2019/11/28
Version for Third Part IoT Platform Integration
Product BOB 1.0 and 1.1, PN 3.x and 4.x; Sensor version: MPU and KX
Sensor firmware version v0.3.5 or higher / v0.4.5 or higher

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Table of content

Document history

2019/08/27: document compilation for third party platform integration
2019/08/30: header coding corrected for some uplink frames; added byte#2 (bat level) on STATE frame; added ‘chart examples’;
2019/9/2: payload examples added; fixed for KX frames;
2019/9/10: changes only for downlink payloads after fw improvements (V0.4.4); removed ‘very slow measurement’; added Alarm threshold; Enable/Disable state index shifted!
2019/9/17: some wording changes in the fields explanations;
2019/9/25: adding chapter about variants KX and MPU; Important, fix for Start message header!
2019/10/15 : Adding raw payload examples and correct downlink values
2019/11/28 : Report message table correction (anomaly distribution) and payload decryption examples

Product Variants ‘MPU’ and ‘KX’

Product variants

BOB ASSISTANT is available into 2 major variants, depending on the mounted accelerometer sensor. Those 2 variants present both different range of measurement, accuracy, and therefore monitoring capabilities.

	Sensor type	**PN***	**Monitored frequencies**	**Sampling rate**	**32 values FFT report**	**Available for markets**
BOB 1.0	MPU	3.x	20 Hz - 500 Hz	1000 Hz	32 values between 0 and 500Hz (step 16 Hz)	EU only
BOB 1.1	KX	4.x	20 Hz - 12800 Hz	Low Frequency 800Hz and High Frequency 25600Hz	32 values between 0 and 3200 Hz (step 100Hz)	EU US as prototype

*label at the back of the product

Incidence on Payload type identification

Each type of message is identified using the byte 0.
Value is different between KX and MPU in order to know if the message is coming from a MPU or KX device.
Example: for the frame ‘report’, a MPU payload would be identified by the byte 0 = ‘r’, as for KX sensor, the payload would be identified by the byte 0 = ‘R’. See the payload tables for more details.

Incidence on Payload data content

MPU and KX are sending the same message. However, the **peak frequency** value is calculated using the following Low Frequency data rate.
MPU:

- FREQ_SAMPLING_ACC_LF = FREQ_SAMPLING_ACC_HF =1000 Hz

KX:

- FREQ_SAMPLING_ACC_LF = 800Hz
- FREQ_SAMPLING_ACC_HF = 25600Hz

Uplink payloads (Device to LoRa server)

Introduction

BOB ASSISTANT sends 4 types of messages: LEARNING, REPORT, ALARM and STATE. The payload for each message has a different structure, and each message type is identified with the byte 0 of the payload (header).

- LEARNING occurs only during the Learning phase (up to 7 days);
- REPORT is sent each 3 hours (default configuration);
- ALARM message is sent when anomaly level reaches XX% (25% default).
- STATE is sent when the measured equipment changes its state from ON to OFF or OFF to ON (start/stop), or when sensor is on.

STATE message is the first applicative payload sent by the device after power-on.

LEARNING MESSAGE payload structure

Byte	Signification	Value (dec)	Real_Value	Unit	Range	Description
0	MPU = "L" or KX = "I"	MPU = 76 (hex=0x4C) Or KX = 108 (hex=0x6C)		const		Head (Learning)
1	Learning percentage	0~100	Value	%	[0, 100]	0-100: Percentage of learning process, int. Followed by the last sample (only 0-100 are learning, others are system messages)
2	Vibration level (vl_1)	0~127	Value	g	[0, 127]	vl = (vl_1 * 128 + vl_2 + vl_3 / 100) / 10 / 121.45, float; the threshold of vibration level is 0.01g
3	Vibration level (vl_2)	0~127	Value			
4	Vibration level (vl_3)	0~127	Value			
5	Peak frequency index (where is the maximum value of vibration)	0~127	Value + 1	Hz		int Frequency_index = Value + 1 Frequency_value = (Value + 1) * FREQ_SAMPLING_ACC_LF / 256
6	Temperature	0~127	Value - 30	°C	[-30, 97]	The Value is constrained to be with a range [-30 97], int
7	Learning from 0 or additional learning	0~1	Value			1: Learning from 0; 0: Additional learning
8~39	FFT signal (needed to be calculated with vibration level)	0~127		g; Hz		Value_g = Value * vl / 127; Frequency_hz = (i * 4 + 4) * FREQ_SAMPLING_ACC_HF / 256 (i is the index of FFT array, begins from 0, ends by 31)

