HIGHLAND TECHNOLOGY

Model P400
Benchtop Digital Delay/ Pulse Generator

Technical Manual

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1 Introduction and Scope

1.1 Scope

This document is the technical manual for the Highland Technology Model P400 benchtop digital delay generator, Highland part number 23A400-1.

1.2 Introduction

The P400 is a versatile, four-channel digital delay and pulse generator. The unit supports five trigger sources.

Internal direct digital synthesis (DDS) rate generator

External logic input

Line input (via external adaptor)

Remote serial input

Manual pushbutton

Any of these five trigger sources can be gated by an external signal. Each of the four channels can be programmed to trigger on the leading or trailing edge of any other channel, or on the leading edge of the trigger. Channel timings can be specified as an initial delay and pulse-width or as a pair of leading and trailing edge-delays. In both modes, the resolution is one picosecond and the timing cycle must complete within 999.999… seconds of the start of the cycle.

In addition to programming the edge timings, the following parameters may be set independently for each channel:

VH (pulse high) and VL (pulse low) levels

Pulse polarity

1.3 Operating And Safety Precautions

When using AC-line power, use only the external AC adaptor furnished with the P400. (See page 3 for power specifications.)

Do not apply potentials to any P400 outputs.

Do not apply more than ±5 volts to the TRIGGER input.

Do not apply more than 0 to +5 volts to the GATE or CLOCK connectors.

The high-speed semiconductors used in the P400 are necessarily static sensitive. Use standard antistatic precautions when using the P400.

During powerup and powerdown, it is possible that the P400 may create undesired outputs at the T0, A, B, C, D, or GATE outputs. Do not use the P400 in situations where such outputs may result in compromises in personnel safety or equipment damage.

2 Specifications

Table 1. P400 Specifications

FUNCTION	Four-channel digital delay and pulse generator Independently programmable delay/pulse width/polarity/high level/low level on all four delay outputs A, B, C, and D
CHANNELS	Four outputs of programmable delay, pulse width, polarity, and voltage levels
TRIGGER SOURCES	Internal DDS synthesizer, external source, AC line with external transformer adaptor, remote command, and manual pushbutton
TRIGGER RATE	10 MHz maximum
EXTERNAL TRIGGER INPUT	Programmable threshold: -2.4 to +4.6 V Programmable slope Programmable termination: 50 Ω or 1 MΩ Minimum pulse width: 2 ns at 0 to 2 V (25 ns in burst mode)
LINE TRIGGER INPUT	3-24 VRMS using external AC adaptor
DDS TRIGGER RATE	0.01 Hz to 10 MHz in 0.01 Hz steps
PULSE OUTPUTS (A TO D AND T0)	V_{OH} programmable -4.3 to +11.8 V V_{OL} programmable -5.0 to +4.1 V 0.1 V steps, 50 Ω source impedance 4 V/ns slew rate
INSERTION DELAY	25.0 ns ± 500 ps
DELAY RESOLUTION	1 ps, delay or width of A,B,C,D outputs

DELAY RANGE	999.999999999999 seconds, delay or width of A, B, C, D outputs, total delay + width not to exceed 999.999999999999 seconds A to D timings are relative to T0 rising edge
DELAY ACCURACY	T0, rises 25 ns ± 500 ps after trigger A to D outputs, ± 400 ps ± timebase error A to D delay and width edges are monotonic to 50 ps
JITTER	T0, 20 ps RMS max from external trigger A to D outputs (25 ps RMS + timebase jitter) max, either edge from external trigger or any other output
GATE INPUT	V_{IH}: +3.5 V min, +6 V max V_{IL}: -0.5 V min, +1.5V max Programmable active high/low
GATE OUTPUT	V_{IH}: +5 V typ, V_{IL}: 0 V typ 50 Ω source impedance, programmable active high/low
10 MHZ CLOCK INPUT	V_{IH}: +3.5 V min, +6 V max V_{IL}: -0.5 V min, +1.2 V max 0.7 V min hysteresis
10 MHZ CLOCK OUTPUT	V_{OH}: +5 V typ, V_{OL}: 0 V typ 50 Ω source impedance
DDS OUTPUT	Sine wave, 4 V p-p typical, 50 Ω source impedance
COMMUNICATIONS	Standard RS-232 with SCPI-like command set Optional Ethernet using Telnet mode Command set identical to RS-232 mode

INDICATORS	20-character by 4-line, alphanumeric display LEDs indicate selected channel, activity, triggers, communications, and errors
TIMEBASE	Standard TCXO: Initial calibration ±0.25 PPM Drift <2 PPM/year Temperature coefficient below 50 ppb/°C Jitter below 4 ns per second of delay Optional OCXO: Initial calibration ±0.1 PPM Drift <1 PPM/year Temperature coefficient below 3.6 ppb/°C Jitter below 400 ps per second of delay Either oscillator can be phase-locked to an external 10 MHz source
PACKAGING	8" (W) x 12” (L) x 4.5" (H), exclusive of external power module Weight: 8 lbs
POWER	100 to 240 VAC, 47 to 63 Hz, 60 W max using AC adaptor furnished Operable from +24 VDC, 2.5 amps max via 2.5 mm x 5 mm female connector

OPTIONS	Rear-panel transformer-isolated 5 to 50 V programmable high-voltage pulse outputs 10BASE-T and 100Base-T Ethernet Ovenized oscillator timebase (OCXO) Single/dual rackmount adaptors OEM versions
CONFORMANCE	Designed to meet UL/FCC/CE requirements

3 Theory of Operation

3.1 Basic Timing

Figure 1 depicts the basic P400 timing cycle.

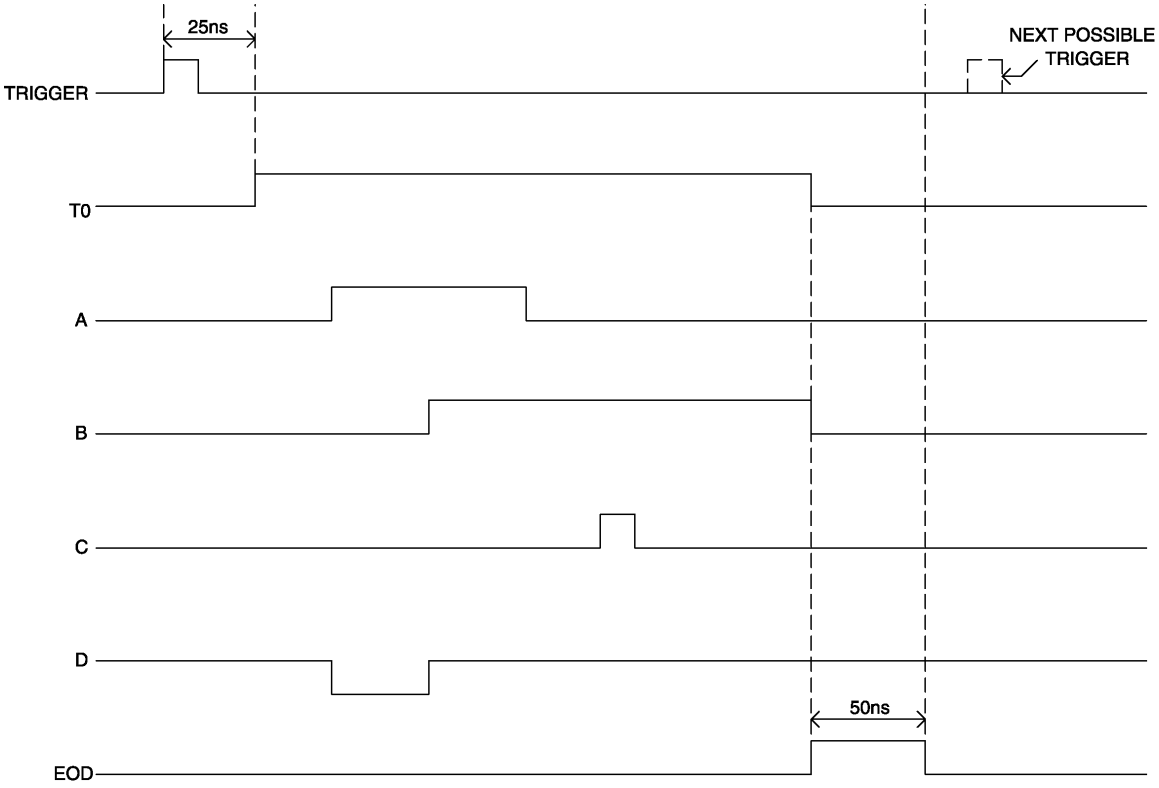

Figure 1. Example Timing Diagram

A timing cycle begins 25 ns after a trigger pulse is received. T0 is asserted, transitioning from VL (programmed low level) to VH (programmed high level), indicating the start of the timing cycle. After the initial delay, each channel's output is asserted, transitioning from VL to VH or VH to VL, depending on the output polarity. Channel timing is relative to the leading edge of T0, not to the trigger pulse.

When the last channel is deasserted, the T0 output falls, transitioning from VH to VL. At this point, end-of-delay (EOD) is declared and the internal EOD signal is asserted for approximately 50 ns. During this time, all outputs are reset to their default state, the 50 MHz oscillator is disabled, the HIT flip-flop is held in reset and the T0 output is

driven to VL. When the EOD interval expires the P400 is ready to accept new trigger pulses.

If the last programmed edge is programmed to be k ns after T0, the P400 will accept triggers separated by (k + 60) ns up to the specified 10 MHz max. For very short programmed delays, the P400 will typically externally trigger above 13 MHz. .

3.2 Block Diagram and Basic Functions

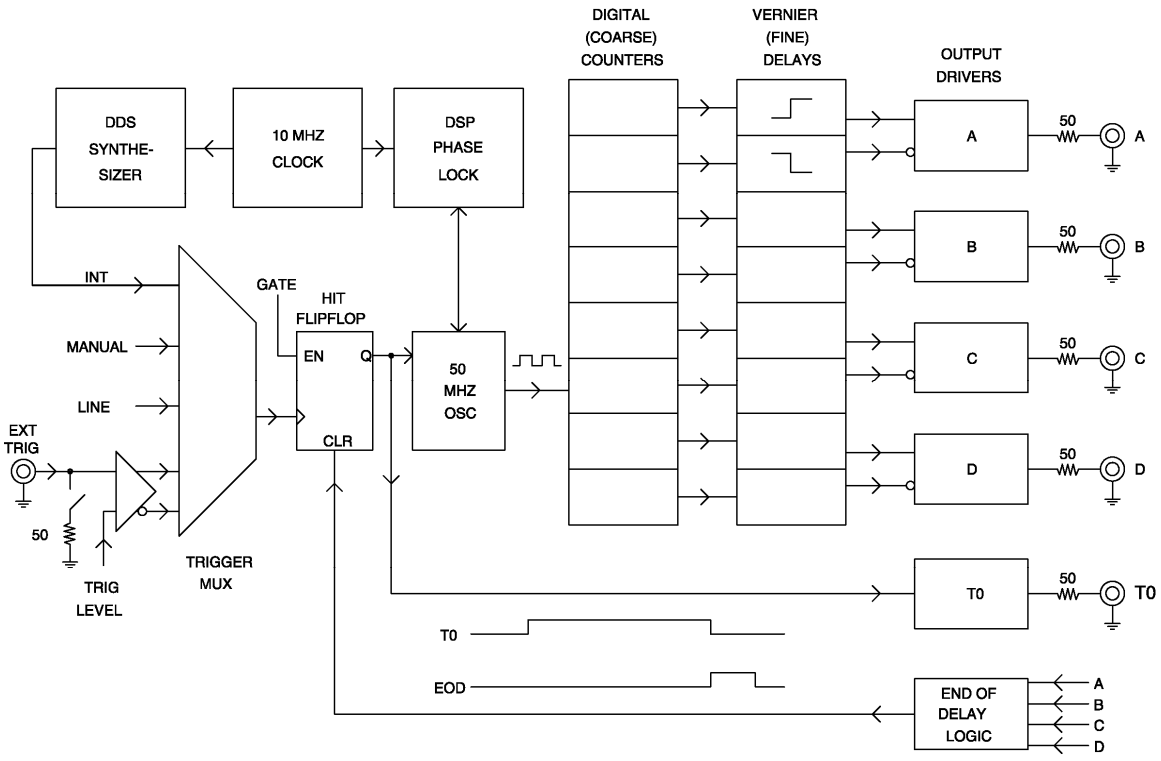

Figure 2. Block Diagram

The P400 contains the following logic blocks and functions:

TRIGGER MULTIPLEXER. This circuit selects one of four possible trigger sources: internal, external input, AC line input, or manual single-shot.

