Sensor Report – Reflective Optical Sensor TCRT1000

April 28, 2008

Context

A pulse, an indication of a heart rate when counted over the timespan of a minute, can be detected in several ways. From electro-piezo touch heart-rate monitors to chest-strap monitors to PPG (photopleysmography) or optical heart rate detection there is a lot of opportunity to expand current implementations for sensing heart rate in a new way.

Sites for Detection

"The cardiovascular pulse is generated in the heart, when the chambers contract and blood bursts into the aorta from the left chamber. The blood travels through the arterial network and returns back to the heart through the vein network (Carola *et al.* 1990).

The wrist in the human hand offers a fascinating location for a noninvasive measurement device. The main arteries in the wrist, especially the radial artery, are close to the skin surface and consequently pulsation can be easily detected. In addition, the wrist bone under the radial artery offers good mechanical support for the measurement device. From a practical point of view, the measurement location is very handy, since the pulsation is easily detected and the measurement device is easy to put on. Therefore you don't need any special skills to use the device."

Figure 11. MRI from cross section of wrist.

Many different sensor types for pulse detection in the wrist have been developed. Pulse detection in heart rate and blood pressure measurements has been implemented by means of piezoelectric sensors, where the mechanical stimulus generated by the pressure pulse in converted to an electrical signal for further signal processing (Im *et al.* 1995, Tamura *et al.*1995). A strain gauge differential pressure sensor was used in a measurement system where a low-pressure cuff was wrapped around the wrist and then the pressure modulation in the cuff caused by the pressure pulse was measured with strain gauges (Dupuis & Eugne 2000). New electrostatic materials like electromechanical film (EMFi) and polyvinylidene fluoride (PVDF) have been used in sensors for pulse detection in the radial artery (Sorvoja 1998, Ruha *et al.*1996). Fiber optic sensors have also been used (Gagnadre *et al.* 1998). Here a multimode optical fiber is placed between two aluminium plates. The force generated by the pressure pulse causes variation in the modal distribution in the fiber and the pulse is detected using a photodetector.

Optical sensors in cardiovascular pulse detection typically measure the optical power variation which is due to absorption or scattering when the amount of blood in the measurement volume varies. This kind of measurement is called photo-plethysmography (PPG) and it was invented in the 1930s (Hertzman 1937). PPG is mainly used for measuring the pulsation in the capillary network, but it is also applied to measurements above the radial artery (Hast 1999, Aritomo *et al.* 1999). The shape of the pulse can be easily obtained from the tissue, but it cannot be used to study absolute values, when the amplitude of the signal is considered. It is important to point out that there are many variables which affect the PPG signal. For example, in the capillary system the amount of blood vessels is different between people, and for this reason the signal amplitude varies because the measurement volume contains a different amount of blood. However, it has to be noted that measurement of time intervals between cardiovascular pulses using the PPG technique can be used to diagnose many different cardiovascular diseases. In pulse oximetry, two different wavelengths are used and from the ratio of the two signals, the percent of blood haemoglobin saturation with oxygen can be calculated (Northrop 2002).

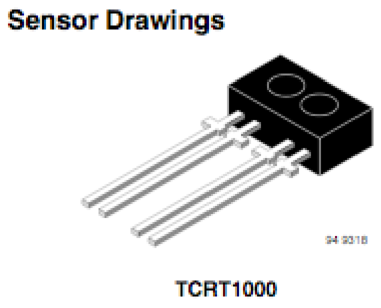
Possible Applications

Application of Optical Reflex Sensors
TCRT1000, TCRT5000, CNY70
Vishay Telefunken optoelectronic sensors contain infrared-emitting diodes as a radiation source and
phototransistors as detectors.

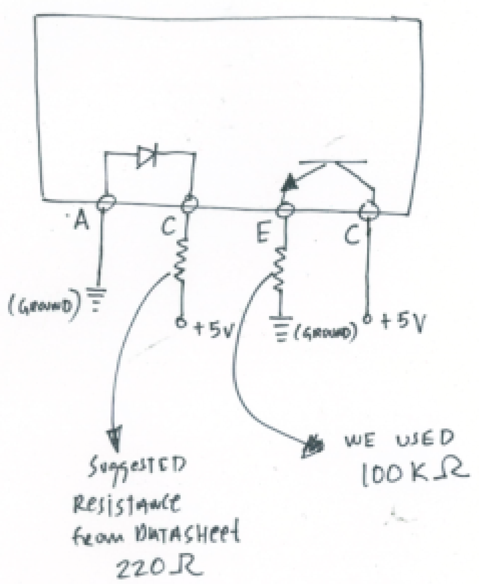
Typical applications include:
Copying machines
Video recorders
Proximity switch
Vending machines
Printers
Object counters
Industrial control

