2022년 IoT기반 스마트 솔루션 개발자 양성과정

Embedded Application

10-PPG Sensor

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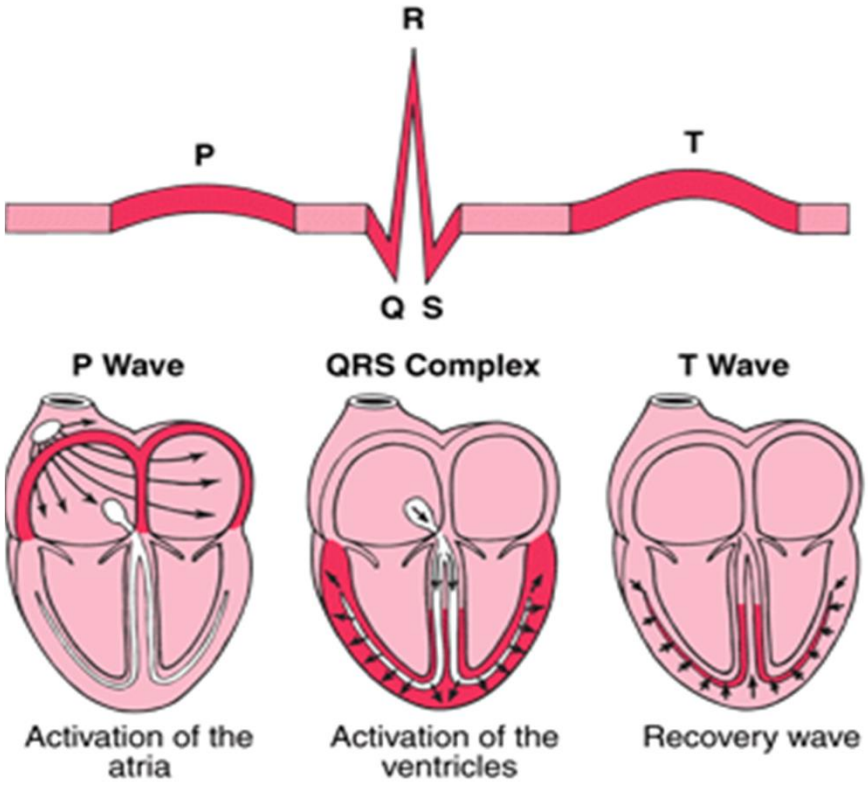
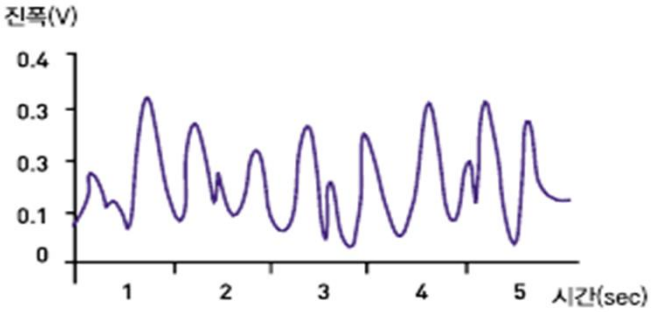
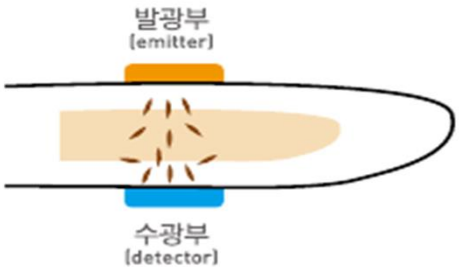
Heartbeat

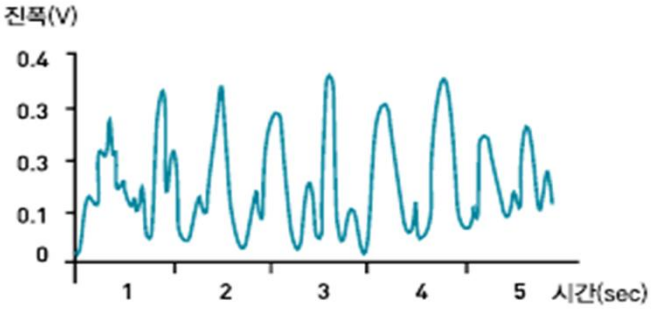

R
P
T
Q S
P Wave
QRS Complex
T Wave
Activation of the atria
Activation of the ventricles
Recovery wave


Normal Heartbeat
Fast Heartbeat
Slow Heartbeat
Irregular Heartbeat

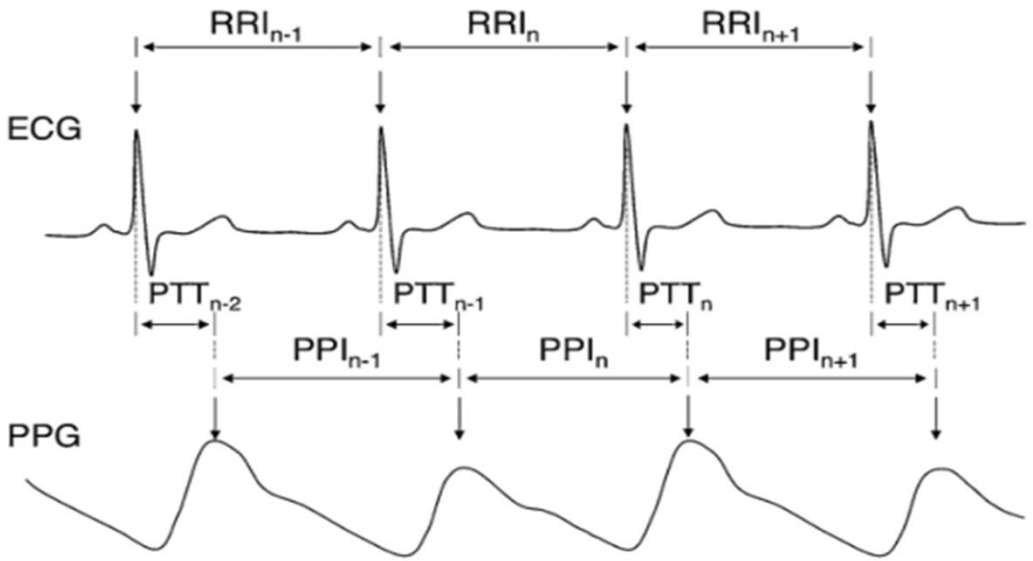
PhotoPlethymoGraph [PPG]





