



AVTECH ELECTROSYSTEMS LTD.

NANOSECOND WAVEFORM ELECTRONICS
SINCE 1975

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INSTRUCTIONS

MODEL AVO-5C-C

0 TO 8 AMPS, 5 MHz

5 – 50 ns PULSE WIDTH

PULSED LASER DIODE DRIVER

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: 613-226-5772 or 1-800-265-6681

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Manual Reference: /fileserver1/officefiles/instructword/avo-5c/avo-5c-c,edition_i.odt.

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INTRODUCTION

The AVO-5C-C is a high performance instrument capable of generating up to 8 Amps into low impedance loads at repetition rates up to 5 MHz. The output pulse width is variable from 5 to 50 ns, and the sync delay is variable up to 200 ns. The rise and fall times are less than 3 ns typically. The maximum duty cycle is 10%.

Instruments with the "-P" model suffix can generate 0 to +8A, whereas instruments with the "-N" model suffix can generate 0 to -8A. Instruments with the "-PN" suffix can generate both polarities.

Two output modules are provided. The AVO-5C-TA output module requires a 6 Ohm load, and can generate up to 4 Amps of current through this load. The AVO-5C-TB output module requires a 1.5 Ohm load, and can generate up to 8 Amps of current through this load. The lower-current AVO-5C-TA produces output waveforms with less distortion (i.e., ringing), and should be used instead of the AVO-5C-TB whenever possible.

The AVO-5C-TA output module contains a current-doubling transformer, which requires a load impedance of approximately 6.2 Ohms (e.g., a 5 Ohms resistor in series with a diode with 1.2 Ohms of parasitic resistance). The amplitude at the output of the output module (V_{OUT}) can vary from 0 to 25V, approximately, when operating into a 6.2 Ohm load, providing up to 4 A of current.

The AVO-5C-TB output module contains a current-quadrupling transformer, which requires a load impedance of approximately 1.5 Ohms. The amplitude at the output of the output module (V_{OUT}) can vary from 0 to 12V, approximately, when operating into a 1.5 Ohm load, providing up to 8 A of current.

When driving a diode load in series with a resistor, the diode current is given by:

$$I_{DIODE} = (V_{OUT} - V_{DIODE}) / (R_{SERIES} + R_{DIODE})$$

where V_{DIODE} is the voltage drop across the diode, R_{DIODE} is the parasitic resistance of the diode, and R_{SERIES} is the resistance of the series resistor. $R_{SERIES} + R_{DIODE}$ should be equal to 6.2 Ohms for the AVO-5C-TA, and 1.5 Ohms for the AVO-5C-TB.

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

AVAILABLE OPTIONS

This instrument is available with several options:

-EA Option: the amplitude can be controlled by an externally generated 0 to +10V analog control voltage.

-M Option: a monitor output is provided.

SPECIFICATIONS

Model:	AVO-5C-C ¹
Amplitude ^{3,4} :	0 to 8 A
Required load impedance:	1.5 Ω
Pulse width (FWHM):	5 to 50 ns
Maximum duty cycle:	10%
Rise and fall times: (20%-80%)	≤ 3 ns (with AVO-5C-TA) ≤ 6 ns (with AVO-5C-TB)
PRF:	0 to 5 MHz
Output impedance:	≈ 3 Ohm
Polarity ⁸ :	Positive or negative or both (specify)
Propagation delay: (Ext trig in to pulse out)	≤ 150 ns
Jitter:	± 100 ps $\pm 0.03\%$ of sync delay (Ext trig in to pulse out)
Trigger required:	External trig mode: +5 Volts, 50 to 500 ns (TTL)
Variable Sync delay: (Sync out to pulse out)	0 to 200 ns
Sync output:	+ 3 Volt, 200 ns, will drive 50 Ohm loads
Monitor output option ⁹ :	Provides a 20 dB attenuated coincident replica of main output.
Connectors:	OUT: Solder terminals, or optional plug-in socket similar to AVX-S3 series ¹⁰ Other: BNC
Power requirements:	100 - 240 Volts, 50 - 60 Hz
Dimensions: Mainframe:	100 \times 430 \times 375 mm (3.9" \times 17" \times 14.8") (H \times W \times D)
Transformer Module:	23 \times 28 \times 38 mm (0.9" \times 1.1" \times 1.5") (H \times W \times D)
Chassis material:	Cast aluminum frame and handles, blue vinyl on aluminum cover plates
Mounting:	Any
Temperature range:	+ 5°C to + 40°C

- 1) -C suffix indicates stand-alone lab instrument with internal clock and line powering. (See <http://www.avtechpulse.com/formats/> for additional details of the basic instrument formats).
- 2) -B suffix indicates IEEE-488.2 GPIB and RS-232 control of amplitude, pulse width, PRF and delay. (See <http://www.avtechpulse.com/gpib>).
- 3) For analog electronic control (0 to + 10 V) of amplitude, suffix model number with -EA. Electronic control units also include standard front-panel controls.
- 4) The minimum useful amplitude is approximately 20% of the maximum amplitude. The waveform may be distorted below this level.
- 5) The AVO-5 mainframe is essentially identical to Model AVL-2 and therefore may be used as a 320 Volt, 50 Ohm pulse generator (SMA output connectors). See <http://www.avtechpulse.com/speed/avl-2>.
- 6) The load impedance for the AVO-5 may be reduced to as low as zero Ohms. The maximum output amplitude increases for lower load impedances, to a maximum of 50 A at zero Ohms. However, the rise time, fall time, and waveform distortion (ringing) may increase at impedances lower than 3 Ohms, due to the impedance mismatch. See <http://www.avtechpulse.com/appnote/techbrief14> for details.
- 7) For variable rise, fall time option, add suffix -T1 to model number. Control is by a 10-position switch. Not available on -B units.
- 8) Indicate desired polarity by suffixing model number with -P or -N (i.e. positive or negative) or -PN for dual polarity option.
- 9) For monitor option add suffix -M.
- 10) To specify diode socket mounting option, suffix model number with -S3. When ordering, customer must also specify the diode package type (e.g. TO-18) and the required pin connections (e.g. anode, cathode, ground, etc.). See AVX-S Series for readily available package mounting. Contact Avtech for special or different packages.

EUROPEAN REGULATORY NOTES

EC DECLARATION OF CONFORMITY

We Avtech Electrosystems Ltd.
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Canada K2C 3H4

declare that this pulse generator meets the intent of Directive 89/336/EEC 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.

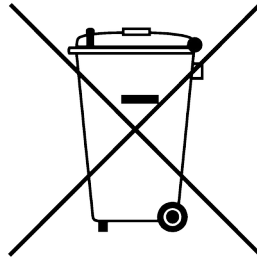
DIRECTIVE 2002/96/EC (WEEE)

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.



