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 ecnomic and environmental friendly.

3.Design:

1) component:

- MMA7455L - XYZ-axis accelerometer:

The MMA7455L is a Digital Output (I^2C/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.

Top View

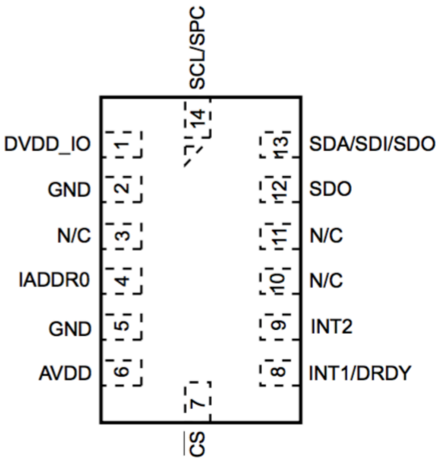
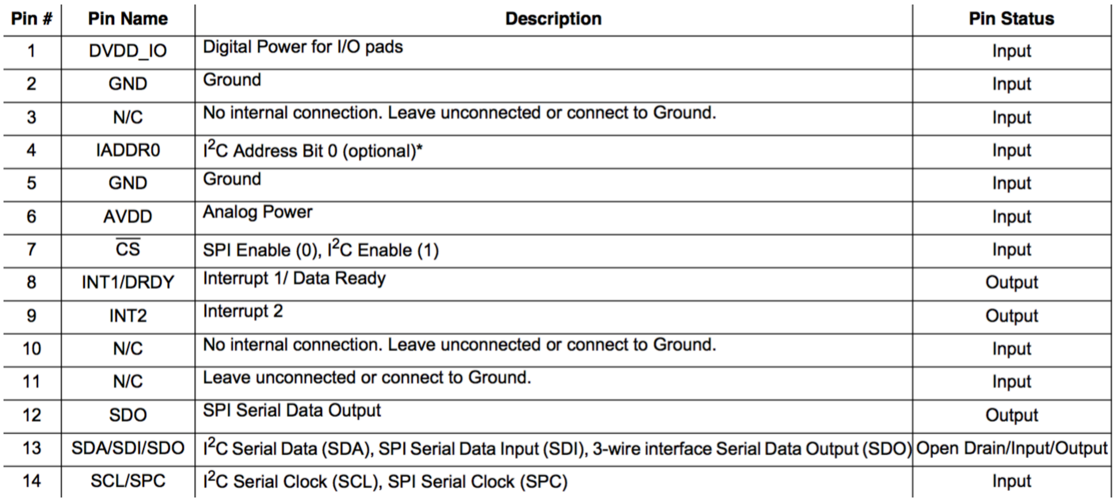


