HIGHLAND TECHNOLOGY

Model P330

Capacitive Level Sensor Simulator

Technical Manual

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1 Introduction

Fluid levels are commonly measured using coaxial capacitance probes. If the probe is located some distance from the measurement instrument, a 3-wire capacitance measurement is used to eliminate the effects of cable capacitance.

The common configuration of measuring instrument and probe is:

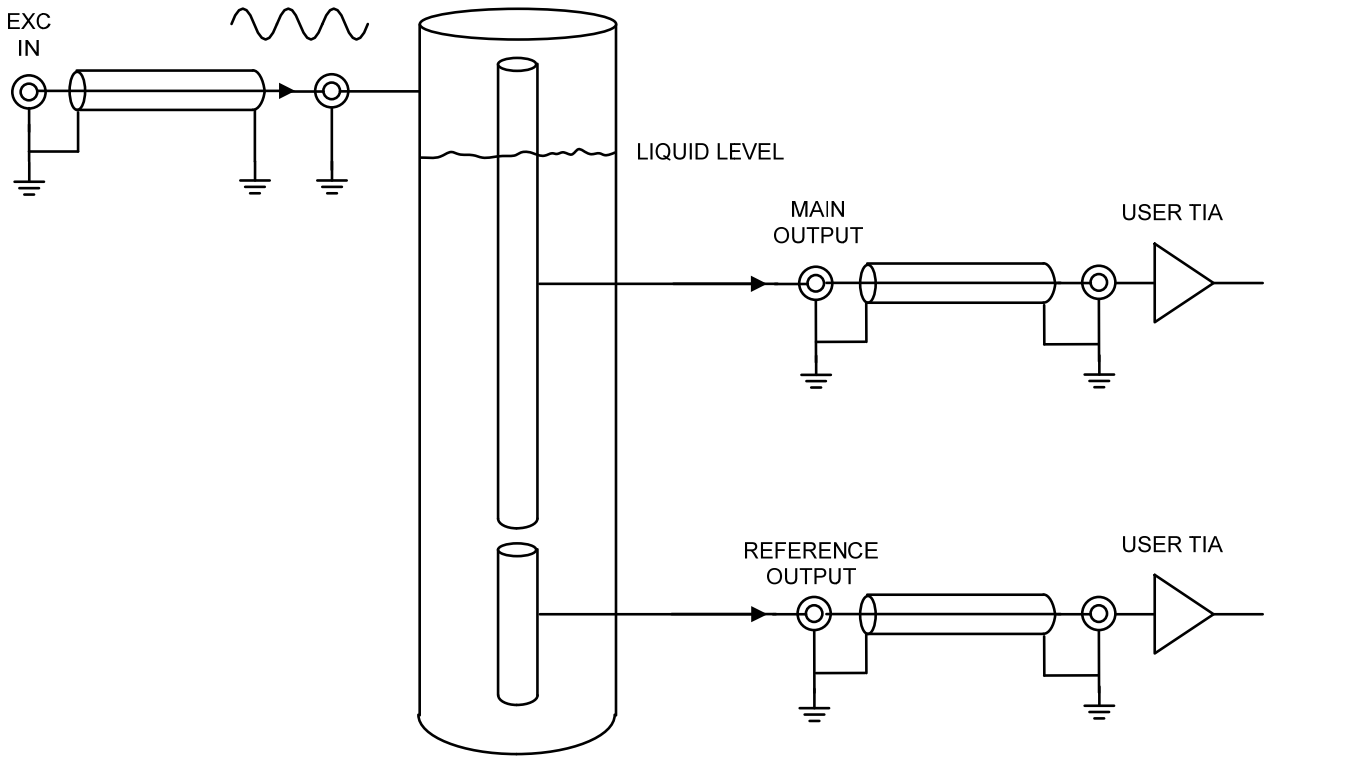

Figure 1: Oil Level Sensor Configuration

The excitation source is typically a sine wave in the audio range, amplitude perhaps 10 volts RMS. The excitation voltage induces AC current into the measurement and reference electrodes proportional to the capacitance between these electrodes and the driven outer tube. If the returned current signals drive low-input-impedance transimpedance amplifiers, this system is insensitive to cable capacitances.

The return currents are proportional to the respective 3-wire capacitances. At zero fluid level, capacitance is determined by the geometry and the dielectric constant of air or vapor. Capacitance increases as fluid fills the space between the outer and inner electrodes. Organic fluids typically have dielectric constants around 2, so the capacitance roughly doubles from empty to full.

The reference electrode is usually fully submerged. It is used to measure actual fluid dielectric constant to improve the accuracy of computed level.

Organic fluids are good insulators, but can be contaminated by water or other conductive materials, so the fluid impedance can have both capacitive and conductive components. The AC currents induced by capacitance and conductance are 90 degrees apart, so a pair of phase-sensitive measurement after the TIA can separately quantify the capacitance and the resistance.

