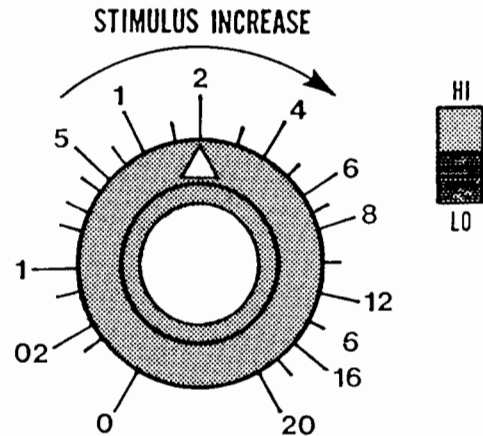
4.1.1 The POLARITY switch determines the polarity of the SIU8T output, independent of a ground reference, providing no grounds have been attached to the stimulating electrodes or their leads. In the NORMAL position, the red output terminal is positive with respect to the black OUTPUT terminal. In the REVERSE position, the black OUTPUT terminal is positive with respect to the red OUTPUT terminal.



4.2 Output Voltage

4.2.1 The SIU8T output is essentially constant voltage which implies a low output impedance. If the electrode impedance is reasonably stable during an experiment, a constant voltage source produces constant current. However, certain types of electrodes and/or experimental conditions can provide a significant variation in electrode impedance. Under these conditions, stimulus current will vary. Refer to the Appendices at the rear of this manual for a detailed discussion on Constant Voltage vs. Constant Current Sources for Pulse Stimulation.

4.2.2 The SIU8TA model will provide a maximum of 250 volts with the STIMULUS INCREASE control at maximum and an input of 150 volts, with no load. With a 3,000 Ω load, the maximum output voltage is 200 volts.



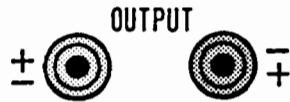
4.2.3 With the HI-LO switch (SIU8TB models and later) in the HI position, the SIU8T will provide a maximum output voltage of approximately 250 volts with the STIMULUS INCREASE control at maximum and an input of 150 volts, with no load. In the LO position the maximum output voltage is approximately 140 volts. With a 3,000 Ω load, the maximum output voltage is approximately 200 volts and 125 volts respectively.

OPERATION OF THE SIU8T

Sections 4.3 - 4.5

4.3 Output Terminals

4.3.1 Beginning with the model SIU8TC, the output terminals are *GRASS SAFELEAD™* patient connection terminals that conform to UL, CSA, and FDA requirements. These terminals have no exposed metal conductors and prevent connection or contact to power cables, extension cords, wall sockets and other power sources.



The terminals are 0.059-inch (1.5 mm) diameter and accept only 1.5 mm diameter female connectors. Adaptors are provided with each unit to aid in altering existing leads.

Older models, with miniature binding posts, accepted either standard 0.081-inch (2 mm) diameter pin plugs or bare wires.

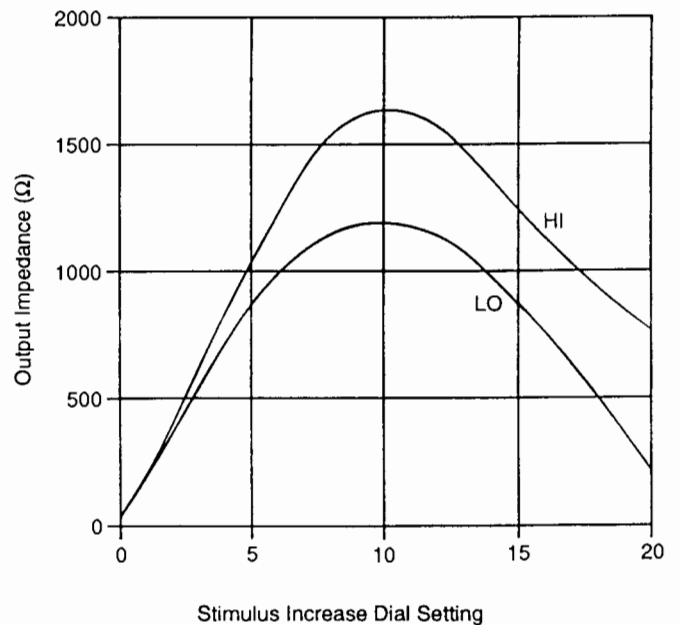
4.4 Leakage Resistance and Capacitance

4.4.1 The use of a special transformer in the SIU8T provides very low leakage resistance and capacitance between the output terminals and ground. Resistance from either output terminal and ground is greater than $10^{12} \Omega$. Capacitance is approximately 33 picofarads.

