

## INSTRUCTIONS

MODEL AVR-5B-B

0 TO 500 Volts, 10 kHz 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 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

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## INTRODUCTION

The AVR-5B-B is a high performance, GPIB and RS232-equipped instrument capable of generating 0 to 500V at repetition rates up to 10 kHz into 50  $\Omega$  loads. The pulse width is variable from 100 ns to 100  $\mu$ s, and the duty cycle may be as high as 1%. Rise and fall times are fixed at less than 30 ns. The AVR-5B-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 output pulse width can be set to follow an input trigger pulse width.

The output voltage polarity depends on the model number:

- "-P" units: 0 to +500 Volts
- "-N" units: 0 to -500 Volts
- "-PN" units: 0 to  $\pm$ 500 Volts

The AVR-5B-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.

The instrument is protected against overload conditions (such as short circuits) by an automatic control circuit. An internal power supply monitor removes the power to the output stage for five seconds if an average power overload exists. After that time, the unit operates normally for one second, and if the overload condition persists, the power is cut again. This cycle repeats until the overload is removed.

## AVAILABLE OPTIONS

- EA Option: The amplitude can be controlled by an externally generated 0 to +10V analog control voltage.
- R5 Option: Rack-mount kit.
- HN Option: The standard N-type output connector is replaced with an HN-type connector.
- MHV Option: The standard N-type output connector is replaced with an MHV-type connector.
- SHV Option: The standard N-type output connector is replaced with an SHV-type connector.

## HIGH-VOLTAGE PRECAUTIONS

**CAUTION:** This instrument provides output voltages as high as 500 Volts, so extreme caution must be employed when using this instrument. The instrument should only be used by individuals who are thoroughly skilled in high voltage laboratory techniques. The following precautions should always be observed:

- 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 amplifier is turned off.
- 4) Consider using attenuators to reduce observed signals to lower and safer voltages.
- 5) Keep in mind that all cables, connectors, oscilloscope probes, and loads must have an appropriate voltage rating.

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.

### SPECIFICATIONS

|                                                |                                                                                                                                 |
|------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| Model:                                         | AVR-5B-B                                                                                                                        |
| Amplitude: -P units:<br>-N units:<br>-PN units | 0 to +500 Volts, to $R_L \geq 50$ Ohms<br>0 to -500 Volts, to $R_L \geq 50$ Ohms<br>0 to $\pm 500$ Volts, to $R_L \geq 50$ Ohms |
| Rise time:                                     | $\leq 30$ ns                                                                                                                    |
| Fall time:                                     | $\leq 30$ ns                                                                                                                    |
| PRF:                                           | 1 Hz to 10 kHz                                                                                                                  |
| Max. duty cycle:                               | 1%                                                                                                                              |
| Average power out<br>(maximum):                | 50 W                                                                                                                            |
| Computer control:                              | GPIO and RS-232 interfaces included                                                                                             |
| Propagation delay:                             | $\leq 100$ ns (Ext trig in to pulse out)                                                                                        |
| Jitter:                                        | $\pm 100$ ps (Ext trig in to pulse out)                                                                                         |
| Trigger required:                              | Internal Mode: +5 Volt, 50 ns or wider (TTL)<br>External Mode: +5 Volt, $PW_{IN} = PW_{OUT}$ (TTL)                              |
| Sync delay:                                    | Sync out to pulse out: Variable 0 to $\pm 100$ $\mu$ s                                                                          |
| Sync output:                                   | + 3 Volts, 200 ns, will drive 50 Ohm loads                                                                                      |
| Connectors:                                    | Out: N type, Trig: BNC, Sync: BNC, Gate: BNC                                                                                    |
| Power, AC:                                     | 120/240 Volts (switchable) 50 - 60 Hz                                                                                           |
| Dimensions:                                    | Mainframe: 100 mm x 430 mm x 375 mm (3.9" x 17" x 14.8")                                                                        |
| Chassis material:                              | Anodized aluminum, with blue plastic trim                                                                                       |
| 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.