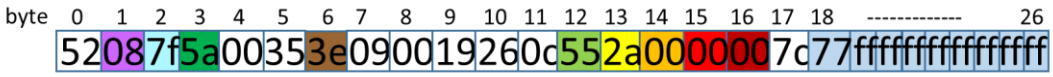
REPORT MESSAGE payload structure

Byte	Signification	Value (dec)	Real_Value (dec)	Unit	Range	Description
0	MPU = "R" or KX = "r"	MPU = 82 (hex=0x52) Or KX = 114 (hex=0x72)		const		Head (Report)
1	Anomaly level in % (drift with respect to the reference vibration signature)	0~127	Value * 100 / 127	%	[0, 100]	int
2	Operating time of the monitored equipment over the report length	0~127	Value * report length / 127	%	[0, 100]	int report length = byte 6
3	Time, in minutes, spent in the [0% - 10%] range of anomaly level	0~127	Value * operating time / 127	%	[0, 100]	int
4	Number of alarms during this report period	0~127	Value		[0,)	int
5	Temperature	0~127	Value - 30	°C	[-30, 97]	int
6	Report period (R_V)	0~127	Value	Minute		R_V <= 59, period_report unit is minute, int; R_V > 59, period_report unit is minute (R_V - 59)*60, int
7	Report ID	0~9	Value		[0, 9]	int, used to identify the message (increase with time)
8	Vibration level (vl_1)	0~127	Value	g	[0, 127]	Max amplitude (on 3 bytes) vl = (vl_1 * 128 + vl_2 + vl_3 / 100) / 10 / 121.45
9	Vibration level (vl_2)	0~127	Value			
10	Vibration level (vl_3)	0~127	Value			
11	Peak frequency index (frequency at highest amplitude recorded)	0~127	Value + 1			int Freq_index = Value + 1 Freq_value = (Value + 1) * FREQ_SAMPLING_ACC_LF / 256
12	Time, in minutes, spent in the [10% - 20%] range of anomaly level	0~127	(Total operating time - time in the [0-10%] anomaly range)*Value/ 127	mn	[0, 100]	int
13	Time, in minutes, spent in the 20% - 40%] range of anomaly level	0~127	(Total operating time - time in the [0-10%] anomaly range)*Value/ 127	mn	[0, 100]	int

Byte	Signification	Value (dec)	Real_Value (dec)	Unit	Range	Description
14	Time, in minutes, spent in the [40% - 60%] range of anomaly level	0~127	(Total operating time - time in the [0-10%] anomaly range)*Value/ 127	mn	[0, 100]	int
15	Time, in minutes, spent in the [60% - 80%] range of anomaly level	0~127	(Total operating time - time in the [0-10%] anomaly range)*Value/ 127	mn	[0, 100]	int
16	Time, in minutes, spent in the e [80% - 100%] range of anomaly level	0~127	(Total operating time - time in the [0-10%] anomaly range)*Value/ 127	mn	[0, 100]	int
17	Battery percentage	0~127	Value * 100 / 127	%	[0, 100]	int
18	Anomaly level reaches 20 % (Prediction based on the data of last 24 hour	0~255	Value	hour	[0, 255]	int, if 255 means infinite
19	Anomaly level reaches 50 % (Prediction based on the data of last 24 hours)	0~255	Value	hour	[0, 255]	int, if 255 means infinite
20	Anomaly level reaches 80 % (Prediction based on the data of last 24 hours)	0~255	Value	hour	[0, 255]	int, if 255 means infinite
21	Anomaly level reaches 20 % (Prediction based on the data of last 30 days)	0~255	Value	day	[0, 255]	int, if 255 means infinite
22	Anomaly level reaches 50 % (Prediction based on the data of last 30 days)	0~255	Value	day	[0, 255]	int, if 255 means infinite
23	Anomaly level reaches 80 % (Prediction based on the data of last 30 days)	0~255	Value	day	[0, 255]	int, if 255 means infinite
24	Anomaly level reaches 20 % (Prediction based on the data of last 6 months)	0~255	Value	month	[0, 255]	int, if 255 means infinite
25	Anomaly level reaches 50 % (Prediction based on the data of last 6 months)	0~255	Value	month	[0, 255]	int, if 255 means infinite
26	Anomaly level reaches 80 % (Prediction based on the data of last 6 months)	0~255	Value	month	[0, 255]	int, if 255 means infinite

