Package Monitor

Group 7
Ran Wei & Yan Zhang
Background

- Rough handling of parcels
- Stolen and lost properties
- Broken parcels
Solution

Package monitor

• Record acceleration in delivering process
• Record if the package has been opened in delivering process
• Show what happened to this package when Recipient got the package
Component

- MMA7455L XYZ-axis accelerometer
  $\pm 2g/\pm 4g/\pm 8g$

Principle of operation
The center beam moves with acceleration, each capacitor value will change

![Simplified Transducer Physical Model](image-url)

*Figure 3. Simplified Transducer Physical Model*
• Parallax Serial LCDs (Liquid crystal displays):
  2 rows $\times$ 16 characters
Power requirement: +5V DC, 20mA-80mA
• **Parallax Serial LCDs (Liquid crystal displays):**

<table>
<thead>
<tr>
<th>MODE</th>
<th>SW1</th>
<th>SW2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>2,400</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>9,600</td>
<td>OFF</td>
<td>ON</td>
</tr>
<tr>
<td>19,200</td>
<td>ON</td>
<td>ON</td>
</tr>
</tbody>
</table>

Switches are for self-testing and adjust baud rate.
• Photoresistor

use as light sensor

Dark R↑
light R↓
Cost accounting

• 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

• Mass production cost

LCD displays ($2)
Mass production of microcontroller would be cheaper ($4)
Cheapest accelerometer ($3)
Others ($0.5)
Total: $9.5
Circuit
' {$STAMP BS2}
  ' {$PBASIC 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 accelerometer
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
'DATA ready status is NOT OUTPUT TO INT1 PIN
'3-wire SPI mode
'Self Test NOT enabled
'+/-8g sensitivity mode
'Measurement mode

INPUT Control

INPUT Photo

Cycles=0 'Initialize Cycles
Function=1 '1: real time; 0: max value of acceleration
OpenTime=0 'Initialize OpenTime
ReadDataLoop:
Address=\textbf{XOUT8:GOSUB} DataIn \quad 'Read in X-Axis acceleration value
XAccel=ReceiveData|($FF00*ReceiveData.\texttt{BIT7}) \quad 'Sign extend the two's complement byte so
\textbf{IF ABS} \ XAccel> \textbf{ABS} \ Xmax \ \textbf{THEN} \ Xmax=XAccel \quad 'negative numbers can be properly displayed
\quad 'Xmax stores the max value of acceleration of X-Axis

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

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

Cycles=Cycles+1 \quad 'Cycles increases until Cycles reaches vertrefresh
\textbf{IF} \ Control=1 \ \textbf{THEN} \ Function=Function+1 \quad 'If the button is pressed, change the value of Function
ButtonLoop:

IF Control=1 THEN
  'Wait until the button released
  '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]

Decimal=XAccel+3

'Display the X, Y, and Z accelerometer values

"+3 +8 -2" are calibration value for different axis

GOSUB Display

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  
'Select register Address (first bit: 1 write/ 0 read)'

SHIFTOUT DATAPin, CLKPin, MSBFIRST, [(Address|0x1000000)<<1]  
'Write value to Address'

HIGH CSPin  
'End transmission'

RETURN

**DataIn:**

LOW CSPin  
'Select register Address (first bit: 1 write/ 0 read)'

SHIFTOUT DATAPin, CLKPin, MSBFIRST, [Address<<1]  
'Read value from Address'

SHIFTIN DATAPin, CLKPin, MSBPRE, [ReceiveData]  
'End transmission'

HIGH CSPin  
'RETURN'
Display:

IF Decimal>32768 THEN  
  Decimal=−Decimal  
  'Judge the sign of value  
  ‘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  
  'Show first two number of decimal part

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
Data analysis

- We record maximum acceleration in different conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Maximum X</th>
<th>Y</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>-0.68</td>
<td>-1.68</td>
<td>1.50</td>
</tr>
<tr>
<td>Running</td>
<td>-2.12</td>
<td>-1.68</td>
<td>2.87</td>
</tr>
<tr>
<td>Bus</td>
<td>-0.62</td>
<td>-0.43</td>
<td>1.56</td>
</tr>
<tr>
<td>Subway</td>
<td>-1.00</td>
<td>-0.75</td>
<td>1.31</td>
</tr>
<tr>
<td>Shaking</td>
<td>-5.50</td>
<td>-2.87</td>
<td>4.75</td>
</tr>
<tr>
<td>Shaking inside box</td>
<td>-2.00</td>
<td>-1.06</td>
<td>2.93</td>
</tr>
<tr>
<td>Falling from 8cm</td>
<td>-1.50</td>
<td>-0.87</td>
<td>6.31</td>
</tr>
</tbody>
</table>
A Video on the bus