4.5 Output Impedance

4.5.1 The output impedance of the SIU8T is relatively low making the output essentially a constant voltage circuit.

4.5.2 The output impedance does vary, however, with the setting of the HI-LO switch and the STIMULUS INCREASE control as shown below:



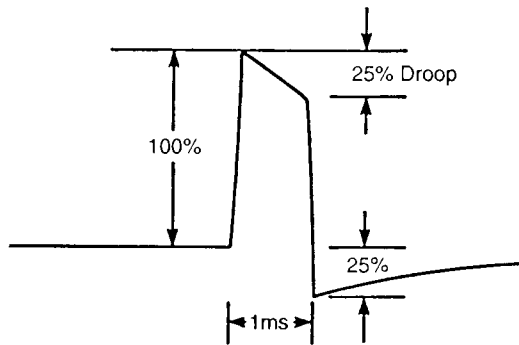
OUTPUT IMPEDANCE VS. STIMULUS INCREASE DIAL SETTING
FIGURE 4.5.1

WAVEFORM Section 5.1

5 WAVEFORM

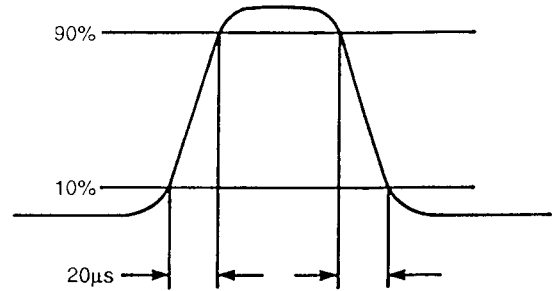
5.1 Pulse Duration

5.1.1 The isolation transformer essentially limits the maximum pulse duration to approximately 1 ms. The output waveform deviates from an ideal square wave by sag or droop of approximately 25%, with a 3,000 Ω resistive load, with a 1 ms pulse.



SIU8T OUTPUT WAVEFORM
FIGURE 5.1.1

5.1.2 The rise/fall time of the SIU8T output is 20 μ s measured between the 10 and 90% amplitude points of the waveform, as shown below, with a 3,000 Ω resistive load.



SIU8T OUTPUT RISE/FALL TIME
FIGURE 5.1.2

SERVICE AND MAINTENANCE

Section 6.1

6 SERVICE AND MAINTENANCE

6.1 Service

6.1.1 The SIU8T circuitry is relatively simple and should not require frequent service. However, factory service is available and recommended if adjustments are necessary on the instrument. Make certain, however, that the malfunction is in the SIU8T and not in the Stimulator or other accessory equipment. Disconnect the SIU8T from the Stimulator. Checking procedure is as follows:

If a malfunction in the SIU8T assembly is suspected, first check at the cable connector of the SIU8T with a DC ohmmeter as follows:

- a. Read continuity between terminal 2 and 3 (jumper wired between these two terminals).
- b. No connection between terminal 1 and terminal 2 or 3.
- c. No connection between terminal 4 and terminal 2 or 3.
- d. With switch off, no connection between terminal 1 and 4.

Next, read the resistance across the output terminals as follows:

- e. With STIMULUS INCREASE control at 0, should be essentially 0 Ω (short circuit).
- f. With STIMULUS INCREASE control at 20, should be approximately 50 Ω .

SIU8TA = 50 Ω

SIU8TB

(and later models)

HI = 50 Ω

LO = 35 Ω

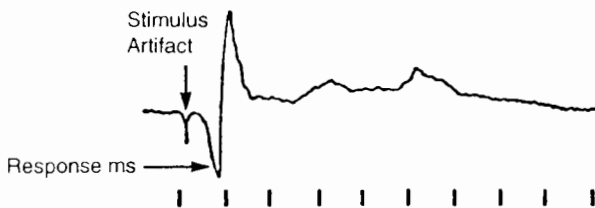
6.1.2 If difficulty is encountered, contact the Technical Support Services Department at Grass Instrument Division of Astro-Med, Inc. for additional information.