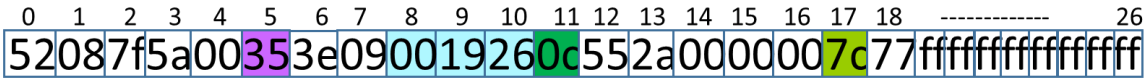
Example of vibration anomaly data extraction

Decrypted payload



Byte(s)	Description	hex.	dec.	Value	Unit	Comments / indirect data
1	Average anomaly level	08	8	8 x 100 / 127 = 6,3	%	Calculated over « machine on » time
2	Operating time	7f	127	127 x 180/127 = 180	mn	Report length = 180 mn Operating rate in pourcentage : [dec. Value] * 100 / 127
3	Time spent in the [0-10%] range of anomaly	5a	90	90 x 180 / 127 = 128	mn	To have the value in pourcentage : [value in min] / [Report length] * 100
6	Report length	3e	62	(62 -59) x 3 = 180	min	If value < 59 →= value If value > 59 →= (value – 59) * 60
12 13 14 15 16	[10-20%] [20-40%] [40-60%] [60-80%] [80-1000%]	55 2a 00 00 00	85 42 0 0 0	(180 – 128) x 85 / 127 = 35 (180 – 128) x 42 / 127 = 17 (180 – 128) x 0 / 127 = 0 (180 – 128) x 0 / 127 = 0 (180 – 128) x 0 / 127 = 0	min min min min min	Raw data of time in anomaly in the payload are given on the « bad vibration » period : operating time –(0-10%] time To have the value in pourcentage : [value in minutes] / [Report length] * 100
18-26	Anomaly predictions 24h : 20% - 50% - 80% 30d20% - 50% - 80% 6mo20% - 50% - 80%	77 ff ff ff ff ff ff ff ff	119 255 255 255 255 255 255 255 255	119 / / / / / / / /	hours days months	Projection are calculated with a linear regression using data of the previous 24h, reps. 30 days , and 6 months. If value = 255, we suggest not to display any value

Example other data extraction



Byte(s)	Description	hex.	dec.	Value	Unit	Comments
5	Temperature	35	53	53-30 = 23	°C	Hardware offset
8,9,10	Maximum vibration amplitude	00 19 26	0 25 38	(0 x 128 + 25 + 38 / 100) / 10 / 121.45 = 0,0209	g	
11	Peak frequency	0c	12	12+ 1 = 13	Hz	
17	Battery percentage	7c	124	124 x 100 / 127 = 97,6	%	Estimated from IA running and Lora RX/TX transmissions + sleep

ALARM MESSAGE payload structure

Byte	Signification	Value (dec)	Real_Value	Unit	Range	Description

0	MPU = “A” or KX = "a"	MPU = 65 Or KX = 97		const		Header (Alarm)
1	Anomaly level	0~127	Value * 100 / 127	%	[0, 100]	int
2	Temperature	0~127	Value - 30	°C	[-30, 97]	int
3	NA	NA	NA		NA	NA
	Vibration level (vl_1)	0~127	Value	g	[0, 127]	vl = (vl_1 * 128 + vl_2 + vl_3 / 100) / 10 / 121.45
5	Vibration level (vl_2)	0~127	Value			
6	Vibration level (vl_3)	0~127	Value			
7	NA	NA	NA	NA	NA	NA
8~39	FFT signal (needed to be calculated with vibration level)	0~127		g; Hz		Value_g = Value * vl / 127; Frequency_hz = (i * 4 + 4) * FREQ_SAMPLING_ACC_HF / 256 (i is the index of FFT array, begins from 0, ends by 31)

STATE MESSAGE payload structure

(STATE message is the first applicative payload sent by the device after power-on)

Byte	**Signification**	**Value (dec)**	**Real_Value**	**Description**
0	MPU/KX = “S”	MPU = 83 (hex=0x53) or KX = 83 (hex=0x53)		Header (State) : same value for any type of Inertial Motion Unit)
1	sensor & machine states	100~101;125~126	(Value)	100: Sensor start; 101: Sensor stop; 125: Machine stop; 126: Machine start
2	Battery percentage	0~127	Value * 100 / 127	% [0,100]

Downlink (LoRa to device)

Only one byte constitutes a downlink message (byte in HEX). Commands have to be sent one by one.

