Programmable Isolated High-Powered Stimulator

4100

INSTRUCTION MANUAL
FOR
PROGRAMMABLE ISOLATED HIGH-POWERED STIMULATOR

MODEL 4100

Each Programmable Isolated High Powered Stimulator delivered complete with:

10' Ethernet Cable
Rack Mount Hardware

Version 5.0
March, 2020

A-M Systems,
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WARNING

THIS EQUIPMENT IS NOT INTENDED FOR USE ON HUMAN SUBJECTS IN ANY WAY.

Document

The information contained in this manual was as accurate as possible at the time of publishing, but is subject to change without notice and should not be construed as a commitment by A-M Systems, Changes may have been made to the hardware or firmware it describes since publication. A-M Systems, reserves the right to change specifications as required. For the latest information please check our website (http://www.a-msystems.com) or contact A-M Systems, directly.

Manual Document Number
5027915 Rev 05

Safety

This instrument is provided with terminal for protective grounding. Before applying power, verify that the correct safety precautions are taken (see the following warnings). In addition, note the external markings on the instrument that are described under Safety Symbols. Do not operate the instrument with its cover removed. Replace fuse only with specified type.

Supply Voltage

This equipment can be operated at 120V/60Hz, or 220V/50Hz, as determined by the position of the fuse box on the rear panel. Other voltage/frequency combinations are not recommended unless the manufacturer is contacted before first usage.

WARNING

Do not attach a line voltage that does not match the line voltage specified on the rear panel.

Before turning on the instrument, you must connect the protective earth terminal of the instrument to the protective earth conductor of the (mains) power cord. The mains plug must only be inserted in a socket outlet with a protective earth contact.

Service should be performed by trained personnel only. To avoid dangerous electric shock, do not perform any service unless qualified to do so.

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a safety hazard.

Safety Symbols

The product is marked with this symbol when it is necessary for you to refer to the instruction manual in order to protect against damage to the product.

WARNING

The Warning symbol calls attention to a procedure or practice, which, if not correctly performed could result in injury. Do not proceed beyond a Warning symbol until the indicated conditions are fully understood and met.

CAUTION

The Caution symbol calls attention to a procedure or practice, which, if not correctly performed could result in damage to the product. Do not proceed beyond a caution until the indicated conditions are fully understood and met.

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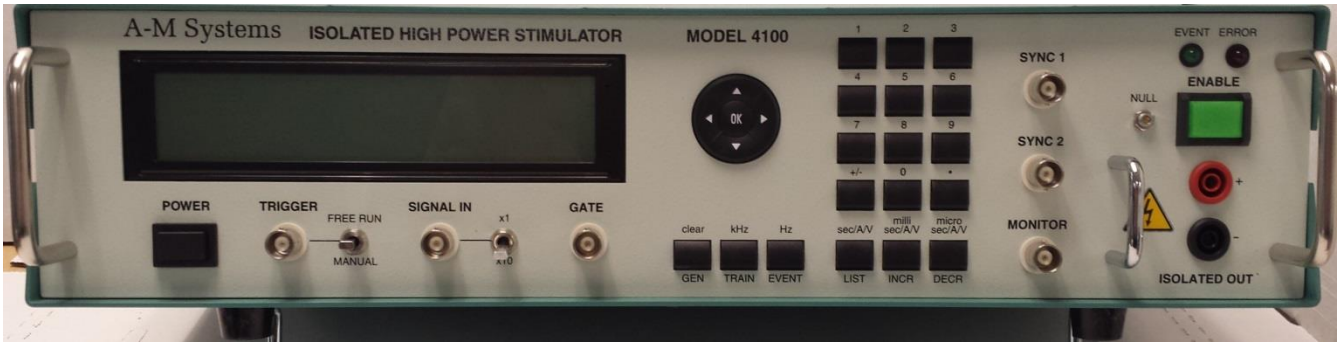


1. General Description

The *Model 4100 Programmable Isolated High-Powered Stimulator* is a single channel programmable stimulator designed for a wide variety of applications, including field stimulation. It is highly flexible, being capable of delivering trains comprised of monophasic, biphasic, ramped, triangular, or trapezoidal waveforms.

Instrument control is accomplished by the front panel interface or via software applications utilizing Ethernet connections. Timing can be triggered and gated using either internal or external commands. Sync pulses are available for use by other instruments and can track a variety of critical timing features.

The *Model 4100 Programmable Isolated High-Powered Stimulator* can produce pulses ranging in duration from two microseconds to 25 days. Amplitudes can be set to range from –200V to +200V at 100mA. These outputs are already isolated; no external SIU is needed.

The *Model 4100 Programmable Isolated High-Powered Stimulator* can also serve as a linear isolator using its SIGNAL IN circuitry. The 4100 will scale and isolate any waveform you can provide.

The *Model 4100 Programmable Isolated High-Powered Stimulator* also provides multiple independent sync pulses that can serve as timing instructions for other instruments.

The Model 4100 Programmable Isolated High-Powered Stimulator is not approved for clinical or operating room experiments in human subjects.

When you receive your Model 4100, confirm that everything in the packing list is included. Make sure there are no obvious signs of internal damage, such as rattling. Pick up the instrument and tilt in gently from side to side, and listen for anything that might be loose. If you hear any suspicious noises, contact A-M Systems immediately.

2. SAFETY INSTRUCTIONS

*** SAFETY WARNING ***

SAFE AND PROPER USE OF THIS INSTRUMENT IS THE RESPONSIBILITY OF THE USER OF THIS INSTRUMENT.

A-M Systems provides information on its products and associated hazards, but it assumes no responsibility for the after-sale operation and safety practices.

ALL PERSONNEL WHO WORK WITH OR ARE IN THE PRESENCE OF THIS INSTRUMENT MUST TAKE PRECAUTIONS TO PROTECT THEMSELVES AGAINST POSSIBLE SERIOUS INJURY, INCLUDING THE RISK OF FATALITY.

NOT FOR HUMAN USE.

The high voltage/high current nature of this device dictates the use of caution when operating this equipment. THERE ARE NO USER SERVICEABLE COMPONENTS INSIDE THE INSTRUMENT. Any repairs should be made by the trained personnel of A-M Systems. OBSERVE ALL SAFETY PRECAUTIONS LISTED BELOW.

Normal use of test equipment exposes you to a certain amount of danger from electrical shock because testing must sometimes be performed where exposed voltage is present. An electrical shock causing 10 milliamps of current to pass through the heart will stop most human heartbeats. Voltage as low as 35 volts DC or AC rms should be considered dangerous and hazardous since it can produce a lethal current under certain conditions. Higher voltages pose an even greater threat because such voltage can more easily produce a lethal current. Your normal work habits should include all accepted practices to prevent contact with high voltages, and to steer current away from your heart in case of accidental contact with a high voltage. You will significantly reduce the risk factor if you know and observe the following safety precautions

1) The Model 4100 Isolated High Power Stimulator should be serviced only by personnel experienced in high voltage pulsed power systems.

2) NEVER connect or disconnect the High Voltage output cables while the stimulator is in operation. ALWAYS switch power off and wait at least 30 seconds before connecting or disconnecting cables. Failure to observe these precautions can result in potential electric shock to personnel.

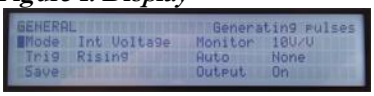
3) Pulsed power systems are capable of random triggering via transients and therefore when the stimulator is turned on, or high voltage is present in the unit, assume it is possible to get a pulse on the output cable.

3. Front & Rear Panels

This chapter describes the front and rear panel controls and connectors on the Model 4100.

Front Panel

Figure 1. Display



Display

The liquid crystal display (LCD) on the Model 4100 indicates the status of all of the settings required to control the Model 4100 functions.

Figure 2. Power

Power

Depressing this button turns on the instrument; the front panel display should illuminate.

Trigger

Figure 3. Trigger

Timing can be initiated either by software or by this switch and BNC connector on the Front Panel.

When set to **FREE RUN**, timing begins immediately, and after completion of the defined timing cycle, a new timing cycle begins. This continues until the switch is moved to the center position. When the switch is in the middle position (indicated by the horizontal line), timing cycles start when valid triggering events occur: presentation of a 5V pulse to the BNC or initiate commands from the software. When momentarily depressed into the **MANUAL** position, a single timing cycle starts immediately. ***Note***: If set to free run, the instrument will repeat timing independent of the software settings.

Signal In

Figure 4. Signal In

User generated waveforms can be scaled, isolated, and converted to constant Voltage or Current by the Model 4100. Application of any signal between +/- 10V to this BNC will result in a properly converted output at the Isolated High Power banana plug output connectors.

Actual gain on your signal is set by the MODE on the ***GENeral*** screen or the software: Settings include 10mA/V, 1mA/V, 100uA/V, 20V/V. For example, if you set Signal In to 10mA/V, that means that for every volt in your input signal, you would see a 10mA output signal amplitude.

If your signal generating device is limited to outputs under +/-1V in amplitude, the adjacent switch can add an additional 10x gain your input signal for maximal signal output.

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Gate

Figure 5. Gate

Timing will continue, but the Isolated Signal Output and Monitor will be disabled when a ground level signal (0 volts) is presented to the GATE BNC: If there is a HOLD value, the Isolated Signal Output amplitude will be held at HOLD. If there is no HOLD value, Isolated Signal Output will be held at 0V. MONITOR Output will move to 0 Volts.

Keypad

Figure 6. Keypad

The keypad provides numeric data entry to the device. +/- will toggle the sign of the entered numeric value. No values are active until the **OK** button of the navigation wheel is pressed.

Navigation Wheel

Figure 7. Navigation Wheel

Pressing any of the directional triangles will move the cursor in the display to the next available variable. Pressing **OK** enters the value to the unit's microcontroller.

Units & Screen Navigation

Figure 8. Units and Screen Navigation

When the cursor is placed over an active variable, these buttons take the upper labels as their function. Otherwise, they take on the lower functionality.

CLEAR deletes the last number entered.

KHZ sets the units in a frequency field to kHz.

HZ sets the units in a frequency field to Hz.

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SEC/A/V sets the units to Seconds or Amps or Volts as appropriate for the active variable.

MILLI SEC/A/V sets the units to milliseconds or milliamps or millivolts as appropriate for the active variable.

MICRO SEC/A/V sets the units to microseconds or microamps or microvolts as appropriate for the active variable.

GEN returns the display to the initial ***GENERAL*** screen

TRAIN returns the display to the initial ***TRAIN*** screen

EVENT returns the display to the initial ***EVENT*** screen

LIST returns the display to the ***EVENT LIST*** screen

INCR will either increase the numeric value by the predesignated step size, or cycle through the available entries in a list.

DECR will either decrease the numeric value by the predesignated step size, or cycle through the available entries in a list in reverse order

Syncs

These SYNC BNCs can be configured to provide 5V level outputs synchronized in times with particular timing events depending on user selected options in the general configuration screen. Options include: Train Delay, Train Duration, Event Delay, Total Event Duration, Event Duration 1, Event Duration 2, Event Duration 3, and assorted clock intervals.

Figure 9. Syncs

Monitor

Figure 10. Monitor

The signal at this output is a non-isolated low power version of the output signal, and can be used for monitoring the actual output without loading the device. It is provided for use as an oscilloscope or A/D system input signal. Users have the options of several scaling factors: 0.1V/V, 1V/V, 10V/V, 20V/V, 10 uA/V, 100uA/V, 1mA/V, and 10mA/V. The maximum output level at the monitor BNC is +/-10V. It is critical to select the appropriate setting for the monitor such that the largest event in the train to be delivered does not exceed 10V on the monitor (Monitor Output = Actual Output Amplitude * Monitor Scaling). For example, if the monitor is set to 0.1V/V setting, all events must be 1V or less for an accurate and proportional monitor signal. If any events exceed 1V, the monitor output will be in error. ***Note***: When *Instrument Enable* is disabled (unlit / out), the monitor will not produce outputs.

Setting	0.1V/V	1V/V	10V/V	20V/V	10uA/V	100uA/V	1mA/V	10mA/V
Max Signal	±1V	±10V	±100V	±200V	±100uA	±1mA	±10mA	±100mA

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Figure 11. LEDs

LED Indicators

The green EVENT light illuminates according to the settings of SYNC1. The red ERROR light illuminates if an error in a timing setting or an amplitude value occurs.

Figure 12. Enable

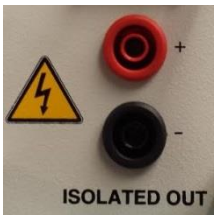
Enable

This switch needs to be depressed and illuminated for signals generated to be presented to the output banana connectors. Pressing this switch while the green light is on will disconnect the isolated high power output connectors from the unit's output circuit and turn off the switch's light.

Pulse timing will continue uninterrupted. So, if the switch is then depressed while the display indicates "Generating Pulses", it is possible that incomplete pulses will be immediately delivered to the electrodes.

This lamp will flash when the output is enabled, pulses are being generated, and they are of high voltage or current values.

Figure 13. Isolated High Power Output



Isolated High Power Output WARNING

These touch-proof banana plug compatible connectors provide the high-power isolated device output. This connector is designed for traditional or sheathed banana plugs.

Use of a common dual banana plug to BNC adapter is STRONGLY DISCOURAGED as it can lead to significant, including fatal, injury.

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Bias Adjust

Figure 14. Offset Adjust

This trimpot adjusts the output offset. This should be zeroed by monitoring the isolated high power output while the unit is on, the output is enabled, but the unit is not generating pulses. This should be done after the instrument has been on for at least 30 minutes, and with a resistive load across the output leads that is of approximately the same value as your experimental load.

Rear Panel

Power Cord Connector

Figure 15. Power Cord Input

This connector contains a drawer with a 250V fuse. Replace only with fuses of identical value.

Ethernet

Figure 16. Ethernet

This connector enables a personal computer running any of the supplied Windows/Matlab/Labview/OSx/iOS/Android programs to control the Model 4100 by attaching it the internet. IP Address is set by the CONFIGURE screen variable. If no Ethernet connector is available on the host computer, then the use of a USB to Ethernet adapter is recommended.

USB

Figure 17. USB

This connector is provided to enable control of the program via user written software, or by A-M Systems supplied firmware update software. *Note that the supplied Windows\OSx\iOS\Android software cannot use the USB connector, and must use the Ethernet connector.* However, users of Matlab/Labview, or their own programs can use the USB connector.

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Digital Out

At this time, this connector is not used and is reserved for future expansion

Figure 18. Digital I/O

Serial Number & MAC Address

A label affixed to the rear panel indicates the instruments unique MAC (media access control) address that your network administrator might require during installation of the Model 4100 on your network.

Figure 19. MAC Address

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4. Overview & Definitions

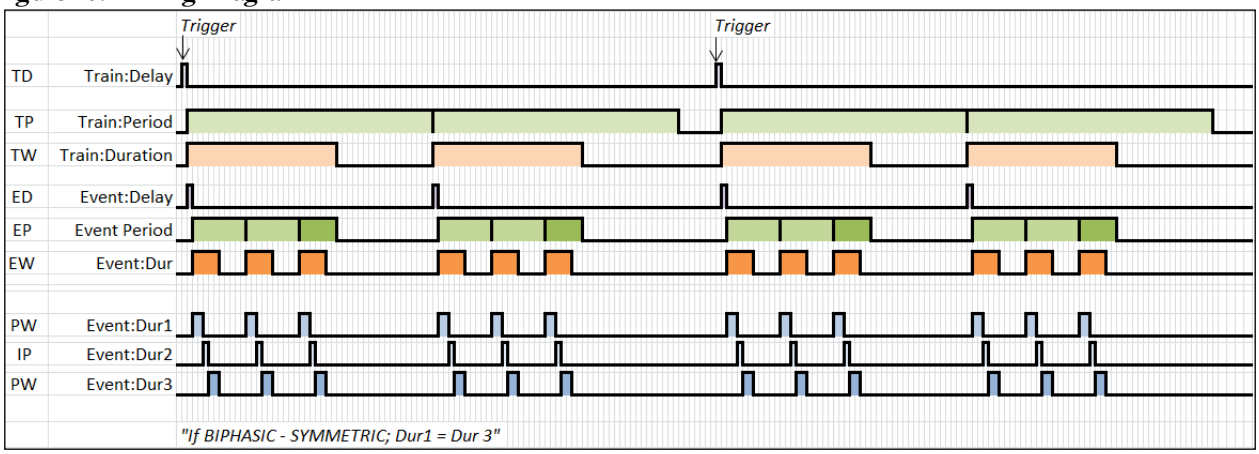
This section will present an overview of instrument function, including timing diagrams and definitions. Detailed information about instrument functions, settings, and programming follow later in the manual.

The Model 4100 allows users to define events, and then link those events into trains for the instrument to produce. Events can vary in waveform shape, amplitude, timing, and count. Events can be grouped together in sequence, and the timing of the delivery sequence can be controlled.

The next section covers the assorted timing definitions the Model 4100 follows.

Timing Trains and Events

Figure 20. Timing Diagram



Trains

A train consists of a repeating sequence of events.

Following a trigger input (TR), there are 3 defined time periods:

1) Train delay (TD): duration from trigger input to onset of first pulse. There is only a single TD per Trigger, regardless of the number of trains requested per trigger.

2) Train Duration (or Train width, TW): epoch beginning at end of train delay; events are generated during Train Duration

3) Train period (TP): interval between onset of successive train durations (widths)

The number of trains delivered per TRIGGER is determined by Train Number (TN)

Simultaneous with the onset of the Train Width (TW) period is the onset of Event Timing.

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The entire sequence of events, as determined but the event list, is completed within one TW period.

Similar to a train, there are 3 defined time periods in event timing, where the end of one begins the next:

1) Event delay (ED): duration from end of Train Delay to the onset of first event. There is only a single ED per Train, regardless of the number of events requested per train.
2) Event Duration (or width, EW): duration of the event
3) Event period (EP): interval between the onsets of successive events

Triggering, Gating & Counting

The onset of train timing requires a TRIGGER input. Triggers can be internally or externally generated. An internal trigger occurs when the unit is set to Free Run.

External triggers are TTL inputs to front BNC's, that can initiate train timing either on their leading or their trailing edge, or the use of the assorted software control programs.

NOTE: Triggers that arrive during active train sequence timing are ignored (trigger #5 below)

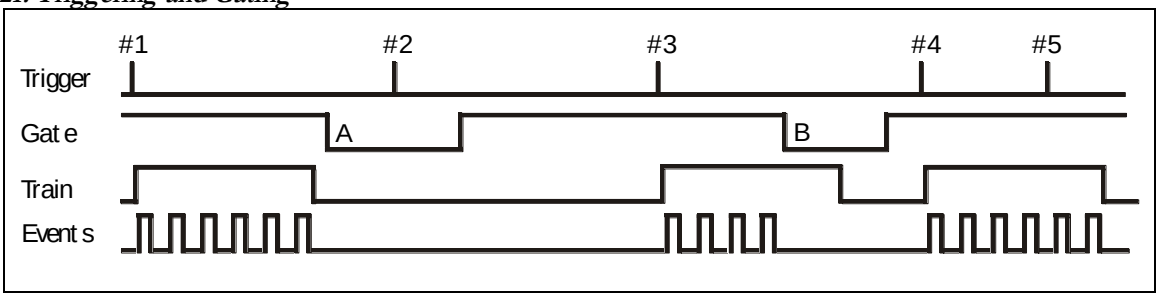
GATING. The operation of the output can be gated, such that if the GATE signal is low, the channel will not respond to any trigger inputs, and the output will go to the HOLD voltage (if defined) or 0V.

Some examples are diagramed below:

Gate occurrence A prevented train generation in response to trigger #2

Gate occurrence B terminated output generation during train triggered by trigger #3.

Figure 21. Triggering and Gating



COUNTING

The user determines the number of train timing sequences to be delivered by setting the Train Number. Once the defined number of train sequences has been completed, train timing generation ceases and the channel can accept new trigger input.

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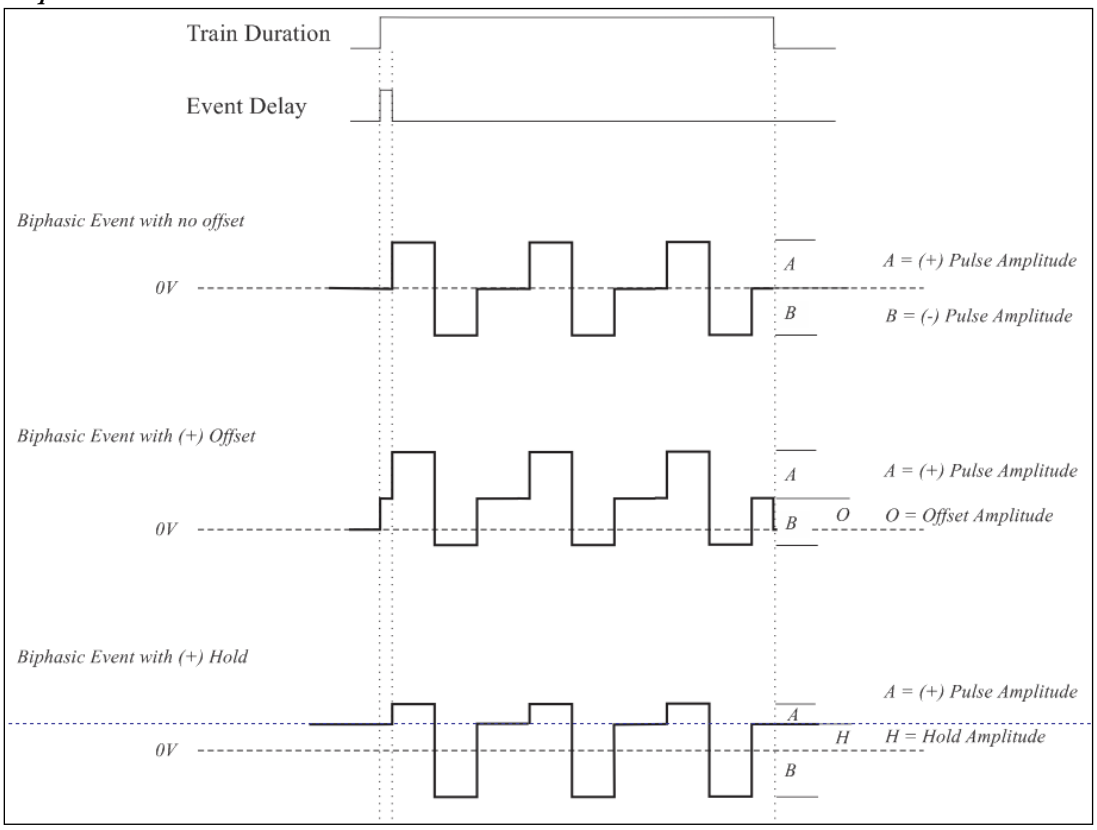
Output – Hold and Offset

The output can be shifted by a constant amount. This amplitude can either be a HOLD, or an OFFSET, and is determined by a setting on the TRAIN screen. HOLD voltages/currents are applied as long as the Model 4100 is on. They are not applied during EVENT durations. OFFSETS are applied only during TRAIN timing, and sum with any specified EVENT amplitudes. Holds or Offsets can be either voltages or currents, and can be positive or negative.

