ubpulse H3 HRV Analysis Communication Standard

ubpulse H3 HRV analysis communication standard - Based on LXSDF T2

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Abstract – ubpulse H3 can be used for HRV inspection, the inspection is started by the start command at the host side or auto started by the device, and when the inspection is completed, the signal processing process is performed in the device, and the final inspection result data is transmitted through the serial communication. This document describes the LXSDF T2 deployment situation of HRV inspection related data. Since the contents of this document are based on the LXSDF T2 format, it is essential to refer to the document ID LXD12 and document ID LXD13, which is a general measurement data communication standard.

Required reference documentation

Documentation ID : LXE12, Documentation title : LXSDF T2 communication standard. Download : https://github.com/LAXTHA/LXSDF/raw/master/LXE12_LXSDFT2_CommunicationStandard_en.pdf
Documentation ID : LXE13, Documentation title : ubpulse H3 Measurement data communication standard. Download: https://github.com/ubpulse/ubpulse-H3/raw/master/LXE13_ubpulseH3_CommunicationSpec_Measure_en.pdf

Contents

ubpulse H3 HRV analysis operation flow.

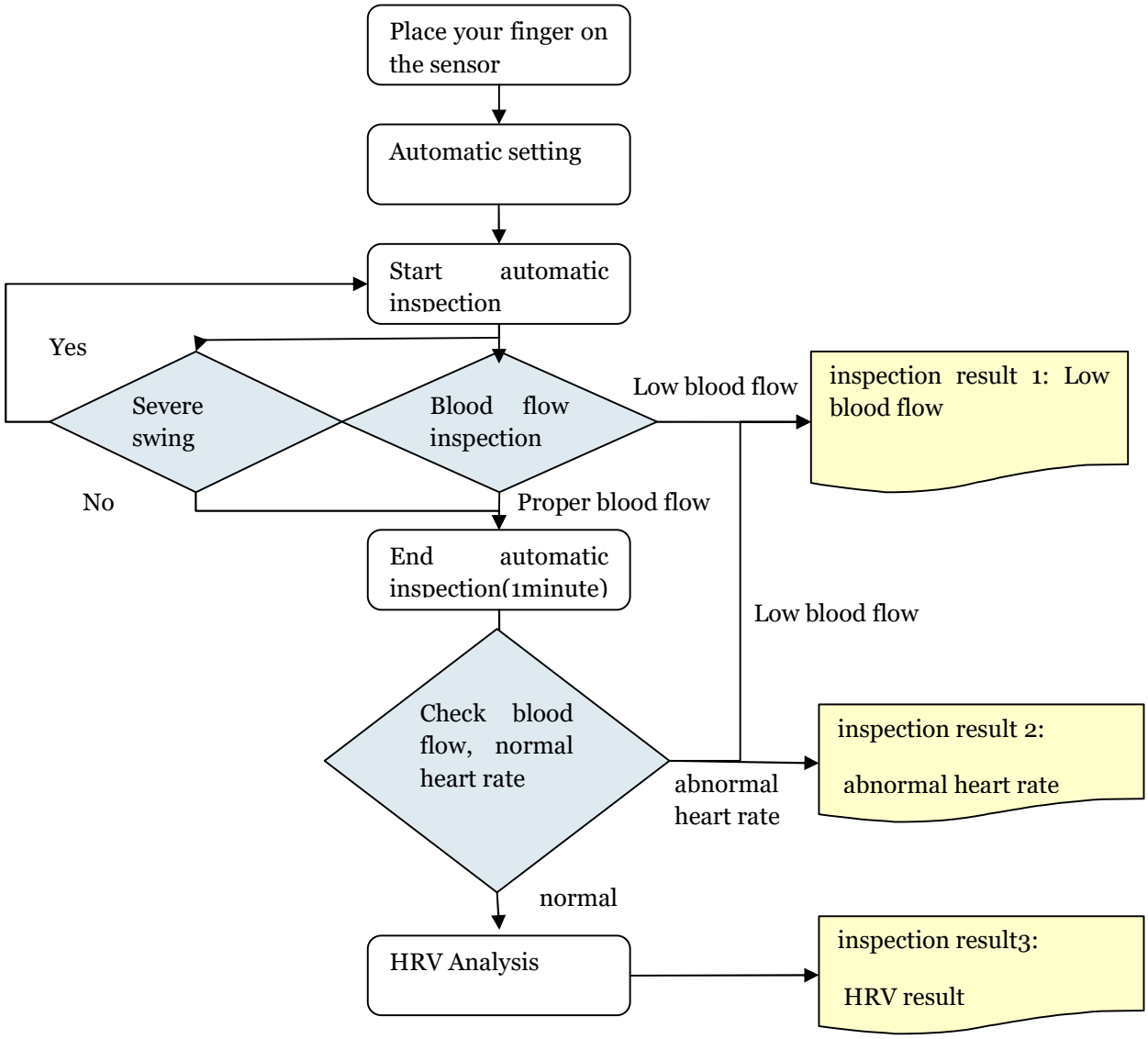


Figure 1. Overall flow of device operation after placing a finger on the device.

When the user places a finger on the ubpulse H3, the device detects it and achieves the optimum signal measurement condition in the automatic setting process which takes about 3 seconds. After 3 seconds, the device will automatically enter the inspection mode by itself. If the blood flow of the user is abnormally small in the inspection mode, the inspection is automatically stopped before one minute is completed, and the result of the "low blood flow determination" is displayed.

If the user moves his or her fingers heavily during the measurement, the inspection will start again from the beginning.

If there is no serious "abnormal low blood flow", the inspection is stopped at 1 minute after the normal time, and then the "low blood flow" is judged again. In the case of low blood flow, the result of "low blood flow judgment" is presented. If the blood flow is not low, the "abnormal heart rate" is determining. If the "abnormal heart rate" is abnormal, the "abnormal heart rate" is expressed. And arrhythmia are the most common causes of abnormal heart rate, and HRV analysis can not be applied when there is such an abnormal heart rate.

HRV analysis is performed when there is neither low blood flow nor abnormal heart rate, and the final analysis results are summarized and expressed.

Assign ubpulse H3 data to LXSDF T2 RX data format.

HRV inspection abnormal heart rate / low blood flow judgment value stting command.

