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NANOSECOND WAVEFORM ELECTRONICS  
SINCE 1975

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OTTAWA, ONTARIO  
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## INSTRUCTIONS

MODEL AVR-D4-B

5-10V GATE, 20-225V / 0-40A DRAIN

SWITCHING TIME TEST PULSER

FOR POWER MOSFETS

SERIAL NUMBER: \_\_\_\_\_

### WARRANTY

Avtech Electrosystems Ltd. warrants products of its manufacture to be free from defects in material and workmanship under conditions of normal use. If, within one year after delivery to the original owner, and after prepaid return by the original owner, this Avtech product is found to be defective, Avtech shall at its option repair or replace said defective item. This warranty does not apply to units which have been disassembled, modified or subjected to conditions exceeding the applicable specifications or ratings. This warranty is the extent of the obligation assumed by Avtech with respect to this product and no other warranty or guarantee is either expressed or implied.

### TECHNICAL SUPPORT

Phone: 888-670-8729 (USA & Canada) or +1-613-686-6675 (Intl)

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Manual Reference: /fileserver2/officefiles/instructword/avr-d4/AVR-D4-B.ed1.odt.  
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## INTRODUCTION

The AVR-D4-B is a high performance, GPIB and RS232-equipped test system that generates a gate pulse and a DC drain bias for pulse testing of power MOSFETs, as per MIL-STD-750-3, Method 3472.2.

The instrument mainframe connects to a test jig. The test jig accepts a variety of daughterboards. Each daughterboard will accept a specific package and pinout, and will have a specific resistance in series with the drain, and a specific resistance in series with the gate.

The DC drain bias is adjustable from 20V to 225V, positive or negative, using the AMP1 front-panel menu, or commands like "volt1 +100". The maximum drain pulse current is  $\pm 40$  A.

The gate pulse amplitude is adjustable from 5V to 10V, using the AMP2 front-panel menu, or commands like "volt2 10". The gate pulse width is adjustable from 0.5 to 2 us, with  $< 10$  ns rise times at the input to  $R_{GATE}$ . The rise times at the gate itself will be somewhat slower, due to the gate-source and gate-drain capacitances of the DUT. The polarity of the gate amplitude is automatically set to the same polarity as the drain bias.

Attenuated replicas of the gate and drain voltage are provided on output connectors on the test jig. These waveforms must be measured with a user-supplied oscilloscope. The desired switching time values -  $t_{d(on)}$ ,  $t_r$ ,  $t_{d(off)}$ ,  $t_f$  - may then be calculated from these waveforms.

The AVR-D4-B includes an internal trigger source, but it can also be triggered or gated by an external source. A front-panel pushbutton can also be used to trigger the instrument.

The AVR-D4-B features front panel keyboard and adjust knob control of the output pulse parameters along with a four line by 40-character backlit LCD display of the output amplitude, pulse repetition frequency, and delay. The instrument includes memory to store up to four complete instrument setups. The operator may use the front panel or the computer interface to store a complete "snapshot" of all key instrument settings, and recall this setup at a later time.

This instrument is intended for use in research, development, test and calibration laboratories by qualified personnel.

## MODEL NUMBER HISTORY

This model was originally developed as a special order item, with model number AVR-D4-B-MS1. It is now offered as a standard item (model AVR-D4-B), with unchanged specifications.

## SPECIFICATIONS

Model <sup>1</sup> :	AVR-D4-B
Basic test:	The AVR-D4-B generates a gate pulse and a DC drain bias for pulse testing of power MOSFETs, as per MIL-STD-750-3, Method 3472.2. The instrument mainframe connects to a test jig. The test jig accepts a variety of daughterboards. Each daughterboard will accept a specific package and pinout, and will have a specific resistance in series with the drain, and a specific resistance in series with the gate.
Gate pulse amplitude:	5V to 10V, positive or negative.
Gate pulse width (FWHM):	0.5 us to 2 us
Gate rise time (20%-80%):	< 10 ns, at input to R <sub>GATE</sub>
Minimum allowed R <sub>GATE</sub> :	2.2 Ω
Pulse repetition frequency:	1 to 100 Hz
DC drain bias:	20V to 225V. Same polarity as gate pulse.
Maximum drain pulse current:	± 40 A
Included daughterboards:	<p>None. The daughterboards are ordered separately, using the model number <i>AVX-D4-SLASH-PKG-RGATE-RDRAIN</i>. The parts in italics must be replaced with:</p> <ul style="list-style-type: none"> <li>-SLASH code: Replace with the PRF-19500 slash sheet suffix (for example, -542J) that specifies the device package and pinout.</li> <li>-PKG code: Replace the "-PKG" suffix with the name of the package that will be accepted. Choose from -TO204AA, -TO204AE, -TO254AA, or -TO205AF. Other leaded packages can be readily accommodated. SMT packages can also be handled, if the user specifies a readily-available socket or provides an appropriate socket.</li> <li>-RGATE code: specify the gate resistance that will be installed on the daughterboard. Use "-7R5" for 7.5Ω, for example. +/- 5% accuracy.</li> <li>-RDRAIN code: specify the drain resistance that will be installed on the daughterboard. Use "-28R1" for 28.1Ω, for example. +/- 5% accuracy.</li> </ul>
Outputs:	Two voltage waveforms (gate and drain) must be monitored on a user-provided oscilloscope to measure $t_{d(on)}$ , $t_{d(off)}$ , $t_r$ , and $t_f$ . The AVR-D4-B itself does not include any measurement functionality.
Propagation delay:	≤ 150 ns (Ext trig in to pulse out)
Jitter:	± 100 ps ± 0.03% of sync delay (Ext trig in to pulse out)
Trigger required:	External trigger mode: TTL, 50 ns or wider
Sync delay:	Variable 0 to ± 1 second (sync out to pulse out)
Sync output:	+3 Volts, 100 ns, will drive 50 Ohm loads
Gated operation:	Active high or low, switchable.
Connectors:	Out, Trig, Sync, Gate: BNC
GPIB & RS-232 control <sup>1</sup> :	Standard feature on all -B units.
Ethernet port, for remote control using VXI-11.3, ssh, telnet, & web:	Optional <sup>2</sup> . Recommended as a modern alternative to GPIB / RS-232. See <a href="http://www.avtechpulse.com/options/vxi">http://www.avtechpulse.com/options/vxi</a> for details.
Settings resolution:	The resolution of the timing parameters varies, but is always better than 0.15% of the set value. The amplitude resolution is typically 0.02% of the maximum amplitude.
Settings accuracy:	Typically ± 3% (plus ±1V or ± 2 ns) after 10 minute warmup. For high-accuracy applications requiring traceable calibration, verify the output parameters with a calibrated oscilloscope.
Power requirements:	100 - 240 Volts, 50 - 60 Hz
Dimensions:	100 mm x 430 mm x 375 mm (3.9" x 17" x 14.8")
Chassis material:	Cast aluminum frame and handles, blue vinyl on aluminum cover plates
Mounting:	Any. Add -R5 to the model number to add a rack-mount kit.
Temperature range:	+5°C to +40°C

1) -B suffix indicates IEEE-488.2 GPIB and RS-232 control of amplitude and frequency. See <http://www.avtechpulse.com/gpib> for details.

2) Add the suffix -VXI to the model number to specify the Ethernet port.

## REGULATORY NOTES

### FCC PART 18

This device complies with part 18 of the FCC rules for non-consumer industrial, scientific and medical (ISM) equipment.

This instrument is enclosed in a rugged metal chassis and uses a filtered power entry module (where applicable). The main output signal is provided on a shielded connector that is intended to be used with shielded coaxial cabling and a shielded load. Under these conditions, the interference potential of this instrument is low.

If interference is observed, check that appropriate well-shielded cabling is used on the output connectors. Contact Avtech ([info@avtechpulse.com](mailto:info@avtechpulse.com)) for advice if you are unsure of the most appropriate cabling. Also, check that your load is adequately shielded. It may be necessary to enclose the load in a metal enclosure.

If any of the connectors on the instrument are unused, they should be covered with shielded metal "dust caps" to reduce the interference potential.

This instrument does not normally require regular maintenance to minimize interference potential. However, if loose hardware or connectors are noted, they should be tightened. Contact Avtech ([info@avtechpulse.com](mailto:info@avtechpulse.com)) if you require assistance.

### EC DECLARATION OF CONFORMITY



We                      Avtech Electrosystems Ltd.  
                             P.O. Box 5120, LCD Merivale  
                             Ottawa, Ontario  
                             Canada K2C 3H5

declare that this pulse generator meets the intent of Directive 2004/108/EG for Electromagnetic Compatibility. Compliance pertains to the following specifications as listed in the official Journal of the European Communities:

EN 50081-1 Emission

EN 50082-1 Immunity

and that this pulse generator meets the intent of the Low Voltage Directive 72/23/EEC as amended by 93/68/EEC. Compliance pertains to the following specifications as listed in the official Journal of the European Communities:

EN 61010-1:2001 Safety requirements for electrical equipment for measurement, control, and laboratory use

#### DIRECTIVE 2002/95/EC (RoHS)

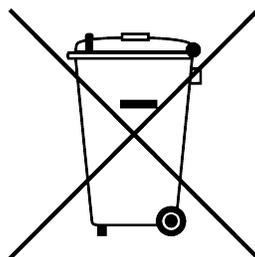
This instrument is exempt from Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the Restriction of the use of certain Hazardous Substances (RoHS) in electrical and electronic equipment. Specifically, Avtech instruments are considered "Monitoring and control instruments" (Category 9) as defined in Annex 1A of Directive 2002/96/EC. The Directive 2002/95/EC only applies to Directive 2002/96/EC categories 1-7 and 10, as stated in the "Article 2 - Scope" section of Directive 2002/95/EC.

#### DIRECTIVE 2002/96/EC (WEEE)

European customers who have purchased this equipment directly from Avtech will have completed a "WEEE Responsibility Agreement" form, accepting responsibility for WEEE compliance (as mandated in Directive 2002/96/EC of the European Union and local laws) on behalf of the customer, as provided for under Article 9 of Directive 2002/96/EC.

Customers who have purchased Avtech equipment through local representatives should consult with the representative to determine who has responsibility for WEEE compliance. Normally, such responsibilities will lie with the representative, unless other arrangements (under Article 9) have been made.

Requirements for WEEE compliance may include registration of products with local governments, reporting of recycling activities to local governments, and financing of recycling activities.



## AC POWER SUPPLY REGULATORY NOTES

This instrument converts the AC input power to the +24V DC voltage that powers the internal circuitry of this instrument using a Tamura AAD130SD-60-A switching power supply. According to the manufacturer, the Tamura AAD130SD-60-A has the following certifications:

UL60950-1  
IEC60950 -1  
CSA C22.2 No. 60950- 1  
EN60950 -1

and is compliant with:

EN61000-3-2  
EN61000-4-2 Level 2  
EN61000-4-2 Level 3 (Air Only)  
EN61000-4-4 Level 3  
EN61000-4-5 Level 3  
EN61000-4-11  
CISPR 11 and 22 FCC Part 15 Class B (conducted)

## FIRMWARE LICENSING

Instruments with firmware versions 5.00 or higher use open-source software internally. Some of this software requires that the source code be made available to the user as a condition of its licensing. This source code is distributed on the device itself. To access it, log in as user “source” with password “source”. The source files are provided in this user's home directory, and are accessible using standard viewing and file transfer tools (such as vim, sz, and scp).

Earlier firmware versions do not contain any open source software.

## INSTALLATION

### VISUAL CHECK

After unpacking the instrument, examine to ensure that it has not been damaged in shipment. Visually inspect all connectors, knobs, liquid crystal displays (LCDs), and the handles. If the instrument has been damaged, file a claim immediately with the company that transported the instrument.

The following items should be with the instrument:

- 1) A power cord.
- 2) A GPIB cable.
- 3) Two instrumentation manuals (this manual and the “Programming Manual for -B Instruments”).
- 4) One 2m DB25 control cable
- 5) One 2m SMA-to-SMA coaxial cable
- 6) Two 60cm BNC-to-SMA coaxial cables
- 7) Two 50 Ohm BNC feed-through terminators
- 8) One AVX-D4-JIG1 test jig

### POWER RATINGS

This instrument is intended to operate from 100 - 240 V, 50 - 60 Hz.

The maximum power consumption is 57 Watts. Please see the “FUSES” section for information about the appropriate AC and DC fuses.

This instrument is an “Installation Category II” instrument, intended for operation from a normal single-phase supply.

### CONNECTION TO THE POWER SUPPLY

An IEC-320 three-pronged recessed male socket is provided on the back panel for AC power connection to the instrument. One end of the detachable power cord that is supplied with the instrument plugs into this socket. The other end of the detachable power cord plugs into the local mains supply. Use only the cable supplied with the instrument. The mains supply must be earthed, and the cord used to connect the instrument to the mains supply must provide an earth connection. (The supplied cord does this.)

 Warning: Failure to use a grounded outlet may result in injury or death due to electric shock. This product uses a power cord with a ground connection. It must be connected to a properly grounded outlet. The instrument chassis is connected to the ground wire in the power cord.

The table below describes the power cord that is normally supplied with this instrument, depending on the destination region:

Destination Region	Description	Option	Manufacturer	Part Number
United Kingdom, Hong Kong, Singapore, Malaysia	BS 1363, 230V, 50 Hz	-AC00	Qualtek	370001-E01
Australia, New Zealand	AS 3112:2000, 230-240V, 50 Hz	-AC01	Qualtek	374003-A01
Continental Europe, Korea, Indonesia, Russia	European CEE 7/7 "Schuko" 230V, 50 Hz	-AC02	Qualtek	364002-D01
North America, Taiwan	NEMA 5-15, 120V, 60 Hz	-AC03	Qualtek	312007-01
Switzerland	SEV 1011, 230V, 50 Hz	-AC06	Qualtek	378001-E01
South Africa, India	SABS 164-1, 220-250V, 50 Hz	-AC17	Volex	2131H 10 C3
Japan	JIS 8303, 100V, 50-60 Hz	-AC18	Qualtek	397002-01
Israel	SI 32, 220V, 50 Hz	-AC19	Qualtek	398001-01
China	GB 1002-1, 220V, 50 Hz	-AC22	Volex	2137H 10 C3

## PROTECTION FROM ELECTRIC SHOCK

 Operators of this instrument must be protected from electric shock at all times. The owner must ensure that operators are prevented access and/or are insulated from every connection point. In some cases, connections must be exposed to potential human contact. Operators must be trained to protect themselves from the risk of electric shock. This instrument is intended for use by qualified personnel who recognize shock hazards and are familiar with safety precautions required to avoid possibly injury. In particular, operators should:

1. Keep exposed high-voltage wiring to an absolute minimum.
2. Wherever possible, use shielded connectors and cabling.
3. Connect and disconnect loads and cables only when the instrument is turned off.
4. Keep in mind that all cables, connectors, oscilloscope probes, and loads must have an appropriate voltage rating.

5. Do not attempt any repairs on the instrument, beyond the fuse replacement procedures described in this manual. Contact Avtech technical support (see page 2 for contact information) if the instrument requires servicing. Service is to be performed solely by qualified service personnel.

