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NANOSECOND WAVEFORM ELECTRONICS
SINCE 1975

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OTTAWA, ONTARIO
CANADA K2C 3H4

INSTRUCTIONS

MODEL AVP-3S-C

0 TO 10 VOLTS, 1 MHz

HIGH SPEED PULSE GENERATOR

WITH 60 ps RISE TIME

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 +1-613-226-5772 (Intl)

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TABLE OF CONTENTS

WARRANTY	2
TECHNICAL SUPPORT	2
TABLE OF CONTENTS	3
INTRODUCTION	5
AVAILABLE OPTIONS	6
SPECIFICATIONS	7
EUROPEAN REGULATORY NOTES	8
EC DECLARATION OF CONFORMITY	8
DIRECTIVE 2002/95/EC (RoHS)	8
DIRECTIVE 2002/96/EC (WEEE)	8
INSTALLATION	10
VISUAL CHECK	10
POWER RATINGS	10
CONNECTION TO THE POWER SUPPLY	10
PROTECTION FROM ELECTRIC SHOCK	11
ENVIRONMENTAL CONDITIONS	11
FUSES	13
AC FUSE REPLACEMENT	13
DC FUSE REPLACEMENT	14
FUSE RATINGS	14
FRONT PANEL CONTROLS	15
REAR PANEL CONTROLS	18
GENERAL INFORMATION	20
BASIC TEST ARRANGEMENT	20
BASIC PULSE CONTROL	20
AMPLITUDE INTERACTION	21
POLARITY CONTROL	21
MINIMIZING WAVEFORM DISTORTIONS	22
USE 50Ω TRANSMISSION LINES AND LOADS	22
USE LOW-INDUCTANCE LOADS	22
PREVENTING DAMAGE	22
MECHANICAL INFORMATION	23
TOP COVER REMOVAL	23

ELECTROMAGNETIC INTERFERENCE.....	23
MAINTENANCE.....	23
REGULAR MAINTENANCE.....	23
CLEANING.....	23
WIRING DIAGRAMS.....	24
WIRING OF AC POWER.....	24
PCB 158M - LOW VOLTAGE POWER SUPPLY, 1/3.....	25
PCB 158M - LOW VOLTAGE POWER SUPPLY, 2/3.....	26
PCB 158M - LOW VOLTAGE POWER SUPPLY, 3/3.....	27
PCB 168B - HIGH VOLTAGE DC POWER SUPPLY.....	28
PCB 126C - OSCILLATOR AND TRIGGER CIRCUIT.....	29
MAIN WIRING - POSITIVE UNITS.....	30
MAIN WIRING - DUAL CHANNEL UNITS.....	31
PERFORMANCE CHECK SHEET.....	32

Manual Reference: /filesserver1/officefiles/instructword/avp/old/AVP-3S-C,ed3.odt.

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INTRODUCTION

The AVP-3S-C is a high performance instrument capable of generating up to 10V into 50 Ω loads at repetition rates up to 1 MHz. The rise time is less than 60 ps. The fall time varies, but is typically 100 ps at minimum pulse width, and < 250 ps at maximum pulse width. The pulse width is variable from 0.2 to 2 ns.

Instruments with the “-P” model suffix can generate 0 to +10V, whereas instruments with the “-N” model suffix can generate 0 to -10V.

Instruments with the “-PN” suffix have two output connectors, only one of which is active at a time. One provides positive pulses, the other provides negative pulses. A front panel switch determines which output is active.

Instruments with the “-2CHPP” option have two output connectors. Both can be enabled at the same time. Both generate positive output amplitudes. Each output has independent pulse width and amplitude controls. The two channels share a common trigger source, and have a variable delay separation of 0 to ± 50 ns. Instruments with the “-2CHNN” option are similar, except that both outputs are negative. Similarly, instruments with the “-2CHPN” option have two outputs - one positive, and one negative.

Each output is designed to drive 50 Ω loads. (A 50 Ω load is required for proper operation.) Each output is AC-coupled.

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

AVAILABLE OPTIONS

The AVP-3S-C is available with several options:

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

-ECL Option: the input trigger levels are ECL, rather than TTL.

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

-EW Option: the output pulse width can be controlled by an externally generated 0 to +10V analog control voltage.

-M Option: a monitor output is provided.

-OS Option: an externally generated DC offset can be added to the output.

-OT Option: an internally generated DC offset, controlled by a front-panel dial, can be added to the output.

-2CHPP Option: Two active outputs (both positive).

-2CHPN Option: Two active outputs (one positive, one negative).

-2CHNN Option: Two active outputs (both negative).

SPECIFICATIONS

Model:	AVP-3S-C ¹
Amplitude ^{3,4,8} : (50 Ohm load)	0 - 10 Volts
Pulse width ³ : (FWHM)	0.2 - 2 ns
PRF: external trigger mode: internal trigger:	0 Hz to 1 MHz 100 Hz to 1 MHz
Rise time (20%-80%) ⁷ :	≤ 60 ps
Fall time (80%-20%) ⁷ :	≤ 250 ps (typically 100 ps at minimum pulse width)
Polarity:	specify -P, -N, or -PN
Dual-Polarity Option Style:	Two outputs (+ and -). Only one active at a time.
Two channel option:	Optional ⁷ .
Propagation delay: (Ext trig in to pulse out)	≤ 70 ns (Ext trig in to pulse out)
Jitter, Ext trig in to pulse out:	±15 ps
DC offset or bias insertion:	Optional ¹⁰ . Apply required DC offset or bias in the range of ± 50V (250 mA max) to back panel solder terminal.
Trigger required:	Ext trig mode: +5 Volt, 50 ns to 500 ns (TTL)
Sync delay:	Variable 0 to 500 ns (sync out to pulse out)
Sync output: (-B, -C only)	+3 Volts, 200 ns, will drive 50Ω
Monitor output option ¹¹ :	Provides a 20 dB (x10) attenuated coincident replica of main output
Connectors: OUT, MONITOR: TRIG:	SMA BNC
Optional accessory kit:	Add the suffix "-AK1" to the model number to include the recommended accessory kit. Consists of three SMA, 18 GHz, 2 Watt attenuators (10, 20 & 30 dB) for use on the output, and two 50 Ohm, 1 GHz, 1 Watt feed-through terminators (one SMA, one BNC) for use on external trigger inputs.
Power requirement:	100 - 240 Volts, 50 - 60 Hz
Dimensions (H x W x D):	100 mm x 430 mm x 375 mm (3.9" x 17" x 14.8")
Chassis material:	anodized aluminum, with blue plastic trim.
Mounting, Temperature range:	Any, +5°C to +40°C