On the host side, the judgment reference value used for the abnormal heart rate determination and the determination reference value used for the "low blood flow determination "can be set as a result of the HRV inspection on the apparatus. If the number of "abnormal heartbeats" in the measured heartbeats for one minute is equal to or greater than the reference value, the "abnormal heartbeat" is reported in the inspection result. If the heart rate is below the threshold value, HRV analysis is performed after correcting the abnormal heart rate in the apparatus. Since the correction process is to artificially change the value of the abnormal heart rate time interval to the range of the normal heart rate time interval, the HRV analysis result is not reproducible when the amount of correction is increased. Therefore, it is reasonable to perform correction processing to five or less. In such a case, HRV analysis results in which the autonomic nervous system characteristics of the user are not distorted can be obtained. In the case of severe arrhythmia (a typical example of abnormal heart rate), HRV analysis can not be applied because more than half of the total heart rate is abnormal heart rate.

If the PI of the user is very low and the blood flow is low, normal measurement is impossible and the blood flow is judged to be low. Most people have a PI greater than 1%, and devices with more than 1% blood flow can be reliably measured, but less than 1% of low blood flow is often observed in cold hands woman. If the user has a temporary decrease in blood flow, warm the hand and increase the blood flow to 1% or more and inspect. It can not be examined if it is constitutionally low blood flow.

Instruction Contents	LXSDF T2 RX Data Placement	Explanation.
Abnormal heartbeat determination reference value setting	Cmd0: 128 Cmd1: 3 Cmd2: Determination reference value	The command can be transmitted to change the determination reference value used in the abnormal heartbeat determination in the device.. The criterion value is an integer between 1 and 30 If this command is not executed on the host side, the basic setting inside the device is set to 5. That is, when the abnormal heart rate is five or more, the abnormal heart rate is determined
Low blood flow judgment reference value setting.	Cmd0: 128 Cmd1: 4 Cmd2: Determination reference value	A determination reference value used in determination of a low blood flow inside the apparatus can be set on the host side. The PI used for the criterion is multiplied by 100 and delivered as Cmd2. An integer from 1 to 250 is possible, corresponding to a PI of 0.3% to 2.5%. The default setting on the device is 80 (0.8%).
Abnormal heart rate correction strength	Cmd0: 128 Cmd1: 5 Cmd2: compensate strength	The allowable quantity of abnormal heart rate is calibrated internally. Enter the correction strength as Cmd2. An integer from 1 to 10. 1, it is the middle value between the mean value and the abnormal heart rate interval. As the number increases, it becomes closer to the average value. The device default is 4.