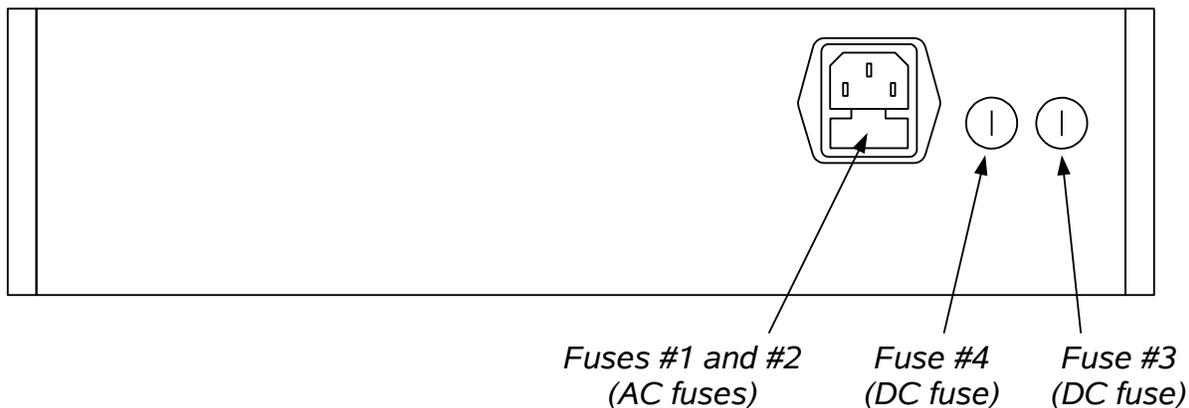
## ENVIRONMENTAL CONDITIONS

This instrument is intended for use under the following conditions:

1. indoor use;
2. altitude up to 2 000 m;
3. temperature 5 °C to 40 °C;
4. maximum relative humidity 80 % for temperatures up to 31 °C decreasing linearly to 50 % relative humidity at 40 °C;
5. Mains supply voltage fluctuations up to  $\pm 10$  % of the nominal voltage;
6. no pollution or only dry, non-conductive pollution.

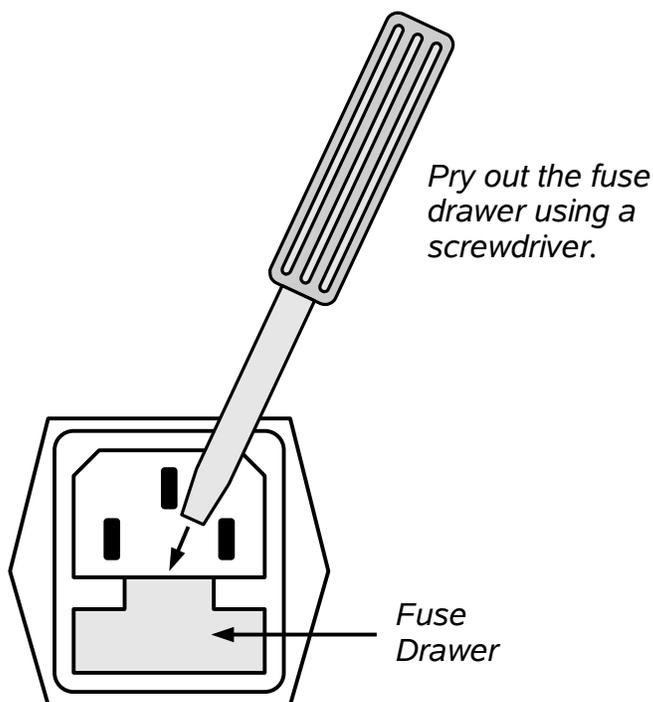
## FUSES

This instrument contains four fuses. All are accessible from the rear-panel. Two protect the AC prime power input, and two protect the internal DC power supplies. The locations of the fuses on the rear panel are shown in the figure below:



### AC FUSE REPLACEMENT

To physically access the AC fuses, the power cord must be detached from the rear panel of the instrument. The fuse drawer may then be extracted using a small flat-head screwdriver, as shown below:



## DC FUSE REPLACEMENT

The DC fuses may be replaced by inserting the tip of a flat-head screwdriver into the fuse holder slot, and rotating the slot counter-clockwise. The fuse and its carrier will then pop out.

## FUSE RATINGS

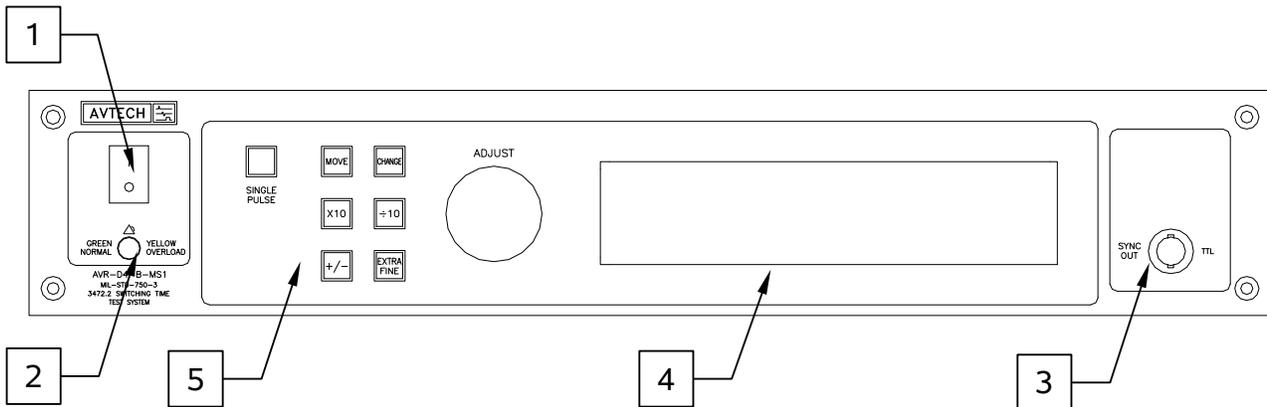
The following table lists the required fuses:

Fuses	Nominal Mains Voltage	Rating	Case Size	Recommended Replacement Part	
				Littelfuse Part Number	Digi-Key Stock Number
#1, #2 (AC)	100-240V	0.5A, 250V, Time-Delay	5×20 mm	0218.500HXP	F2416-ND
#3 (DC)	N/A	1.6A, 250V, Time-Delay	5×20 mm	021801.6HXP	F2424-ND
#4 (DC)	N/A	0.5A, 250V, Time-Delay	5×20 mm	0218.500HXP	F2416-ND

The recommended fuse manufacturer is Littelfuse (<http://www.littelfuse.com>).

Replacement fuses may be easily obtained from Digi-Key (<http://www.digikey.com>) and other distributors.

## FRONT PANEL CONTROLS



1. **POWER Switch.** This is the main power switch. When turning the instrument on, there is normally a delay of 5-10 seconds before anything is shown on the main display.

If the main menu does not appear after 30 seconds, turn off the instrument and leave it off for at least 60 seconds before applying power again.

Allow 30 seconds before re-powering an instrument that has been switched off. If the power is switched more frequently than that, the turn-on delay may be longer (up to 20 seconds) as the internal software performs filesystem checks, or the instrument may remain unresponsive indefinitely.

2. **OVERLOAD Indicator.** When the instrument is powered, this indicator is normally green, indicating normal operation. If this indicator is yellow, an internal automatic overload protection circuit has been tripped. If the unit is overloaded (by operating at an exceedingly high duty cycle or by operating into a very low impedance), the protective circuit will disable the output of the instrument and turn the indicator light yellow. The light will stay yellow (i.e. output disabled) for about 5 seconds after which the instrument will attempt to re-enable the output (i.e. light green) for about 1 second. If the overload condition persists, the output will be disabled again (i.e. light yellow) for another 5 seconds. If the overload condition has been removed, the instrument will resume normal operation.

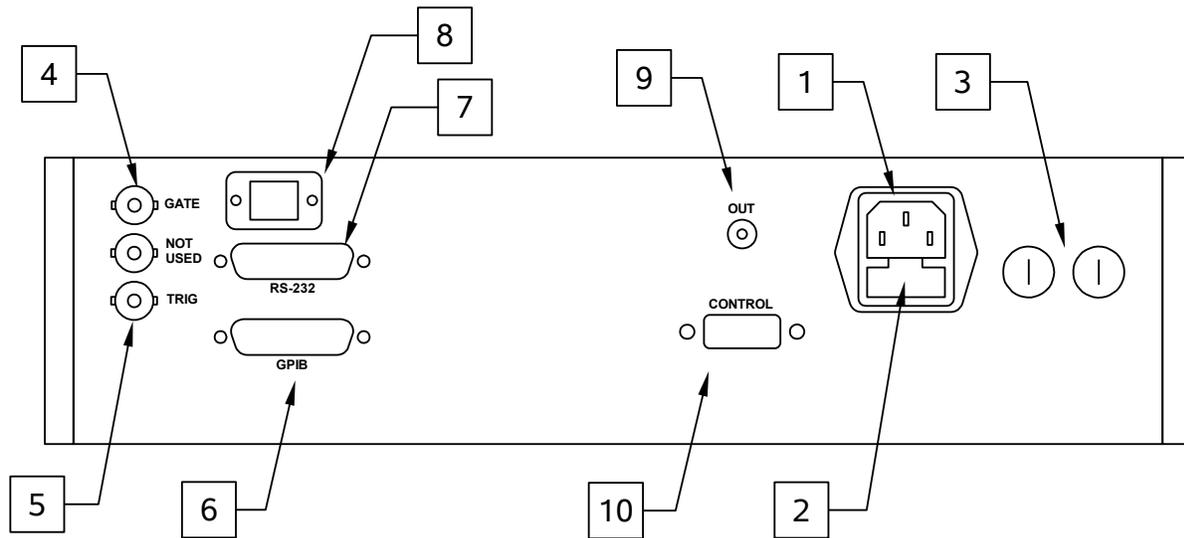
This overload indicator may flash yellow briefly at start-up. This is not a cause for concern.

3. **SYNC OUT.** This connector supplies a SYNC output that can be used to trigger other equipment, particularly oscilloscopes. This signal leads (or lags) the main output by a duration set by the "DELAY" controls and has an approximate amplitude of +3 Volts to  $R_L > 50\Omega$  with a pulse width of approximately 100 ns.

4. LIQUID CRYSTAL DISPLAY (LCD). This LCD is used in conjunction with the keypad to change the instrument settings. Normally, the main menu is displayed, which lists the key adjustable parameters and their current values. The “Programming Manual for -B Instruments” describes the menus and submenus in detail.
5. KEYPAD.

Control Name	Function
MOVE	This moves the arrow pointer on the display.
CHANGE	This is used to enter the submenu, or to select the operating mode, pointed to by the arrow pointer.
×10	If one of the adjustable numeric parameters is displayed, this increases the setting by a factor of ten.
÷10	If one of the adjustable numeric parameters is displayed, this decreases the setting by a factor of ten.
+/-	If one of the adjustable numeric parameters is displayed, and this parameter can be both positive or negative, this changes the sign of the parameter.
EXTRA FINE	This changes the step size of the ADJUST knob. In the extra-fine mode, the step size is twenty times finer than in the normal mode. This button switches between the two step sizes.
ADJUST	This large knob adjusts the value of any displayed numeric adjustable values, such as frequency, pulse width, etc. The adjust step size is set by the "EXTRA FINE" button.  When the main menu is displayed, this knob can be used to move the arrow pointer.

## REAR PANEL CONTROLS



*Note: some connectors may be in different positions than shown above, depending on the exact combination of options ordered.*

1. **AC POWER INPUT.** An IEC-320 C14 three-pronged recessed male socket is provided on the back panel for AC power connection to the instrument. One end of the detachable power cord that is supplied with the instrument plugs into this socket.
2. **AC FUSE DRAWER.** The two fuses that protect the AC input are located in this drawer. Please see the “FUSES” section of this manual for more information.
3. **DC FUSES.** These two fuses protect the internal DC power supplies. Please see the “FUSES” sections of this manual for more information.
4. **GATE.** This TTL-level (0 and +5V) logic input can be used to gate the triggering of the instrument. This input can be either active high or active low, depending on the front panel settings or programming commands. (The instrument triggers normally when this input is unconnected). When set to active high mode, this input is pulled-down to ground by a 1 k $\Omega$  resistor. When set to active low mode, this input is pulled-up to +5V by a 1 k $\Omega$  resistor.
5. **TRIG.** This TTL-level (0 and +5V) logic input can be used to trigger the instrument, if the instrument is set to triggering externally. The instrument triggers on the rising edge of this input. The input impedance of this input is 1 k $\Omega$ . (Depending on the length of cable attached to this input, and the source driving it, it may be desirable to add a coaxial 50 Ohm terminator to this input to provide a proper transmission line termination. The Pasternack ([www.pasternack.com](http://www.pasternack.com)) PE6008-50 BNC feed-thru

50 Ohm terminator is suggested for this purpose.)

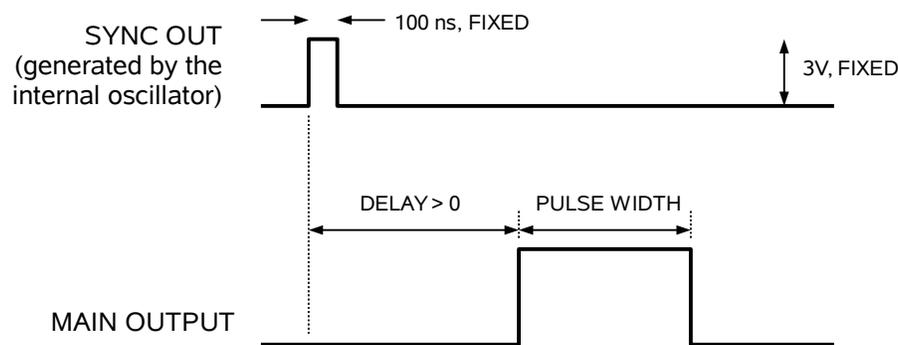
6. GPIB Connector. A standard GPIB cable can be attached to this connector to allow the instrument to be computer-controlled. See the “Programming Manual for -B Instruments” for more details on GPIB control.
7. RS-232 Connector. A standard serial cable with a 25-pin male connector can be attached to this connector to allow the instrument to be computer-controlled. Instruments with firmware versions of 5.00 or higher require a user name (“admin”) and a password (“default”, as shipped from the factory) when logging into a serial terminal session. See the “Programming Manual for -B Instruments” for more details on RS-232 control.
8. Network Connector. (Optional feature. Present on -VXI units only.) This Ethernet connector allows the instrument to be remotely controlled using the VXI-11.3, ssh (secure shell), telnet, and http (web) protocols. See the “Programming Manual for -B Instruments” for more details.
9. OUT Connector. This SMA connector provides the trigger signal to the test jig. It should be connected to the IN connector on the test jig.
10. CONTROL Connector. This DB-25 female connector should be connected to the corresponding CONTROL connector on the test jig using the supplied DB-25 cable.

## TIMING CONTROL

### BASIC TIMING CONTROL

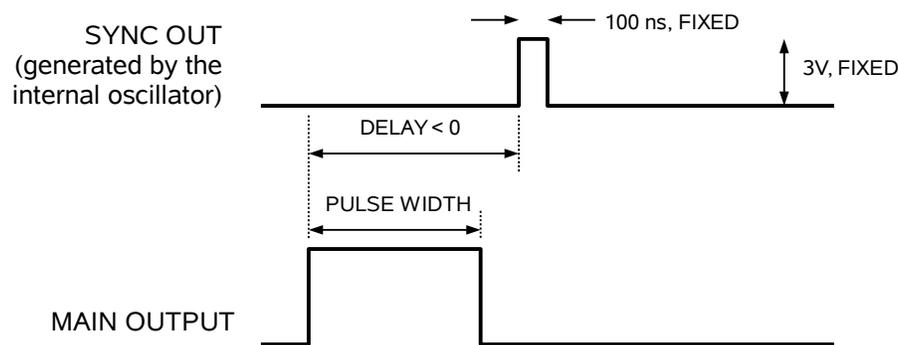
This instrument can be triggered by its own internal clock or by an external TTL trigger signal. In either case, two output channels respond to the trigger: OUT and SYNC. The OUT channel is the signal that triggers the gate drive circuit. Its pulse width is variable. The SYNC pulse is a fixed-width TTL-level reference pulse used to trigger oscilloscopes or other measurement systems. When the delay is set to a positive value the SYNC pulse precedes the OUT pulse. When the delay is set to a negative value the SYNC pulse follows the OUT pulse.

