



SVX 1.1

**DIRECTED ENERGY, INC**

**SVX PULSER**

**OPERATION MANUAL**

**SERIAL NO:** \_\_\_\_\_

**DATE:** \_\_\_\_\_

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\*\*\*\*\* WARNING \*\*\*\*\*

SAFE OPERATING PROCEDURES AND PROPER USE OF THE EQUIPMENT ARE THE RESPONSIBILITY OF THE USER OF THIS SYSTEM.

Directed Energy, Inc (DEI) provides information on its products and associated hazards, but it assumes no responsibility for the after-sale operation and safety practices.

ALL PERSONNEL WHO WORK WITH OR ARE EXPOSED TO THIS EQUIPMENT MUST TAKE PRECAUTIONS TO PROTECT THEMSELVES AGAINST POSSIBLE SERIOUS AND/OR FATAL BODILY INJURY. DO NOT PERFORM INTERNAL REPAIR OR ADJUSTMENTS UNLESS ANOTHER PERSON CAPABLE OF RENDERING FIRST AID AND RESUSCITATION IS PRESENT.

## 1.0 GENERAL DESCRIPTION

The DEI SVX is a high voltage solid state pulse generator designed to drive low inductance, resistive loads, typically into 50 ohms.

The pulser utilizes high-speed power MOSFETs as the high voltage switches, incorporated into a low impedance configuration featuring a multi-layer stripline-style output bus.

The power switch module receives support power from the 120VAC line, and high voltage power from the switch mode power supply (DEI #5040-0027). This module also contains a low voltage power supply, providing support power to the switch mode supply, and an internal oscillator.

The internal oscillator provides a drive pulse to the power switch module to gate on and off the output pulse. The oscillator may be operated in either an internal or an external mode. In external mode, the trigger line provides the pulse recurrence frequency (PRF), while the SVX provides the pulse width through the "Pulse Width" potentiometer. A sync line is provided from the oscillator.

**2.0 SPECIFICATIONS****OUTPUT POWER**

Maximum Value.....800 volts  
Polarity.....Positive  
Maximum Current.....20 amperes  
Means of adjustment.....Front Panel  
Output High Voltage Connector.....Type BNC,  
Front Panel

**TRIGGER**

Trigger Source.....Int or Ext  
Trigger Input (External).....+5V +/-1V,  
Into 50 ohms  
Trigger Rise Time (External).....<20ns  
Minimum Trigger Pulse Width (External).....75ns  
Maximum Trigger Pulse Width (External).....3us  
Input Trigger Connector.....Type BNC,  
Front Panel

**OUTPUT PULSE ELECTRICAL CHARACTERISTICS**

Pulse Rise Time.....<30ns (10%-90%)  
Pulse Width.....75ns to 3us,  
Pulse Width Adjustment.....Front Panel  
Pulse Recurrence Frequency.....Single Shot to  
30KHz, controlled by ext  
trigger, 190Hz to 30KHz,  
controlled by int trigger  
Droop (At 18A, 1us PW).....<5%  
Over/undershoot.....<5%  
Jitter.....<0.5ns shot-to-shot  
Sync Monitor.....TTL output  
into 50 ohms  
Sync Monitor Connector.....Type BNC,  
Front Panel

**GENERAL**  
Input AC Power.....110/220 VAC, 50/60Hz  
Dimensions.....9.0" D x 3.6" W x 3.6" H  
Weight.....Approx. 6 lbs.

### 3.0 SAFETY

The high voltage nature of this device dictates the use of caution when operating or servicing this equipment. The following is a summary of general safety precautions that must be observed during all phases of operation and repair of the SVX.

#### 3.1 Operating Safety Summary

The safety information contained in this summary is for both operating and servicing personnel. Specific warnings may be found throughout this manual, but may not appear in this summary.

##### 3.1.1 Power Source

The pulser is designed to operate from a power source that will not apply more than 120 volts 50-60Hz between the supply conductors or between either supply conductor and ground. A protective grounding connection by way of the grounding conductor in the AC power cord is essential.

##### 3.1.2 Grounding

The pulser is grounded through the grounding conductor of the AC power cord. To avoid electrical shock, plug the pulser into a properly wired receptacle before making connection to any input or output connectors. Use only a power cord that is in good condition.

##### 3.1.3 Cover Removal

To avoid personal injury, do not remove the side covers. Do not operate the pulser while the covers are removed. The covers do not contain safety interlocks!

##### 3.1.4 General Operating Precautions

Do not remove the input or output cables while the pulser is in operation. Never short-circuit the high voltage output of the pulser. Failure to observe these precautions can result in potential electric shock to personnel, arcing, and damage to the connectors and system.

Any pulsed power system is capable of random triggering via transients. Therefore when the pulser is turned on, or high voltage is present in the chassis, assume it is possible to get a pulse on the output connector.