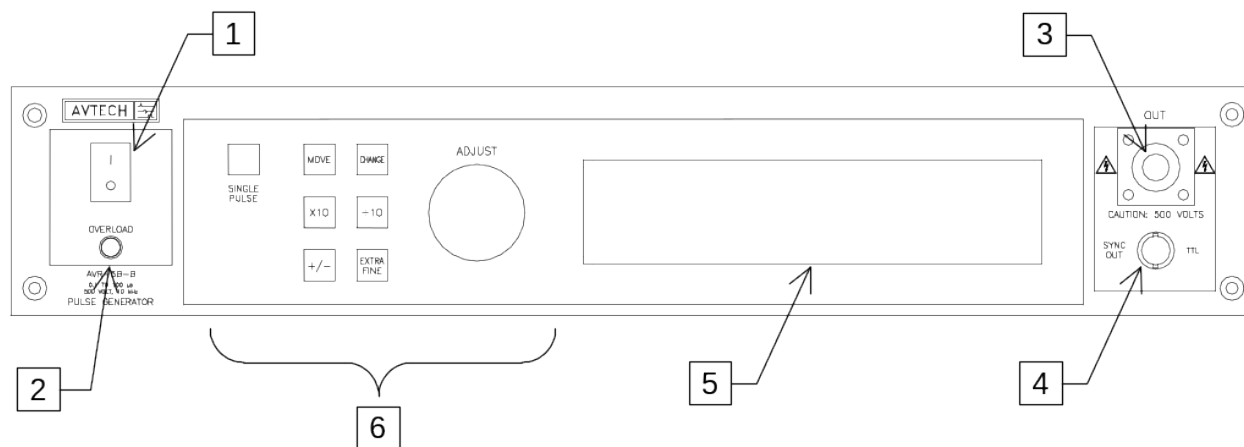
In the 120V setting, a 1.5A slow blow fuse is required. In the 240V setting, a 0.75A slow blow fuse is required.

### 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. **POWER Switch**. This is the main power switch.
2. **OVERLOAD**. The AVR-5B-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 is only likely to come on in two situations:

- Briefly at startup. This is not a cause for concern.
- When a low-impedance load ( $R_L < 50\Omega$ ), or a short-circuit, is connected to the output. In this case, turn off the instrument and connect the proper load.

Note that the output stage will safely withstand a short circuited load condition.

3. **OUT CONNECTOR**. This N-type connector provides the output to a  $50\Omega$  (or higher) load.
4. **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  $R_L > 1K$  with a pulse width of approximately 200 ns.

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.                                                                                                                                                                |
| $\times 10$  | If one of the adjustable numeric parameters is displayed, this increases the setting by a factor of ten.                                                                                                                                                            |
| $\div 10$    | 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.<br><br>When the main menu is displayed, this knob can be used to move the arrow pointer. |

6. 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 "OP1B Interface Programming Manual" describes the menus and submenus in detail.

## REAR PANEL CONTROLS



1. **AC POWER INPUT.** 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 1.5A slow blow fuse is required. In the 240V setting, a 0.75A slow blow fuse is required. See the “Installation” section for more details.

2. **3.15A Fuse.** This time-delay (slow-blow) fuse protects the output stage.
3. **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).
4. **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.
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.

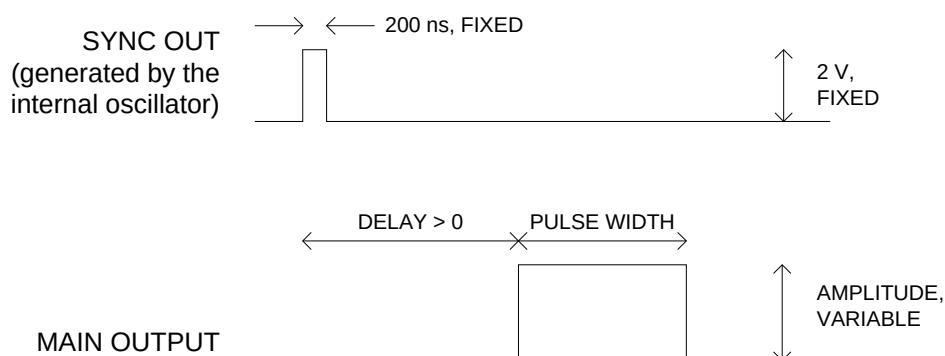
6. RS-232 Connector. A standard serial cable with a 25-pin male connector can be attached to this connector to allow the instrument to be computer-controlled. See the “OP1B Interface Programming Manual” for more details on RS-232 control.

