SOLAR ELECTRONICS COMPANY

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INSTRUCTION MANUAL
FOR
SOLAR MODEL 9355-1
PULSE GENERATOR

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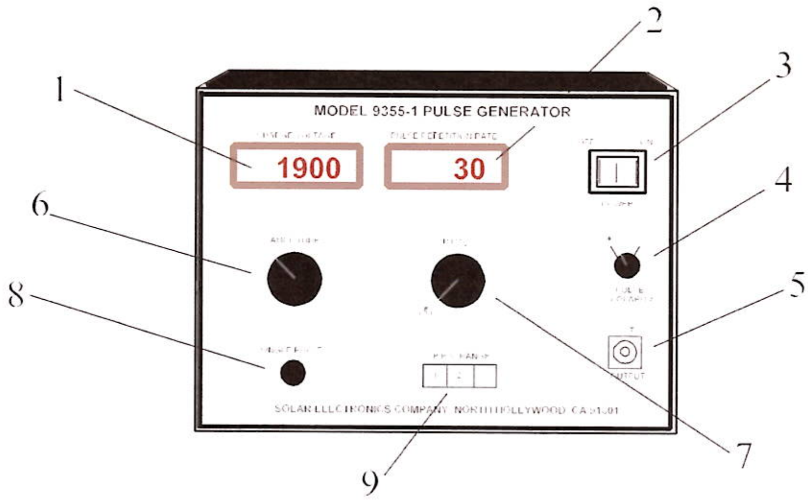

Funtions

1. **Charge Voltage Display** - Digital display of charged line voltage.
2. **Pulse Repetition Rate Display** - Digital display of pulse repetition rate (pps).
3. **Power Switch** - Energizes generator.
4. **Pulse Polarity Switch** - Controls pulse polarity
5. **Output Connector** - Type "N" panel receptacle, Charged line pulse output.
6. **Amplitude Knob** - Controls charged voltage amplitude
7. **P.P.S (Pulses Per Seconds) Knob** - Controls pulse repetition rate
8. **Single Pulse Pushbutton** - Initiates single pulse when pps knob in "OFF" position.
9. **P.P.S Range Pushbuttons** - Selects one of three overlapping pulse repetition rate ranges covering 0.6 to 150 pps.

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SECTION 1

1. INTRODUCTION

The **Model 9355-1 Pulse Generator** was designed to provide the type of pulse signal required to perform MIL-STD-461E and MIL-STD-462D, Test Method CS115, Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation, Test method CS115 is used to verify the ability of the EUT to withstand pulse signals coupled onto EUT associated cabling.

The Model 9355-1 may also be used as an impulse calibrator to provide an adjustable spectral output up to 150 dBµS/MHz over the frequency range of 1 kHz to 10 MHz constant within ± 1 dB.

1.1. General Description

The **Model 9355-1** is a 50 ohm coaxial charged line that is discharged across a 50-ohm load. The pulse is 35 nanoseconds in duration with rise and fall times, less than 2 nanoseconds. The pulse repetition rate is continuously controllable over three overlapping bands from 0.6 to 150 pps. The charge line potential is continuously adjustable from 2 volts to over 2000 volts. with a pulse polarity selector switch for a positive or negative going pulse. Digital display of both charge voltage and pulse rate is displayed on the front panel.

1.2. **Optional Accessories** Recommended for CS115 Testing:

SOLAR TYPE 9233-50-TS-50-N

Line impedance stabilization network

SOLAR TYPE 9125-1

Calibration fixture used in MIL-STD-461E, Figure CS115-2 (or MIL-STD-462D, Figure CS115-1), calibration setup for probes with a window size from 1.25" to 1.50". Frequency range of 20 Hz to 500 MHz.

SOLAR TYPE 9123-1N

Current Monitoring Probe Frequency range 10 kHz to 500 MHz.

SOLAR TYPE 9142-1N

Current Injection Probe. Frequency range 1 MHz to 400 MHz, 200 W.

SOLAR Type 9410-1 Attenuator:

The Type 9410-1 high voltage 50 ohm Attenuator has an insertion loss from dc to 1 GHz of **40 dB ± 2 dB**, and an average wattage dissipation capability of 2.5 watts. The Attenuator will reduce the pulse voltage (a result of 6 amperes flowing through 50 ohms = 300 v max.) from exceeding most oscilloscope limitations. (See your oscilloscope manual for more details on 50 ohm input).

SOLAR Type 9841-1 Termination:

The Type 9841-1 high voltage 50 ohm termination has a VSWR under 1.50 from dc to 1.5 GHz, and an average wattage dissipation capability of 2 watts.

SECTION 2

2. SPECIFICATIONS

OUTPUT PULSE:

charging voltage adjustable	2 to 2000 volts
rise/fall time	<2 nanoseconds
duration time	<35 nanoseconds
pulse repetition rate	from 0.6 to 150 P.P.S.*
peak current during calibration	0->5 amperes
peak current with 50 ohm load	0-20 amperes

POWER REQUIREMENTS

115 60 Hz or 230 V, 50 Hz	45 Watts maximum

* CS115 requires repetition rate of 30 p.p.s. only. Variable rate allows one to use 9355-1 low frequency impulse generator.

CAUTION !

The charged line is discharged through a mercury switch mounted vertically within the Model 9355-1 Pulse Generator. This unit must be operated in a vertical position or flooding may occur causing sluggish or erratic operation for several minutes until the mercury settles.

SECTION 3

3. OPERATING & CALIBRATING INSTRUCTIONS:

3.1. GENERAL: MIL-STD-461E and MIL-STD-461D/462D, test Method CS115 is a susceptibility test that subjects the input and output cables and conductors of the EUT to an impulse excitation signal. This test will verify the EUT's ability to perform normally in the presence of this signal. The impulse excitation signal consists of a special pulse with a duration of at least 30 nanoseconds and with a rise and decay time of less than 2 nanoseconds. These pulse parameters remain constant, only the pulse amplitude and repetition rate can be changed. Method CS115 consists of two parts;(1) CALIBRATION, paragraph 3.2 and (2) EUT TESTING, paragraph 3.3.