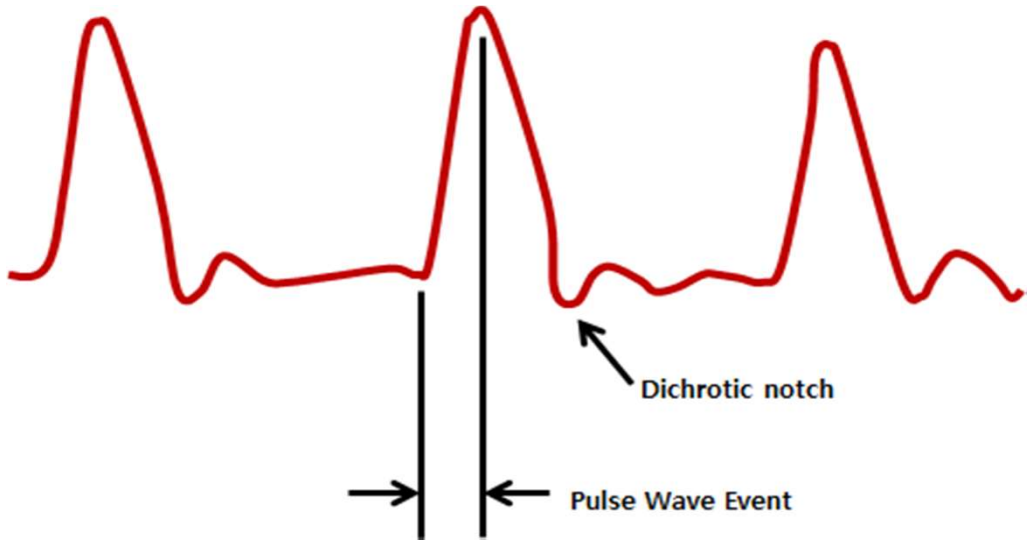


ECG & PPG


RRI$_{n-1}$
RRI$_n$
RRI$_{n+1}$
ECG
PTT$_{n-2}$
PTT$_{n-1}$
PTT$_n$
PTT$_{n+1}$
PPI$_{n-1}$
PPI$_n$
PPI$_{n+1}$
PPG

PPG Sensor 동작

- PPG는 심장박동의 모니터링 용도로 사용 가능한 모듈
- 적외선 LED에서 방출하는 적외선으로 혈관 압력의 미세한 변화를 수신부에서 감지

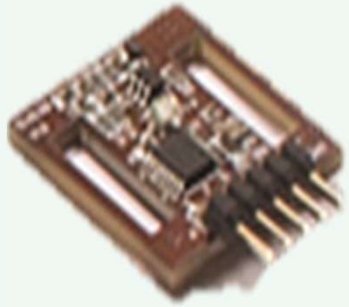


관련 지식

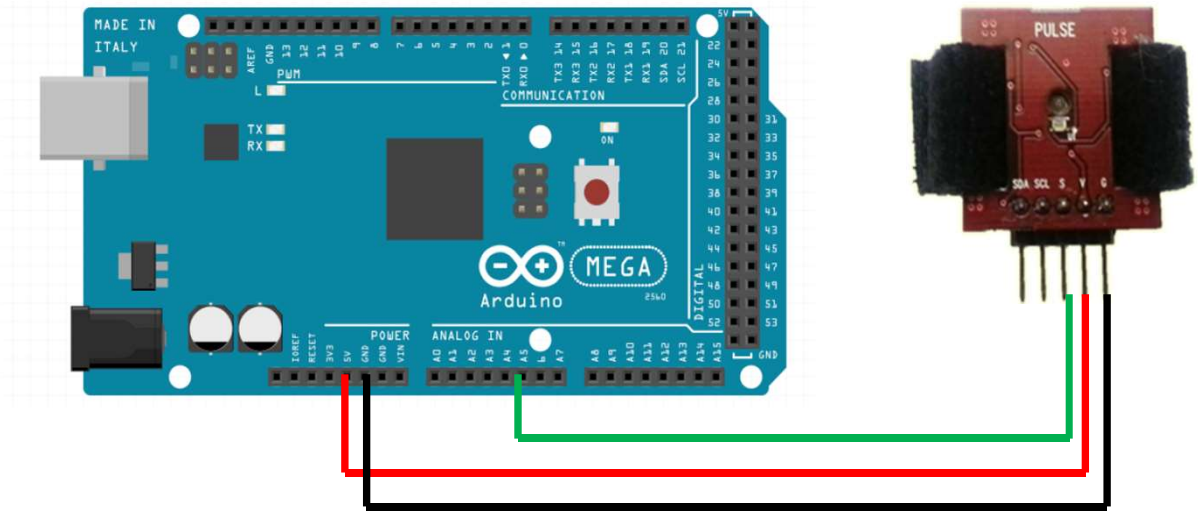
- 실내조명에 의한 간섭이 많이 발생
- 겉에 커버를 사용하여 외부 빛을 차단하여 간섭을 최소화

신생아 (0~3개월)	영아 (3~6개월)	유아 (6~12개월)	어린이 (1~10년)	성인 (10세 이상 어린이 포함)	운동선수
100~150	90~120	80~120	70~130	60~100	40~60

PPG Sensor

센서 모듈 외형	모듈 항목	모듈 항목의 내용
	펄스 센서	MCP6004
	감지 센서	Light Photo Sensor
	동작 전압	3.3V
	입력/출력	5pin Header (2.54mm pitch)
	크기	27x33mm
적외선 LED에서 방출하는 적외선이 혈관압력의 변화에 따라서 심박을 측정하는 센서		

