Smart Software Project

Lab: Week 10

Infrared Sensors

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Today

- Lab announcement
- Infrared sensor
- Lab assignment #7
- Course announcement

Class Schedule

Week	Lecture Contents	Lab Contents
Week 1	Course introduction	Arduino introduction: platform & programming environment
Week 2	Embedded system overview & source management in collaborative repository (using GitHub)	Lab 1: Arduino Mega 2560 board & SmartCAR platform
Week 3	ATmega2560 Micro-controller (MCU): architecture & I/O ports, Analog vs. Digital, Pulse Width Modulation	Lab 2: SmartCAR LED control
Week 4	Analog vs. Digital & Pulse Width Modulation	Lab 3: SmartCAR motor control (Due: HW on creating project repository using GitHub)
Week 5	ATmega2560 MCU: memory, I/O ports, UART	Lab 4: SmartCAR control via Android Bluetooth
Week 6	ATmega2560 UART control & Bluetooth communication between Arduino platform and Android device	Lab 5: SmartCAR control through your own customized Android app (Due: Project proposal)
Week 7	Midterm exam	
Week 8	ATmega2560 Timer, Interrupts & Ultrasonic sensors	Lab 6: SmartCAR ultrasonic sensing
Week 9	Infrared sensors & Buzzer	Lab 7: SmartCAR infrared sensing
Week 10	Acquiring location information from Android device & line tracing	Lab 8: Implementation of line tracer
Week 11	Gyroscope, accelerometer, and compass sensors	Lab 9: Using gyroscope, accelerometer, and compass sensors
Week 12	Project	Team meeting (for progress check)
Week 13	Project	Team meeting (for progress check)
Week 14	Course wrap-up & next steps	
Week 15	Project presentation & demo I (Due: source code, presentation slides, & poster slide)	Project presentation & demo II
Week 16	Final week (no final exam)	

Lab Session

- Practice in-lab programming exercises based on the lecture materials
- Upload source codes for lab assignments in Ewha Cyber Campus after the lab session
  - Due: 11:59pm on the lab day
- Once you are done, you can leave the session after checking with me or TA
- Or, continue to work on programming for other homework assignments

Lab Policy

- 1) Please check out your SmartCAR (& Nexus 7 tablet) as soon as you arrive at the classroom
- 2) Please complete lab assignments
- 3) Upload required files to Ewha Cyber Campus
- 4) Check with me or TA
- **5) Please upload a null firmware to SmartCAR before you return it!!!**
  - **This will be a part of your lab score**
- 6) Please remove files that you created or downloaded in your computer after you are done
  - Remove your project completely
- 7) Please shut down your computer before you leave
- 8) Return the checked-out SmartCAR (& Nexus 7 tablet) to TA

NOTE: How to run SmartCAR in Lab

- Power OFF
  - Compile your code
  - Lift up your SmartCAR with your hand
  - Upload your code
- Disconnect the USB cable
- Go to find a spacious area
- Put it down there
- Power ON
- It will run your firmware
- After test, turn power OFF

