ECGR 4101/5101 FALL 2017

Embedded Systems

Project: Temperature Control System using Cloud services on Smart Device

Introduction:

Developed Embedded-IoT platform by establishing connections between Raspberry Pi, IBM Bluemix cloud service and Android Device using Node Red Application. Node Red is a flow-based development tool developed by IBM for wiring together hardware devices, APIs and online services as part of the Internet of Things. The Raspberry Pi is interfaced with a toy motor and a sensor.

Objectives:

1. The Raspberry Pi should be able to sense the value of the sensor using SPI communication.
2. The Raspberry Pi should be able to send the value of the sensor to the IBM Bluemix Cloud and display the same on an Android device.
3. The Android phone should be able to control the toy motor remotely.
4. To create a flow using Node Red Application that gets the sensor values from Raspberry Pi using MQTT. Email updates should then be sent to the user regarding the sensor values.

Supply List:

For this project, you will need the following components:

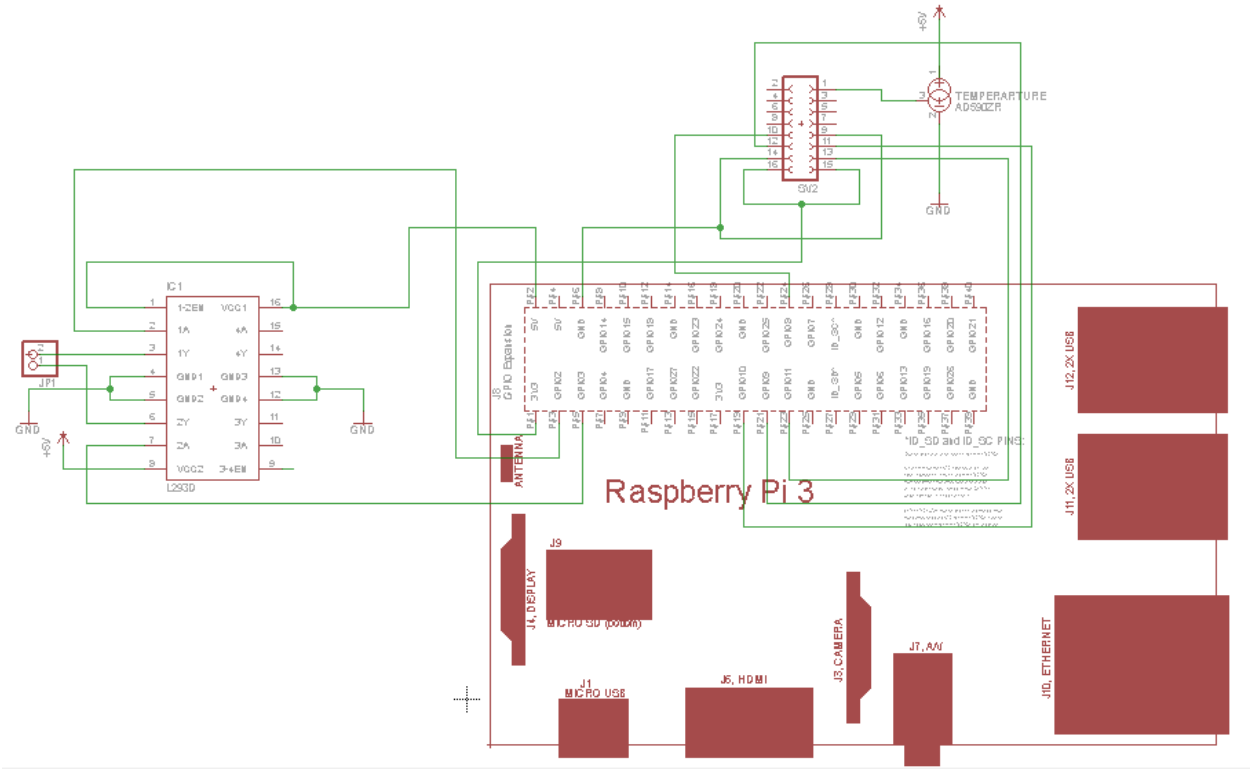
- Raspberry Pi 2/3 model B with Noobs OS.
- Toy motor.
- Motor driver IC (L293D).
- ADC IC (MCP 3008).
- Connectors
- Power supply for Raspberry Pi.
- An IBM Bluemix account.
- Node Red Application installed on Raspberry Pi.
- MQTT installed on Raspberry Pi.