The internal trigger source is derived from the programmable DDS frequency synthesizer. The DDS synthesizer can be programmed from 0.01 Hz to 10 MHz in 0.01 Hz steps.

The external trigger input is conditioned by a precision voltage comparator before connecting to the TRIGGER MULTIPLEXER. The reference input of the comparator is connected to a programmable voltage source. Trigger polarity and input impedance are programmable.

All triggers can be gated on or off by applying an asynchronous TTL-level signal to the GATE connector. In addition, both the internal and the external triggers can be configured to pass *n* of *m* triggers, thereby providing burst capability.

HIT FLIP-FLOP. The Hit Flip-Flop initiates the timing cycle and enables the main timing oscillator. The output of the Hit Flip-Flop is connected through a driver to the T0 output. The EOD logic clears the flip-flop when all channels have completed their output pulses, preparing the P400 for a new timing cycle.

10 MHZ CLOCK. This temperature-compensated, crystal-controlled oscillator (TCXO) is the timing reference for all delays. An optional ovenized oscillator (OCXO) is also available. The OCXO is more stable over time and temperature than the TCXO and contributes less jitter to long delays. The 10-MHz clock can be locked to an external 10-MHz clock through the CLOCK connector on the back panel.

50-MHZ OSCILLATOR. This oscillator provides the coarse (20-ns granularity) component of all delays. A DSP-based phase-lock system locks the 50-MHz oscillator to the internal crystal-controlled 10-MHz clock, making the oscillator as accurate as the clock while preserving phase coherency to the original trigger.

DIGITAL (COARSE) COUNTERS. The output of the 50-MHz oscillator is connected to eight digital counters, two for each output channel. The first counter times the leading edge of the pulse, the second counter times the trailing edge.

VERNIER DELAYS. A fine-resolution delay circuit follows each digital counter to interpolate delays to 1-ps resolution. The output of each vernier delay is connected to an output driver.

OUTPUT DRIVERS. Each of the four channels has a single output driver. The output driver combines the leading-edge and the trailing-edge signals to produce a single channel output. Each driver has programmable polarity, and high and low voltage levels.

MICROPROCESSOR SYSTEM An internal 32-bit microprocessor subsystem manages the P400. It interacts with the front-panel controls and displays and the external RS-232 and Ethernet interfaces.

POWER SUPPLIES Voltage regulators generate the required internal voltages from the 24 VDC input on the back panel. These regulators are typically powered by the external, AC-powered, universal-input, switching power supply furnished with each unit.

4 Quick Start: Pulse-Train Example

1. Basic operation of the P400 may be demonstrated using its default configuration. To invoke this mode, turn the unit off, and then turn it back on while holding the numeric "0" key down.

2. When the trigger screen appears and "LOADING DEFAULT CONFIG" is displayed, release "0." Press the START button to begin pulsing.

   The default setup enables internal triggering at 1.00 KHz. Channels A, B, C, and D produce sequential 100 microsecond positive pulses, with baselines of 0 volts and pulse height +4 volts into a high-impedance load.

3. Connect an oscilloscope to the P400, with the T0 pulse applied to scope Channel 1, and trigger on the rising edge of this signal.

4. Connect available additional scope channels to P400 outputs A, B, C, and D. Set the scope to 100 μsec/cm horizontal, 5v/cm vertical.

   The scope display should look similar to that shown in Figure 3. The traces are, from top to bottom, signals T0, A, B, C, and D. (Voltages are not shown to scale in this figure.)

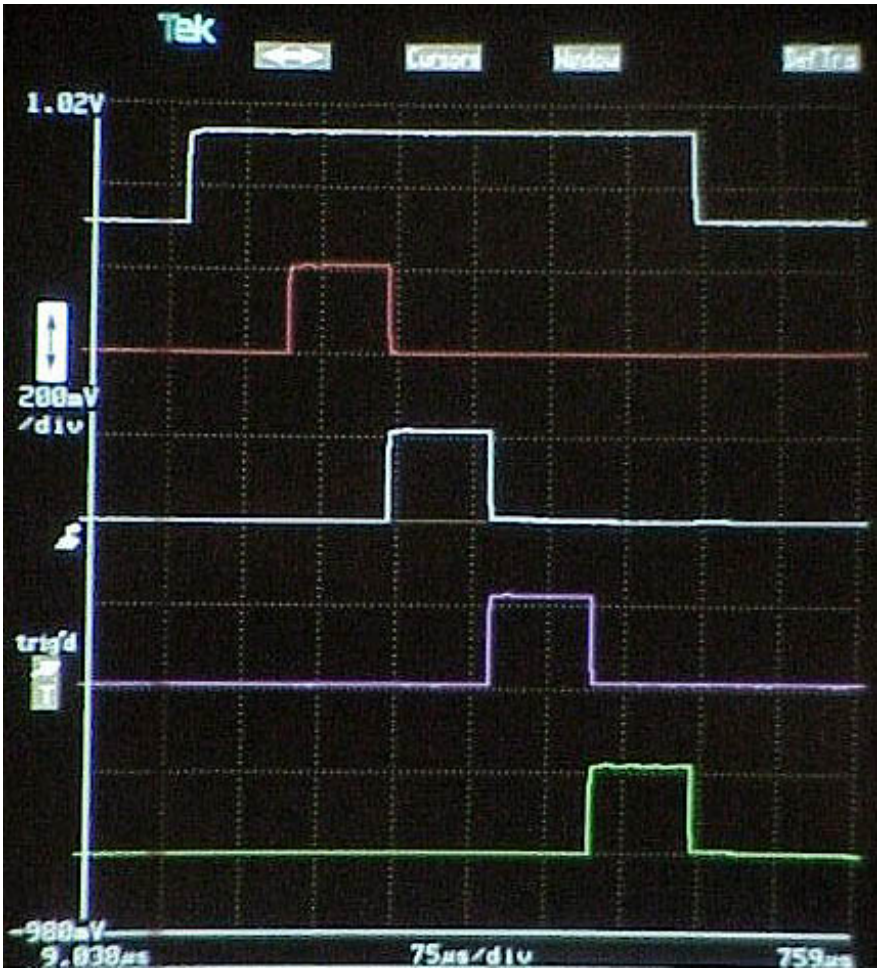

Figure 3. Pulse-Train Example Timing

One can now vary menu settings and observe changes in the scope display.

Some suggested operations to try are:

Push the STOP and RUN buttons to control pulsing off/on

Push the "A" button to bring up the Channel A display. Use the arrow keys to pan the cursor to various control fields, then use the spinner knob to vary parameters and observe the effects on the scope display.

Note that, if you change pulse delay or width such as to make the trailing edge of the pulse exceed 500 μs after trigger, the T0 pulse width will extend to track the Channel A falling edge, demonstrating that the P400 timing cycle runs until all channels are done.

Push the TRIG button and pan the cursor to the 100 Hz digit of the trigger rate field. Use the spinner or the numeric keypad to alter the trigger rate. Note that as

you set the trigger rate above 2 KHz, the P400 will begin missing triggers, and the "RATE" LED will illuminate, because the unit is receiving triggers before the previous timing cycle is completed.

Push the HELP button, then scroll through the Help text using the spinner knob. While in Help mode, you can press any other button to jump to the section of text that explains that function. Press HELP again to return to normal mode.

5 Operating Instructions

5.1 Front- and Rear-Panel Overview

The front panel is shown in Figure 4 and described in Table 2.

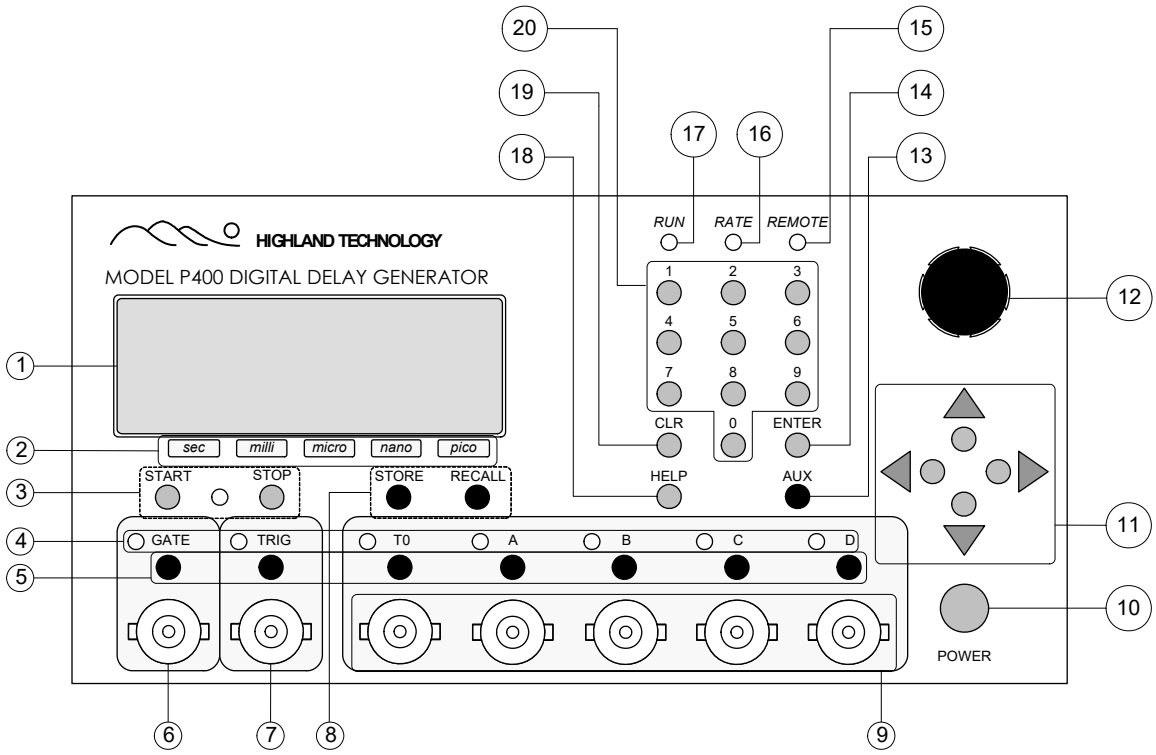

Figure 4. Front Panel

Table 2. Front-Panel Features

1	**20-Character by 4-Line Display** P400 operator interface display
2	**Time Display Labels** These identify engineering unit positions in time displays
3	**START and STOP Keys** Start and stop triggering or manually trigger a delay, indicated by the adjacent red/green LED The P400 always powers up in the STOP state.
4	**Activity LEDs** These indicators light when the associated function is active
5	**Menu Keys** These keys select the gate, trigger, and channel menus
6	**Gate Connector** Gates the trigger source
7	**Trigger Connector** Input for an external trigger source to the P400
8	**STORE and RECALL Menu Keys** These keys store and recall P400 configurations
9	**Channel Connectors** Outputs of the T0, A, B, C, and D channels
10	**POWER Button** This button turns the P400 on and off
11	**Scroll Keys** Provide navigation through the menus
12	**Spinner Knob** Rotating this knob changes menu items. Pressing and rotating the knob allows movement through a menu
13	**AUX Menu Key** This key displays the auxiliary menu
14	**ENTER Key** Accepts numeric values
15	**REMOTE LED** This LED flashes when the P400 is accessed remotely
16	**RATE LED** This LED flashes when trigger rate is incompatible with delay settings
17	**RUN LED** This LED lights when a timing cycle is active
18	**HELP Menu Key** Displays the Help menu
19	**CLR Key** Clears the digits at and to the right of the cursor
20	**Numeric Keypad** Enters numbers in delay, width, voltage and frequency menu items or selects a memory location in the store and recall menus

The rear panel is shown in Figure 5 and described in Table 3.

