HB400 User Manual revision 1

Summary:

- Universal data acquisition and controlling board
- zProc™-compatible
- Standard 4x20 Character LCD display
- Standard 3-button keypad
- 8 channels of standard 10 bit analog input
- 4 channels of PWM output[1]
- 8 channels of current-sink digital output
- USB2.0 with USB mini-B connection
- Single +5V DC power supply (can be powered by the USB connection)
- zProc™ mobile mode with 16K program storage and 8M data storage
- Passcode protection of settings, calibrations, program code and data
- Onboard real-time clock with alarm with 2 programmable alarms and 8 programmable timers
- Analog/digital channels can be expanded by adding up to 3 external HB500 boards[2]

[1] Shared with the lower 4 channels of digital output. PWM operation must be enabled through hardware setup.
[2] Not included in the HB400 package. HB500 boards with the same address code cannot be used together.

Contents

Safety The end user assumes all safety responsibility of using this product. Do not test or operate this product if a program running on this product may incur any property damage, personal injury, or death. Make sure to disconnect any power supply before servicing this product.

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Warranty This product carries a one (1) year limited warranty starting from the day of purchase. The warranty is limited to the replacement of a defect product with a new product of the same or newer model. The warranty is void if the product has been modified, or damaged from caused other than normal use.

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Power supply

The HB400 is powered by a single +5V DC power supply. This power can be introduced either through the +5V screw terminal or through the USB connection. If a HB500 board is attached, this board can also be powered by the power supply of the HB500 power jack.

Analog Inputs

HB400 has 8 channels of analog voltage inputs (A[0]~A[7]). Each channel read analog voltage input of 0~4.8V, and assign the value to A[i]. These channels have internal over-voltage protections to prevent over-voltage damage.

Table 1 Analog input specifications

Absolute Maximum Voltage	35 V
Absolute Minimum Voltage	-35V
Input Range	0~4.8 V
Input Impedance	>100 MΩ
Resolution	10 bit
Maximum Sample Rate	100 Hz
Internal Low Pass Filter	170 Hz

Table 2 Signal input connections (terminal block)

Pin	Description	Comment
1	Ground	
2	A[0]	
3	A[1]	
4	A[2]	
5	A[3]	
6	A[4]	
7	A[5]	
8	A[6]	
9	A[7]	
10	+5V	output 400 mA max

Correction and Calibration

Each of the standard analog input channels has been pre-calibrated by factory to measure the correct voltage value. In case there is significant deviation

of the measured value, a Voltage Correction Factor (VCF) can be applied to correct such deviation. The voltage correction factor can be assigned from the hardware setup window on the zProc IDE. The transfer function is given by

$$V_{corrected} = VCF \times V_{measured}$$

It is also possible to convert the voltage value into any other physical value using analog calibration function. The analog calibration function can be configured from the hardware setup window on the zProc IDE. Several calibration models can be assigned. Each calibration model has up to 4 parameters, namely K_0, K_1, K_2, and K_3. A unit consisting of no more than 4 characters can also be assigned to the calibration. All the calibration parameters are saved into the flash memory of the hardware unit. The following are the calibration formulae supported by HB400:

polynomial:

$$A = K_0 + K_1 V + K_2 V^2 + K_3 V^3$$

power:

$$A = K_0 + K_1 (V + K_2)^{K_3}$$

exponential:

$$A = K_0 + K_1 e^{K_2 V}$$

logarithmic (natural):

$$A = K_0 + K_1 \ln (V + K_2)$$

log-log (natural):

$$\ln(A - K_0) = K_1 + K_2 \ln (V + K_3)$$

In the above formulae, V is the voltage value measured on a specific analog input channel (in Volt), and A is the calibrated PRV of that channel. If a mathematical exception occurs, the calibration set the value 0 to the PRV. For example, in the logarithmic formula, if the value of $(V+K_2)$ is negative or zero, the value of A is set to zero.

Feedback Control

The first 4 channels of the analog inputs on the mother board can be supported by internal feedback PID control using the matching analog output channel (PWM). The feedback controls can be enabled or disabled from the hardware setup window on the zProc IDE, along with the control parameters and default setpoint value *S*. A matching analog output signal is an analog output with the same index as that of object analog input. The control algorithm is expressed as

$$a = K_p e + K_i \int_0^t e dt + K_d \frac{dE}{dx}$$

where $E = S - A$ is the control error and K_p, K_i, K_d, are control parameters which can be configured from the hardware setup window on the zProc IDE.