Past impulse excitation testing of EUT's indicated, generally, that the impedance of input and output circuits fall in the 100 ohm range. Hence the "100 ohm loop" setup was devised as an appropriate circuit impedance for a preliminary calibration setup, refer to Figure CS115-2 of MIL-STD-461E (Figure CS115-1 of MIL-STD-462D) specification.

The impulse excitation results from the high frequency energy contained in the fast rise and fall time of the pulse and associated current. In a 100 ohm loop the gradual decline of the pulse amplitude (between the pulse rise time and the fall time, refer to MIL-STD- 461E, Figure A-13 or MIL-STD-462D, Figure A-11) is due to a lack of low frequency response of the injection probe. However, this is immaterial, only the high frequency energy contained in the fast rise and fall time is important to this susceptibility test. The energy produced in the fall time is equal to that of the rise time but of opposite going polarity. Of interest is the stipulated minimum pulse duration of 30 nanosecond - this provides a sufficient time interval for the spectral energy burst caused by the 2 nanosecond rise time to die down before the next burst from the 2 nanosecond fall time occurs.

3.2. CALIBRATION:

3.2.1. Equipment used in the calibration setup:

a) **Model 9355-1 Pulse Generator**: The Model 9355-1 provides the pulse shape, amplitude and pulse repetition rate range that is called for by Method CS115.

b) SOLAR **Type 9125-1 Calibration Fixture**: The Type 9125-1 fixture is designed to accept current probes with 32 to 44 mm diameter window sizes. The 9125-1 design is described in MIL-STD-461E, appendix page A075, Figure A-9 (MIL-STD-462D, Appendix page A-58, Figure A-8.)

c) SOLAR **Type 9142-1N Current Injection Probe**: The purpose of the injection probe is to efficiently inject a high magnitude output pulse from the pulse generator into the conductor or cable under test. The probe has sufficient 3 dB bandwidth to provide a pulse rise and fall time of less than 2 nanoseconds. The probe also has good efficiency (or low insertion loss).

d) SOLAR **Type 9410-1 High Voltage Attenuator**: The Type 9410-1 (50 ohm input/50 ohm output) attenuator has an insertion loss from dc to 1 GHz of 40 dB and an average input wattage rating of 2.5 watts. The attenuator will reduce the peak pulse voltage (a result of 6 amperes flowing through 50 ohms = 300 V) to 3 volts, well within the input voltage range of most oscilloscopes.

The attenuator insertion loss versus frequency is constant (+/- 2 dB) from dc to 500 MHZ and above, with a rise time well under 2 nanoseconds. Most attenuators are designed to handle CW signals with an emphasis on wattage capability and a minor consideration to voltage rating, e.g. a 300 V CW signal across 50 ohms requires an attenuator to dissipate:

$$Watts = \frac{E^2}{R} = \frac{300^2}{50} = 1800$$

In the CS115 test, with 30 pps, at 300 V peak and a pulse duration of 35 nanoseconds, the average dissipation is only about 0.002 watts!

e) Solar **Type 9841-1 50 ohm Coaxial Load**: An inexpensive load designed for 1,000 volt peak pulses of low duty cycle. The average dissipation rating is 2 watts. Typical input VSWR in a 50 ohm system is under 1.50 from dc to over 1 Ghz. The only question with using a standard 50 ohm load is it's ability to tolerate possible peak voltages up to 1000 volts?

f) Oscilloscope: The oscilloscope must have a 50 ohm input and a minimum real time bandwidth of 400 MHZ. The Tektronix TDS 3052 or equivalent would be adequate for this requirement.

3.2.2. Equipment Setup For Calibration:

a) Connect the equipment as shown in Figure CS115-1 in this section.

3.2.3. Calibration Test Procedure:

a) Energize the equipment and allow time for stabilization.

b) Adjust Model 9355-1 controls:

1) PPS -- To 30 pps or to "OFF" for manual push-button.
2) AMPLITUDE -- To 200 volts.
3) POLARITY -- Optional + or -.

c) Adjust oscilloscope controls for a display of the Model 9355-1 pulse. The display should be similar to Figure A-13 of MIL-STD-461E (Figure A-11 of MIL-STD-462D.) Rise and fall times of the pulse (between the 10% and 90% points) should be less than 2 nS.

d) Increase the Model 9355-1 AMPLITUDE control for a PEAK voltage indication on the oscilloscope of 250 volts (2.5 V at output of 9410-1 40 dB attenuator). This is a peak current of 250 V / 50 ohms = 5 Amperes.

e) Record the Model 9355-1 amplitude control setting in volts that provided the 100 ohm loop current of 5 amperes. This completes the Calibration procedure.

3.3. EUT TESTING:

3.3.1. Equipment used in EUT testing Setup:

a) SOLAR **Model 9355-1 Pulse Generator**: The Model 9355-1 provides the pulse shape, amplitude and repetition rate range that is called for by Method CS115.

b) SOLAR **Type 9142-1N Current Injection Probe**: The purpose of the injection probe is to efficiently inject a high magnitude output pulse from the pulse generator into the conductor or cable under test. The probe has sufficient 3 dB bandwidth to provide a pulse rise and fall time of less than 2 nanoseconds. The probe also has good efficiency (or low insertion loss).

c) Oscilloscope: The oscilloscope must have a 50 ohm input impedance and a real time bandwidth that is 400 MHZ or greater. The Tektronix TDS 3052 or equivalent would be adequate for this requirement.

d) SOLAR **Type 9233-50-TS-50-N LISN**: This Line Impedance Stabilization Network has the impedance characteristics from 10 kHz to 10 MHZ required by MIL-STD-461E, paragraph 4.3.6 (MIL-STD-462D, paragraph 4.6.) Should there be concern about the presence of high levels of impulsive interference from the power line above 10 MHZ then Solar **Type 8905-50-TS-50-N LISN** might be considered. This LISN duplicates the MIL-STD-461E and MIL-STD-462D, Figure 7 impedance from 10 kHz to 10 MHZ and then sustains an impedance of 40 ohms to 400 MHZ.

e) SOLAR **Type 9123-1N Current Monitoring Probe** (10 kHz - 500 MHZ): This probe has sufficient 3 dB bandwidth to provide a pulse rise and fall time under 2 nanoseconds. SOLAR **Type 9249-1N**, a 2.62 inch diameter window probe, has similar bandwidth characteristics if a larger window size is required. The transfer impedance of these monitoring probes varies from 2 to 5 ohms above 1 MHZ, which provides high output voltage at high pulse levels. It is recommended that the **Type 9410-1 High Voltage Attenuator**, be placed ahead of the oscilloscope to provide adequate protection.