INSTALLATION

VISUAL CHECK

After unpacking the instrument mainframe and the transformer module, examine to ensure that they have not been damaged in shipment. Visually inspect all connectors, knobs, and handles. Confirm that a power cord and an instrumentation manual (this manual), are with the instrument. If the instrument has been damaged, file a claim immediately with the company that transported the instrument.

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	Manufacturer	Part Number
Continental Europe	European CEE 7/7 "Schuko" 230V, 50Hz	Qualtek (http://www.qualtekusa.com)	319004-T01
United Kingdom	BS 1363, 230V, 50Hz	Qualtek (http://www.qualtekusa.com)	370001-E01
Switzerland	SEV 1011, 2 30V, 50Hz	Volex (http://www.volex.com)	2102H-C3-10
Israel	SI 32, 220V, 50Hz	Volex (http://www.volex.com)	2115H-C3-10
North America, and all other areas	NEMA 5-15, 120V, 60 Hz	Qualtek (http://www.qualtekusa.com)	312007-01

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 ± 10 % of the nominal voltage;
6. no pollution or only dry, non-conductive pollution.

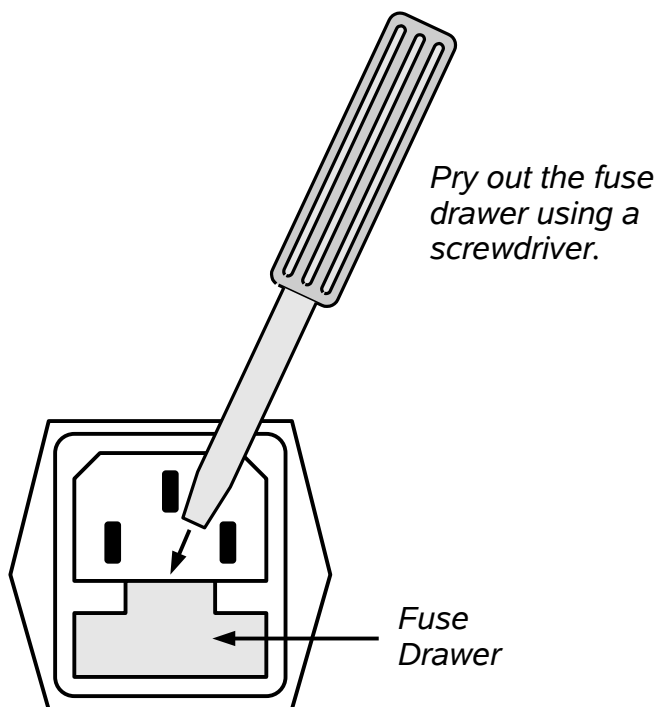
FUSES

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

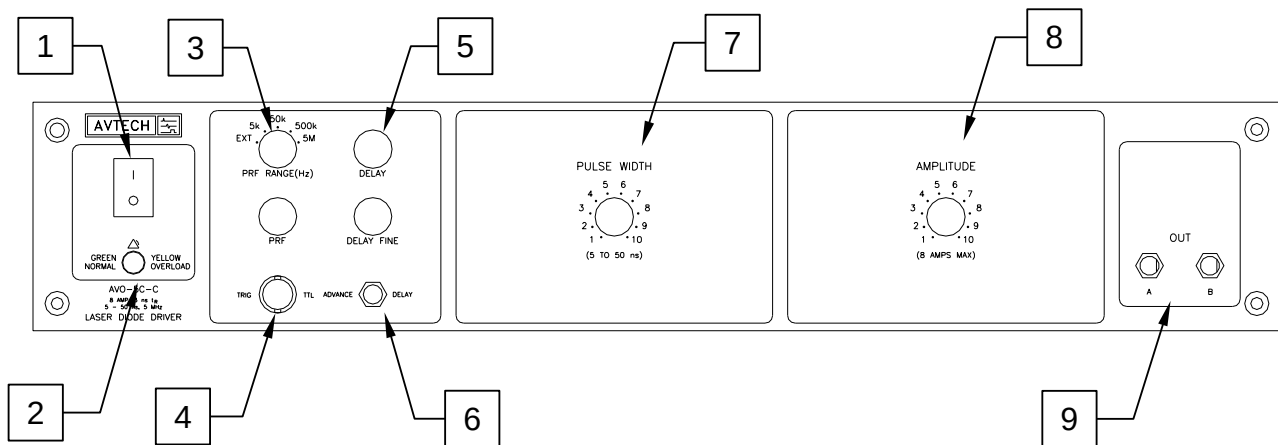
The following table lists the required fuses:

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	0.8A, 250V, Time-Delay	5×20 mm	0218.800HXP	F2418-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 may be a delay of several seconds before the instrument appears to respond.
- 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) PRF Range Switch. This switch sets the pulse repetition frequency (PRF) range of the internal oscillator. The marked value of each position is the upper limit of the 10:1 range, approximately. The vernier dial directly below the switch varies the PRF within the set range.

If this switched is set to the "EXT" position, the instrument is triggered by a signal applied to the TRIG connector, rather than by the internal oscillator.

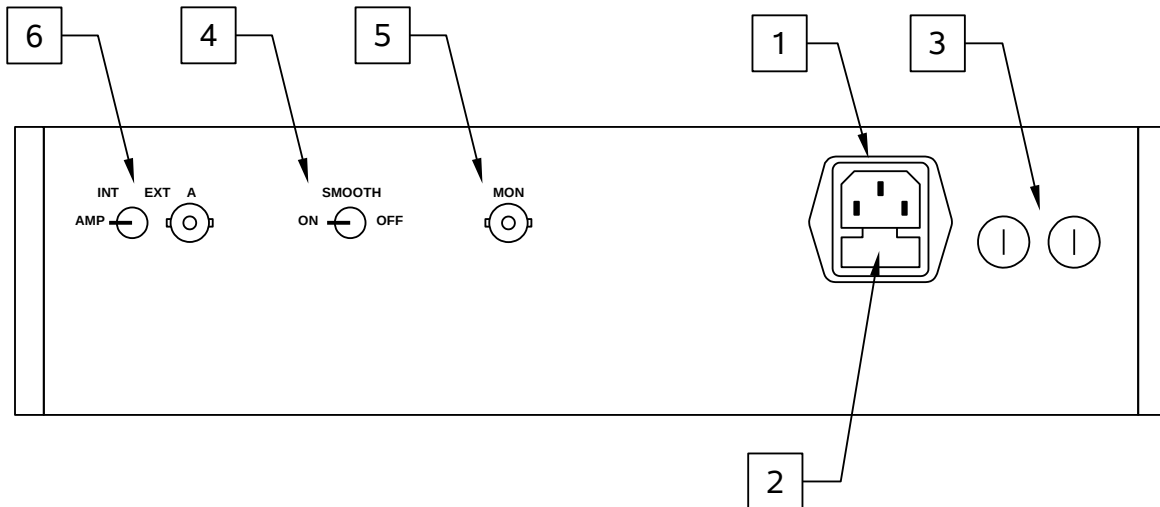
- 4) TRIG Connector. When the PRF Range Switch is set to "EXT", the instrument is triggered by a TTL pulse applied to this connector. The pulse must be at least 50 ns wide.

