BM201-VSD EVM Kit hardware running with VSD Key Value Python Demo software

Date: October 2020

For configuring BM201-VSD EVM Kit hardware to run with VSD Key Value Python Demo software, please refer to the following instructions for setting up the software and hardware properly.

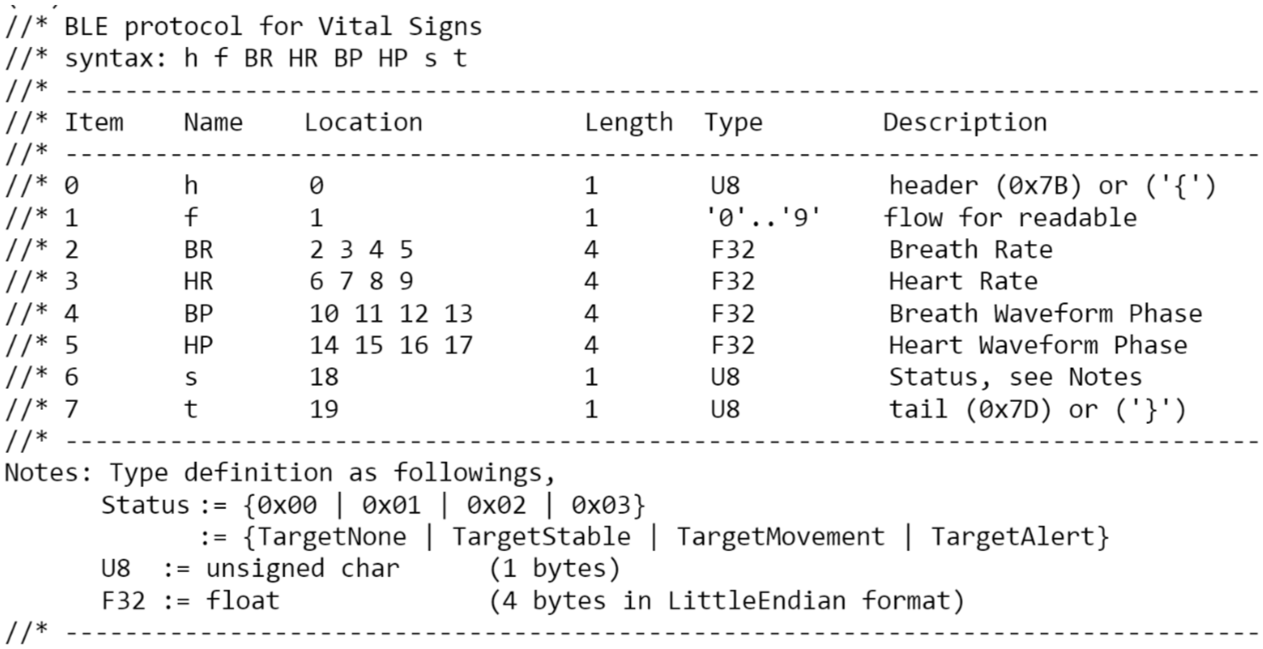
On software side, you may find Key Data / Key Value (kv) Python Code examples for Joybien Vital Signs Detection (VSD) for Heart Beat Rate and Breath Rate demo on GitHub at:

https://github.com/bigheadG/mmWave then select VSD Folder:
https://github.com/bigheadG/mmWave/tree/master/VSD then you may find:
vitalSign_ex0_kv.py and vitalSign_ex1_Thread_kv.py files for VSD-kv demo examples;

and that the Key Data / Key Value baud rate setting within the Python Code is set at 115200 bps; and based on Key Data Protocol found at:

https://github.com/bigheadG/mmWaveDocs/blob/master/V01_VSD_vitalSignsBLEProtocol_v01_03_pdf.pdf ;

where you may find a 20-Byte VSD Protocol in every 50ms frame (also suitable for Bluetooth BLE communication) with the structure below:



```
//* BLE protocol for Vital Signs
//* syntax: h f BR HR BP HP s t
//* --------------------------------------------------------------------------
//* Item    Name    Location          Length  Type        Description
//* --------------------------------------------------------------------------
//* 0       h       0                 1       U8          header (0x7B) or ('{')
//* 1       f       1                 1       '0'..'9'    flow for readable
//* 2       BR      2 3 4 5           4       F32         Breath Rate
//* 3       HR      6 7 8 9           4       F32         Heart Rate
//* 4       BP      10 11 12 13       4       F32         Breath Waveform Phase
//* 5       HP      14 15 16 17       4       F32         Heart Waveform Phase
//* 6       s       18                1       U8          Status, see Notes
//* 7       t       19                1       U8          tail (0x7D) or ('}')
//* --------------------------------------------------------------------------
Notes: Type definition as followings,
      Status := {0x00 | 0x01 | 0x02 | 0x03}
             := {TargetNone | TargetStable | TargetMovement | TargetAlert}
      U8  := unsigned char       (1 bytes)
      F32 := float               (4 bytes in LittleEndian format)
//* --------------------------------------------------------------------------
```