HRV "stop inspection start" Result data request.

It is used to send HRV inspection related commands from host to ubpulse H3. The list of commands is shown in the table below.

Instruction Contents	LXSDF T2 RX Data Placement	Explanation.
HRV inspection started	Cmd0: 128 Cmd1: 1 Cmd2: 0	From the point of receipt of the start command, the data necessary for HRV analysis is newly saved. (Data from the previous session is deleted.)
Stop inspection HRV	Cmd0: 128 Cmd1: 0 Cmd2: 0	Stop inspection HRV
HRV analysis data request 0	Cmd0: 128 Cmd1: 2 Cmd2: 0	The device that received the command transmits all data except analysis numbers 1 and 4 in the analysis data.
HRV analysis data request 1	Cmd0: 128 Cmd1: 2 Cmd2: 1	The device that received the command transmits the item number 4 "histogram" from the analysis data.
HRV analysis data request 2	Cmd0: 128 Cmd1: 2 Cmd2: 2	The device that received the command transmits the item number 1 "heart rate measurement data" from the analysis data

Host's inspection start/stop command

If the host sends a inspection start command, if the finger is present, the inspection data is in the inspection start state even when the reliability is not high. Once the host has initiated the inspection with the start of inspection command, if the instability that occurs later on the device, and the automatic setting in the device is performed, the inspection is performed from the beginning without interruption from the host, Until the command is sent, the device goes through the test itself.

When the stop command is received from the device, the stop command is effectively stopped only when the stop command is received. Otherwise, the stop command is received but is returned without any processing do.

Analysis data request command 0,1,2.

When the analysis data request command is transmitted to the device, the device transmits the corresponding data if it is not currently being inspection. If the analysis data request command is sent during the inspection, the device does not transmit data to the host.

When the inspection status is in the non-progress status or the stop status, the data is transmitted to the host in response to the analysis data request command. However, it corresponds to the meaningful data only when the analysis data hold status (PCD Bit 5) is 1.

The relationship between the automatic inspection start function of the device and the test command of the host.

Automatic inspection function of the device: The function to automatically start inspection when the user inserts a finger. The automatic inspection function is performed only once after the user inserts the finger, and does not enter the automatic inspection when the user keeps the finger inserted after the completion of one inspection. If you remove your finger and insert it again, it will always go into automatic inspection..

Priority of host start command and automatic inspection function.

The command of the host takes precedence. If the host sends the command to start the inspection after the device has already started the automatic inspection, the inspection starts again from the beginning.

The host sends a stop inspection command.

If the host sends a inspection stop command after the device has started the automatic test, the device does not enter the automatic inspection. When the host starts the inspection again, the inspection is resumed. If the user releases the finger again, device enter the automatic Inspection.

ubpulse H3 data allocation to LXSDF T2 TX data format.

HRV inspection status information.

Data item	LXSDF T2 TX Packet Data placement	
Whether the test is proceeding	PCD Bit 7, Bit 6 of PC 16	0 (00): non-progress. 1 (01): In progress 2 (10): Stopped (fingered) 3 (11): Stopped (cause of low blood flow)
Type of test result.	PCD Bit5, Bit4 of PC16	0 (00): Non-retained test data 1 (01): Test result 1: Low blood flow 2 (10): test result 2: abnormal heart rate 3 (11): Test result 3: HRV test result
inspection time remaining	/PCD of PC17	Time remaining in seconds
Quantity of measurement data of heart rate time interval	PCD of PC18: high byte of quantity PCD of PC19: lower byte of quantity	Quantity = High byte X 256 + Low byte

Whether the inspection is proceeding.

When the host is instructed to start the HRV test, the device enters the state for HRV inspection and proceeds until it completes unless there is reason to suspend it.

The state value has a value of 0,1,2,3.