Some typical numbers for the main level-sense electrode might be

Excitation frequency	10 KHz	
Excitation voltage	10 volts RMS	
Dry capacitance	100 pF	Xc = 159 Kohms
Fluid dielectric constant	2	
Maximum full capacitance	200 pF	Xc = 79 Kohms
Corresponding TIA input	125 uA RMS	90° phase lead
Resistance	1 Megohm	
Corresponding TIA input	10 uA RMS	0° phase shift

The P330 simulates four such coaxial level sensors.

2 P330 Overview

There are four independent simulation channels, named A, B, C, and D. Each is programmable to have three ranges of capacitance in parallel with three ranges of resistance. Once ranges are programmed, capacitance or conductance (reciprocal resistance) can be programmed from near 0 to 1.00 of range with 16 bit resolution. This allows, for example, the 500 pF range to have from 10 to 500 pF equivalent capacitance, and the 50K resistance range to present a minimum of 50K and an upper resistance of 1M. Each resistance range can be extended beyond its declared upper limit at reduced accuracy and resolution.

Each channel common is electrically isolated from box ground and from other channels. The excitation input and simulated capacitance output connectors of each channel share the isolated common.

It is assumed that for each channel the excitation input arrives at the P330 on a shielded coaxial cable, generally grounded by the user, and the simulated capacitor current leaves on another coaxial cable. The user's instrument is assumed to measure the output current using a low-input-impedance amplifier, a transimpedance amplifier or equivalent.

The functional equivalent of each P330 channel is:

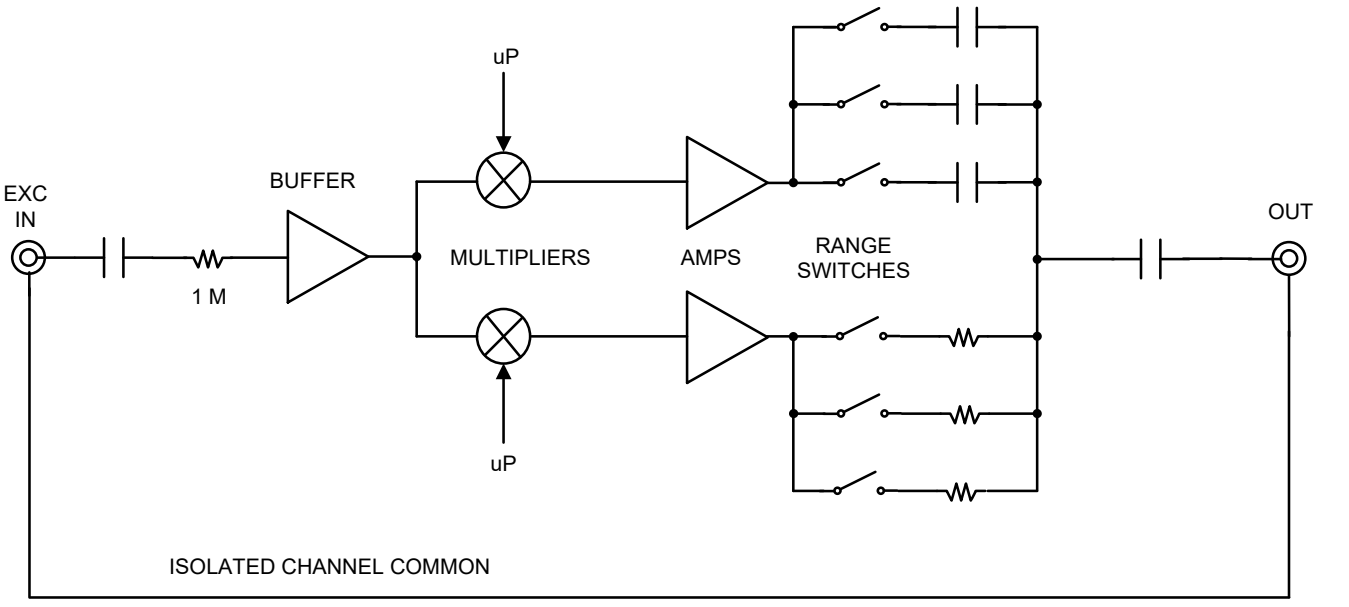

Figure 2: P330 Channel

The user's sine wave excitation input is scaled by two precision programmable multipliers and applied to range-selected capacitors and resistors, effectively scaling the value of the selected capacitor or resistor into the user's transimpedance amplifier.

There is provision for measuring and reporting the excitation voltage and frequency of each channel.