### 3.2 Servicing Safety Summary

The pulser contains dangerous voltages and stored energy. DEI strongly recommends that all repairs and adjustments be performed by factory qualified personnel. DEI will not be responsible for personal injury or damage to the pulser that occurs during repair by any party other than the factory.

#### 3.2.1 Servicing Procedure

Do not perform internal repair or adjustments unless another person capable of rendering first aid and resuscitation is present.

#### 3.2.2 Internal Energy Storage

The pulser contains capacitors that are used as energy storage elements. When charged, these capacitors contain in excess of 0.8 joules of stored energy. This is sufficient energy to cause injury. **Assure that the AC power cord is disconnected from the pulser, and that the capacitor bank is fully discharged and a shorting strap installed before any repairs or adjustments are attempted.** Verify with a voltmeter that all circuits are de-energized before servicing. The voltmeter used to make these measurements must be certified for use at 1000VDC and 110VAC or greater. Dangerous voltages, floating ground planes and energy storage exist at several locations in the pulser. Touching connections and/or components could result in serious injury.

#### 4.0 OPERATING CONSIDERATIONS

##### 4.1 Output

The pulser is designed to operate into a predominantly resistive load with a small inductive term. An unterminated or improperly terminated output will cause excessive aberrations on the output waveform and could possibly damage the pulser. To ensure this does not occur, observe the following precautions:

- Use good quality cable and connectors;
- Make all external connections tight and as short as possible;
- Use terminators or impedance-matching devices to avoid reflections;
- Ensure that all external cables and hardware have adequate voltage and power ratings;
- Be extremely careful not to short the output of the pulser to ground, as this can cause damage to the pulser.

##### 4.2 Pulse Risetime and Falltime

The physical and electrical characteristics of the cable transmitting the pulse determine the characteristic impedance, velocity of propagation and the amount of signal loss. Several feet of cable can attenuate high frequency information in a pulse with a fast rise time. It is therefore important to keep these cables as short as is practical.

##### 4.3 Impedance Matching

If a pulse travels down a transmission line and encounters a mismatch, a reflection is generated and sent back along the line to the source. The amplitude and polarity of the reflection are determined by the impedance mismatch. If the reflected signal returns before the output pulse ends, it adds or subtracts from the amplitude of the pulse. This will distort the pulse shape and amplitude.

##### 4.4 Trigger Input

When in external mode, an input trigger of +5V +/-1V into 50 ohms with a risetime of <20ns is required to gate on the pulser. Departure from these values can result in a loss of performance. These trigger requirements are met by any high quality low voltage pulse generator. The trigger should be set to +5V +/-1V into 50 ohms before the trigger cable is attached to the pulser trigger input. If the trigger input is greater than +5V into 50 ohms, pulse stretching can occur.

## 5.0 PREPARATION FOR USE

### 5.1 General

After unpacking, initial inspection and preliminary electrical check procedures should be performed to assure that the unit is in good working order. If it is determined that the unit is damaged, the carrier should be notified immediately. Repair problems should be directed to the service department, Directed Energy, Inc. (DEI), Fort Collins, Colorado. Telephone: (303) 493-1901.

### 5.2 Initial Inspection

1. Inspect unit for exterior mechanical damage.
2. Inspect power input cord and input power module for obvious signs of damage.

### 5.3 Input Power Cord

The input power cord terminates externally in a three-prong polarized plug. The unit chassis is wired to the plug through the line cord, and therefore, the insertion of the plug into a compatible receptacle, hooked up to a grounded input, will automatically ground the unit. **The unit should not be operated without a grounded AC input!**

## 6.0 OPERATING INSTRUCTIONS

### 6.1 Controls And Indicators

#### 6.1.1 Power Switch and Indicator Lamp

The switch labeled "ON/OFF" controls all AC power in the chassis. The lamp above the switch illuminates when AC power is turned on.

#### 6.1.2 Fault Indicator

The Fault lamp flashes when a fault condition is encountered. Fault conditions include an internal or external short, or an output power requirement in excess of the capabilities of the high voltage power supply. If the fault light illuminates, the unit should not be operated until the cause of the fault is rectified. In the event of excess power requirements, the power should be reduced by decreasing the PRF, decreasing the output pulse width, lowering the power, or some combination thereof, until the lamp extinguishes. If these actions fail to extinguish the lamp, a problem exists with either the load or with the pulser itself.

#### 6.1.3 Voltage Adjustment

This potentiometer controls the output voltage pulse.

#### 6.1.4 Pulse Width Adjustment

Pulse width is adjusted with the potentiometer labeled "Pulse Width". This adjustment functions when the pulser is either internally or externally triggered.

#### 6.1.5 Frequency Adjustment

When internally triggered, the pulse recurrence frequency is controlled by the "Frequency" potentiometer. When externally triggered, this control is disabled.

#### 6.1.6 SYNC Connector

The BNC connector labeled "SYNC" replicates the width and frequency of the output pulse, and is used to synchronize an oscilloscope to the output pulse. Output is +1V into 50 ohms.