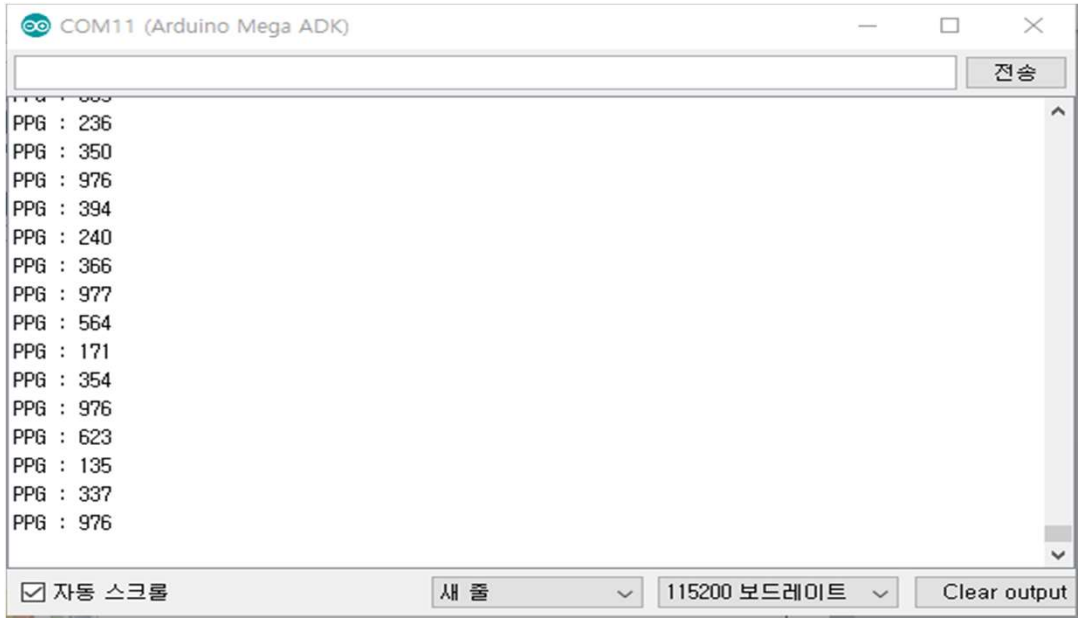
Wiring


MADE IN
ITALY
PWM
COMMUNICATION
POWER
ANALOG IN
DIGITAL
MEGA
Arduino
PULSE
SDA SCL S V G

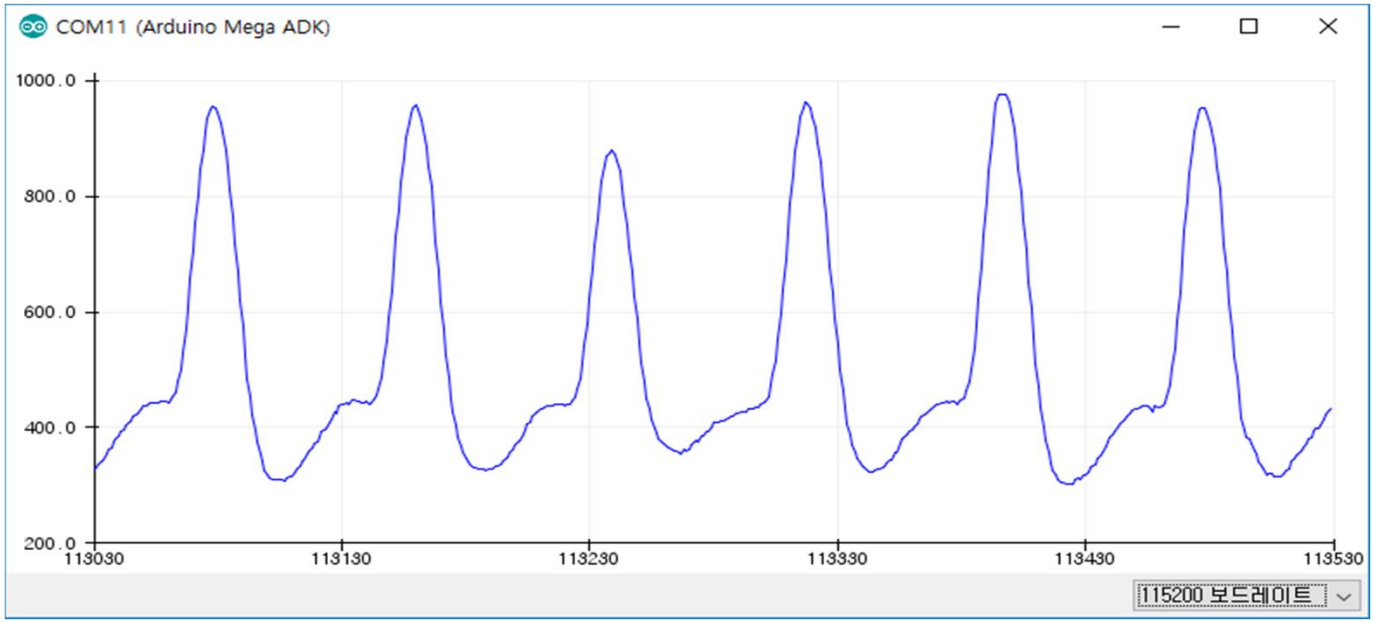
PPG Wave

```
#define PPG  A5
unsigned int adPulse;

void setup( ) {
  Serial.begin(115200);
  pinMode(PPG, INPUT);
}

void loop( ) {
  adPulse = analogRead(PPG);
  Serial.print("PPG : ");
  Serial.println(adPulse);
  delay(10);
}
```