The switching provisions of each channel are:

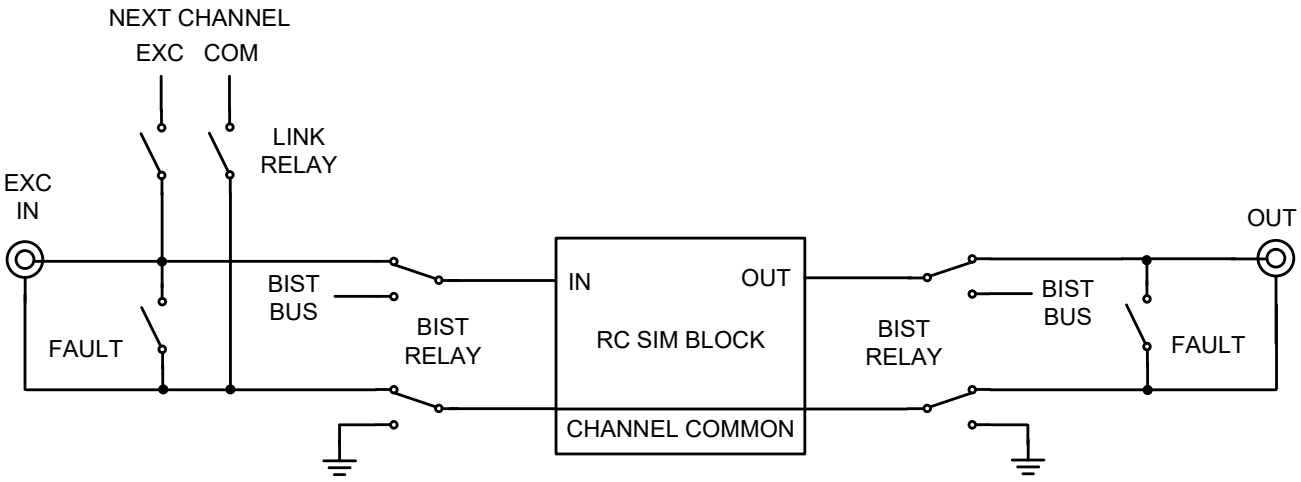

Figure 3: Channel Switching

The relays are shown in their normal positions, where the isolated channel is connected to the excitation and output BNC connectors.

When the BIST relays are actuated, the channel is disconnected from the BNC connectors, grounded, and connected to the excitation and output BIST self-test busses.

A fault relay is provided to allow the input and output connectors to be shorted, simulating cable shorts. Shorting relay contacts are protected by polyfuses rated for 60 volts max.

There are two channel link relays. One allows the excitation connector of channel A to be paralleled with that of channel B, which allows a dual-element level sensor to be simulated with just three coaxial cable connections. A second relay allows linking channels C and D.

Features Include:

- Four independent, isolated channels of simulated capacitive fuel/oil/fluid level sensor simulation
- Three ranges of 3-wire capacitance and three ranges of resistance/conductance per channel
- Monotonic, glitch-free settings within each range
- 16 bit capacitance and conductance resolution
- Simulates sensor cable open/shorted faults
- Measures and reports excitation amplitudes and frequencies

- Includes BIST built-in-self-test and status/excitation LEDs
- Ethernet and USB interfaces
- Internal LOCK switch may be set to disable writes to nonvolatile memory

3 Specifications

FUNCTION	4-channel 3-wire capacitive fluid level sensor simulator
CHANNELS	A B C D, capacitance+resistance, independent, isolated
FREQUENCY RANGE	1 KHz to 50 KHz at specified accuracy, functional from 250 Hz to 250 KHz
EXCITATION INPUT	44 volts p-p max sine or triangle, AC coupled, 100K nom input impedance
CAPACITANCE RANGES	5-50 pF, 10-500 pF, 100-5000 pF
RESISTANCE RANGES	5K-100K, 50K-1M, 500K-10M Resistance ranges can be extended at reduced accuracy
ACCURACY	Capacitance: ± 2% of range ± 1 pF Resistance: 5K-100K 50K-1M ± 1% of setting 500K-1M 1M-10M ± 5% of setting Sine phase error: 1.5 degree Typ. 1KHz to 50 KHz
RESOLUTION	16 bits, capacitance or conductance
OUTPUTS	20 mA RMS max, AC coupled
CONNECTORS	2 BNCs per channel, excitation and output One 2.4 mm barrel for +24 power
COMMUNICATIONS	USB serial port emulator, 115.2 Kbaud 10/100 Mbps Ethernet
CALIBRATION INTERVAL	One year
POWER	External 24 volts DC, AC adapter furnished
PACKAGING	7.0" (L) x 8.5" (W) x 2.5" (H) Aluminum enclosure
INDICATORS	LEDs indicate power, communications, excitations, USER
BIST	Functional self-test provided

4 Connectors

Two BNC connectors are provided per channel, EXCITATION and OUTPUT. The outer shells are connected to channel common but isolated from ground. The Pomona 5299 adapter is available to accommodate triaxial connectors.

Excitation and output signals are AC coupled.

5 BIST

Basic functional self-test can be invoked via serial command. BIST is a functional/failure test and not usable as an accuracy test or calibration verification.