#### 6.1.7 Trigger Connector and Switch

The BNC connector labeled "TRIGGER" is the input to externally trigger the pulser. The trigger line provides the pulse recurrence frequency (PRF), while the pulse width is controlled through the "Pulse Width" potentiometer. An input trigger of +5V +/-1V into 50 ohms with a risetime of <20ns is required to gate on the pulser. When externally triggered, the "Trigger" switch should be set to EXT.

## 6.2 Operation

Before turning on the unit, ensure that all output adjustments are set to ZERO, and the output connector is connected to an appropriate load.

The output pulse should be monitored at the load with a high speed oscilloscope and appropriate probes and/or attenuators.

Turn ON the AC power, and slowly increase the Voltage, Pulse Width and Frequency adjustments while monitoring the oscilloscope until the desired output is generated. If the Fault lamp illuminates, reduce voltage, frequency or pulse width until the lamp extinguishes. If the lamp does not extinguish, if there is no output from the pulser, or the output is severely distorted, set the Voltage Adjust to zero. Leave the pulser connected to the AC input without high voltage and with all connectors in place for approximately one minute to bleed off the stored energy, then disconnect the AC power to the unit and refer to the Troubleshooting Section of this manual.

## 6.3 Power-Down Procedures

These procedures should be followed prior to handling the output cable, connectors or load:

1. Set the Voltage Adjust dial to zero.
2. Leave the pulser connected to the AC input without high voltage and with all connectors in place for approximately one minute to bleed off the stored energy.
3. Turn OFF the unit.
4. Disconnect the AC power to the unit.

## 7.0 TROUBLESHOOTING

### WARNING

The pulser contains capacitors that are used as energy storage elements. When charged, these capacitors contain in excess of 0.8 joules of stored energy. This is sufficient energy to cause serious injury. **Assure that the AC power cord is disconnected from the pulser, and that the capacitor bank is fully discharged and a shorting strap installed before any repairs or adjustments are attempted.** Verify with a voltmeter that all circuits are de-energized before servicing. The voltmeter used to make these measurements must be certified for use at 1000VDC and 110VAC or greater. Dangerous voltages, floating ground planes and energy storage exist at several locations in the pulser. Touching connections or components could result in serious injury.

## 7.1 Troubleshooting Procedures

Before attempting to service or troubleshoot the pulser, review the servicing safety summary in Section 3.0.

The power MOSFETs utilized in the pulser are mounted underneath the printed circuit board, and utilize the mounting plate as a heat sink. In the unlikely event that a MOSFET need be replaced, it is highly recommended that the unit be returned to the factory for servicing.

The table below summarizes potential problems and their solutions. If these recommendations do not resolve the problem, DEI customer service can be contacted for further assistance.

<u>SYMPTOM</u>	<u>SOLUTIONS</u>
1. No AC ON Lamp.	-AC power not plugged in. -Fuse(s) are blown. See fuse replacement instructions in Section 7.1.1.
2. No output pulse.	-No input trigger. -Input trigger voltage too low. -Input trigger pulse width too short. Increase width. -Input trigger frequency too high. Reduce frequency. -Trigger switch incorrectly set. -High voltage supply set too low. Increase high voltage setting. -Output not connected correctly. Check all cables and connections. -Pulser is damaged. Contact DEI customer service.

### 7.1.1 Fuses

To avoid fire hazard or damage to the pulser, use only 3A fast blow fuses (Littelfuse #312003 or equivalent). Fuse replacement should be performed by qualified personnel only. Assure that the AC power cord is disconnected from the pulser, and that the capacitor bank is fully discharged and a shorting strap installed before fuse replacement is attempted. Verify with a voltmeter that all circuits are de-energized before servicing. The voltmeter used to make these measurements must be certified for use at 1000VDC and 110VAC or greater.

The fuses are located in the corner of the printed circuit boards. To access the circuit boards, remove the retaining screws for the power entry module, and remove the rear panel. Then remove the corner and side screws from the

front panel. The front panel and PCB assemblies will then slide out from the case, providing access to the fuses.

### 7.2 Factory Service

If the procedures above fail to resolve an operational problem, please contact the factory for further assistance:

DIRECTED ENERGY, INC.  
2301 RESEARCH BLVD  
SUITE 101  
FORT COLLINS, CO 80526  
(303) 493-1901  
FAX (303) 493-1903

## 8.0 SYSTEM FAILURE MODES

The SVX is capable of generating large amplitude voltage pulses with fast rise and fall times. It is the user's responsibility to assure that the interconnect cables and load do not create transients, over-current or over-voltage conditions that could damage the pulse generator.

### 8.1 Over-Current Failure

When the output is shorted, the pulser can deliver near 40A of current (depending on cabling, HV power supply setting, etc.). A current pulse of this magnitude is in excess of the driver's maximum specification, and may cause damage to the pulser, load and/or associated cabling.

### 8.2 Over-Voltage Failure

One may incorrectly assume that the voltage across the MOSFET switching device could never exceed the 800V maximum setting of the high voltage control. It is possible to create voltages in excess of 800V by driving an improperly terminated cable or by generating L di/dt spikes caused by an inductive load.