Figure 22. Output Offsets



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5. Operation Guide

A Train of Identical Events

This chapter describes how to program the Model 4100 to produce a basic train of pulses in order to explore its functionality. Arrow indicators (➡) highlight actions to be performed during the tour.

➡ ***1.*** Depress and hold **GEN** on the front panel while turning the power on. Do not release the **GEN** button for 5 seconds. The Model 4100 will load a preloaded train definition that will produce two pulse trains consisting of two monophasic pulses from its onboard memory.

➡ ***2.*** Connect **SYNC1** to Channel 1 on your oscilloscope. Set the oscilloscope amplitude to 5V/div.

➡ ***3.*** Connect **MONITOR** to Channel 2 on your oscilloscope. Set the oscilloscope amplitude to 5V/div.

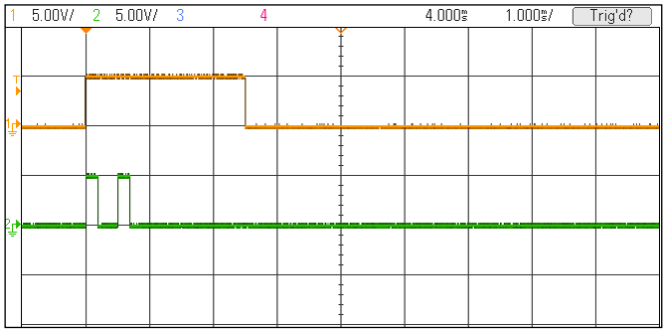
➡ ***4.*** Configure your scope time-base to be triggered by Channel 2 and the sweep speed set to 1ms/div.

➡ ***5.*** Depress the Model 4100 **ENABLE** button so it illuminates.

➡ ***6.*** Momentarily depress **TRIGGER** switch from its middle position and release.

Your scope display should look like Figure 23; if not, confirm that your scope trigger is set to Channel 1 rising trigger and that the horizontal trace is adjusted to the farthest left side of the screen).

Figure 23. Scope: Monophasic Pulse Train



Channel 1 on your oscilloscope (upper trace in Figure 23) should show one sync equivalent to Train Duration indicating the time period that the 4100 can generate stimulus events (see Chap 4 for timing definitions). In this case, the train duration is 2.5ms long.

Channel 2 (lower trace) on your oscilloscope display should show two pulse trains, each consisting of two monophasic pulses. Each pulse should be 200us in duration and have an amplitude of +5V. The two pulses should have an onset-to-onset pulse period of 500us.

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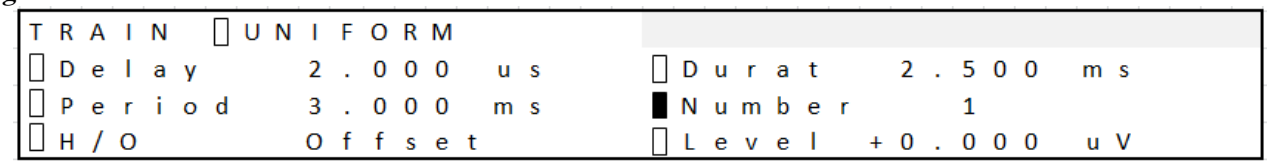
➡ ***7.*** Press **TRAIN** to display the TRAIN screen, where the basic timing parameters of stimulus trains are programmed.

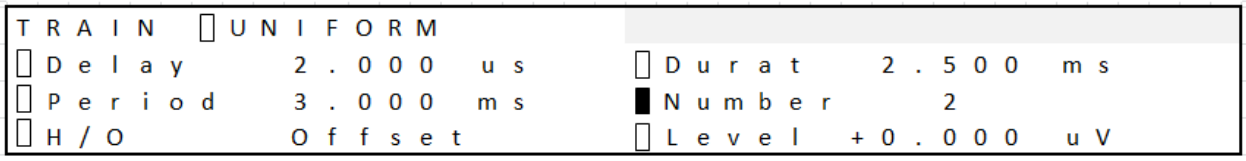
Figure 24. Train Definition

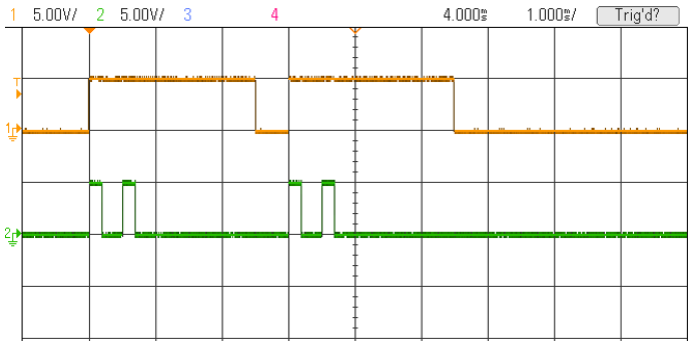


➡ ***8.*** Using the arrow navigation keys, navigate the cursor to the space just to the left of NUMBER and enter a value of *2* followed by hitting **OK** on the circular navigation switch. Momentarily depress the TRIGGER switch. The oscilloscope display should now indicate two trains, each 2.5ms in duration, with the second train starting 3ms after onset of the first train (Figure 25; next page). *Note: Trains must have a 2.0uS delay at a minimum from Trigger onset to Stimulus Onset.*

*The circular navigation switch moves the cursor around the LCD according to the directional arrows. Pressing '**OK** is typically required to enter the value. For the Figures that follow of the LCD screens, the cursor locations are indicated by the small box outlines. These outlines are not actually displayed on the screen; rather, the black filled cursor jumps from location to location. The shaded area in these figures is reserved for the system to display status information or error messages.*

Figure 25. Train Number





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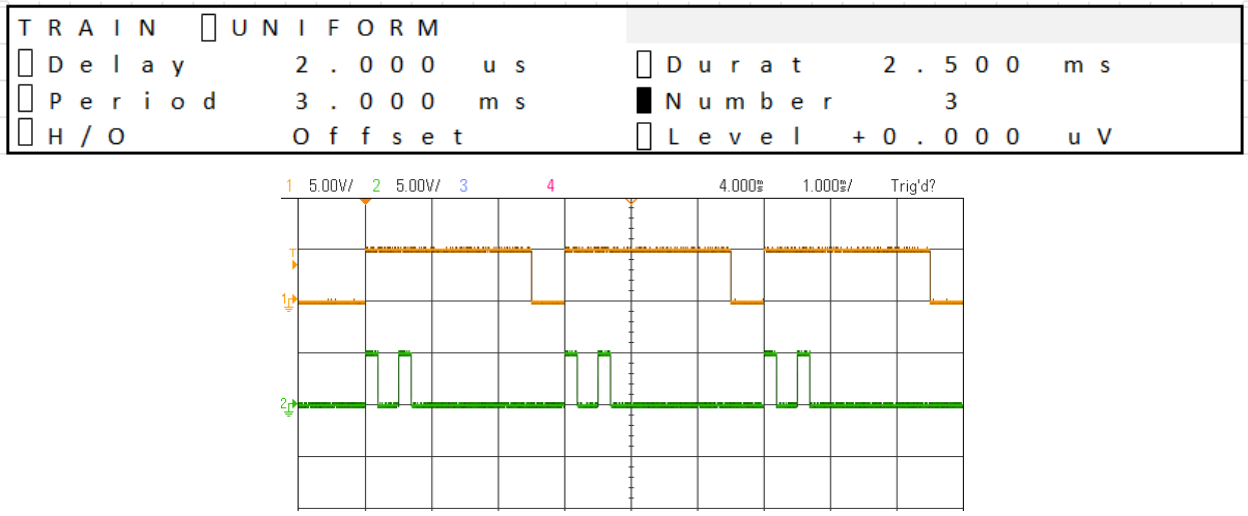
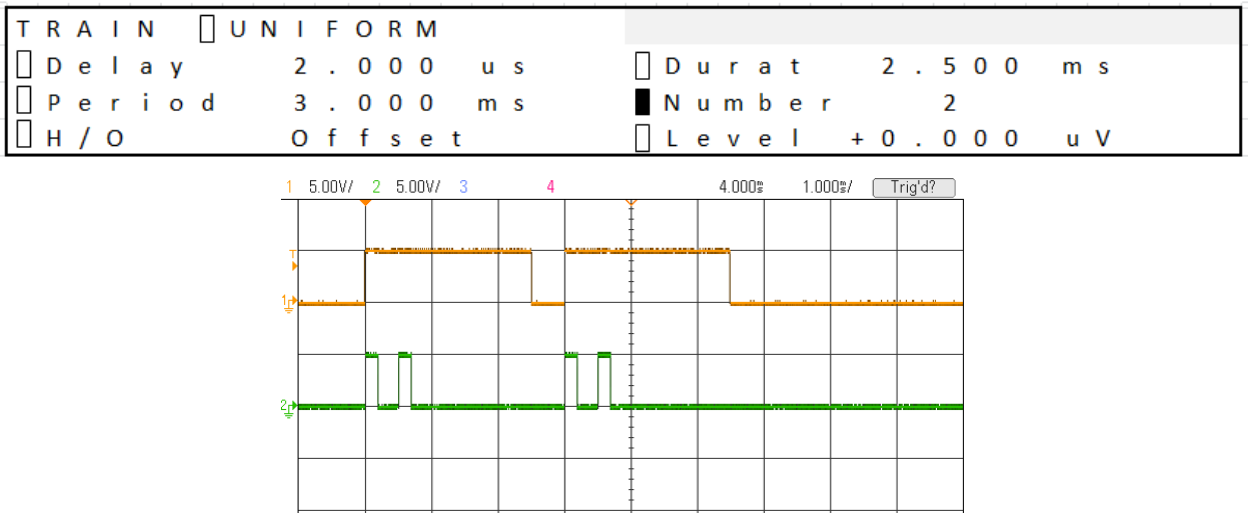
➡ ***9.*** Change NUMBER to *3*, hit **OK,** and trigger timing by momentarily depressing the TRIGGER switch. The oscilloscope display should now indicate three identical trains (Figure 26).

Figure 26. Train Number



➡ ***10.*** Change NUMBER back to *2*, hit **OK,** and trigger timing by momentarily depressing the TRIGGER switch. The oscilloscope display should now indicate two identical 2.5ms duration trains with a train period of 3.0ms (Figure 27).

Figure 27. Train Number



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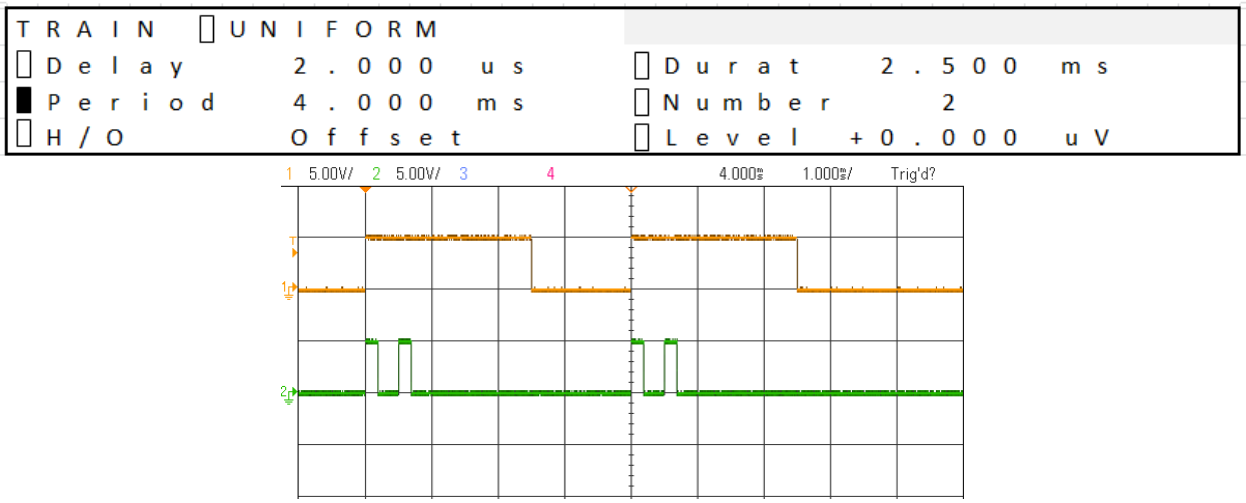
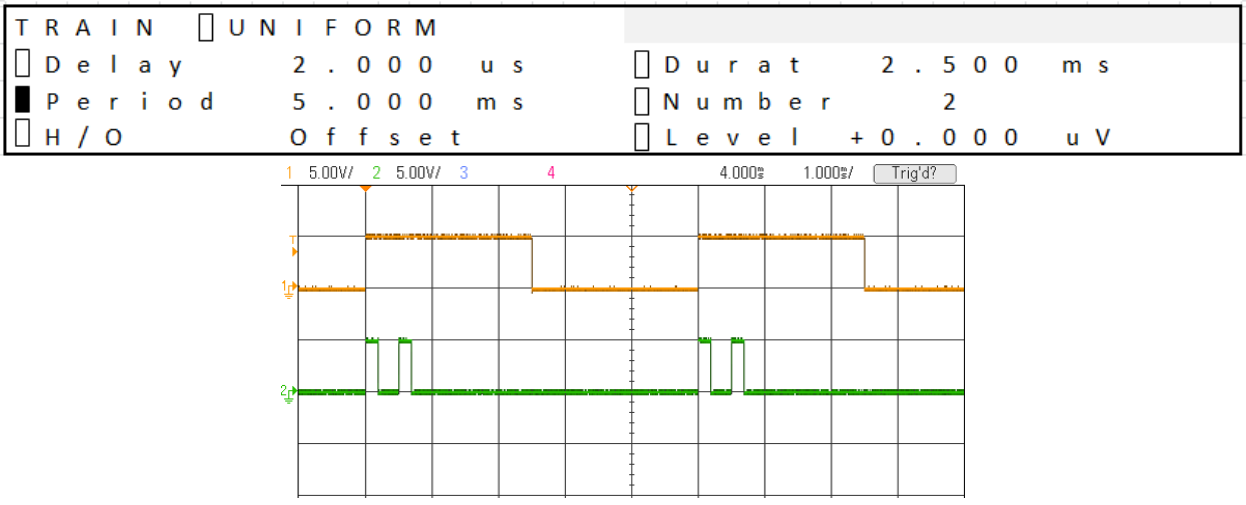
➡ ***11.*** Change PERIOD to *4.0ms*, hit **OK,** and trigger timing by momentarily depressing the **TRIGGER** switch. The train period should increase to 4.0ms (Figure 28).

Figure 28. Train Period



➡ ***12.*** Change PERIOD to *5.0ms*, hit **OK,** and trigger timing by momentarily depressing the **TRIGGER** switch. The train period should increase to 5.0ms (Figure 29).

Figure 29. Train Period



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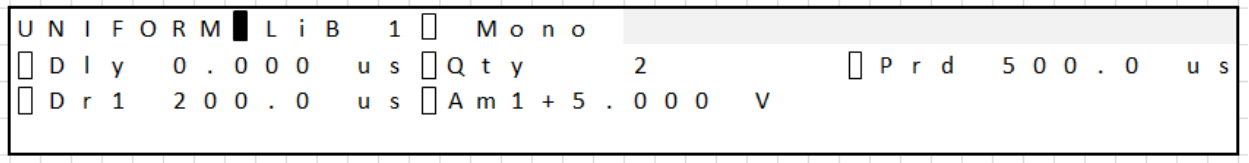
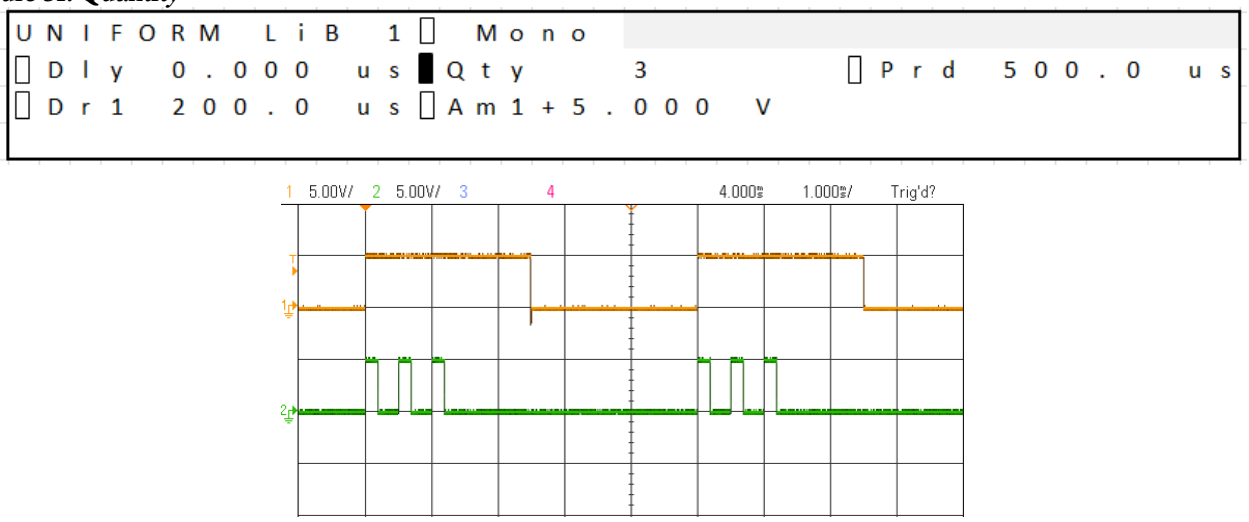
➡ ***13.*** Press **EVENT** to display the EVENT screen, where the basic parameters of the event are programmed. In this case, the event is a 200us duration monophasic 5V pulse, given twice at a period of 500us.

Figure 30. Monophasic Pulse Definition



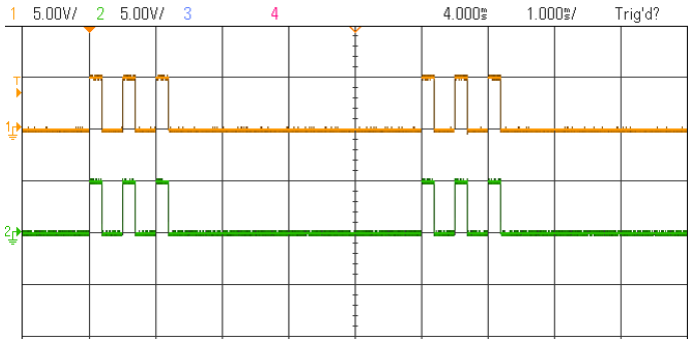
➡ ***14.*** Using the arrow navigation keys, navigate the cursor to the space just to the left of QTY and enter a value of *3* followed by hitting **OK** on the circular navigation switch. Momentarily depress the **TRIGGER**. The output should now have three monophasic pulses in each train epoch (Figure 31).

Figure 31. Quantity



➡ ***15.*** Press **GEN** twice. Change SYNC1 to *EvTotDur* by pressing **INCR** and moving through the settings. Momentarily depress the **TRIGGER**. You should now see on Channel 1 a TTL level sync pulse of the same duration as the monophasic pulse being displayed on Channel 2. Return SYNC1 to *TrainDur*.