These pulses are illustrated below, assuming internal triggering and a positive delay:



*Figure A*

If the delay is negative, the order of the SYNC and OUT pulses is reversed:



*Figure B*

The next figure illustrates the relationship between the signal when an external TTL-level trigger is used:

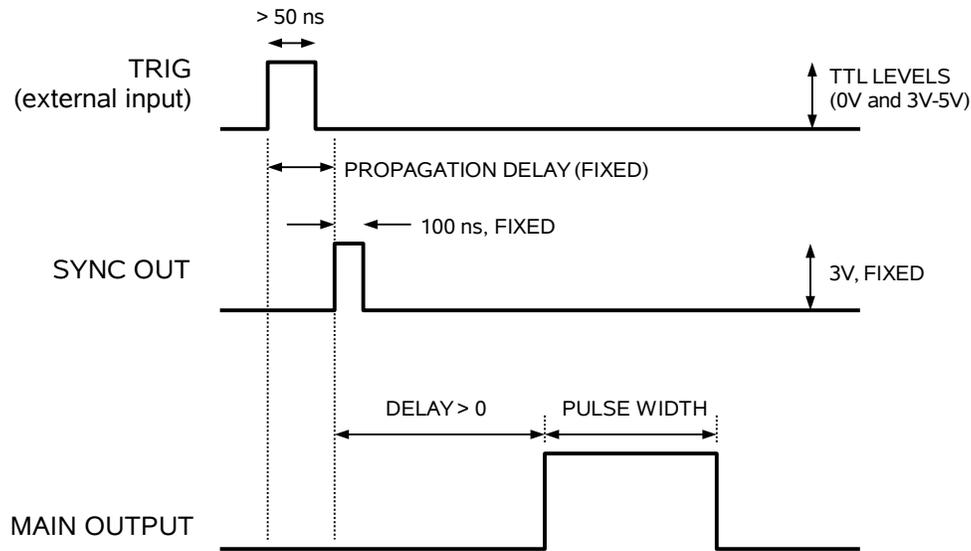


Figure C

As before, if the delay is negative, the order of the SYNC and OUT pulses is reversed.

## TRIGGER MODES

This instrument has four trigger modes:

- Internal Trigger: the instrument controls the trigger frequency, and generates the clock internally.
- External Trigger: the instrument is triggered by an external TTL-level clock on the back-panel TRIG connector.
- Manual Trigger: the instrument is triggered by the front-panel “SINGLE PULSE” pushbutton.
- Hold Trigger: the instrument is set to not trigger at all.

These modes can be selected using the front panel trigger menu, or by using the appropriate programming commands. (See the “Programming Manual for -B Instruments” for more details.)

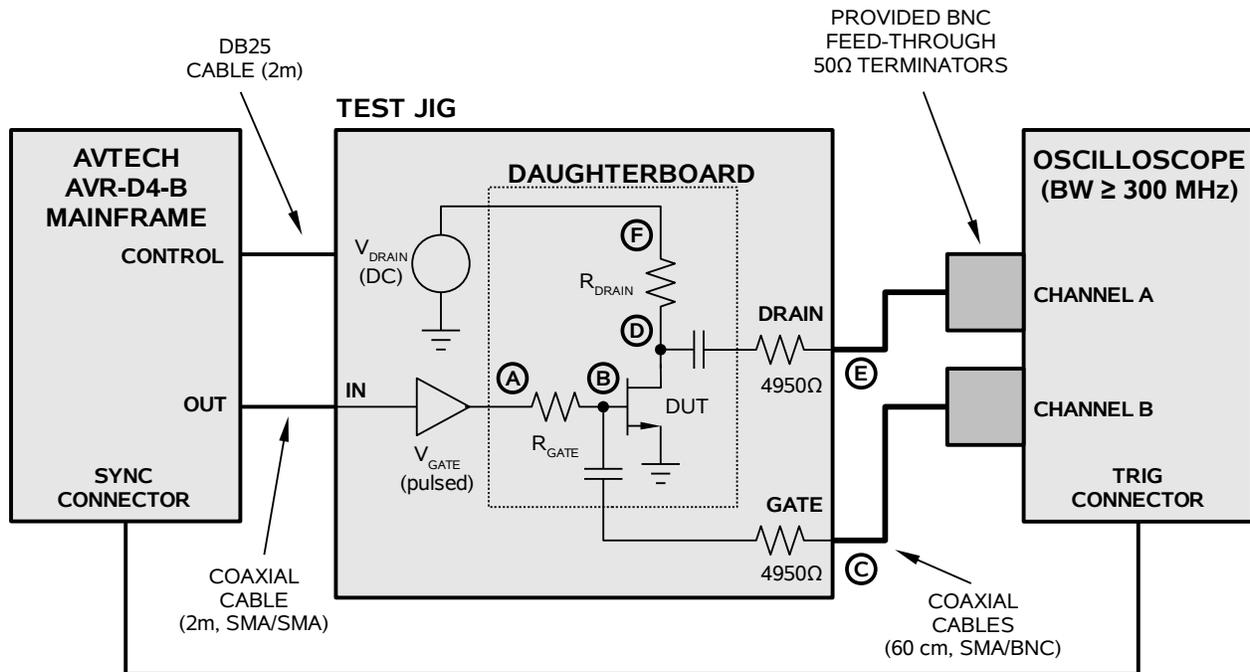
## GATING MODES

Triggering can be suppressed by a TTL-level signal on the rear-panel GATE connector. The instrument can be set to stop triggering when this input high or low, using the front-panel gate menu or the appropriate programming commands. When gated, the output

will complete the full pulse width if the output is high, and then stop triggering. Pulses are not truncated.

## AMPLITUDE CONTROL

The basic test arrangement for the AVR-D4-B is shown in the figure below:



The mainframe connects to the test jig using a 2m length of SMA-to-SMA coaxial cable, and a 2m length of DB-25 cable. The cable lengths are not critical.

The SYNC output of the mainframe should be used to trigger the oscilloscope.

The test jig has two outputs, labeled “GATE” and “DRAIN”. Each is fed into the input of an oscilloscope by a 60 cm length of BNC-to-SMA coaxial cable, with a 50 Ohm feed-through terminator at the oscilloscope end of the cabling. The oscilloscope input impedance should be 1 M $\Omega$  or higher.

### SETTING THE DRAIN DC BIAS

The bias applied to the DUT drain may be varied from 20V to 225V, using the “AMP1” front-panel menu, or by sending commands like:

```
volt1 +100
```

The amplitude must be positive for N-channel devices, and negative for P-Channel devices. Take care to use the correct polarity.

## SETTING THE GATE DRIVE AMPLITUDE

The amplitude of the pulse applied to the DUT gate may be varied from 5V to 10V using the “AMP2” front-panel menu, or by sending commands like:

```
volt2 10
```

The instrument ignores the polarity of this setting. Internally, the gate amplitude is set to be the same as the drain bias polarity.

## COAXIAL CABLE LENGTHS

The coaxial cable lengths are not critical. They may be increased or decreased as desired.

The cables connecting the GATE and DRAIN signals to the oscilloscope must have identical lengths, to avoid introducing timing skews.

## ACCESSIBLE VOLTAGES

DC and pulse voltages of up to 250V are generated in the test jig. For this reason, the output is automatically disabled when the test jig lid is open. The lid must be closed to obtain measurements.



Shielded cabling should be used for all connections to the IN, GATE, and DRAIN terminals on the test jig.

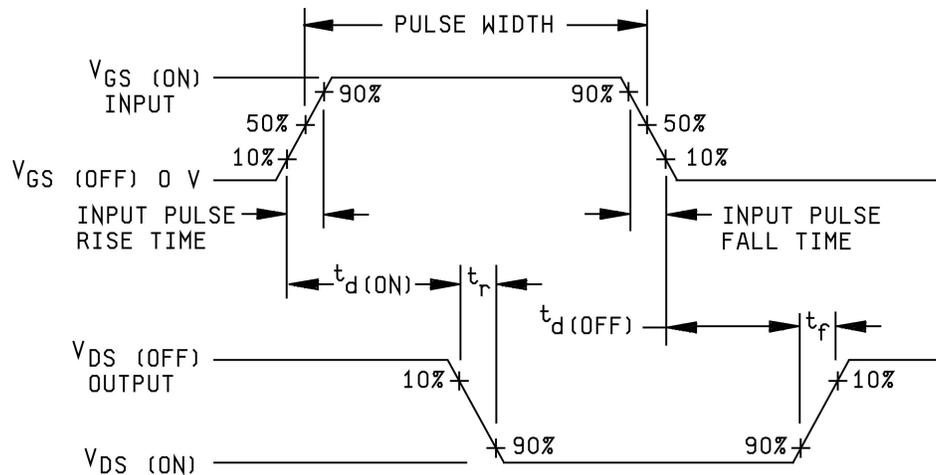


When used properly (with a 50 Ohm termination), the maximum voltage on the DRAIN terminal will be < 2.5V, approximately. However, if the terminator is not connected, the maximum voltage will at the DRAIN terminal may be as high as 250V. You may need to consider whether this scenario would damage your oscilloscope, and take appropriate precautions.

## BASIC MEASUREMENT THEORY

The basic procedure for measuring the forward recovery voltage and time is described in method 3472.2 of MIL-STD-750-3. The user should familiarize themselves with this method before using this instrument.

The basic parameters are shown in Figure 3472-2 of MIL-STD-750-3, reproduced in part here:



Direct access to  $V_{GS}$  (the gate waveform) and  $V_{DS}$  (the drain waveform) is not provided on the test jig output connectors. Instead, both signals pass through a capacitance in series with a  $4950\Omega$  series resistance (following the scheme used in Figure 3472-4 of MIL-STD-750-3). The  $4950\Omega$  resistance, combined with the  $50\Omega$  terminator, creates a 100:1 voltage divider.

The DRAIN and GATE outputs of the test jigs are therefore AC-coupled 100:1 attenuated replicas of the actual drain and gate waveforms.

## SAMPLE CALCULATIONS AND WAVEFORMS

The 2N6766 N-Channel MOSFET specifications are contained in MIL-PRF-19500/543N. It specifies that the 2N6766 should be tested with:

$$\begin{aligned} V_{GATE} &= +10 \text{ V} \\ R_{GATE} &= 2.35 \Omega \\ V_{DRAIN} &= +100 \text{ V} \\ I_{DRAIN} &= +30 \text{ A} \end{aligned}$$

The required drain resistance is then:

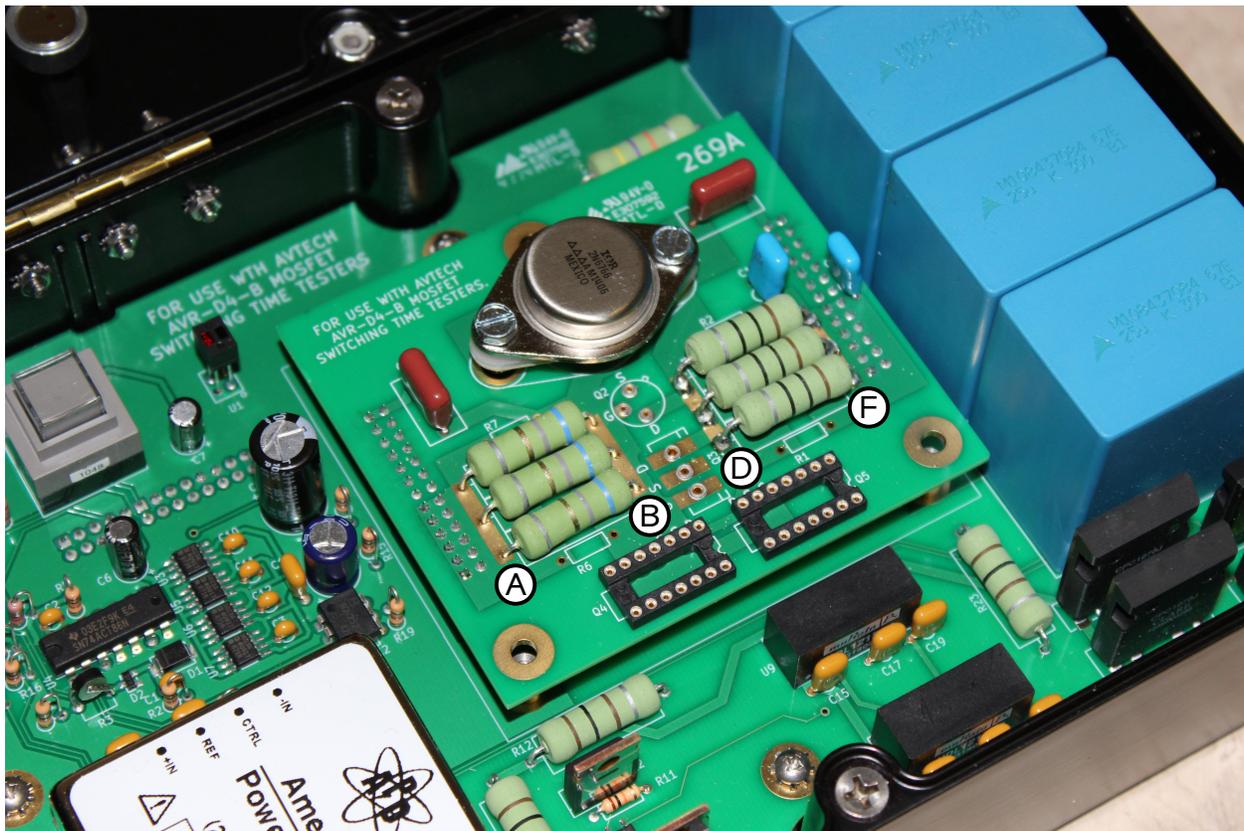
$$R_{DRAIN} \approx V_{DRAIN} / I_{DRAIN} = 3.33\Omega$$

If the device has a particularly high resistance, a more exact calculation would be:

$$R_{\text{DRAIN}} = (V_{\text{DRAIN}} - V_{\text{DS(ON)}}) / I_{\text{DRAIN}}$$

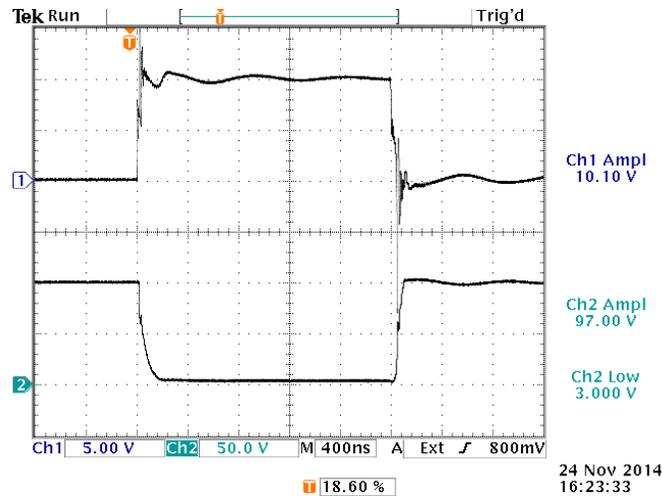
Avtech recommends the use of Ohmite OY-series resistors for  $R_{\text{DRAIN}}$ , due to their extremely robust pulse handling capabilities, and their low inductance.