Circuit Design:

Before we get started with the coding, we are going to need to connect additional hardware. We shall begin by connecting the motor to the Raspberry Pi board. You may use any of the 26 GPIO pins to connect the L293D motor driver IC to the board. Ensure to connect the VCC and the GND pins.

TIP: Do not connect the motor directly to the board, always do it via the motor driver IC. The board can only provide around 20mA which is sufficient to glow an LED. The motors may need around 400mA and thus connecting the motor to the board directly may damage the board.

The Raspberry Pi does not have an internal analog to digital circuit, so we will be using the ADC IC (MCP3008). The circuit diagram for this project is given below:

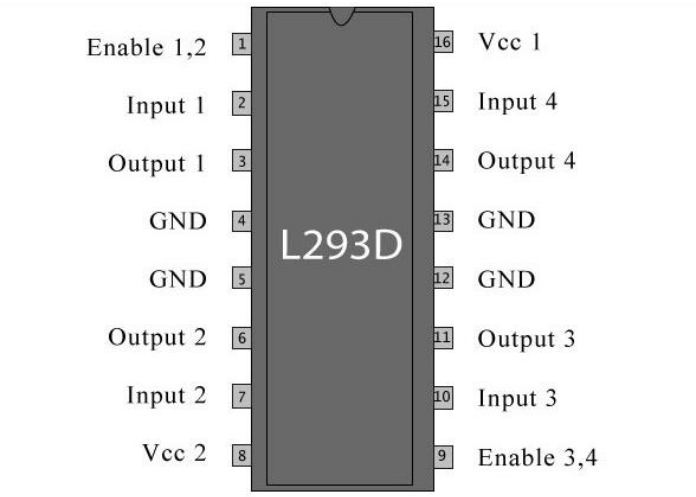


Components required: The various hardware and software components used in this project are as follows:

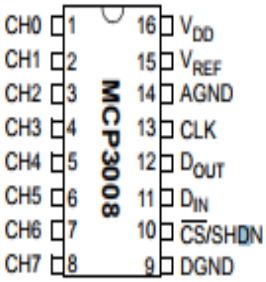
- **Hardware Components:**

1. **Raspberry Pi model:** A Raspberry Pi model is a series of small single-board computers which features System on Chip (SoC) with an integrated ARM compatible Central Processing Unit (CPU) and Graphics Processing Unit (GPU). To store the Operating System and program memory, Secure Digital (SD) cards are used.

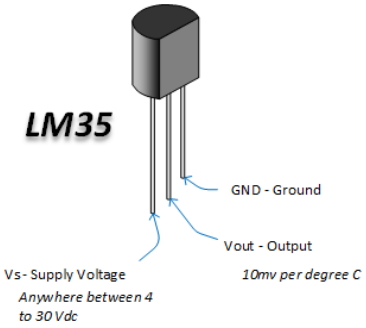
2. **L293D:** It is a motor driver IC with 16 pin configurations out of which 2 pins are dedicated for inputs, 2 for outputs, 1 for ENABLE for each motor. Since the motor driver IC deals with heavy currents and heat problems, so a heat sink mechanism is implemented on this IC by providing the IC with 4 ground pins. H-bridge is implemented in this IC to control the current flow throughout the IC.



3. **MCP3008:** The Raspberry Pi does not have an internal A/D converter hence this IC provides the external A/D conversion. The Raspberry Pi communicates with the MCP3008 using SPI serial interface protocol. MCP3008 is 8 channels 10-bit A/D Converter. The MCP3004/3008 devices operate over a broad voltage range (2.7V - 5.5V).