Figure 32. Event Sync



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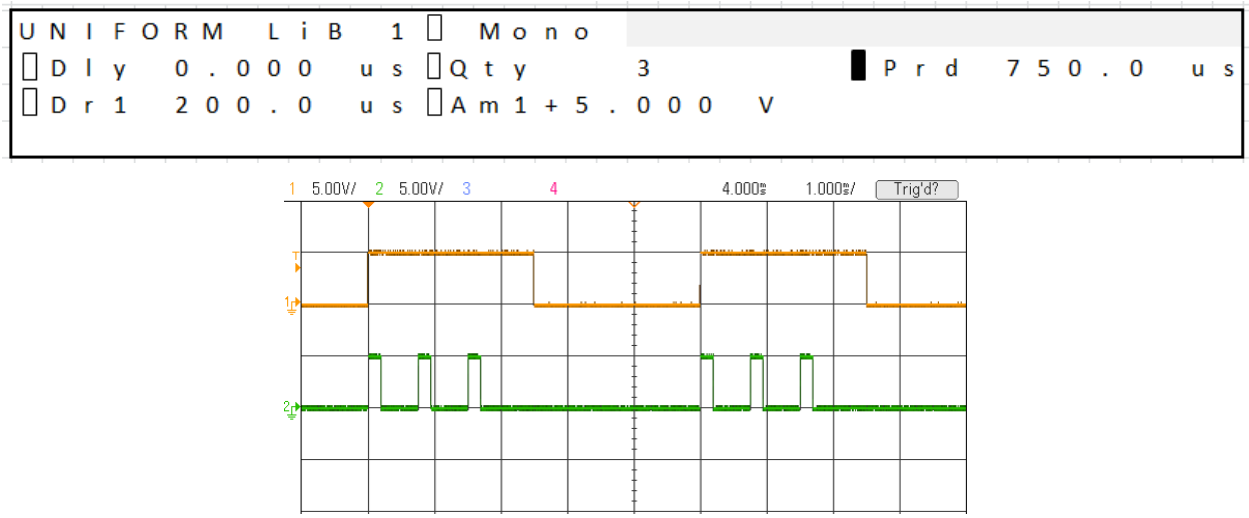
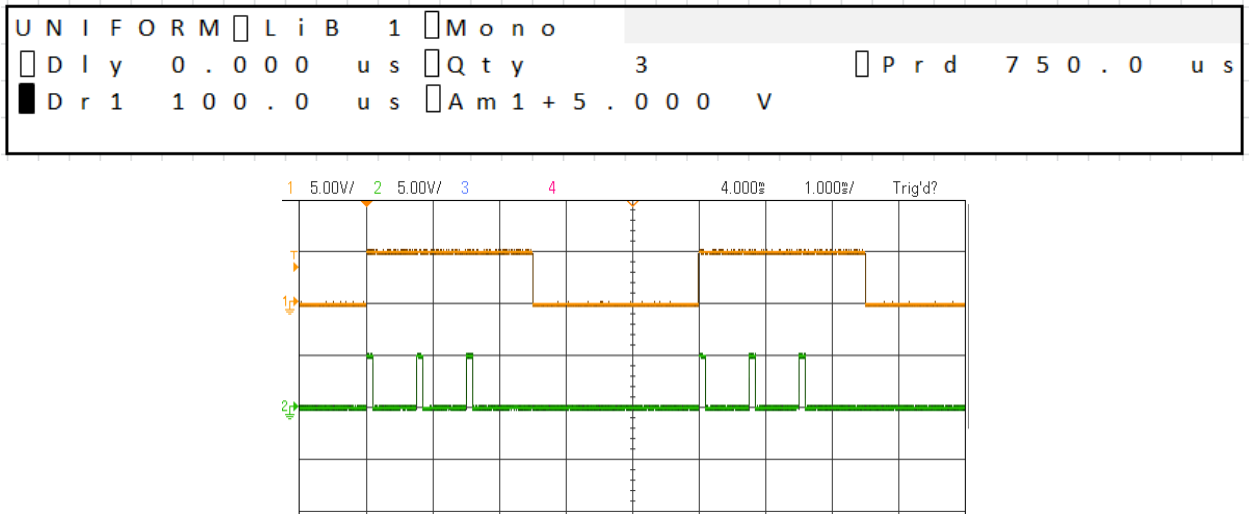
➡ ***16.*** Press **EVENT**. Navigate the cursor to PRD and enter *750*. Then press the **micro S/A/V** button. Momentarily depress the **TRIGGER**. This will change the pulse period to 750 microseconds instead of 500 microseconds, and the output should change accordingly (Figure 33).

Figure 33. Period



➡ ***17.*** Change DR1 and enter *100us* before pressing **OK**. This will change the event duration to 100 milliseconds instead of 200 milliseconds. Depress **TRIGGER**. The output should change accordingly:

Figure 34. Duration



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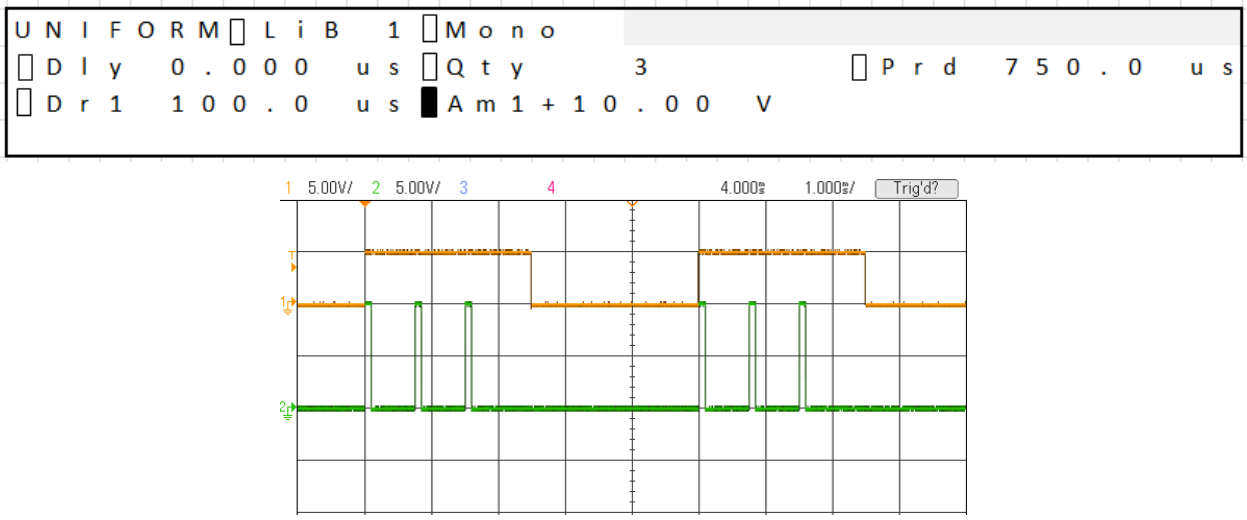
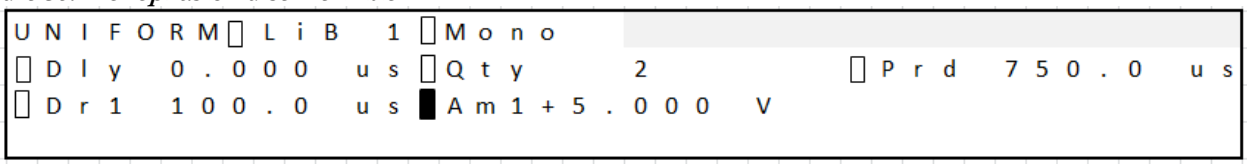
➡ ***18.*** Change AM1 to *10.00V* by entering 10.00**,** and pressing the **S/A/V** button before pressing **OK**. Momentarily depress the **TRIGGER**. Confirm that the scope display changes to two trains, each consisting of three 100us duration positive 10V pulses.

Figure 35. Amplitude



➡ ***19.*** Return the settings to the following state:

Figure 36. Monophasic Pulse Definition



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Event Types:

The Model 4100 High Powered Isolated Stimulator can create monophasic, biphasic, or ramp waveforms (Figure 37).

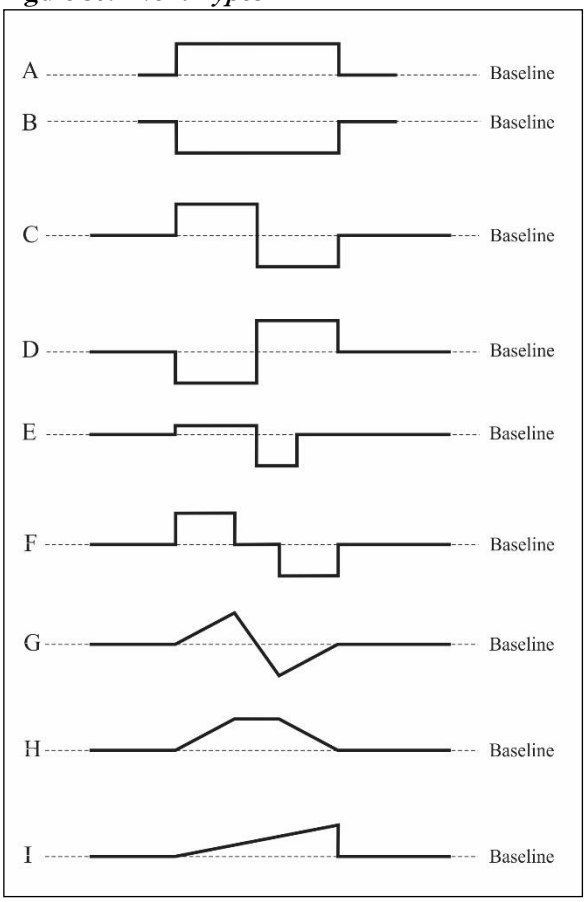
Monophasic waveforms can be *(A)* positive or *(B)* negative in polarity.

Biphasic waveforms can be *(C, D)* symmetric (where the two phases of the waveform have the same duration, and same amplitude (but of opposite polarity), or *(E)* asymmetric, where the two phases of the waveform can have different durations and/or amplitudes.

Biphasic waveforms can also have an interphase period of no/Hold/Offset amplitude between the two phases *(F)*.

Ramps are defined by their peak voltages and the durations of each phase. Ramp waveforms include triangular *(G)*, trapezoidal *(H)*, and sawtooth *(I)*.

Figure 37. Event Types



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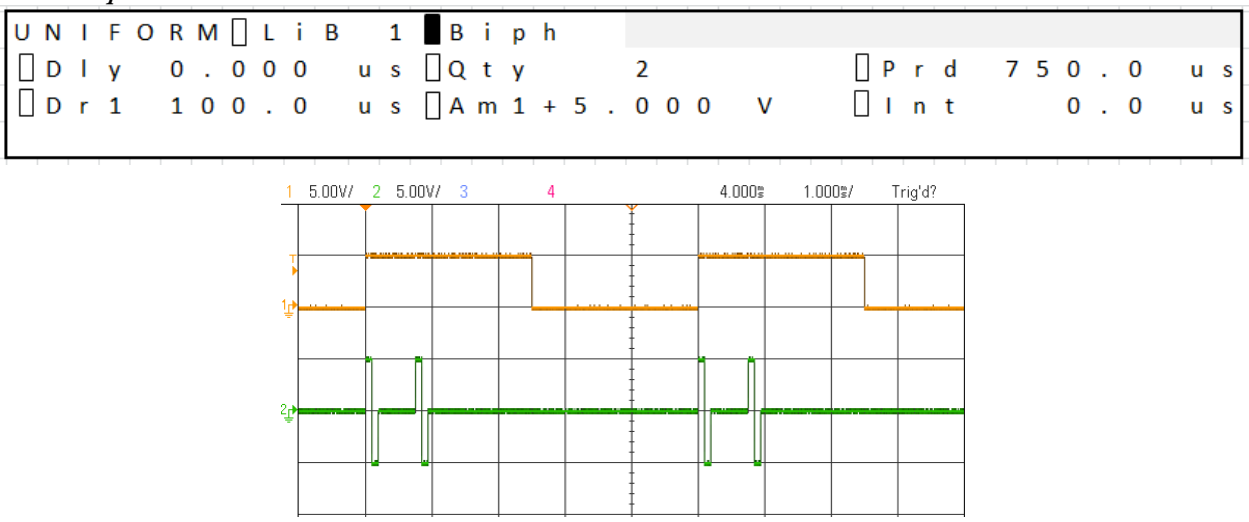
Biphasic Events

➡ ***20.*** Navigate the cursor to the left of the word *Mono* and press **INCR** once; *Biph* will appear. Match the settings displayed to those in Figure 38.

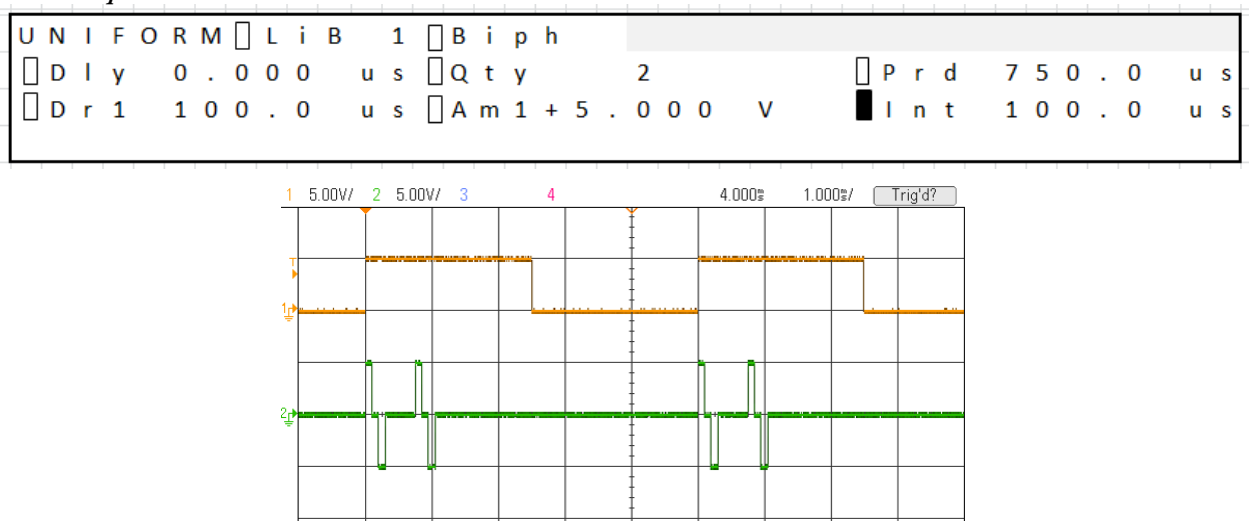
Figure 38. Biphasic Pulse Definition



Momentarily depress the **TRIGGER**. The two monophasic pulses should immediately become biphasic pulses where the first phase is +5V in amplitude, and the second phase is -5V in amplitude. When Mode is set to *Biph*, both amplitudes are determined by AM1, with the second phase being opposite in polarity of the first phase. The duration of each phase is set by DR1. In addition, a biphasic waveform has an interphase setting, which is an adjustable time period between the two phases where the amplitude is determined by the *Hold\Offset* setting.

➡ ***21.*** Change INT to *100us*. Press **OK**. Momentarily depress the **TRIGGER**. A short interphase segment should appear.

Figure 39. Biphasic Pulse Definition



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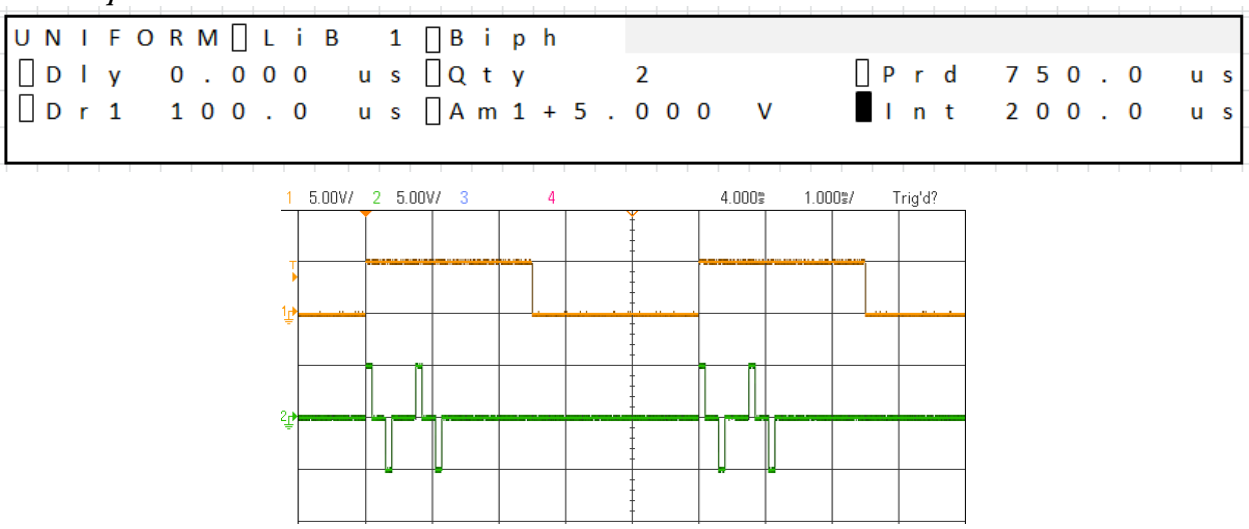
➡ ***22.*** Change INT to *200us*. Press **OK.** Momentarily depress the **TRIGGER**. The interphase segment should increase in duration.

Figure 40. Biphasic Pulse Definition

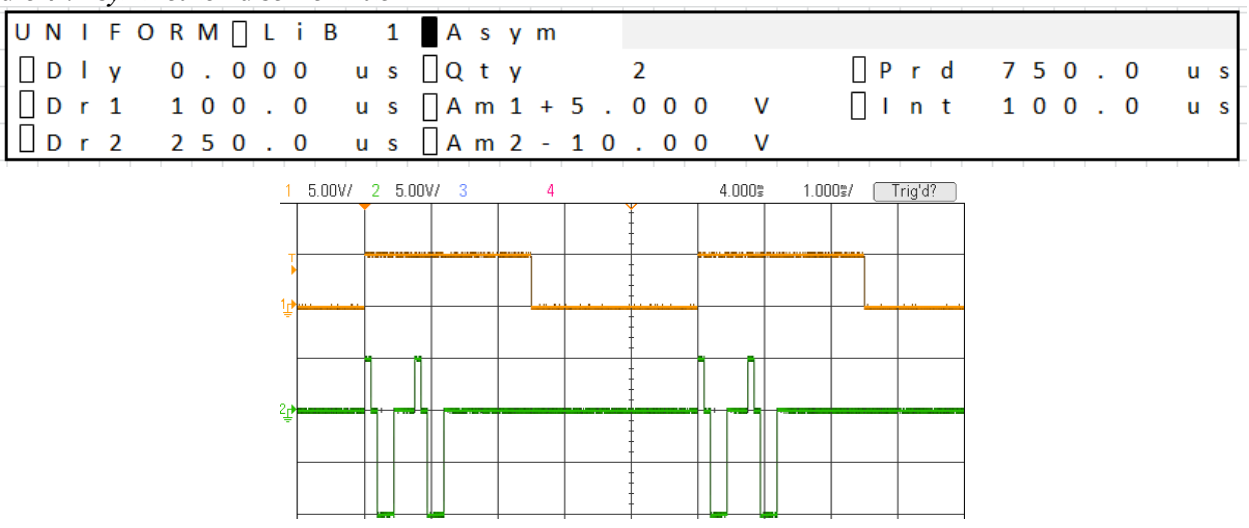


➡ ***23.*** Change INT to *100.0us*.

Asymmetric Events

➡ ***24.*** Change the Event Type from *Biph* to *Asym*. The *Asym* screen adds two new parameters (DUR2 and AM2) to determine the duration and amplitude of the asymmetric waveform respectively. Each phase can have different amplitudes and/or durations. Match the settings to those in Figure 41. Momentarily depress the **TRIGGER**.

Figure 41. Asymmetric Pulse Definition



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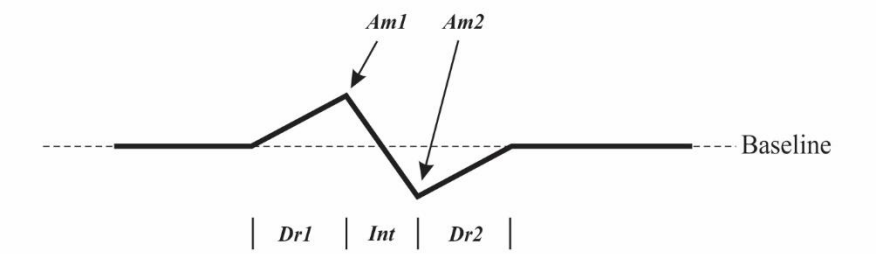
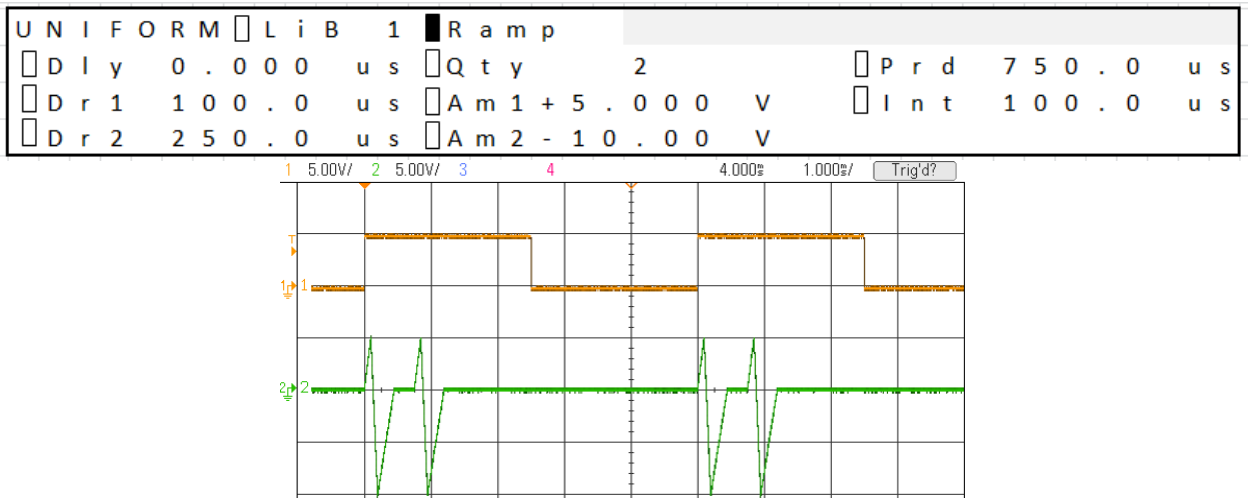
Ramp Events

➡ ***25.*** Change the Event Type from *Asym* to *Ramp*. Momentarily depress the **TRIGGER**.

Figure 42. Ramp Event Definition





In the example above, AM2 is of opposite polarity than AM1, resulting in the triangular shaped waveform. It is possible for both amplitudes to have the same polarity, resulting in a trapezoidal waveform.