5.1 LEDs

There are four front-panel LED indicators.

The green PWR LED will light dimly to indicate power and blink once every two seconds to indicate that the unit is operating normally. It will blink twice per second while full BIST is being run.

The blue COMM LED will flash whenever the P330 receives a serial command over either the USB or Ethernet ports.

The red ERR LED will blink to indicate a module error. The blinking pattern indicates a category of error:

One blink	Channel programming error
Two blinks	BIST failure
Three blinks	Calibration table error
Four blinks	Power supply error

Calibration table and power supply errors indicate fatal hardware problems.

The orange USR LED may be programmed with the USER serial command. This LED is useful for distinguishing between multiple P-series instruments in the field.

5.2 LOCK SWITCH

An internal slide switch, in its LOCK position, prevents any writes to nonvolatile memory. After this switch is set, tamper-evident stickers may be applied over cover access screws.

6 Communications

USB and Ethernet ports are provided. Both are active simultaneously.

6.1 USB Interface

The P330 emulates a serial port using the FTDI FT230XS USB interface chip. This is a very common USB/serial interface chip, and many operating systems include appropriate drivers by default.

Documentation and drivers are available at http://www.ftdichip.com

Standard ASCI commands can be used through the USB serial port to communicate with the P330. USB can also be used to configure Ethernet IP address and ports.

The serial port protocol is:

Baud	115,200
Data bits	8
Stop Bits	1
Parity	None

6.2 Ethernet Interface

Ethernet is a raw TCP socket at port 2000. Users can open a common Telnet terminal program and connect to the P330 and type the commands of section 7.

The as-shipped IP address mode is DHCP with host name “P330-xxxxx” where xxxxx is the unit serial number, zero-padded to five digits (for example “P330-00012” for serial number twelve). The "IP" command can be used to set a static IP address, or to return to DHCP mode, equivalent to setting the IP address to 0.0.0.0.

The P330 also allows the ASCII commands and replies to be accessed in UDP mode, at a default port 5650. UDP may be suitable for some industrial applications but does not have the protocol checks of TCP.

The UDP port may also be changed with an Ethernet or USB serial command.

6.3 General Comments

The P330 accepts ASCII commands from the USB interface or from the Ethernet port. Commands set capacitance and resistance ranges, values within each range, and invoke status replies. Capacitance and resistance changes are executed immediately.

A family of HELP commands is available, summarizing serial commands and operating modes.

The P330 ignores serial input while it is processing the current command line.

In the following section, text using normal typewriter forn such as

`SEt<cr>`

represents a command string sent to the P330, terminated with a carriage return character.

Italicized typewriter text such as

`OK<cr><lf>`

represents the reply from the P330. All commands must be terminated with a semicolon or a <cr>; all reply lines are terminated by <cr><lf>.

6.3.1 Command Strings

Users send serial ASCII command strings to the P330, to which the P330 replies. Because the P330 may spend milliseconds to process commands, user software must wait for a response to each command line before sending another command.

Each command consists of a command keyword followed by optional arguments. Multiple commands may be sent in a single line separated by semicolons. When the full line is received, indicated by the final <cr> character, the buffered line is executed atomically.

All commands must be terminated by either an end of line indicator (carriage return ASCII 13, denoted <cr>) or a semicolon separator (;). Linefeeds (ASCII 10, denoted <lf>) are ignored.

Keywords may be fully spelled out or may be sent as their first two letters; only the first two letters are significant. In this documentation, a word that has two possible forms is written with the short form capitalized, and the rest of the word in lower-case letters. The actual P330 protocol is case insensitive.

Examples:

`CApacitance`	Indicates that the short form is `CA`, and the long form is `CAPACITANCE`, both of which are recognized commands.

All forms are case insensitive. At least one space is required to separate command words from arguments.

Most value-setting command may be sent without an argument, in which case they become queries of the associated value.

`CApacitance A 500`	Sets the channel A capacitance to 500 pF
`CApacitance A`	Queries channel A capacitance value, which returns: *`500`*.

Certain incoming ASCII characters are treated specially:

- A blank input line, whitespace and <cr> only, evokes the response *`<cr><lf>`*.
- Double-quotation marks (ASCII 34, '"') are not ignored. They are used in the SET command for names that have spaces in them. Do not use them elsewhere or the P330 command parser may confuse them as part of the command or argument.

Numbers are evaluated as described in specific commands. When floating-point number is expected, use decimal notation, not exponential or engineering notation. For example use "0.123", not "123e-3" or "123m". When an integer is expected, a leading "0x" will be evaluated as base-16 (hexadecimal) number, and the other formats will be evaluated as base-10 (decimal).

6.3.2 Reply Strings

Each received command will evoke a reply indicating the execution status of the command. For query commands, the reply is the requested data. For other commands, successful completion will yield a reply of *`OK`*. If multiple commands are issued on one line, multiple responses will be sent back on a single line, separated by semicolons, For example:

```
SEt A 1 2; SEt B 2 3; SEt C 3 3; SEt D 0 0
```

To which it would reply

```
OK; OK; OK
```

All reply strings are terminated with carriage return/linefeed <cr><lf> characters.