Lab Announcement

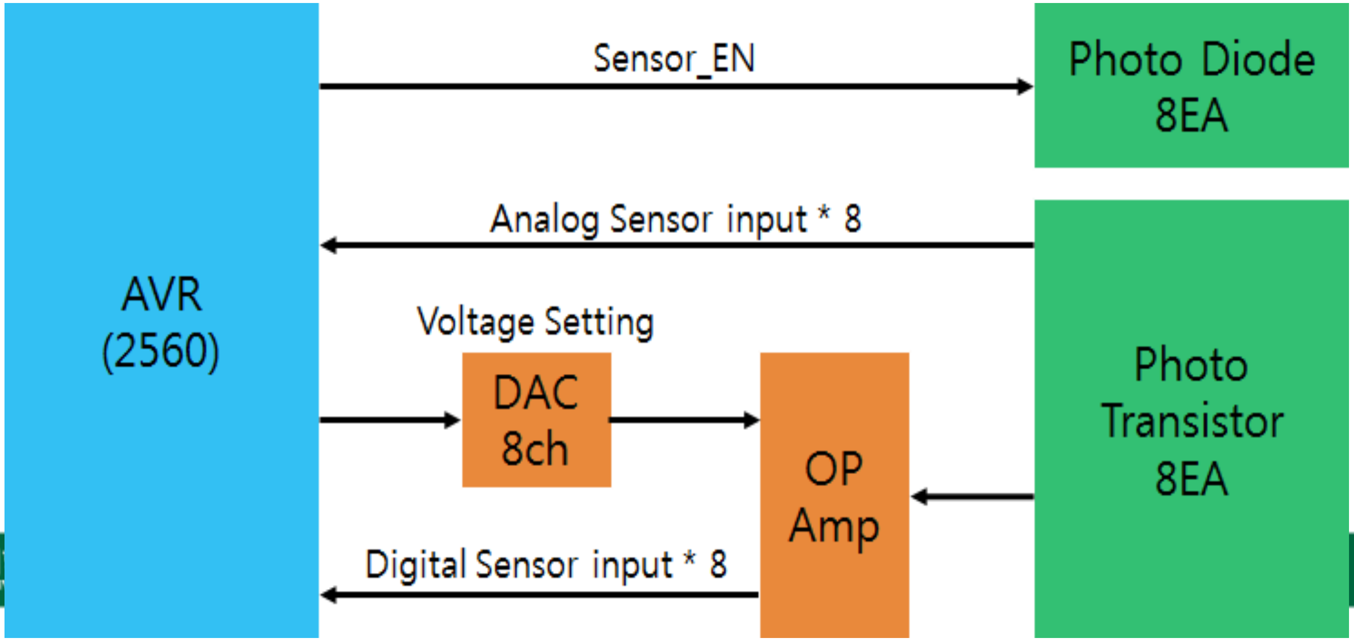
- Bluetooth pairing “headache”
  - Because there are so many Bluetooth devices in the classroom with the same name
    - “**155v2.1.7_hb**” <- SmartCAR
  - So please go outside with your SmartCAR and your Android device, and then pair them
  - Please do not pair with other students’ devices

Today

- Lab announcement
- **Infrared sensor**
- Lab assignment #7
- Course announcement

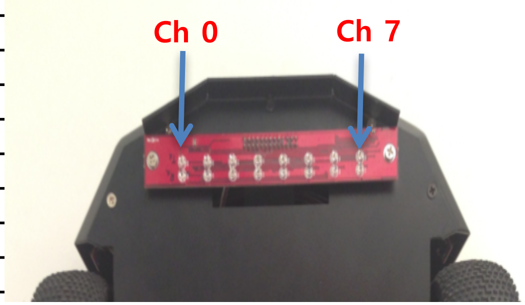
Infrared Sensors in SmartCAR

- Sensor_EN
  - Enable infrared sensors
- Analog sensor input
  - Measure infrared level in analog
- Digital sensor input
  - measure infrared level in digital
- Block diagram of infrared sensors in SmartCAR



SmartCAR Infrared Sensor Port Configuration

Type	Name	Port / Number	Etc
Digital Input	SENSOR_1 (LEFTMOST)	PC7 / 30	
	SENSOR_2	PC6 / 31	
	SENSOR_3	PC5 / 32	
	SENSOR_4	PC4 / 33	
	SENSOR_5	PC3 / 34	
	SENSOR_6	PC2 / 35	
	SENSOR_7	PC1 / 36	
	SENSOR_8 (RIGHTMOST)	PC0 / 37	
Analog Input	SENA_1 (LEFTMOST)	PF0 / A0	
	SENA_2	PF1 / A1	
	SENA_3	PF2 / A2	
	SENA_4	PF3 / A3	
	SENA_5	PF4 / A4	
	SENA_6	PF5 / A5	
	SENA_7	PF6 / A6	
	SENA_8 (RIGHTMOST)	PF7 / A7	
	SEN_EN	PA4 / 26	
DAC	S_DIN	PL7 / 42	
	S_SCLK	PL6 / 43	
	S_SYNCN	PL5 / 44	



