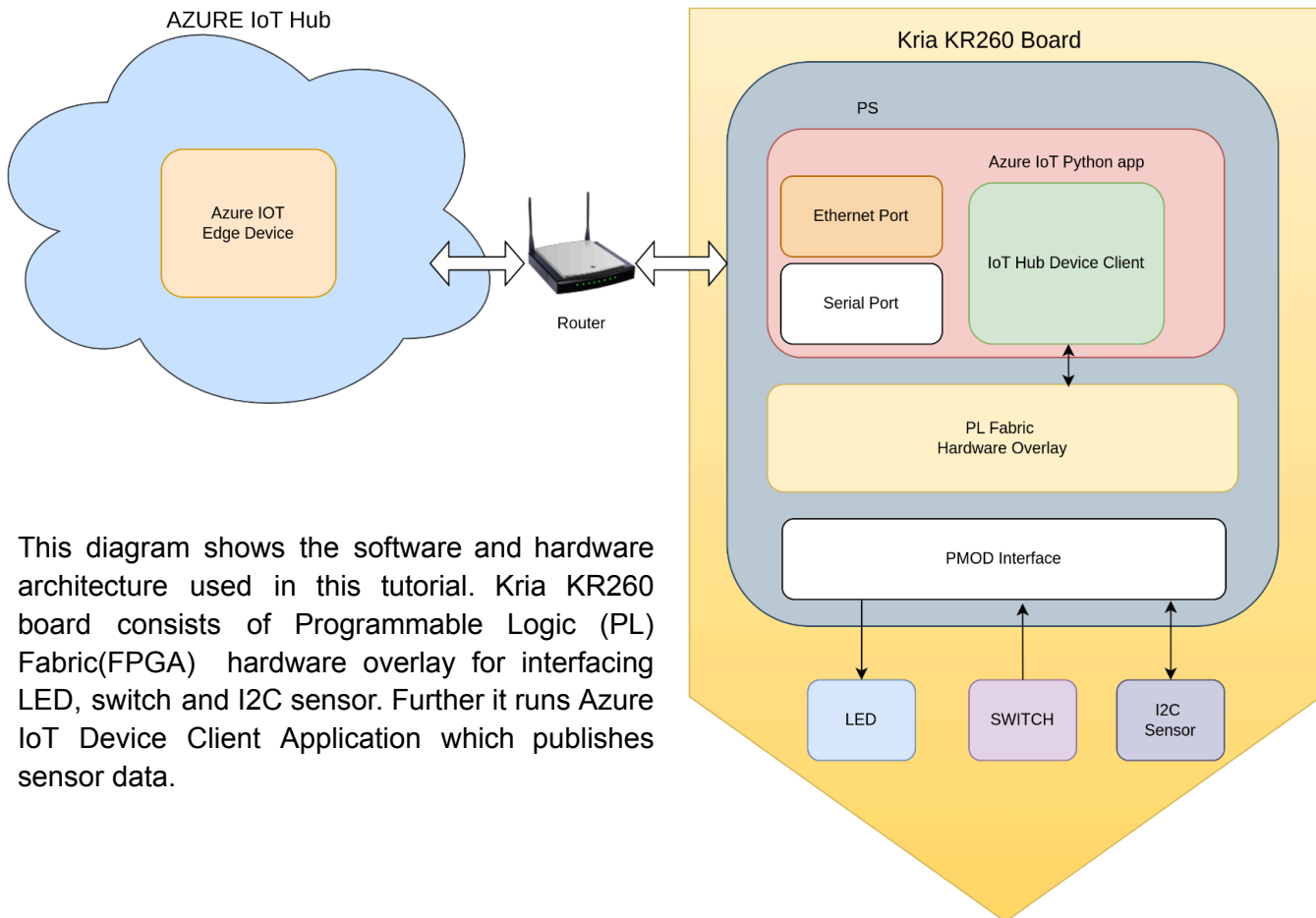
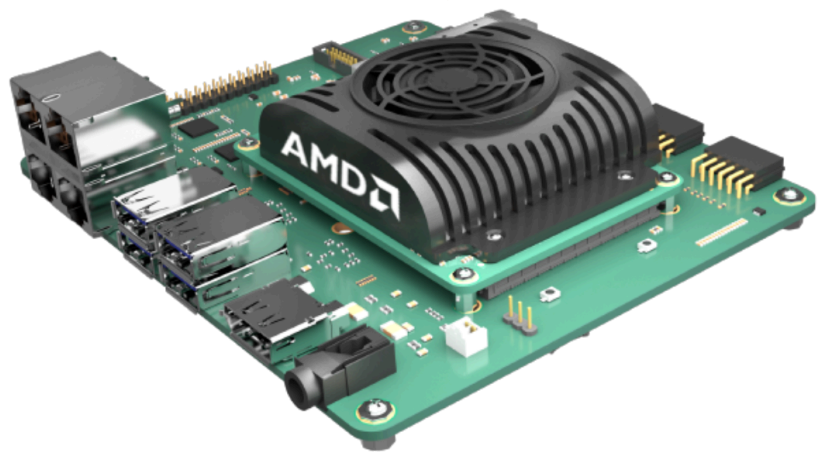