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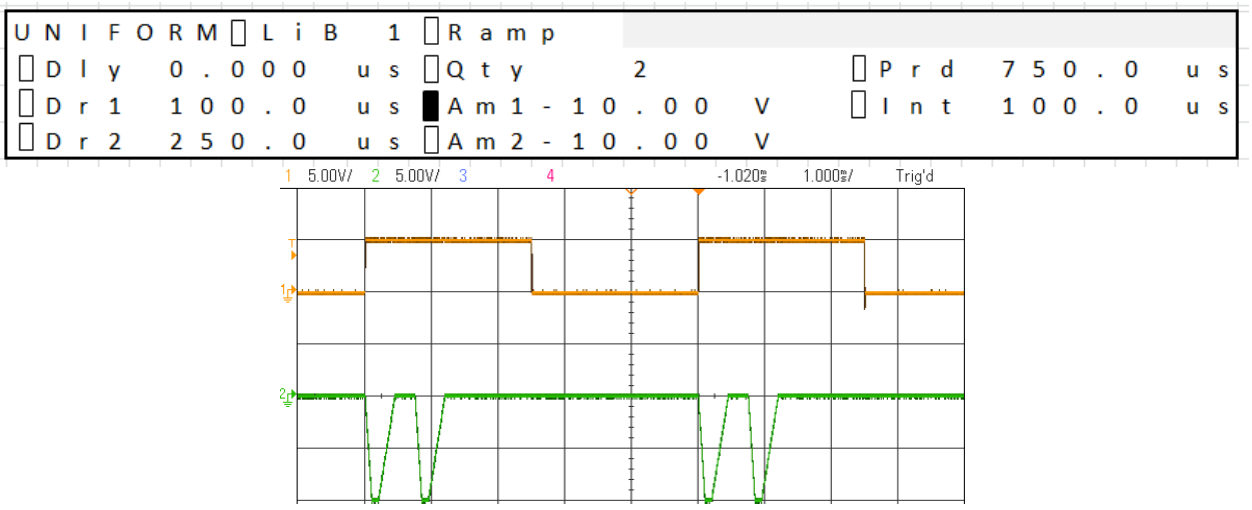
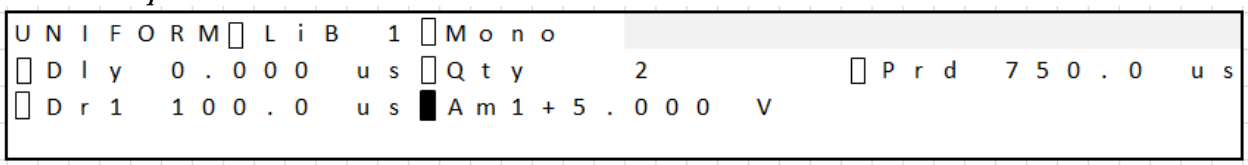
➡ ***26.*** Change AM1 TO *-10V*. Momentarily depress the **TRIGGER**.

Figure 43. Ramp Event



➡ ***27.*** Return the instrument to the settings seen in Figure 44:

Figure 44. Monophasic Pulse Definition



This background provides the basics of model 4100 operation, but the real power in the Model 4100 lies in its ability to enable the combination of multiple waveform types into a single train, and the ease in which the linked waveform types can be quickly changed.

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The Library & Linking Events

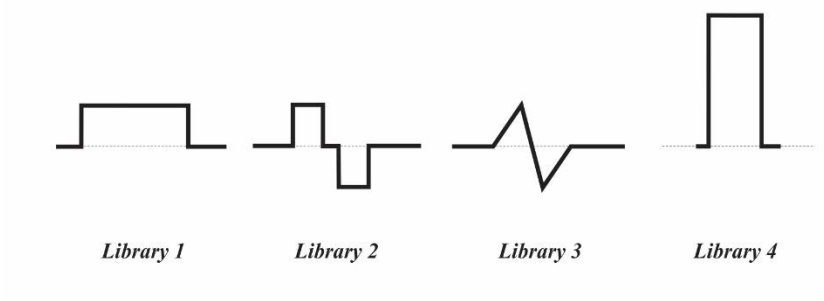
The Model 4100 enables users to store up to 20 different waveform definitions and link those definitions in any order to form complicated trains of waveforms. One way to think about this feature is that each stored waveform is one letter in a 20 letter alphabet, and with that 20 letter alphabet, users are able to spell countless words.

Stored waveform definitions comprise the library, and the event list is used to specify the order in which the waveform definitions, or events, are generated.

Up until now, the examples given in the demo consisted of trains comprised of a single event type. Because all of the event waveform types in the train were the same, the UNIFORM train definition was used where the stimulator delivers the parameters defined in a single library position. However, at any time, there was only a single event defined, or in the analogy of the alphabet, only one letter was defined. The next step is to define multiple letters in the alphabet to be used in forming complicated stimulus trains. To do this, it is necessary to define multiple events in the library and then define the train by linking the events in the order you want them delivered.

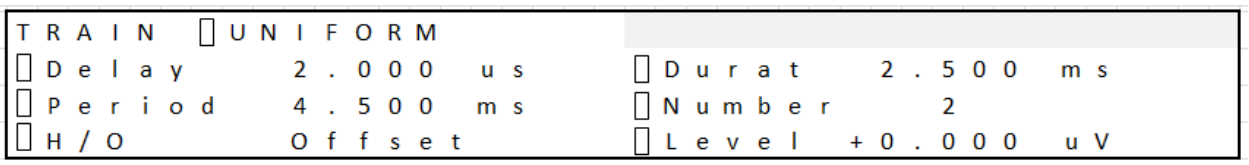
Previously, we have only been looking at the monophasic event defined in Library position 1 that was pre-filled when the instrument was turned on with the **GEN** button depressed. At that time, three additional event definitions were pre-stored in the library: a biphasic pulse, a ramp, and a different monophasic pulse, in positions 2 through 4 respectively.

Figure 45. The Library



➡ ***28.*** Update the **TRAIN** settings to the following values:

Figure 46. Uniform Train Definition



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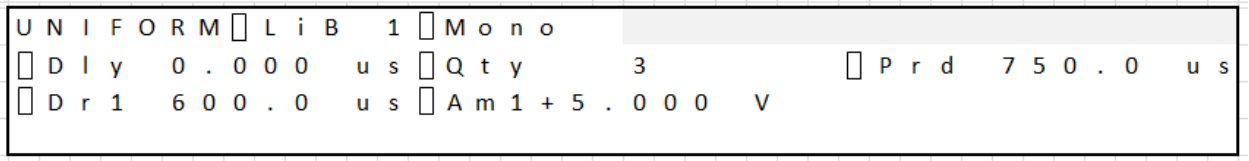
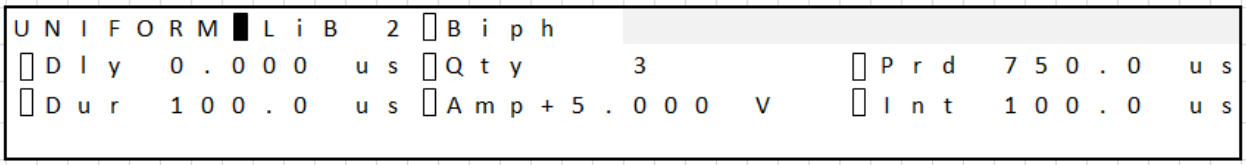
➡ ***29.*** Press **EVENT**, and set the values to match Figure 47.

Figure 47. Library #1



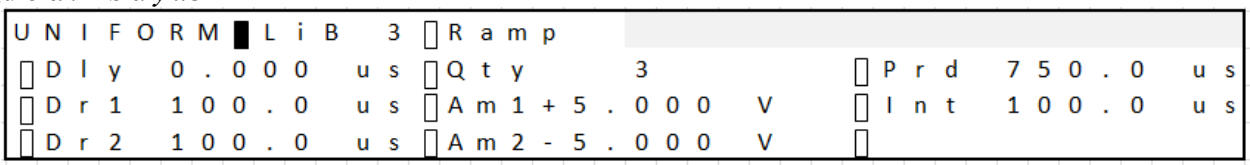
➡ ***30.*** Navigate to the left of LIB and enter *2***.** This will read the values stored in Library Position 2: a +/-5V biphasic waveform.

Figure 48. Library #2



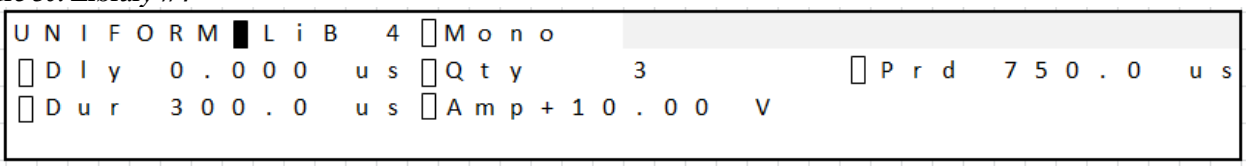
➡ ***31.*** Change LIB to *3***.** This will read the values stored in library Position 3: a ramp waveform.

Figure 49. Library #3



➡ ***32.*** Navigate to the left of LIB and enter *4***.** This will read the values stored in library Position 4: a positive monophasic waveform with a larger amplitude than the event stored in Position 1.

Figure 50. Library #4

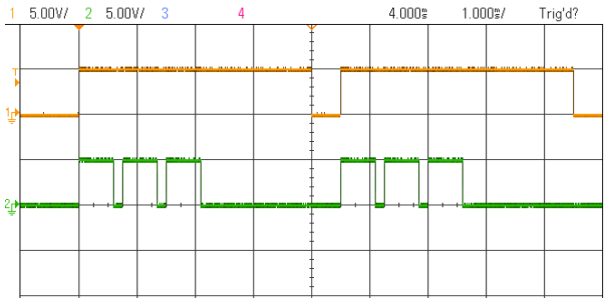


➡ ***33.*** Decrease LIB to *1***.**

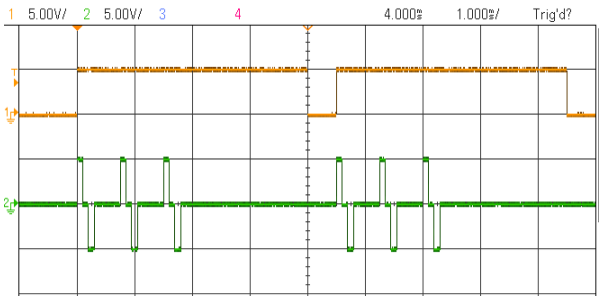
➡ ***34.*** Set to **TRIGGER** to free run. The stimulator will now deliver the event referred to by the LIBRARY positon selected by the index number; in this case, LIB = *1*. Changing the index number instructs the stimulator to deliver the event defined in that library position. You can change the index number either by entering the value desired and pressing **OK** or using the **INCR** or **DECR** buttons. As you advance through the different library positions, you should observe the following waveforms.

Figure 51. Uniform Train Examples

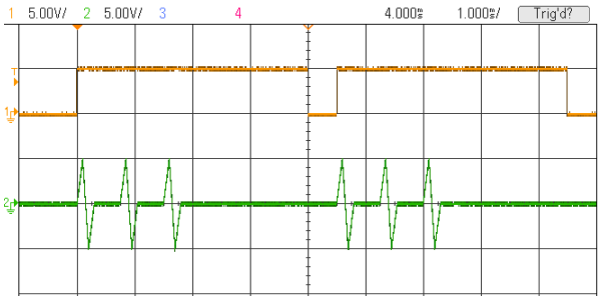
LIB = *1*



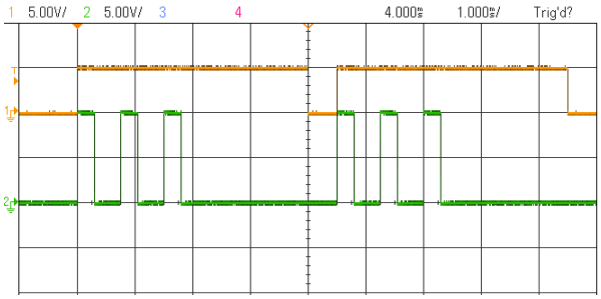
LIB = *2*



LIB = *3*



LIB = *4*



➡ ***35.*** Return **TRIGGER** to the middle position. Update the quantity on the four events to *1* (instead of 3).

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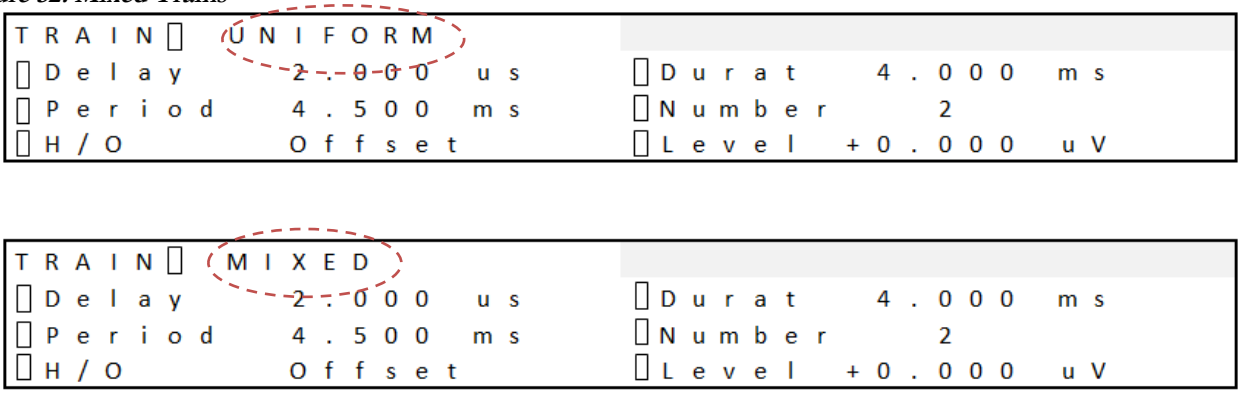
Linking different event types into a single train

In order to deliver trains consisting of multiple event types, it is necessary to specify which event types to use, and in which order to use them. For that, we use a new screen, the *EVENT LIST*.

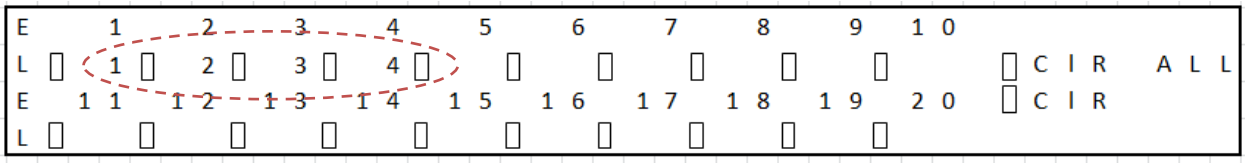
➡ ***36.*** Press **TRAIN**. Navigate to the mode setting and change *Uniform* to *Mixed* by pressing the **INCR** button. This will enable you to link different library definitions into a single train. Set DURAT to *4.000 ms*.

Figure 52. Mixed Trains



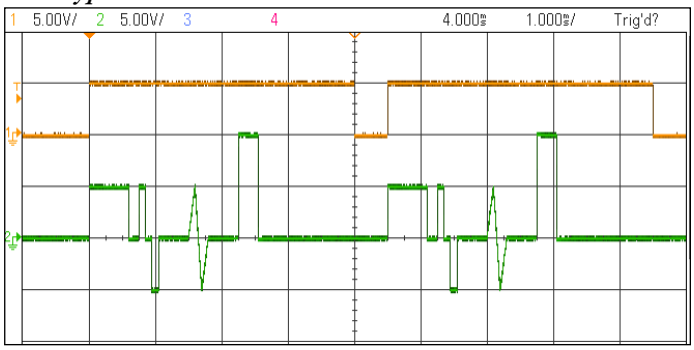
➡ ***37.*** Press **LIST**. This opens the Event List screen:

Figure 53. The Event List



The upper row is the event order; the lower row indicates the library definition associated with that event. Thus, in Figure 53 above, the event defined in library position 1 will be delivered first. The event defined in library position 2 will be delivered next. With the preloaded event list, the scope display should look like Figure 54 below after you momentarily depress the **TRIGGER** button.

Figure 54. Train of Mixed Event Types



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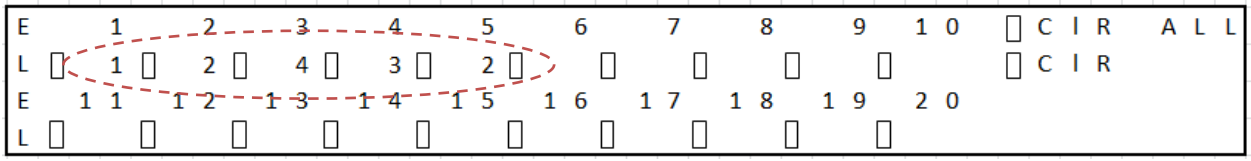
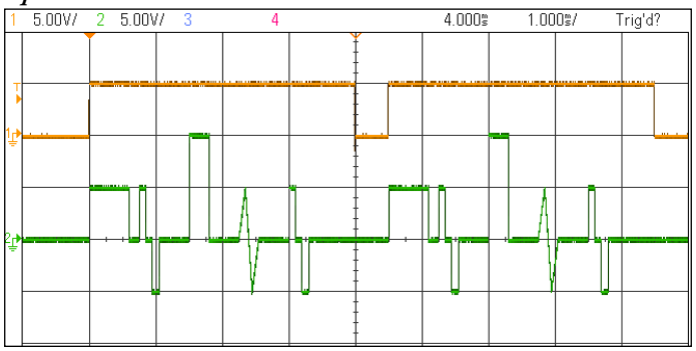
➡ ***38.*** Press **LIST**. Modify the Event List as below using the navigate buttons and the keypad. You will need to press **OK** after each library position entry. The new event list order should be *1 – 2 – 4 – 3 – 2*.

Figure 55. Event List Example



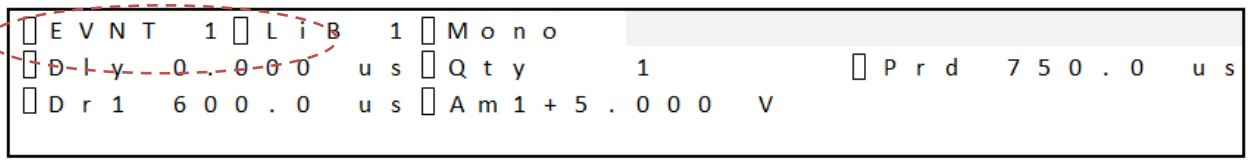
You should observe a new train, with five events, but now in a different order than before. Note the library positions below the event numbers match the revised event list order.

Figure 56. Mixed Train Example

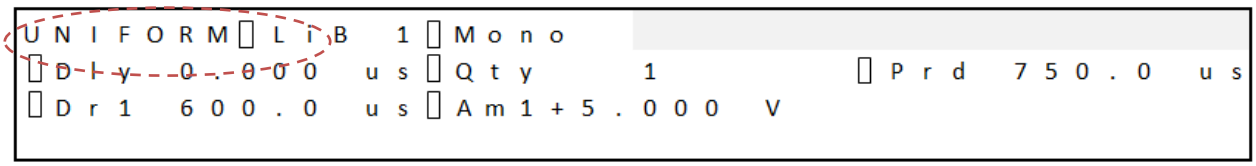


➡ ***39.*** Press **EVENT**. This will display the Mixed Train Event screen. It is slightly different from the Uniform Train Event screen displayed below.

Figure 57. Mixed Train Event Screen



Uniform Train Event Definition - Monophasic Screen



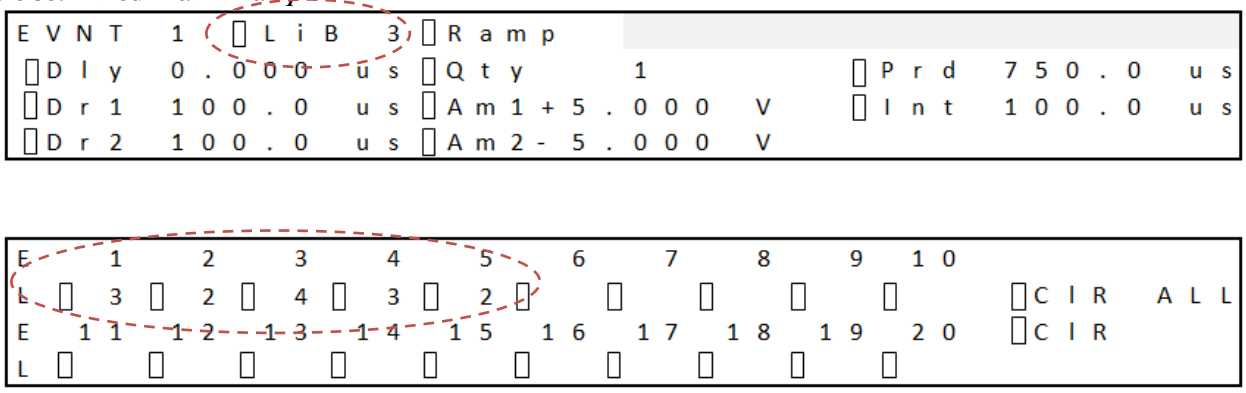
Instead of the word UNIFORM appearing and the library position being delivered, the event number is listed, and the library position associated with the EVENT number in the *EVENT LIST* is displayed.

Incrementing the EVENT number will step you through the event list, and display the definitions in the associated library positions. Currently, the event list is *E1L1 : E2L2 : E3L4 : E4L3 : E5L2*, meaning that the first event is library position 1, the second event (E2) is library position 2 (L2), the third event (E3) is library position 4 (L4), and so on. Thus, the definition in library 1 will be displayed when Event 1 is selected in the EVENT screen. Incrementing to Event 2 will display the values stored in library position 2. If the stimulator is generating pulses, you will see the event as defined in library position 2. Further incrementing Event will result in subsequent changes in the waveform being generated.

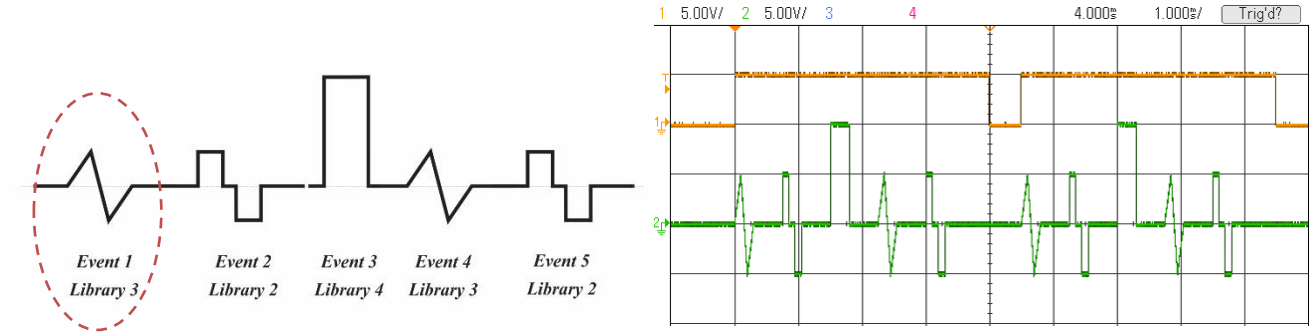
Changing the LIB value in a mixed event screen will change the library – event association in the event list for that event only.