The feedback control algorithm is updated at a fixed update time as configured on the hardware configuration window. The update time will be rounded to a multiplitude of 5.5 milliseconds, with the minimum value being 5.5 milliseconds.

When the HB400 is powered up, each feedback controls is loaded with the respective default setpoint, and feedback logic starts immediately. The setpoint values can be changed by a zProc program. The default setpoint values are restored when the zProc program ends or is stopped.

Digital Outputs and PWM Outputs

HB400 provides up to 8 channels of amplified digital outputs (d[0]~d[7]) that can be used to drive relays, valves, switches, etc. The digital output can be used directly to drive small DC load, such as solid-state relay, etc. An external DC power supply may be needed if the relay requires an operating voltage other than +5V. See Figure 1 and Figure 2 for connection instructions.

The first 4 channels can be configured (through zProc IDE) into 4 channels of PWM outputs functioning as pseudo analog output channels (a[0]~a[3]). The duty cycle of the PWM (0~100%) corresponds linearly to the analog output value (0~5V). The PWMs can be used directly to control on-off elements such as relays or heaters. In this case, the load connections are the same

as those of the digital outputs (See Figure 1 and Figure 2). The PWM can also be filtered into voltage output to control DC motors.

The PWM can be operated at 3 different cycle frequencies: high (183.11 Hz), medium (45.78 Hz), and low (15.26 Hz). The cycle frequency can be configured through the zProc IDE interface.

Table 3 Digital output specifications

Output type	Darlington - open collector	
Maximum current	500 mA	
Status of a[i] = 1	Current draw (open)	
Status of a[i] = 0	High impedance (closed)	

Table 4 Analog PWM output specifications

Output type	Darlington - open collector	
Maximum current	400 mA	
PWM Output		
Cycle Frequency	15.26/45.78/183.11 Hz	Configured on zProc IDE
Duty Range	0~100 %	
Equivalent PRV value	0~5	
Status of duty=100%	Current draw	
Status of duty=0%	High impedance	
Resolution	16 bit	

Table 5 Signal output connections (terminal block)

Pin	Description	Comment
1	Ground	
2	d[0]/a[0]	a[0] if PWM mode is enabled
3	d[1]/a[1]	a[1] if PWM mode is enabled
4	d[2]/a[2]	a[2] if PWM mode is enabled
5	d[3]/a[3]	a[3] if PWM mode is enabled
6	d[4]	
7	d [5]	
8	d[6]	
9	d[7]	
10	+5V	output 400 mA max

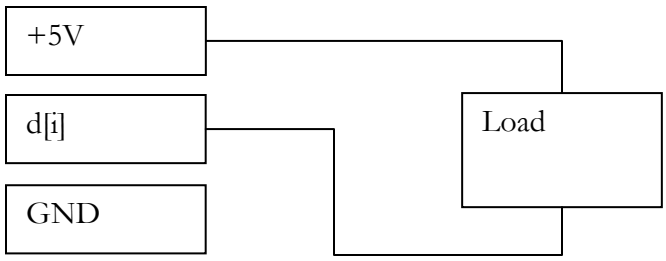


Figure 1. Digital output: driving a load using onboard +5V DC power output

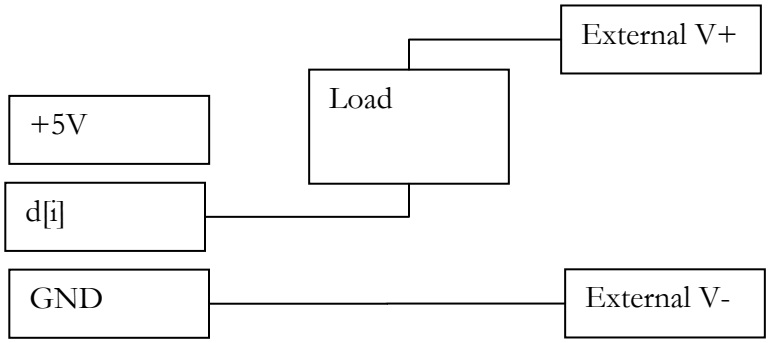


Figure 2. Digital output: driving a load using external DC power supply (e.g. a +24V power supply)