Serial Monitor



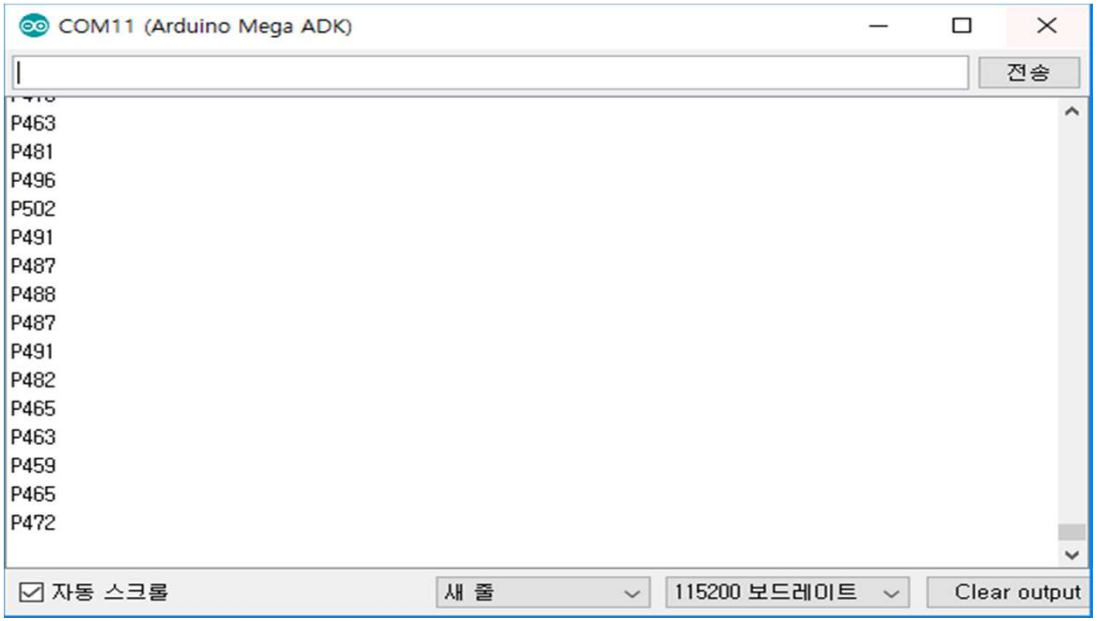
Serial Plotter



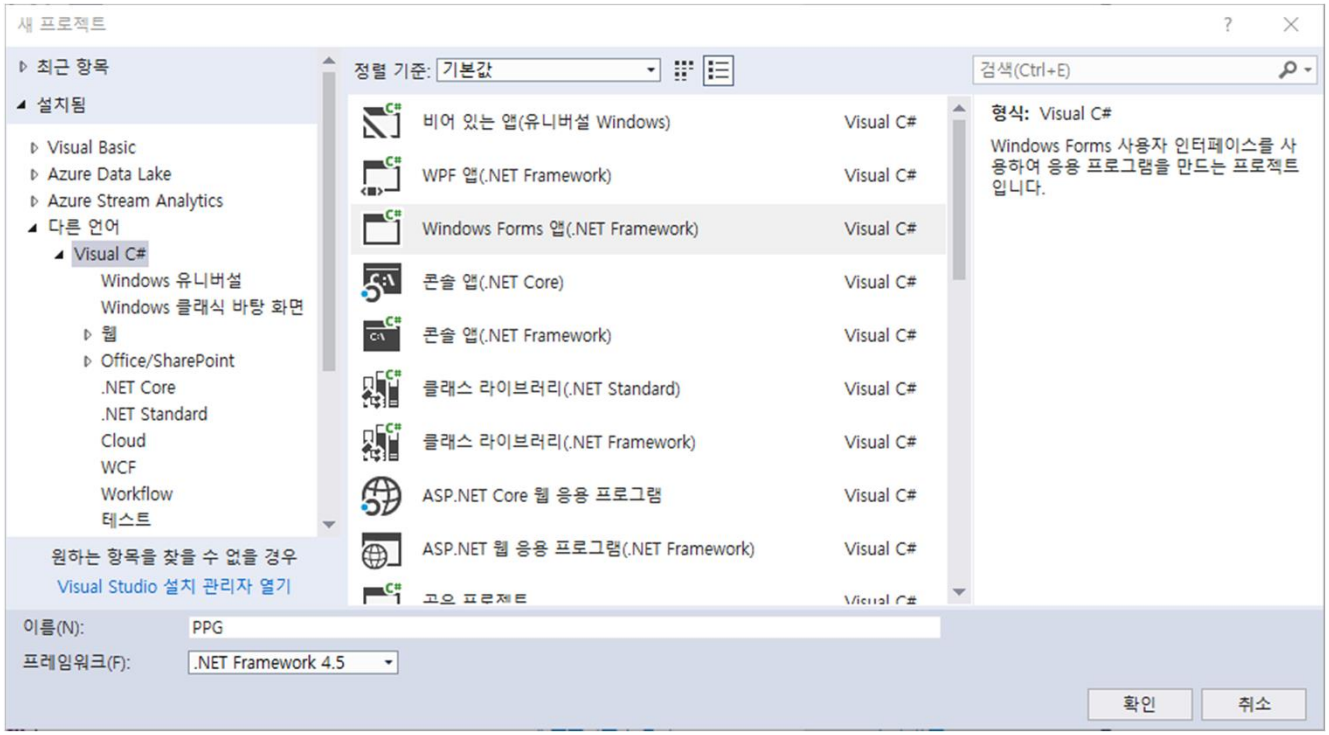
PPG SPP

```
#define PPG   A5
unsigned int adPulse;

void setup( ) {
  Serial.begin(115200);
  pinMode(PPG, INPUT);
}

void loop( ) {
  adPulse = analogRead(PPG);
  Serial.print('P');
  Serial.print(adPulse);
  Serial.print('₩n');
  delay(20);
}
```