➡ ***40.*** Press the EVENT button and change LIB from *1* to *3*. Confirm that the settings match those in Figure 58, upper. Press LIST and observe that the EVENT LIST also updates to match the lower display.

Figure 58. Mixed Train Example



Pressing **TRIGGER** will result in the following waveforms:



Note that Event 1 has now updated to the definition in library position 3, the ramp.

Changing any parameter of the library definition in a mixed event screen will change the library itself, and that will be reflected in all of the events linked to that library position in the event list.

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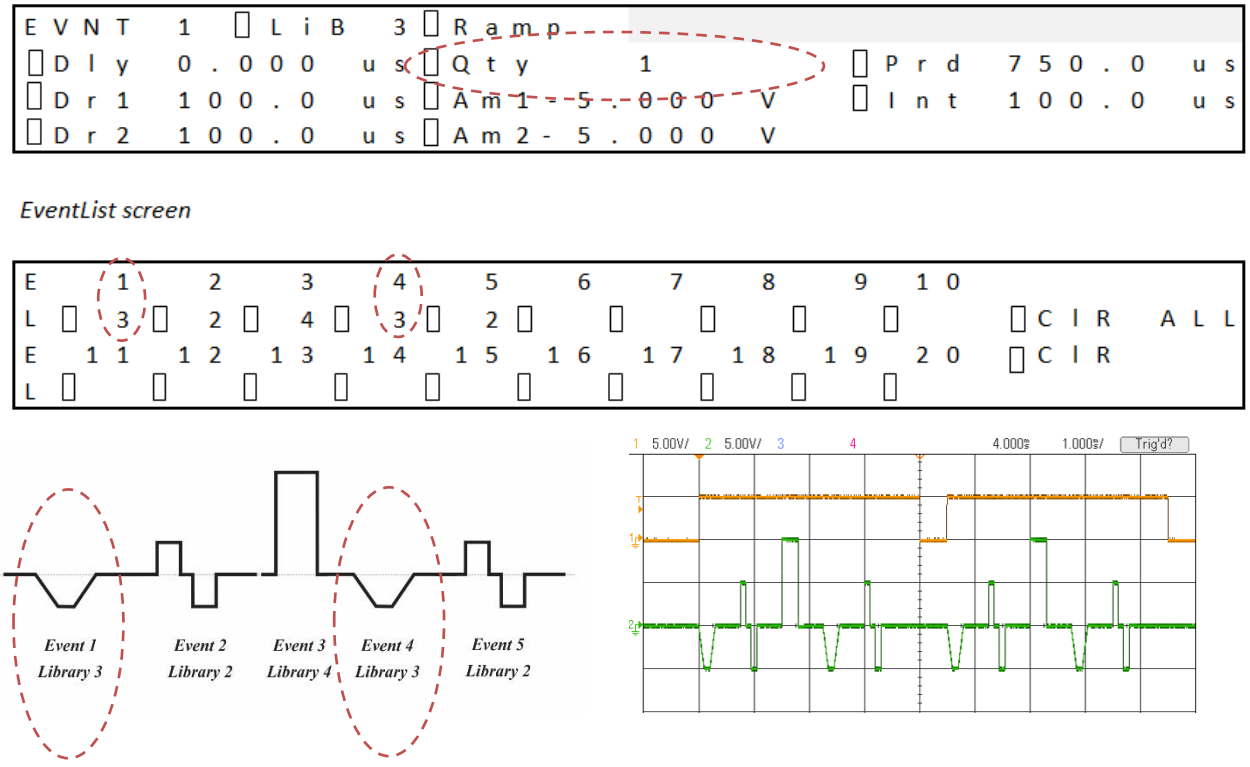
➡ ***41.*** Press **EVENT**. Navigate to AM1 and enter *-5V*. This changes the definition stored in library position 3, and all events linked to library position 3 will update with the new amplitude value. Depress **TRIGGER**.

Figure 59. Change Library Parameter



➡ ***42.*** Press TRAIN. Set mode to *Uniform*.

AutoFill and AutoCount

The Model 4100 has two built-in algorithms to simplify programming for common protocols. Accessed on the GEN screen, the AUTO function can be set to *None*, *Fill*, and *Count*.

AUTO:*Fill* is the implementation of the protocol that can be summarized as Deliver events for the specified time duration. In this case, the user defines the events to be generated, the event intervals, and the train duration, but does not specify the total quantity of events.

➡ ***43.*** Change your oscilloscope timebase to *5ms/div*.

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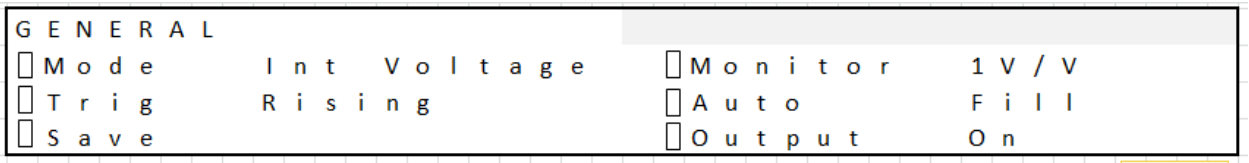
➡ ***44.*** Press **GEN**. Set AUTO to *Fill*.

Figure 60. Auto:Fill



➡ ***45.*** Press **EVENT**. Change LIB to *1*. Change DUR1 to *100us*.

➡ ***46.*** Press **TRAIN**. Change Change DURAT to *10ms*.

Figures 30 to 33 illustrate the changes in the generated waveform when TRAIN:DURAT is changed from *10ms* to *20ms* to *30ms* resulting in pulses being delivered for the entire train duration. Momentarily depress **TRIGGER** after each change in DURAT.

Figure 61. AutoFill at 10ms

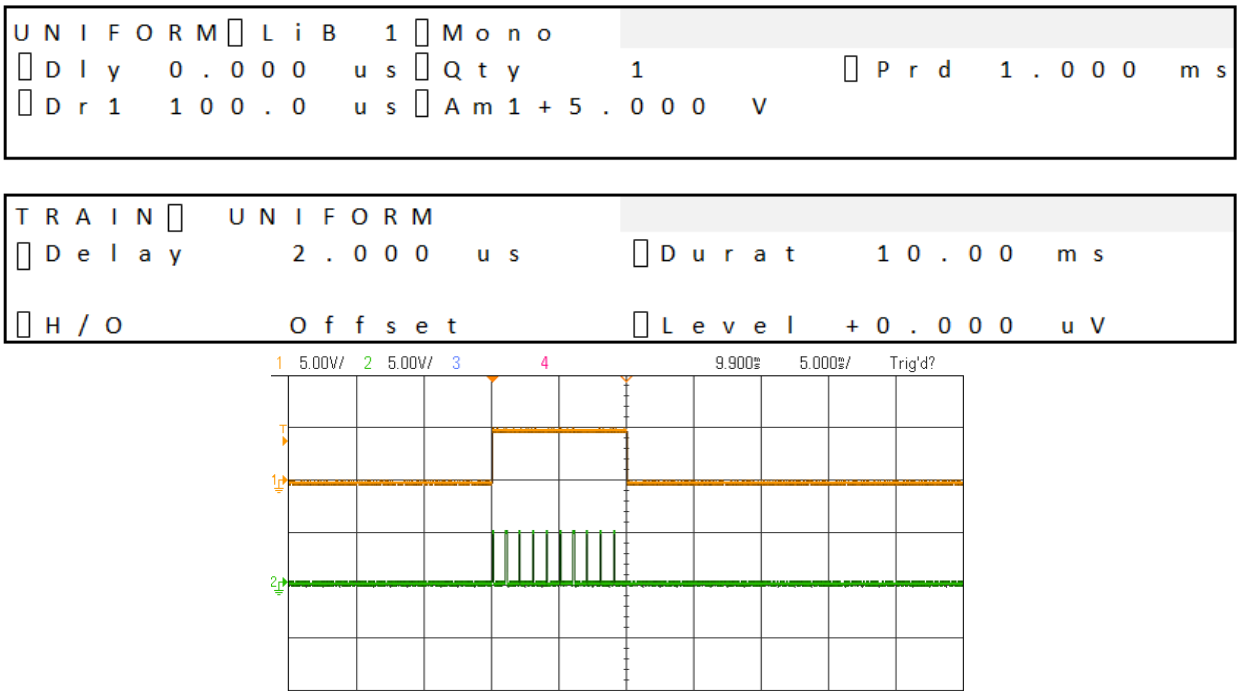


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Figure 62. AutoFill at 20ms

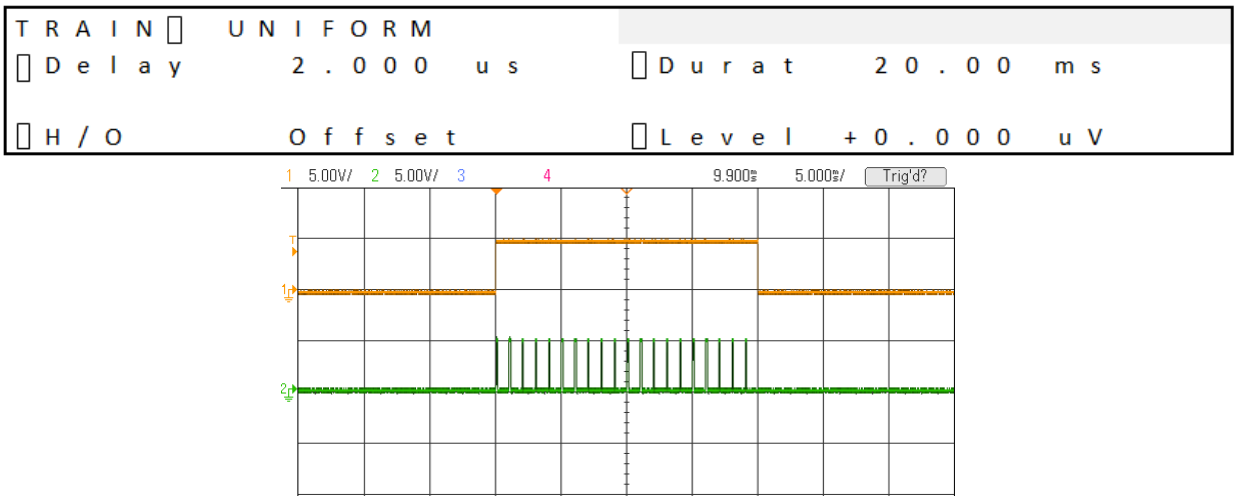
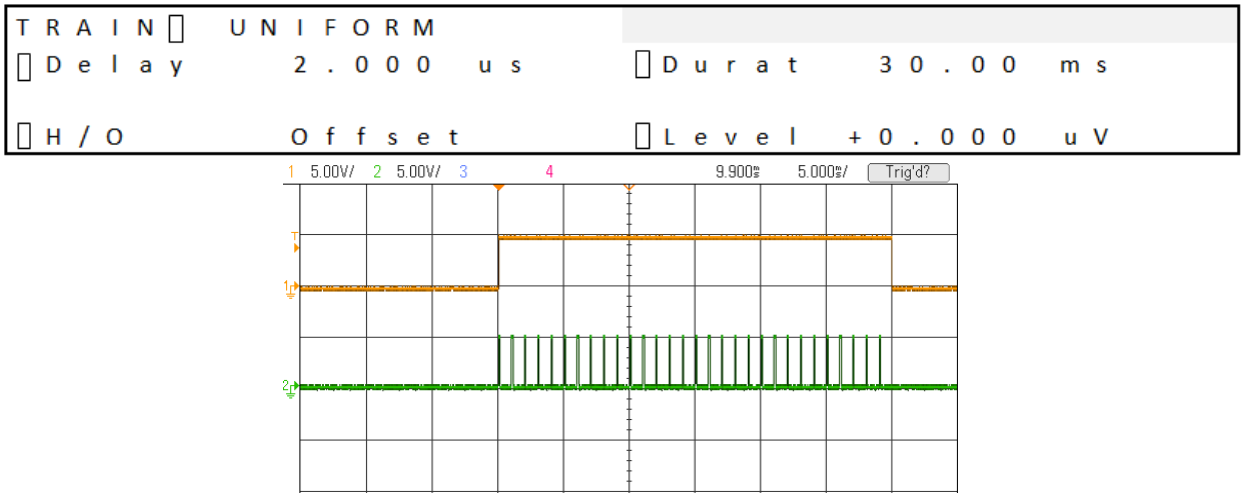


Figure 63. AutoFill at 30ms



If in the TRAIN:*Uniform* mode, the Model 4100 will repeat the selected event until the train duration elapses. No partial events will be delivered. If in the TRAIN:*Mixed* mode, the Model 4100 will fill the entire specified train duration with the events as ordered in the EVENT LIST, but will only fill in increments of the entire event list. For example, if the EVENT LIST consisted of three events, AUTO:*Fill* would repeat the full sequence of the three events. If at the end of the train duration, there is insufficient time to deliver the complete sequence of three events, the 4100 will stop delivering events.

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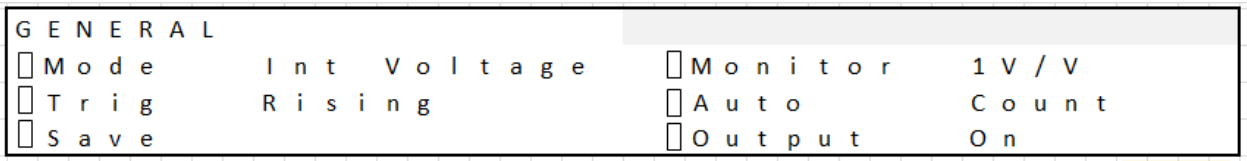
AUTO:*Count* is the implementation of the protocol that can be summarized as Deliver the specified quantity of events. In this case, the user defines the events to be delivered, the event intervals, and the quantity of events, but does not specify the train duration. Instead, the Model 4100 will calculate the minimum train width required to completely deliver the requested number of events at the requested interval when given a single trigger input.

Figures 64 to 67 illustrate the changes in the generated waveform when QTY is changed from 5 to 10 to 20 resulting in the specified number of pulses being delivered, and train duration automatically adjusting to allow those pulses to be delivered.

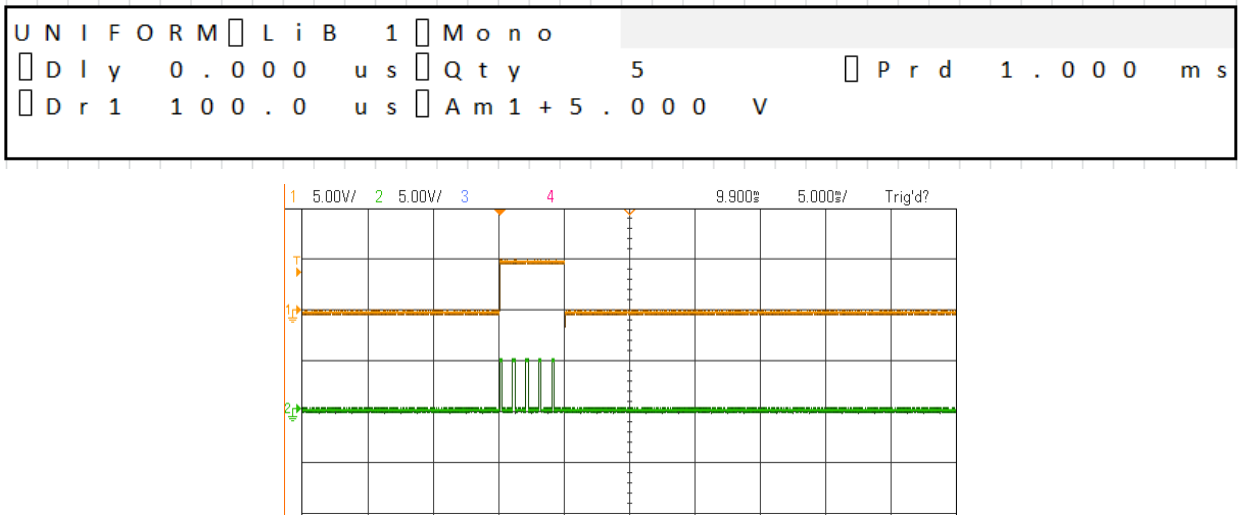
➡ ***47.*** Press **GEN**. Set AUTO to *Count*.

➡ ***Figure 64. Auto:Count***



48. Press **EVENT**. Set QTY to *5*. Set PRD to *1.000ms*. Momentarily depress **TRIGGER**.

Figure 65. Auto:Count = 5



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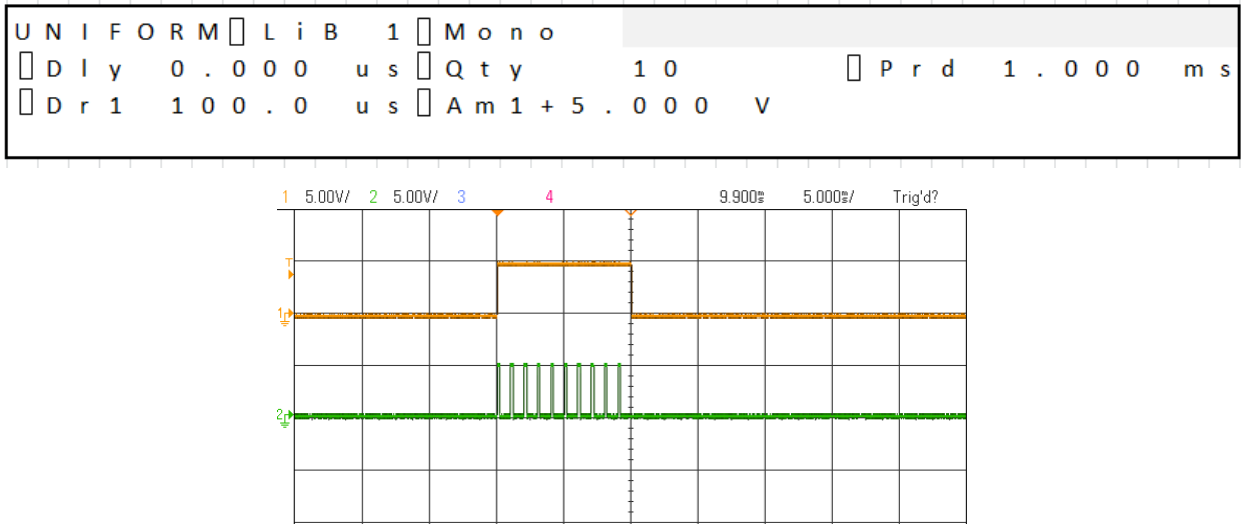
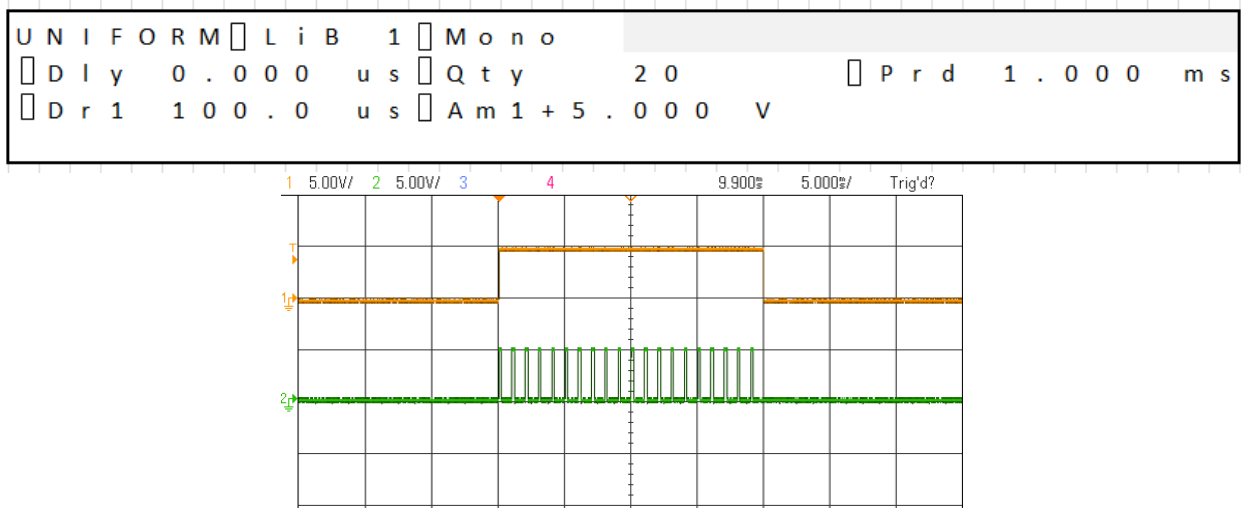
➡***49.*** Change QTY to *10*. Momentarily depress **TRIGGER**.

Figure 66. Auto:Count = 10



➡***50.*** Change QTY to *20*. Momentarily depress **TRIGGER**.

Figure 67. Auto:Count = 20



➡***51.*** Change **GEN**. Set AUTO to *None*. Change your oscilloscope timebase to *1ms/div*.

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Offset and Hold

OFFSET and HOLD allow the user to set amplitude adjustments to the baseline. They differ in the following way:

1) OFFSET is only active during TRAIN DURATION; HOLD is always active as long as the instrument is enabled.

