

INSTRUCTION MANUAL



KEPCO An ISO 9001 Company.

**BOP 1000W
RETROFIT
KIT 219-0533**

BOP 1000W FIRMWARE RETROFIT KIT

1. DESCRIPTION

Kepeco KIT 219-0533 contains the PROMs used to upgrade the firmware for BOP 1000W power supplies. The upgraded firmware supports faster serial communication, faster measurement rate, and improves LIST command functionality:

- Provides ability to trigger external devices during execution of a lists generated either remotely via SCPI commands or from the front panel.
- Provides ability to use trigger input of BOP to step through a list.
- Provides repeat functionality to speed up list creation.
- Provides ability to control what appears at the output when stopping a list executed from the front panel.
- Provides ability to assign different values for positive and negative limits upon startup.
- Supports 0.001 Hz sine and triangle waveform operation.

2. APPLICABILITY

This KIT applies only to

- Models BOP 72-14MG and BOP 100-10MG, all revisions
- Models BOP 10-75-MG, revision 3 and higher
- Model BOP 36-28MG, revision 7 and higher
- Models BOP 50-20MG and BOP 20-50MG, revision 1 and higher

NOTE: For revisions not listed above, please consult factory.

Kepeco can provide firmware that has been pre-configured for a particular unit. The serial number of the unit is added to part number of the kit to indicate the unit to which the kit applies.

When the upgrade is complete, a five digit number is added to the Model number of the modified unit to identify the upgrade(s) installed.

3. INSTALLATION INSTRUCTIONS

3.1 MATERIAL REQUIRED (See Table 1.)

3.2 PRELIMINARY PROCEDURE

1. Prior to upgrade, turn on unit and note the serial number when it is displayed during power-up. Record Serial number for configuration after upgrade is complete.
2. If pre-configured chip is provided, verify the serial number of the unit matches the serial number of the kit (KIT 2190533-[serial number])

3.3 DISASSEMBLY PROCEDURE

1. Turn power off, disconnect the unit from source power and remove line cord.
2. Remove the two mounting ears from the chassis by removing three screws from each.

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- Remove the top cover of the unit by removing 14 screws as follows: two at top of the front panel, four at each side, (one towards the rear, three at the bottom) and four at the top of the rear panel.

TABLE 1. MATERIAL REQUIRED

| MATERIAL | LOCATION | QUANTITY |
|--|----------------------|----------|
| • PROM U9: Replaces U9 in Distribution Board A6. | Provided in this Kit | 1 |
| • PROM U2: Replaces U2 in Digital Board A1. | Provided in this Kit | 1 |
| • PROM U24: Replaces U24 in Digital Board A1. | Provided in this Kit | 1 |
| • Resistor (Kepco P/N 115-2490) Replaces R82 in Digital Board A1. | Provided in this Kit | 1 |
| • Resistor (Kepco P/N 115-2386) Replaces R92 and R93 in Digital Board A1. | Provided in this Kit | 2 |
| • Instruction Manual (Kepco P/N 228-1644) | Provided in this Kit | 1 |
| • ESD (Electrostatic Discharge) wrist strap (Kepco P/N 114-0080) | Provided in this Kit | 1 |
| • IC Extractor (Kepco P/N 114-0079) | Provided in this Kit | 1 |
| • Connector (Kepco P/N 142-0527) Mates with Trigger Port. | Provided in this Kit | 1 |
| • Capacitor Assembly: Kepco P/N 117-0999 wired to lug (for BOP 36-28MG only) | Provided in this kit | |

- Observe back of front panel-mounted circuit breaker. If a Printed Circuit Board is present, skip this step. If not, tag and remove the four quick disconnect cables from circuit breaker.
- Disconnect ribbon cable attached to Distribution board A6A1 (see Figure 1) going to Front End Control board A4A3 connector J1.
- Disconnect ribbon cable attached to Distribution board A6 going to Digital board A1J2.
- Disconnect two 4-pin connectors (or, on some units one 4-pin and one 6-pin connector) (J12, J15, Figure 2), and one 5-pin connector (J14, Figure 2) wired with twisted pairs from Distribution board A6. Pull on the twisted pair where it enters the connector; if necessary, a screwdriver can be used to apply enough pressure to front panel to slightly increase separation between front panel and Distribution board A6, enough for the connectors to be removed.

CAUTION: Failure to pull the fan connector straight back can damage the connector.

- Remove fan connector (J10, Figure 2) from Distribution board A6 by pulling connector straight back
CAUTION: Removing the outer screws first can result in damage to the front panel.
- At the bottom of the chassis, first remove the two inner screws, then the two outer screws securing front panel to chassis and separate front panel and Distribution board A6 from the chassis.
- For units without lug wires, carefully pull the front panel straight back from the chassis to disengage the circuit breaker pins and separate the front panel from the chassis
- Pry black cover off front panel ADJUST knob. Then remove ADJUST knob by releasing the nut.