In this example,  $R_{\text{GATE}}$  can be implemented using three 6.8 Ohm resistors in parallel, and  $R_{\text{DRAIN}}$  can be implemented using three 10 Ohm resistors in parallel. A daughterboard arrangement that implements this is shown below:

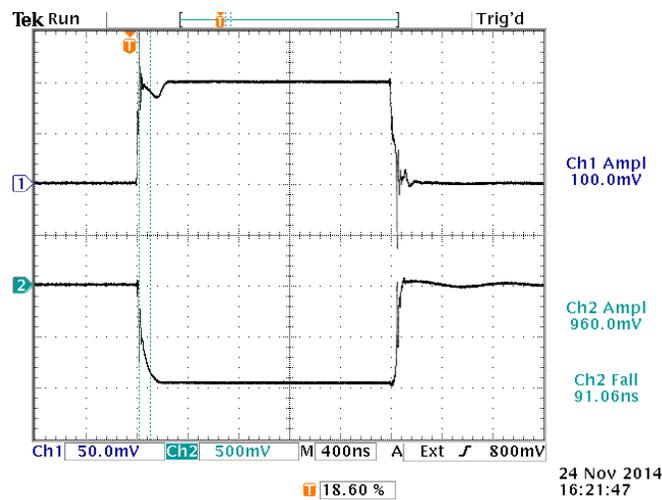


The A, B, D, and F locations correspond to the points marked in the test setup diagram on page 23. (The C and E locations are connectors on the rear panel of the jig).

With the pulse width set to 2 us, the following waveforms occur at the gate (top) and drain (bottom) – points B and D in the test setup diagram on page 23:



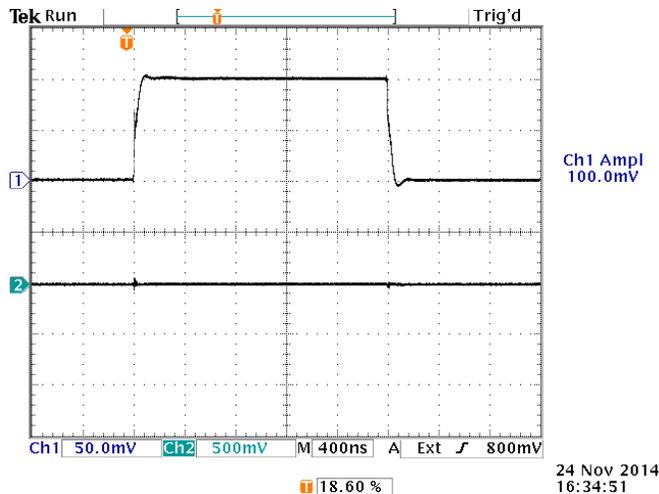
The 100:1 attenuated, AC-coupled, versions of these waveforms are provided at the test jig output connectors – points C and E in the test setup diagram on page 23:



The last waveform shows a measurement of  $t_R$  of 91.06 ns. (MIL-PRF-19500/543N specifies  $t_R < 190$  ns, so this DUT passes easily.)

### GATE PULSE FLATNESS

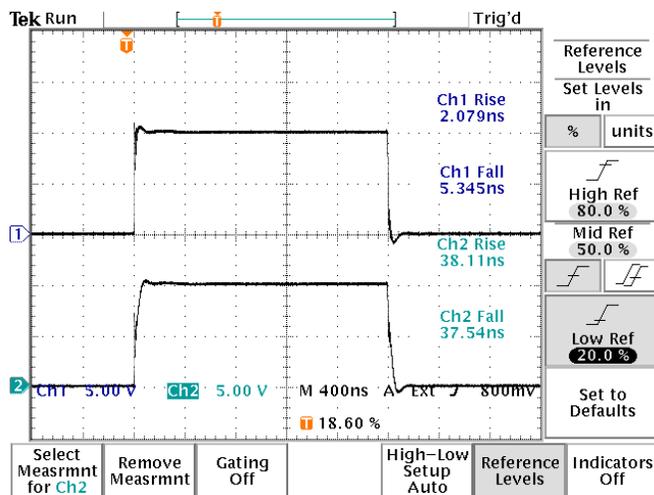
The gate waveforms shown above are not perfectly flat-topped. This is to be expected, as some of the (much larger) drain signal will couple through the drain-gate capacitance. This can be confirmed by reducing the drain voltage to zero, so that no pulse is coupled from the drain to the gate:



The “dip” immediately after the gate leading edge disappears.

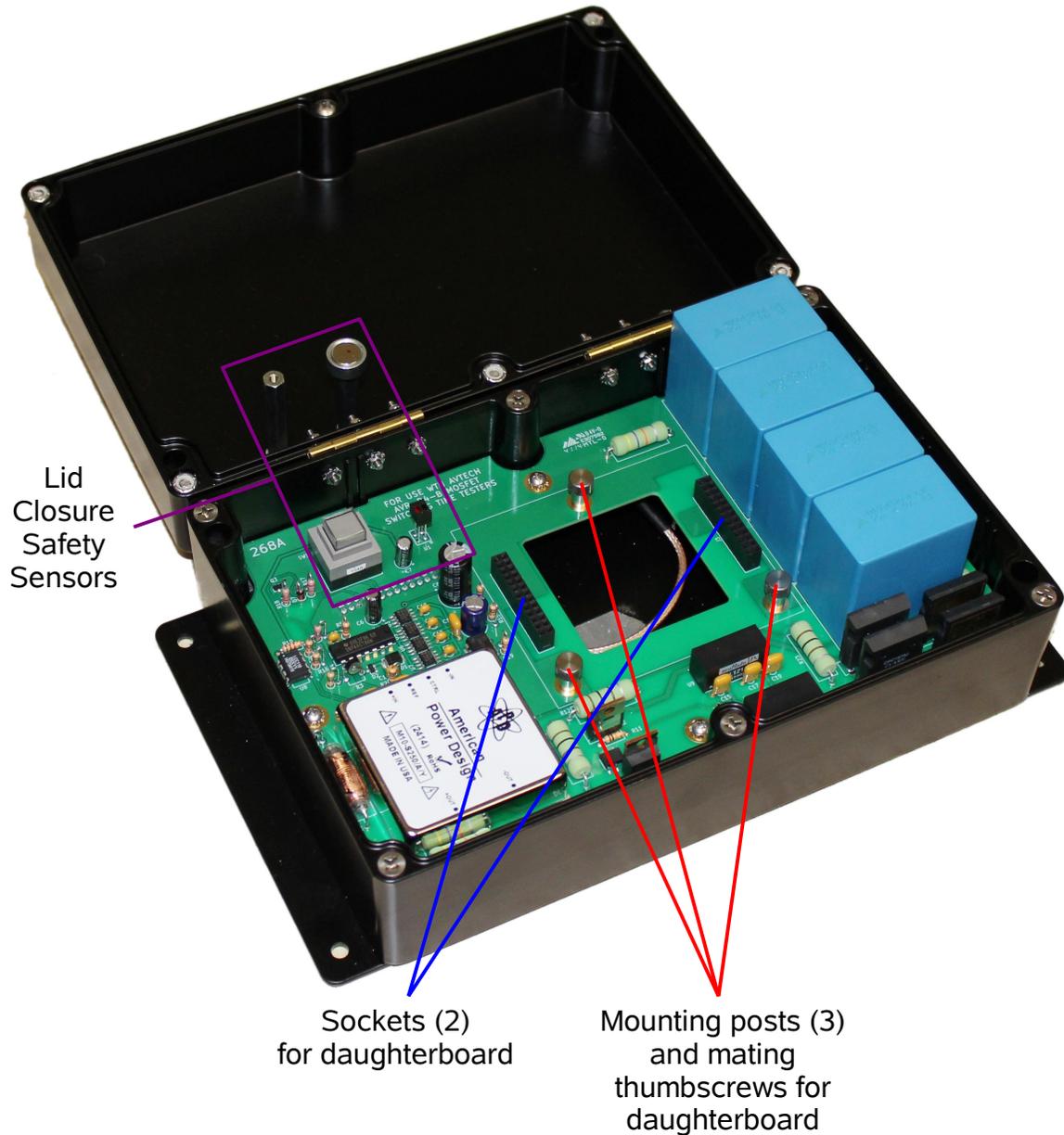
### GATE PULSE SWITCHING TIME

The AVR-D4-B provides a fast-switching gate pulse, with rise and fall times (20%-80%) of less than 10 ns, at the input to  $R_{GATE}$ . The rise and fall times of the gate voltage (at the output of  $R_{GATE}$ ) will be slower, due to the RC time constant of  $R_{GATE}$  and the gate capacitance, and other MOSFET effects. This is shown below, at points A and B in the test setup diagram on page 23, with the 2N6766 installed:



## TEST JIG MECHANICAL ASPECTS

The interior of the standard AVX-D4-JIG1 test jig is shown below:



The main circuit board contains the control circuitry, gate driver circuitry, and the high-voltage bipolar power supply for the drain bias.

The cutout in the central area is provided to accommodate long pin lengths that may protrude from installed daughterboards.

The IN, GATE, DRAIN, and CONTROL connectors are on the rear of the jig, below the hinges:



The C and E points correspond to the points marked in the test setup diagram on page 23.

### ACCESSING OTHER ELECTRICAL SIGNALS

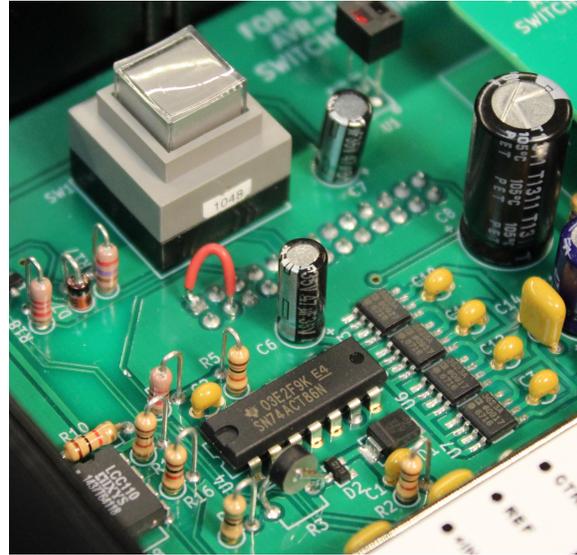
The safety interlocks prevent operation of the test jig when its lid is open, for operator safety. However, this also prevents probe of active boards in situ, when developing new daughterboards or debugging the performance of existing ones. For example, it may be useful to observe the gate drive signal at the input to  $R_{GATE}$ , or the true drain voltage (rather than an AC-coupled attenuated replica).

The interlock may be temporarily overridden by soldering a jumper between pins 1 and 4 (diagonally opposite pin 1), as shown below:

Normal interlock operation:



Interlock override:



 Caution: High voltages (up to 250V DC) are present inside the test jig during normal operation. Interlock overrides should only be used by skilled engineers who have reviewed and understood the schematic diagram of the jig, which is included in this manual. Do not override the safety interlock for regular production use.

## DAUGHTERBOARDS

The AVX-D4-JIG1 jig accepts daughterboards to handle different device packages and test conditions. The daughterboards plug into two sockets on the main test jig, and may be secured in place using three thumbscrews.

The daughterboards are ordered separately, using the model number AVX-D4-*SLASH-PKG-RGATE-RDRAIN*. The parts in italics must be replaced with:

-SLASH code: Replace with the PRF-19500 slash sheet suffix (for example, -542J) that specifies the device package and pinout.

-PKG code: Replace the “-PKG” suffix with the name of the package that will be accepted. Choose from -TO204AA, -TO204AE, -TO254AA, or -TO205AF. Other leaded packages can be readily accommodated. SMT packages can also be handled, if the user specifies a readily-available socket or provides an appropriate socket.

-RGATE code: specify the gate resistance that will be installed on the daughterboard. Use “-7R5” for 7.5 $\Omega$ , for example. +/- 5% accuracy.

-RDRAIN code: specify the drain resistance that will be installed on the daughterboard. Use “-28R1” for 28.1 $\Omega$ , for example. +/- 5% accuracy.

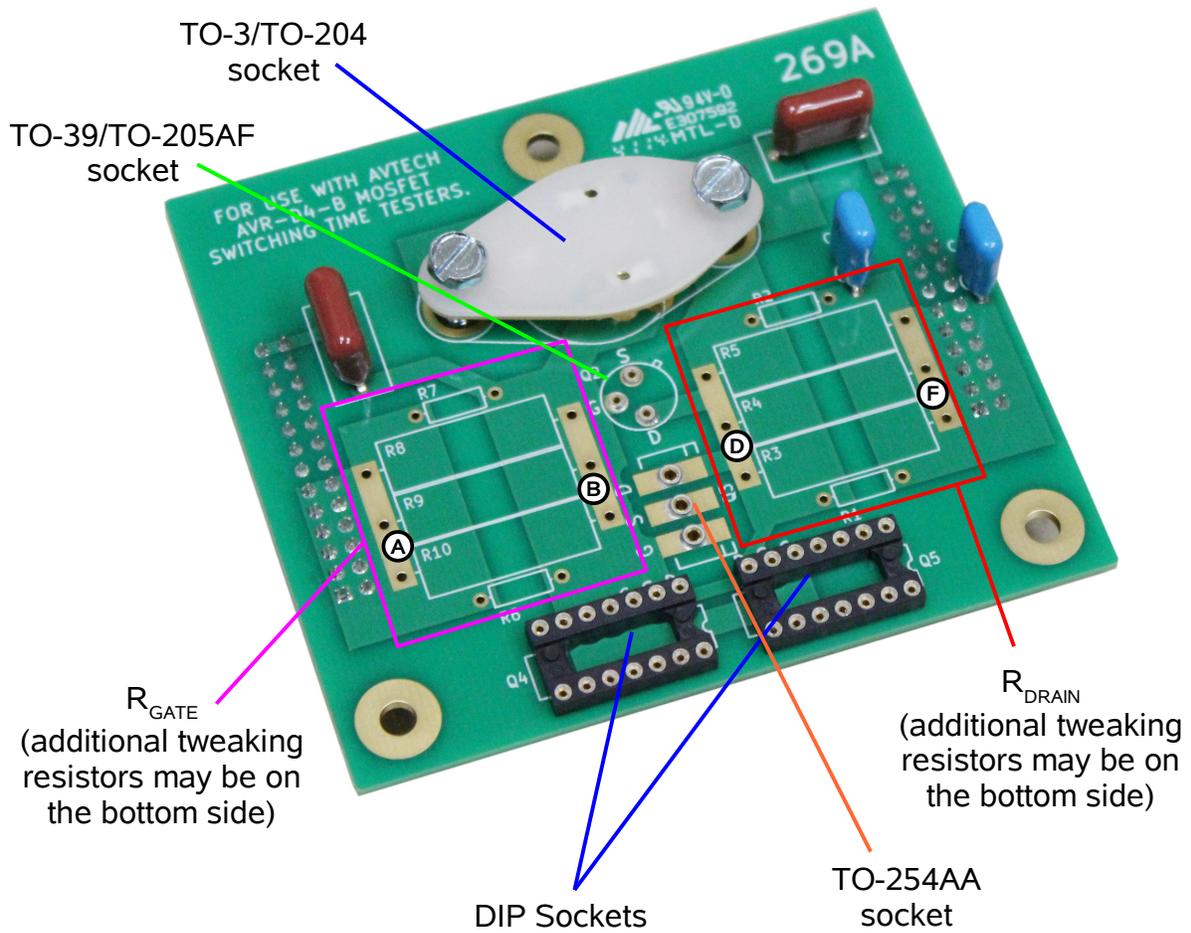
### STANDARD DAUGHTERBOARD

A standard daughterboard design (PCB 269A) will accept various DIP, TO-3/TO-204, TO-39/TO-205AF, and TO-254AA pinouts. The CAD files for this PCB are freely available for download at:

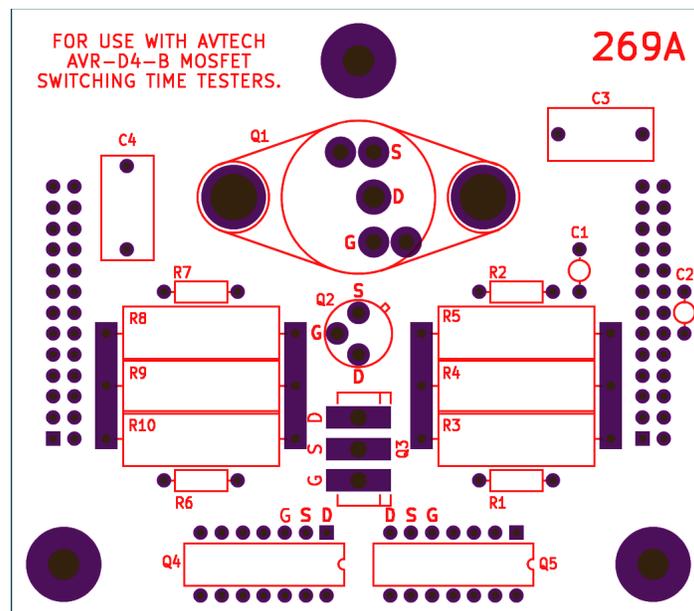
[http://www.avtechpulse.com/semiconductor/avr-d4/#support\\_files](http://www.avtechpulse.com/semiconductor/avr-d4/#support_files)

The schematic is included later in this manual.