The Type 9123-1N Current Monitoring Probe is provided with a standard correction factor (dBCF) graph that presents dBCF versus frequency over the probe frequency range of 10 kHz to 500 MHZ. This graph is only useful for narrowband signals that are confined to a known frequency or a narrow frequency range. This graph will be useless for the Model

b) Adjust Model 9355-1 controls:

1) PPS -- To 30 pps or to "OFF" for manual push-button.
2) AMPLITUDE -- To 200 volts.
3) POLARITY -- Optional + or -.

c) Adjust oscilloscope controls for a display of the Model 9355-1 pulse. The display should be similar to Figure A-13 of MIL-STD-461E (Figure A-11 of MIL-STD-462D.) Rise and fall times of the pulse (between the 10% and 90% points) should be less than 2 nS.

d) Increase the Model 9355-1 AMPLITUDE control for a PEAK voltage indication on the oscilloscope of 250 volts (2.5 V at output of 9410-1 40 dB attenuator). This is a peak current of 250 V / 50 ohms = 5 Amperes.

e) Record the Model 9355-1 amplitude control setting in volts that provided the 100 ohm loop current of 5 amperes. This completes the Calibration procedure.

3.3. EUT TESTING:

3.3.1. Equipment used in EUT testing Setup:

a) SOLAR **Model 9355-1 Pulse Generator**: The Model 9355-1 provides the pulse shape, amplitude and repetition rate range that is called for by Method CS115.

b) SOLAR **Type 9142-1N Current Injection Probe**: The purpose of the injection probe is to efficiently inject a high magnitude output pulse from the pulse generator into the conductor or cable under test. The probe has sufficient 3 dB bandwidth to provide a pulse rise and fall time of less than 2 nanoseconds. The probe also has good efficiency (or low insertion loss).

c) Oscilloscope: The oscilloscope must have a 50 ohm input impedance and a real time bandwidth that is 400 MHZ or greater. The Tektronix TDS 3052 or equivalent would be adequate for this requirement.

d) SOLAR **Type 9233-50-TS-50-N LISN**: This Line Impedance Stabilization Network has the impedance characteristics from 10 kHz to 10 MHZ required by MIL-STD-461E, paragraph 4.3.6 (MIL-STD-462D, paragraph 4.6.) Should there be concern about the presence of high levels of impulsive interference from the power line above 10 MHZ then Solar **Type 8905-50-TS-50-N LISN** might be considered. This LISN duplicates the MIL-STD-461E and MIL-STD-462D, Figure 7 impedance from 10 kHz to 10 MHZ and then sustains an impedance of 40 ohms to 400 MHZ.

e) SOLAR **Type 9123-1N Current Monitoring Probe** (10 kHz - 500 MHZ): This probe has sufficient 3 dB bandwidth to provide a pulse rise and fall time under 2 nanoseconds. SOLAR **Type 9249-1N**, a 2.62 inch diameter window probe, has similar bandwidth characteristics if a larger window size is required. The transfer impedance of these monitoring probes varies from 2 to 5 ohms above 1 MHZ, which provides high output voltage at high pulse levels. It is recommended that the **Type 9410-1 High Voltage Attenuator**, be placed ahead of the oscilloscope to provide adequate protection.

The Type 9123-1N Current Monitoring Probe is provided with a standard correction factor (dBCF) graph that presents dBCF versus frequency over the probe frequency range of 10 kHz to 500 MHZ. This graph is only useful for narrowband signals that are confined to a known frequency or a narrow frequency range. This graph will be useless for the Model

9355-1 pulse or any impulse signal that is broadband, spread out over the entire probe frequency range.

The monitoring probe is still essential to measure the broadband signal current. A single, broadband, correction factor value can be determined for the monitoring probe and used to accurately measure the broadband, impulse signal, independent of the impedance of the circuit under test. We have tentatively chosen to call this factor “Spectral Transfer Impedance” or Zst ohms, and it can also be used as dBZst ohms or dB correction factor (dBCF). This factor need only be determined once as long as the individual equipment test items used in the calibration setup and the EUT setup remain the same. Or, as long as the overall rise and fall times remain the same.

4. NOTES ON DERIVING Zst

To determine the monitoring probe Zst: The following procedure was used on the equipment and setups presented in this manual. Actual data values are given.

1) Figure CS115-1 Calibration Setup was used, as shown in this section.

2) Paragraph 3.3 Calibration test procedure was repeated, only using a peak of 400V as viewed on the oscilloscope. This provides a peak current of 400V/50 ohms = 8 amperes

3) The setup was changed by adding a **Type 9123-1N** monitoring current probe on the 100 ohm loop and terminating it into a second **Type 9410-1** attenuator. This was done by installing a second, smaller calibration fixture, such as a **Solar Type 9251-1**, in series with the existing **Type 9125-1** fixture. It was now observed that the original 400 volt oscilloscope indication had dropped to 364 volts. This was largely the result of the overall rise time increasing because of adding the Type 9123-1N monitoring probe, see " NOTES ON RISE TIME" below. The loop current is now 364V/50 ohms = 7.28 amperes.

4) The oscilloscope input cable was then removed from the Type 9410-1 attenuator in the 100 ohm loop and connected to the output of the 9123-1N monitoring probe attenuator. The voltage measured was 33.2 volts. The Zst factor required to provide a current of 7.28 amperes (same current measured by the first Type 9410-1 attenuator still in the 100 ohm loop) is:

33.2V/7.28A = 4.56 ohms = 13.18 dB ohms = -13.18 dBCF = Zst.

Value -13.18 dBCF is the broadband correction factor (Zst) for the 9123-1N monitoring probe when used with the equipment setup of Figure CS115-2 as shown in this manual.

4.1. NOTES ON RISE TIME

Rise time (r) can be computed as follows:

$r = 0.35 / BW$

Where: BW is the bandwidth in Hertz between the 3 dB down points.