KR260 to Azure IoT Architecture

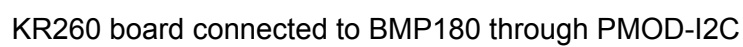


This diagram shows the software and hardware architecture used in this tutorial. Kria KR260 board consists of Programmable Logic (PL) Fabric(FPGA) hardware overlay for interfacing LED, switch and I2C sensor. Further it runs Azure IoT Device Client Application which publishes sensor data.



1. Kria KR260 board
2. BMP180 Module (Available at [Amazon](#))
3. Connecting wires

1. Ubuntu 22.04 for Kria KR260 board
2. Azure account



Preparing Ubuntu 22.04 OS for KRIA KR260 board

Download the Ubuntu 22.04 image from the [download link](#)

Ubuntu Desktop 22.04 LTS

The version of Ubuntu with up to 10 years of long term support, until April 2032.

Works on:

- ✓ KR260 Robotics Starter Kit
- ✓ KV260 Vision AI Starter Kit

ⓘ Please check the [AMD Kria™ Wiki](#) for the platform's latest boot firmware, technical documentation, and the [Ubuntu for AMD-Xilinx Devices Wiki](#) for known issues and limitations.

[Download 22.04 LTS](#)

[Kria™ KR260 Getting Started Guide for Ubuntu 22.04](#)

[Kria™ KV260 Getting Started Guide for Ubuntu 22.04](#)

Next, prepare the SD card with the above downloaded Ubuntu image using burning tools like Balena Etcher.

Now boot the KR260 with the SD card with Ethernet and USB to Serial cable connected to board. We will be using Serial console for initial access and debugging and Ethernet network for accessing through SSH and KR260 connected to the internet.

For initial login here are the Login Details:

Username : ubuntu

Password: ubuntu

This will ask to change the password. So update the password and login the system.

After successful login, one can access the KR260 device console.

Installing hardware overlay

Get the KR260 firmware folder. It contains:

- kr260_i2c.bit.bin
- kr260_i2c.dtbo
- shell.json

Copy these file to the KR260 board. For firmware to be loaded using xmutil (FPGA manager), one has to copy these file at “/lib/firmware/xilinx”.

For this create the folder at “kr260-i2c” at “/lib/firmware/xilinx” and copy the files in “kr260-i2c” folder.

```
cd /lib/firmware/xilinx
sudo mkdir kr260-i2c
sudo cp <kr260-firmware directory>/krc260_i2c* ./
sudo cp <kr260-firmware directory>/shell.json ./
```

Next, check the available fpga firmware using `xmutil listapps` command. `kr260-i2c` will be available in the list.

```
ubuntu@kria:~$ sudo xmutil listapps
[sudo] password for ubuntu:
      Accelerator      Accel_type      Base      Base_type      #slots(PL+AIE)      Active_slot
      kr260-i2c      XRT_FLAT      kr260-i2c      XRT_FLAT      (0+0)      -1
      k26-starter-kits      XRT_FLAT      k26-starter-kits      XRT_FLAT      (0+0)      0,
```

