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Hitachi® H48C 3-Axis Accelerometer Module (#28026)

General Description

The Hitachi H48C 3-Axis Accelerometer is an integrated module that can sense gravitational (g) force of ±3g on three axes (X, Y, and Z). The module contains an onboard regulator to provide 3.3-volt power to the H48C, analog signal conditioning, and an MCP3204 (four channel, 12-bit) analog-to-digital converter to read the H48C voltage outputs. All components are mounted on a breadboard-friendly, 0.7 by 0.8 inch module. Acquiring measurements from the module is simplified through a synchronous serial interface. With the BASIC Stamp® 2 series, for example, this is easily handled with the SHIFTOUT and SHIFTIN commands.

Features

- Measure ±3 g on any axis
- Uses MEMS (Micro Electro-Mechanical System) technology, with compensation for calibration-free operation
- Onboard regulator and high-resolution ADC for simple connection to microcontroller host - compatible with BASIC Stamp 2 series SHIFTOUT and SHIFTIN commands
- Free-fall output indicates simultaneous 0g an all axes
- Small, breadboard-friendly package: 0.7" x 0.8" (17.8 mm x 20.3 mm)
- Wide operational range: -25° to 75° C

Application Ideas

- Tilt measurement in robotics applications
- Multi-axis vibration measurement in transit and shipping systems
- Multi-axis movement/lack-of-movement for alarm systems

Packing List

Verify that your H48C Accelerometer kit is complete in accordance with the list below:

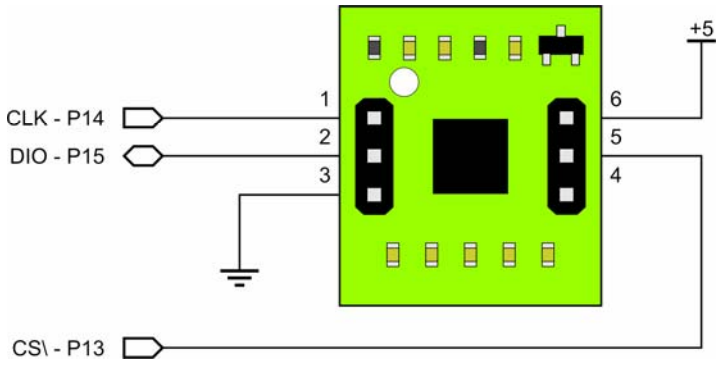
- Hitachi H48C 3-Axis Accelerometer module
- Documentation

Note: Demonstration software files may be downloaded from www.parallax.com.
(*See http://www.parallax.com/detail.asp?product_id=28026*)

Essential Connections

Connecting the H48C module to the BASIC Stamp 2 controller is a straightforward operation, requiring just three I/O pins (the CLK and DIO pins may be shared in systems requiring the use of more than one H48C module). See Figure 1 for connection details.

Figure 1. H48C Connections



How It Works

Through MEMS (Micro Electro-Mechanical System) technology and built-in compensation, the H48C accelerometer provides simultaneous outputs through analog conditioning circuitry to an MCP3204 ADC. To "read" g-force of a given axis we actually read the voltage output from that axis and calculate g-force using this formula:

G = ((axis – vRef) / 4095) x (3.3 / 0.3663)

In the formula, *axis* and *vRef* are expressed in counts from the ADC, 4095 is the maximum output count from a 12-bit ADC channel, 3.3 is the H48C supply voltage, and 0.3663 is the H48C output voltage for 1g (when operating at 3.3v). In practice this can be simplified to:

G = (axis – vRef) x 0.0022

Using the BASIC Stamp 2 module as a host controller, we should multiply the 0.0022 by 100 (to 0.22) to express the result in units of 0.01g. Using the ** operator, we are able to multiply by 0.22 and convert the raw readings to g-force with this bit of code:

```
IF (axCount >= rvCount) THEN
  gForce = (axCount - rvCount) ** GfCnv     ' positive g-force
ELSE
  gForce = -((rvCount - axCount) ** GfCnv)  ' negative g-force
ENDIF
```