Computed rise times of the equipment items involved:

Type #	BW	Rise Time (r)
9355-1	—	<0.1 nS
TDS 3054B	500 MHz	0.7 nS
9142-1N	395 MHz	0.88 nS
9123-1N	480 MHz	0.790 nS
9410-1	1100 MHz	0.310 nS
9841-1	1500 MHz	0.233 nS

When several equipment rise time (r) components are operating in sequence the overall rise time (R) becomes:

$$R = \sqrt{(r1)^2 + (r2)^2 + (r3)^2 + (r4)^2 \ldots}$$

4.1.1. Equipment Setup for EUT testing:

a) Connect the equipment as shown in Figure CS115-2 in this section.

b) It is suggested that a high voltage attenuator be placed ahead of the oscilloscope for protection.

4.1.2. EUT Testing, Susceptibility Evaluation:

a) Turn on the equipment and allow time for stabilization.

b) Adjust the Model 9355-1 Pulse Generator, as a minimum, for the amplitude setting in volts in paragraph 3.2.3, step d) of this manual. *(d.) Increase the Model 9355-1 AMPLITUDE control for a PEAK voltage indication on the oscilloscope of 250 volts (2.5 V at output of Type 9410-1 40 dB attenuator). This is a peak current of 250 V / 50 ohms = 5 Amperes).*

c) Adjust the pulse repetition rate to 30 pps.

d) Monitor the EUT for degradation of performance during testing.

e) Whenever susceptibility is noted, determine the level at which the undesirable response is no longer present and verify that it is above the MIL-STD-461 requirement.

f) Record the peak current induced in the cable as indicated on the oscilloscope.

g) Repeat 3.3.3 b) through 3.3.3 f) on each cable bundle interfacing with each electrical connector on the EUT. For power cables, perform 3.3.3 b) through 3.3.3 f) on complete power cables (high sides and returns) and on the power cables with the power returns excluded from the cable bundle.

4.1.3. Data Presentation:

a) Provide tables showing statements of compliance with the MIL-STD-461 requirement for the susceptibility evaluation of 3.3.3 b) through 3.3.3. g) and the induced current level for each interface connector.

b) Provide any susceptibility thresholds which were determined.

c) Provide oscilloscope photographs of injected waveforms with test data.

MIL-STD-462D

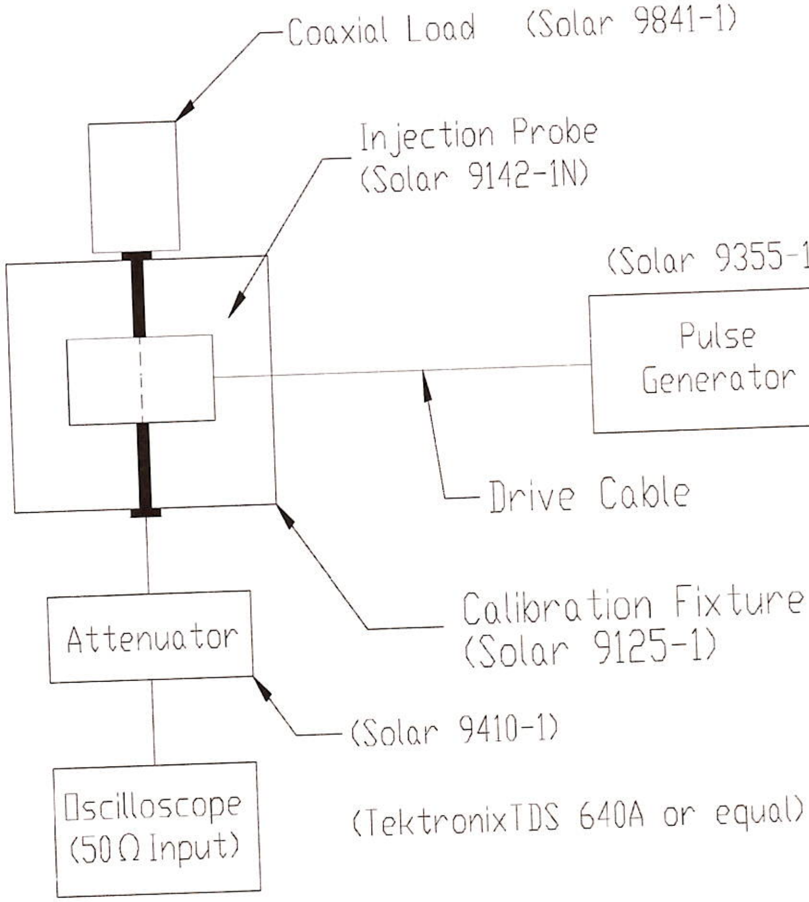
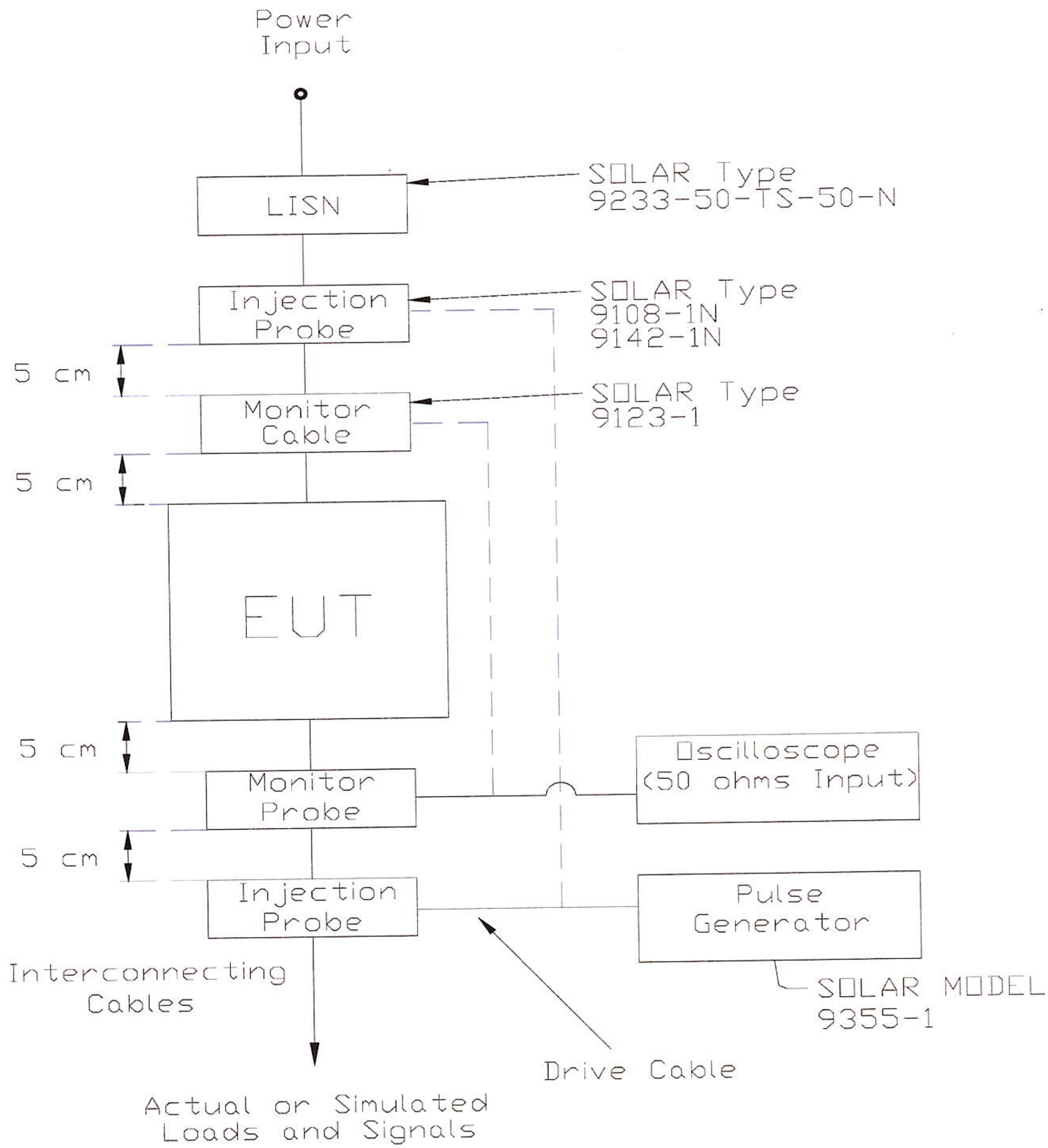