## GENERAL INFORMATION

### BASIC PULSE CONTROL

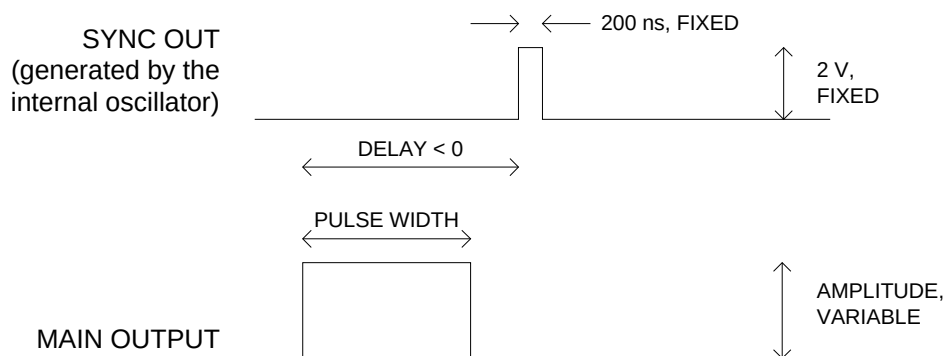
This instrument can be triggered by its own internal clock or by an external TTL trigger signal. In either case, two output channels respond to the trigger: OUT and SYNC. The OUT channel is the signal that is applied to the load. Its amplitude and pulse width are variable. The SYNC pulse is a fixed-width 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:

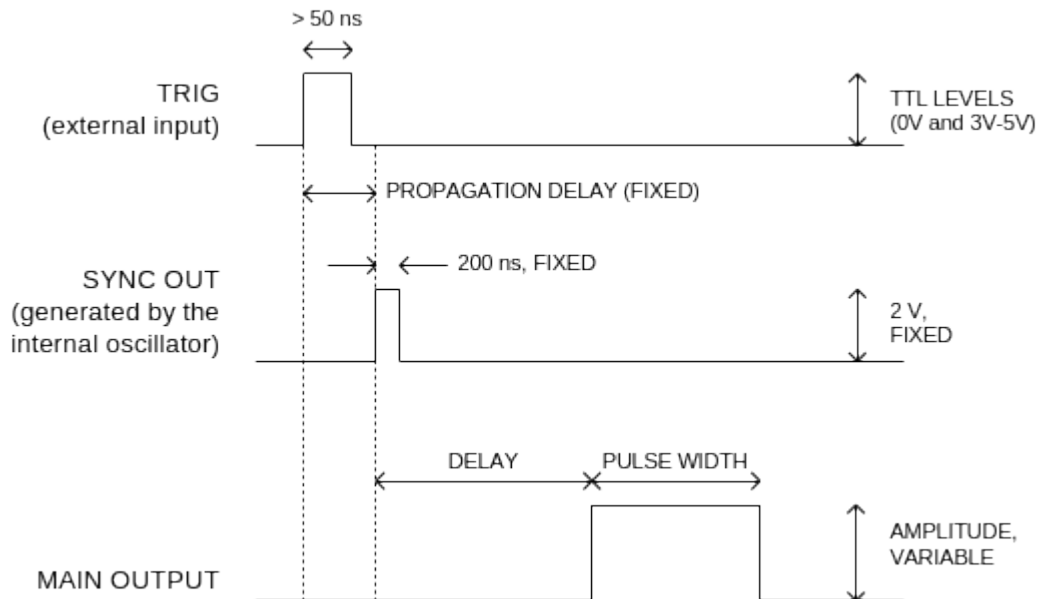


Figure C

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

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:

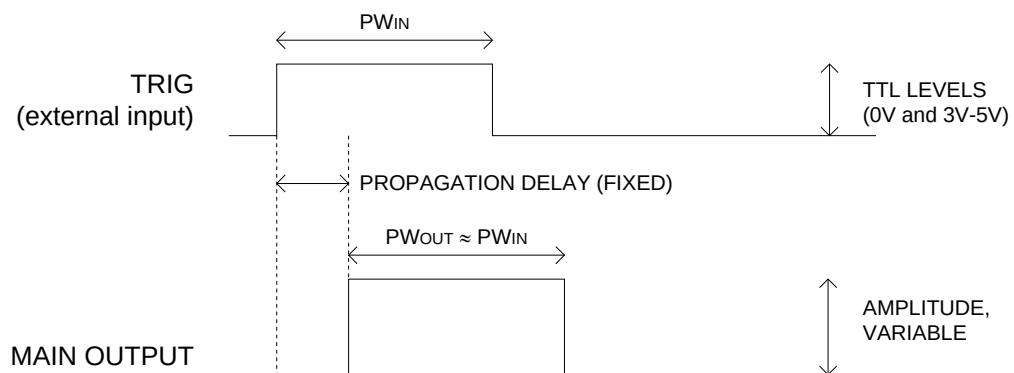


Figure D

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.)

### PULSE WIDTH MODES

This instrument has two pulse width modes:

- Normal: the instrument controls the output pulse width.
- $PW_{IN}=PW_{OUT}$ : the output pulse width equals the pulse width of the trigger signal on the “TRIG” connector. The instrument must be in the external trigger mode.