When the PRF Range Switch is set to one of the four internal oscillator ranges, this

connector is an output, which supplies a 2V, 50 ns wide pulse for each trigger event. This output may be used to trigger oscilloscopes or other equipment.

- 5) Delay Controls. When the PRF Range Switch is set to one of the four internal oscillator ranges, the main output is advanced or delayed relative to the TRIG output pulse (item 3). The delay is variable up to 200 ns, approximately, using the DELAY and DELAY FINE dials.
- 6) Advance/Delay Switch. When the PRF Range Switch is set to one of the four internal oscillator ranges, this switch determines whether the TRIG output precedes the main output (ADVANCE mode), or whether the TRIG output occur after the main output (DELAY mode).
- 7) Pulse Width Control. This dial controls the pulse width.
- 8) Amplitude Control. This dial controls the amplitude.
- 9) OUT. This array of two connectors is the mainframe output. These connectors must be connected directly to the two connectors on the output module with the supplied RG316 cables. ("-PN" units will have two sets of output connectors; one for the positive outputs, and one for negative outputs.)

REAR PANEL CONTROLS

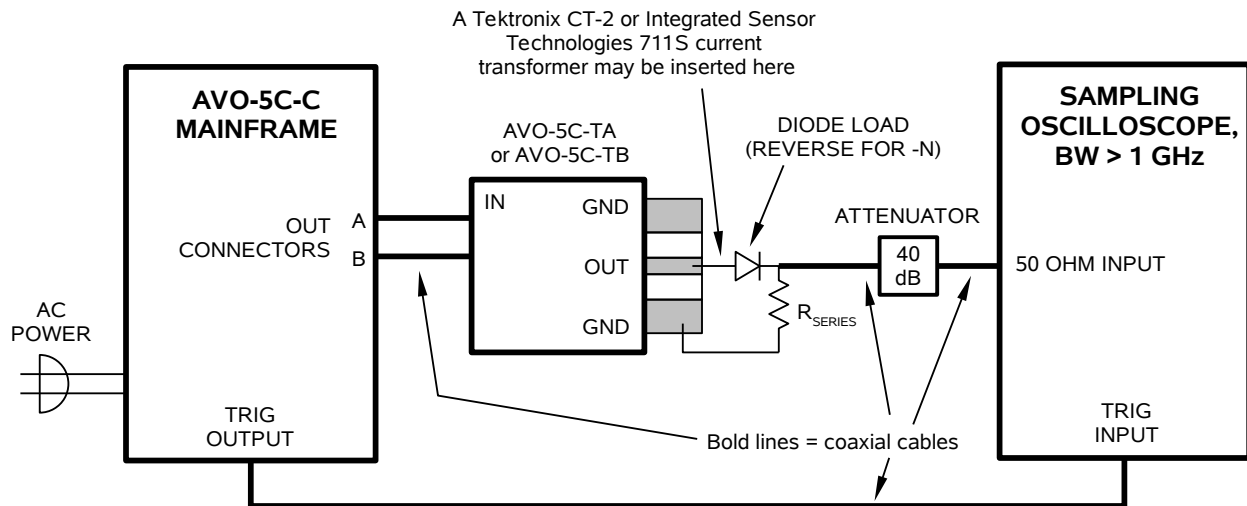


1. AC POWER INPUT. An IEC-320 C14 three-pronged recessed male socket is provided on the back panel for AC power connection to the instrument. One end of the detachable power cord that is supplied with the instrument plugs into this socket.
2. AC FUSE DRAWER. The two fuses that protect the AC input are 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. SMOOTH ON/OFF SWITCH. When this switch is set to the “ON” position, the rise and fall times of the main outputs are deliberately slowed down by a few nanoseconds. This can have the beneficial effect of reducing ringing and waveform distortions as well. In general, this switch should be set to “OFF” when using the AVO-5C-TA output module (because waveforms generated with it normally have minimal distortion) and it should be set to “ON” when using the higher-current AVO-5C-TB output module (because it introduces noticeable ringing at times).
5. MON OUTPUT CONNECTOR. (Present on units with -M option only.) This SMA connector output provides a 20 dB attenuated coincident replica of main output, for monitoring purposes.
6. AMP SWITCH & INPUT. (Present on units with -EA option only.) To control the output amplitude with an external voltage, set the rear-panel switch to the “EXT” position and apply 0 to +10V to the adjacent connector ($R_{IN} \geq 10k\Omega$).

GENERAL INFORMATION

BASIC TEST ARRANGEMENT

The AVO-5C-C should be tested with a sampling oscilloscope with a bandwidth of at least 1 GHz to properly observe the high-speed waveform. A typical test arrangement is shown below:



The attenuator is required to prevent damage to the sampling oscilloscope.

OUTPUT MODULES

The AVO-5C-C consists of two parts, the mainframe and the output module. Two different output modules (the AVO-5C-TA and the AVO-5C-TB) are provided. The mainframe is a voltage pulser, designed to operate into two 50 Ohm load impedances in parallel (for a total of 25 Ohms).

The AVO-5C-TA output module contains a current-doubling transformer, which requires a load impedance of approximately 6.2 Ohms (e.g., a 5 Ohms resistor in series with a diode with 1.2 Ohms of parasitic resistance). The amplitude at the output of the output module (V_{OUT}) can vary from 0 to 25V, approximately, when operating into a 6.2 Ohm load, providing up to 4 A of current.

The AVO-5C-TB output module contains a current-quadrupling transformer, which requires a load impedance of approximately 1.5 Ohms. The amplitude at the output of the output module (V_{OUT}) can vary from 0 to 12V, approximately, when operating into a 1.5 Ohm load, providing up to 8 A of current.


When driving a diode load in series with a resistor, the diode current is given by:


$$I_{DIODE} = (V_{OUT} - V_{DIODE}) / (R_{SERIES} + R_{DIODE})$$

where V_{DIODE} is the voltage drop across the diode, R_{DIODE} is the parasitic resistance of the diode, and R_{SERIES} is the resistance of the series resistor. $R_{\text{SERIES}} + R_{\text{DIODE}}$ should be equal to 6.2 Ohms for the AVO-5C-TA, and 1.5 Ohms for the AVO-5C-TB.

Aside from providing the required termination, the added series resistance may also be used to monitor the output current waveform. However, better results (i.e., with less distortion) are normally obtained if a current transformer, such as a Tektronix (<http://www.tek.com>) CT-2 or an Integrated Sensor Technologies (<http://www.isensortech.com>) model 711S, is used to measure the current.