APPENDIX A Sections 7.1 - 7.2

7 APPENDIX A

7.1 Stimulus Artifact

7.1.1 When a stimulus pulse is introduced to a preparation to evoke a response, an electrical artifact appears in the recording instrumentation as the result of the spread of the stimulus current to the recording electrodes. This artifact precedes the evoked response in time as indicated in the CRO record of Figure 7.1.1. The delay between stimulus artifact and the evoked response is dependent upon stimulation parameters and the characteristic properties of the preparation.

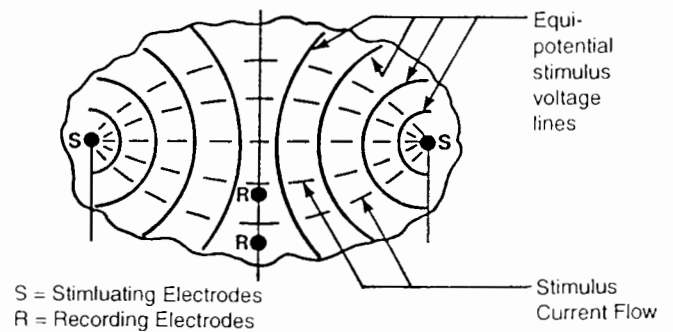


STIMULUS ARTIFACT
FIGURE 7.1.1

7.1.2 Some stimulus artifact is desirable to establish the time of stimulation. However, excessive stimulus artifact may obliterate the display of the desired response as is often the case when small evoked potentials are sought after a stimulus pulse of excessive amplitude or duration.

7.2 Sources and Reduction of Stimulus Artifacts

7.2.1 Excessive stimulus artifact results when the recording electrodes unavoidably measure the field distribution of the stimulus voltage through the preparation. The size of the stimulus and the proximity of the recording and stimulating electrode pairs contribute to the artifact amplitude. See Figure 7.2.1.



STIMULUS VOLTAGE FIELD DISTRIBUTION
FIGURE 8.2.1

NOTE: For optimum recording results, use independent stimulating and recording electrodes and keep recording electrodes perpendicular to stimulus current flow, if possible.

7.2.2 To alleviate stimulus artifact:

- Isolate the stimulus pulse from ground and thereby reduce the circulating ground currents between the stimulator, preparation and recording instrument.
- Space stimulating and recording electrodes as far from each other as possible and position them for maximum cancellation of field effects.
- Use as small a stimulator pulse with as short a duration as is possible (approximately 0.1 milliseconds).

APPENDIX A

Sections 7.2 - 7.3

7.2.3 If the field distribution pattern of stimulus current causes substantial stimulus voltage between the recording electrodes, the resulting artifact cannot be avoided.

7.3 Stimulus Isolation

7.3.1 Isolation of the signal from ground is most effective in the reduction of those artifacts due to ground currents arising from the stimulating and recording systems which are conductively joined by the preparation. When stimulus isolation is used during cortical stimulation, and in similar instances when a large volume of tissue surrounds closely spaced stimulating electrodes, the stimulus current sets up a three-dimensional field pattern, wherein the strength of the field usually decreases with the cube of the distance from the stimulating electrode. Isolation of the stimulus from ground in this instance is particularly effective because it reduces ground currents. Stimulus isolation is particularly necessary with multichannel recording. It is also valuable from the standpoint of safety, because it isolates the stimulating electrodes from ground. It has the further advantage of permitting direct addition of stimuli of either algebraic sign.

7.3.3 The high quality, general purpose Stimulators, S44, S48, S88, S11, S8800 and S10DSCM do not have "built-in" isolation and constant current circuits because these are not always desirable. The more limited Grass S9 series do have built-in isolation, but not constant current output. In many applications, a very low output impedance of high power

is required and is featured in the S11, S44, S48, S88 S8800 and S10DSCM. The S10DSCM without the SIU8T has limited capabilities for these applications. With the aid of a biomedical engineer, the output safety interlock can be defeated to allow the output voltage (and current) to be used *without isolation* from ground. Such an output will stimulate in solutions, will drive a long lead line or other capacitive loads without degrading the stimulus pulse. This is not possible with a high impedance source (constant current). It is possible and economical to drive isolated and high impedance circuits, but it is not economical to build low impedance outputs from high impedance sources. Furthermore, it is most often desirable to have the isolating and constant current circuits as close to the preparation as possible to preserve the isolation and fidelity of the stimulus. Thus, separate cabinets for these circuits are preferred. Furthermore, not all applications require SIUs and/or CCUs. The argument for this system is like that for high impedance probes for amplifiers.

