<u>INSTRUCTIONS</u>

MODEL AVRH-3-B

0 TO 3000 VOLTS, 100 ns RISE TIME

HIGH PERFORMANCE PULSE GENERATOR
WITH IEEE 488.2 AND RS-232 CONTROL

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 dissembled, 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
Fax: 613-226-2802 or 1-800-561-1970

E-mail: info@avtechpulse.com
World Wide Web: http://www.avtechpulse.com

TABLE OF CONTENTS

Manual Reference: /fileserver1/officefiles/instructword/avrh/AVRH-3-B,ed4.doc, created April 11, 2002

INTRODUCTION

The AVRH-3-B is a high performance, GPIB and RS232-equipped instrument capable of generating 3000V into loads of 1 kΩ or higher, at repetition rates up to 1 kHz. The output pulse width is variable from 200 to 2500 ns, and the sync delay is variable up to ±5 μs. The rise time is fixed at less than 100 ns.

Instruments with the "-P" model suffix can generate 0 to +3000V, whereas instruments with the "-N" model suffix can generate 0 to -3000V. Instruments with the "-PN" suffix can generate both polarities.

The AVRH-3-B is a highly flexible instrument. Aside from the internal trigger source, it can also be triggered or gated by external TTL-level signals. A front-panel pushbutton or a computer command can also be used to trigger the instrument.

The AVRH-3-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 width, 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.

AVAILABLE OPTIONS

The AVRH-3-B is available with the follow option:

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

SPECIFICATIONS

Model:	AVRH-3-B
GPIB and RS-232 control:	Standard on -B units.
Amplitude:	0 to 3000 Volts (to R $\geq$ 1000 Ohms)
Rise time:	$\leq$ 100 ns
Fall time:	$\leq$ 100 ns
Pulse width:	200 ns to 2.5 μs
PRF:	0 to 1 kHz
Duty cycle (max):	0.25 %
Average power out (max):	25 Watts
Polarity:	Models with "-P" suffix: Positive Models with "-N" suffix: Negative Models with "-PN" suffix: Positive and Negative
Propagation delay:	$\leq$ 130 ns (Ext trig in to pulse out)
Jitter (Ext trig in to pulse out):	$\pm$ 100 ps $\pm$ 0.03% of sync delay
Trigger required: (ext trig mode)	Normal PW mode: + 5 Volts, 50 ns or wider (TTL) $PW_{IN} = PW_{OUT}$ mode: + 5 Volts, $PW_{IN} = PW_{OUT}$ (TTL)
Sync delay:	Variable 0 to $\pm$ 5 μs (sync out to pulse out)
Sync output:	+ 3 Volts, 200 ns, will drive 50 Ohm loads
Gated operation:	Synchronous or asynchronous, active high or low, switchable. Suppresses triggering when active.
Connectors:	Out: SHV, Trig: BNC, Sync: BNC, Gate: BNC
Power requirements:	120/240 Volts (switchable) 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:	cast aluminum frame and handles, blue vinyl on aluminum cover plates
Mounting:	Any
Temperature range:	+ 15° to + 40°C

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. Confirm that a power cord, a GPIB cable, and two instrumentation manuals (this manual and the "OP1B Interface Programming Manual") are with the instrument. If the instrument has been damaged, file a claim immediately with the company that transported the instrument.

PLUGGING IN THE INSTRUMENT

Examine the rear of the instrument. There will be a male power receptacle, a fuse holder and the edge of the power selector card visible. Confirm that the power selector card is in the correct orientation.

For AC line voltages of 110-120V, the power selector card should be installed so that the "120" marking is visible from the rear of the instrument, as shown below:

For AC line voltages of 220-240V, the power selector card should be installed so that the "240" marking is visible from the rear of the instrument, as shown below:

If it is not set for the proper voltage, remove the fuse and then grasp the card with a pair of pliers and remove it. Rotate horizontally through 180 degrees. Reinstall the card and the correct fuse.

In the 120V setting, a 1.0A slow blow fuse is required. In the 240V setting, a 0.5A slow blow fuse is required.

LABVIEW DRIVERS

A LabVIEW driver for this instrument is available for download on the Avtech web site, at http://www.avtechpulse.com/labview. A copy is also available in National Instruments' Instrument Driver Library at http://www.natinst.com/.