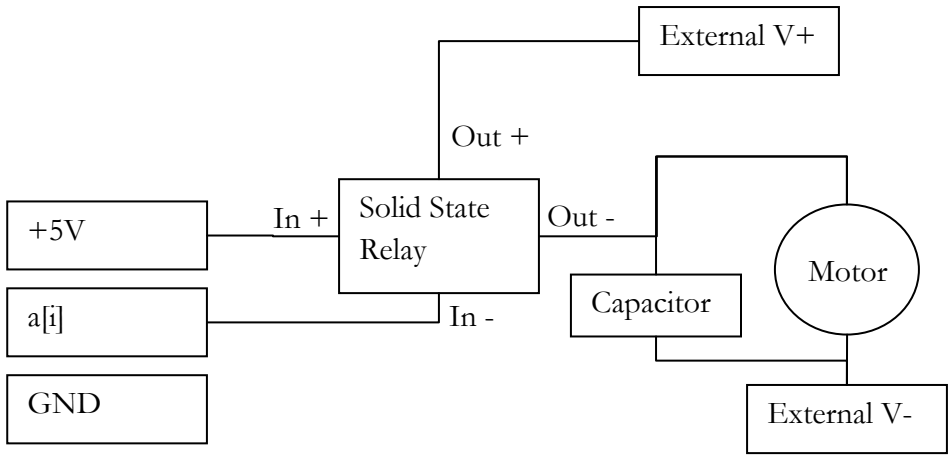


Figure 3. Example of using PWM output to control DC motor speed.

LCD Display

The HB400 comes with a standard 4x20-character LCD. The LCD can be programmed using the "write display" command. Its content can be cleared by the command "clear display". Refer to zProc User Manual for details.

The HB400 also comes with a 16-pin ribbon cable connector that can be connected to an external 80 character compatible LCD display (Hitachi HD44780 or Samsung KS0066 compatible) via a ribbon cable. The connections are defined as below.

Table 6 External LCD connector – 4x20-format (single core)

Pin	Description	Comment
1	Ground	
2	+5V	
3	VEE	
4	RS	
5	R/W	
6	E	
7	D0	
8	D1	
9	D2	
10	D3	
11	D4	
12	D5	
13	D6	
14	D7	
15	+5V/LED+	
16	LED-	

Keypad/Buttons

The HB400 comes with 3 standard onboard buttons. Any status change of the button will trigger a keypad event in zProc. The value of *eventcode* contains the value of keypad operation, which is determined bitwise by Table 7.

Table 7 Keypad eventcode

Bit	7	6	5	4	3	2	1	0
Value	0	U1	C1	D1	0	U0	C0	D0

U1/C1/D1: Status of upper/center/bottom buttons before event

U0/C0/D0: Status of upper/center/bottom buttons after event

1 = pressed; 0 = released

For example, if a center button is pressed, then the event code can be calculated as a binary value of 00000010 (2). Similarly, releasing a center button gives a binary value of 00100000 (32).

You can also detect the eventcode by running a simple program as below:

```
Begin:
      - Sleep
      - End

Event Keypad:
      - write {eventcode}
      - Return
```

Note that any status change of the buttons triggers an event. This include pressing-down or releasing of any key or key combinations.

Menu Operation

The HB400 supports menu operation. The menu operation is initiated by a zProc program only. To initiate/populate a menu list, use the keyword "add menu". You can add multiple lines to the menu using the "add menu" keyword. The HB400 supports up to 16 menu lines, each line may contain up to 16 text characters – extra characters will be neglected.

When the "add menu" command is executed, the HB400 is switched to menu operation mode. In menu mode, a list of menu is displayed on the LCD screen. Pressing the top/bottom buttons will roll up/down the selection cursor, while pressing the middle button will trigger a menu event. When a menu event is triggered, the *eventcode* value is set to the current selection index, starting from 0.