3.4 DIGITAL BOARD A1 COMPONENT REPLACEMENT (SEE FIGURE 1)

NOTE: Steps 1 and 2 can be skipped if brief trigger pulses (less than one second) are used.

- On Digital board A1, locate resistor R82 (see Figure 1). Unsolder and remove R82 and replace with Kepco P/N 115-2490 supplied with kit.
- On Digital board A1, locate resistors R92 and R93 (see Figure 1). Unsolder and remove R92 and R93 and replace with Kepco P/N 115-2386 supplied with kit.
- On Digital board A1, locate PROM, U2 (see Figure 1).

CAUTION: FAILURE TO USE THE ESD WRIST STRAP MAY DAMAGE THE PROM!

4. Take the ESD wrist strap from kit and use the peel and stick area to connect the wrist strap to the chassis of the BOP. Place the wrist strap on your arm as indicated by the instructions for the wrist strap.
5. Touch the IC tube to the chassis of the BOP. Open one end.
6. Pry out the PROM U2 using an IC extractor. Insert the hook, first into one slot and then the other, and gently pry out the PROM. Place the PROM in the tube and close the tube.
7. Open the other end of the IC tube and remove the replacement PROM U2 from the tube.
8. Insert the PROM into the socket, insuring the dot on the chip is oriented as shown in Figure 1.

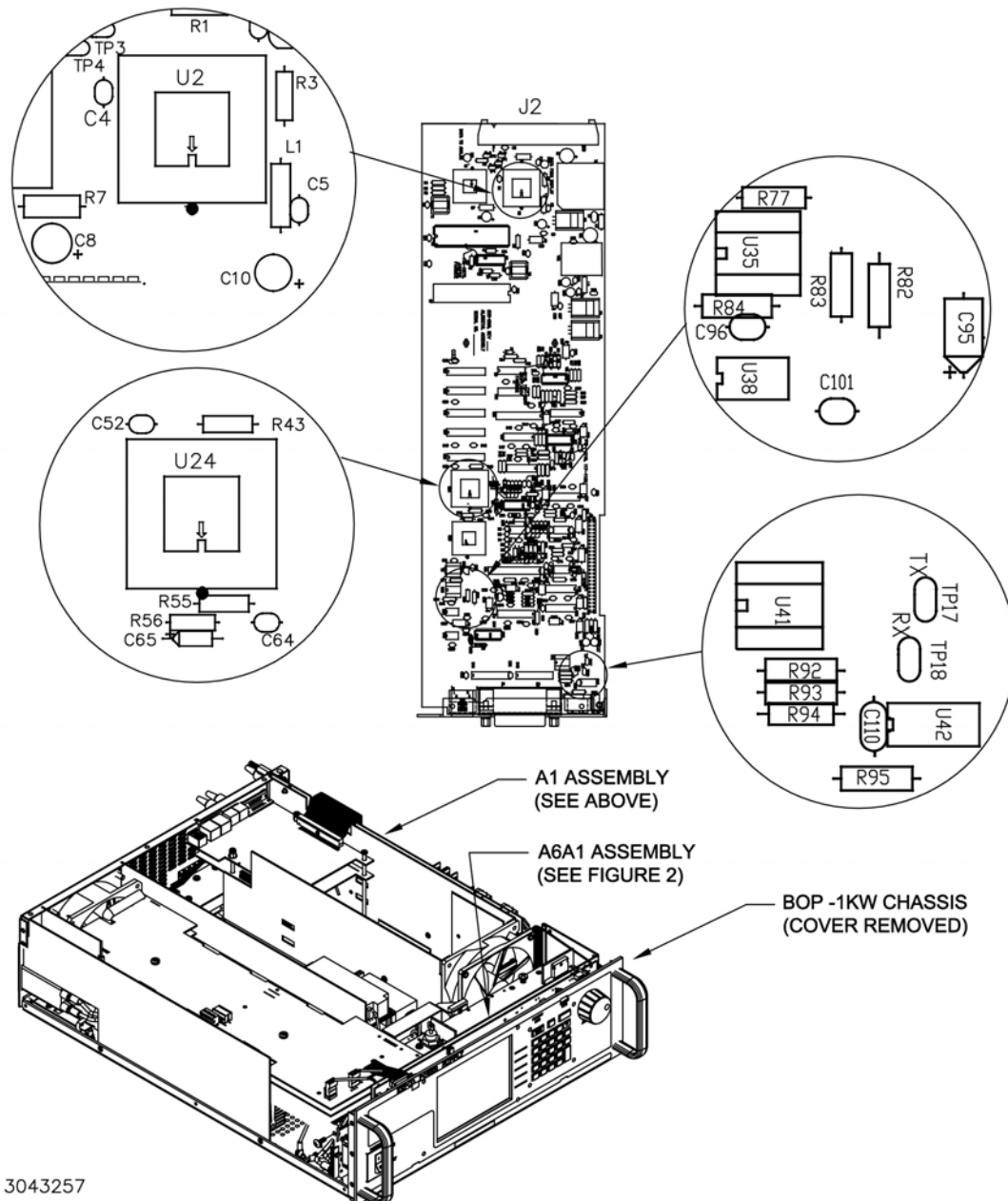


FIGURE 1. DIGITAL BOARD A1 PROM LOCATIONS

9. Pry out the PROM U24 using an IC extractor. Insert the hook, first into one slot and then the other, and gently pry out the PROM. Place the PROM in the tube and close the tube.
10. Open the other end of the IC tube and remove the replacement PROM U24 from the tube.
11. Insert the PROM into the socket, insuring the dot on the chip is oriented as shown in Figure 1.
12. Reclose the IC tube. Remove wrist strap and disconnect it from the BOP chassis.