Renew learning phase or over-learning

Byte to send (hex)	Downlink Port	Signification
50	1	Restart learning from 0
51	1	Additional Learning

Restart learning will erase the previous knowledge and learn 50 new samples

Additional Learning will learn 50 new samples

Changing measurement period

Byte to send (hex)	Downlink Port	Signification
52	1	Very Fast Mode
53	1	Fast Mode
54	1	Recommended Mode
55	1	Slow Mode

Measurement period ranges

Mode	Learning Period	Detection Period
Very Fast	10 sec	20 sec
Fast	20 sec	2 min
Recommended	60 sec	5 min
Slow	2 min	10 min

Activate/deactivate STATE MESSAGE

Byte to send (hex)	Downlink Port	Signification
56	1	Enable State Message
57	1	Disable State Message

The message “Enable State Message” activates the start/stop machine notification
The message “Disable State Message” deactivates the start/stop machine notification (used mostly to spare sensor energy in case of frequent state transitions)

Note:
2 years warantly is guaranteed for nominal operation which implies :

- 5 min period measurement
- 8 start/stop messages per day

Note : Start/stop messages and battery life

We recommend to automatically deactivate start/stop messages if the total number of message received during the first month of operation is more than 500. A warning should be displayed to users.
The ability for the user to manually deactivate start/stop message is optionnal

ALARM MESSAGE threshold

Byte to send (hex)	Downlink Port	Signification
58	1	Alarm Threshold when anomaly > 10%
59	1	Alarm Threshold when anomaly > 15%
5A	1	Alarm Threshold when anomaly > 20%
5B	1	Alarm Threshold when anomaly > 25%

Additional computation (at server level)

To get the **Operating Time**: (Report Period * Percentage Vibration) / 100

The peak frequency value is calculated using the following Low Frequency data rate.
MPU:

- FREQ_SAMPLING_ACC_LF = FREQ_SAMPLING_ACC_HF =1000 Hz

KX:

- FREQ_SAMPLING_ACC_LF = 800Hz
- FREQ_SAMPLING_ACC_HF = 25600Hz

Vibration Level value is split in 3 Bytes. In order to get the real value, you must apply the equation describe in the Description column (payload table).

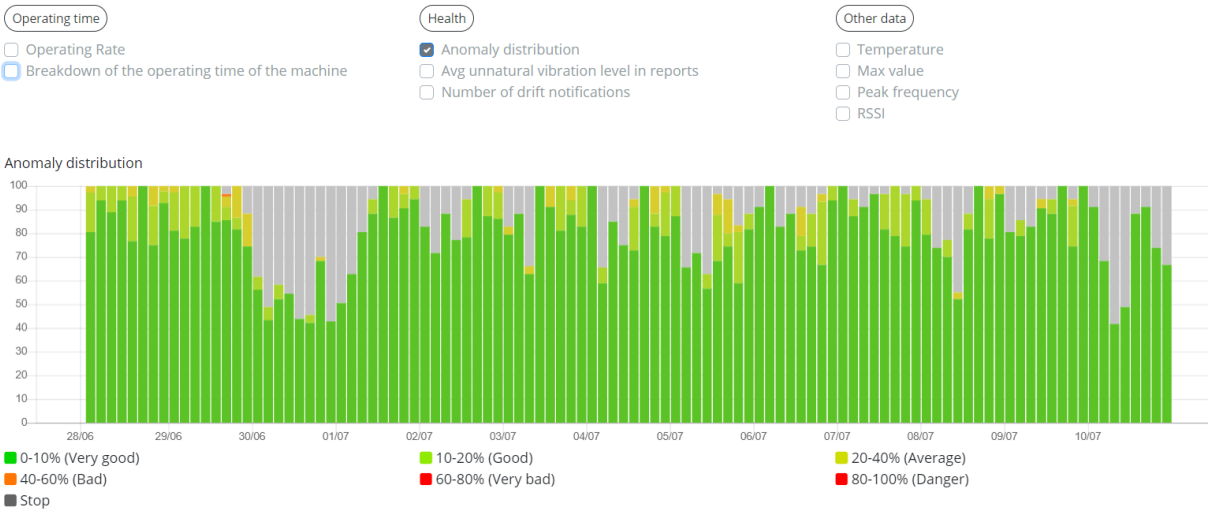
Charts examples

Breakdown of the operating time of the machine

Time of operation, expressed in minutes, over a 3 hours period of analysis.