L di/dt spikes are created when current flowing through an inductor is interrupted (i.e. current is turned off). The amplitude of the resultant voltage spike is defined by the formula:

$$V = L \, di/dt,$$

where L is the circuit inductance, di is the current value at turn off and dt is the time it takes for the current to get to zero (i.e. fall time). By monitoring the voltage output of the pulser, the user can measure L di/dt voltage spikes. With this measurement, the user can determine the actual voltage across the MOSFET switching device, with the formula:

$$V_{\max} = [L \, di/dt] + V_{\text{supply}}$$

where

$L \, di/dt$  = peak of the negative-going spike;  
 $V_{\text{supply}}$  = panel meter voltage;  
 $V_{\max}$  = 800 volts.

Any time the test setup (e.g. interconnect cables and/or load resistance) is changed, it will be necessary to again verify that  $V_{\max}$  is no greater than 800 volts.

**APPENDIX**

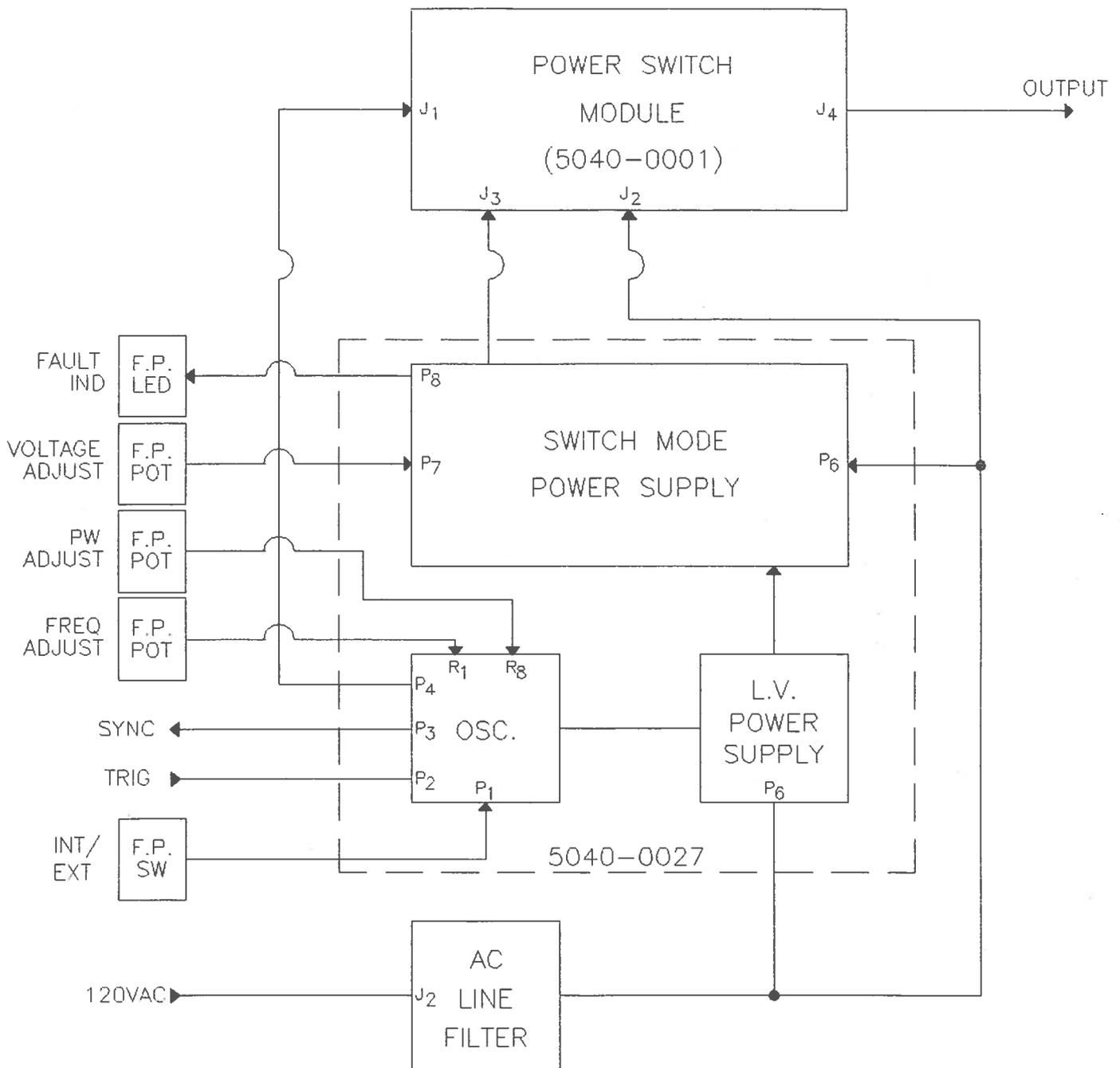
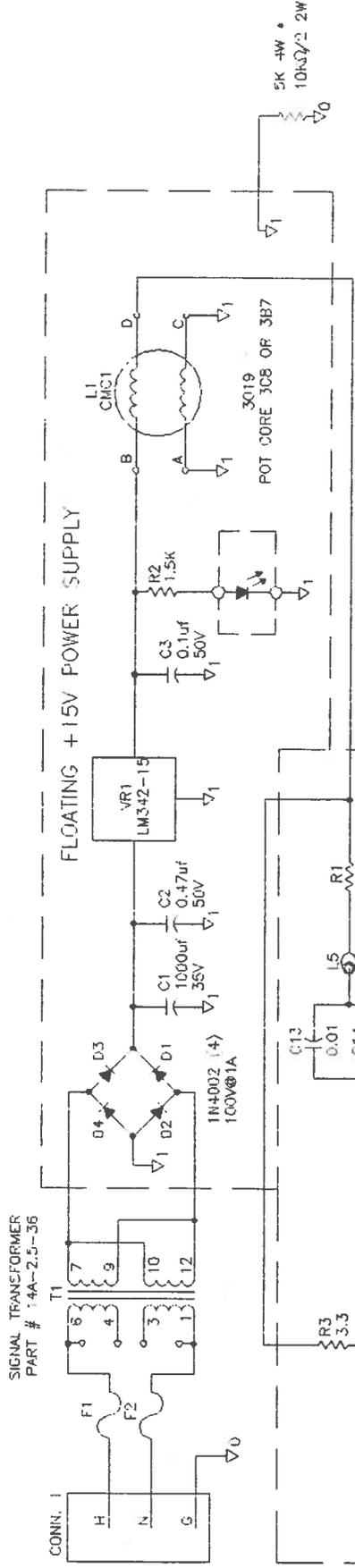
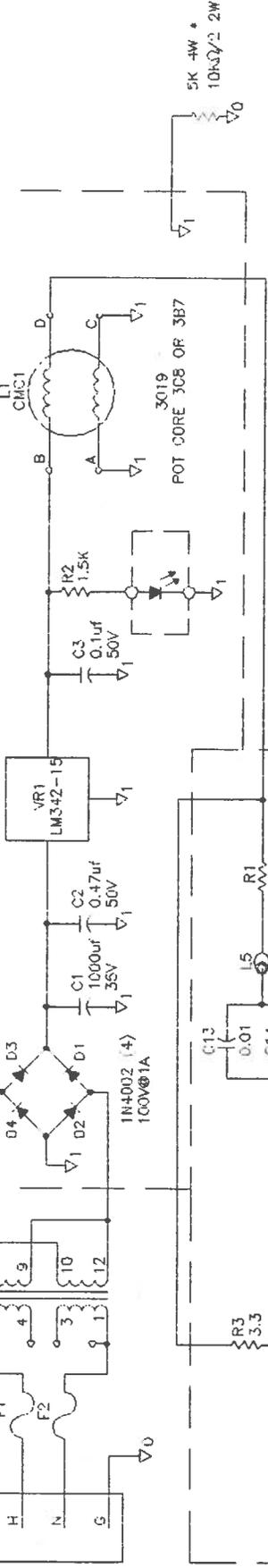