3.5 DISTRIBUTION BOARD A6A1 PROM REPLACEMENT (SEE FIGURE 2)

CAUTION: Note which screws do not use flat washers and tag for reassembly.

1. Perform this step for BOP 36-26MG only; for all other models, skip to step 2. For the BOP 36-28MG, this step insures the front panel adjuster does not have erratic operation.
 - a. Remove screw in upper left hand corner of front panel securing A6A1 to the front panel.
 - b. Install the screw just removed through the lug of the capacitor assembly supplied, and reinstall the screw (hand tight); refer to Figure 2, Detail A.
 - c. Solder the other end of the capacitor to pin 2 of J12 as shown in Figure 2, Detail A.

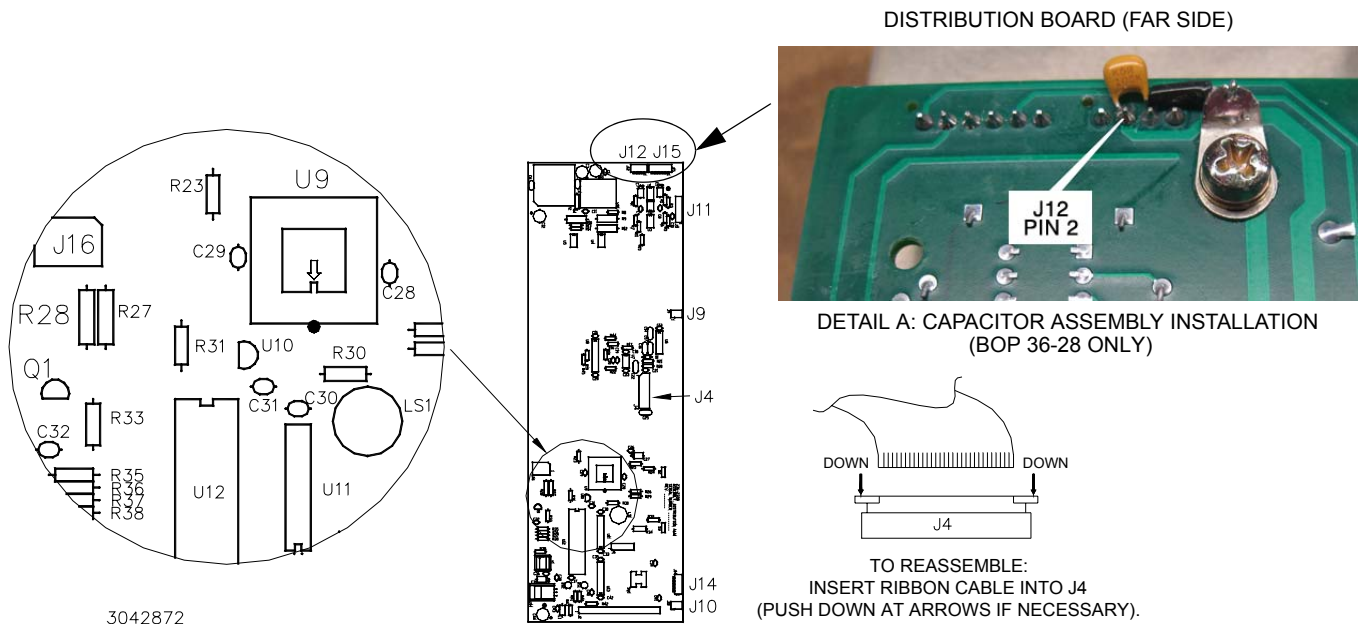


FIGURE 2. DISTRIBUTION BOARD A6A1 COMPONENT LOCATION

2. Remove seven screws, seven lockwashers and five flat washers securing the Distribution board A6A1 to the front panel. Carefully separate the Distribution board A6A1 from the front panel. The PROM on the Distribution board A6A1 is now accessible for replacement (it is not necessary to disconnect the ribbon cables between the front panel and Distribution board A6) to replace the PROM.
3. Place Distribution board A6A1 on an ESD mat (if an ESD mat is not available, place the Distribution board on the top cover) and locate PROM U9 (see Figure 2).

CAUTION: FAILURE TO USE THE ESD WRIST STRAP MAY DAMAGE THE PROM!