If an error occurs while processing a command or an incorrect command was entered, the reply will be an error number and the type of the error. If the error occurred for a line with multiple commands, the P330 will abort without performing the remaining commands on the line.

The errors are:

Error message	Comments
E01: Command not found	The P330 did not recognize a keyword as valid.
E02: Argument missing or invalid	The P330 did not recognize an argument as valid for the keyword.
E03: Invalid range	A specific version of E02.
E04: Hardware error	Always considered a critical error.
E05: Flash locked	Returned if either FLASH WRITE or FLASH ERASE is used before FLASH UNLOCK, or the board switch is in LOCK position.
E07: Checksum fail	Returned if a LOAD command is used but the user settings as read from flash fail a checksum. Unless a SAVE command has never been used, this is a critical error.
E08: Help file not found	Replied if the help file in flash cannot be accessed. This is a critical error, because it indicates either an invalid firmware image in the flash or a flash hardware error.
E10: Not permitted	Replied If the commands SAVE, FLASH UNLOCK, FLASH WRITE, or FLASH ERASE are used while the DIP switches do not permit modification of nonvolatile memory (see section **Error! Reference source not found.**, **Error! Reference source not found.**).

6.3.3 UDP protocol

The UDP protocol has the following additional limitations:

1. Datagrams should be limited to at most 768 octets (not counting the transport-layer headers). Reply packets will also be limited to this size.
2. A serial command must end in the same packet in which it begins. Multiple serial commands may otherwise be sent in the same packet. UDP serial commands in a packet may be delimited the same way as with UART or TCP.
3. Replies will be one packet replied for each packet received. If the requested data exceeds the length of the packet, the reply will be truncated. (This is rare. It is assumed that only a few serial commands will be received at a time.)
4. The end of a datagram will be treated like an end of line whether and end-of-line character exists there or not.

6.4 P330 Command Summary

The following is a summary of ASCII commands which may be sent to the P330:

Function	Generic form	Example
Set range	SEt {chan} {cap}, {res}	SET A 2 3
Set capacitance	CApacitance {chan} {value}	CA B 362.4
Set resistance	REsistance {chan} {value}	RE D 58950
Identify box	IDent	ID
Reboot	BOot	BO
Status report	STatus {field}	STAT STAT POWER
Self test	BIst GO	BI GO
	BIst Status	BI ST
	BIst Abort	BI AB
	BIst REport	BI RE
Set IP address	IPset {address}	IP DHCP IP 0.0.0.0 IP 192.168.0.0
Set UDP port	POrt {port}	PORT 5650
User LED	USer {on/off}	US ON
Link channels	LInk {chans}	LINK AB ON
Fault simulation	FAult {chan} {type}	FA B E
Save	SAve	SAVE
Help	HElp	HELP
Network status	NEtstat {field}	NETSTAT NETSTAT DHCP
Flash operations	FLash UNlock	FL UN
	FLash ERase	FL ER
	FLash WRite {srecord}	FL WR S224001312...
	FLash CHecksum	FL CH

6.5 Command Details

6.5.1 Channel SET Command

The `SEt` command establishes a channel capacitance range, and its resistance range.

Usage is of the pattern:

```
SEt {channel} {cap_range} {res_range}
```

Capacitance ranges are:

Range	Description
0	open circuit
1	5 - 50 pF
2	10 - 500 pF
3	100 - 5000 pF

Resistance ranges are

Range	Description
0	open circuit
1	5K - 100K
2	50K - 1 Meg
3	500K - 10 Meg

Examples:

`SEt B 2 1` Set channel B to its 500 pF and 5K ohm ranges

`SEt B` Query channel B range settings. The reply will be `2 1.`

6.5.2 Channel CAPACITANCE Command

The `CApacitance` command sets the simulated capacitance for a given channel, with the numeric argument being in picofarads, within the specified limits for each range.

```
CApacitance {chan} {value}
```

Use decimal notation, not exponential or engineering notation for the capacitance value.

Examples:

`CAP D 295.4` Set channel D capacitance to 295.4 pF

`CAP D` Query channel D capacitance. The reply will be in fixed-point format, to 0.1 pF resolution, for example 295.4

Setting a capacitance outside the current range will return an error message.

6.5.3 Channel Resistance Command

The command `REsistance` command sets the simulated resistance for a given channel, with numeric argument being in ohms.

```
RES {chan} {value}
```

It is illegal to set a resistance below the lower limit of the current range. Resistances can be set up to 10x the specified upper limit of the current range at reduced accuracy.

Examples:

`RES B 135000`	Set the channel B resistance to 135 K ohms.
`RES B`	Query channel B resistance. The reply will be an integer number of Ohms.