The output modules connect to the mainframe using two 2-foot long miniature coaxial cables. Carbon film or carbon composition resistors may be used for R_{SERIES} but all leads must be as short as possible (< 0.1 inch). Solder leads directly to the GND and OUT terminals.

 Caution: Use moderate heat when soldering to the OUT terminal.

 Caution: The average power dissipated in the load resistance can be substantial. The maximum average power is $(8\text{A})^2 \times 1.5 \text{ Ohms} \times 10\% \text{ duty cycle} = 9.6 \text{ Watts}$. The resistance must be cooled appropriately. Elevated temperatures (> 40°C) may cause the output transformers to stop operating correctly.

WAVEFORM DISTORTIONS

Two output modules are provided. The AVO-5C-TA output module requires a 6 Ohm load, and can generate up to 4 Amps of current through this load. The AVO-5C-TB output module requires a 1.5 Ohm load, and can generate up to 8 Amps of current through this load. The lower-current AVO-5C-TA produces output waveforms with less distortion (i.e., ringing), and should be used instead of the AVO-5C-TB whenever possible.

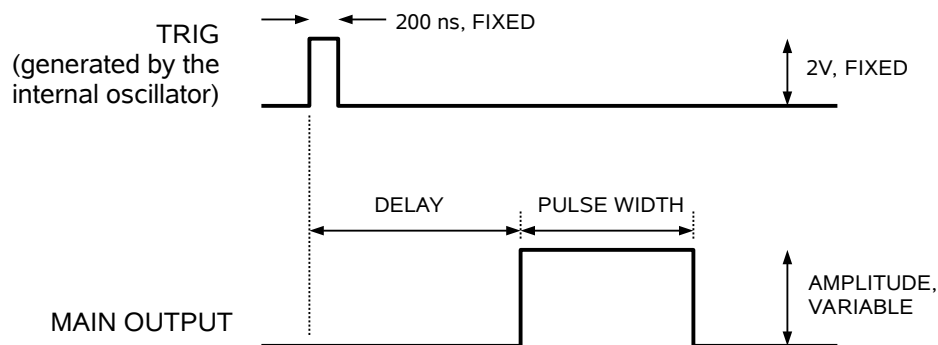
To help reduce output waveform distortions, a rear-panel SMOOTH switch is provided. When this switch is set to the "ON" position, the rise and fall times of the main outputs are deliberately slowed down by a few nanoseconds. This can have the beneficial effect of reducing ringing and waveform distortions as well. In general, this switch should be set to "OFF" when using the AVO-5C-TA output module (because waveforms generated with it normally have minimal distortion) and it should be set to "ON" when using the higher-current AVO-5C-TB output module (because it introduces noticeable ringing at times).

BASIC PULSE CONTROL

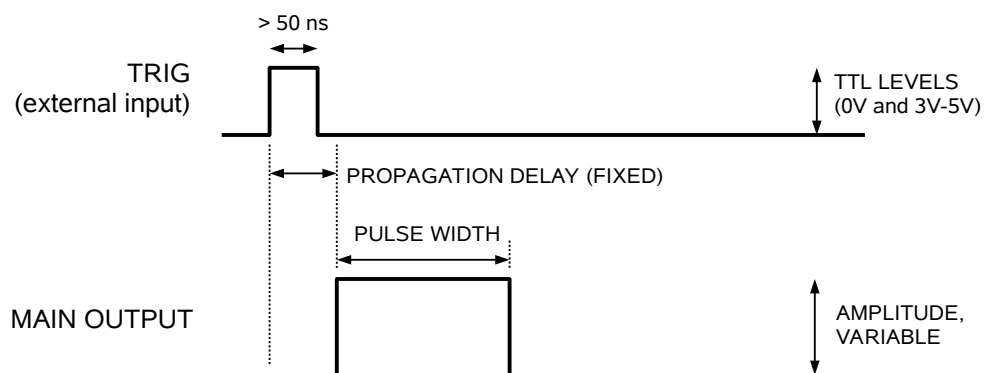
This instrument can be triggered by its own internal clock or by an external TTL trigger signal. When triggered internally, two mainframe output channels respond to the trigger: OUT and SYNC.

- OUT. This is the main output.
- TRIG. The TRIG pulse is a fixed-width TTL-level reference pulse used to trigger oscilloscopes or other measurement systems.

The TRIG output precedes the main output. These pulses are illustrated below:



When triggered externally, the TRIG connector acts as an input. The delay controls do not function in this mode. This illustrated below:



PARAMETER INTERACTION

The pulse width, amplitude, and frequency controls may all interact to some extent.

If you change the PRF by switching ranges, the output pulse may “disappear” because the pulse width has shifted. Simply adjust the pulse width control until the pulse re-appears.

MINIMIZING WAVEFORM DISTORTIONS

USE LOW-INDUCTANCE LOADS

Lenz's Law predicts that for an inductive voltage spike will be generated when the current through an inductance changes. Specifically, $V_{\text{SPIKE}} = L \times dI_{\text{LOAD}}/dt$, where L is the inductance, I_{LOAD} is the load current change, and t is time. For this reason, it is important to keep any parasitic in the load low. This means keeping wiring short, and using low inductance components. In particular, wire-wound resistors should be avoided.

PREVENTING DAMAGE


The AVO-5C-C may fail if triggered at a PRF greater than 5 MHz, or if the duty cycle exceeds 10%.

The lifetime of the switching elements in the pulse generator module is proportional to the running time of the instrument. For this reason the prime power to the instrument should be turned off when the instrument is not in use.


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.