Next load the `kr260-i2c` firmware, which contains necessary hardwares(gpio) and interfaces. In our Greengrass Demo we will be using these gpio to trigger the publishing data to AWS Greengrass IoT cloud server and also actuate GPIO on the message received from AWS cloud.

```
sudo xmutil unloadapp
sudo xmutil loadapp kr260-i2c
```

```
ubuntu@kria:~$ sudo xmutil unloadapp
remove from slot 0 returns: 0 (0k)
ubuntu@kria:~$ sudo xmutil loadapp kr260-i2c
[ 1035.828900] OF: overlay: WARNING: memory leak will occur if overlay removed, property: /fpga-full/firmware-name
[ 1035.839040] OF: overlay: WARNING: memory leak will occur if overlay removed, property: /fpga-full/pid
[ 1035.848277] OF: overlay: WARNING: memory leak will occur if overlay removed, property: /fpga-full/resets
[ 1035.857771] OF: overlay: WARNING: memory leak will occur if overlay removed, property: /fpga-full/uid
[ 1035.867399] OF: overlay: WARNING: memory leak will occur if overlay removed, property: /__symbols__/overlay0
[ 1035.877241] OF: overlay: WARNING: memory leak will occur if overlay removed, property: /__symbols__/overlay1
[ 1035.887085] OF: overlay: WARNING: memory leak will occur if overlay removed, property: /__symbols__/afi0
[ 1035.896579] OF: overlay: WARNING: memory leak will occur if overlay removed, property: /__symbols__/clocking0
[ 1035.906509] OF: overlay: WARNING: memory leak will occur if overlay removed, property: /__symbols__/clocking1
[ 1035.916438] OF: overlay: WARNING: memory leak will occur if overlay removed, property: /__symbols__/overlay2
[ 1035.926280] OF: overlay: WARNING: memory leak will occur if overlay removed, property: /__symbols__/axi_gpio_0
[ 1035.936329] OF: overlay: WARNING: memory leak will occur if overlay removed, property: /__symbols__/misc_clk_0
[ 1035.946346] OF: overlay: WARNING: memory leak will occur if overlay removed, property: /__symbols__/axi_iic_0
[ 1035.956281] OF: overlay: WARNING: memory leak will occur if overlay removed, property: /__symbols__/misc_clk_1
[ 1035.966299] OF: overlay: WARNING: memory leak will occur if overlay removed, property: /__symbols__/axi_iic_1
[ 1035.976227] OF: overlay: WARNING: memory leak will occur if overlay removed, property: /__symbols__/axi_intc_0
[ 1035.986243] OF: overlay: WARNING: memory leak will occur if overlay removed, property: /__symbols__/axi_intc_1
[ 1036.067970] xiic-i2c 80020000.i2c: IRQ index 0 not found
kr260-i2c: loaded to slot 0
ubuntu@kria:~$ [ 1036.203709] zocl-drm axi:zyxclmm_drm: IRQ index 32 not found
```

Now, check the available i2c channels available in the system using `i2cdetect` i2c utility tool.

```
sudo i2cdetect -l
```

```
ubuntu@kria:~$ sudo i2cdetect -l
i2c-1  i2c          Cadence I2C at ff030000          I2C adapter
i2c-2  i2c          ZynqMP DP AUX                      I2C adapter
i2c-3  i2c          i2c-1-mux (chan_id 0)                  I2C adapter
i2c-4  i2c          i2c-1-mux (chan_id 1)                  I2C adapter
i2c-5  i2c          i2c-1-mux (chan_id 2)                  I2C adapter
i2c-6  i2c          i2c-1-mux (chan_id 3)                  I2C adapter
i2c-7  i2c          xiic-i2c 80020000.i2c          I2C adapter
i2c-8  i2c          xiic-i2c 80030000.i2c          I2C adapter
ubuntu@kria:~$
```

`i2c-8` channel will be used to connect to BMP180 sensor.

Connecting BMP180 to AXI I2C Bus

Connect BMP180 sensors, Vcc, GND, I2C SDA and I2C SCLK pins to PMOD as explained below:

PMOD1-> 6 - I2C SCLK

PMOD1-> 8 - I2C SDA

PMOD1-> GND - BMP180 GND

PMOD1->Vcc - BMP180 Vcc

11	9	7	5	3	1	PMOD UPPER
12	10	8	6	4	2	PMOD LOWER
Vcc	GND	I/O	I/O	I/O	I/O	

PMOD port numbering

After connecting BMP180 sensor to KR260 PMOD port, use i2c utility tools to scan for the available devices in i2c-8 channel.

```
sudo i2cdetect -y 8
```