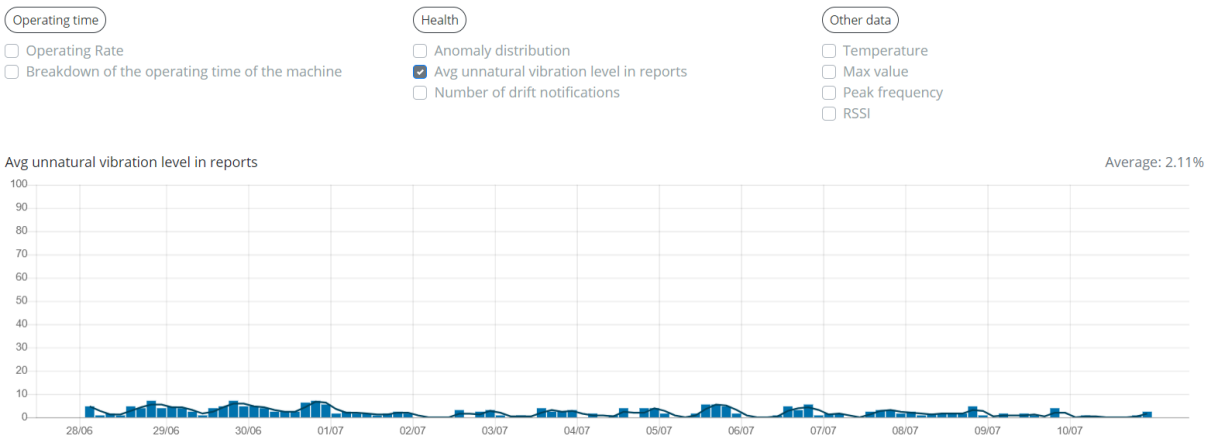
Anomaly distribution

Displays the level of abnormal vibration, related to a percentage of time spent in each zone, from very good (green) to very bad (red). Each bar shows a 3hour period of time. Gray zone exhibits the time the machine is off



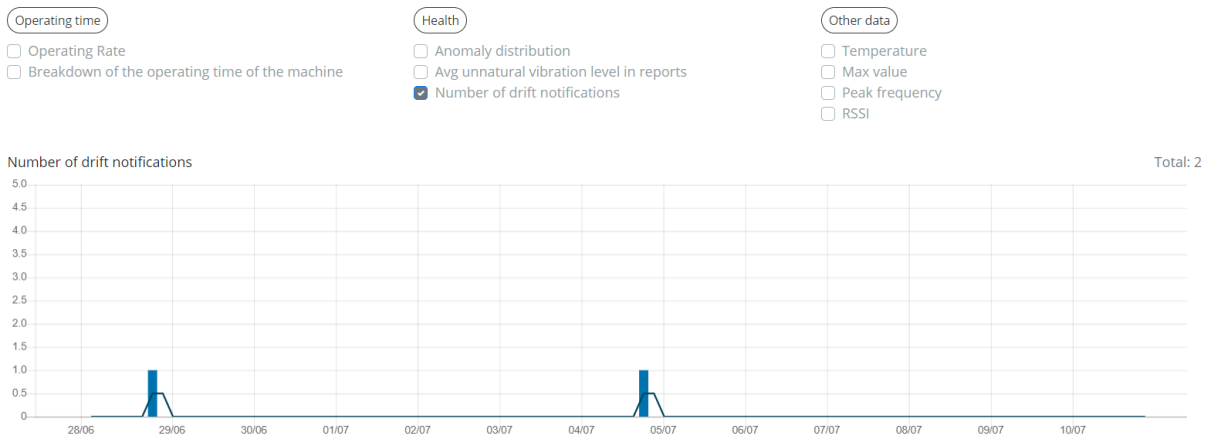
Average unnatural vibration level in reports

Vibration drift ratio mean value, calculated over a 3h period, and compared to the reference vibration signature(s). Custom notifications are usually set on this value (see elsewhere)