The characteristics of the Grass SIUs permit the shielding of stimulating and recording electrode leads, thus reducing the capacitive coupling between recording and stimulus leads. For maximum reduction of artifact, the SIU should be placed as close to the preparation as is possible. Ideally, short unshielded leads to the electrodes should be used and every attempt should be made to reduce conduction and capacitance between the output leads, recording leads and ground to a minimum. If it is not possible to use short electrode leads, use 2-wire shielded low capacitance cable.

APPENDIX B

Section 8.1

8 APPENDIX B

8.1 Constant Voltage vs. Constant Current Sources for Pulse Stimulation

8.1.1 While the principal factor responsible for electrical stimulation is current, the amount of voltage required to produce this current is a function of the impedance presented by the electrodes and the surrounding tissue. This varies widely. Some procedures, such as the production of massive seizures in animals, utilize large, low impedance electrodes and yet require relatively high voltage. In the stimulation of single cells with microelectrodes, however, even though the current is in microamperes or less, the electrode impedance is high and consequently a high voltage is also required. In other cases, both voltage and current may be low.

8.1.2 "CONSTANT VOLTAGE" inherently means a low impedance source. In this case, the voltage waveform is preserved to the electrode. Current waveform and phase are only dependent on the load impedance. A low source impedance can be relied on to provide the source voltage at the electrode metal-liquid interface independent of cable and similar shunt capacitances.

8.1.3 "CONSTANT CURRENT" on the other hand infers a very high source impedance. Its drawback is that it is difficult, if not impossible, to preserve either current or voltage waveform values when cable, lead or similar shunt capacities are in the "real circuit". This is particularly true with currents below 10 μA and gets worse with smaller currents and consequently higher source and load impedances. On the other hand, "Constant Current" sources offer the advantage of being able to "preset" currents for higher currents and lower impedances, and to provide currents more independent of tissue and electrode impedances. "Constant Current" sources are especially practical with large currents (over 100 μA). For DC stimulation "Constant Current" is most advantageous and shunt capacities have no effects.

8.1.4 Everything is relative though, and ratio of source and load impedances (including the resistive and capacitive components) need to be evaluated for proper understanding of "Constant Voltage/Constant Current". What is more important to recognize is that frequently the current or voltage that is measured in the lead wires is hardly the same as it appears at the interface of the tissue and electrode because of diffusion. Furthermore, it should be remembered that the important stimulus parameter is current density, i.e., amperes per unit area at the specific responding tissue.

$$\frac{\text{Amperes}}{\text{mm}^2}$$

APPENDIX B

Section 8.1

A general purpose Stimulator, such as the S11, S44, S48, S88 or S8800 must satisfy the greatest number of applications and represent the most desirable compromise between voltage and current requirements. A low source impedance is also required to drive such accessories as the SIU and CCU. The output, therefore, is a low impedance "constant voltage" emitter follower type. The output source impedance of the S11, S44, S48, S88 and S8800 Stimulators is 250 ohms on the X.01, X.1 and X1 positions of the VOLTAGE multiplier switch and can be selected to be 250 ohms, 100 kilohms or 25 ohms in one of the three X10 positions. The X10(SIU) position is used in conjunction with all Stimulus Isolation Units and for most direct stimulating applications. The X10(100k Ω) position is used to provide a constant current output in the range of 0.15 to 1.5 mA, providing electrode impedances are 10 kilohms or less. The X10(25 Ω) position is useful when electrode impedances are low and/or when large stimulating currents are required. The S11, S44, S48, S88 and S8800 Stimulators can deliver up to 150 mA to the preparation. Currents over 150 mA are possible with a slight modification to the appropriate plug-in printed circuit board. Consult the factory for details.