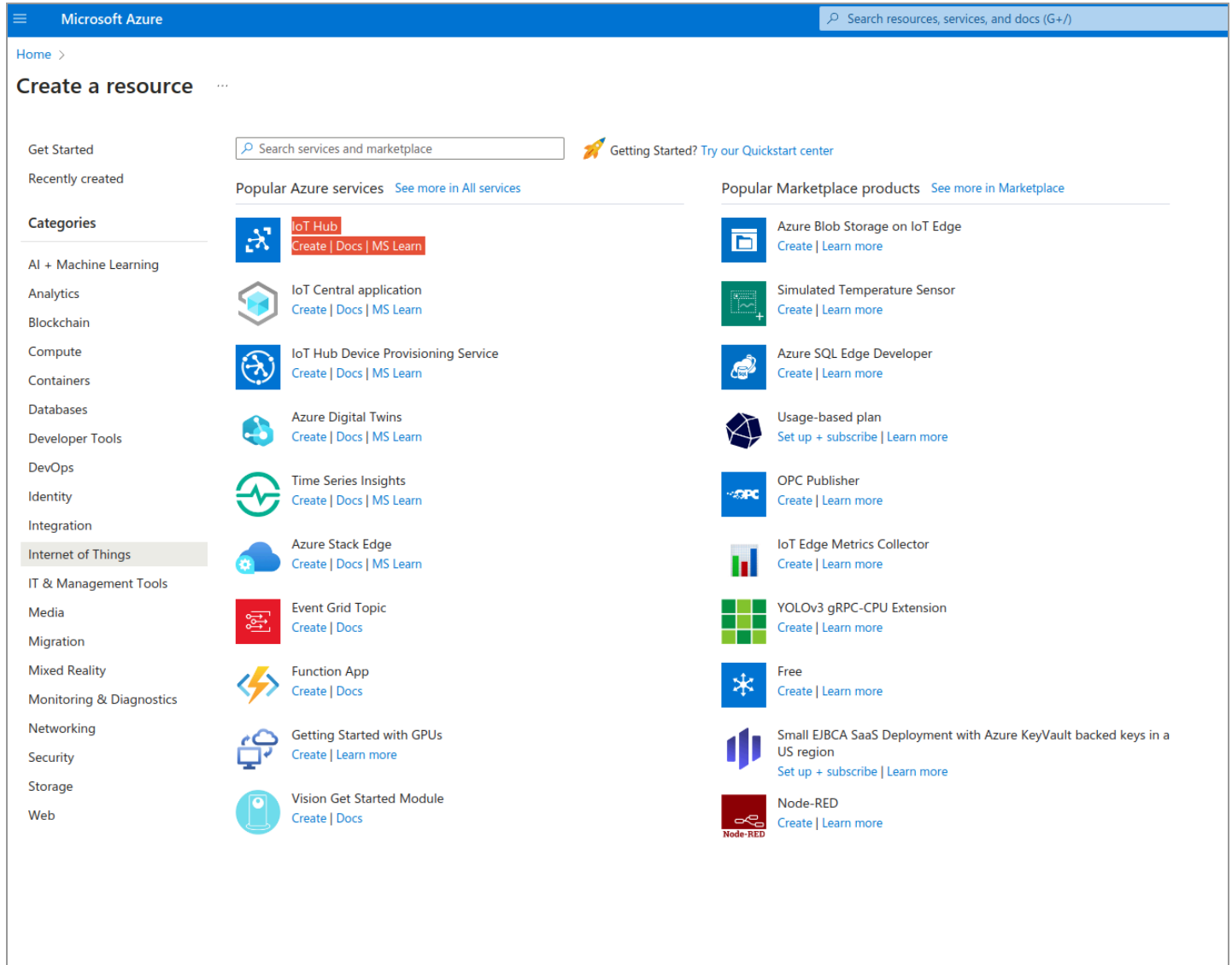
```
ubuntu@kria:~$ sudo i2cdetect -y 8
    0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:  -- -- -- -- -- -- -- -- -- -- -- -- -- --
10:  -- -- -- -- -- -- -- -- -- -- -- -- -- --
20:  -- -- -- -- -- -- -- -- -- -- -- -- -- --
30:  -- -- -- -- -- -- -- -- -- -- -- -- -- --
40:  -- -- -- -- -- -- -- -- -- -- -- -- -- --
50:  -- -- -- -- -- -- -- -- -- -- -- -- -- --
60:  -- -- -- -- -- -- -- -- -- -- -- -- -- --
70:  -- -- -- -- -- -- 77
ubuntu@kria:~$
```

In i2c scan, we find a device is available at address '77', which corresponds to BMP180 i2c sensor. Next we will add the component for publishing BMP180 sensor data to the AWS IoT cloud.