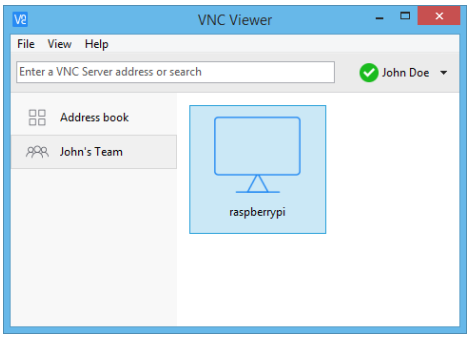
4. **LM35:** The LM35 series are precision Integrated circuit temperature devices with an output voltage linearly proportional to the Centigrade temperature. LM35 has a sensitivity of 10mV which means for every 10mV change in the voltage value will result in change in temperature of 1 degree.



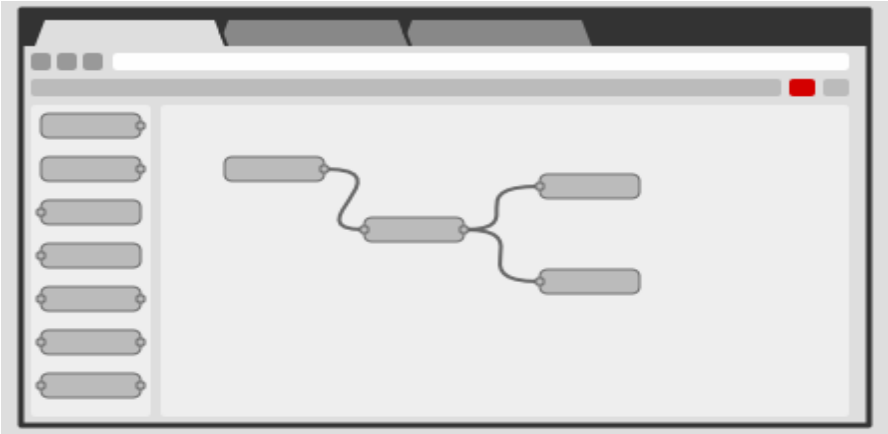
- **Software Components:**

1. **Putty:** It is a free open-source serial Console, terminal emulator and network file transfer application. It supports various network protocols that include SSH, Telnet, rlogin, raw socket connection and SCP.

2. **VNC Server (Remote Access Server):** It is the remote administrative tool that stands for Virtual Network Computing. It can transfer files from the local system to the remote workstation or vice versa with the work being performed via the remote connection. Its features also include automatic SSH (Secured Shell) connectivity with the UNIX/Linux systems.



3. **Node-Red:** It is a programming tool for wiring together hardware devices, APIs and online services in new and interesting ways. It provides a browser-based editor that makes it easy to wire together flows using the wide range of nodes in the palette that can be deployed to its runtime in a single-click. JavaScript functions can be created within the editor using a rich text editor. A built-in library allows you to save useful functions, templates or flows for reuse.



4. **IBM-Bluemix:** IBM Bluemix is a cloud platform as a service developed by IBM. It supports several programming languages and services as well as integrated DevOps to build, run, deploy and manage applications on the cloud.

Block Diagram:

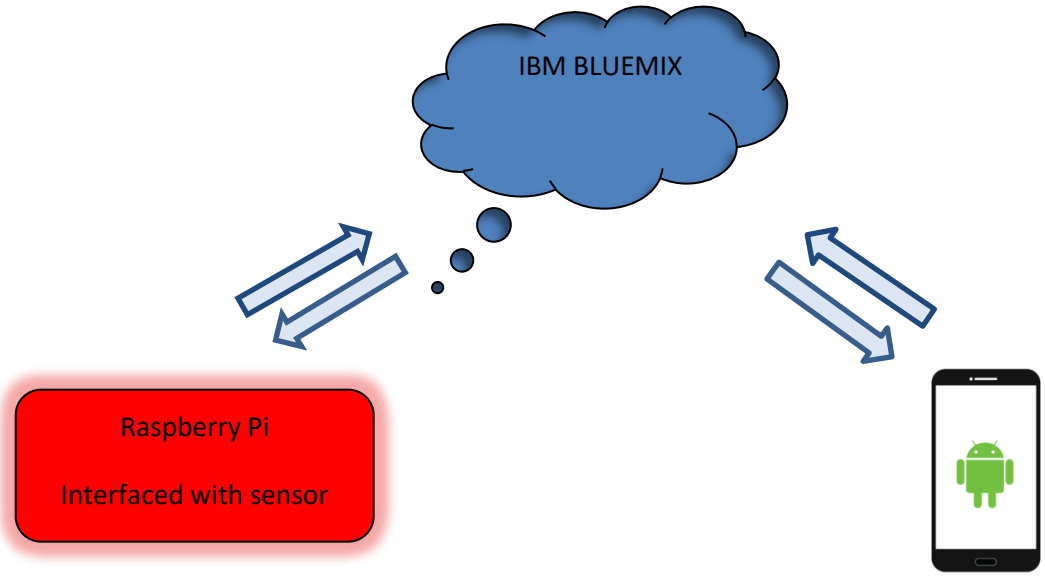
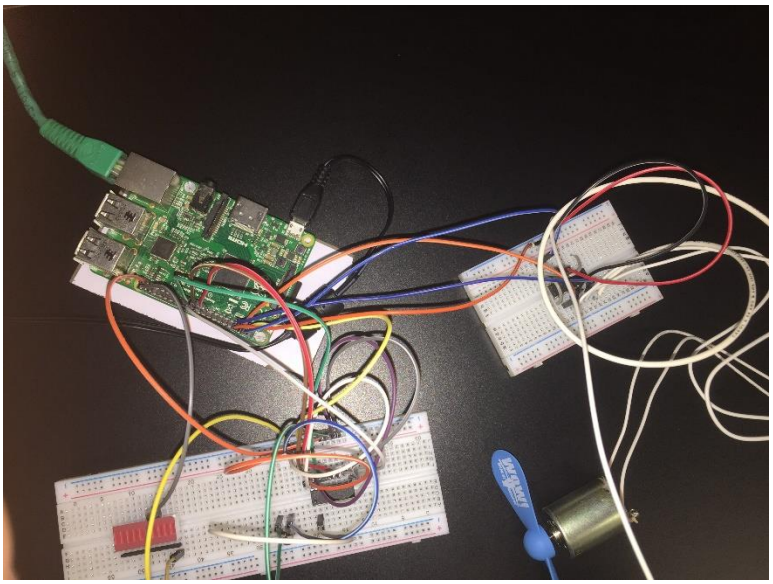
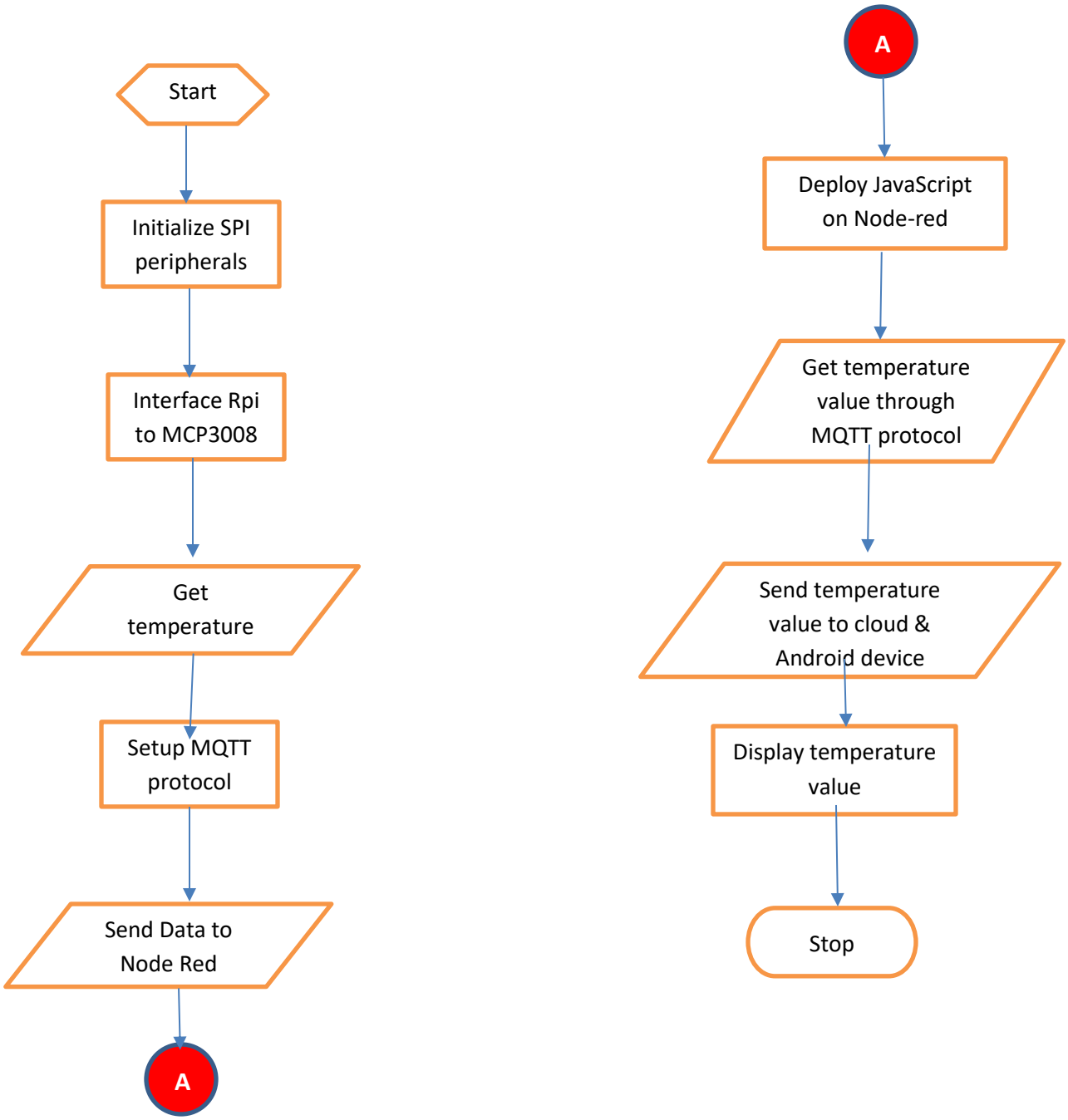