FRONT PANEL CONTROLS
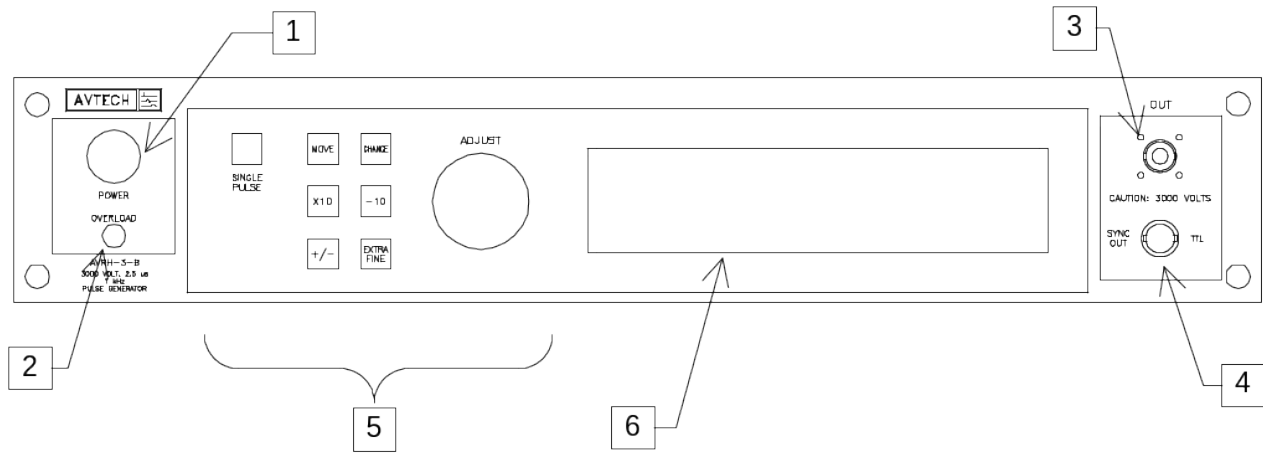
1. <u>POWER Switch</u>. The POWER push button switch applies AC prime power to the primaries of the transformer, turning the instrument on. The push button lamp (#382 type) is connected to the internal +15V DC supply.

2. <u>OVERLOAD</u>. The AVRH-3-B is protected in its internal software against conflicting or dangerous settings. As an additional protective measure, an automatic overload circuit exists, which controls the front panel overload light. 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 turn the output of the instrument OFF and turn the indicator light ON. The light will stay ON (i.e. output OFF) for about 5 seconds after which the instrument will attempt to turn ON (i.e. light OFF) for about 1 second. If the overload condition persists, the instrument will turn OFF again (i.e. light ON) for another 5 seconds. If the overload condition has been removed, the instrument will turn on and resume normal operation.

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

3. <u>OUT CONNECTOR</u>. This SHV connector provides the main output signal, into load impedances of 1kΩ or higher. (The panel connector will mate to King Model 1705-2 connector for RG58A cable.)

4. <u>SYNC OUT</u>. 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 > 1kΩ with a pulse width of approximately 200 ns.

5. <u>LIQUID CRYSTAL DISPLAY (LCD)</u>. 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 "OP1B Interface Programming Manual" describes the menus and submenus in detail.

6. <u>KEYPAD</u>.

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

1. <u>AC POWER INPUT</u>. A three-pronged recessed male connector is provided on the back panel for AC power connection to the instrument. Also contained in this assembly is a slow-blow fuse and a removable card that can be removed and repositioned to switch between 120V AC in and 240V AC in.

   For AC line voltages of 110-120V, the power selector card should be installed so that the "120" marking is visible from the rear of the instrument.

   For AC line voltages of 220-240V, the power selector card should be installed so that the "240" marking is visible from the rear of the instrument.

   If it is not set for the proper voltage, remove the fuse and then grasp the card with a pair of pliers and remove it. Rotate horizontally through 180 degrees. Reinstall the card and the correct fuse.

   In the 120V setting, a 1.0A slow blow fuse is required. In the 240V setting, a 0.5A slow blow fuse is required. See the "Installation" section for more details.

2. <u>1.5A SB</u>. This fuse protects the DC power supply to the output stage.

3. <u>GATE</u>. 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 kΩ resistor. When set to active low mode, this input is pulled-up to +5V by a 1 kΩ resistor.

4. <u>TRIG</u>. 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 kΩ. (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) PE6008-50 BNC feed-thru 50 Ohm terminator is suggested for this purpose.)

When triggering externally, the instrument can be set such that the output pulse width tracks the pulse width on this input, or the output pulse width can be set independently.