Follow these steps after installing AWS greengrass core device in the KR260 board as mentioned in Kria connect to AWS IoT - GPIO document.

Create IoT Hub in Azure Portal:

- Go to Azure portal " <https://portal.azure.com> ".
- Create a resource >> IoT Hub.



Next, create one IoT Hub Service and fill in the necessary details

Project details

Choose the subscription you'll use to manage deployments and costs. Use resource groups like folders to help you organize and manage resources.

Subscription * ⓘ

Azure subscription 1 ▼

Resource group * ⓘ

(New) KR260_edge_group ▼

[Create new](#)

Instance details

IoT hub name * ⓘ

Kriahub ✓

Region * ⓘ

East US ▼

Tier *

Free ▼

Free trial explores the app with live data. Trials cannot scale or be upgraded later.

[Compare tiers](#)

Daily message limit * ⓘ

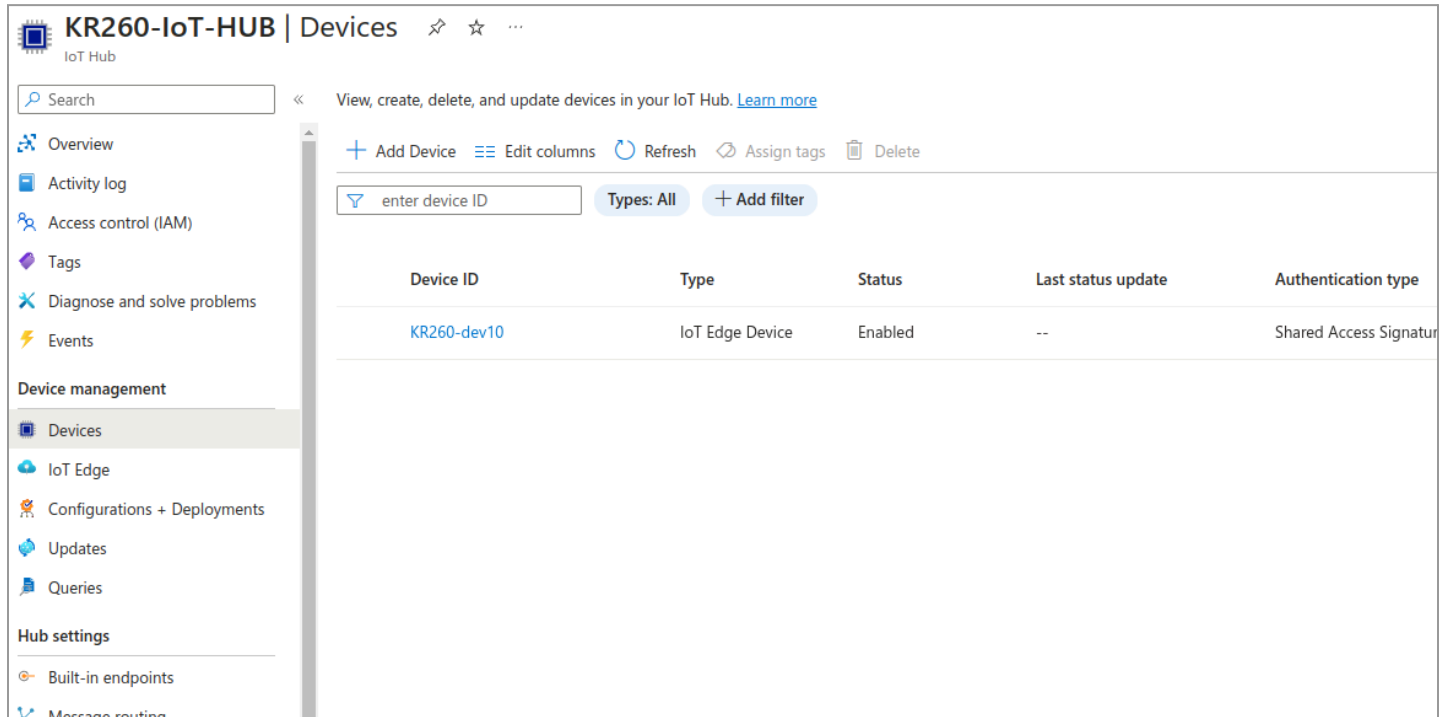
8,000 N/A ▼

✗ Free IoT hubs are limited to one per subscription

- Click on Review+ Create button to create the Azure IoT Hub.
- Next, create a device where you can actually receive some data from the hardware.

Create an IoT Device

Go to the IoT Device and click on new, and give the device ID



KR260-IoT-HUB | Devices [View, create, delete, and update devices in your IoT Hub. Learn more](#)

Search: « [View, create, delete, and update devices in your IoT Hub. Learn more](#)

[+ Add Device](#) [Edit columns](#) [Refresh](#) [Assign tags](#) [Delete](#)

[Types: All](#) [+ Add filter](#)

Device ID	Type	Status	Last status update	Authentication type
KR260-dev10	IoT Edge Device	Enabled	--	Shared Access Signature

Device management

- Devices**
- IoT Edge
- Configurations + Deployments
- Updates
- Queries


Hub settings


- Built-in endpoints
- Message routing

Next Click on +Add Device to add the device to the IoT Hub. This will open the form for creating the device.

Home > KR260-IoT-HUB | Devices >


Create a device

 Find Certified for Azure IoT devices in the Device Catalog


Device ID * 

kr260-dev


☐ IoT Edge Device

Authentication type 


Symmetric key X.509 Self-Signed X.509 CA Signed

Auto-generate keys 

☒

Connect this device to an IoT hub 

Enable Disable

Parent device 

No parent device