Figure: Shows the block diagram of the system

Connected Circuit:



Flowchart:


Start
Initialize SPI peripherals
Interface Rpi to MCP3008
Get temperature
Setup MQTT protocol
Send Data to Node Red
A
A
Deploy JavaScript on Node-red
Get temperature value through MQTT protocol
Send temperature value to cloud & Android device
Display temperature value
Stop

Procedure to setup the Raspberry Pi as an IoT device:

1. Follow the procedure from the link given below to setup your Raspberry Pi as an IOT device and get connected with the IBM Bluemix Cloud:
   https://developer.ibm.com/recipes/tutorials/raspberry-pi-4/

2. Installing Node RED on Raspberry Pi:
   https://nodered.org/docs/hardware/raspberrypi

3. Installing MQTT on Raspberry Pi:
   http://www.instructables.com/id/Installing-MQTT-BrokerMosquitto-on-Raspberry-Pi/

References:

1. Python Programming Tutorials by Programming Knowledge
   https://youtu.be/41qgdwd3zAg

2. For dependency errors of libssl1.0.0:
   https://github.com/ibm-watson-iot/device-raspberrypi/issues/17

3. Setting node red on android:
   https://nodered.org/docs/platforms/android

4. Smartphone as an IoT device:
   https://www.ibm.com/developerworks/library/iot-mobile-phone-iot-device-bluemix-apps-trs/

5. GUI for the Android device
   https://diyprojects.io/node-red-install-uninstall-easely-modules-palette-manager/#.Wi3Ped-nHIU