- 30~37: ports to read digital values at receiver based on reference voltage set-up in OP AMP
- A0~A7: ports to read analog values at receiver
- 26: enable infrared emitter - ‘1’ turning on emitter
- 42~44: ports for configuring reference voltage in Serial DAC
  - Configure reference voltages for 8 pins in OP AMP

Part I: Serial DAC Control

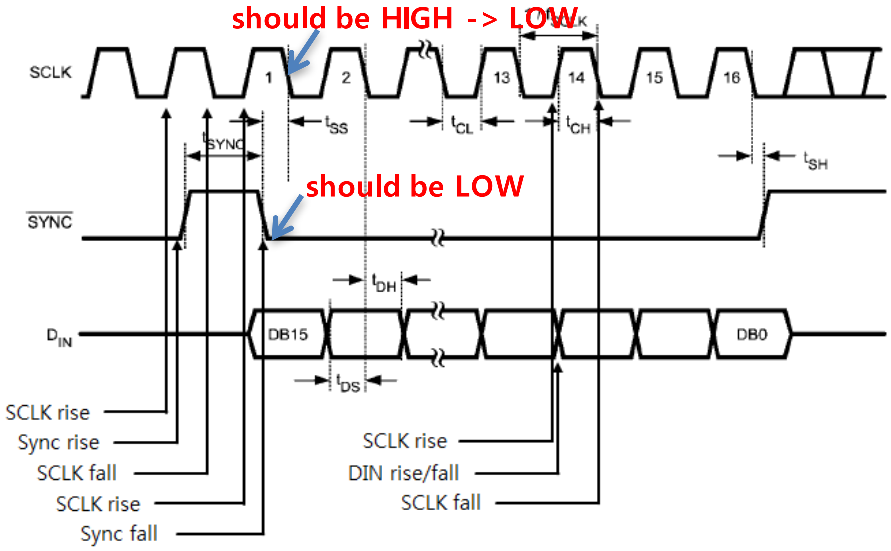
```
void DAC_CH_Write(unsigned int ch, unsigned int da)
{
    unsigned int data = ((ch << 12) & 0x7000) |
                        ((da << 4) & 0x0FF0);
    DAC_setting(data);
}

void DAC_setting(unsigned int data)
{
   int z;

   digitalWrite(S_SCLK,HIGH);
   delayMicroseconds(1);
   digitalWrite(S_SCLK,LOW);
   delayMicroseconds(1);
   digitalWrite(S_SYNCN,LOW);
   delayMicroseconds(1);
   for(z=15;z>=0;z--)
   {
     digitalWrite(S_DIN,(data>>z)&0x1);
     digitalWrite(S_SCLK,HIGH);
     delayMicroseconds(1);
     digitalWrite(S_SCLK,LOW);
     delayMicroseconds(1);
   }
   digitalWrite(S_SYNCN,HIGH);
}
```

12 4

0	CH2	CH1	CH0	D7	D6	D5	D4	D3	D2	D1	D0	X	X	X	X

DATA Bits

CH2	CH1	CH0	channel
0	0	0	A
0	0	1	B
0	1	0	C
0	1	1	D
1	0	0	E
1	0	1	F
1	1	0	G
1	1	1	H


should be HIGH -> LOW

should be LOW

Threshold for Digital Sensor Input Decision

```
#define S_DIN              42
#define S_SCLK             43
#define S_SYNCN            44
#define IN_SEN_EN          26

int SensorA[8] = {A0,A1,A2,A3,A4,A5,A6,A7};
int SensorD[8] = {30,31,32,33,34,35,36,37};

void setup()
{
   int z;
   int dac_val_min[8] =
                    {59,94,81,79,166,104,108,77};
   int dac_val_max[8] =
              {443,627,678,603,957,761,797,559};

   Serial.begin(115200);

   pinMode(IN_SEN_EN,OUTPUT);
   pinMode(S_DIN,OUTPUT);
   pinMode(S_SCLK,OUTPUT);
   pinMode(S_SYNCN,OUTPUT);
   digitalWrite(S_SCLK,LOW);
   digitalWrite(S_SYNCN,HIGH);
   digitalWrite(IN_SEN_EN,HIGH);
```