These modes can be selected using the front panel pulse width menu, or by using the appropriate programming commands. (See the “OP1B Interface Programming Manual” 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. This input can also be set to act synchronously or asynchronously. When set to asynchronous mode, the GATE will disable the output immediately. Output pulses may be truncated. When set to

synchronous mode, the output will complete the full pulse width if the output is high, and then stop triggering. No pulses are truncated in this mode.

### 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. The polarity remains at its last setting.

### OUTPUT IMPEDANCE

The AVR-5B-B features an output impedance of the order of several Ohms (rather than 50 Ohms). The following consequences of this feature should be noted:

- When used to switch some semiconductor devices (eg. bipolar and VMOS power transistors), the AVR unit will yield much faster switching times than those provided by 50 Ohm pulse generators.
- The AVR unit will safely operate in to load impedances in the range of 50 Ohms to an open circuit. However, the fall time may degrade for load impedances higher than fifty Ohms.
- The AVR unit may be effectively converted to a fifty Ohm output impedance generator by placing a fifty Ohm carbon composition resistor in series with the output of the unit and the load. The maximum available load voltage will then decrease to 250 Volts (from 500 Volts).

### PREVENTING OUTPUT STAGE FAILURE

The output stage is protected against overload condition by the overload module and a 3.0 A slow blow fuse on the main frame back panel. However, the output switching elements may fail if the unit is triggered at a PRF exceeding 10 kHz or at duty cycles resulting in an average output power in excess of 50 Watts. Heating and subsequent possible failure of the output stage is reduced if the following action is taken where possible:

- PRF is kept to a minimum, i.e. operate in a low PRF range when possible rather than in a high PRF range.
- Keep the output PW to a minimum.



- Never apply an externally generated voltage to the output port.
- Reduce the amplitude below 100 Volts before changing the output polarity. Note that internal protection circuits will prevent the polarity from switching when the amplitude is set higher than  $\pm 100\text{V}$ , until the internal power supplies have discharged the voltage on the internal energy-storage capacitors to below  $\pm 100\text{V}$ . This may take several tens of seconds.

### ELECTROMAGNETIC INTERFERENCE

To prevent electromagnetic interference with other equipment, all used outputs should be connected to shielded  $50\Omega$  loads using shielded  $50\Omega$  coaxial cables. Unused outputs should be terminated with shielded  $50\Omega$  BNC terminators or with shielded BNC dust caps, to prevent unintentional electromagnetic radiation. All cords and cables should be less than 3m in length.

### 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.

### TOP COVER REMOVAL

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).

**CAUTION!** Extreme caution should be followed when using this instrument as it generates output pulse amplitudes as high as 500 Volts. DC potentials as high as 550 Volts are generated internally. It is therefore highly recommended that the unit be returned to Avtech for all repairs beyond the replacement of the AC line fuse or the DC rear-panel fuse.

## 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.

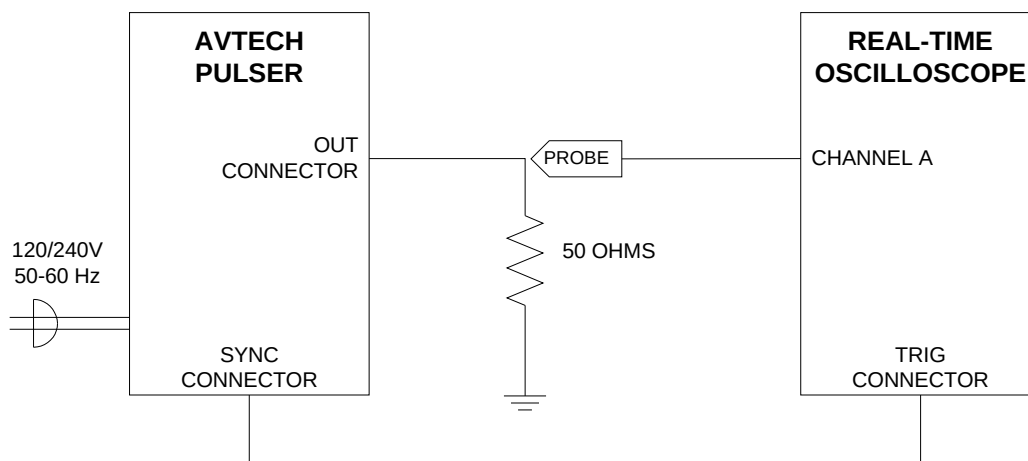
Before proceeding with this procedure, finish read this instruction manual thoroughly. Then read the “Local Control” section of the “OP1B Interface Programming Manual” thoroughly. The “Local Control” section describes the front panel controls used in this operational check - in particular, the MOVE,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