On hardware side, to run these VSD Key Data/Value Python demo codes, you please place the corresponding HAT-Board JUMPERs to the correct positions (then attach the BM201-VSD Module on top of the HAT-Board), including:

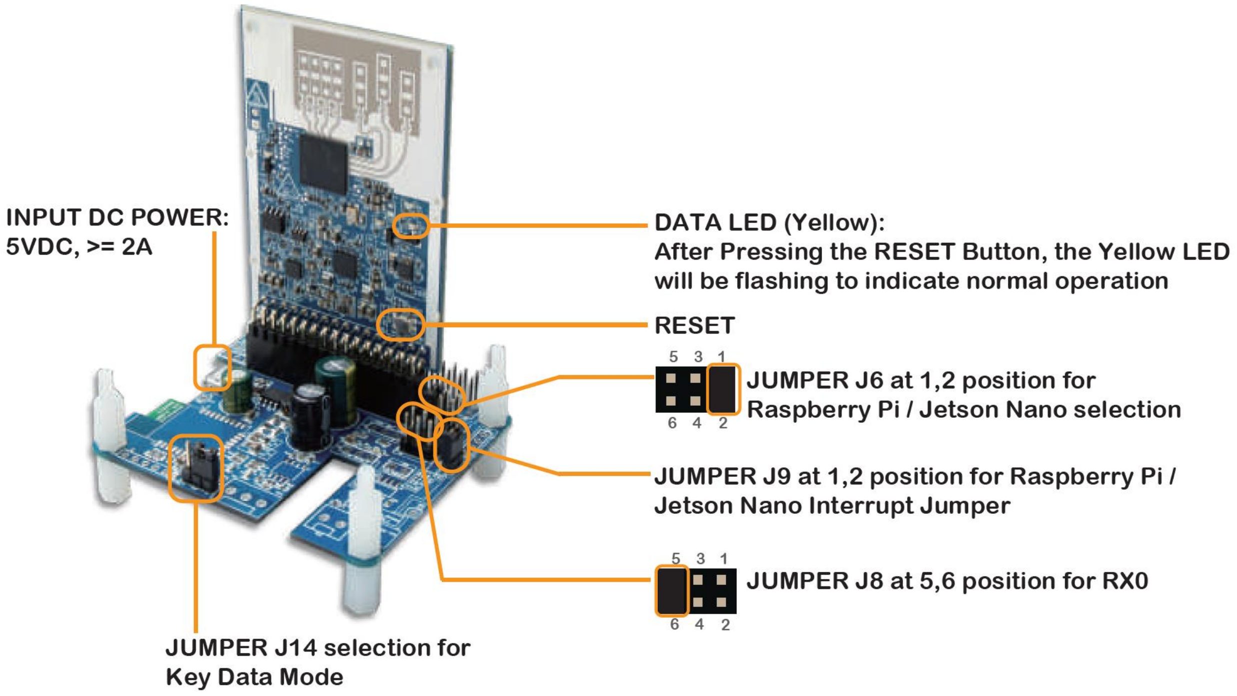
1. JUMPER J14 at 2,3 position for Key Data selection (for running baud rate at 115200 bps).
2. JUMPER J8 at 5,6 position

And if you are using Raspberry Pi or Jetson Nano, please place the following jumpers to the correct positions:

3. JUMPER J6 at 1,2 position for sending Tx data out to Raspberry Pi / Jetson Nano.
4. JUMPER J9 at 1,2 position for Raspberry Pi / Jetson Nano Interrupt

After JUMPER changes, please press RESET on mmWave Module to re-start running Vital Signs Detection using the new hardware configuration; and the Yellow DATA LED will be flashing to indicate that the VSD detection is functioning properly.

(B) Key Data Mode



INPUT DC POWER: 5VDC, >= 2A

DATA LED (Yellow): After Pressing the RESET Button, the Yellow LED will be flashing to indicate normal operation