4. Use the peel and stick area of the wrist strap to connect the wrist strap to an ESD mat (or to the top cover if an ESD mat is not available). Place the wrist strap on your arm as indicated by the instructions for the wrist strap.
5. Touch the IC tube to the ESD mat or top cover. Open one end of the IC tube.
6. Pry out the PROM U9 using an IC extractor. Insert the hook, first into one slot and then the other, and gently pry out the PROM. Place the PROM in the tube and close the tube.
7. Open the other end of the IC tube and remove the replacement PROM U9 from the tube.
8. Insert the PROM into the U9 socket, insuring the dot on the chip is oriented as shown in Figure 2.
9. Reclose the IC tube. Remove wrist strap and disconnect it from the BOP.

3.6 REASSEMBLY

1. Carefully line up the 14-pin header on Distribution board A6A1 with the corresponding socket on the front panel, and the Distribution board LED's with the corresponding cutouts in the front panel and press the Distribution board into place.
2. Secure Distribution board A6A1 to the front panel using seven screws, seven lockwashers and five flat washers as noted during disassembly.
3. Slide the ADJUST knob over the shaft of the ADJUST control and secure using nut and washer. Press black cover onto front panel ADJUST knob.
4. Carefully line up circuit breaker pins with corresponding connectors on front panel and carefully mate front panel and chassis. If circuit breaker incorporates a Printed Circuit Board, it may be necessary to press the PCB onto the circuit breaker.

CAUTION: Installing the inner screws first can result in damage to the front panel.

5. Attach front panel with Distribution board A6A1 to the chassis first using two outer screws at the bottom of the chassis, then two inner screws.
6. Connect two 4-pin connectors (or one 4-pin and one 6-pin connector), and one 5-pin connector attached to twisted pairs to connectors J12, J15 and J14, respectively on Distribution board A6A1 (see Figure 2). The 4-pin connectors can plug into either J12 or J15; holding the wires, line up the pins on an angle, then push until straight and press into place; if necessary a screwdriver can be used to apply enough pressure to front panel to slightly increase separation between front panel and Distribution board A6A1, enough for the connectors to be inserted.
7. Attach the fan connector (J10, Figure 2) by inserting the connector straight into the mating socket.
8. Connect ribbon cable from Distribution board A6 to Digital board connector A1J2.
9. Connect ribbon cable from A4A3 module to Distribution board A6A1 connector J11.
10. If Circuit breaker does not have a Printed Circuit Board, connect the four wires to the circuit breaker in accordance with the tags on the wires.
11. Attach the cover to the chassis using 14 screws.
12. Attach the two mounting ears to the chassis using three screws for each.
13. Install the power cord, connect the unit to source power, turn on power supply and proceed to Initialization, PAR. 4
14. At the rear of the unit, for Models BOP 10-75-MG-26566, BOP 20-50MG-26828 and BOP 36-28MG-26567, add the following marking to the model number: -26887 to identify the unit as having the GPIB firmware upgrade installed. For all other models, add -26886 to the model number to identify the unit as having the firmware upgrade installed.

4. INITIALIZATION

After the hardware upgrade has been completed it is necessary to configure the unit using the following procedure.

NOTE: For KIT part numbers that have a unit serial number, the unit type, max/min settings and calibration have been pre-configured; perform ONLY steps 2 and 3 of the following procedure.

1. At the front panel, press **F5** then use **↑** to highlight **Unit Type**. Press **F1** to select unit type. Highlight applicable model (should match nameplate on front panel) and press **F4**.
2. At the front panel, press **F5** then use **↓** to highlight **Power Up Settings**. Press **F1** to display the Max/Min Settings menu. Press **F2** to set all the Power Up settings to the factory default. Then press **F4** to save the settings for power-up.
3. At the front panel, press **F5** then use **↓** to highlight **Protected Settings**. Press **F1** to display the Protected Settings menu. Press **F2** to set all the Protected settings to the factory default. Then press **F4** to save the settings for power-up.
4. To establish the Serial Number use a remote interface to send the string DIAG:SER n where n is complete serial number recorded during the preliminary procedures (PAR. 3.2, step 1).
5. .Cycle power to the unit, turning it OFF, then ON using the POWER ON/OFF circuit breaker.
6. Calibrate the unit in accordance with the applicable Technical Manual for BOP 1000W.

5. INSTRUCTION MANUAL CHANGES

All Sections:

SECTION 1, Table 1-2: LIST command characteristics for “string” type waveform (Remote only) Change: FROM: For <126 different dwell times: 3933
TO: For <122 different dwell times: 3933

Table 1-2: Function Generator characteristics for Frequency
Change: FROM: 0.01 to 443 Sine, Triangle
TO: 0.001 to 443 Sine, Triangle

SECTION 2, Table 2-3,
pin 3 Change FROM: “SIGNAL NAME Not Used” TO: “SIGNAL NAME Input Trigger”
FROM: “FUNCTION TO: “FUNCTION Allows external trigger to control BOP LIST execution.”