8.1.5 Accessory units are available for connection to the output of the S11, S44, S48, S88 and S8800 Stimulators. **The SIU5** is a radio frequency (RF) type of isolation unit with an output impedance of approximately 1000 ohms. **The SIU8T** is a transformer coupled constant voltage isolation unit. No DC component will appear in the output. Maximum duration is about one millisecond as a near square wave. **The PSIU6** is an optically isolated Constant Current Unit providing currents from 0.1 μ A to 10 mA. **The SIU7** is an optically isolated Constant Current Unit having a maximum pulse duration of 5 ms. **The CCU1** is a Constant Current Unit providing currents from 50 μ A to 50 mA but does not isolate the stimulator output from ground reference. However, the CCU1 can be used in conjunction with the SIU5 in which case the stimulus would be isolated from ground.

CIRCUIT DIAGRAMS

Section 9.1

9 CIRCUIT DIAGRAMS

9.1 Explanation of Circuit Diagrams

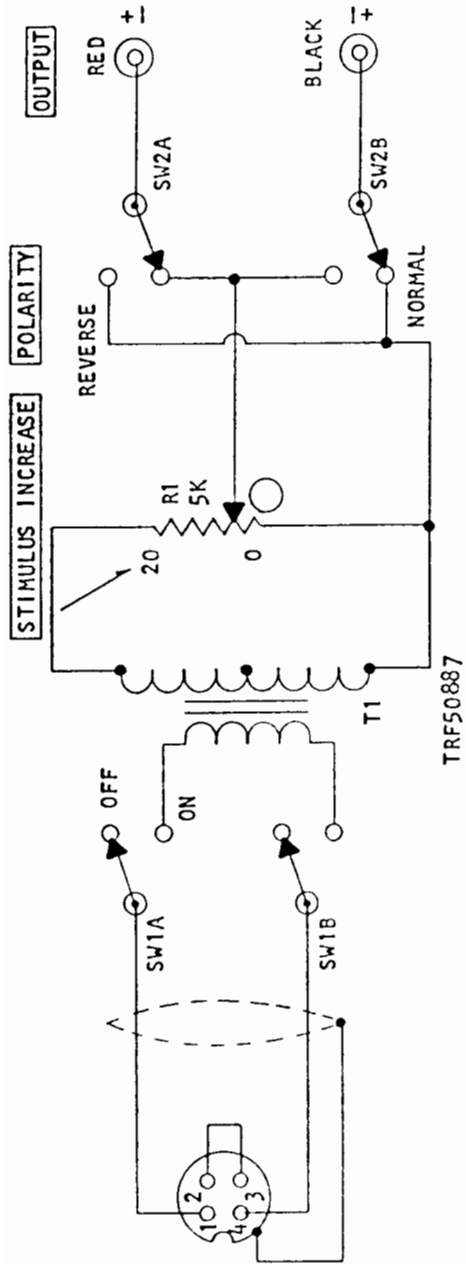
9.1.1 This manual contains all of the circuit diagrams with values of components for all models which have evolved from the basic design. The succession of design changes are indicated by the last letter subscript and are in alphabetical order. For instance, the basic design SIU8T is followed with a letter subscript such as A, B, C, D, etc. as in SIU8TE which represents a change from the SIU8TE. There may have

been minor changes in a few components within any model with the same subscript letter. The circuit presented here with a certain subscript letter would be the last one prior to the introduction of a more substantial change, such as when the SIU8TE supersedes the SIU8TE. The last subscript circuit in this manual is the latest one available at the date of publication.

To identify the appropriate circuit, check the last letter subscript of your instrument model number and identify with the circuit print with exactly the same model number.