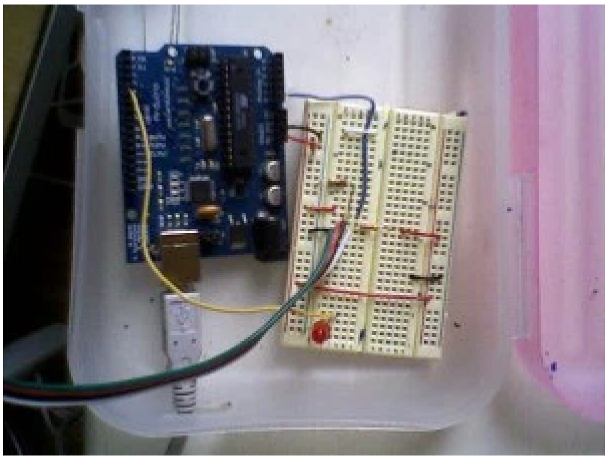
The Sensor

Data Sheet: data_sheet


Sensor Drawings
TCRT1000

The Circuit


A
C
E
C
(GROUND)
+5V
(GROUND)
+5V
Suggested Resistance from DATASHEET 220Ω
WE USED 100KΩ



Detecting HR from Wrist with A Threshold

Arduino Code:

```
int an1, an2, an3 = 0;

void setup() {
Serial.begin(19200);
}

void loop() {
an1 = analogRead(0);
delay(5);
// an2 = analogRead(1);
delay(5);
// an3 = analogRead(2);
Serial.print("X");
Serial.println(an1,DEC);
// Serial.print("Y");
// Serial.println(an2,DEC);
//Serial.print("Z");
//Serial.println(an3,DEC);
delay(15);
}
```

Processing:

```
import processing.serial.*;

String buff = "";
int val = 0;
int xPos,yPos,zPos = 0;
int displaySize = 10 ;
int an1;
int an1synth;//synthesized value so the waveform is a little clearer for now
int threshold= 3;// have a constant threshold value
//an1 pot; an2 ir;
int lastx=0;
int lasty=0;
int marker;//counter for checking 60 second intervals
boolean finterval=false;

Serial port;

void setup()
{
background(80);
size(800,600);
smooth();
port = new Serial(this, Serial.list()[1], 9600);
}
```

```
void draw(){
// new background over old
fill(80,5);
noStroke();
rect(0,0,width,height);

// wipe out a small area in front of the new data
stroke(255,0,0);
line(0,375,800,375);//threshold line
noStroke();
fill(80);
rect(xPos+displaySize,0,50,height);

// check for serial, and process
while (port.available() > 0) {
serialEvent(port.read());
}

}

void serialEvent(int serial) {
float m = millis();
float m1=(m%60000);
println("m1 is" + m1);
if(m1 ==0)//check if 60 samples are done and draw a vertical black line
{
print("set to true");
stroke(255);// white vertical line
line(lastx,400, lastx, 0);
// marker=0;//reset marker back to zero
}
print(" Value of Sensor X "); //header variable, so we know which sensor value is which
println(an1); //send as a ascii encoded number – we'll turn it back into a number at the other end
//Serial.print(10, BYTE); //terminating character
if(serial != '\n')
{
buff += char(serial);
//print("debug this serial ["+serial+"]");
}
else {
int curX = buff.indexOf("X");
//print("debug this buffer ["+buff+"]");
if(curX >=0)
{
String val = buff.substring(curX+1);
an1 = Integer.parseInt(val.trim());
an1synth=(an1*100)/10;
xPos=xPos+2;
if(xPos > width)
{
xPos = 0;
}
/*sensorTic2(xPos, 400- threshold );
xPos++;*/
sensorTic1(xPos,400- an1synth);
}
// Clear the value of "buff"
buff = "";
}
}

void sensorTic1(int x, int y)
{
//stroke(0,0,255);
stroke(0,0,255);
//fill(255,0,0);
//ellipse(x,y,displaySize,displaySize);
```

```
line(lastx, lasty, x,y);
lastx=x;
lasty=y;
}
```

Video

Ocorreu um erro.

Não é possível executar o JavaScript.

Implementations of HR on Wrist

In the late Spring to Summer of 2008, ExmoCare, a engineering and product development firm in New York city will be releasing the second generation of their wearable health monitor watch called the BT2. This wearable device uses a similar reflex optical sensor to continuously detect heart rate in the strap of its wristband. It also has an intergrated bluetooth radio so that recorded heart rate data can be wirelessly sent to the user's computer and viewed online in nicely designed graphs. Images of the BT2 are below. More information about this product can be found online at www.exmocare.com