Status value	meaning	
0	Inspection is not in progress	Before the start of the inspection, when the inspection is completed.
1	Inspection in progress	After the device enters inspection mode
2	Suspension (Reason: Removed finger during inspection.)	
3	Suspension of examination (Reason: low blood flow)	

If there is a situation where an error can be made in the inspection result (automatic setting on the device, or the finger movement is large), the device automatically restarts the inspection from the beginning without stopping the inspection.

Inspection result type.

Indicates four types of inspection result types.

Status value	meaning	
0	Non-retention of inspection data	the time of inspection entry, inspection data is always in a non-retention state.
1	Low blood flow	If the blood flow was judged to be progressing during the inspection, or if the blood flow was judged after 1 minute, it becomes 1.
2	Abnormal heart rate.	If 1 minute inspection is completed and abnormal heartbeat is detected, it becomes 2.
3	HRV was analyzed.	HRV analysis is performed when there is neither low blood flow nor abnormal heart rate after completion of 1 minute inspection, and it becomes 3.

HRV inspected Remaining Time.

The time remaining in seconds until the inspection starts and ends. The test starts from 60 seconds, while the test is proceeding. The value decreases to 0 when the test is completed.

Quantity of measurement data of heart rate time interval.

During the inspection, the device stores the heart rate time interval of the subject and represents the amount of stored data from the start to the present point in time.

HRV analysis data

When the test is completed, the device has HRV analysis data, and the analysis data is transmitted from the device by transmitting a data request command from the host. The analysis data is transmitted from **PCD Type 1, 2, 3, 4 of the LXSDF T2 TX packet to the PCD, and once transmitted, the PCD Type is restored to 0 again**.

In the table below, PCD [n] is the PCD value when PC (packet count) is n.

Station number	Data item	Data type	LXSDF T2 placement.	Remarks
1	Heart rate time measurement data	2byte array	**PCD[] of PCD Type3,4 (5,6)**	Measurement raw data. Unit : millisecond.
2	Histogram	1byte array.	**PCD[] of PCD Type2**	Heart rate time Histogram unit : Quantity.
3	Heart rate	1byte array	**PCD[0] of PCD Type1**	Heart rate per minute . unit : bpm Range of values : 30 ~ 250 bpm
4	PI (Perfusion Index)	2byte array	**PCD[1], PCD[2] of PCD Type1**	unit : % The transmitted value is divided by 100 and expressed to two decimal places. 0.01~25.0
5	HRV Index	1byte integer	**PCD[3] of PCD Type1**	unit : none. The transmitted value is divided by 10 and expressed to one decimal place.
6	Autonomic Activity	1Byte integer.	**PCD[4] of PCD Type1**	Unit : msec^2. The transmitted value is divided by 10 and expressed to one decimal place.1.0~20.0
7	Sympathetic Activity	1Byte integer.	**PCD[5] of PCD Type1**	Unit : msec^2 The transmitted value is divided by 10 and expressed to one decimal place.1.0~20.0
8	Parasympathetic Activity	1Byte integer.	**PCD[6] of PCD Type1**	Unit : msec^2 The transmitted value is divided by 10 and expressed to one decimal place.1.0~20.0
9	Autonomic balance - sympathy **(Note 1)**	1Byte integer.	**PCD[7] of PCD Type1**	Sympathy: Percentage of sympathy from parity unit : % Example: 54 means 54% if delivered. 1 ~ 99
10	Heart rate size determination value **(Note 2)**	1Byte integer.	**PCD[8] of PCD Type1**	clinical data based step 5
11	-	1Byte integer.	**PCD[9] of PCD Type1**	don't care.
12	Heart rate variability size determination value	1Byte integer.	**PCD[10] of PCD Type1**	clinical data based step 5
13	-	1Byte integer.	**PCD[11] of PCD Type1**	don't care
14	Autonomic nerve activity sizing value.	1Byte integer.	**PCD[12] of PCD Type1**	clinical data based step 5
15	Sympathetic activity size determination value	1Byte integer.	**PCD[13] of PCD Type1**	clinical data based step 5
16	Parasympathetic activation size determination value	1Byte integer.	**PCD[14] of PCD Type1**	clinical data based step 5
17	Autonomic balance - sympathetic size determination value **(Note 3)**	1Byte integer.	**PCD[15] of PCD Type1**	clinical data based step 5

(Note 1)

100 * sympathetic activity / (sympathetic activity + parasympathetic activity)% values are recorded.