FIGURE CS115-1
CALIBRATION SETUP



Power
Input
LISN
SOLAR Type
9233-50-TS-50-N
Injection
Probe
SOLAR Type
9108-1N
9142-1N
5 cm
Monitor
Cable
SOLAR Type
9123-1
5 cm
EUT
5 cm
Monitor
Probe
Oscilloscope
(50 ohms Input)
5 cm
Injection
Probe
Pulse
Generator
Interconnecting
Cables
SOLAR MODEL
9355-1
Drive Cable
Actual or Simulated
Loads and Signals

5. VERIFICATION of internal voltages (To help identify malfunction only)

For no output Check D.C. voltages on power supply board . (No adjustment)
Measure across C3, +25 V DC . . . . ______
Measure across C4, +25 V DC . . . . ______
Measure across C14 , +5 V DC . . . . ______
Measure across C22, +5 V DC . . . . ______

Display driver board. If meter does not read 2000 vdc at full amplitude ± 20%
Adjust low voltage offset R 25 TP. 5 to 1.99 V DC. . . . . ______
Adjust high voltage offset R 23 TP. 3 to 2 V DC. . . . . ______

Charge line measurements use 5000 V DC voltmeter.
Measure Z1 max 2000 Charge voltage . . . . ______
Compare display for maximum voltmeter reading. 2000 v dc . . . . ______
Adjust output for 100 Volts . . . . ______
Compare meter reading to Z1 . . . . ______

Check voltmeter tracking .
If meter does not read 2000 v dc at full amplitude ± 20%

VOLTAGE METER DISPLAY			VOLTAGE ON Z1	
100	______	(Adjust Trimpot 2)	100	______
1000	______		1000	______
2000	______	(Adjust Trimpot 4)	2000	______

Adjust trimpot R4 until display matches high output at Z1.
Adjust trimpot 25 coarse tuning or 21 fine tuning until display matches low output at Z1.
Repeat "adjustment" several times.

Pulse repetition rate overlapping Approx. (No adjustment)
Verify p.p.s by first turning the charge voltage to "0", Connect scope probe to the output.
The oscilloscope display should coincide with the p.p.s display.
Band 1. Below 0.60 P.P.S. to above 3.8 . . . . ______
Band 2. Below 3.7 P.P.S. to above 24.0 . . . . ______
Band 3. Below 23 P.P.S. to above 150 . . . . ______
Single pulse . . . . ______

Pulse characteristics. (No adjustment)
Rise time < 2 nS . . . . ______
Decay time <2 nS . . . . ______
Duration > 30 nS . . . . ______
Pulse shape stability (provided mercury switch has settled) . . . . ______
Polarity (negative pulse) . . . . ______
Peak amplitude 900 V ± 50 V . . . . ______