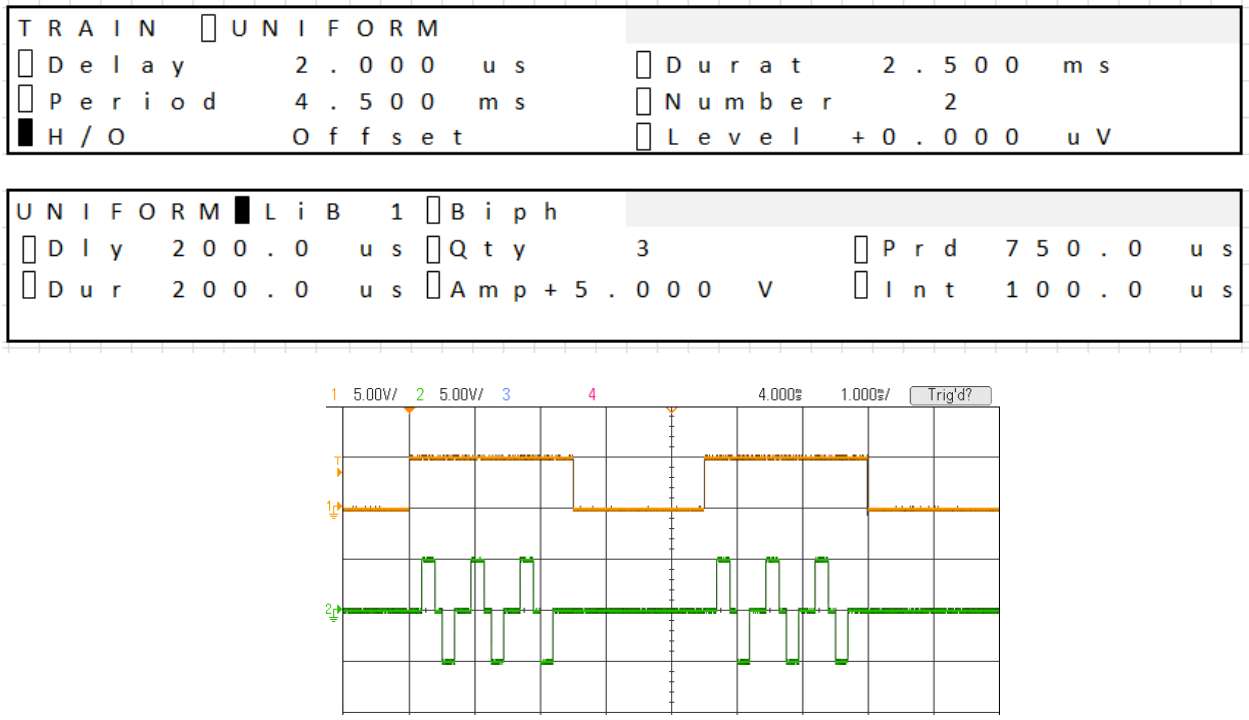
2) OFFSET sums with event amplitudes; HOLD does not.

Note: Both Offset and Hold apply to the interphase timing segment of Biphasic, Asymmetric, and Ramp waveforms.

Figures 68 to 70 illustrate the changes in the generated waveform when OFFSET is changed from *0V* to *2V* to *5V* resulting in the vertical shift of the biphasic waveform, including the interphase period. Note that the vertical shift occurs only during the TRAIN DURATION (sync displayed on the upper trace).

➡ ***52.*** Set the instrument to the following values. Depress **TRIGGER** momentarily.

Figure 68. Offset: 0V



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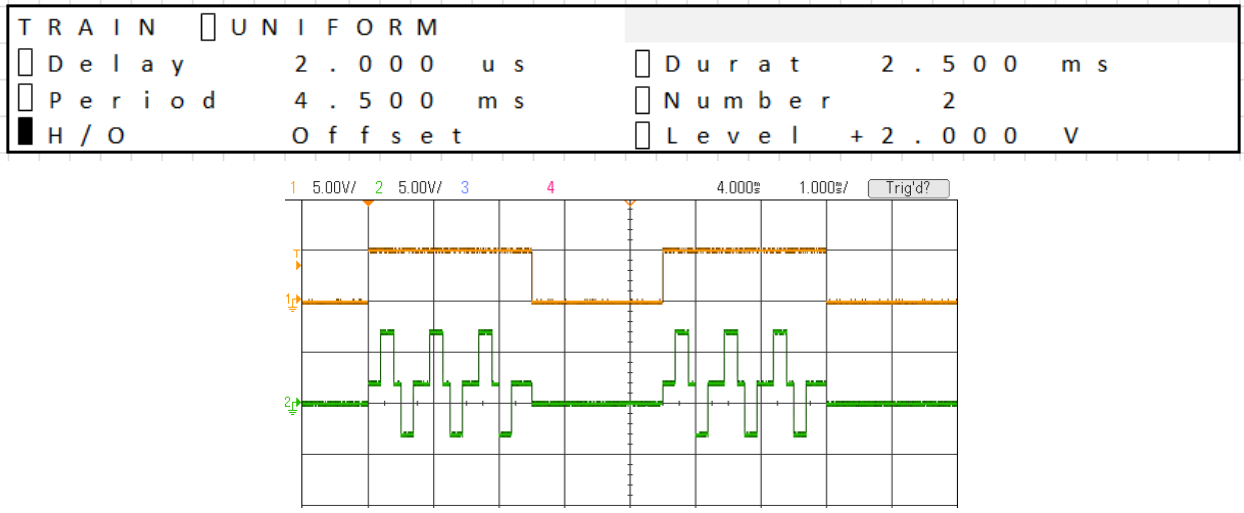
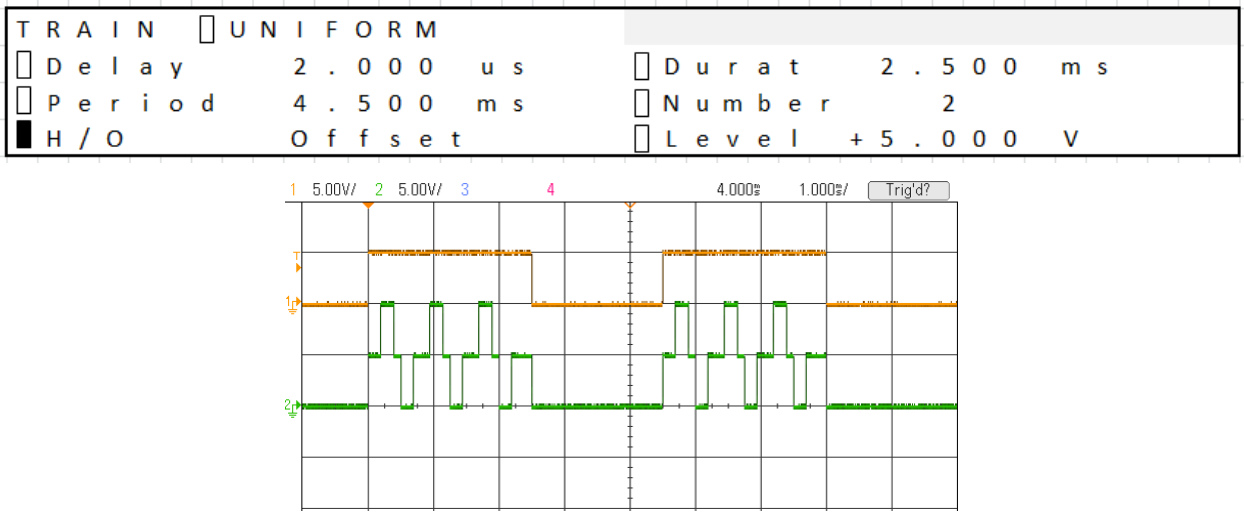
➡ ***53.*** Press **TRAIN**. Change LEVEL to *2V*. Depress **TRIGGER** momentarily.

Figure 69. Offset: 2V



➡ ***54.*** Press **TRAIN**. Change LEVEL to *5V*. Depress **TRIGGER** momentarily.

Figure 70. Offset: 5V



Also note that the amplitude of the biphasic pulse is determined using the OFFSET value as the baseline, so in Figure 70, it is a +/- 5V change from an offset of 5V, meaning the amplitudes end up at +10V and 0V respectively.

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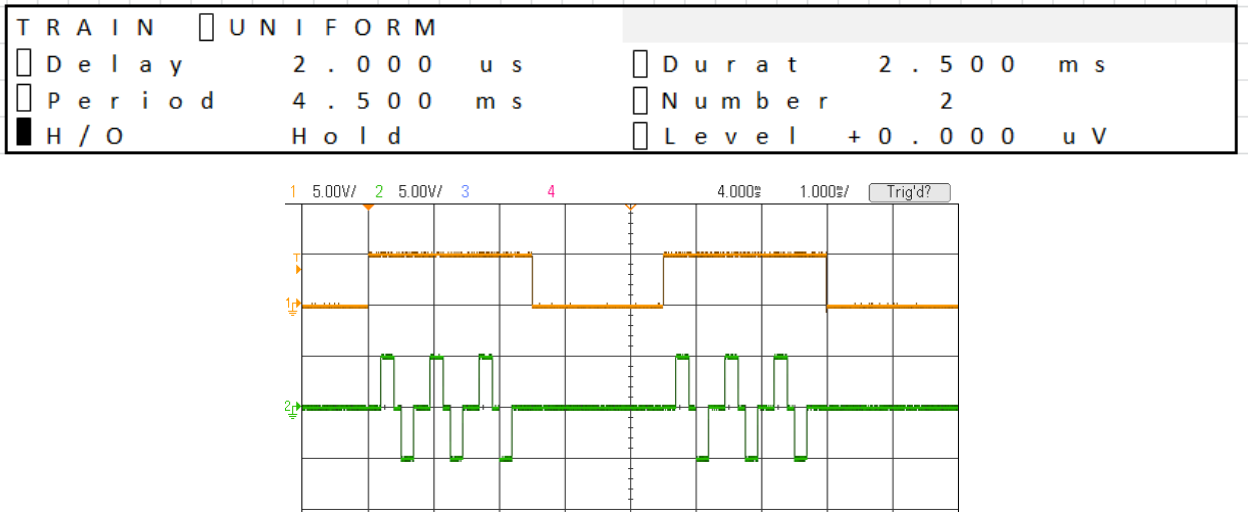
HOLD operates slightly differently, as it is always active, and it does not sum with the requested amplitudes. Figures 71 to 73 illustrate changes in the generated waveform when HOLD LEVEL is changed from *0V* to *2V* to *5V* on the TRAIN page.

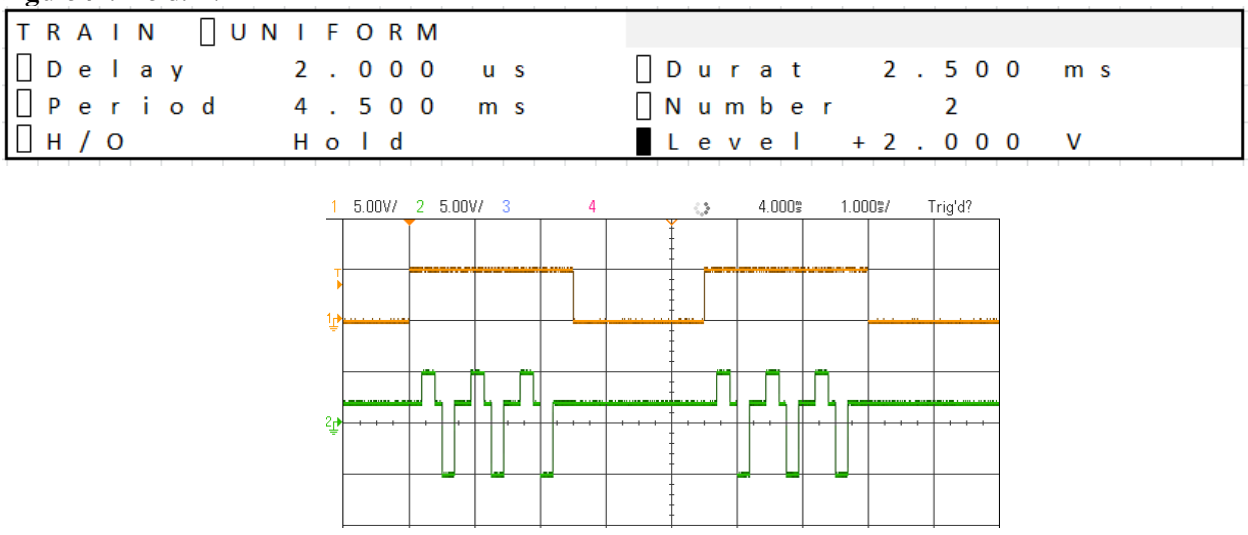
➡ ***55.*** Press **TRAIN**. Set the instrument to the following values. Depress **TRIGGER** momentarily.

Figure 71. Hold: 0V



➡ ***56.*** Press **TRAIN**. Change LEVEL to *2V*. Depress **TRIGGER** momentarily.

Figure 72. Hold: 2V



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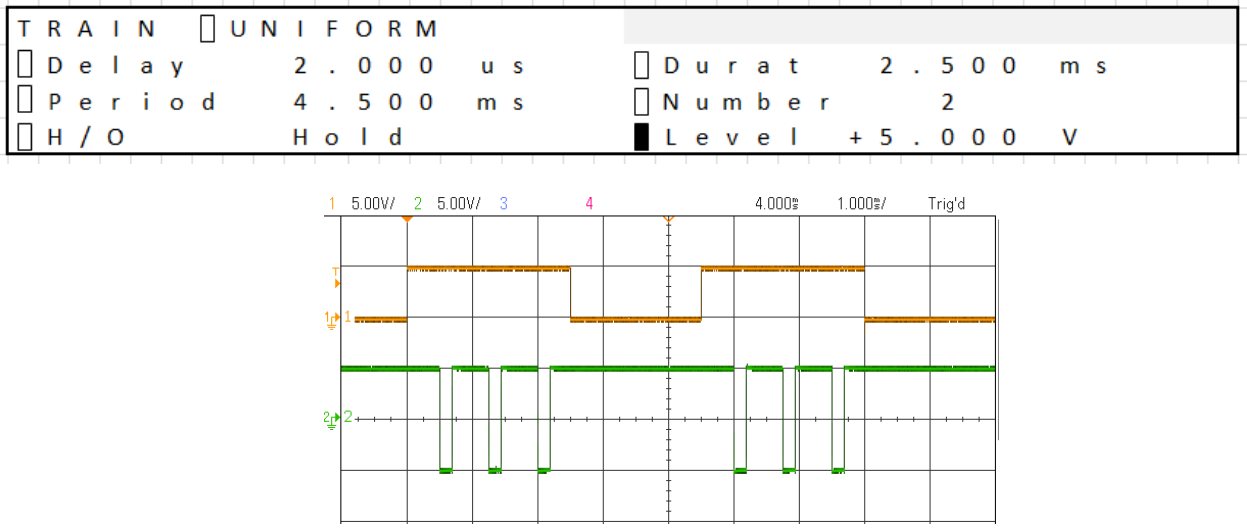
➡ ***57.*** Change LEVEL to *5V*. Depress **TRIGGER** momentarily.

Figure 73. Hold: 5V



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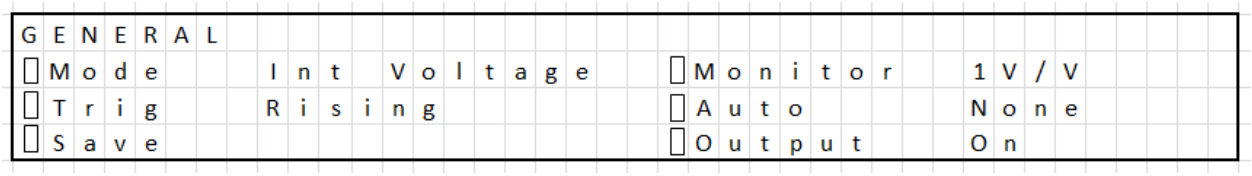
Additional Menu Settings

➡58. Press **GEN.**

The general screen provides access to several useful settings.

Figure 74. General Screen



MODE determines if the Model 4100 is producing voltage or current pulses using its internal circuitry (*Int Voltage, Int Current*) or acting as an analog isolator and scaling the user supplied signal to the **SIGNAL IN** BNC (*Ext 10mA/V, Ext 1mA/V, Ext 100uA/V, Ext 20V/V*). If using the **SIGNAL IN** BNC the output signal generated by the Model 4100 is proportional to the input signal as determined by the selected setting: e.g., if the user selects "*Ext 1mA/V*, and supplies a 5 volt signal to the BNC, the output will be 5mA.

MONITOR determines the scaling of the front panel Monitor BNC. Users have the options of several scaling factors: *0.1V/V, 1V/V, 10V/V, 20V/V, 10 uA/V, 100uA/V, 1mA/V, and 10mA/V***.** The maximum output level at the monitor BNC is +/-10V.

TRIG determines the edge direction of the Ext Trig input signal that will successfully begin Model 4100 timing (*Rising, Falling*).

AUTO determines if simplified train construction rules are applied. *Count* and *Fill* are described in Chapter 5.

SAVE stores all settings in current use on the 4100 in the on-board non-volatile memory. These settings will be preserved after the instrument is powered off.

OUTPUT determines if the High Voltage output jacks are connected to the analog signal circuitry. Turning OUTPUT off places the unit in a Test Mode. Test mode is provided to enable monitoring of the signal to be delivered without actually generating output pulses at the isolated banana jacks. All timing rules apply; the monitor will be active for use in evaluating the output signals without actually stimulating your preparation or experimental subject.

NOTE: If output is off, there will be no *HOLD* amplitude either.

In Test Mode, the Instrument Enable button will be unlit, indicating no actual output is being generated. However, the Event light will still illuminate according to the timing of SYNC1.

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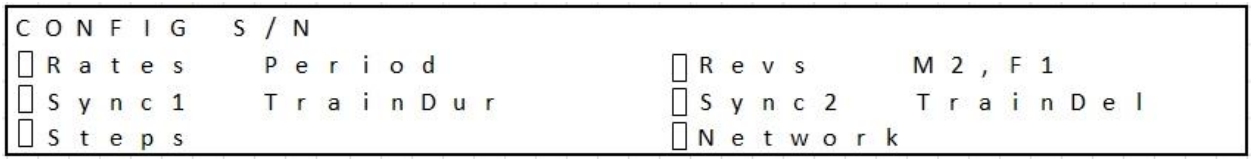
➡59. Pressing **GEN** results in the display of the CONFIGURE screen.

Figure 75. General Screen



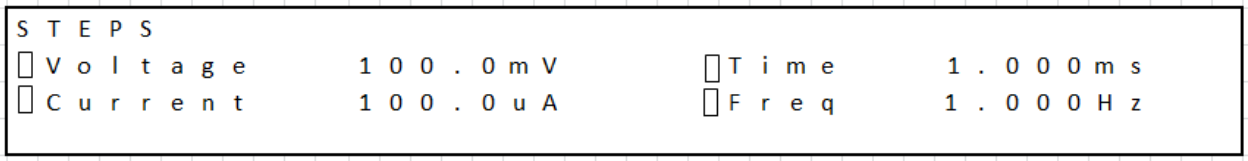
RATES determines if timing variables are entered in units of *Period* (microseconds, milliseconds, or seconds) or *Freq* (Hz, kHz).

REVS indicates the current Microcontroller (*M*) and FPGA (*F*) firmware versions loaded. This is useful if contacting A-M Systems for technical support.

SYNC1 and **SYNC2** determine the timing characteristics the front panel **SYNC1** BNCs will provide. Options include: *Train Delay, Train Duration, Event Delay, Total Event Duration, Event Duration 1, Event Duration 2, Event Duration 3, and assorted clock intervals.*

STEPS displays the Step screen, and allows the user to enter time and amplitude delta step sizes that will be added to the selected value when *Inc* or *Dec* are pressed.

Figure 76. Steps screen



NETWORK displays the Network screen, and allows the user to set their own appropriate Ethernet values for the Model 4100 to be found by the computer software (covered in **Section 6: Software**).

Error and Warning symbols

Errors in timing settings will be indicated by the steady illumination of the red ERROR lamp and the display of an error message on the LCD screen.

Excessive output in voltage (>±200V) or current (>100mA) will be indicated by the flashing illumination of the red ERROR lamp.

Generation of high voltage pulses (>±50V) will be indicated by the flashing illumination of the green **ENABLE** lamp.

Prior to generating high voltage\current events, the Model 4100 will ask for an acknowledgement on the front panel display that the user recognizes the pulses to be generated can be dangerous and safety precautions will be taken. Pressing **OK** to this question will allow the Model 4100 to generate these large amplitude events.

At any time, pressing the illuminated green **ENABLE** switch will result in the release of the switch back to the disable position and the darkening of the lamp. When the switch is out, and the lamp is off, no output is being generated, and all timing has ceased. For proper operation to continue, the green **ENABLE** switch must be depressed again.

6. Software

Installation under Windows 10

This section will present an overview of the included software application. This application can be downloaded and installed via iTunes or the Play Store, and can run on: Windows 8, 10; Apple iOS and OSx, and Android systems. Contact A-M Systems for Matlab and LabView programming solutions.

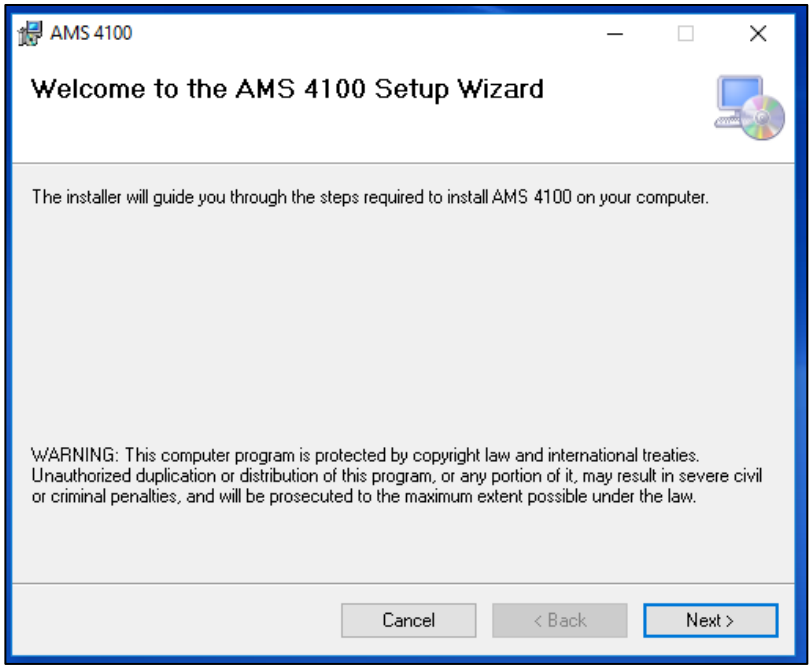
Note: Your computer video driver must be capable of supporting OpenGL 2.1 or greater.