The following is a simple program demonstrating how the menu operation works:

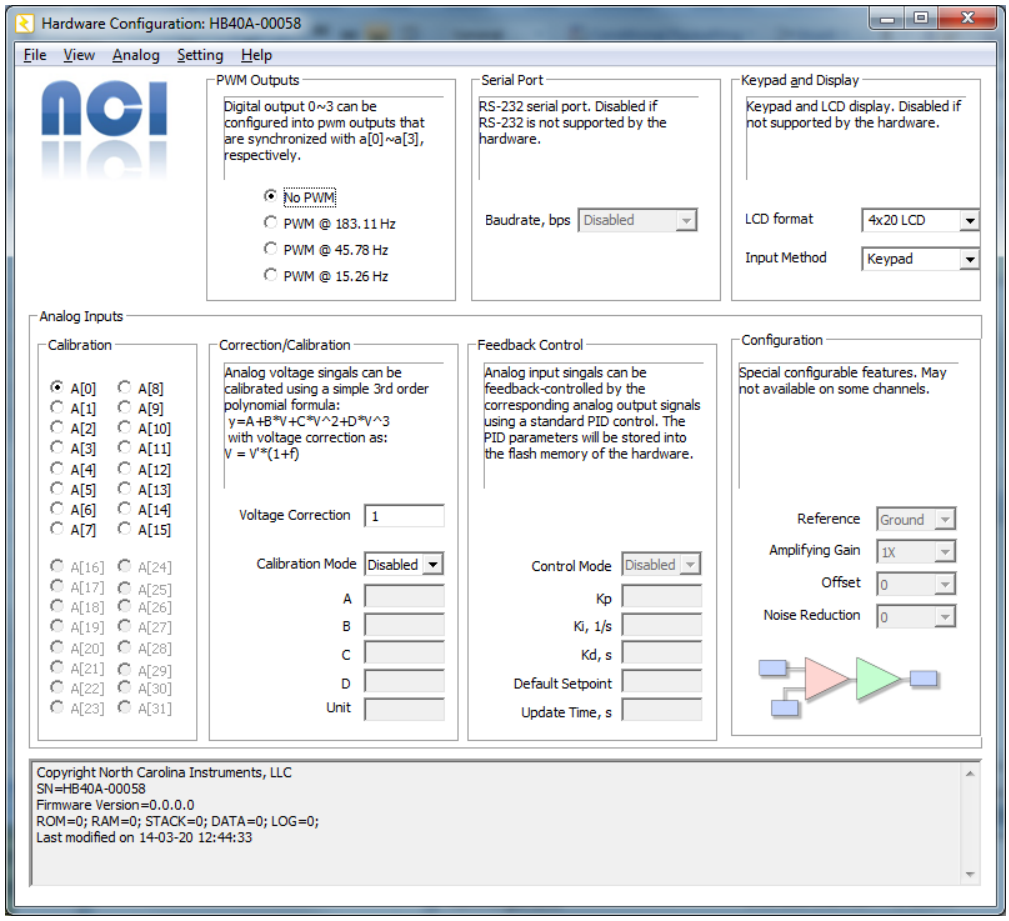
```
Begin
      -  Clear Menu
      -  Add menu "Menu item 0"
      -  Add menu "Menu item 1"
      -  Add menu "Menu item 2"
      -  Add menu "Menu item 3"
      -  Add menu "Menu item 4"
      -  Add menu "Menu item 5"
      -  Add menu "Exit Program"
      -  Sleep
      -  End

Event Menu:
      -  Write "You selected menu #{eventcode}"
      -  If eventcode=6 then end
      -  Return
```

Configurations

The HB400 can be configured through the hardware setup window on the zProc IDE. Click Menu|Tools|Setup[3] to access the hardware setup window. When the menu is clicked, the hardware setup window shows up:

[3] The hardware setup menu will be available only when the hardware is connected on the USB, and no program is currently running. Also, the hardware driver has to be selected to NCI Hummingbird.



Meanwhile, a popup window of product image also shows up, with the red/green dots on the product image window indicating the current-selected analog input channel.

Analog Input Configuration

To configure an analog channel, you must first select the channel on the left-side of the hardware setup window. Note that some fields on the window may be disabled (grayed), if the corresponding properties are not configurable.