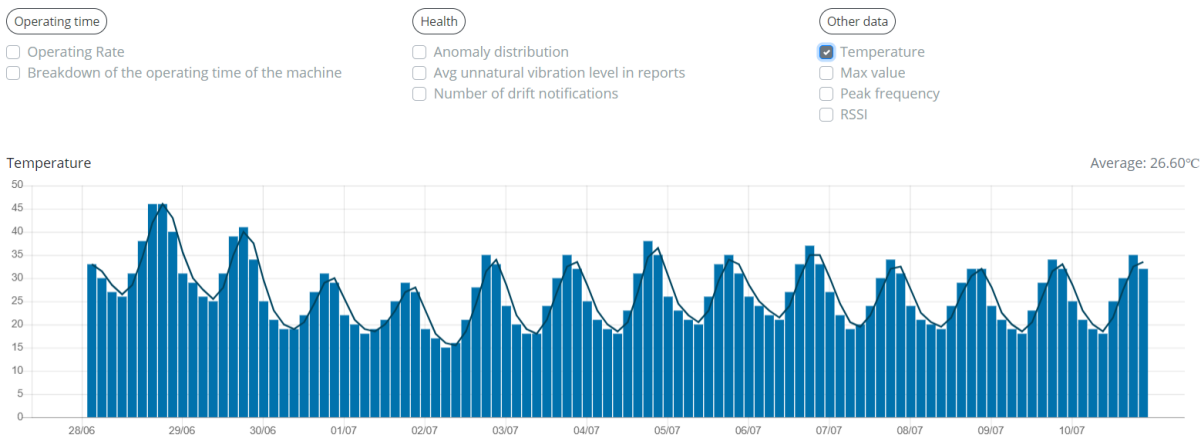
Number of drift notifications

Number of alarms that BoB has sent, when anomaly level exceeds 25%



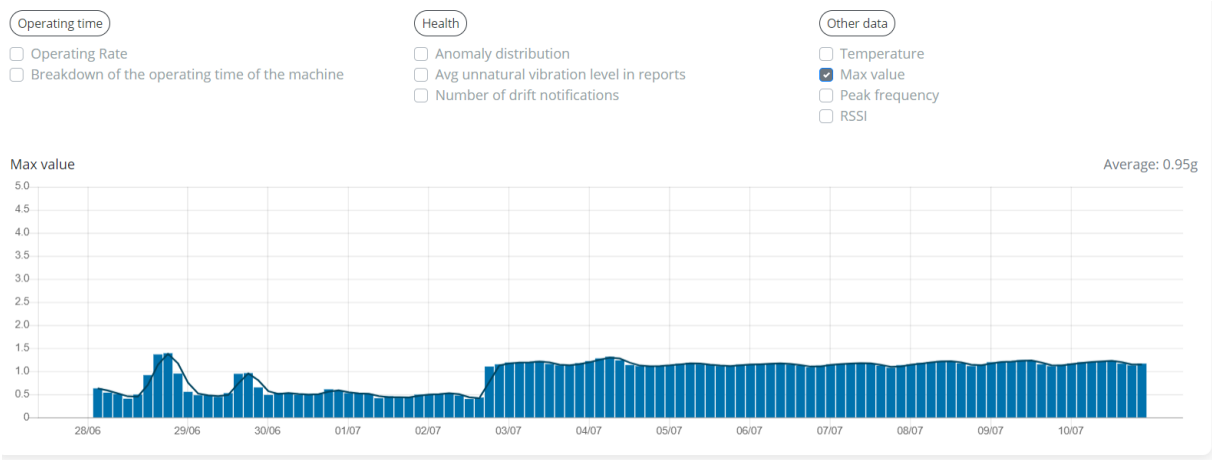
Temperature

Average temperature reported every 3h. Please note that this temperature is not the surface temperature of your machine, but an ambient average value measured inside the sensor casing.