- 1) -C suffix indicates stand-alone lab instrument with internal clock and line powering. No suffix indicates miniature module requiring DC power and external trigger. (See <http://www.avtechpulse.com/formats> for details of the four 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 +10V) of amplitude, pulse width or DC offset suffix model number with -EA or -EW or -EO. Electronic control units also include standard front-panel controls. -EW not available on -B units.
- 4) For operation at amplitudes of less than 20% of full-scale, best results will be obtained by setting the amplitude near full-scale and using external attenuators on the output.
- 5) For 20-500 ns pulse width, suffix model number with -W. Rise times increase to 150 ps for -W units. -W units have a propagation delay of 30 ns.
- 6) Indicate desired polarity by suffixing model number by -P or -N (i.e. positive or negative) or -P-PN or -N-PN for dual-polarity option where the suffix preceding -PN indicates the polarity at the mainframe output port.
- 7) For the two channel option, add the suffix -2CHPP for two positive outputs, the suffix -2CHNN for two negative outputs, or the suffix -2CHPN for the one positive output and one negative output.
- 8) For the double pulse option add the suffix -DPP for a unipolar output, and add the suffix -DPN for a bipolar output. Note that the maximum amplitude is reduced to 70% for DP option units.
- 9) Add the suffix -TNT to the model number to specify the Telnet / Ethernet control option.
- 10) For externally applied DC offset option suffix model number with -OS. The Avtech AVX-T bias tee can also be used to obtain DC offset. For internally generated DC offset option (0 to ±5V) add suffix -OT or -EO to model number. (The -OT option is controlled by a front-panel dial, whereas the -EO option can be controlled by a front-panel dial or by an external 0 to +10V voltage). -OT, -EO not available on modules.
- 11) For monitor option add suffix -M.
- 12) For ECL trigger option, add suffix -ECL.

EUROPEAN REGULATORY NOTES

EC DECLARATION OF CONFORMITY

We Avtech Electrosystems Ltd.
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Ottawa, Ontario
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.

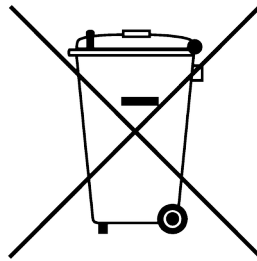
DIRECTIVE 2002/96/EC (WEEE)

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

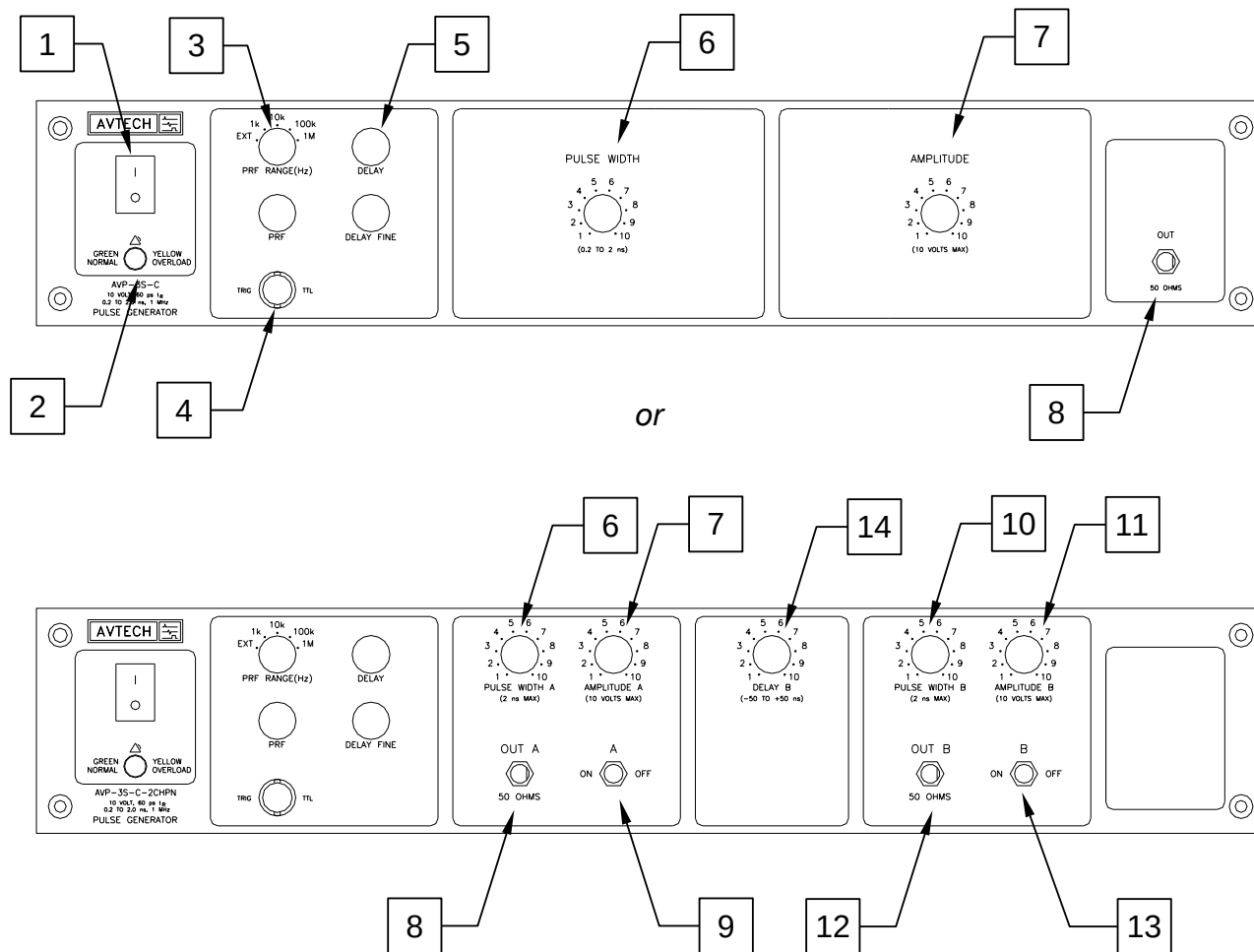
The following table lists the required fuses:

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	0.8A, 250V, Time-Delay	5×20 mm	0218.800HXP	F2418-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 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, 200 ns wide pulse for each trigger event. This output may be used to trigger oscilloscopes or other equipment.