FIGURE 1.  
SVX PULSER  
BLOCK DIAGRAM

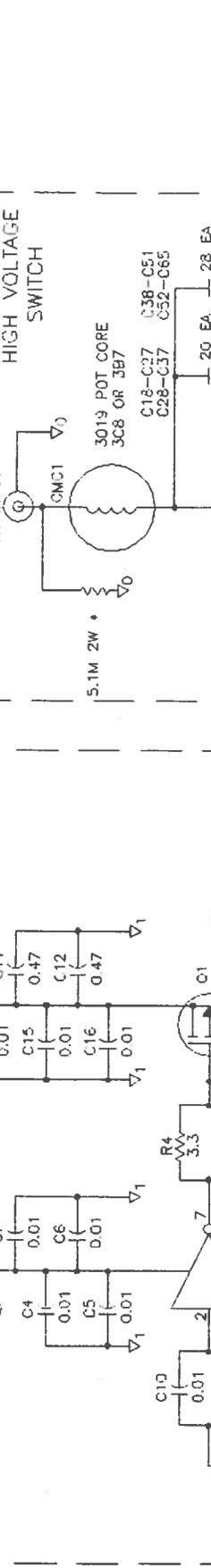
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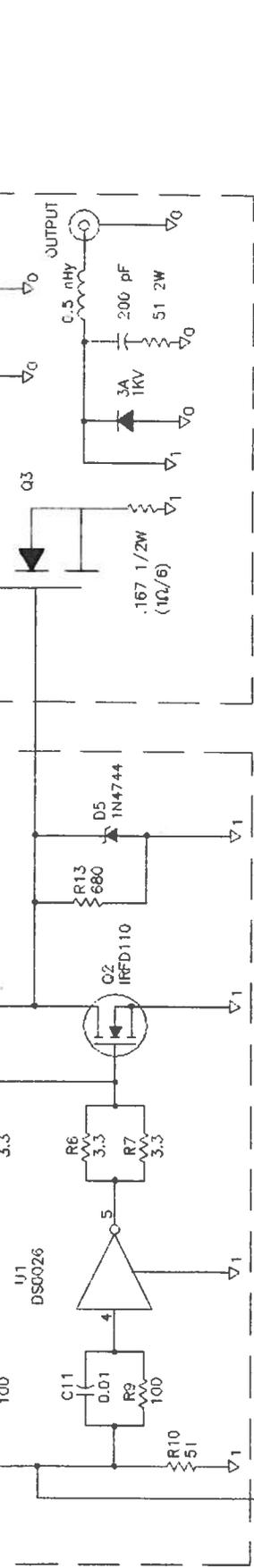
### FLOATING +15V POWER SUPPLY