5. GPIB Connector. A standard GPIB cable can be attached to this connector to allow the instrument to be computer-controlled. See the "OP1B Interface Programming Manual" for more details on GPIB control.

6. 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. See the "OP1B Interface Programming Manual" for more details on RS-232 control.

7. AMP Connector. (Optional feature. Present on "-EA" units only.) The output amplitude can be set to track the voltage on this input. Zero Volts in corresponds to zero amplitude output, and +10V in corresponds to maximum amplitude out. This mode is activated by selecting "Ext Control" on the front-panel amplitude menu, or with the "source:voltage external" command. (For -PN units, the output polarity remains at its last setting before the amplitude is switched to the external amplitude mode.)

GENERAL INFORMATION

BASIC PULSE 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.

- OUT. This is the main output. The maximum output voltage is $\pm3000V$.

- SYNC. 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, positive delay, and positive amplitude:

Figure A

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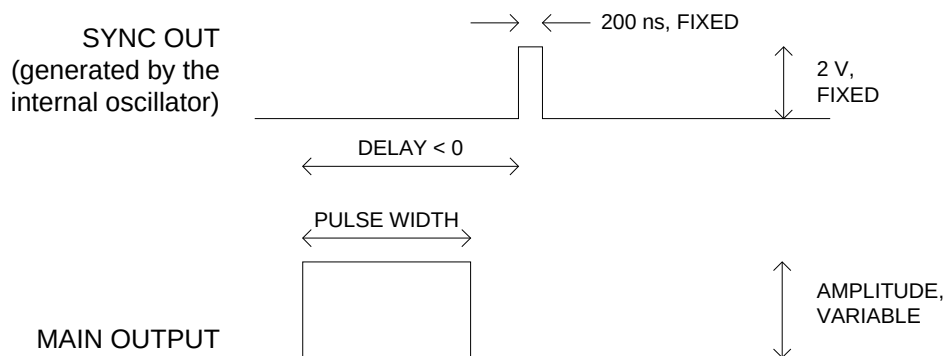
Figure B

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

Figure C

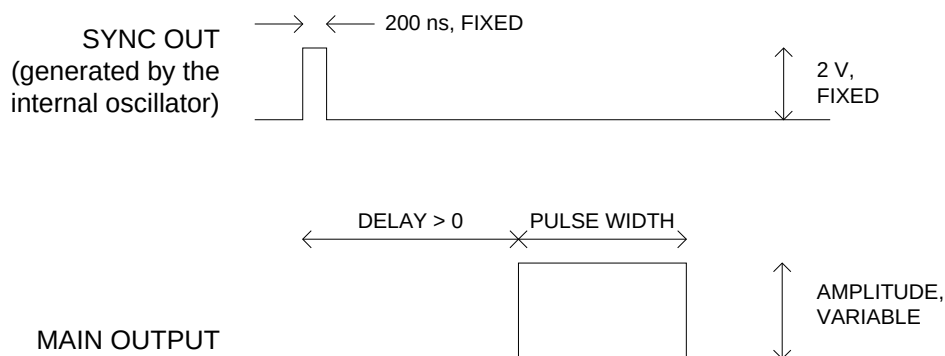As before, if the delay is negative, the order of the SYNC and OUT pulses is reversed.
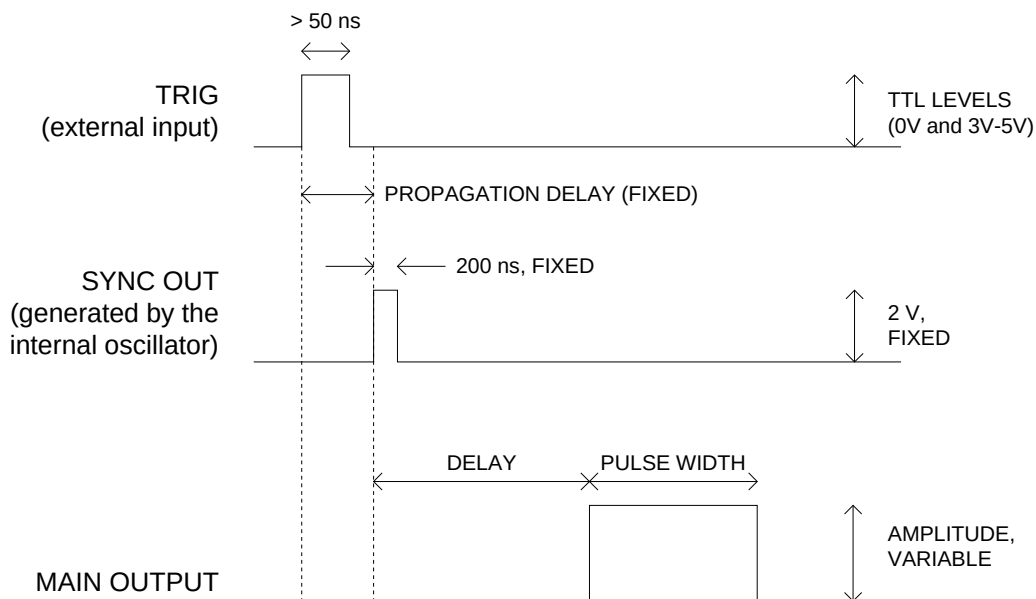
The last figure illustrates the relationship between the signal when an external TTL-level trigger is used in the $PW_{IN}=PW_{OUT}$ mode. In this case, the output pulse width equals the external trigger's pulse width (approximately), and the delay circuit is bypassed:
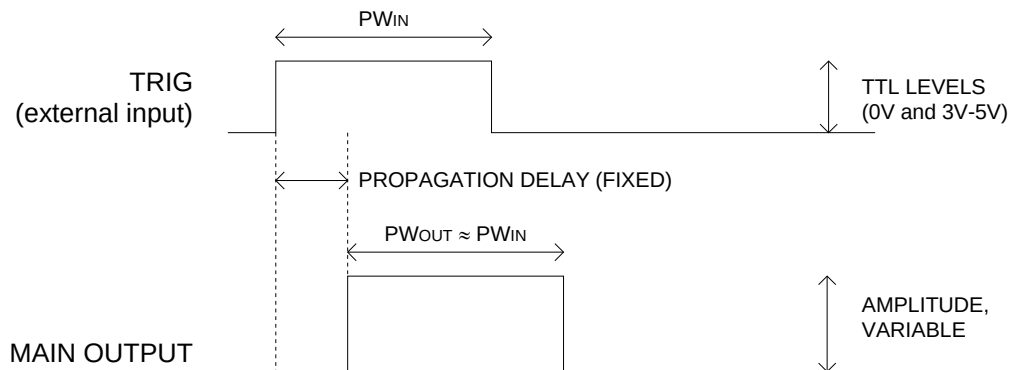