For example, if 48 were transmitted, the sympathetic activity was 48% and the parasympathetic activity rate was 52% (100 - 48).

Sympathy: paralysis = 48:52

(Note 2)

The size determination value for the stations 12 to 16.

Size determination value	meaning
0	Very small
1	small
2	Standard
3	large
4	very large

(Note 3)

Note: Analysis of autonomic balance - sympathetic size determination value

(Vigor + sympathetic sense) x 100% of voicemail 9, so the meaning according to the size judgment value as shown in the table below.

Size determination value	Sympathetic / paraplegic	meaning.
0	very small	The feeling of parity is much greater than that of sympathy.
1	small	The feeling of parity is greater than that of sympathy.
2	standard	Standard ratio.
3	large	Correspondence is greater than parity.
4	very large	Correspondence is much greater than paranoid.

Data placement description.

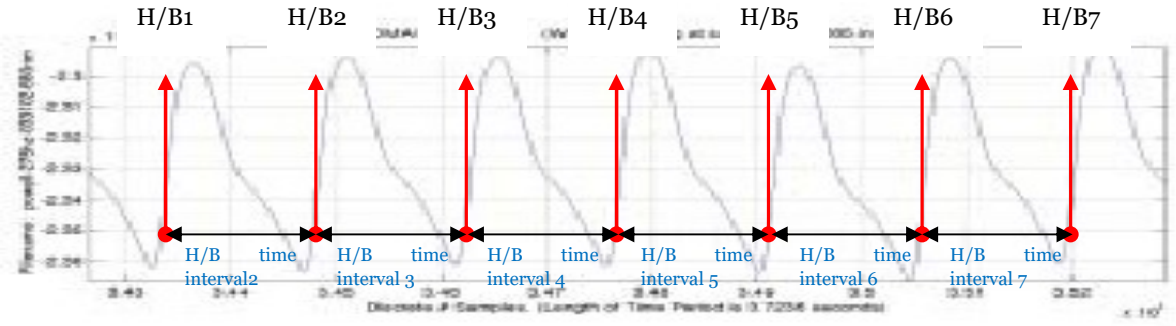
Analysis data station number	PCD Type	PC (Packet Count) Maximum Value	Explanation
1	3,4 or 3,4,5,6	Variable	(Note1)
2	2	225	The histogram data is a 1-byte array, the size of the array is 225, and the value of the packet count corresponds directly to the array indices 0 to 224. (Note 2)
3~17	1	15	

(Note 1)

The PC maximum value is variable for each test and its value is determined by the "number of heartbeat interval measurement data" of the HRV test status data described above.Heart rate time interval measurement data refers to heart rate time intervals in the figure below.

If the number is less than 128, for example, 120, the time interval is 2 bytes. Therefore, 240 bytes are sufficient to transmit, so that data is transmitted only in PCD Type 3, and the maximum packet count is 240 at this time.

If the number is greater than 128, for example, 200 bytes, 400 bytes are required. Therefore, 128 data transfers are completed while PCD Type = 3 and the PC maximum value is 255, and 2 bytes of data for the remaining 72 segments are transferred to the PCD It is transmitted until Type = 4 and reaches PC maximum value 144.



(H/B = Heart Beat)

Heart rate time interval data format.