The section that follows covers installation procedures for Windows 10. If you require instructions for previous versions of Windows, please contact A-M Systems.

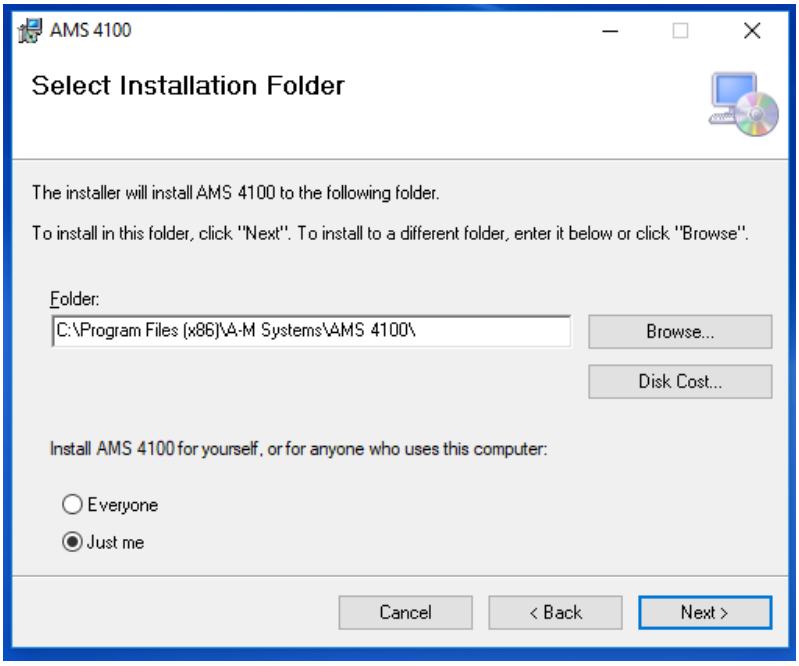
This software controls all features of the amplifier via the ethernet port.

Download the most recent version of Model 4100 control software from www.a-msystems.com. The software is located on the Model 4100 webpage.

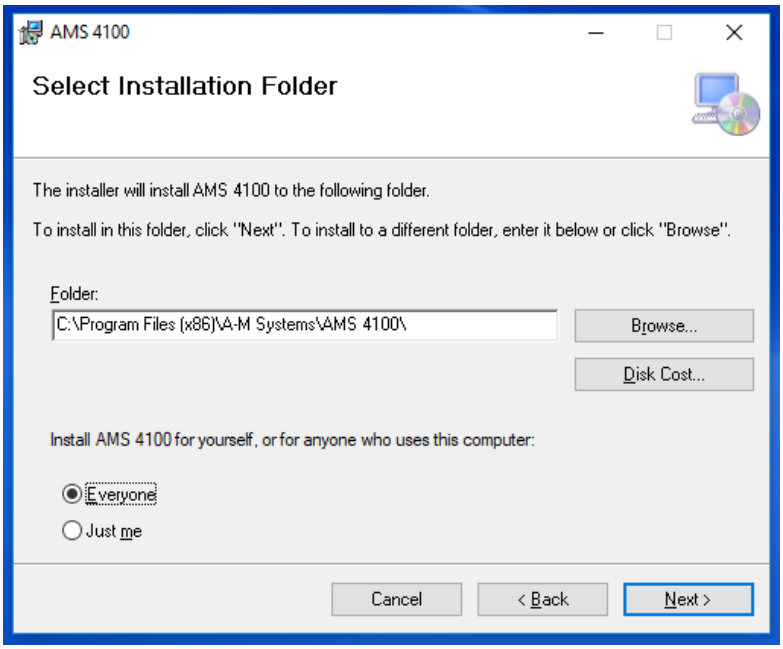
Run the downloaded MSI file. A Windows 10 dialog box will open:



Click "Next" to proceed. A second dialog box will appear asking for the location where you would like the program to be installed.



Most users select "Everyone" before proceeding.



Confirm that you would like to install the software.

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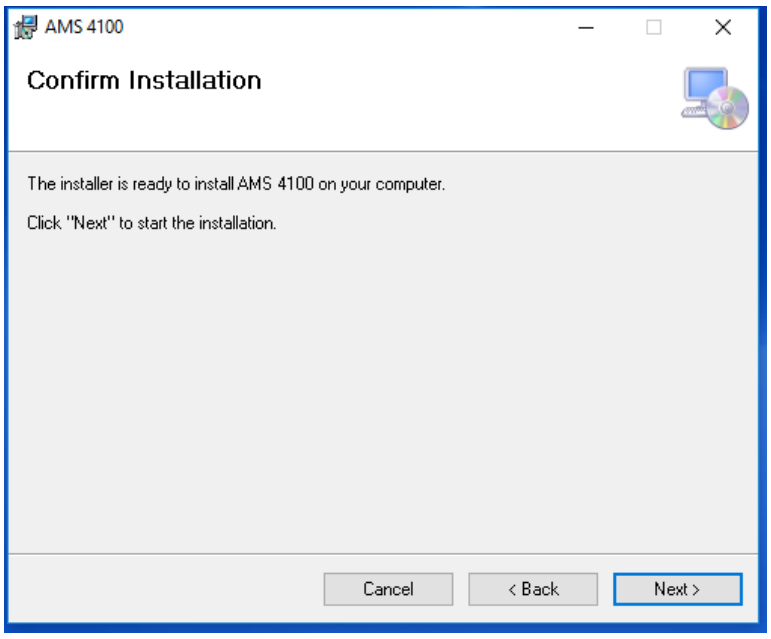
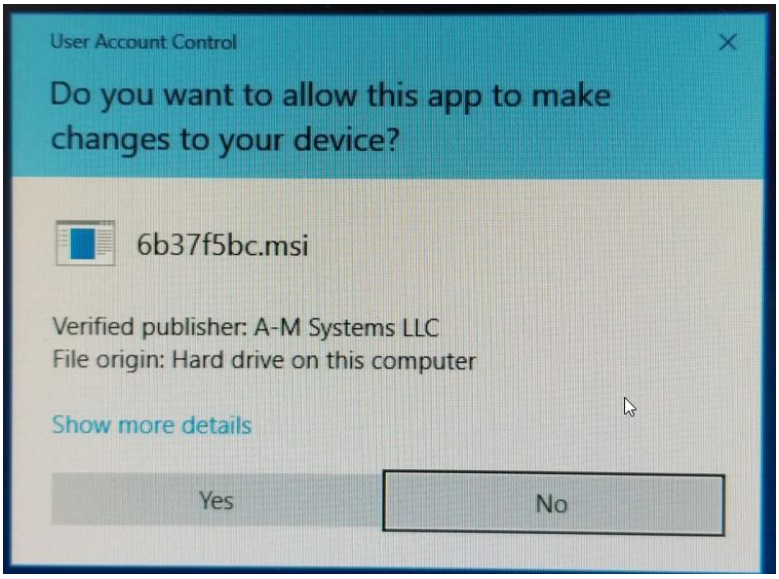
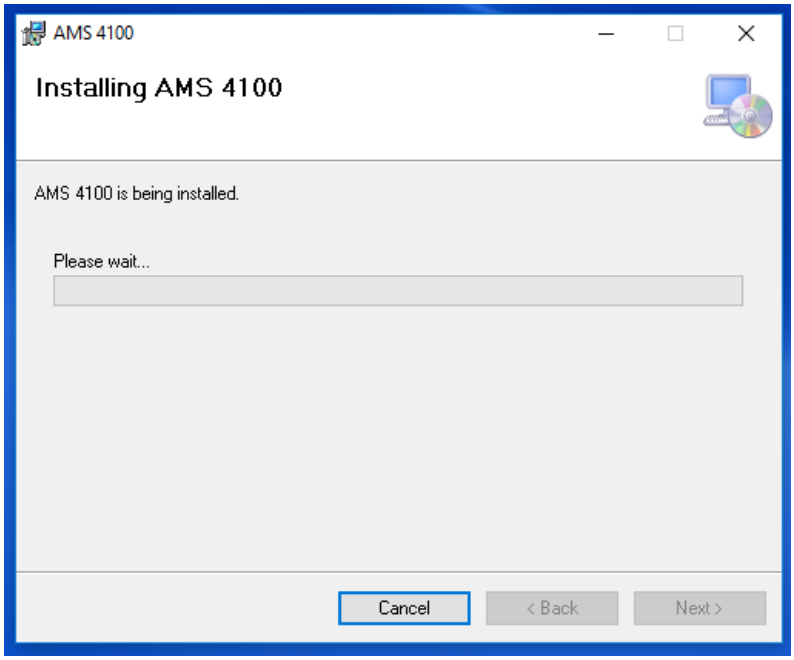


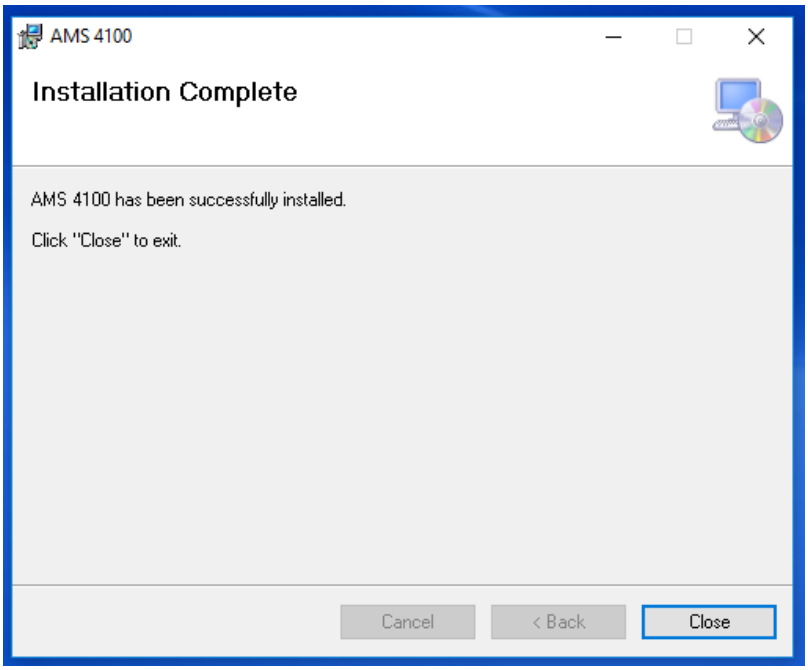
At this point, Win 10 might ask you if you want to allow the program to be installed. Answer yes to proceed.



Installation will continue.



A final dialog box will appear once the installation is complete.



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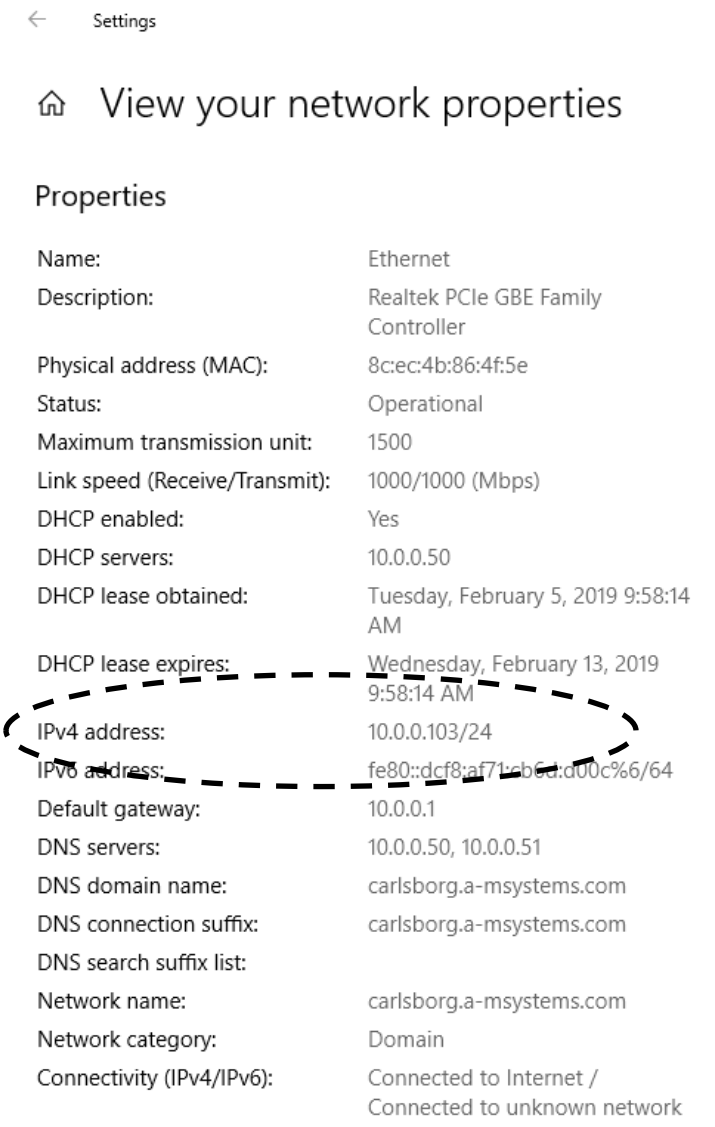
Network Configuration – Using an existing network

Identify the IP Address on your computer by examining the TCP/IPv4 parameters under your network card settings menu.

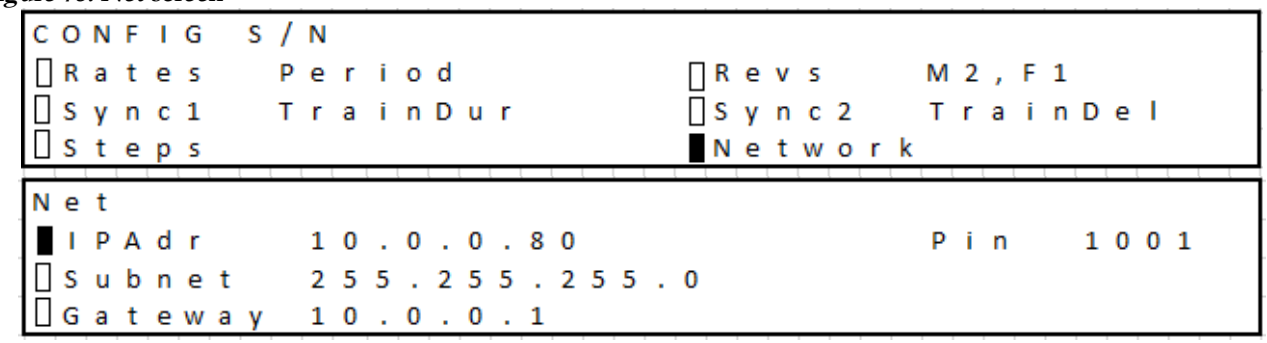
Figure 77. Computer Network Properties



Note the TCP\IPv4 address of your host computer. In this case, it is 10.0.0.103.
Select a nearby number on the network that is available (not being used by any other device) to be assigned to the Model 4100.

On the 4100 front panel, open the NETWORK screen by navigating to the NETWORK field on the CONFIGURE screen (Press **GEN** until the CONFIGURE screen appears), and then selecting "Ok"

Figure 78. Net screen



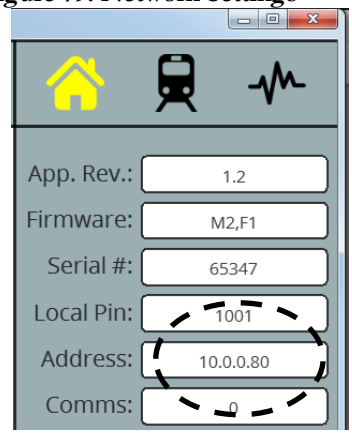
Navigate to IPAddress and set the values to an approved number on your network. For this example, the Model 4100 will be assigned "10.0.0.80." Note that it is unlikely that the Subnet and the Gateway numbers require attention. A PIN (can be user modified) is used to prevent unauthorized access to the unit via software. This number must also be entered into the software application in order for the software to control the instrument.

Open the software application and Click on the HOME icon twice to access the communication settings.

Enter the address of the instrument in the right hand column. This address should match the value you entered on the NET screen. Enter the same PIN as entered on the instrument.

Note: The Model 4100 and the control computer must be on the same local area network.

Figure 79. Network Settings



If the network was configured properly, the circular arrows in the top row of the PC software will change color from gray to yellow.

Figure 80. Communication Status

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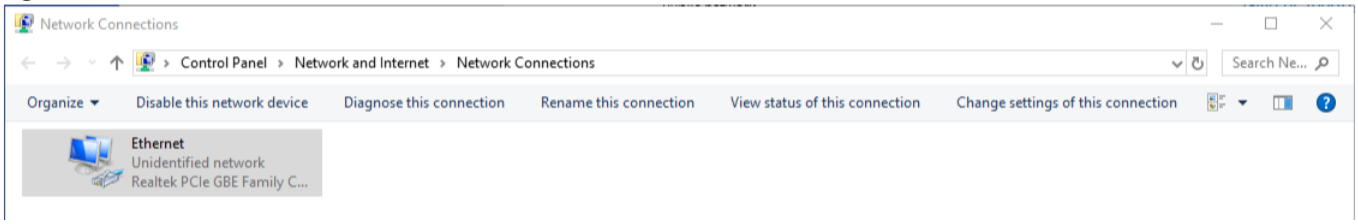
Direct PC to Model 4100 connection

If there is no available network, then you can connect the Model 4100 directly to your computer using the ethernet cable.

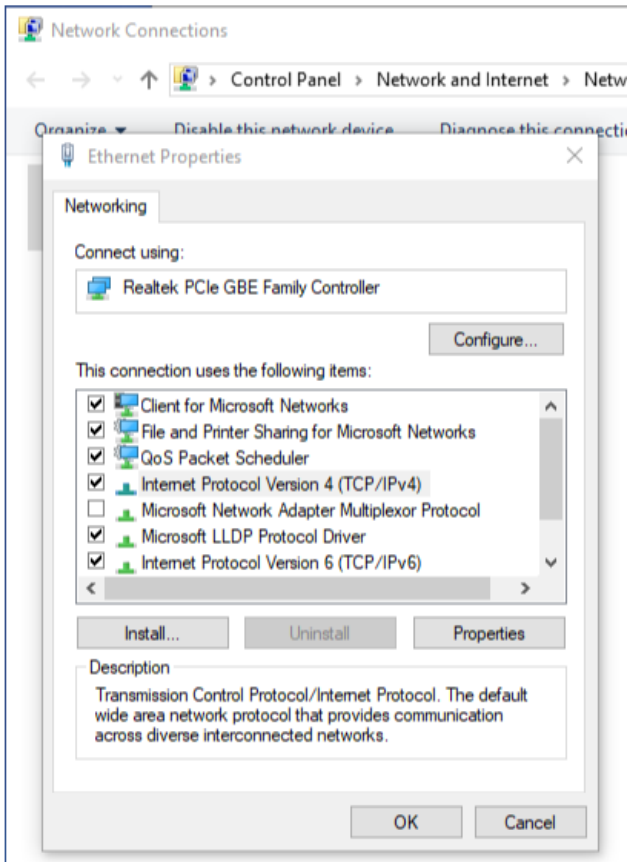
After connecting the Model 4100 to your computer, navigate to your computer's network settings page and find the properties for the computer's network card.

Figure 81. Direct Network Connection



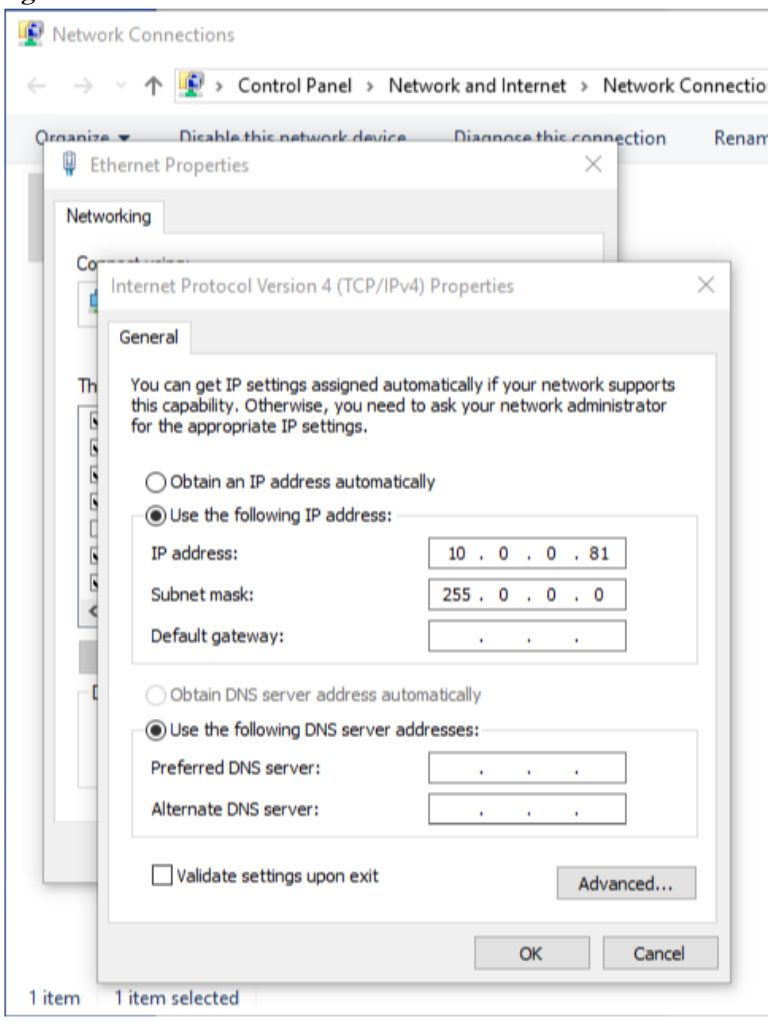
Open the settings of the network card, and view the TCP/IPv4 properties.