CIRCUIT DIAGRAMS

Section 9.1

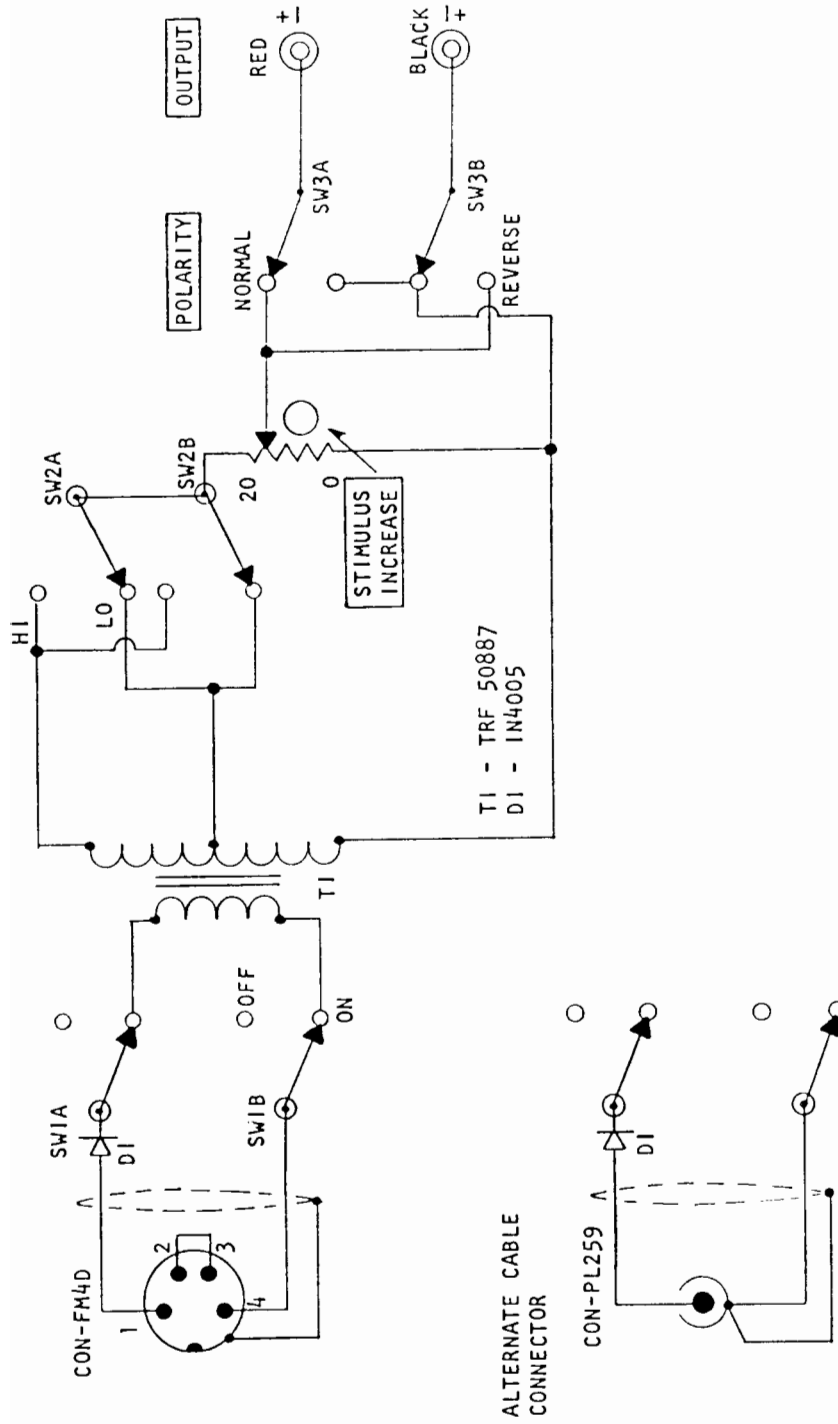


MODEL SIU8TA STIMULUS ISOLATION UNIT CIRCUIT DIAGRAM - #51063
(Part 1 of 1)