Mode	DB[15:12]	DB[11:0]	Etc
WRM	1000	XXXX XXXX XXXX	0x8000
WTM	1001	XXXX XXXX XXXX	0x9000

```
   for (z=0; z<8; z++)
      pinMode(SensorD[z], INPUT);

   DAC_setting(0x9000); //for Write-Through Mode

   for (z=0; z<8; z++)
   {
      int mean_val =
     (dac_val_min[z]+dac_val_max[z])/2;  //10-bit

      DAC_CH_Write(z, mean_val >> 2);
      //should be 8-bit
   }
}
```

Print measurements to UART

```
void infrared_sensor_read()
{
    int z;

    for(z=7;z>=0;z--)
    {
        unsigned int val = analogRead(SensorA[z]);

        Serial.print(val);
        Serial.print("  ");
    }

    Serial.println("");

    for(z=7;z>=0;z--)
    {
        unsigned int val = digitalRead(SensorD[z]);
        Serial.print(val);
        Serial.print("  ");
    }
}
```

```
void serialEvent()
{
    int command = Serial.read();

    switch (command)
    {
        …
        …
        case 11:
            infrared_sensor_read();
            break;

        default:
    }
}
```

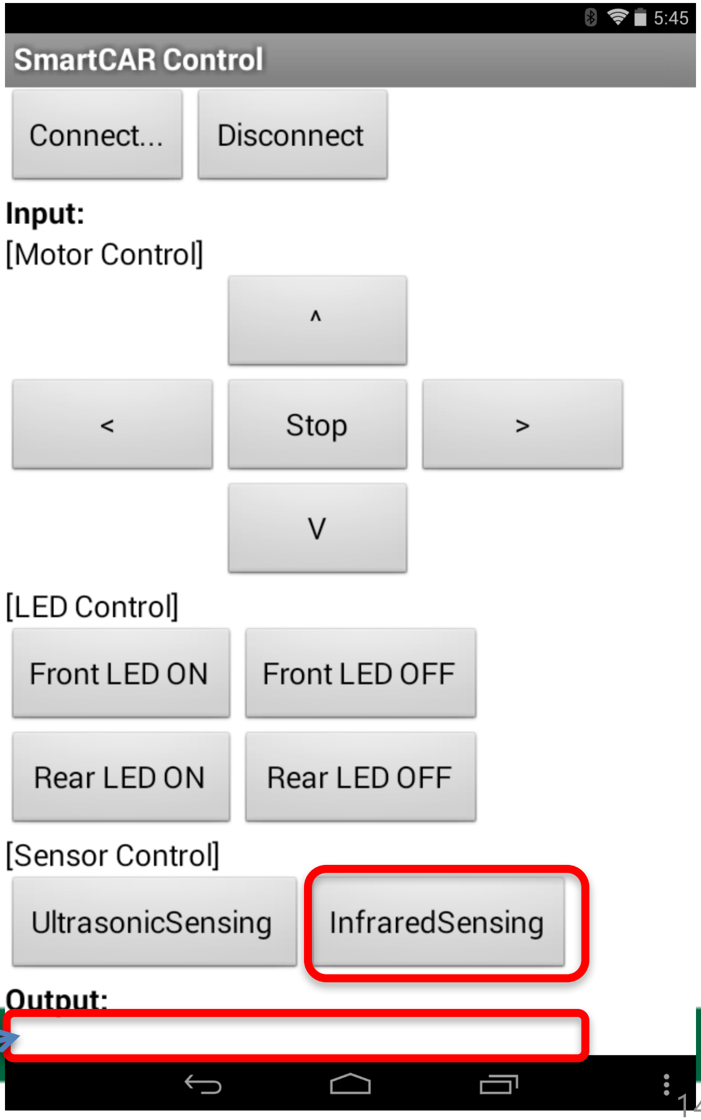
- If the SmartCAR receives a byte of 11, it prints out
  - analog values
  - digital values