[Set a parent device](#)

After this device will be available in the IoT hub Device list.

Next, look into device information for getting the keys and connection string.

[Home](#) > [KR260-IoT-HUB](#) | [Devices](#) >

KR260-dev10

[Save](#) [Set modules](#) [Manage child devices](#) [Troubleshoot](#) [Device twin](#) [Refresh](#)

Device ID ⓘ

KR260-dev10

Primary key ⓘ

.....

Secondary key ⓘ

.....

Primary connection string ⓘ

.....

Secondary connection string ⓘ

.....

IoT Edge runtime response ⓘ

200 -- OK

Tags [\(edit\)](#)

No tags

Enable connection to IoT Hub ⓘ

☒ Enable
 ☐ Disable

Parent device ⓘ

No parent device

[Modules](#)
[IoT Edge hub connections](#)
[Deployments and Configurations](#)

Name	Type	Specified in Deployment	Reported by Device	Runtime Status	Exit Code
\$edgeAgent	IoT Edge System Module	✓ Yes	✓ Yes	running	NA
\$edgeHub	IoT Edge System Module	✓ Yes	✓ Yes	running	NA
SimulatedTemperatureSensor	IoT Edge Custom Module	✓ Yes	✓ Yes	running	NA

Copy the “Primary Connection String” which will be used in the python application for sending the sensor data to IoT hub.

Installing python packages

azure.iot.device python module is required to create a azure IoT device at the edge device. Install it using python pip3:

```
sudo pip3 install azure-iot-device
```

Further for getting 'bmp180' sensor data from i2c, install bmp180 python driver module from git. For installing, run following commands:

```
git clone https://github.com/m-rtijn/bmp180
cd bmp180
```

Update the ~/bmp180/bmp180/bmp180.py to use i2c-8 channel by changing following lines:

```
Copyright 2015-2017
Released under the MIT license.
"""

import smbus
import math
from time import sleep

class bmp180:
    # Global variables
    address = None
    bus = smbus.SMBus(8)
    mode = 1 # TODO: Add a way to change the mode

    # BMP180 registers
    CONTROL_REG = 0xF4
    DATA_REG = 0xF6

    # Calibration data registers
ubuntu@kria:~/bmp180/bmp180$ ls
__init__.py  __pycache__  bmp180.py
```

Install the bmp180 module by running:

```
sudo python3 setup.py install
```

Adding python application in KRIA

Copy the azure_bmp180.py example code to the KR260 board.