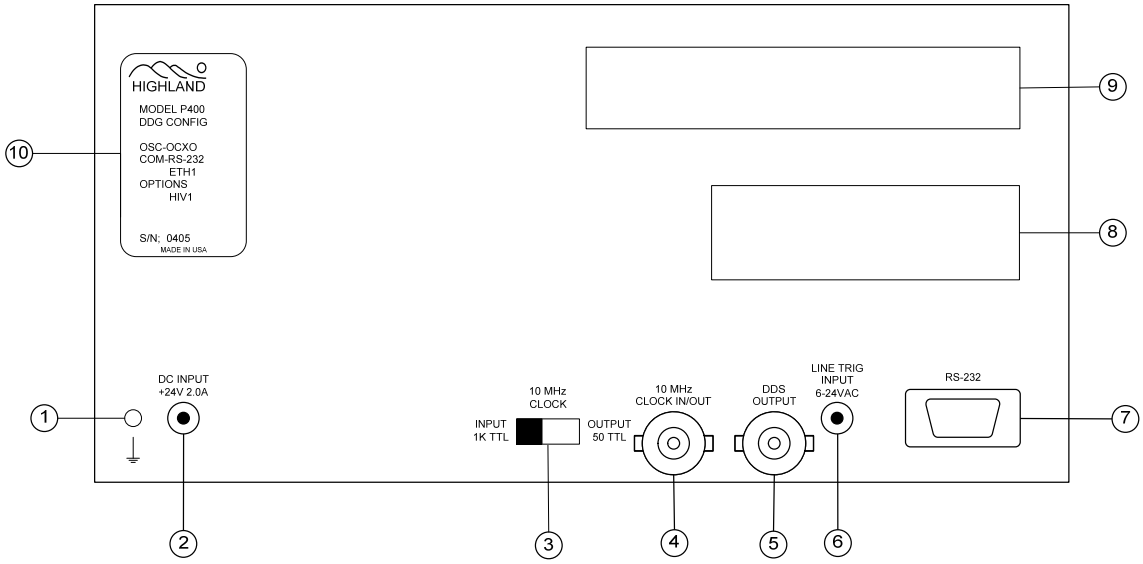

Figure 5. Rear Panel

Table 3. Rear-Panel Features

1	**Ground Point** An earth ground wire may be secured to this receptacle with a 6-32 screw.
2	**Power Connector** 24 VDC input from the external power supply furnished with the P400
3	**10 MHz Clock Connector Switch** This switch configures the 10MHz clock connector as a high impedance input or a low impedance output
4	**10 MHz Clock Input/Output** BNC connector
5	**DDS Output** Sine wave output from the internal DDS frequency synthesizer
6	**Line Trigger Input** 6 to 24 VAC input for triggering the P400 synchronous to the AC line
7	**RS-232 DB9 Connector** Provides for remote serial control
8	Location for Ethernet option connector if installed
9	Location for optional outputs; e.g., high-voltage, if installed.
10	The P400 label indicates model, serial number, and options installed.

5.2 Help Mode

The Help mode displays operating instructions for the P400. To access Help, press the HELP key, shown in Figure 4. To exit the Help menu press the HELP key a second time. The initial lines of the help page explain further the use of the help facility.

5.3 Menu Navigation

The various menus are invoked by pressing the menu selection keys adjacent to the associated functions of the front panel. The P400 has no submenus.

Within any menu, the cursor may be moved by using either the up (▲), down (▼), left (◀), right (▶) keys or by pressing and turning the spinner knob. Although within any menu there are only four lines visible in the display, actual page lengths vary. One may scroll up and down to see the entirety of any menu page.

There are two kinds of user-settable fields: Numeric and non-numeric.

Non-numeric items are altered by positioning the cursor anywhere within the field, and rotating the spinner to make selections.

To alter numeric values, locate the cursor beneath the digit of interest and then either rotate the spinner knob or begin entering digits with the numeric keypad. Keypad-entered digits will flash until installed by pressing the ENTER key. Digits entered using the spinner knob will roll over to the next digit when 9 or 0 is reached. Pressing the clear key (CLR$_t$) will clear all of the digits at and to the right of the cursor.

5.4 Gate Menu

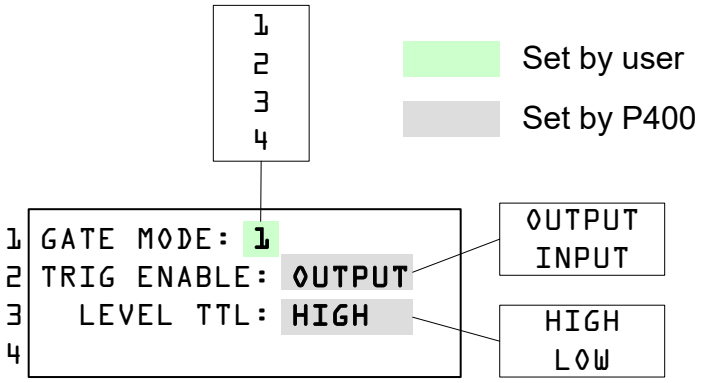

Figure 6. Gate Menu

To display the Gate menu, press the GATE key. this menu configures the GATE connector. Turn the spinner knob or use the numeric keypad to select to select one of the four possible gate modes.

If the gate is configured as an output it will be active (selectably HIGH or LOW) when triggering is enabled. In burst mode, it will be active during the "pulsing" period of a burst cycle.

If gate is selected to be an input, an active input level (selectable as TTL HIGH or LOW) enables triggers.

The four user-selectable gate modes are:

1. The GATE connector is an output, and goes TTL high when triggers are enabled. It will, for example, pulse high during the active segment of a burst-mode trigger cycle.

2. Gate is an output as in mode 1, but is active-low.

3. Gate is an input which, if TTL high, enables triggering. Its logic level is essentially ANDed with any other trigger permissives. The input has a resistive pullup to +5 volts, so "open" is treated as "high".

4. Gate is an input as in case 3, but is active-low.

The GATE led lights if the gate logic is in its trigger-enable condition, so is always on in modes 1 and 2. If it is off, the P400 cannot be triggered.

5.5 Trigger Menu

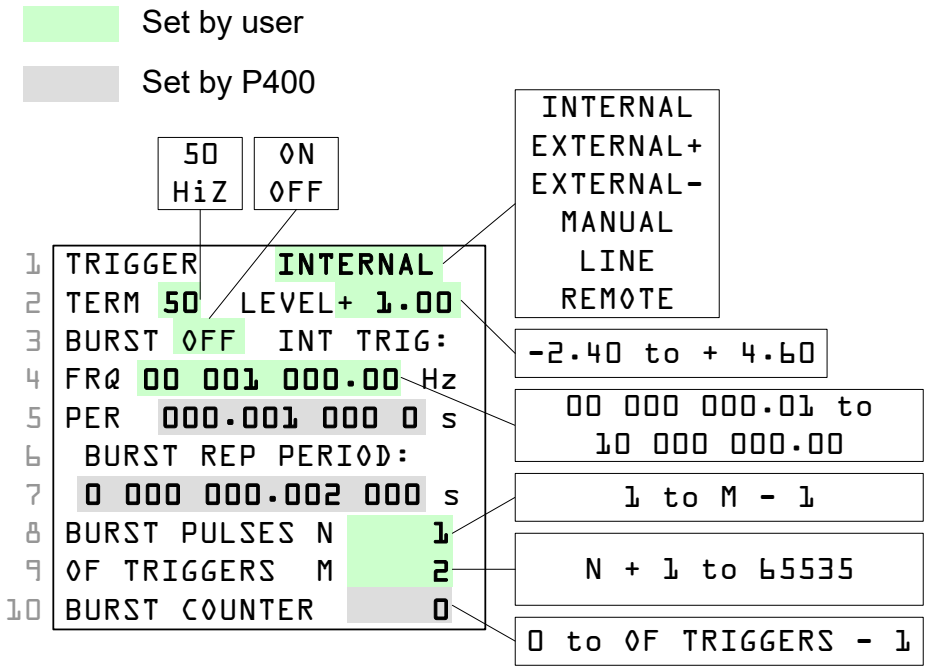

Figure 7. Trigger Menu

Press the TRIG key to display the Trigger menu. Place the cursor on Line 1 of the display, and use the spinner knob to select the trigger source. If spurious triggers might constitute a hazard, press the STOP button before altering any trigger menu items, and press START only after all desired trigger setups have been edited.

When internal trigger mode is selected, the P400 is triggered by the internal DDS generator at the rate shown in Line 4, FRQ. Line 5, PER, is set by the P400 to display the period corresponding to the trigger frequency in Line 4.

When external mode is selected, the P400 accepts a trigger applied to the trigger connector on the front panel. EXTERNAL+ responds to a rising edge, and EXTERNAL- triggers on a falling edge. The trigger level can only be adjusted when using EXTERNAL trigger mode.

The TERM item on Line 2 allows the external trigger input to be selected as high-impedance (1 Megohm) or as a 50-ohm termination.

When MANUAL triggering is selected, press the START button to trigger the P400. If the START button is held down, the P400 will continue to trigger at about 3 Hz.

When line mode is selected, the P400 will trigger at the local AC line rate. An external transformer must apply 4 to 24 VAC to the line trigger input connector on the rear panel (Figure 5).

When REMOTE mode is selected, the P400 may be triggered by RS-232 or Ethernet command.

Burst mode may be enabled or disabled using the menu item on Line 2. When burst is enabled, the P400 generates N pulses for every M applied triggers, where N is programmed on Line 8 of the menu, and M is set on Line 9. For example, if BURST PULSES (N) is set to 4 and OF TRIGGERS (M) is set to 20 then, if the P400 is triggered at a constant rate, the output would appear to be a burst of four pulses followed by a gap corresponding to 16 missed triggers. The BURST REP PERIOD item (Line 7) displays the time interval between bursts when internal triggering is used; this is equivalent to PER * M.

Note: When using the P400 in burst mode with an external trigger source, the trigger source must have a minimum pulse width of 25 ns.

5.6 Channel T0 Menu

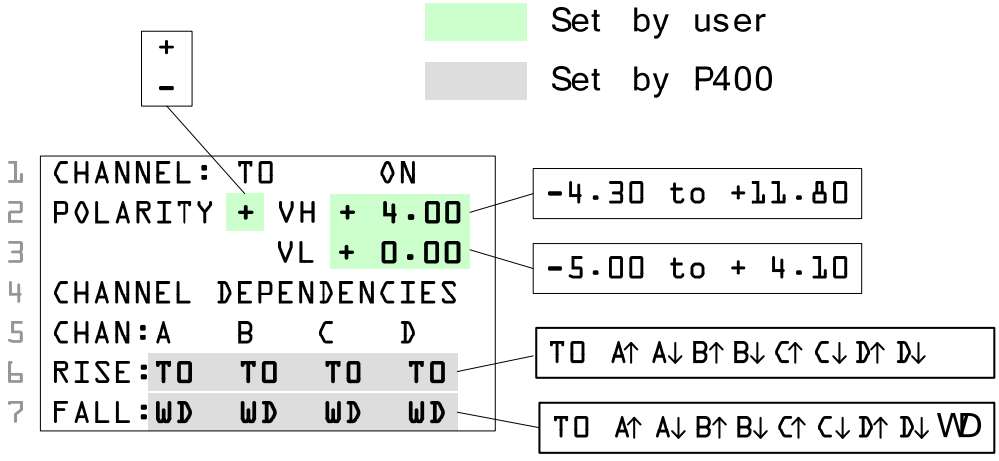

Figure 8. Channel T0 Menu

Press the T0 key to display the Channel T0 menu. This menu is used to configure the T0 output and to display the channel dependencies.