  from 8 infrared sensors

Part II: SmartCAR Control App

- http://ai2.appinventor.mit.edu
- Click on "New Project"
- Enter "SmartCAR_Ctr" in Project Name (One word, no space)

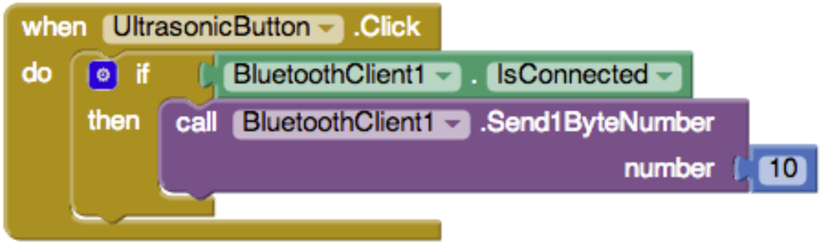
- Under "User Interface"
  - Drag-and-drop "ListPicker" component
    - To select a Bluetooth device
  - Drag-and-drop "Button" component
  - Drag-and-drop "Label" component
- Under "Layout"
  - Drag-and-drop "TableArrangement"
  - Drag-and-drop "TableArrangement"
- Under "Connectivity"
  - Drag-and-drop "BluetoothClient"
    - **Uncheck "Secure"**
- Under "Sensors"
  - Drag-and-drop "AccelerometerSensor"



BTOutput (Label)

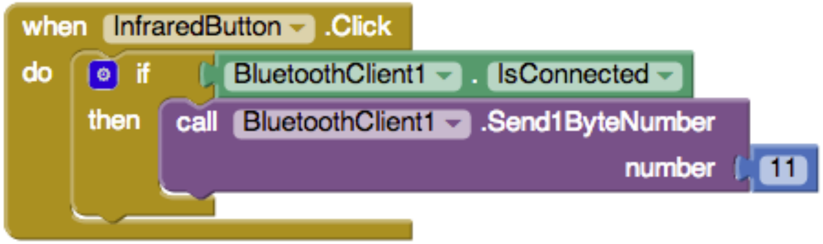
SmartCAR Sensor Control

- Sensing Ultrasonic sensor (command byte: 10)
  - Send “10” in number using “BluetoothClient.Send1ByteNumber”



```
when UltrasonicButton .Click
do  if   BluetoothClient1 . IsConnected
    then call BluetoothClient1 .Send1ByteNumber
                                  number 10
```