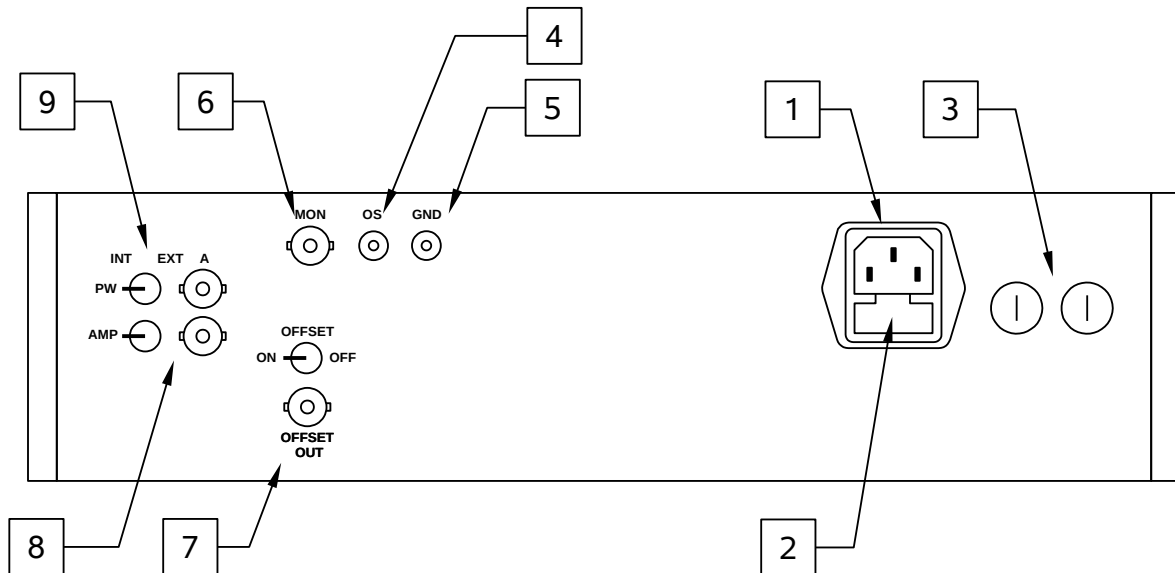
- 5) Delay Controls. When the PRF Range Switch is set to one of the four internal oscillator ranges, the main output is advanced or delayed relative to the TRIG output pulse (item 3). The delay is variable up to 200 ns, approximately, using the DELAY and DELAY FINE dials.
- 6) Pulse Width Control (A). This dial controls the pulse width of Output "A" (item 8).
- 7) Amplitude Control (A). This dial controls the amplitude of Output "A" (item 8).
- 8) OUT Connector (A). This SMA connector provides the main output. This output *requires* a 50Ω load to function properly.

Instruments with the "-PN" suffix have two output connectors, only one of which is active at a time. One provides positive pulses, the other provides negative pulses. A front panel switch (not shown in the drawing above) determines which output is active.

- 9) OUTPUT ON/OFF (A). *Present on two-channel units only*. This switch enables or disables the associated output.
- 10) Pulse Width Control (B). *Present on two-channel units only*. This dial controls the pulse width of Output "B" (item 12).
- 11) Amplitude Control (B). *Present on two-channel units only*. This dial controls the amplitude of Output "B" (item 12).
- 12) OUT Connector (B). *Present on two-channel units only*. This SMA connector provides the second output. This output *requires* a 50Ω load to function properly.
- 13) OUTPUT ON/OFF (B). *Present on two-channel units only*. This switch enables or disables the associated output.

- 14) RELATIVE DELAY. *Present on two-channel units only.* This dial controls the relative delay between the two outputs, over a range of -50 to +50 ns. (The two outputs share a common trigger source).

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. OS INPUT CONNECTOR. (Present on units with -OS option only.) A DC offset in the range of $\pm 50\text{V}$ (250 mA max) may be applied to this solder terminal. The DC offset will appear on the output. When this feature is not used, the OS input should be connected to ground (using the adjacent GND connector). This is especially important when driving loads containing a diode.
5. GND CONNECTOR. (Present on units with -OS option only.) This solder terminal is connected to ground. It may be used to ground the OS input connector.
6. 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.
7. OFFSET ON/OFF SWITCH & OUTPUT. (Present on units with -EO or -OT options only). This switch enables the offset feature when it is set to “ON”. When it is set to “OFF”, no offset is added to the output. The internally generated offset is available at the “OFFSET OUT” BNC connector, for monitoring purposes. To add an offset to inverted pulses on units with the dual polarity option (-PN), connect this terminal to

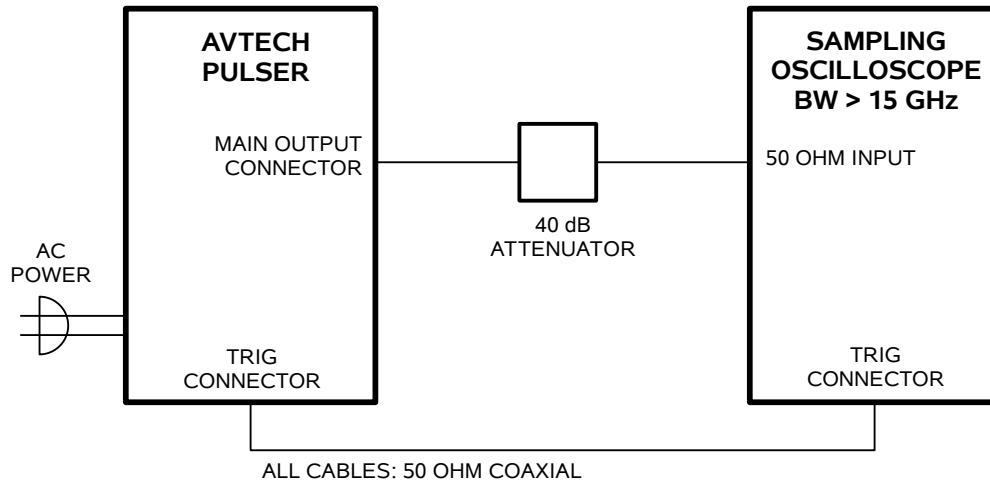
the DC terminal of the inverting transformer (see the “POLARITY INVERSION” sections in this manual for further details).