Applying Setting

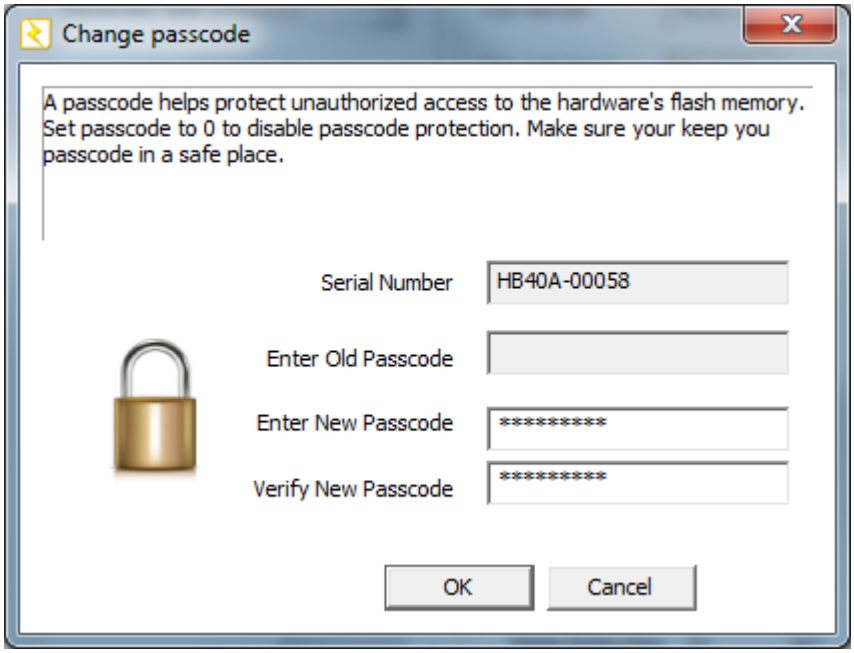
Change the properties as you want. When you are done with the changes, you must apply the changes by clicking Menu | Setting | Apply Setting; otherwise you changes will be discarded.

It is strongly recommended that you sign your name in the memo field. This is helpful in keeping track of the configuration changes. Note that the current date/time is automatically recorded and does not need to be in the signature field.

Passcode Protection

In some applications, you may want to protect data stored in the flash memory (hardware settings, analog calibrations, mobile program code, and mobile data) from unauthorized modifications. You can do this by applying a passcode to the hardware unit by clicking Menu|Setting|Change Passcode.

A passcode is any integer number with a maximum of 9 digits. Once a passcode is assigned, a passcode verification window will show up each time an attempt to modify the flash memory is being made. No changes can be made to the hardware's flash memory unless a passcode is matched.



Make sure that the passcode is kept in a safe place. In case a passcode is lost, please contact NCI for a key to unlock the passcode. You will need to provide your zProc serial number when contacting NCI. A temporary key will be sent to you to unlock the hardware. The temporary key is valid only for 24 hours. So make sure to change the passcode before the key expires.

You can disable the passcode protection by setting the passcode to 0.

Changing Hardware Name

Each hardware unit has its unique serial number. Moreover, you can assign a name to the hardware unit. The name can be any text no more than 16 characters. Once the settings are applied, the name will be saved to the hardware's internal flash memory. It will also show up on the home screen on the LCD monitor.

zProc™ Mobile Operation

HB400 supports zProc™ mobile operation with 16K program storage memory (ROM), 1K variable memory (RAM), and 4M data storage memory. Mobile operation enables the HB400 unit to run an internal program without the need of connecting to a host computer.

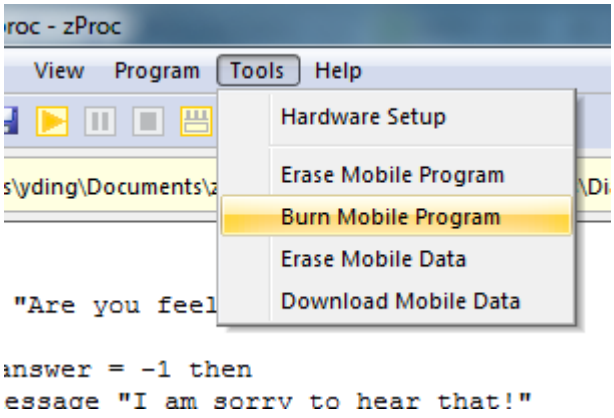
Burning Mobile Program

HB400 support mobile zProc program with big-endian single precision (.zbesp) format with a total of 16K program storage (ROM), 1K of variable space (RAM), and 8M non-volatile data storage. Also, it reserves 1K of RAM as stack memory (used to temporarily store local data when calling to a function).