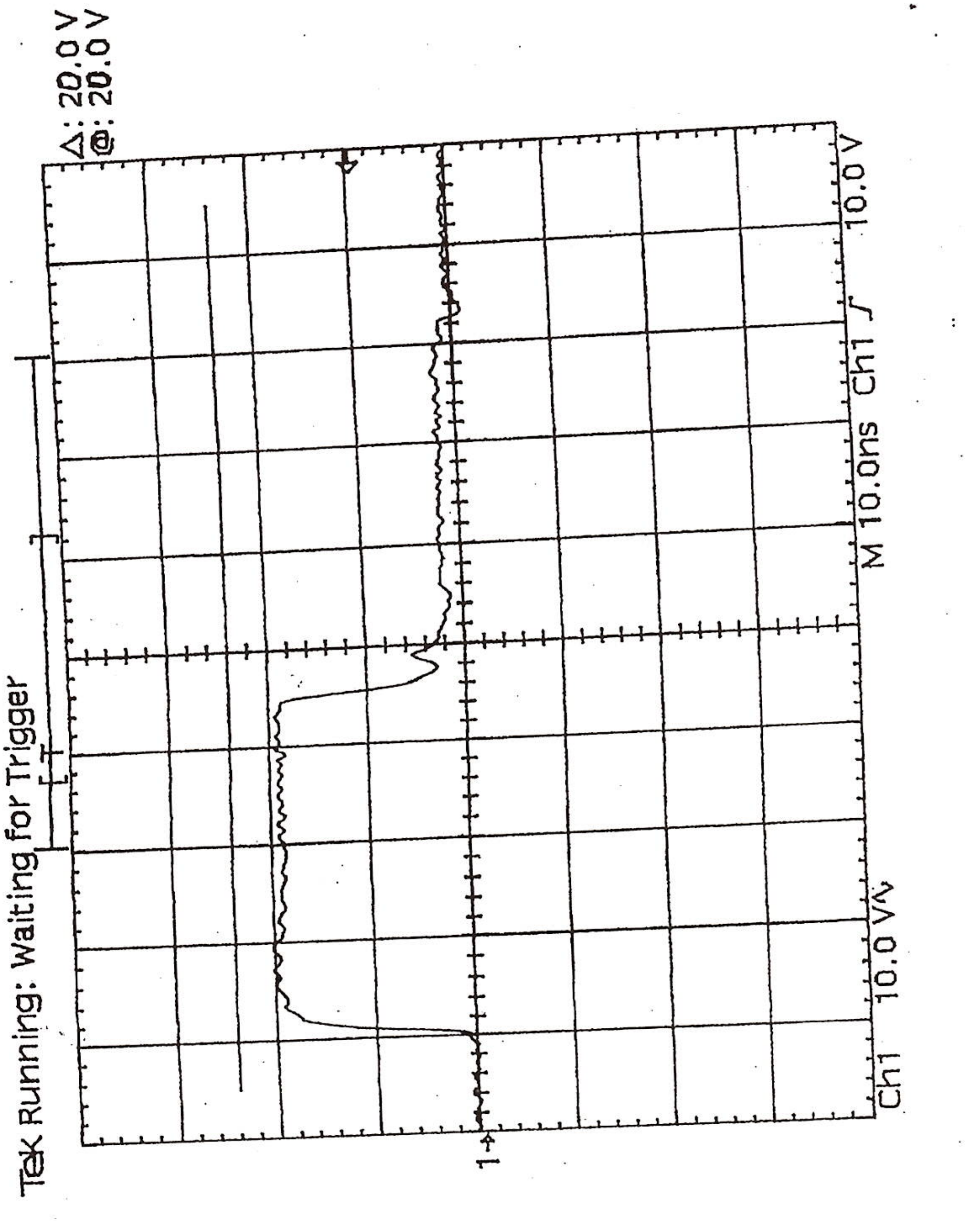
Model 9355-1 PARTS LIST

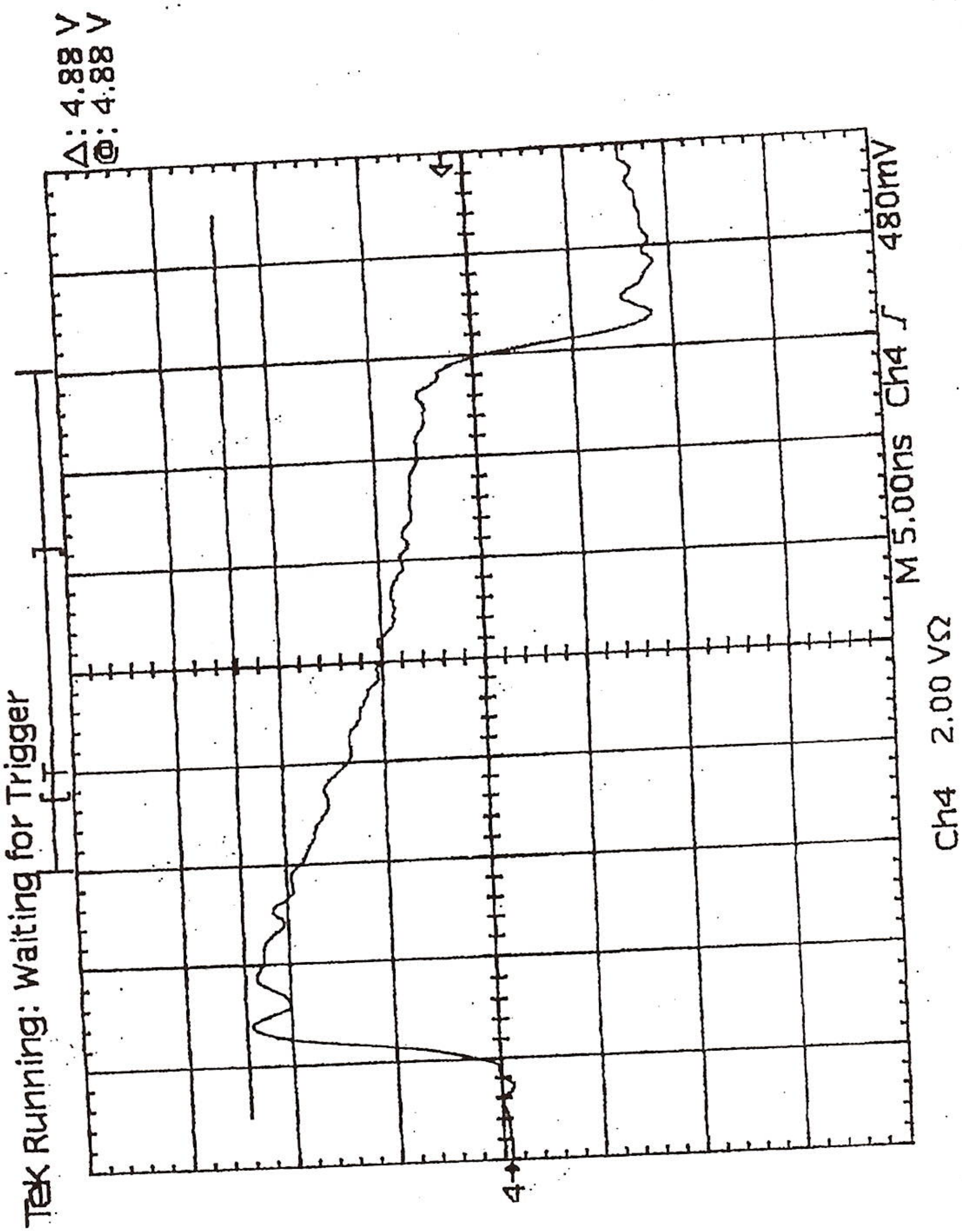
C1, C2	Capacitor, 10μF ± 10% 1000VDC Oilfilled	Cornell Dubilier T10W10N
C3, C4	Capacitor, 500μF ± 10% 50V Electrolytic	Sprague TVA-1315
C5	Capacitor, .47μF ± 20% 100VDC	Electrocube 230B1B474
C6, C12	Capacitor, .01μF ± 10% 200VDC Ceramic	Kemet CKR06BX103KR
C7	Capacitor, .18μF ± 10% 100VDC Polyfilm	Electrocube 230B1B184K
C8	Capacitor, .03μF ± 10% 100VDC Polyfilm	Electrocube 230B1B303K
C9	Capacitor, .0047μF ± 10% 100VDC Polyfilm	Electrocube 230B1B472K
C14, C22	Capacitor, 1000μF ± 10% 500V Electrolytic	Sprague 501D108 M010NP
C15, C18	Capacitor, .47μF ± 10% 50V Ceramic	Kemet CKR06BX474KR
C16	Capacitor, 1000pF ± 10% 500VDC Dipped Mica	Arcolectric CM06FD102J03
C17	Capacitor, 33μF ± 10%16V Tantalum	Sprague 199D336 X9016D
C19	Capacitor, .1 μF ± 20%, 100V Ceramic	Kemet CKR06BX104KR
C20	Capacitor, 62pF ± 5% 500V Dipped Mica	Arcolectric CM04ED620J03
C21	Capacitor, Ceramic Trimmer	Tusonix 0518-00G-7.0
CR9, CR10	Rectifier Bridge, 1A 100 V	Diodes Inc. DB102
CR11, CR12, CR13	Diode, 1W 200 V	Diodes Inc. J2
D1 thru D8	Diode Rectifier, 1000 V	Motorola IN4007
DS1, DS2, DS3	Lamp, P/O S4, S5, S6	G.E. 3 27
F1, F2	Fuse, 3AG 1A (for 115V) Fuse, 3AG .5A (for 230V)	Littelfuse 312001 Littelfuse 312500
FL1	Filter, AC Power Line	Solar 828254
IC1	IC, Timer	Texas Intruments SN74LS
J1	Connector, TNC	Kings KA79-78
J2	Connector, TNC	Amphenol RG-88/U
J3	Connector, BNC	KA-51-18
J4	Connector, TNC/N	Amphenol UG-1095B/U
L1	Coil, 150 μHμ	Solar 8850-150uH