The basic arrangement of the PCB is shown below:



The A, B, D, and F locations correspond to the points marked in the test setup diagram on page 23. The gate, drain, and source (G, D, S) pin locations are noted on the silkscreening:



All sockets are wired in parallel.

TO-3/TO-204 packages must be screwed in the socket using the provided screws. The screws contact the case, which provides the drain connection.

#### MODIFYING R<sub>DRAIN</sub>

It may be necessary to reduce  $R_{\text{DRAIN}}$  slightly compared to the calculated value to compensate for the parasitic resistance of the MOSFET. This is easily accomplished by soldering additional resistance in parallel across the existing drain resistors. This can be done on either side of the PCB.

The additional resistors must be capable of handling the peak voltage and peak power dissipation. The pulser can provide voltages as high as 225V. Avtech recommends the use of Ohmite OY-series resistors for  $R_{\text{DRAIN}}$ , due to their extremely robust pulse handling capabilities, and their low inductance.

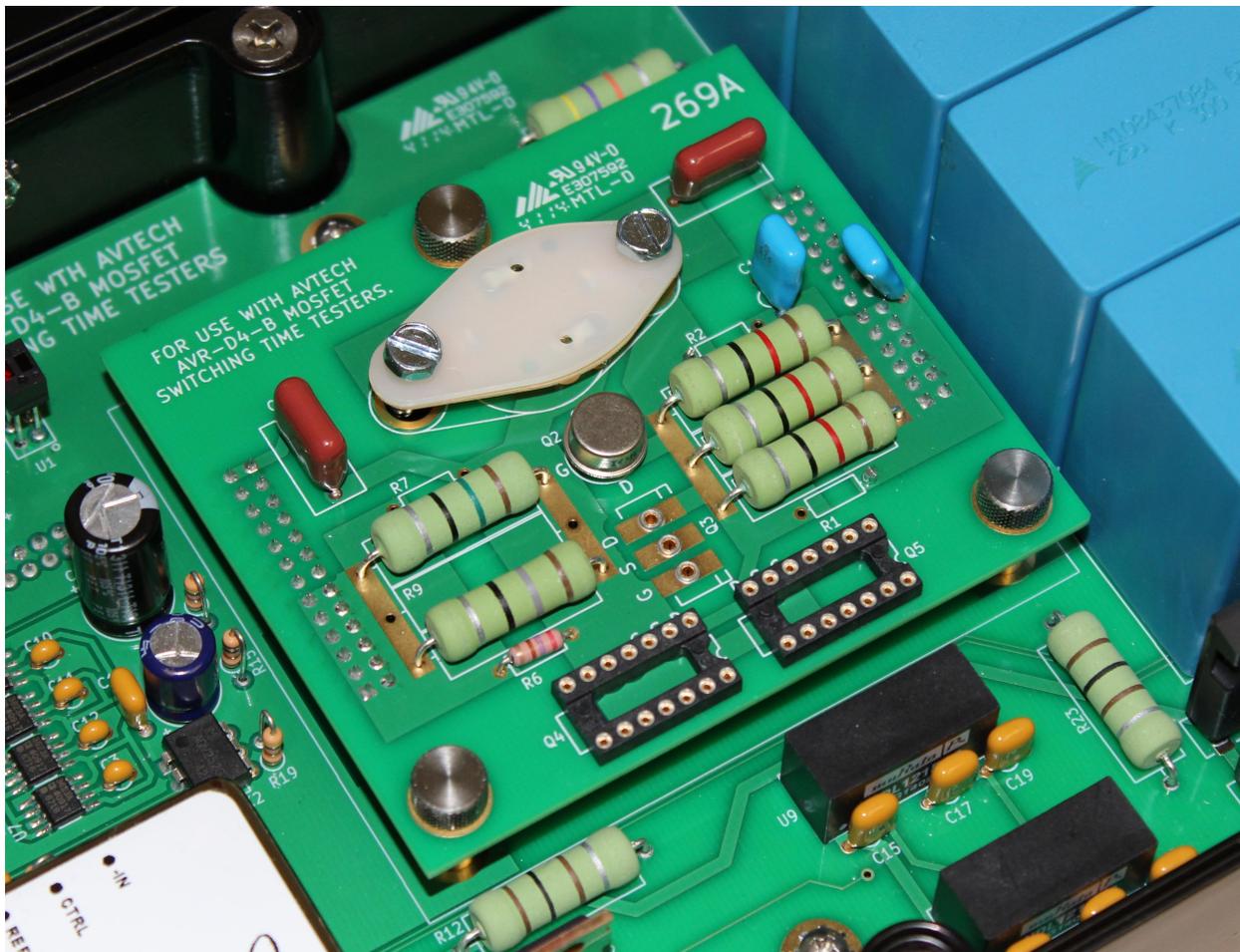
## TYPICAL TEST RESULTS

### AVX-D4-557L-TO205AF-7R5-3R75

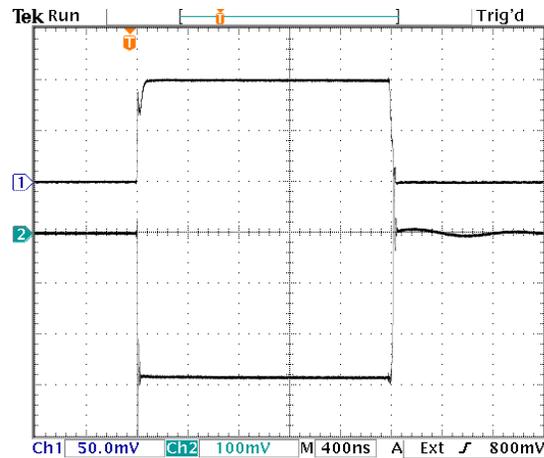
The AVX-D4-557L-TO205AF-7R5-3R75 daughterboard is appropriate for testing the 2N6796 as specified in MIL-PRF-19500/557L. This slash sheet specifies a gate voltage of +10V, a drain voltage of +30V, a drain current of +8A, and  $R_{GATE} = 7.5\Omega$ .

Assuming there is minimal voltage across the drain-source path during conduction, the required drain resistance  $R_{DRAIN} \approx 30V / 8A = 3.75\Omega$ .

This photo shows an International Rectifier 2N6796 installed in the AVX-D4-557L-TO205AF-7R5-3R75, which in turn is screwed down onto the AVX-D4-JIG1 main board.

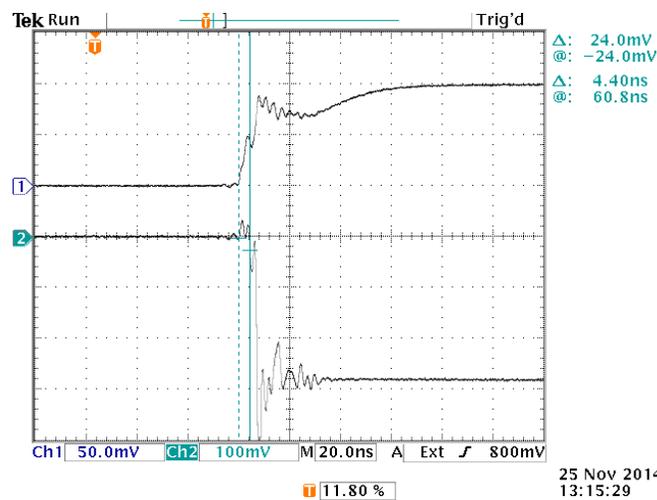


With this arrangement, the following waveforms are obtained at the GATE and DRAIN outputs:



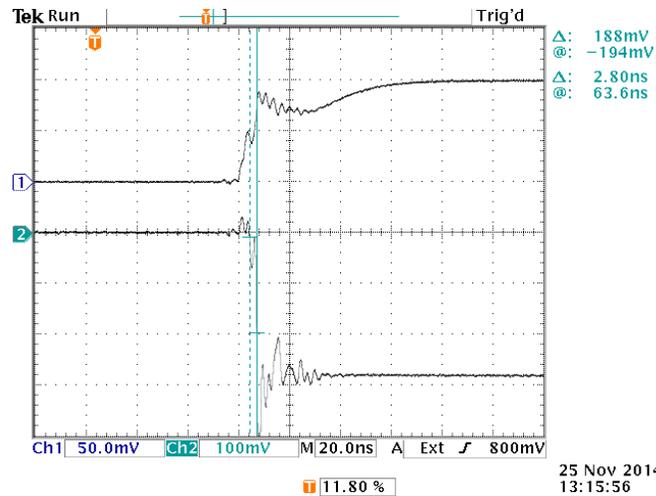
Top:  $V_{GS}$  (+10V)  
 Bottom:  $V_{DS}$  (slightly less than +30V)

The same waveforms are shown below, zoomed in on the leading edge:



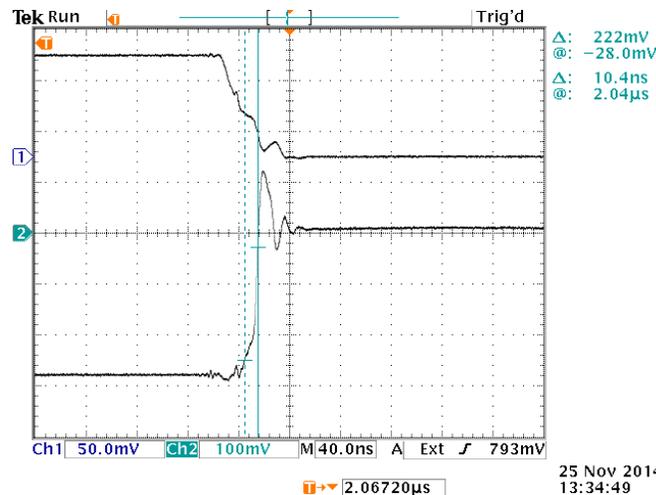
$t_{D(ON)}$  is measured from the 10% point of  $V_{GS}$  to the 10% point of  $V_{DS}$  (see the definitions on page 25), giving  $t_{D(ON)} = 4.4$  ns (easily meeting the MIL-PRF-19500/557L specification of 30 ns).

The next waveform is the same, with re-positioned cursors:



$t_r$  is measured as the 10%-90% switching time of  $V_{DS}$  (see the definitions on page 25), giving  $t_{D(ON)} = 2.8$  ns (easily meeting the MIL-PRF-19500/557L specification of 75 ns).

Next, the waveforms are zoomed in on the trailing edges:



$t_{D(OFF)}$  is measured from the 10% point of  $V_{GS}$  to the 90% point of  $V_{DS}$  (see the definitions on page 25). However, in this case, the value is actually less than zero, clearly meeting the < 40 ns specification. (A greater-than-zero value would be obtained if the faster-switching voltage at the input to  $R_{GATE}$  was used as the starting reference, but Method 3472 calls for the more slowly-switching  $V_{GS}$  to be used.)

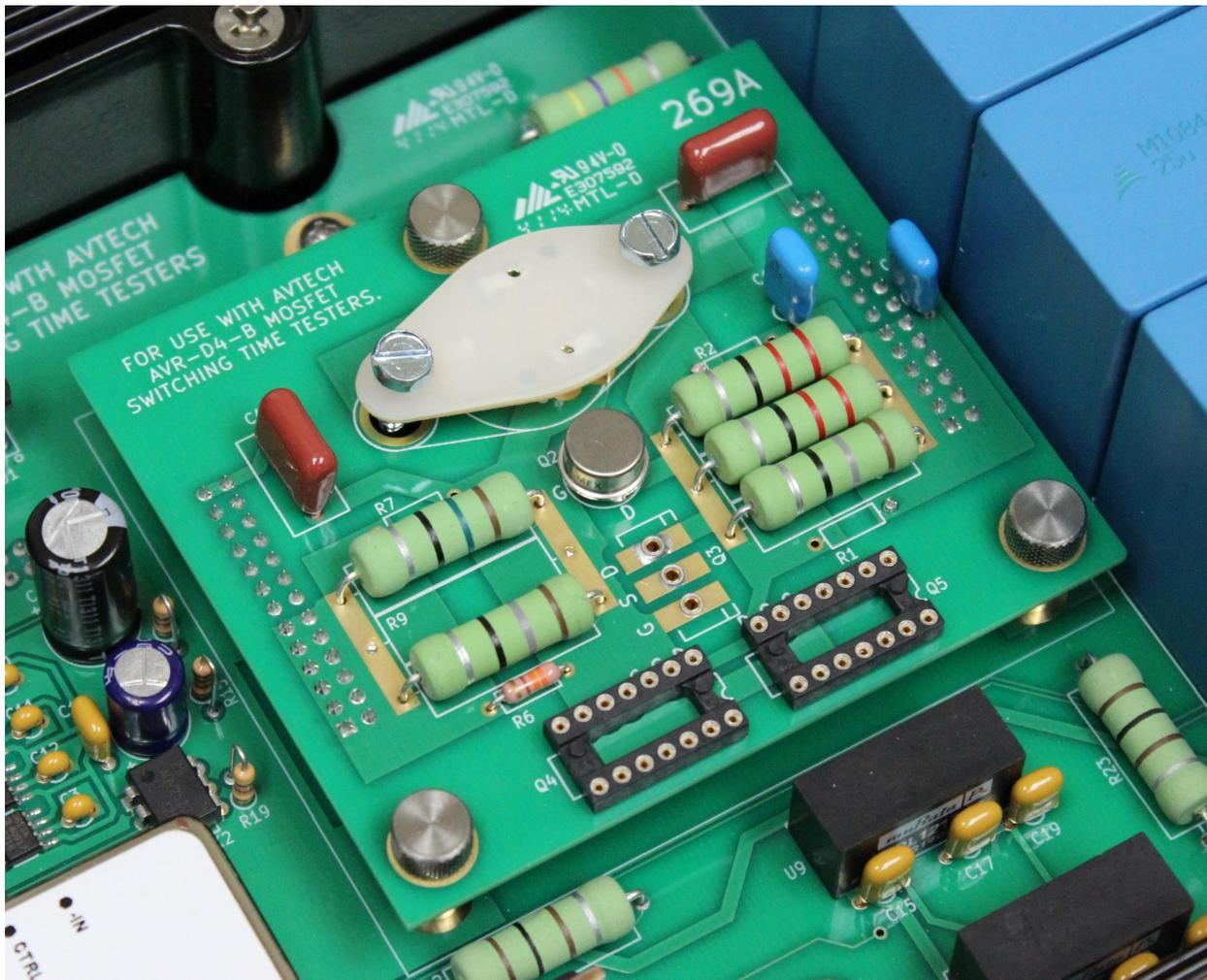
Instead, the cursors on the waveform show the calculation of  $t_f$  (90% to 10% of  $V_{DS}$ ) as 10.4 ns, meeting the 45 ns specification.