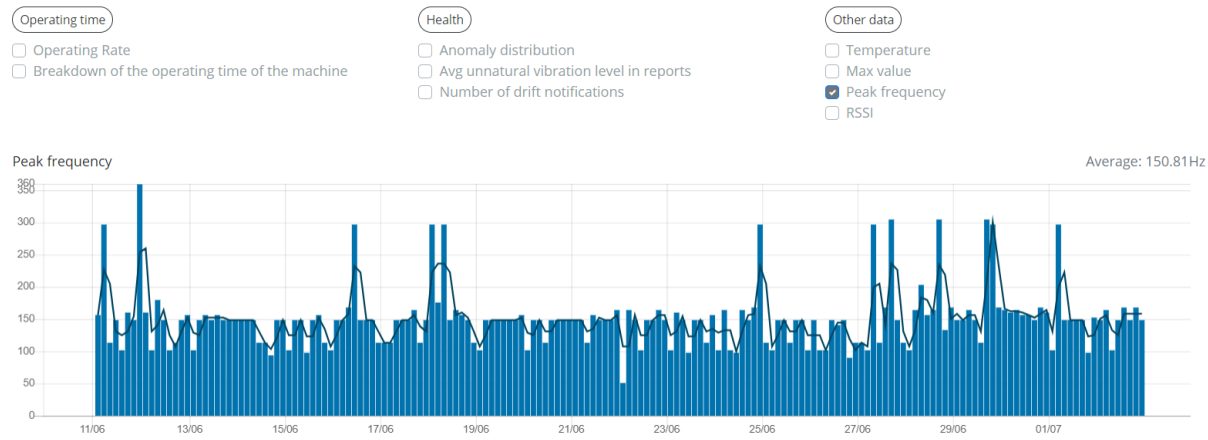
Max. vibration value

Maximum vibration amplitude in [g].



Peak Frequency

Frequency related to the maximal amplitude reported



Report view

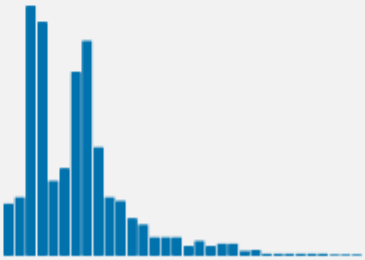
Report

Machine	-
BOB's ID	-
BOB's name	BOB7754
Description de BOB	-
Rapport envoyé	2019/07/23 08:27:53
Operating Time	180 min
Operating Rate	100 %
Time in Anomaly Stop 0-10% (Very good) 10-20% (Good) 20-40% (Average) 40-60% (Bad) 60-80% (Very bad) 80-100% (Danger)	
Unnatural vibration level	16.5 %
Number of drift notifications	0
Peak Frequency	207.03125 Hz
Max vibration amplitude	0.0575 g
Temperature	32 °C
RSSI	-42 dBm
Report length	180 min
Battery percentage	76 % Remaining: ~ 3 years

Anomaly prediction / Observed period	Last 24 hours	Last 30 days	Last 6 months
Anomaly 20 %	0 hours	infini	infini
Anomaly 50 %	194 hours	infini	infini
Anomaly 80 %	infini	infini	infini

Vibration drift Alarm view

Alarm

Machine	Demo fleet
BOB's ID	70b3d531c0001189
BOB's name	BOB7754
Description de BOB	-
Rapport envoyé	2019/06/05 16:22:35
Unnatural vibration level	64.6 %
Peak Frequency	39 Hz
Max vibration amplitude	0.0639 g
Temperature	31 °C
RSSI	-21 dBm
Signature vibratoire	 0 Hz fs/2

Payload examples

Raw payload

Payload samples for MPU version (BoB v1.0 / PN:3.x)

Type	Payload cleartext (hex)	frame number	Comment
UPLINK	417f3800010c2e156551377f3b7d63425a4e231b1711101a100c0b0a0a0707050605060505050506	10	Anomaly
UPLINK	52017f7f003802000108460c00000000007fffffffffffffffff	9	Report
UPLINK	537e7f	8	machine on
UPLINK	537d7f	7	machine off
UPLINK	4c640109140c38010303087f0704130301020101010101010101010100000000010000000000	6	Learning complete
UPLINK	4c500108090c38010304097f0704140202030101010101010101010101000100000000000000	5	Learning 80%
UPLINK	4c3c0109580c38010303087f0703130302030101010101010101010101000000000000000000	4	Learning 60%
UPLINK	4c28010a5a0c38010303087f0703130202030101010101010101010101010001000000000	3	Learning 40%
UPLINK	4c14010b3e0c38010203097f0703130202030201010101010101010100010100000000000000	2	Learning 20%
UPLINK	4c00010e2e0c38010204097f0503110202030101010101010101010101000000000000000000	1	Learning process start
UPLINK	53647f		Sensor start
JOIN			

Payload samples for KX version (BoB v1.1 / PN:4.x)