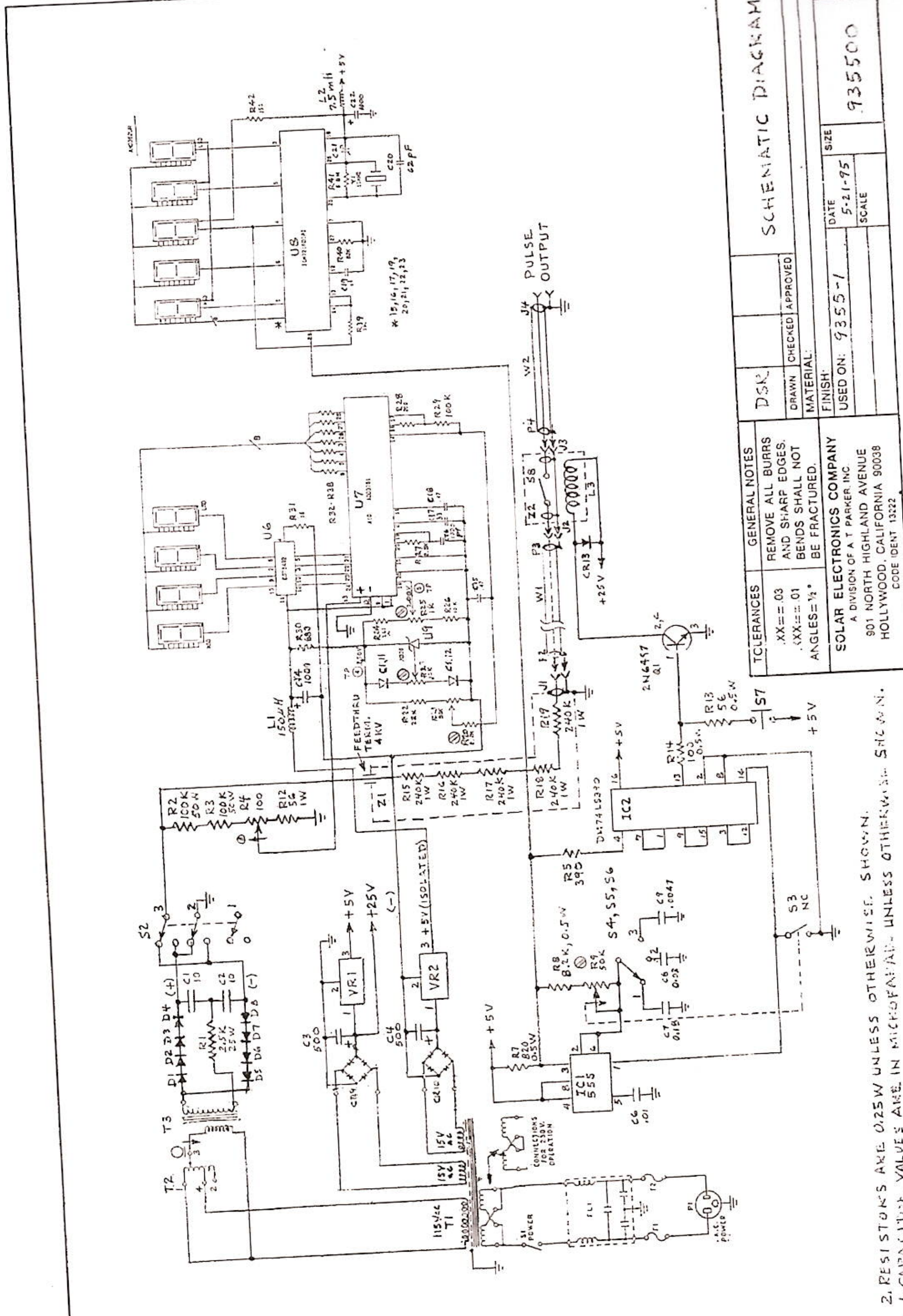
L2	Coil, 7.5 mH	Solar 8850-7.5mH
L3	Coil, Driving	Solar 935527
P1	Receptacle, AC Power Module	Panel Components 83010122
P2	Plug, Connector	KA-51-18
P3	Plug, Connector	Amphenol UG-89B/U
P4	Plug, Connector Replaced 5/11/98	Kings KA-59-143 Kings KA-51-143
Q1	Transistor	National 2N6497
R1	Resistor, 2.5K ohm ± 5% 25W Wirewound	Ohmite L25J2K5
R2, R3	Resistor, 100K ohm ± 5% 50W Wirewound	Ohmite L50J100K
R4	Potentiometer, 100 ohm ± 5% 2W Locking	Clarostat RV4LAYS A1014
R5, R6	Resistor, 51K ohm ± 5% 1/4W Carbon	Allen Bradley RCR07GF513J
R7	Resistor, 820 ohm ± 5% 1/2W Carbon	Allen Bradley RCR20GF821J
R8	Resistor, 8.2K ohm ± 5% 1/2W Carbon	Allen Bradley RCR07GF822J
R9	Potentiometer w/ Switch, 50K ohm ± 10% 5W	Clarostat JA1N200P503UA
R10, R11	Resistor, 1M ohm ± 5% 1/4W Carbon	Allen Bradley RCR07GF105J
R12	Resistor, 50K ohm ± 5% 1W Carbon	Allen Bradley RCR32GF564J
R13	Resistor, 56 ohm ± 5% 1/2W Carbon	Allen Bradley RCR20GF560J
R14	Resistor, 100 ohm ± 5% 1/2W Carbon	Allen Bradley RCR20GF101J
R15, R16, R17, R18, R19	Resistor, 240K ohm ± 5% 1W Carbon	Allen Bradley RCR32GF244J
R20	Resistor, 8.2K ohm ± 5% 1/4W Carbon	Allen Bradley RCR07GF822J
R21	Trimpot, 50K ohm ± 10% 3/4W	Bourns 3006P-1-503
R22	Resistor, 22K ohm ± 5% 1/4W Carbon	Allen Bradley RCR07GF223J
R23	Trimpot, 10K ohm ± 10% 3/4W	Bourns 3006P-1-103
R24	Resistor, 261 ohm ± 1% 1/4W	Dale RN55G2610F
R25	Trimpot, 1K ohm ± 10% 3/4W	Bourns 3006P-1-102