VH is the T0 output's high level, and VL is the low level. The T0 output is always ON, and may not be inverted. Output voltages will be halved when driving an external 50Ω load.

The channel dependencies indicated on Lines 6 and 7 are updated automatically by the P400 and appear on this menu for convenience. Dependencies are not alterable by the user on this page, but they are set by the user on menu pages for Channels A through D. If a channel is in delay/width mode, its fall is shown as WD.

5.7 Channel A through D Menus

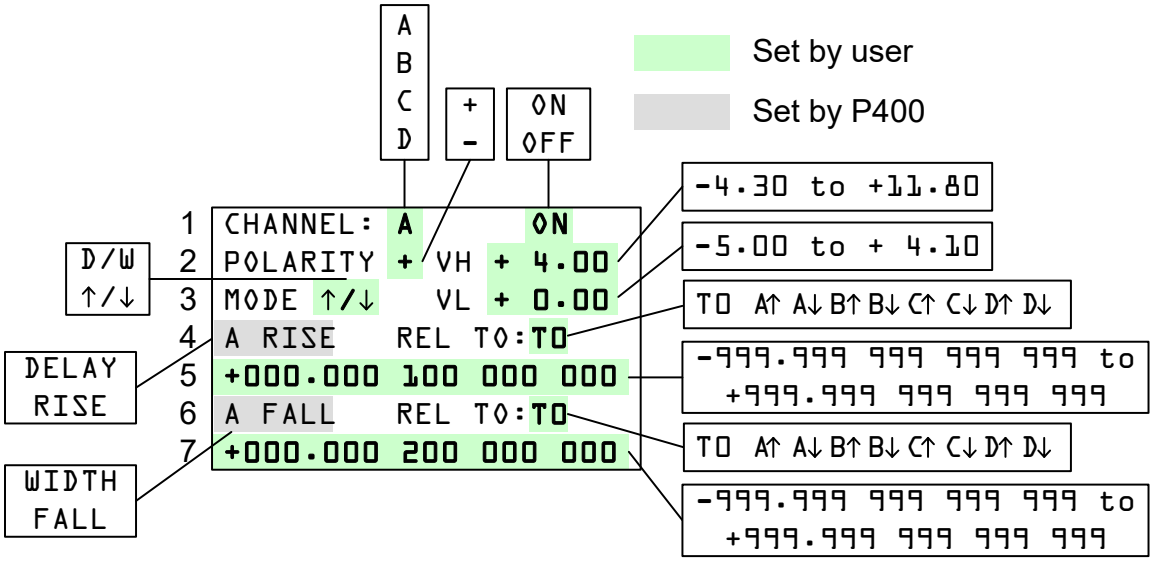

Figure 9. Channel A through D Menus

There are four channel menus. A typical menu, Channel A, is shown. Press the appropriate button on the front panel to select the desired channel menu.

VH is the selected channel's output's high level, and VL is the low level.

If polarity is set as positive and the channel is quiescent (non-triggered), output voltage level is VL, and the active pulse level is VH. If polarity is set to negative, the output is inverted, i.e., VH is the quiescent state, and VL is the active output level. If a channel is set to OFF, it remains at its quiescent level.

Note that VH and VL levels are as measured into a high-impedance load. If external 50Ω termination is used, output levels will be one-half those shown. For example, to produce ECL levels with an external 50 Ωtermination to ground, set VH to –1.6 V and VL to –4.0 V. The P400 output should not swing more than 5 volts while driving high-impedance loads (see Section 6).

When a channel mode is selected as D/W, the output pulse is characterized by by an initial delay followed by a width. In this mode, Lines 4 and 6 will show "delay" and

"width." If the channel mode is selected as κ/λ, the modes in Lines 4 and 6 will indicate "rise" and "fall," and the user may program the times of the rising and the falling edges in Lines 5 and 7.

The timing of a channel may be set relative to the rising edge of T0 or to the rising or the falling edges of any other channel. Note that all timing events must be completed in less than 1,000 seconds from the trigger, so that no delay and width can sum to more than 999.999 999…

In delay-and-width mode the REL TO variable in Line 6 does not appear.

A channel's rise, fall, or delay values can be negative provided no edges are programmed to occur before T0. Negative time settings are only meaningful if the channel is set relative to another channel (A – D).

The P400 does not permit circular or illogical timings and dependencies.

5.8 Auxiliary Menu

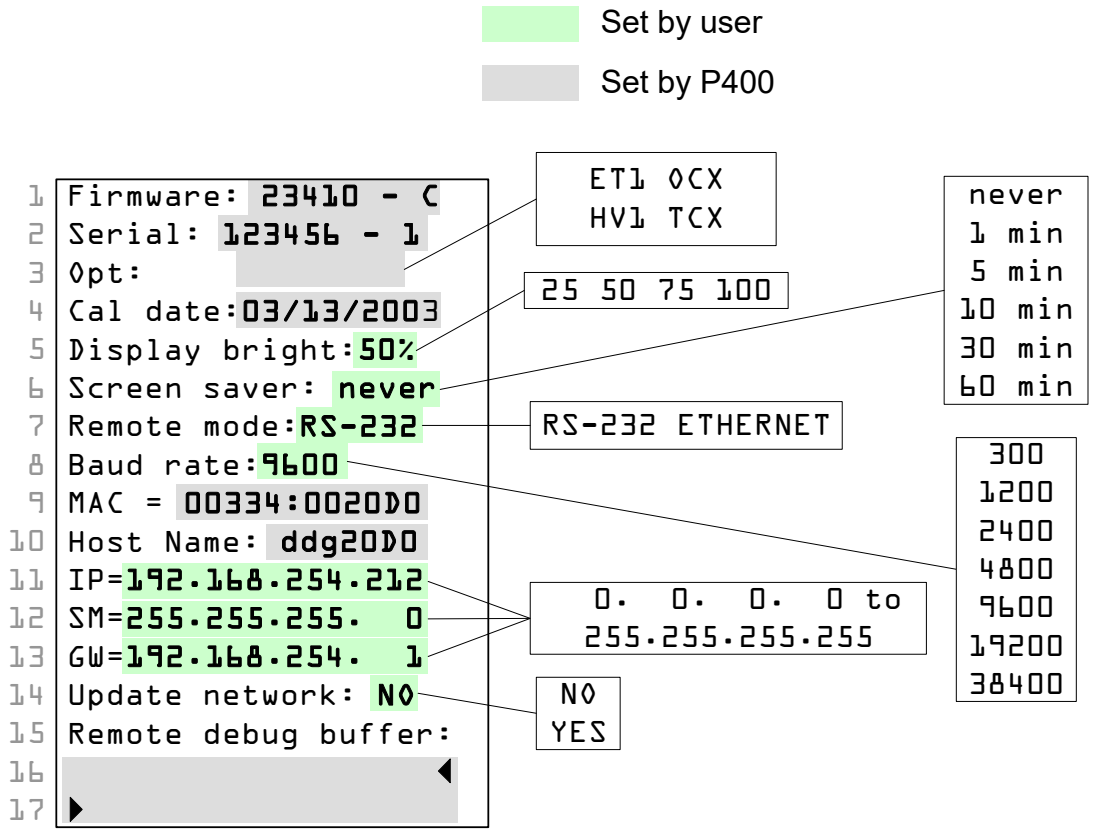

Figure 10. Auxiliary Menu

Press the AUX key to display the Auxiliary menu. This menu is used to configure the P400 auxiliary functions, including remote operation, and to display product-specific information.

The firmware revision and unit serial number are shown at the top of the menu. Lines 3 and 4 show the installed options and calibration date. All of these lines are set by the P400 and are not user-adjustable.

Line 5 allows the display and the front panel LEDs to be set to one of four brightness levels. Line 6 enables the screensaver, which dims the display to minimum brightness after the selected time interval until front panel action resumes.

Remote mode (Line 7) allows the user to select either the standard RS232 communication mode or other optional communication interfaces if installed. If RS232 is slected, the baud rate is selected by the user in Line 8.

If the Ethernet option is installed, Lines 9 through 13 display the mac address, the host name, the internet protocol address, the subnet mask, and the gateway address. For details of these items, see Section 7. To save Ethernet settings and update network connections, set UPDATE NETWORK in Line 14 to “yes.”

Line 16, the input buffer, displays the last incoming 20 characters, and Line 17, the output buffer, displays the first 20 reply characters. Line 16 is cleared when a serial command is processed.

See Chapter 7 for information on programming the P400 remote features.

5.9 Store and Recall Menus

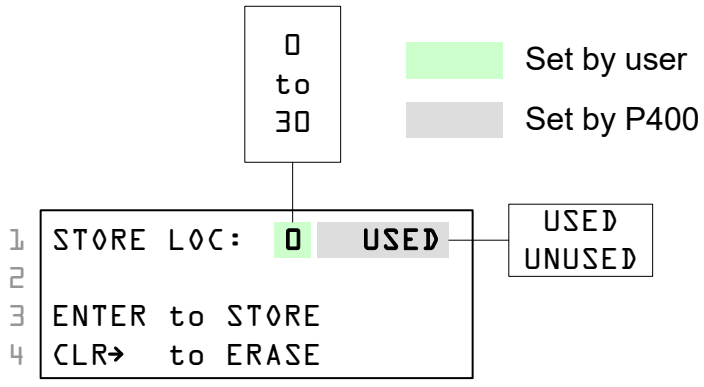

Figure 11. Store Menu

Press the STORE key to display the Store menu. Use this menu to save the current P400 configuration. All programmable settings are saved except the run state, which defaults to stop (no delays generated) at powerup.

Select one of the thirty-one memory locations by turning the spinner knob. Alternatively, you can select a memory location by entering the location number with the numeric keypad and pressing the ENTER key.

After selecting a memory location, press the ENTER key to store the configuration. The P400 will display a wait screen for approximately three seconds as the configuration is saved.

Erase a stored configuration by selecting the memory location and pressing the CLR→ key. The P400 will display a wait screen for approximately three seconds as the configuration is erased. It is not necessary to erase a memory location before storing a new configuration. WARNING: The P400 will automatically overwrite the old menu configuration when STORE is pressed.

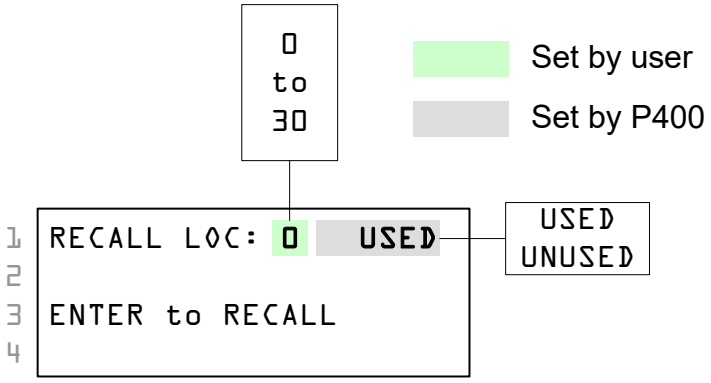

Figure 12. Recall Menu

Press the RECALL key to display the Recall menu. Use this menu to recall a previously saved configuration. All programmable settings are recalled except the run state, which defaults to stop (no delays generated).