Figure D

In general, the delay, pulse width, and frequency (when in the internal mode), of the OUT pulse can be varied with front panel controls or via the GPIB or RS-232 computer interfaces.

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 "OP1B Interface Programming Manual" for more details.)

WARNING: The output stage may be damaged if triggered by an external signal at a pulse repetition frequency greater than 1 kHz.

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.

SYSTEM DESCRIPTION

The AVRH-3-C generates a 3,000 Volt pulse by first generating a 750 Volt pulse of the desired width. This pulse is then supplied to a x4 transformer which increases the output amplitude to 3,000 Volts (to R_L > 1K Ohms). DC potentials as high as 800 Volts are employed in the generation of the 750 Volt pulse so extreme caution must be employed when repairing this instrument. It is therefore highly recommended that the unit be returned to Avtech for all repairs beyond the replacement of the 1.0 Amp line fuse or the 1.0 Amp SB rear panel fuse.

AUDIBLE HUM

Note that when the amplitude or PRF or PW are increased, the output stage of the unit may emit an audible hum. This noise is normal and is due to the step-up transformer in the output stage.

TOP COVER REMOVAL

CAUTION: DC potentials as high as 800 Volts and pulse potentials as high as 3,000 Volts exist in the interior of the instrument. For this reason it is recommended that the top cover of the unit should not be removed and that the unit should be returned to the factory for servicing, if required.

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 BNC dust caps, to prevent unintentional electromagnetic radiation. All cords and cables should be less than 3m in length.

OPTIONAL FEATURES

RACK MOUNTING, "-R5" OPTION

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.

ELECTRONIC AMPLITUDE CONTROL, "-EA" OPTION

The output amplitude can be set to track the voltage on this input. Zero Volts in corresponds to zero amplitude output, and +10V in corresponds to maximum amplitude out. This mode is activated by selecting "Ext Control" on the front-panel amplitude menu, or with the "source:voltage external" command. For -PN units, the output polarity remains at its last setting before the amplitude is switched to the external amplitude mode.