RESET

JUMPER J6 at 1,2 position for Raspberry Pi / Jetson Nano selection

JUMPER J9 at 1,2 position for Raspberry Pi / Jetson Nano Interrupt Jumper

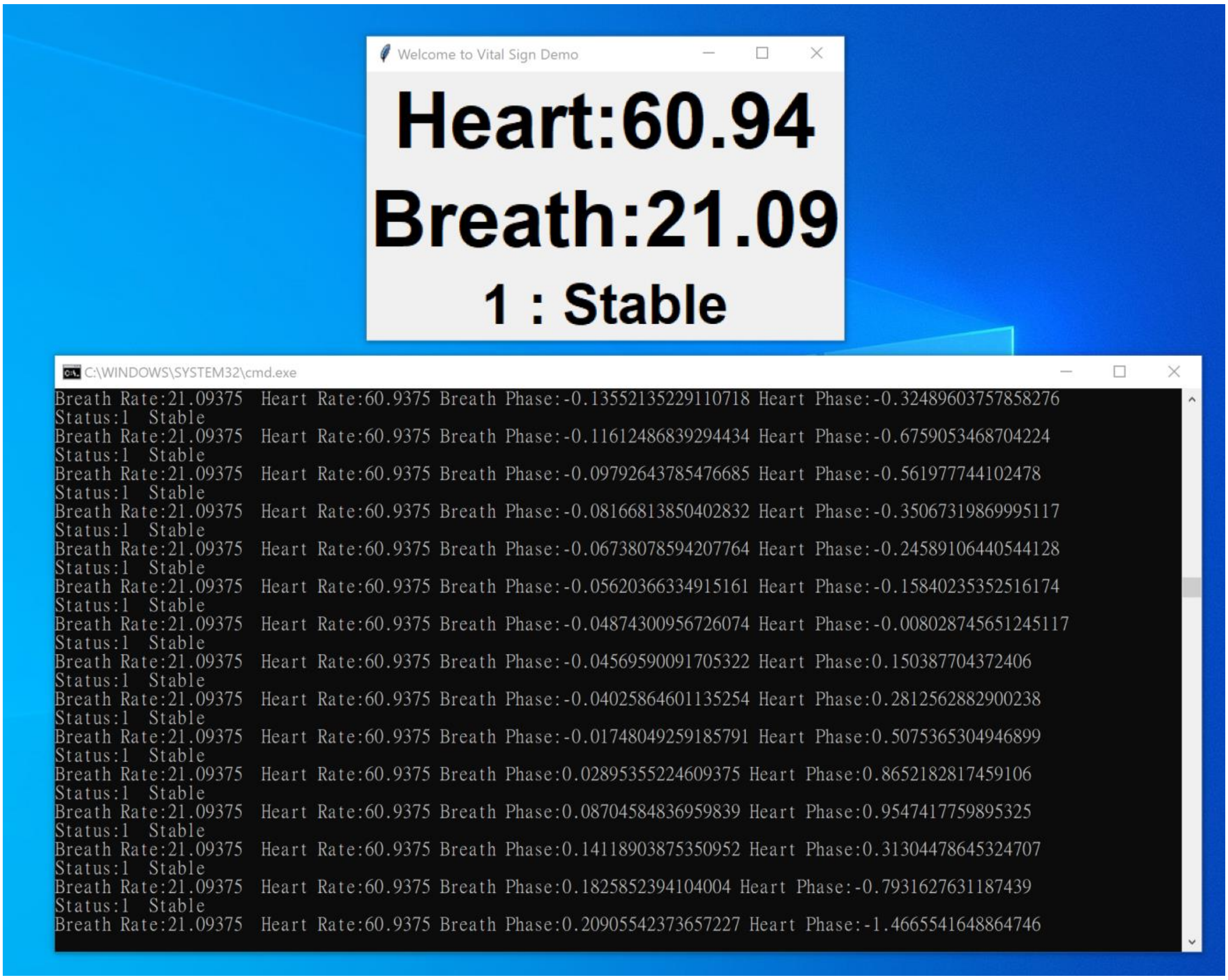
JUMPER J8 at 5,6 position for RX0

JUMPER J14 selection for Key Data Mode

For the execution after properly configured the software and hardware, and pending the Key Value Python Code executed, you may see on your computer with a Terminal Screen showing Status, Breath Rate, Heart Rate, Breath Phase, and Heart Phase; and may have another message box showing Heart Rate, Breath Rate, and STATUS flag.

And the states of the STATUS flag are as follows:

STATUS = numeric value of 0 means None or No People Present,
STATUS = numeric value of 1 means Stable with People Present,
STATUS = numeric value of 2 means Movement with People Present,
STATUS = numeric value of 3 means Alert with People Present, but with No Breathing / Vital Signs.



```
Heart:60.94
Breath:21.09
1 : Stable
```

```
Breath Rate:21.09375  Heart Rate:60.9375 Breath Phase:-0.13552135229110718 Heart Phase:-0.32489603757858276
Status:1  Stable
Breath Rate:21.09375  Heart Rate:60.9375 Breath Phase:-0.11612486839294434 Heart Phase:-0.6759053468704224
Status:1  Stable
Breath Rate:21.09375  Heart Rate:60.9375 Breath Phase:-0.09792643785476685 Heart Phase:-0.561977744102478
Status:1  Stable
Breath Rate:21.09375  Heart Rate:60.9375 Breath Phase:-0.08166813850402832 Heart Phase:-0.35067319869995117
Status:1  Stable
Breath Rate:21.09375  Heart Rate:60.9375 Breath Phase:-0.06738078594207764 Heart Phase:-0.24589106440544128
Status:1  Stable
Breath Rate:21.09375  Heart Rate:60.9375 Breath Phase:-0.05620366334915161 Heart Phase:-0.15840235352516174
Status:1  Stable
Breath Rate:21.09375  Heart Rate:60.9375 Breath Phase:-0.04874300956726074 Heart Phase:-0.008028745651245117
Status:1  Stable
Breath Rate:21.09375  Heart Rate:60.9375 Breath Phase:-0.04569590091705322 Heart Phase:0.150387704372406
Status:1  Stable
Breath Rate:21.09375  Heart Rate:60.9375 Breath Phase:-0.04025864601135254 Heart Phase:0.2812562882900238
Status:1  Stable
Breath Rate:21.09375  Heart Rate:60.9375 Breath Phase:-0.01748049259185791 Heart Phase:0.5075365304946899
Status:1  Stable
Breath Rate:21.09375  Heart Rate:60.9375 Breath Phase:0.028953552246O9375 Heart Phase:0.8652182817459106
Status:1  Stable
Breath Rate:21.09375  Heart Rate:60.9375 Breath Phase:0.08704584836959839 Heart Phase:0.954741775989532S
Status:1  Stable
Breath Rate:21.09375  Heart Rate:60.9375 Breath Phase:0.14118903875350952 Heart Phase:0.3130447864532470７
Status:1  Stable
Breath Rate:21.09375  Heart Rate:60.9375 Breath Phase:0.1825852394104004 Heart Phase:-0.7931627631187439
Status:1  Stable
Breath Rate:21.09375  Heart Rate:60.9375 Breath Phase:0.20905542373657227 Heart Phase:-1.4665541648864746
```

After both VSD Python software and mmWave hardware are set up properly and running (and note that the physical distance from mmWave Module to a single target person is in 30cm ~ 90cm range; and no obstacles or other persons in that range), you may then proceed with mmWave VSD data post processing using STATUS flag and Heart & Breath data for further VSD detection algorithm enhancements with the following considerations (as example conditions):

1. May check for a rolling time period/window of, say, 5/10/20 seconds or more to see which of the STATUS flags is 'dominant' in this time period, then identify the STATUS with such dominant flag-value for the entire period (and disregard other non-dominant STATUS flag-values and their related Heart & Breath Rate data, since these data may be just environment noise).

2. When the dominant STATUS = 0, then there's no people present for the given period. At this time, DON'T show Heart Beat Rate and Breath Rate data value on screen (since it is meaningless without a person in front of the mmWave Sensor); and the reason why there are Heart Beat Rate & Breath Rate data running even without a person in front, is that the mmWave VSD sensor is always running regardless whether there's a person; and the sensor may just 'feed' the environment noise into the VSD algorithms for the calculation (which in the end, you must disregard).

3. When the dominant STATUS = 1, then there's a person present for the given period and in relatively STABLE position. And for each and every 50ms data frame having STATUS = 1 in this given time period, you may find the rolling average or statistical distribution of Heart Beat Rate or Breath Rate, and/or 'relatively' suitable/normal upper & lower bound values for each of the Heart Beat Rate or Breath Rate data (while removing any sudden 'spikes' with extremely high or extremely low data values received due to noise) to indicate the state of the person under observation. And you may display the MEAN or the statistical confidence level value of the data for data monitoring purpose.

   You may further analyze the data collected here using advanced algorithms or using Machine Learning to further interpret the monitored data.

4. When the dominant STATUS = 2, then there's a person present for the given period, but not in stable state, and with MOVEMENT. You may disregard the Heart Beat Rate and Breath Rate data obtained in this given time period, because the target person moves too much to give correct data reading.

   However, you may observe a greater time range when this person is detected with STATUS = 2 (such as overnight with mostly STATUS = 2, which means that the person may not sleep well that night).

5. When the dominant STATUS = 3, then there's a person present, but without Breathing / Vital Signs; so you should issue an ALERT message out immediately to call for help. At this time, DON'T show Heart Beat Rate and Breath Rate data value on screen (since it is meaningless due to the person is without Vital Signs).

   Note that there may be Heart Beat Rate and Breath Rate Data collected by the mmWave Sensor at this time, for the reason that the mmWave VSD sensor is 'seeing' the environment noise, and 'feeding' the noise into the VSD algorithms for the calculation (which in the end, you must disregard).

If you'd like to perform further research using BM201-VSD mmWave EVM Kit, you may also consider using VSD raw data mode for analysis; and you may refer to: https://github.com/bigheadG/mmWaveDocs/blob/master/DriverVitalSigns_DevelopersGuide.pdf for TI Lab Guide, or other Joybien VSD Python Codes running in raw data mode.