Figure 1. Pin Connections

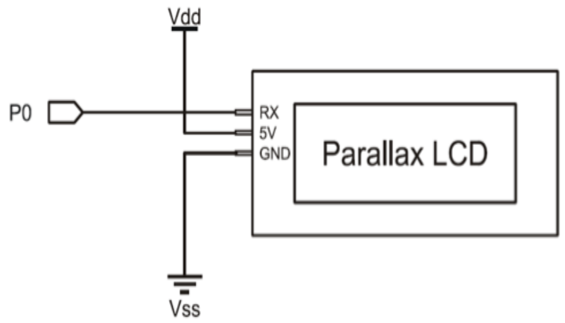


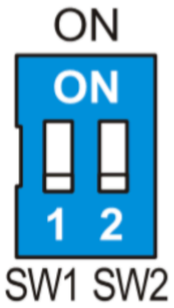
Pin #	Pin Name	Description	Pin Status
1	DVDD_IO	Digital Power for I/O pads	Input
2	GND	Ground	Input
3	N/C	No internal connection. Leave unconnected or connect to Ground.	Input
4	IADDR0	I^{2}C Address Bit 0 (optional)*	Input
5	GND	Ground	Input
6	AVDD	Analog Power	Input
7	$\overline{CS}$	SPI Enable (0), I^{2}C Enable (1)	Input
8	INT1/DRDY	Interrupt 1/ Data Ready	Output
9	INT2	Interrupt 2	Output
10	N/C	No internal connection. Leave unconnected or connect to Ground.	Input
11	N/C	Leave unconnected or connect to Ground.	Input
12	SDO	SPI Serial Data Output	Output
13	SDA/SDI/SDO	I^{2}C Serial Data (SDA), SPI Serial Data Input (SDI), 3-wire interface Serial Data Output (SDO)	Open Drain/Input/Output
14	SCL/SPC	I^{2}C Serial Clock (SCL), SPI Serial Clock (SPC)	Input

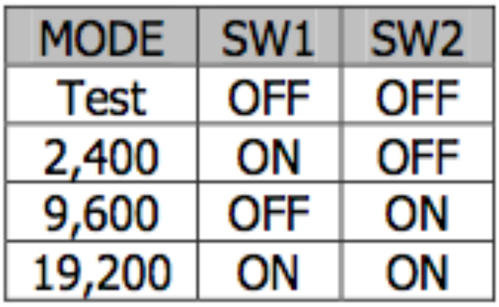
- Parallax Serial LCDs (Liquid crystal displays):

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.



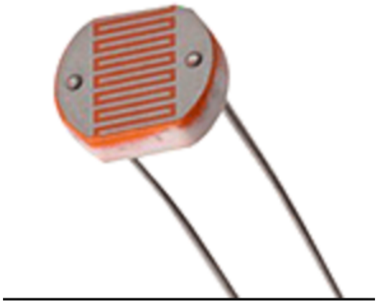




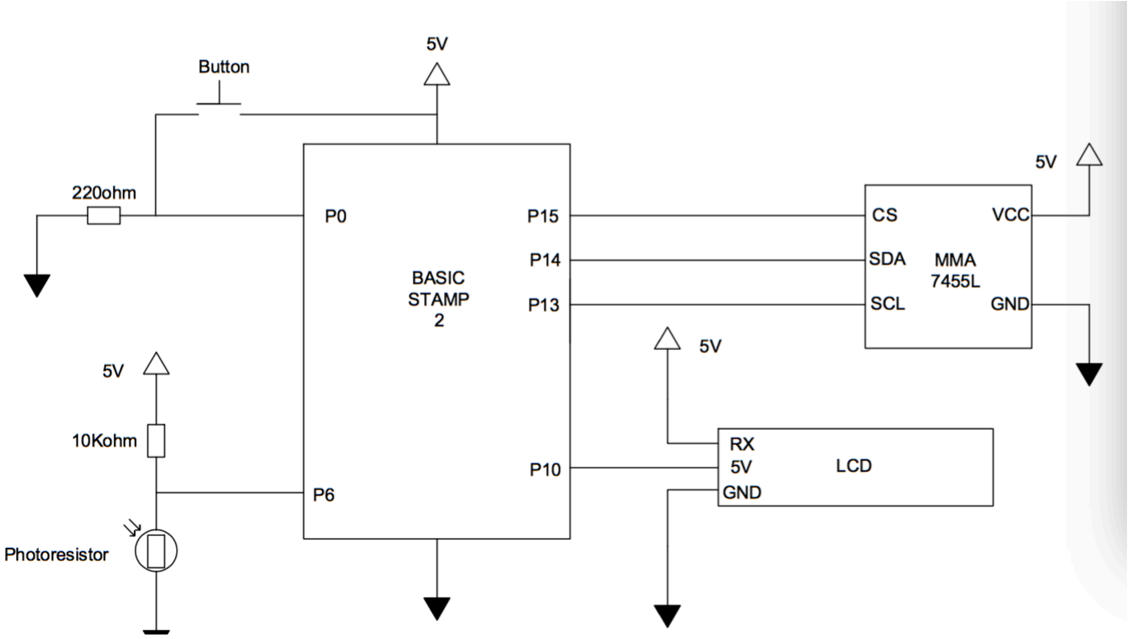
MODE	SW1	SW2
Test	OFF	OFF
2,400	ON	OFF
9,600	OFF	ON
19,200	ON	ON