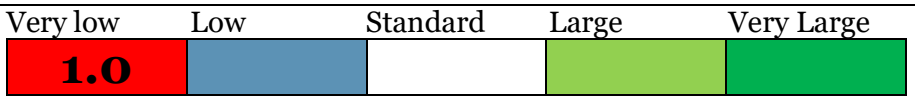
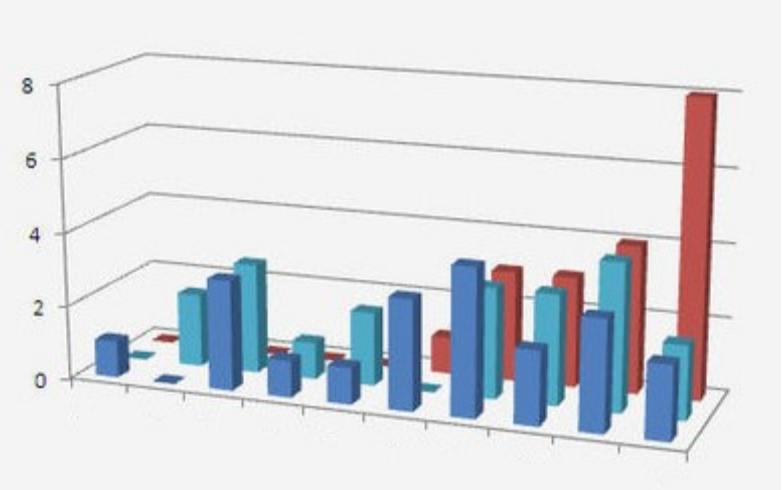
PC=0 PCD : The Higher byte of the heart rate time interval 1.
PC=1 PCD : The Lower byte of the heart rate time interval 1.
PC=2 PCD : The Higher byte of the heart rate time interval 2.
PC=3 PCD : The Lower byte of the heart rate time interval 2.
.
.
.
PC= 2 x total heart rate - 1: upper byte of last heart rate time interval
PC= 2 x total heart rate: lower byte of last heart rate time interval
The heart rate time interval is in milliseconds, and the value is calculated by calculating the upper byte x 256 + lower byte.

(Note 2)

The meaning of the transmitted histogram data.
The heart rate in each interval is divided by 0.2 seconds to 2 seconds in 0.008 seconds.
In other words,
PC 0 : Heart rate at 0.2 to 0.2008 sec interval
PC 1 : Heart rate at 0.208 seconds to 0.216 seconds
,
,
PC 224 : 1.992 seconds to 2 seconds of heart rate

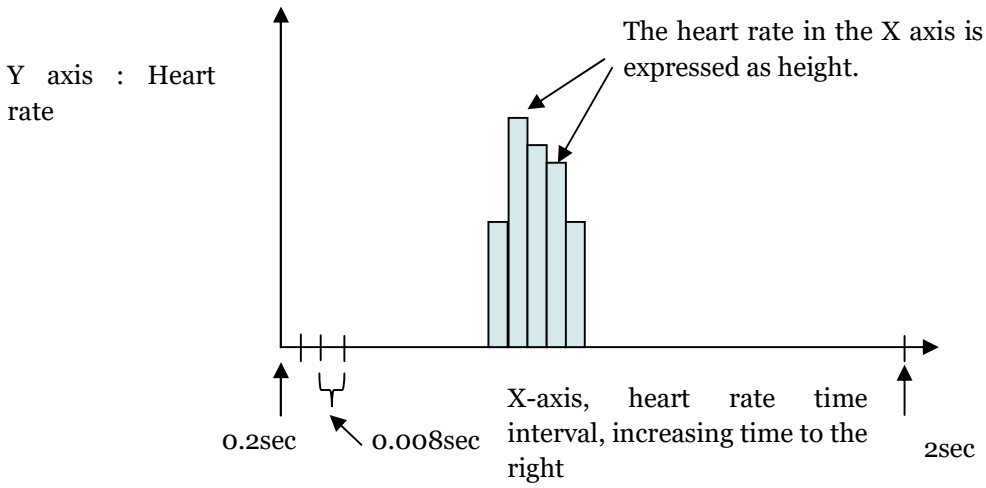
References - Examples of information representation.

Expression Examples - Heart rate histogram, heart rate variability.

Inspection items	test results
Heart rate variability	
Heartbeat histogram (If the previous three inspection data are expressed together)	

Histogram representation methods and information.

The histogram data provided by the device is the heart rate corresponding to the interval between heartbeats at intervals of 0.2 seconds to 2 seconds at the heartbeat interval of 0.008 seconds. As shown in the example of the figure below, the X axis is the time rate and the Y axis is the heart rate A histogram representation of the height corresponding to the quantity is appropriate..



Limitations on histogram representation should not only represent all of the measurements, but also the readability and comprehensibility of the information presented by the user. There is no compulsory regulation that must be followed in expression, and the key point is to achieve the following expression goals.

Histogram representation goal.