SECTION 3,
PAR. 3.2.5, refers to Table 3-3; add the following entries to Table 3-3:

| SETTING | CHOICES | FUNCTION |
|---------|---------|----------|
|---------|---------|----------|

| | | |
|--|-------------------------|--|
| Waveform Stop Note: Accessed by pressing F3 (Display) from the power up screen. | Output Off | When waveform is stopped (e. g., by pressing F5), output freezes at whatever level the waveform was at when F5 was pressed, then after a brief delay output is set to STANDBY (disabled). |
| | Last Level | When waveform is stopped (e. g., by pressing F5), waveform runs through full cycle. The output stops at the last generated value of the waveform (e.g., for a sinewave segment of 0° to 270°, 10V amplitude, 0V offset, when F5 is pressed the output will end up at -10V. |
| | Current lvl | When waveform is stopped (e. g., by pressing F5), output freezes at whatever level the waveform was at when F5 was pressed. |
| REMOTE DEBUG | OFF ON | OFF - LCD does not show programmed settings for main and protection channels while in remote mode of operation (local mode is unaffected). ON - Programmed settings for main and protection channels are displayed, however the unit responds more slowly. |

PAR. 3.3.7, After 2nd paragraph “To change the default settings . . . abort the change.” add new paragraph:
To change the power-up default settings to use different positive and negative limits, first set the bipolar levels as described above. Then refer to PAR. 3.3.3.1 and set the independent limits as desired. When complete, press **F4** to save for power-up.

PAR's. 3.3.9.7 and 3.3.9.8, refer to Table 3-11; modify the TYPE setting as shown below:

| SETTING | CHOICES | FUNCTION |
|---------|---------|---|
| TYPE | Trigger | Determines whether high level, low level or high-to-low edge is required at trigger port to allow waveform to continue. NOTE: Offset does not affect trigger, 0V offset is recommended. |

PAR. 3.6.3.4, 1st paragraph Change FROM: “126 different dwell times” TO: “122 different dwell times”

PAR. 3.6.3.4, 2nd paragraph Change FROM: “126 different segments” TO: “122 different segments”

Table 3-9: Sine, Triangle and Ramp Waveform Frequency vs. Points

Change: FROM: Frequency FROM: 0.01
TO: Frequency FROM: 0.01 (0.001 sine and triangle)

Table 3-11: Waveform Segment Details Menu

Change: FROM: Sine or Triangle: 0.01 to 443 Hz
TO: Sine or Triangle: 0.001 to 443 Hz

APPENDIX A, PAR. A.6

*IDN? query <Main Revision>.<Flash Revision> fields return 2.21.

APPENDIX B

The following commands/queries are added to Appendix B.

B.33.1 [SOURCE:]LIST:REPeat COMMAND

LIST:REP

Syntax: Short Form: LIST:REP <int_value1>,<int_value2>,<array>
Long Form: LIST:REPeat <int_value1>,<int_value2>,<array>

where <int_value1> is start point to be copied
<int_value2> is end point to be copied
<array> is a series of comma separated values representing the new programmed current (Amps) for current list, or programmed voltage (Volts) for voltage list.

Description: **Copies points from existing list using the same dwell times, but different output settings.** Copies the contents of the dwell entries in the list from the start point to the end point and adds them to the end of the list. The setting value for each copied point is defined by the value in the array. This process is repeated until either a) an invalid programmed current or voltage is found, b) all entries in the array have been copied or c) the list is full.

This command must be preceded by LIST:CURR or LIST:VOLT command and the starting and end point values must be valid, otherwise a -221 "Settings conflict" error results. The entries on the dwell list must match the values in the current or voltage list, otherwise a -236 "Lists Unbalanced" error results. (See Figures B-2A and B-2B.)

B.34.1 [SOURCE:]LIST:SET:TRIGger COMMAND

LIST:SET:TRIG

Syntax: Short Form: LIST:SET:TRIG value
Long Form: LIST:SET:TRIGger value
where:
<value> = trigger pulse-width between 0.00025 and 0.033 second

Description: **Establishes external output trigger pulse-width.** Used to set the pulse-width of a trigger provided by the BOP to trigger an external device. (See Figure B-2B.)

B.34.2 [SOURCE:]LIST:SET:TRIGger? QUERY

LIST:SET:TRIG?

Syntax: Short Form: LIST:SET:TRIG? Long Form: LIST:SET:TRIGger?
Returns <value> = trigger pulse-width between 0.00025 and 0.033 second

Description: **Returns pulse-width of output used to trigger external device.** If sample pulse duration has not been set, error 100- "command error" results.

B.34.3 [SOURCE:]LIST:SET:WAIT COMMAND

LIST:SET:WAIT

Syntax: Short Form: LIST:SET:WAIT value
Long Form: LIST:SET:WAIT value
where: <value> = time-out for a wait command between .00025 and .033 seconds

Description: **Establishes the time-out for a wait command.** If this command is not sent, the time out period will be 0 indicating an infinite wait time. (See Figures B-2A and B-2B.)

B.34.4 [SOURCE:]LIST:SET:WAIT? QUERY

LIST:SET:WAIT?