1. Connect a cable from the SYNC OUT connector to the TRIG input of an oscilloscope. Connect a 50W (or higher) 50Ω load to the OUT connector and place the scope probe across this load. The load resistor must have a voltage rating of at least 500V. The power dissipated in the resistor is given by

$$P = \frac{V^2}{R} \times \frac{PW}{T} = \frac{V^2}{R} \times PW \times f ,$$

where “V” is the output voltage, “R” is the load resistance, “PW” is the pulse width, and “T” is the pulse period (1/frequency), and “f” is the frequency.

2. Set the oscilloscope to trigger externally with the vertical setting at 100 Volts/div and the horizontal setting at 1 μs/div. Be sure that your oscilloscope and probe setup can handle the maximum amplitude of 500V. An attenuator might be necessary to avoid damaging the probe and oscilloscope.



The 50Ω load resistor should be rated for at least 500V of voltage and 50W of power.

3. Turn on the AVR-5B-B. The main menu will appear on the LCD.
4. To set the AVR-5B-B to trigger from the internal clock at a PRF of 1 kHz:
  - The arrow pointer should be pointing at the frequency menu item. If it is not, press the MOVE button until it is.
  - Press the CHANGE button. The frequency submenu will appear. Rotate the ADJUST knob until the frequency is set at 1 kHz.
  - The arrow pointer should be pointing at the “Internal” choice. If it is not, press MOVE until it is.
  - Press CHANGE to return to the main menu.
5. To set the delay to 1  $\mu$ s:
  - Press the MOVE button until the arrow pointer is pointing at the delay menu item.
  - Press the CHANGE button. The delay submenu will appear. Rotate the ADJUST knob until the delay is set at 1  $\mu$ s.
  - The arrow pointer should be pointing at the “Normal” choice. If it is not, press MOVE until it is.
  - Press CHANGE to return to the main menu.
6. To set the pulse width to 1  $\mu$ s:
  - Press the MOVE button until the arrow pointer is pointing at the pulse width menu item.
  - Press the CHANGE button. The pulse width submenu will appear. Rotate the ADJUST knob until the pulse width is set at 1  $\mu$ s.
  - The arrow pointer should be pointing at the “Normal” choice. If it is not, press MOVE until it is.
  - Press CHANGE to return to the main menu.
7. At this point, nothing should appear on the oscilloscope.
8. To enable the output:

- Press the MOVE button until the arrow pointer is pointing at the output menu item.
- Press the CHANGE button. The output submenu will appear.
- Press MOVE until the arrow pointer is pointing at the “ON” choice.
- Press CHANGE to return to the main menu.

9. To change the output amplitude:

- Press the MOVE button until the arrow pointer is pointing at the amplitude menu item.
- Press the CHANGE button. The amplitude submenu will appear. Rotate the ADJUST knob until the amplitude is set at +200V (or -200V for "-N" instruments).
- Observe the oscilloscope. You should see 1  $\mu$ s wide, 200V pulses.
- Rotate the ADJUST knob. The amplitude as seen on the oscilloscope should vary.
- Reduce the amplitude to 50V (or -50V for "-N" instruments), using the adjust knob.
- *For "-PN" units only:* Change the output polarity by pressing the “+/-” button. The output amplitude should become negative, and you should see -50V pulses on the oscilloscope. (Avoid switching polarity when the amplitude is higher than 100V. Reduce the amplitude first.)
- Rotate the ADJUST knob. The amplitude as seen on the oscilloscope should vary.
- Press CHANGE to return to the main menu.

10. Repeat step 9, but set the amplitude to zero.

11. 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 1 us        | (sets the pulse width to 1 us)  |
| pulse:delay 2 us        | (sets the delay to 2 us)        |
| volt 200                | (sets the amplitude to 200 V)   |
| 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 1 us         | (sets the pulse width to 1 us)                    |
| pulse:delay 2 us         | (sets the delay to 2 us)                          |
| output on                | (turns on the output)                             |
| volt 200                 | (sets the amplitude to 200 V)                     |
| 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 1 us        | (sets the pulse width to 1 us) |
| pulse:delay 2 us        | (sets the delay to 2 us)       |
| volt 200                | (sets the amplitude to 200 V)  |
| output on               | (turns on the output)          |

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.)

| <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>   EXTeRnal |                                  |
| :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 CHECK SHEET