PROTECTING YOUR INSTRUMENT

TURN OFF INSTRUMENT WHEN NOT IN USE

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. In the case of failure, the switching elements are easily replaced following the procedure described in a following section.

DO NOT EXCEED 1 kHz

The output stage may be damaged if triggered by an external signal at a pulse repetition frequency greater than 1 kHz.

REDUCE FREQUENCY AND PULSE WIDTH

In general, the lifetime of the output stage will be extended if the pulse repetition frequency and the pulse width are kept as low as possible.

USE A HIGH-IMPEDANCE LOAD

The load impedance must be 1 kΩ or higher (preferably $\geq$ 10 kΩ). The output stage may be damaged if lower impedances are used.

OPERATIONAL CHECK

This section describes a sequence to confirm the basic operation of the instrument. It should be performed after receiving the instrument. It is a useful learning exercise as well.

Before proceeding with this procedure, finish reading this instruction manual thoroughly. Then read the "Local Control" section of the "OP1B Interface Programming Manual" thoroughly. The "Local Control" section describes the front panel controls used in this operational check - in particular, the MOVE, CHANGE, and ADJUST controls.
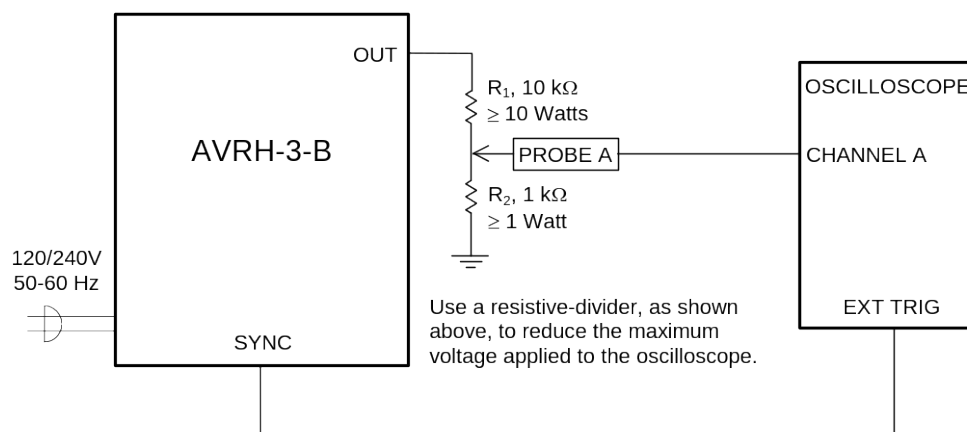
BASIC TEST ARRANGEMENT

1. Connect the pulse generator to a sampling oscilloscope as shown above. Note that:

   a) EXTREME CAUTION SHOULD BE FOLLOWED WHEN USING THIS INSTRUMENT AS IT GENERATES OUTPUT PULSE AMPLITUDES AS HIGH AS 3,000 VOLTS.

   b) The TRIG output channel provides TTL level signals (approximately 0 and +3V). To avoid overdriving the TRIG input channel of some scopes, a 20 dB attenuator may be required at the input to the scope trigger channel.

   c) The bandwidth capability of components and instruments used to display the pulse generator output signal (attenuators, cables, connectors, etc.) should exceed 50 MHz. Also, the coaxial cable between the SHV output connector and the load should not exceed about 0.5 meters (or the rise time will be degraded).

d) The load impedance should not be less than 1 kΩ as this will result in possible damage to the output stages. For test purposes, the test load should be greater than 10 kΩ. To protect the oscilloscope, two high-voltage resistors should be used to form a resistive-divider-type load. By using a 10 kΩ and a 1 kΩ resistor, as shown above, the voltage measure by the oscilloscope will be reduced by a factor of 11, compared to the voltage at the output connector.

e) Set the oscilloscope to trigger externally with the vertical setting at 50 V/div and the horizontal setting at 100 ns/div.

2. Turn on the AVRH-3-B. The main menu will appear on the LCD.

3. To set the AVRH-3-B to trigger from the internal clock at a PRF of 100 Hz:

   a) The arrow pointer should be pointing at the frequency menu item. If it is not, press the MOVE button until it is.

   b) Press the CHANGE button. The frequency submenu will appear. Rotate the ADJUST knob until the frequency is set at 100 Hz.

   c) The arrow pointer should be pointing at the "Internal" choice. If it is not, press MOVE until it is.

   d) Press CHANGE to return to the main menu.