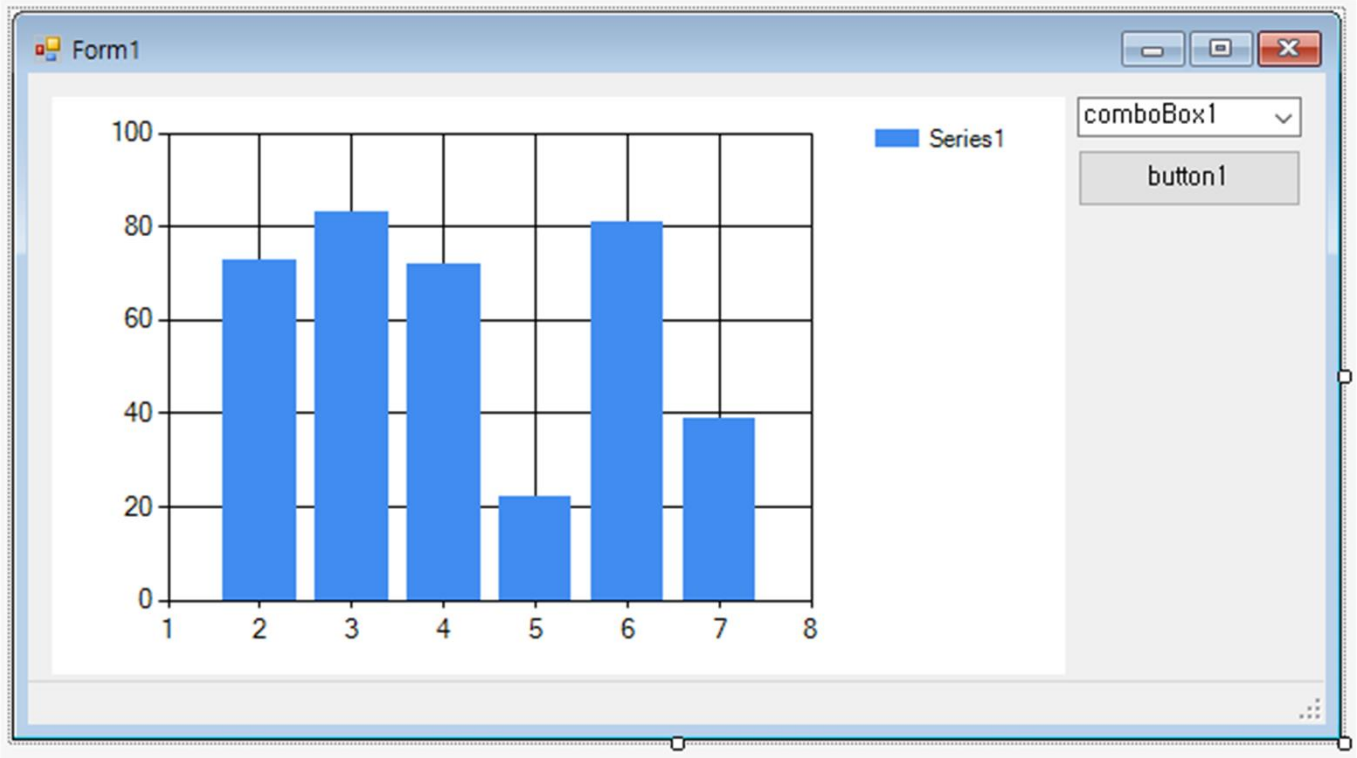
Serial Monitor



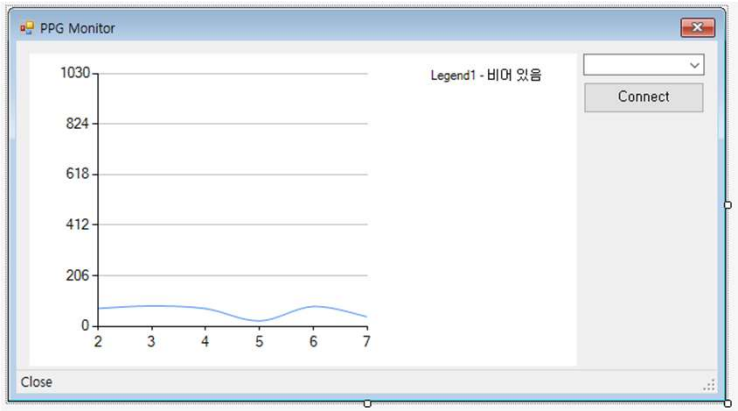
C# PPG - 새프로젝트


새 프로젝트
최근 항목
설치됨
Visual Basic
Azure Data Lake
Azure Stream Analytics
다른 언어
Visual C#
Windows 유니버설
Windows 클래식 바탕 화면
웹
Office/SharePoint
.NET Core
.NET Standard
Cloud
WCF
Workflow
테스트
원하는 항목을 찾을 수 없을 경우
Visual Studio 설치 관리자 열기
정렬 기준: 기본값
검색(Ctrl+E)
비어 있는 앱(유니버설 Windows) Visual C#
WPF 앱(.NET Framework) Visual C#
Windows Forms 앱(.NET Framework) Visual C#
콘솔 앱(.NET Core) Visual C#
콘솔 앱(.NET Framework) Visual C#
클래스 라이브러리(.NET Standard) Visual C#
클래스 라이브러리(.NET Framework) Visual C#
ASP.NET Core 웹 응용 프로그램 Visual C#
ASP.NET 웹 응용 프로그램(.NET Framework) Visual C#
형식: Visual C#
Windows Forms 사용자 인터페이스를 사용하여 응용 프로그램을 만드는 프로젝트입니다.
이름(N): PPG
프레임워크(F): .NET Framework 4.5
확인
취소

Form Design

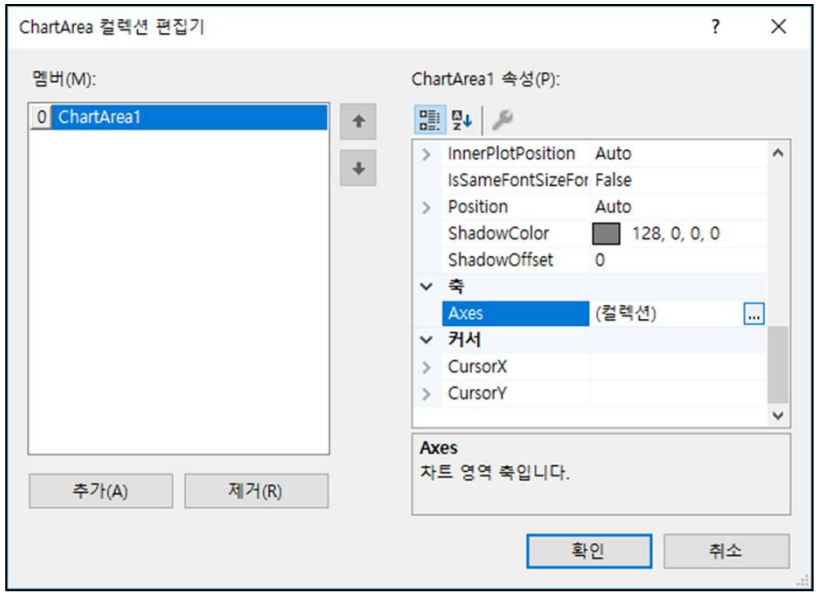


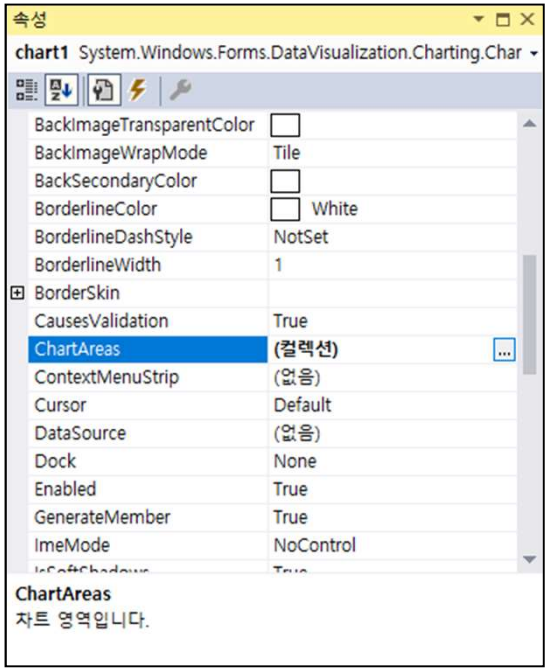
Property



Form1	
Text	PPG Monitor
MaximizeBox	False
MinimizeBox	False
FormBorderStyle	FixedSingle
ToolStripComboBox1	
Name	cmbComPort
ToolStripButton1	
Name	btnConnect
Text	Connect
ToolStripStatusLabel1	
Name	Status
Text	Close