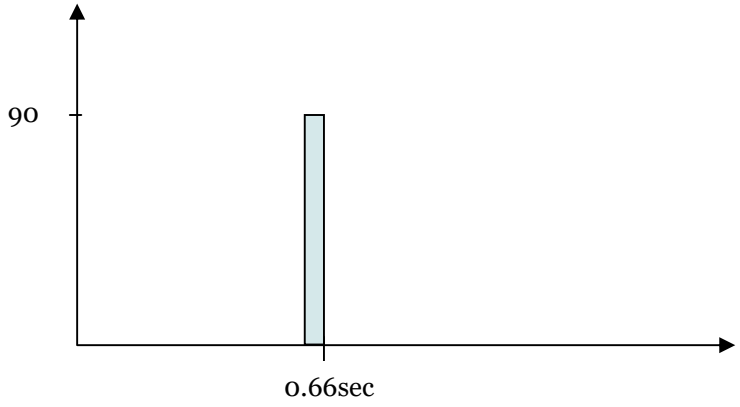
The core of the information to be grasped in the histogram is that it is used to judge the degree of sharpness or widespread distribution of the subject in the test, so it is important to visually grasp the data in the expression of the data.

Considerations for achieving a histogram representation goal.

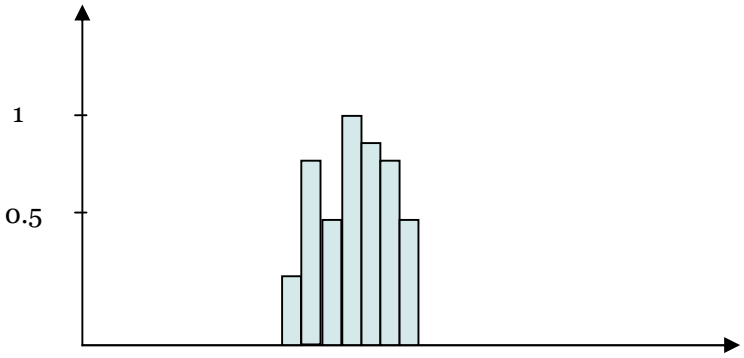
1. The scale of the X-axis (= minimum representation unit), which can affect the geometry of the histogram distribution, is fixed. If the X-axis scale has a different scale for each measurement, it is difficult to make relative comparison with another person's test result.

2. The minimum and maximum values of the x-axis of the histogram do not have to be 0.2 or 2 seconds provided by the device. A heart rate interval of 0.2 seconds is a very high heart rate corresponding to a heart rate of 300 bpm, and a heart rate interval of 2 seconds is a very slow heart rate of 30 heart rate per minute. For the completeness of the measurement itself, the device calculates and provides all the measurements in the 0.2 second and 2 second intervals. However, in a practical product application, the heart rate is rarely more than 150, and rarely less than 50. Therefore, the maximum and minimum values of the X-axis of the histogram can be determined in consideration of a practical situation.

3. Range of Y-axis values - the maximum value you can have. If the test result of the subject ascends at a heart rate of 90 per minute (heart rate interval = 0.66 sec) without change of heart rate interval for 1 minute measurement time, the value of Y axis will be 90 as shown below.



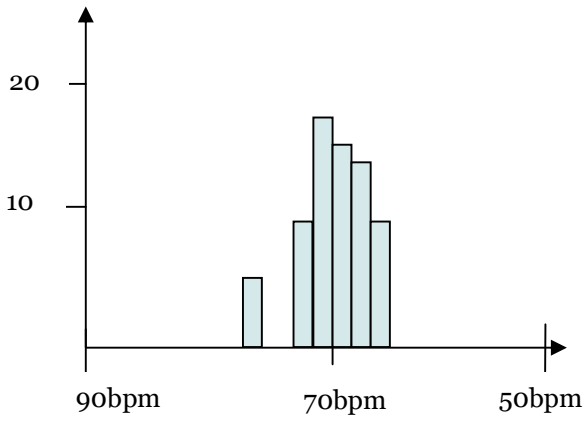
However, in reality, the heart rate interval of a person changes from a small value to a large value for one minute, and since the distribution of the individual and the maximum value of the Y axis fluctuate greatly, the method of fixedly designating the maximum value of the Y axis is not suitable. The value of the Y-axis is preferably changed dynamically whenever the inspection result is expressed. Alternatively, the remaining values may be scaled and expressed by setting the mode to 1. As shown in the figure below, if the mode is 20, the mode is expressed such that the mode is expressed as 1 when expressed in the Y axis, and the height expression is expressed as a real number by dividing all the remaining values by 20. The advantage of this approach is that the charts that are represented always maintain a fixed setting so it is convenient for coding, but since the heart rate information is gone, the user has to say, "How many times did it jump?" It is a disadvantage in that it leaves a question



Expression example.