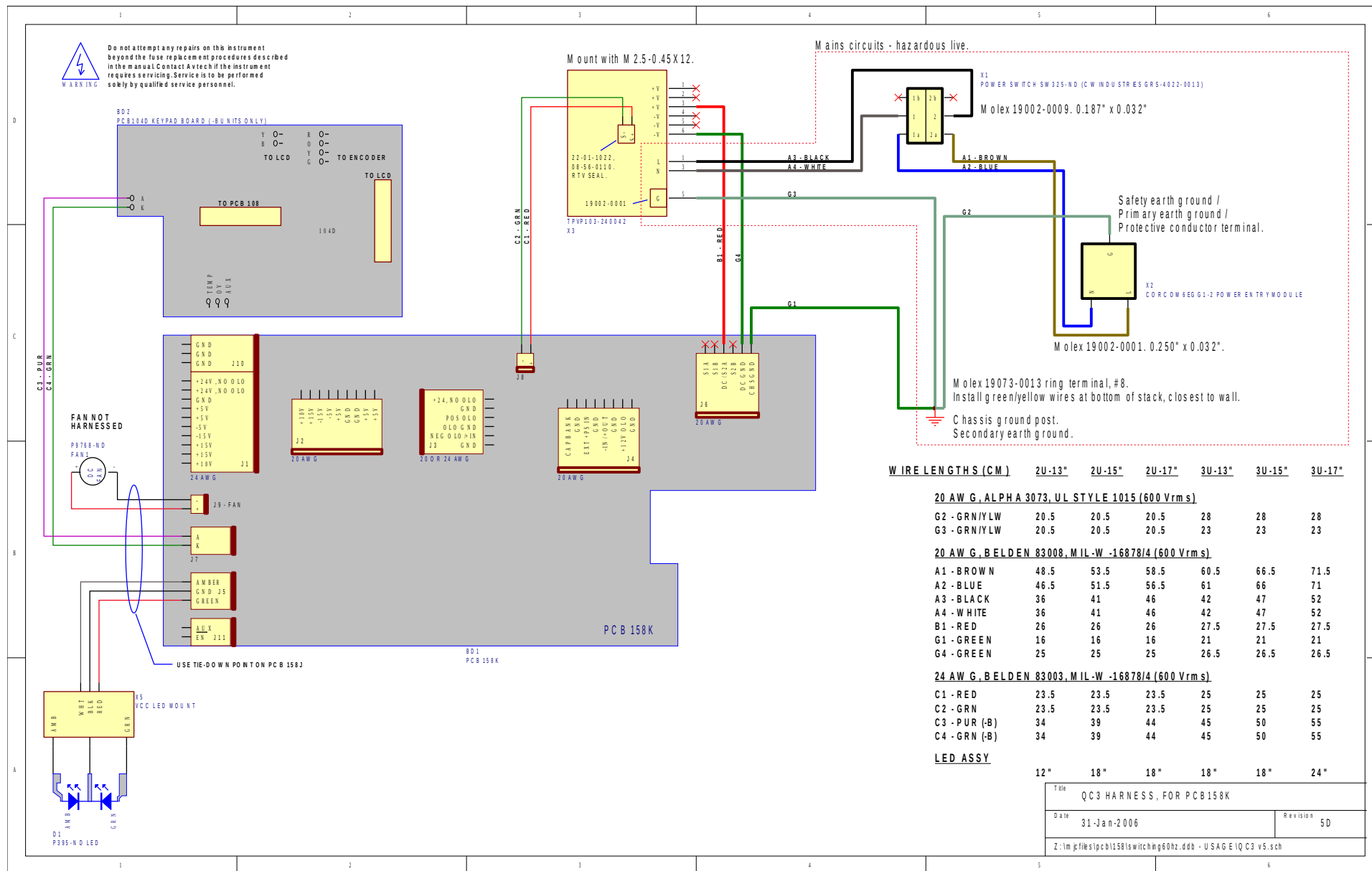
On occasion, one or more of the four rear-panel fuses may require replacement. All fuses can be accessed from the rear panel. See the “FUSES” section for details.

CLEANING

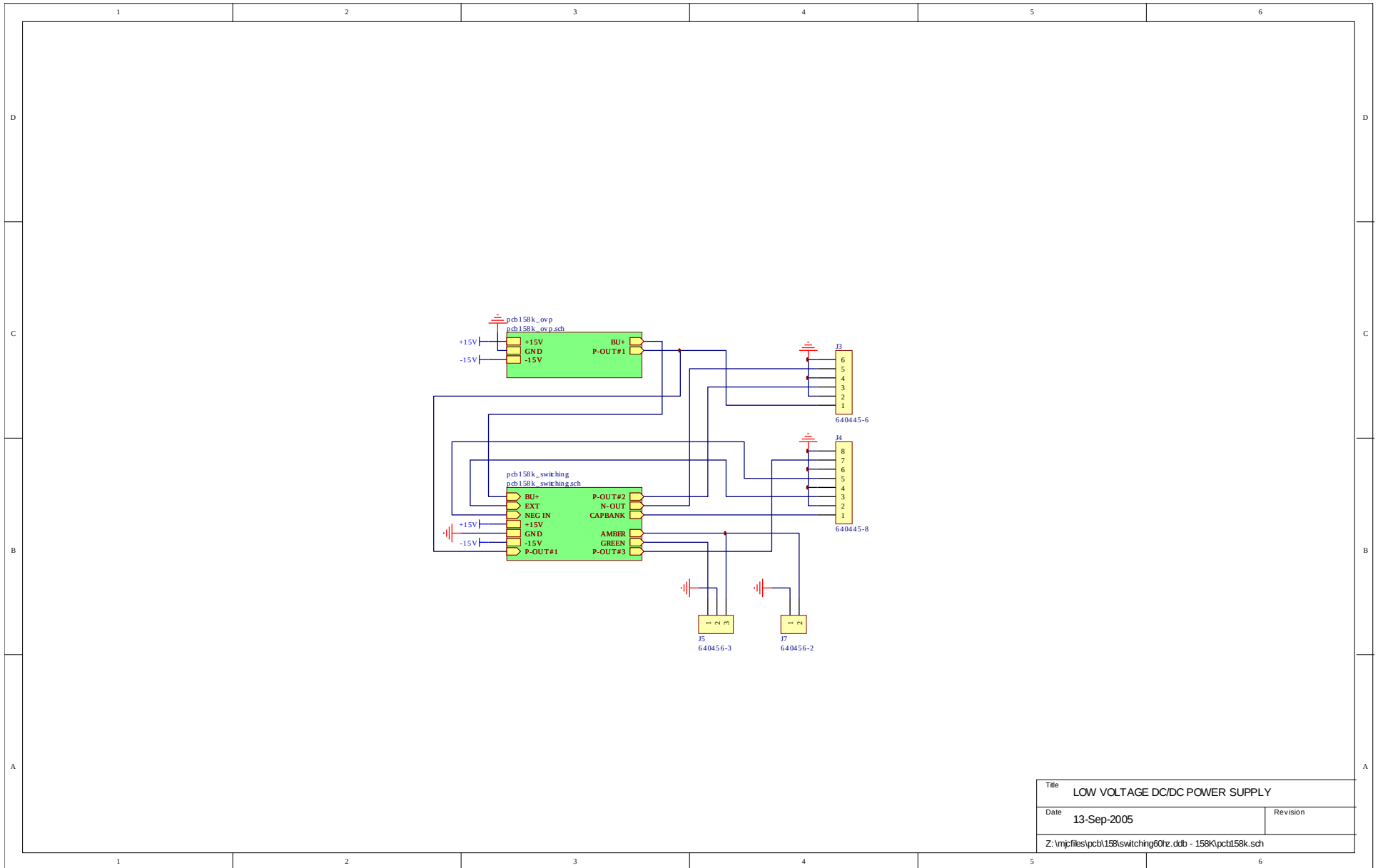
If desired, the interior of the instrument may be cleaned using compressed air to dislodge any accumulated dust. (See the “TOP COVER REMOVAL” section for instructions on accessing the interior.) No other cleaning is recommended.