### AVX-D4-564H-TO205AF-7R5-6R16

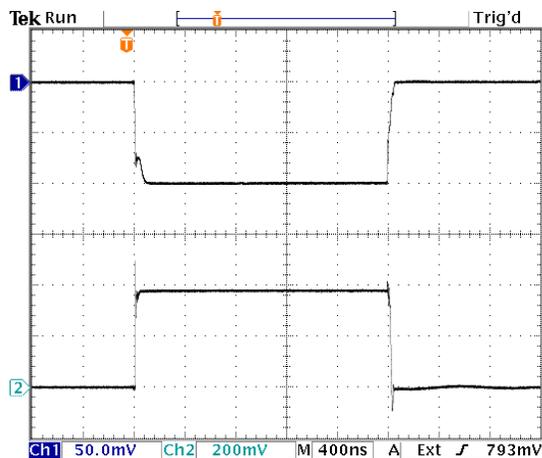
The AVX-D4-564H-TO205AF-7R5-6R16 daughterboard is appropriate for testing the 2N6849 as specified in MIL-PRF-19500/564H. This slash sheet specifies a gate voltage of -10V, a drain voltage of -40V, a drain current of -6.5A, and  $R_{\text{GATE}} = 7.5\Omega$ .

Assuming there is minimal voltage across the drain-source path during conduction, the required drain resistance  $R_{\text{DRAIN}} \approx -40\text{V} / -6.5\text{A} = 6.15\Omega$ .

This photo shows an International Rectifier 2N6849 installed in the AVX-D4-564H-TO205AF-7R5-6R16, which in turn is screwed down onto the AVX-D4-JIG1 main board.



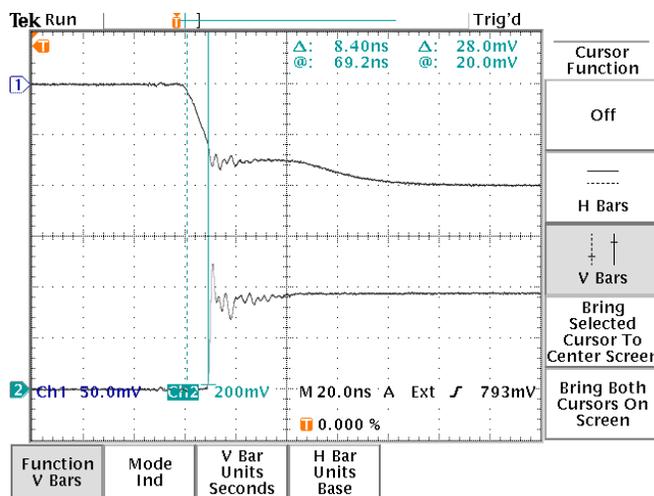
With this arrangement, the following waveforms are obtained at the GATE and DRAIN outputs:



25 Nov 2014  
14:06:30

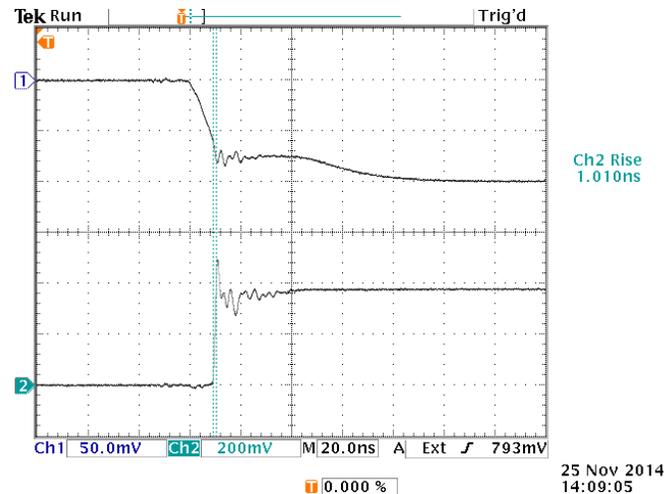
Top:  $V_{GS}$  (-10V)  
Bottom:  $V_{DS}$  (slightly less than -40V)

The same waveforms are shown below, zoomed in on the leading edge:



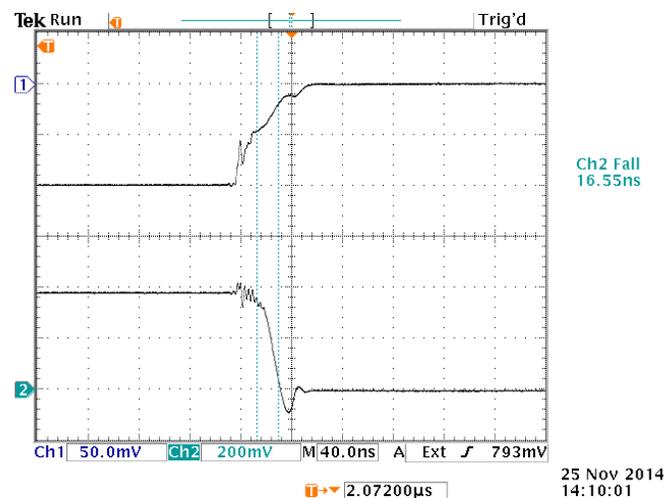
$t_{D(ON)}$  is measured from the 10% point of  $V_{GS}$  to the 10% point of  $V_{DS}$  (see the definitions on page 25), giving  $t_{D(ON)} = 8.4$  ns (easily meeting the MIL-PRF-19500/564H specification of 60 ns).

The next waveform is the same, with re-positioned cursors:



$t_r$  is measured as the 10%-90% switching time of  $V_{DS}$  (see the definitions on page 25), giving  $t_{D(ON)} = 1.0$  ns (easily meeting the MIL-PRF-19500/564H specification of 140 ns).

Next, the waveforms are zoomed in on the trailing edges:



$t_{D(OFF)}$  is measured from the 10% point of  $V_{GS}$  to the 90% point of  $V_{DS}$  (see the definitions on page 25). However, in this case, the value is actually less than zero, clearly meeting the < 140 ns specification. (A greater-than-zero value would be obtained if the faster-switching voltage at the input to  $R_{GATE}$  was used as the starting reference, but Method 3472 calls for the more slowly-switching  $V_{GS}$  to be used.)

Instead, the cursors on the waveform show the calculation of  $t_f$  (90% to 10% of  $V_{DS}$ ) as 16.55 ns, meeting the 140 ns specification.

## PROGRAMMING YOUR PULSE GENERATOR

### KEY PROGRAMMING COMMANDS

The “Programming Manual for -B Instruments” describes in detail how to connect the pulse generator to your computer, and the programming commands themselves. A large number of commands are available; however, normally you will only need a few of these. Here is a basic sample sequence of commands that might be sent to the instrument after power-up:

*rst	(resets the instrument)
trigger:source internal	(selects internal triggering)
frequency 1000 Hz	(sets the frequency to 1000 Hz)
pulse:delay 1 us	(sets the delay to 1 us)
pulse:width 2 us	(sets the gate pulse width to 10 us)
volt1 -30	(sets $V_{\text{DRAIN}}$ to -30V)
volt2 -10	(sets $V_{\text{GATE}}$ to -10V)*
output on	(turns on the output)

For triggering a single event, this sequence would be more appropriate:

*rst	(resets the instrument)
trigger:source hold	(turns off all triggering)
output on	(turns on the output)
pulse:delay 1 us	(sets the delay to 1 us)
pulse:width 2 us	(sets the gate pulse width to 10 us)
volt1 -30	(sets $V_{\text{DRAIN}}$ to -30V)
volt2 -10	(sets $V_{\text{GATE}}$ to -10V)*
trigger:source immediate	(generates a single non-repetitive trigger event)
trigger:source hold	(turns off all triggering)
output off	(turns off the output)

To set the instrument to trigger from an external TTL signal applied to the rear-panel TRlg connector, use:

*rst	(resets the instrument)
trigger:source external	(selects internal triggering)
pulse:delay 1 us	(sets the delay to 1 us)
pulse:width 2 us	(sets the gate pulse width to 10 us)
volt1 -30	(sets $V_{\text{DRAIN}}$ to -30V)
volt2 -10	(sets $V_{\text{GATE}}$ to -10V)*
output on	(turns on the output)

\* Note: the polarity of “volt2” commands is actually ignored. The circuitry will ensure that the gate voltage polarity is the same as the drain voltage polarity. The polarity of the “volt1” commands is important.

These commands will satisfy 90% of your programming needs.

## ALL PROGRAMMING COMMANDS

For more advanced programmers, a complete list of the available commands is given below. These commands are described in detail in the “Programming Manual for -B Instruments”. (Note: this manual also includes some commands that are not implemented in this instrument. They can be ignored.)

<u>Keyword</u>	<u>Parameter</u>	<u>Notes</u>
LOCAL OUTPut:		
: [STATE]	<boolean value>	
: PROTection		
: TRIPped?		[query only]
REMOTE		
[SOURce]:		
: FREQuency		
[: CW   FIXed]	<numeric value>	
[SOURce]:		
: PULSe		
: PERiod	<numeric value>	
: WIDTh	<numeric value>	
: DELay	<numeric value>	
: GATE		
: LEVel	High   Low	
[SOURce]:		
: VOLTage		
[: LEVel]		
[: IMMEDIATE]		
[: AMPLitude]	<numeric value>	
: PROTection		
: TRIPped?		[query only]
STATUS:		
: OPERation		
: [EVENT]?		[query only, always returns "0"]
: CONDition?		[query only, always returns "0"]
: ENABle	<numeric value>	[implemented but not useful]
: QUEStionable		
: [EVENT]?		[query only, always returns "0"]
: CONDition?		[query only, always returns "0"]
: ENABle	<numeric value>	[implemented but not useful]
SYSTEM:		
: COMMunicate		
: GPIB		
: ADDRess	<numeric value>	
: SERial		
: CONTrol		

:RTS	ON   IBFull   RFR	
:[RECeive]		
:BAUD	1200   2400   4800   9600	
:BITS	7   8	
:ECHO	<boolean value>	
:PARity		
:[TYPE]	EVEN   ODD   NONE	
:SBITS	1   2	
:ERRor		
:[NEXT]?		[query only]
:COUNT?		[query only]
:VERSion?		[query only]
TRIGger:		
:SOURce	INTernal   EXTernal   MANual   HOLD   IMMEDIATE	
*CLS		[no query form]
*ESE	<numeric value>	
*ESR?		[query only]
*IDN?		[query only]
*OPC		
*SAV	0   1   2   3	[no query form]
*RCL	0   1   2   3	[no query form]
*RST		[no query form]
*SRE	<numeric value>	
*STB?		[query only]
*TST?		[query only]
*WAI		[no query form]

## MECHANICAL INFORMATION

### TOP COVER REMOVAL

If necessary, the interior of the instrument may be accessed by removing the four Phillips screws on the top panel. With the four screws removed, the top cover may be slid back (and off).

 Always disconnect the power cord and allow the instrument to sit unpowered for 10 minutes before opening the instrument. This will allow any internal stored charge to discharge.

There are no user-adjustable internal circuits. For repairs other than fuse replacement, please contact Avtech (info@avtechpulse.com) to arrange for the instrument to be returned to the factory for repair. Service is to be performed solely by qualified service personnel.

 Caution: High voltages are present inside the instrument during normal operation. Do not operate the instrument with the cover removed.

### RACK MOUNTING

A rack mounting kit is available. The -R5 rack mount kit may be installed after first removing the one Phillips screw on the side panel adjacent to the front handle.

### ELECTROMAGNETIC INTERFERENCE

To prevent electromagnetic interference with other equipment, all used outputs should be connected to shielded loads using shielded coaxial cables. Unused outputs should be terminated with shielded coaxial terminators or with shielded coaxial dust caps, to prevent unintentional electromagnetic radiation. All cords and cables should be less than 3m in length.

## MAINTENANCE

### REGULAR MAINTENANCE

This instrument does not require any regular maintenance.

On occasion, one or more of the four rear-panel fuses may require replacement. All fuses can be accessed from the rear panel. See the “FUSES” section for details.

### CLEANING

If desired, the interior of the instrument may be cleaned using compressed air to dislodge any accumulated dust. (See the “TOP COVER REMOVAL” section for instructions on accessing the interior.) No other cleaning is recommended.

### TRIGGER DAMAGE

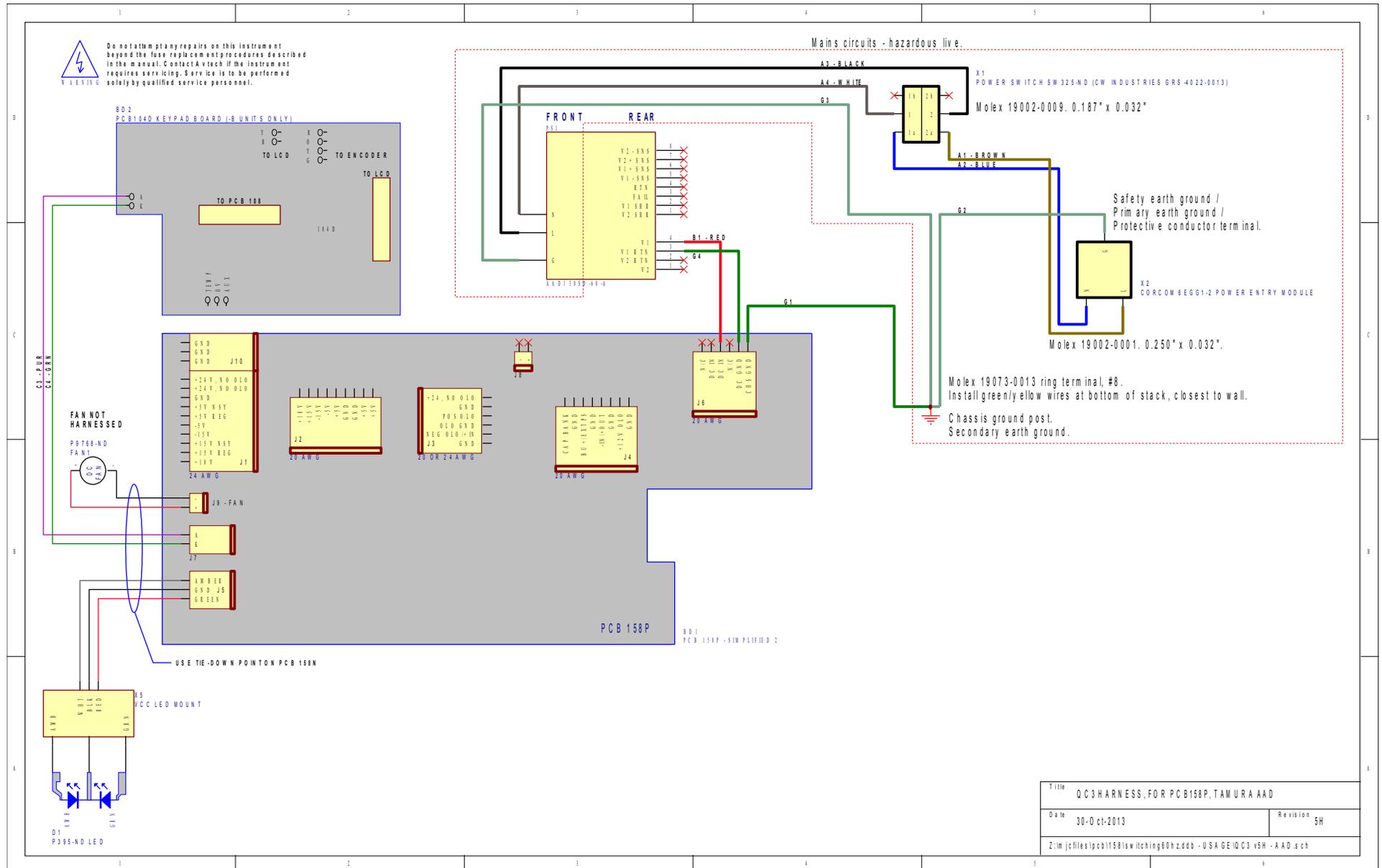
The rear-panel TRIG input, used in the external trigger mode, is protected by a diode clamping circuit. However, the protection circuit is not foolproof, and it is possible for a grossly excessive signal to damage the trigger circuitry on the main timing control board (the 4×10 inch board on the right side of the instrument).