R26	Reisstor, 10K ohm ± 5% 1/4W Carbon	Allen Bradley RCR07GF103J
R27	Resistor, 2.5K ohm ± 5% 1/4W Carbon	Allen Bradley RCR07GF252J
R28	Resistor, 200 ohm ± 5% 1/4W Carbon	Allen Bradley RCR07GF201J
R29	Resistor, 100K ohm ± 5% 1/4W Carbon	Allen Bradley RCR07GF104J
R30	Resistor, 680 ohm ± 5% 1/4W Carbon	Allen Bradley RCR07GF681J
R31	Resistor, 16 ohm ± 5% 1/4W Carbon	Allen Bradley RCR07GF160J
R32 thru R38	Resistor, 8 x33 ohm ohm ± 2% Array	Dale MDP1603
R39	Resistor, 1K ohm ± 5% 1/4W Carbon	Allen Bradley RCR07GF102J
R40	Resistor, 82K ohm ± 5% 1/4W Carbon	Allen Bradley RCR07GF823J
R41	Resistor, 6.8M ohm ± 5% 1/4W Carbon	Allen Bradley RCR07GF823J
R42	Resistor, 150 ohm ± 5% 1/4W Carbon	Allen Bradley RCR07GF151J
S1	Switch, Pushbutton Power	Carlingswitch LRGSCK-221
S2	Switch, Ceramic Rotary	Centralab 2552
S3	Switch, P/O R9, SPST	Clarostat CS-1
S4, S5, S6	Switch, Pushbutton 3-station Interlock	Switchcraft 67031K-512
S7	Switch, Pushbutton 1P2P	Miroswitch BZ-2R
S8	Switch, P/O Z2	Solar
T1	Transformer, Power	Solar 935517
T2	Variac, 115VAC	Superior 10C
T3	Transformer, High Voltage	Solar 935522
U1 Thru U5	Not Used	
U6	I.C., Digit Driver LED Display	National DS75492N
U7	I.C., Digit DVM/Analog-Digital Display	National ADD370ICCN
U8	I.C., Frequency Counter/Timer	Intersil ICM7216DIPI
U9	Voltage Reference	National LM236H-2.5
VR1, VR2	Volatage Regular, 5V	National Semiconductor LM340AT5
W1	Cable Assembly (Long)	Solar 9355-1/F

W2	Cable Assembly (Short)	Solar 9355-1/E
XA1, XA2	Not Used	
XA3	Socket, 8 Pin I.C.	McKenzie DIP308-001B
XA4	Not Used	
XA5	Socket, 16 Pin I.C.	McKenzie DIP316-001B
XA6	Socket, 14 Pin I.C.	McKenzie DIP314-001B
XA7, XA8	Socket, 28 Pin I.C.	Mckenzie DIP628-001B
Y1	Crystal, 10 MHz	Micronium 76F843
Z1	Isolating Resistor Assembly	Solar 9355-1/H
Z2	Relay Assembly	Solar 9355-1/G


Tek Running: Waiting for Trigger
Δ: 20.0 V
@: 20.0 V
Ch1 10.0 V
M 10.0ns Ch1
10.0 V


Tek Running: Waiting for Trigger
Δ: 4.88 V
@: 4.88 V
Ch4 2.00 VΩ
M 5.00ns Ch4 ∫ 480mV



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