Select one of the thirty-one memory locations by turning the spinner knob. Alternatively, you can select a memory location by entering the location number with the numeric keypad and pressing the ENTER key.

After selecting a memory location, press the ENTER key to recall the configuration. The P400 will display a wait screen for approximately three seconds as the configuration is recalled, then it will return to the trigger menu.

If you do not want to keep the new configuration, press the RECALL key to return to the Recall menu, then press the CLR→ key to restore the P400 to its previous state.

5.10 Power-Up States

Press the POWER button to turn the P400 on or off. The P400 starts in the last configuration used before power down. On power-up, all programmable settings are restored to their previous state except RUN state, which is set to STOP. The display shows the Trigger menu.

The P400 can be set to a demonstration mode by pressing and holding the “0” key while powering up. See Section 4, “Quickstart,” for details.

5.11 High Voltage Option

P400 DDGs may be furnished with the P450 high-voltage option. This adds five rear-panel BNC connectors which produce transformer-isolated high-voltage pulses corresponding to the T0, A, B, C, and D pulses.

If the high-voltage option is installed, the AUX menu will include five user-programmable variables which set the voltage levels of each of the five HV outputs. The levels may be set from 0 to 50 volts (measured into an external 50 ohm load) in 0.1 volt steps. Output is inherently low impedance so should be terminated in 50 ohms to maintain proper pulse shapes.

CAUTION: do not connect easily-damaged loads to the high-voltage outputs without suitable protection, shunt zener diodes or equivalent.

An equivalent circuit of the HV output is shown in Figure 13.

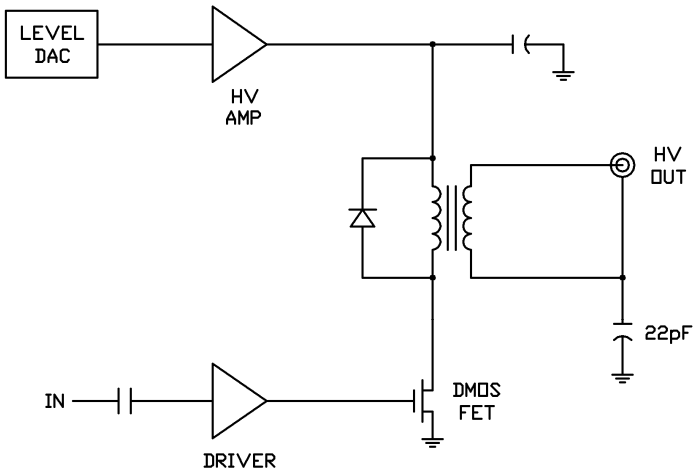

Figure 13. High Voltage Output Equivalent Circuit

Because the HV outputs can furnish very high peak power (all five channels deliver 250 watts simultaneously at 50 volts out) the duty cycle and pulse widths are inherently limited. Pulse widths are also limited by transformer core saturation.

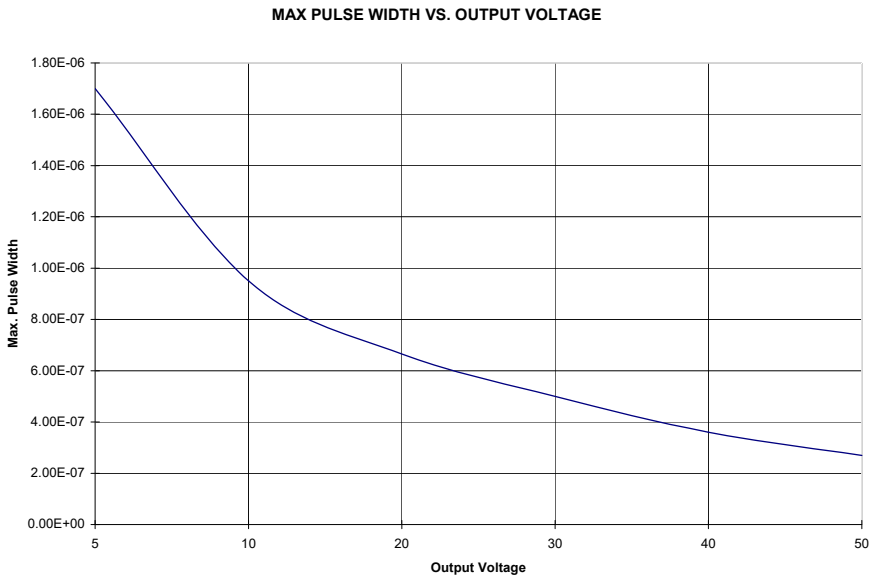

Figure 14. Pulse width as a function of output

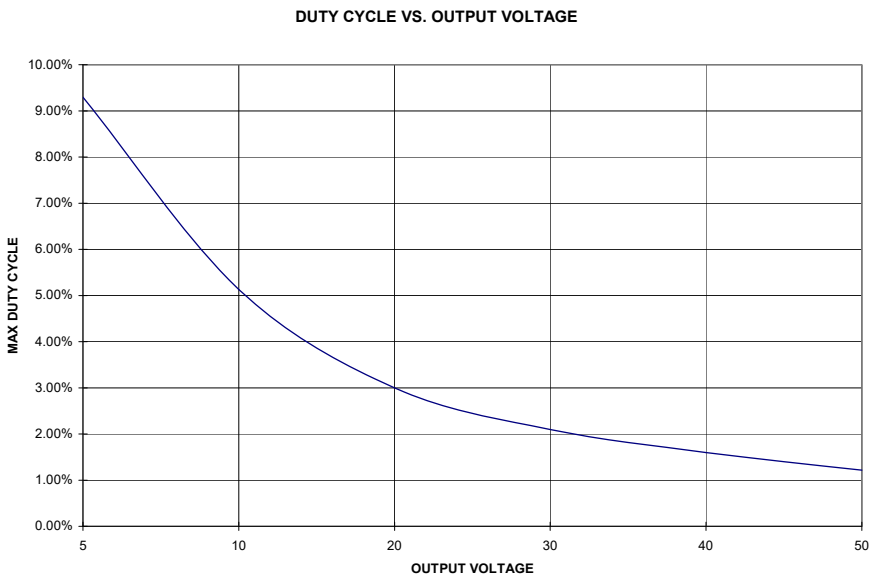

Figure 15. Duty Cycle

Figure 14 and Figure 15 show the maximum available pulse width and duty cycle available from any one channel; channels are independent so these limits do not depend on other channels. The drivers are current-limited and will not be damaged if programmed beyond these limits.

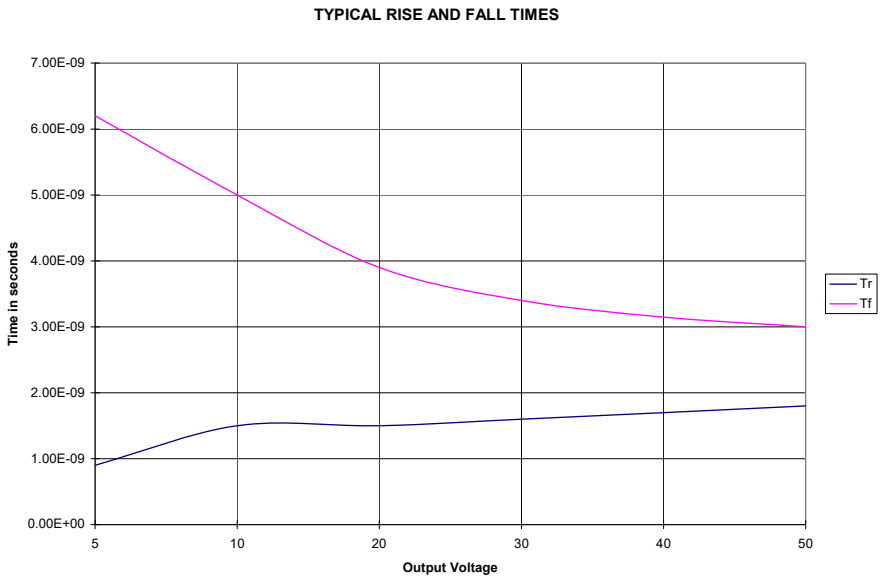

Figure 16. Pulse rise and fall times

Figure 16 shows typical rise and fall times at various voltages, again terminated into a 50 ohm load. At higher duty cycles, transformer circulating current helps

the load pull the outputs back to zero, so fall times will approach risetime at high duty cycles or rep-rates.

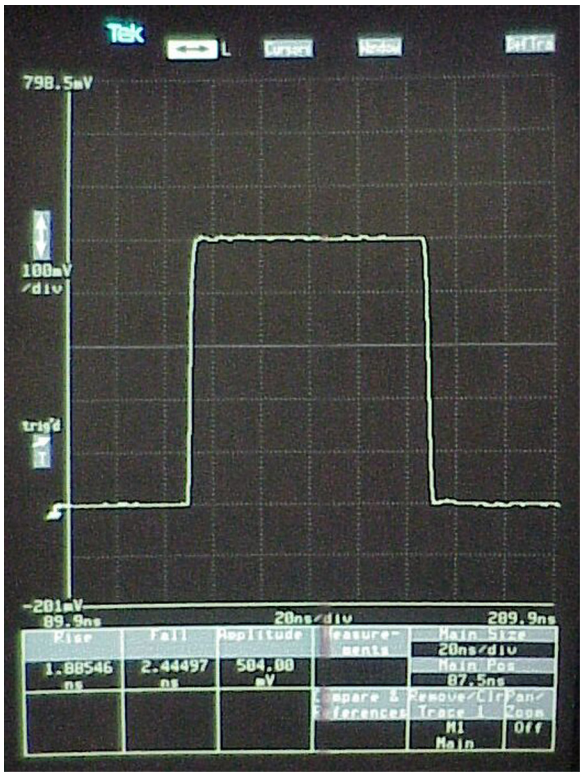

Figure 17. Typical 50-volt output pulse

Outputs are positive pulses, but are isolated so can be inverted by external wiring. Cleanest negative pulses will result from adding a coaxial crossover (swapping inner and outer conductors) some distance from either the P400 or the load. If any ringing is observed, slipping a ferrite core or EMI suppressor over the cable near the crossover will usually improve pulse shapes.

6 Typical Performance

Figure 18 shows an oscilloscope plot of two typical pulse waveforms, as displayed on a 500 MHz oscilloscope with the oscilloscope terminating both signals at 50 ohms.

The upper trace is a 0 to 5 volt "TTL" step. The P400 was programmed to output 0 (VL) and 10-volt (VH) levels, which are divided by a factor of two by the termination. The lower trace is an ECL-level pulse, with the voltage at the load swinging from -0.8 to -2 volts; this channel was programmed for VH of –1.6 volts and VH of –4.0 volts.