WIRING DIAGRAMS

WIRING OF AC POWER

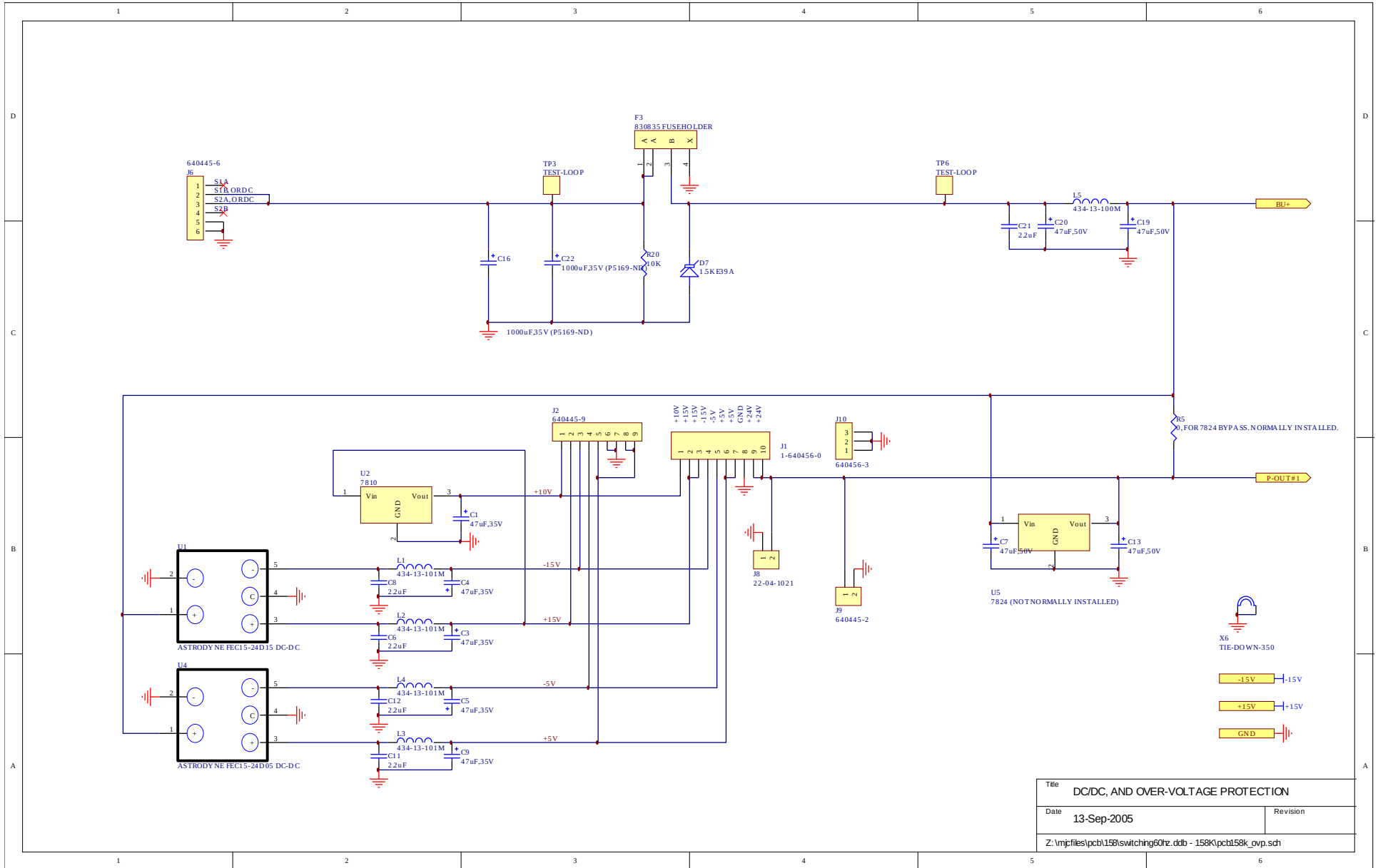


PCB 158K - LOW VOLTAGE POWER SUPPLY, 1/3

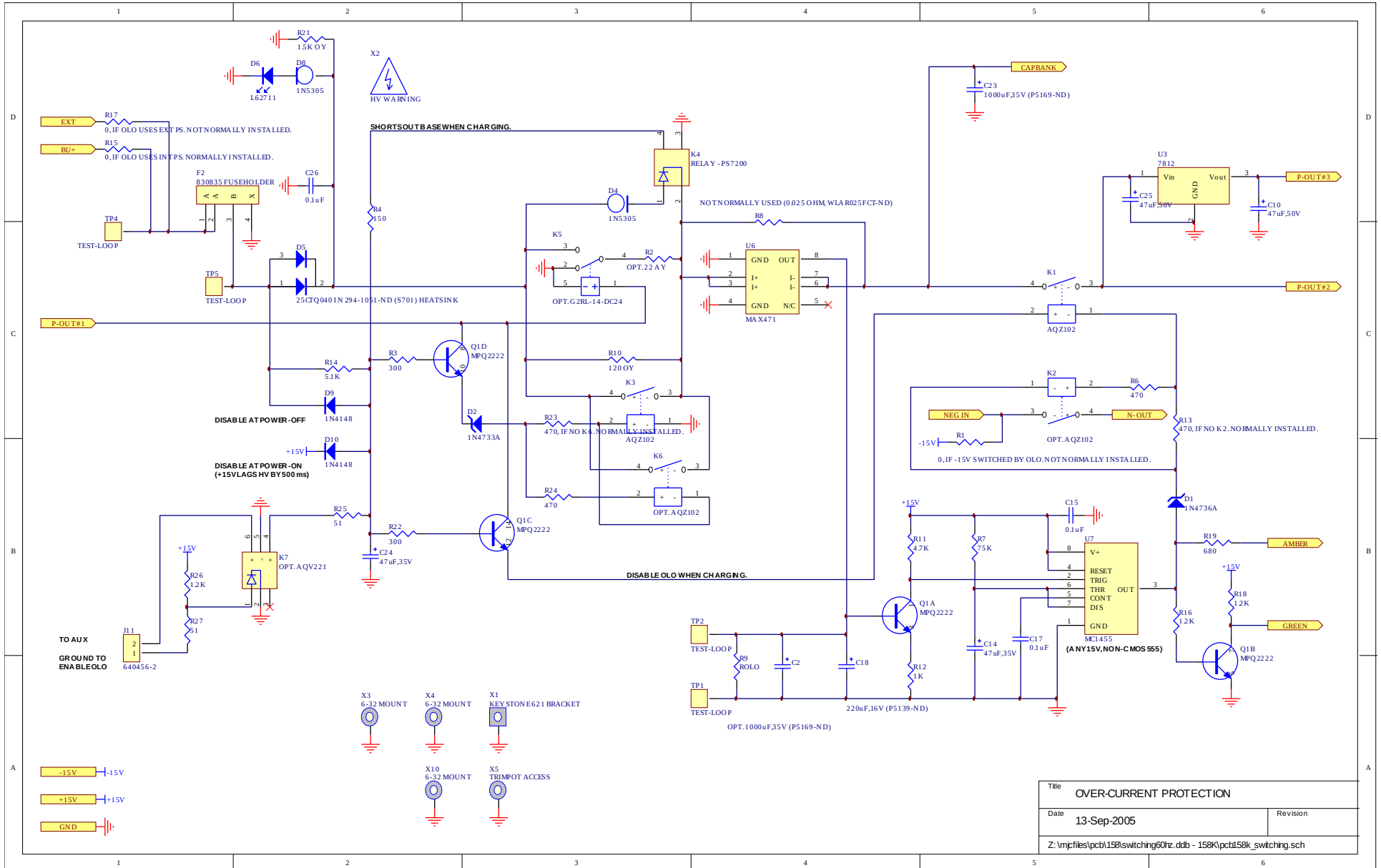


Title	LOW VOLTAGE DC/DC POWER SUPPLY	