To use the mobile operation mode, a zProc™ program is burnt into the ROM. To burn a program into HB400, click Menu|Tools|Burn Mobile Program on the zProc IDE. Note that a zCode program can be burnt into an HB400 via the zProc IDE only if both the program ROM and RAM are within the allowable size range.

Note: Program code previously stored in the ROM will be permanently erased. If a passcode has been set, you will need to enter the correct passcode to erase the zCode program. If you forget your passcode, please contact your hardware manufacturer.

After the program is successfully burnt into the HB400, it will automatically start each time the unit is powered up (with a time-delay no more than 2 milliseconds after power is stabilized).



When the mobile program is running, the HB400 does not need to be connected to a computer. If a program command relates to reading data from the computer (e.g., from a front panel element or from a data source file), it will temporarily hold the program until response from the computer is received or a time-out of 32 millisecond is reached. In the later case, a "hardware disconnection" event is triggered. You can write certain program code to address such scenario.

A zCode program burnt into an HB400 unit runs automatically each time the unit is powered up. You can skip running the zCode by pressing the center button when the unit is powered up.

Note: After the HB400 is powered up, it may take a few seconds before the USB connection is established between HB400 and a host computer. Thus, to ensure data is properly exchanged between HB400 and the host computer, you may need to add a "wait" line in the beginning of a program, such as:

```
Begin
      Wait 5 seconds
      ‘ start your program here
```

```
End
```

Erasing Mobile Program

To erase the zCode program, click Menu|Tools|Erase Mobile Program, and the mobile program will be erased. Note: if a passcode has been set, you will need to enter the correct passcode to erase the zCode program.

Downloading Mobile Data

Your program may contain "write" command that records data into a data file or other non-volatile media. The HB400 has internal flash memory (data storage memory) that can store certain amount of data from the "write" command. The data is subsequently written to the data storage memory until the memory is full.

To download the mobile data, click Menu|Tools|Download Mobile Data, and chose a file to which the downloaded data will be stored.

Erasing Mobile Data

To erase the mobile data, click Menu|Tools|Erase Mobile Data. All data stored in the data storage room will be permanently erased. Note: if a passcode has been set, you will need to enter the correct passcode to erase the zCode program.

Real-time Clock and Alarms

The HB400 has a built-in real-time clock (RTC) that provides real-time date and time. The RTC is powered with a rechargeable lithium battery so the real-time can be kept and updated when the HB400 is unpowered. The RTC is synchronized with the local date and time from a host computer each time the HB400 is connected to the host computer via the zProc IDE.

The RTC also provides two independent alarm sources (alarm 0 and alarm 1) that can be programmed and used by a mobile program. Each alarm can be set by the command "set alarm". Once an alarm is up, a *Timer Event* is triggered, with eventcode set to 1000 or 1001 respectively for alarm 0 and alarm

1. As an example, the following program sets a real-time alarm 0 for every Monday morning at 8:00AM:

```
Begin
  Set alarm 0 = XX-XX-XX 02 00:00:00
  Sleep
End

Event Timer
  if eventcode=1000 then: Write “Good morning,
monday!”
Return
```

For details of the set alarm command, refer to zProc language reference.

Note that the RTC alarms can only be set by a mobile program. A host program will not set the RTC alarms. Likewise, the mobile program will not set any alarms on the host computer. Furthermore, all the RTC alarms will be disabled if no mobile program is running.

Timers

The HB400 has 8 built-in timer resources that can be used by a mobile program. The resolution of each timer is about 6 milliseconds. When a timer is up, a Timer event is triggered (with the eventcode set to 0~7 respectively for Timer 0~7).

Nonvolatile Data Recording

The HB400 has a built in 4 megabytes flash memory for mobile program data recording (“write” command). The flash memory is written incrementally until all 4 megabytes are used, in which case all “write” command will be skipped. Writing to flash memory is incremental. The unit does not erase the flash memory data when the unit is powered down or up. The next run of a mobile program will start writing data from the location where the previous location of “write”.