Syntax: Short Form: LIST:SET:WAIT? Long Form: LIST:SET:WAIT?
Returns <value> = time-out for a wait command between 0.00025 and 0.033 second

Description: **Returns the time-out for a wait command.** Returns 0 if LIST:SET:WAIT not sent, indicating infinite wait time.

- NOTES: 1. The power supply is assumed to be operating in constant voltage mode.
2. The WAIT commands provide a method to synchronize multiple instruments to a common control pulse. This example assumes BOP and a number of switching DVMs are connected to a Unit Under Test (UUT). The DVMs are programmed to wait 1 millisecond after a high pulse is received from the host computer, then take a few measurements. The same high pulse is applied to the Trigger Input (pin 3 of the BOP Trigger Port); the negative-going edge of this pulse will cause the BOP to increment the output to the next level. Thus, each time the host computer issues a positive pulse, the BOP increments and the DVMs take measurements on the trailing (negative-going) edge of the positive pulse. The positive pulse must be greater than 4 milliseconds in width for this example to operate correctly.
3. The explanation below shows how each step of the list functions once the list is entered and VOLT:MODE LIST (the last step) is executed.

| | |
|-------------------------------------|--|
| list:cle | Clears the list. |
| list:volt:apply level,.001,0 | Establishes the list as a voltage list, output set to 0V. |
| list:wait:high 0 | Maintains output at 0V, waits for Input trigger high before proceeding. |
| | --- Host computer issues high pulse. Trigger input goes high and List proceeds to next point. |
| list:wait:low 0 | Maintains output at 0V, waits for Input Trigger low before proceeding. |
| | --- Input Trigger goes low at trailing (negative-going) edge of pulse from host commuter and List proceeds to next point. One millisecond after pulse issued, DVM takes measurements. |
| list:wait:high 1.1 | Sets output to 1.1V (next point in waveform), waits for Input Trigger high before proceeding. |
| | --- Host computer issues another high pulse. Trigger input goes high and List proceeds to next point. |
| list:wait:low 1.1 | Maintains output at 1.1V, waits for Input Trigger low before proceeding. |
| | --- Input Trigger goes low at trailing (negative-going) edge of pulse from host computer and List proceeds to next point. One millisecond after pulse issued, DVM takes measurements. |
| list:dwel:points? | Returns the current point location (6). (Used for list:repeat.) |
| list:wait:high 2.2. | Sets output to 2.2V (next point in waveform), waits for Input Trigger high before proceeding. |
| | --- Host computer issues another high pulse. Trigger input goes high and List proceeds to next point. |
| list:wait:low 2.2 | Maintains output at 2.2V, waits for Input Trigger low before proceeding. |
| | --- Input Trigger goes low at trailing (negative-going) edge of pulse from host computer and List proceeds to next point. One millisecond after pulse issued, DVM takes measurements. |
| list:dwel:points? | Returns the current point location (8). |
| list:repeat 6,7,3.3,4.4,5.5,6.6,7.7 | Repeats step 6 and 7 (list:wait:high and list:wait:low), except each pair is set to the voltage specified in the array. This adds 10 points to the list and sets the output values of each pair to be 3.3V, 4.4V, 5.5V, 6.6V, 7.7V. |
| list:count 2 | Implements the waveform through two loops of the data. |
| list:skip 1 | Bypass the first step in the repeated points. |
| curr 5::outp on | Set output on, output current to 5A. |
| | --- Ensure Input Trigger is low. |
| VOLT:MODE LIST | Executes the above list. At each low transition of the trigger line the BOP increases its output voltage in 1.1 volt increments. The time period for each increment is controlled not by the internal clock of the BOP but rather the high-to-low edge of the pulse from the host computer. The use of LIST:WAIT:HIGH followed by LIST:WAIT:LOW ensures the BOP waits for a high-to-low edge transition on the trigger input before increasing the output. |

FIGURE B-2A. USING LIST:WAIT COMMANDS TO CONTROL GENERATION OF A WAVEFORM MEASURED BY MULTIPLE EXTERNAL DEVICES USING A SINGLE EXTERNAL PULSE

- NOTES: 1. The power supply is assumed to be operating in constant voltage mode.
2. This example assumes a BOP and a DVM is connected to a Unit Under Test (UUT). The DVM is connected to EXT_E/ EXT_C (pins 5/6 of the BOP External Protection port). When the BOP outputs a low EXT_E/ EXT_C, The DVM takes a series of measurements and places its wait line low. The DVM Wait line is connected to the Trigger Input (pin 3 of the of the BOP. When the Trigger Input goes high (indicating the DVM has completed its measurements) the BOP will advance to the next point. For this example it is assumed that the DVM will complete its measurement within 25 milliseconds to 75 milliseconds unless a problem is encountered. A “dead man” timer is implemented that allows up to 99 milliseconds for the measurement to complete before automatically proceeding to the next point, thereby preventing hang-ups due to a measurement problem.
3. The explanation below shows how each step of the list functions once the list is entered and VOLT:MODE LIST (the last step) is executed.