Type	Payload cleartext (hex)	frame number	Comment
UPLINK	6137320003105C0E201F45462A171F18483E454C285D7F37241610181C10180D0E0E070C110C0A0C	10	Anomaly
UPLINK	72097f5f00313e0700284c537f000000007cffffffffffffff	9	Report
UPLINK	537e7d	8	machine on
UPLINK	537d7d	7	machine off
UPLINK	6c64002d190133014c7f4731542f383531263326292c403046433d472c181e252e34232c38202531	6	Learning complete
UPLINK	6c5000333f013301407f3d25572f3228333b251c231b2e3831492d26241812181f1d182d2029383a	5	Learning 80%
UPLINK	6c3c00384b013301347f4f2a512830343a2221152d1c273242492d331e171618262413221b2d3841	4	Learning 60%
UPLINK	6c2800394e013301417f432b4f2f36232d23261c242731233a452d341714171a261f1c2324333738	3	Learning 40%
UPLINK	6c140031150134013c7f3c284b2a393f29321f1e223248294754492b191616202720212a2d28383b	2	Learning 20%
UPLINK	6c00001f3f013601407f5b4467393c303176301c332b61345b7e303e2318373f333f2231444a4245	1	Learning process start
UPLINK	53647f		Sensor start
JOIN			

KX version Decode examples

LEARNING TYPE

Payload: [6c6401015c0a3b0104067f0b060f6706051f130f411707140707142808132507040303020202020202]


```
{
  "type": "learning",
  "sensor": "KX",
  "msg": {
     "temperature": 29,
     "learningfromscratch": 1,
     "learningpercentage": 100,
     "vibrationlevel": 0.107,
     "peakfrequencyindex":11,
     "peakfrequency":34.38,

     "fft": [
        0.0034,
        0.0051,
        0.107,
        0.0093,
        0.0051,
        0.0126,
        0.0868,
        0.0051,
        0.0042,
        0.0261,
        0.016,
        0.0126,
        0.0548,
        0.0194,
        0.0059,
        0.0168,
        0.0059,
        0.0059,
        0.0168,
        0.0337,
        0.0067,
        0.016,
        0.0312,
        0.0059,
        0.0034,
        0.0025,
        0.0025,
        0.0017,
        0.0017,
        0.0017,
        0.0017,
        0.0017
     ]
  }
}
```


REPORT TYPE

Payload: [720D7F27013B0206001B011A7F000000007FFFFFFFFFFFFFFFFF]


```
{
   "type": "report",
   "sensor": "KX",
   "msg": {
      "batterypercentage": 100,
      "anomalylevel": 10.2,
      "anomalylevelto20last6mo": 255,
      "nbalarmreport": 1,
      "operatingtime": 2,
      "totalunknown6080": 0,
      "totalunknown4060": 0,
      "totalunknown2040": 0,
      "anomalylevelto80last30d": 255,
      "vibrationlevel": 0.0222,
      "totalunknown1020": 1,
      "anomalylevelto80last6mo": 255,
      "anomalylevelto50last24h": 255,
      "anomalylevelto20last24h": 255,
      "anomalylevelto50last30d": 255,
      "temperature": 29,
      "reportlength": 2,
```

```
      "anomalylevelto20last30d": 255,
      "peakfrequencyindex": 27,
      "totalunknown80100": 0,
      "totaloperatingtimeknown": 1,
      "anomalylevelto50last6mo": 255,
      "anomalylevelto80last24h": 255
    }
}
```

ALARM TYPE

Payload: [611C3B010044351C7F121D1D101D2F302B291E15110C0909080807070605040303030202010201020102]


```
{
   "type": "alarm",
   "sensor": "KX",
   "msg": {
      "temperature": 29,
      "vibrationlevel": 0.0564,
      "anomalylevel": 22,
      "fft": [
         0.0564,
         0.008,
         0.0129,
         0.0129,
         0.0071,
         0.0129,
         0.0209,
         0.0213,
         0.0191,
         0.0182,
         0.0133,
         0.0093,
         0.0076,
         0.0053,
         0.004,
         0.004,
         0.0036,
         0.0036,
         0.0031,
         0.0031,
         0.0027,
         0.0022,
         0.0018,
         0.0013,
         0.0013,
         0.0013,
         0.0009,
         0.0009,
         0.0004,
         0.0009,
         0.0004,
         0.0009
      ]
   }
}
```

STATE TYPE

Payload: [73647F]


```
{
   "type": "state",
   "sensor": "KX",
   "msg": {
      "state": 0,
      "batterypercentage": 100
   }
}
```


--- end of document ---