- 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

```
' {$STAMP BS2}
' {$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 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
                                                            '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=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
```

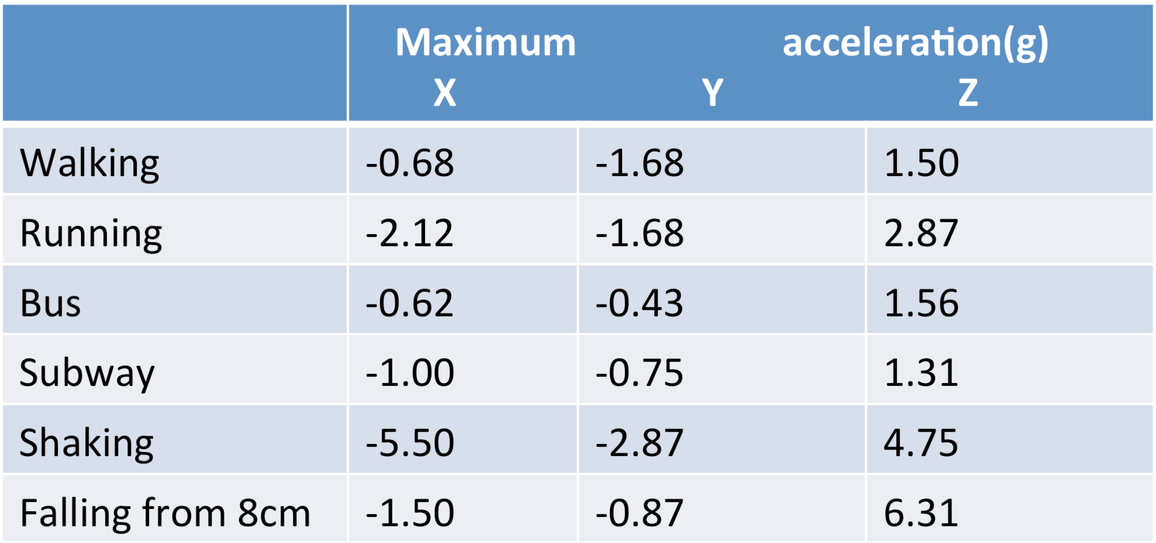
```
  Address=ZOUT8:GOSUB DataIn                                     'Read in Z-Axis
acceleration value
  ZAccel=ReceiveData|($FF00*ReceiveData.BIT7)               'Sign extend the two's
complement byte so
  IF ABS ZAccel> ABS Zmax THEN Zmax=ZAccel                   'negative numbers can be
properly displayed
                                                                 'Zmax stores the max value
of acceleration of Z-Axis
  Cycles=Cycles+1                                                'Cycles increases until
Cycles reachs vertrefresh
  IF Control=1 THEN Function=Function+1                        'If the button is pressed,
change the value of Function
  ButtonLoop:                                                    'Wait unitl 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]
  Decimal=XAccel+3                                               'Display the X, Y, and Z
accelerometer values
```

```
  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                                                    'End transmission
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                                                    'End transmission
RETURN

Display:
IF   Decimal>32768 THEN                                        'Judge the sign of value
  Decimal=-Decimal                                           'Negative data has to be
transformed brfore 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
```

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.



	Maximum acceleration(g)		
	X	Y	Z
Walking	-0.68	-1.68	1.50
Running	-2.12	-1.68	2.87
Bus	-0.62	-0.43	1.56
Subway	-1.00	-0.75	1.31
Shaking	-5.50	-2.87	4.75
Falling from 8cm	-1.50	-0.87	6.31

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. Runing 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 frafile products to be broken.