The IC that is most likely to fail under these conditions is installed in a socket. It is a standard TTL IC in a 16-pin plastic DIP package, model 74F151 or equivalent.

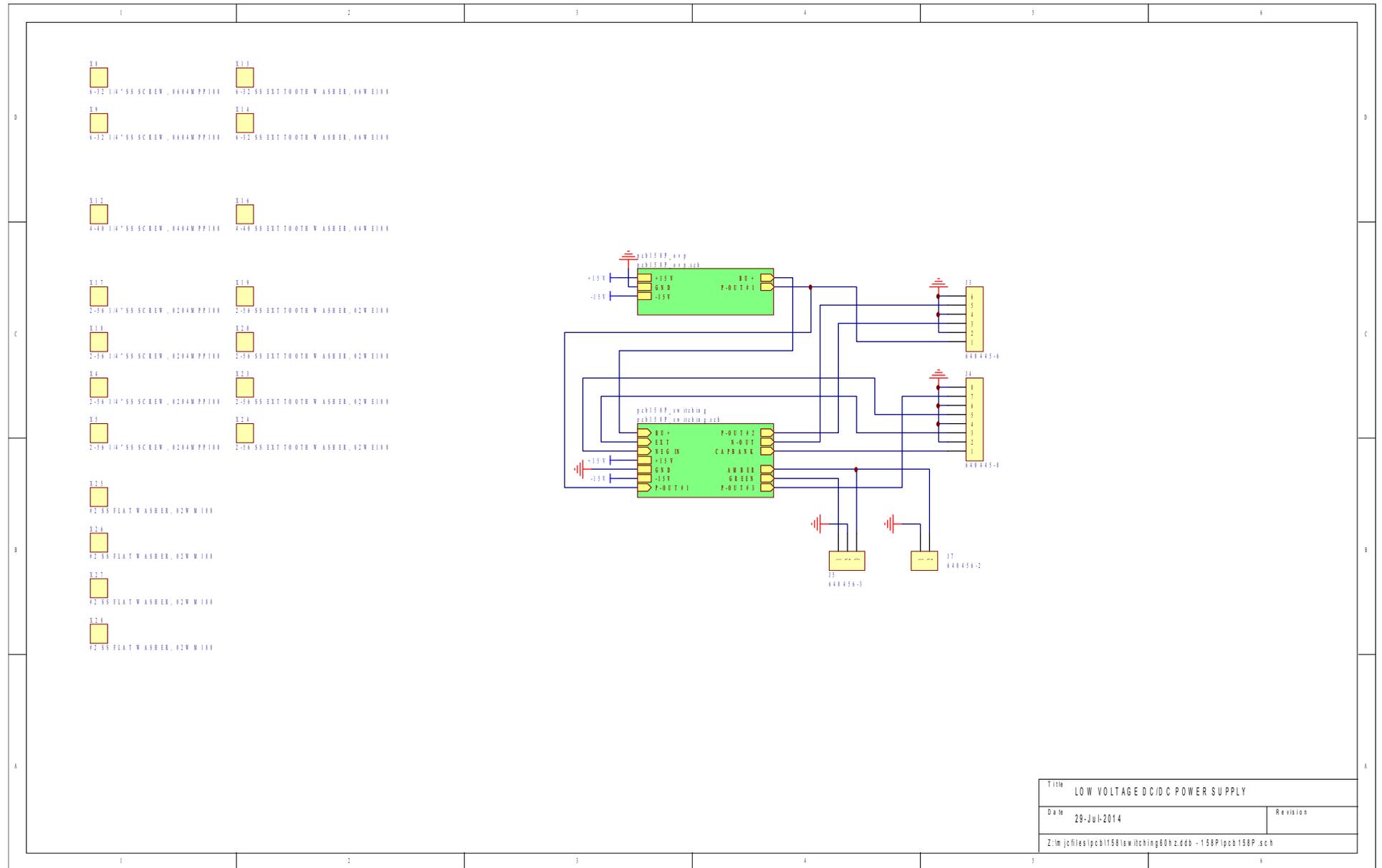
If you suspect that this IC has been damaged, turn off the power and replace this IC. It may be replaced by a 74F151, 74LS151, 74ALS151, or 74HCT151.