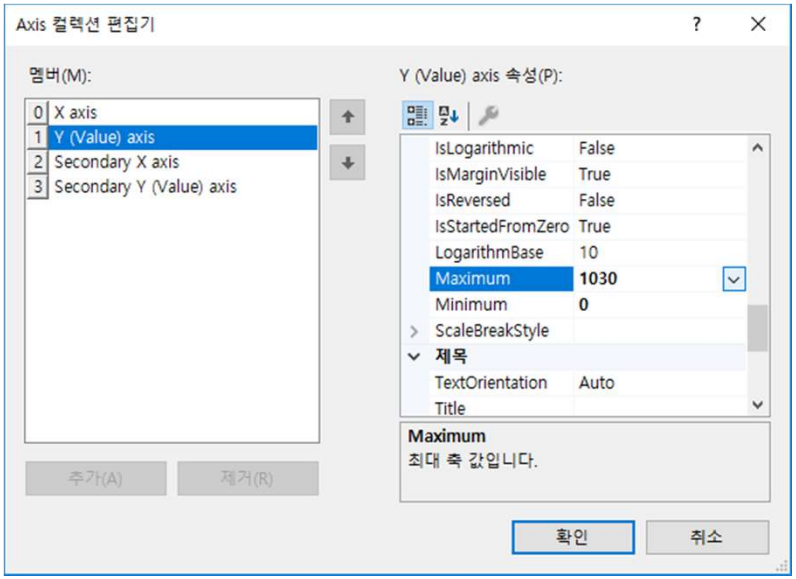
Chart Area Collection



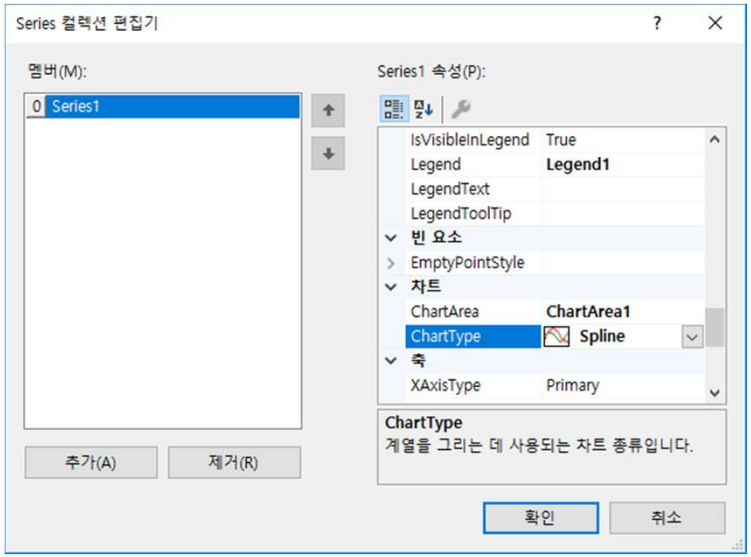


Axis Collection

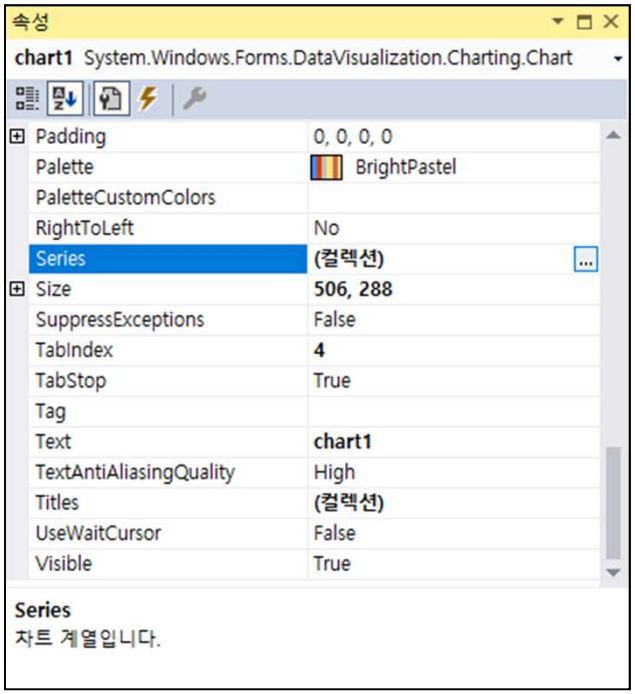
Y (Value) axis	
Maximum	1030
Minimum	0



Series Collection



Series1	
ChartType	Spline
isVisibleInLegend	False



Define

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Threading.Tasks;
using System.Windows.Forms;
using System.IO.Ports;

namespace PPG
{
    public partial class Form1 : Form
    {
        SerialPort ComPort = new SerialPort();
        private delegate void SetTextDelegate(string getString);

        public Form1()
        {
            InitializeComponent();
            ComPort.DataReceived += new SerialDataReceivedEventHandler(DataReceived);
        }
```

Form

```
private void Form1_Load(object sender, EventArgs e)
{
    cmbComPort.Items.Clear();
    var portName = System.IO.Ports.SerialPort.GetPortNames();
    cmbComPort.Items.AddRange(portName);
    cmbComPort.SelectedIndex = cmbComPort.Items.Count - 1;
}

private void Form1_FormClosing(object sender, FormClosingEventArgs e)
{
    if (ComPort.IsOpen)
    {
        ComPort.Close();
        ComPort.Dispose();
        ComPort = null;
    }
    Status.Text = "Form Closing.";
}
```

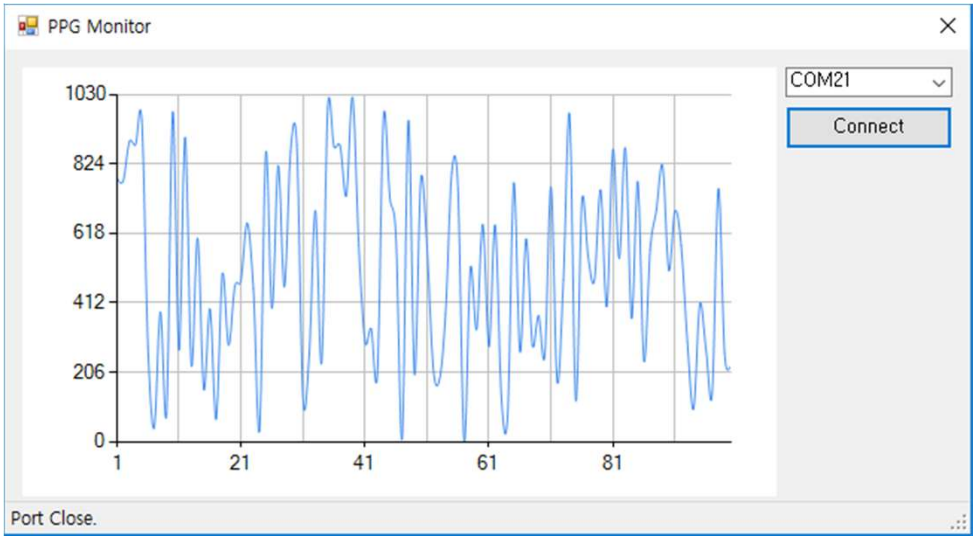
btnConnect_Click