8. 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 ($R_{IN} \geq 10k\Omega$).
9. PW SWITCH & INPUT. (Present on units with -EW option only.) To control the output pulse width 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 AVP-3S-C should be tested with a sampling oscilloscope with a bandwidth of at least 15 GHz to properly observe the high-speed waveform. (The cables and attenuators must also have a bandwidth of at least 15 GHz.) A typical test arrangement is shown below:



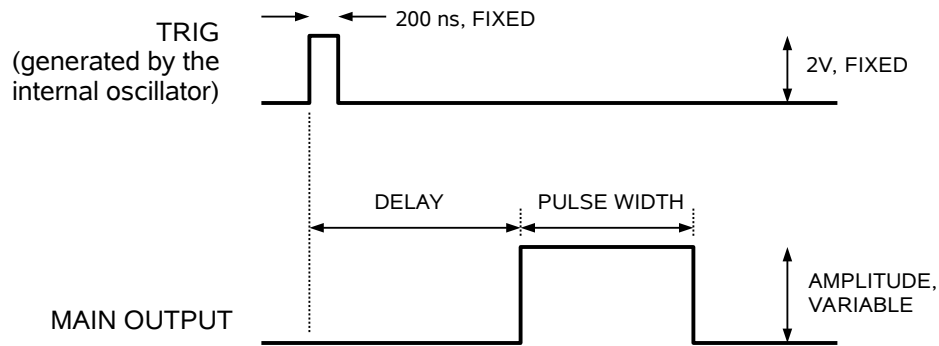
The attenuators are required to prevent damage to the sampling oscilloscope. A 40 dB attenuator with sufficient voltage rating should be used on the main output.

BASIC PULSE CONTROL

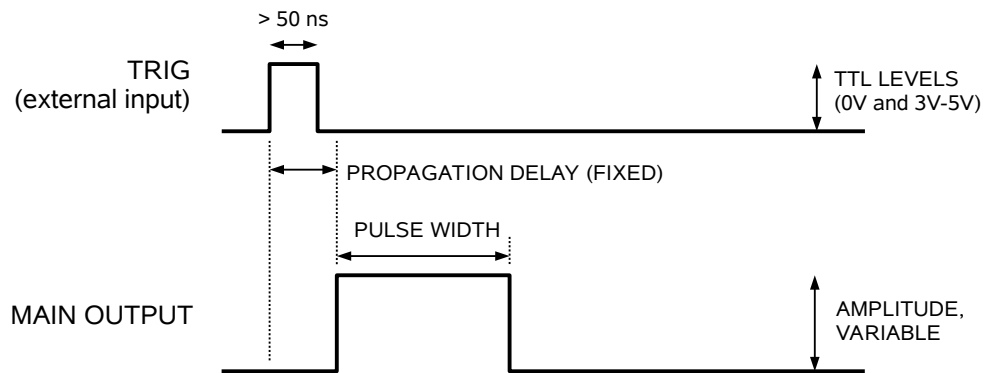
This instrument can be triggered by its own internal clock or by an external TTL trigger signal. When triggered internally, two mainframe output channels respond to the trigger: OUT and SYNC.

- OUT. This is the main output. The maximum output voltage is 10V.
- 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:



AMPLITUDE INTERACTION

Some properties of the output pulse may change as a function of the amplitude setting. For some demanding applications, it may be desirable to use a combination of external attenuators and the amplitude pot to achieve the desired output amplitude.

POLARITY CONTROL

Instruments with the "-PN" suffix have two output connectors, only one of which is active at a time. One provides positive pulses, the other provides negative pulses. A front panel switch determines which output is active.

MINIMIZING WAVEFORM DISTORTIONS

USE 50Ω TRANSMISSION LINES AND LOADS

Connect the load to the pulse generator with 50Ω transmission lines (e.g. RG-58 or RG-174 cable).

This instrument requires a 50Ω load for proper operation. It will not properly drive a high-impedance load. The output stage will be damaged if it is operated into an open circuit (or any other high impedance). Failures due to improper output loading are not covered by the warranty.

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 AVP-3S-C may fail if triggered at a PRF greater than 1 MHz.

This unit is designed to operate into a load impedance of 50 Ohms and the output stage will be damaged if it is operated into an open circuit (or any other high impedance). Failures due to improper output loading are not covered by the warranty.

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 before opening the instrument.

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.

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

ELECTROMAGNETIC INTERFERENCE

To prevent electromagnetic interference with other equipment, all used outputs should be connected to shielded 50Ω loads using shielded 50Ω coaxial cables. Unused outputs should be terminated with shielded 50Ω 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.