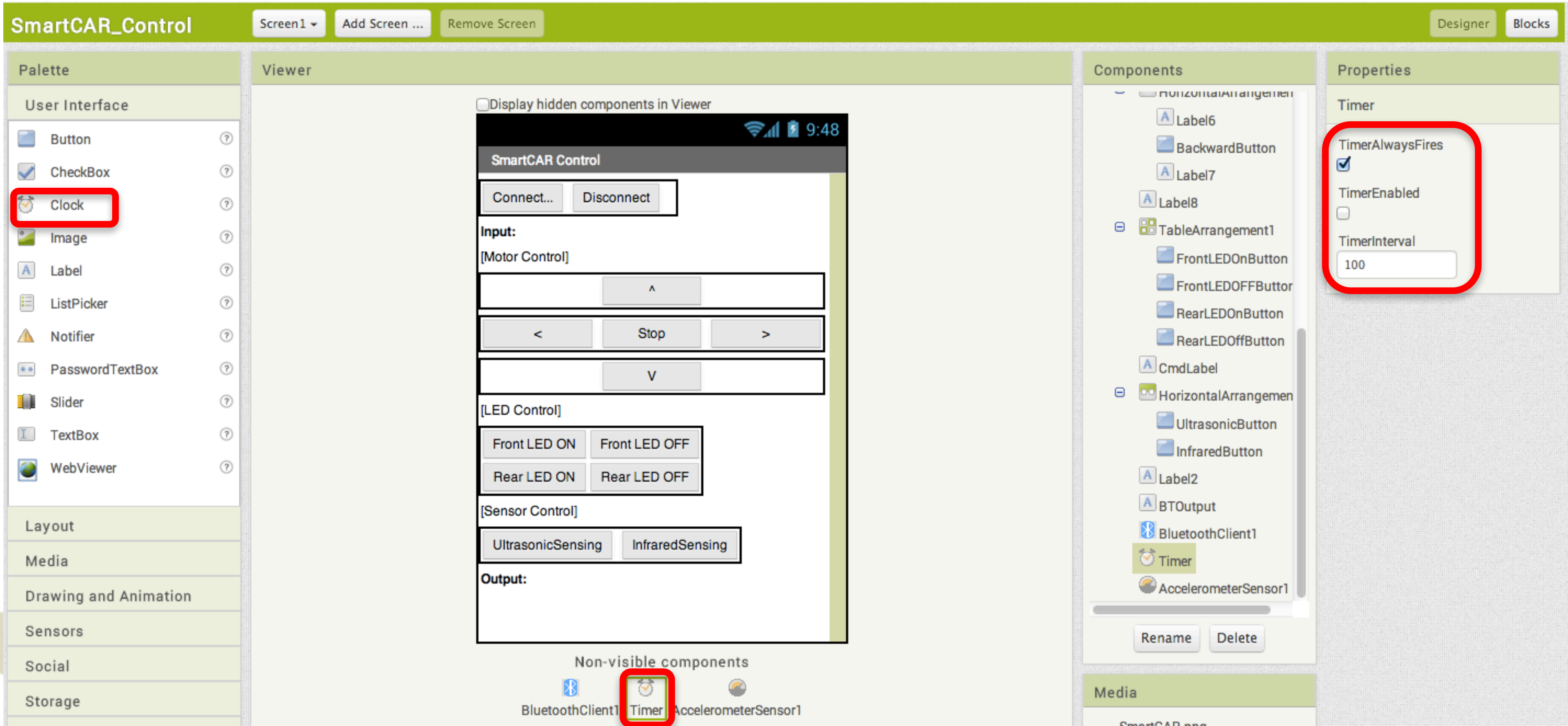
- Sensing Infrared sensor (command byte: 11)
  - Send “11” in number using “BluetoothClient.Send1ByteNumber”



```
when InfraredButton .Click
do  if   BluetoothClient1 . IsConnected
    then call BluetoothClient1 .Send1ByteNumber
                                  number 11
```

Receiving Bytes from SmartCAR

- Use “Clock” component: timer functionality
  - To periodically check whether any data have been received from Bluetooth
  - TimerAlwaysFires? : to select whether to expire periodically or not
  - TimerEnabled : to select whether to initially enable or not