```
private void btnConnect_Click(object sender, EventArgs e)
{
    if (btnConnect.Text == "Connect")
    {
        if (ComPort.IsOpen)
        {
            Status.Text = "Already used.";
        }
        else
        {
            ComPort.PortName = cmbComPort.Text;
            ComPort.BaudRate = 115200;
            ComPort.DataBits = 8;
            ComPort.Parity = Parity.None;
            ComPort.StopBits = StopBits.One;
            ComPort.Handshake = Handshake.None;
            ComPort.Open();
            ComPort.DiscardInBuffer();
            btnConnect.Text = "Close";
            Status.Text = "Port Open.";
        }
    }
    else
    {
        ComPort.Close();
        Status.Text = "Port Close.";
        btnConnect.Text = "Connect";
    }
}
```

DataReceived

```
private void DataReceived(object sender, System.IO.Ports.SerialDataReceivedEventArgs e)
{
    string rxd = ComPort.ReadTo("₩n");
    this.BeginInvoke(new SetTextDelegate(SerialReceived), new object[] { rxd });
}

private void SerialReceived(string inString)
{
    int PPGSignal = Convert.ToInt16(inString.Substring(1, inString.Length - 1));

    chart1.Series["Series1"].Points.Add(PPGSignal);
}
```

Debug Run


PPG Monitor
COM21
Connect
1030
824
618
412
206
0
1
21
41
61
81
Port Close.

Scope Chart Style

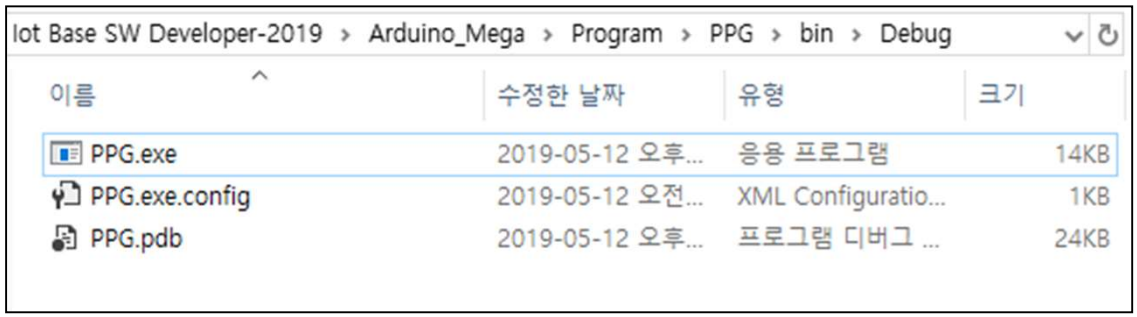
Axis Collection : X axis	
Maximum	1030
Minimum	0
Enable	False

```
private void SerialReceived(string inString)
{
    int PPGSignal = Convert.ToInt16(inString.Substring(1, inString.Length - 1));

    chart1.Series["Series1"].Points.Add(PPGSignal);
    if (chart1.Series["Series1"].Points.Count > 100)
    {
        chart1.Series["Series1"].Points.Clear();
    }
}
```

Strip Chart Style

```
private void SerialReceived(string inString)
{
    int PPGSignal = Convert.ToInt16(inString.Substring(1, inString.Length - 1));

    chart1.Series["Series1"].Points.Add(PPGSignal);
    if (chart1.Series["Series1"].Points.Count > 100)
    {
        chart1.Series["Series1"].Points.RemoveAt(0);
    }
}
```

Files


Iot Base SW Developer-2019 › Arduino_Mega › Program › PPG › bin › Debug
이름
수정한 날짜
유형
크기
PPG.exe
2019-05-12 오후...
응용 프로그램
14KB
PPG.exe.config
2019-05-12 오전...
XML Configuratio...
1KB
PPG.pdb
2019-05-12 오후...
프로그램 디버그 ...
24KB

Heart Rate Setup( )

```
#define PPG  A5
unsigned int adPulse;

unsigned long time_20mS = 0, time_3S = 0;
#define index_MAX 20
unsigned char Pulse_Data[index_MAX];
unsigned char Pulse_count = 0;
bool Pulse_Rise = false;
unsigned char Index = 0, Index_flag = 0;
unsigned int ADC_Data[4] = {0, 0, 0, 0};

void setup( ) {
  Serial.begin(115200);
  pinMode(PPG, INPUT);

  time_20mS = millis( );
  time_3S = time_20mS;
}
```

Heart Rate Loop( ) 1

```
void loop( ) {
  if((time_20mS + 20) < millis( )){
    time_20mS += 20;
    adPulse = analogRead(PPG);
    if((adPulse < ADC_Data[0]) && (ADC_Data[0] < ADC_Data[1]) &&
(ADC_Data[1] < ADC_Data[2]) && (ADC_Data[2] < ADC_Data[3]) && Pulse_Rise)    {
      if((ADC_Data[3] - adPulse) > 100) {
        Pulse_Rise = false;
        Pulse_count++;
      }
    } else if((adPulse > ADC_Data[0]) && (ADC_Data[0] > ADC_Data[1]) &&
(ADC_Data[1] > ADC_Data[2]) && (ADC_Data[2] > ADC_Data[3]) && (Pulse_Rise == false)){
      if((adPulse - ADC_Data[3]) > 100){   Pulse_Rise = true;     }
    }