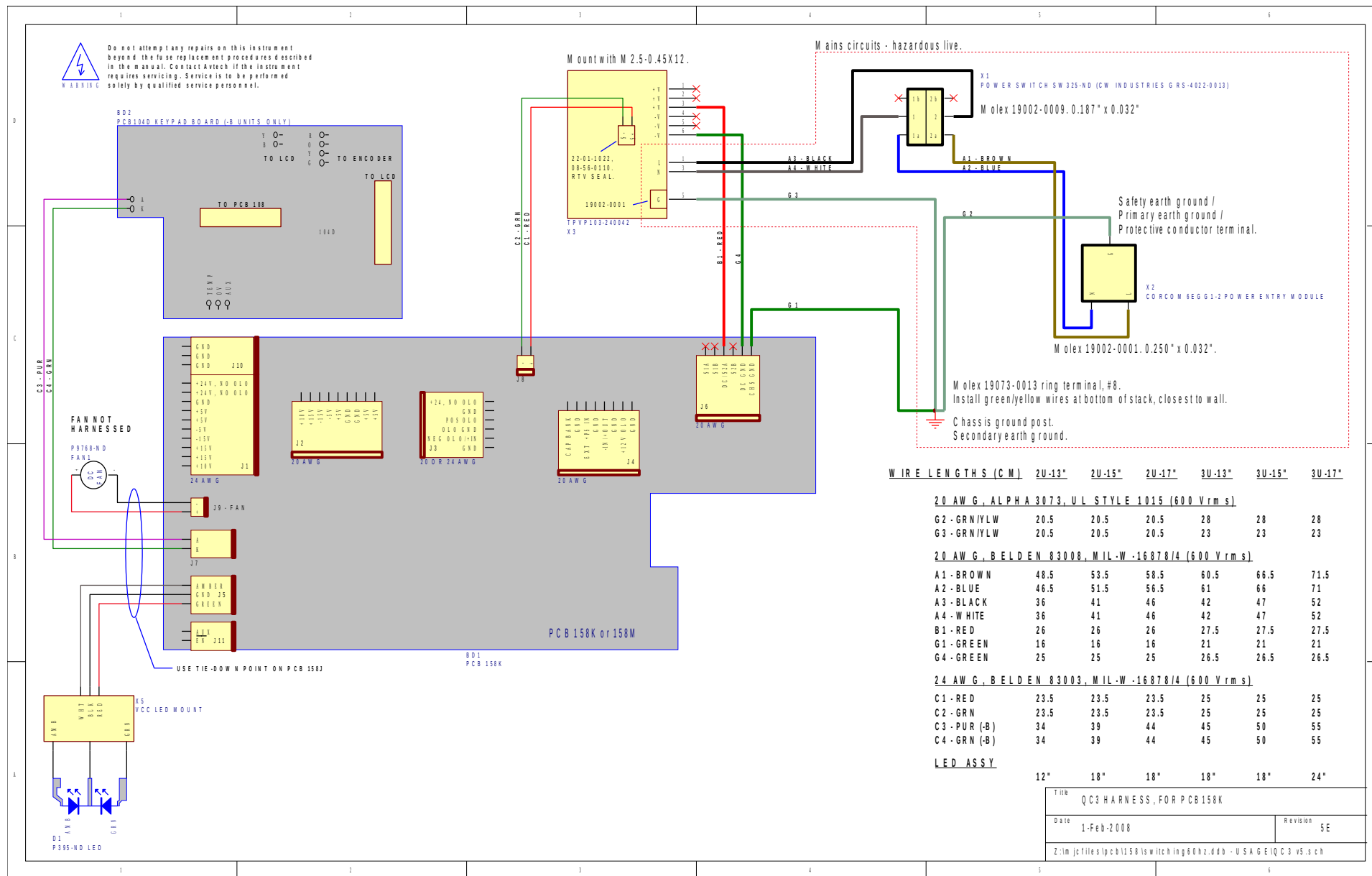
On occasion, one or more of the four rear-panel fuses may require replacement. All fuses can be accessed from the rear panel. See the “FUSES” section for details.

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.

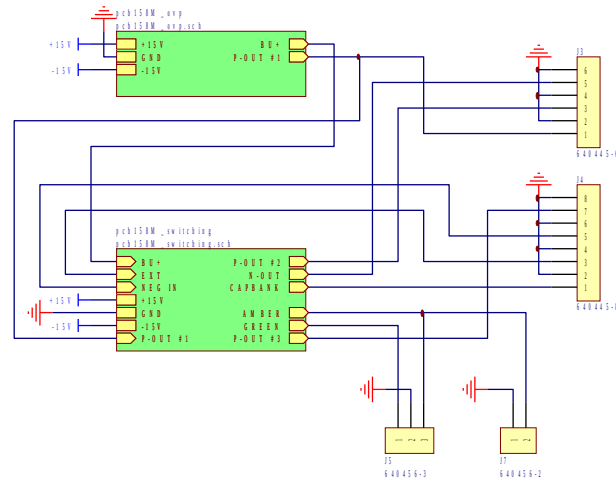
WIRING DIAGRAMS

WIRING OF AC POWER



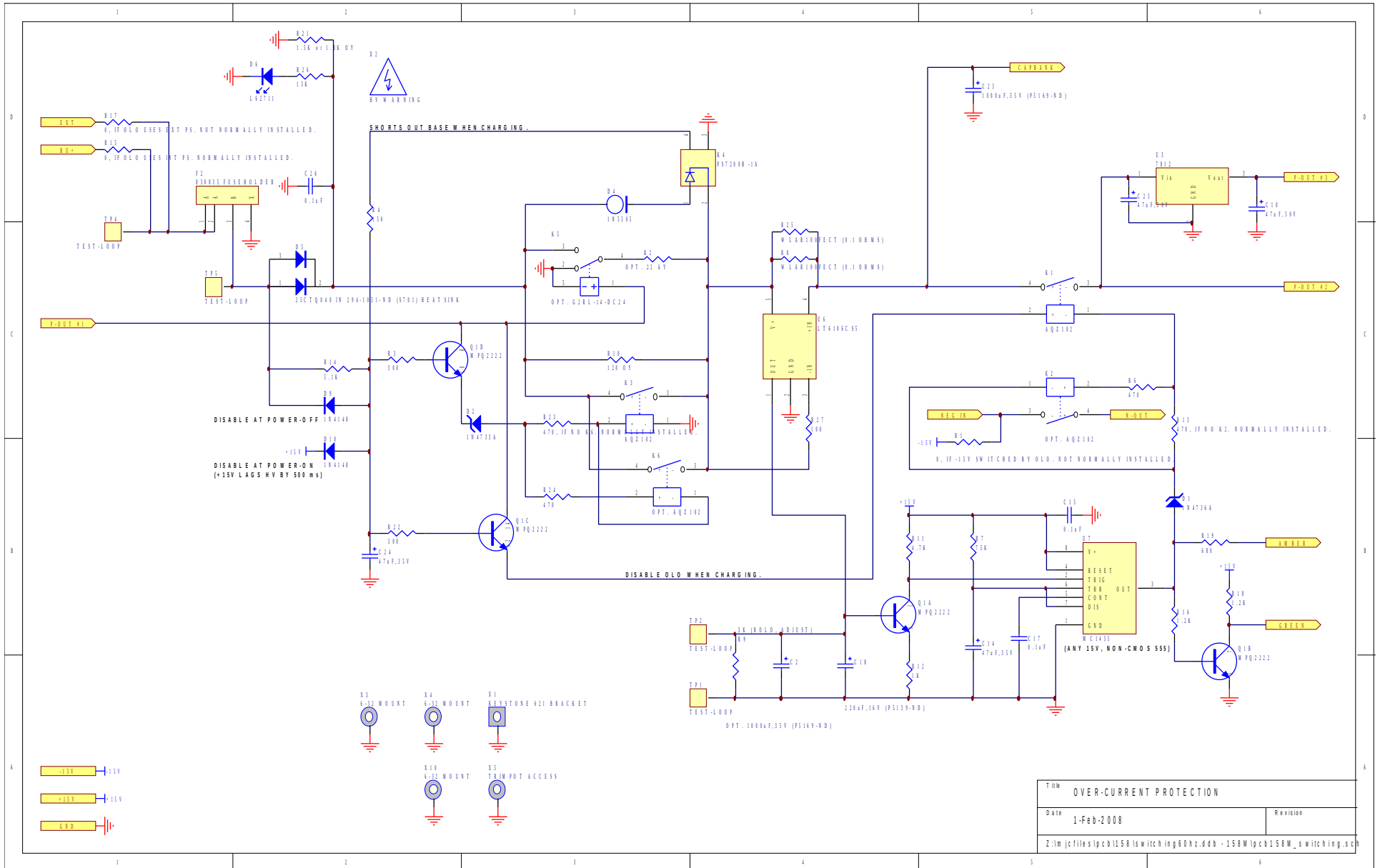
Title: QCS HARNESS, FOR PCB158K	
Date: 1-Feb-2008	Revision: SE
Z:\im\jctiles\lpc\cb1158\lsw\litching\60hz\ddb - U.S.A.GE\IQ C3 v5.sch	