Next update the "CONNECTION STRING" with the above Primary Connection string.

```

1 import random
2 import time
3 from bmp180 import bmp180
4
5 bmp = bmp180(0x77)
6
7
8 from azure.iot.device import IoTHubDeviceClient, Message
9
10 CONNECTION_STRING = "<Connection String>"
11
12 TEMPERATURE = 20.0
13 HUMIDITY = 60
14 MSG_TXT = '{"temperature": {temperature},"humidity": {humidity}}'
15
16 def iot_hub_client_init():
17     client = IoTHubDeviceClient.create_from_connection_string(CONNECTION_STRING)
18     return client
19
20 def iot_hub_client_telemetry_sample_run():
21
22     try:
23         client = iot_hub_client_init()
24         print ( "IoT Hub device sending periodic messages, press Ctrl-C to exit" )
25         while True:
26
27             temperature = TEMPERATURE + (random.random() * 15)
28             humidity = HUMIDITY + (random.random() * 20)
29             msg_txt_formatted = MSG_TXT.format(temperature=bmp.get_temp(), humidity=humidity)
30             message = Message(msg_txt_formatted)
31

```

Then run the application in console:

```
sudo python3 azure_bmp180.py
```

Here is the console log after a successful message send to Azure IoT hub.

```

ubuntu@kria:~$ sudo python3 azure_bmp180.py
IoT Hub Quickstart #1 - Simulated device
Press Ctrl-C to exit
IoT Hub device sending periodic messages, press Ctrl-C to exit
Sending message: {"temperature": 40.0641054832476,"pressure": 87702.42108554466}
Message successfully sent
Sending message: {"temperature": 40.0641054832476,"pressure": 87693.25119464338}
Message successfully sent
Sending message: {"temperature": 40.0523917363651,"pressure": 87700.52978966695}
Message successfully sent
Sending message: {"temperature": 40.04067743940643,"pressure": 87700.52978966695}
Message successfully sent
Sending message: {"temperature": 40.05824867855125,"pressure": 87702.13451080855}
Message successfully sent
Sending message: {"temperature": 40.0641054832476,"pressure": 87700.07092057214}
Message successfully sent
Sending message: {"temperature": 40.00024242577674,"pressure": 87699.52251504514}

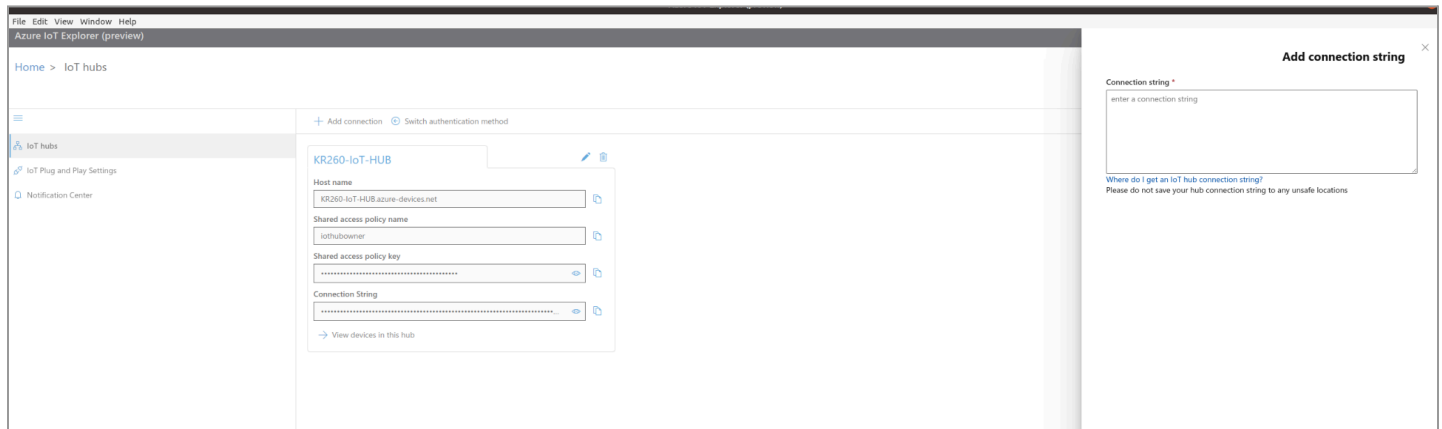
```

