Mechatronic

Term Project 2015 Fall

Group 7
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1. Background:
Recently, we found out some express companies treated our packages violently, even worse, some packages had been opened before they were sent to our home. As online shopping becomes a widely used shopping mode in modern society, this problem becomes a hot issue. Customers are curious about what their packages has experienced during delivering process. Our group is seeking for a solution to monitor delivering process to help customers know more, and further help regularize courier's behavior, avoid packages being thrown or stolen.

2. Cost accounting:
   1) bill of material:
      - Basic stamp 2 board: $22.90
      - MMA7455L - XYZ-axis accelerometer: $9.99
      - Parallax Serial LCDs (Liquid crystal displays): $29.99
      - photoresistor: $0.1
      - resistors (10kΩ and 220Ω): $0.1
      - wires: $0.1
      - total: $63.18

   2) cost analysis for mass production
   We can reduce the cost in mass production by replacing LCD with 8 digital 7 segment led displays, which is only $2. Considering that a large scale of production of microcontrollers would also be cheaper, the cost could be further reduced to below $10. Also, this product can be recycled and reused for many times, it is economical and environmental friendly.

3. Design:
   1) component:
      - MMA7455L - XYZ-axis accelerometer:
      The MMA7455L is a Digital Output (I²C/SPI), low power, low profile capacitive micromachined accelerometer featuring signal conditioning, a low pass filter, temperature compensation, self-test, configurable to detect 0g through interrupt pins (INT1 or INT2), and pulse detect for quick motion detection. 0g offset and sensitivity are factory set and require no external devices. The 0g offset can be customer calibrated using assigned 0g registers and g-Select which allows for command selection for 3 acceleration ranges (2g/4g/8g). The MMA7455L includes a Standby Mode that makes it ideal for handheld battery powered electronics.
Parallax Serial LCDs (Liquid crystal displays):

The Parallax 2×16 Serial LCD has two sixteen-character-wide rows for displaying messages. The display is controlled by serial messages from the BASIC Stamp. The BASIC Stamp sends these messages from a single I/O pin that is connected to the LCD's serial input.
The LCD's RX pin is for the signal and should be connected to a BASIC Stamp I/O pin. The Parallax Serial LCD has a self-test mode to make sure it's in working order and that the contrast is properly set. There are two switches labeled (SW1 and SW2) on the back of the LCD module, for self-test mode and baud rate adjustment.

- photoresistor

  Photoresistor is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity; in other words, it exhibits photoconductivity. A photoresistor is made of a high resistance semiconductor. In the dark, a photoresistor can have a resistance as high as several megohms (MΩ), while in the light, a photoresistor can have a resistance as low as a few hundred ohms.
2) circuit

4. Basic2 Code

' {STAMP BS2}
' {SPBASIC 2.5}

x VAR BYTE
CLKPin PIN 13 ' Clock Pin
DATAPin PIN 14 ' Data Pin
CSPin PIN 15 ' Chip Select Pin
Control PIN 0 ' Button Pin
Photo PIN 6 ' Photoresistor Pin

XOUT8 CON $06 ' 8 bits output value X, All Address are 6 bits(1-6)
YOUT8 CON $07 ' 8 bits output value Y
ZOUT8 CON $08 ' 8 bits output value Z
MCTL CON $16 ' Mode control
Vertrefresh CON 20 ' LCD shows the result after get 20 sets of data from sensor.

XAccel VAR WORD ' Variables to store incoming RAW data from the accelerometer
YAccel VAR WORD
ZAccel VAR WORD

Xmax VAR WORD ' Variables to store maximum data
Ymax VAR WORD
Zmax VAR WORD
Address    VAR WORD  ' Variables for reading and writing data to the acclerometer
SendData   VAR BYTE
ReceiveData VAR BYTE

Decimal    VAR WORD  ' Variable for changing data into decimal
Cycles     VAR BYTE   ' Variable to control the vertrefresh of LCD
Function   VAR BIT    ' Variable to switch the function of LCD
OpenTime   VAR BYTE   ' Variable to store the number of time the box opened.

Main:
   Address = MCTL: SendData = %01100001: GOSUB DataOut  'Set the Mode control register
   NOT OUTPUT TO INT1 PIN
   'DATA ready status is
   '3-wire SPI mode
   'Self Test NOT enabled
   '+/-8g sensitivity mode
   'Measurement mode

   INPUT Control
   INPUT Photo
   Cycles=0
   Function=1
   'Initialize Cycles
   '1: real time; 0: max value of acceleration
   OpenTime=0
   'Initialize OpenTime

ReadDataLoop:
   Address=XOUT8:GOSUB DataIn  'Read in X-Axis acceleration value
   XAccel=ReceiveData|($FF00*ReceiveData.BIT7)  'Sign extend the two's complement byte so
   IF ABS XAccel> ABS Xmax THEN Xmax=XAccel  'negative numbers can be properly displayed
   'Xmax stores the max value of acceleration of X-Axis