Setting a resistance outside the current range will return an error message.

6.5.4 IDENT Command

The `IDent` command returns an ID string of the form:

`P330-1A SN 1234 FIRMWARE xxxxx IP xxx.xxx.xxx.xxx MAC xx:xx:xx:xx:xx:xx`

The *`-1A`* following the *`P330`* means dash (version) 1, hardware revision A. Firmware will usually be 23E330 followed by the firmware revision letter, for example *`23E330A`*

6.5.5 BOOT command

The `BOot` command reboots the P330 software, simulating a power up. All SAVED items will be restored.

6.5.6 STATUS Command

The `STatus` command returns a summary report of the state of the P330. Report looks like this:

```
P330-1A 00003 Firmware 23E330A IP 172.16.0.135 MAC 00:07:54:00:00:62
CAL: OK
ERR: 0
UPTIME: 100.000
IMAGE: FACTORY
LOCK: NORM
POWER: 5.118 3.340 1.238 3.003 15.058 -15.022
```

The report includes:

Unit and firmware ID,

IP address, MAC address, port

Internal power supply voltages

If `STatus` is followed by an argument, a single-line report will follow. Arguments are case-insensitive and only their first two characters will be evaluated.

`STatus IMage`	Returns FACTORY if the currently running image is the factory image, or UPGRADE if the currently running image is an upgrade.
`STatus CAlibration`	returns the status of the calibration table, OK or DEFAULT
`STatus POwer`	Returns the internal power supply voltages.
`STatus LOck`	Returns the status of the lock switch on the internal PCB. The reply will be either LOCK or NORM. If the reply is LOCK, then the SAVE command and the firmware upgrade procedure cannot be performed.
`STatus Error`	Returns 0 if there are no errors. Otherwise it will return the number of blinks of the red LED, to indicate the highest-priority error.

6.5.7 BIST Commands

The `BIst` command controls the Built in Self-Test of the P330. `BIst GO` runs a full self-test and returns an OK statement. The user can verify test completion with the `BIst STatus` command.

The P330 will remain in BIST mode until BIST is complete or it has been aborted by the user using the command `BIst ABort`. Normal operation on the channels outputs will be suspended during BIST.

The `BIst` command can be followed by an argument; a single-line response will follow with the exception of `BIst REport`.

`BIst GO`	Runs a complete Self-Test. Replies *OK.*
`BIst ABort`	Terminate a BIST if it is in progress.
`BIST STatus`	Returns the status of BIST. Replies are: *NOT RUN* BIST has never run. *RUNNING* BIST is in operation. *OK* all BIST tests were successful. *FAIL* one or more tests of BIST were not successful.
`BIST REport {chan}`	Reports the verbose results of BIST for a channel if one has completed during the current power cycle. If not, then the reply will be one of *NOT RUN*, *RUNNING*, or *ABORTED*

6.5.8 IP Command

The `IP` command sets the Ethernet IP address.

```
IP {ipaddress}
```

It may be issued over the Ethernet or USB ports. Examples are:

`IP 192.168.254.183`	Sets a static IP address
`IP 0.0.0.0`	Sets DHCP mode
`IP DHCP`	Sets DHCP mode
`IP`	With no argument is a query

The setting takes place immediately. Use the `SAve` command to save a new IP address in nonvolatile memory, for use after power down/power up cycle.

6.5.9 SUBNET Command

The `SUbnet` command sets the Ethernet subnet mask.

```
SUbnet {mask}
```

The value will be stored and can be saved in nonvolatile memory using the `SAve` command. The subnet value will be used only while the unit is in static-IP mode.

Examples:

`SUbnet 255.255.255.0`	Sets subnet mask
`SUbnet`	With no argument is a query.

6.5.10 PORT Command

The `POrt` command sets the UDP port that the P330 listens on

```
POrt {value}
```

The TCP port is unaffected by this command.

Examples:

`POrt 5650`	Sets UDP port
`POrt`	With no argument is a query.

This command should not be used to set the UDP port below 1024, which is usually reserved for network functions.

6.5.11 Network Status Command

The `NEtstat` command returns a summary report of the Ethernet connection. If no argument is given then the reply will be a space-delimited line containing:

```
<IP> <hostname> <DHCP> <link>
```

for example:

```
192.168.1.20 P330-00012 1 1
```

The `NEtstat` command can be followed by an argument; a single-line response will follow.

Valid arguments are:

`NEtstat IP`	Returns the current IP address
`NEtstat HOst`	Returns the unit hostname
`NEtstat DHCP`	Returns *`1`* if DHCP, *`0`* if static IP
`NEtstat LInk`	Returns *`1`* if the 100-Mbit link is up

6.5.12 USER Command

The `USer` command manages the orange user LED.

```
USer ON
```

Causes the orange user LED to start blinking.

```
USer OFf
```

Turns the orange user LED off.