# WIRING DIAGRAMS

## WIRING OF AC POWER

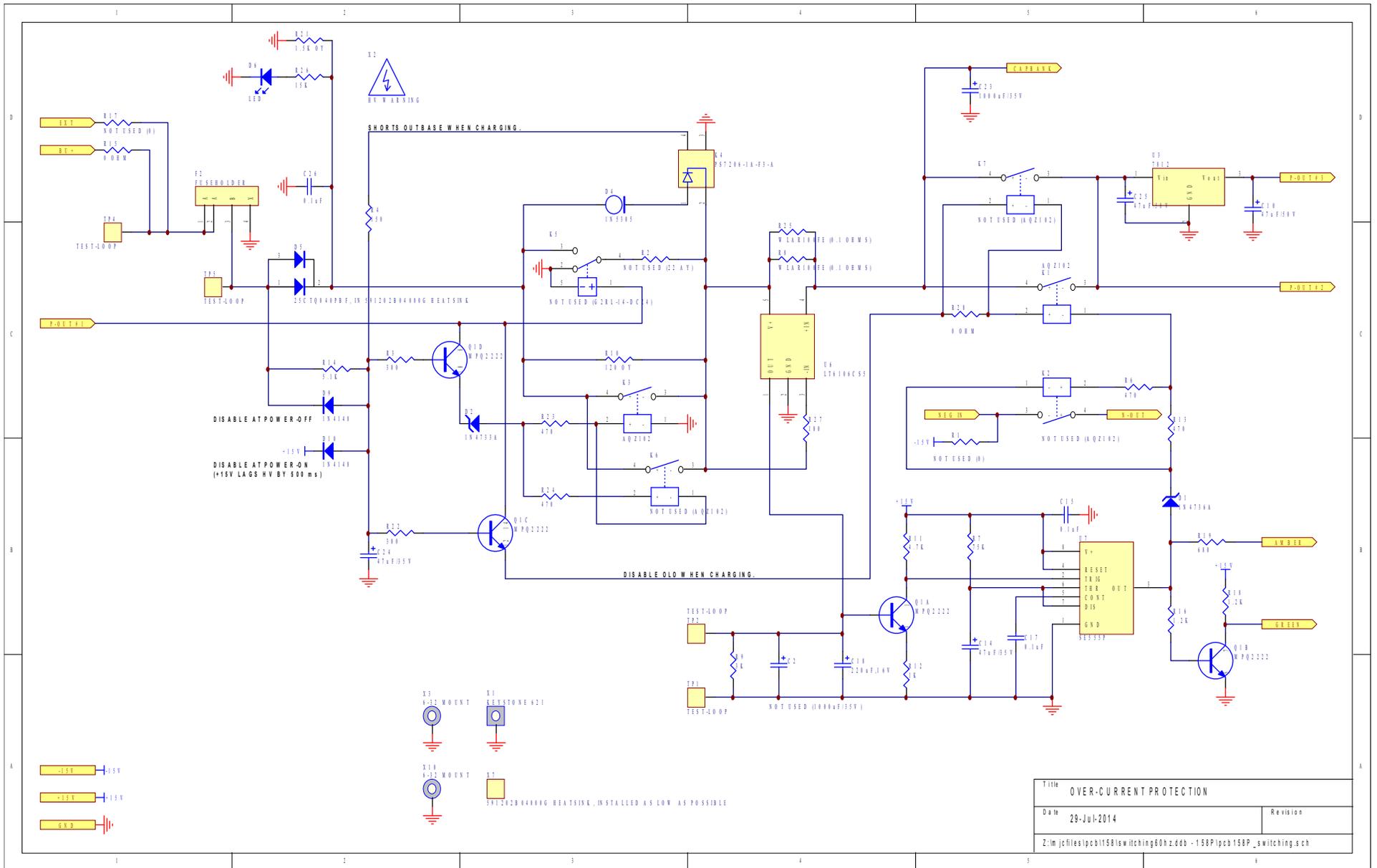


# PCB 158P - LOW VOLTAGE POWER SUPPLY, 1/3

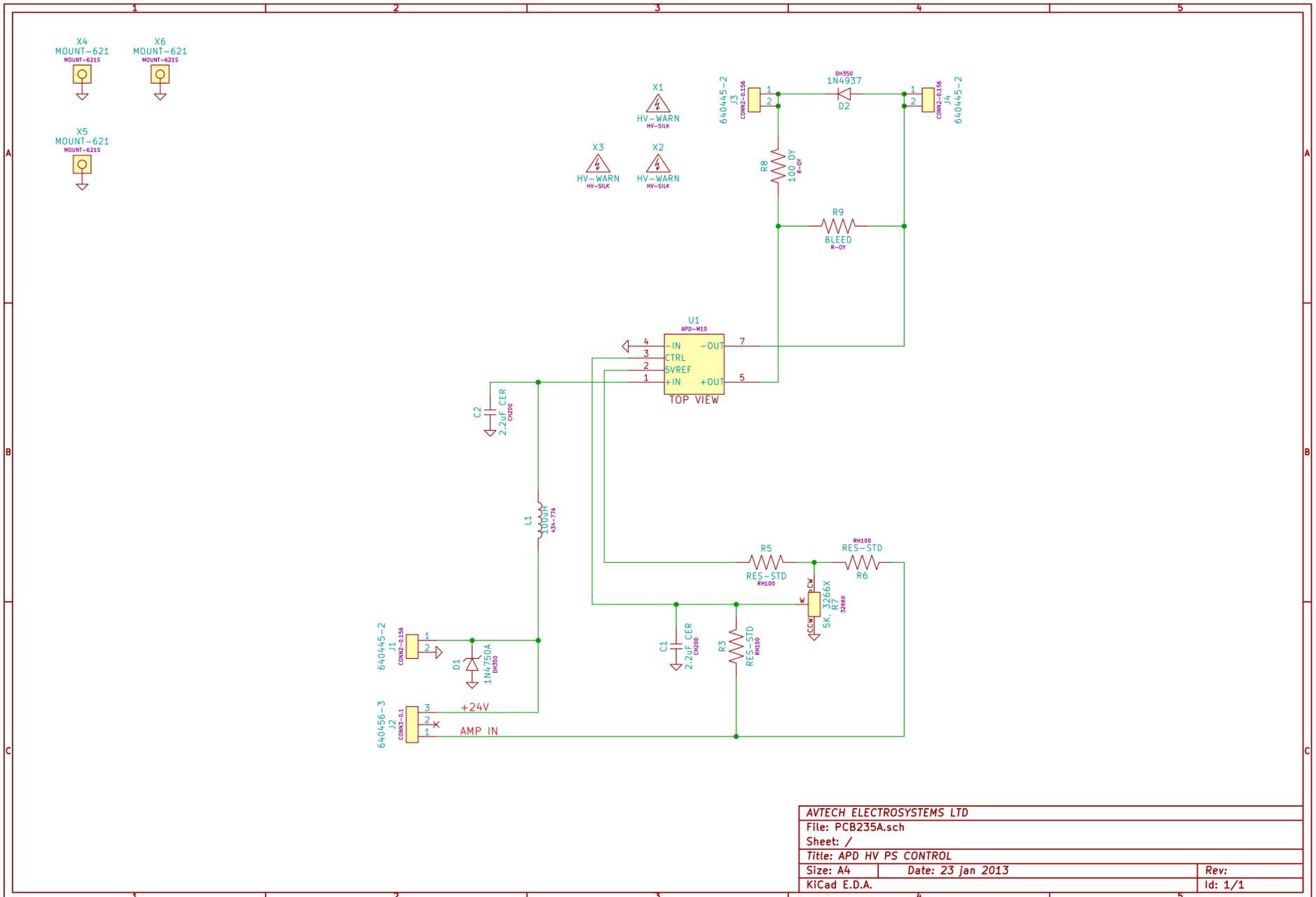




# PCB 158P - LOW VOLTAGE POWER SUPPLY, 3/3

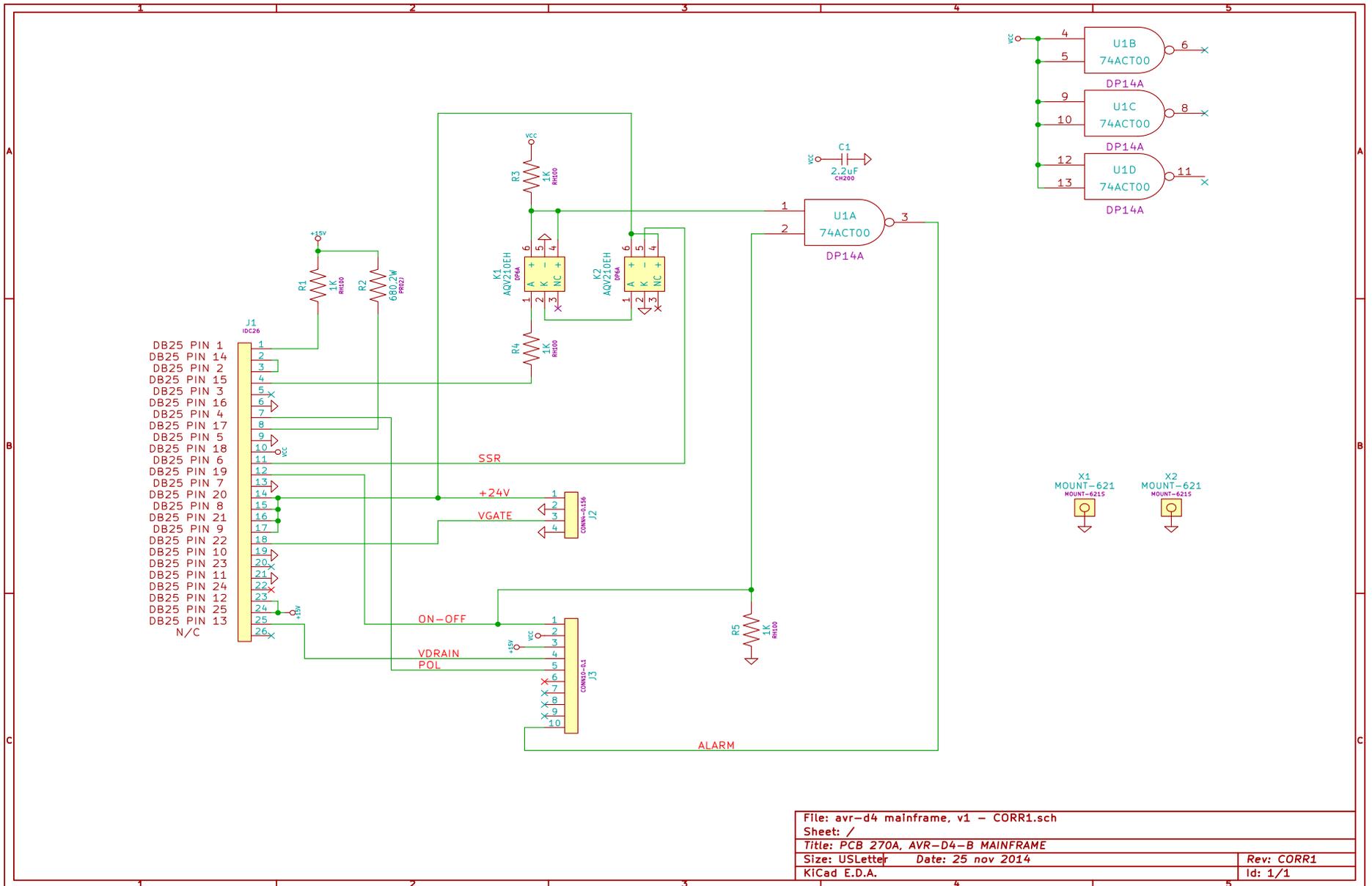


# PCB 235A - HIGH VOLTAGE DC POWER SUPPLY

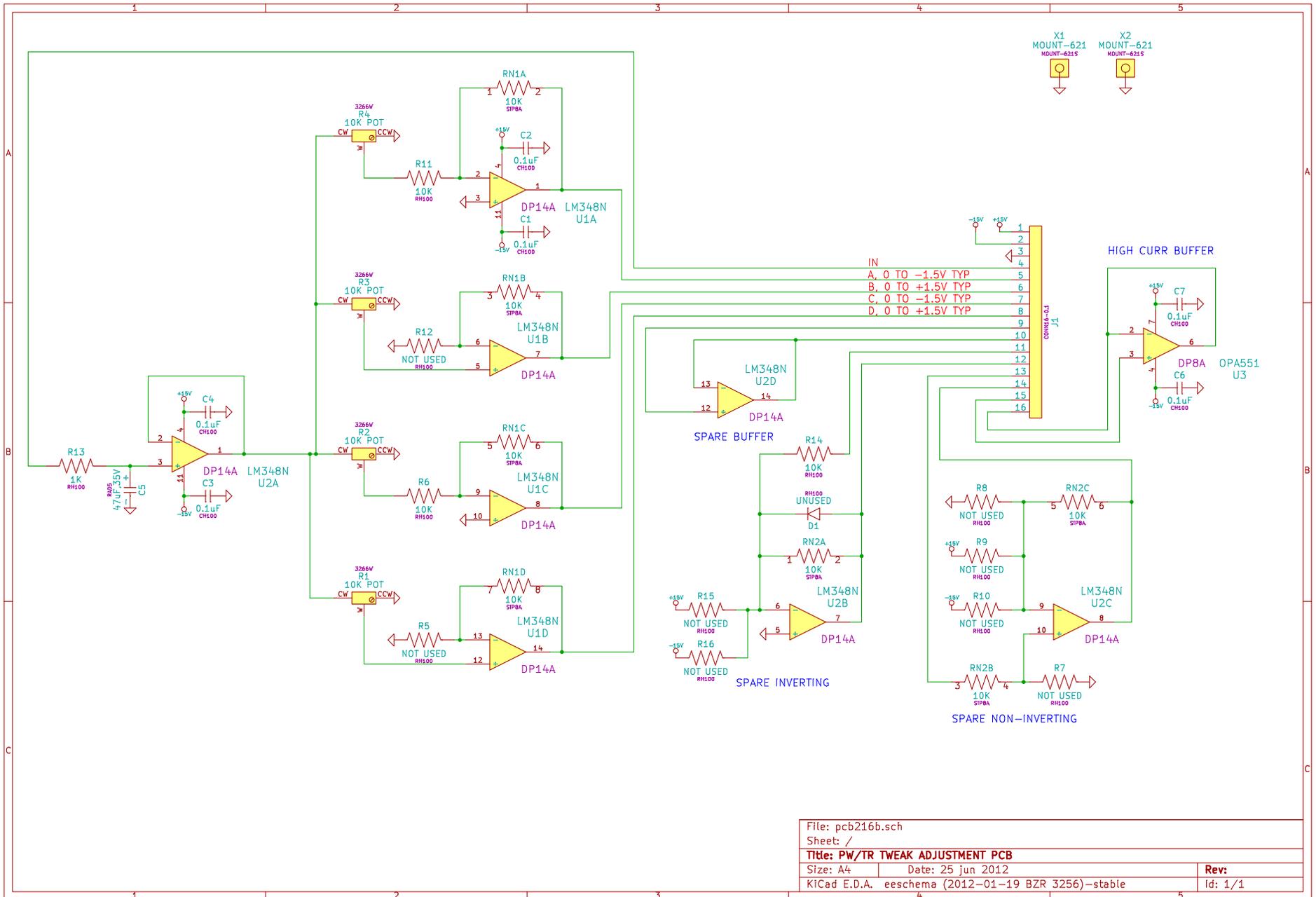


AVTECH ELECTROSYSTEMS LTD		
File: PCB235A.sch		
Sheet: /		
Title: APD HV PS CONTROL		
Size: A4	Date: 23 Jan 2013	Rev:
KICad E.D.A.		Id: 1/1

# PCB 270A - INTERLOCK CONTROL

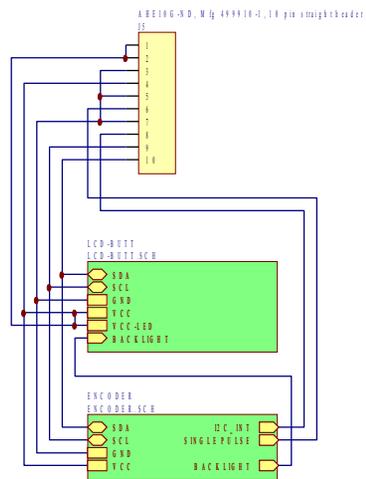


# PCB 216B - MISC OP AMPS



File: pcb216b.sch		
Sheet: /		
Title: PW/TR TWEAK ADJUSTMENT PCB		
Size: A4	Date: 25 jun 2012	Rev:
KiCad E.D.A. eeschema (2012-01-19 BZR 3256)-stable		Id: 1/1

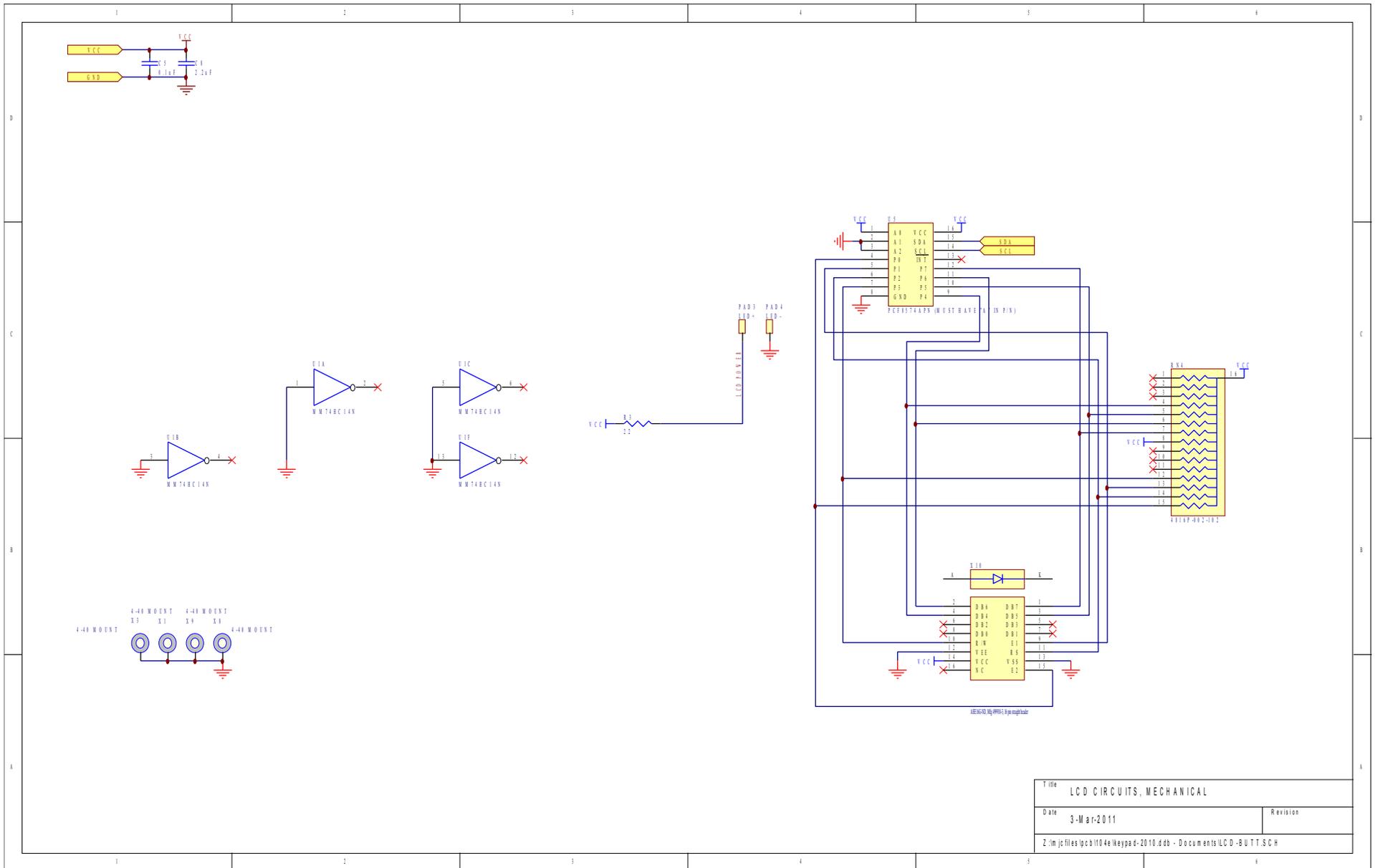
# PCB 104E - KEYPAD / DISPLAY BOARD, 1/3



Title		PANEL TOP-LEVEL SCHEMATIC	
Date	3-Mar-2011	Revision	
Z:\m\j\files\pcb\104e\keypad-2010.dwg - Documents\Panel.rtd.pjt			



# PCB 104E - KEYPAD / DISPLAY BOARD, 3/3

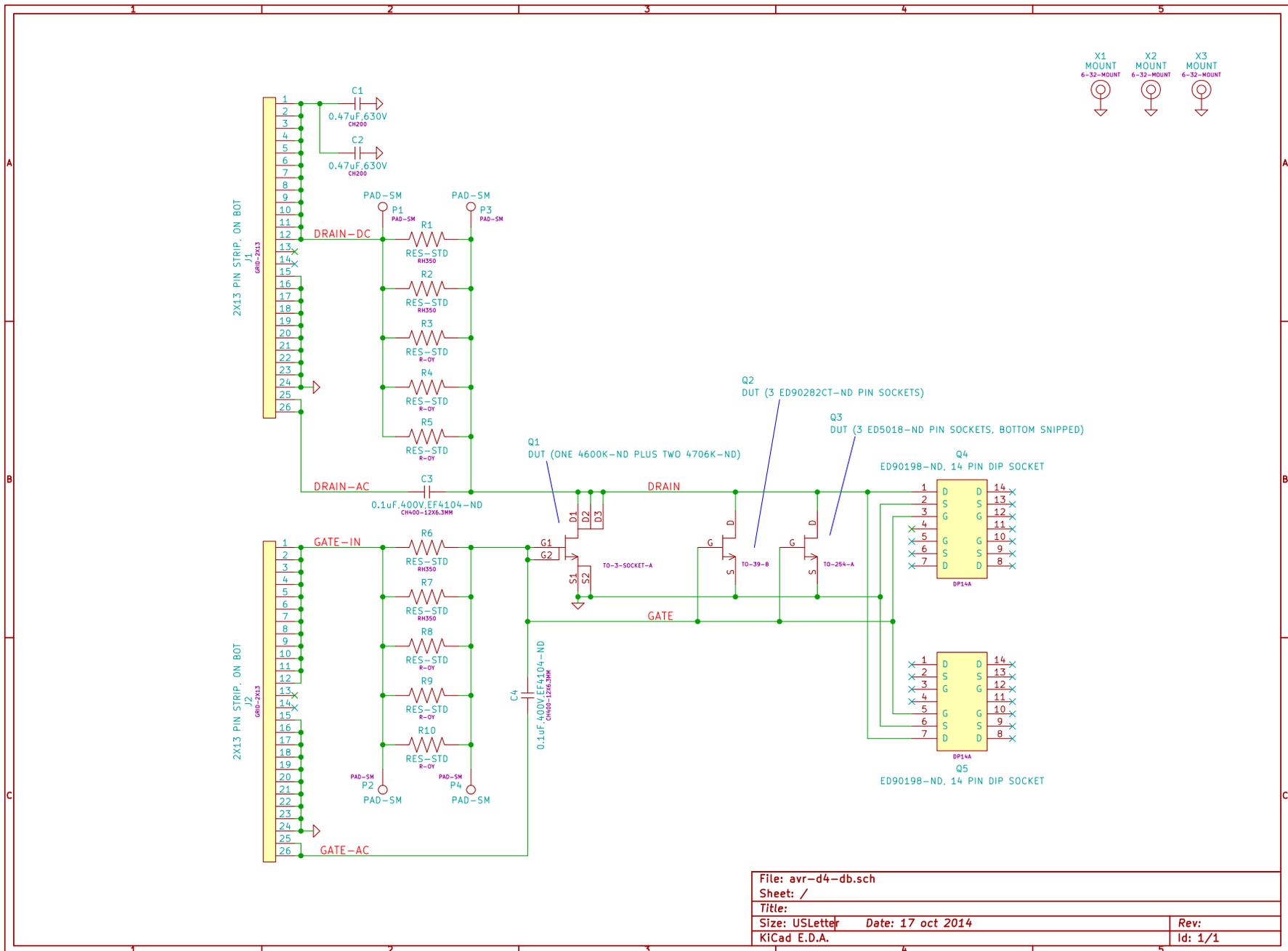


Title LCD CIRCUITS, MECHANICAL	
Date 3-Mar-2011	Revision
Z:\m\j\files\pcb\104e\keypad-2010.dwg - Documents\LCD-BUTT.SCH	





# STANDARD DAUGHTERBOARD WIRING



PERFORMANCE CHECK SHEET