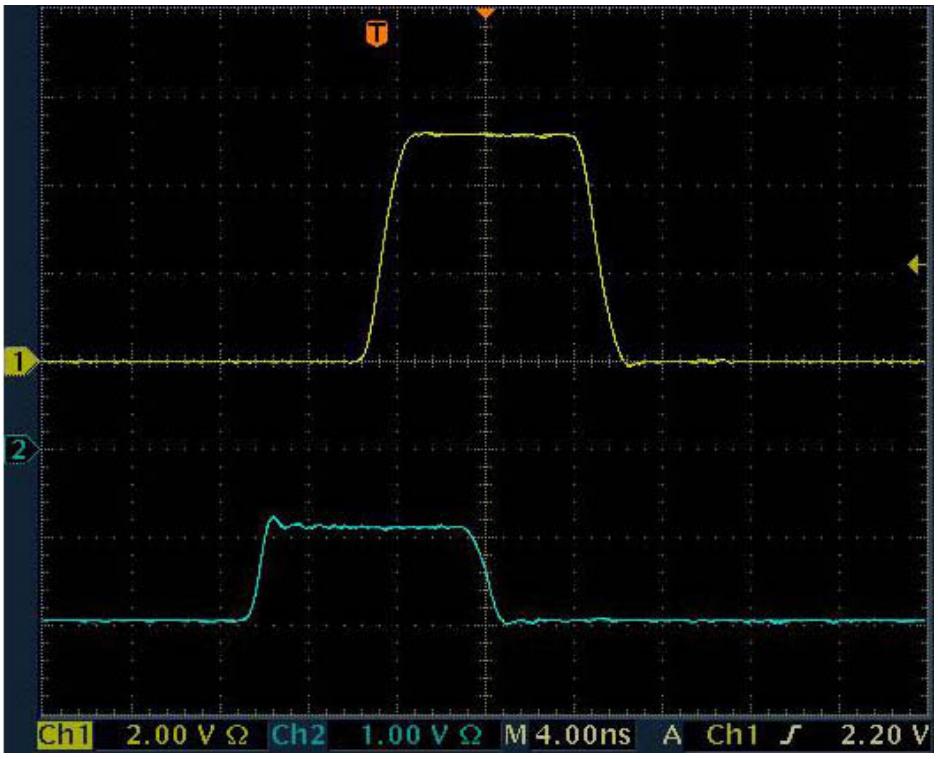

Figure 18. Typical Output Waveforms

Using the P400 with high impedance (unterminated) loads can have unintended consequences. The waveform shown in Figure 19 is a 0 to 10-volt pulse driving a length of coaxial cable into a high-impedance load, as viewed at the cable end. The stairstep on the falling edge is a result of the limited pull-down current capability of the

P400 output stage. To avoid this situation, do not set the P400 output to swing more than 5.00 volts while driving high-impedance loads.

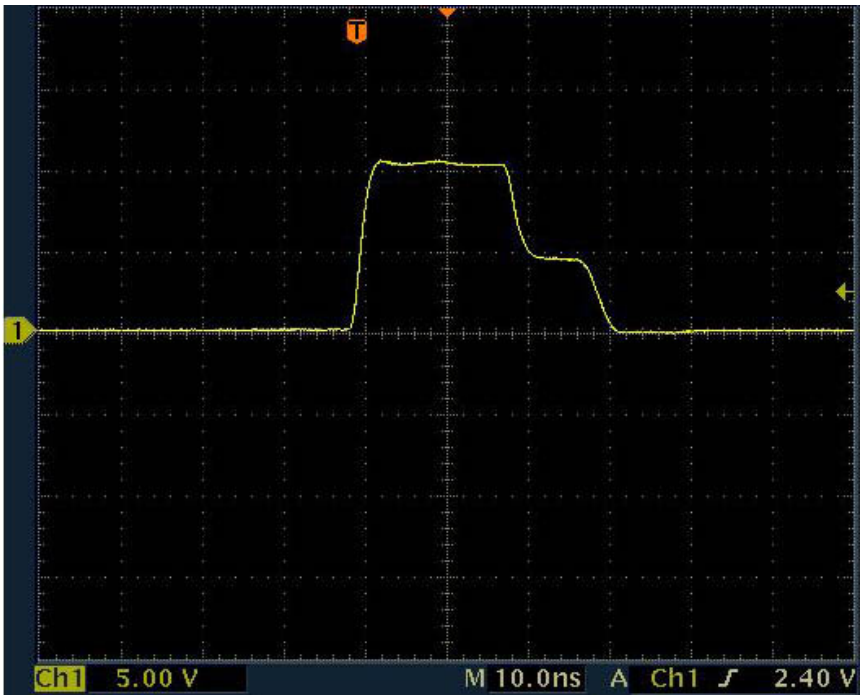

Figure 19. 10 V Pulse with High-Impedance Termination

6.1 Typical Jitter Performance

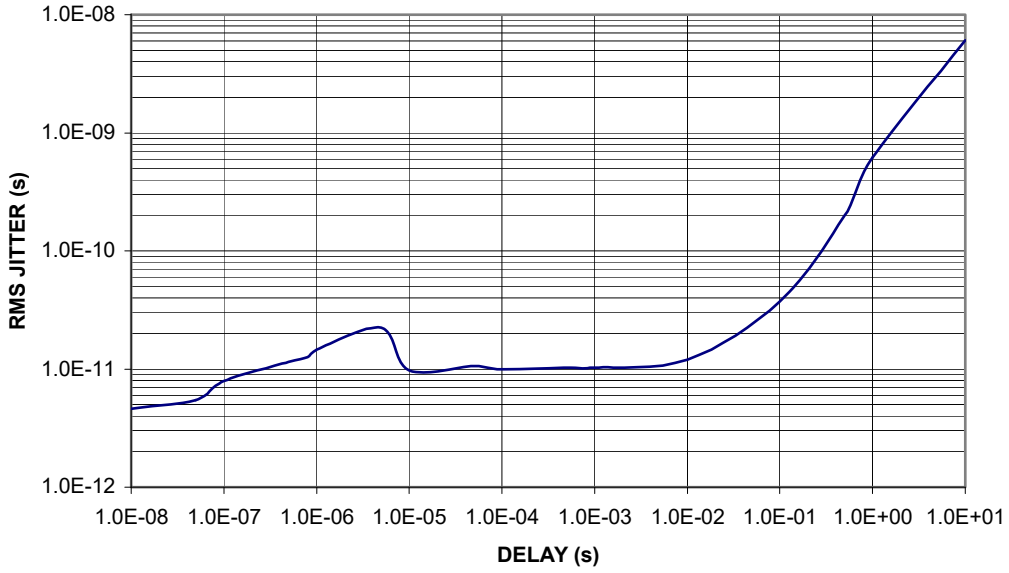

Figure 20. Typical RMS Jitter

Figure 20 is a graph of typical RMS jitter as a function of programmed delay. The measurement was made using a 2-volt asynchronous external trigger from a Tektronix PG-502 pulse generator, with delay measured on a type 11801 sampling oscilloscope. At longer delays, the oscilloscope jitter increases to unusable levels, so longer delays were measured by using the scope to characterize the jitter between two independent P400s programmed to generate slightly different delays. The delay increase beginning around 10 milliseconds is a result of the phase noise of the TCXO timebase internal to the P400. The OCXO timebase option moves this corner out by at least 10:1.

Note that jitter increases for delays from 0 to about 3 μs, at which time the DSP phase lock system begins to discipline the 50 MHz gated oscillator.

7 Remote Programming

The P400 can be used as a stand-alone instrument or may be connected to a host computer. The P400 supports serial commands for almost every action that can be performed using the front panel.

All commands support both the SCPI long-form and the short-form mnemonic and are not case sensitive; for example, “TRIGGER” or “trig” may be used to specify the trigger command. Colons separate each command and instruct the unit's command parser to move down a level in the command tree hierarchy. In situations where two commands are issued without changing levels, a semicolon separates the commands. The colon preceding the first command in a SCPI message instructs the parser in the instrument to reset itself to the root level in the hierarchy. Commas separate parameters such as numeric, extended numeric, discrete and Boolean. Unless specifically noted, all commands have a query form, usually the command followed by a question mark.

7.1 P400 Commands

The P400 uses mandatory remote control commands defined in the IEEE488.2-1987 standard. This command set consists of program commands and status queries that are common to all devices. Currently these commands only clear the remote debug buffer.

Table 4. P400 Commands

BURst CounterCLear
Command: BUR:CCL<CR><LF>
Response: OK<CR><LF>
Query: BUR:CCL?<CR><LF>
Response: *count*<CR><LF>
Description: Resets the burst counter to 0. Sending the query returns the current burst counter value. *count* will be between 0 and BURst TRIGger – 1.

Example: Clear the Burst Counter.
`BUR:CCL<CR><LF>` reply: `OK<CR><LF>`
 	
Example: Query Burst Counter value.
`BUR:CCL?<CR><LF>` reply: `31251<CR><LF>`

BURst MODe
Command: BUR:MOD *enable*<CR><LF>
Response: OK<CR><LF>
Query: BUR:MOD?<CR><LF>
Response: *enable*<CR><LF>
Description: Enables or disables the burst mode. The possible values for *enable* are shown below. ON Enable burst mode OFF Disable burst mode

Example: Enable the Burst Mode.
`BUR:MOD ON<CR><LF>` reply: `OK<CR><LF>`
 	
Example: Query Burst Mode.
`BUR:MOD?<CR><LF>` reply: `ON<CR><LF>`

BURst:PULse
Command: BUR:PUL *pulses*<CR><LF>
Response: OK<CR><LF>
Query: BUR:PUL?<CR><LF>
Response: *pulses*<CR><LF>
Description: Sets the number of pulses, n, per burst cycle. *Pulses* can be set from 1 to BURst TRIGger – 1.

Example: Set the Burst Pulse value to 32,000
`BUR:PUL 32000<CR><LF>` reply: `OK<CR><LF>`
 	
Example: Query Burst Pulse value.
`BUR:PUL?<CR><LF>` reply: `32000<CR><LF>`

BURst TRIGger
Command: BUR:TRIG *trig*<CR><LF>
Response: OK<CR><LF>
Query: BUR:TRIG?<CR><LF>
Response: *trig*<CR><LF>
Description: Sets the number of triggers, m, per burst cycle. *trig* can be set from BURst PULse + 1 to 65535.

Example: Set the Burst Trigger value to 65,000.
`BUR:TRIG 65000<CR><LF>` reply: `OK<CR><LF>`
 	
Example: Query Burst Trigger value.
`BUR:TRIG?<CR><LF>` reply: `65000<CR><LF>`

CHANnel Delay/Width	
Command:	CHAN:DW *a*<CR><LF>
Response:	OK<CR><LF>
Query:	CHAN:DW? *a*<CR><LF>
Response:	DW<CR><LF>
Description: Sets the channel's timing mode to Delay/Width. The possible values for *a* are shown below. A Channel A Timing Mode B Channel B Timing Mode C Channel C Timing Mode D Channel D Timing Mode	

Example: Set Channel to D/W, Delay/Width mode.
`CHAN:DW A<CR><LF>` reply: `OK<CR><LF>`
 	
Example: Query Channel A.
`CHAN:DW? A<CR><LF>` reply: `DW<CR><LF>`	

CHANnel NEGative	
Command:	CHAN:NEG *a*<CR><LF>
Response:	OK<CR><LF>
Query:	CHAN:NEG? *a*<CR><LF>
Response:	NEGative<CR><LF>
Description: Sets the channel's output polarity to negative. The channel's output starts at VH and transitions to VL after the delay time. At the end of the width time the channel's output transitions from VL to VH. The possible values for *a* are shown below. A Channel A Output Polarity B Channel B Output Polarity C Channel C Output Polarity D Channel D Output Polarity	

Example: Set Channel A Polarity to Negative.
`CHAN:NEG A<CR><LF>` reply: `OK<CR><LF>`
 	
Example: Query Channel A Polarity.
`CHAN:NEG? A<CR><LF>` reply: `NEGative<CR><LF>`	

CHANnel OFF

Command: CHAN:OFF *a*<CR><LF>

Response: OK<CR><LF>

Query: CHAN:OFF? *a*<CR><LF>

Response: OFF<CR><LF>

Description: Disables the channel's output. The possible values for *a* are shown below.

A	Channel A Output
B	Channel B Output
C	Channel C Output
D	Channel D Output

CHANnel ON

Command: CHAN:ON *a*<CR><LF>

Response: OK<CR><LF>

Query: CHAN:ON? *a*<CR><LF>

Response: ON<CR><LF>

Description: Enables the channel's output. The possible values for *a* are shown below.

A	Channel A Output
B	Channel B Output
C	Channel C Output
D	Channel D Output

Example: Set Channel A OFF.

`CHAN:OFF A<CR><LF>` reply: `OK<CR><LF>`

Example: Query Channel A ON or OFF.