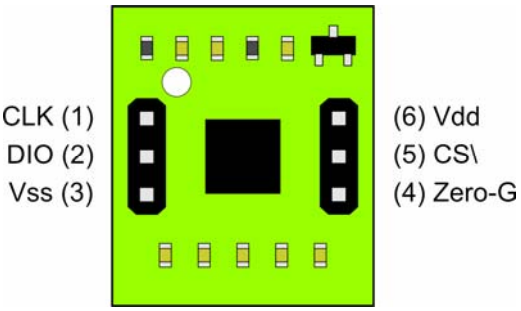
Note the **IF-THEN** structure which prevents a negative number from being divided – this is illegal in PBASIC 2.x and will not return the correct result. By restructuring the conversion equation for negative g-forces we can indeed arrive at the correct value. The output value, *gForce*, is a signed integer.

In application the analog signal conditioning circuitry affects the rate at which readings can be taken H48C module. The filter/buffer circuit is designed to minimize noise while maintaining the highest possible signal resolution into the ADC. By design, the filter circuit limits MC48C axis output rail-to-rail rise/fall time to about five milliseconds. Since MCP3204 has a significantly higher sample rate, the

sampling rate of the module is dictated by the filter circuitry and works out to about 200 samples per second.

Pin Definitions and Ratings

(1) CLK	Synchronous clock input
(2) DIO	Bi-directional data to/from host
(3) Vss	Power supply ground (0v)
(4) Zero-G	"Free-fall" output; active-high
(5) CS\	Chip select input; active-low
(6) Vdd	+5vdc

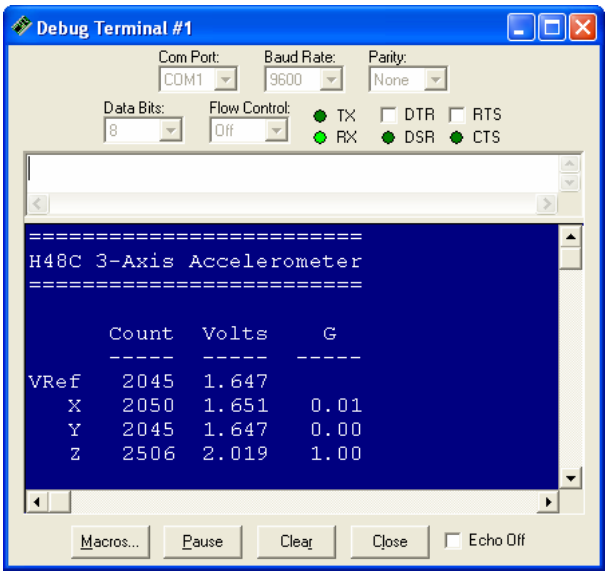


Symbol	Quantity	Minimum	Typical	Maximum	Units
V_{DD}	Operating voltage	4.5	5.0	5.5	V
V_{SS}	Ground reference connection		0		V
I_{DD}	Supply current		7	10	mA
V_{IH}	High Level Voltage Input †	0.7 V_{DD}			V
V_{IL}	Low Level Voltage Input †			0.3 V_{DD}	V
V_{OH}	High Level Voltage Output †	4.1			V
V_{OL}	Low Level Voltage Output †			0.4	V
	Sample Rate			200	sps
	ADC (MCP3204) Resolution †		12		bits
	Measurement Range §	-3		3	g
	Sensitivity §		366.3		mV/g
	Accuracy §	10			%
	Non-linearity §	-2		2	%
	Operating Temperature Range §	-25		75	°C
	High Level Zero-G Voltage Output §	3.2	3.3		V
	Zero-G Output Delay §			1	ms

† From Microchip MCP3204 Datasheet
§ From Hitachi H48C Datasheet

Demonstration Program

This demonstration uses the BASIC Stamp 2 series microcontroller to read the reference voltage and output channels from the H48C using the onboard MCP3204 analog-to-digital converter. For each channel the raw count, channel voltage, and g-force for the X, Y, and Z axes are displayed as shown below:



BASIC Stamp 2 Source Code

```
' ================================================================================
'
'   File....... H48C_3-Axis.BS2
'   Purpose.... Hitachi H48C 3-Axis Accelerometer Demonstration
'   Author..... Copyright (c) 2005-2006 Parallax, Inc.
'   E-mail..... support@parallax.com
'   Started....
'   Updated.... 02 FEB 2006
'
'   {$STAMP BS2}
'   {$PBASIC 2.5}
'
' ================================================================================


' -----[ I/O Definitions ]--------------------------------------------------

Dio             PIN     15                      ' data to/from module
Clk             PIN     14                      ' clock output
CS              PIN     13                      ' active-low chip select


' -----[ Constants ]-------------------------------------------------------

XAxis           CON     0                       ' adc channels
YAxis           CON     1
ZAxis           CON     2
```

```
VRef            CON     3

Cnt2Mv          CON     $CE4C                   ' counts to millivolts
                                                '   0.80586 with **
GfCnv           CON     $3852                   ' g-force conversion
                                                '   0.22 with **

' -----[ Variables ]----------------------------------------------------

axis            VAR     Nib                     ' axis selection
rvCount         VAR     Word                    ' ref voltage adc counts
axCount         VAR     Word                    ' axis voltage adc counts
mVolts          VAR     Word                    ' millivolts
gForce          VAR     Word                    ' axis g-force

dValue          VAR     Word                    ' display value
dPad            VAR     Nib                     ' display pad


' -----[ Initialization ]------------------------------------------------

Reset:
  HIGH CS                                       ' deselect module
  DEBUG CLS,                                    ' paint display
        "=========================", CR,
        "H48C 3-Axis Accelerometer", CR,
        "=========================", CR,
        CR,
        "      Count  Volts    G  ", CR,
        "      -----  -----  -----", CR,
        "VRef                    ", CR,
        "   X                    ", CR,
        "   Y                    ", CR,
        "   Z                    "


' -----[ Program Code ]--------------------------------------------------

Main:
  FOR axis = XAxis TO ZAxis                     ' loop through each axis
    GOSUB Get_H48C                              ' read vRef & axis counts

    dValue = rvCount                            ' display vRef count
    DEBUG CRSRXY, 6, 6
    GOSUB RJ_Print

    dValue = axCount                            ' display axis count
    DEBUG CRSRXY, 6, (7 + axis)
    GOSUB RJ_Print

    mVolts = rvCount ** Cnt2Mv                  ' convert vref to mv
    DEBUG CRSRXY, 13, 6,                        ' display
          DEC (mVolts / 1000), ".",
          DEC3 mVolts

    mVolts = axCount ** Cnt2Mv                  ' convert axis to mv
    DEBUG CRSRXY, 13, (7 + axis),
```

```
          DEC (mVolts / 1000), ".",
          DEC3 mVolts

    ' calculate g-force
    ' -- "gForce" is signed word

    IF (axCount >= rvCount) THEN
      gForce = (axCount - rvCount) ** GfCnv     ' positive g-force
    ELSE
      gForce = -((rvCount - axCount) ** GfCnv)  ' negative g-force
    ENDIF
    DEBUG CRSRXY, 20, (7 + axis),               ' display g-force
          " " + (gForce.BIT15 * 13),
          DEC1 (ABS(gForce) / 100), ".",
          DEC2 ABS(gForce)
  NEXT
  PAUSE 200
  GOTO Main


' -----[ Subroutines ]------------------------------------------------------

' Reads VRef and selected H48C axis through an MCP3204 ADC
' -- pass axis (0 - 2) in "axis"
' -- returns reference voltage counts in "rvCount"
' -- returns axis voltage counts in "axCounts"

Get_H48C:
  LOW CS
  SHIFTOUT Dio, Clk, MSBFIRST, [%11\2, VRef\3]  ' select vref register
  SHIFTIN  Dio, Clk, MSBPOST, [rvCount\13]      ' read ref voltage counts
  HIGH CS
  PAUSE 1
  LOW CS
  SHIFTOUT Dio, Clk, MSBFIRST, [%11\2, axis\3]  ' select axis
  SHIFTIN  Dio, Clk, MSBPOST, [axCount\13]      ' read axis voltage counts
  HIGH CS
  RETURN

' -------------------------------------------------------------------------

' Right-justify value in 5-digit field
' -- move cursor first, then call with value in "dValue"

RJ_Print:
  LOOKDOWN dValue, >=[10000, 1000, 100, 10, 0], dPad
  DEBUG REP " "\dPad, DEC dValue
  RETURN
```