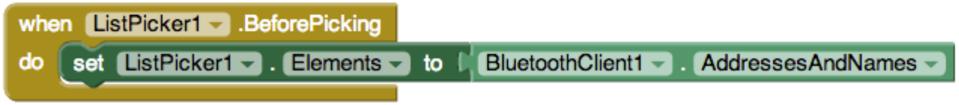
TimerAlwaysFires
☑

TimerEnabled
□

TimerInterval
100

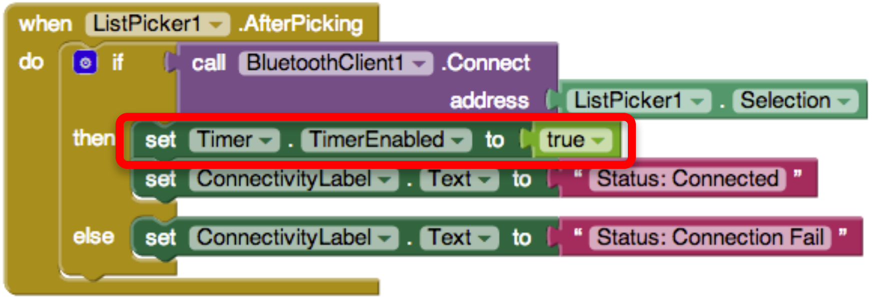
Receiving Bytes from SmartCAR

- 1) When Bluetooth is connected, then the timer is enabled
- 2) When "Timer" expires, check if there are received

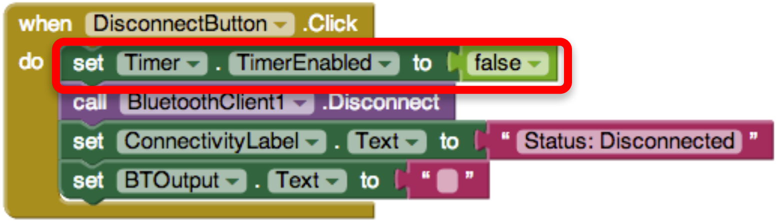


```
when ListPicker1 .BeforePicking
do  set ListPicker1 . Elements to  BluetoothClient1 . AddressesAndNames
```

1)

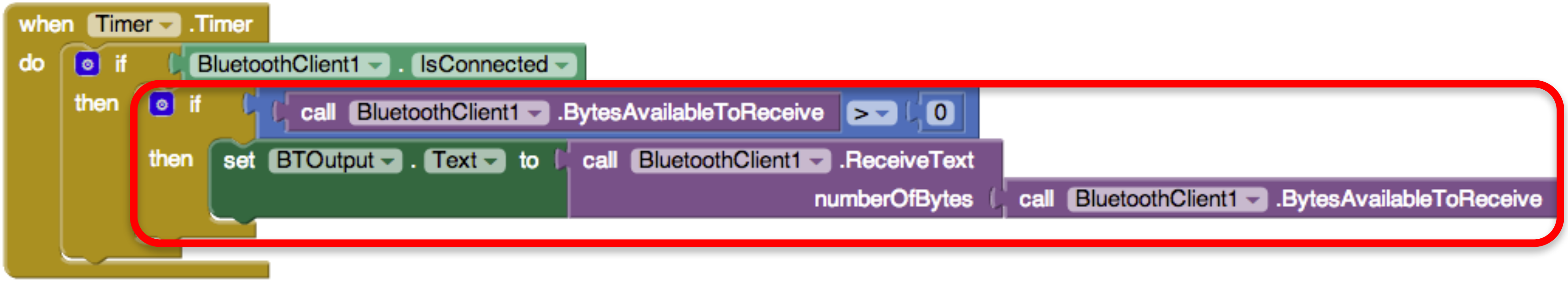


```
when ListPicker1 .AfterPicking
do   if    call BluetoothClient1 .Connect
                     address  ListPicker1 . Selection
     then  set Timer . TimerEnabled to  true
           set ConnectivityLabel . Text to  " Status: Connected "
     else  set ConnectivityLabel . Text to  " Status: Connection Fail "
```



```
when DisconnectButton .Click
do  set Timer . TimerEnabled to  false
    call BluetoothClient1 .Disconnect
    set ConnectivityLabel . Text to  " Status: Disconnected "
    set BTOutput . Text to  " "
```