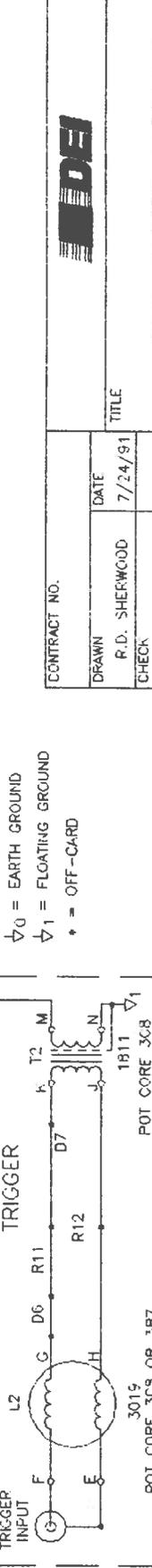
### GATE DRIVE



### HIGH VOLTAGE SWITCH



### TRIGGER



$\nabla_0$  = EARTH GROUND  
 $\nabla_1$  = FLOATING GROUND  
 \* = OFF-CARD

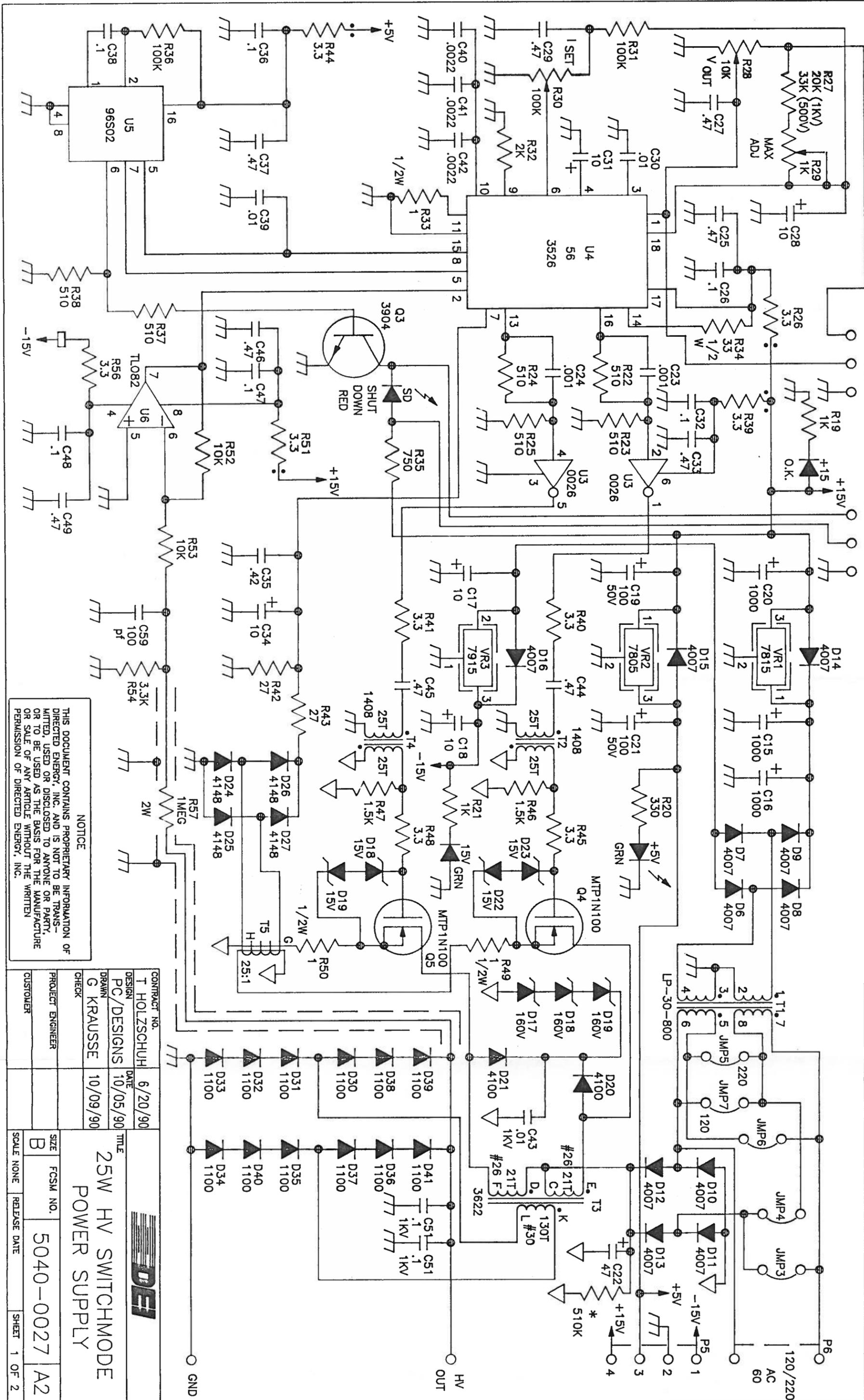
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CONTRACT NO.		TITLE	
DRAWN	R.D. SHERWOOD	DATE	7/24/91
CHECK	G. KFAUSSE	DATE	7/24/91
DESIGN			
DESIGN ACTIVITY			
CUSTOMER			
SIZE	A	FCSM NO.	6040-3001
SCALE		DWG NO.	
RELEASE DATE		REV	A
SHEET	1	OF	1