    for(char k=3; k>0; k--)  ADC_Data[k] = ADC_Data[k-1];
    ADC_Data[0] = adPulse;
  }
```

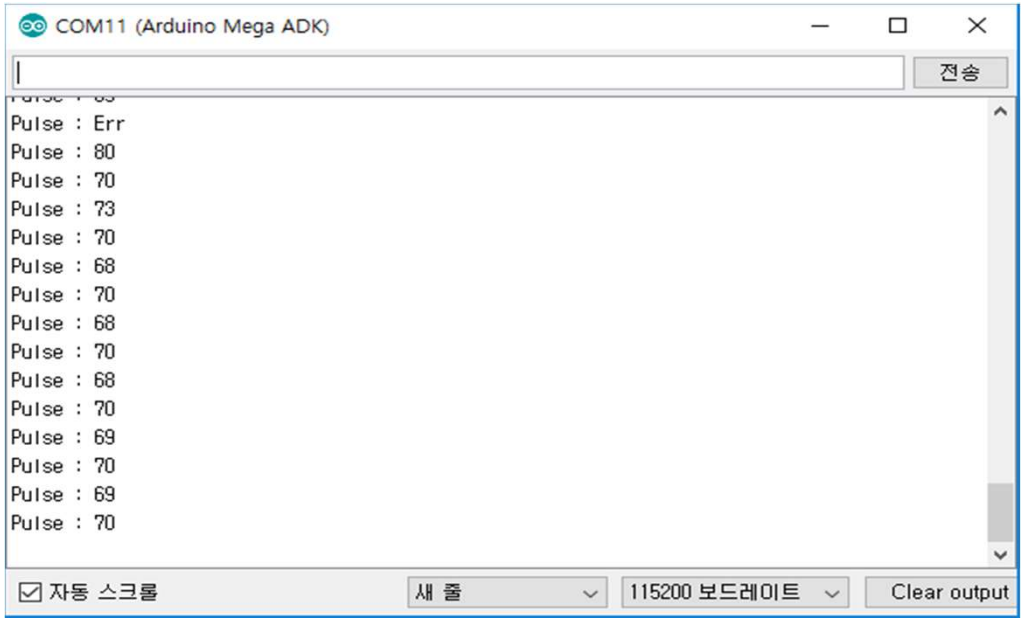
Heart Rate Loop( ) 2

```
 if((time_3S + 3000) < millis( )){
    time_3S += 3000;
    if(Pulse_count > 8) Pulse_Data[Index] =0;
    else Pulse_Data[Index] = Pulse_count;

    Pulse_count = 0;

    if (++Index>=index_MAX) Index=0;
    if(Index_flag < index_MAX){  Index_flag++;   }

    unsigned int Pulse_sum = 0;
    for(char k=0; k<Index_flag; k++){   Pulse_sum += Pulse_Data[k];    }
    if(Index_flag < index_MAX)  Pulse_sum = Pulse_sum * index_MAX / Index_flag;

    if(Pulse_sum < 20) PulseInit( );
    SendPPG(Pulse_sum);
  }
}
```

Heart Rate function

```
void PulseInit( ){
  Index = 0;
  Index_flag = 0;
  time_20mS = millis();
  time_3S = time_20mS;
}

void SendPPG(int PulseRate){
  Serial.print("Pulse : ");
  if(PulseRate < 20){
    Serial.println("Err");
  }else{
    Serial.println(PulseRate);
  }
}
```

Serial Monitor



Heart Rate Setup( )

```
#define PPG  A5
unsigned int adPulse;
unsigned int BPM;
unsigned long time_20mS = 0, time_3S = 0;
#define index_MAX 20
unsigned char Pulse_Data[index_MAX];
unsigned char Pulse_count = 0;
bool Pulse_Rise = false;
unsigned char Index = 0, Index_flag = 0;
unsigned int ADC_Data[4] = {0, 0, 0, 0};

void setup( ) {
  Serial.begin(115200);
  pinMode(PPG, INPUT);

  time_20mS = millis( );
  time_3S = time_20mS;
}
```

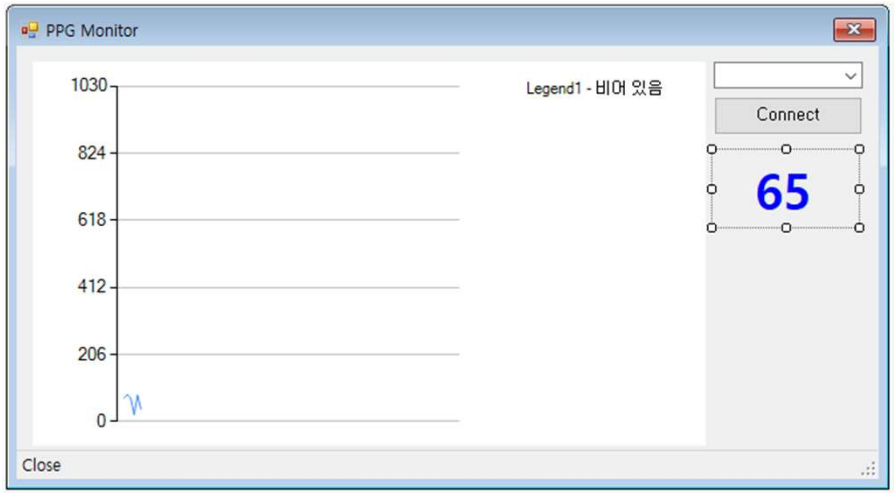
Heart Rate Loop( ) 1

```
void loop( ) {
  if((time_20mS + 20) < millis()){
    time_20mS += 20;
    adPulse = analogRead(PPG);
    if((adPulse < ADC_Data[0]) && (ADC_Data[0] < ADC_Data[1]) &&
(ADC_Data[1] < ADC_Data[2]) && (ADC_Data[2] < ADC_Data[3]) && Pulse_Rise)    {
      if((ADC_Data[3] - adPulse) > 100) {
        Pulse_Rise = false;
        Pulse_count++;
      }
    } else if((adPulse > ADC_Data[0]) && (ADC_Data[0] > ADC_Data[1]) &&
(ADC_Data[1] > ADC_Data[2]) && (ADC_Data[2] > ADC_Data[3]) && (Pulse_Rise == false)){
      if((adPulse - ADC_Data[3]) > 100){   Pulse_Rise = true;     }
    }

    for(char k=3; k>0; k--)  ADC_Data[k] = ADC_Data[k-1];
    ADC_Data[0] = adPulse;
    SendPPG();
  }
```

Heart Rate function

```
void PulseInit( ){
  Index = 0;
  Index_flag = 0;
  time_20mS = millis( );
  time_3S = time_20mS;
}

void SendPPG( ){
  Serial.print("P");
  Serial.print(adPulse);
  Serial.print('₩n');

  Serial.print("B");
  Serial.print(BPM);
  Serial.print('₩n');
}
```

BPM Display



Label1	
AutoSize	False
Font	맑은 고딕, 27.75pt, style=Bold
ForeColor	Blue
Text	65
TextAlign	MiddleCenter

SerialReceived

```
private void SerialReceived(string inString)
{
    string Code = inString.Substring(0, 1);
    int PPGSignal = Convert.ToInt16(inString.Substring(1, inString.Length - 1));

    if (Code == "P")
    {
        StripChart(PPGSignal);
    }
    else
    {
        label1.Text = PPGSignal.ToString();
    }
}
```