Date	13-Sep-2005	Revision
Z:\mpjfiles\pcb158\switching01rz.ddb - 158K\pcb158k.sch		

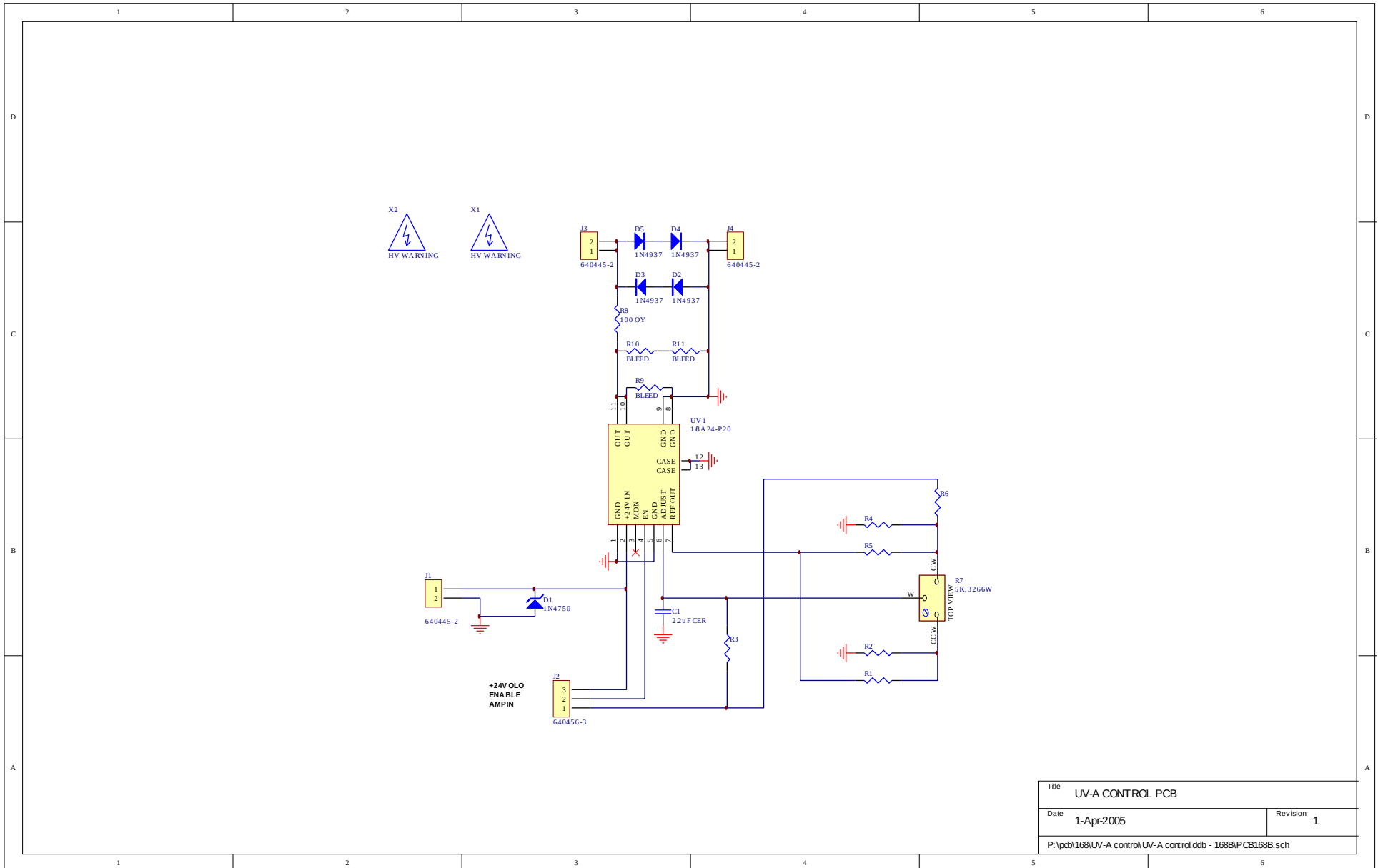
PCB 158K - LOW VOLTAGE POWER SUPPLY, 2/3