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

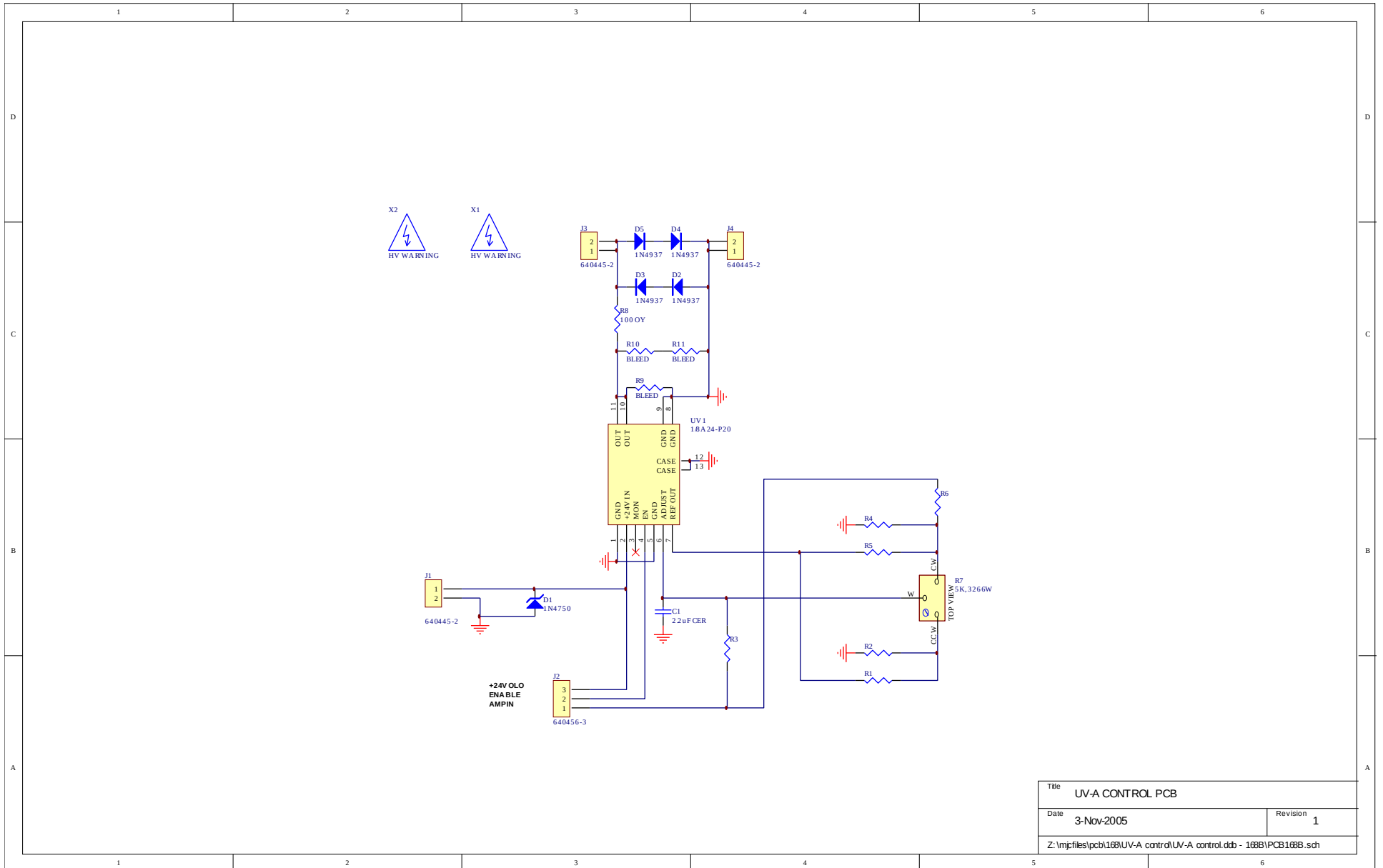


Title		LOW VOLTAGE DC/DC POWER SUPPLY
Date	1-Feb-2008	Revision
Z:\lm\jc\files\ipc\b1158\low\litch\ing60hz.dbb - 158M\ipc\b1158M.sch		