| | |
|---|--|
| list:cle | Clear list. |
| List:set:wait .0333 | Set wait time to max allowed value (33 milliseconds). |
| list:set:trigger .001,ON | Set trigger pulse width to 1 millisecond. Transistor across pins 5 and 6 of External Protection Port is now set off. |
| list:volt:apply level,.001,10 | Create first point (10V). |
| list:dwel:points? | Returns 10. |
| list:trigger 10 | Maintains output at 10V, generates a 1 millisecond 0V trigger pulse applied to DVM, causing DVM to make measurement. |
| | Trigger input low while DVM makes measurement. |
| list:wait:high 10 | Wait for DVM to complete measurement for 33 milliseconds. Proceed to next step if trigger input goes high (meaning the measurement is complete) or 33 milliseconds elapsed, whichever comes first. |
| | Trigger input low while DVM makes measurement. |
| list:wait:high 10 | Wait for DVM to complete measurement for another 33 milliseconds. Proceed to next step if trigger input goes high (meaning the measurement is complete) or 33 milliseconds elapsed, whichever comes first |
| | Trigger input low while makes measurement. |
| list:wait:high 10 | Wait for DVM complete measurement for another 33 milliseconds (these three steps allow a maximum wait time of 99 milliseconds. Proceed to next step if trigger input goes high (meaning the measurement is complete) or 33 milliseconds elapsed, whichever comes first. |
| list:repeat 10,13,20,30,40,50,60,70,80,90 | Repeats steps 10 through 13 (from list:apply level to the third list:wait:high 10) for the other 8 voltages (20, 30, . . . 90). |
| list:count 10 | Repeat sequence ten times. |
| curr 2::outp on | Establishes BOP output current of 2A. |
| volt:mode list | Executes the above list. A level is applied to the BOP output. One 1 millisecond later the transistor at EXT_E and EXT_C (pins 5 and 6 of the External Protection Port) conducts, providing a low to the DVM. The DVM immediately places the BOP trigger input low. The BOP waits for the trigger input to go high, then outputs the next level in the list. If the trigger input never goes high, the three wait statements will maintain the level for 33 milliseconds each. After 99 milliseconds (three wait statements) has expired, the new voltage level will be provided at the output. In this example, the pulse must be less than 1 millisecond. but at least 50 microseconds long to insure proper operation of the program. |

FIGURE B-2B. USING LIST:WAIT COMMANDS TO ALLOW AN EXTERNAL DEVICE TIME TO FUNCTION WHILE IMPOSING A MAXIMUM WAIT TIME

B.35 [SOURce:]LIST:TRIGger COMMAND

Syntax: Short Form: LIST:TRIG <value>
 Long Form: LIST:TRIGger <value>
 where:
 <value> = programmed current (Amps) for current list, or programmed voltage (Volts) for voltage list.

Description: **Similar to LIST:VOLT or LIST:CURR, except also allows Output Off flag of External Protection Port to be used to trigger an external device.** In addition to setting the output to the <value> specified (for duration established by LIST:SET:TRIG), causes the Output Off flag transistor (EXT_E, pin 5, and EXT_C, pin 6, of the External Protection port) to be set to the state (on or off) for the duration set by the LIST:SET:TRIG command.

If the trigger duration is not established by the LIST:SET:TRIG command, a -221 "Settings conflict" error results. This command must be preceded by LIST:CURR or LIST:VOLT command, otherwise a -221 "Settings conflict" error results. The entries on the dwell list must match the values on the current or voltage list, otherwise a -226 "Lists Not Same Length" error results. (See Figure B-2B.)

B.34.1 [SOURce:]LIST:WAIT:HIGH COMMAND

LIST:WAIT:HIGH

Syntax: Short Form: LIST:WAIT:HIGH value
 Long Form: LIST:WAIT:HIGH value
 where:
 <value> = programmed current (Amps) for current list, or programmed voltage (Volts) for voltage list.

Description: **Waits for the trigger input to go high before advancing to next step.** When the command is executed the output is immediately set to the <value>. Pins 1 (GND) and 3 of the Trigger Port are used as the input trigger. If the trigger input is high (TTL logic 1 or open circuit) and a wait time has been established by LIST:SET:WAIT, the step is immediately skipped. If the trigger input is low (TTL logic 0 or short-circuit), the unit will proceed to the next step when either a) the trigger input goes high or b) the wait time expires (non-zero wait values only), whichever comes first. If the wait time is 0, the unit must wait until the trigger input goes high before proceeding to the next step.

In all cases, the trigger input must be high or low for at least 4 milliseconds to be considered stable. This 4 millisecond delay provides a noise filter to insure only a level causes the output change.

This command must be preceded by LIST:CURR or LIST:VOLT command, otherwise a -221 "Settings Conflict" error results. The entries of the dwell list must match the values in the current or voltage list, otherwise a -236 "Lists Unbalanced" error results. (See Figures B-2A and B-2B.)