6.5.13 FAULT Simulation Command

The `FAult` command simulates system faults.

```
FAULT {chan} {type}
```

Channel inputs and outputs can be simultaneously shorted to channel common, and outputs can be set open-circuit. {type} is one of S, Z, or N, as demonstrated in the examples below.

Examples:

`FAULT B S`	short channel B excitation and output
`FAULT C S`	short channel C excitation and output
`FAULT D Z`	simulate open output on channel D
`FAULT B N`	return channel B to normal operation
`FAULT B`	query fault status on channel B

6.5.14 LINK Command

The command `LInk` controls the two channel link relays.

```
LInk {channel-pair} {state}
```

Examples:

`LINK AB ON`	parallels the excitation connectors of channels A and B
`LINK AB OFF`	disconnects channels A and B
`LINK CD ON`	parallels the excitation connectors of channels C and D
`LINK CD OFF`	disconnects channels C and D
`LINK AB`	query link status between channels A and B

6.5.15 SAVE and LOAD Commands

The `SAve` command saves all current setups to nonvolatile memory.

```
SAve
```

This includes channel ranges, resistances, and capacitances, and the current IP address.

The `LOad` command reloads saved setups from nonvolatile memory.

```
LOad
```

If setups were never previously saved, then the default settings will be loaded instead.

The internal slide switch must be in the NORM position to permit saves to nonvolatile memory. In the LOCK position, the box is secure and no data may be saved.

6.5.16 HELP Command

The `HElp` command returns documentation about the serial command set.

6.5.17 FLASH UNLOCK Command

The `FLash UNlock` command enables firmware upgrade operations. The internal slide switch must be in the NORM position to permit writes to nonvolatile memory. In the LOCK position, the box is secure and no data may be saved.

The `FLash UNlock` command is required before the `FLash ERase` and `FLash WRite` commands, as a safety against accidental calls to either from taking effect. This command only needs to be called once. It will remain in effect until a reboot.

6.5.18 FLASH ERASE Command

The `FLash ERase` command erases the upgrade portion of the flash. The `FLash UNlock` command must have been called first, and the internal slide switch must be configured to permit writes to nonvolatile memory. This command may take up to thirty seconds to execute. Most of the P330's normal operations will be stalled during this time.

6.5.19 FLASH WRITE Command

The `FLash WRite` command writes a line of an S-Record to the upgrade portion of the boot flash. The `FLash UNlock` command must have been called first, and the internal slide switch must be configured to permit writes to nonvolatile memory. A typical S-Record line is less than 80 characters.

Only data-type S-Record lines (those that start with "S1", "S2", or "S3") will be evaluated. Others will be ignored; if they are valid, however, the P330 will reply *`OK`* to facilitate a clean upgrade routine using a file that may have S-Record lines which are not data-type.

If the address field of the S-Record is out of range of the upgrade firmware flash address, an error will be replied instead of OK. Do not ignore this error. It could imply that the wrong file is being used for upgrading the firmware.

6.5.20 FLASH CHECKSUM Command

The `FLash CHecksum` command runs a checksum of the factory and upgrade firmware images in the P330's flash. This may take up to five seconds. The reply is in the form of

`FF:<result>, FH:<result>, UF:<result>, UH:<result>`

where *FF* and *FH* pertain to the factory image and *UF* and *UH* pertain to the upgrade image, and *<result>* is one of the following:

OK	Image is present and the checksum passed.
NP	Image was not found
ER	Image was found but the checksum failed

The reply for the factory images should always be *OK*. The reply for the upgrade images should be either both *NP* (if never upgraded) or both *OK*. The expected result for a new P330 is:

FF:OK, FH:OK, UF:NP, UH:NP

7 Boot Flow And Firmware Upgrade

The P330 contains two major address spaces in its boot ROM (the “flash”): one for the factory image, and one for an upgrade image.

The P330’s boot loader will search for and checksum the upgrade image in the flash. If the upgrade image exists and it has a valid checksum, the P330 will boot into it. Otherwise the P330 will boot into the factory fallback image.

The P330 may have its firmware upgraded by physically replacing the plug-in program flash chip furnished by Highland, or by using the FLASH commands. The P330’s software only permits modification of the upgrade firmware, not the factory firmware.

The firmware upgrade procedure requires an upgrade image, in the form of an S-Record file (with a “.28” extension) provided by Highland Technology. The procedure is as follows:

1. Ensure that the internal slide switch is in the NORM position and then send FLASH UNLOCK to the P330, to enable modifying the flash. Wait for the reply OK.
2. Send FLASH ERASE to the P330. Wait for the reply OK. This may take up to thirty seconds.
3. Open the S-Record file and perform the following loop:
    a. Read a line of text from the S-Record.
    b. Send FLASH WRITE, with the line from the S-Record as an argument, to the P330.
    c. Wait for the reply OK.
    d. Repeat with the next line, until end-of-file is reached.
4. Send FLASH CHECKSUM to the P330. Wait up to five seconds for the reply. The expected reply is “FF=OK, FH=OK, UF=OK, UP=OK”. This indicates that the upgrade images are all present with passing firmware checksum tests.
5. Send BOOT to the P545 to reboot it. If the upgrade procedure was successful, then the reply to STATUS IMAGE will be UPGRADE.