`CHAN:OFF? A<CR><LF>` reply: `OFF<CR><LF>`

CHANnel POSitive

Command: CHAN:POS *a*<CR><LF>

Response: OK<CR><LF>

Query: CHAN:POS? *a*<CR><LF>

Response: POSitive<CR><LF>

Description: Sets the channel's output polarity to positive. The channel's output starts at VL and transitions to VH after the delay time. At the end of the width time the channel's output transitions from VH to VL. The possible values for *a* are shown below.

A	Channel A Output Polarity
B	Channel B Output Polarity
C	Channel C Output Polarity
D	Channel D Output Polarity

Example: Query Channel A Polarity.

`CHAN:POS? A<CR><LF>` reply: `POSitive<CR><LF>`

CHANnel Rise/Fall

Command: CHAN:RF *a*<CR><LF>

Response: OK<CR><LF>

Query: CHAN:RF? *a*<CR><LF>

Response: RF<CR><LF>

Description: Sets the channel's timing mode to Rise/Fall. The possible values for *a* are shown below.

A	Channel A Timing Mode
B	Channel B Timing Mode
C	Channel C Timing Mode
D	Channel D Timing Mode

Example: Set Channel to ↑/↓, Rising/Falling mode.

`CHAN:RF A<CR><LF>` reply: `OK<CR><LF>`

Example: Query Channel A.

`CHAN:RF? A<CR><LF>` reply: `RF<CR><LF>`

CHANnel VHIgh

Command: CHAN:VHI *a*, *volts*<CR><LF>

Response: OK<CR><LF>

Query: CHAN:VHI? *a*<CR><LF>

Response: *volts*<CR><LF>

Description: Sets channel *a*'s VH to *volts*. The possible values for *a* are shown below.

A	Channel A VH
B	Channel B VH
C	Channel C VH
D	Channel D VH

volts can be from –4.30 to +11.80 in 0.10 increments. VH must be set at least 0.20 above VL. It is not necessary to include the sign for zero or positive values. The query response will always include the sign.

Example: Set Channel A VHI to +5.00V.

`CHAN:VHI A, 5.0<CR><LF>` reply: `OK<CR><LF>`

Example: Query Channel A VHI value.

`CHAN:VHI? A<CR><LF>` reply: `+ 5.0<CR><LF>`

CHANnel VLOw

Command: CHAN:VLO *a*,*volts*<CR><LF>

Response: OK<CR><LF>

Query: CHAN:VLO? *a*<CR><LF>

Response: *volts*<CR><LF>

Description: Sets channel *a*'s VL to *volts*. The possible values for *a* are shown below.

A	Channel A VL
B	Channel B VL
C	Channel C VL
D	Channel D VL

volts can be from –5.00 to +4.10 in 0.10 increments. VL must be set at least 0.20 below VH. It is not necessary to include the sign for zero or positive values. The query response will always include the sign.

Example: Set Channel A VLO to -2.50V.
`CHAN:VLO A, -2.5<CR><LF>` reply: `OK<CR><LF>`

Example: Query Channel A VLO value.
`CHAN:VLO? A<CR><LF>` reply: `- 2.5<CR><LF>`

CLear Status

Command: *CLS<CR><LF>

Response: OK<CR><LF>

Query: None

Response: None

Description: This command clears the input serial buffer.

Example:
`*CLS<CR><LF>` reply: `OK<CR><LF>`

GATE MODe

Command: GATE:MOD *mode*<CR><LF>

Response: OK<CR><LF>

Query: GATE:MOD?<CR><LF>

Response: *mode*<CR><LF>

Description: Sets the gate mode. The possible values for *gate* are shown below.

1	Output, TTL high when trigger is enabled.
2	Output, TTL low when trigger is enabled.
3	Input, Trigger is enabled when the input is at TTL high.
4	Input, Trigger is enabled when the input is at TTL low.

Example: Set the Gate to Mode 1.

`GATE:MOD 1<CR><LF>` reply: `OK<CR><LF>`

Example: Query Gate Mode.

`GATE:MOD?<CR><LF>` reply: `1<CR><LF>`

MEMory CLEar

Command: MEM:CLE *n*<CR><LF>

Response: OK<CR><LF>

Query: MEM:CLE? *n*<CR><LF>

Response: *status*<CR><LF>

Description: Erases the configuration in location *n*. *n* can be set from 0 to 30. Allow three seconds for the unit to clear the configuration before sending another command.

status may be USED or UNUSED.

Example: Clear memory location 0.

`MEM:CLE 0<CR><LF>` reply: `OK<CR><LF>`

Example: Query memory location 0

`MEM:CLE? 0<CR><LF>` reply: `UNUSED<CR><LF>`

Note: Wait 3 seconds for command to finish execution before sending another command.

MEMory RECall	
Command:	MEM:REC *n*<CR><LF>
Response:	OK<CR><LF>
Query:	MEM:STO? *n*<CR><LF>
Response:	*status*<CR><LF>
Description: Recalls the unit's configuration in location *n*. *n* can be set from 0 to 30. Allow three seconds for the unit to recall the configuration before sending another command. *status* may be USED or UNUSED.	

Example: Recall configuration from memory location 1.
`MEM:REC 1<CR><LF>` reply: `OK<CR><LF>`
 	
Example: Query memory location 1.
`MEM:REC? 1<CR><LF>` reply: `UNUSED<CR><LF>`
 	
Note: Wait 3 seconds for command to finish execution before sending another command.	

MEMory REStore	
Command:	MEM:RES<CR><LF>
Response:	OK<CR><LF>
Query:	MEM:RES?<CR><LF>
Response:	*status*<CR><LF>
Description: Restores the unit's configuration prior to the last MEM:REC command. Allow three seconds for the unit to restore the configuration before sending another command. If a MEM:REC command was not sent before this command is sent then *status* is UNUSED otherwise *status* is USED.	

Example: Restore the units configuration.
`MEM:RES<CR><LF>` reply: `OK<CR><LF>`
 	
Example: Query Restore to see if it's available.
 	
`MEM:RES?<CR><LF>` reply: `UNUSED<CR><LF>`
 	
Note: Wait 3 seconds for command to finish execution before sending another command.	

MEMory STOre	
Command:	MEM:STO *n*<CR><LF>
Response:	OK<CR><LF>
Query:	MEM:STO? *n*<CR><LF>
Response:	*status*<CR><LF>
Description: Stores the unit's configuration in location *n*. *n* can be set from 0 to 30. Allow three seconds for the unit to store the configuration before sending another command. *status* may be USED or UNUSED.	

Example: Store the Unit configuration at location 0.
`MEM:STO 0<CR><LF>` reply: `OK<CR><LF>`
 	
Example: Query memory location 0.
`MEM:STO? 0<CR><LF>` reply: `USED<CR><LF>`
 	
Note: Wait 3 seconds for command to finish execution before sending another command.	

ReSeT	
Command:	*RST<CR><LF>
Response:	OK<CR><LF>
Query:	None
Response:	None
Description: This command clears the input serial buffer.	
Example: `*RST<CR><LF>` reply: `OK<CR><LF>`	

STArt	
Command:	STA<CR><LF>
Response:	OK<CR><LF>
Query:	None
Response:	None
Description: Sending this command is the same as pressing the START button.	
Example: `STA<CR><LF>` reply: `OK<CR><LF>`	

STOp	
Command:	STO<CR><LF>
Response:	OK<CR><LF>
Query:	None
Response:	None
Description: Sending this command is the same as pressing the STOP button.	
Example: ST0<CR><LF> reply: 0K<CR><LF>	

TIME DELay

Command: TIME:DEL*n delay units*<CR><LF>

Response: OK<CR><LF>

Query: TIME:DEL*n*?<CR><LF>

Response: *delay*<CR><LF>

Description: Sets the time delay for channels A through D. The possible values for *n* are shown below.

1	Delay for channel A leading edge
2	Delay for channel A trailing edge
3	Delay for channel B leading edge
4	Delay for channel B trailing edge
5	Delay for channel C leading edge
6	Delay for channel C trailing edge
7	Delay for channel D leading edge
8	Delay for channel D trailing edge

delay can be set from -999.999999999999 to +999.999999999999 in one picosecond increments. It is not necessary to include the sign for zero or positive values.

The possible values for *units* are shown below. The default value is seconds.

PS	or	E-12	for picoseconds
NS	or	E-9	for nanoseconds
US	or	E-6	for microseconds
MS	or	E-3	for milliseconds

The query response is always in seconds and includes the sign.

Example: Set Channel A rising edge delay to 10 milliseconds.
`TIME:DEL1 0.01<CR><LF>` reply: `OK<CR><LF>`

Example: Set Channel A rising edge delay to 10 nanoseconds.
`TIME:DEL1 10NS<CR><LF>` reply: `OK<CR><LF>`

Example: Query Channel A rising edge delay.
`TIME:DEL1?<CR><LF>` reply: `+ 000.000 000 010 000 <CR><LF>`

TIME RELative To

Command: TIME:RELT*n m*<CR><LF>

Response: OK<CR><LF>

Query: TIME:RELT*n*?<CR><LF>

Response: *m*<CR><LF>

Description: Sets the channel *n* edge relative to channel *m* edge. The possible values for *n* and *m* are shown below.

0	Channel T0 leading edge (*m* only)
1	Channel A leading edge
2	Channel A trailing edge
3	Channel B leading edge
4	Channel B trailing edge
5	Channel C leading edge
6	Channel C trailing edge
7	Channel D leading edge
8	Channel D trailing edge

When Channel *n*'s mode is set to Delay/Width only the leading edge can be set relative to a Channel *m* edge. The unit will return ?33<CR><LF> when trying to set Channel *n*'s trailing edge. In Rising/Falling mode (↑/↓) both Channel *n*'s edges can be set relative to a Channel *m* edge.

Example: Set channel B relative to the falling edge of channel A :

`TIME:RELT3 2<CR><LF>` **reply:** `OK<CR><LF>`

Example: Query.

`TIME:RELT3?<CR><LF>` **reply:** `2<CR><LF>`

TRIGger EXECute

Command: TRIG:EXEC<CR><LF>

Response: OK<CR><LF>

Query: None

Response: None

Description: Triggers the unit when in remote mode.

Example: Trigger the unit remotely

`TRIG:EXEC<CR><LF>` reply: `OK<CR><LF>`

*NOTE: No Query for this command

TRIGger FREQuency

Command: TRIG:FREQ *freq units* <CR><LF>

Response: OK<CR><LF>

Query: TRIG:FREQ?<CR><LF>

Response: *freq*<CR><LF>

Description: Sets the internal trigger frequency from 10 mHz to 10.000 000 00 MHz in 10 mHz increments. The default units are Hertz. The possible values for *units* are shown below.

MHZ	or	E-3	for milliHertz
HZ	or	E0	for Hertz (may be omitted)
KHZ	or	E3	for KiloHertz
		E6	for MegaHertz

The query response is always in Hertz.

Example: Set the internal trigger frequency to 1Mhz.

`TRIG:FREQ 1E6<CR><LF>` reply: `OK<CR><LF>`

Example: Query the unit for the trigger source.

`TRIG:FREQ?<CR><LF>` reply: `+001 000 000.000 000<CR><LF>`

TRIGger INPUT POLarity

Command: TRIG:INPUT:POL *pol*<CR><LF>

Response: OK<CR><LF>

Query: TRIG:INPUT:POL?<CR><LF>

Response: *pol*<CR><LF>

Description: Sets the trigger input polarity to rising (positive) or falling (negative) edge. The possible values for *pol* are shown below.

POS	Trigger starts on the rising edge
NEG	Trigger starts on the falling edge

This command is only valid for external trigger sources. See <TRIG:SOUR> for details.

Example: Set the input trigger polarity to positive.

`TRIG:INPUT:POL POS<CR><LF>` reply: `OK<CR><LF>`

Example: Query the unit for the input trigger polarity.