4. To set the delay to 100 ns:

   a) Press the MOVE button until the arrow pointer is pointing at the delay menu item.

   b) Press the CHANGE button. The delay submenu will appear. Rotate the ADJUST knob until the delay is set at 100 ns.

   c) The arrow pointer should be pointing at the "Normal" choice. If it is not, press MOVE until it is.

   d) Press CHANGE to return to the main menu.

5. To set the pulse width to 500 ns:

   a) Press the MOVE button until the arrow pointer is pointing at the pulse width menu item.

   b) Press the CHANGE button. The pulse width submenu will appear. Rotate the ADJUST knob until the pulse width is set at 500 ns.

c) The arrow pointer should be pointing at the "Normal" choice. If it is not, press MOVE until it is.

d) Press CHANGE to return to the main menu.

6. At this point, nothing should appear on the oscilloscope.

7. To enable the output:

a) Press the MOVE button until the arrow pointer is pointing at the output menu item.

b) Press the CHANGE button. The output submenu will appear.

c) Press MOVE until the arrow pointer is pointing at the "ON" choice.

d) Press CHANGE to return to the main menu.

8. To change the output amplitude:

a) Press the MOVE button until the arrow pointer is pointing at the amplitude menu item.

b) Press the CHANGE button. The amplitude submenu will appear. Rotate the ADJUST knob until the amplitude is set at +1000V (or -1000V for "-N" models).

c) Observe the oscilloscope. You should see 500 ns wide, 1000V pulses. (Note that the resistor-divider load reduces the oscilloscope voltage by a factor of 11.) If you do not, you may need to adjust the delay setting to a value more compatible with your sampling oscilloscope. Repeat step 4 if required. You may also need to adjust the sampling scope controls.

d) Rotate the ADJUST knob. The amplitude as seen on the oscilloscope should vary. Return it to 1000V.

e) ("-PN" units only) Press the +/- button on the front panel. The amplitude as seen on the oscilloscope should flip polarity, to -1000V.

f) Press CHANGE to return to the main menu.

9. Try varying the pulse width, by repeating step (5). As you rotate the ADJUST knob, the pulse width on the oscilloscope will change. It should agree with the displayed value.

This completes the operational check.

PROGRAMMING YOUR PULSE GENERATOR

KEY PROGRAMMING COMMANDS

The "OP1B Interface Programming Manual" 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:width 500 ns        (sets the pulse width to 500 ns)
pulse:delay 20 ns         (sets the delay to 20 ns)
volt:ampl 2500            (sets the amplitude to +2500 V)
                          ("-N" units should use "volt:ampl -2500)
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)
pulse:width 500 ns        (sets the pulse width to 500 ns)
output on                 (turns on the output)
volt:ampl 2500            (sets the amplitude to +2500 V)
                          ("-N" units should use "volt:ampl -2500)
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 TRIG connector, use:

```
*rst                      (resets the instrument)
trigger:source external   (selects internal triggering)
pulse:width 500 ns        (sets the pulse width to 500 ns)
pulse:delay 1 us          (sets the delay to 1 us)
volt:ampl 2500            (sets the amplitude to +2500 V)
                          ("-N" units should use "volt:ampl -2500)
output on                 (turns on the output)
```

To set the output pulse width to track the trigger pulse width in external mode, use:

```
*rst                        (resets the instrument)
trigger:source external     (selects external triggering)
pulse:width in              (PW_OUT = PW_IN)
output on                   (turns on the output)
volt:ampl 2500              (sets the amplitude to +2500 V)
                            ("-N" units should use "volt:ampl -2500)
```

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 "OP1B Interface Programming Manual". (Note: this manual also includes some commands that are not implemented in this instrument. They can be ignored.)

Keyword	Parameter	Notes
LOCAL		
OUTPut:		
:[STATe]	<boolean value>	
:PROTection		
:TRIPped?		[query only]
REMOTE		
[SOURce]:		
:FREQuency		
[:CW | FIXed]	<numeric value>	
[SOURce]:		
:PULSe		
:PERiod	<numeric value>	
:WIDTh	<numeric value> | IN	
:DCYCle	<numeric value>	
:HOLD	WIDTh | DCYCle	
:DELay	<numeric value>	
:GATE		
:TYPE	ASYNC | SYNC	
:LEVel	HIgh | LOw	
[SOURce]:		
:VOLTage		
[:LEVel]		
[:IMMediate]		
[:AMPLitude]	<numeric value> | EXTernal	
: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]
```

PERFORMANCE CHECKSHEET