Software used for upgrading the firmware should also check for replies of the type:

Enn: description of error

The flash upgrade procedure should abort upon such errors.

A new P330, or a physical update chip, will ship with only its factory firmware image installed.

8 Packaging and Dimensions

The P330 has mounting holes on the bottom to allow fixed mounting. Use #4-40 screws. A mounting flange, model P51 is available. If using the mounting flange to secure the P330, Highland will provide all screws necessary. A rackmount adapter is also available. All dimensions are in inches.

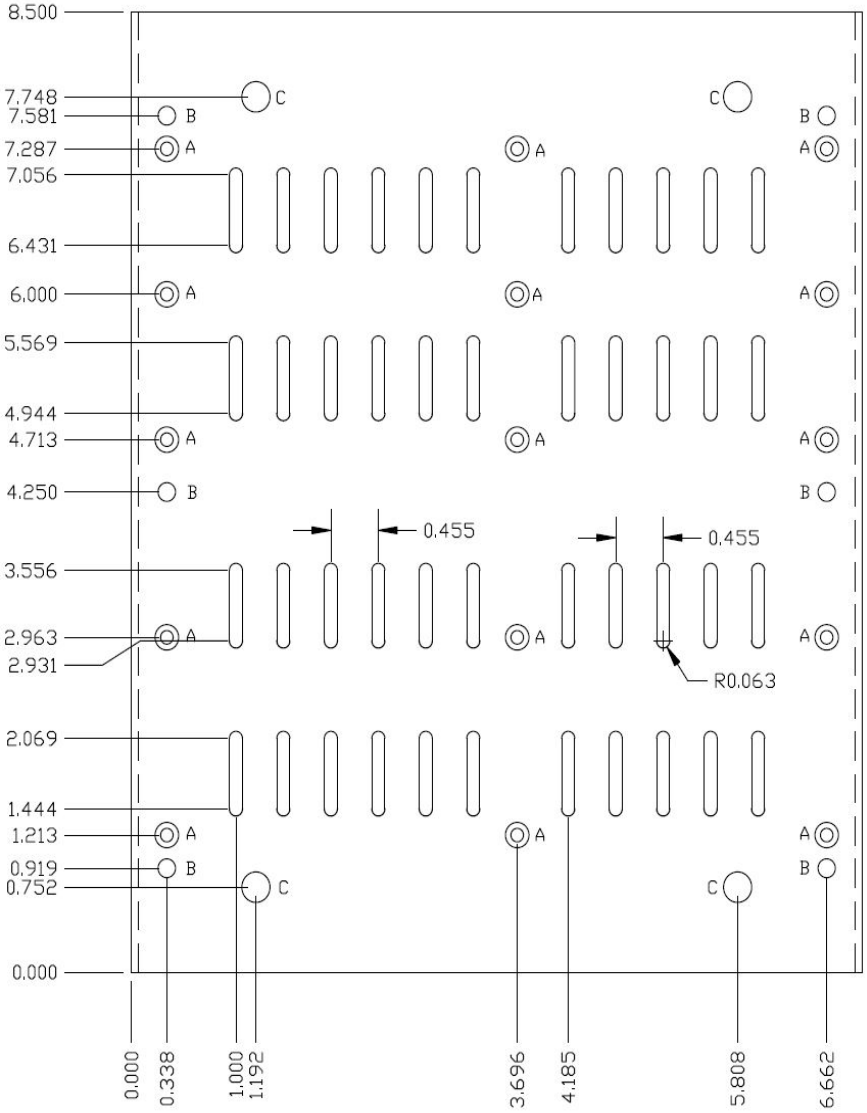

Figure 4: Dimensions of P330 Enclosure, Bottom view.

The unit is 2.25 inches tall, not including the rubber feet.

Figure 5: P330 Front Panel

Figure 6: P330 Back Panel

9 Versions

P330-1: 4-channel benchtop capacitive level sensor simulator

10 Customization

Consult factory for information about additional custom versions.

11 Hardware and Firmware Revision History

11.1 Hardware Revision History

Revision A Aug 2018
Initial release of main PCA 23A331A

11.2 Firmware Revision History

Revision B May 2019
Fixes a bug that causes a configuration-error led pattern under some valid circumstances.

Revision A Nov 2018
Initial release 23E470A1

12 Accessories

J24 24 volt 1.2 amp power supply (furnished with purchase)

J27 2.1 x 5.5 mm barrel to pigtail power cable

P10 19" rack mount shelf (two p-boxes per rack)

P51 Mounting Flange