As an example of a method of achieving the above goals and improving readability and comprehension, the following method is also possible.

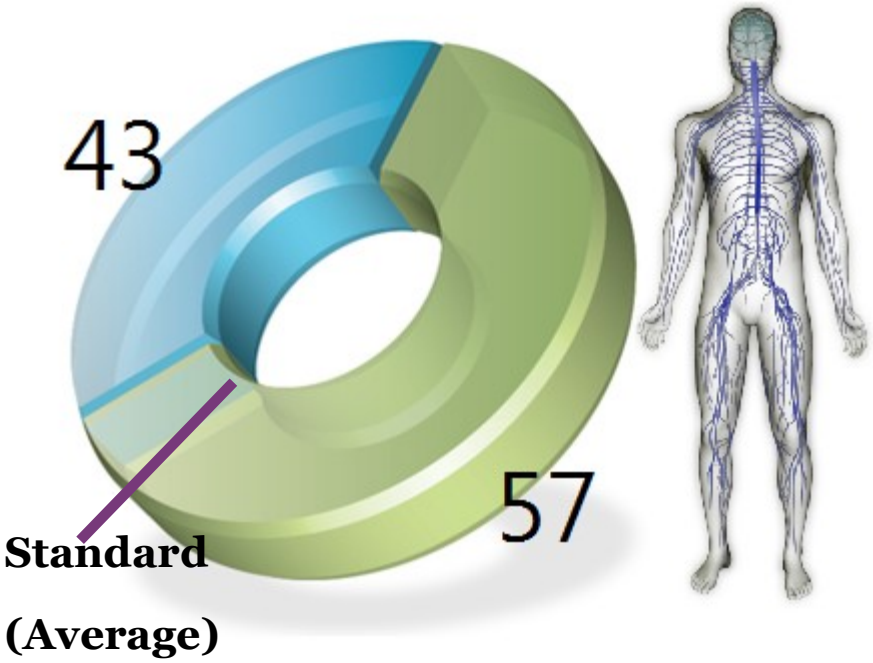
1. The values of the Y-axis are dynamically represented by referring to the histogram's mode at every measurement. In the figure below, 20 is expressed, but the reason for this expression is that the mode is expressed as 17 because the mode is 17. When examining another subject, the maximum value of the Y axis may be 10 or 40, so it must be dynamically configurable for each test result.
2. The information used for data representation on the X-axis is the heartbeat interval, but in terms of expression, it is expressed as the heart rate per minute. To better understand the heart rate per minute than the heart rate interval, users should be able to see the values presented on the X axis for intuitive understanding.
3. A histogram corresponding to the average heart rate of the heartbeat histogram is placed at the center of the X axis and a new value is calculated every time the histogram is expressed so that the minimum value and the maximum value of the X axis are the same interval from the average heart rate. Example of calculating the minimum and maximum values - If the result of 1 minute is 70 bpm (heart rate interval = 0.857 seconds) is the average heart rate, the center of the histogram X axis is set to 0.857 seconds. The maximum value on the X axis is 50 bpm (heart rate interval = 1.2 seconds) minus 20 bpm at 70 bpm. On the other hand, the minimum value of the X axis is from 70 bpm to 20 bpm plus 90 bpm (heart rate interval = 0.66 seconds).



Expression example. - Autonomic, sympathectic, parastmapathetic activation.

Inspection items	Inspection results
Autonomic nerve activity	Very low / Low / Standard / Large / Very large — **6.3**
Sympathetic activity	Very low / Low / Standard / Large / Very large — **5.8**
Parasympathetic activity.	Very low / Low / Standard / Large / Very large — **7.5**

Expression example - Autonomic balance.



Revision History

Release Date	Doc. ID	Description of Change
2018-03-16	LXE14 V1.0	First Release