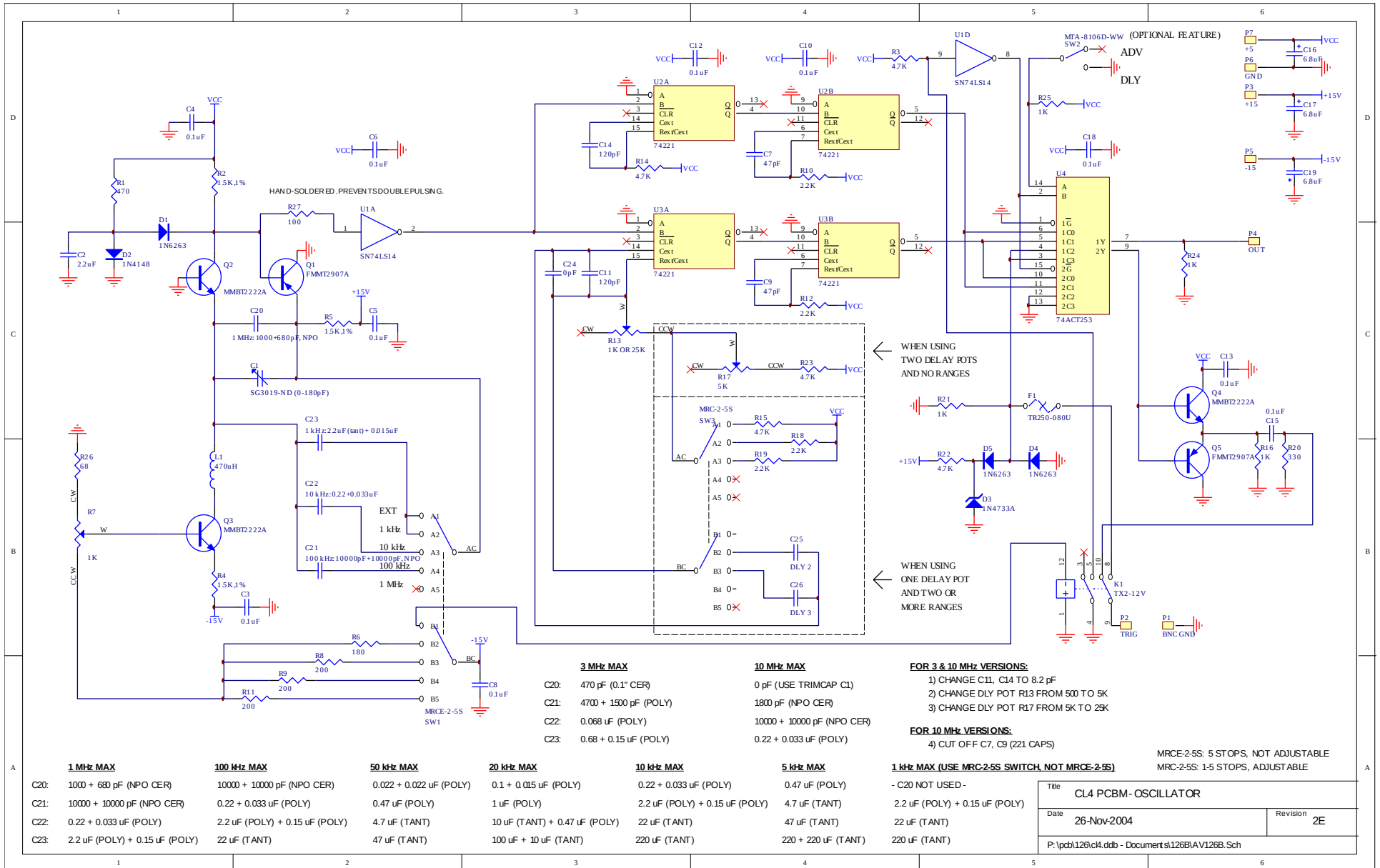
PCB 158K - LOW VOLTAGE POWER SUPPLY, 3/3



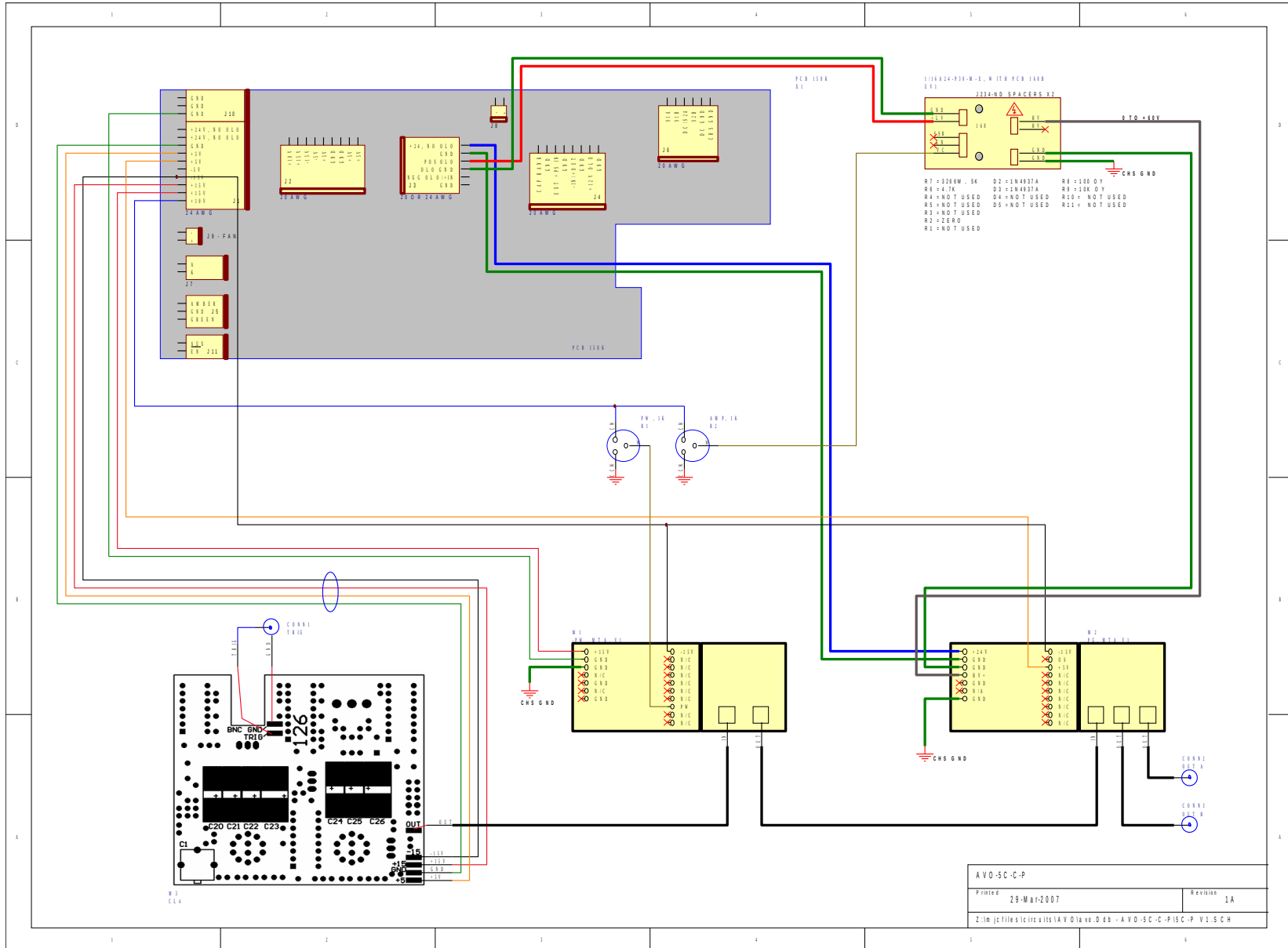
PCB 168B - HIGH VOLTAGE DC POWER SUPPLY



PCB 126B - OSCILLATOR AND TRIGGER CIRCUIT



MAIN WIRING



PERFORMANCE CHECK SHEET