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

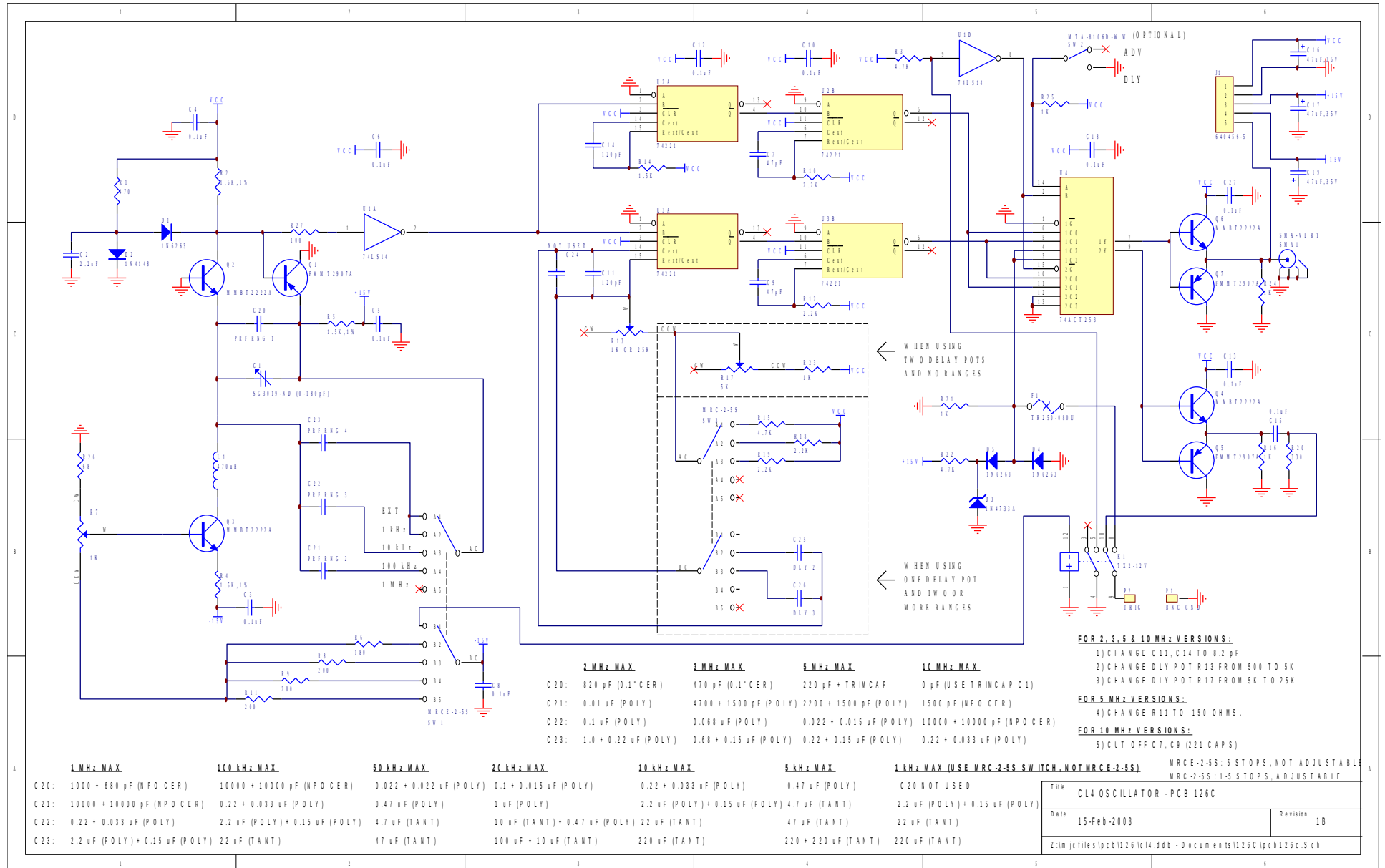


PCB 168B - HIGH VOLTAGE DC POWER SUPPLY

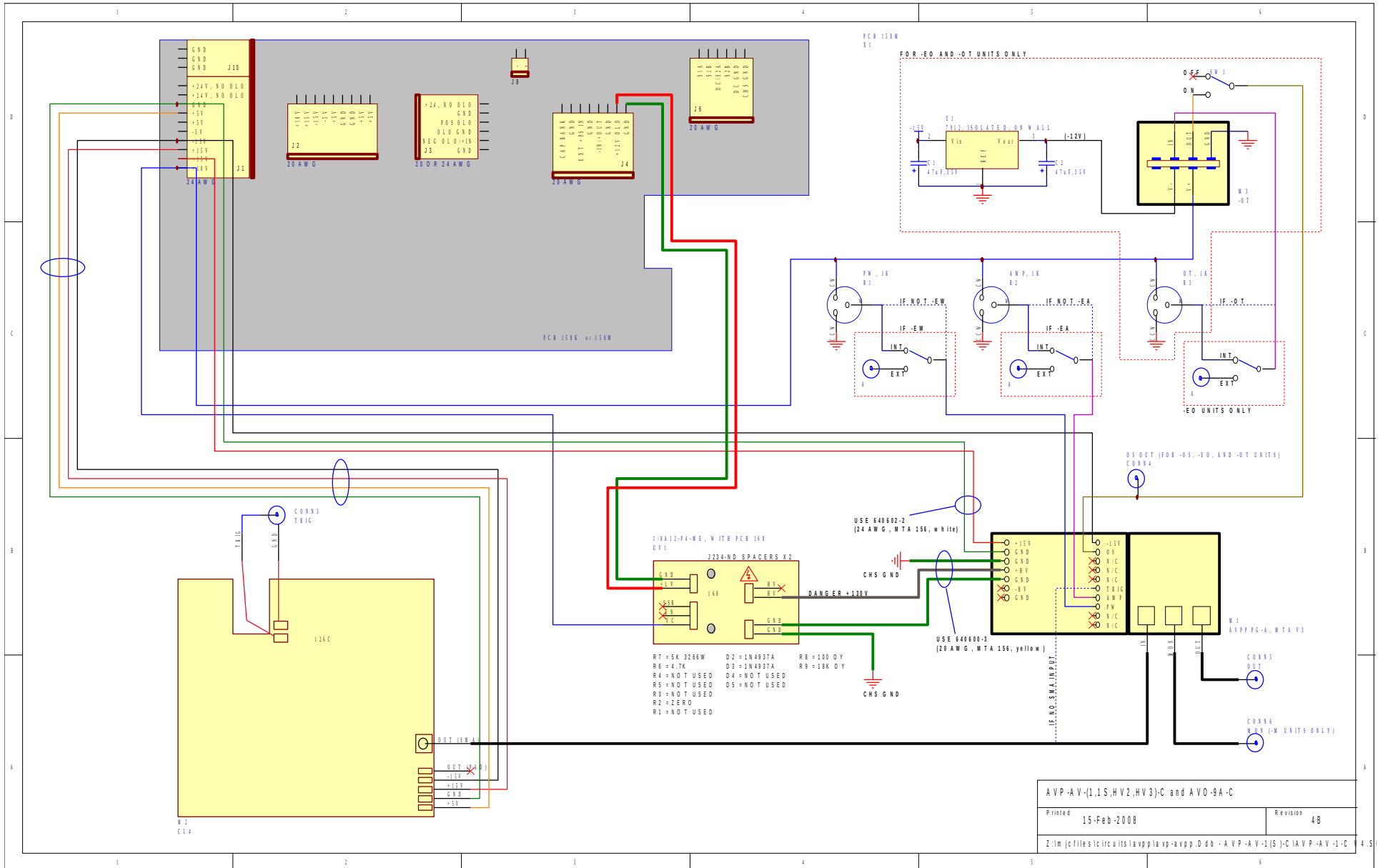


Title UV-A CONTROL PCB	
Date 3-Nov-2005	Revision 1
Z:\mpjfiles\pcb168\UV-A control\UV-A control.ddb - 168B\PCB168B.sch	

PCB 126C - OSCILLATOR AND TRIGGER CIRCUIT

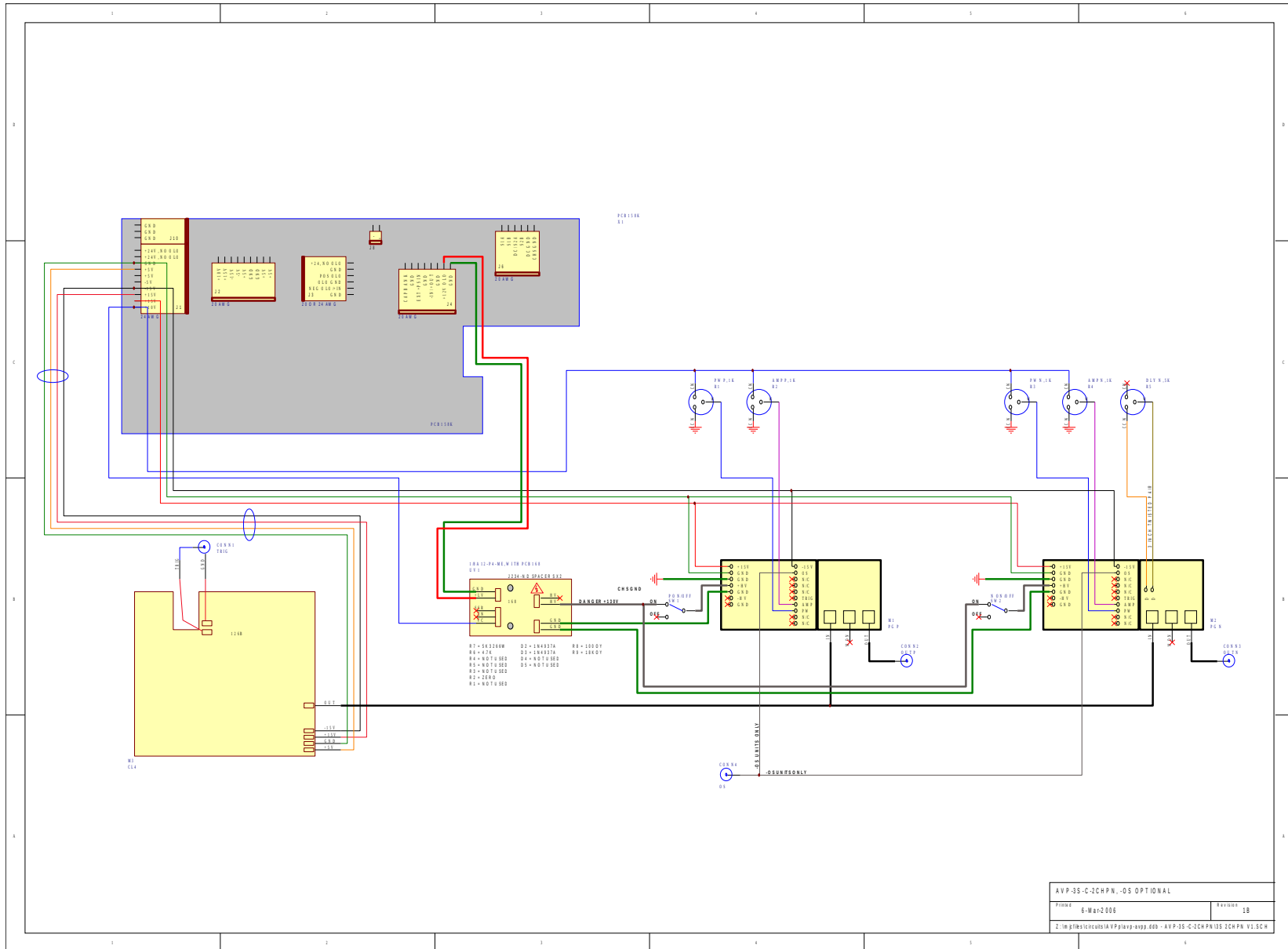


MAIN WIRING - POSITIVE UNITS



AVP-AV-(1,1S,HV2,HV3)-C and AV0-9A-C	
Printed	15-Feb-2008
Revision	4B
Z:\lm\jct\files\lc\irc\units\avpp\la\vp-avpp.D db - AVP-AV-1(S)-C\AVP-AV-1-C	

MAIN WIRING - DUAL CHANNEL UNITS



AVP-3S-C-2CRPN...0S OPTIONAL	
Printed	6-Mar-2008
Revision	18
Z:\m\p\m\1000001\AVP\app\app.dwg - AVP-3S-C-2CRPN\3S-2CRPN-V1.SCH	

PERFORMANCE CHECK SHEET