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CIRCUIT DIAGRAMS

Section 9.1

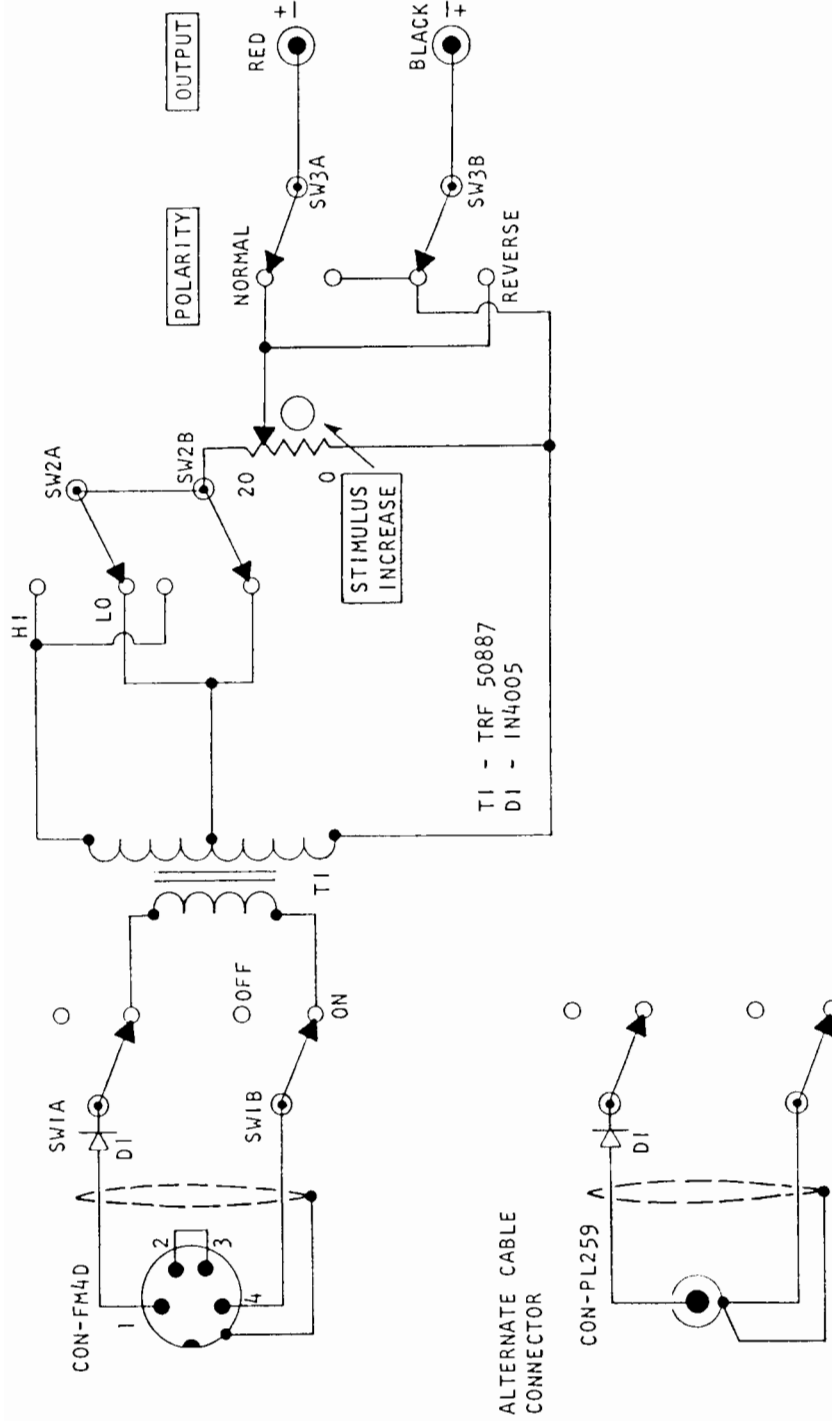


MODEL SIU8TB STIMULUS ISOLATION UNIT CIRCUIT DIAGRAM - #51063-4
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CIRCUIT DIAGRAMS

Section 9.1



MODEL SIU8TC STIMULUS ISOLATION UNIT CIRCUIT DIAGRAM - #51063-5
(Part 1 of 1)

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or e-mail:

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chart paper, recording
accessories and catalog
and quotation requests.

Instrument Applications

for technical assistance.

**Technical Support
Services**

for troubleshooting
advice, repair and
replacement service.

*Please identify the model
and serial number of your
instrument.*

SERVICE

HERE'S WHAT TO DO

OUR WARRANTY IS FOR ONE YEAR

**WE HAVE PROMPT, EFFICIENT FACTORY SERVICE
TO BACK IT UP**

However, our warranty does **not** cover transportation costs if repairs become necessary. Universities and hospitals have Purchasing and Receiving Departments that must be informed.

**A PURCHASE ORDER NUMBER OR AUTHORIZATION
IS NECESSARY.**

Therefore, we urge you to contact them before contacting us.