Viewing message in Host Machine

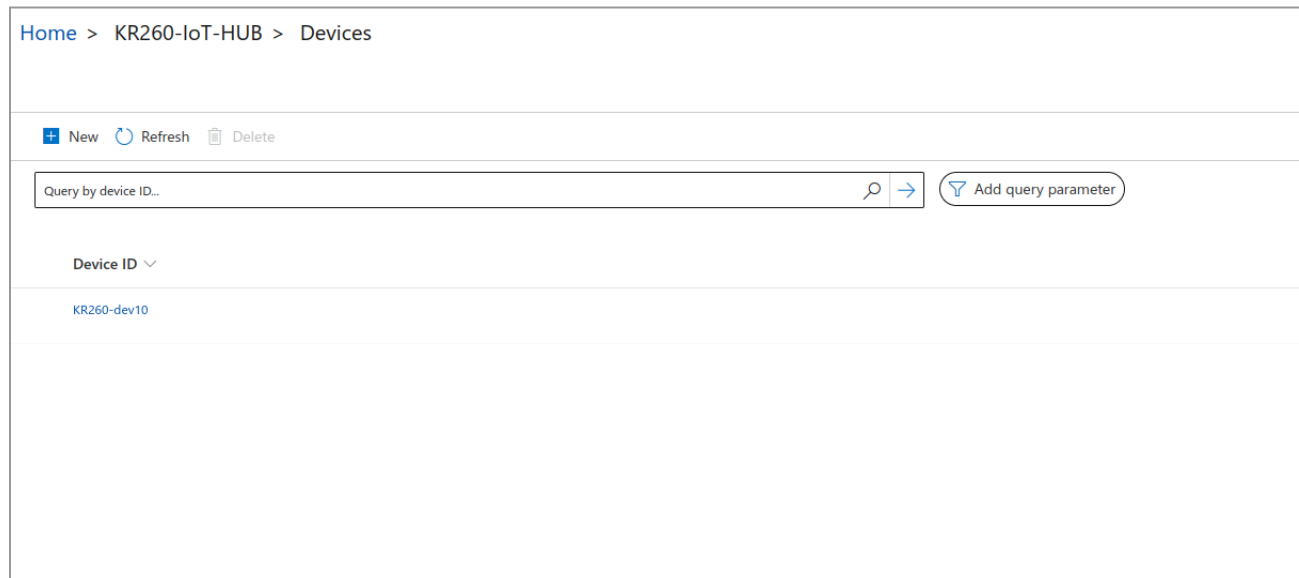
For viewing the message published by Azure IoT Device in KR260, one can use Azure IoT explorer available in following link:

<https://github.com/Azure/azure-iot-explorer/releases>

In IoT Hubs page of the application, in +Add connection copy the connection string for the IoT hub and save the configs:



One can find the corresponding device list in the IoT HuB page of Azure IoT explorer application.



Just click onto the device to view the device information and also the message send by python application running in the KR260 board.

For viewing the message send to device, go to Telemetry and click the >Start button. After this one can view the message send to the device.

[Home](#) > [KR260-IoT-HUB](#) > [Devices](#) > [KR260-dev10](#) > [Telemetry](#)

[Direct method](#)

[Cloud-to-device message](#)

[Module identities](#)

☐ No

☒ Yes

☐ Show system properties

Receiving events...

```

Tue Jan 02 2024 16:17:56 GMT+0545 (Nepal Time):
{
  "body": {
    "temperature": 40.36847058912238,
    "pressure": 87685.14153315352
  },
  "enqueuedTime": "Tue Jan 02 2024 16:17:56 GMT+0545 (Nepal Time)",
  "properties": {
    "temperatureAlert": "false"
  }
}

Tue Jan 02 2024 16:17:53 GMT+0545 (Nepal Time):
{
  "body": {
    "temperature": 40.36847058912238,
    "pressure": 87685.14153315352
  },
  "enqueuedTime": "Tue Jan 02 2024 16:17:53 GMT+0545 (Nepal Time)",
  "properties": {
    "temperatureAlert": "false"
  }
}
        
```

Now we can collect the sensor data into the database and also create logic to trigger actions on the basis of sensor data.