   Address=YOUT8:GOSUB DataIn  'Read in Y-Axis acceleration value
   YAccel=ReceiveData|($FF00*ReceiveData.BIT7)  'Sign extend the two's complement byte so
   IF ABS YAccel> ABS Ymax THEN Ymax=YAccel  'negative numbers can be properly displayed
   'Ymax stores the max value of acceleration of Y-Axis
Address=ZOUT8:GOSUB DataIn 'Read in Z-Axis acceleration value
ZAccel=ReceiveData|($FF00*ReceiveData.BIT7) 'Sign extend the two's complement byte so
IF ABS ZAccel> ABS Zmax THEN Zmax=ZAccel 'negative numbers can be properly displayed

of acceleration of Z-Axis
Cycles=Cycles+1 'Cycles increases until Cycles reaches vertrefresh
IF Control=1 THEN Function=Function+1 'If the button is pressed, change the value of Function

ButtonLoop: 'Wait until the button released
IF Control=1 THEN 'Show the result of OpenTime, when the button is pressed
SEROUT 10, 84, [22, 12] 'Clear the screen
PAUSE 5
IF OpenTime<2 THEN '1 is first time close box;
0 is test mode
SEROUT 10, 84, ["Never open",13,13] 'Two 13 make sure only show the message once
ELSE
SEROUT 10, 84, ["Open ",DEC OpenTime-1," times",13,13]
ENDIF
PAUSE 50
GOTO ButtonLoop
ENDIF

IF Function=0 THEN 'LCD shows the max data
XAccel=Xmax 'Change the value to the max value
YAccel=Ymax
ZAccel=Zmax
ENDIF

IF Cycles=Vertrefresh THEN 'Start to show the value in LCD
SEROUT 10, 84, [22, 12] 'Initialize LCD and clear the screen
PAUSE 5
SEROUT 10, 84, [" X:   Y:   Z:",13] 'Display the X, Y, and Z accelerometer values
Decimal=XAccel+3

GOSUB Display
"+3 +8 -2" are calibration value for different axis
Decimal=YAccel+8
GOSUB Display
Decimal=ZAccel-2
GOSUB Display
Cycles=0
'Reset Cycles
ENDIF
IF Photo=0 THEN
'0: bright ; 1: dark
PAUSE 50
IF Photo=1 THEN OpenTime=OpenTime+1
'If the light changes from bright to dark, OpenTime+1
ENDIF
GOTO ReadDataLoop
'Back to read in data

DataOut:
LOW CSPin
'Pull chip select pin low to start transmission
SHIFTOUT DATAPin, CLKPin, MSBFIRST, [(Address|%1000000)<<1] 'Select register Address(first bit: 1 write/ 0 read)
SHIFTOUT DATAPin, CLKPin, MSBFIRST, [SendData] 'Write value to Address
HIGH CSPin
'REturn

DataIn:
LOW CSPin
'Pull chip select pin low to start transmission
SHIFTOUT DATAPin, CLKPin, MSBFIRST, [Address<<1] 'Select register Address
SHIFTIN DATAPin, CLKPin, MSBPRE, [ReceiveData] 'Read value from Address
HIGH CSPin
'REturn

Display:
IF Decimal>32768 THEN
Decimal=-Decimal
'Negative data has to be transformed before divided by 16
IF (Decimal//16)=1 THEN
'If the decimal part of the value is below 0.1, show the .06 directly
SEROUT 10, 84,["-","DEC Decimal/16",".06 "]
'0.0625 is accuracy of the sensor
ELSE
'16 means 1g in the data from the sensor of the mode 00
SEROUT 10, 84,["-","DEC Decimal/16",".",DEC2 (Decimal//16)*100/16," "]
ENDIF

ELSE
  IF (Decimal\(16\)) = 1 THEN
    'Show the positive data
    SEROUT 10, 84, [DEC Decimal/16, ".06 "]
  ELSE
    SEROUT 10, 84, [DEC Decimal/16, ",.DEC2 (Decimal/16)\*100/16, " ]
  ENDIF
ENDIF
RETURN

5. Data analysis:

We record maximum accelerations in different conditions: walking, taking a bus, taking a subway, shaking, and let the device falling down from a height of 8cm.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Maximum acceleration(g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Walking</td>
<td>-0.68</td>
</tr>
<tr>
<td>Running</td>
<td>-2.12</td>
</tr>
<tr>
<td>Bus</td>
<td>-0.62</td>
</tr>
<tr>
<td>Subway</td>
<td>-1.00</td>
</tr>
<tr>
<td>Shaking</td>
<td>-5.50</td>
</tr>
<tr>
<td>Falling from 8cm</td>
<td>-1.50</td>
</tr>
</tbody>
</table>

Table 1. Maximum accelerations in different conditions

From the table above we can see that walking, taking a bus or subway would not generate large accelerations. Running generate a little bit higher accelerations, but still in the safety range. Shaking and falling would generate very large accelerations, which could be harmful. So here we appealing couriers to avoid shaking and falling down parcels to avoid fragile products to be broken.