IF, "Instrument was damaged in transit"

- a. Save packaging materials for inspection by carrier's agent,
- b. Obtain a joint inspection report from the carrier who delivered the instrument,
- c. Report full details immediately to Grass-Telefactor, An Astro-Med, Inc. Product Group

IF, "It doesn't work"

- a. We can **ADVISE** a solution to your problem but we need all the facts, including model and serial number of the instrument and symptoms of the instrument malfunction.
- b. We can **REPLACE** damaged or malfunctioning units.



X381J99



JULY 1995

SUPERSEDES ALL PREVIOUS WARRANTIES

GRASS-TELEFACTOR, An Astro-Med, Inc. Product Group WARRANTS this instrument to the original purchaser (who is the same end user) only. The warranty is not transferable. Material, workmanship and performance as specified are guaranteed:

1. if the *GRASS-TELEFACTOR* seal (when present) is not broken,
2. if there is no evidence of abuse, attempted repairs or modifications without Grass-Telefactor authorization,
3. only if genuine Grass-Telefactor replacement parts are used,
4. only if the instrument is used for its specified uses,
5. if the instrument has not been resold or used in a larger system incorporating non-Grass-Telefactor products not approved by Grass-Telefactor for compatibility.

THIS WARRANTY IS BINDING FOR ONE YEAR from date of initial delivery and is limited to: servicing and/or replacing any instrument or part thereof (except batteries and expendable supplies) returned to the factory for that purpose with transportation charges prepaid and which to the company's satisfaction are found to be malfunctioning.

WARRANTY DISCLAIMERS

Any implied warranties arising out of this sale, including but not limited to the implied warranties of merchantability and fitness for a particular purpose, are limited in duration to the above one (1) year period. Grass-Telefactor shall not be liable for loss of use of the instrument or other incidental or consequential costs, expenses or damages incurred by the purchaser.

Some states do not allow the exclusion or limitation of implied warranties or consequential damages, so the above limitations or exclusions may not apply to you. This warranty gives you specific legal rights, and you may also have other rights that vary from state to state.

DAMAGE UPON ARRIVAL

Each instrument leaves our plant after rigorous tests and performs as specified. The instrument may receive rough handling and damage in transit. The shipment is insured against such

damage. The buyer must report in writing immediately any concealed or apparent damage to the last carrier. Report any damage also to us, and issue an order for replacement or repair. Our invoice for such service will then be evidence in the claim. Hold all packaging material.

MALFUNCTIONS OCCURRING WITHIN WARRANTY PERIOD

Our prices include replacement of malfunctioning parts, modules and even complete instruments when all conditions of sale are met and if we decide it necessary. It does not include:

1. provide for any transportation charges,
2. provide for services not performed or authorized by us,
3. provide for the cost of repairing instruments which have obviously been abused, modified, or subjected to non-intended uses or to unusual environments for which they have not been designed.

We will discuss by phone or letter suspected malfunctions or aspects of instrument

operation which may be unclear. Advise us of the nature of the malfunction before returning an instrument for repair. Many times a simple suggestion will solve the problem without returning anything. In the case of a malfunction properly diagnosed by Grass-Telefactor as being within a "plug-in" module, circuit board or other part which can readily be replaced without impairment of the instrument fidelity by a procedure which does not require a service man, then it is the responsibility of the owner to make such replacement under the direction of the company with a suitable replacement furnished by the company under the terms of the warranty. The owner has the responsibility for the return or to bear the cost of the replaced unit when requested.

WARRANTY ON SPECIFICATIONS

Grass-Telefactor reserves the right to make changes in design and specifications without notice and without any obligation to install such changes in units previously purchased.

Grass-Telefactor warrants each instrument to satisfy printed specifications available to the purchaser on formal request thirty days prior to date of scheduled delivery. Specifications are the average of typical measurements made on production units under controlled conditions. Statistical variations in individual units due to normal component variations are to be expected and should not alter the intended use of the instrument. However, when parameter characteristics are critical, tolerances are specified and guaranteed. Operating characteristics can be expected to change slightly from printed specifications with age and long term use.

Unless the exact tolerances of any parameter of any instrument are specified on the purchase order and specifically agreed to by Grass-Telefactor it is assumed that our standard production tolerances will satisfy all contractual responsibility.



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