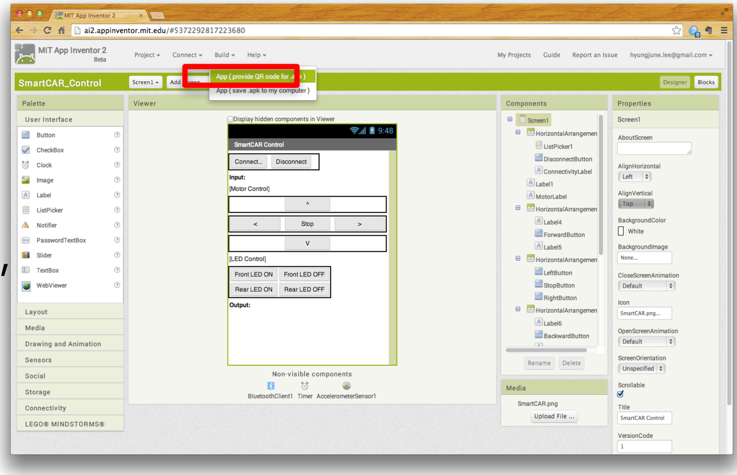
2)



```
when Timer .Timer
do   if    BluetoothClient1 . IsConnected
     then  if    call BluetoothClient1 .BytesAvailableToReceive  >  0
           then  set BTOutput . Text to  call BluetoothClient1 .ReceiveText
                                              numberOfBytes  call BluetoothClient1 .BytesAvailableToReceive
```

How to Run your Android app

- 1. Install "QR Barcode Scanner" in Play Store (Android device)
- 2. Click on "Build" (PC)
  - Click on "App (provide QR code for .apk)"
- 3. Run "QR Barcode Scanner" (Android device)
- 4. Touch the URL link (Android device)
- 5. Select "OK" to install .apk file (Android device)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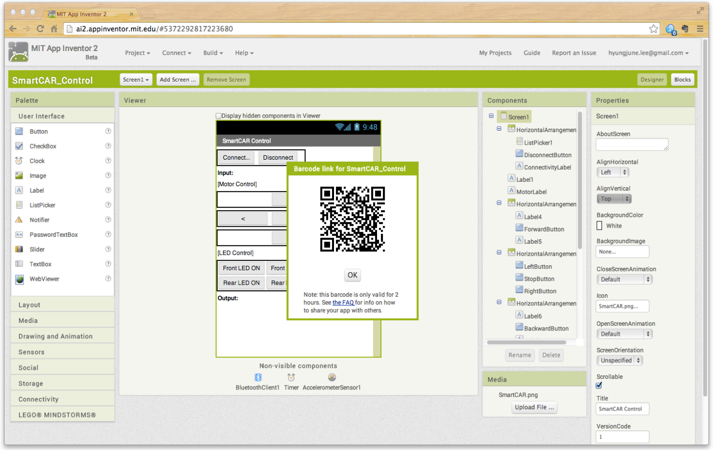
MIT App Inventor 2
Project
Connect
Build
Help
SmartCAR_Control
App (provide QR code for .apk)
App (save .apk to my computer)
Palette
Viewer
Components
Properties



Note: this barcode is only valid for 2 hours. See the FAQ for info on how to share your app with others.

Summary of Steps

- 1) Run an application to measure analog values
  - Remove the blue codes in SmartCAR firmware
  - Measure Analog Infrared Sensor Value on “White”
  - Measure Analog Infrared Sensor Value on “Black”
- 2) Add the voltage setup for digital in setup()
  - Add the blue codes with the measured values
  - Set up the average value
- 3) Run an application to measure analog values as well as digital values

Lab Assignment #7

- Submit three following files to Cyber Campus
  - 1) lab7.cpp (Arduino firmware code)
  - 2) lab7.h (Arduino firmware code)
  - 3) SmartCAR_IR.apk (Android app package)
    - You should set the app icon image to "SmartCAR.png"
    - In App Inventor,
"Build" ➔ "App (save .apk to my computer)"

- Show your result to TA or instructor

Course Announcement

- Next Week Lab session,
  - Line tracing using infrared sensors
  - Getting location information from Android device