Figure 82. IPv4 Settings



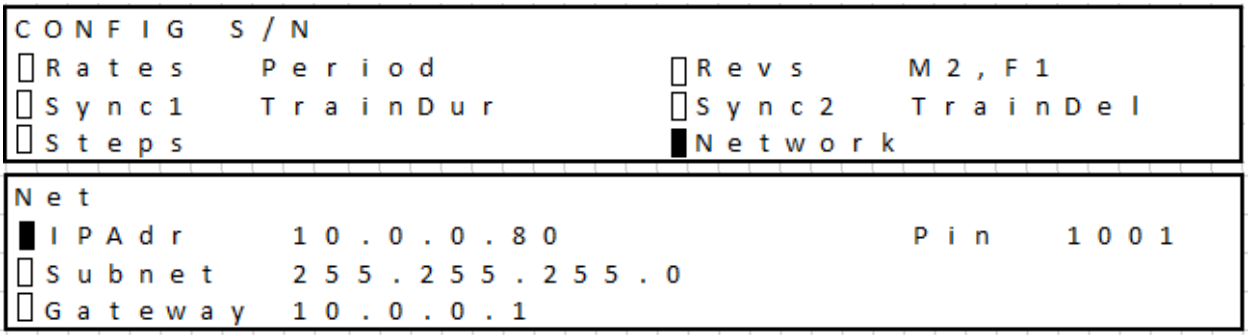
Enter an IP address that is nearby the value you want to set the Model 4100 address to. In this case, the computer network card was set to 10.0.0.81.

Figure 83. IP Address



On the 4100 front panel, open the NETWORK screen by navigating to the NETWORK field on the CONFIGURE screen (Press **GEN** until the CONFIGURE screen appears), and then selecting "Ok." Enter the network address for the Model 4100 on its front panel

Figure 84. 4100 IP Address



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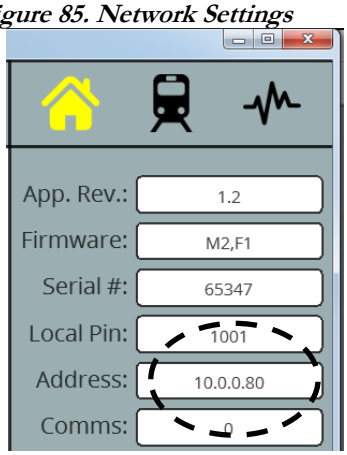
Open the software application and Click on the HOME icon twice to access the communication settings.

Enter the address of the instrument in the right hand column. This address should match the value you entered on the NET screen. Enter the same PIN as entered on the instrument.

Note: The Model 4100 and the control computer must be on the same local area network.

Figure 85. Network Settings

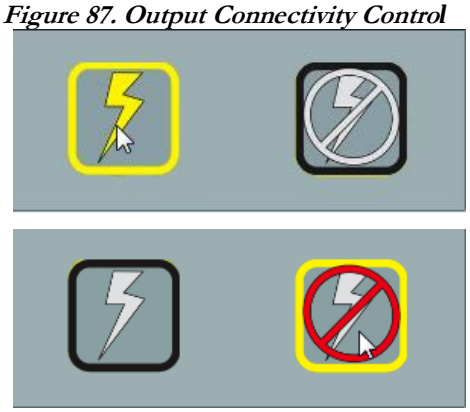


If the network was configured properly, the circular arrows in the top row of the PC software will change color from gray to yellow.

Figure 86. Communication Status

Signal output can be stopped immediately by opening the relay that passes the generated output signal to the output banana connectors. The icons at the bottom right of the software panel control this relay. The Icon highlighted in yellow is the currently active setting. When the lighting bolt is highlighted in yellow (Figure 79, *upper*), the output relay is closed and the signals are delivered to the output banana connectors. When the lightning bolt is overlaid by a red "NOT" symbol (Figure 79, *lower*), the relay is open, and no signal is delivered to the output connectors (though the timing could still be continuing).

Figure 87. Output Connectivity Control



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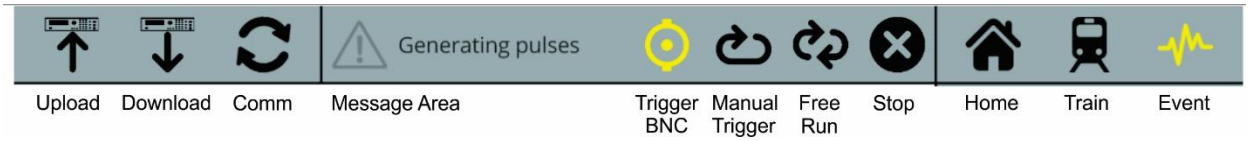
The toolbar is consistent across all pages.

Figure 88. Software: Toolbar



UPLOAD transfers information from the software app to the Model 4100.

DOWNLOAD transfers information from the Model 4100 to the software app.

COMM will spin when information is being transferred.

Status and error messages are displayed in the MESSAGE AREA.

The TRIGGER BNC indicates that the instrument will accept triggers at the front panel BNC connector marked **TRIGGER**.

Clicking on MANUAL TRIGGER initiates the timing sequence. It is equivalent to manually depressing the Trigger switch to the **MANUAL** position and releasing.

Clicking on FREE RUN places the instrument in free run mode. It is equivalent to manually moving the Trigger switch upwards to the **FREE RUN** position.

STOP ceases all timing and output from the Model 4100.

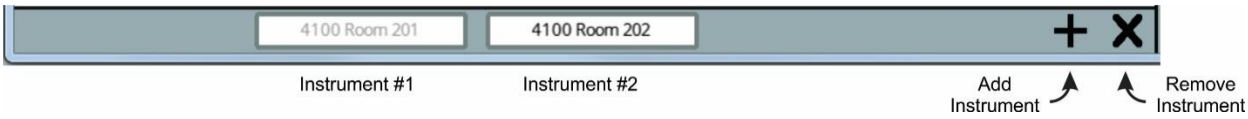
HOME switches the app to the Home screen, and is the equivalent of pressing the **HOME** button.

TRAIN switches the app to the Train definition screen, and is the equivalent of pressing the **TRAIN** button.

EVENT switches the app to the Event definition screen, and is the equivalent of pressing the **EVENT** button.

Yellow indicates which icons are active.

Figure 89. Software: Multi Instrument



Multiple instruments can be controlled by the software application. Add and remove instruments using the "**+**" and "**X**" icons.

An instrument is selected by clicking on the instrument name in the bottom of the window. This toolbar appears on every application page, and any information displayed belongs to the instrument selected.

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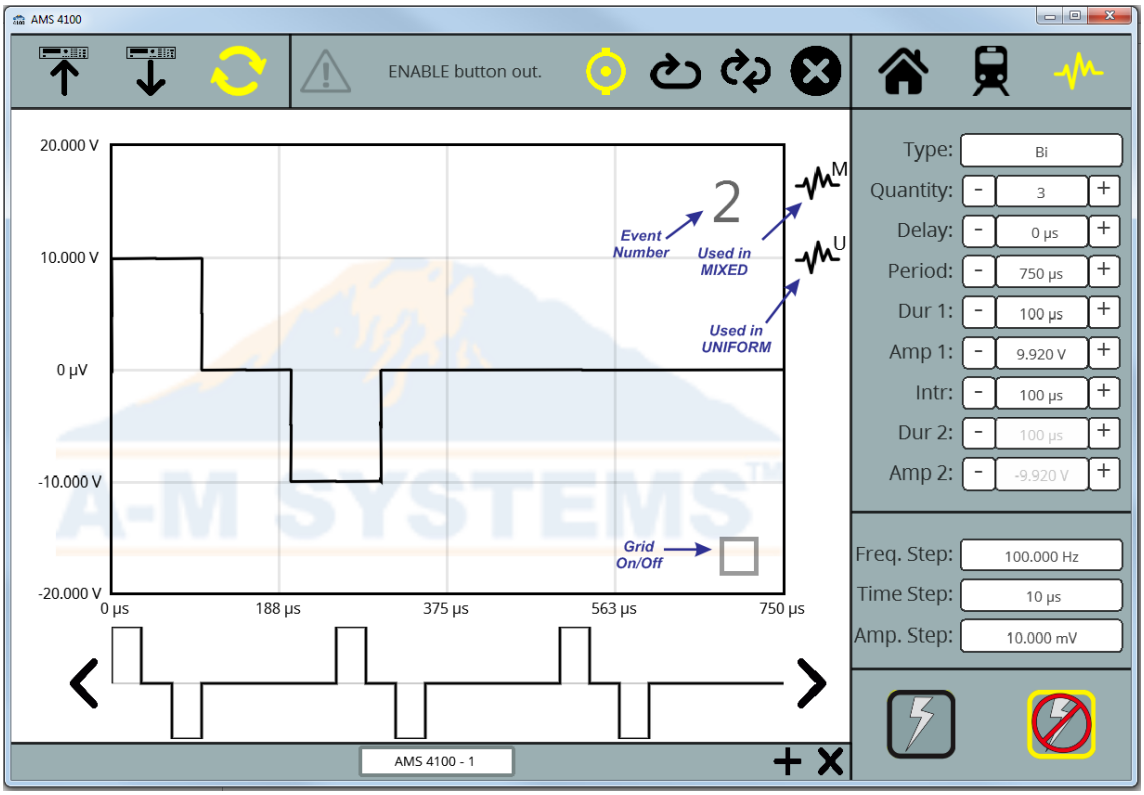
The Event page can be accessed by pressing the signal icon: 

Figure 90. Software: Event Page



Event parameters can be entered in the right hand column. Amplitude and Durations can be adjusted by clicking and dragging (or using touch screen gestures) on the middle graph of the waveform.

The bottom plot reflects the total quantity of events requested of this definition (in this case, 3).

Clicking on either arrowhead decreases\increases the library number, and will advance the screen to the previous\next event in the library.

Note that this screen does not determine which event is being delivered. That is determined by the TRAIN page and Event List. If present, the icon indicates that the library position depicted is being used in the MIXED train definition. If present, the  icon indicates that the library position depicted is being used in the UNIFORM train definition.

Also, notice the Time Step and Amp. Step settings, which facilitate quick and accurate changes in time and amplitude by limiting changes to multiples of the step sizes. These settings determine the increment\decrement changes in amplitude or time for every press of the (+) or (-) icons in the software or the INC or DEC buttons on the front panel.

The checkbox toggles on\off faint grid boxes to assist in identifying where on the trace are active zones you can click\touch to drag and change waveform shapes.

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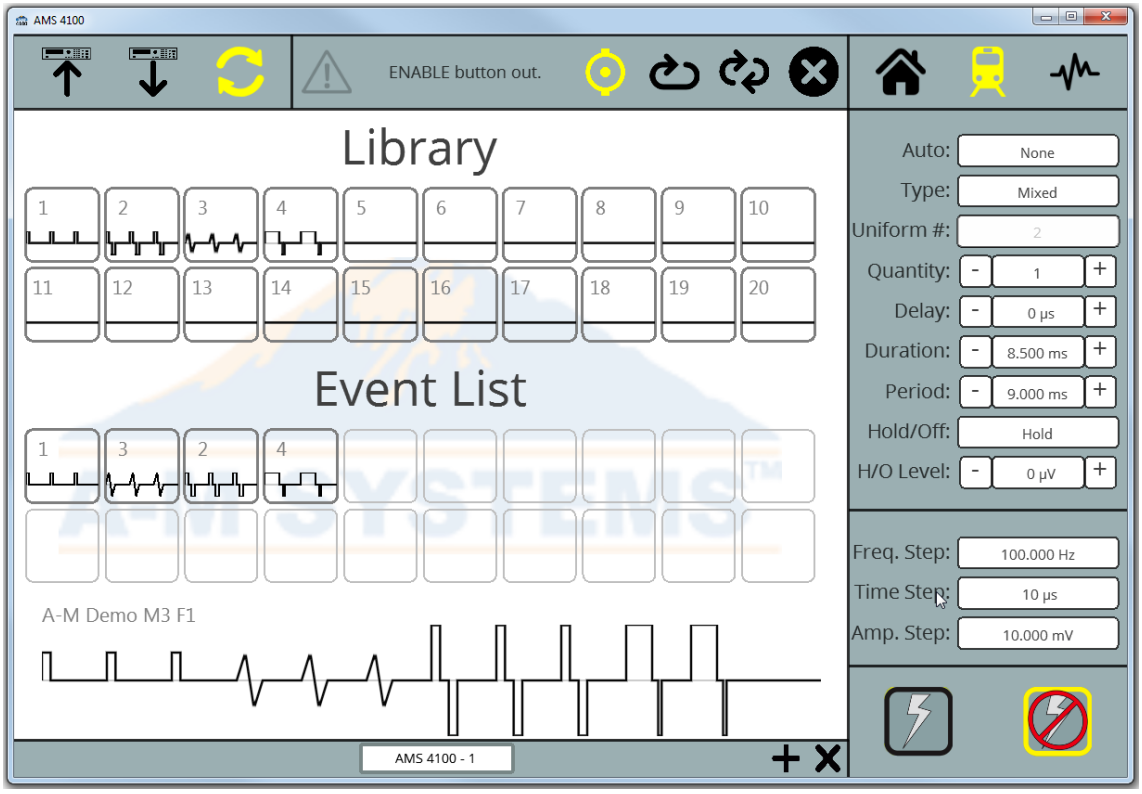
Train and Event List information is entered on the TRAIN Page, which is accessed by selecting the train icon:

Figure 91. Software: Train Page



Events in the library can be dragged down into the Event List to set up the order in which they are delivered. Rearranging the event icons immediately results in reordering the events being generated by the 4100. Pulling an event icon off the Event List removes that event from the ones being generated.

Events can be cloned by dragging them to a different event within the library, allowing quick development of a series of basically similar event types varying only in amplitude perhaps.

In UNIFORM mode, selecting the event within the library itself results in that stimulus being delivered. It does not have to be dragged to the Event List.

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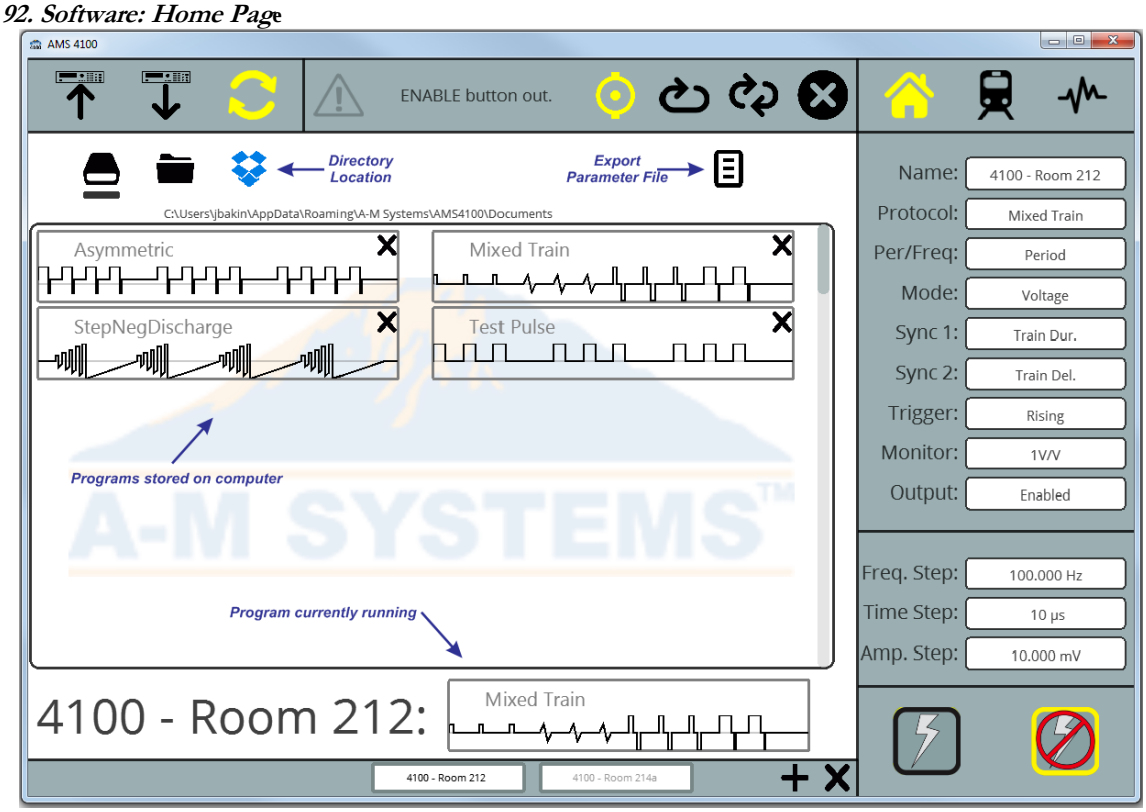
General settings are accessed on the HOME page by pressing on the home icon: 

Pressing the HOME icon while on the home page will display a text summary of all current settings, as well as basic firmware\software information.

Figure 92. Software: Home Page



An additional feature that the software provides that is not present on the instrument itself is the ability to store multiple programs of stimulus information, and quickly change between programs. Programs are stored by dragging the current formulation up to one of the eight program slots. Programs can be uniquely named while in the Current position by clicking within ID box in the upper right.

Programs can be stored on:

a local directory (AppData\Roaming)  , My Documents  , or Dropbox  .

A parameter set can also be viewed\written to a text file. 

To Load a previously defined program onto the Model 4100, drag the image of the program down to the Current Box, and click\touch the Upload button:

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7. Specifications

Wide pulse timing range: 1 μs to 25 hours

Minimum monophasic pulse duration: 1 μs

Minimum biphasic pulse duration: 2 μs

Minimum pulse interval: 3 μs

Minimum train delay: 2 μs

Timing accuracy: better than 0.02%,

Voltage output: ± 200 V with 1 mV resolution

Current output: 100mA with 1 μA resolution

1MHz bandwidth

Dimensions: 17" x 10" x 4" ; 21 lbs

Shipping Dimensions: 23" x 17" x 10" ; 24 lbs

Minimum computer requirements:

Video Driver capable of supporting OpenGL 2.1 or greater.

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8. Warranty

A-M SYSTEMS, LLC

LIMITED WARRANTY

What does this warranty cover?

A-M Systems, LLC (hereinafter, "A-M Systems") warrants to the Purchaser that the Instruments manufactured by A-M Systems (hereinafter the "hardware"), and sold after January 1, 2020, is free from defects in workmanship or material under normal use and service for the lifetime of the hardware. Headstages manufactured by A-M Systems and sold after January 1, 2020, will be repaired under warranty only once per year. This warranty commences on the date of delivery of the hardware to the Purchaser. "Lifetime" is defined as the time all components in the instrument can still be purchased from mainstream, common, electronic component distributors such as Digi-Key Electronics, Newark, or Mouser Electronics.

For hardware sold prior to January 1, 2020, the warranty in effect at time of purchase applies, with the maximum warranty period of three (3) years for new purchases, and one (1) year for those that have been repaired by A-M Systems. For headstages manufactured by A-M Systems and sold prior to January 1, 2020, the maximum warranty period is one (1) year.

What are the obligations of A-M Systems under this warranty?

During the warranty period, A-M Systems agrees to repair or replace, at its sole option, without charge to the Purchaser, any defective component part of the hardware. To obtain warranty service, the Purchaser must return the hardware to A-M Systems or an authorized A-M Systems distributor in an adequate shipping container. Any postage, shipping and insurance charges incurred in shipping the hardware to A-M Systems must be prepaid by the Purchaser, and all risk for the hardware shall remain with Purchaser until A-M Systems takes receipt of the hardware. Upon receipt, A-M Systems will promptly repair or replace the defective unit and then return the hardware (or its replacement) to the Purchaser with postage, shipping, and insurance prepaid by the Purchaser. A-M Systems may use reconditioned or like-new parts or units at its sole option, when repairing any hardware. Repaired products shall carry the same amount of outstanding warranty as from original purchase. Any claim under the warranty must include a dated proof of purchase of the hardware covered by this warranty. In any event, A-M Systems liability for defective hardware is limited to repairing or replacing the hardware.

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What is not covered by this warranty?

This warranty is contingent upon proper use and maintenance of the hardware by the Purchaser and does not cover batteries. Neglect, misuse whether intentional or otherwise, tampering with or altering the hardware, damage caused by accident, damage caused by unusual physical, electrical, chemical, or electromechanical stress, damage caused by failure of electrical power, or damage caused during transportation are not covered by this warranty. Further, no guarantee is made regarding software compatibility with future updated operating systems. Products may not be returned to A-M Systems for service, whether under warranty or otherwise, which are contaminated by infectious agents, radioactive compounds or other materials constituting a health hazard to employees of A-M Systems

What are the limits of liability for A-M Systems under this warranty?

A-M Systems shall not be liable for loss of data, lost profits or savings, or any special, incidental, consequential, indirect or other similar damages, whether arising from breach of contract, negligence, or other legal action, even if the company or its agent has been advised of the possibility of such damages, or for any claim brought against you by another party.

THIS EQUIPMENT IS NOT INTENDED FOR CLINICAL MEASUREMENTS USING HUMAN SUBJECTS.

A-M SYSTEMS DOES NOT ASSUME RESPONSIBILITY FOR INJURY OR DAMAGE DUE TO MISUSE OF THIS EQUIPMENT.

Jurisdictions vary with regard to the enforceability of provisions excluding or limiting liability for incidental or consequential damages. Check the provision of your local jurisdiction to find out whether the above exclusion applies to you.

This warranty allocates risks of product failure between the Purchaser and A-M Systems. A-M Systems hardware pricing reflects this allocation of risk and the limitations of liability contained in this warranty. The agents, employees, distributors, and dealers of A-M Systems are not authorized to make modifications to this warranty, or additional warranties binding on the company. Accordingly, additional statements such as dealer advertising or presentations, whether oral or written, do not constitute warranties by A-M Systems and should not be relied upon. This warranty gives you specific legal rights. You may also have other rights which vary from one jurisdiction to another.

THE WARRANTY AND REMEDY PROVIDED ABOVE IS IN LIEU OF ALL OTHER WARRANTIES AND REMEDIES, WHETHER EXPRESS OR IMPLIED. A-M SYSTEMS DISCLAIMS THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR USE, WITHOUT LIMITATION.

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Revision History

Rev	Date	Description	
1	4/28/16	DCR 202586	Initial Document Release
2	10/27/16	DCR 202705	Update for changes to software, firmware
3	4/30/18	DCR 203007	Update for changes to software, firmware
4	1/18/19	DCR 202615	Review content. Add rev control to content. Change Part # to 5027915
5	3/19/20	DCR 203138	Add direct connection instructions, update warranty