`TRIG:INPUT:POL?<CR><LF>` reply: `POSitive<CR><LF>`

TRIGger INPUT TERMination	
Command:	TRIG:INPUT:TERM *imp*<CR><LF>
Response:	OK<CR><LF>
Query:	TRIG:INPUT:TERM?<CR><LF>
Response:	*imp*<CR><LF>
Description: Sets the trigger input termination impedance. The possible values for *imp* are shown below. 50OHM 50 Ω internal termination HIGHZ High impedance internal termination	

Example: Set the internal trigger termination to 50 Ohm.
`TRIG:INPUT:TERM 50OHM<CR><LF>` reply: `OK<CR><LF>`
 	
Example: Query the unit for the trigger termination source.
`TRIG:INPUT:TERM?<CR><LF>` reply: `50OHM<CR><LF>`	

TRIGger INPUT VOLTage	
Command:	TRIG:INPUT:VOLT *volts*<CR><LF>
Response:	OK<CR><LF>
Query:	TRIG:INPUT:VOLT?<CR><LF>
Response:	*volts*<CR><LF>
Description: Sets the trigger voltage level. *volts* can be set from –2.40 to +4.60 in 0.10 increments. It is not necessary to include the sign for zero or positive values. The query response will always include the sign.	

Example: Set the input trigger level to +2.50V.
`TRIG:INPUT:VOLT 2.5<CR><LF>` reply: `OK<CR><LF>`
 	
Example: Query the input trigger level.
`TRIG:INPUT:VOLT?<CR><LF>` reply: `+2.5<CR><LF>`	

TRIGger Source	
Command:	TRIG:SOUR *src* <CR><LF>
Response:	OK<CR><LF>
Query:	TRIG:SOUR?<CR><LF>
Response:	*src*<OK><LF>
Description: Sets the trigger source. The possible values for *src* are shown below. MAN — Manual trigger LINE — Line input trigger REM — Remote trigger INT — Internal trigger EXT — External trigger	
Example: Set the trigger source to internal trigger. `TRIG:SOUR INT<CR><LF>` reply: `OK<CR><LF>`	

WAIt	
Command:	*WAI<CR><LF>
Response:	OK<CR><LF>
Query:	None
Response:	None
Description: This command clears the input serial buffer.	
Example: `*WAI<CR><LF>` reply: `OK<CR><LF>`	

7.2 Remote Error Codes

Error codes are returned when a command or query sent to the P400 is incorrect, incomplete, or otherwise not accepted.

The formatting for error codes is shown below.

?*nn*<CR><LF>

The possible values for *nn* are shown in Table 7-1.

Table 5. Remote Error Codes

Error Number	Error Name	Comments
21	BUFFER OVERFLOW	A command overloaded the buffer or no line terminator was found.
22	ABORT RECEIVED	An abort character (Ctrl-D) was found while processing input.
23	COMMAND MISSING	Indicates no command word was found where one was expected.
24	COMMAND NOT FOUND	Indicates no match was found for the command word at the current hierarchy level.
25	PARAMETER BUFFER OVERFLOW	Too much data added as parameters.
26	REQUIRED PARAMETER MISSING	
27	TOO MANY PARAMETERS	Also indicates that parameters are not allowed with the command.
28	INVALID QUERY FORM	A query (?) was either not allowed with the command or in the wrong position.
29	QUERY MODE REQUIRED or PARAMETERS NOT ALLOWED IN QUERY MODE	
2A	CHANNEL NO. RANGE ERROR	The requested channel is out of range for the command.
2B	TABLE MISSING	The sub-table or default table could not be determined.
2C	PARAMETER MISMATCH ERROR	The parameter format did not match that required for the command.
30	NUMERIC PARAMETER VALUE ERROR	The numeric value in the parameter was not in the required range or it was missing.
31	ERROR IN NUMERIC FORMAT	See section above on allowed numeric formats.
32	ERROR IN REPLY DATA	Value requested in a query could not be returned.
33	COMMAND ATTEMPTED ILLEGAL OPERATION	The command could not be executed at that time.
40	ERROR IN TIMING DEPENDENCY	
41	ERROR IN SETTING THE TIME	

Error Number	Error Name	Comments
	VALUE	
42	INVALID PASSWORD	The password (required for some commands) was invalid.
43	ERROR IN SETTING VOLTAGE	

7.3 Command Strings

For convenience, multiple commands can be sent to the P400 with only a single <CR><LF> command terminator.

For strings in which the command level is the same for all commands, a single semi-colon separates the commands. If the command level changes for a command in the string, then the command must be preceded by a colon.

The P400 replies to command strings with a string of responses, followed by a single <CR><LF> command terminator.

See Table 6 for examples of command strings.

Table 6. Examples of Command Strings

Set all leading edges to 5ns Command TIME:DEL1 5NS;DEL3 5NS;DEL5 5NS;DEL7 5NS<CR ><LF> Response OK OK OK OK<CR><LF>
Query the VH of all channels (assume all channels are set to +5.00V) Command CHAN:VHI? A;VHI? B;VHI? C;VHI? D<CR><LF> Response + 5.0 + 5.0 + 5.0 + 5.0<CR><LF>
Set the trigger source and frequency then start triggering Command TRIG:SOUR INT;FREQ 5K;:START<CR><LF> Response OK OK OK<CR><LF>

7.4 RS-232 Interface

The P400 standard configuration includes a nine-pin RS-232 connector for remote operation. Select RS-232 mode on the Auxiliary menu by scrolling down to `Remote mode:` and turning the spinner knob until `RS-232` is shown.

A standard serial cable (non-null modem) can be used to connect the P400 to a host computer. Only TX, RX and GND are required for proper operation. For computers that require hardware handshaking the P400 is configured for loopback mode. See Figure 21 for the P400 connector wiring.

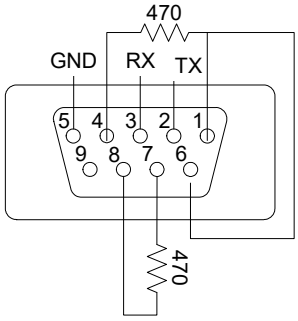

Figure 21. RS-232 Connector Pin-Out

Set the host computer for ASCII protocol, 8 DATA bits, No Parity bit, 1 Stop bit and No Handshake.

7.5 P430 Ethernet Interface

As of January 2015, the P430 Ethernet Adaptor is no longer available. If Ethernet communication is required, we recommend using the B&B Electronics VESP211-232 Ethernet Serial Server, available from Highland Technology as an option on the P400. See section 7.6 for more information.

The P430 Ethernet Adaptor allows for remote operation over a TCP/IP network. Select Ethernet mode on the Auxiliary menu by scrolling down to `Remote mode:` and turning the spinner knob until `Ethernet` is shown.

Connection to the network, e.g. through a hub or router, is through a standard RJ45 Ethernet cable. To connect directly to a computer, a special Ethernet crossover cable must be used.

The P400 communicates through port 2000 in both DHCP and static IP modes.

7.5.1 DHCP-Mode Configuration

To configure the P400 for DHCP mode, follow these steps:

Press the AUX button to display the Auxiliary menu.

Move the cursor down the menu using the scroll keys or spinner knob until `IP=aaa.bbb.ccc.ddd` is shown.

Set the first three digits of the IP address to “0”, and press the ENTER key.

Move the cursor with the right scroll key, set the next three digits of the IP address to “0”, and press the ENTER key.

Repeat steps 3 and 4 for the remaining fields of the IP address.

Move the cursor to `Update network`, and turn the spinner knob until `YES` is shown.

Press the ENTER key.

After performing these steps, the IP address, subnet mask, and gateway address will be assigned by the network.

7.5.2 Static-Mode Configuration

To configure the P400 for static IP mode follow these steps:

Obtain an IP address, subnet mask, and gateway address from your network administrator.

Press the AUX button to display the Auxiliary menu.

Move the cursor down the menu using the scroll keys or spinner knob until `IP=aaa.bbb.ccc.ddd` is shown.

Enter the first three digits of the IP address, and press the ENTER key.

Move the cursor with the right scroll key, enter the next three digits of the IP address, and press the ENTER key.

Repeat steps 4 and 5 for the remaining fields of the IP address.

Move the cursor until `SM=qqq.rrr.sss.ttt` is shown.

Enter the subnet mask in the same manner as the IP address.

Move the cursor until `GW=www.xxx.yyy.zzz` is shown.

Enter the gateway address.

Move the cursor to `Update network`, and turn the spinner knob until `YES` is shown.

Press the ENTER key.

7.5.3 Connecting the P400 to the Network

When the network configuration is complete, you can connect the P400 to the network using the telnet protocol. To connect the P400 to a Windows computer through telnet, follow these steps:

Select “Run…” from the Windows Start menu

In static IP mode, type `telnet aaa.bbb.ccc.ddd 2000`

where `aaa.bbb.ccc.ddd` is the IP address and `2000` is the port number of the P400.

Press <Enter>

In DHCP mode, type `telnet` followed by the *`hostname 2000`* as indicated on the Auxiliary menu.

A telnet session will open and you can begin sending commands to the P400. The P400 commands are explained earlier in this chapter.

7.6 P431 Ethernet Setup

The P431 option is a stand-alone RS232 to Ethernet server. It connects to the RS232 port of the P400 through a standard DB9 cable and to the network through a standard Ethernet cable. Using the accompanying software, it is possible to setup the P431 as either a virtual comport or as an IP device.

To setup the P431, follow the instructions that come with it. When connected to the VESP211-232 through the V-LINX software, note the device's IP address and open TCP port number. If planning to use as an IP device, set the "Port 1 Serial" settings to match those of the P400.

The VESP211-232 Ethernet Serial Server is not addressable by hostname. In order to connect to it, you must know its IP address. This is most easily done in V-Linx but you can also scan the network and look for the server's MAC address, which should begin 00:0E:BE, a prefix unique to B&B Electronics devices. If using the device in IP mode, it is recommended that it be assigned a static IP address.

When the network configuration is complete, you can connect the P400 to the network using the telnet protocol. To connect the P400 to a Windows computer through telnet, follow these steps:

Select "Run…" from the Windows Start menu

Type `telnet aaa.bbb.ccc.ddd yyyy`

where `aaa.bbb.ccc.ddd` is the IP address and `yyyy` is the port number of the VESP211-232.

Press <Enter>

A telnet session will open and you can begin sending commands to the P400. The P400 commands are explained earlier in this chapter.

To connect to the P400 on a Windows computer using virtual com mode, follow the instructions that come with the VESP211-232 to setup the virtual comport. You should now be able to communicate with the P400 as if through a basic RS-232 interface.

8 Versions

P400-2: 4-channel benchtop digital delay and pulse generator

9 Customization

Consult factory for information about additional custom versions.

10 Options and Accessories

The standard P400 Digital Delay generator is equipped with RS232 communication and a temperature-compensated oscillator.

10.1 Options

Options must be installed at the factory.

Available P400 options include:

Option	Part Number	Availability
P420 ovenized crystal oscillator	23A420-1	Currently available
P430 ethernet communication	23A430-1	Discontinued as of April 2015
P431 external ethernet communication	23A431-1	Currently available
P450 high voltage (50 V) rear panel outputs	23A450-1	Currently available

10.2 Accessories

P426 Rack mount for P400

P491 Power supply for P400 (1 furnished with purchase)

P492 AC line triggering transformer for P400

J720 single-channel compact electrical-to-fiberoptic converter

J724 single-channel compact buffered electrical-to-fiberoptic converter

J730 single-channel compact fiberoptic-to-electrical converter

T760 dual-channel compact high voltage optical-to-electrical converter

T860 single-channel compact logic buffer and driver

The Highland Model J720 Electrical-to-Optical Converter is available to convert P400 output channels to 850 nm fiber optic signals. A companion receiver, the J730 is also offered.

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