The "write" command records only ASCII printable characters (text). Each execution of "write" inserts a line of text with an end-of-line character at the end. You can reduce the space of data recording by controlling the precision of the data to be recorded. For example, the formula {A[0], 0.2f} may take much less space than the formula {A[0]} by trimming off unwanted digits below the required precision (e.g., 25.34 as compared to 25.344569).

To download the data, connect the HB400 to a host computer running the zProc IDE, and click Menu|Tools|Download Mobile Data. To completely erase the flash data, connect the HB400 to a host computer running the zProc IDE, and click Menu|Tools|Erase Mobile Data. Note: any local program or mobile program must be stopped before download/erase the flash memory data. Do not disconnect the USB connection during data downloading. Downloading does not erase the data in the hardware's flash memory. You will need to manually erase the memory if you want to do so.

If a passcode has been set, you will need to provide the correct passcode to download or erase the flash memory data.

Dialogs

HB400 supports all dialog commands (input, message, alert, or question). You can use the following keys to respond to a dialog:

Table 8 Dialog key response

Key	Definition
Message/Alert Dialog	
Center Pressed	OK to return
Question Dialog	
Upper Pressed	Roll answer to left (Yes No Cancel)
Lower Pressed	Roll answer to right (Yes No Cancel)
Center Pressed	Select the current answer and return
Input Dialog	
Upper Pressed	Roll the current character to smaller value
Lower Pressed	Roll the current character to bigger value
Center Pressed	Shift to the next character
Center Pressed + Upper Pressed	Shift to the previous character
Center Pressed and Hold for 1 second	Select the current text and return

HB400 can accept up to 16 letters of text input in the input dialog. You can use the upper/lower button to roll a letter to one of a printable ASCII characters, as shown below:.

```
 !"#$%&'()*+,-./0123456789:;<=>?
@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_
`abcdefghijklmnopqrstuvwxyz{|}~
(Note: the first letter is a space)
```

The input text is available as `{$3}` in a complex text. The value, if successfully converted, is stored in the `answer` variable.

zProc Mobile Compatibility Chart

Table 9 lists HB400 support for zProc mobile program extended commands. If a command is not supported, it will be skipped without issuing a warning.

Table 9 zProc Mobile Compatibility Chart

Command	Support
SET DIGITAL	Yes
DISPLAY	Yes
CLEAR DISPLAY	Yes
SETPOINT	Yes
ADD MENU	Yes
WRITE DATA	Yes
WRITE_LOG	No
MESSAGE	Yes
ASK	Yes
INPUT	Yes
READ ANALOG BUFFER	No
ALERT	Yes
SET ALARM	Yes
VIEW CHART	No
HIDE CHART	No
VIEW SCHEMATIC	No
HIDE SCHEMATIC	No
SELECT CHART	No
SELECT CURVE	No
CLEAR CHART	No
CLEAR CURVE	No
PLOT	No

PLAY SOUND	No
LOAD DATA	No
READ DATA	No
READ INPUT	No
WRITE INPUT	No
READ ANALOG CTRL	No
WRITE ANALOG CTRL	No
READ DIGITAL CTRL	No
WRITE DIGITAL CTRL	No
SET PAR	No
GET PAR	No
INTEGRATE PEAKS	No
GET PEAK AREA	No
GET PEAK CONC	No
SELECT HARDWARE	No
ADD ON	No

Adding Extension Boards

You can add up to 3 compatible *Expansion Boards* to the HB400 to extend the number of analog/digital channels. If multiple Expansion Boards are attached, make sure that each of the *Expansion Boards* has a unique address. Make sure that you un-power all units before attaching an *Expansion Board*. After an *Expansion Board* is attached, it will be automatically recognized at the next power-up. You can set up the channels (e.g. analog calibration, PID feedback controlling) on the Hardware Setup window of the zProc IDE.

Board Mounting

HB400 can be easily mounted onto a flat surface using its four standoffs. The dimensions are shown as below.

Horizontal Distance: 3.45 inch (87.6mm)

Vertical Distance: 1.8 inch (45.7mm)

Screw Size: UNC #4-40

Technical Support

For technical support, visit www.carolinainstruments.com

or email support@carolinainstruments.com.