## SVX PULSE MODULE SCHEMATIC

REV	EC	DESCRIPTION	DATE	BY	CHKD	ENG
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A2	-	UPDATE TITLE, R27 VALUE AND R35 VALUE	08/01/91	RS	GK	GK

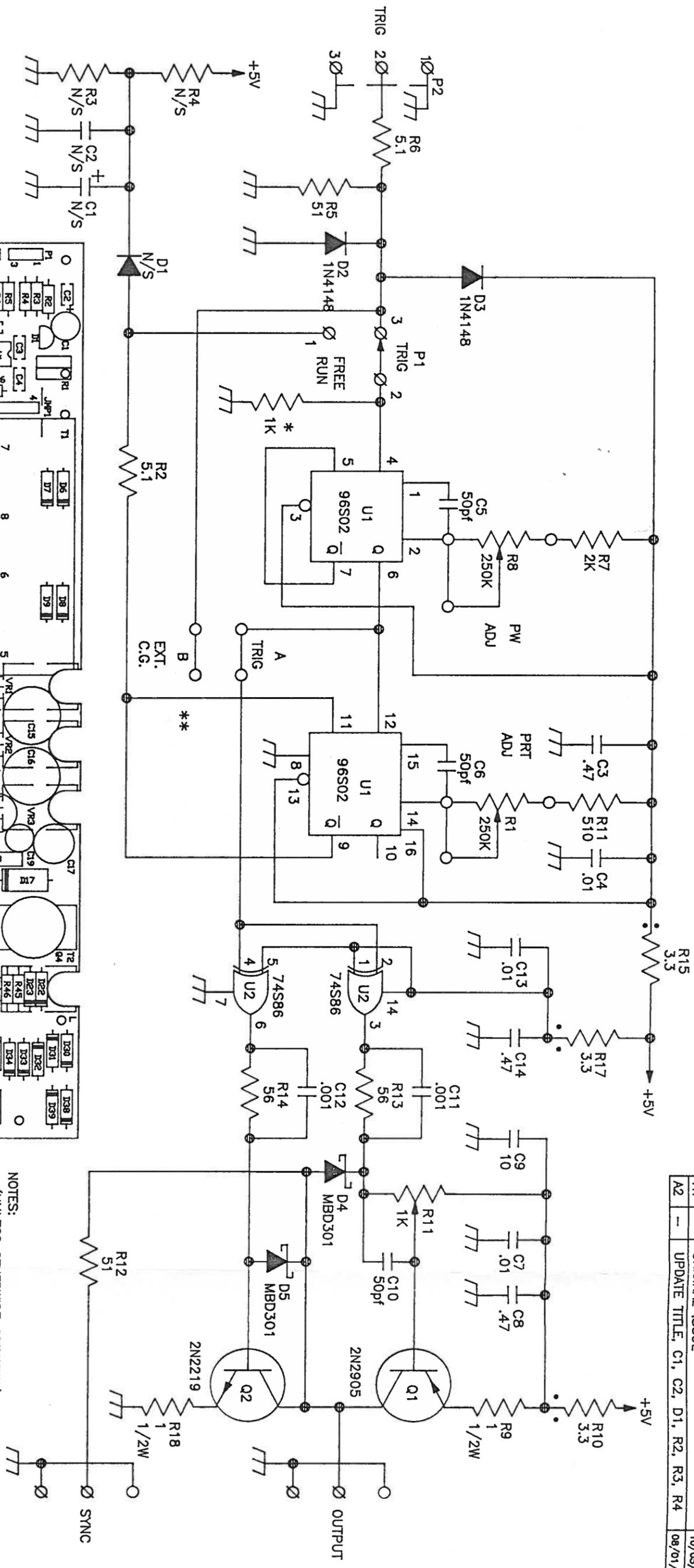


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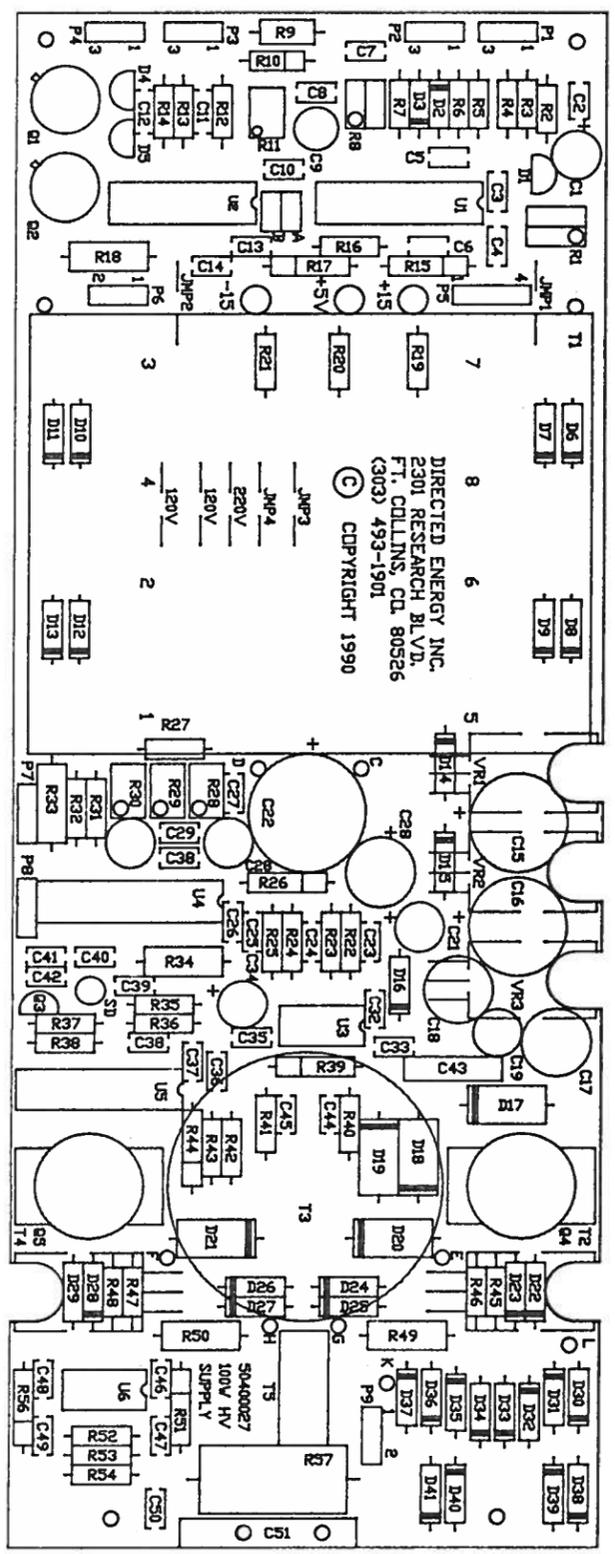
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DESIGN	PC/DESIGNS	DATE	10/05/90
DRAWN	G KRAUSSE	DATE	10/09/90
CHECK			
PROJECT ENGINEER			
CUSTOMER			
TITLE		SIZE	FCSM NO.
25W HV SWITCHMODE POWER SUPPLY		B	5040-0027
SCALE	NONE	RELEASE DATE	
SHEET	1	OF	2



REV	EC	DESCRIPTION	DATE	BY	CHKD	ENG
A1	-	ORIGINAL ISSUE	10/05/90			
A2	-	UPDATE TITLE, C1, C2, D1, R2, R3, R4	08/01/91	RS	GK	GK



- NOTES:  
(UNLESS OTHERWISE SPECIFIED)
1. ALL RESISTOR VALUES ARE IN OHMS.
  2. ALL RESISTORS ARE 1/4 W.
  3. ALL CAPACITOR VALUES ARE IN MICROFARADS.
  4. \* ON BACK SIDE OF CARD.
  5. \*\* ADD.
  6. O ON-CARD / OFF-CARD.
  7. Ø OFF CARD.
  8. N/S = NOT STUFFED



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SILK SCREEN

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CONTRACT NO.		DATE	6/20/90	TITLE	25W HV SWITCHMODE PULSE GENERATOR	SIZE	FCSM NO.	5040-0027	SHEET	2 OF 2
DESIGN	T HOLZSCHUH	DATE	10/05/90	PC/DESIGNS						
CHECK	G KRAUSSE	DATE	10/09/90	PROJECT ENGINEER						
CUSTOMER		SCALE	NONE	RELEASE DATE						