B.34.2 [SOURce:]LIST:WAIT:LEDGe COMMAND

LIST:WAIT:LEDG

Syntax: Short Form: LIST:WAIT:LEDG value
 Long Form: LIST:WAIT:LEDGe value
 where:
 <value> = programmed current (Amps) for current list, or programmed voltage (Volts) for voltage list.

Description: **Waits for the leading edge of the trigger input to go low before proceeding to the next step.** If the trigger input is already low, the signal must go high then low for the leading edge to be accepted. When the command is executed the output is immediately set to the <value>. Pins 1 (GND) and 3 of the Trigger Port are used as the input trigger. If the trigger input goes from high to low (TTL logic 0 or short-circuit) and a wait time has been established by LIST:SET:WAIT, the unit will proceed to the next step when either a) the trigger input goes low or b) the wait time expires (non-zero wait values only), whichever comes first. If the wait time is 0, the unit must wait until the trigger input goes from high to low before proceeding to the next step.

This command must be preceded by LIST:CURR or LIST:VOLT command, otherwise a -221 "Settings Conflict" error results. The entries of the dwell list must match the values in the current or voltage list, otherwise a -236 "Lists Unbalanced" error results. (See Figure B-2C.)

B.34.3 [SOURCE:]LIST:WAIT:LOW COMMAND

LIST:WAIT:LOW

Syntax: Short Form: LIST:WAIT:LOW value
Long Form: LIST:WAIT:LOW value
where:
<value> = programmed current (Amps) for current list, or programmed voltage (Volts) for voltage list.

Description: **Waits for the trigger input to go low before advancing to next step.** When the command is executed the output is immediately set to the <value>. Pins 1 (GND) and 3 of the Trigger Port are used as the input trigger. If the trigger input is low (TTL logic 0 or short-circuit) and a wait time has been established by LIST:SET:WAIT, the step is immediately skipped. If the trigger input is high (TTL logic 1 or open circuit), the unit will proceed to the next step when either a) the trigger input goes low or b) the wait time expires (non-zero wait values only), whichever comes first. If the wait time is 0, the unit must wait until the trigger input goes low before proceeding to the next step.

In all cases, the trigger input must be high or low for at least 2 microseconds to be considered stable. This 2 microsecond delay provides a noise filter to insure only a level causes the output change.

This command must be preceded by LIST:CURR or LIST:VOLT command, otherwise a -221 "Settings Conflict" error results. The entries of the dwell list must match the values in the current or voltage list, otherwise a -236 "Lists Unbalanced" error results. (See Figures B-2A and B-2B.)

- NOTES:
1. The power supply is assumed to be operating in constant voltage mode.
 2. The WAIT commands provide a method to synchronize multiple instruments to a common control pulse. This example assumes BOP and a number of switching DVMs are connected to a Unit Under Test (UUT). The DVMs are programmed to wait 1 millisecond after a low-going edge is received from the host computer, then take a few measurements. The same low-going edge is applied to the Trigger Input (pin 3 of the BOP Trigger Port); the negative-going edge of this pulse will cause the BOP to increment the output to the next level. Thus, each time the host computer issues a positive pulse, the BOP increments and the DVMs take measurements on the trailing (negative-going) edge of the positive pulse. The positive pulse can be very short (less than 2 microseconds) with this functionality.
 3. The explanation below shows how each step of the list functions once the list is entered and VOLT:MODE LIST (the last step) is executed.

| | |
|--|---|
| list:cle | Clears the list. |
| list:volt:apply level,.001,0 | Establishes the list as a voltage list, output set to 0V. |
| list:wait:ledge 0 | Maintains output at 0V, waits for Input trigger to have a high to low edge before proceeding. |
| --- Host computer issues high pulse. Input Trigger goes low at trailing (negative-going) edge of pulse from host computer and List proceeds to next point. One millisecond after pulse issued, DVM takes measurements. | |
| list:dwell:points? | Returns the current point location (3). (Used for list:repeat.) |
| list:repeat 1,2,1.1,2.2,3.3,4.4,5.5,6.6,7.7 | Repeats step 1 and 2 (list:volt:apply lev and list:wait:ledge), except each pair is set to the voltage specified in the array. This adds 14 points to the list and sets the output values of each pair to be 1.1V, 2.2V, 3.3V, 4.4V, 5.5V, 6.6V and 7.7V. |
| list:count 2 | Implements the waveform through two loops of the data. |
| curr 5::outp on | Set output on, output current to 5A. |
| VOLT:MODE LIST | Executes the above list. At each high-to-low transition of the Trigger Port input, the BOP increases its output voltage in 1.1 volt increments. The duration of each increment is not controlled by the internal clock of the BOP, but instead by the high-to-low edge of the pulse from the host computer. |

FIGURE B-2C. USING LIST:WAIT COMMANDS TO CONTROL GENERATION OF A WAVEFORM MEASURED BY MULTIPLE EXTERNAL DEVICES USING THE LOW-GOING LEADING EDGE OF AN EXTERNAL PULSE